

Unraveling Sediment Dynamics within Watersheds from Patterns in Suspended Sediment-Discharge Relationships



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Signs of stress in our watersheds

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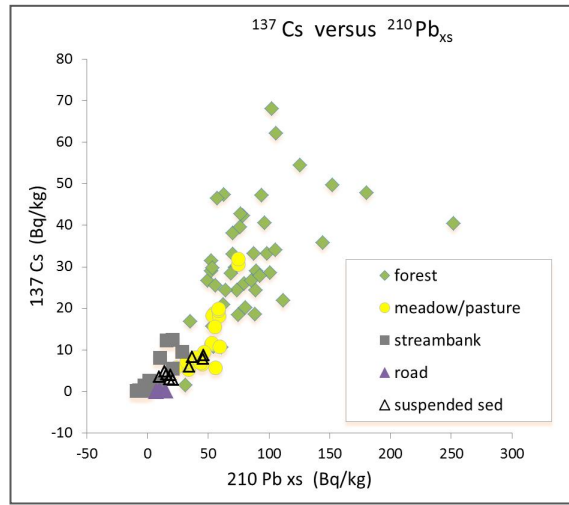
- Fluvial erosion and transport of sediments from:
 - ▣ Streambank erosion
 - ▣ Road Ditches
 - ▣ Agricultural Fields
 - ▣ Stores of in-channel sediments



How do we determine from where riverine sediments originate?

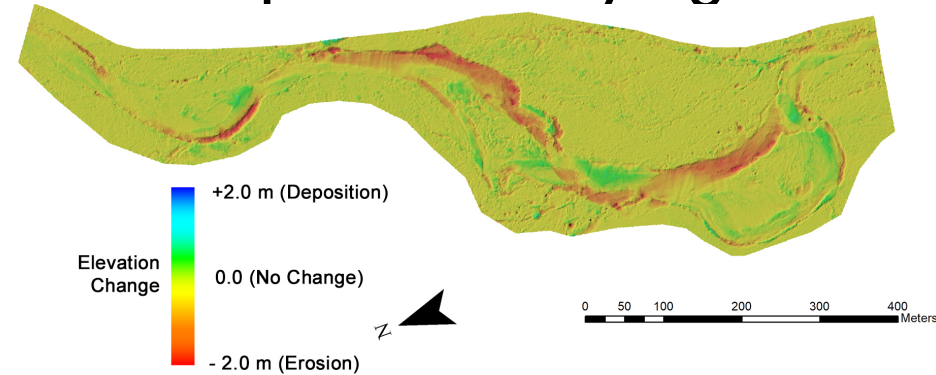
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□ Sediment Tracers

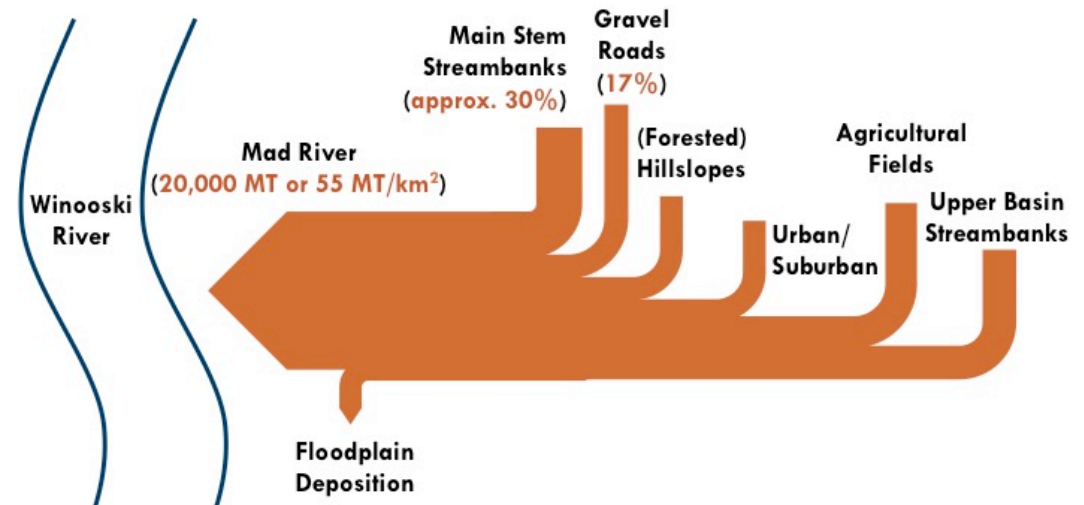


Kristen Underwood

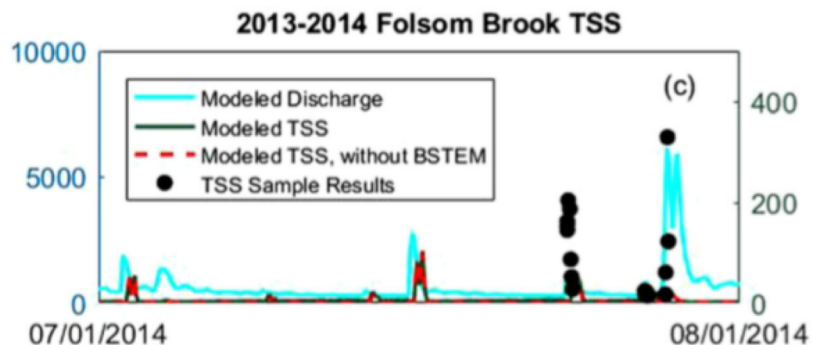
□ Repeat Surveying



□ Sediment Budget

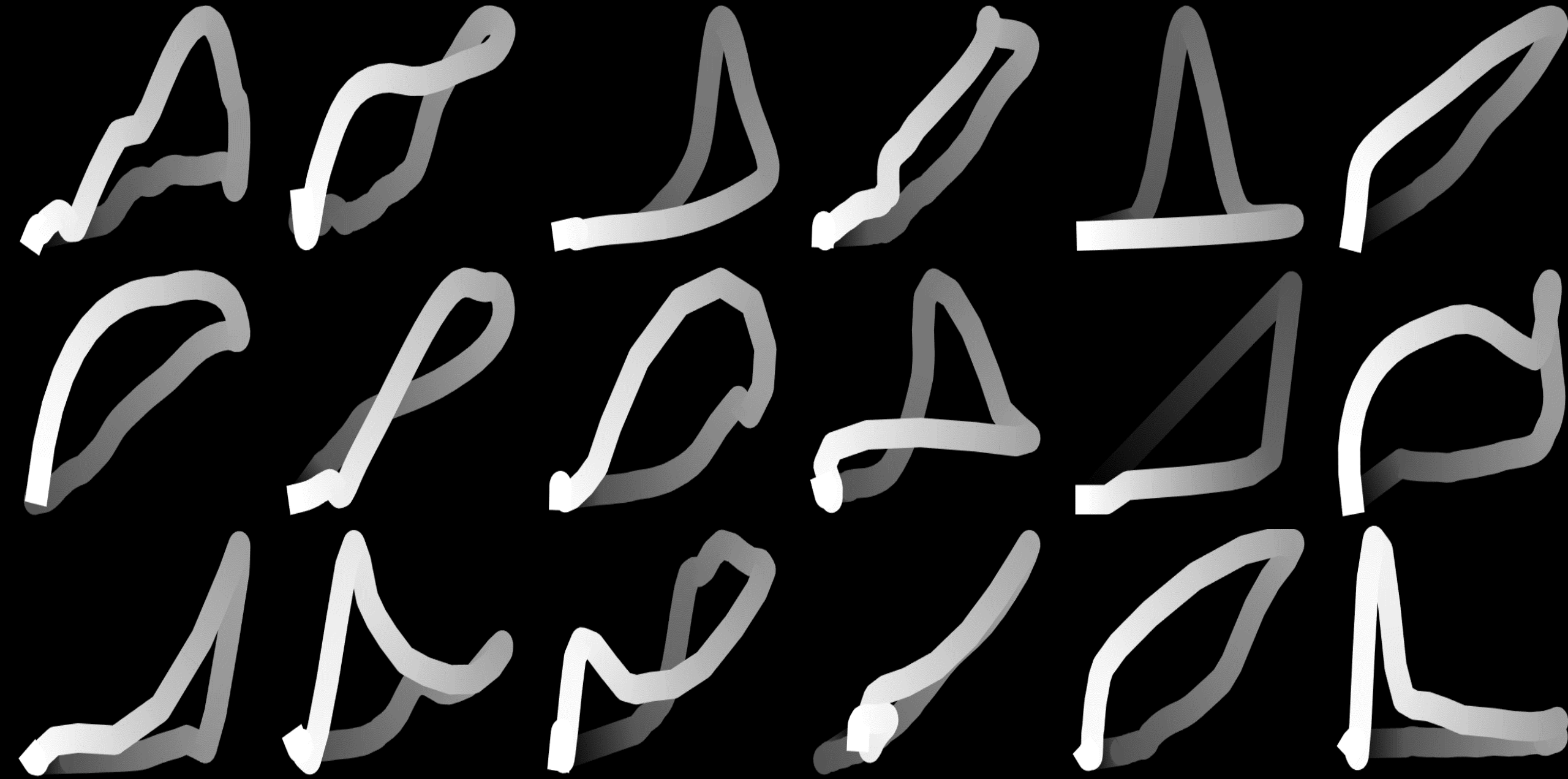


□ Watershed Modeling



Stryker et al. 2017

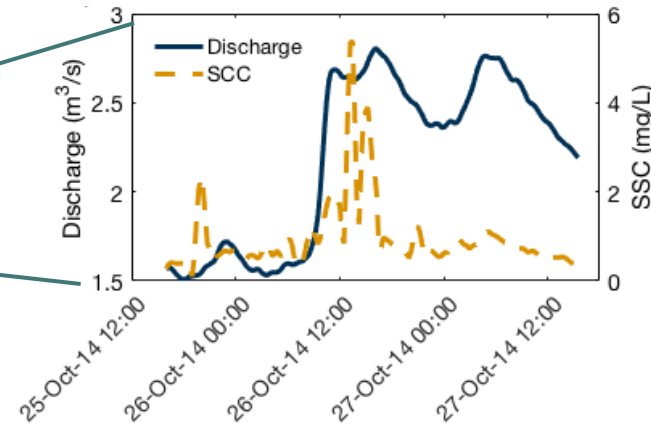
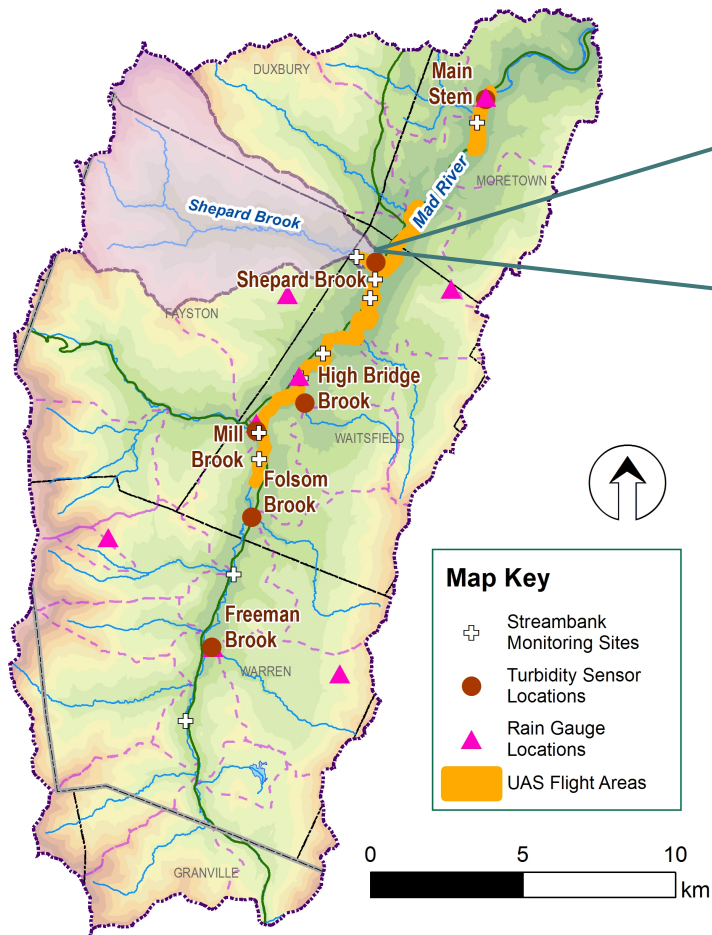
What if we let the watershed tell us what is going on?



