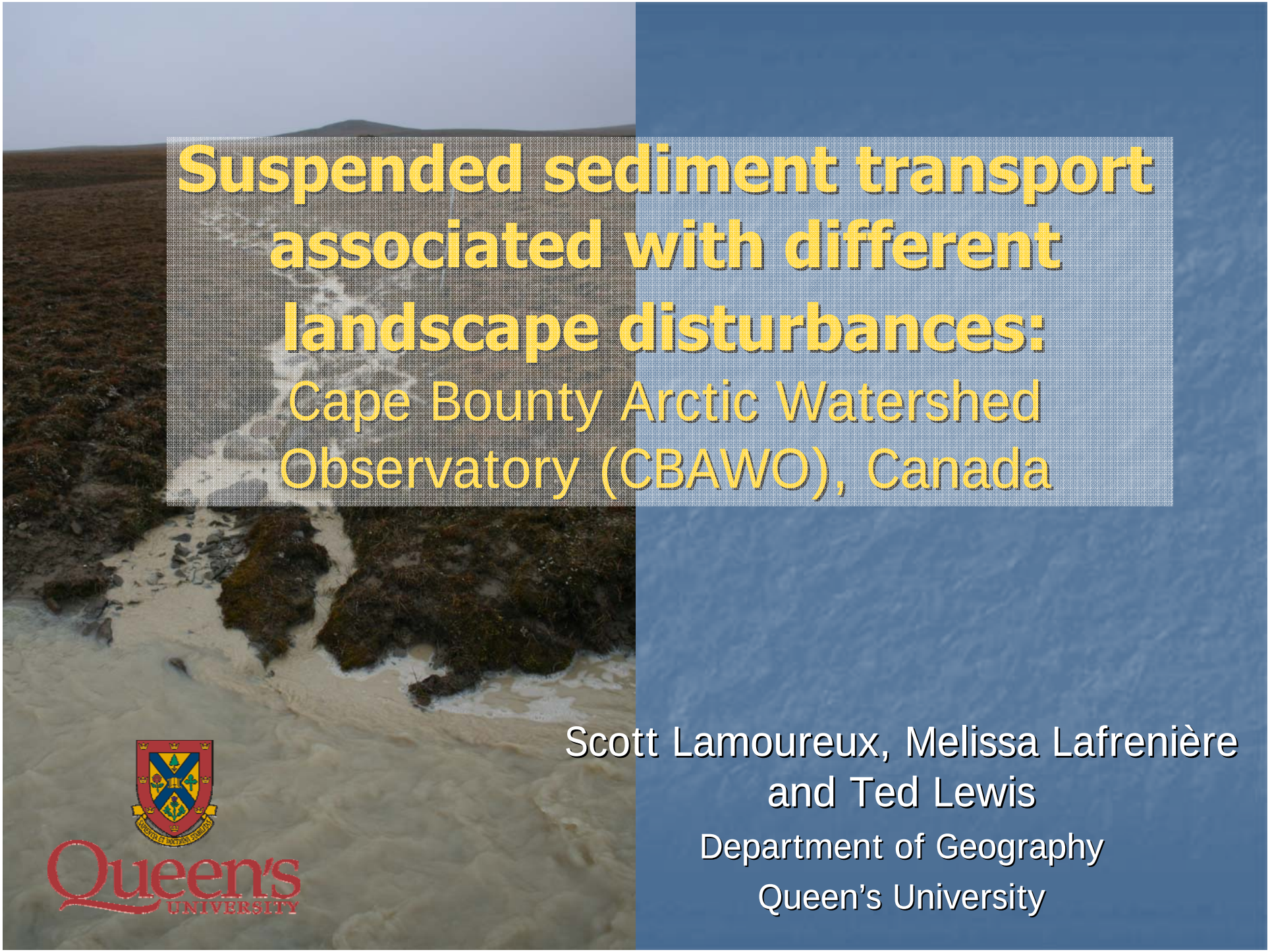

Suspended sediment transport associated with different landscape disturbances:

