CWRA / CGU National conference 2012
HW12: Hydrologic and Water Quality Monitoring and Modeling in Transboundary Lake Systems

Piecing up the (Hydrobiogeochemical) Landscape: a key to Understanding Contrasted Nutrient Export Regimes across Manitoba Streams

Genevieve Ali[1,2,3], Don Flaten[4], Esther Salvano[5], David Lobb[1,4]

[1]Watershed Systems Research Program
[2]Department of Geological Sciences, University of Manitoba
[3]Center for Earth Observation Science, University of Manitoba
[4]Department of Soil Science, University of Manitoba
[5]Manitoba Agriculture, Food and Rural Initiatives

Watershed Systems Research Program (WSRP)

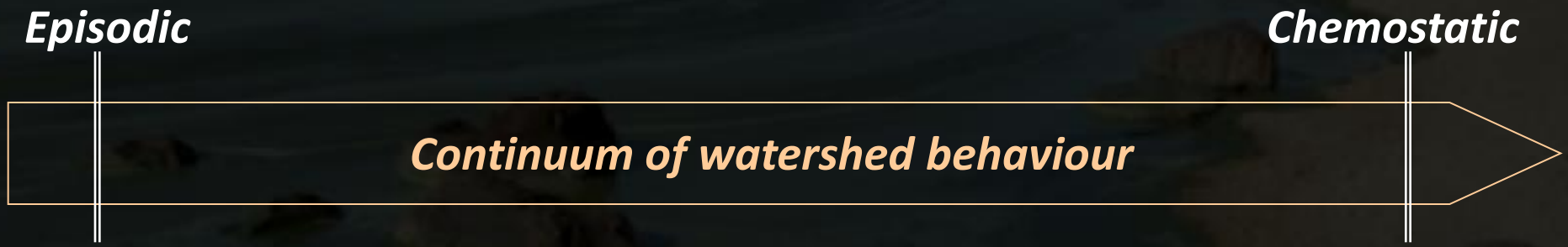
- Established by the Government of Manitoba in 2010
- Ultimate goal: enhance the quality of water resources in Lake Winnipeg and its basin
- Primary concern: nutrients (e.g. phosphorus) and other contaminants




- Fundamental research question:

What are the controlling sources and pathways by which contaminants are exported from Prairie river watersheds to Lake Winnipeg?

Typology of nutrient export dynamics



River discharge: variable
Nutrient concentration: variable
Nutrient sources: contemporary
Export dynamics: source-limited

River discharge: variable
Nutrient concentration: invariant
Nutrient sources: legacy
Export dynamics: transport-limited

Difference in watershed export dynamics can inform management decisions

e.g. Basu et al., 2011; Thompson et al., 2011

Investigating the relevance and physical basis of the export dynamics typology in Manitoba

- 14 sub-watersheds within Lake Winnipeg Basin
- Focus on total phosphorus concentrations

