Sphagnum-dominated Peatlands in the Puget Lowlands of Washington State

Ecology and Response to Adjacent Land Use

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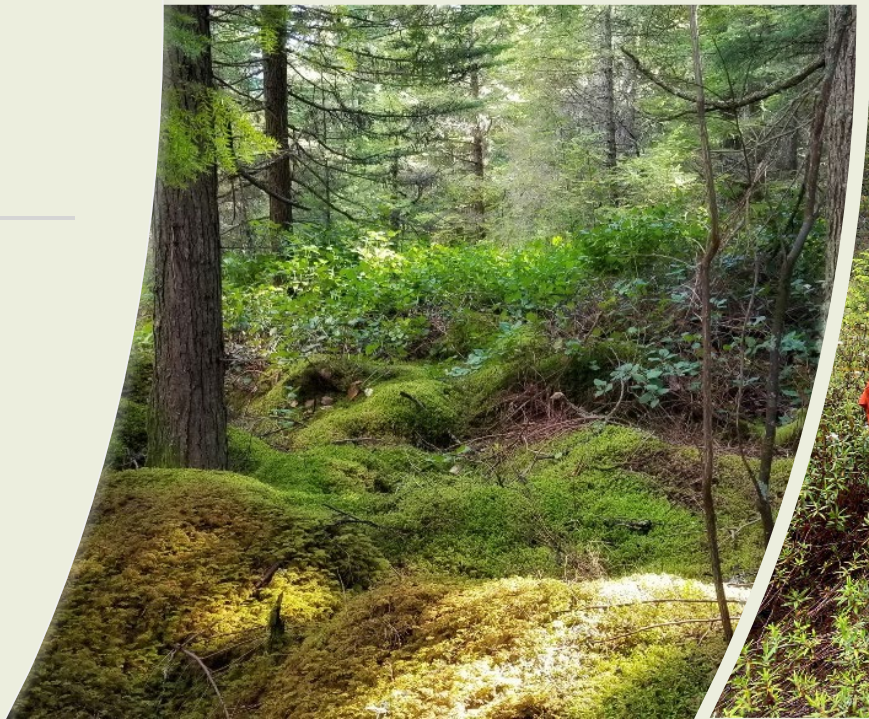

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- **U.S. EPA, Region 10**

- **Landowners**
  - City of Sammamish
  - King County DNR
  - WA DNR Natural Areas
  - SHADOW Lake Nature Preserve
  - Trossachs HOA
  - Evans Creek HOA
  - Echo Falls HOA
  - Capitol Land Trust
  - Green Diamond, Inc.

Overview

- Washington's Peatlands
- Research goals
- Results
- Recommendations

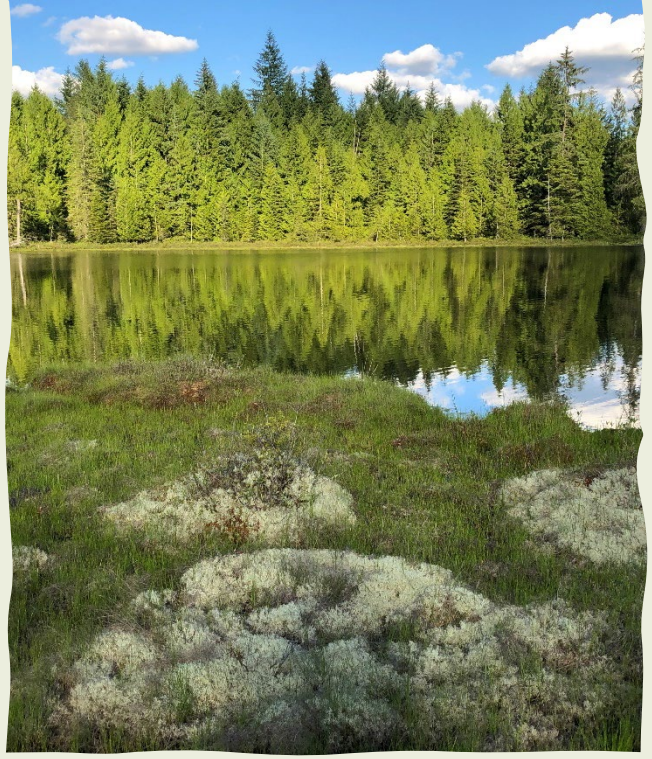
General Peatland Types

Bogs

- ***Ombrotrophic*** (strictly precipitation-fed)
- Conifers abundant
- Ericaceous shrubs
- *Sphagnum*-dominated
- Very acidic

Fens

- ***Minerotrophic*** (groundwater/surface water)
- Conifers occasional
- Sedges and deciduous shrubs
- Mosses variable
- Acidic to alkaline



Washington "Bogs"

- Inconsistent use of the "bog" concept
- Bog can be
  - Ericaceous shrubs + *Sphagnum* + very low pH

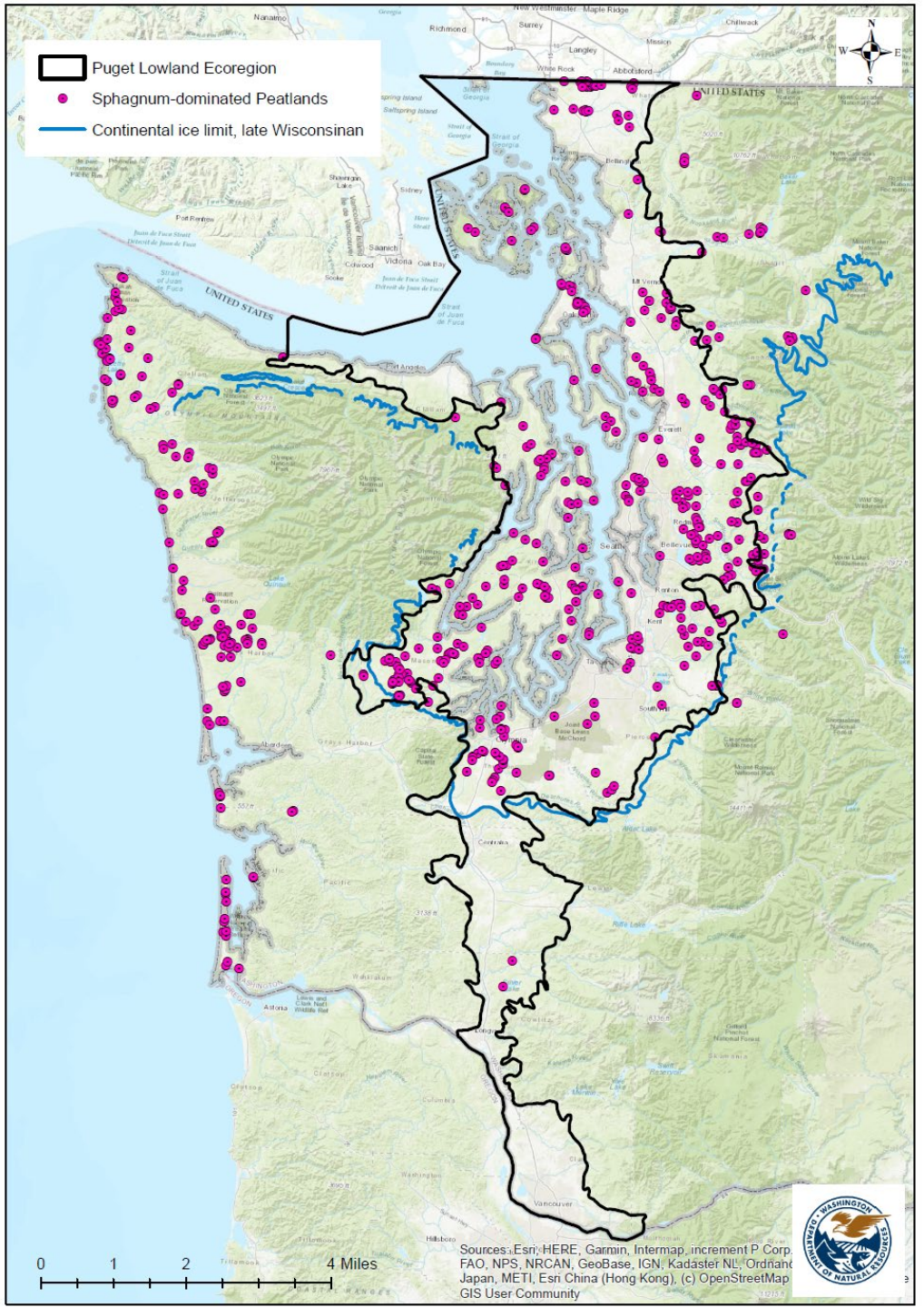
  or
  - Any peatland dominated by *Sphagnum*
- Are they ombrotrophic?
- For this talk *Sphagnum*-dominated peatlands = "bog"

Distribution of *Sphagnum*-dominated Peatlands

- 589 in western WA
- 406 in the Puget Lowland ecoregion

Table 3. Summary of Low Elevation, *Sphagnum*-dominated Peatlands of Western Washington. (Rocchio, unpublished data).

Ecoregion	Total Peatlands	Determination		Confidence		Current Status	
		Field	Aerial Photographs	Confirmed	Uncertain	Extant	Extirpated
North Cascades	33	17	16	22	11	32	1
Northwest Coast	146	64	82	90	56	144	2
Puget Lowland	406	266	140	328	78	348	58
West Cascades	4	1	3	2	2	4	0
Total	**589**	**348**	**241**	**442**	**147**	**528**	**61**



Sphagnum-dominated Peatlands

- <u>Research Target</u>:

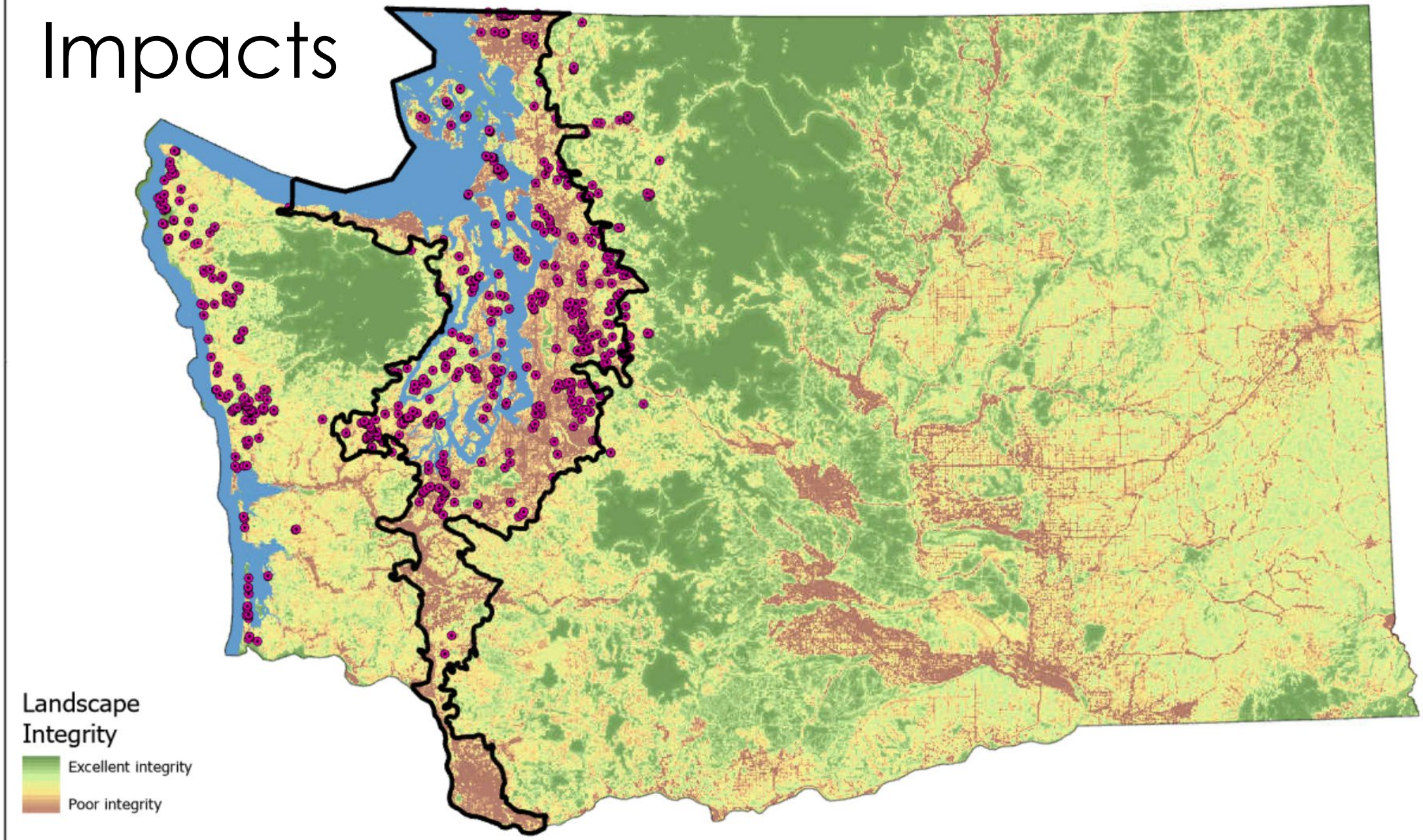
  Puget lowland "bogs"
  - Ericaceous shrubs
  - *Sphagnum* dominant
  - Herbs & deciduous shrubs are sparse
  - Acidic & nutrient poor
  - Ombrotrophic?

