A canopy variety hotspot metric to guide riparian forest planning and planting design decision-making

8th Conference on Natural Channels Systems

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In partnership with the Maritime Aboriginal Peoples Council (MAPC)

INTRODUCTION

Assistant Professor,

Landscape Architecture

BLA program at Dalhousie University

Research:

Nature-based design solutions

Riverscape restoration and planning

GIS-based landscape analysis and 3D digital modelling

BES, Dr. Stephen Murphy

UNIVERSITY OF WATERLOO

MLA, Dr. Robert Corry

UNIVERSITY of GUELPH

PhD, Dr. Peter Ashmore

Western UNIVERSITY · CANADA

DALHOUSIE UNIVERSITY

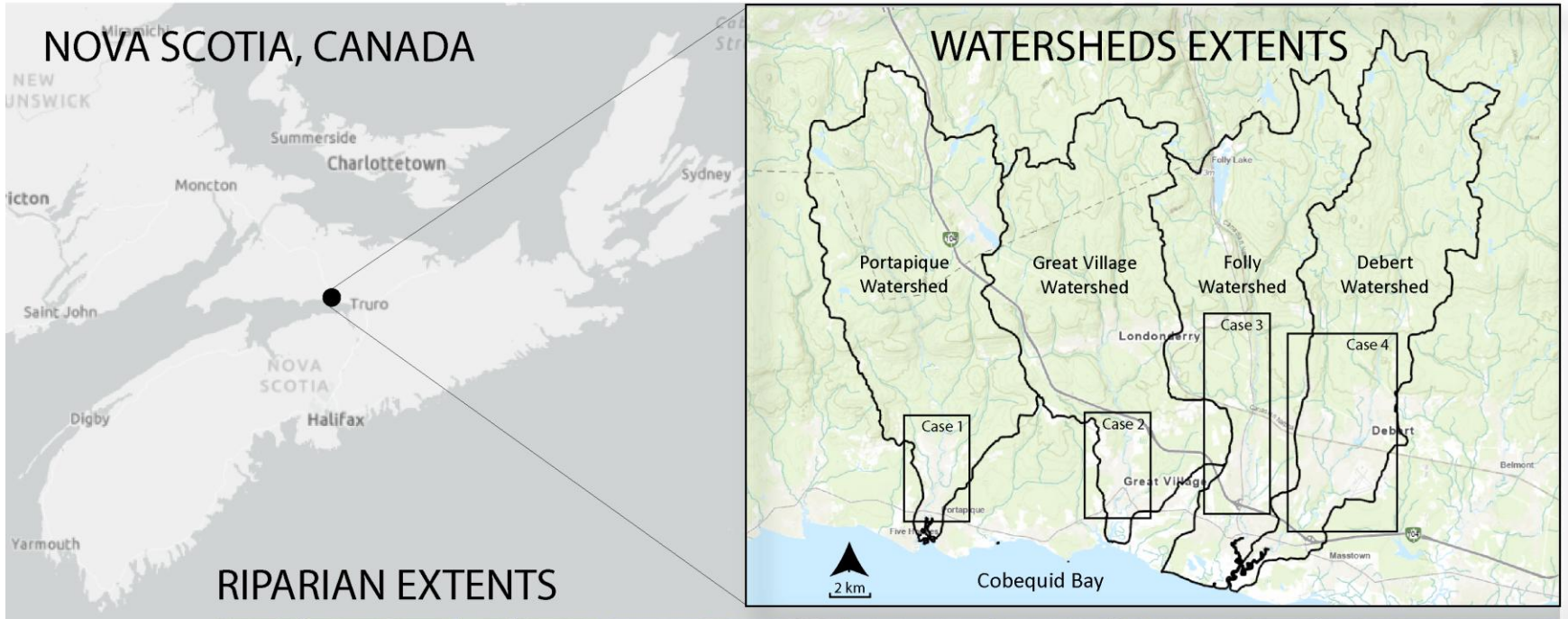
OUTLINE

Assessing Rivers of the Cobequid Bay, NS

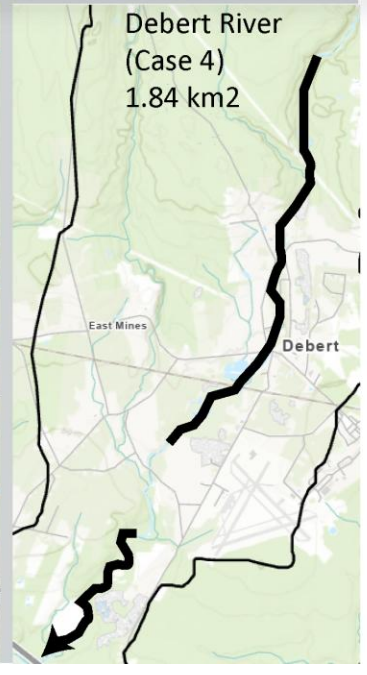
1. Impacts of Hurricane Fiona
   - canopy loss and morphology responses