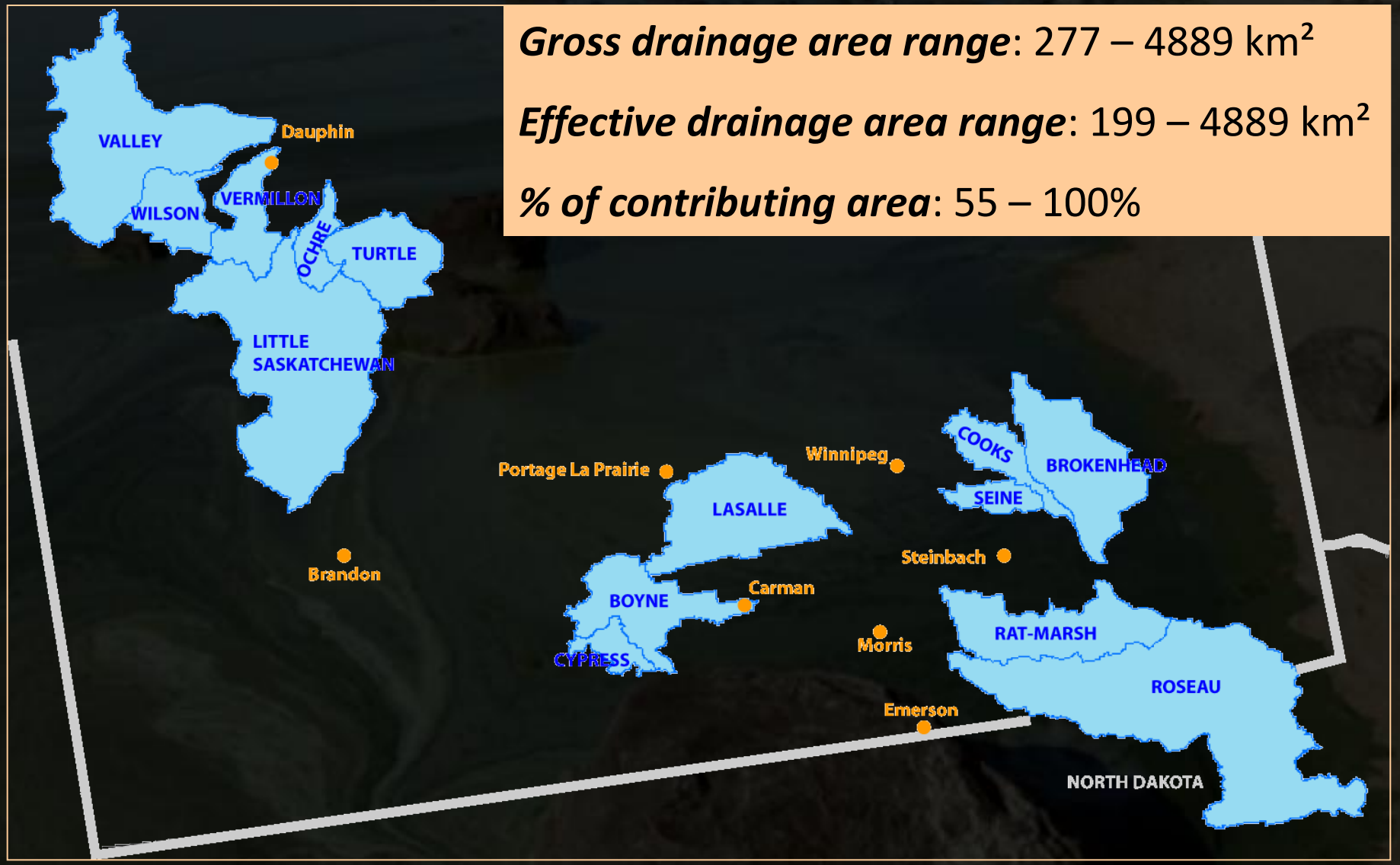
- Two research questions:
  - Can we differentiate Prairie watersheds according to their chemostatic or episodic export dynamics?
  - Can climatic or physiographic characteristics explain (any) differences in dominant watershed export dynamics?