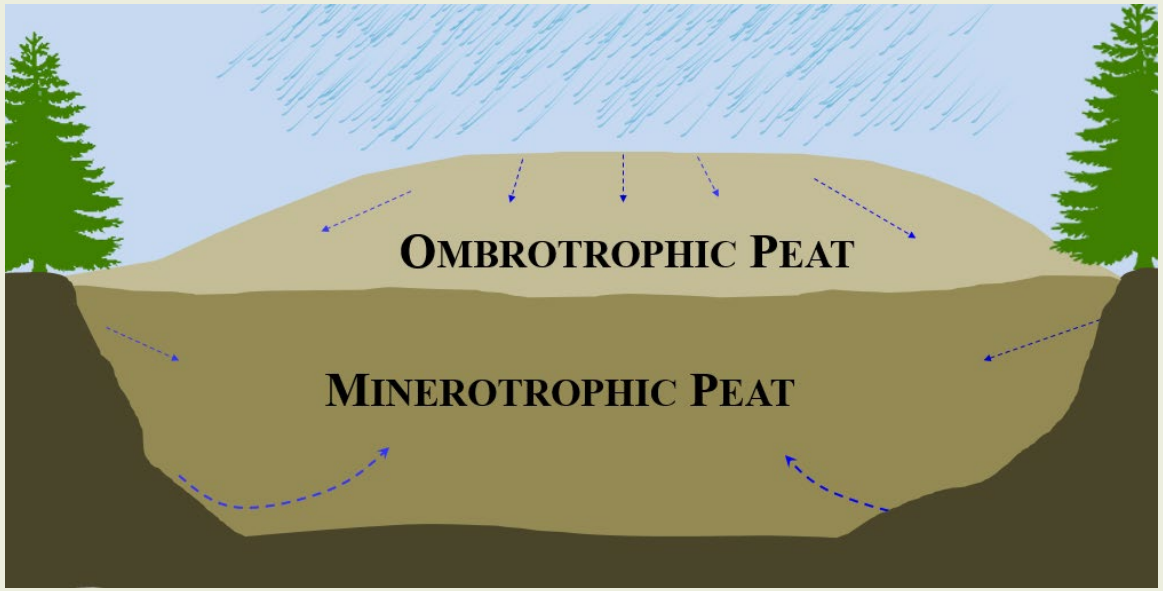
- Fens were <u>excluded</u>
  - Graminoids & deciduous shrubs abundant
  - *Sphagnum* abundant to absent
  - Acidic to alkaline

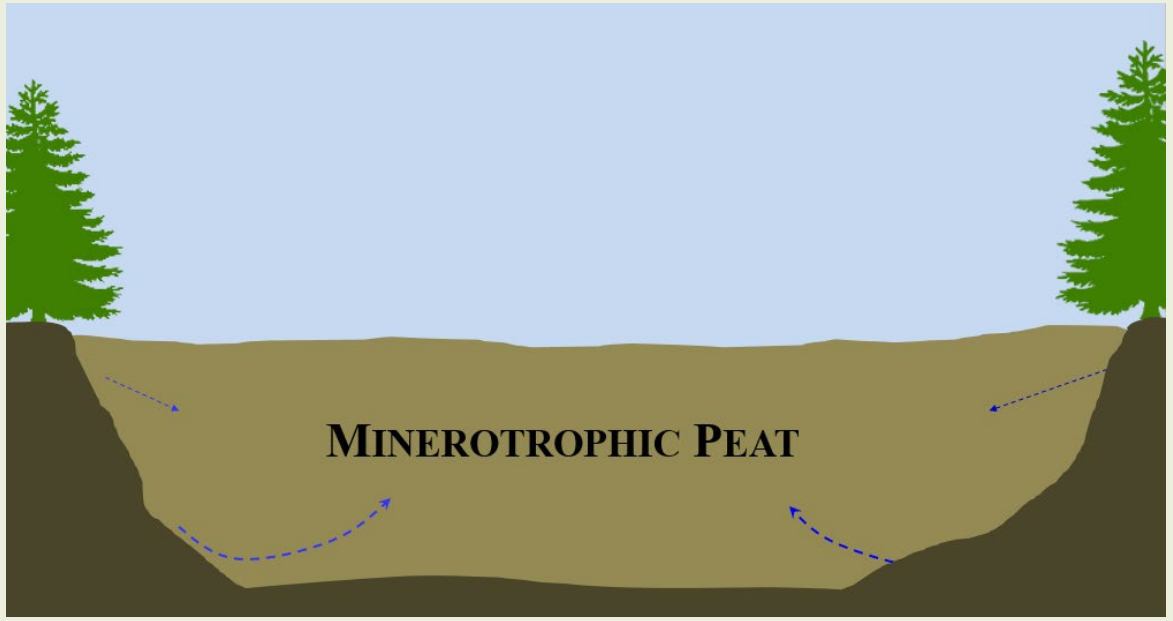
"Bog" ☑

Fen ☒

Impacts







Understanding Water Source(s)

- Proper management prescriptions
- Appropriate regulations
- Effective conservation actions


Austin's peat moss
(*Sphagnum austinii*)


Few-flowered sedge
(*Carex pauciflora*)


Bog potworm
(*Cognettia sphagnetorum*)


Makah / June's copper
(*Tharsalea mariposa* ssp.)


Beller's ground beetle
(*Agonum belleri*)

Conservation Significance

- State Threatened ecosystem
- Carbon sequestration
- Rare species
  - 13% of state's rare plants
  - 2 rare beetles
  - 2 rare butterflies
  - Globally imperiled Georgia Basin bog spider
  - only North American record of *Cognettia sphagnatorum*
  - distinct flora

Project Objective

Document effects of adjacent land use and provide guidance for effective regulation, management, and preservation of these *irreplaceable* wetlands.

Research Questions

- Do ombrotrophic bogs exist in western Washington?
- Does adjacent land use impact *Sphagnum*-dominated peatlands?

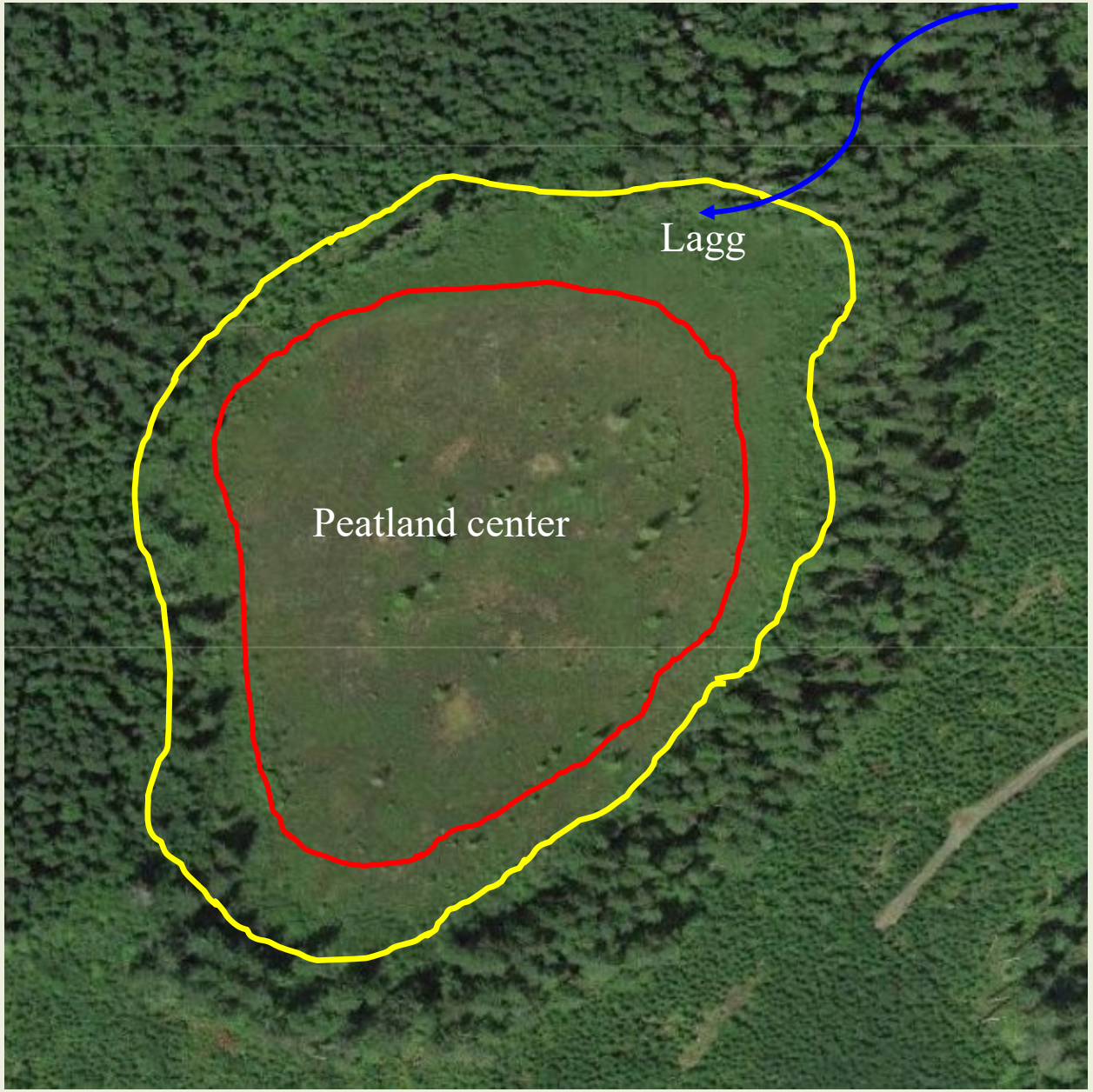
Puget Lowlands Ecoregion

- Glaciated landscape
- Elevation < 150 m (<500 feet)
- Annual precipitation
  - 43 to 254 cm/yr (17 to ~100 in/yr)
- Avg. max temp
  - 5.1 to 6.2^0 C (59-61^0 F)
- Avg. min temp
  - 4.3 to 5.2^0 C (39-46^0 F)
- 70% of precipitation falls between October to March

Ecological Zones

"Bog"

- Peatland Center
  - Bog vegetation
  - Ombrotrophic zone
- Lagg
  - Outer perimeter
  - Minerotrophic zone



Vegetation of the Peatland Center


Pinus contorta var. *contorta*


Rhododendron groenlandicum


Sphagnum rubellum


Kalmia microphylla


Sphagnum capillifolium


Tsuga heterophylla


Sphagnum fuscum

Vegetation of the Lagg


Sphagnum palustre


Carex aquatilis var. *dives*


Swamp species


Malus fusca

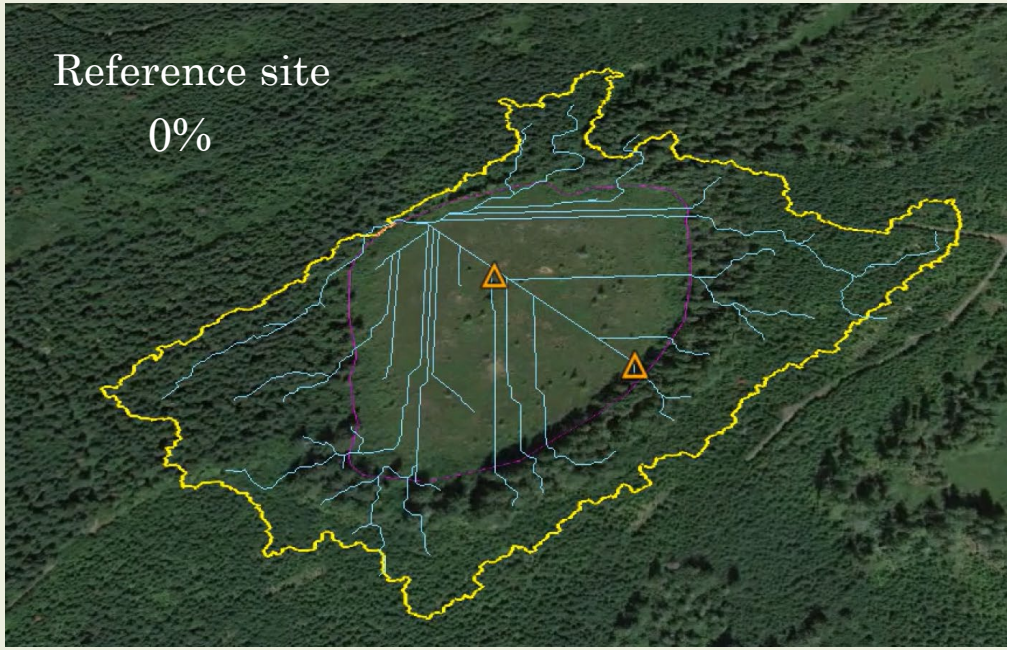

Sphagnum pacificum

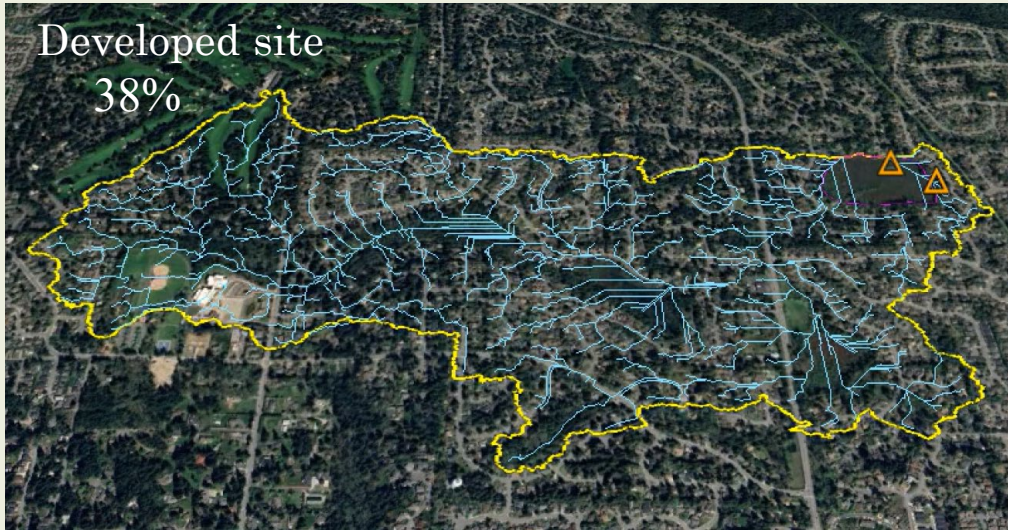

Spiraea douglasii

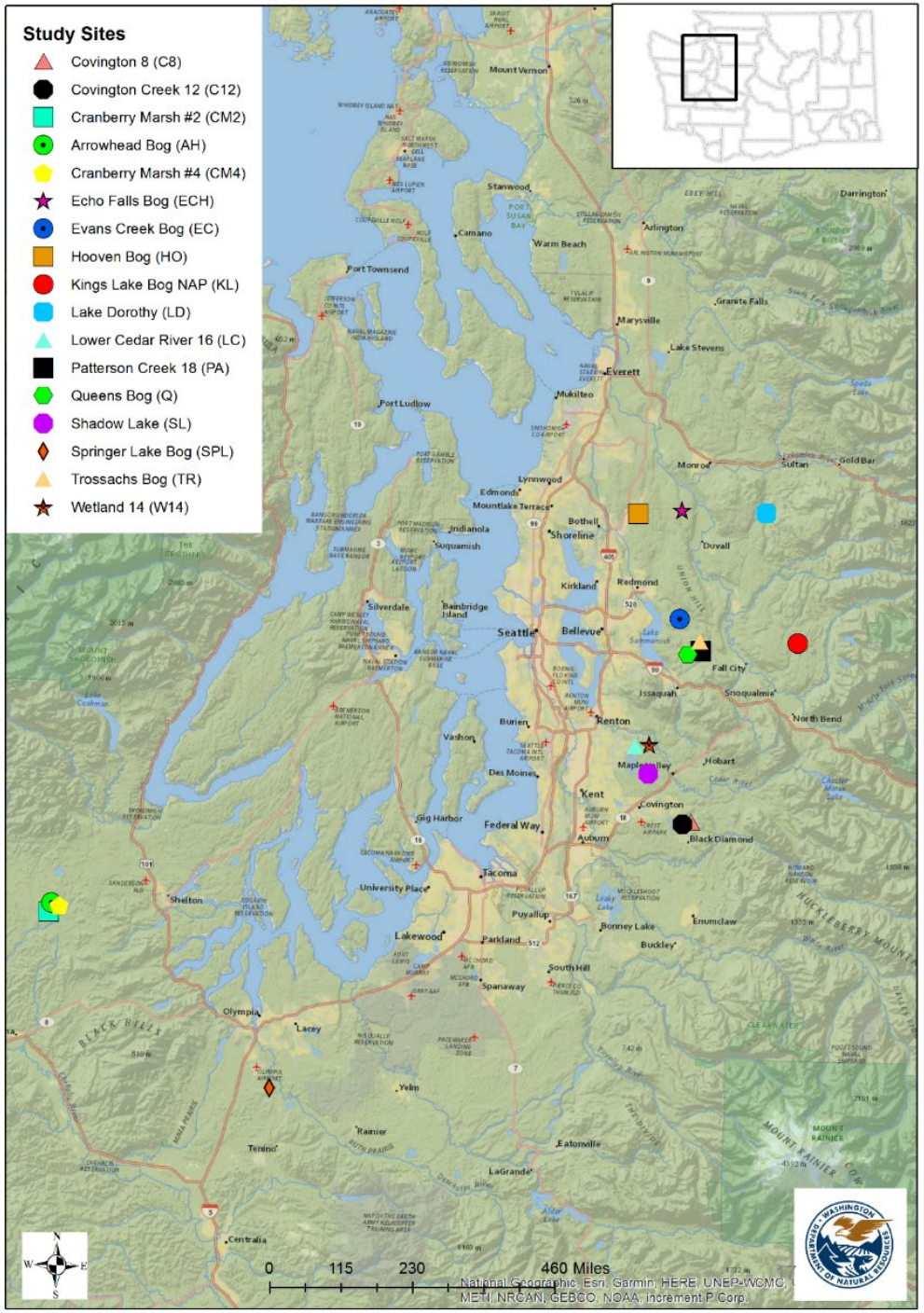
Study Site Selection

17 sites selected

- Reference (5 sites)
- Developed (12 sites)







