# Targeted water storage

## to maintain productive land and restore clean water

Photo credit: Carrie Jennings

Patrick Belmont
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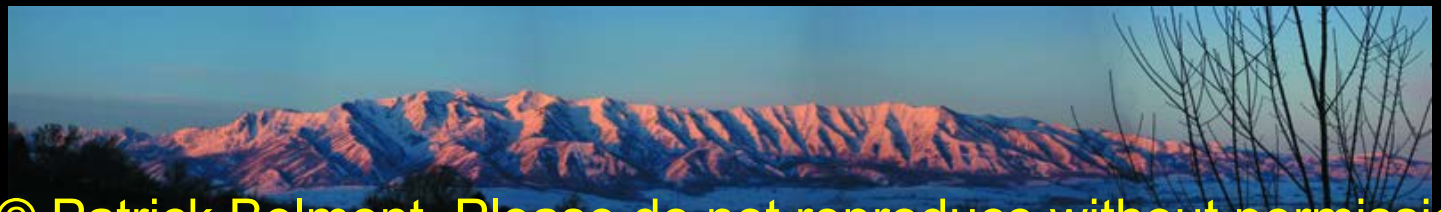
Utah State University



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None of our work would be possible without the tireless and meticulous work of innumerable state and local agency staff
and
the interest and support of south central Minnesotans.

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Resilience under Accelerated Change

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MINNESOTA CORN GROWERS ASSOCIATION

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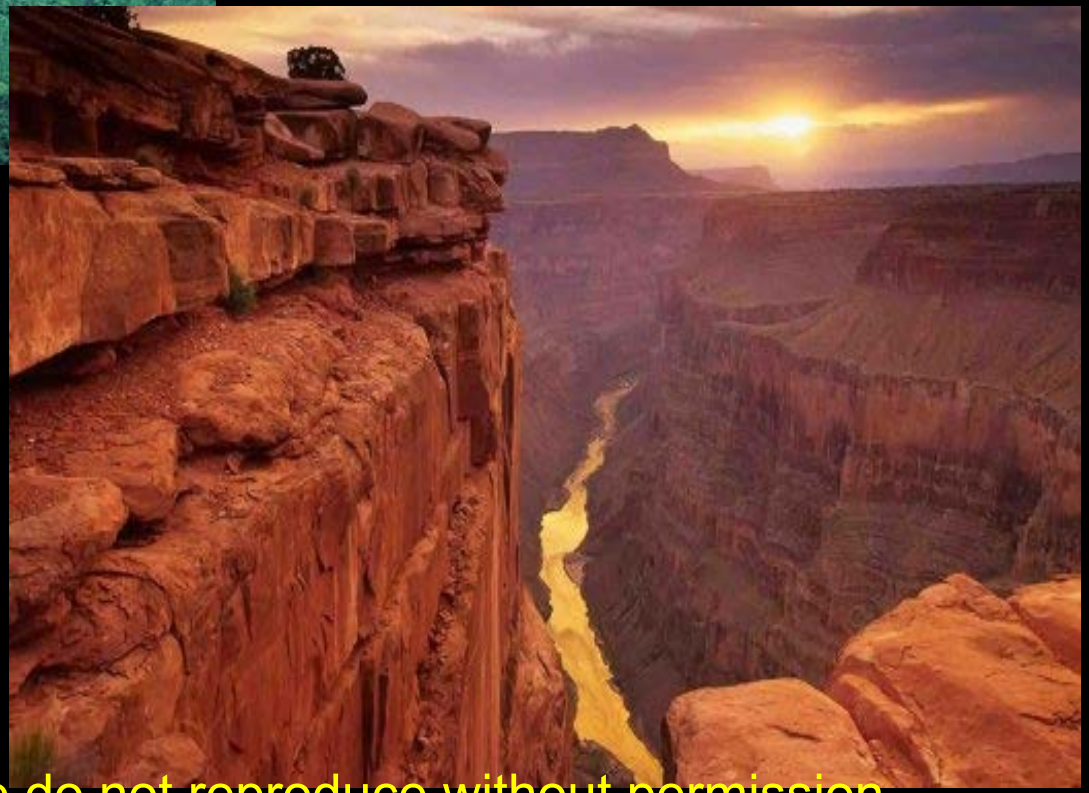
# Rivers are fascinating things…

Williams River, AK, photo by N.D. Smith



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# Today's Question

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## Should Minn water-intens



Michael Olson March

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# Dayton signs bill to mandate buffers to improve water quality and habitat

But critics say law doesn't do enough for clean water.

By Doug Smith Star Tribune | JUNE 13, 2015 — 11:37PM

DOUG SMITH, PHOTO COURTSEY LINCOLN COUNTY SOIL AND WATER CONSERVATION DISTRICT

The Lincoln County Soil and Water Conservation District planted a buffer on private land last week along the Yellow Medicine River. The landowner has enrolled the land in the federal Conservation Reserve Program. Photo courtsey Lincoln...

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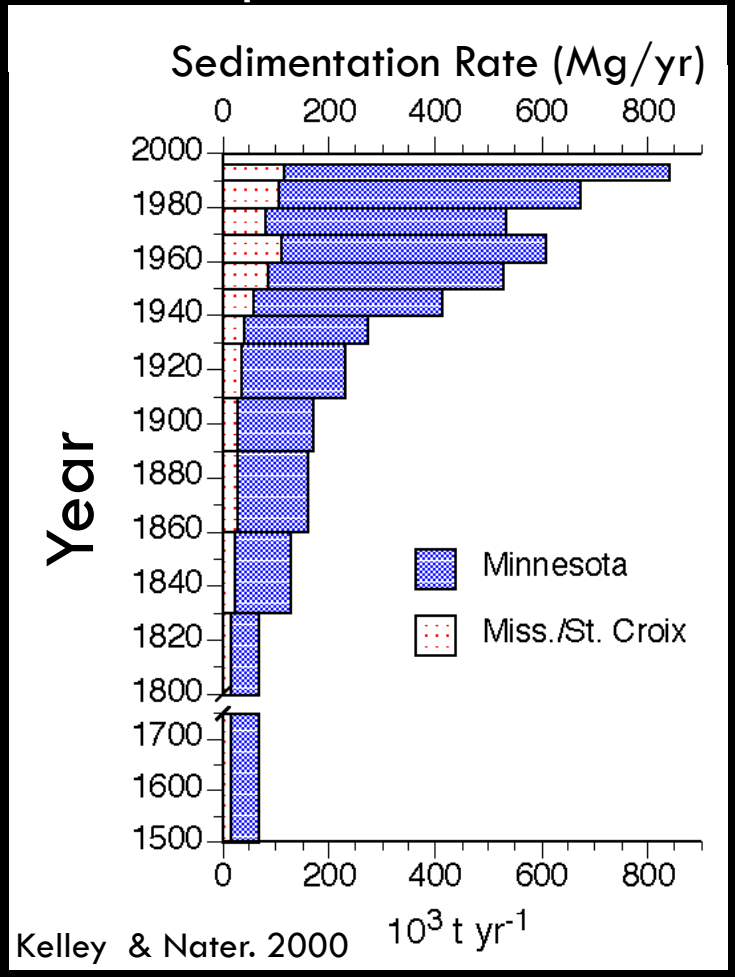
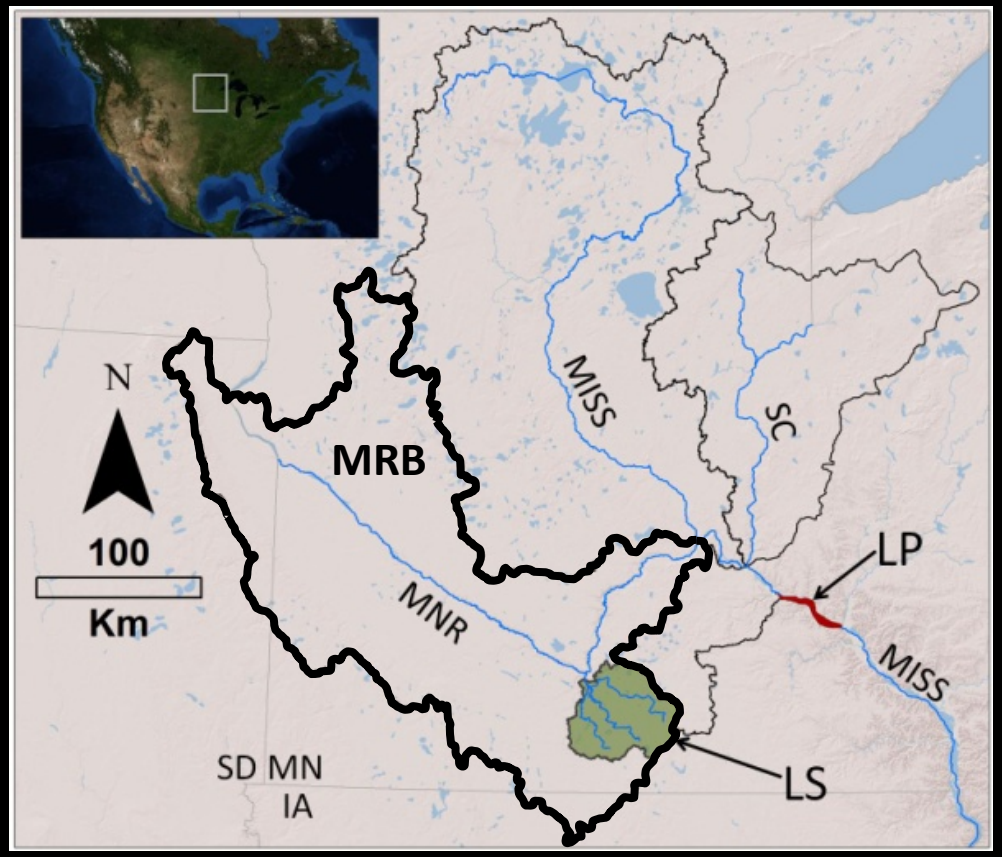
# Sediment, nutrient problems in Minnesota