Study watersheds - Location

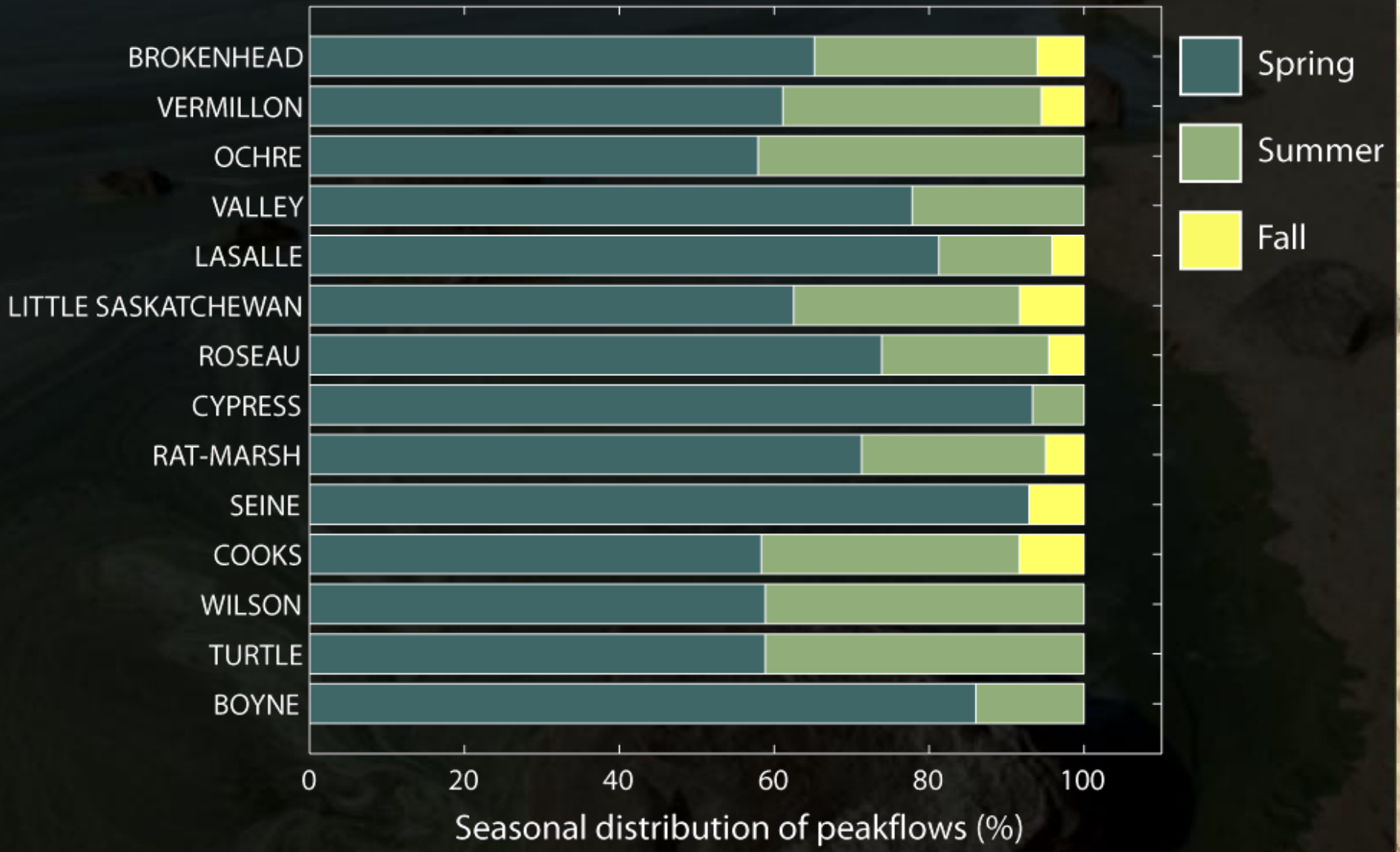
Gross drainage area range: 277 – 4889 km²