What if we let the watershed tell us what is going on?

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- What if we could monitor only the outlet of the watershed and be able to infer sediment dynamics within the watershed?

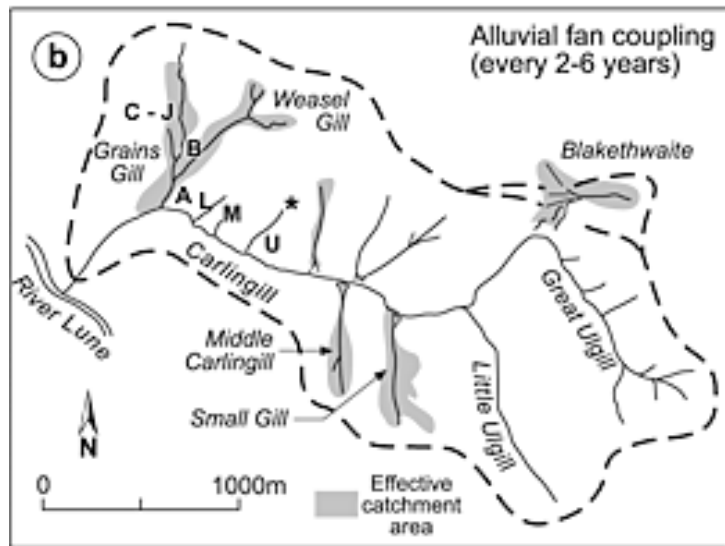


ISCO Autosampler
and Datalogger

DTS-12 In-situ
Turbidity Sensor



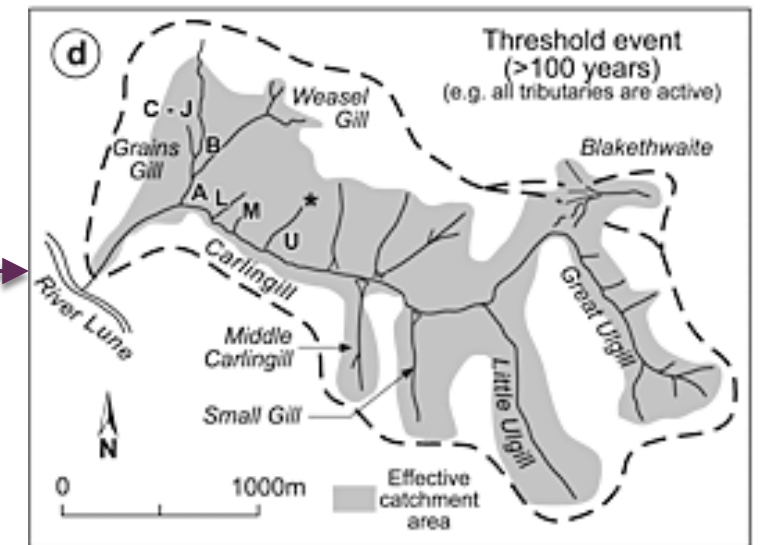
Sediment Connectivity and Sources in Watersheds



Fryirs, 2013 ESPL

VARIABLE

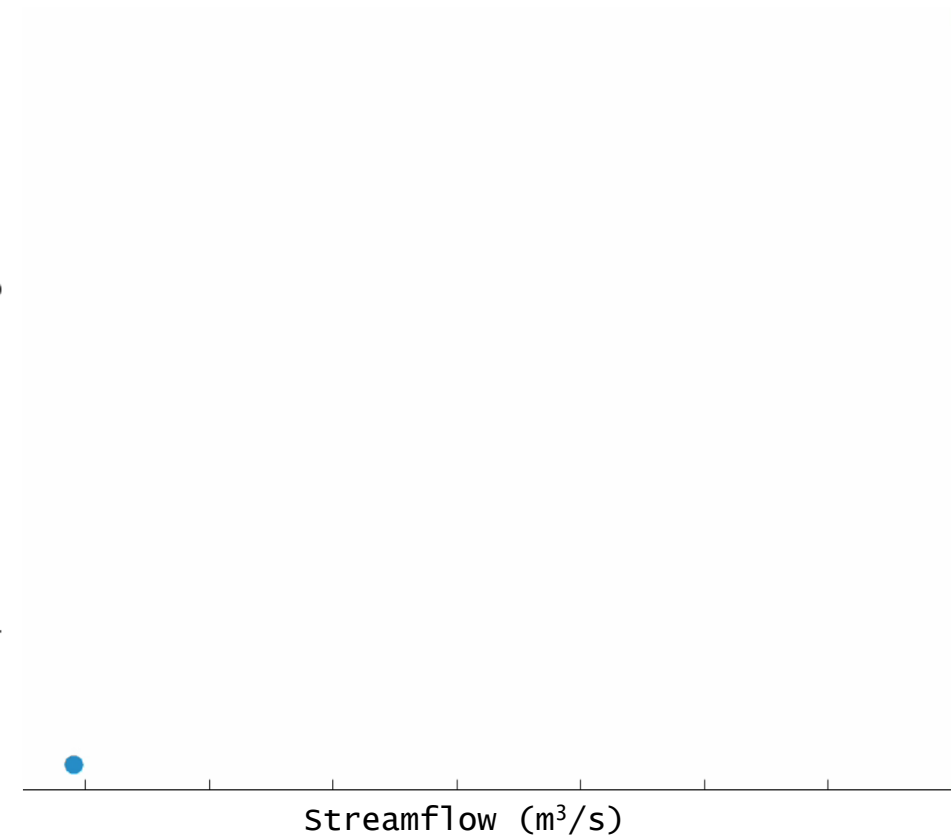
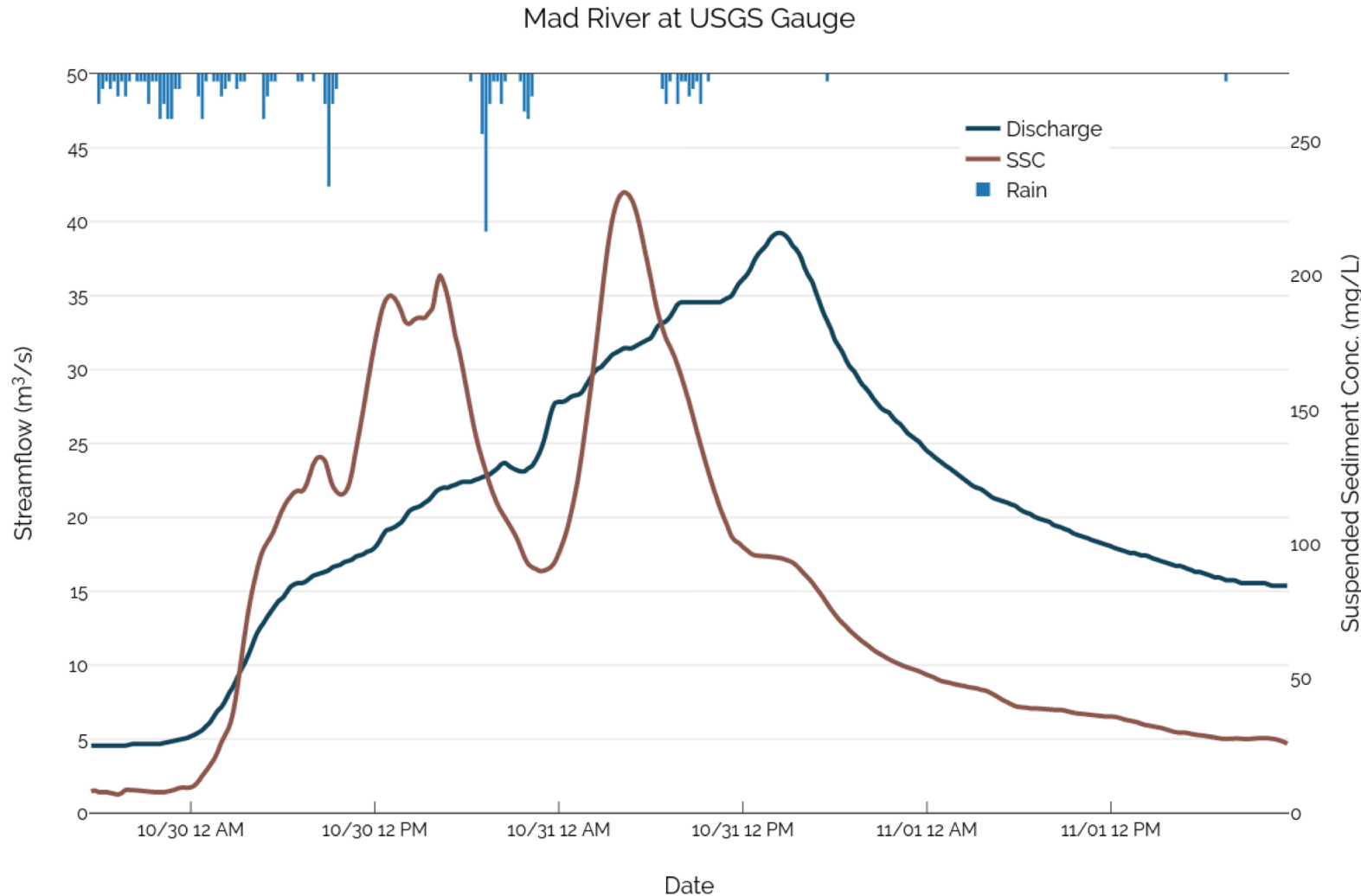
- Sediment Source Areas
 - Location
 - Supply
 - Connectivity
- Susp. Sediment Yield
- SS – Q Relationships