Cape Bounty Arctic Watershed Observatory (CBAWO), Canada

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Department of Geography

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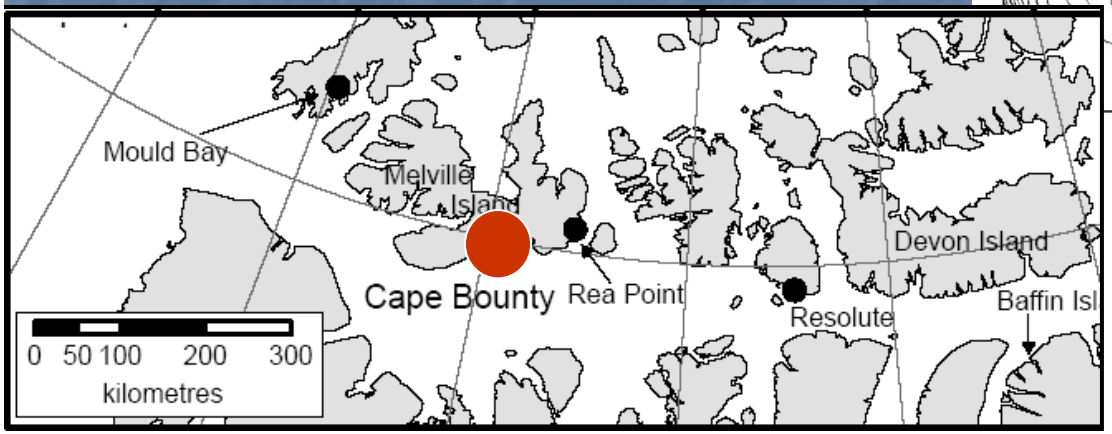
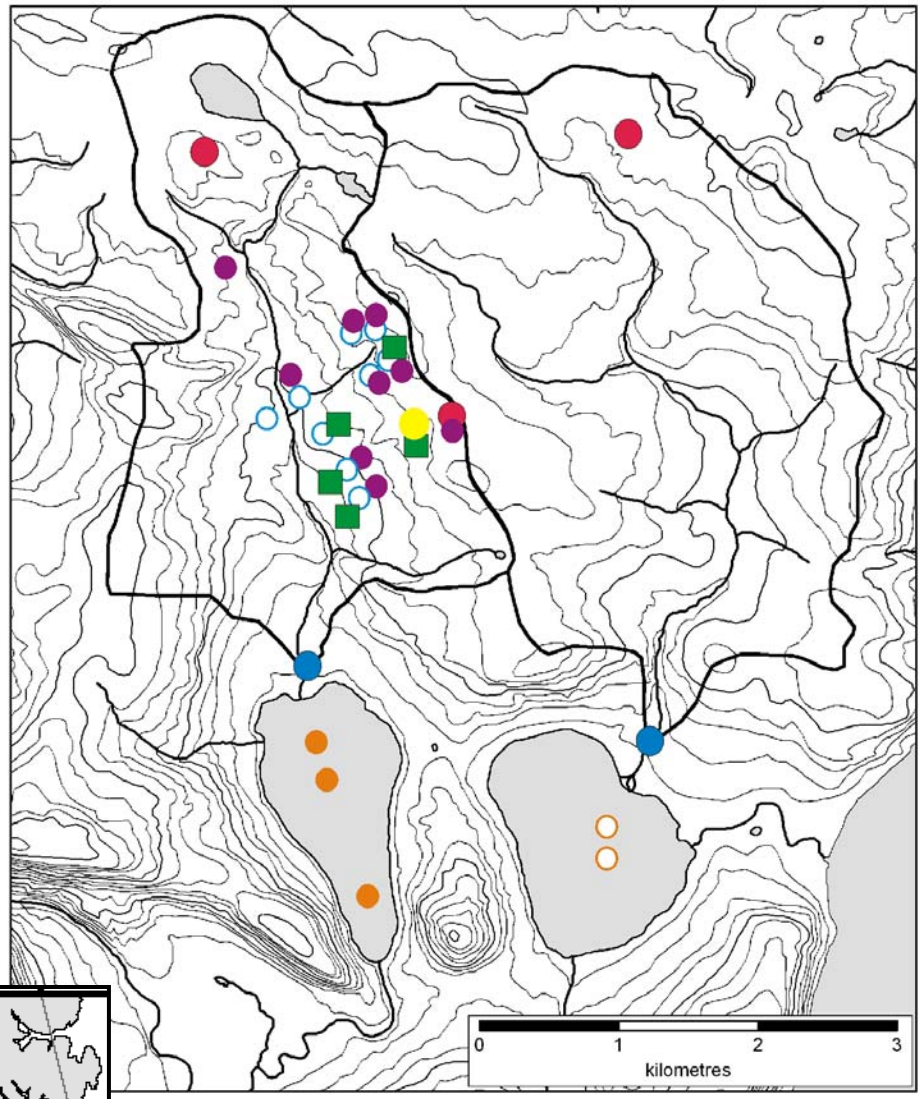
Introduction

- Projected and recent increases to active layer depths have substantial potential implications for landscape stability and watershed yields in polar regions
- Ground ice melting and additional summer precipitation can destabilize slopes and result in active layer detachments (ALD)
- To date, only one study has quantified the watershed-scale sediment fluxes associated with ALD after an episode of intense melting in 2007 (Lamoureux and Lafrenière, in press)
- Hence, the impact of these disturbances on ongoing watershed material fluxes remain poorly constrained

Cape Bounty Arctic Watershed Observatory

- Experimental field site to evaluate the impact of climate change on hydrological, particulate, biochemical and contaminant fluxes
- Related terrestrial processes and responses, particularly to permafrost changes and disturbances



