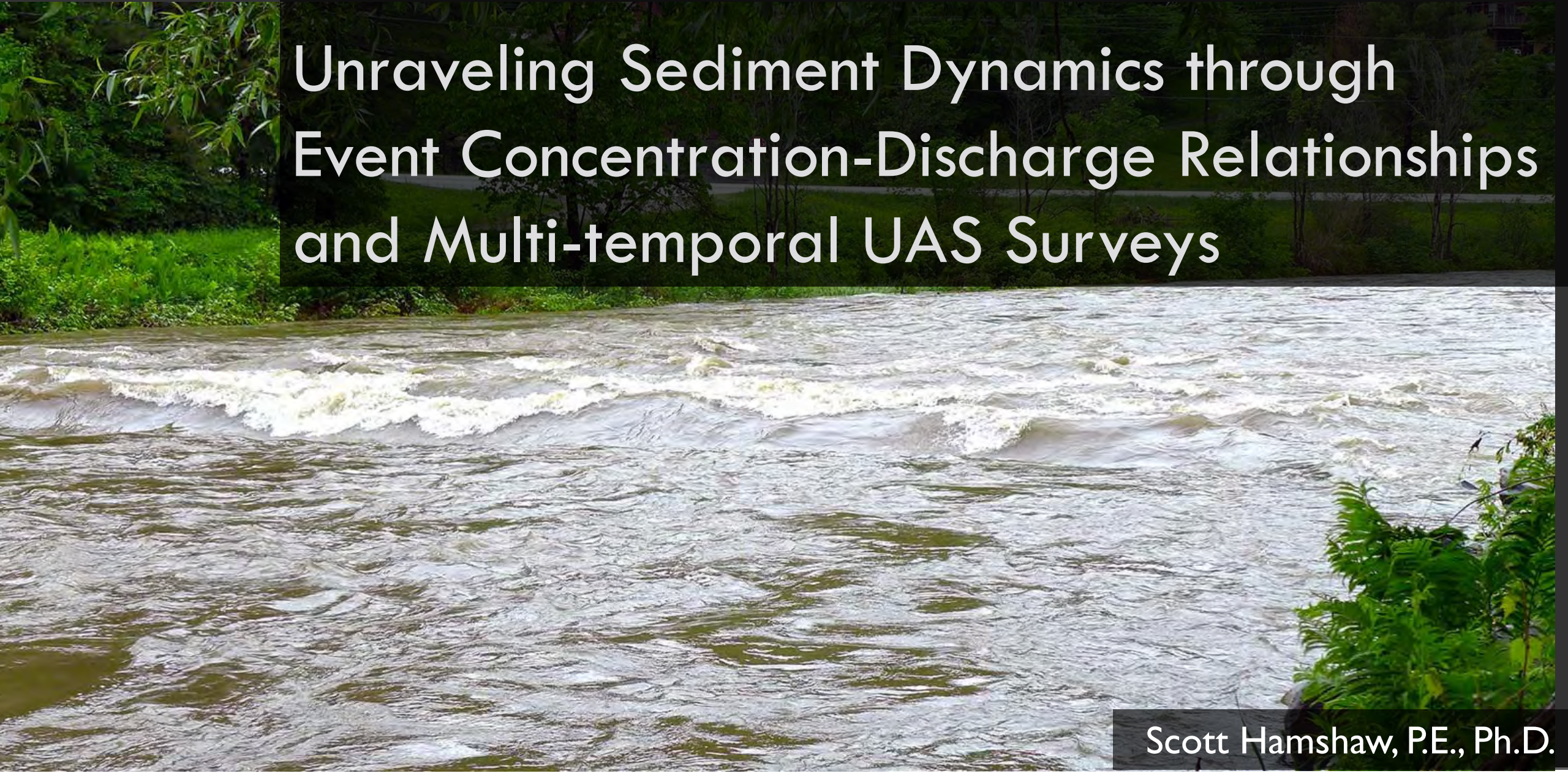
Unraveling Sediment Dynamics through Event Concentration-Discharge Relationships and Multi-temporal UAS Surveys



Scott Hamshaw, P.E., Ph.D.

24-Oct-2018

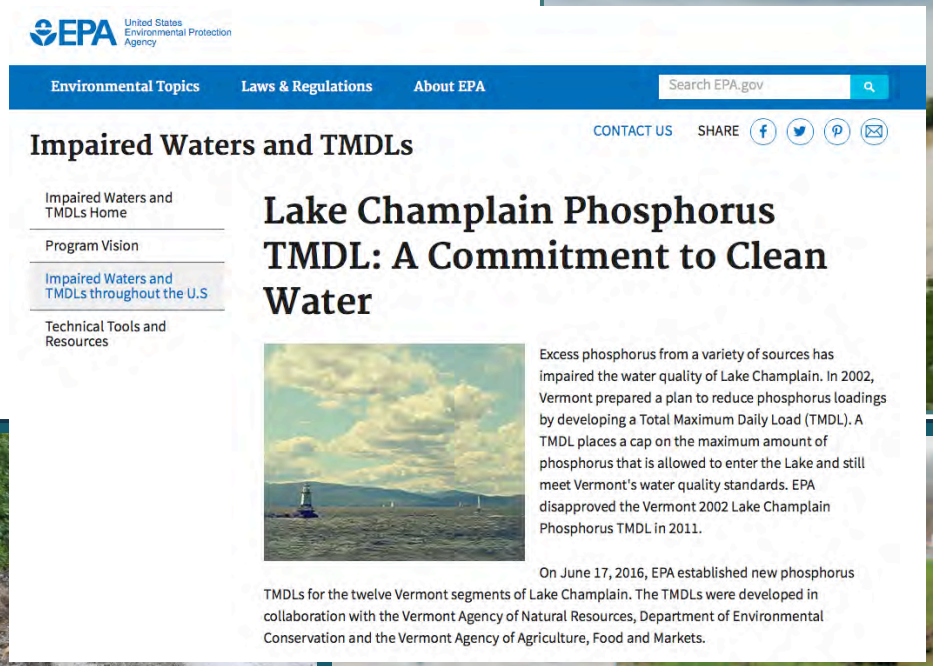
CERM 2018 Conference

The University of Vermont

BREE
Basin Resilience to Extreme Events
in the Lake Champlain Basin

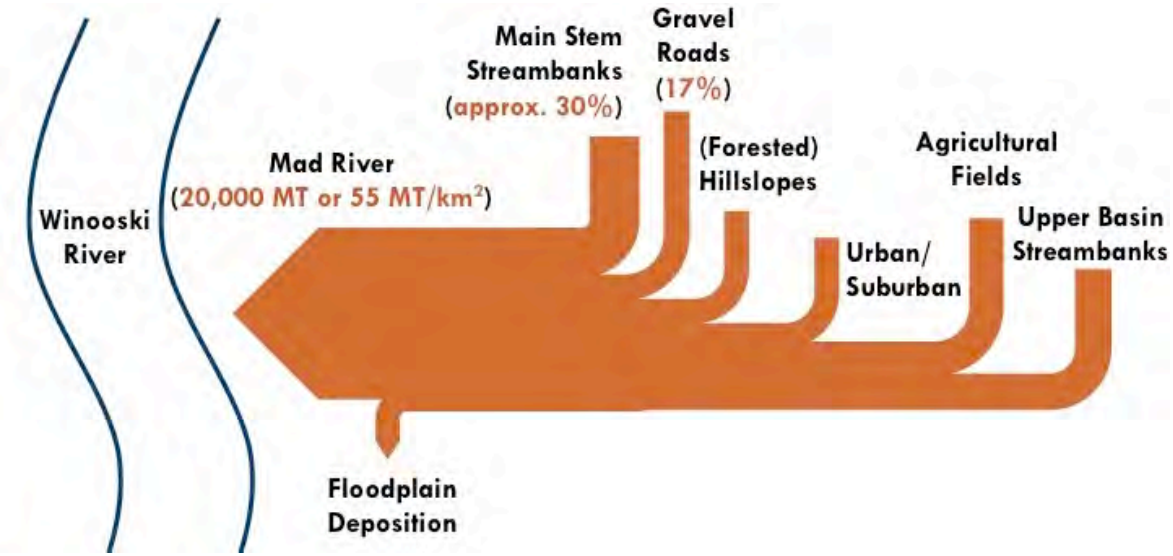
Signs of stress in Lake Champlain watersheds

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

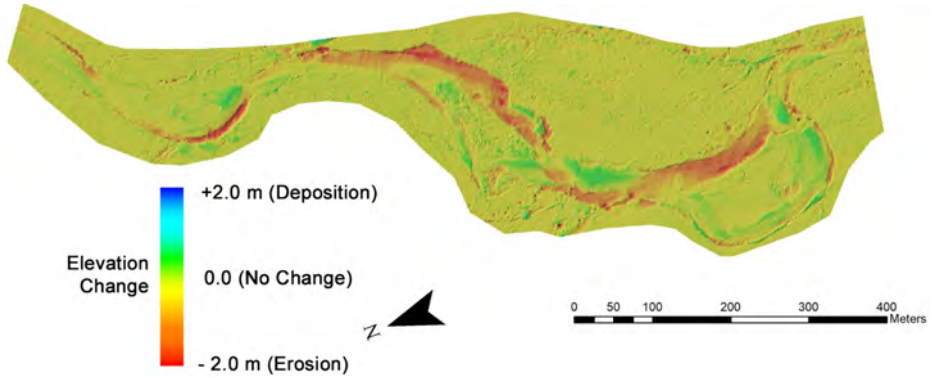


How do we determine from where riverine sediments originate?

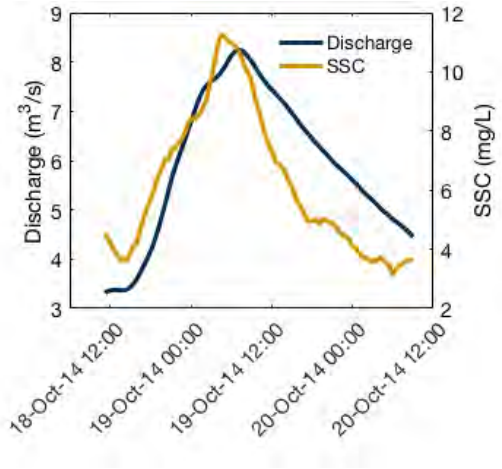
- Sediment Tracers
- Watershed Modeling
- Sediment Budget