Sample Site locations

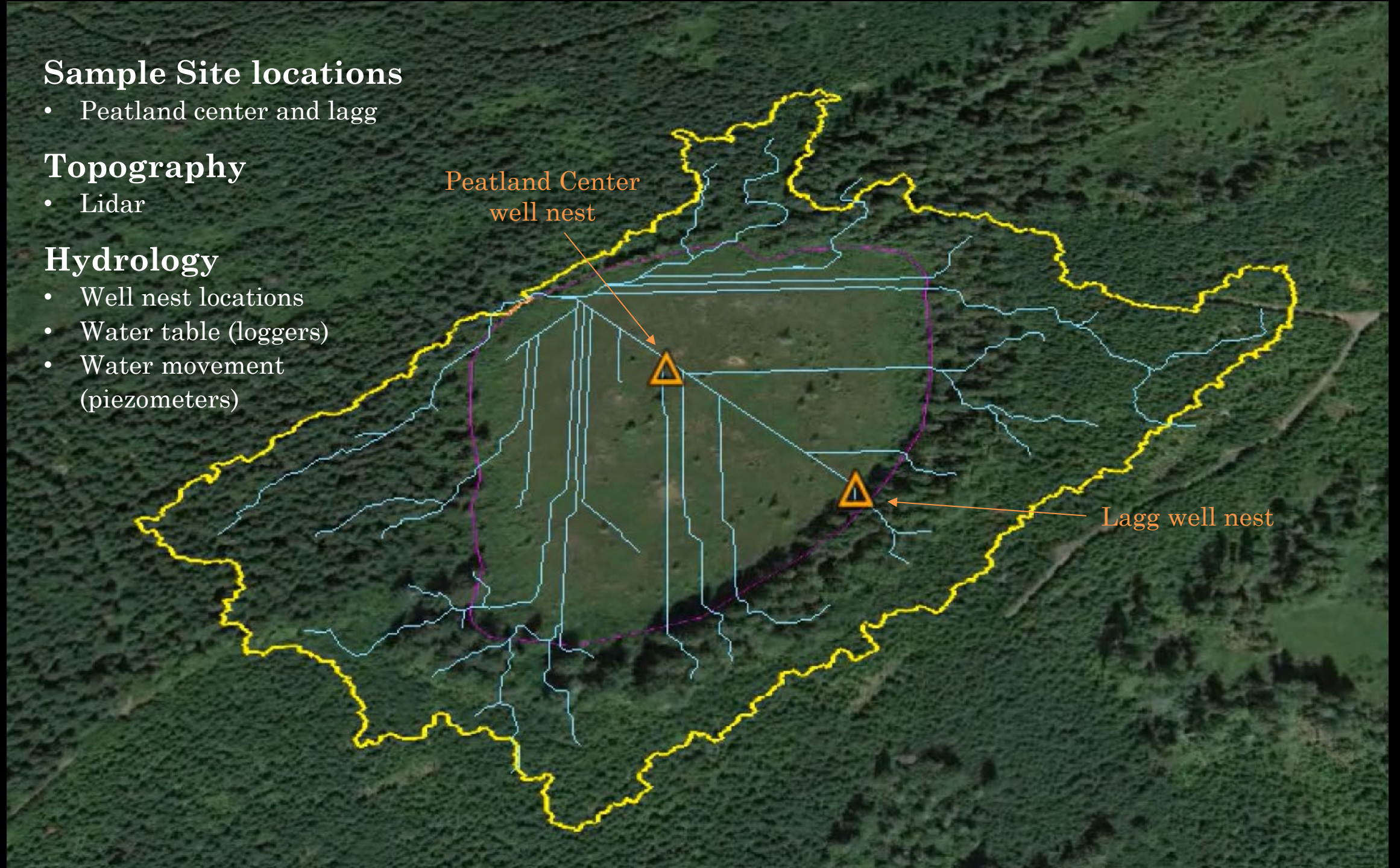
- Peatland center and lagg

Topography

- Lidar

Hydrology

- Well nest locations
- Water table (loggers)
- Water movement (piezometers)



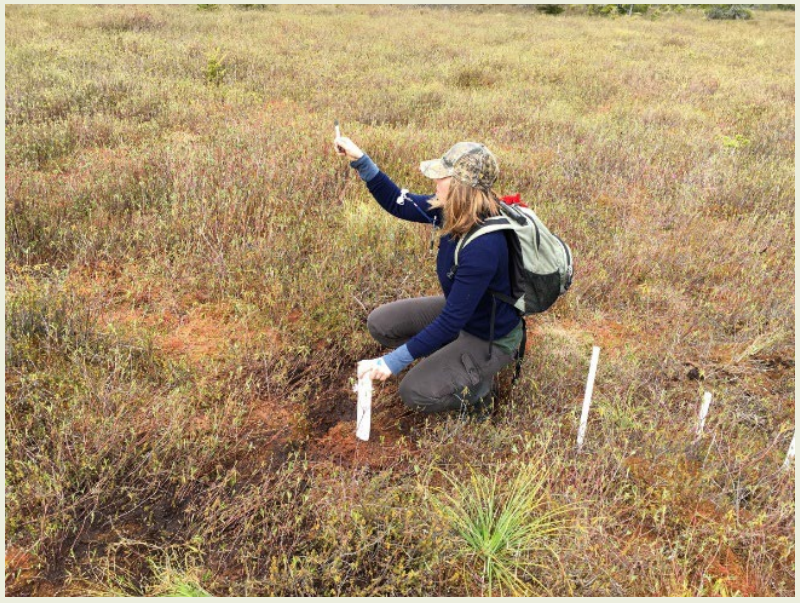
Ecological Measures

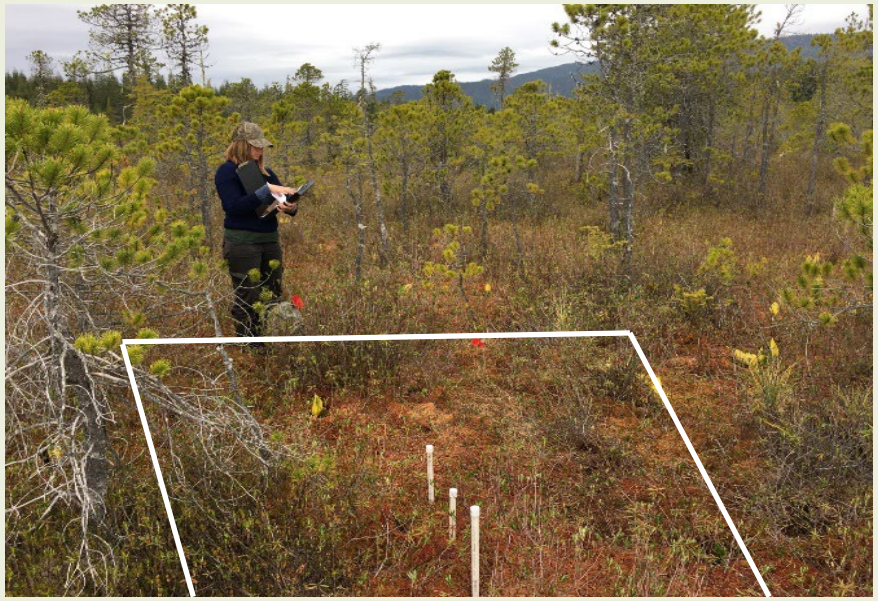
Water chemistry

- pH & EC in the field
- 250 ml samples

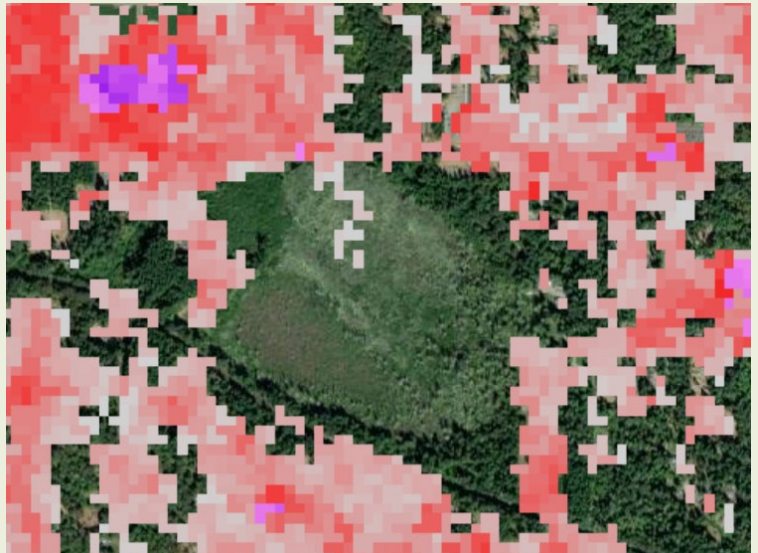
Vegetation

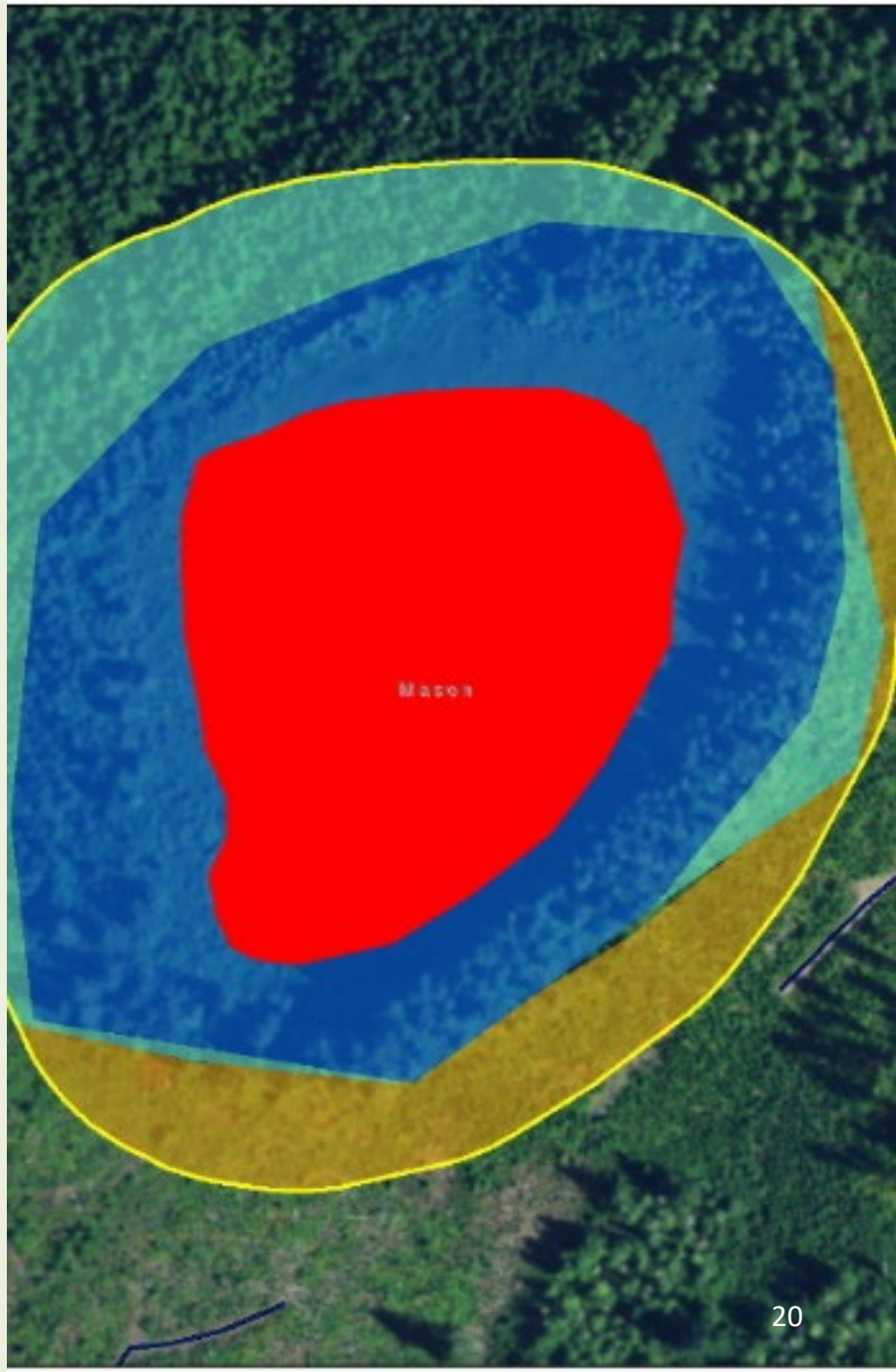
- 100 & 400 m^2 relevé plots
- Abundance
- Nonvascular “groups”





Measuring Land Use





- Stormwater inflows
- Impervious Surface Area
- Land Use Index

Data Analysis

Hydrology
- Annual, seasonal, and monthly timescales

Water Chemistry
- Seasonal time scale (spring & summer)