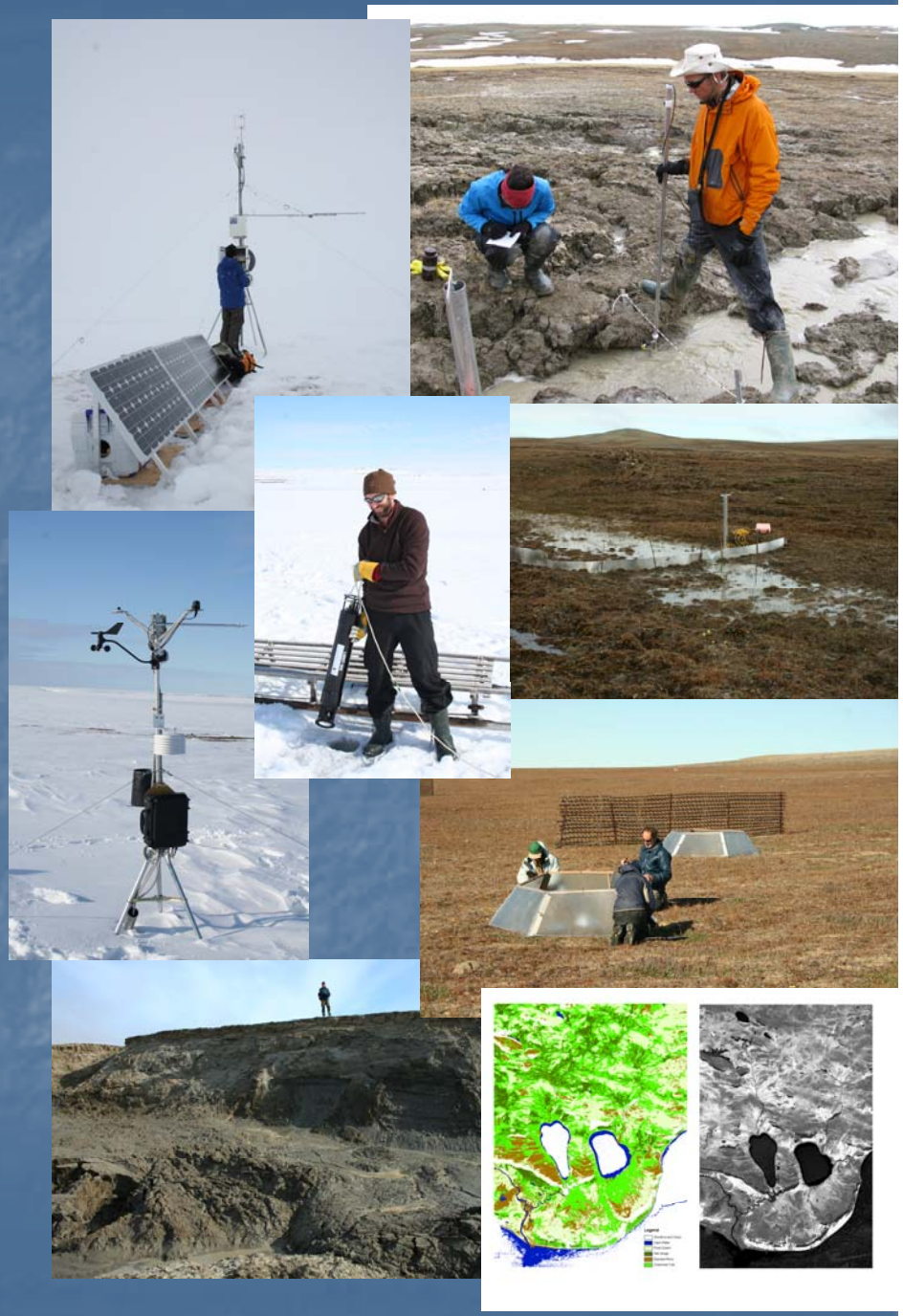


Legend:

- Meteorological station
- River station, pump and manual sampling
- River station, manual sampling
- Soil moisture and active layer temperature station
- Limnology station (CTD, traps, frequent servicing)
- Limnology station (traps, temperature, seasonal servicing)
- Atmospheric flux tower
- **Proposed ITEX/CiCAT vegetation plot sites**

Monitoring program:

- Snow surveys, meteorological stations
- River discharge, suspended sediment, solute, isotope, nutrient and contaminant (Hg) fluxes
  - Nested at paired approximate 0.1, 1 and 10 km^2 scales
- Sedimentary and hydrochemical dynamics in lakes, deposition studies
- Soil gas, nutrient, moisture and vegetation phenology
- Remote sensing of biomass, soil moisture
- Atmospheric CO_2 fluxes
- Sedimentary paleoenvironmental and long term sediment yield work.