2. Mapping riparian forest clusters
   - canopy variety hotspot (CVH) metric

3. Guiding restoration planting design
   - a design decision-making framework



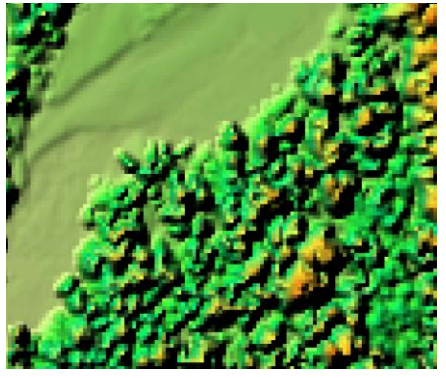
RIPARIAN EXTENTS



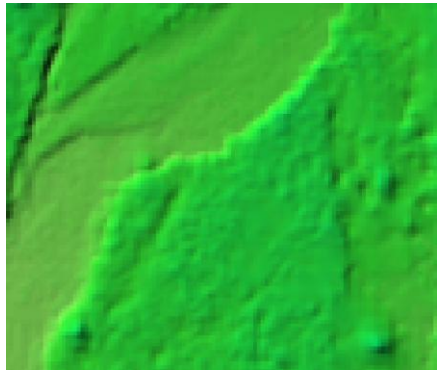
LiDAR Data Extents

Multi-temporal Datasets
2013, 2019, 2024

Imagery



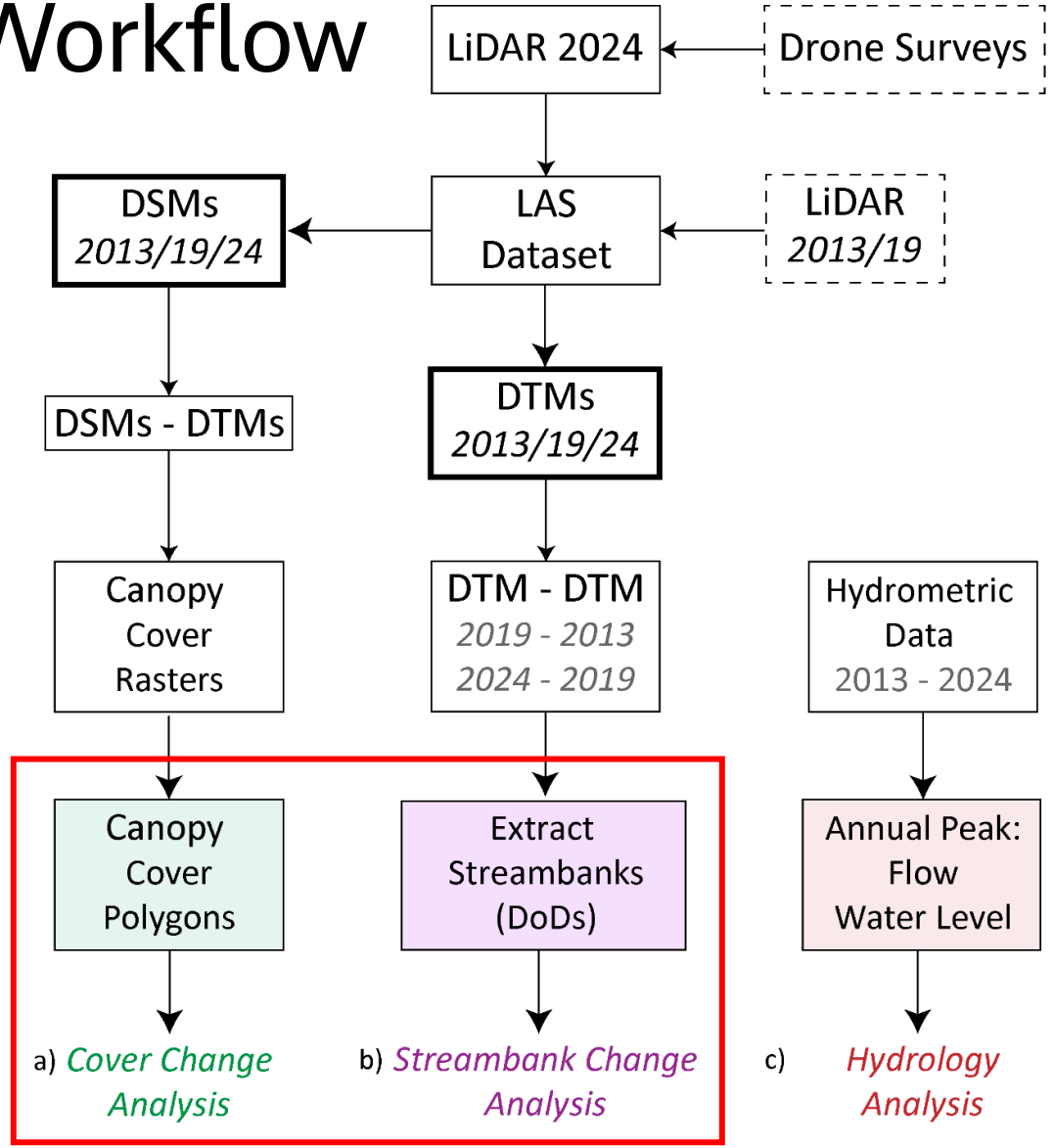
DSM

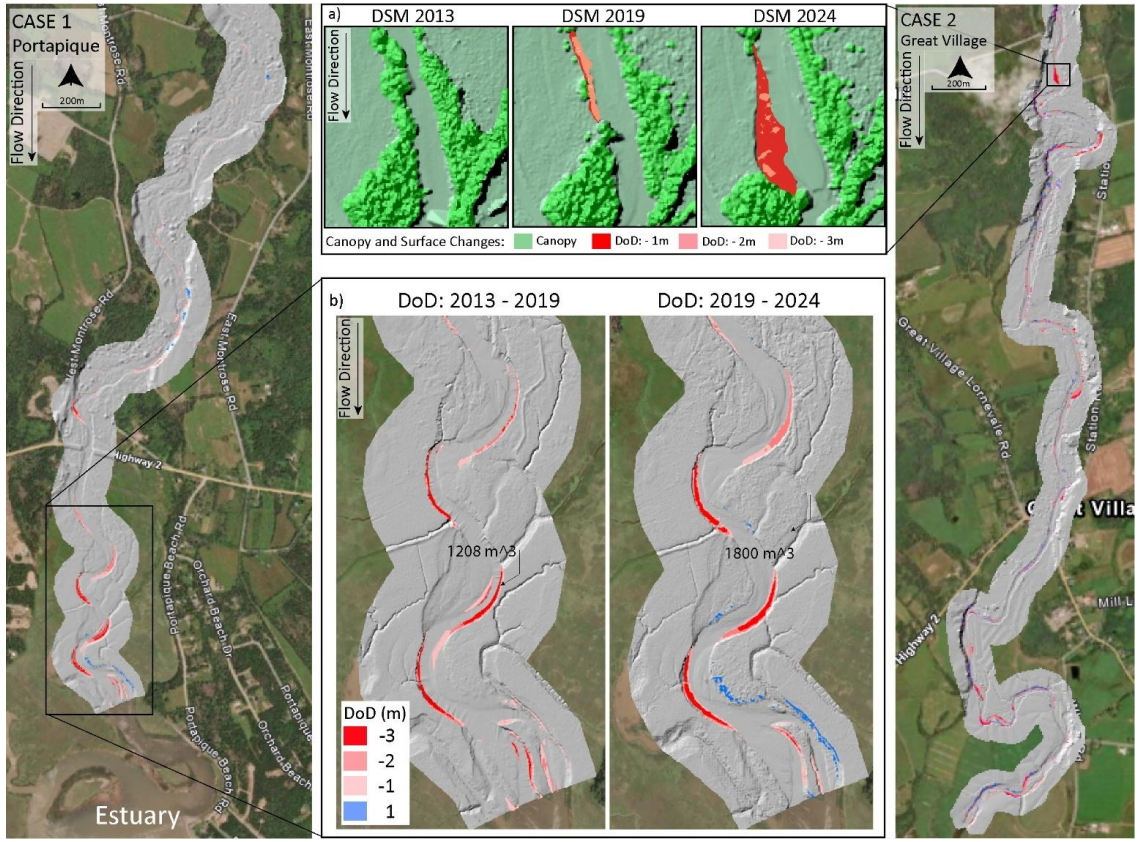


DTM

Impacts of Hurricane Fiona

Workflow





Dawson et al. (2025) ERC: https://doi.org/10.1088/2515-7620/ae2240

Canopy cover loss

Canopy Height	Years	Case 1	Case 2	Case 3	Case 4
Mature (10 m +)	2013 - 2019	18%	39%	12%	19%
	2019 - 2024	**-24%**	**-19%**	**-13%**	**-23%**
Medium (5 – 9 m)	2013 - 2019	8%	14%	13%	3%
	2019 - 2024	-22%	5%	-10%	-7%
Low (1 – 4 m)	2013 - 2019	3%	13%	<1%	-10%
	2019 - 2024	-3%	1%	-3%	13%

Morphology change

Case 1:

-43% scour

+ 99% aggradation

Case 3:

-22% scour

+ 93% aggradation

Case 2:

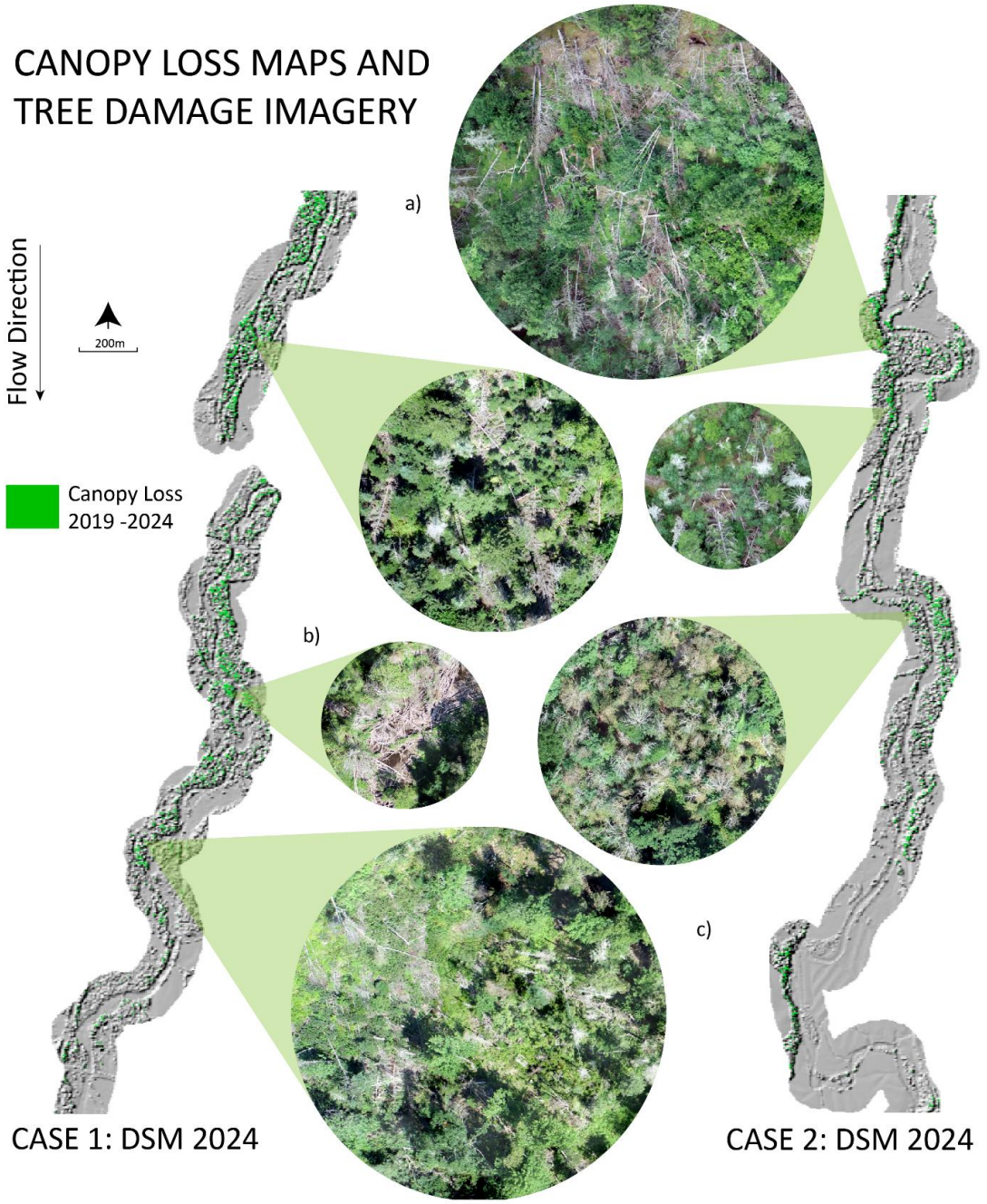
-65% scour

+ 84% aggradation

Case 4:

-45% scour

+ 88% aggradation



Takeaways

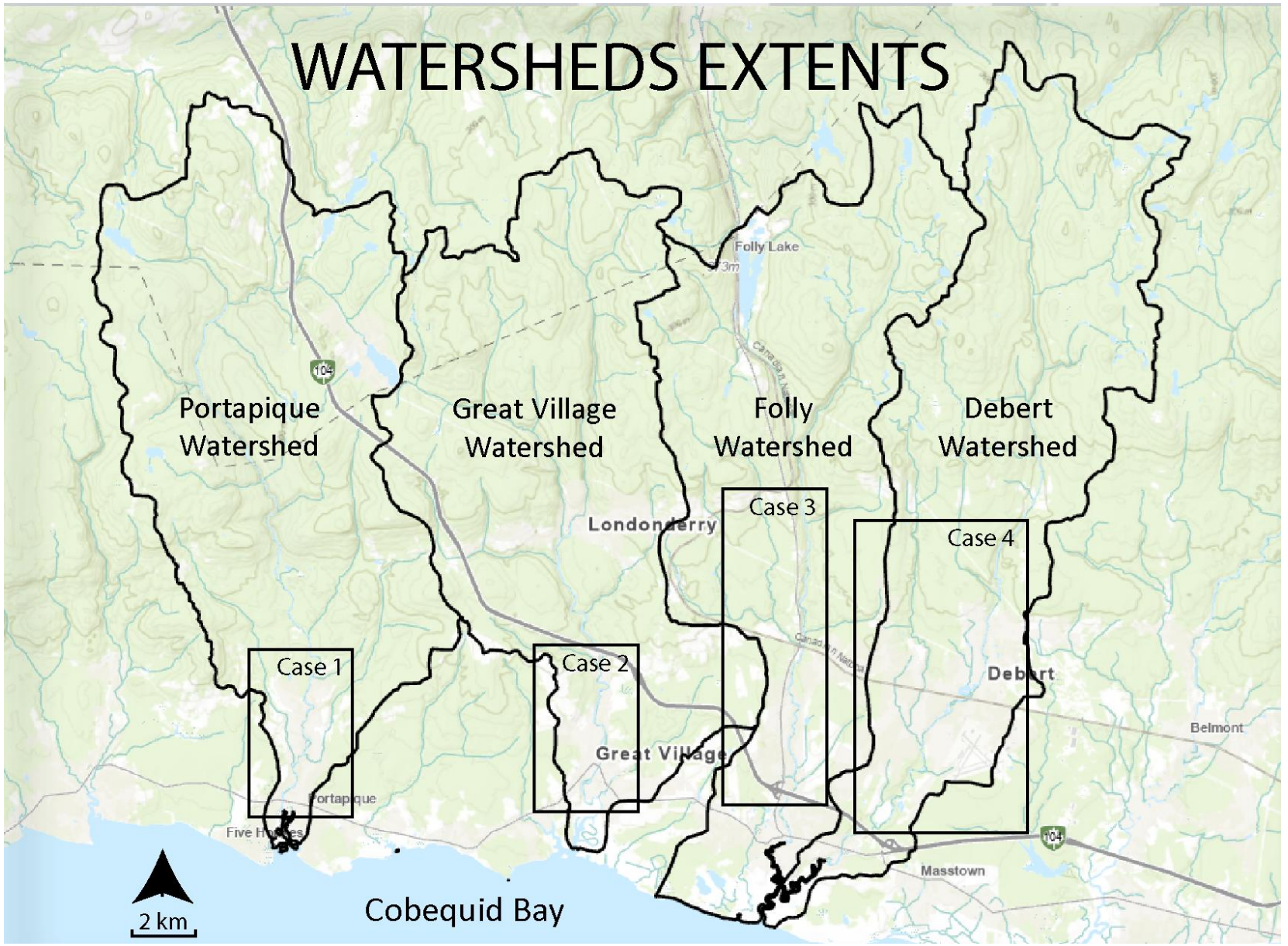
Widespread forest damage

+

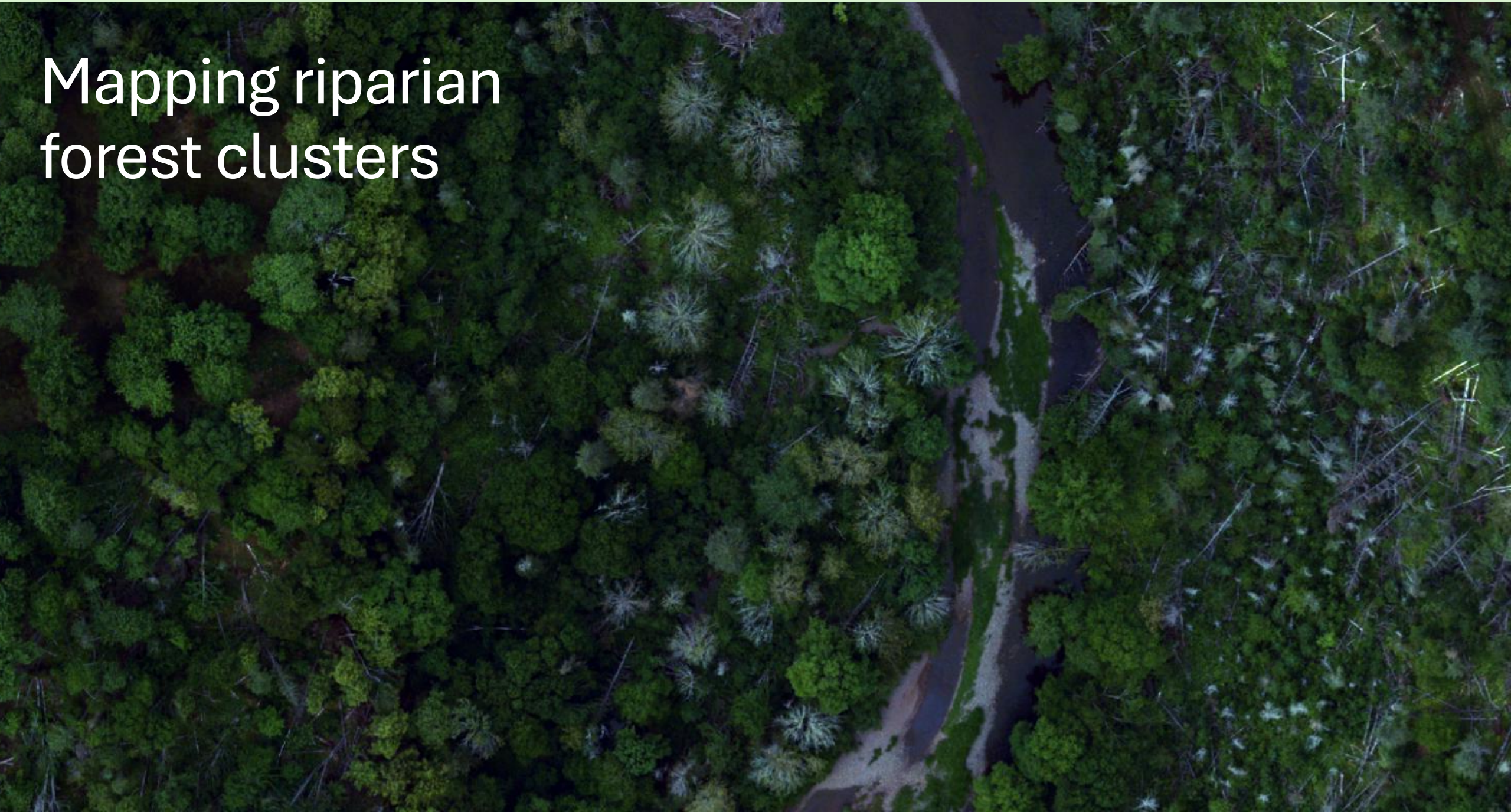
Destabilized soils

=

Likely a sediment regime response to **watershed scale** canopy loss

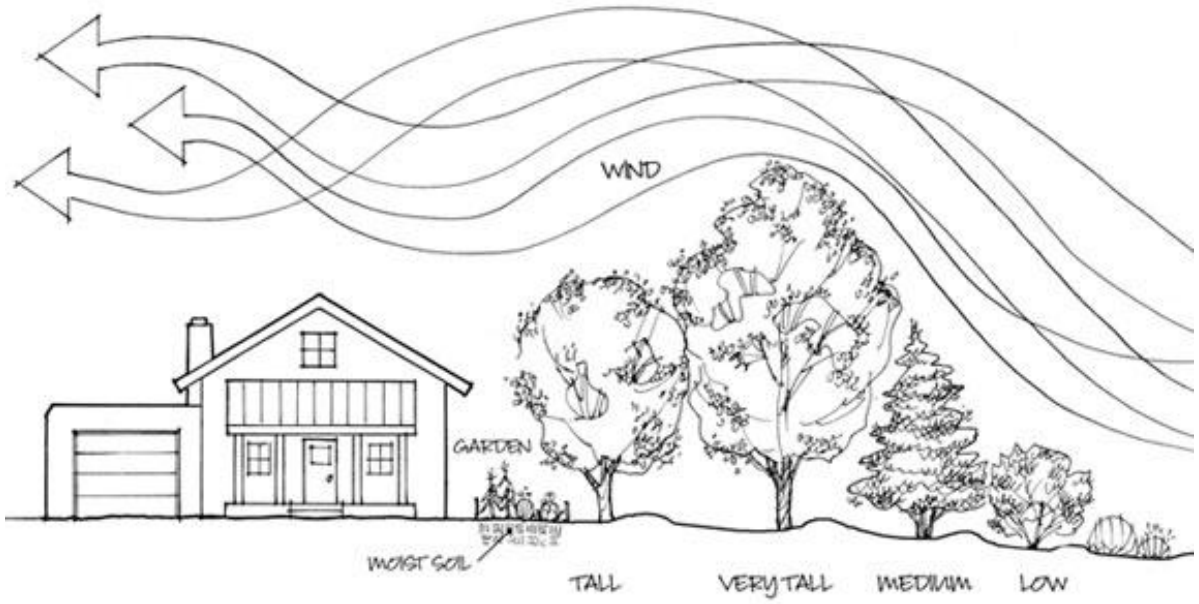


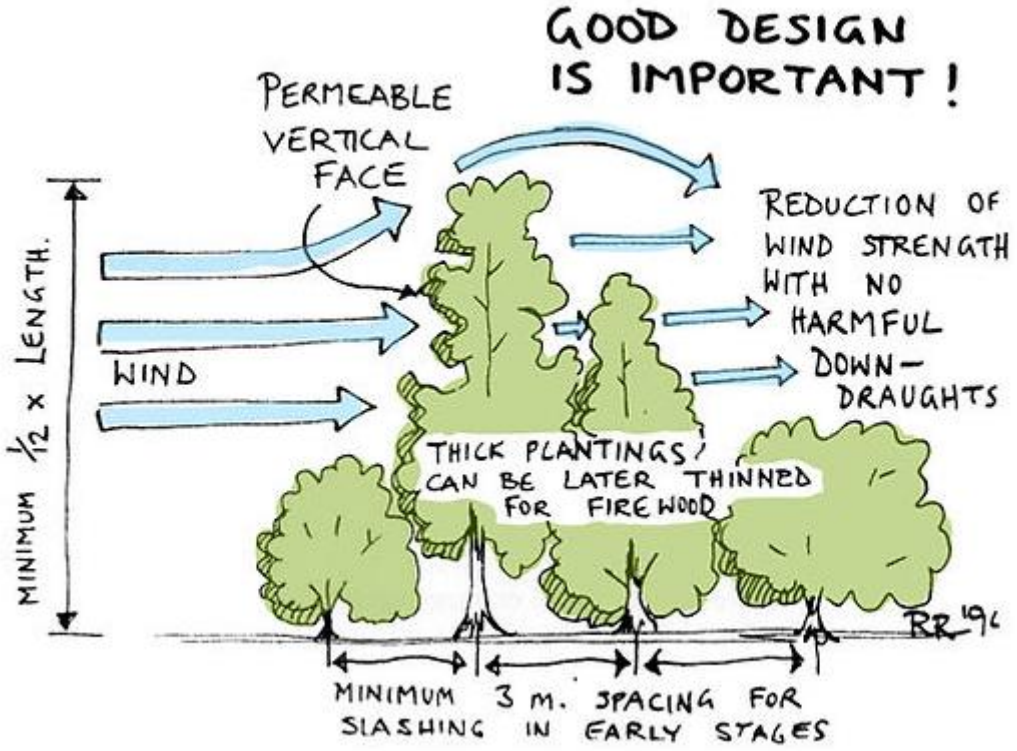
Mapping riparian forest clusters



Conceptualization: Canopy height variety