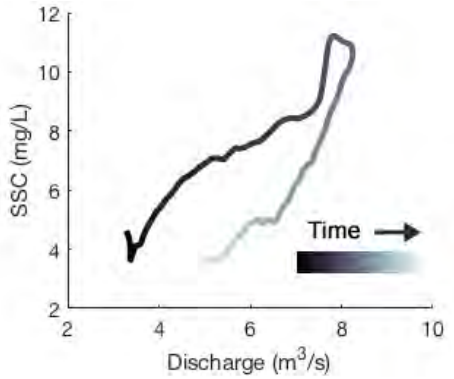


- Repeat Surveying



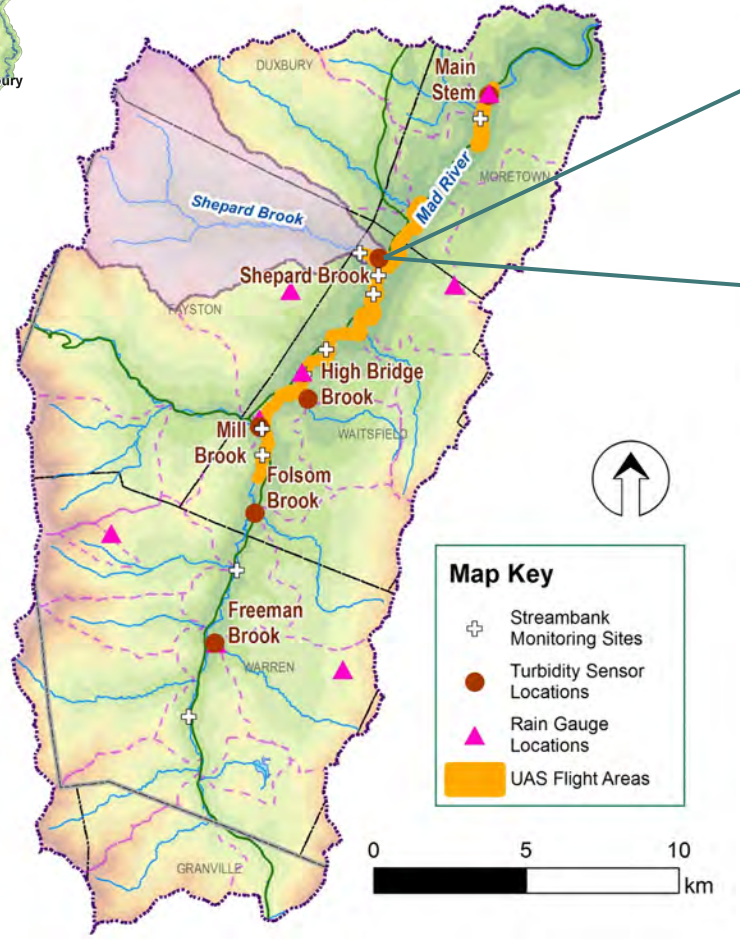
- Hysteresis Analysis

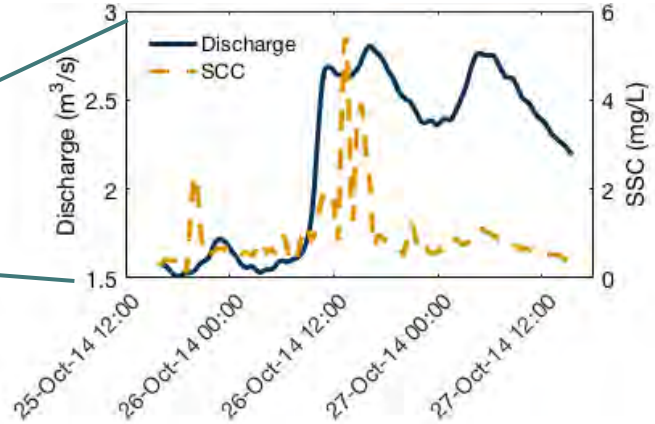




Primary study site – Mad River Watershed

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





SenseFly eBee UAS

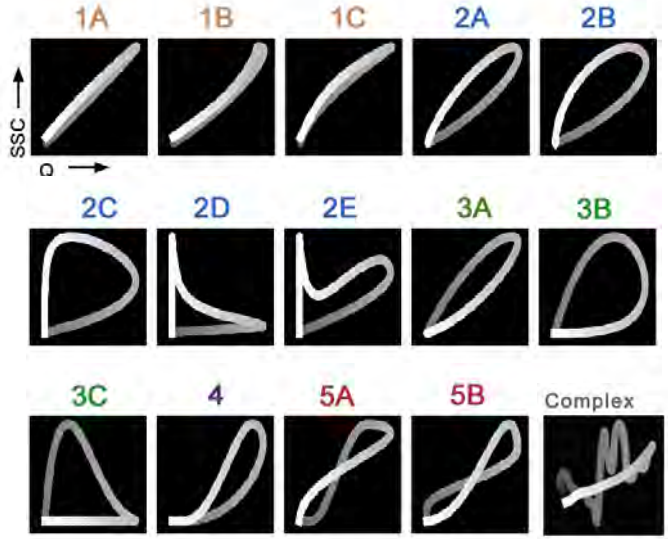
ISCO Autosampler and Datalogger

DTS-12 In-situ Turbidity Sensor

Motivation for analysis of hydrological event data

- *Untapped potential in data-mining high-frequency water quality sensor data*
- *Can improve load estimates, guide watershed modeling & management*

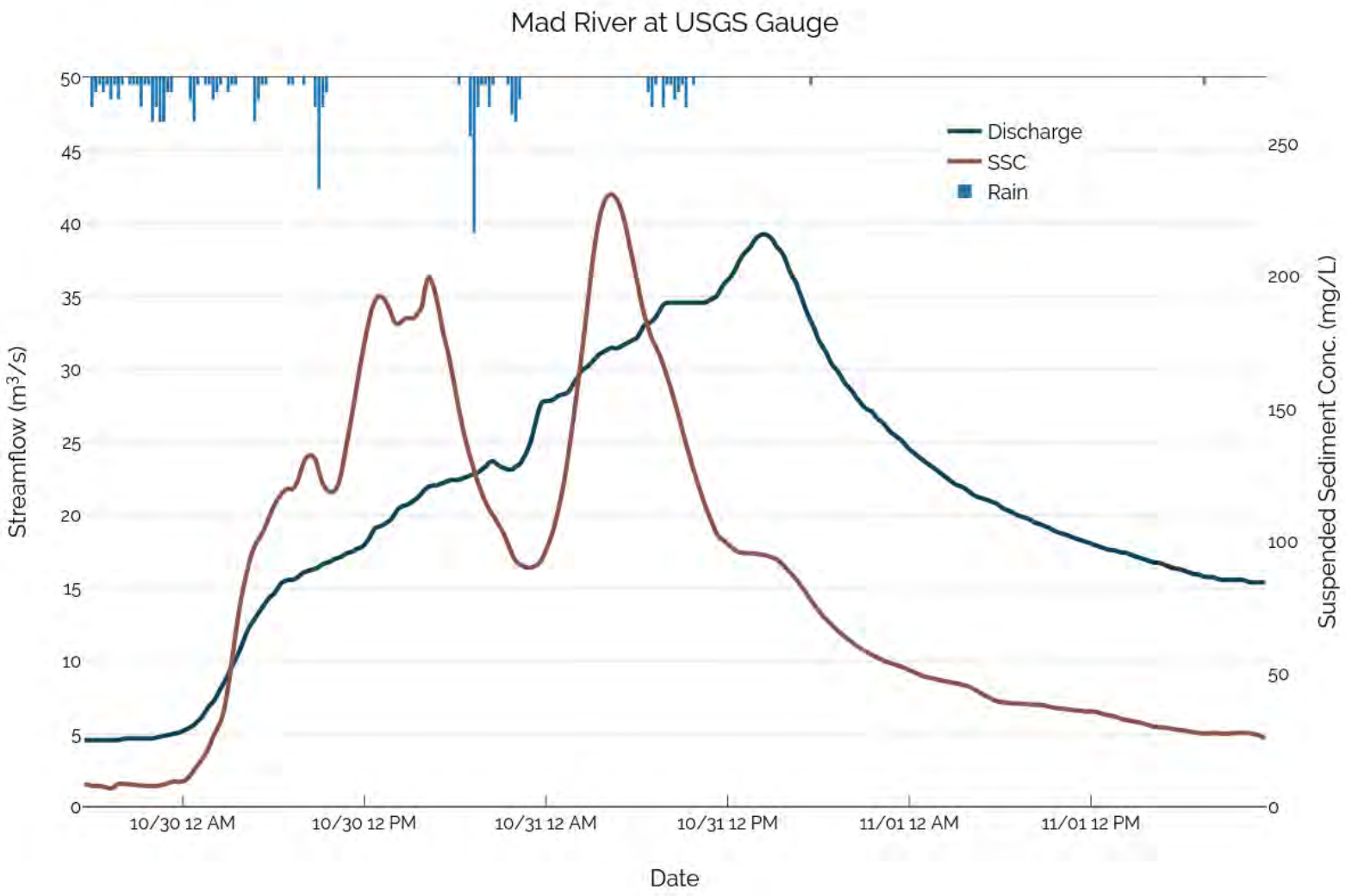
- Expanded library of hysteresis patterns

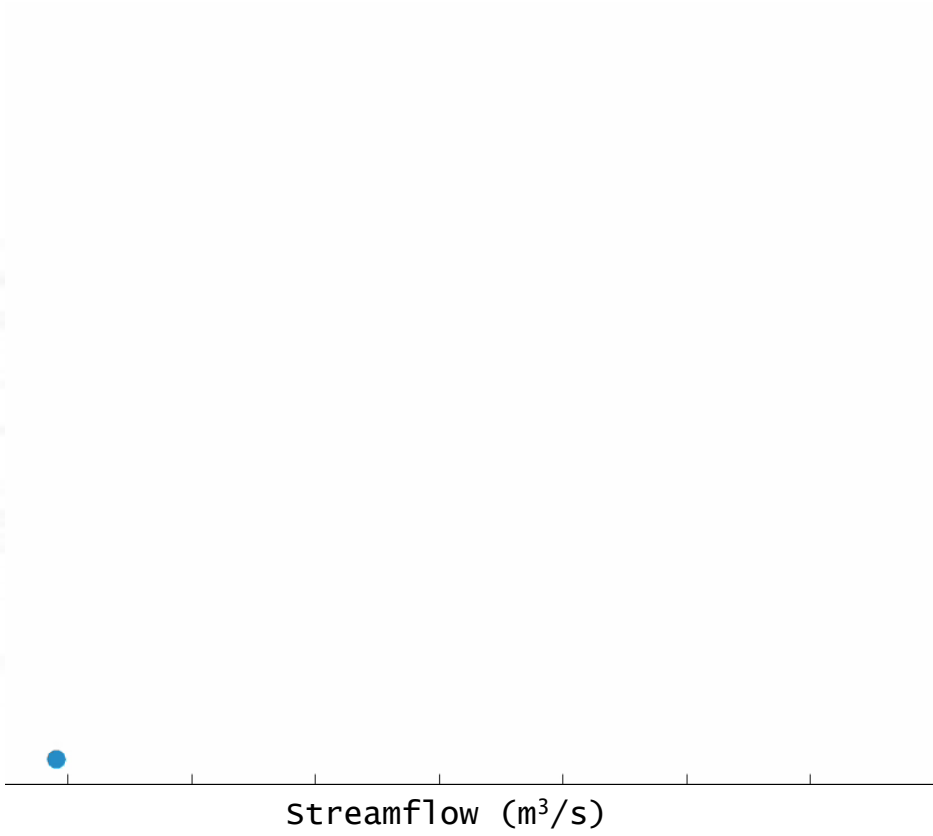


Understand watershed processes
- Sediment sources
- Transport dynamics

Automated Monitoring/Classification
- Shifts in types of events
- Detect key types of events