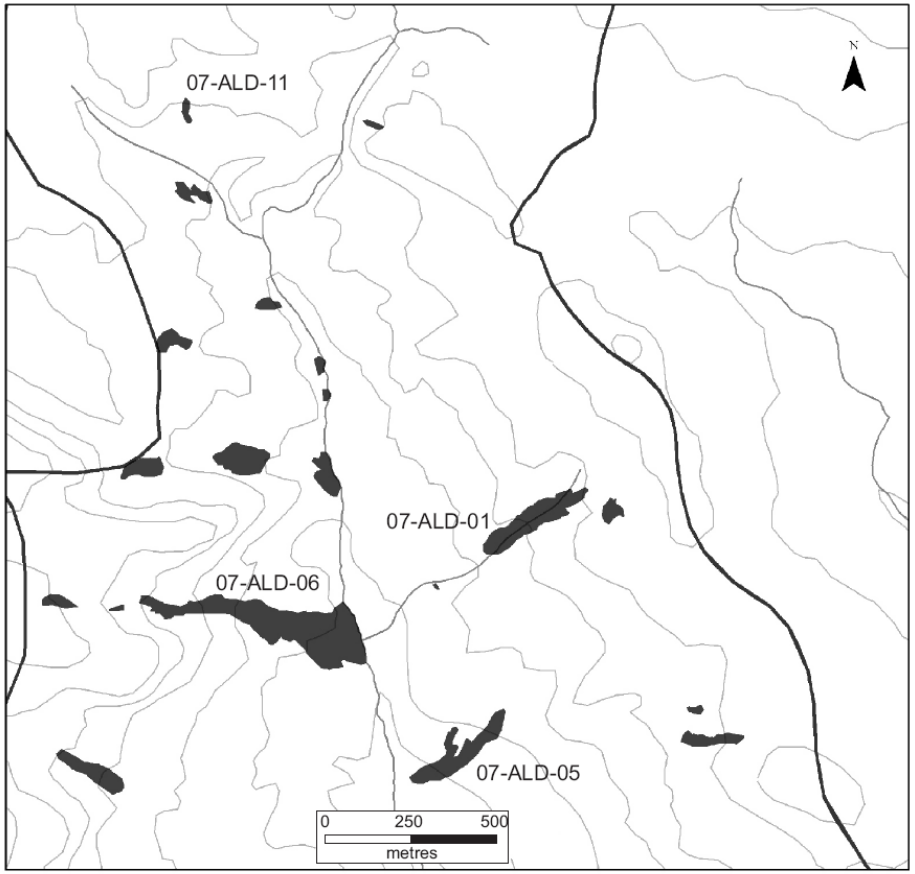


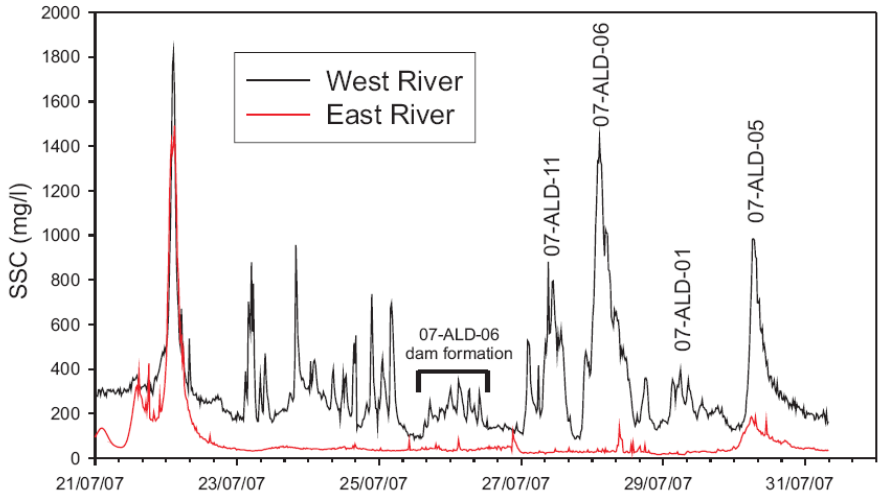
Sediment fluxes:

	West (8.0 km^2)		East (11.6 km$^{2)}$	
Year	**ΣQ (mm)**	**SSQ (Mg)**	**ΣQ (mm)**	**SSQ (Mg)**
2003	57.2	134	64.7	100
2004	100.0	416	112.1	442
2005	67.7	61	76.7	83
2006	155.0	447	120.0	477
2007	127.2	245	113.0	153

- July 2007 was the warmest year on record (mean daily 10.8°C vs. long term 4.0°C)
- Rainfall in late July added to ground ice melt
- ALDs rejuvenated discharge in West River late in 2007
- Turbid conditions for remainder of season
- No discernable effect on the East River
  - Some ALD likely occurred after monitoring ceased in 2007