## Lake Pepin Sedimentation




Minnesota River Basin: 336 impairments for sediment, nutrients, aquatic life

MRB is primary source of sediment and nutrients for Lake Pepin




P. Wilcock

Where is the sediment coming from?

How much is human/natural?

How can we reduce it?

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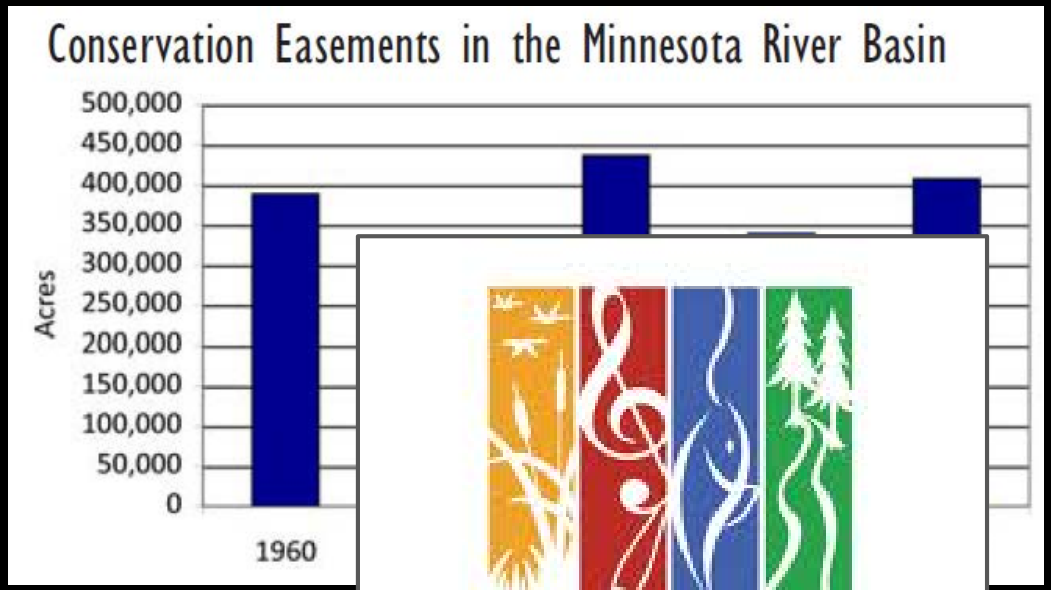
# Past and future investments…

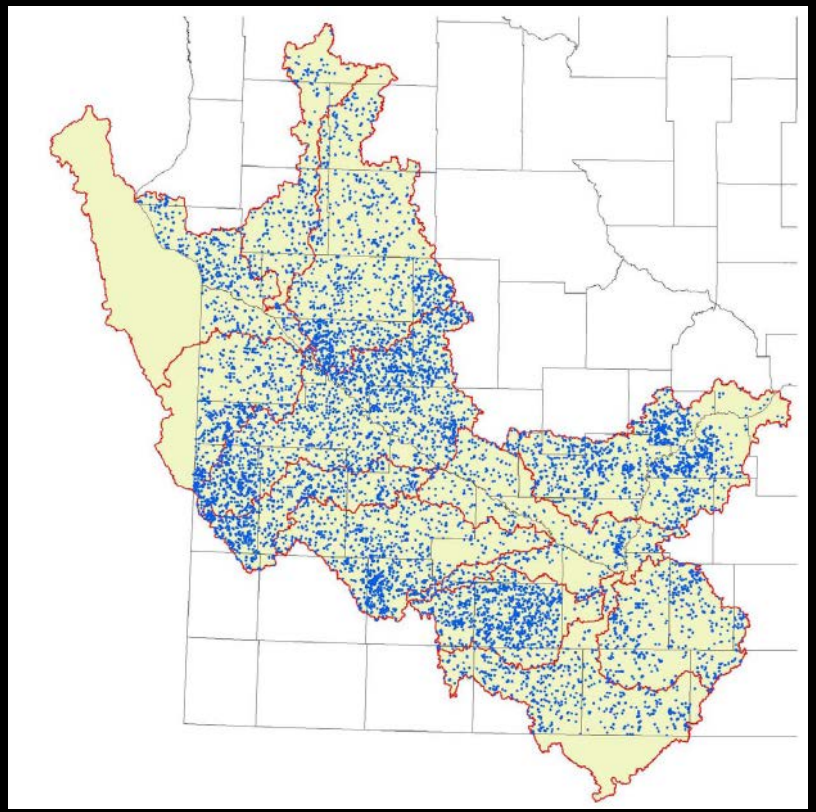
Lots of money invested, but no reduction in sediment?