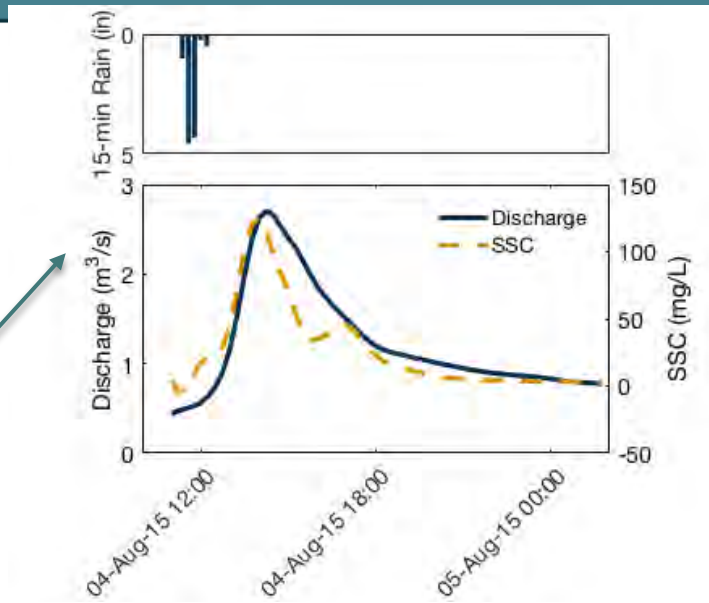
A close look at hydrological events

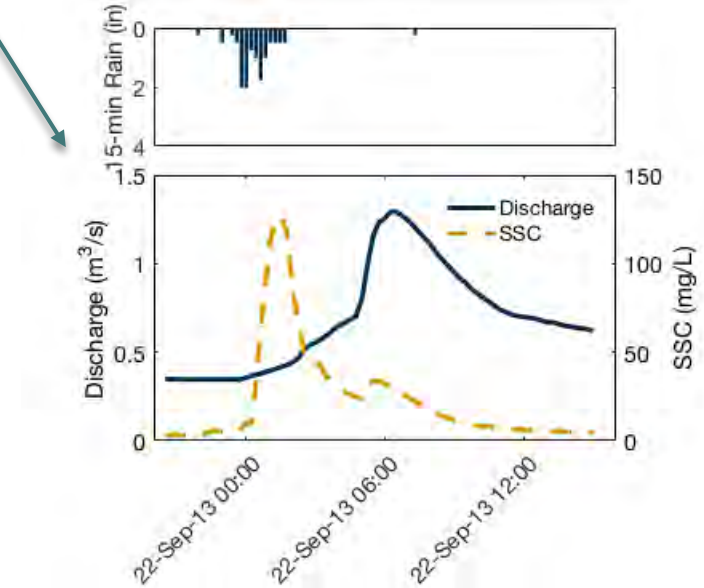




An Example: Two storm events to illustrate event sediment dynamics

- Shepard Brook
  - Aug 4, 2015
  - Sep 22, 2013





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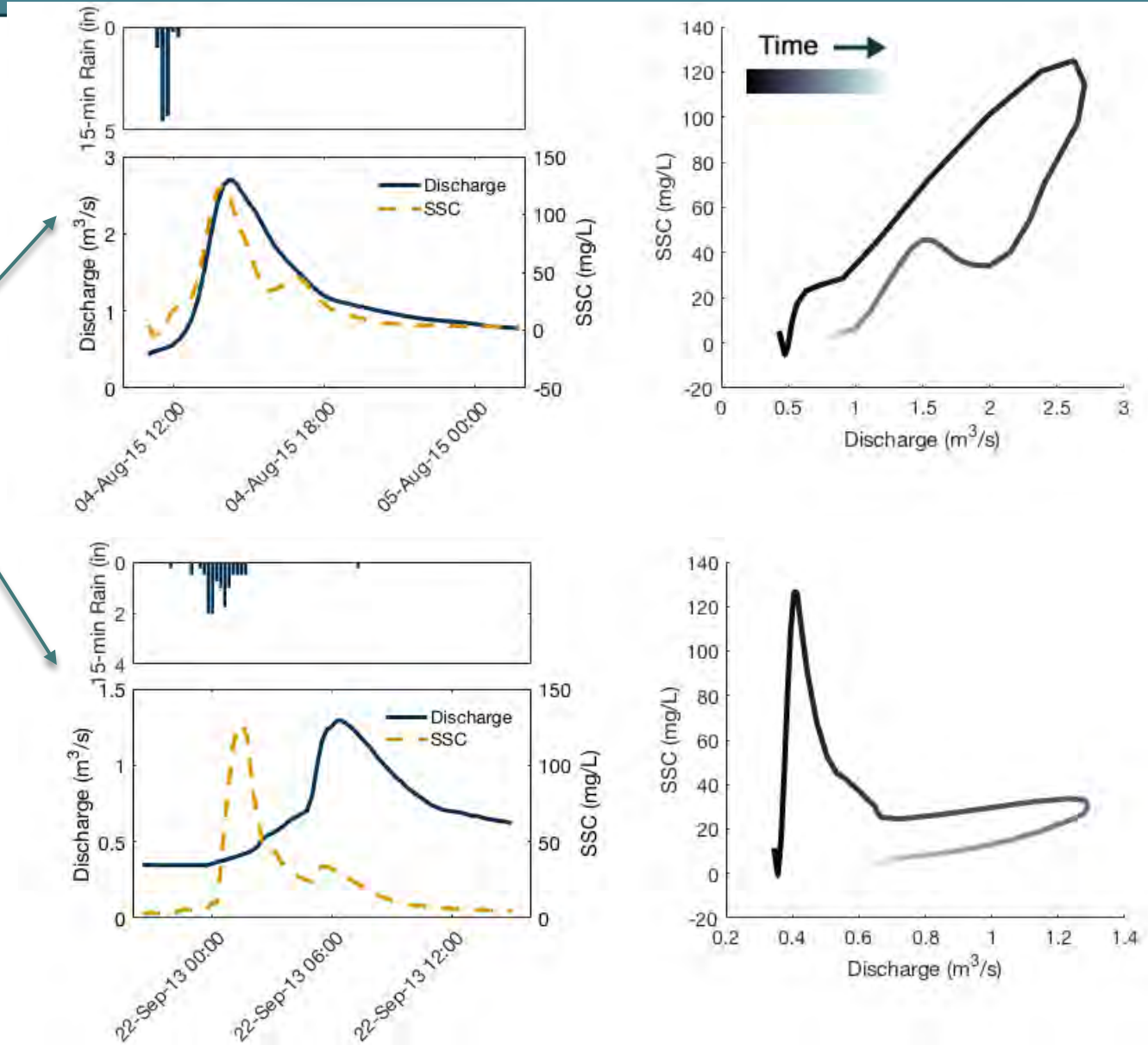
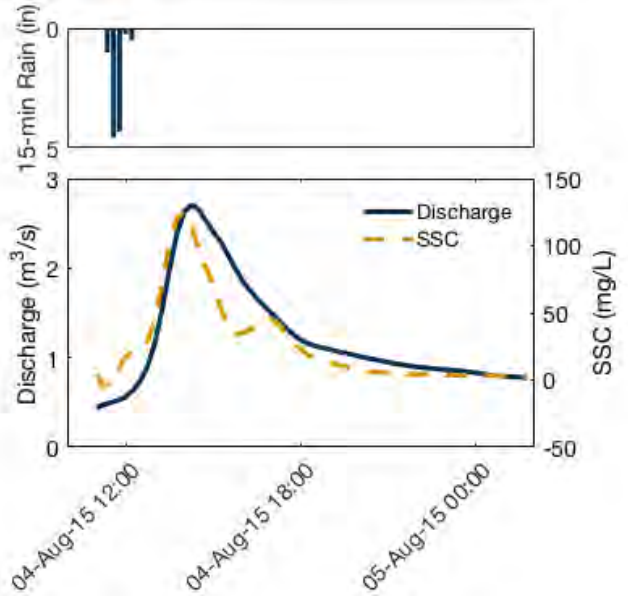
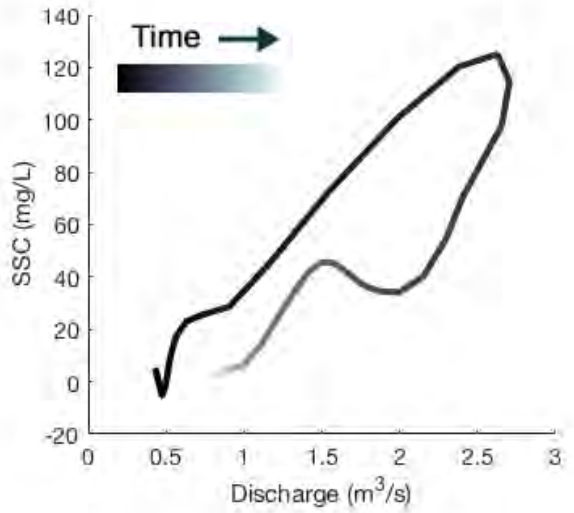
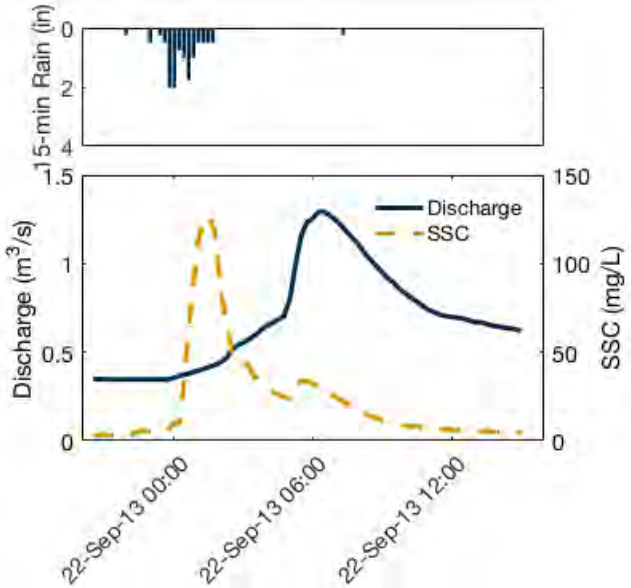


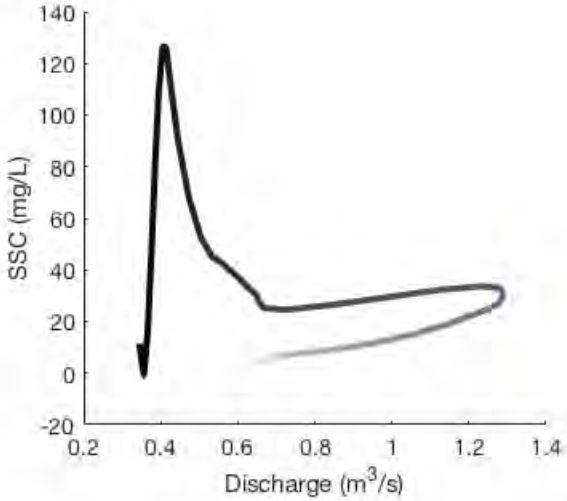
An Example: Two storm events to illustrate event sediment dynamics