Effective drainage area range: 199 – 4889 km²

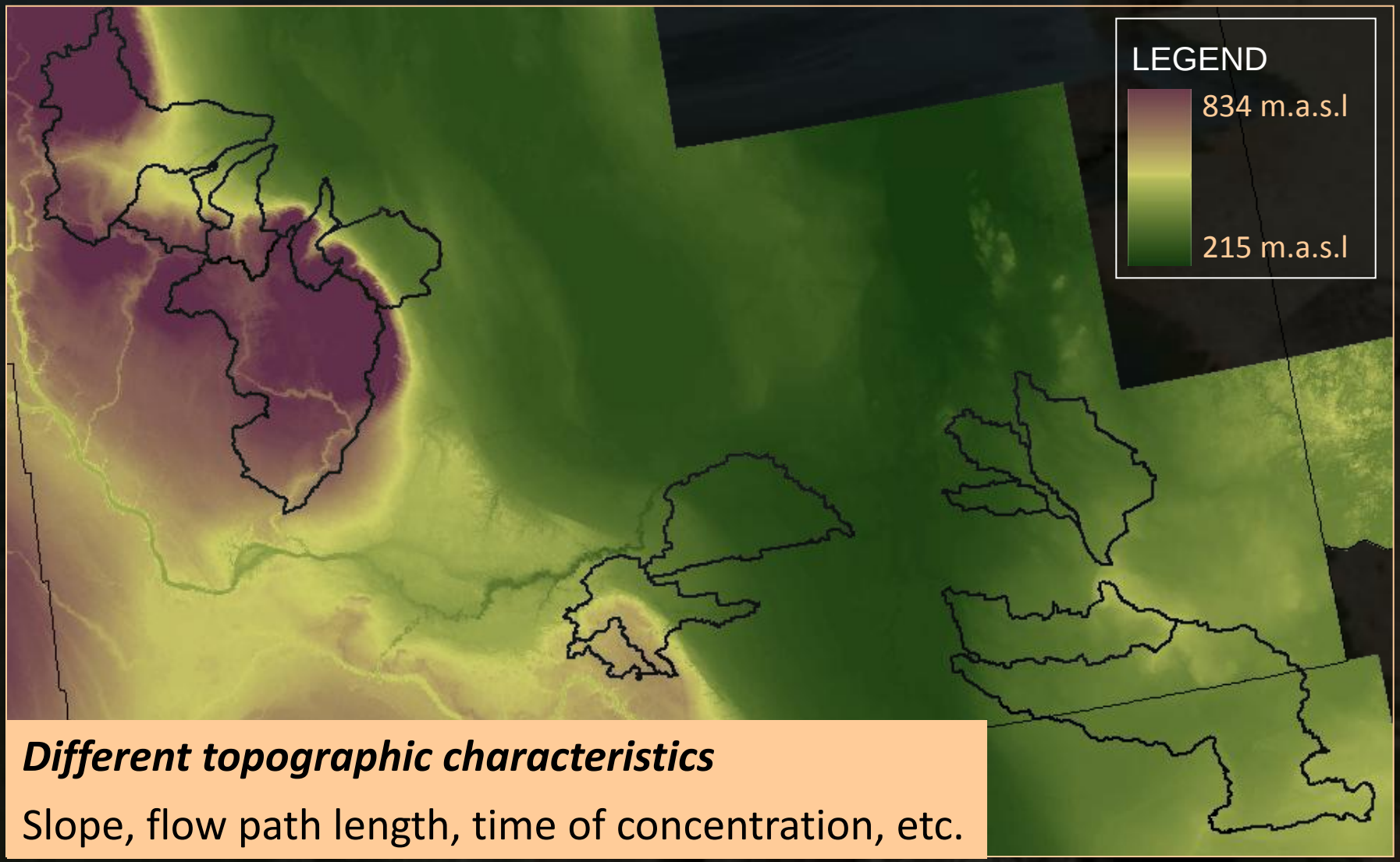
% of contributing area: 55 – 100%



Study watersheds – Runoff regime



