

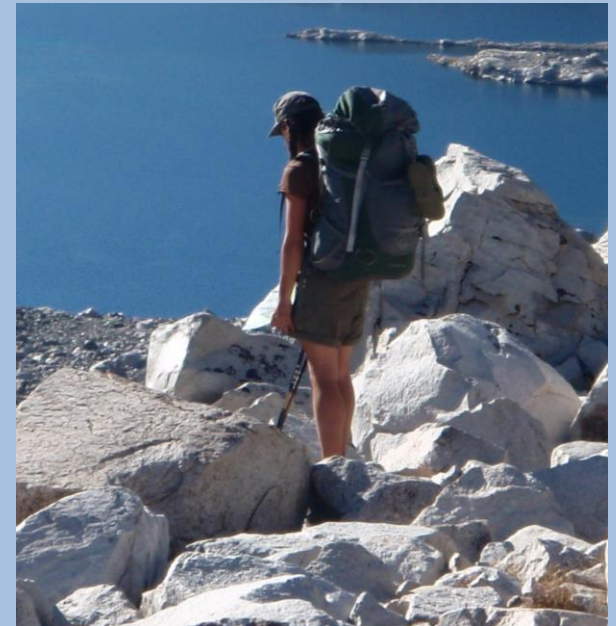


Effects of pack stock use and backpackers on water quality in Yosemite National Park

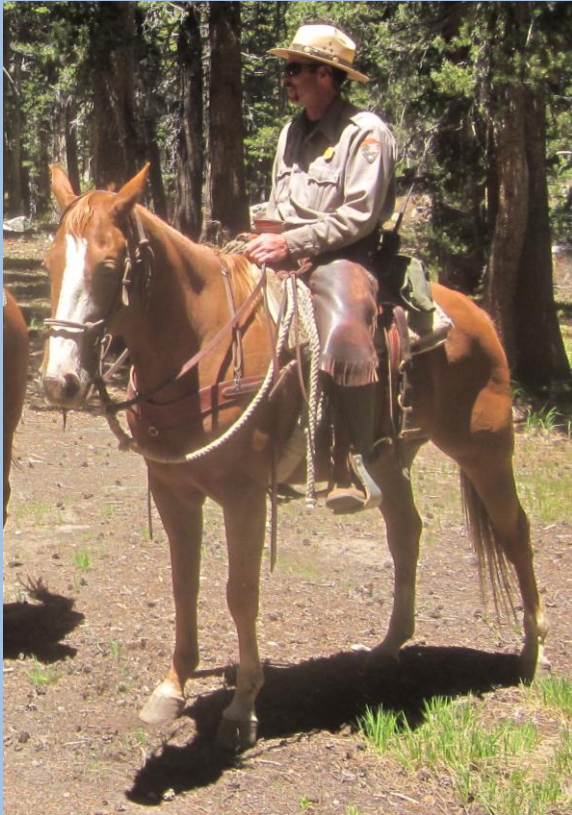
Study period: 2012-2014, preliminary results

Harrison Forrester¹, Dave Clow², Jim Roche¹

1.Yosemite National Park, CA., 2.USGS Colorado Water Science Center



Pack stock use: primarily horses and mules



Grazing and trail use :

Soil loosening

Fecal deposition

Stream crossings: direct physical interaction

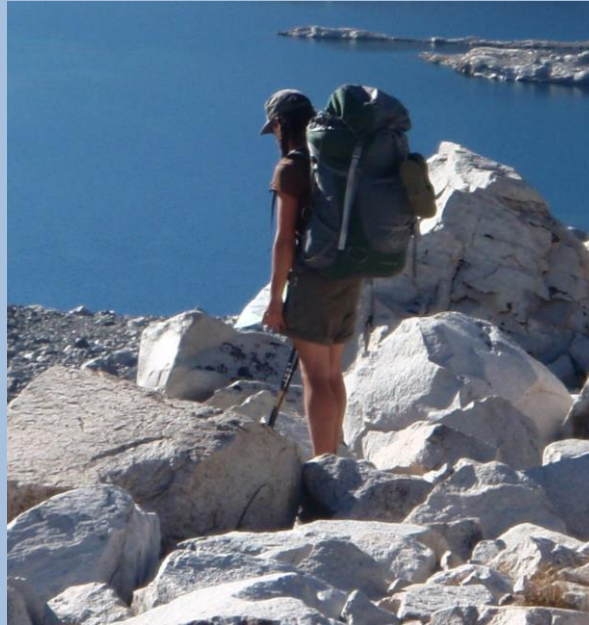


Trail use and grazing:

Soil loosening

Fecal deposition

Backpackers



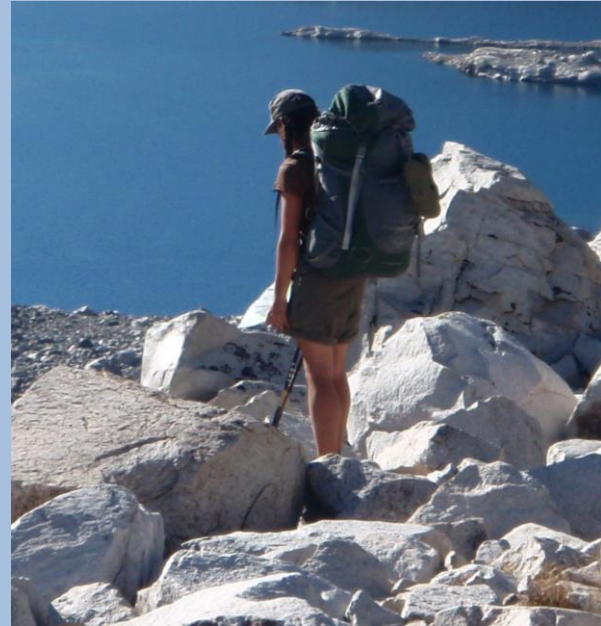
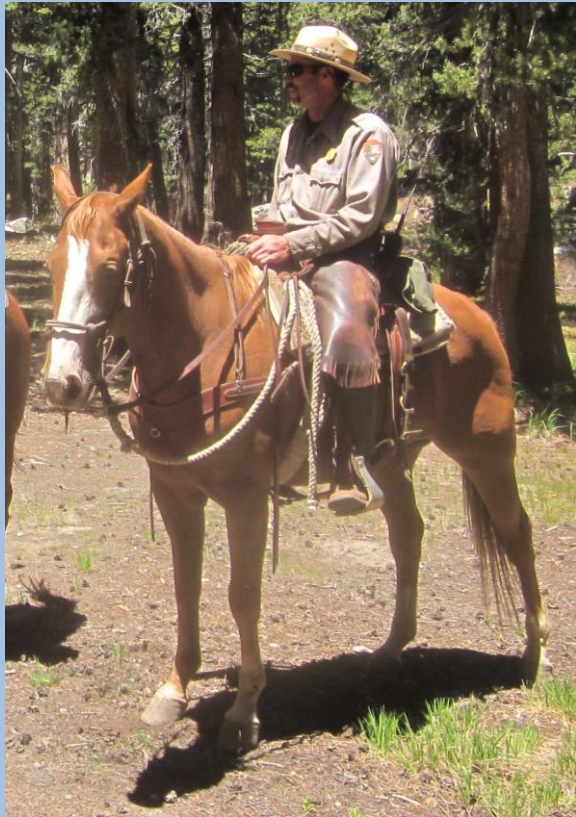
Camping:

Soil compaction

Fecal deposition

- Contaminants of emerging concern (e.g. pharmaceuticals)

Most visitor use occurs on hillslopes, not directly in water bodies



Effects during storms:

Soil loosening, compaction

Fecal deposition, transport

PAIRED SAMPLING UPSTREAM AND DOWNSTREAM

- ROUTINE
- DURING STORMS



Water Quality Indicators

- *E. coli*
- *Nutrients (C,N,P)*
- *Hormones*
- *Suspended Sediment (SSC)*



Fecal deposition, transport

Soil loosening, compaction, erosion

Study Area

Synoptic survey Park-wide water



National Park Service
U.S. Department of the Interior
Yosemite National Park
Resources Management and Science

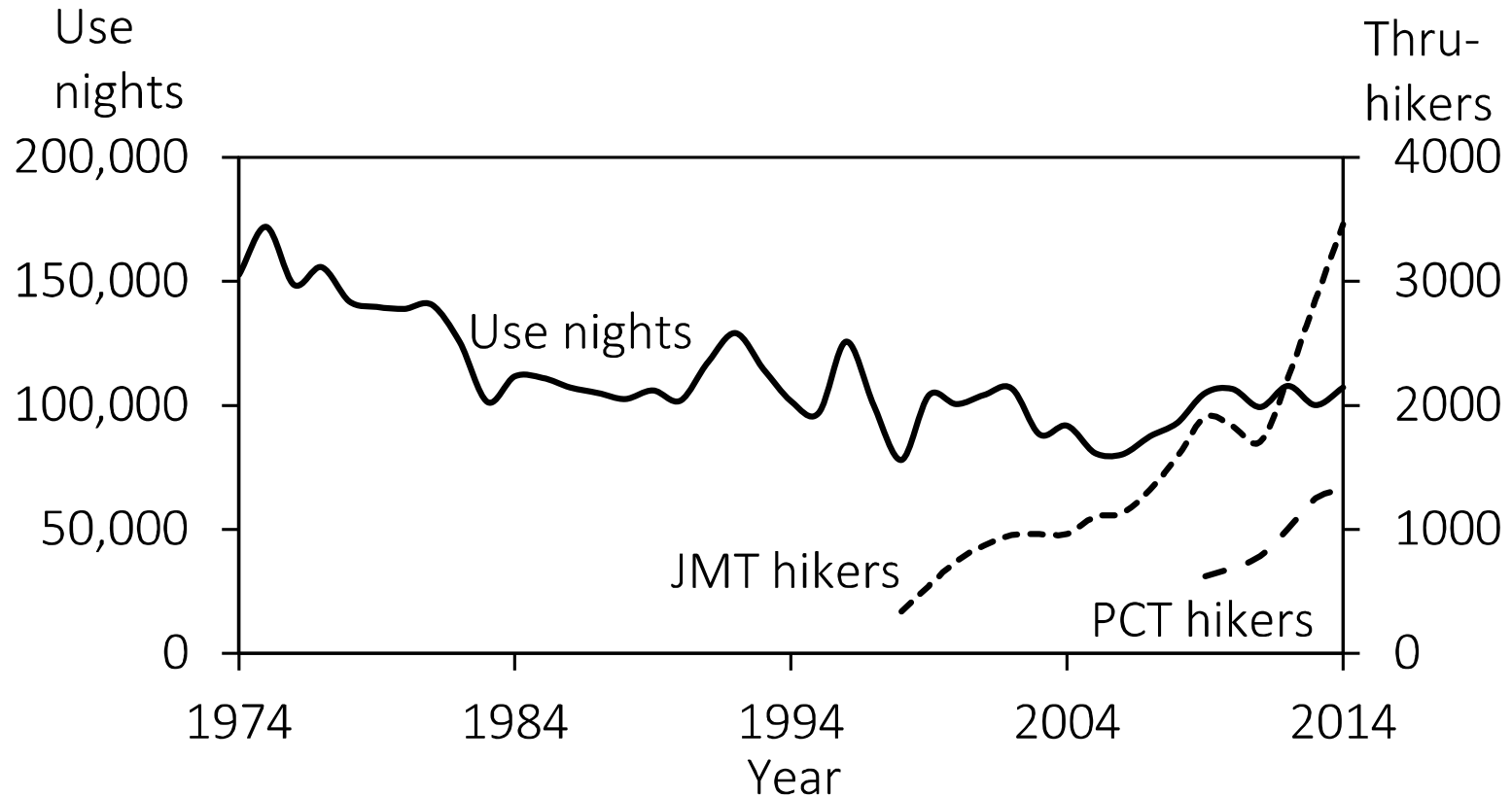
Protecting Threatened & Endangered Wildlife in Wilderness