- Streamflow activated (channel network) sediment sources important

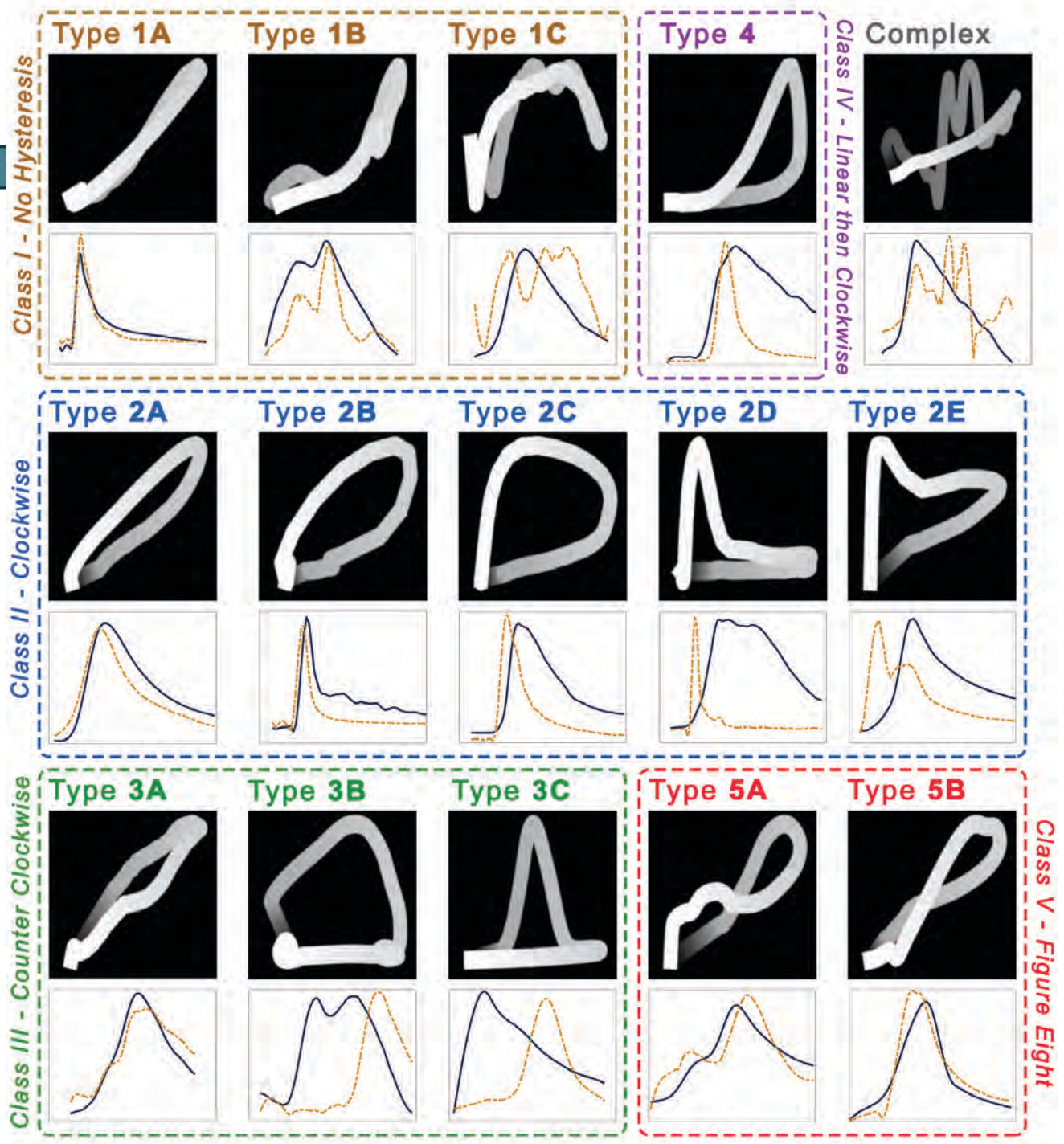




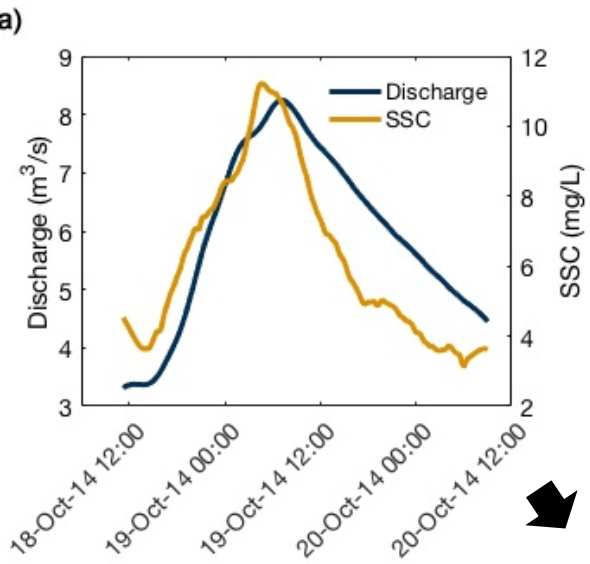
- Connected, rainfall activated, nearby sediment sources important