Decreases wind velocity = increases windthrow-resistance





http://permadesign.com/portfolios/windbreaks

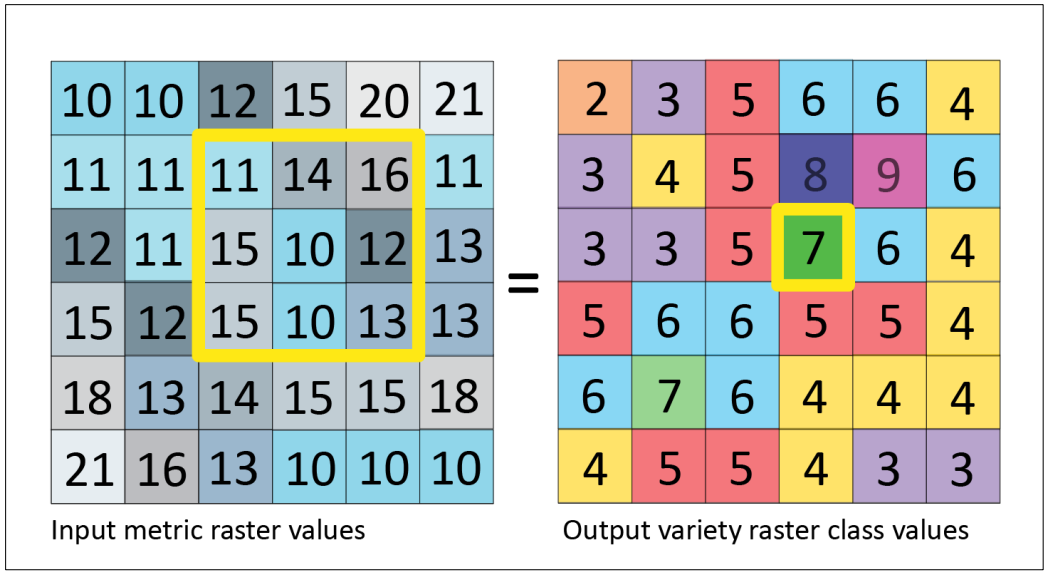
https://www.treesforclimate.com.au/shelterbelts

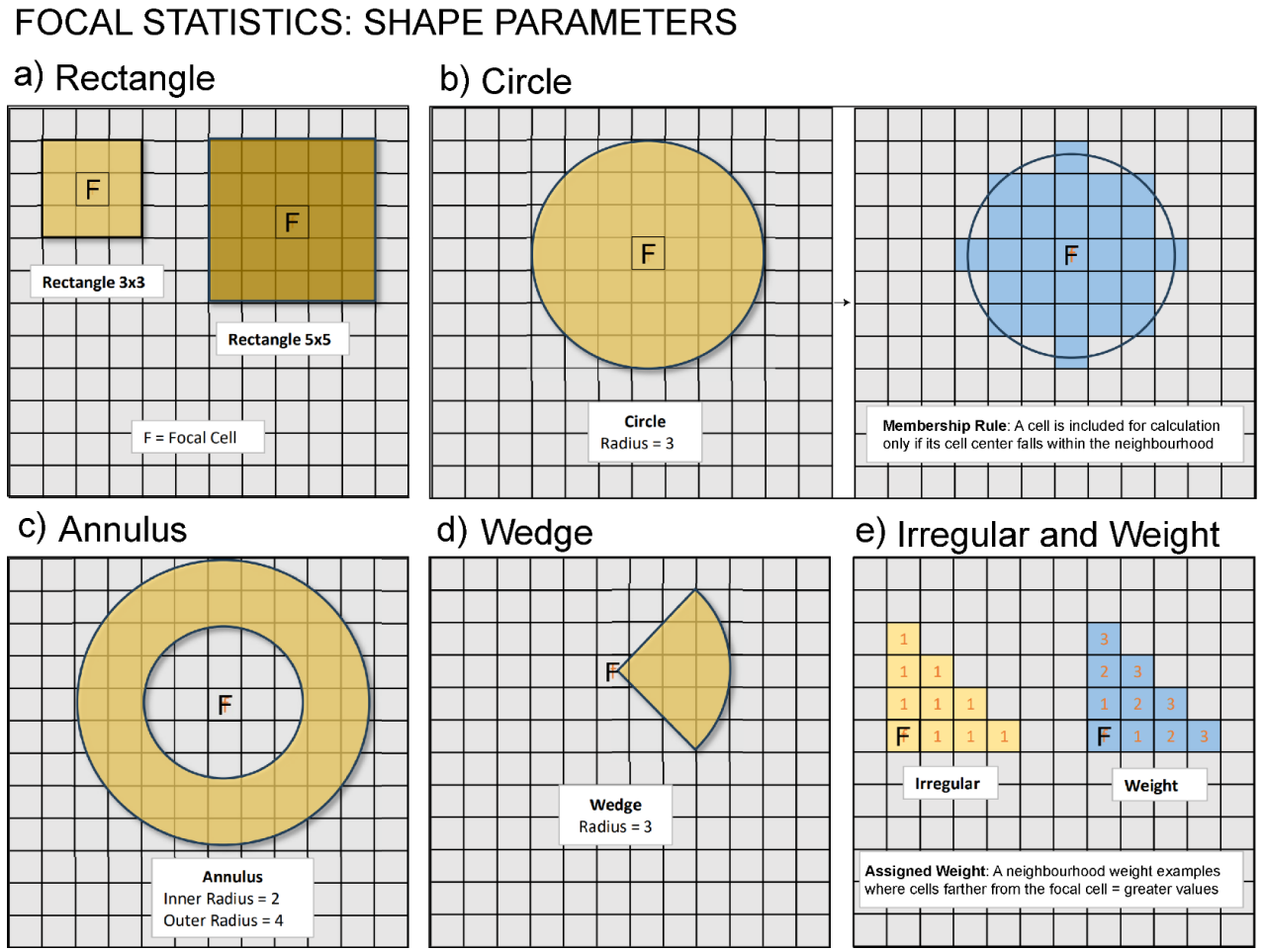
Processing variety

ArcGIS Pro:

Focal Statistic type = '**Variety**'

dimensionless, flexible, scalable





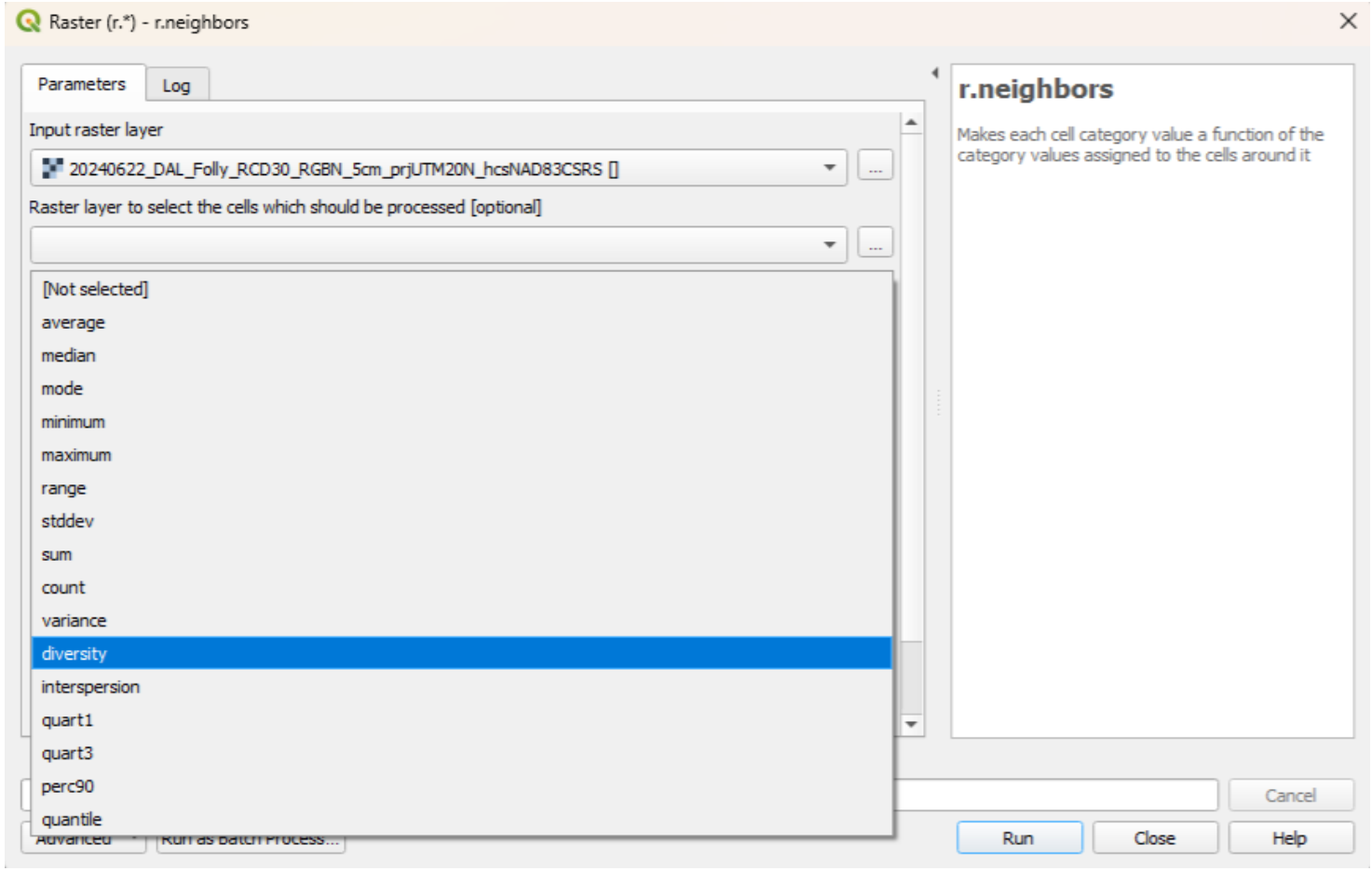
Alternative processing method

QGIS (open source/free):