Molly Thompson, Rachel Mazur, Rob Grasso, & Sarah Stock



Backpacker use: generally increasing since 2006



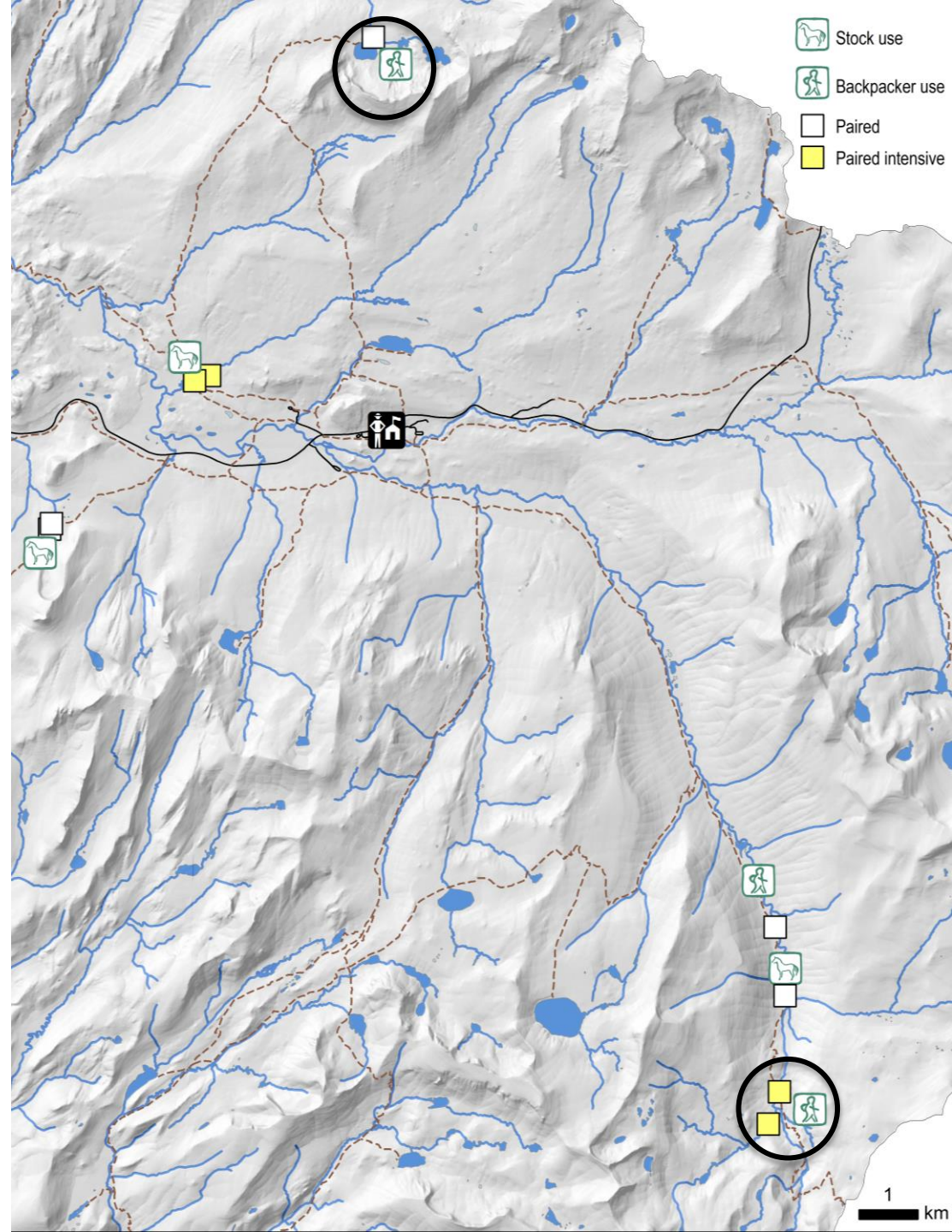
Results:

Routine Sampling

Upstream/Downstream

Backpacker use

- moderate-heavy backpacker use
- increases in water quality indicators observed downstream
- increases were small



Pack stock use in Yosemite: overnight and day use

Administrative:

- Ranger patrol
- Search and Rescue
- Trail maintenance
- Scientific research

Concessionaire:

- High Sierra Camps
- Recreational day rides (stopped after 2015)

Commercial:

- Overnight guided trips
- Drop trips

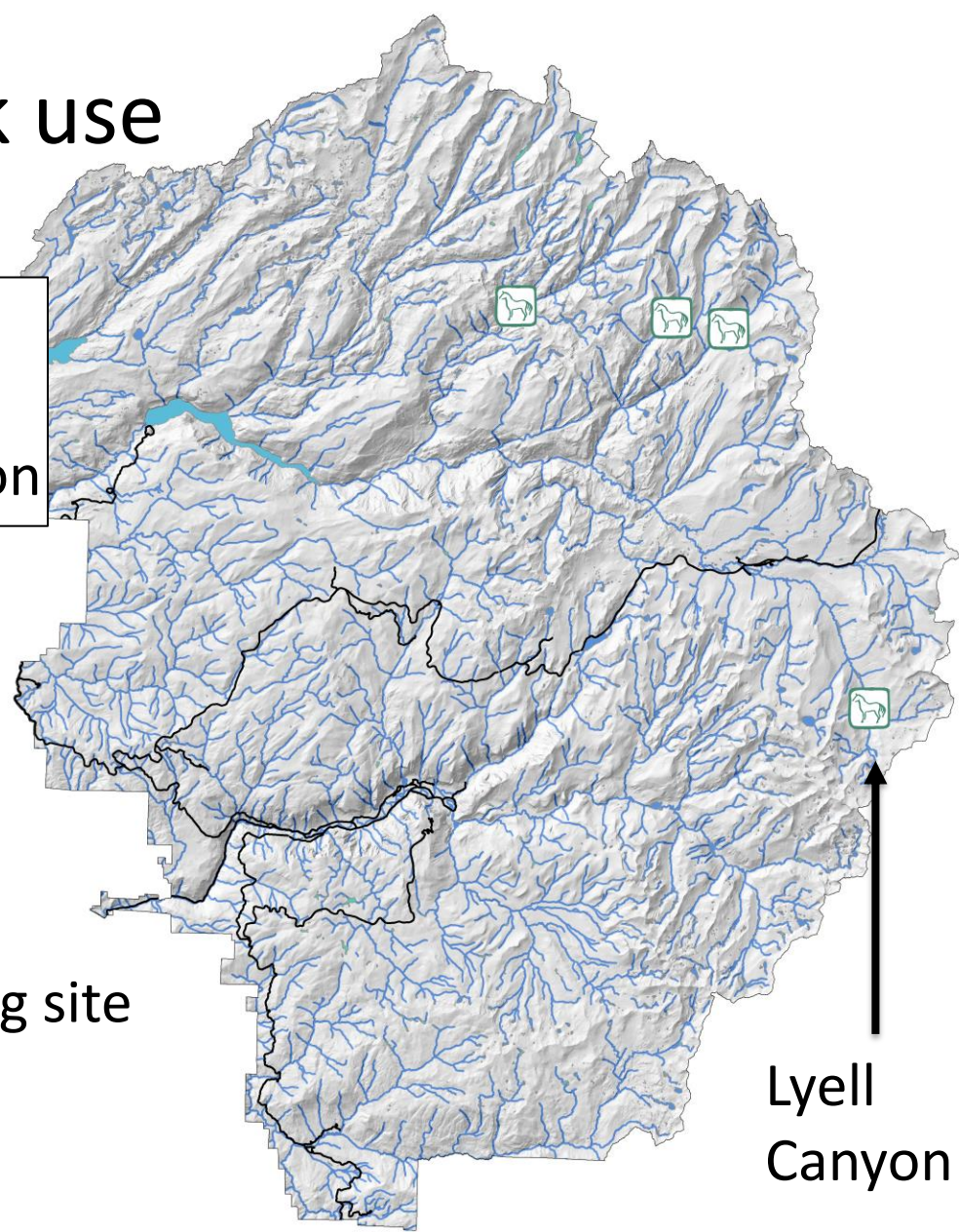
Private use



Overnight pack stock use

2012-2014 Yosemite park-wide
overnight pack stock use/km²
was 25% of Sequoia & Kings Canyon

Lyell Canyon:
most popular pack stock grazing site
in Yosemite



Lyell
Canyon

Results:

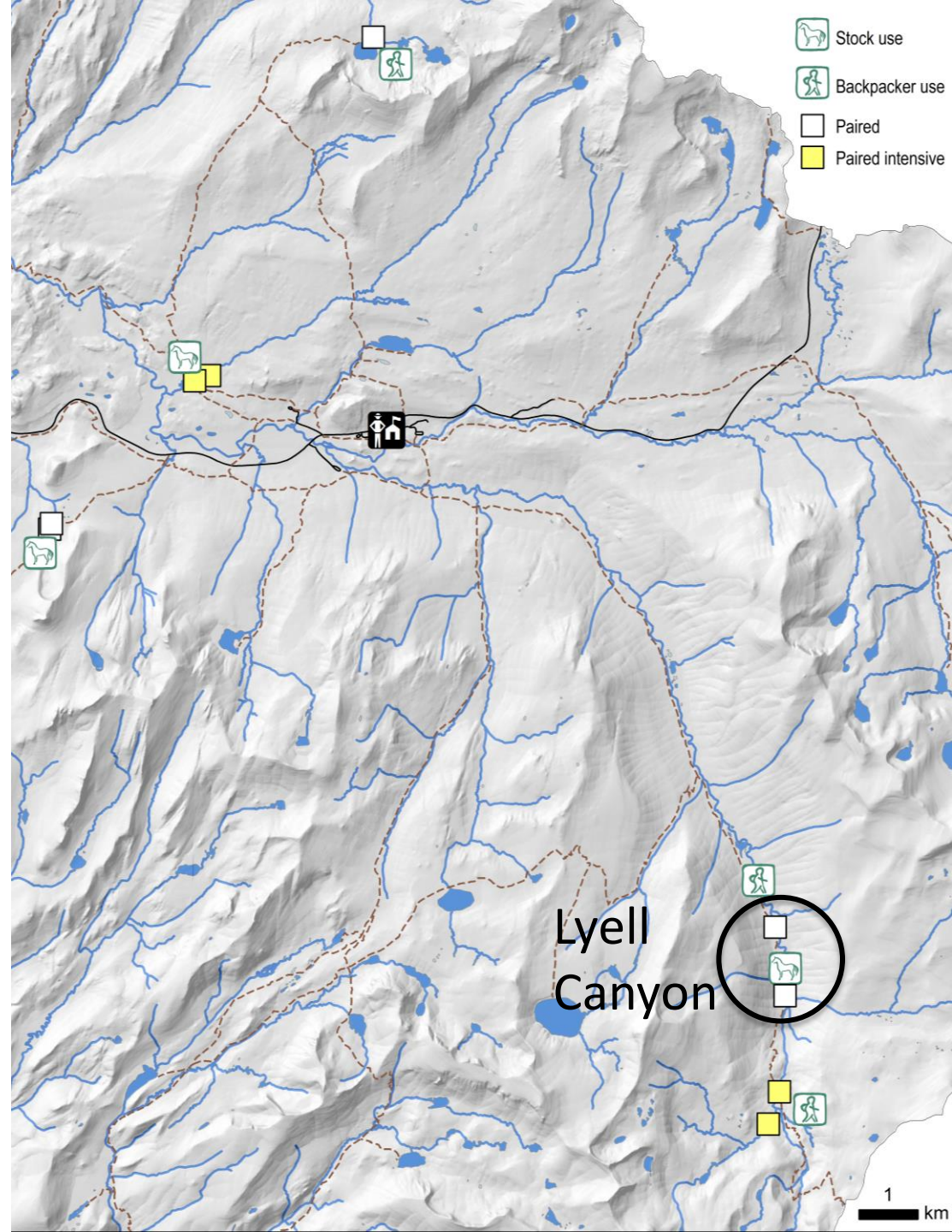
Routine Sampling

Upstream/Downstream

Pack stock grazing

Lyell Canyon:

- During the study period, use was 50% of 2004-2011 mean
- *No increases in water quality indicators observed downstream*



Packstock Day Use: 80% NPS concessionaire

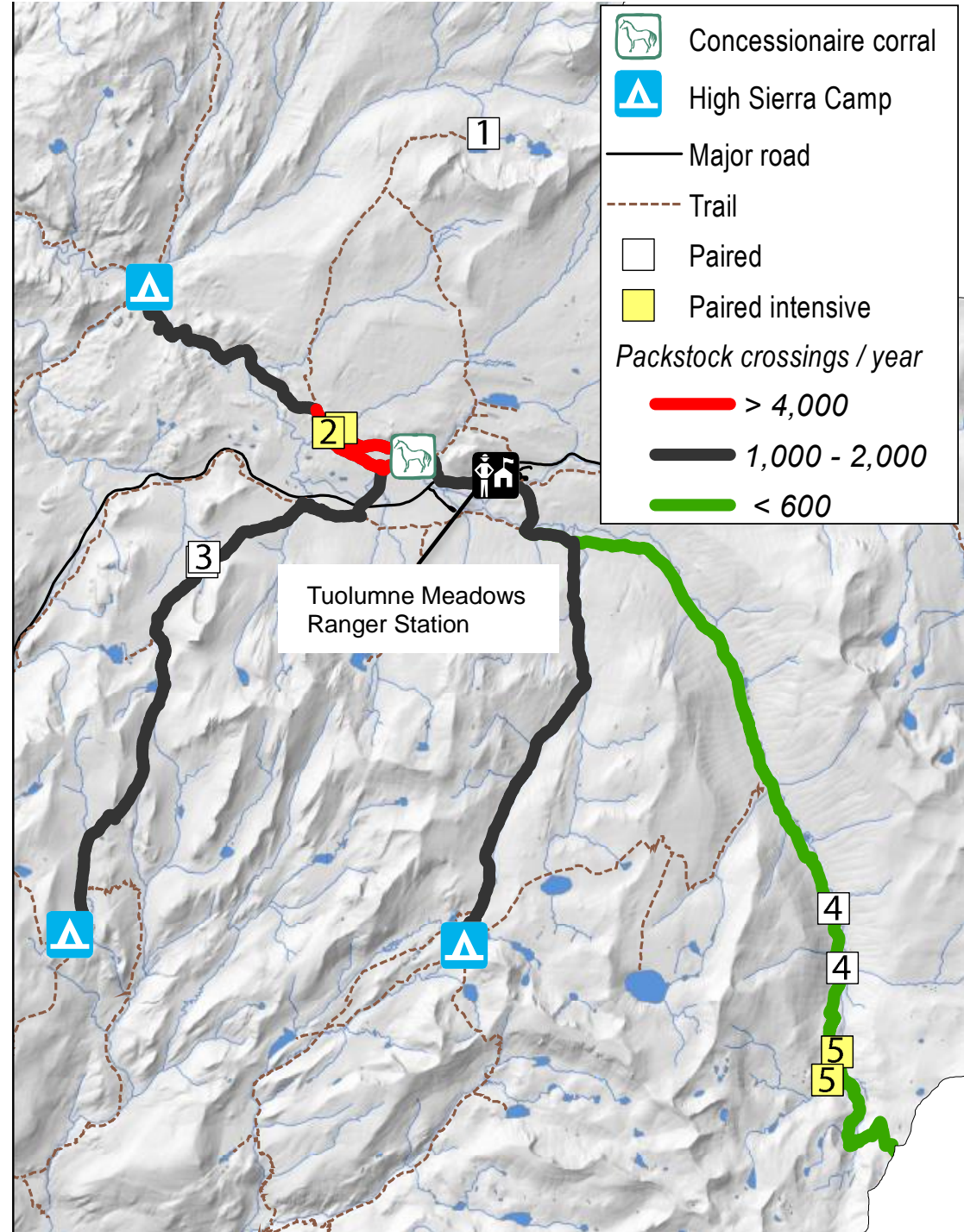
Name	Stock Days	
Incidental Business Permits	2,241	8%
National Park Service - Backcountry Utilities	557	2%
National Park Service - Miscellaneous	140	1%
National Park Service - Ranger patrol	495	2%
National Park Service - Trail Maintenance	2,254	8%
Private	422	2%
Yosemite Concession Services – Day Rides	16,780	63%
Yosemite Concession Services – Special Rides	527	2%
Yosemite Concession Services - Supplies	3,185	12%
Total	26,601	

YOSE Wilderness Office, 2004

Pack stock trail use

High Sierra Camps:

- “potential wilderness additions”
- provide food and lodging services
- operated by NPS concessionaire



Results:

Routine sampling

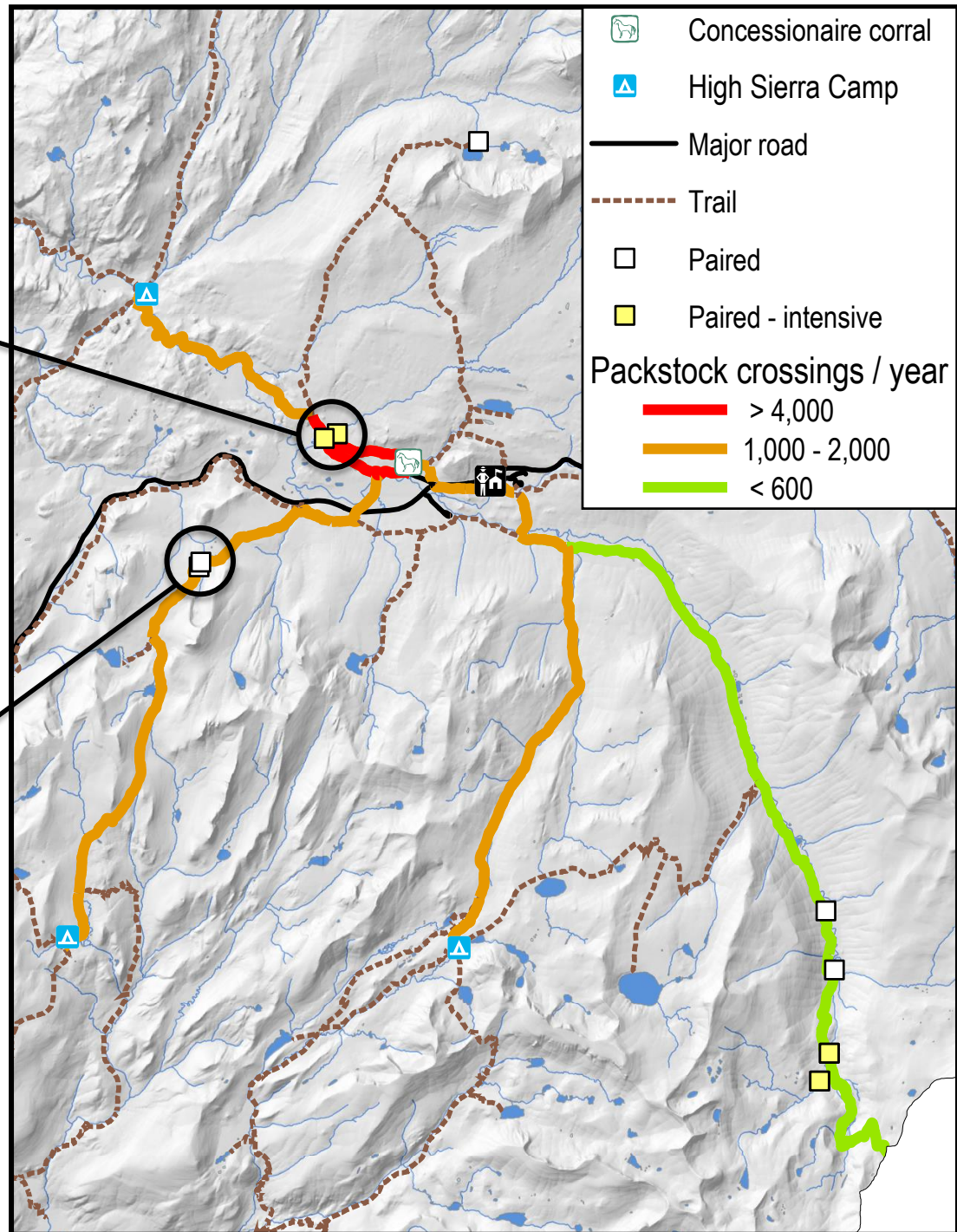
Packstock trail use

Delaney Creek at PCT crossing:

- 2012-2014 mean crossings: 5000
- stream crossing width: 10 m

Cathedral Spring at JMT crossing:

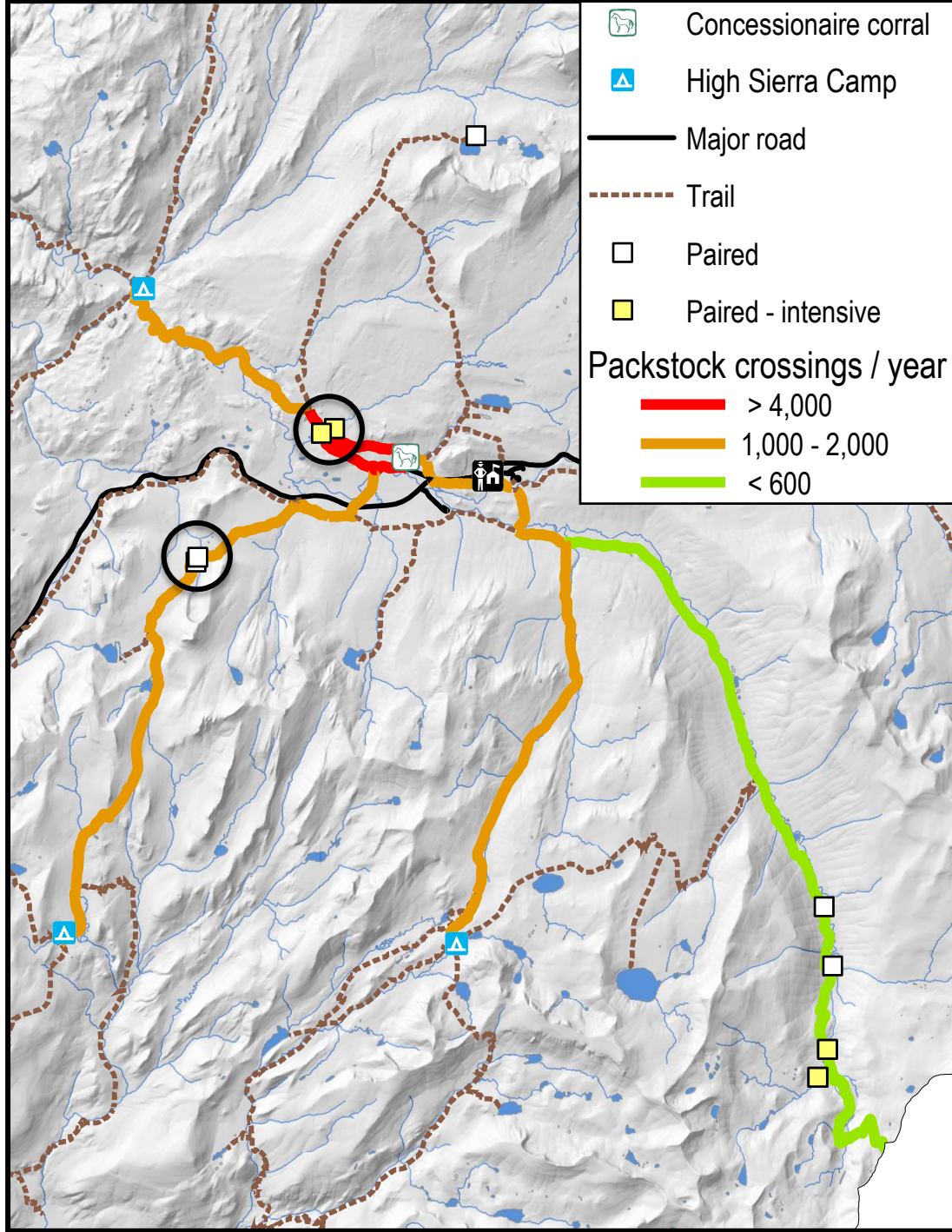
- 2012-2014 mean crossings: 1700
- stream crossing width: 1 m