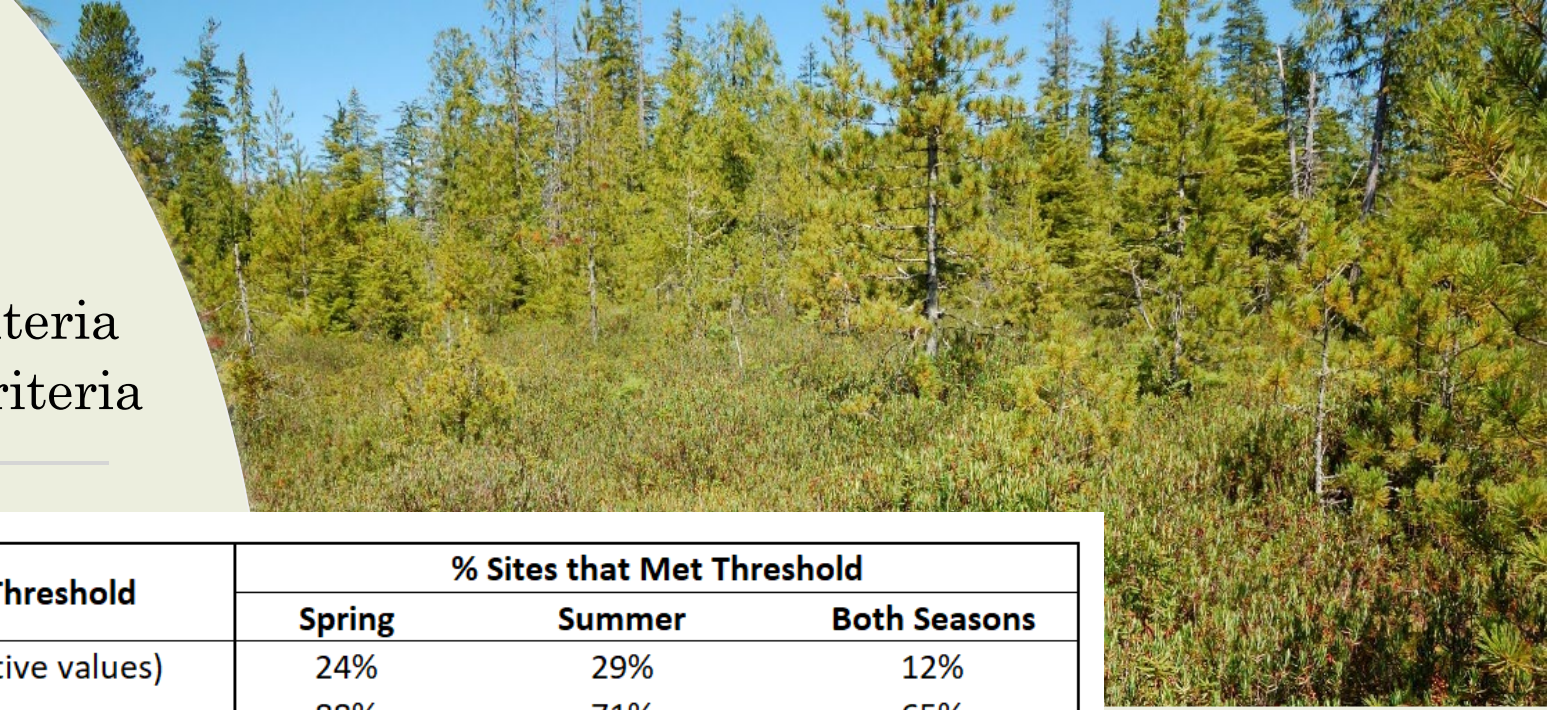
Watershed and Land Use Analysis
- Linear, mixed-effects models
- AIC (Akaike Information Criterion)

Vegetation
- Nonmetric Multidimensional Scaling (NMS) ordinations
- Nonparametric Multivariant Analysis of Variance (PERMANOVA)

Do ombrotrophic bogs exist in western Washington?

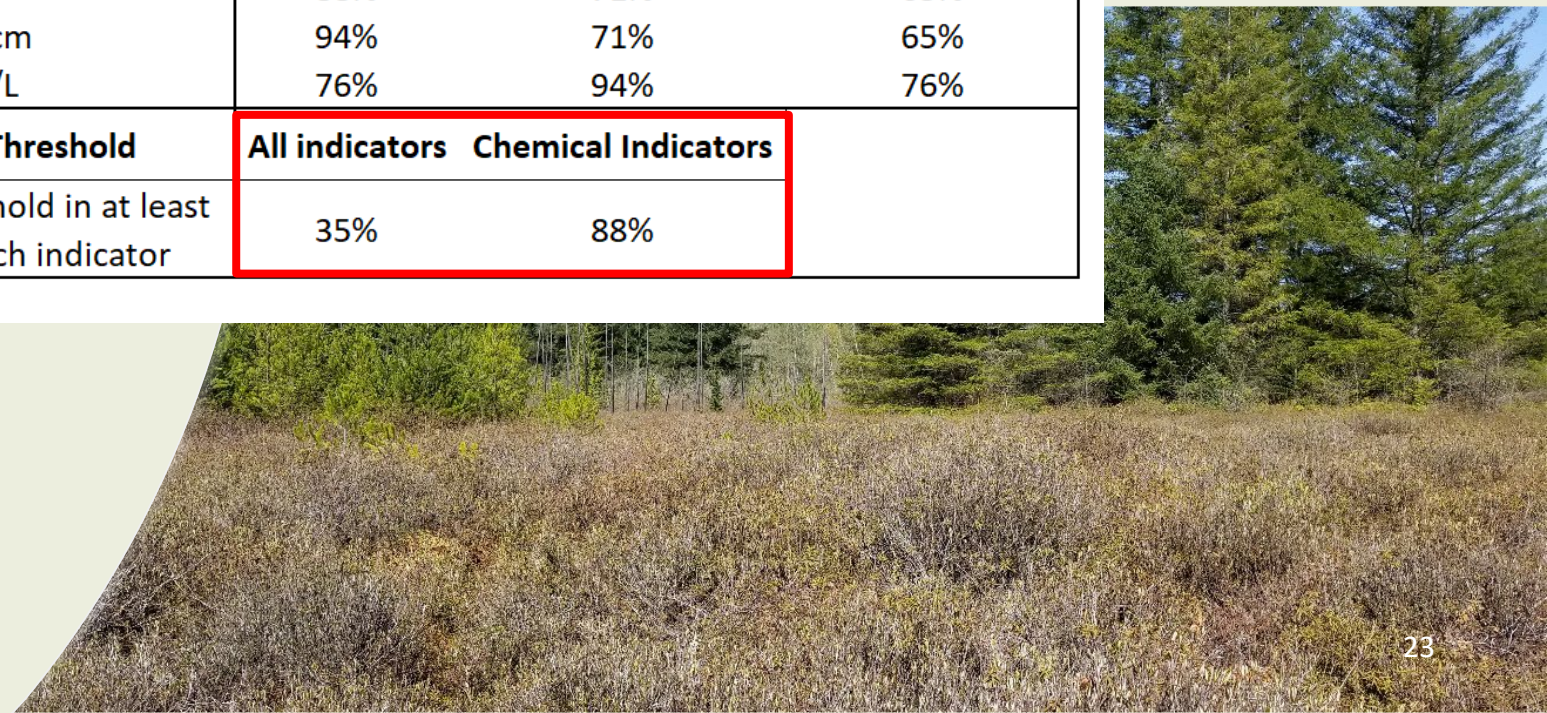
Ombrotrophic?

- 88% of study sites met chemical criteria
- 35% met chemical + hydrological criteria



Ombrotrophic Indicator	Ombrotrophic Threshold	% Sites that Met Threshold		
		Spring	Summer	Both Seasons
Vertical Hydrological Gradient (VHGs)	Downward (negative values)	24%	29%	12%
pH	< 4.5	88%	71%	65%
Electric conductivity	< 50 uS/cm	94%	71%	65%
Calcium	< 2. mg/L	76%	94%	76%

Ombrotrophic Indicator	Ombrotrophic Threshold	All indicators	Chemical Indicators
Preponderance of Evidence	Ombrotrophic threshold in at least one season for each indicator	35%	88%



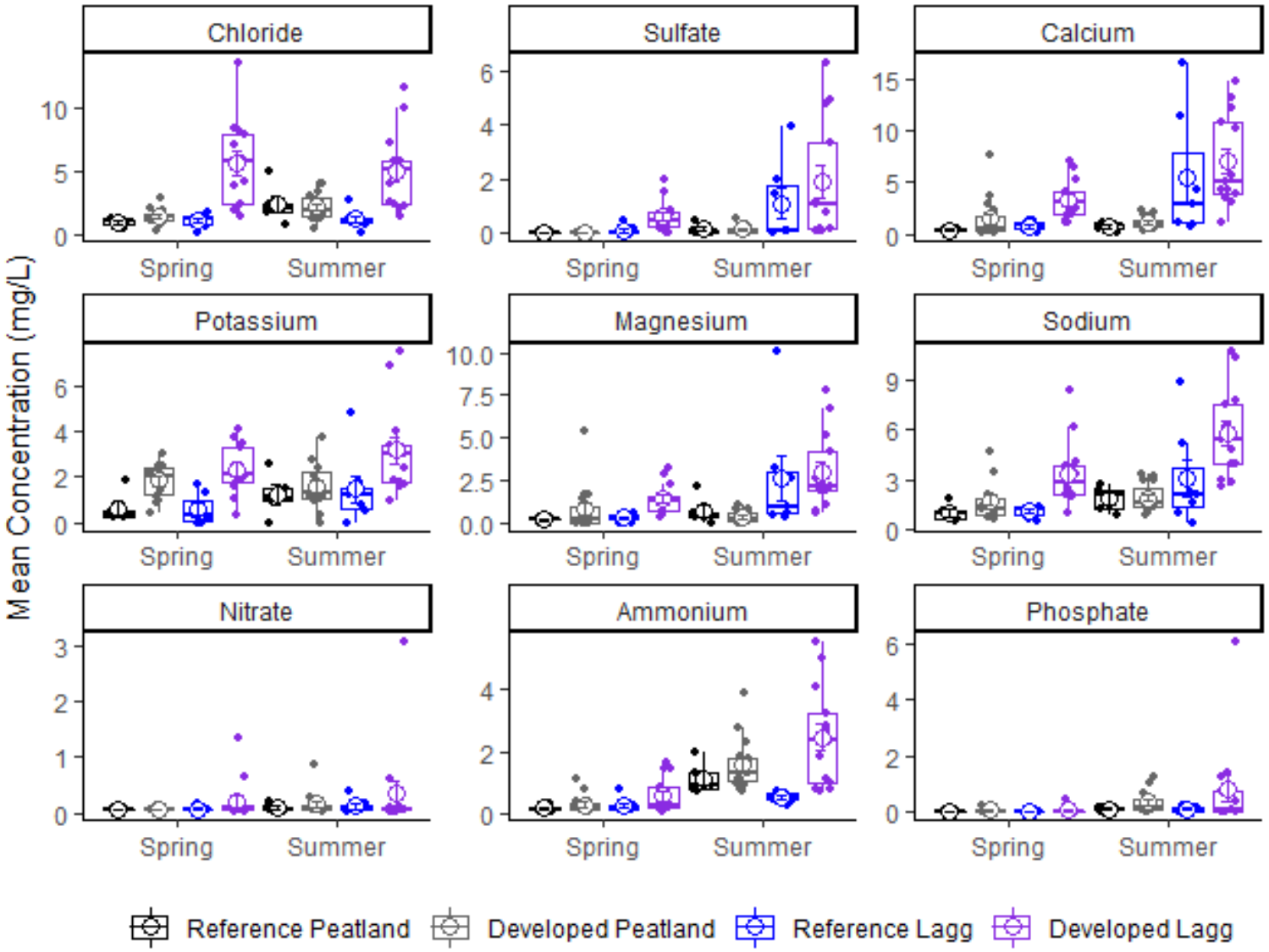
Does adjacent land use impact *Sphagnum*-dominated peatlands?