We will invest a lot more money…let's get the best bang for the buck




Musser et al., 2009

Sediment and nutrient management Projects 1997 - 2008



CLEAN WATER LAND & LEGACY AMENDMENT

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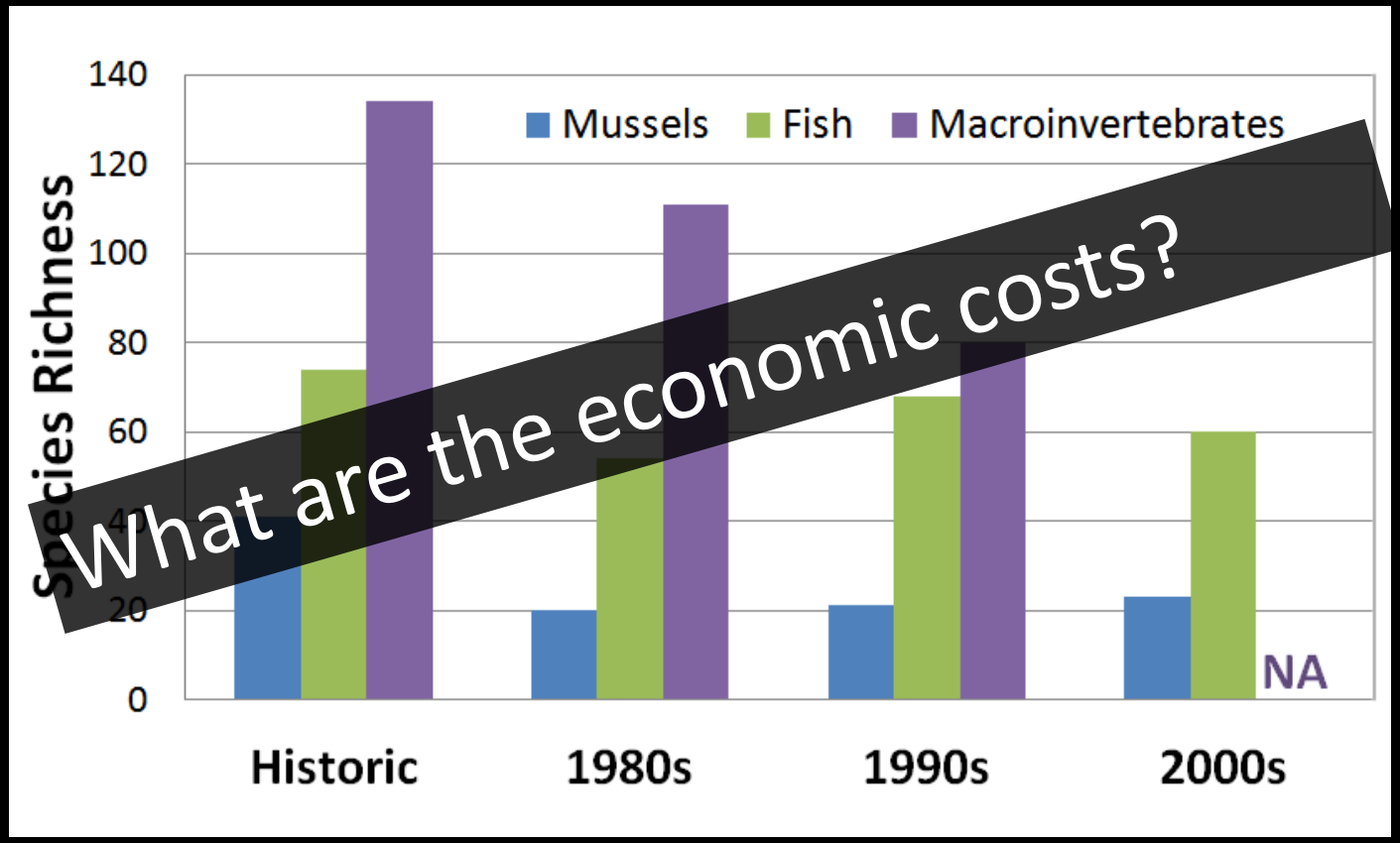
# Water quality, aquatic organisms and recreational value have all been degraded




Mussel biomass/populations have declined

Most desirable fish species have declined

Macroinvertebrate productivity is 10-40x lower than expected - - - -> less N uptake

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# The cause of the problem is obvious, right?

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Carrie Jennings

What do we know?

How do we know it?

What are the implications for management, policy and restoration?

What are we shooting for?

What is desirable?

How do we get there?



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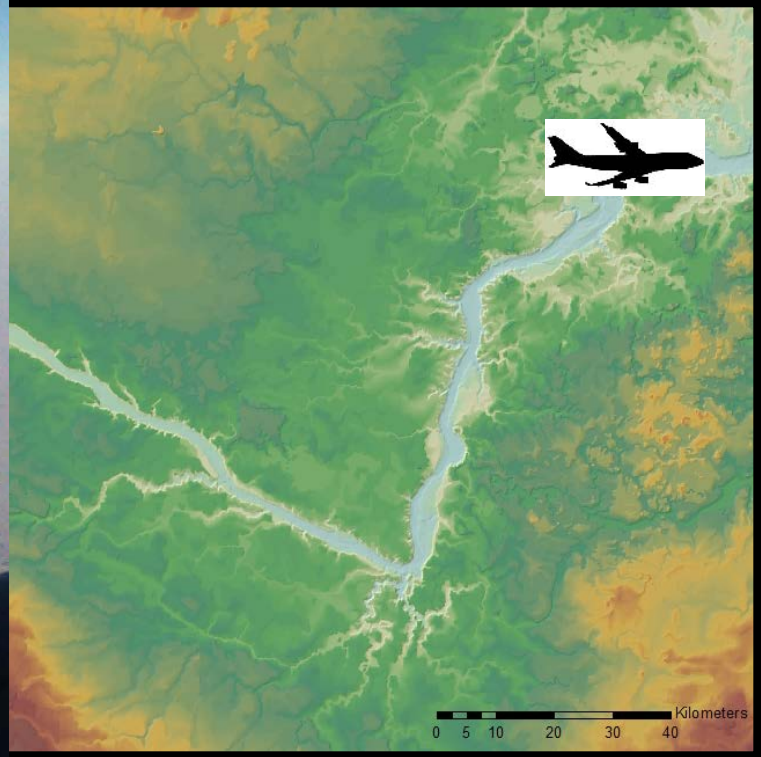
# Geologic history makes this a very sensitive landscape