1.Toolbox - GRASS

2. Raster (r.*) > r.neighbors

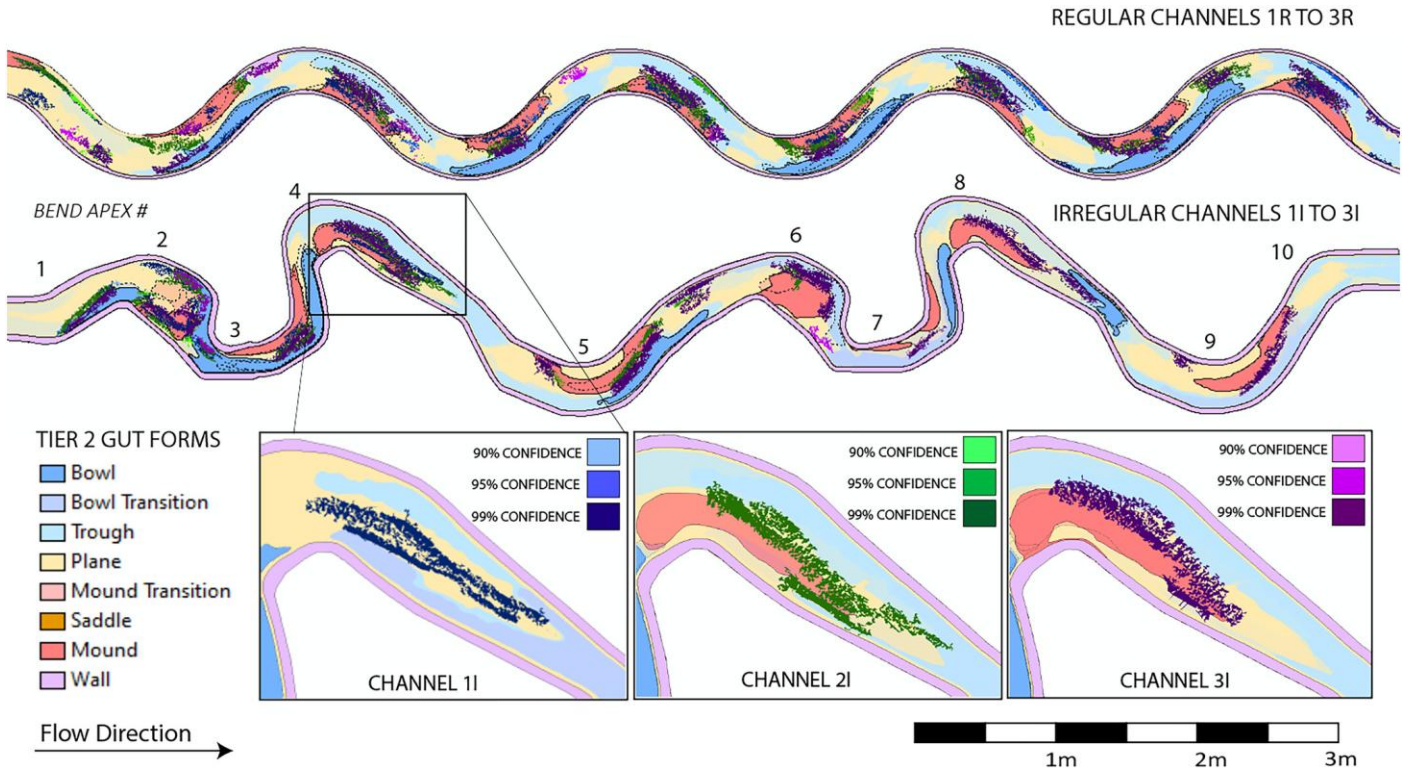
3. Operation > '**diversity**'

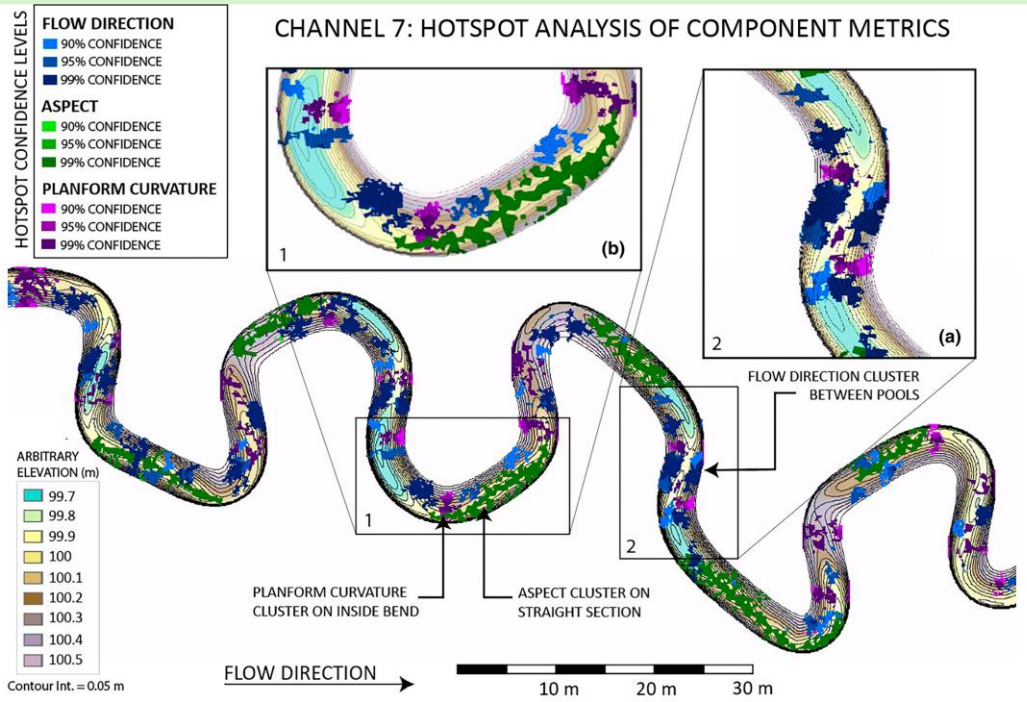


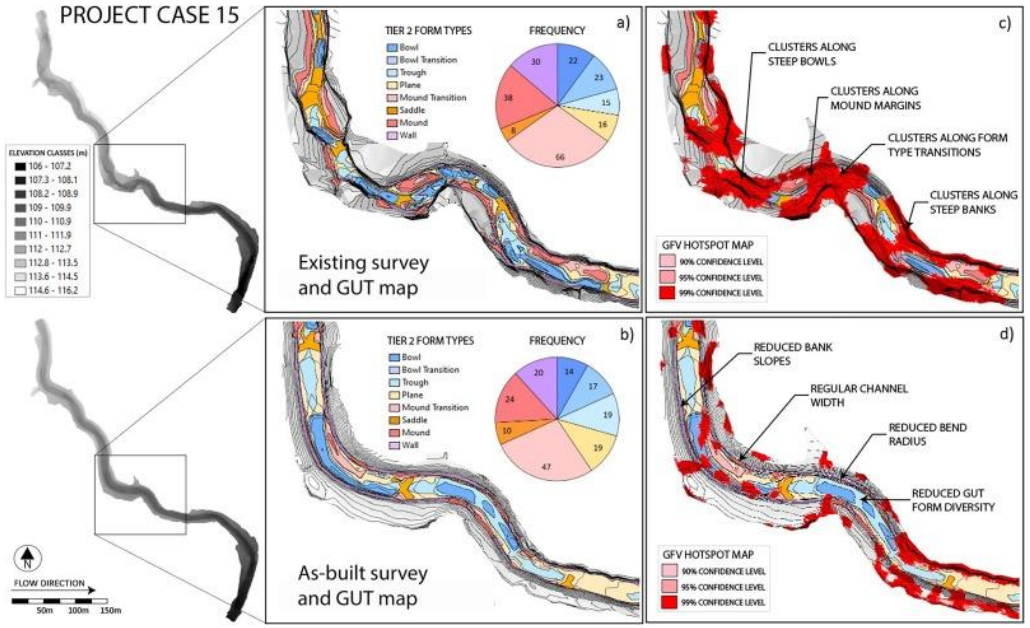
Geomorphic Form Variation (GFV)

Great for mapping in-stream heterogeneity!

Dawson et al. (2024) ESPL: https://doi.org/10.1002/esp.5744
Dawson & Ashmore (2025) RRA: https://doi.org/10.1002/rra.4367
Dawson & Ashmore (2025) EE: https://doi.org/10.1016/j.ecoleng.2024.107437