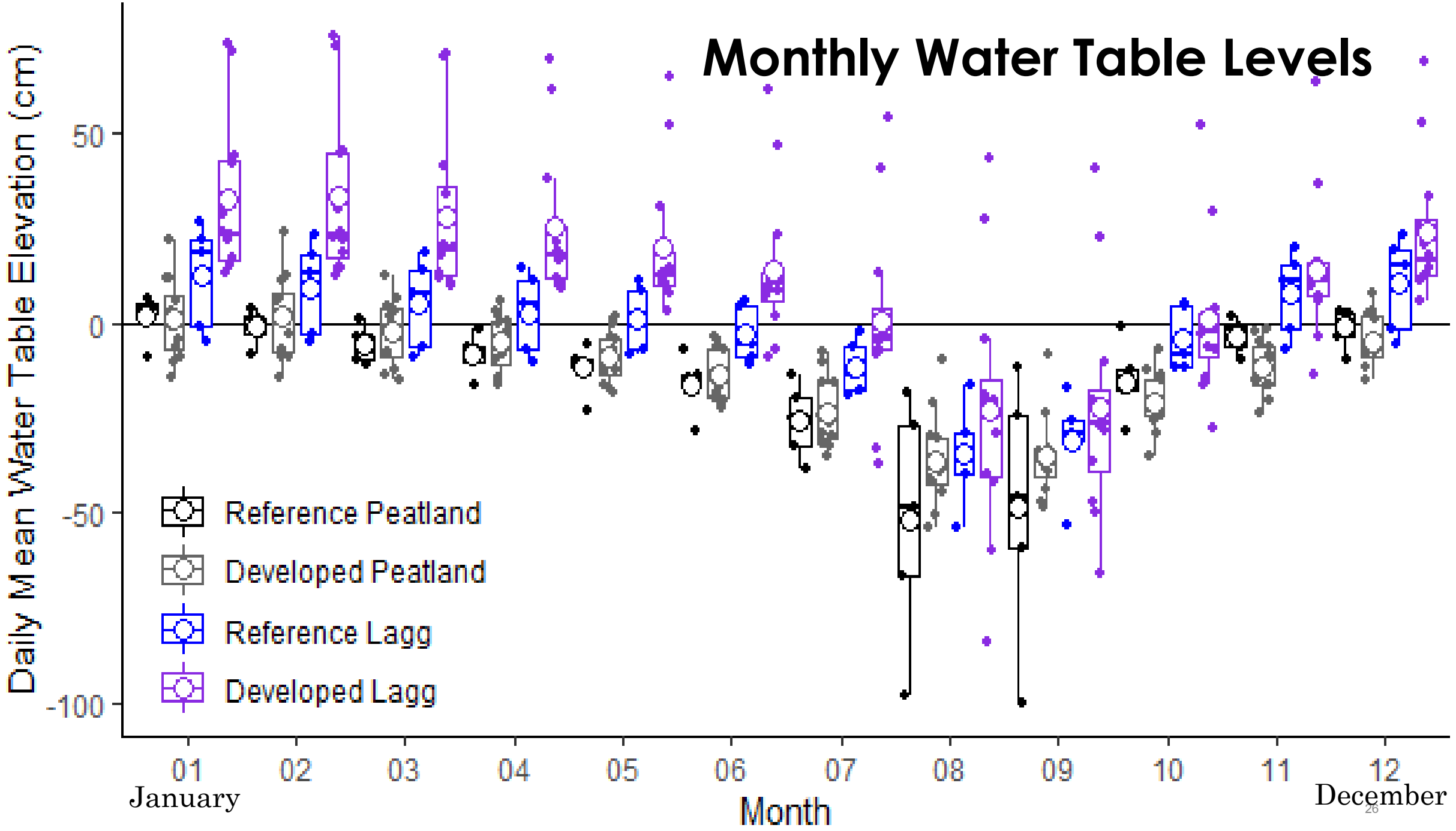
Hydrology

- Shallow water tables

Water chemistry

- pH
- Electric conductivity
- Chloride
- Calcium

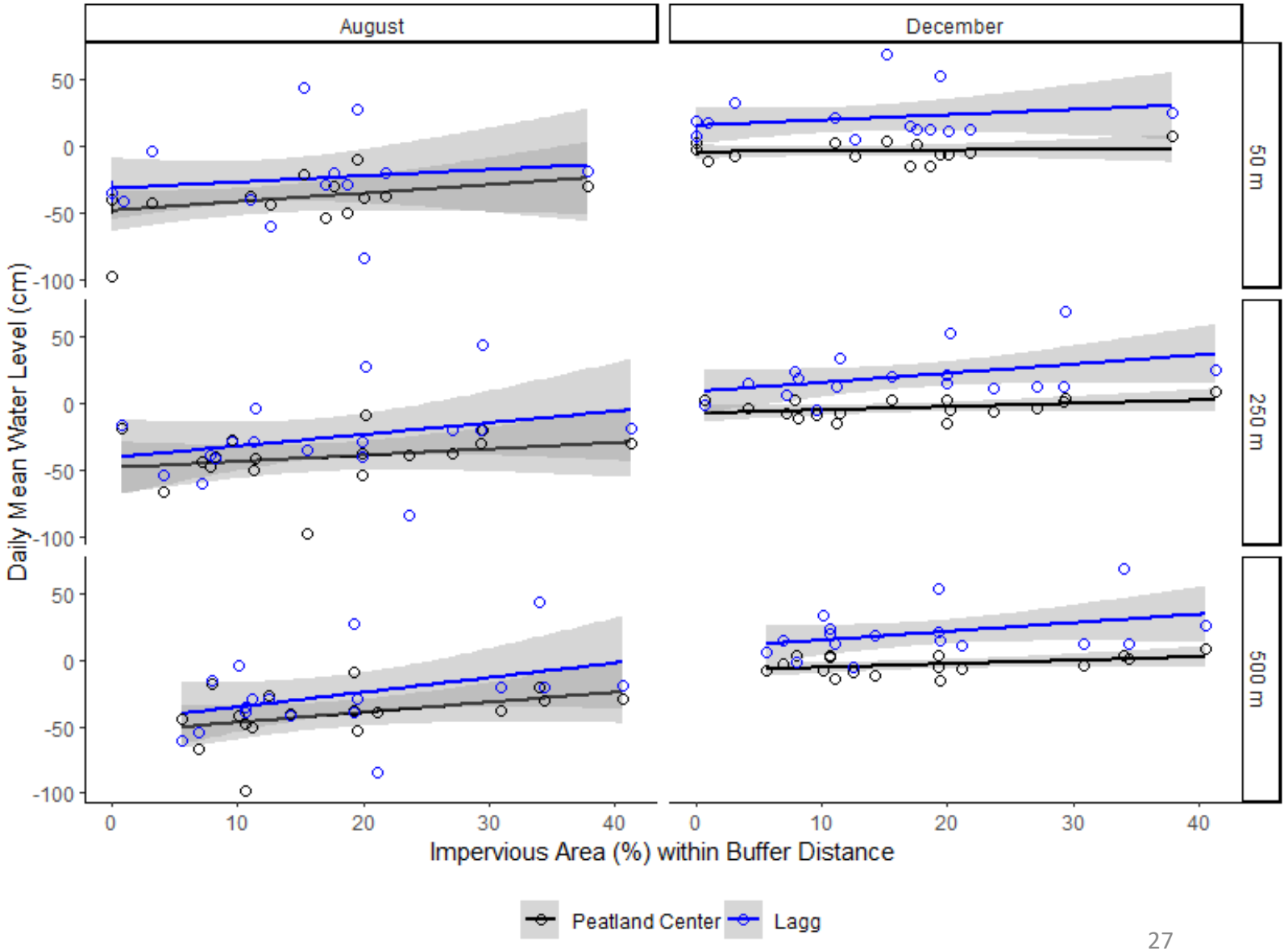


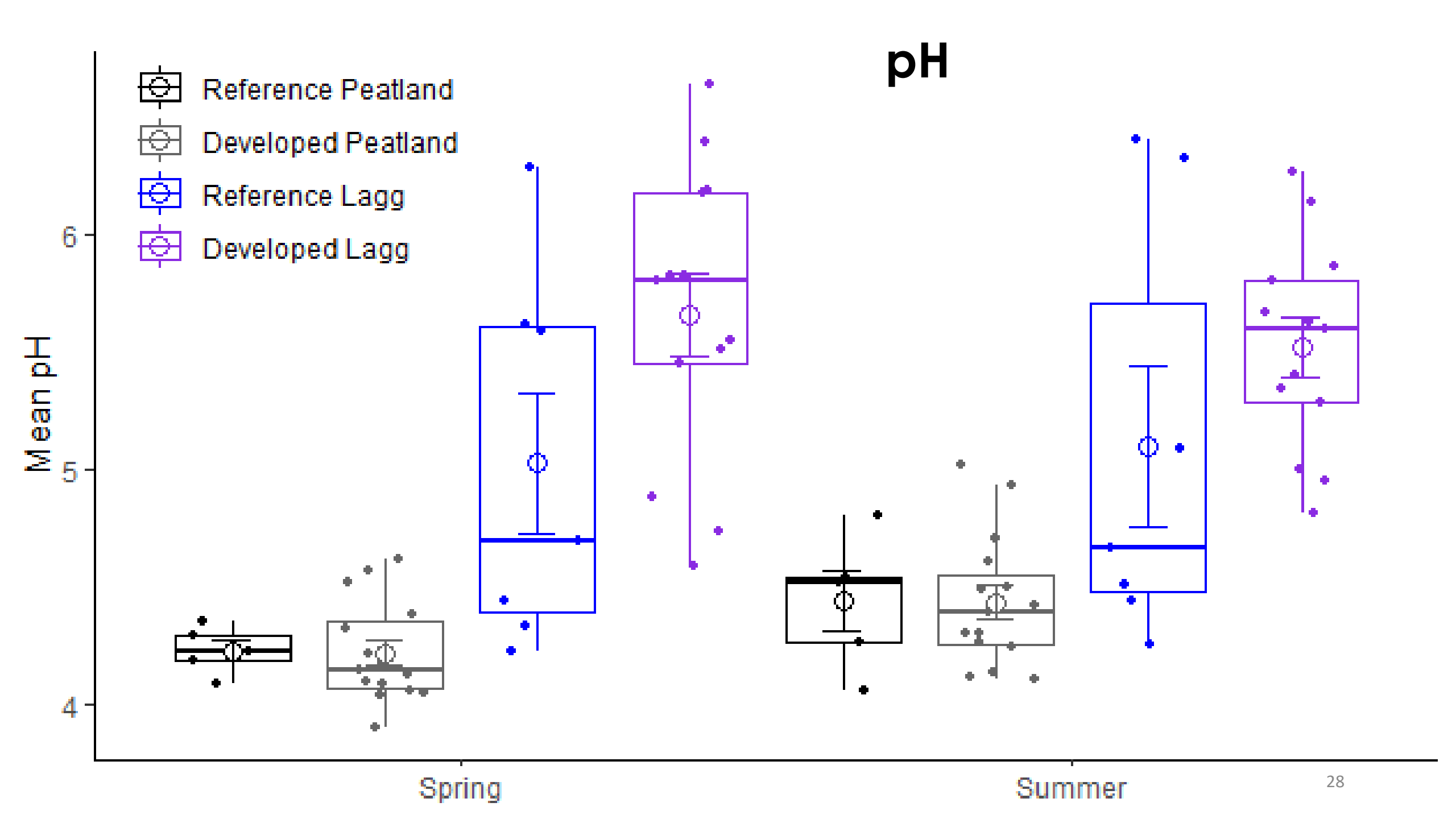

Monthly Water Table Levels
Daily Mean Water Table Elevation (cm)
50
0
-50
-100
Reference Peatland
Developed Peatland
Reference Lagg
Developed Lagg
01
02
03
04
05
06
07
08
09
10
11
12
January
December
Month

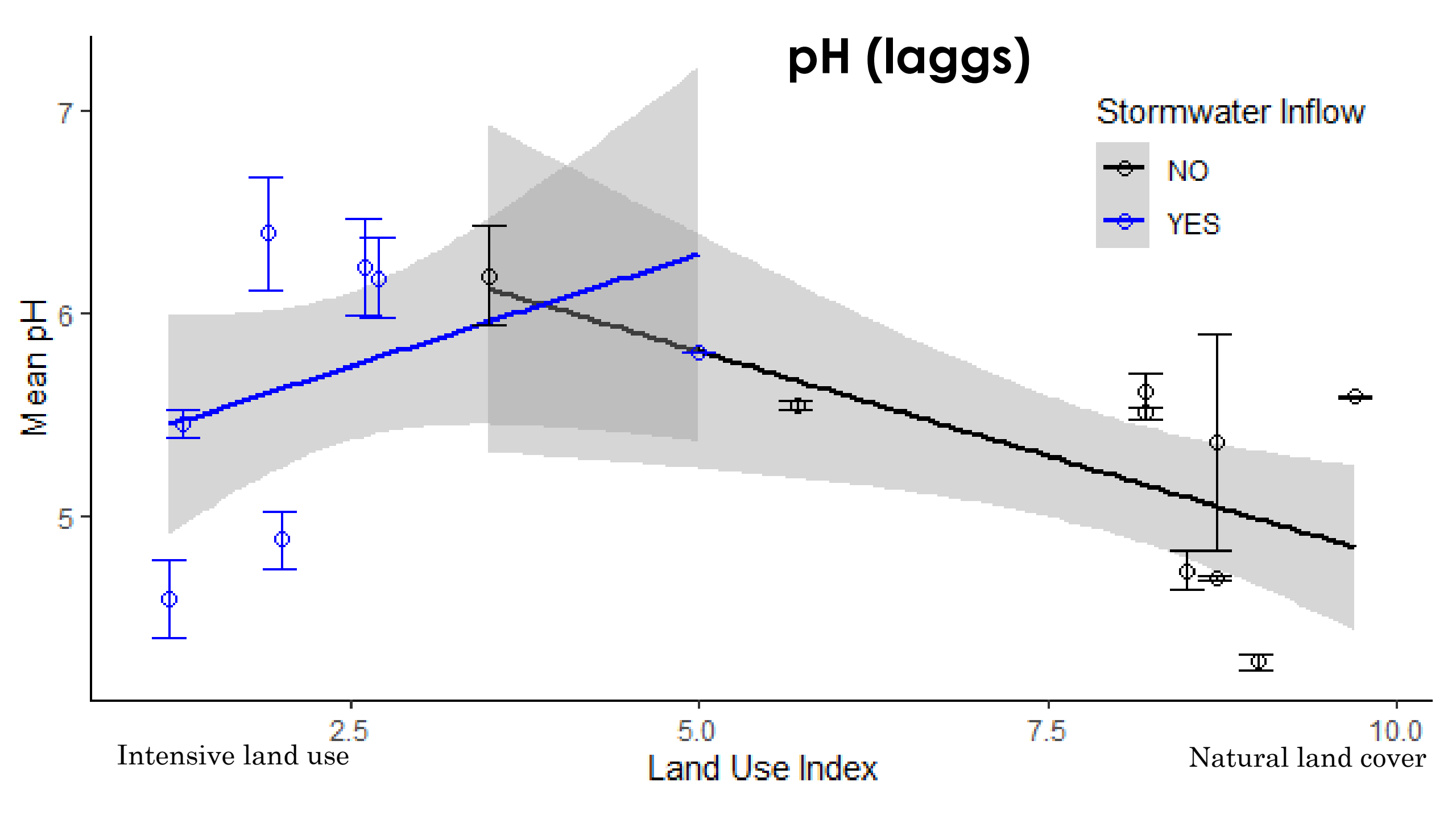
Water Tables

Predictors:

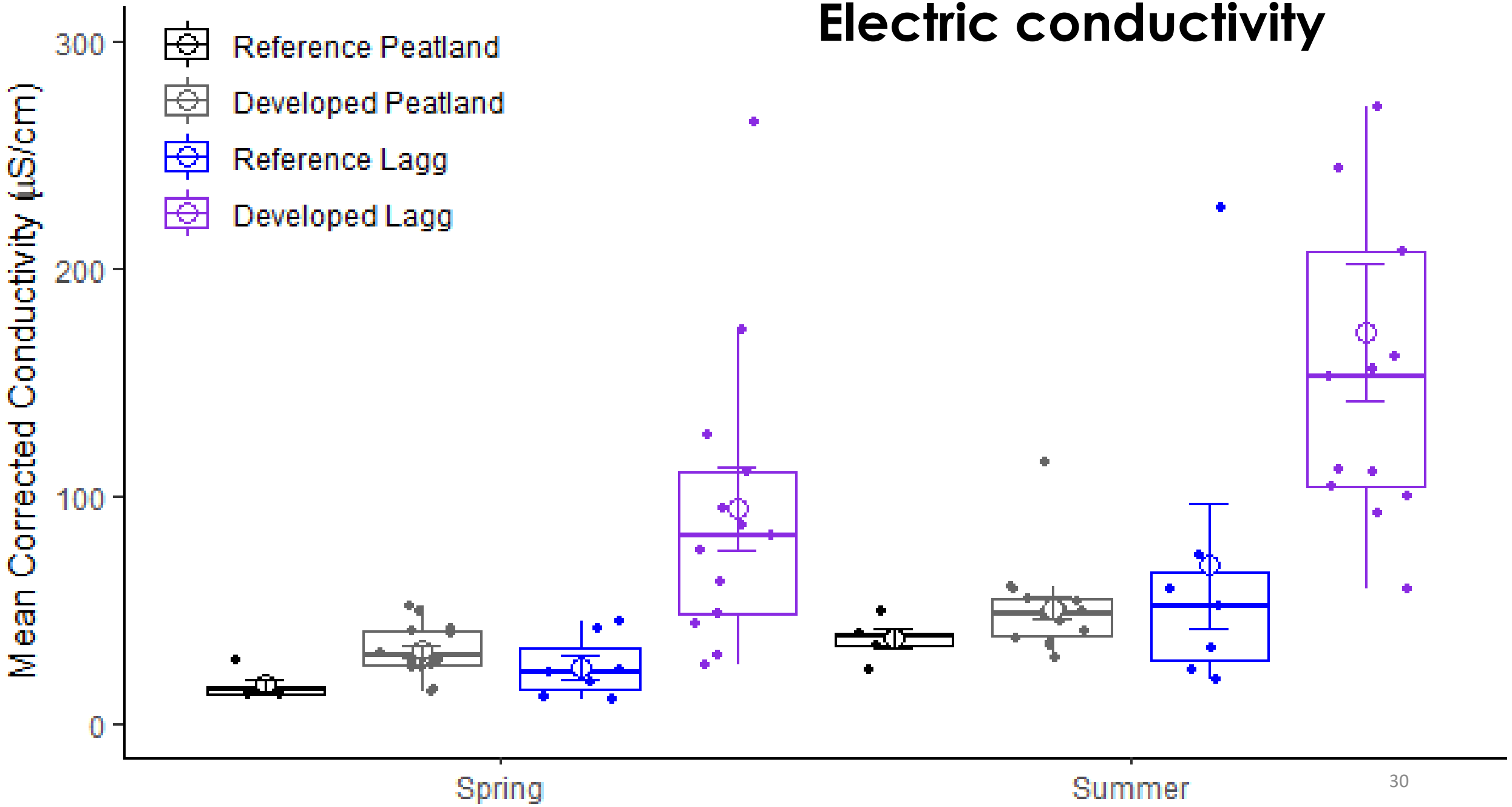
- Impervious surface area
- Watershed size
- Annual precipitation




pH
Reference Peatland
Developed Peatland
Reference Lagg
Developed Lagg
Mean pH
6
5
4
Spring
Summer