Results:
Routine sampling
Packstock trail use

increase in water quality
indicators observed downstream

- larger increase at Delaney Creek
- more packstock crossings
 - longer wetted width
 - more direct physical interaction



Results:

Hormone sampling

11-Ketotestosterone

17-alpha-Estradiol

17-alpha-Ethinyl estradiol

17-beta-Estradiol

human

3-beta-Coprostanol

4-Androstene-3,17-dione

Bisphenol A

Cholesterol

cis-Androsterone

Dihydrotestosterone

Epitestosterone

Equilenin

Equilin

Estriol

Estrone

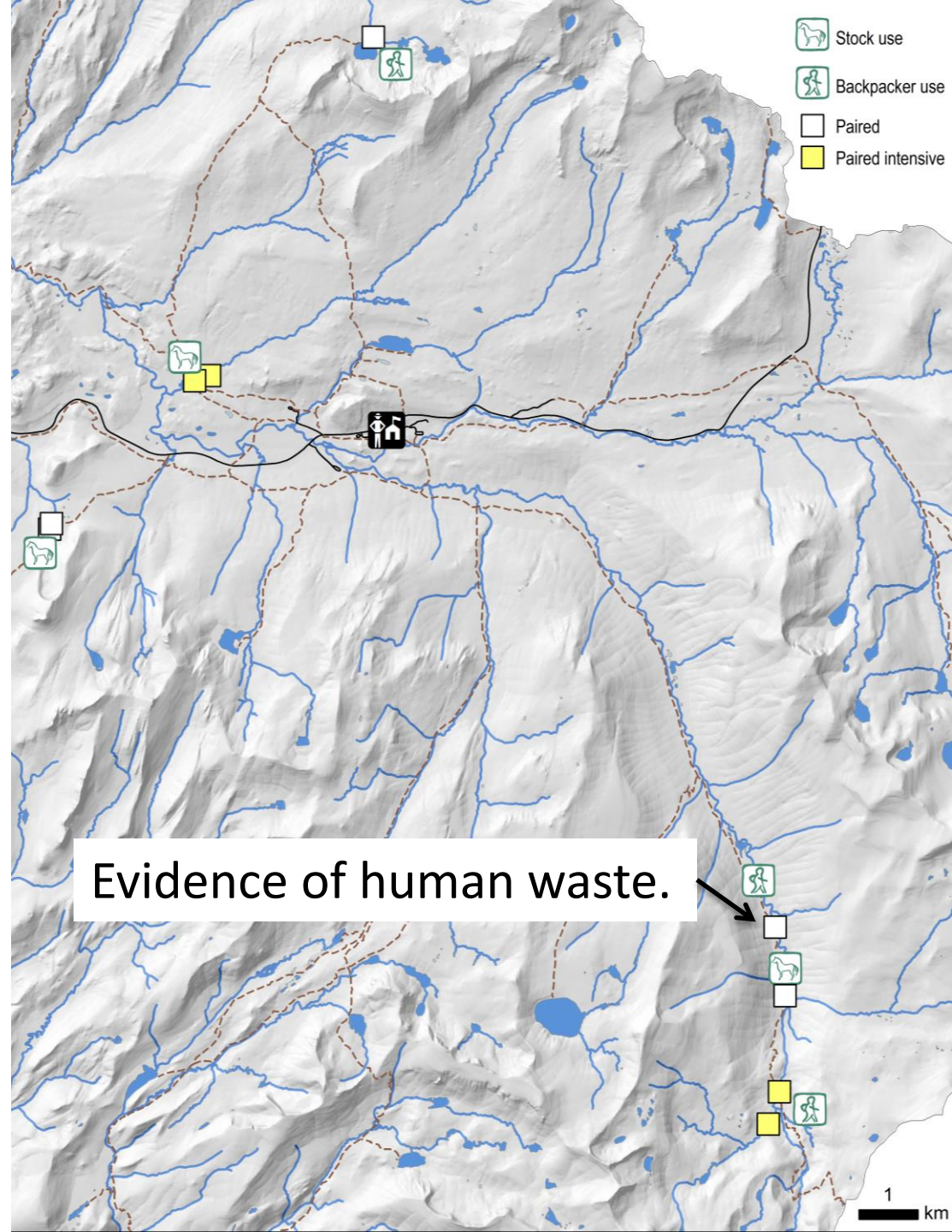
Mestranol

Norethindrone

Progesterone

Testosterone

trans-Diethylstilbestrol



Results:

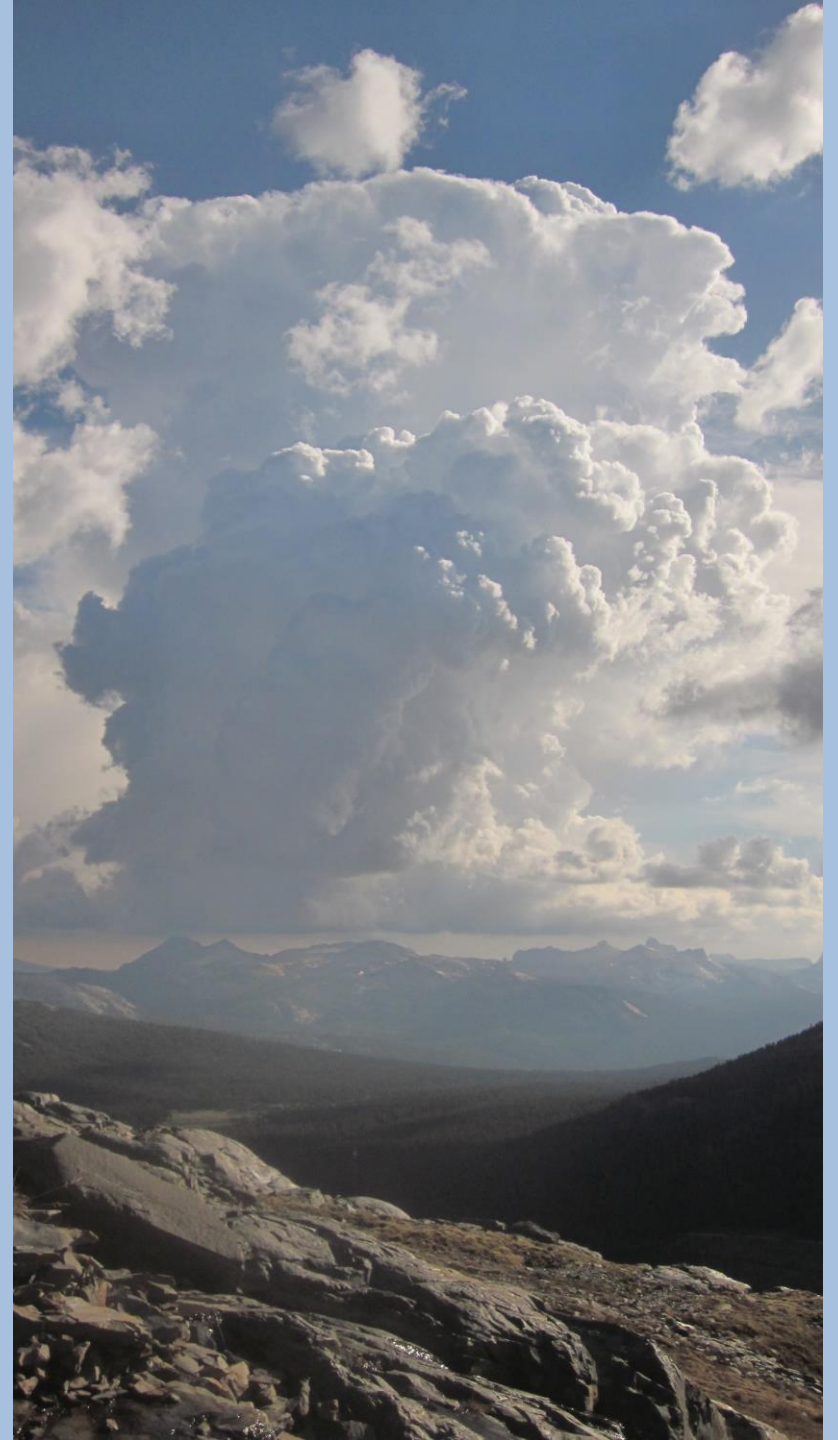
Routine sampling recap

1. Detectable changes in concentrations downstream from backpacker camping and pack stock stream crossings.
2. Most changes were small.
3. Strongest evidence of effects at packstock stream crossings, likely from direct physical interaction with stream.
4. Hormone sampling revealed definitively human sourced estrogen compounds.