Belmont, 2011 *Geomorph*
Glur et al., 2013 *GSA Bull.*

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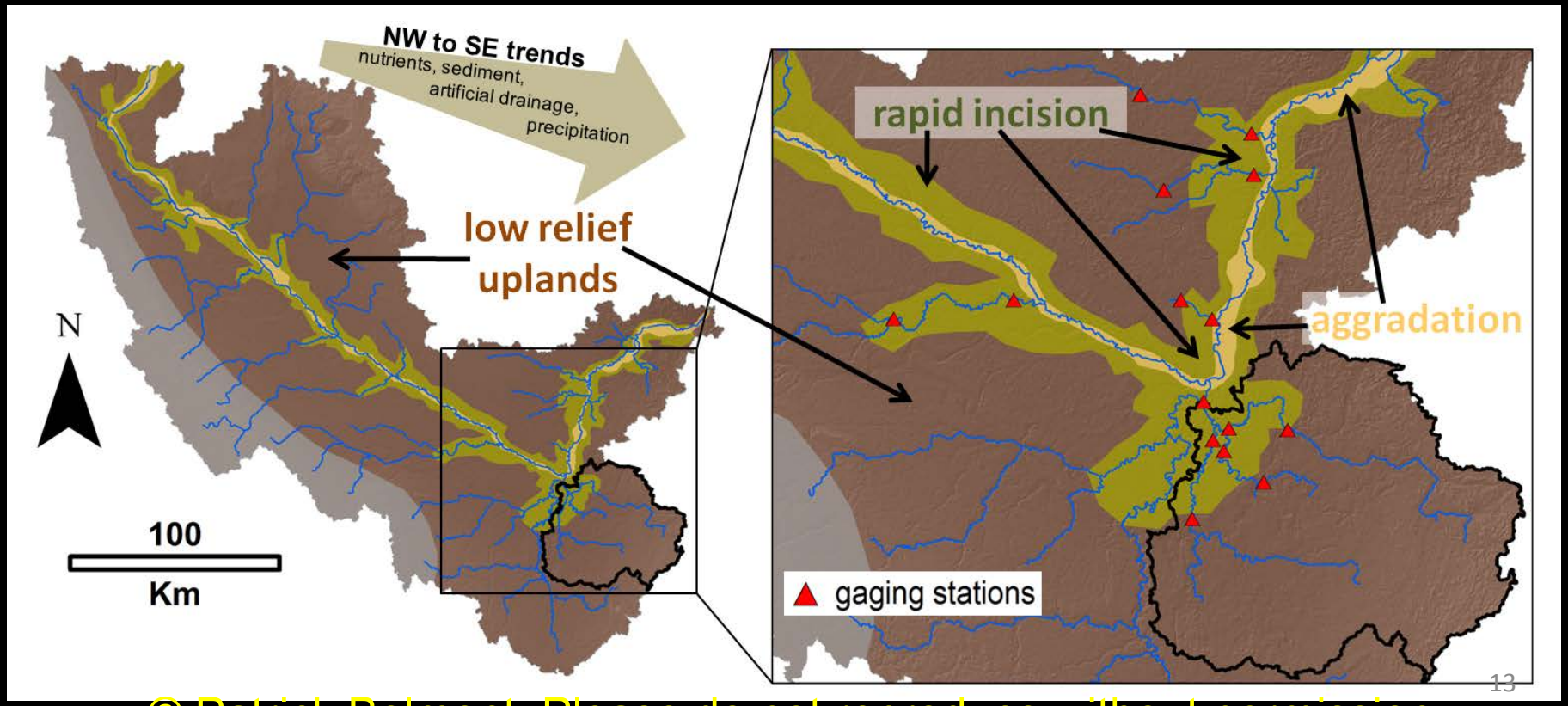
# Geologic history makes this a very sensitive landscape

**Uplands: flat land, passive rivers**

**Knick zone: steep, highly dynamic, incising rivers**

**Minnesota River Valley: rapidly aggrading channel and floodplain**

Each region responds differently to changes in water and sediment loads



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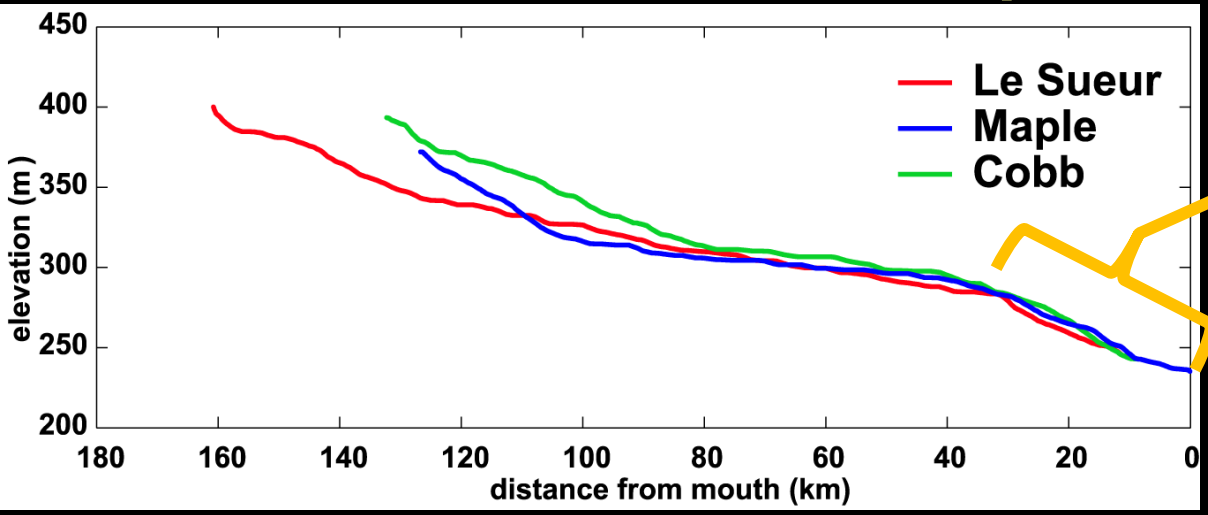
# Le Sueur River example




knick zone

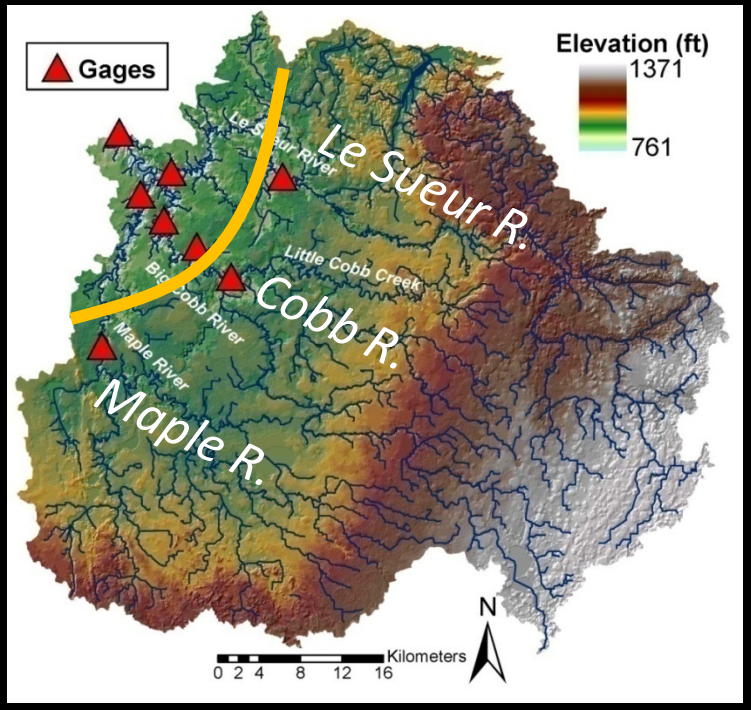
NATURAL

Poorly drained, fine textured soils

Down-cutting rapidly for past 13,400 years

HUMAN

Agriculture and drainage began mid 1800s
Continue to evolve in effectiveness, intensity, precision, productivity, etc.