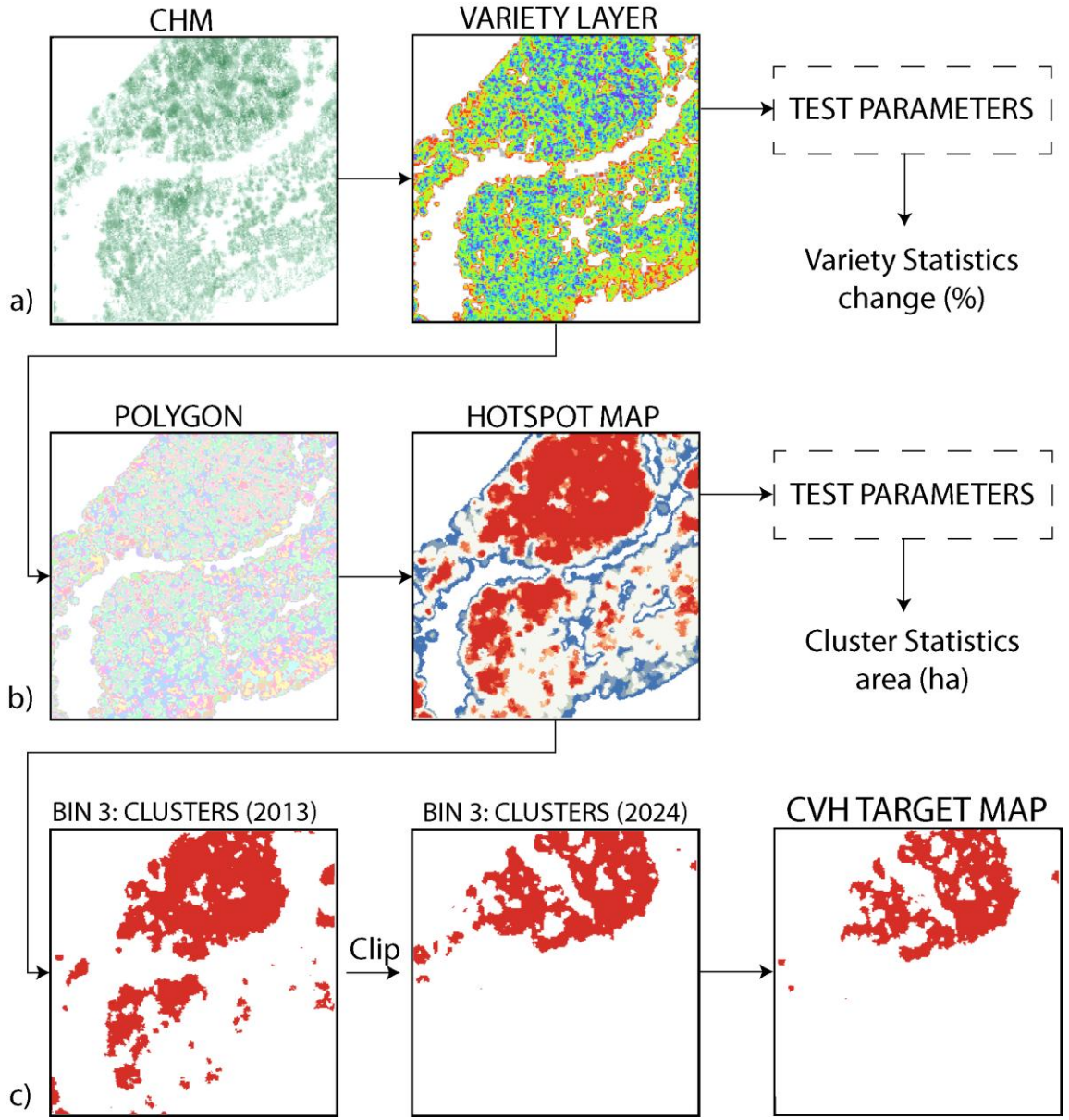




Canopy Variety Hotspot (CVH) metric

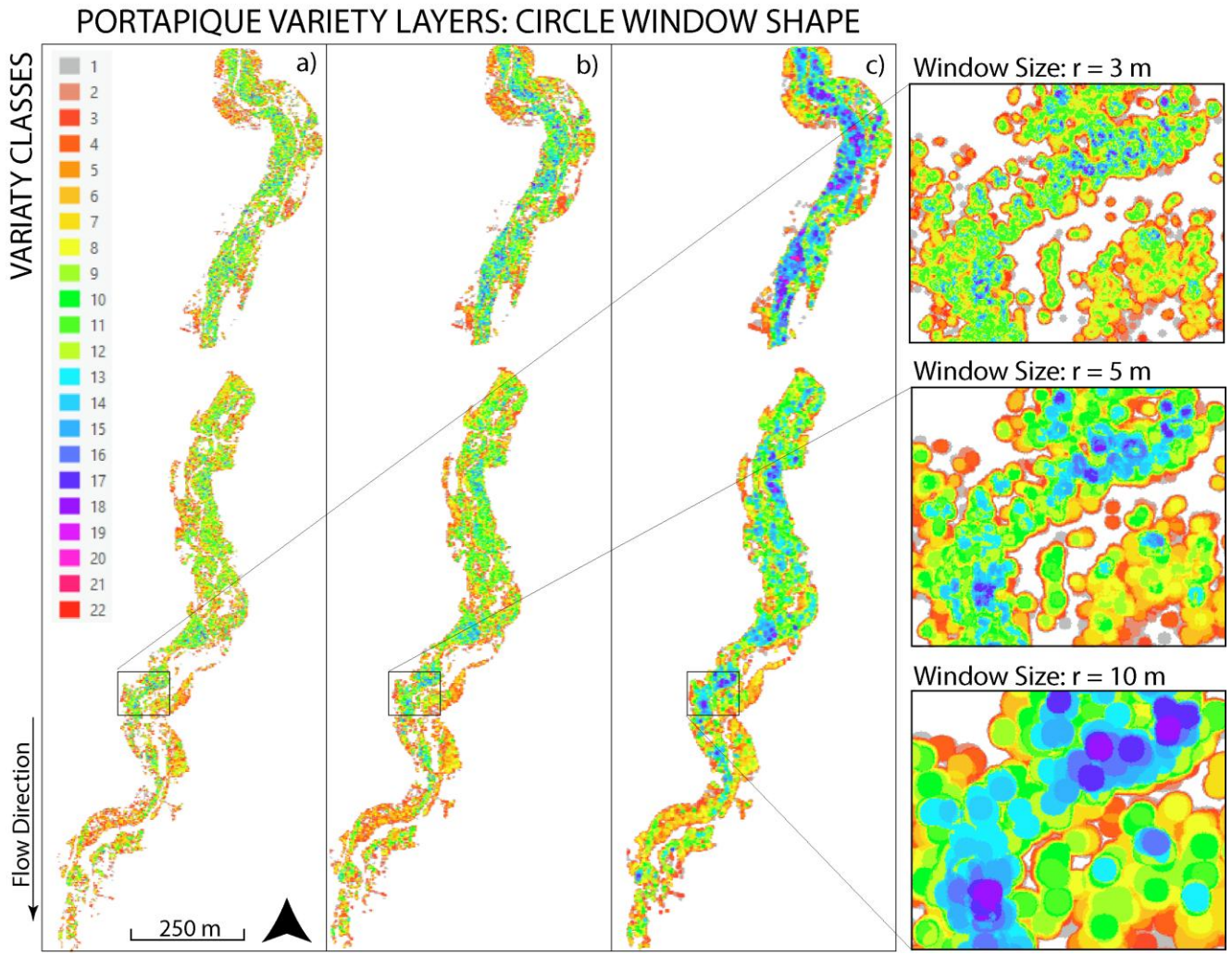
Focal Variety: Potential windthrow-resistance with multi-temporal data (2013 – 2024)
+
Hot Spot Analysis: Mapping canopy clusters
=
CVH Target Maps: Guide tree inventories

Customizable input parameters (scalable)



Dawson et al. (2026) FEM: https://10.1016/j.foreco.2026.123947

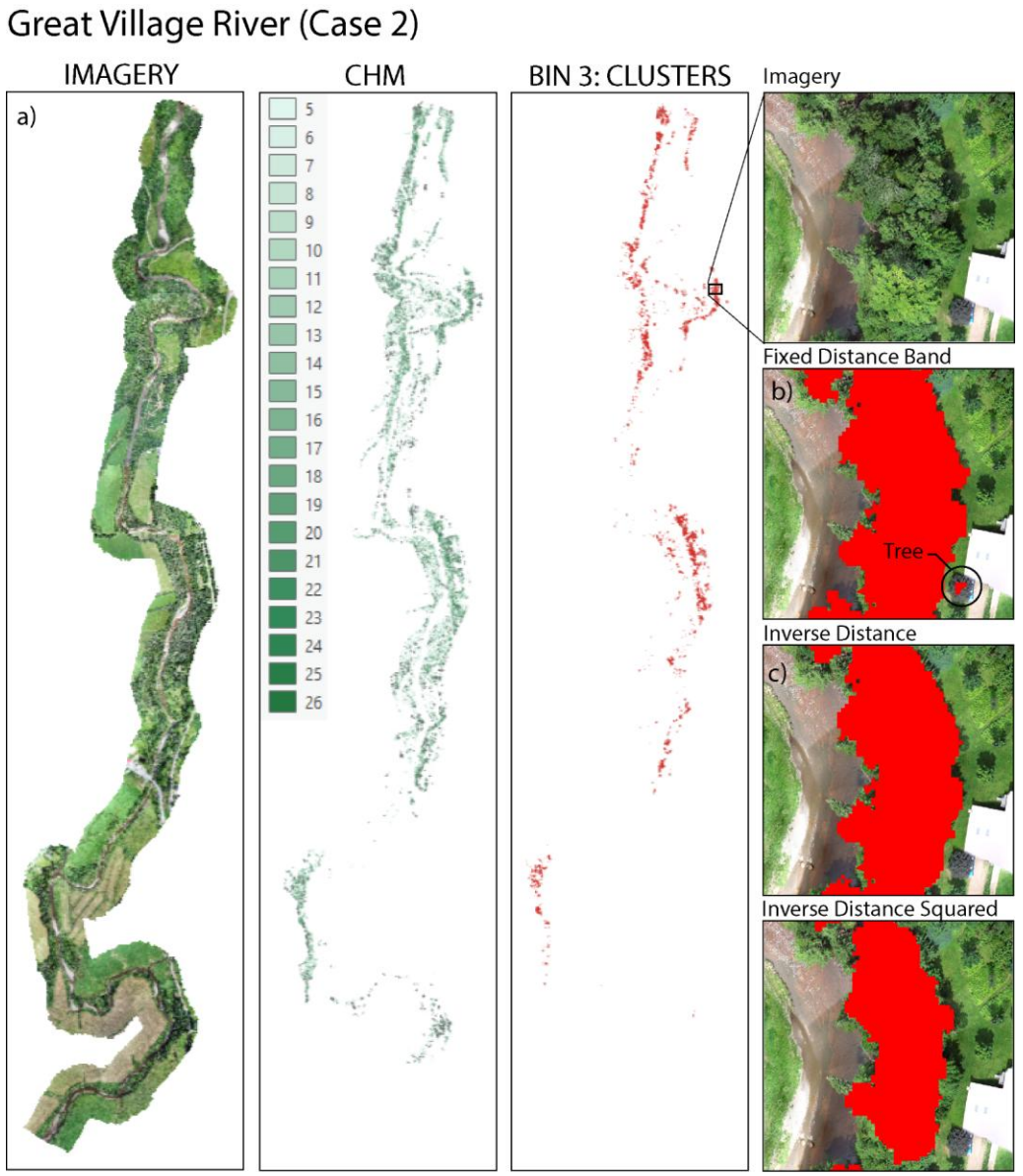
CVH: Testing variety parameters



River Name		Variety Value mean (dimensionless)		
Portapique (Case 1)	Parameter (m)	(2013)	(2024)	Change (%)
	Circle (r=3)	6.49	5.82	**10.41**
	Circle (r=5)	8.30	7.52	9.35
	Circle (r=10)	10.17	9.29	8.61
	Rect. (3x3)	4.02	3.90	8.05
	Rect. (10x10)	8.61	7.84	8.97
	Rect. (20x20)	10.48	9.58	8.59
Folly (Case 3)	Parameter (m)	(2013)	(2024)	Change (%)
	Circle (r=3)	6.50	5.67	**12.74**
	Circle (r=5)	8.39	7.38	11.97
	Circle (r=10)	10.42	9.36	10.21
	Rect. (3x3)	4.01	3.61	10.13
	Rect. (10x10)	8.73	7.72	11.60
	Rect. (20x20)	10.78	9.71	9.97
Great Village (Case 2)	Parameter (m)	(2013)	(2024)	Change (%)
	Circle (r=3)	6.48	5.94	**8.36**
	Circle (r=5)	8.18	7.67	6.24
	Circle (r=10)	9.67	9.28	3.99
	Rect. (3x3)	4.04	3.74	7.40
	Rect. (10x10)	8.46	7.97	5.70
	Rect. (20x20)	9.90	9.54	3.63
Debert (Case 4)	Parameter (m)	(2013)	(2024)	Change (%)
	Circle (r=3)	6.58	5.61	**14.66**
	Circle (r=5)	8.21	7.21	12.20
	Circle (r=10)	9.69	8.77	9.43
	Rect. (3x3)	4.14	3.57	13.72
	Rect. (10x10)	8.47	7.49	11.51
	Rect. (20x20)	9.91	9.01	9.10