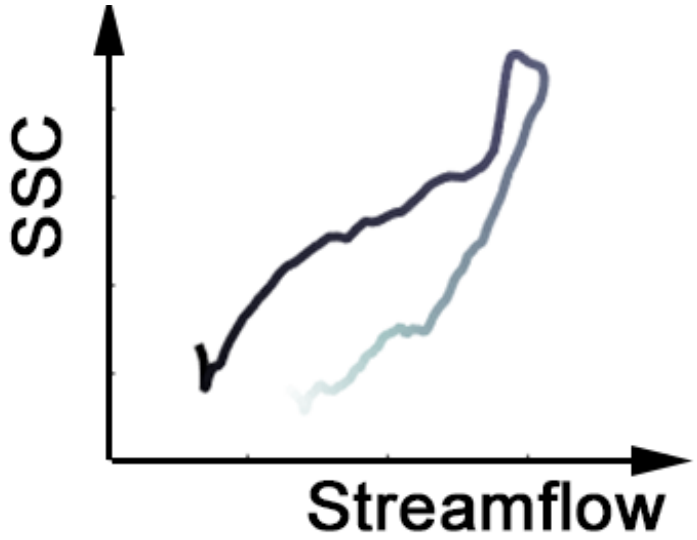
Patterns of Hysteresis

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



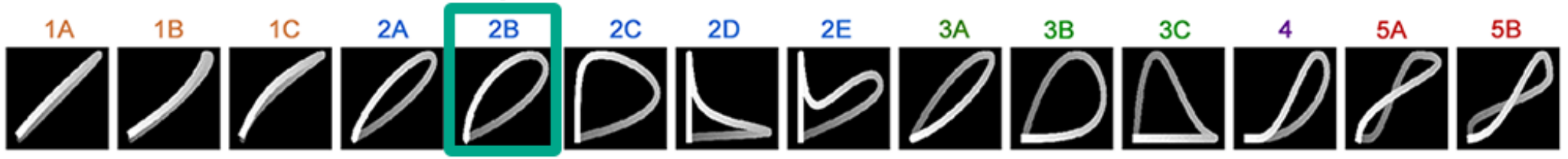
Automated event classification system



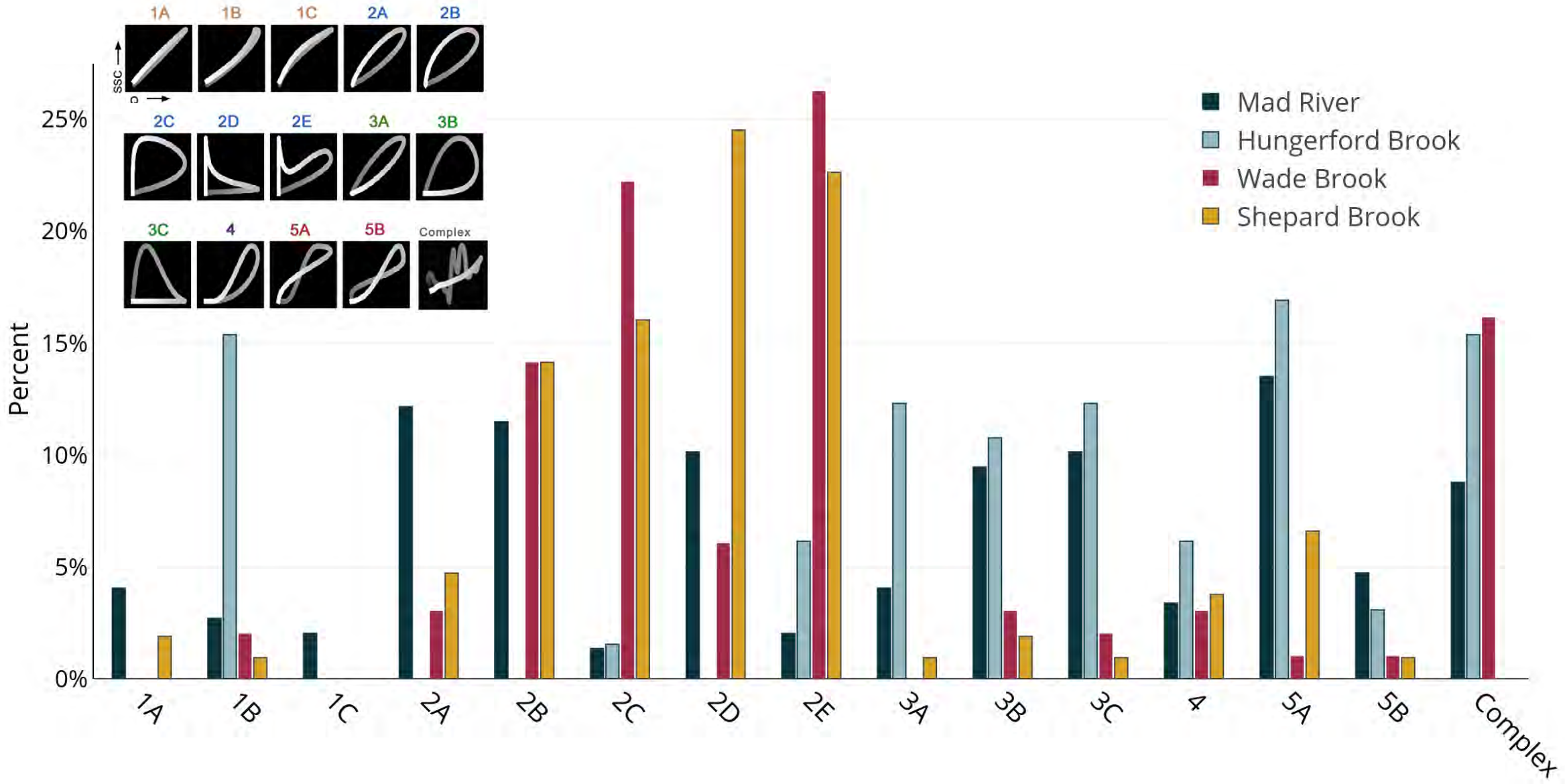


Restricted Boltzmann Machine Classifier

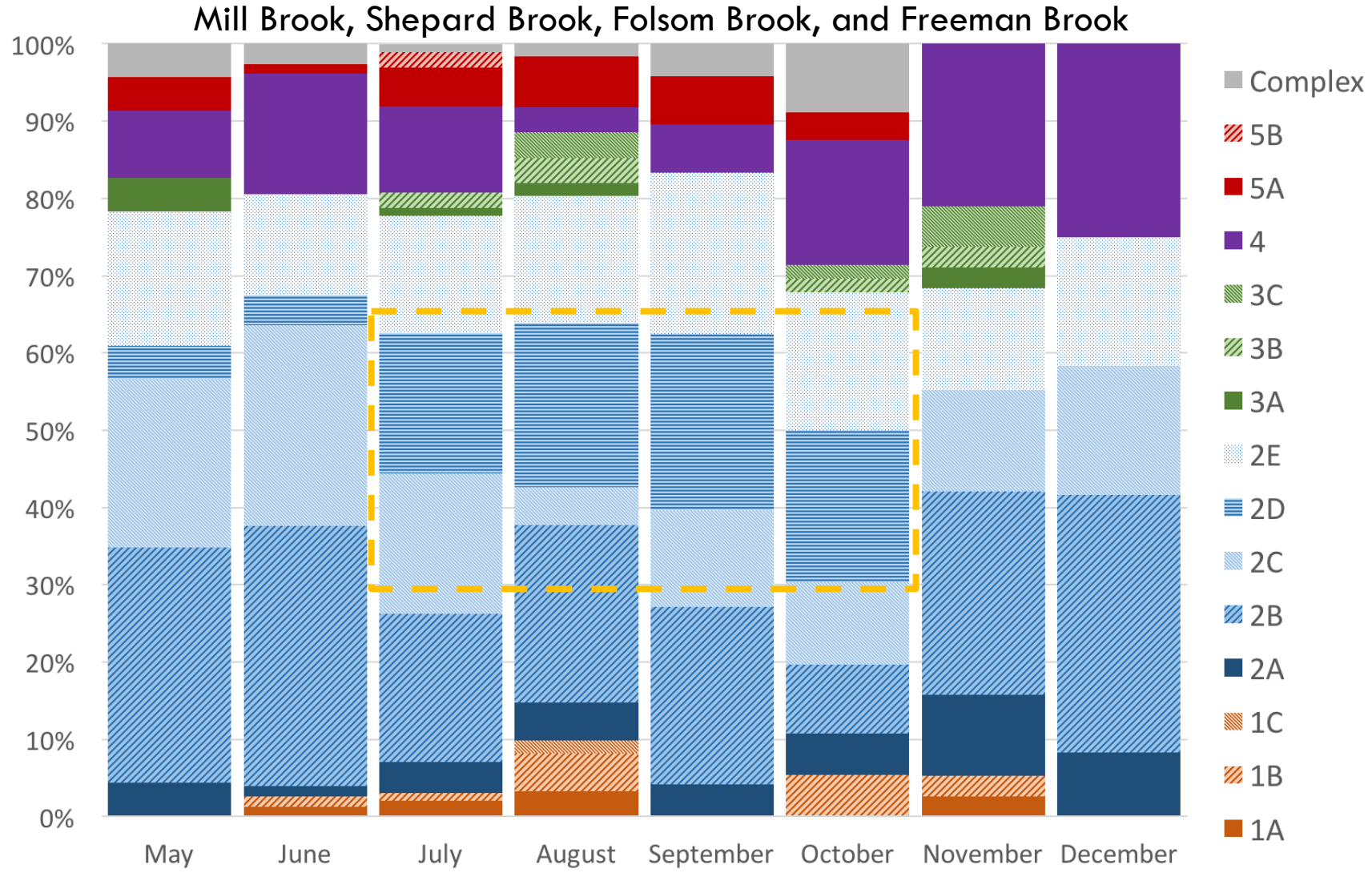
Machine Learning & Deep Learning

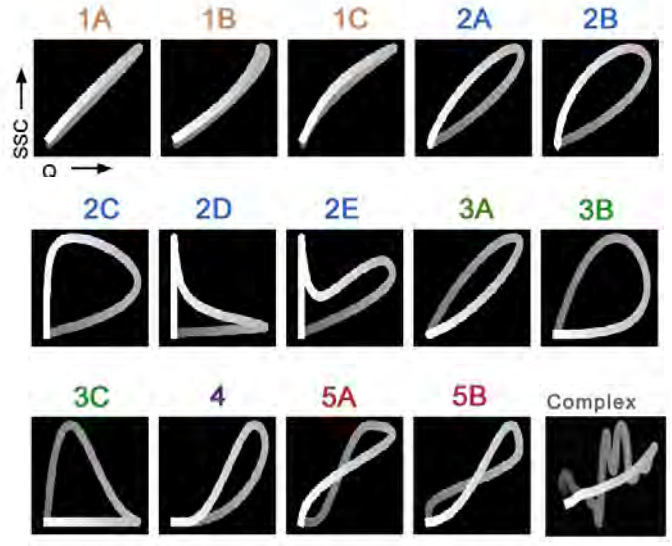


Hysteresis types provide insights on differences across watersheds



Hysteresis types show seasonal trends



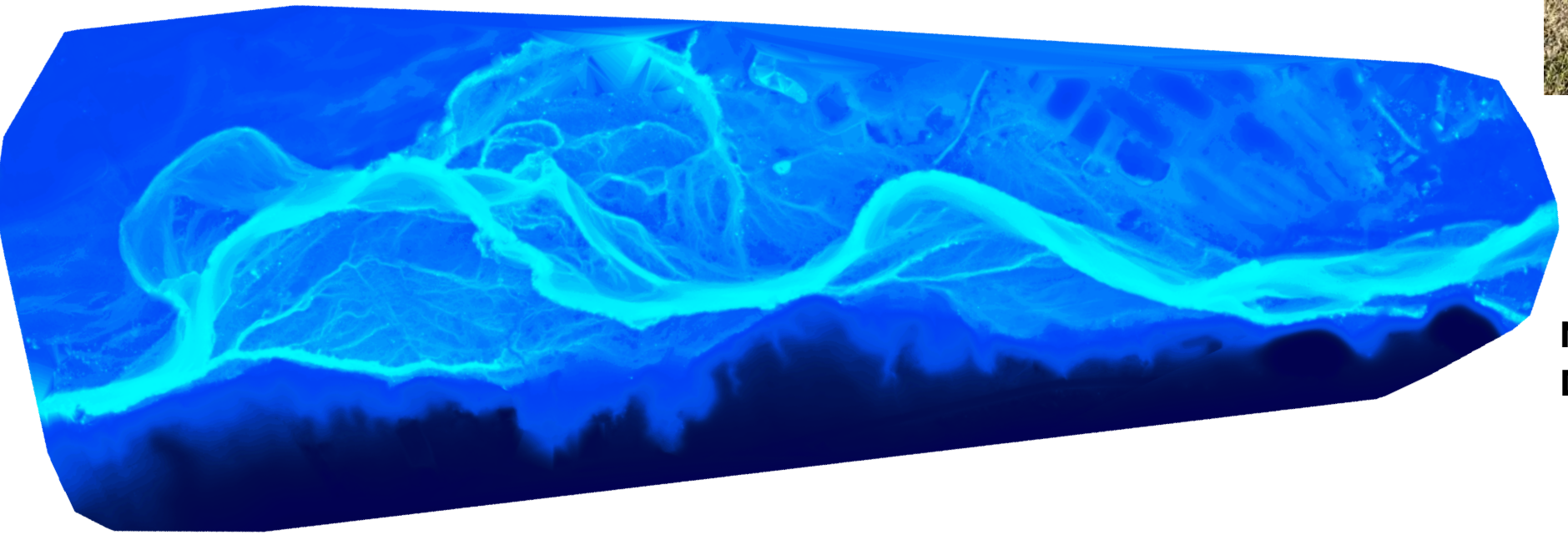


Also identified trends in hysteresis patterns by:

- Site
- Drainage Area Size
- Sediment Load

UAS Surveying of River Corridors

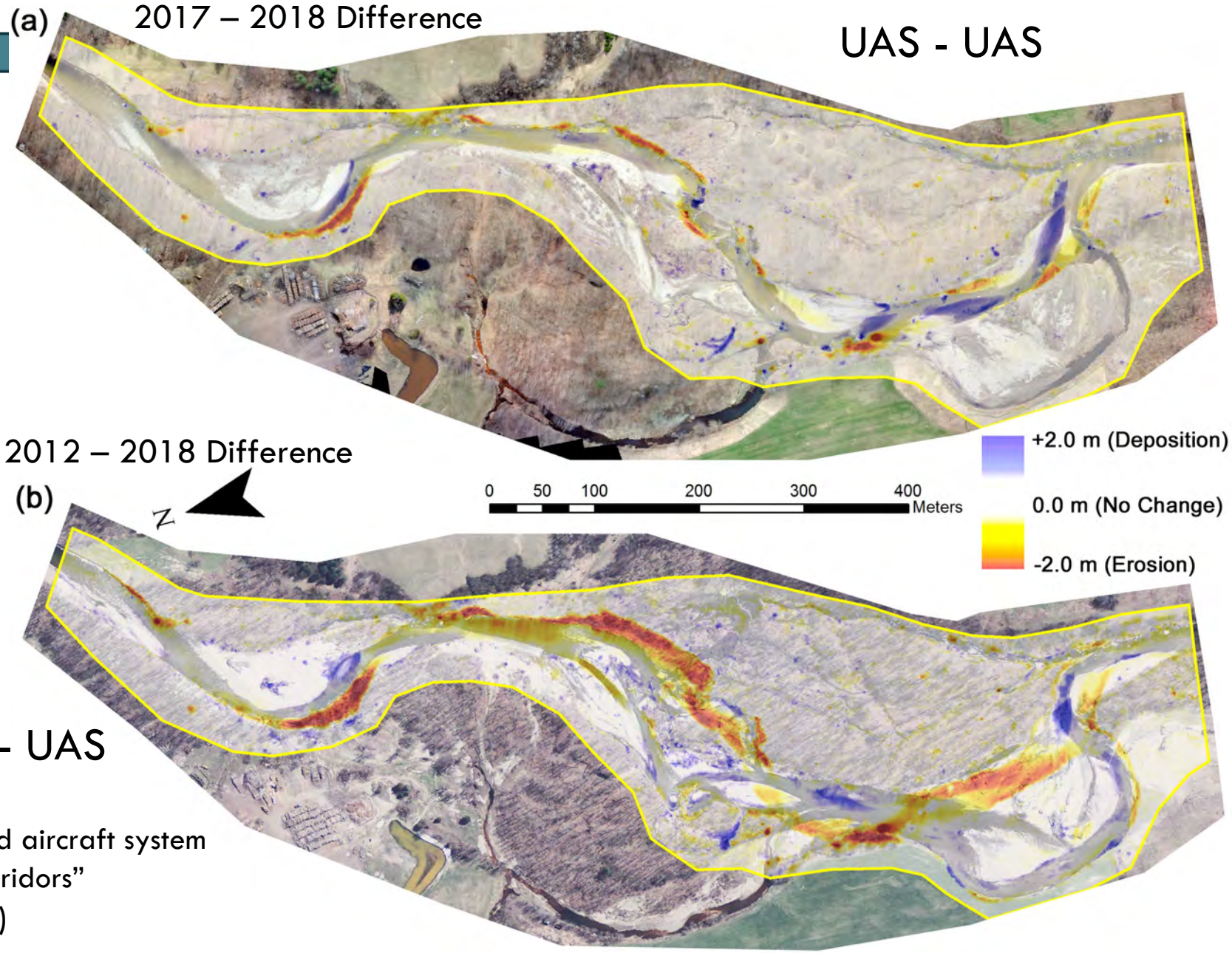
- 30 km of river corridor surveyed (2015-2017)
- Fixed-wing UAS
- More responsive & higher resolution than available airborne lidar



New Haven River 12 cm DEM (detrended)