Fryirs, 2013 ESPL

A close look at hydrological events

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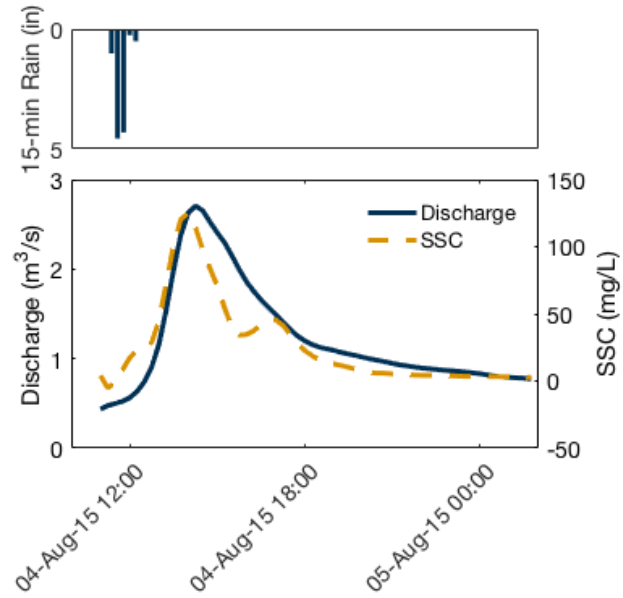


An Example: Two storm events to illustrate event sediment dynamics

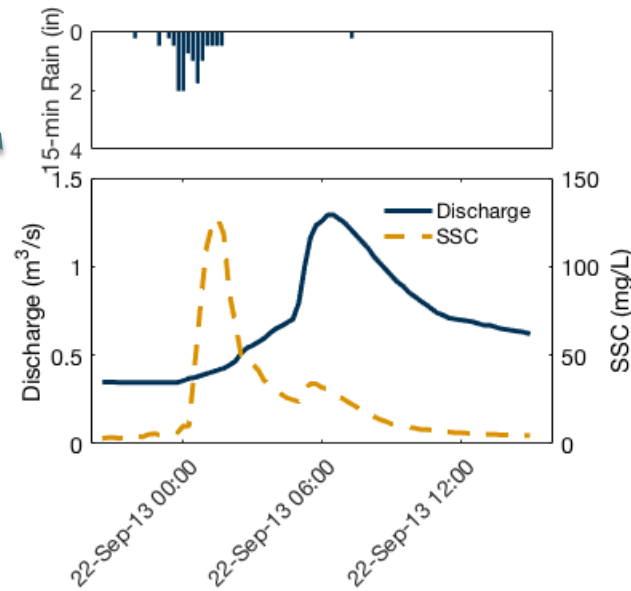
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□ Shepard Brook

■ Aug 4, 2015



■ Sep 22, 2013

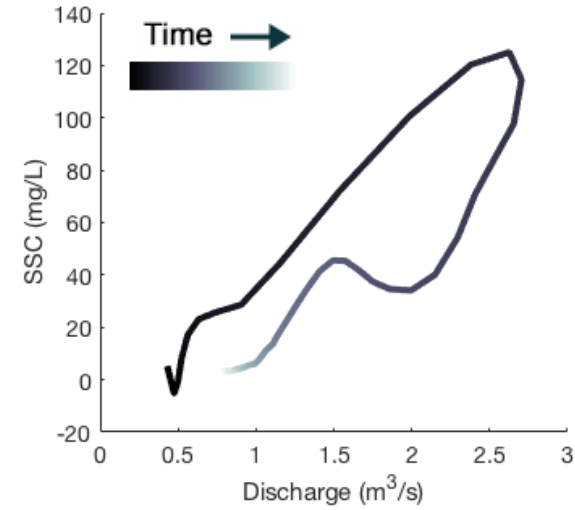
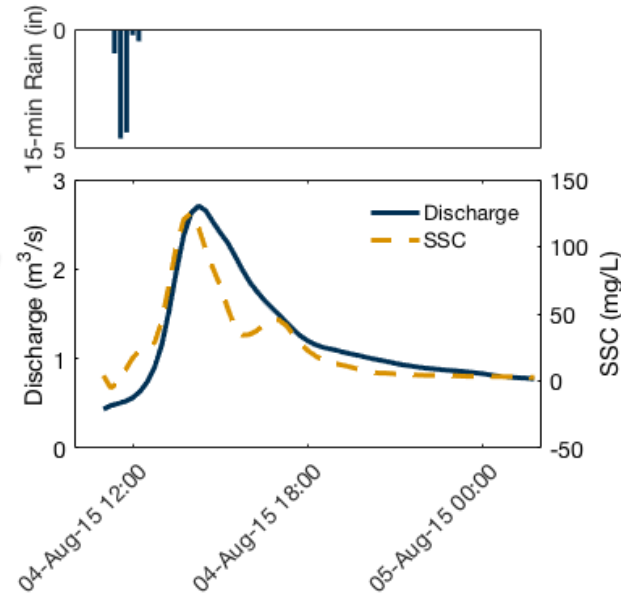


An Example: Two storm events to illustrate event sediment dynamics

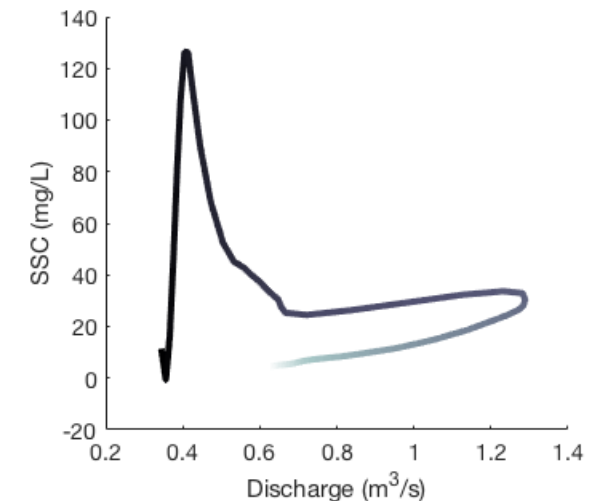
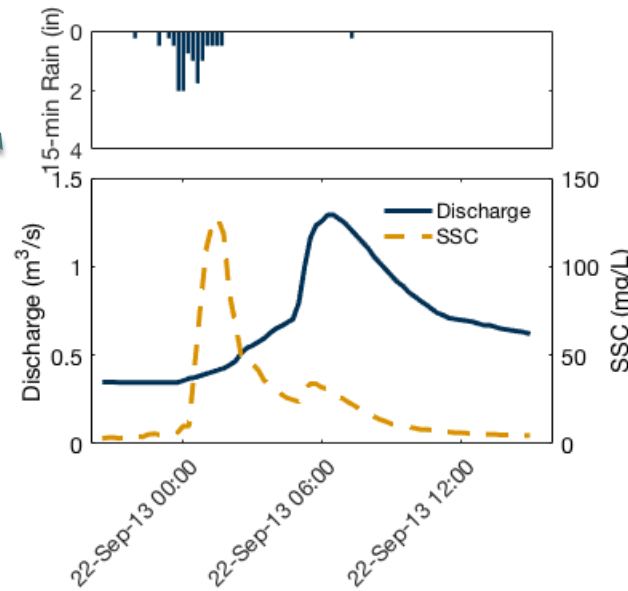
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□ Shepard Brook

■ Aug 4, 2015

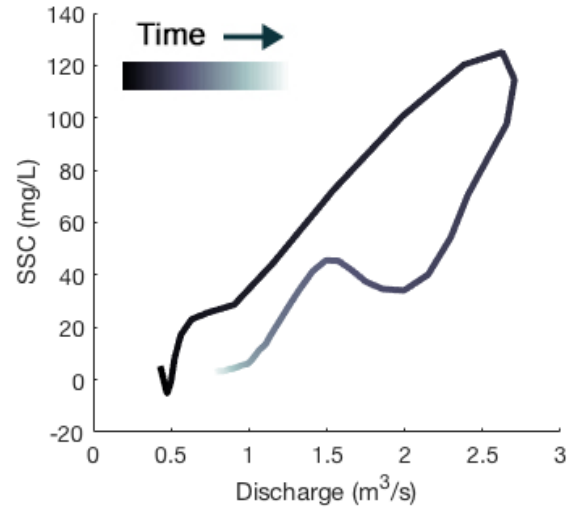
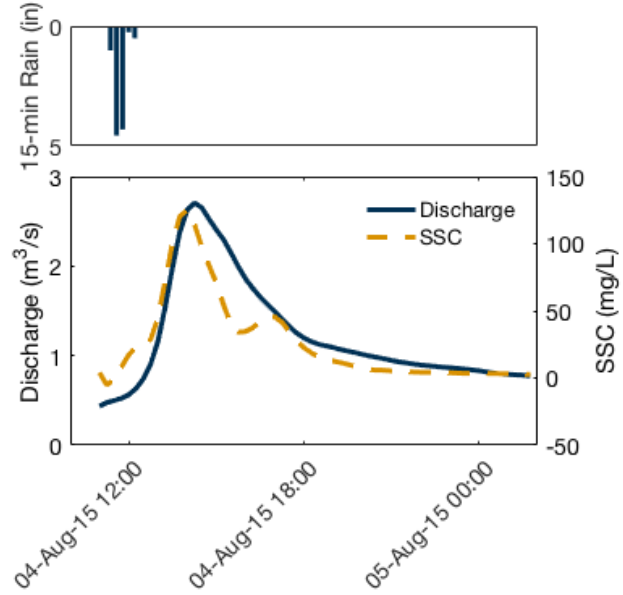


■ Sep 22, 2013

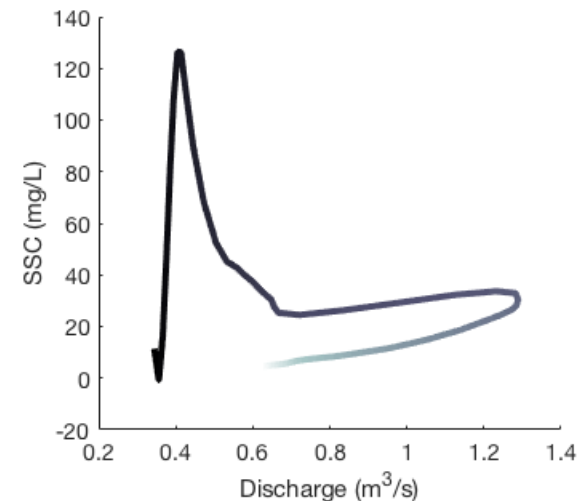
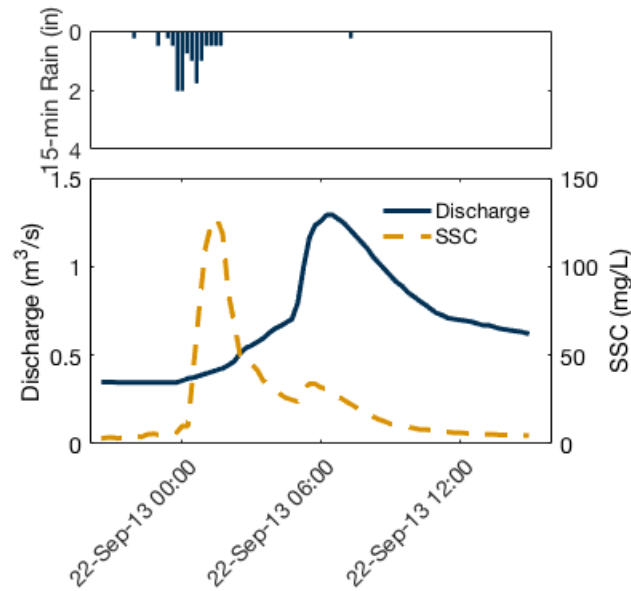


An Example: Two storm events to illustrate event sediment dynamics

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- Streamflow activated (channel network) sediment sources important



- Connected, rainfall activated, nearby sediment sources important

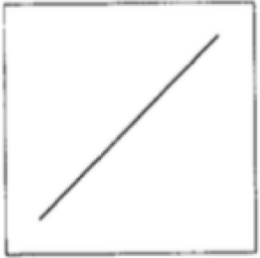
What are hysteresis patterns?