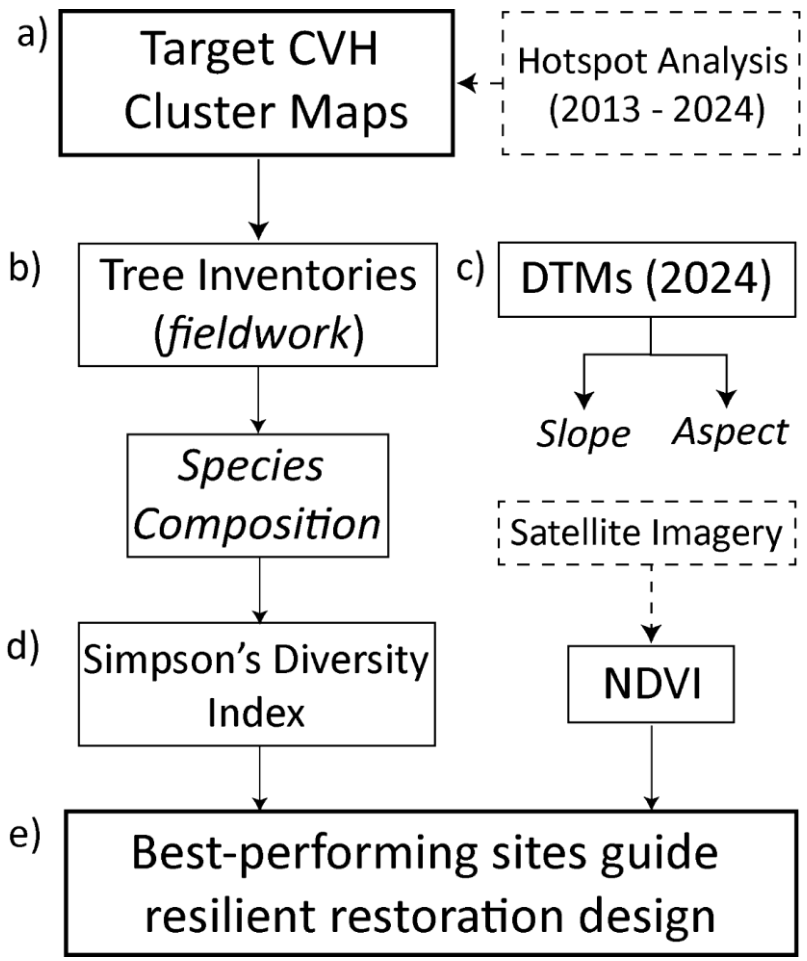
CVH: Testing hotspot cluster parameters

Hotspot Cluster Maps: 99% Confidence, Area (ha)								
Datasets (2024)	Portapique (Case 1)		Great Village (Case 2)		Folly (Case 3)		Debert (Case 4)	
Total Canopy Cover (ha)	79.21		32.11		64.49		60.80	
PARAMETERS	Euclidean	Manhattan	Euclidean	Manhattan	Euclidean	Manhattan	Euclidean	Manhattan
Threshold Distance: 15 m								
Fixed Distance Band	28.32	26.93	11.57	10.91	23.13	22.19	20.58	19.44
Inverse Distance	26.48	24.79	10.64	9.98	21.45	20.00	19.02	17.72
Inverse Distance Squared	17.01	13.40	7.63	6.66	14.87	12.93	12.89	10.88
Proportional Total Change	40%	50%	34%	39%	36%	42%	37%	44%
Threshold Distance: 7.5 m								
Fixed Distance Band	23.27	21.19	9.57	8.89	19.32	17.82	16.85	15.43
Inverse Distance	21.76	19.21	8.99	8.29	17.94	16.47	15.79	14.21
Inverse Distance Squared	14.63	**11.03**	7.01	**6.05**	13.86	**11.68**	11.61	**9.45**
Proportional Total Change	37%	48%	27%	32%	28%	34%	31%	39%
Threshold Effect	Proportional Change (%)							
Fixed Distance Band	18	21	17	19	16	20	18	21
Inverse Distance	18	22	16	17	16	18	17	20
Inverse Distance Squared	14	18	8	9	7	10	10	13