Storm Sampling

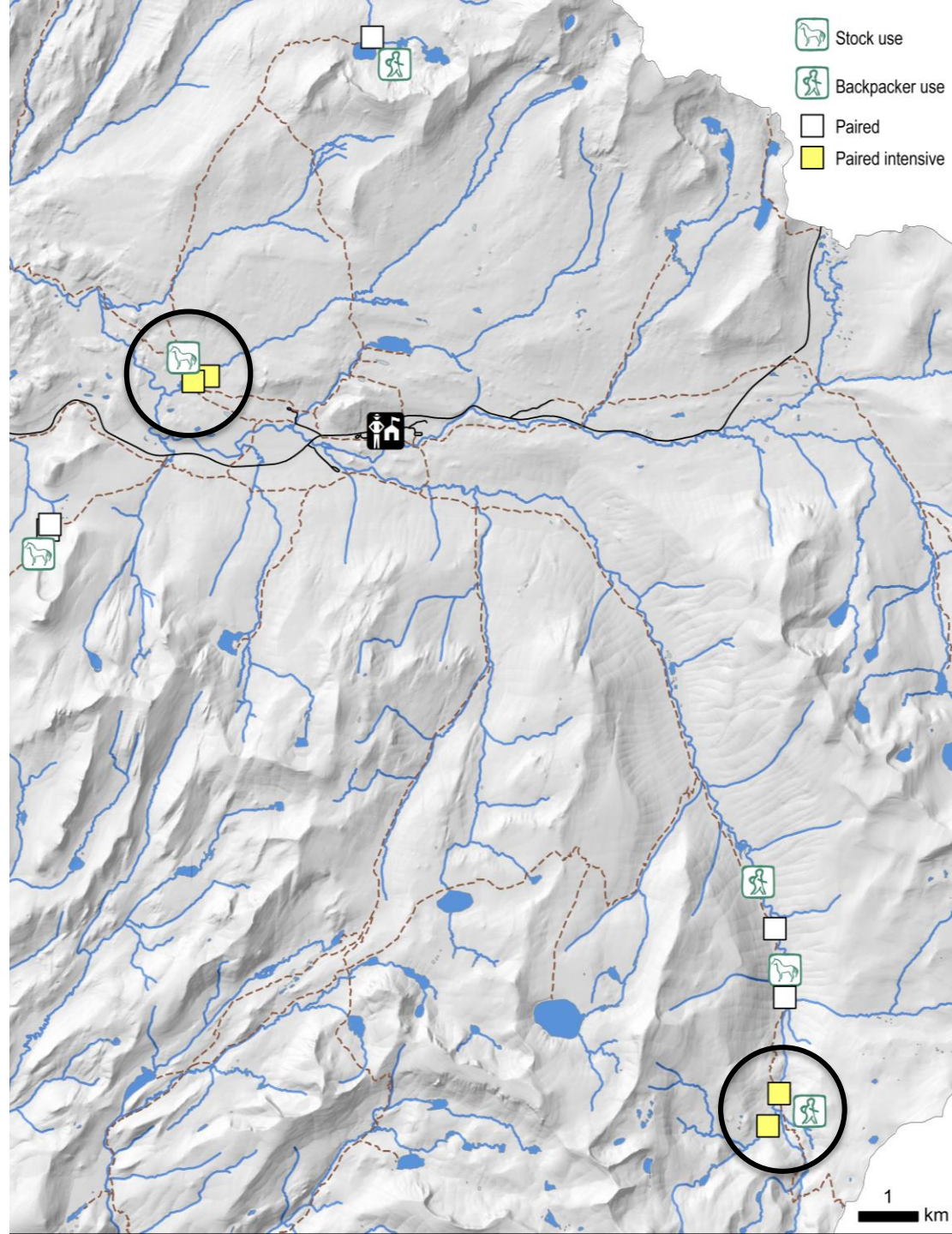




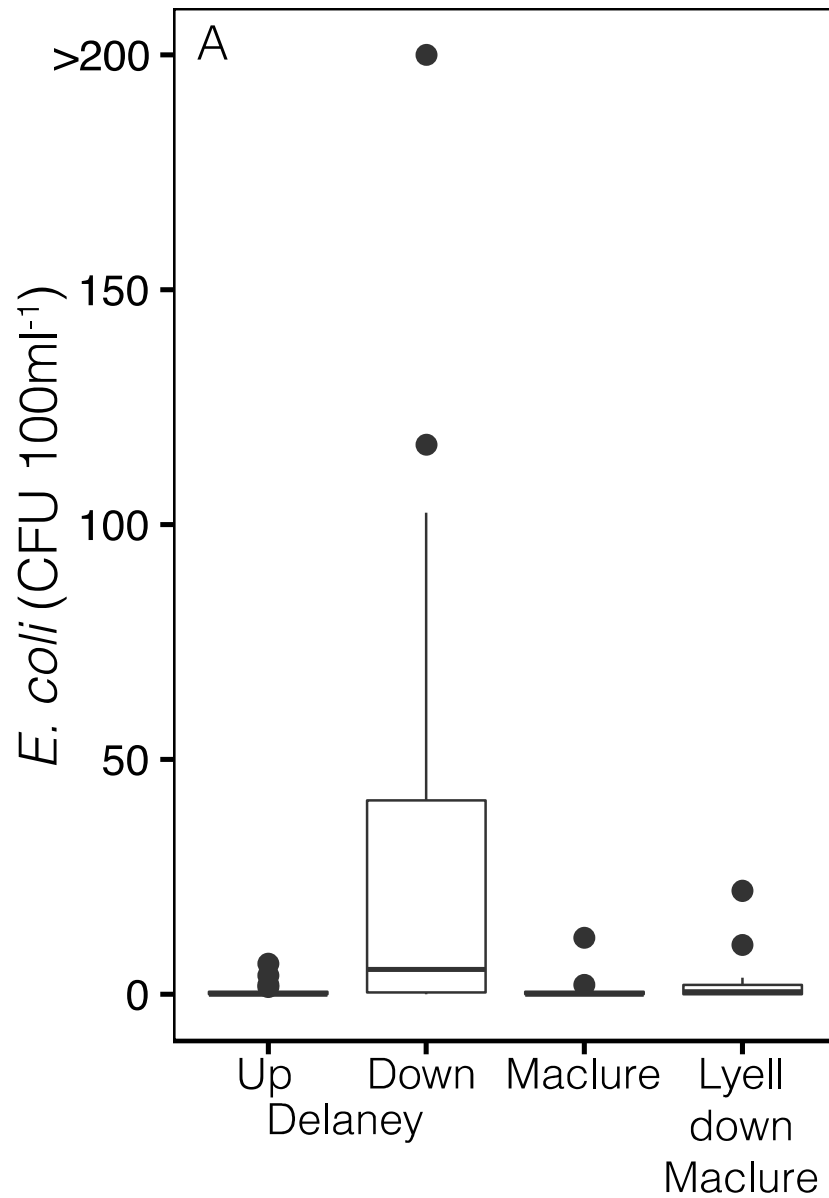
Storm Sampling



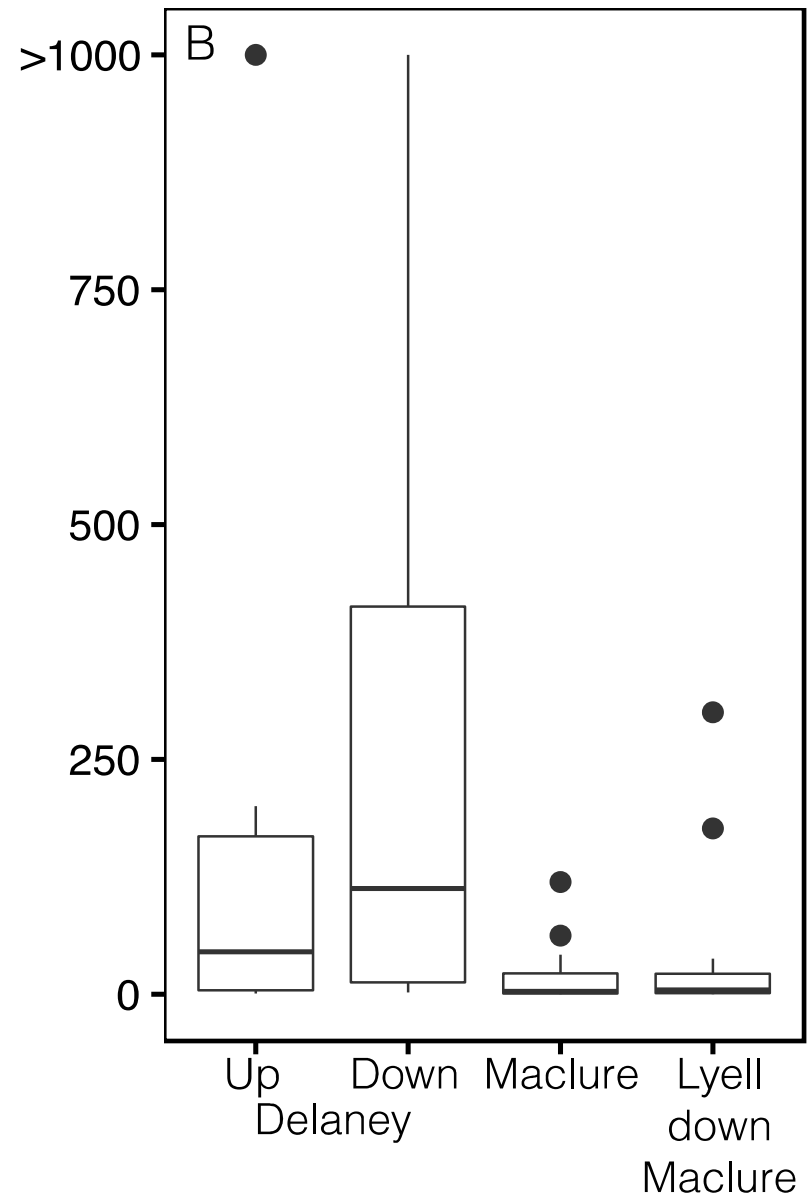
- rain
- stage
- turbidity
- stage-triggered auto sampler
- local telemetry - synchronized
- GOES telemetry



Results: Routine Sampling



Storm Sampling



Storm sampling recap:

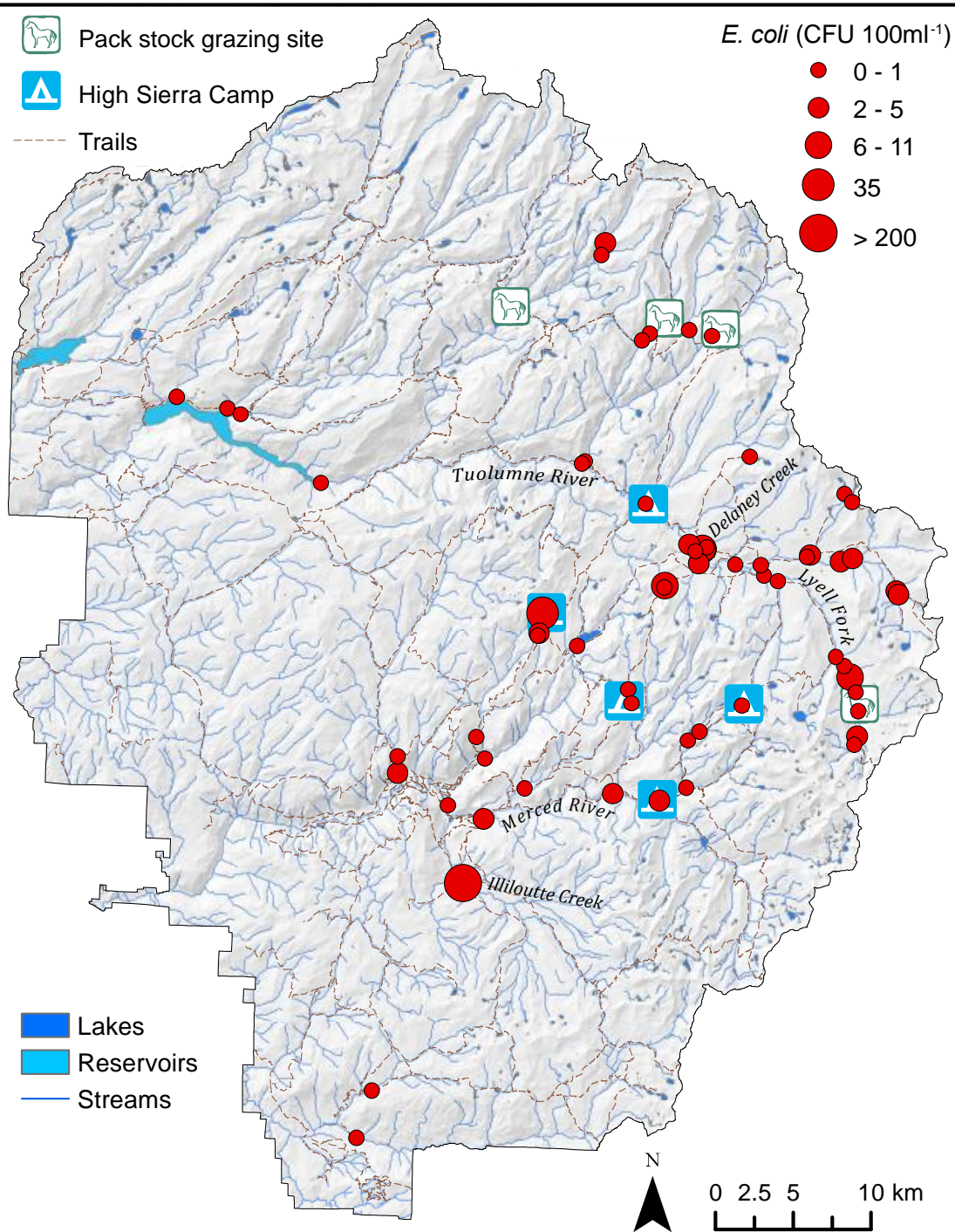
1. Higher concentrations during storms than during routine sampling.
2. Largest effects observed downstream from the pack stock stream crossing.
3. Possible indication of enhanced erosion from compacted soils downstream from backpacker campsites.