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# Modern land and water management

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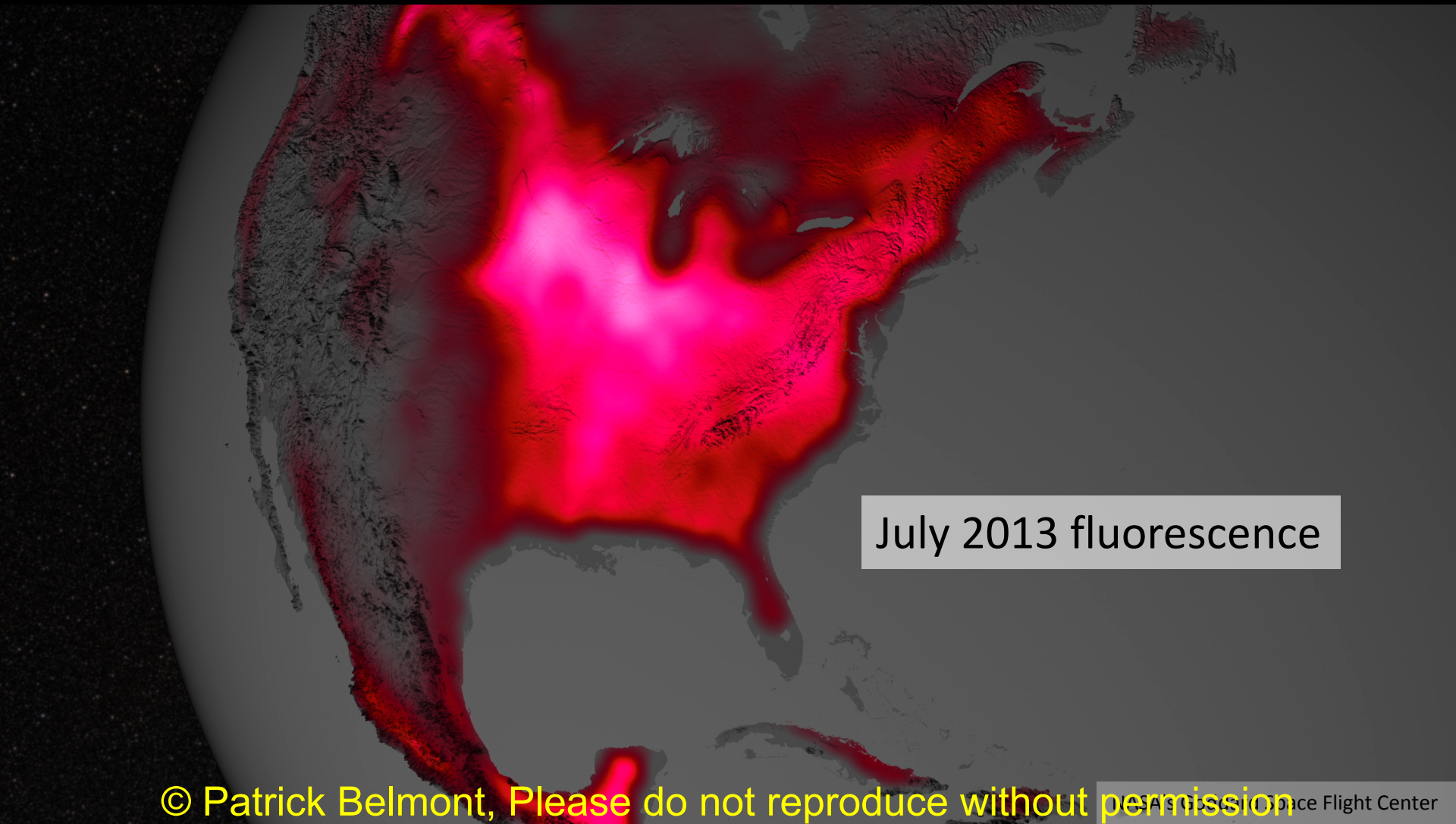
# The up-sides of drainage

1. Crop productivity is way up!
2. More rainfall infiltrates into the soil, less runs off the surface

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# The down-sides of drainage

1. Concentrating flow in some sensitive areas
2. Increasing the amount and rate of water delivered to the river


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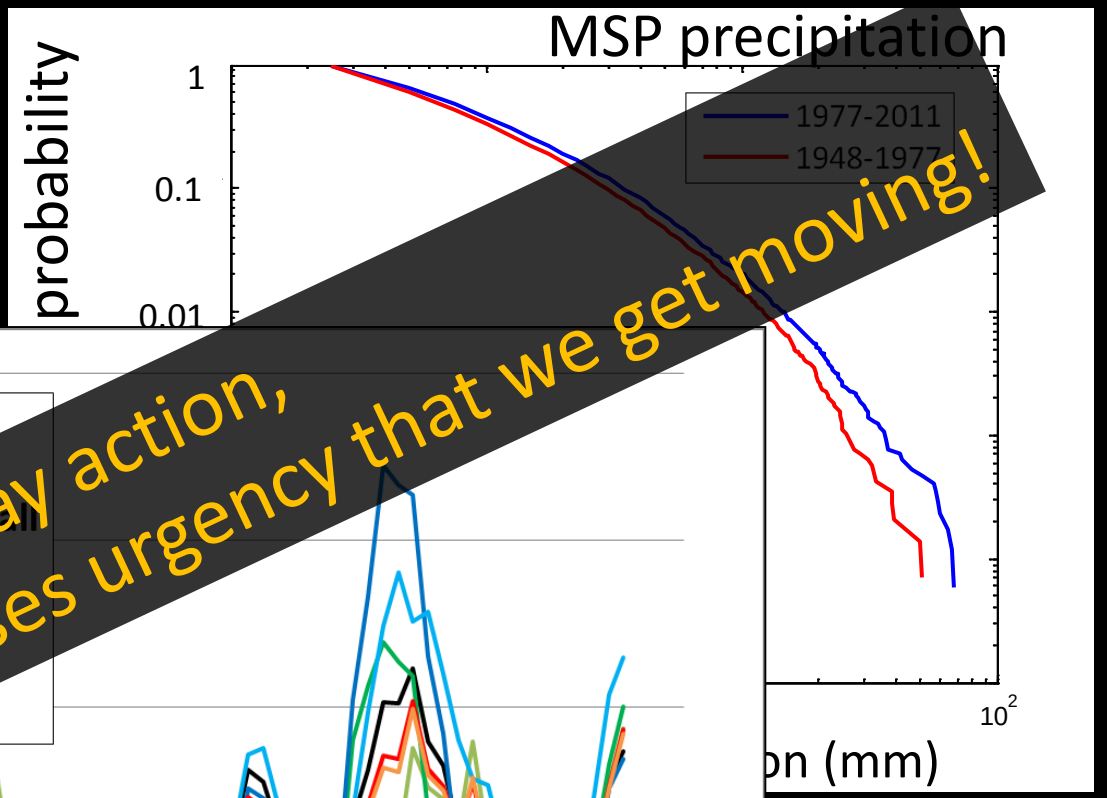
# And we're getting more rain