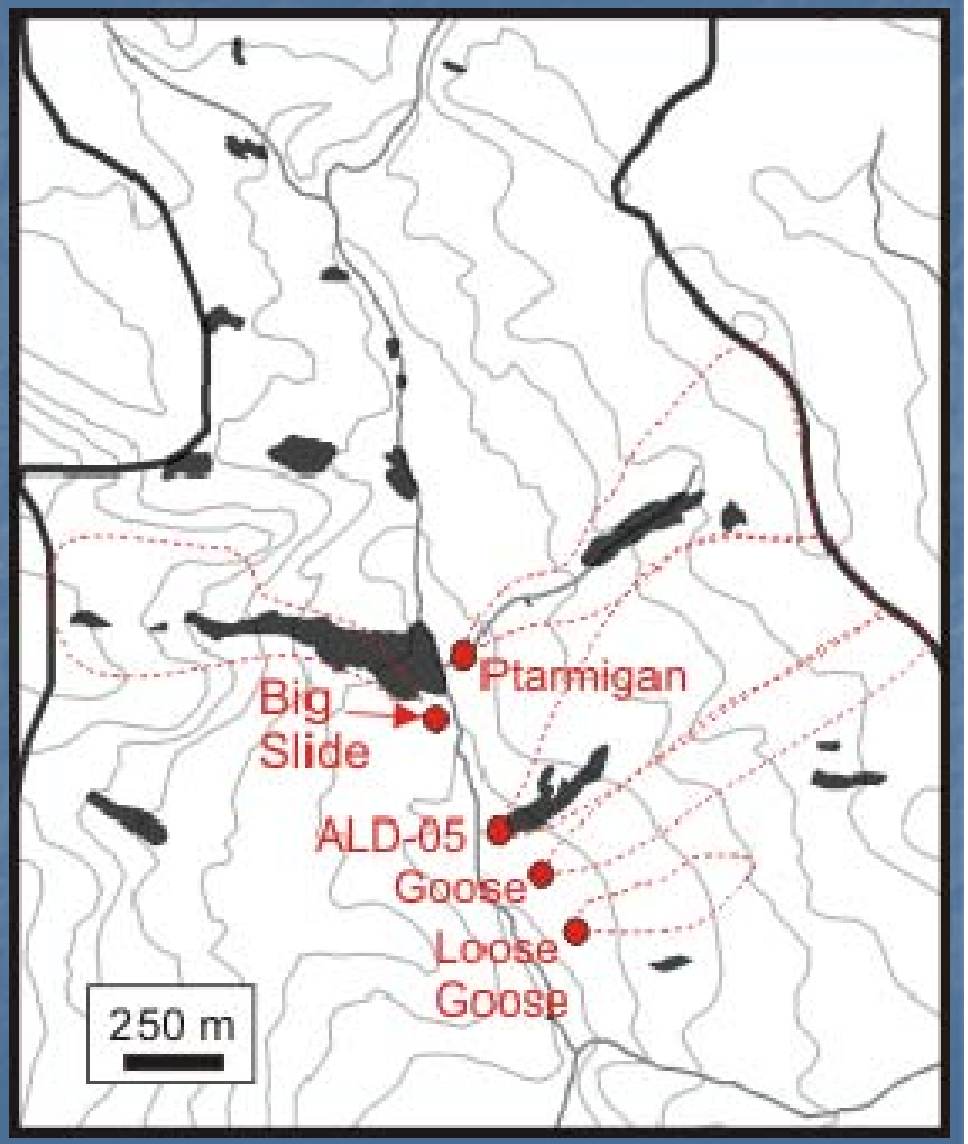
Lamoureux and Lafrenière, in press





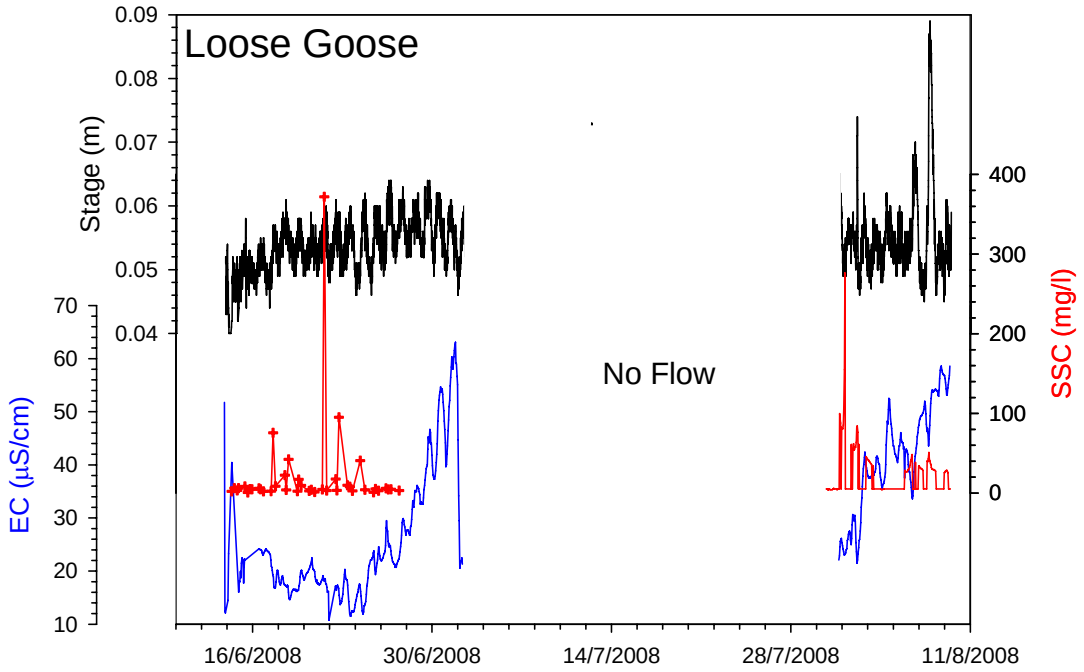
2008 targeted flux monitoring:

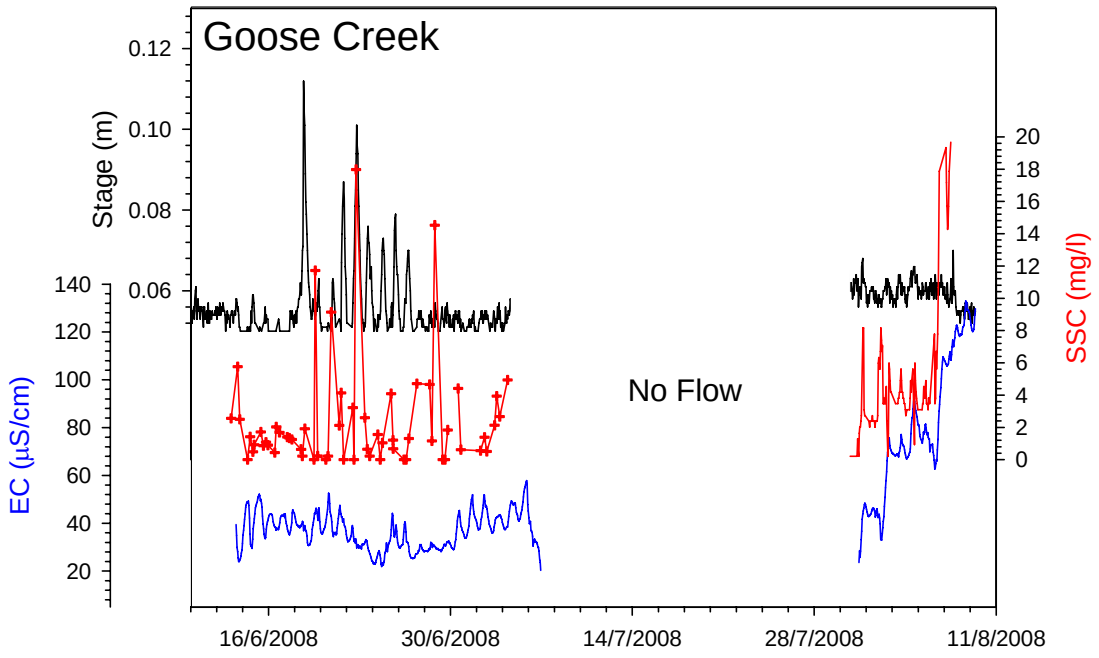
- Goose: undisturbed
- Loose Goose: disturbed prior to 1952
- ALD-05: 2007 disturbance, limited channelization
- Big Slide: largest 2007 disturbance, perennial snow bank
- Ptarmigan: 2007 disturbance, pre-existing channels