Two methods of categorizing hysteresis

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□ Visual Patterns

Class I - Linear



Class II - Clockwise

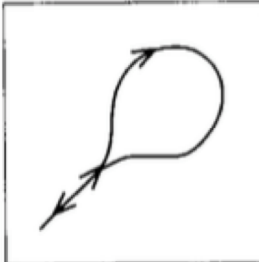


Garnett
Williams,
USGS,
1989

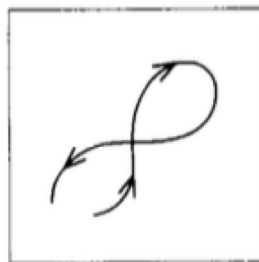
Class III -
Counterclockwise



Class IV - Linear
then Clockwise

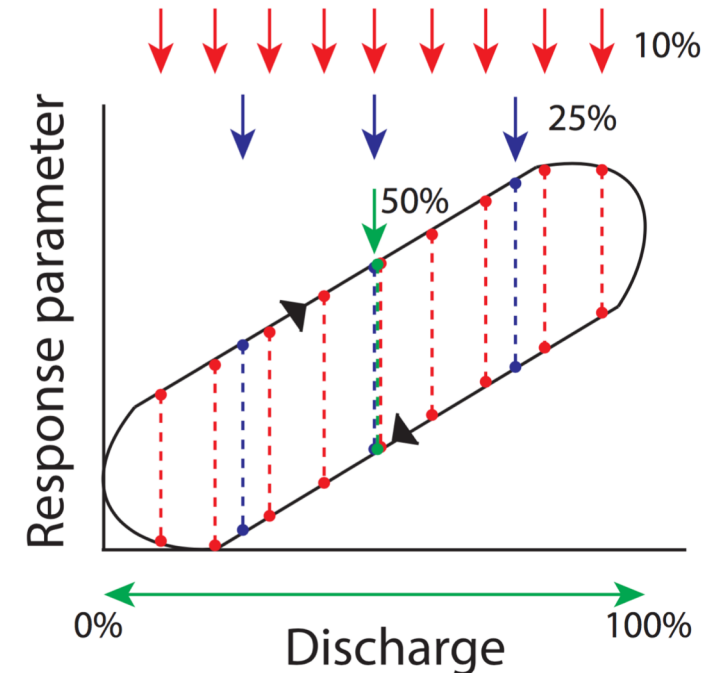


Class V -
Figure-Eight



□ Metrics (e.g. Hysteresis Index)

$$HI = T_{RL} - T_{FL}$$

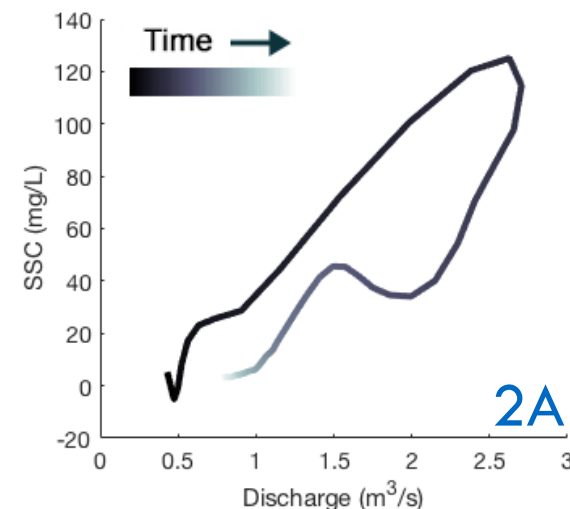
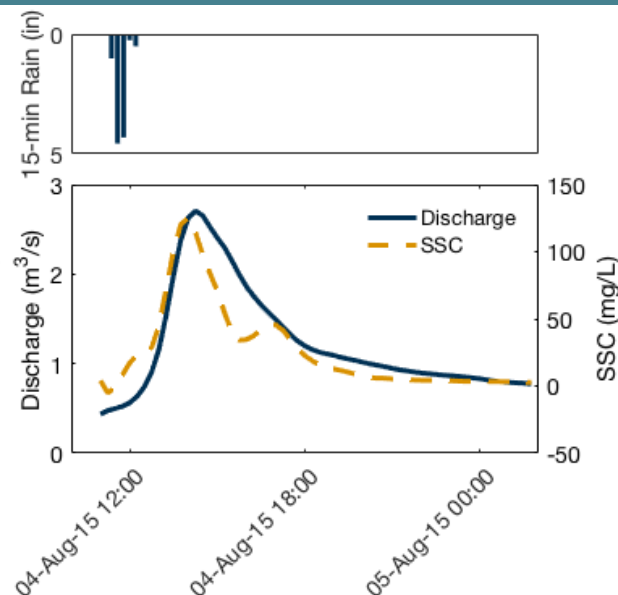


Lloyd et al. 2015

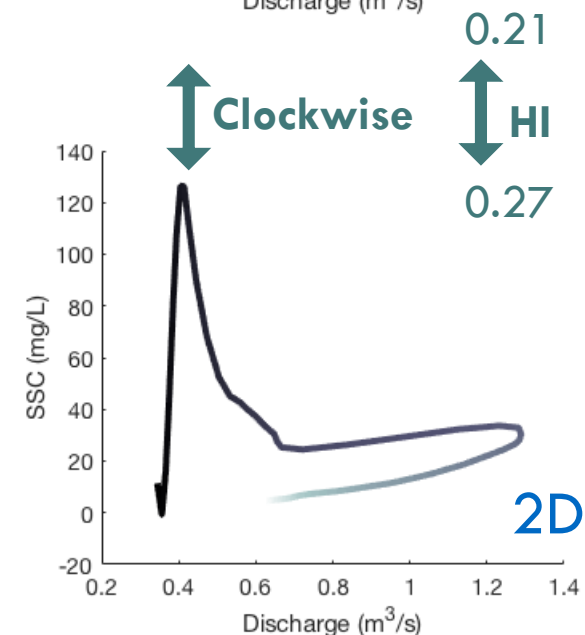
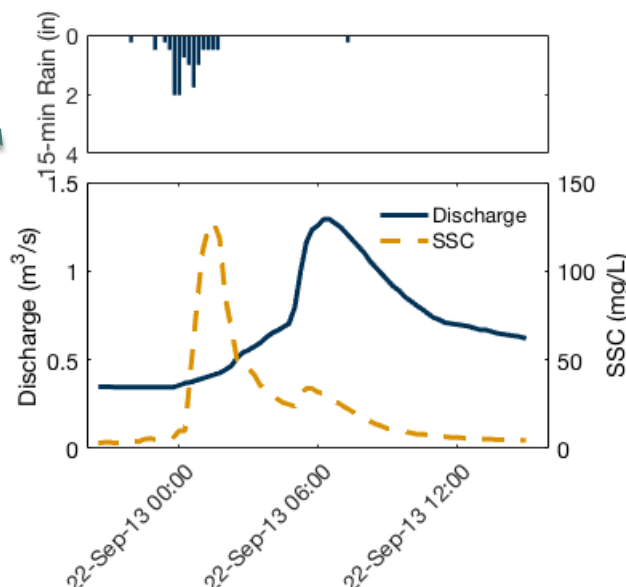
An Example: Looking back at the two storm events

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- 2 storm events
Shepard Brook
- Aug 4, 2015