Surveying geomorphic change with UAS

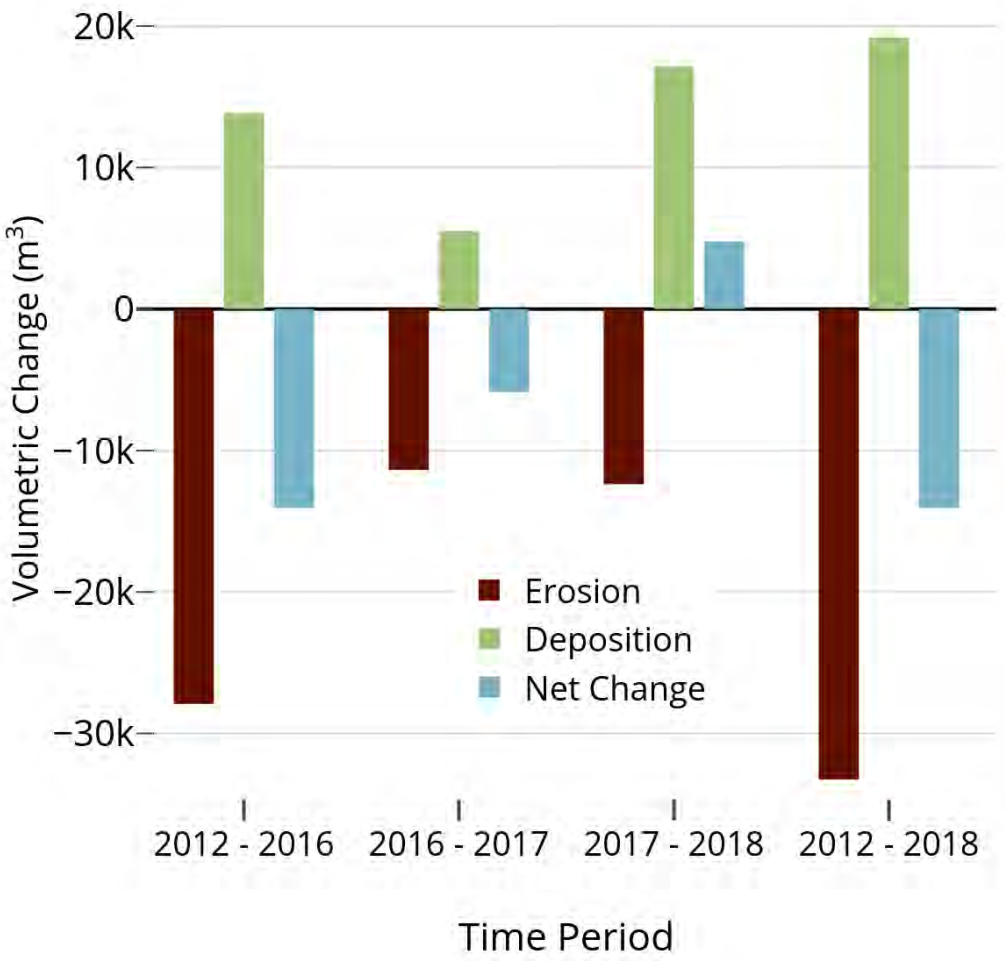
- SfM works for complex vegetation/terrain
  - (Without dense vegetation cover)
- Automatic processing in Pix4D



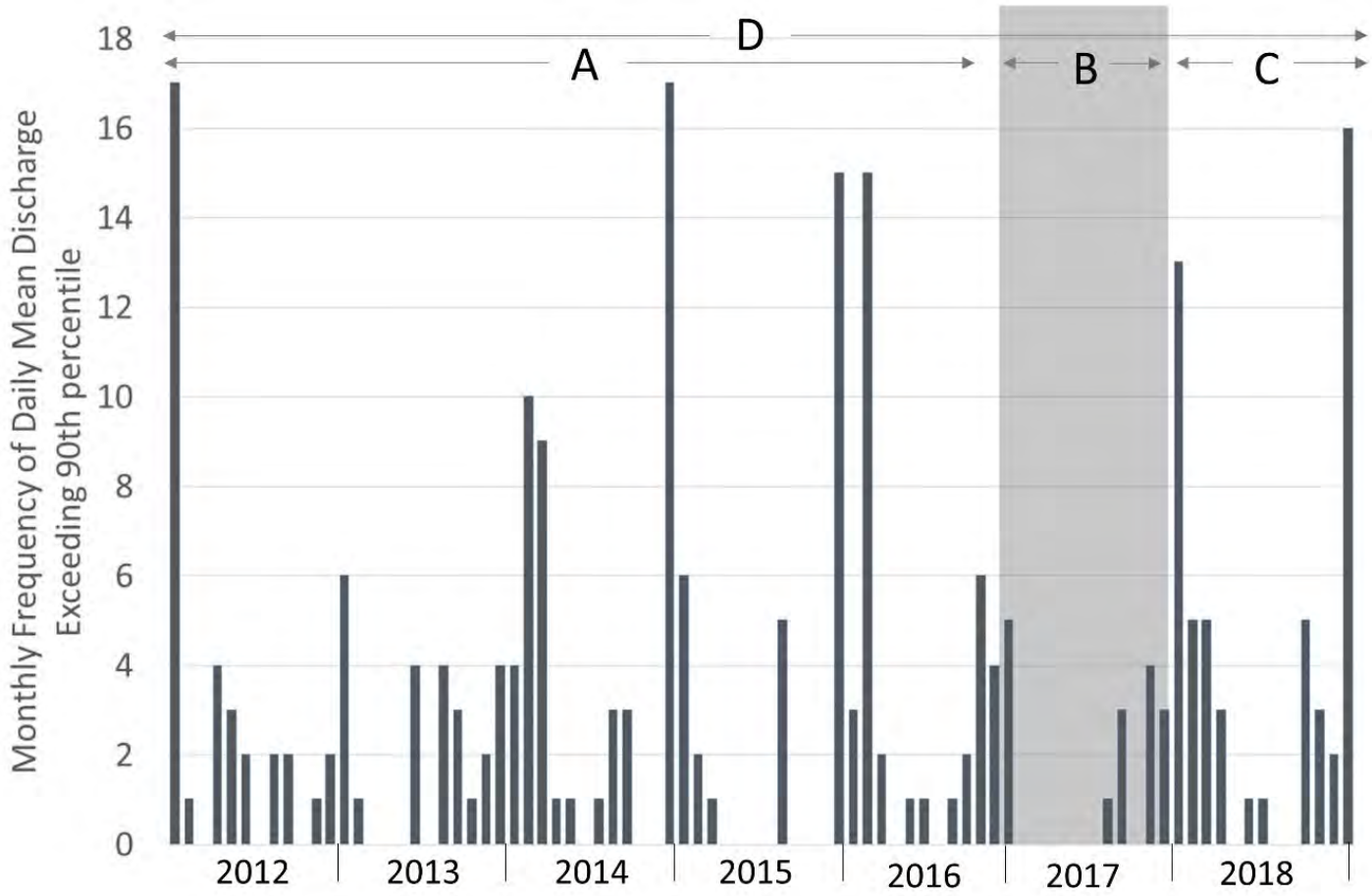
Hamshaw et al. (2018). "Application of unmanned aircraft system (UAS) for monitoring bank erosion along river corridors" *Geomatics, Natural Hazards, & Risk* (In Press)

Analyzing Geomorphic Change and Sediment Transport Regimes

Volumetric Change within River Corridor area of New Haven River



Analysis of Streamflow above Threshold Value for Monitoring Intervals



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- Support provided by:
  - Vermont EPSCoR with (NSF) Grant EPS-1101317 and EPS-1556770
  - NSF Graduate Research Fellowship (Grant No. DGE-0925179NSF)
  - Vermont Water Resources and Lake Studies Center
  - 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

NSF

NIWR

ROBERT & PATRICIA SWITZER FOUNDATION

GRFP NSF GRADUATE RESEARCH FELLOWSHIP PROGRAM

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Special thanks to:

- Donna Rizzo
- Mandar Dewoolkar
- Beverley Wemple
- Andrew Schroth
- Kristen Underwood

The University of Vermont

NSF

RACC Research on Adaptation to Climate Change

BREE Basin Resilience to Extreme Events in the Lake Champlain Basin

Robert & Patricia Switzer Foundation

Supplementary Information

What are hysteresis patterns? Two methods of categorizing hysteresis

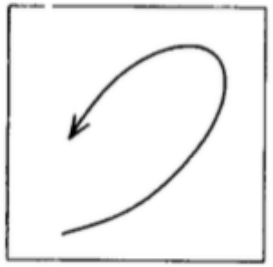
- Visual Patterns

Class I - Linear

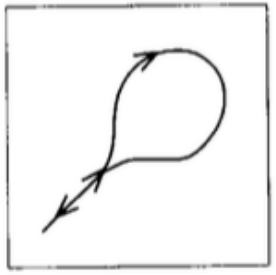
Class II - Clockwise

Garnett Williams, USGS, 1989

Class III - Counterclockwise



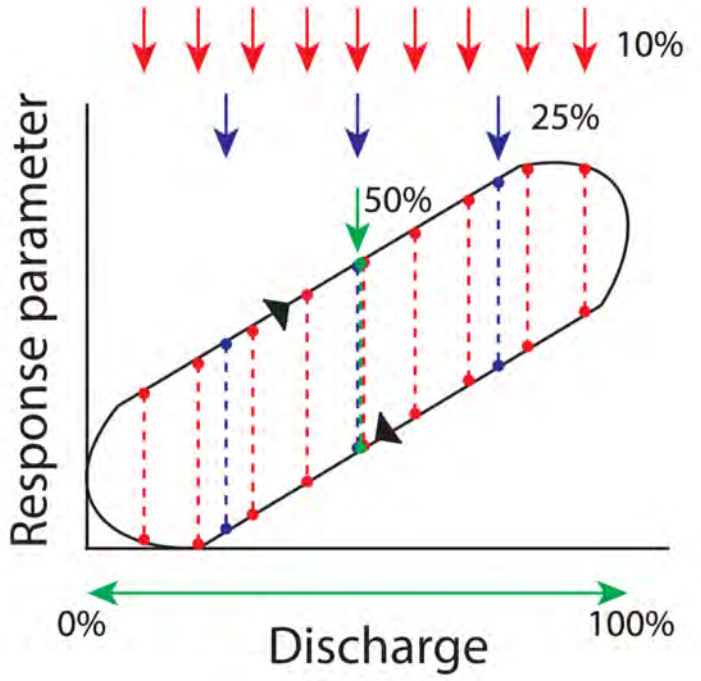
Class IV – Linear then Clockwise



Class V – Figure-Eight

- Metrics (e.g. Hysteresis Index)