Results: Synoptic survey

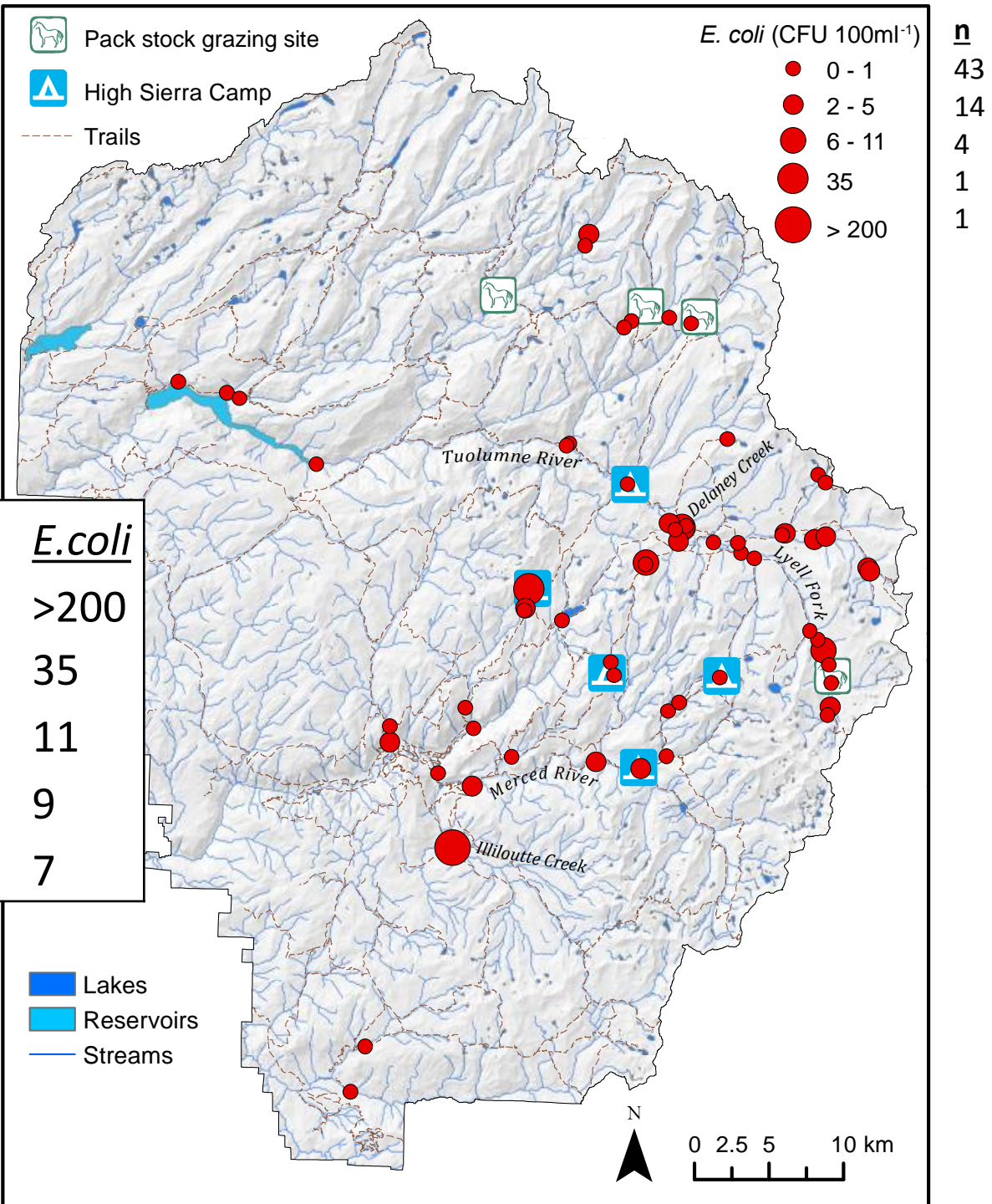
63 sites
3 days
8 people

steady-flow
conditions

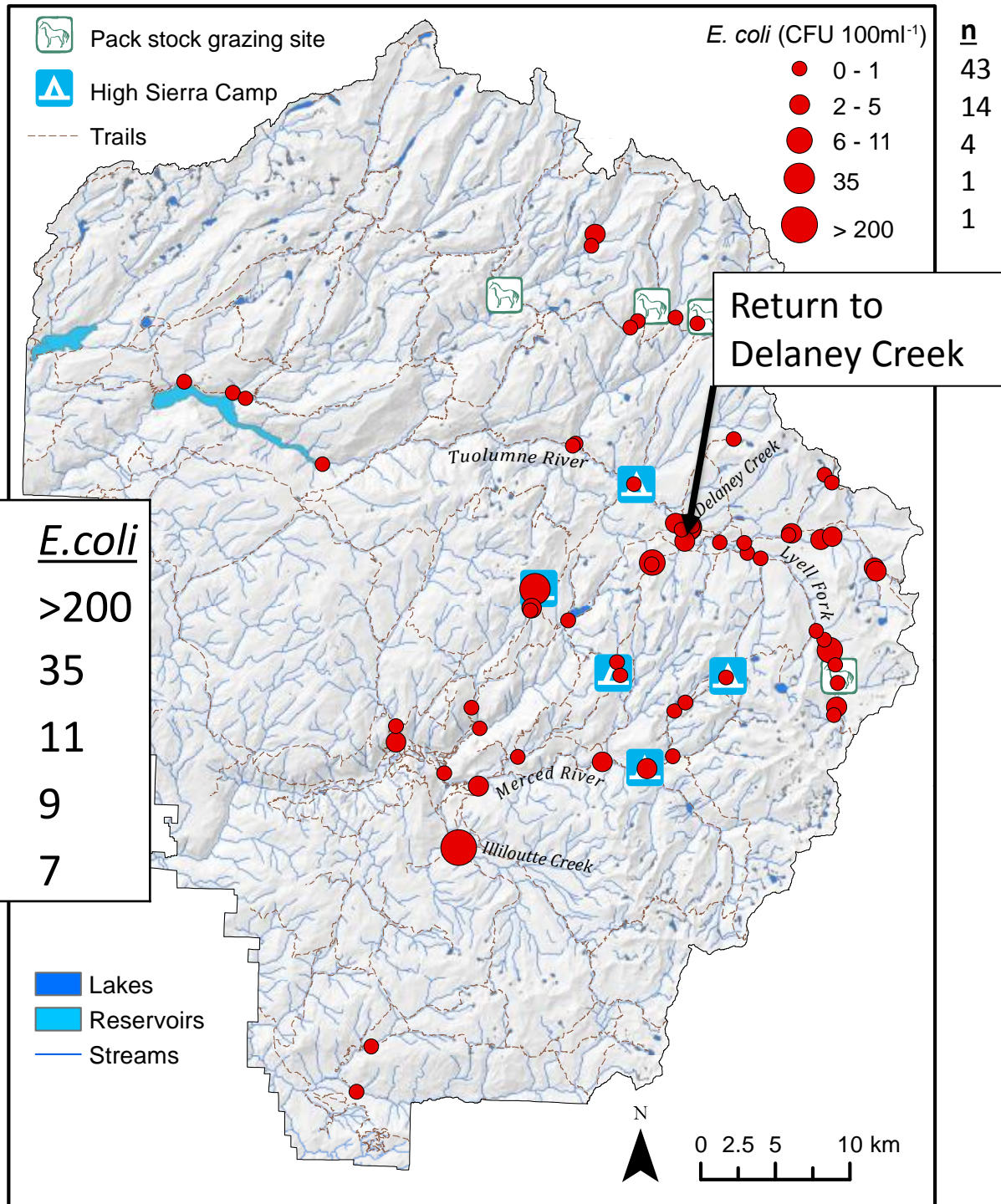


Results:
Synoptic survey

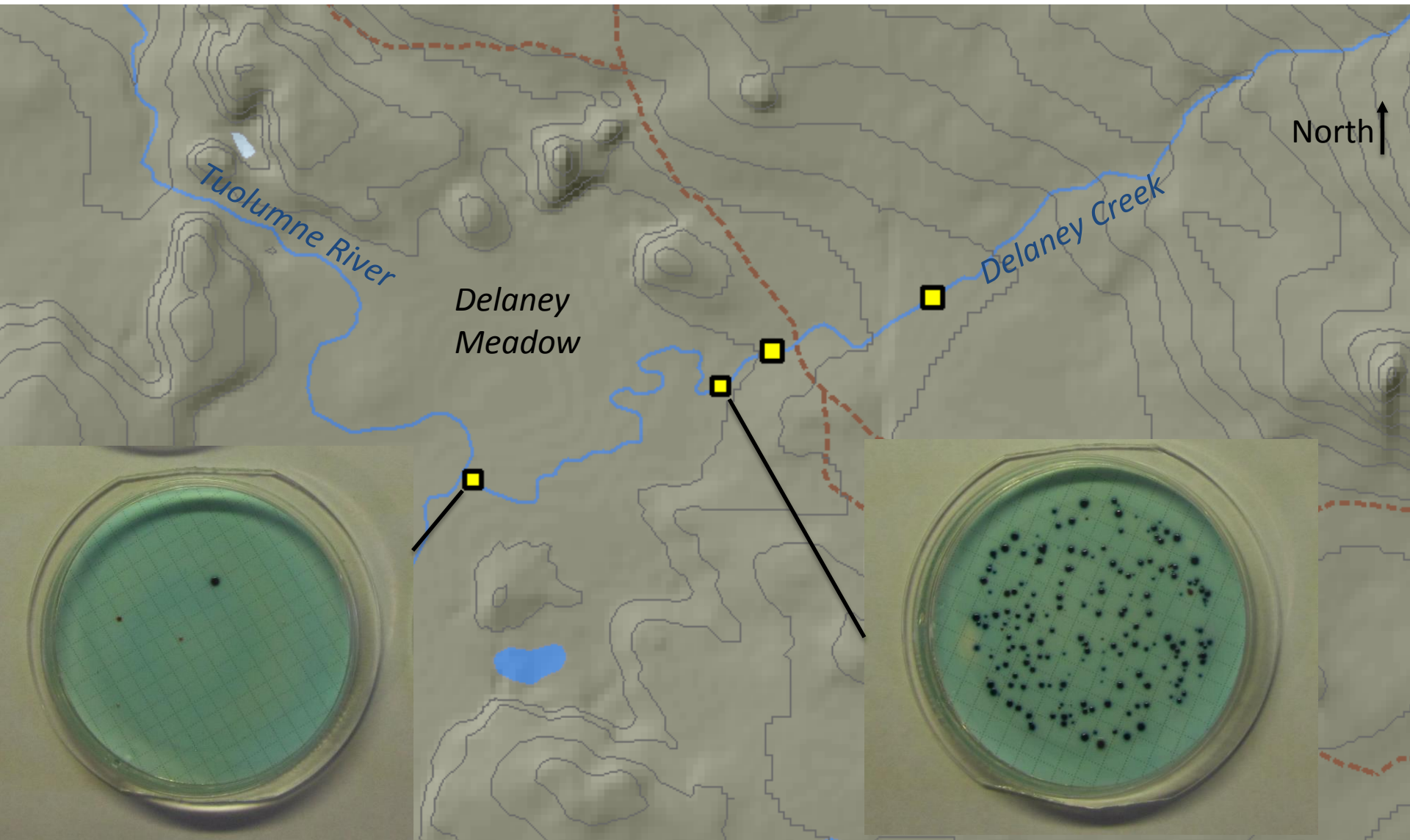
Site	<i>E.coli</i>
Illilouette Cr.	>200
May Lake Outlet	35
Lyell up Middle Lyell Mdw	11
Cathedral Spring down JMT	9
Delaney Cr. down PCT	7