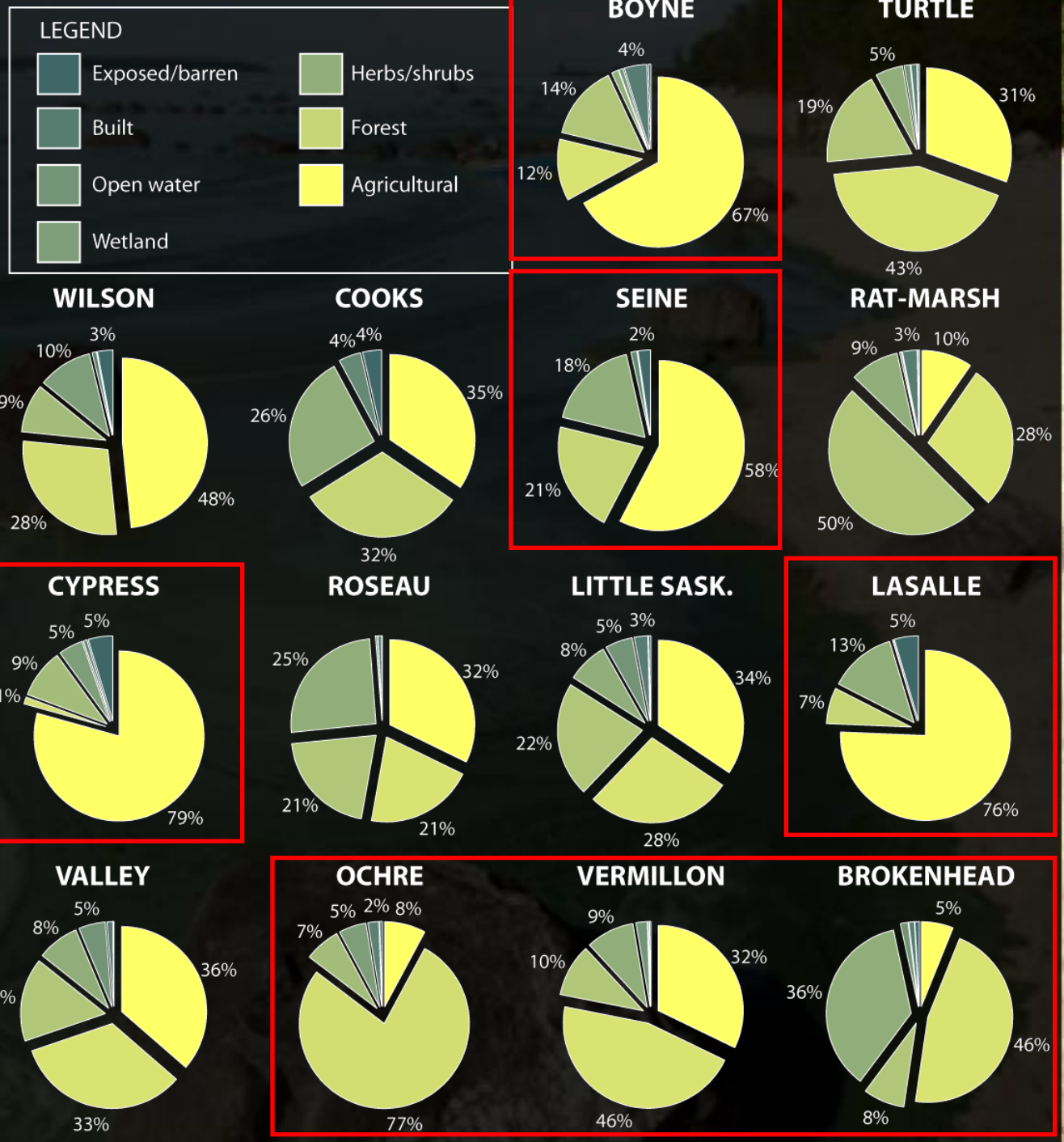
Study watersheds – Digital elevation model



Different topographic characteristics

Slope, flow path length, time of concentration, etc.