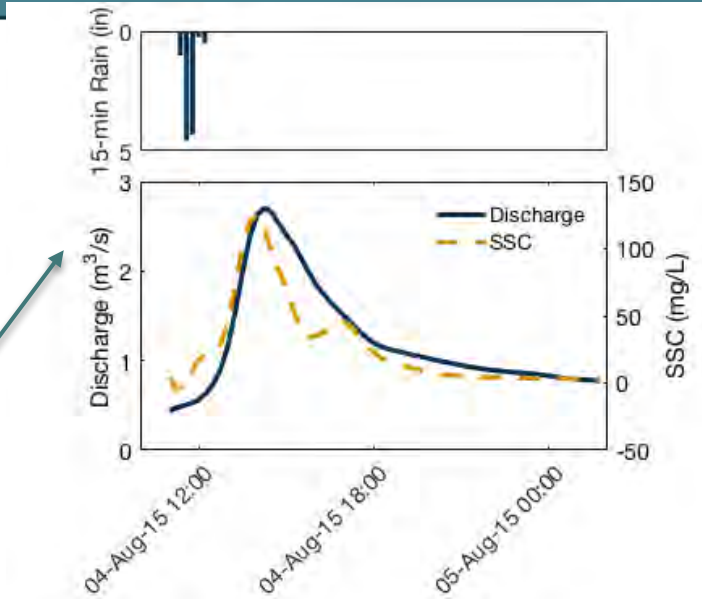
$$HI = T_{RL} - T_{FL}$$

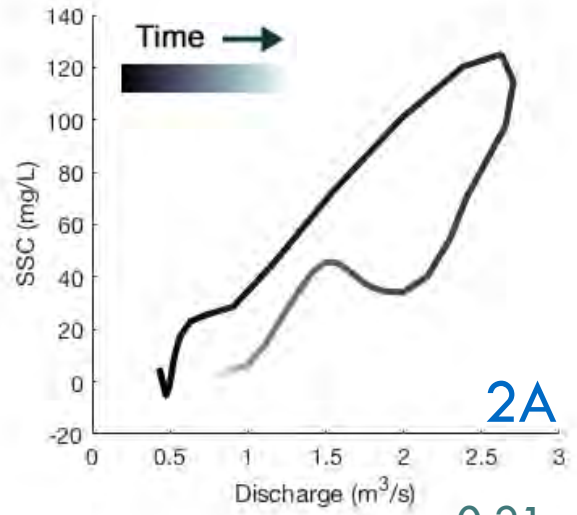


Lloyd *et al.* 2015

An Example: Looking back at the two storm events

- 2 storm events Shepard Brook
  - Aug 4, 2015
  - Sep 22, 2013



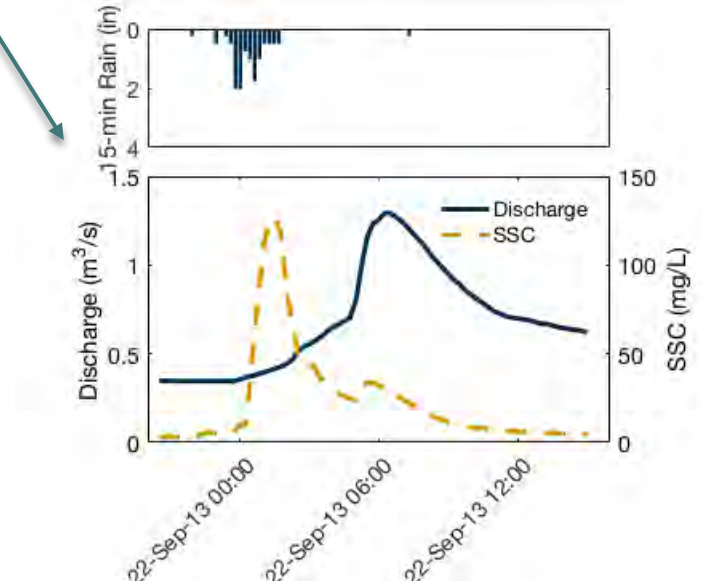


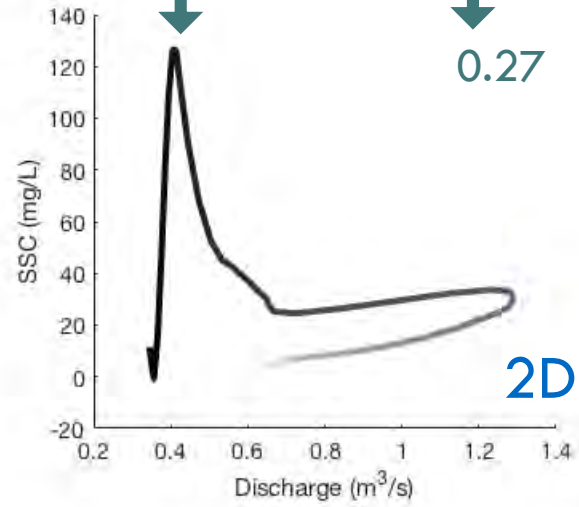
0.21

Clockwise

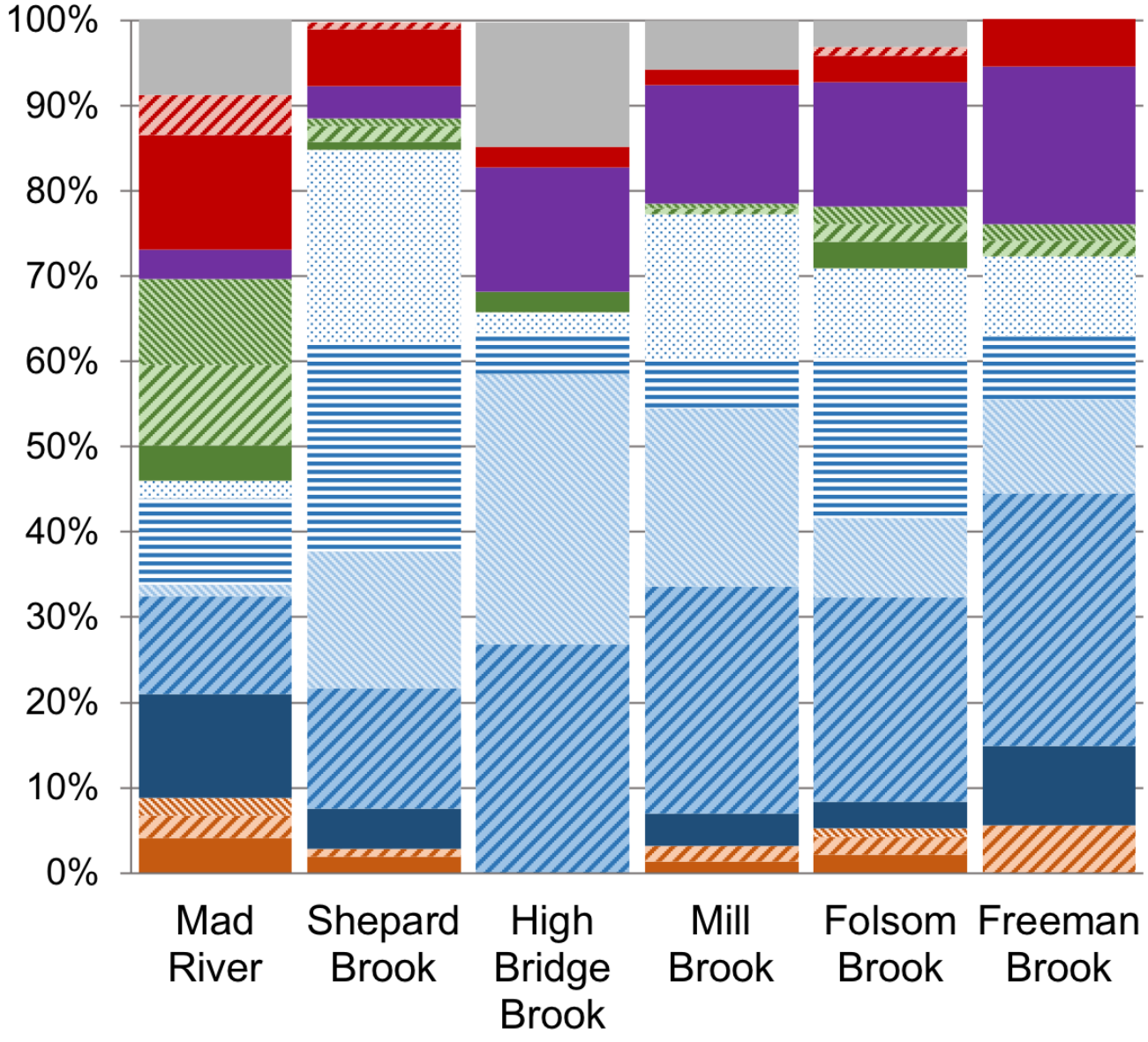
HI

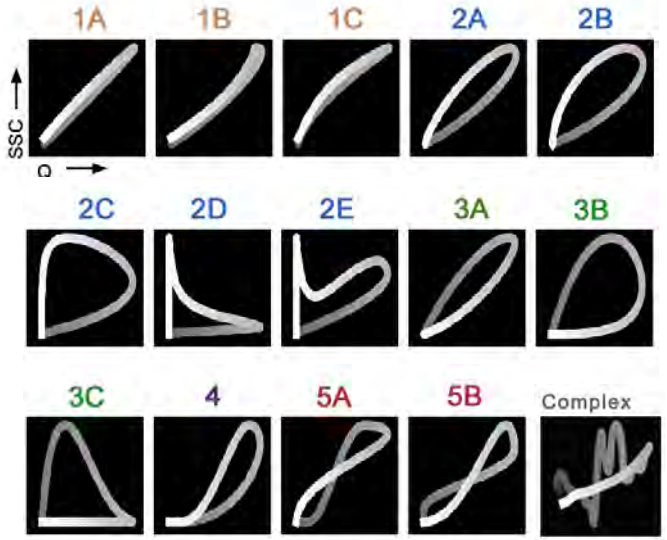
0.27



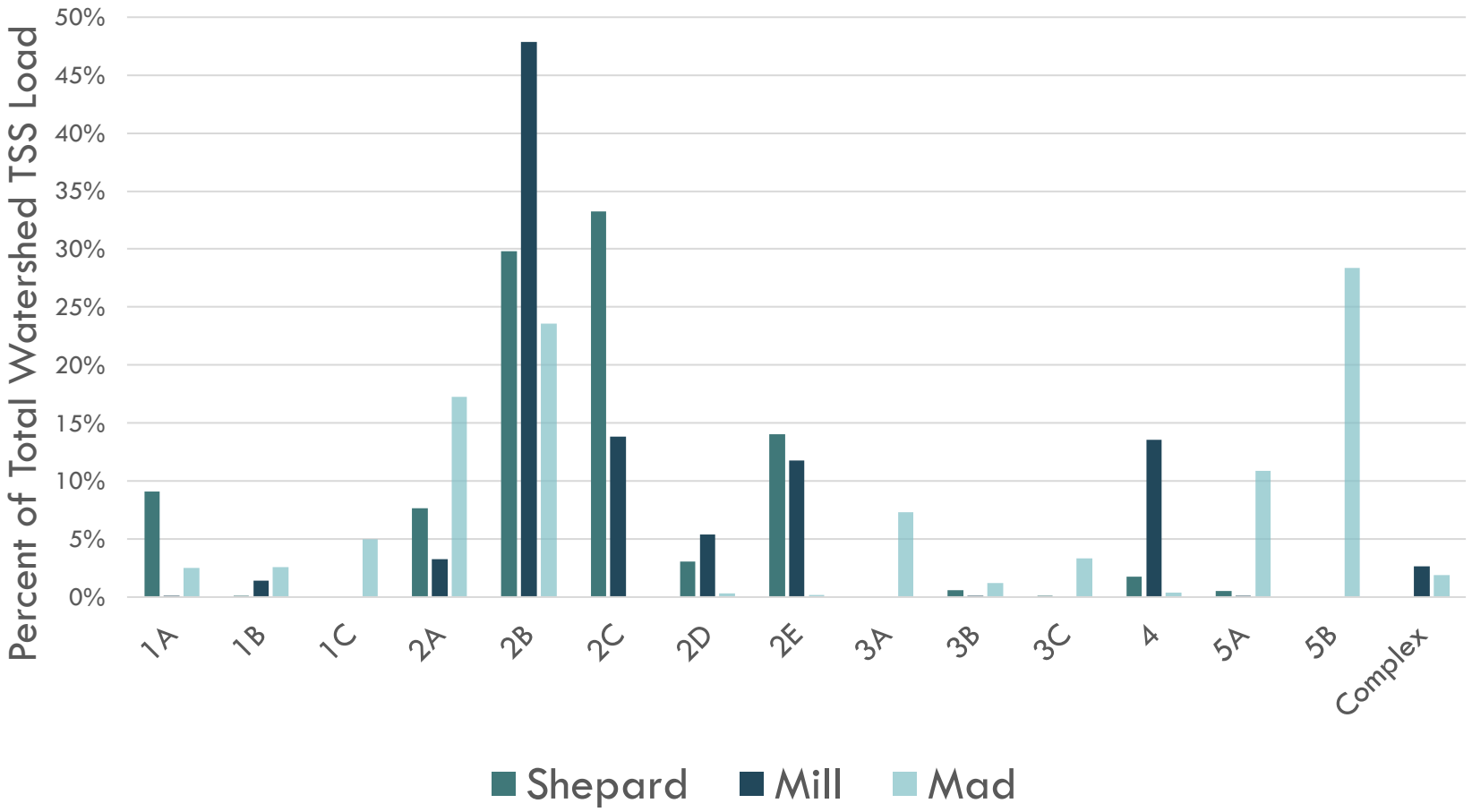