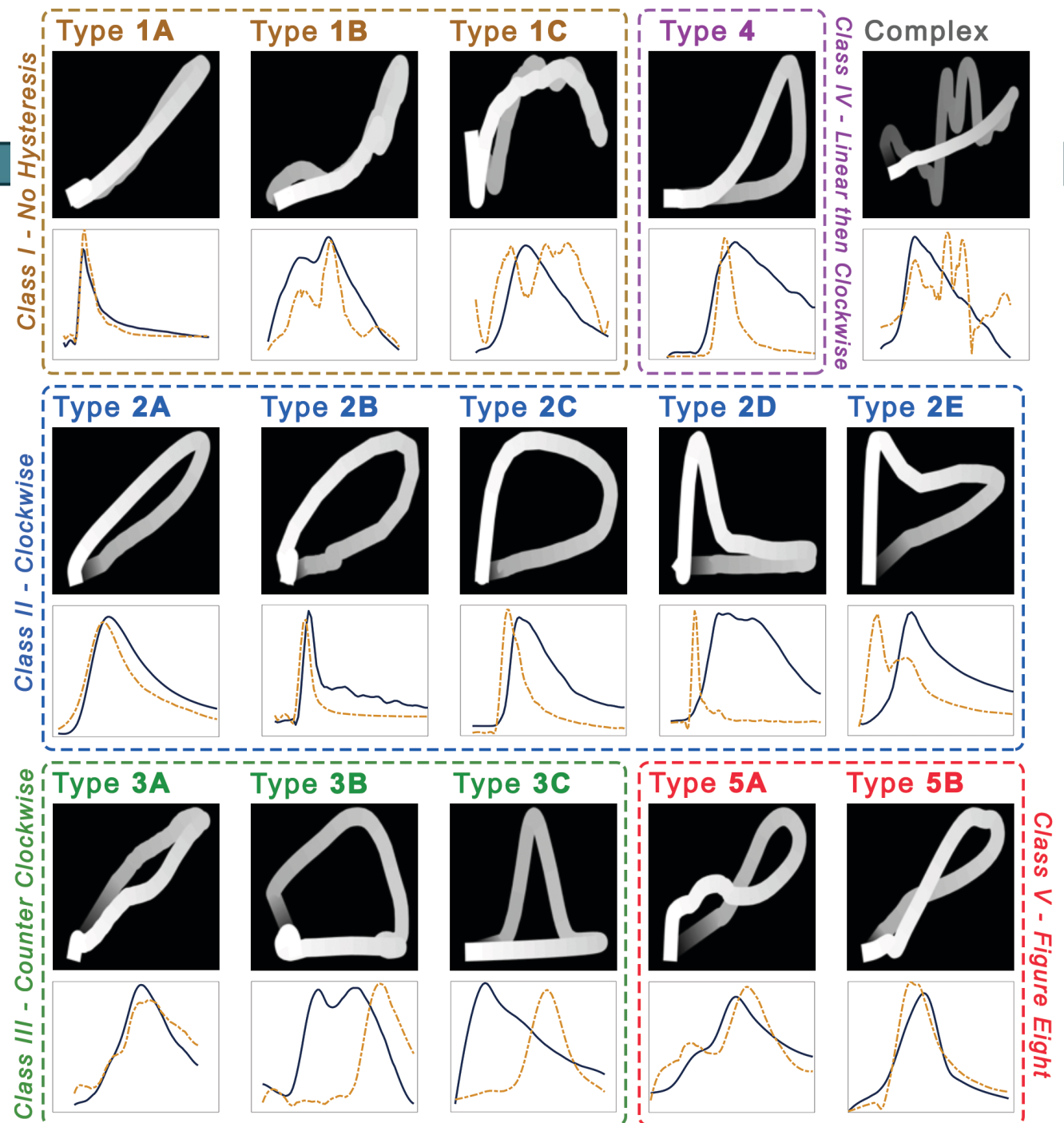
- Sep 22, 2013



Patterns of Hysteresis

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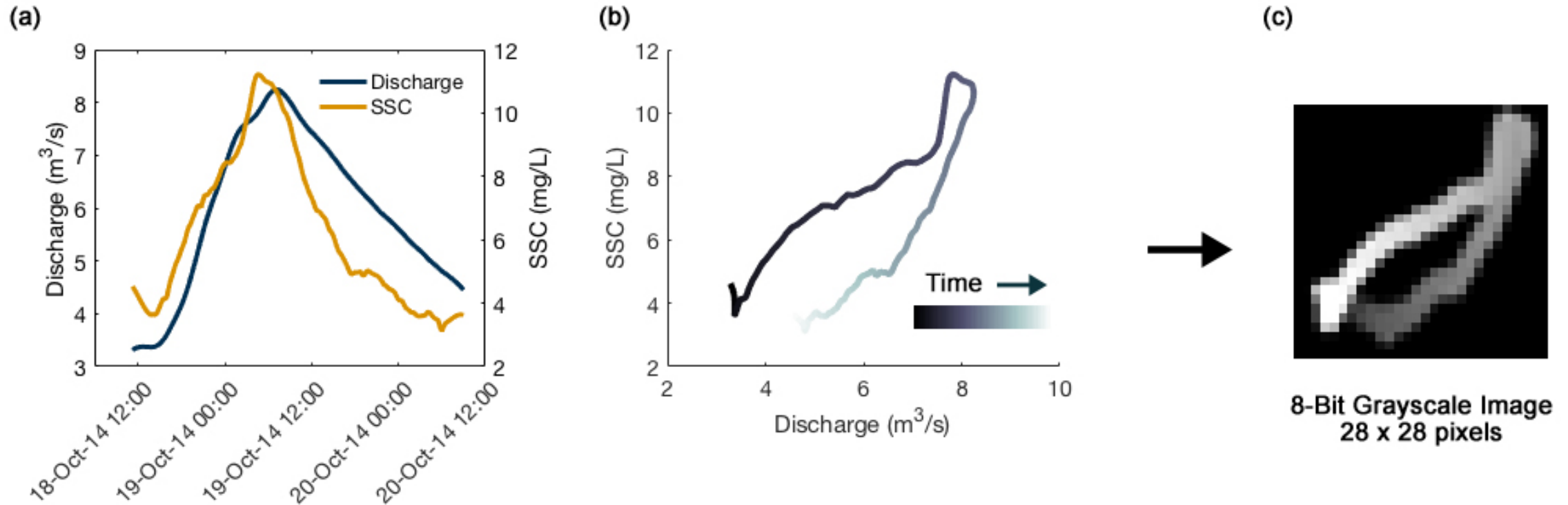
- 14 Types recognized in data from Mad River watershed
- How to automate?



An automated classification system

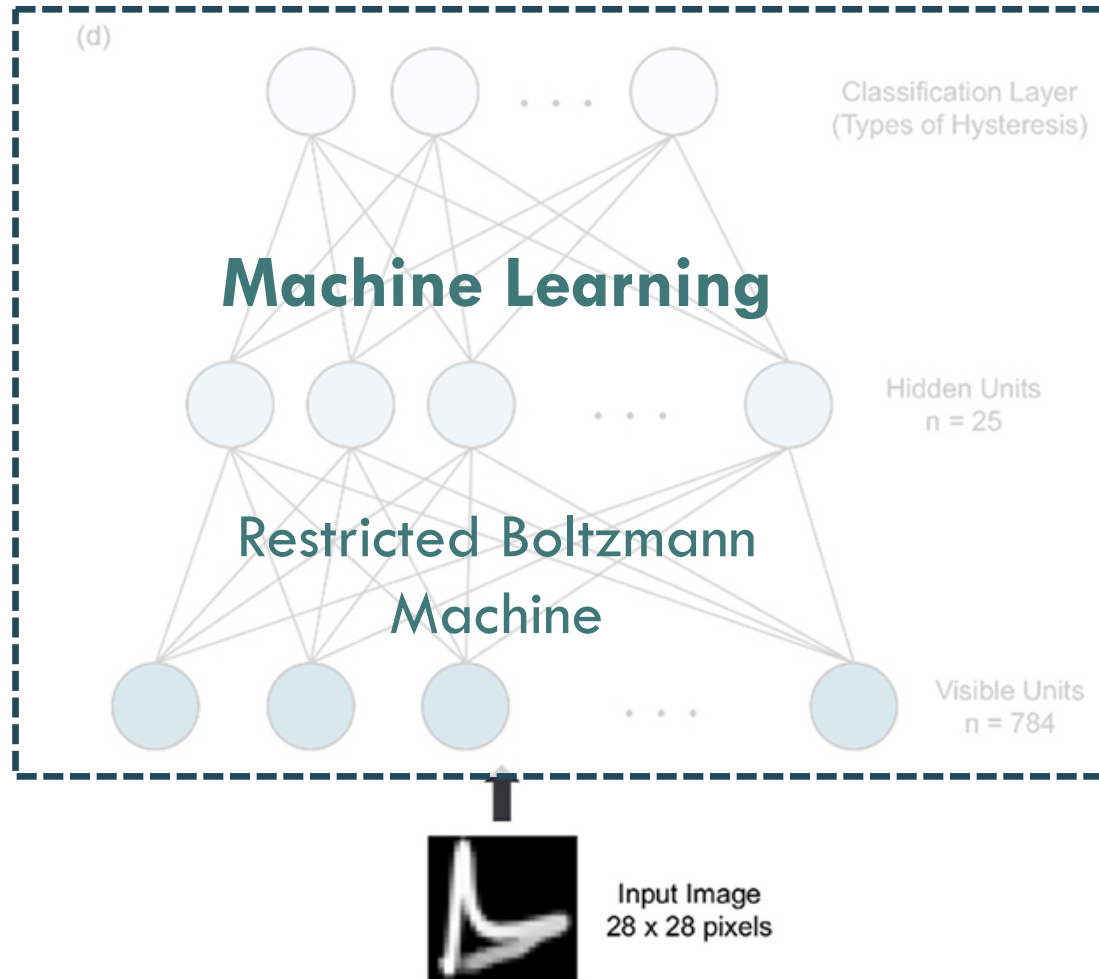
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□ Pattern recognition challenge



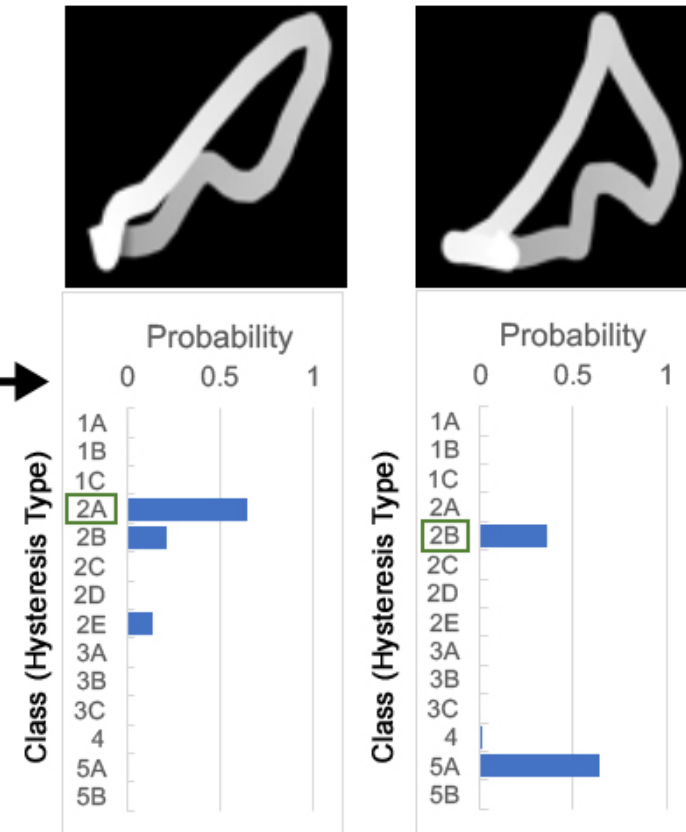
Example of classification of storm events

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(e)