Study watersheds – Land cover and land use



Methods

1. Watershed characterization according to export dynamics

Two metrics of chemostatic behaviour

- CV(Concentration) / CV(Discharge)
  - Chemostat gives value of 0
- R^2 of the linear relationship between Discharge and Load
  - Chemostat gives value of 1

Data

- Co-located discharge values and total phosphorus (TP) concentrations
- Measurement frequency: at least 3 times a year
- Number of data points for each watershed: between 57 and 163

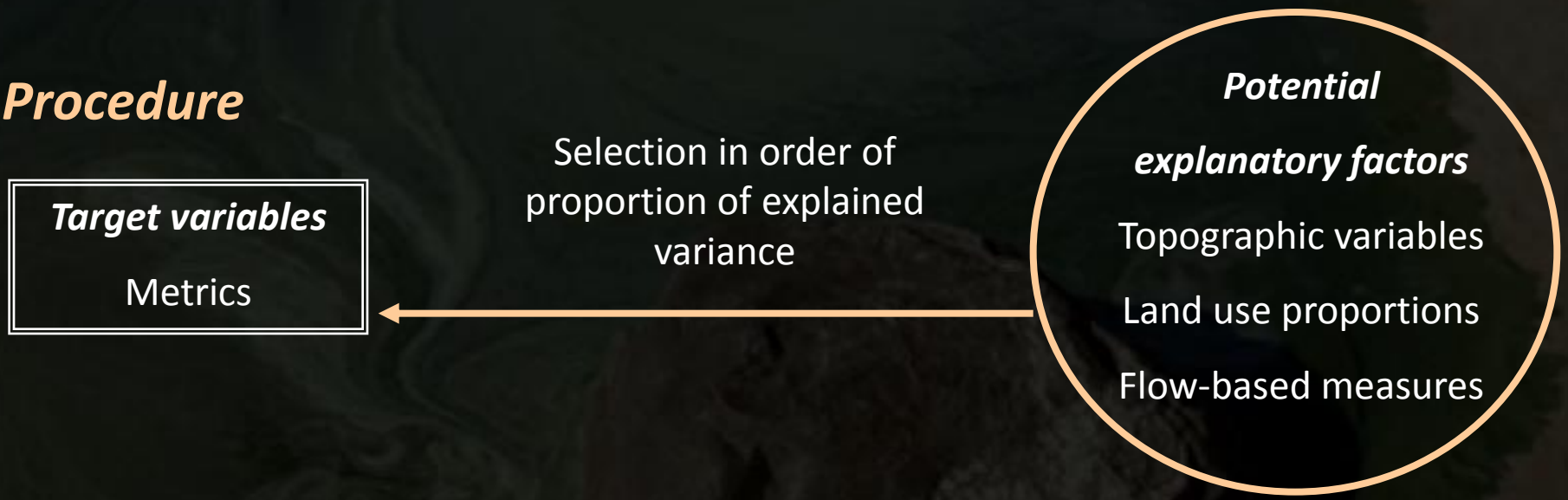
Methods

2. Control factors on watershed export dynamics

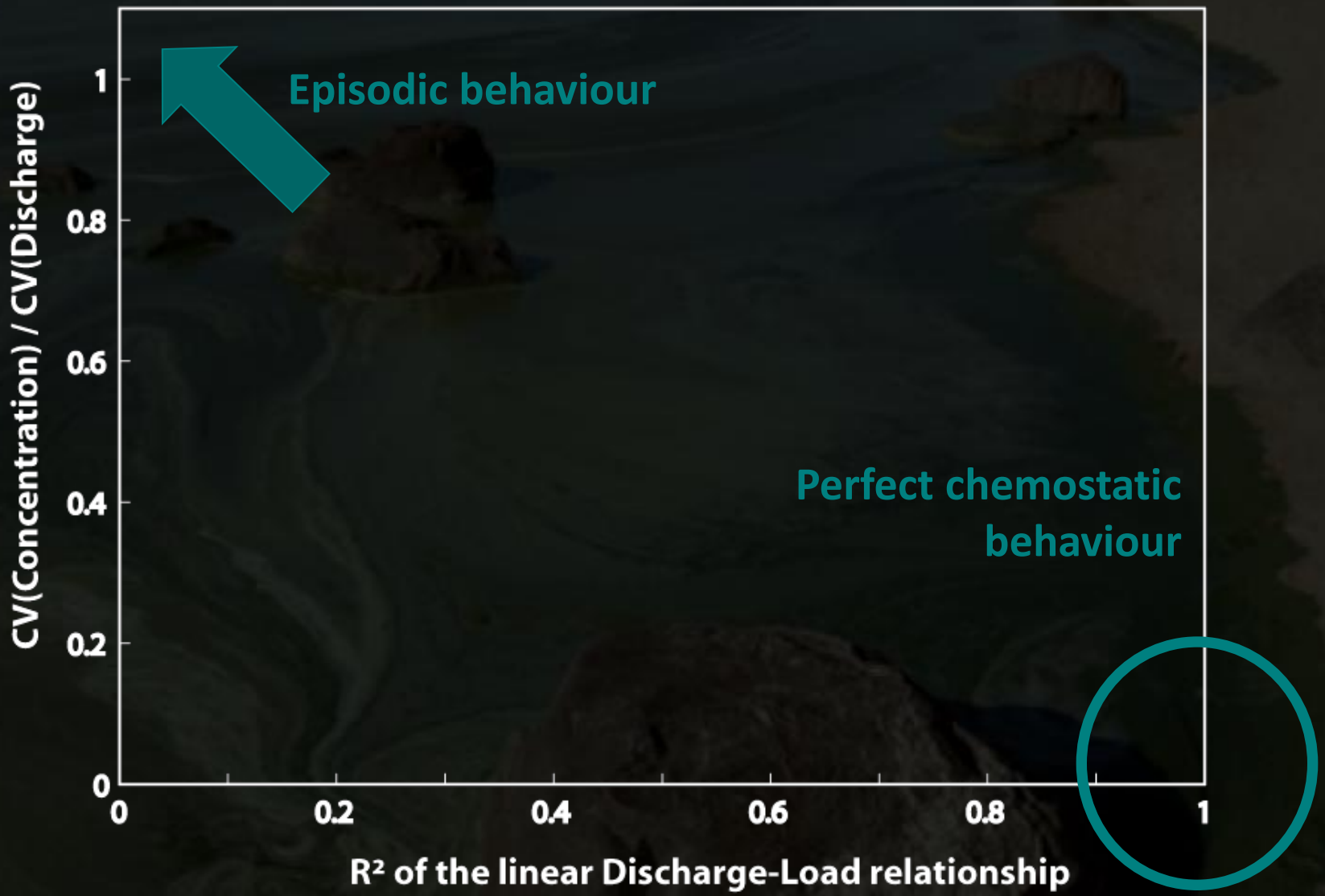
Forward selection multivariate model

- Target variables: Metrics of chemostatic behaviour
- Potential explanatory factors: flow-based and physiographic watershed characteristics