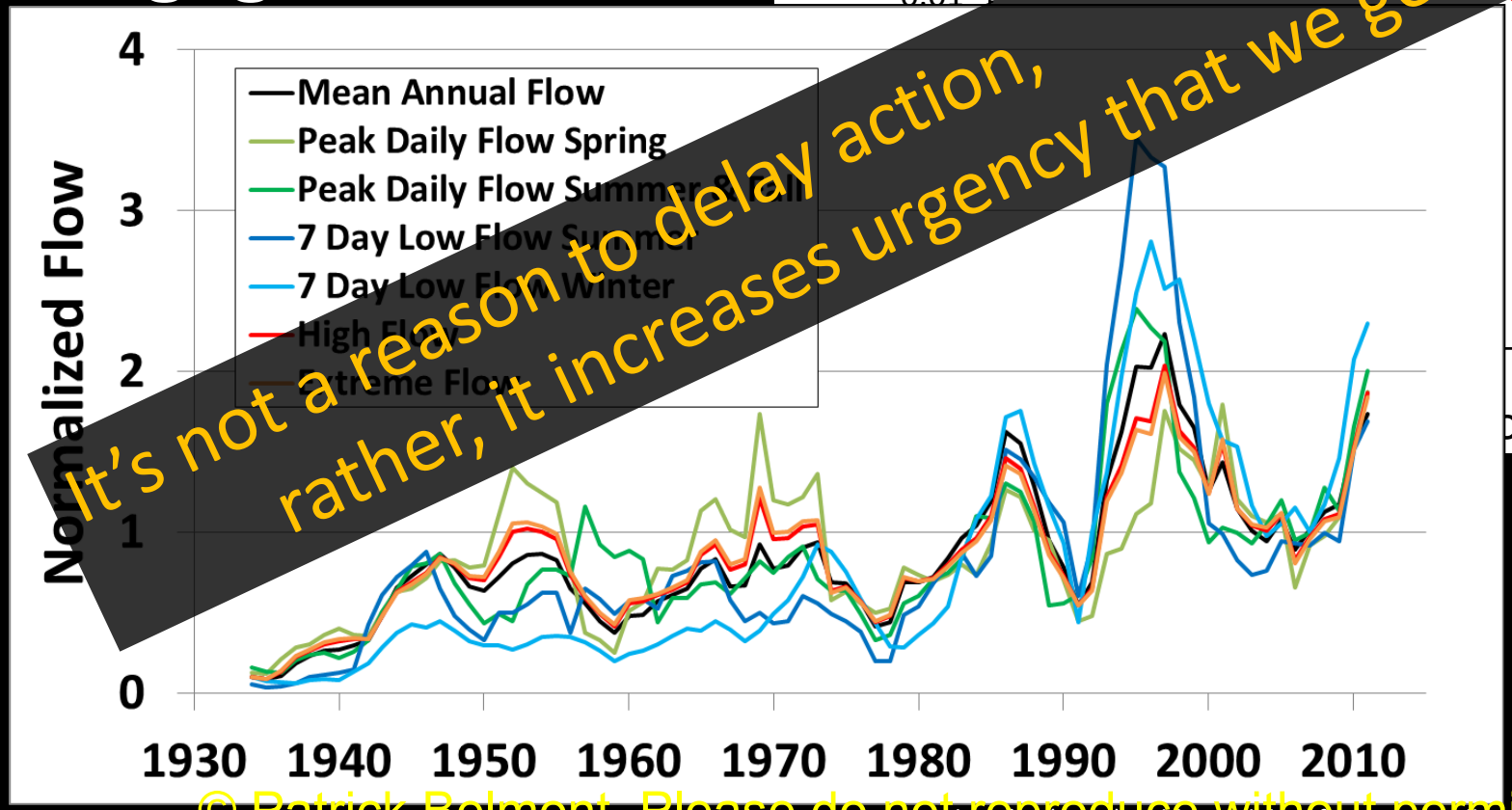
Precip has increased!

Big events are getting bigger

12 gages in MRB




Zeinab Takbiri




It's not a reason to delay action, rather, it increases urgency that we get moving!

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Novotny and Stefan (2007), Additional data from Sara Kelly

# Where is the sediment coming from?




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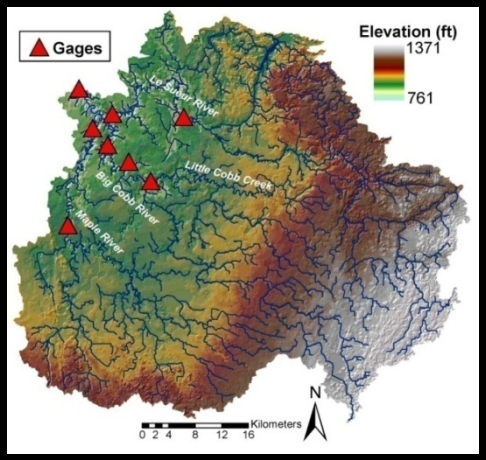
# A Sediment Budget for the Le Sueur Watershed