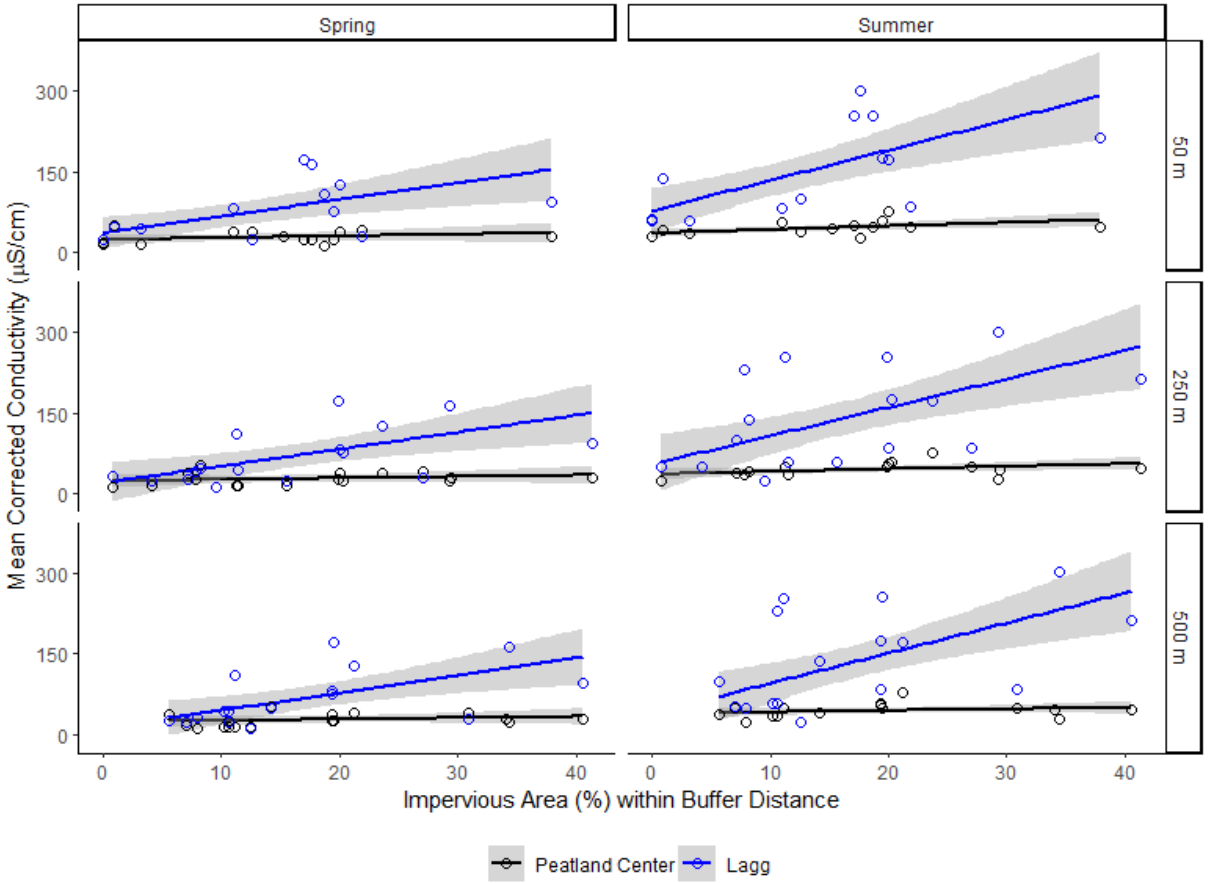

pH (laggs)
Stormwater Inflow
NO
YES
Mean pH
7
6
5
2.5
5.0
7.5
10.0
Land Use Index
Intensive land use
Natural land cover

Electric conductivity

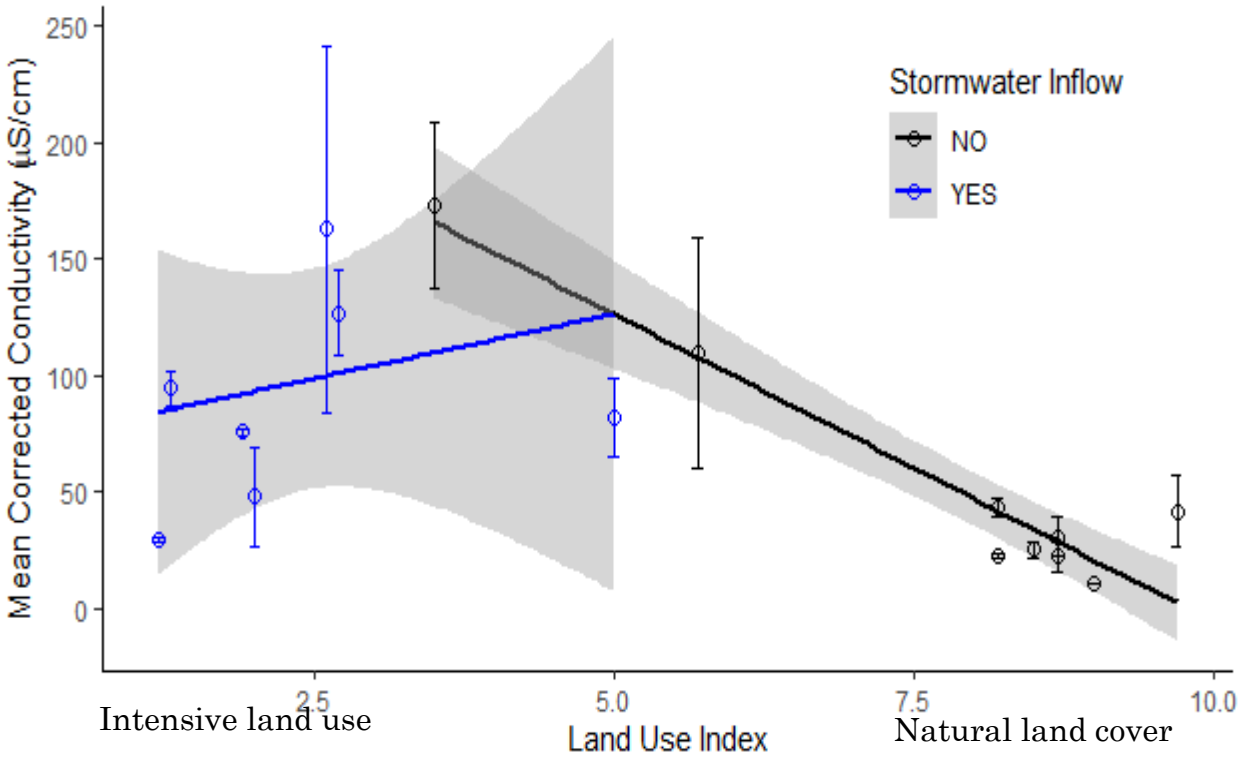


Electric conductivity

- Positive correlation to impervious surface area



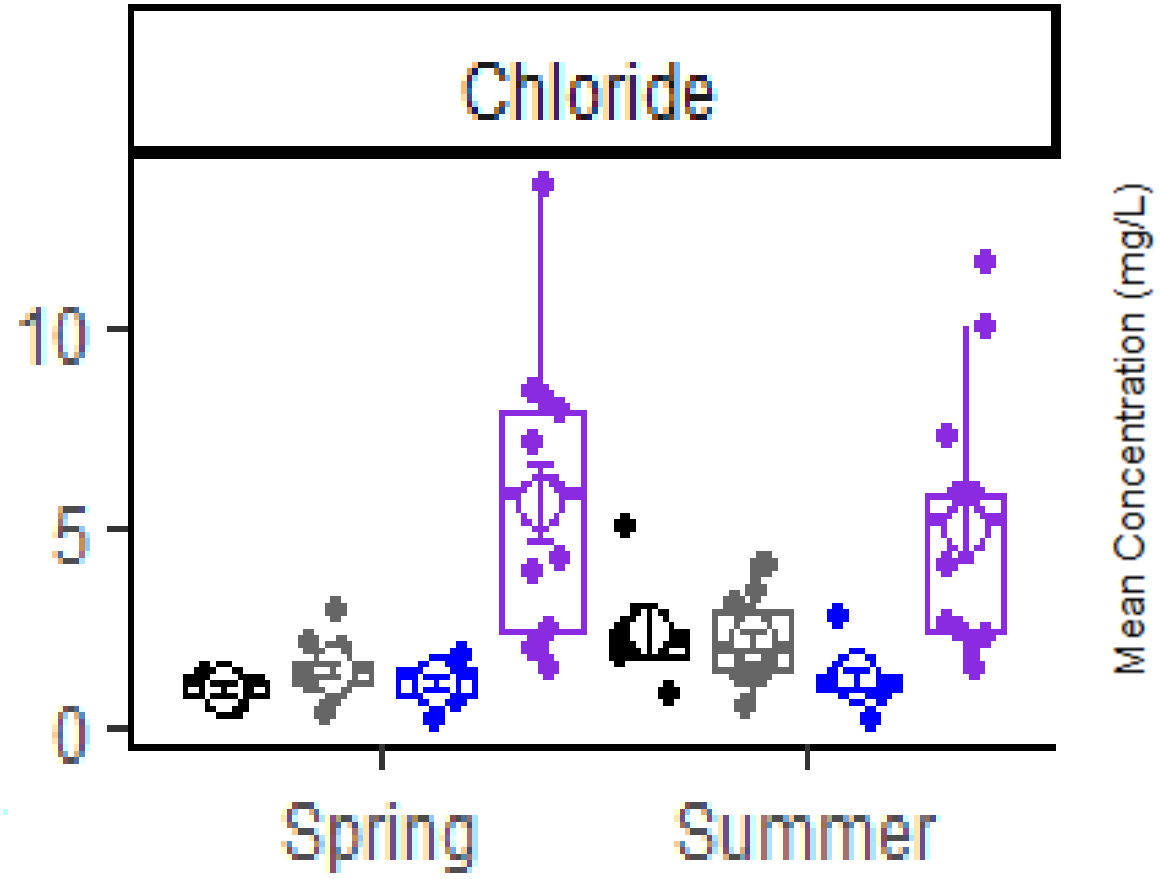
- Stormwater inflows & land use intensity correlated to higher EC



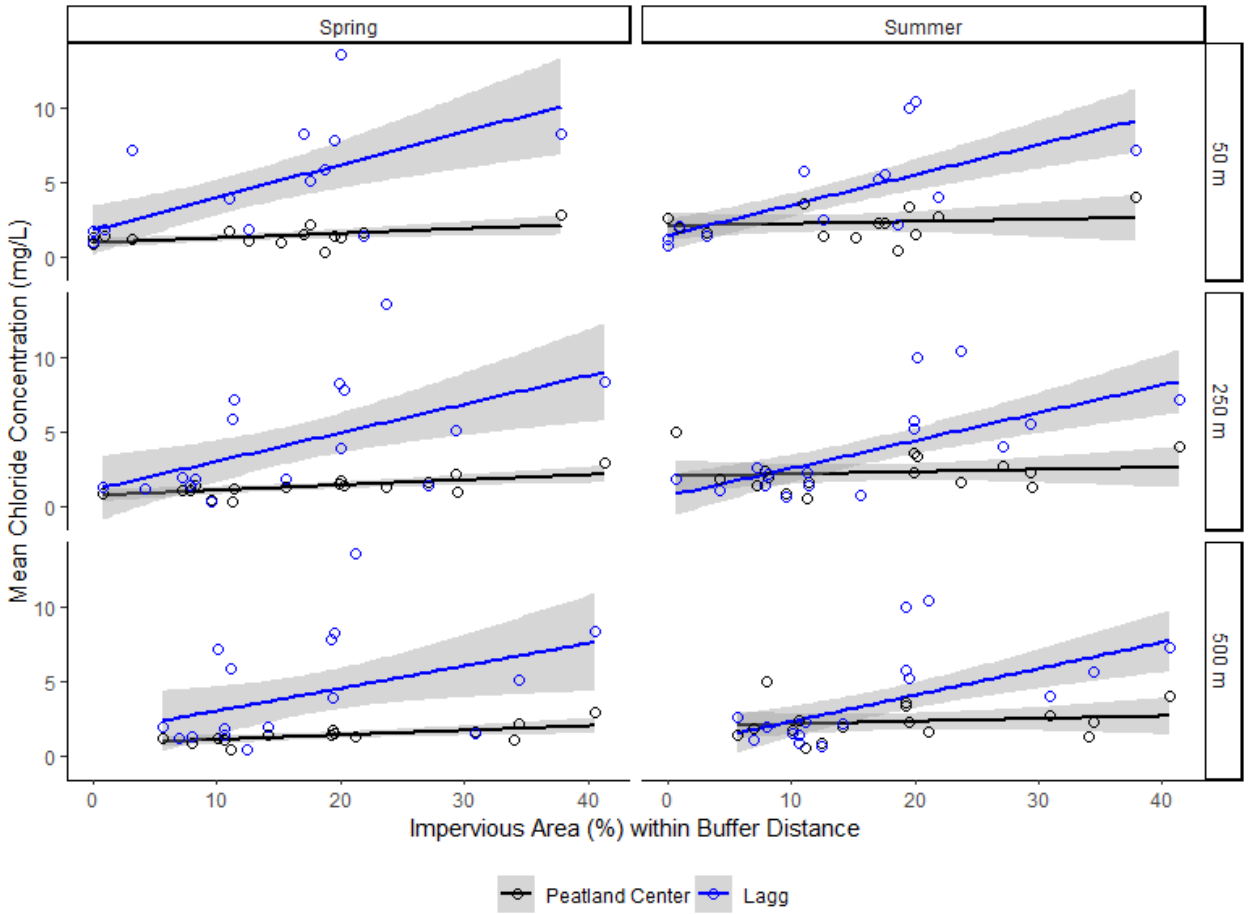
Effects of Land Use Index and the presence of stormwater inflows on mean porewater pH in laggs during spring