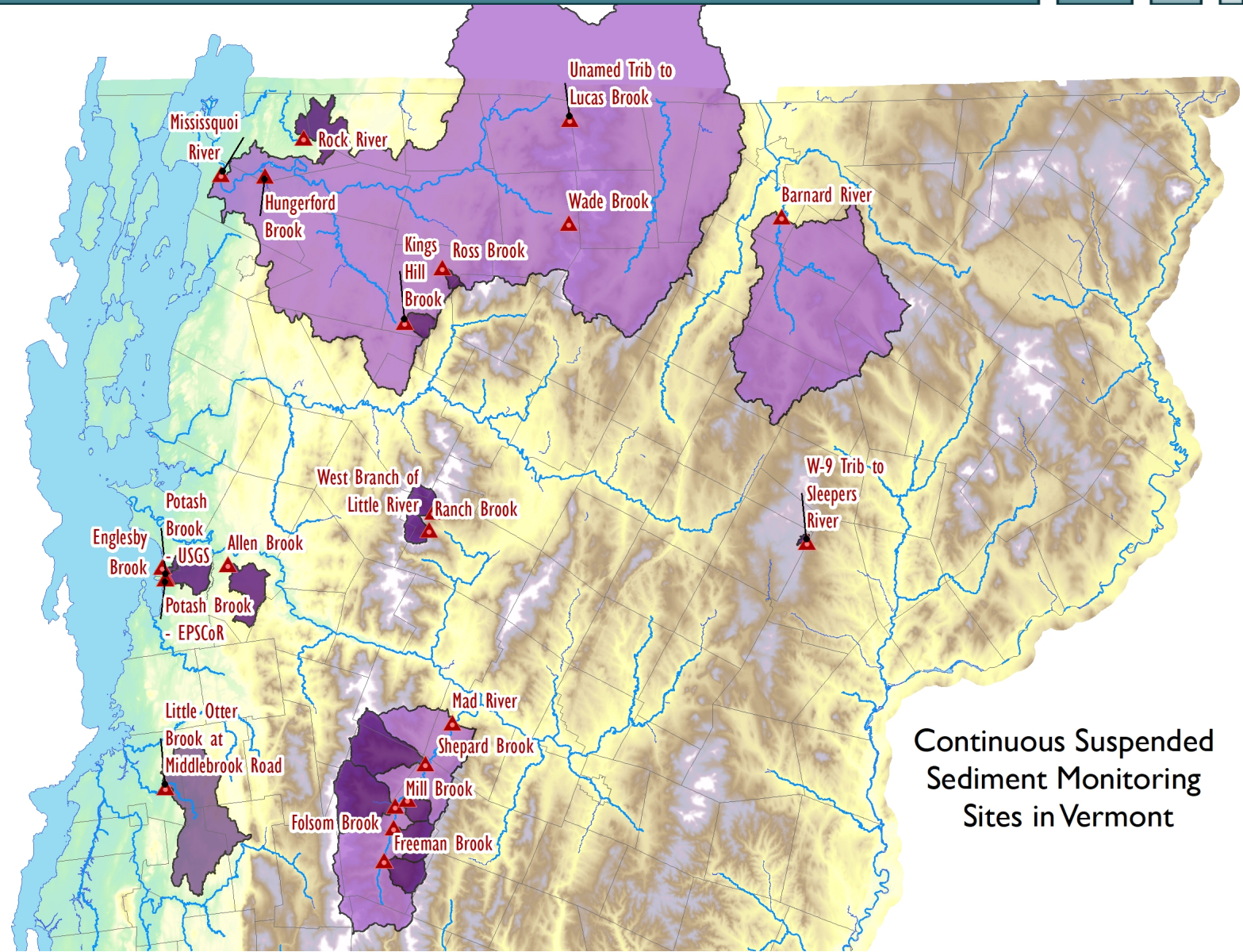
Example Event Classifications



Expand research out into new watersheds

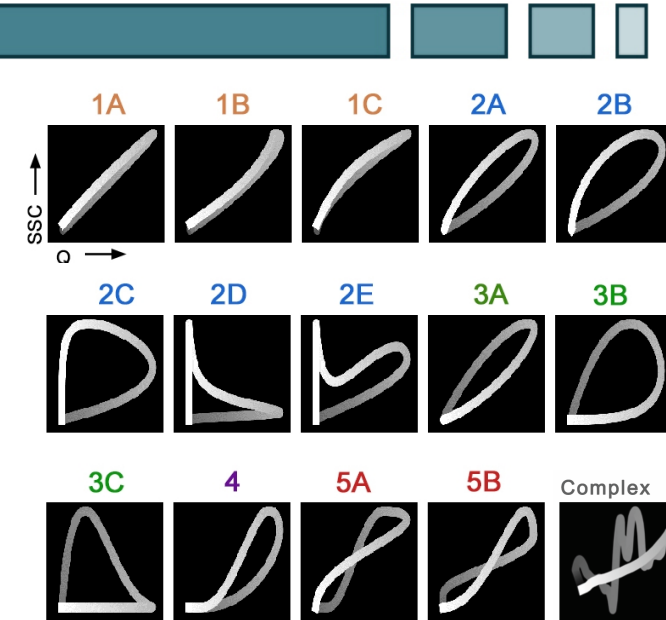
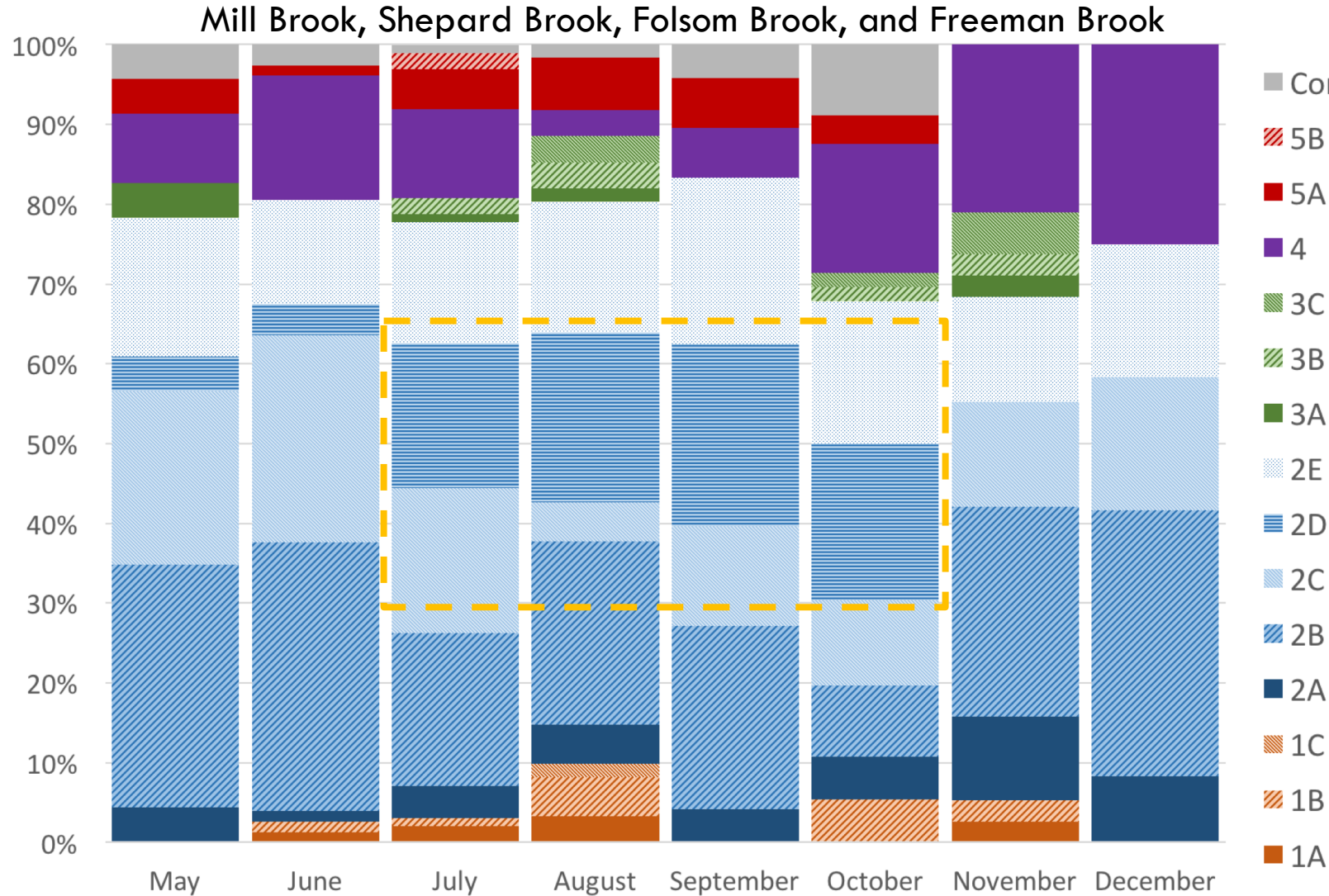
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- Range of:
 - ▣ Land Use/Cover
 - ▣ Geology
 - ▣ Soils
 - ▣ Drainage Area
 - ▣ Topography



Seasonal trends in hysteresis types

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Also identified trends in hysteresis patterns by:

- Site
- Drainage Area Size
- Sediment Load

In summary

- Pattern = f (source proximity, connectivity, ... , supply)
↓
- Hysteresis analysis can guide identification of sediment sources
- High-frequency SS data
↓
- New types of patterns
- Machine learning methods capable of automating classification



The research team

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PhD Advisor



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Beverley Wemple



Andrew Schroth



Arne Bombliès



Don Ross



Jody Stryker



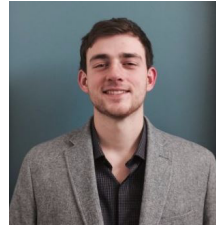
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Katie Change



Alex Morton



Sean Brennan



Jordan Duffy



Kira Kelley



Hanna Anderson



Nathalie Simoes



Wimara Sa Gomes

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- Robert & Patricia Switzer Foundation
- University of Vermont



RACC
Research on Adaptation
to Climate Change



BREE
Basin Resilience to
Extreme Events
in the Lake Champlain Basin



ROBERT & PATRICIA
SWITZER
FOUNDATION



Contact Info & Acknowledgements

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 - 802.324.6221

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- Beverley Wemple
- Andrew Schroth
- Kristen Underwood



The University of Vermont



RACC
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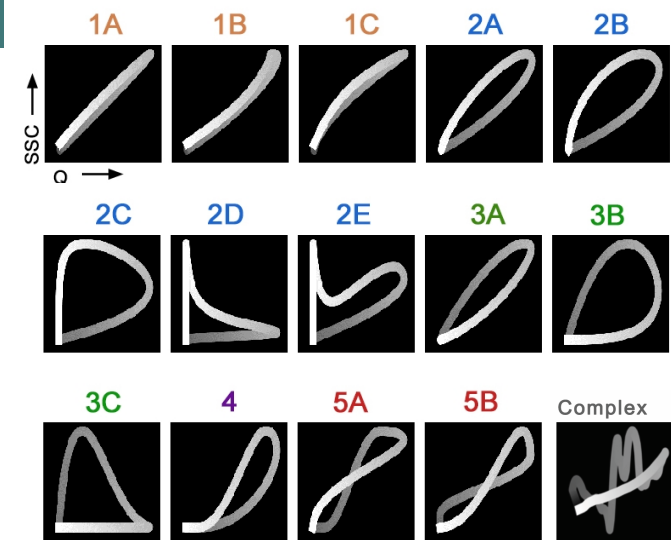
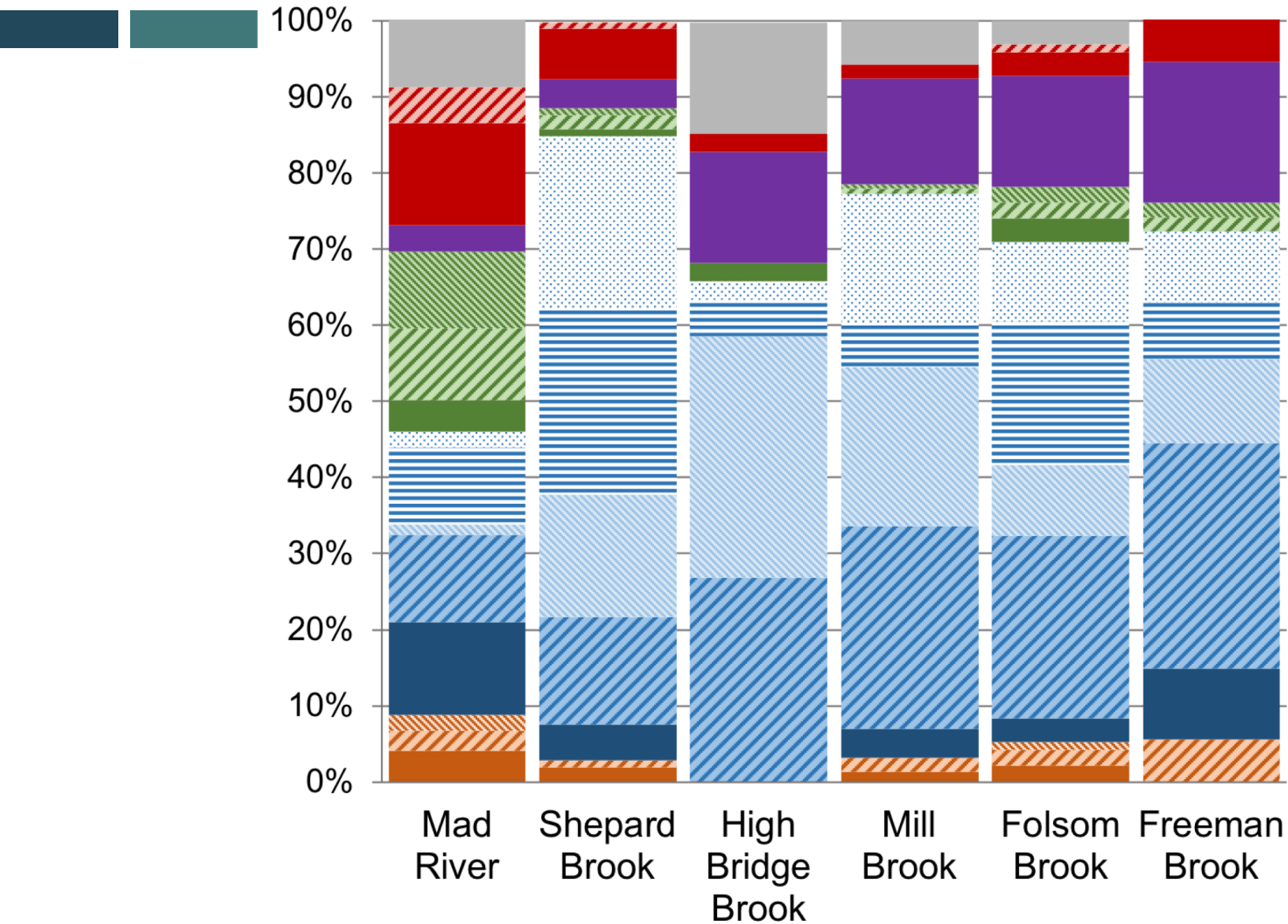