Procedure



Results – Export dynamics patterns



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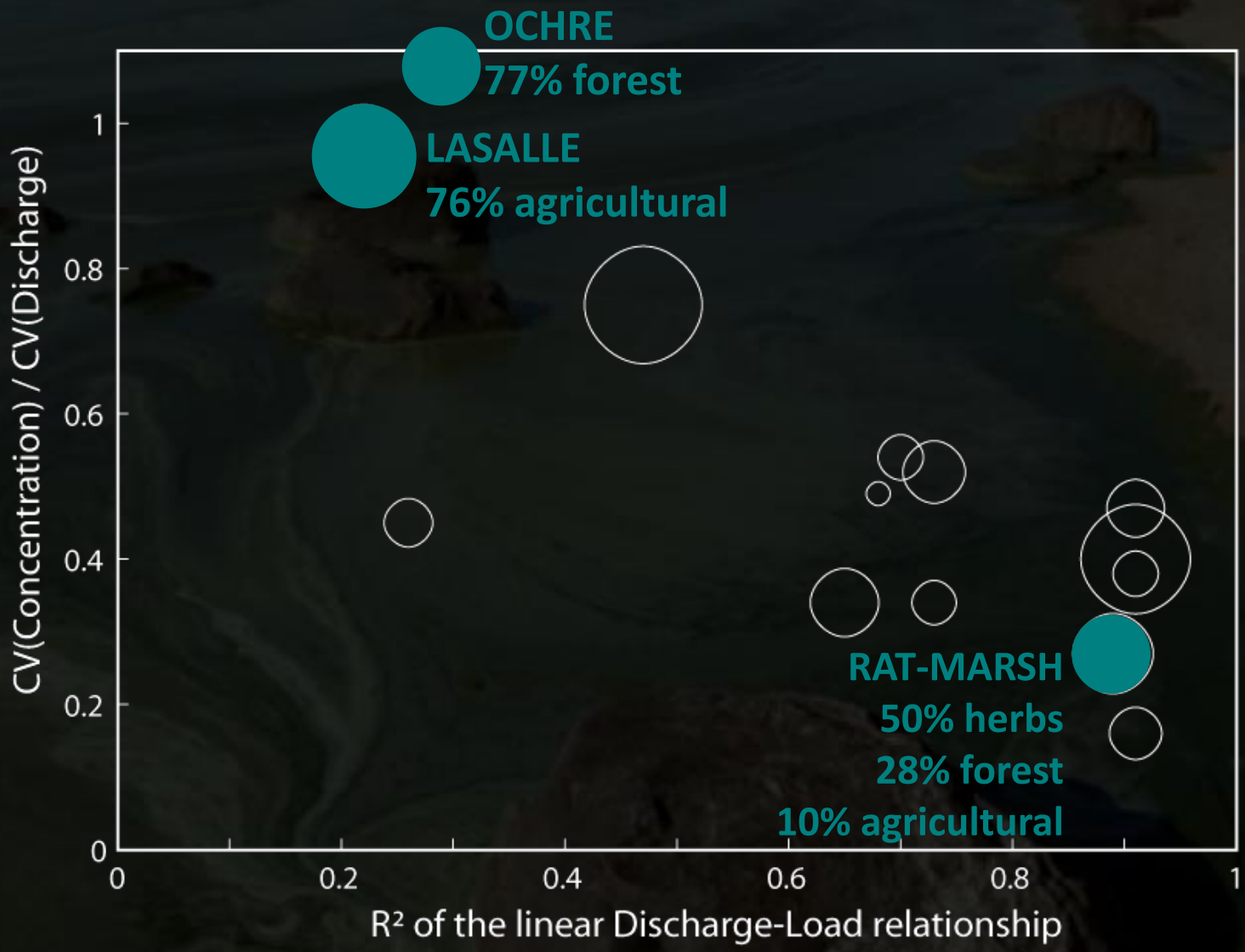

Circle size proportional to annual TP load

Results – Controls on watershed behaviour

Selection order	Watershed characteristics	R^2	Cum. R^2	Adj. R^2
1	Propo…over	0.22	0.22	0.15
2	Pr…land	0.21	0.42	0.32
3	…th	0.08	0.50	0.35
4		0.11	0.61	0.44
5		0.08	0.69	0.50
6	…th	0.07	0.76	0.55
7	Sp…s	0.08	0.84	0.66
8	…	…	…	…

Land use

Hydrologic transport factors

Flow regime

Conclusions and next steps

Across 14 Manitoba streams:

- Different degrees of chemostatic (transport-limited) or episodic (source-limited) behaviour for phosphorus export
- Episodic behaviour is not solely associated with pristine/non agricultural watersheds
- Differences in watershed export behaviour cannot be perceived from the sole analysis of annual TP loads

Generalization across the whole of Lake Winnipeg Basin?

- Consider a larger number of watersheds
- Focus on other contaminants (e.g. nitrogen, pesticides)
- Test the results sensitivity to the temporal resolution of the measurements/sampling

Acknowledgements

- Rick Rickwood

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PFRA

Manitoba Water Stewardship

GeoBase
Building on common ground

USGS
science for a changing world

Agriculture and Agri-Food Canada

Water Survey
Relevés hydrologiques