## Many tools employed…

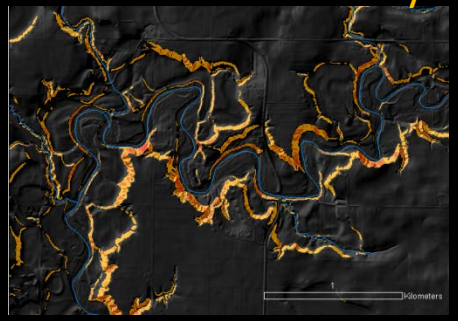
### Sediment fingerprinting

$^{10}Be$ $^{210}Pb$ $^{137}Cs$

### Gages galore!



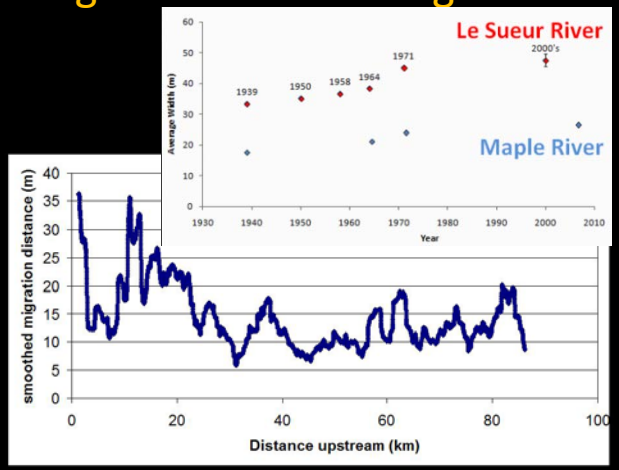

### GeoNet and Lidar Analysis



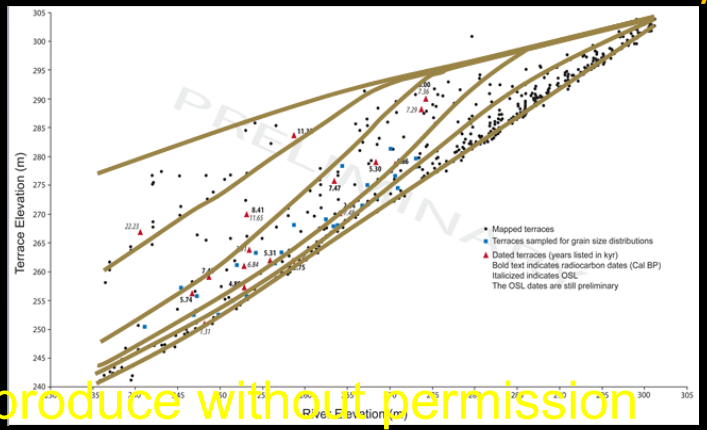
### Field Surveys

### 7 Decades of Air Photos


### Migration & Widening Rates




### 14C & OSL-Dates for Incision History




### 4 Years of Repeat Terrestrial Lidar

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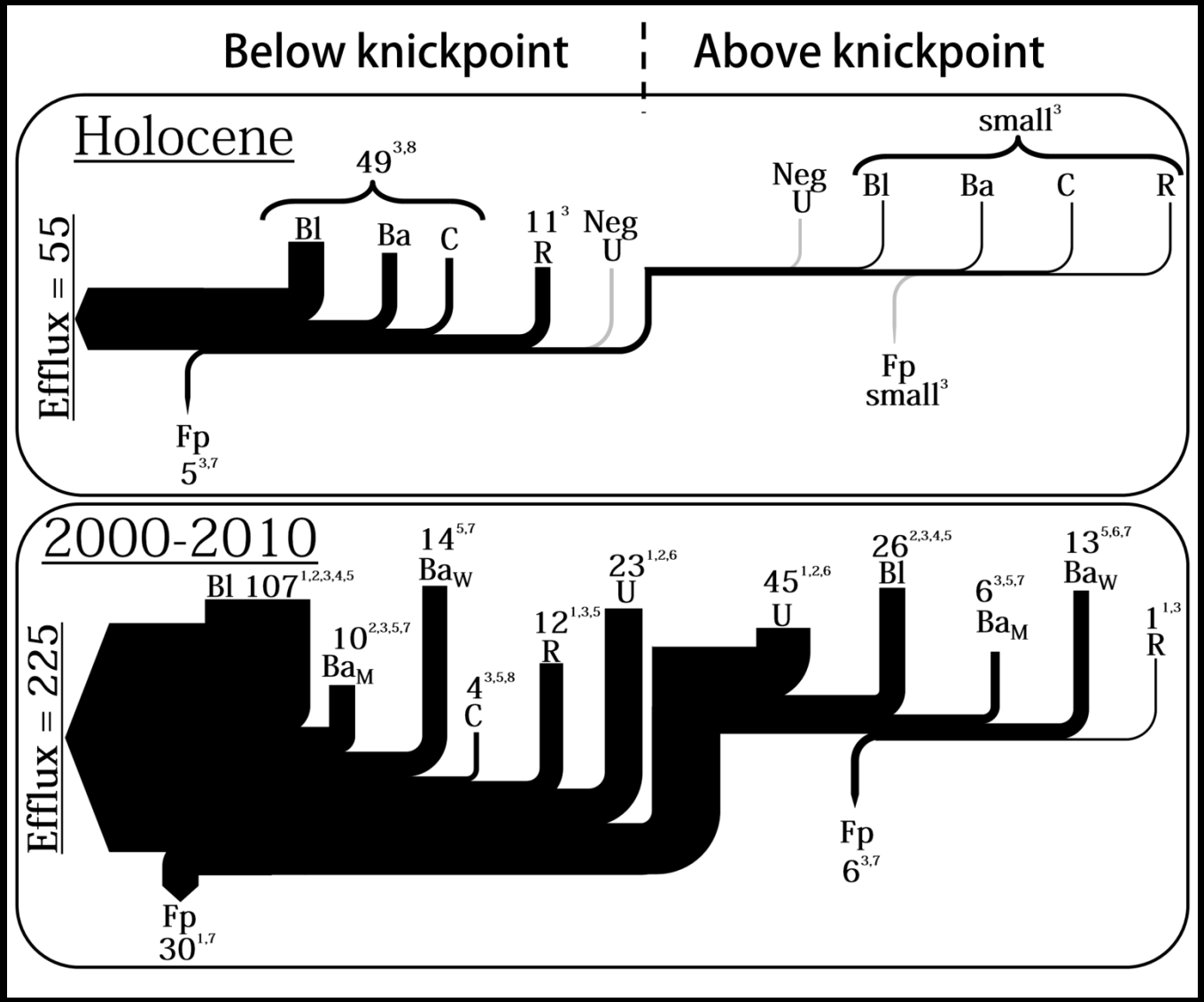
# Le Sueur Sediment Budget

Belmont et al. 2011 ES&T

## Sources

- U: Uplands
- $F_p$: Floodplain
- Bl: Bluffs
- Ba: Banks
- C: Channel incision
- R: Ravines




## Constraints

1. Gaging data
2. Geochemical tracers
3. Aerial lidar analysis
4. Terrestrial lidar scans
5. Air photo analysis
6. Numerical modeling
7. Field surveys
8. Optically Stimulated Luminescence and $^{14}C$ dating

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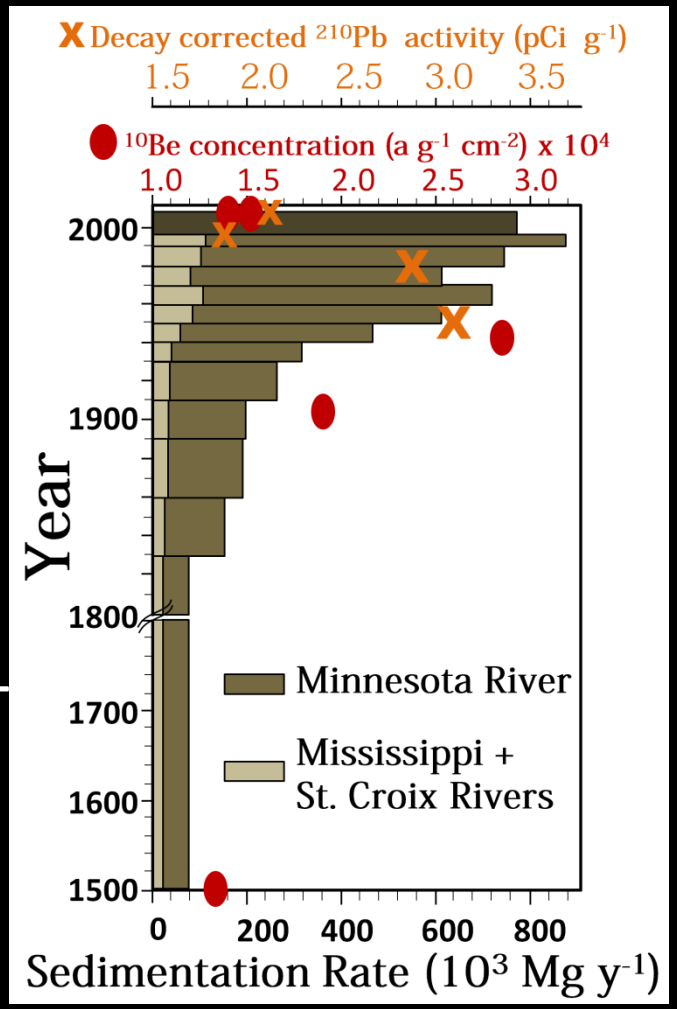
# Corroboration of Le Sueur sediment budget in the geochemical profile of Lake Pepin sediments




## Sediment Fingerprinting Results

Bluffs, banks = [LOW]  Ag field soil = [HIGH]

Late 20th Century: Sediment loading remains high but sources shift from top soil to banks & bluffs

Mid 20th Century: Poor land management causes pulse of upland soil erosion

Pre-settlement: primarily near-channel sources


Belmont et al. 2011 ES&T

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# What do we know now?

1. This is some of the most productive ag land in the world and local economies/communities depend on it staying that way.

2. This landscape is geologically primed to generate lots of sediment.

3. Agricultural drainage has significantly increased flows in the river. It is also raining more, and more intensely.

4. Ag erosion dominated 50+ years ago. Today, most sediment comes from near-channel sources, amplified by increased flows.

→ We need to manage water runoff better!

5. These rivers are special, have been severely degraded, and have great potential for improvement. Better water quality benefits biodiversity, human health, recreation, industry, land values, etc.