BREE
Basin Resilience to
Extreme Events
in the Lake Champlain Basin

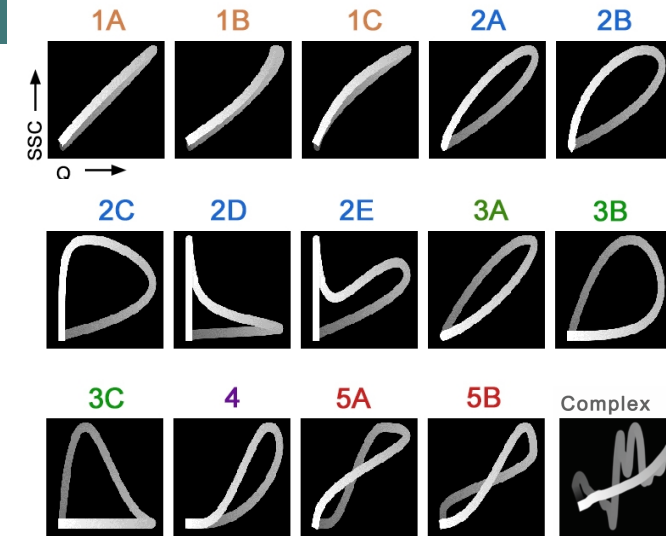
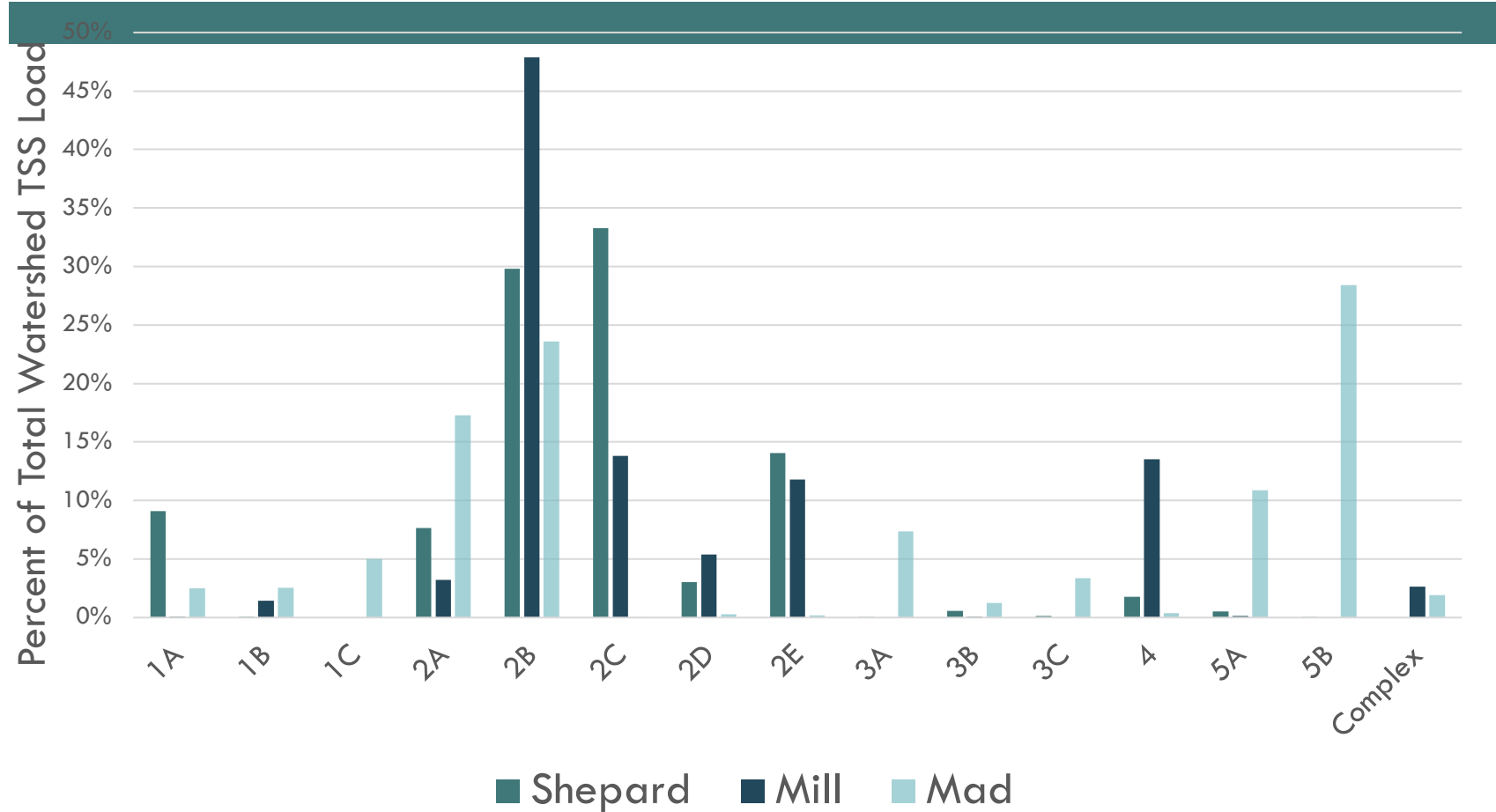
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Supplementary Information