Chloride

- Developed laggs had higher chloride

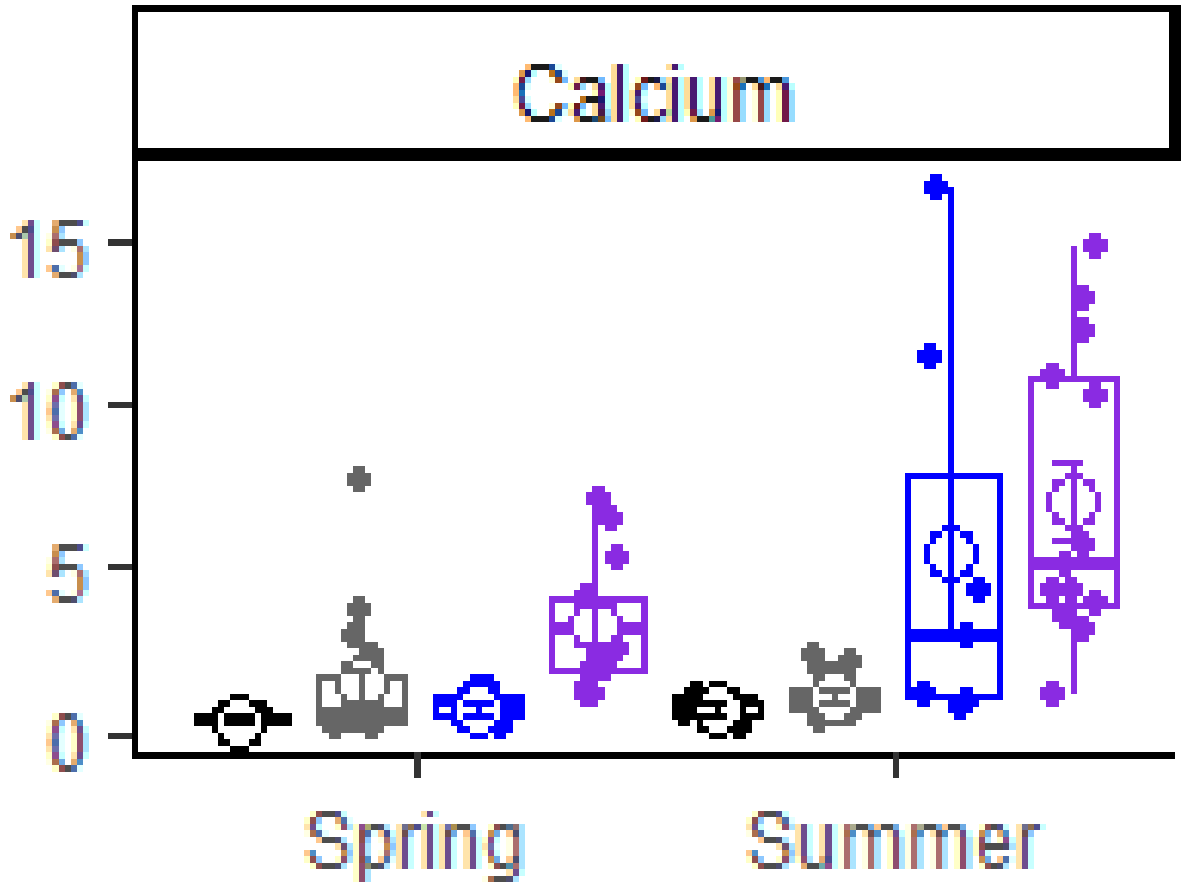


- Correlated with impervious surface area & Land Use Index

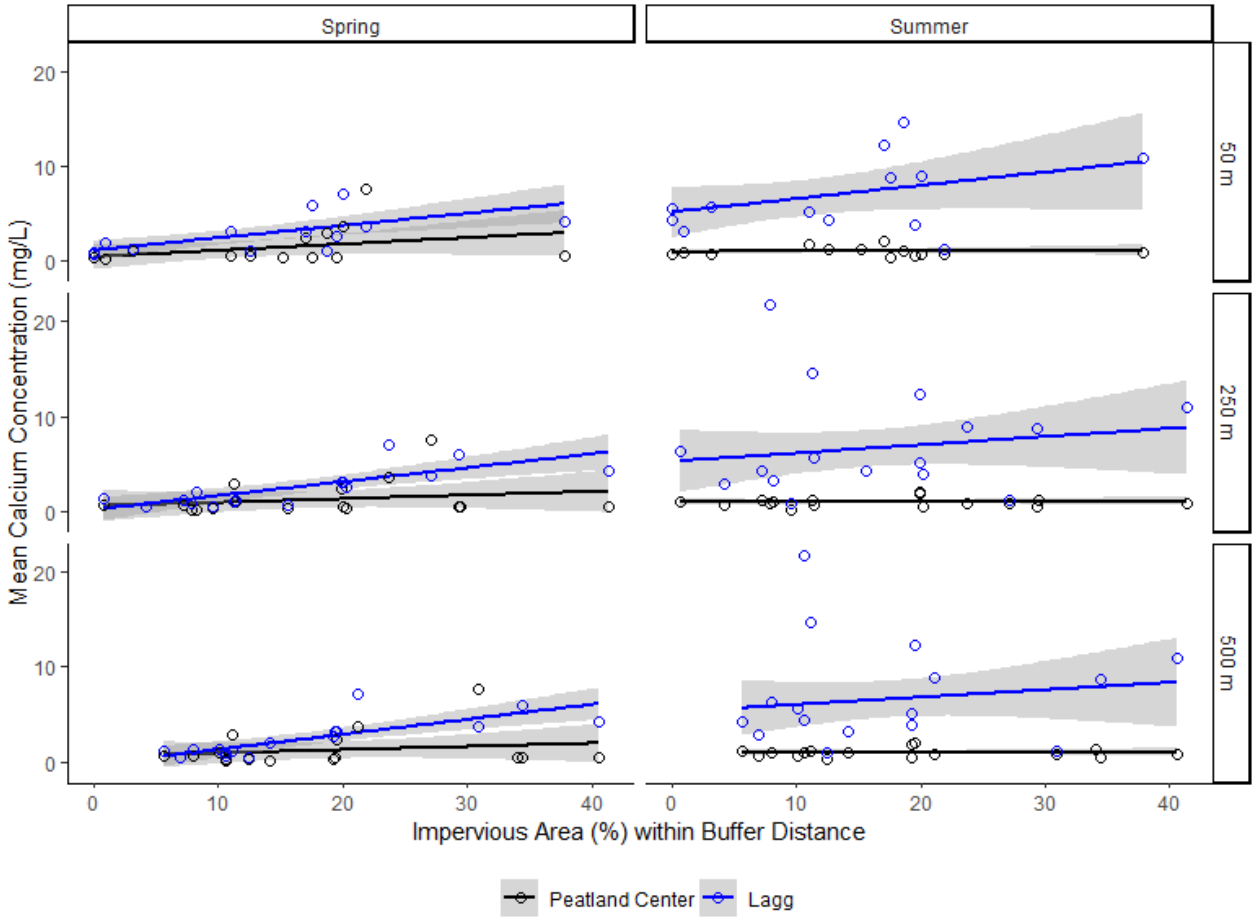


Calcium

- Developed laggs had higher calcium during rainy season
- Weak effects on peatland centers



- Correlated with impervious surface area



Vegetation

Table 3. Growth Form Abundance in Study Sites (average percent ocular cover across sites)

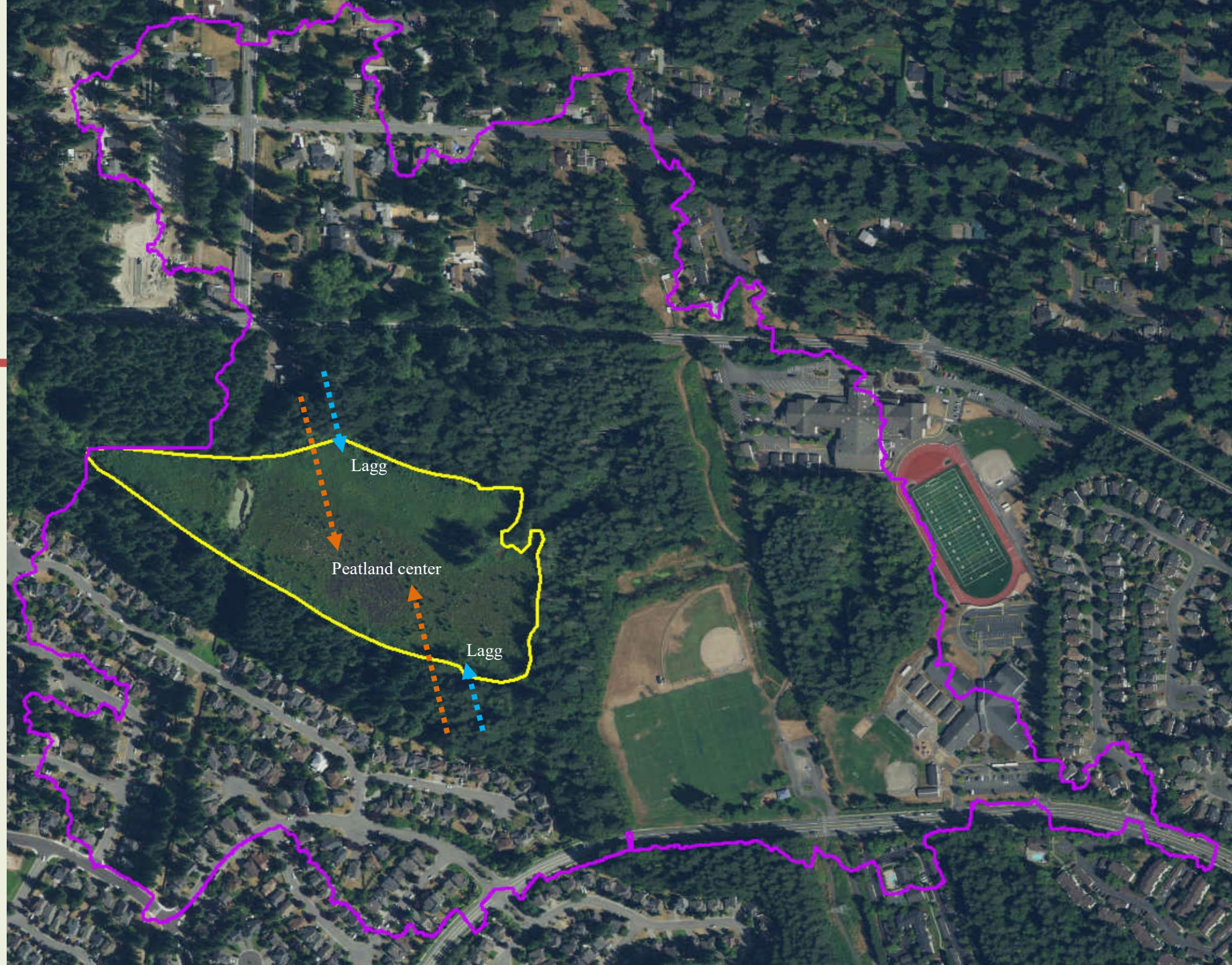
Growth Form		Peatland Centers		Laggs	
		Reference	Developed	Reference	Developed
Dwarf shrubs		3%	2%	1%	1%
Ferns		1%	<1%	4%	1%
Herbaceous dicots		5%	<1%	2%	3%
Herbaceous monocots	Cyperaceae	1%	<1%	26%	↓ <1%
	Poaceae	0%	0%	0%	1%
	Juncaceae	0%	<1%	0%	<1%
Lichen		13%	↓ 4%	5%	0%
Feather mosses		15%	↑ 33%	23%	↓ <1%
Sphagnum spp.		48%	↓ 28%	3%	3%
Ericaceous shrubs		42%	43%	11%	↓ 3%
Deciduous shrubs		1%	↑ 6%	20%	↑ 27%
Trees		2%	2%	7%	9%

The Gist

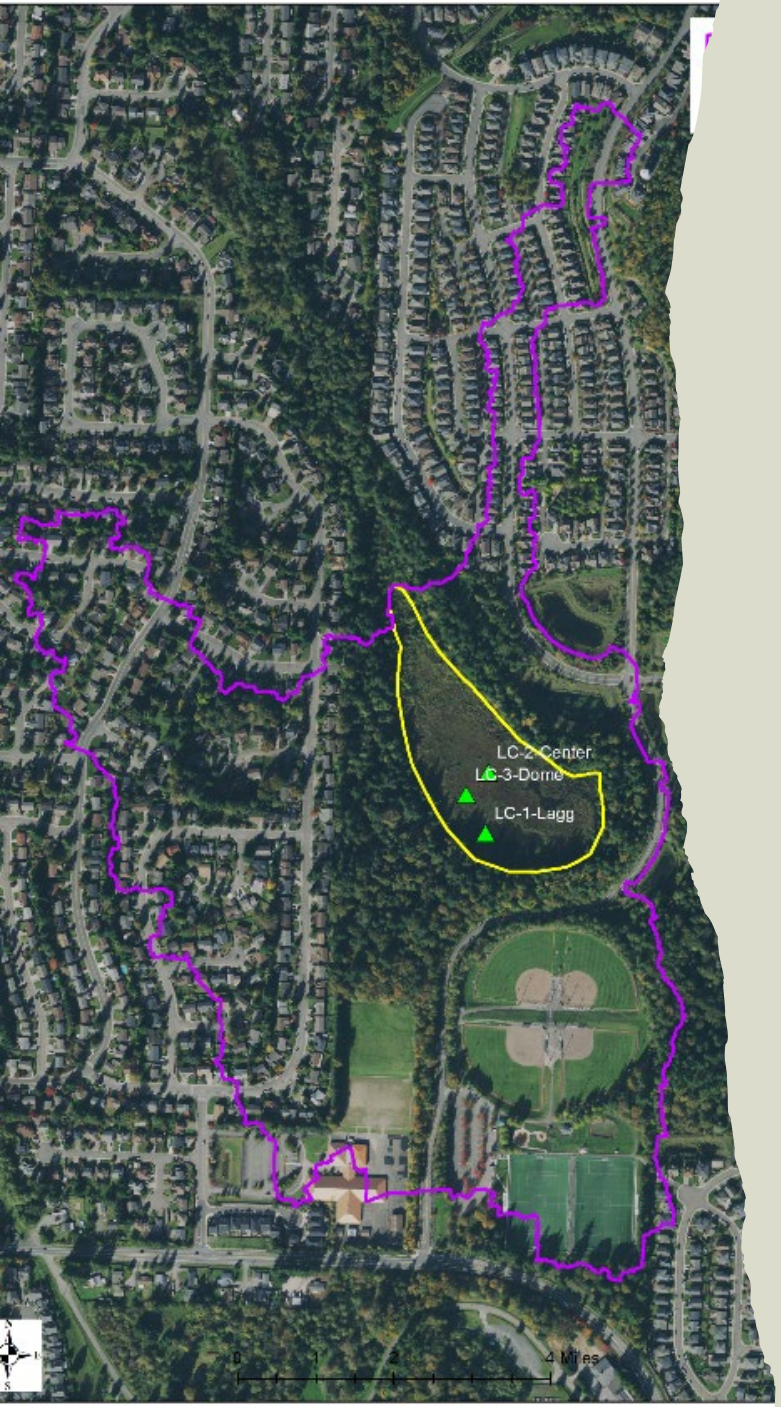
- Hydrological impacts detected in laggs
- Chemical impacts penetrate into peatland centers