Results: Synoptic survey



Paired sampling above and below meadows



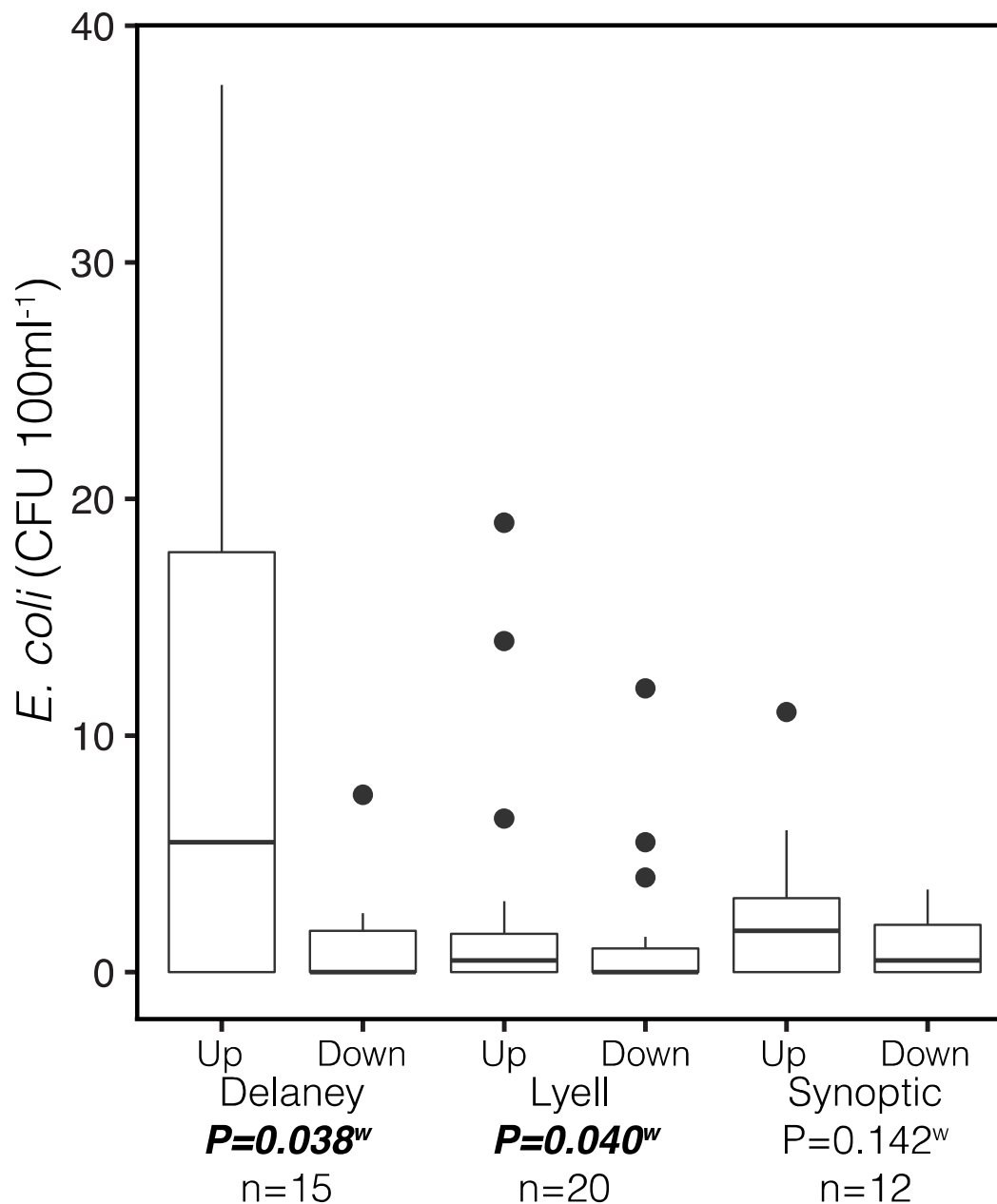
Paired sampling above and below meadows

- Low flow velocity
- Increased UV radiation



Lyell Canyon Meadow

Results:
Paired meadows



Synoptic sampling and paired meadows recap:

1. Generally, concentrations in Yosemite NP are low.
2. Synoptic survey identified high concentrations at a few sites that might be associated with visitor use.
3. Sampling upstream and downstream from meadows, suggests that meadows reduce microbial concentrations.



Conclusions:

1) Generally, concentrations in wilderness areas of Yosemite National Park are exceptionally low.

2) Strongest evidence of effects from pack stock use:

- stream crossings
 - Direct physical interaction with stream
 - Largest effects during storms

3) Strongest evidence of effects from backpacker use:

- Turbidity and SSC spikes at the onset of storm flows

Conclusions:

Meadow Influence on Water Quality:

Ecosystem services



Lyell Canyon Meadow



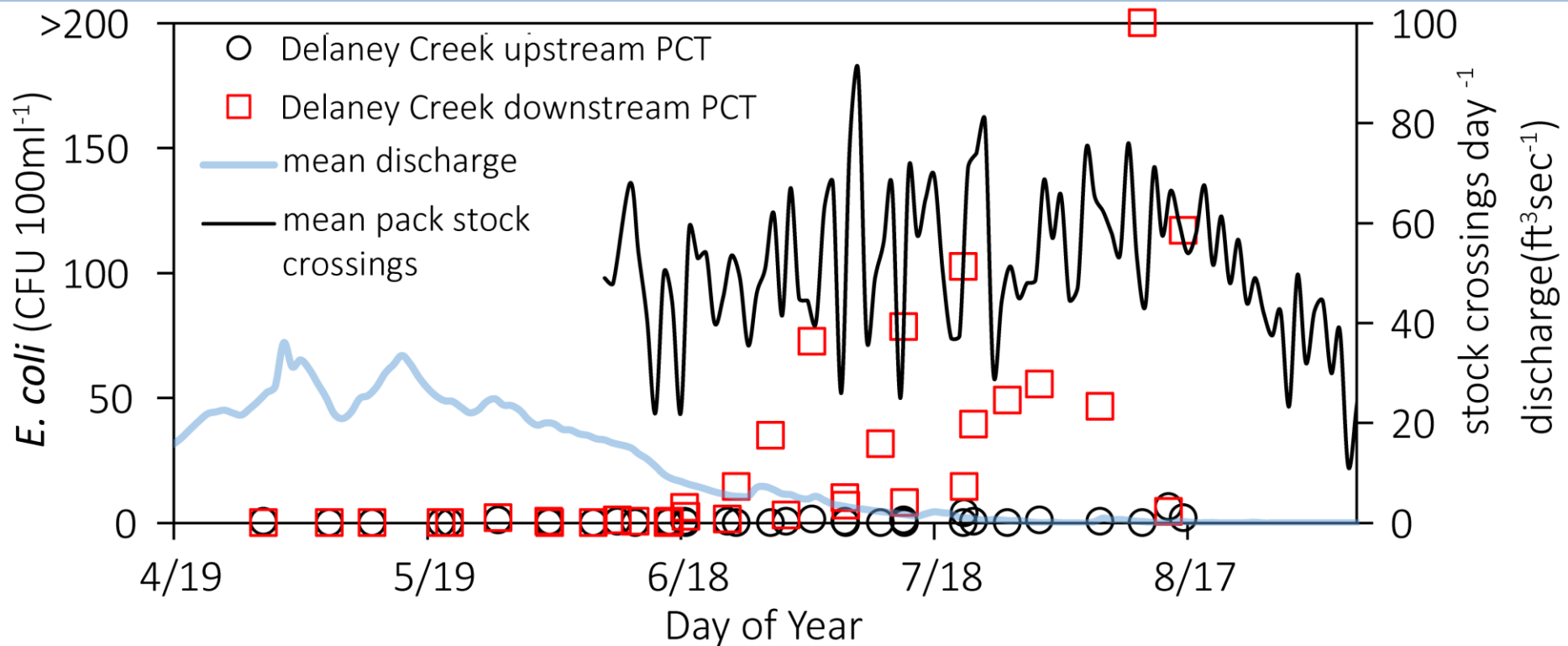
Questions ?



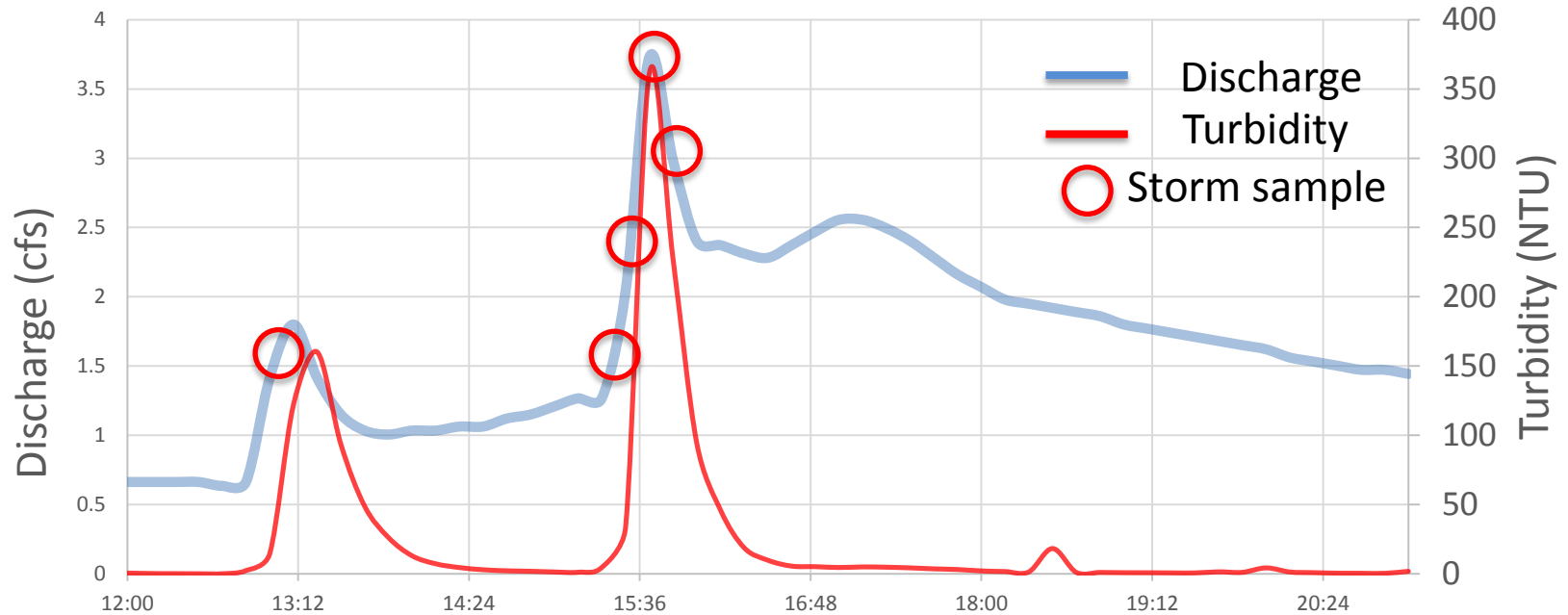
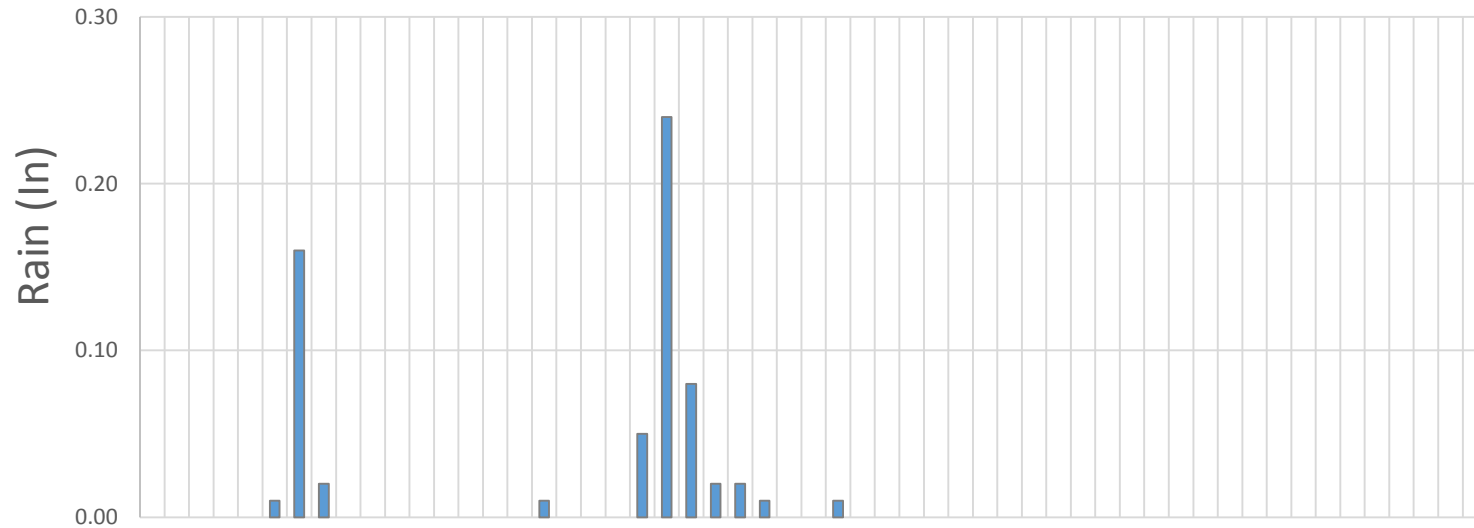
Results:
Routine sampling
Packstock trail use