Differences among watersheds



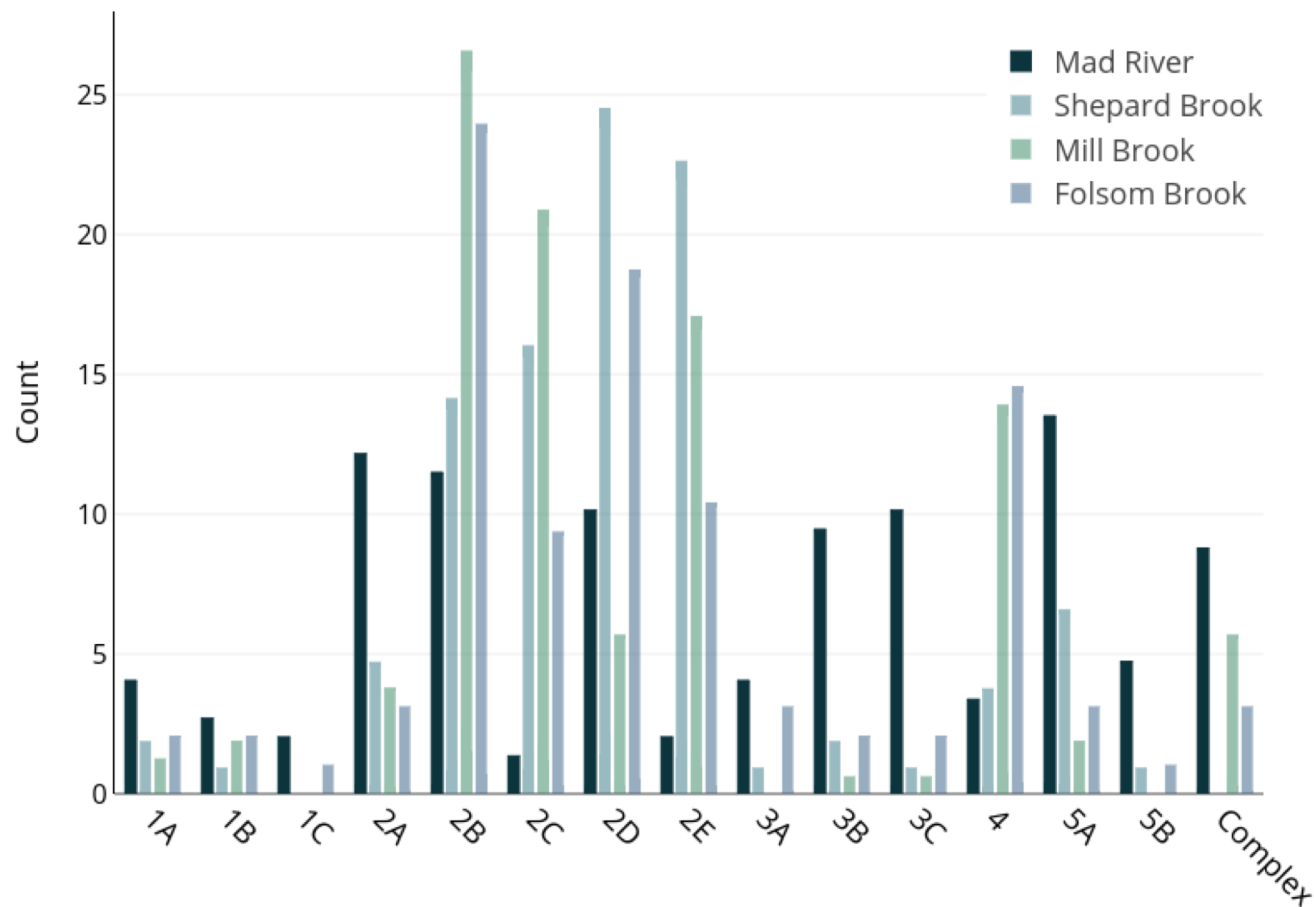
Sediment load by hysteresis type



Effects of spatial scale on hysteresis type

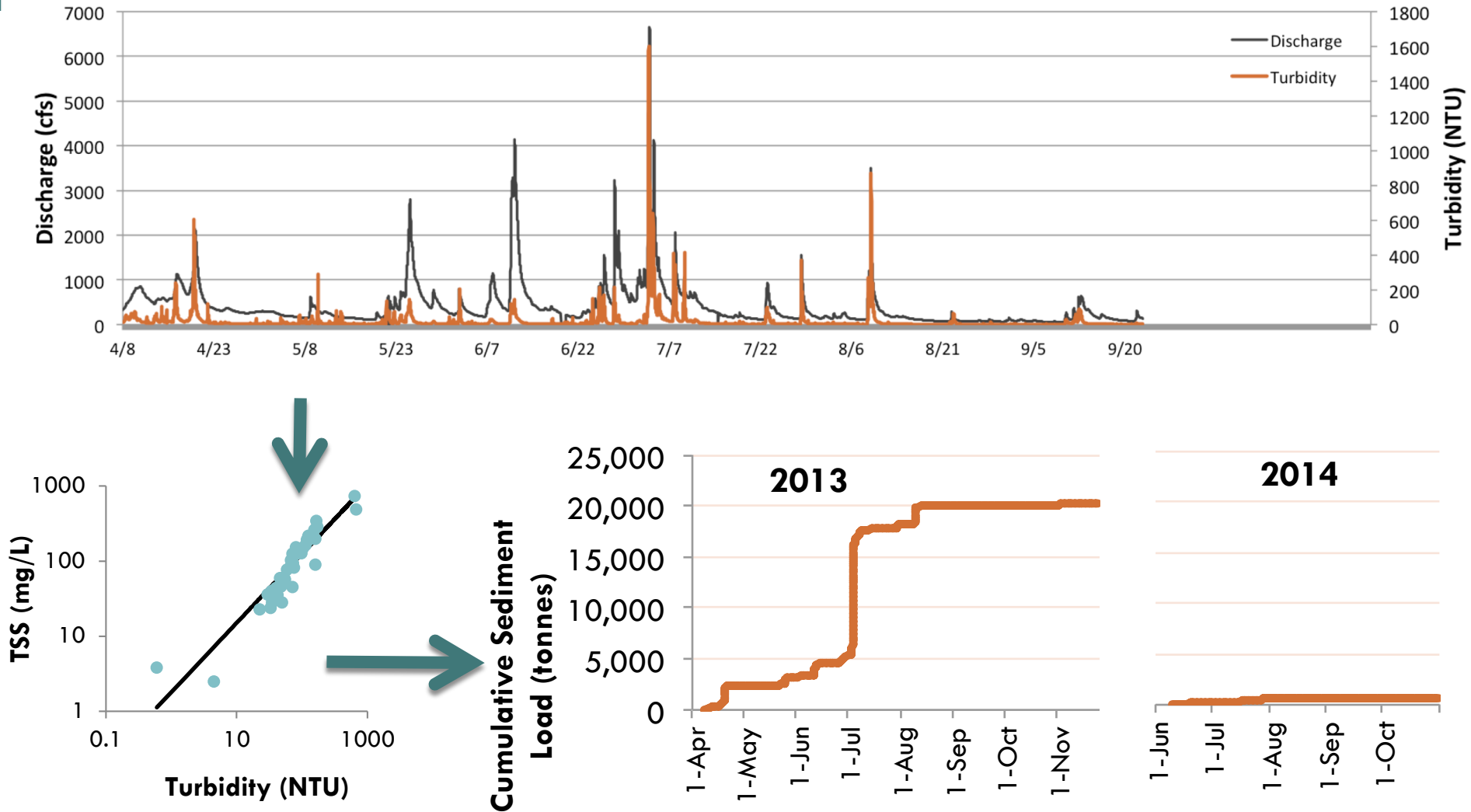
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- Clockwise types (Class II) most common in tributaries
- Mad River more varied in hysteresis types observed



Sediment Load Estimation

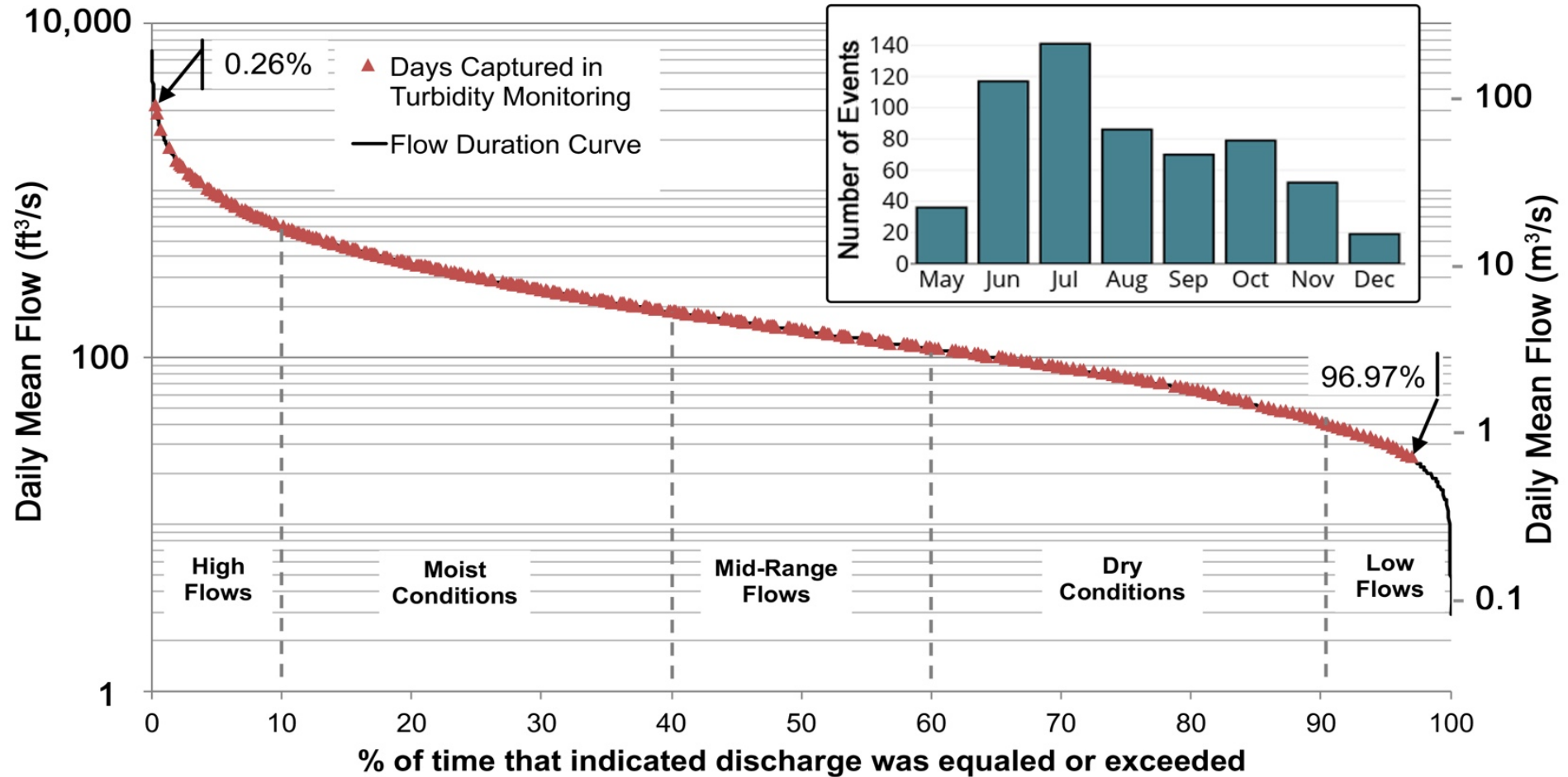
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Hydrology of monitoring period

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600+ events identified



Hydrological event analysis

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Storm
Metrics

SHP 36

Storm Number: 2.14062422

Storm Date: 24-Jun-2014 22:45:00

Rainfall Station: **Fayston Weather (JFR)**

Total Rainfall (mm): **41.40**

Time Since Last Event (hr): **157.75**

Rainfall-Runoff Ratio: **7.35 %**

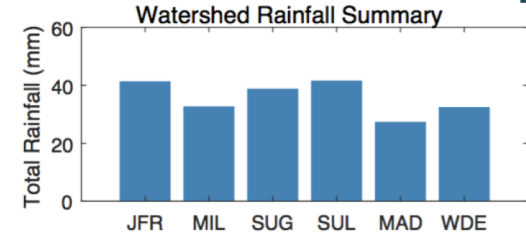
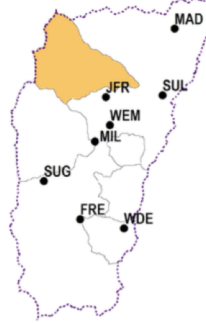
Turbidity Based Load (kg): **22815**

Flood Intensity: **0.505**

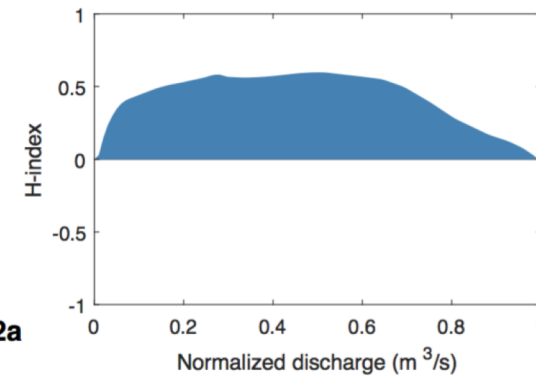
Antecedent Soil Moisture (%): **29.71 %**

Antecedent 7-Day Rainfall (mm): **37.85**

Shepard Brook

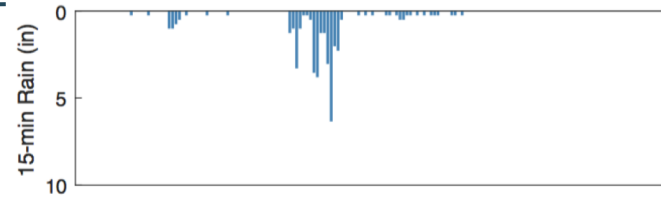


Rainfall
Summary

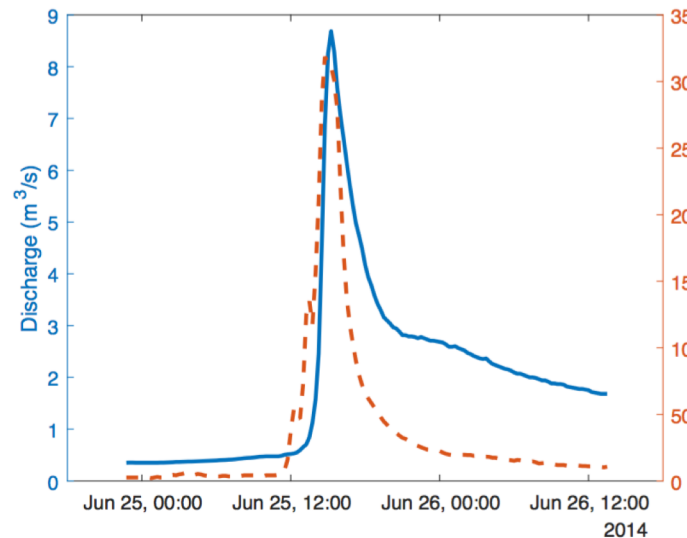


Hysteresis
Index

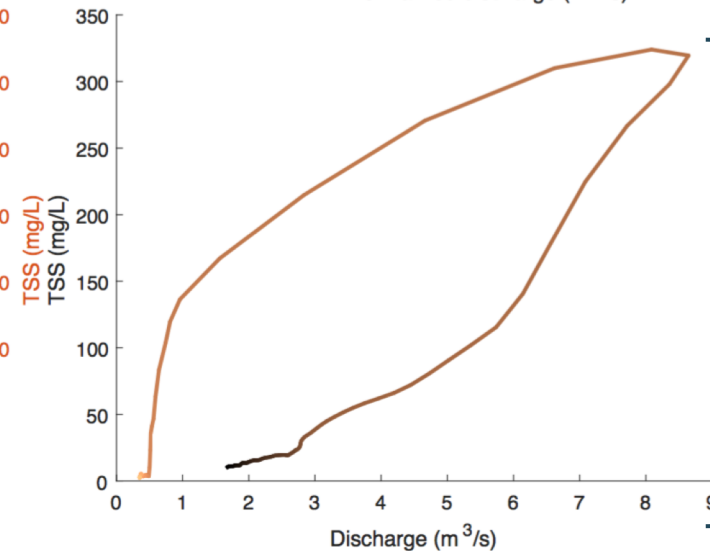
Hyetograph



Hydrograph &
Sedigraph



Class 2a



SSC-
Discharge
Plot