= extent of chemical & vegetation impact

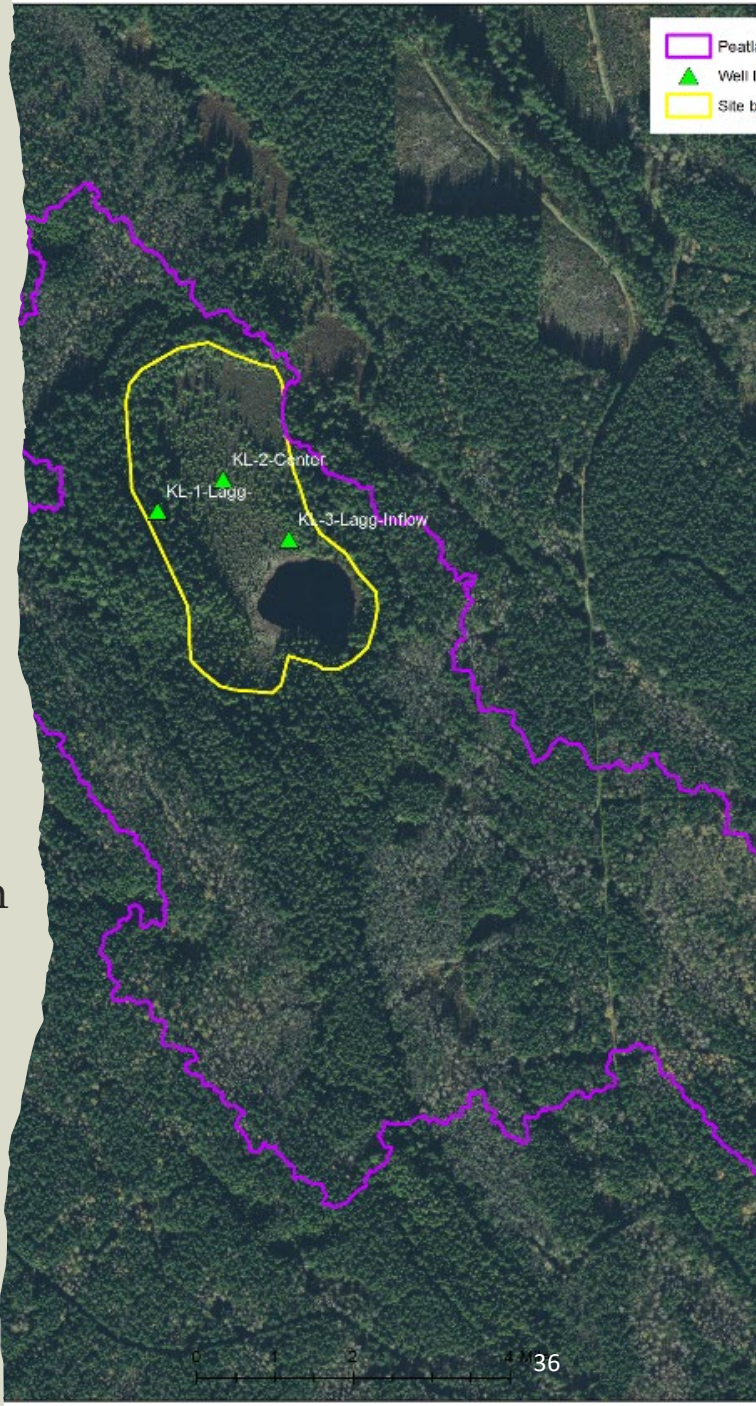
= extent of hydrological impact



RECOMMENDATIONS



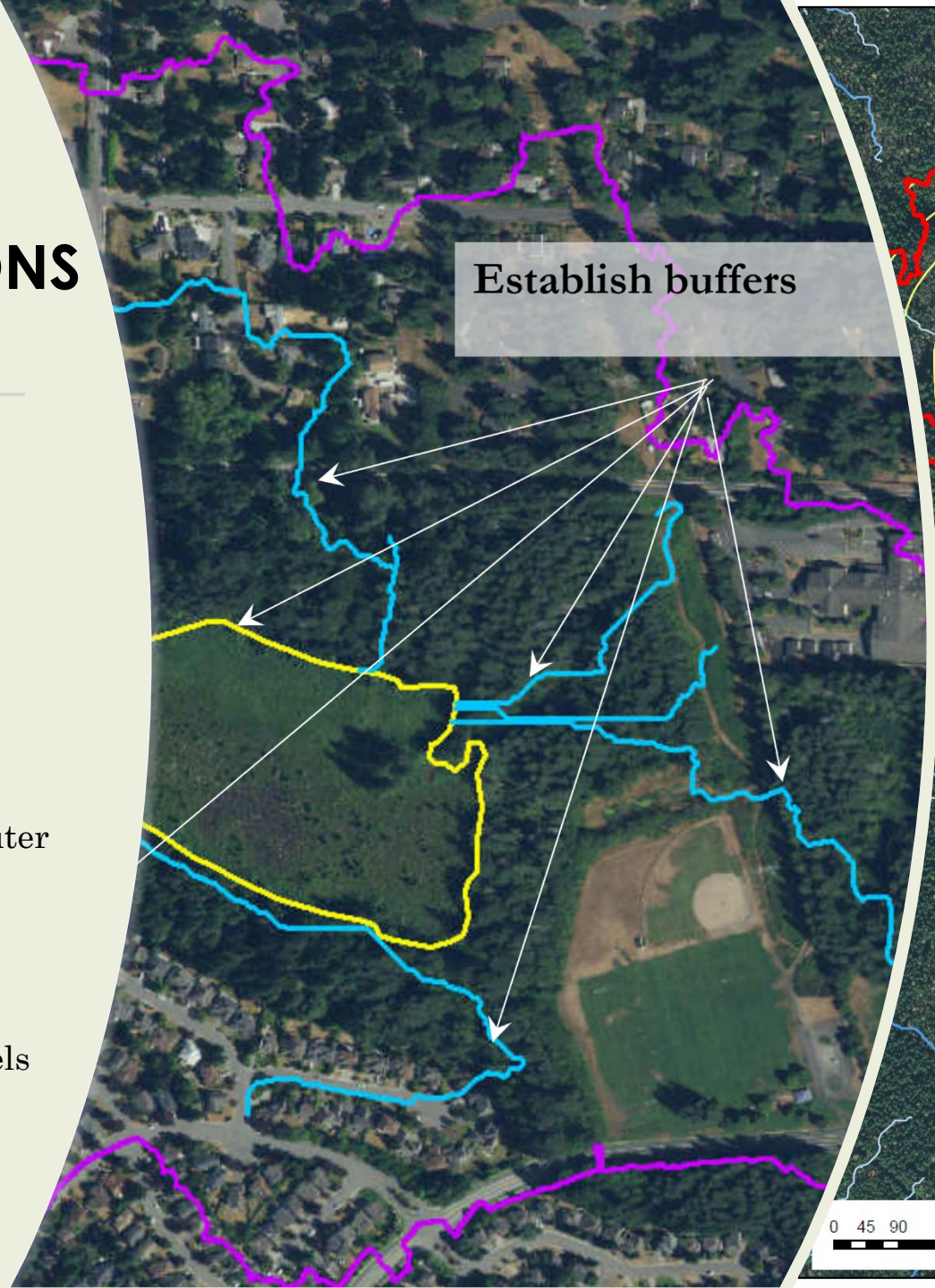
- Minimize impervious surfaces within watershed
- Maintaining natural land cover within watershed
- Stormwater inputs can change the site's ecology
- Avoid any land disturbing activities within the watershed
- Avoid use of calcium-containing materials within the watershed
- Avoid fertilization of forests and lawns within the watershed

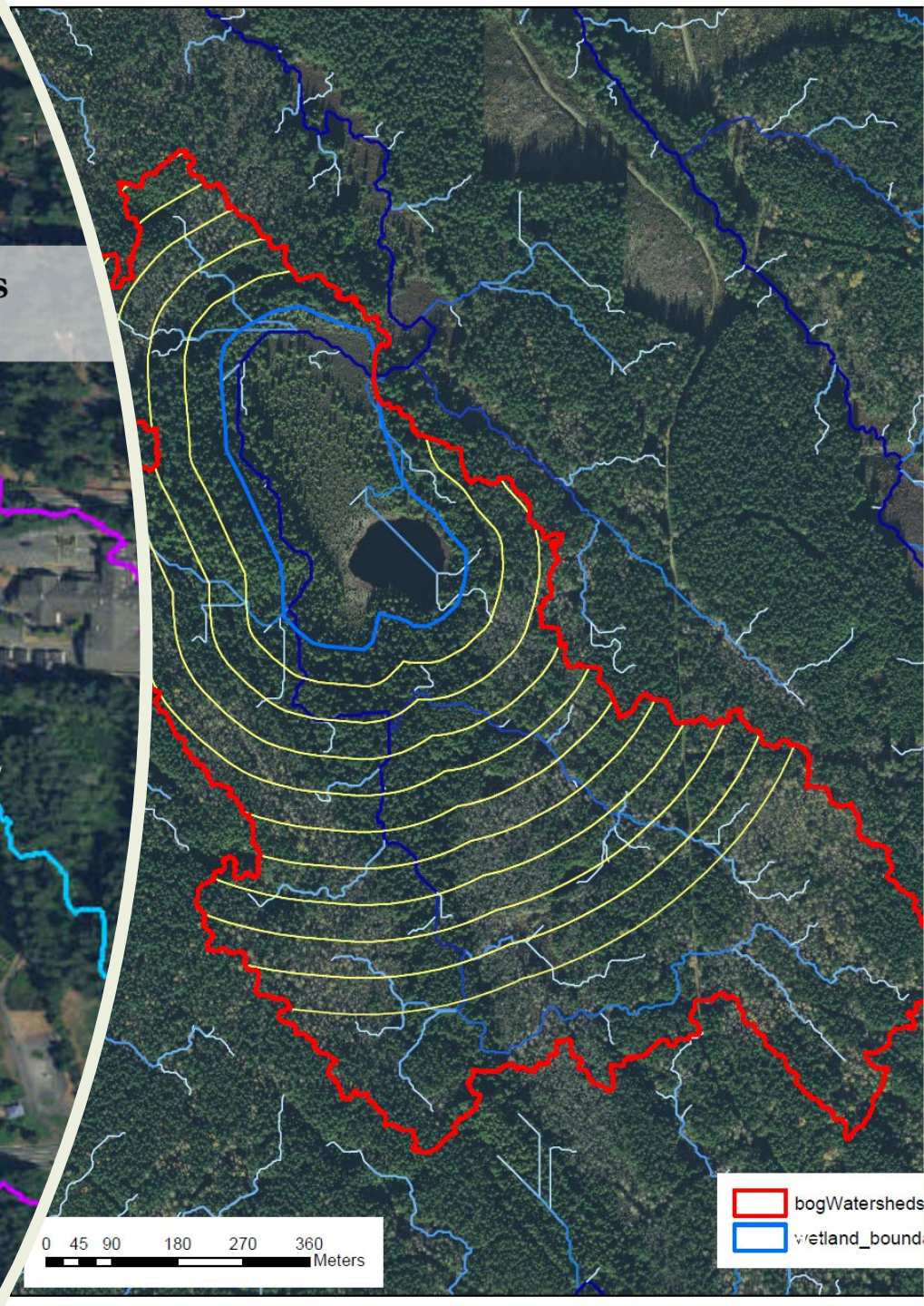


RECOMMENDATIONS

Buffers

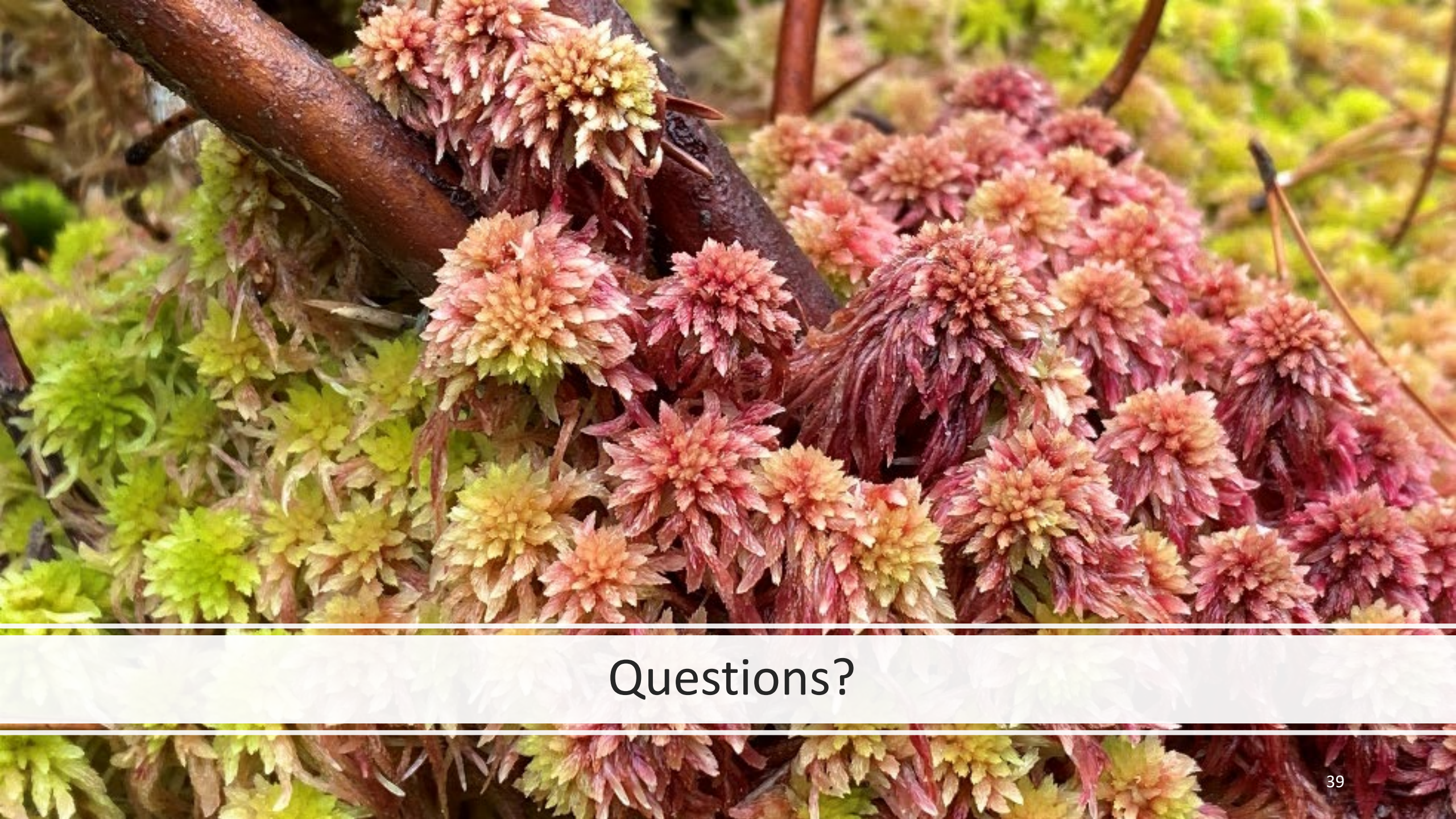
- Protect entire peatland watershed or manage as the buffer
- If entire watershed can't be protected
  - Extend buffers from the outer edge of the lagg
  - Target wide buffer widths within the watershed
  - Establish buffers around contributing inflow channels





Information Needs

- Significance of fire
- Long-term successional dynamics
- Tribal use & management
- Climate change effects



Questions?