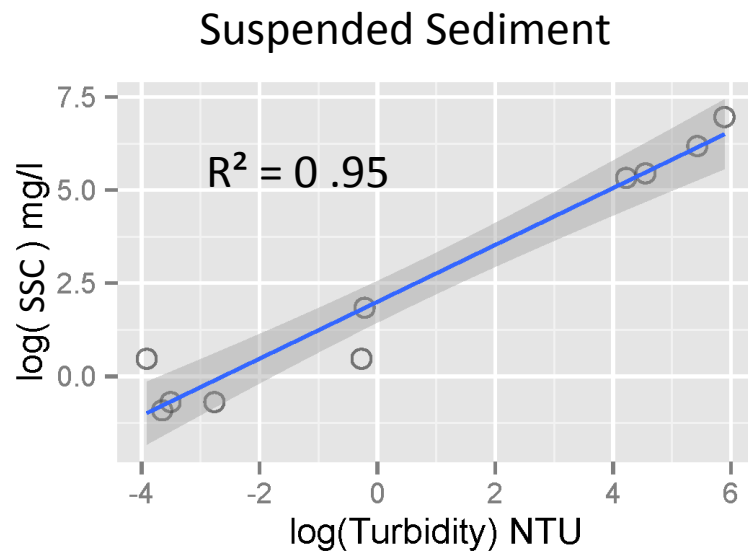
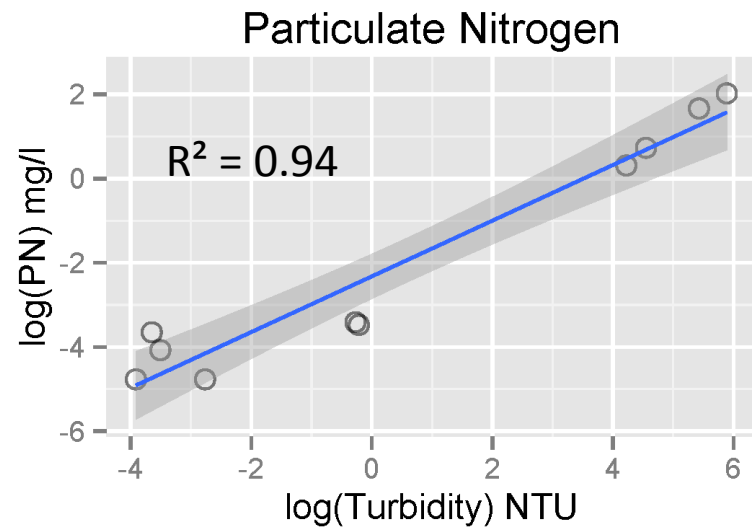
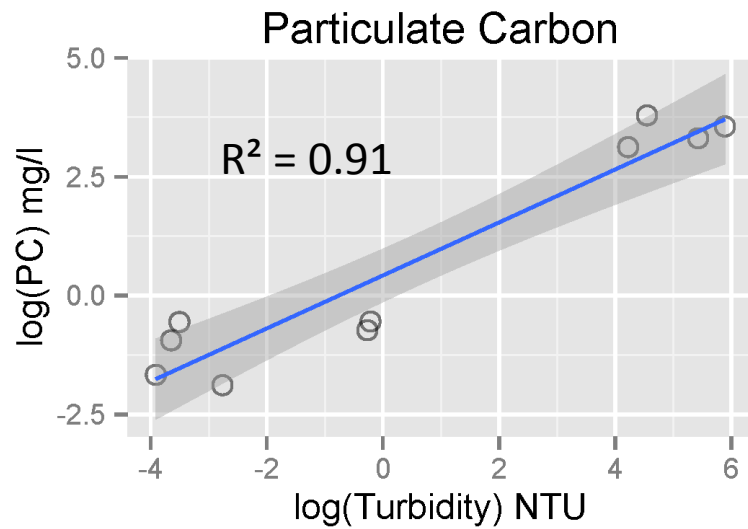
Increase in *E. coli* concentration
during sampling season observed at Delaney Cr.

Not observed at Cathedral Spring



Storm Sampling

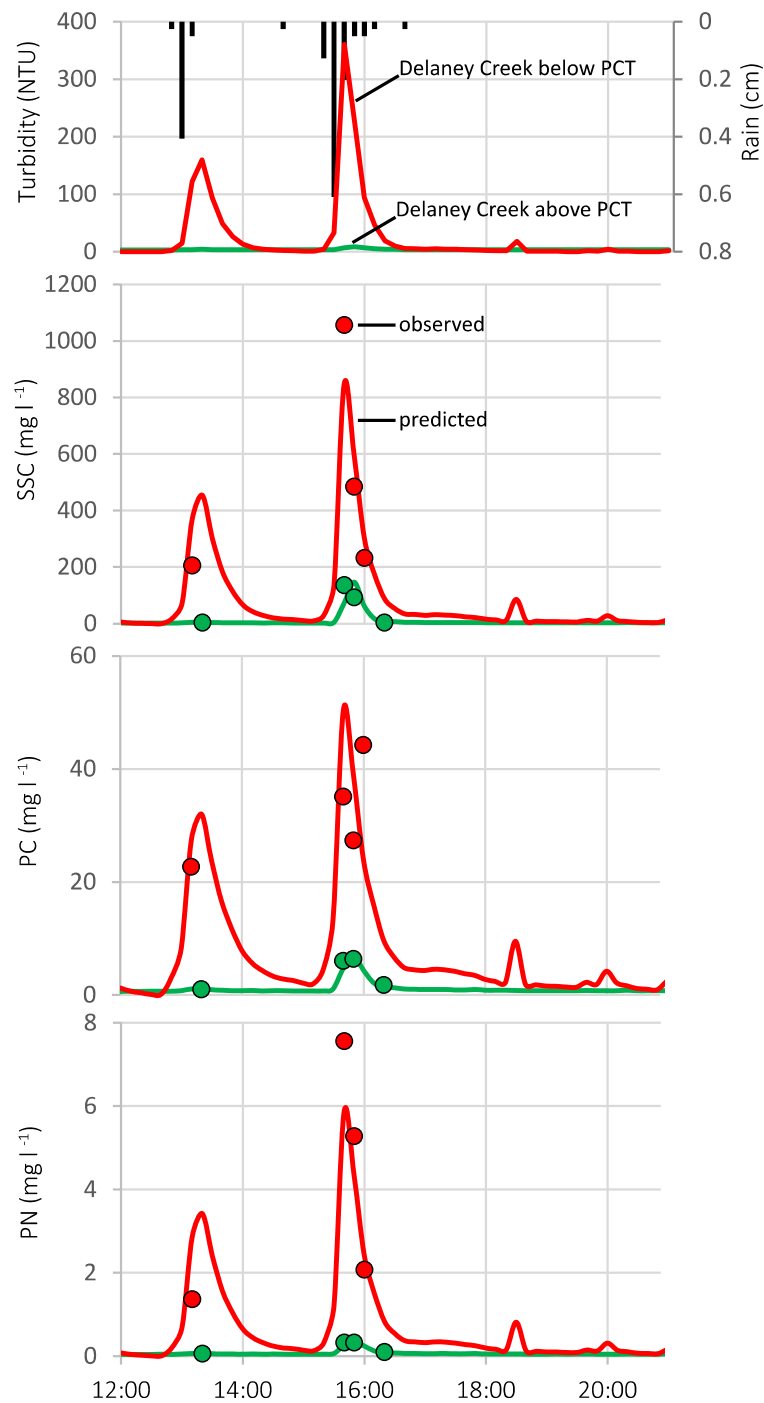




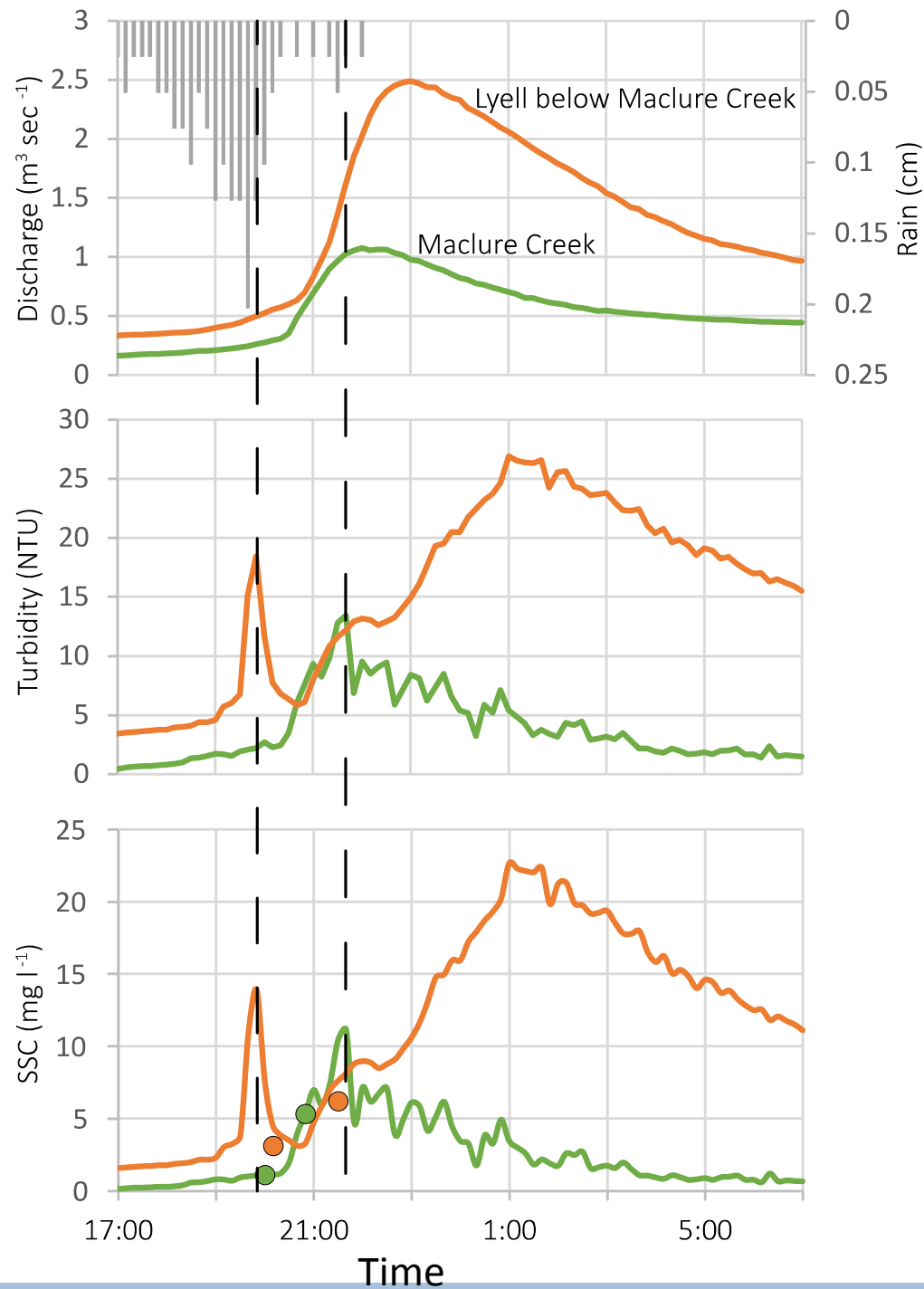
Linear relationship between turbidity and particulates.

Results: Storm Sampling Packstock trail use

July 25, 2013



Results:
Storm Sampling
Packstock trail use



August 19, 2013