Undisturbed or old (pre-1950) fluxes

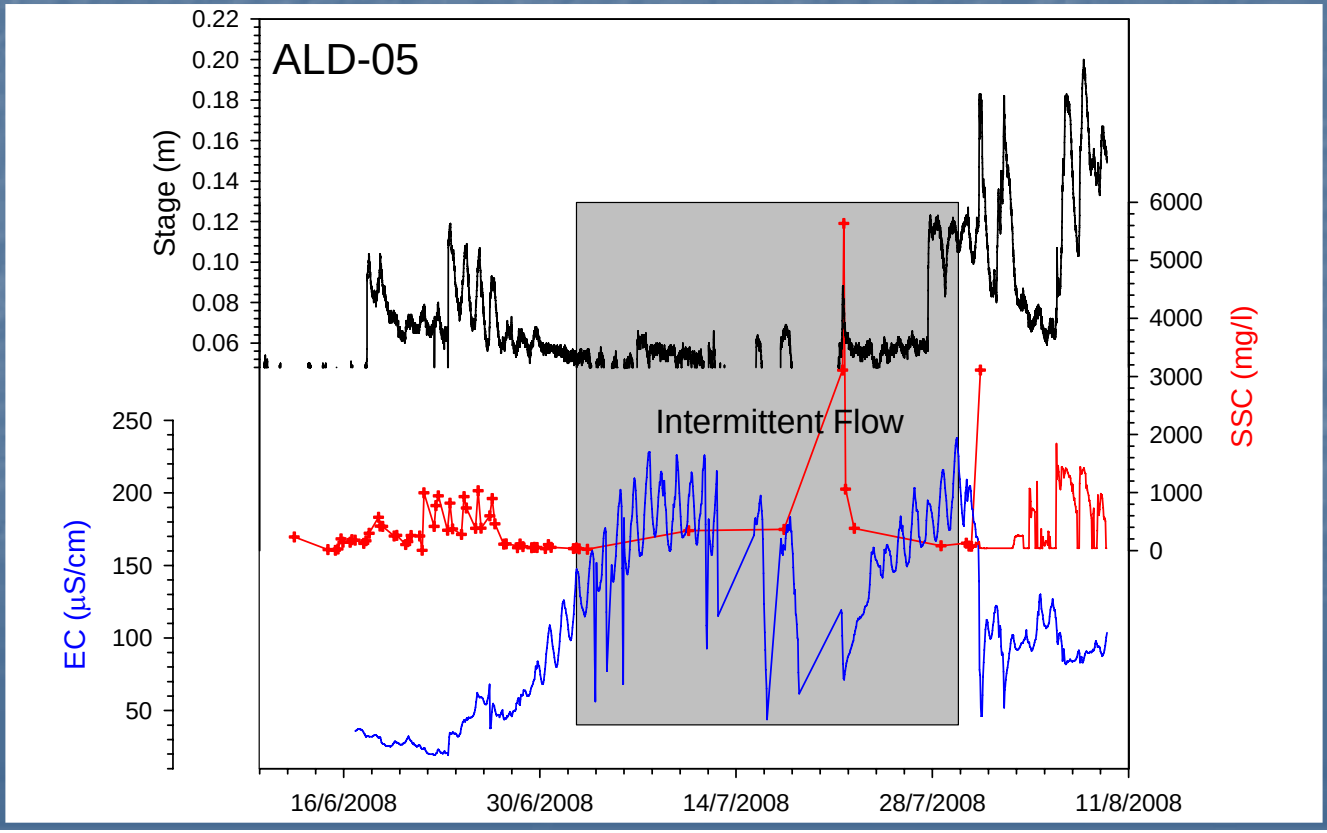
- Ephemeral flow and fluxes
- Low sediment loads throughout season
- Limited evidence for sporadic enhanced transport in the disturbed site during peak snow melt discharge and rainfall runoff