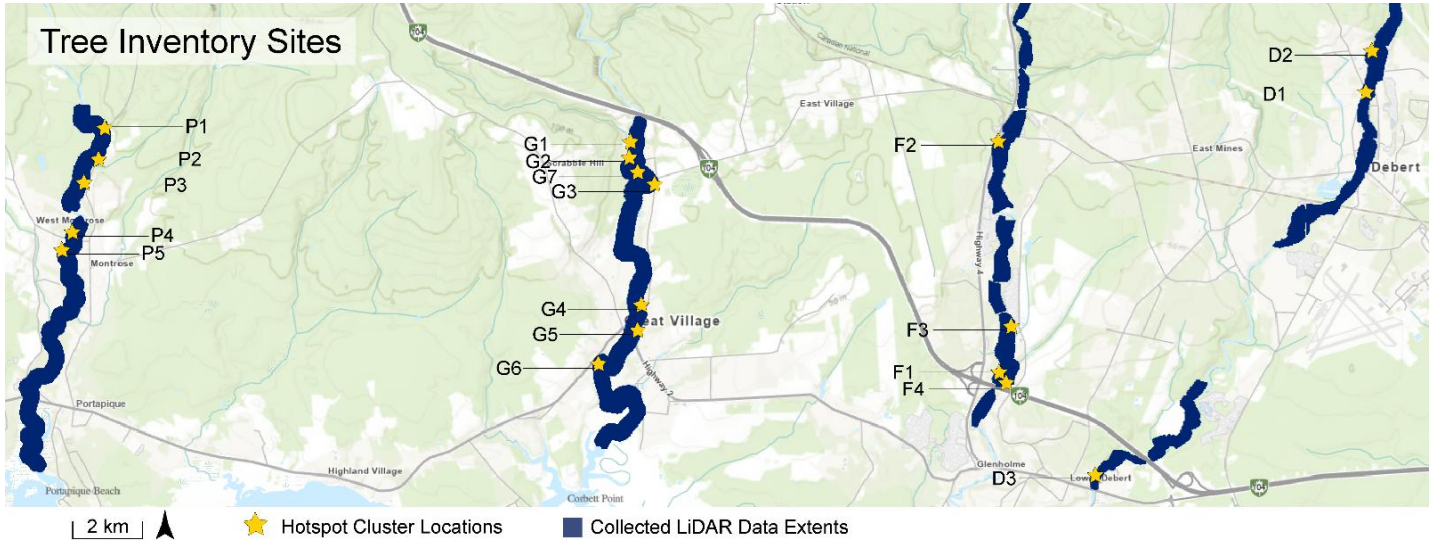


Guiding restoration planting design

Proof-of-Concept Framework

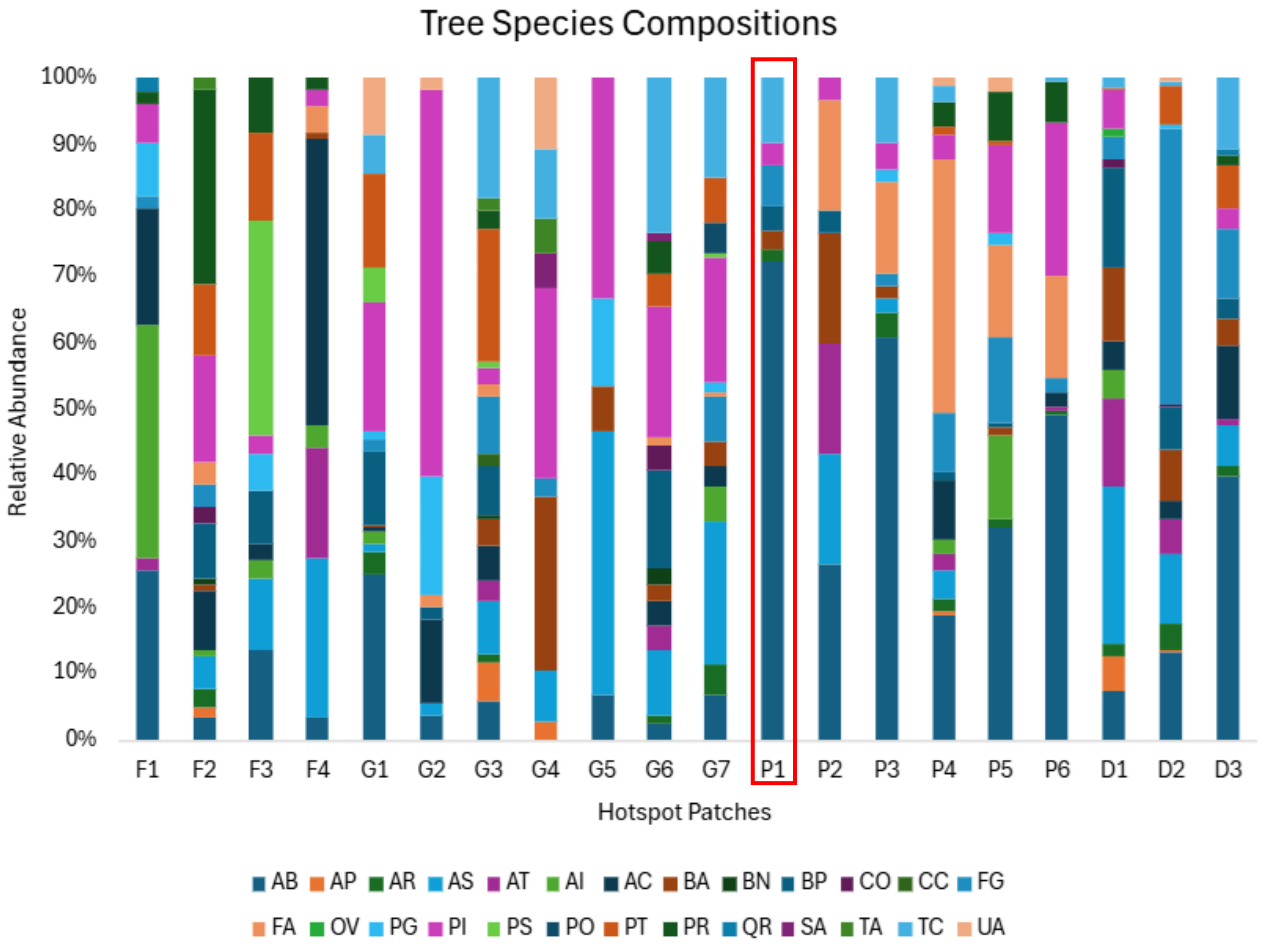


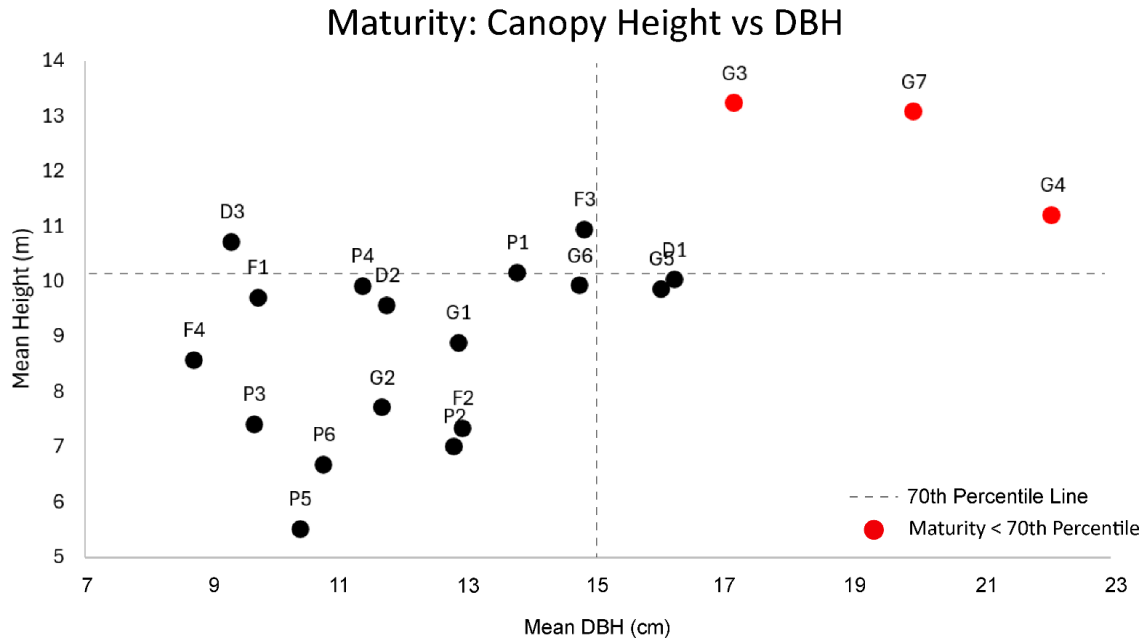
Canopy cluster conditions (20)

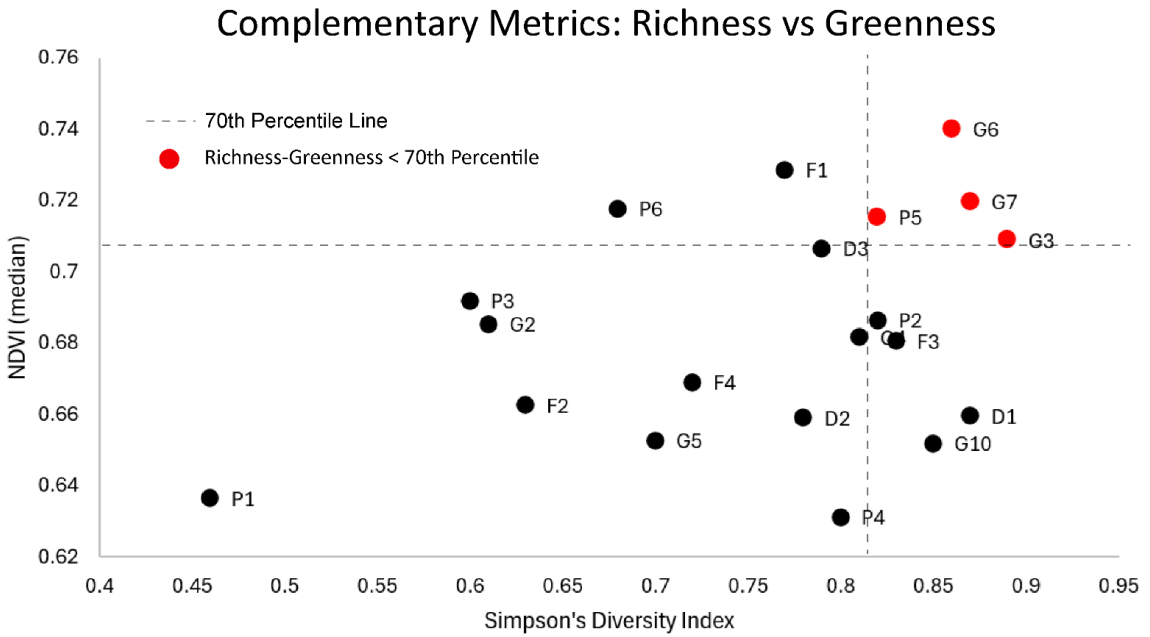


Patch	Area (m^2)	Slope (°)	Aspect (°)	# of Trees	# of Species
F1	264	25	SE	51	9
F2	2,815	13	S	119	16
F3	580	23	W	37	10
F4	992	8	SW	120	9
G1	1,865	23	SE	200	14
G2	808	6	SE	55	8
G3	1,640	26	W	171	18
G4	656	20	SW	38	9
G5	543	33	W	15	5
G6	856	14	E	81	15
G7	1,760	31	E	133	14
P1	1,845	24	W	144	7
P2	753	10	SW	30	7
P3	827	17	SW	51	9
P4	2,088	7	S	202	15
P5	2,953	8	S	159	12
P6	2,701	8	S	177	9
D1	2,238	11	SE	321	15
D2	4,829	14	SE	248	14
D3	2,200	22	SE	198	13

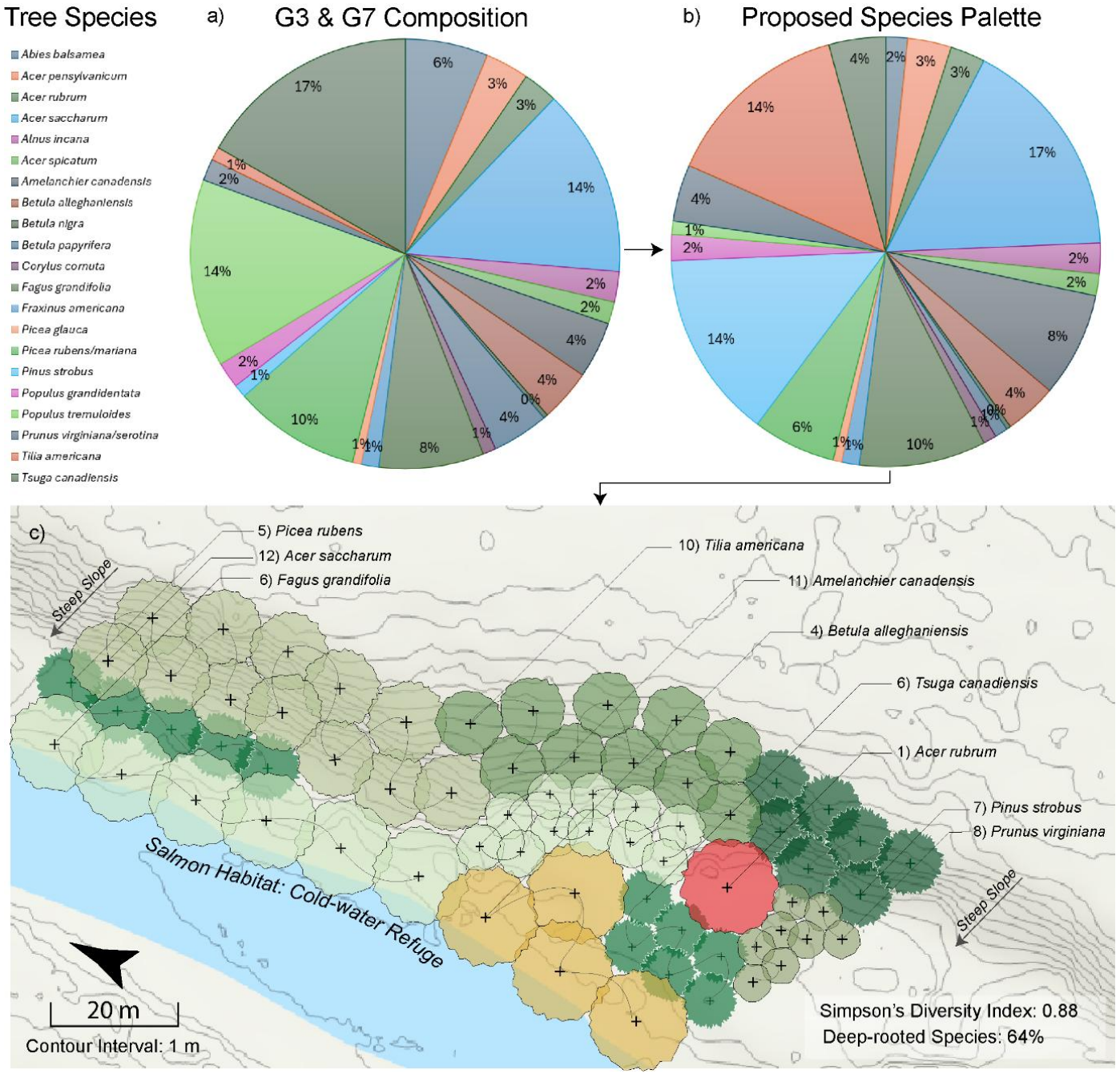
Tree species composition







Conceptual riparian planting design



Future research interests

1. Install a riparian planting design derived by CVH
2. Apply ‘Variety’ to hydraulic rasters and imagery data
3. Comparing ArcGIS ‘variety’ and QGIS ‘diversity’

Thank you for listening

Funding provided by:
The Foundation for Conservation of Atlantic Salmon

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