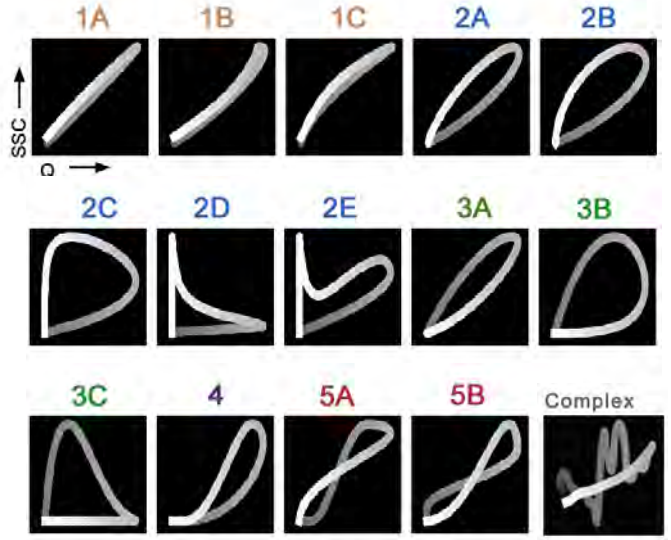
Differences among watersheds





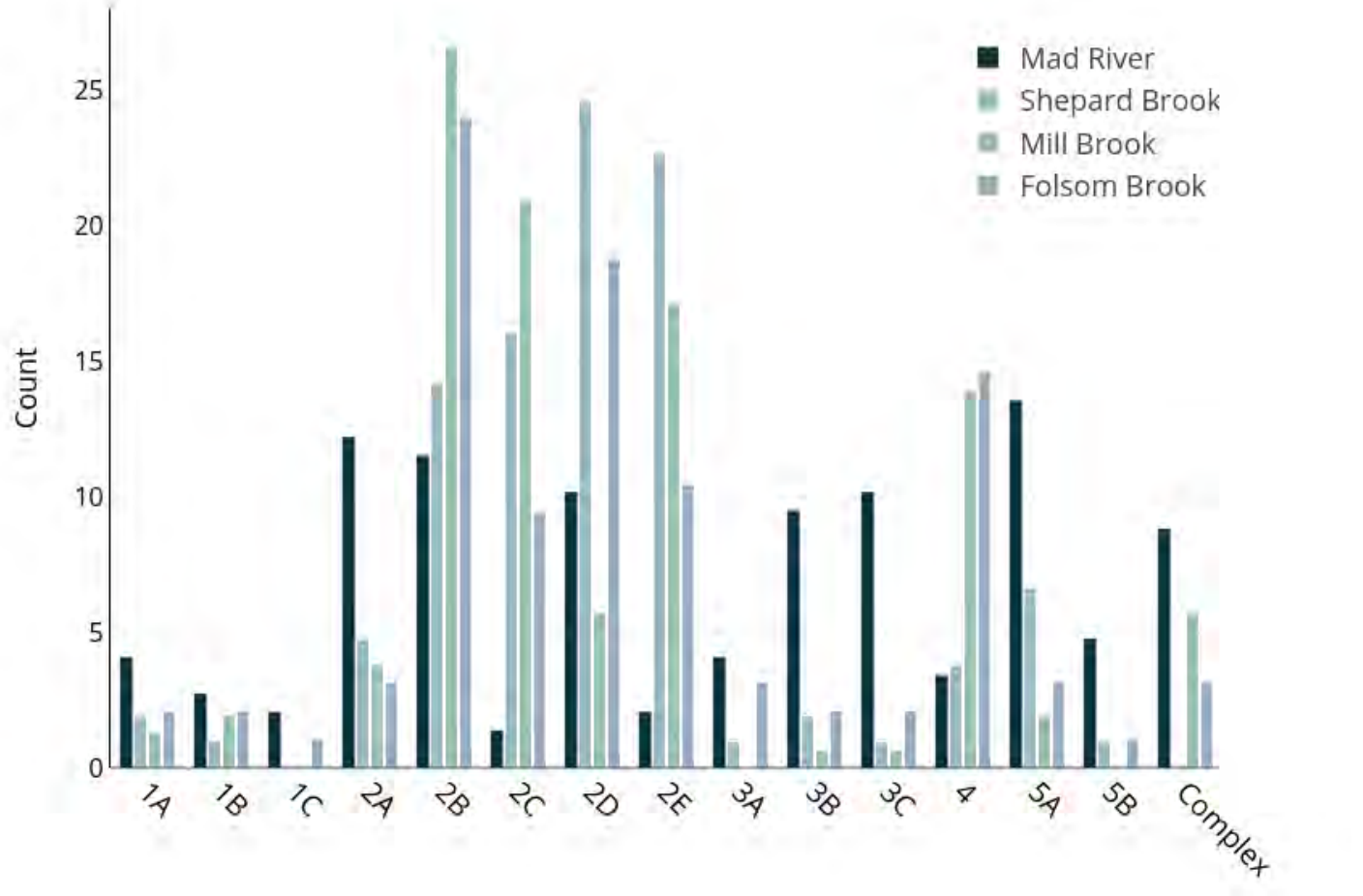
Sediment load by hysteresis type



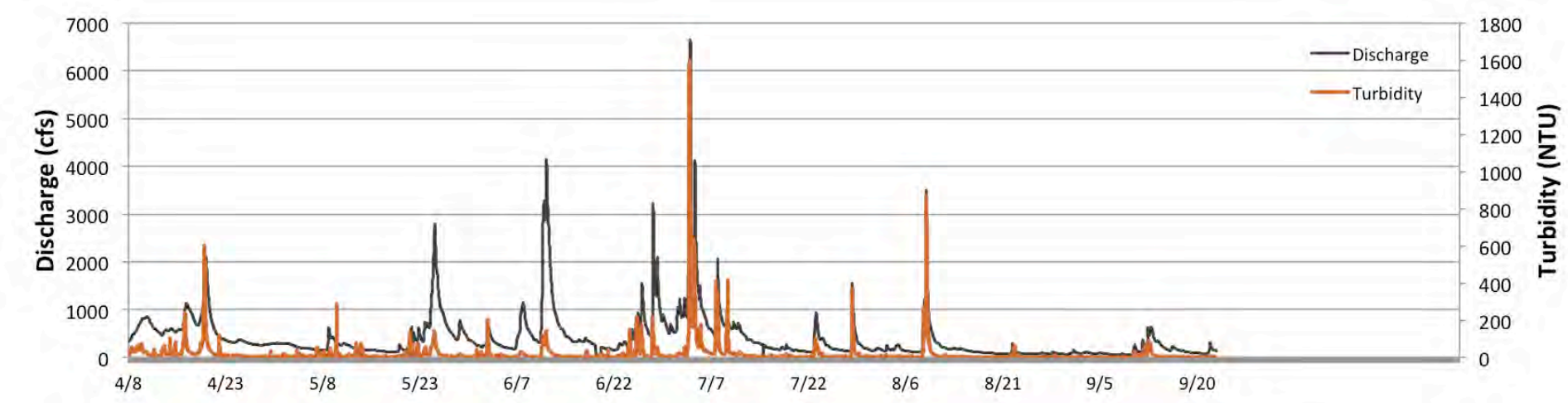


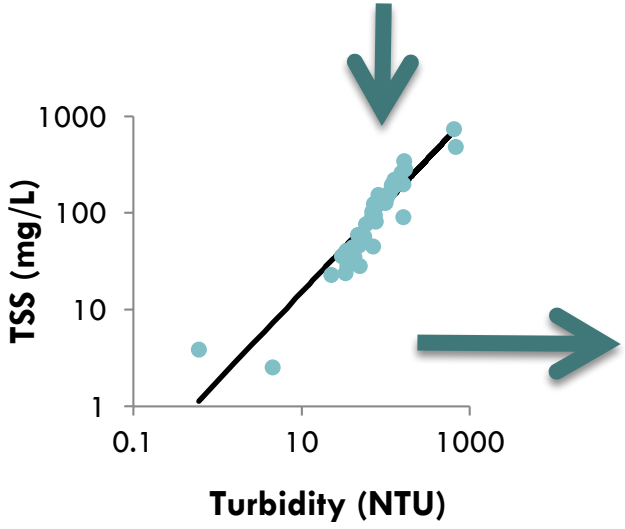
Effects of spatial scale on hysteresis type

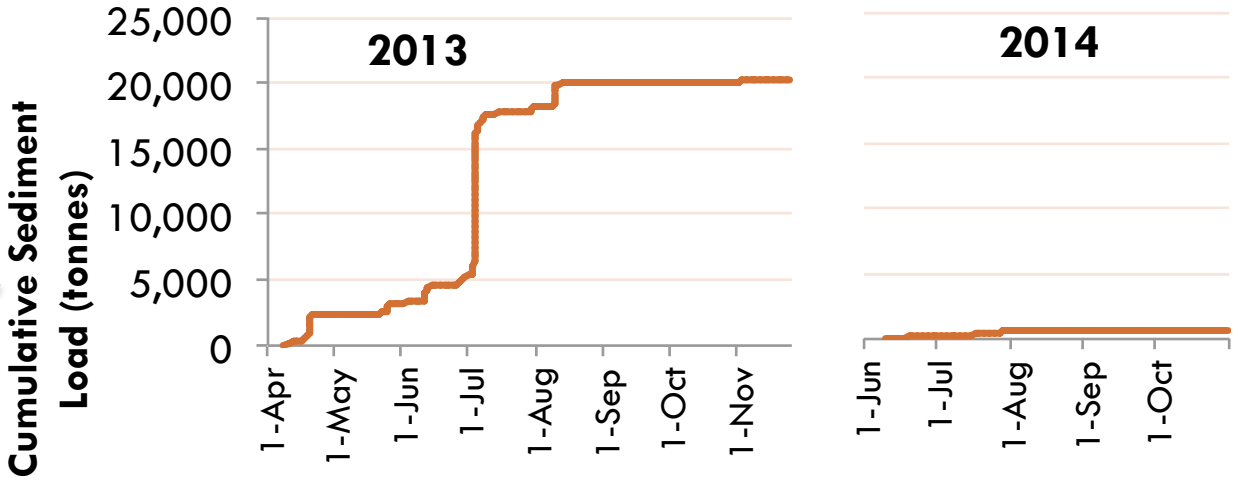
- Clockwise types (Class II) most common in tributaries
- Mad River more varied in hysteresis types observed



Sediment Load Estimation







Hydrology of monitoring period

600+ events identified