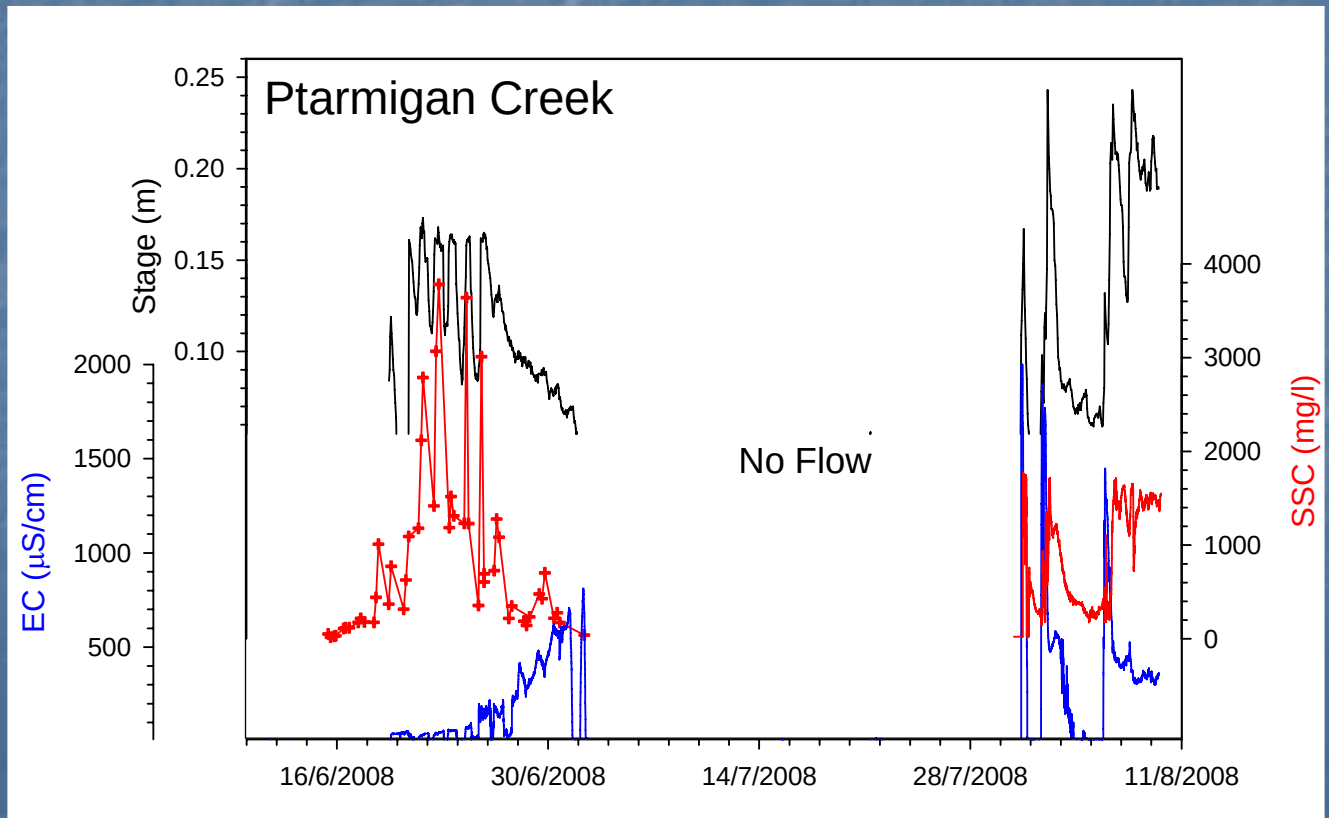
Recent disturbance, limited channelization:

- Greater peak discharge and sediment transport response
  - Sediment concentrations reached >1000 mg/l during snowmelt and rainfall discharge events
- Limited transport during mid-season intermittent flow
  - Extensive ponding of flow mid-season



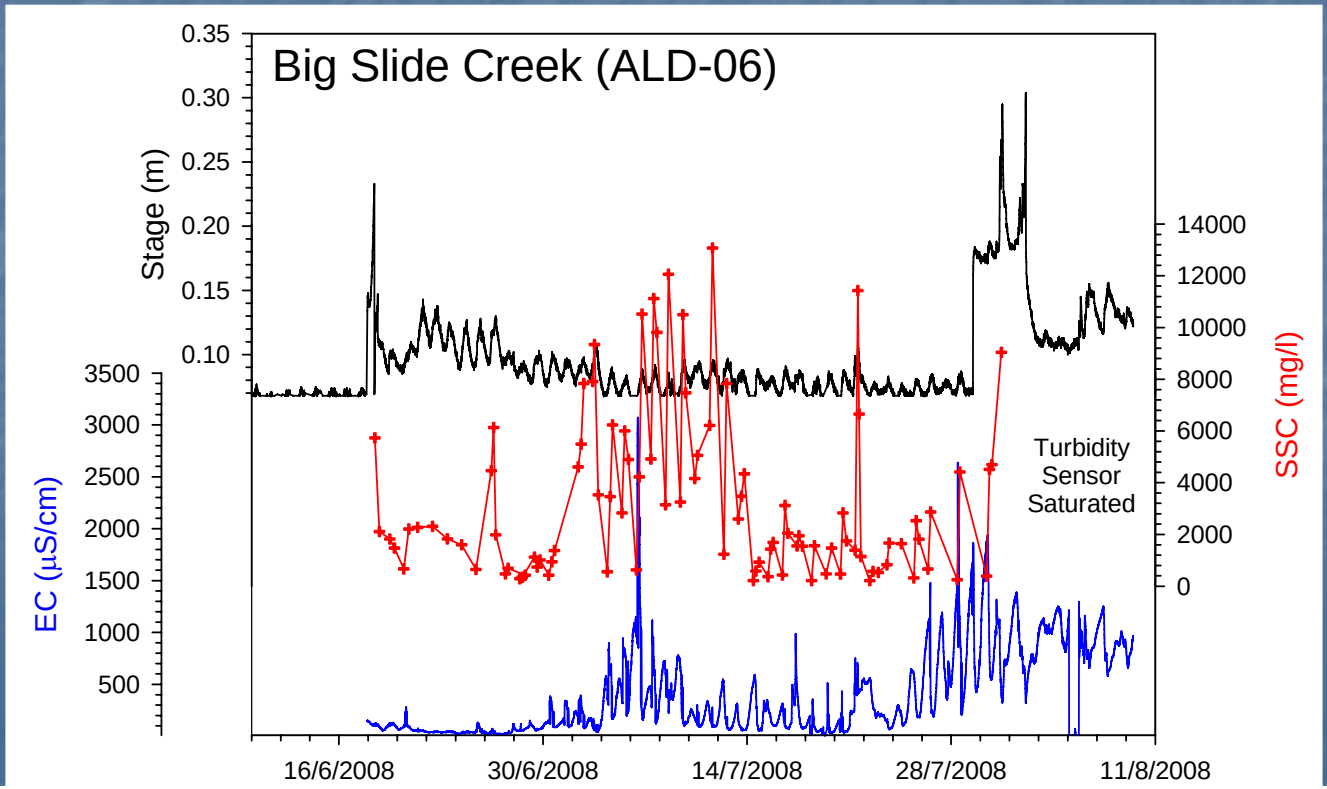
Recent disturbance, extensive channelization:

- Substantial and high sediment transport response during snowmelt period
  - Concentrations exceed 3000 mg/l and sustained at >1000 mg/l
- Limited flow after snowmelt until rainfall rejuvenation



Recent disturbance, extensive channelization, sustained snow melt:

- High sediment load throughout season, reaching maxima after snowmelt peak
  - Load typically >2000 mg/l, frequently >4000 mg/l
- Flow and sediment transport continues throughout the season due to melt from perennial snow bank



Summary results:

Station	Minimum (mg/l)	Maximum (mg/l)	Mean (mg/l)
Big Slide	211.2	13 075.0	3255.6
Ptarmigan	17.4	15 050.0	1140.2
ALD-05	3.1	5 635.3	469.9
Loose Goose	0.7	372.0	20.2
Goose	0.0	193.7	5.5

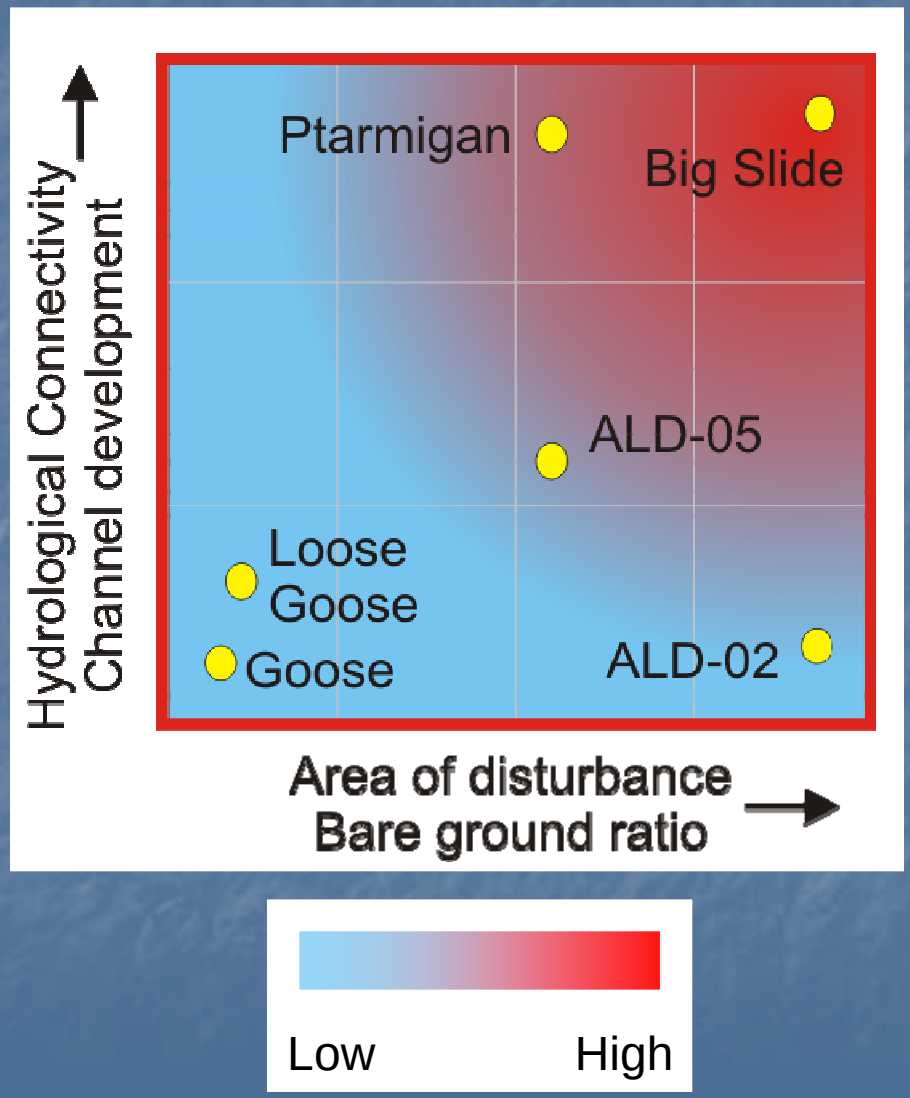
Increasing disturbance →

Key factors in sediment yield response:

- Establishment of channel
  - Crucial for generating through flow and sediment export
  - Complex, discontinuous drainage in ALD is not conducive for rapid routing of flow
    - Frequent ponding and sedimentation
- Water supply
  - Sustained flow from larger watershed or residual snow important in overall fluxes
  - Mid-season low flows encourage formation of channels

Geomorphic yield framework:

- Hydrological connectivity of many disturbances may be quite limited
  - Sediment may be stored down slope and not reach main channel
- Limited channelization within the ALD further reduces fluxes
- Disturbances may capture or divert pre-existing slope drainage patterns
- Hydrologically-isolated ALD like Loose Goose appear to stabilize in several decades, but may still exhibit increased sediment loads at peak flow periods due to exposed soil surfaces



Conclusions:

- Hydrogeomorphic response of ALD is complex
- Depends on morphology, hydrological connectivity, and hydrological regime
- Formation of new slope channels, particularly where flow is sustained beyond the spring freshet has the maximum yield impact
  - Channelization will reduce erosion by focusing runoff
- Isolated ALD, while heavily disturbed, do not promote through flow and sediment transport and have a limited initial (~1-year) effect
  - Stabilization of these ALD will likely not increase yield in subsequent years.
- ALD relaxation times in terms of sediment transport remain poorly understood
  - Sedimentary record, vegetation studies and modelling may further assist

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