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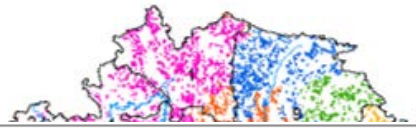
# Water detention basins (aka. ephemeral wetlands) reduce sediment loading downstream

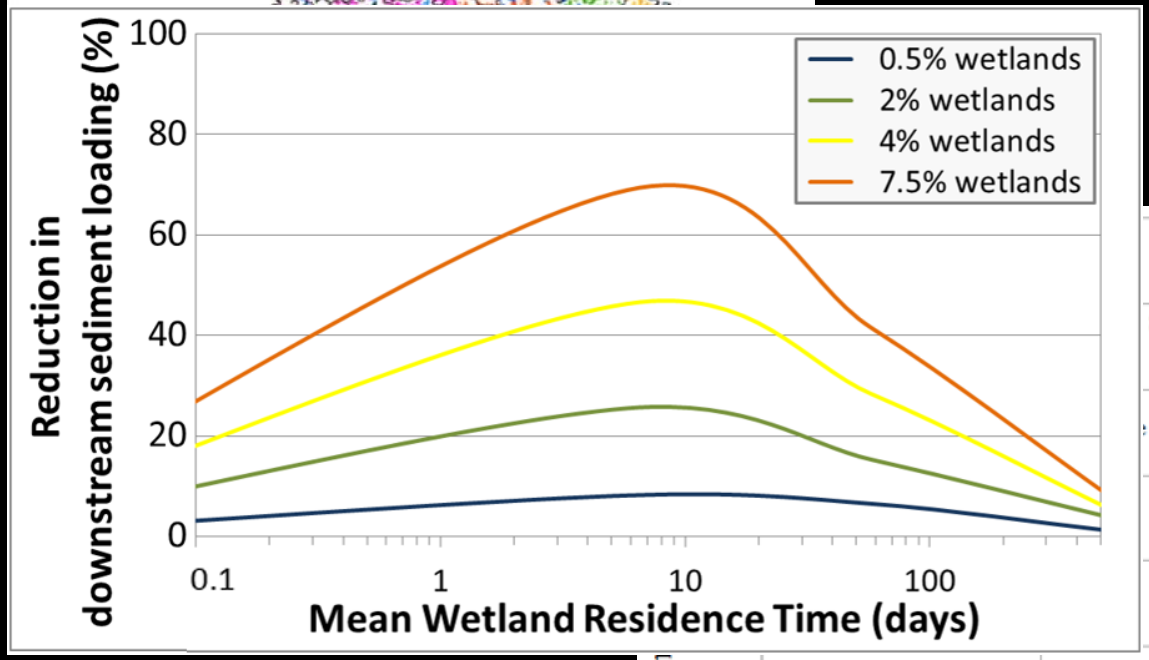
0.5 - 7.5%
of total area



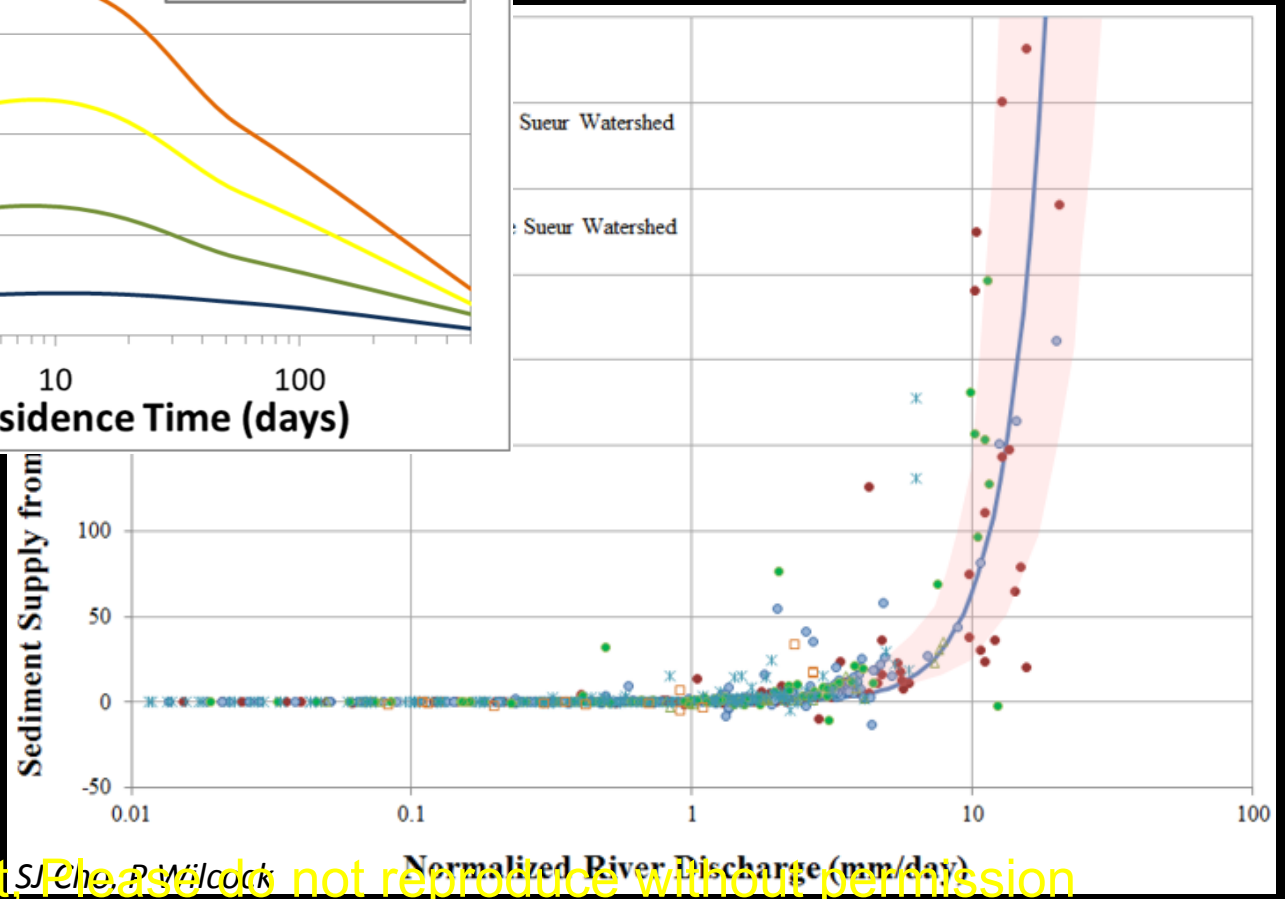
Temporary water storage

→ Reduces peak flows downstream

→ Reduces bluff erosion in the knick zone




*N Mitchell, K Gran*




*SJ Cheng, B Wilcock*

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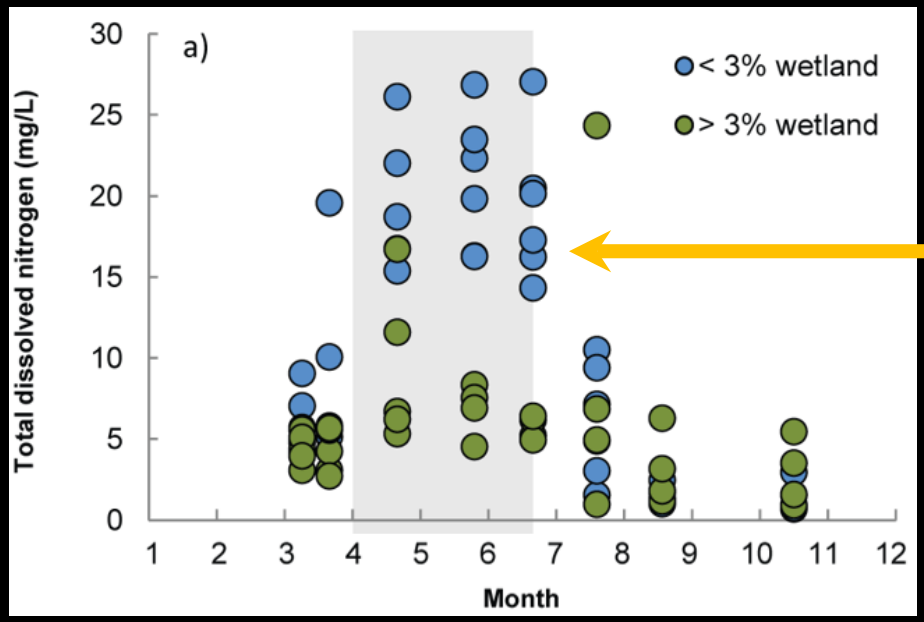
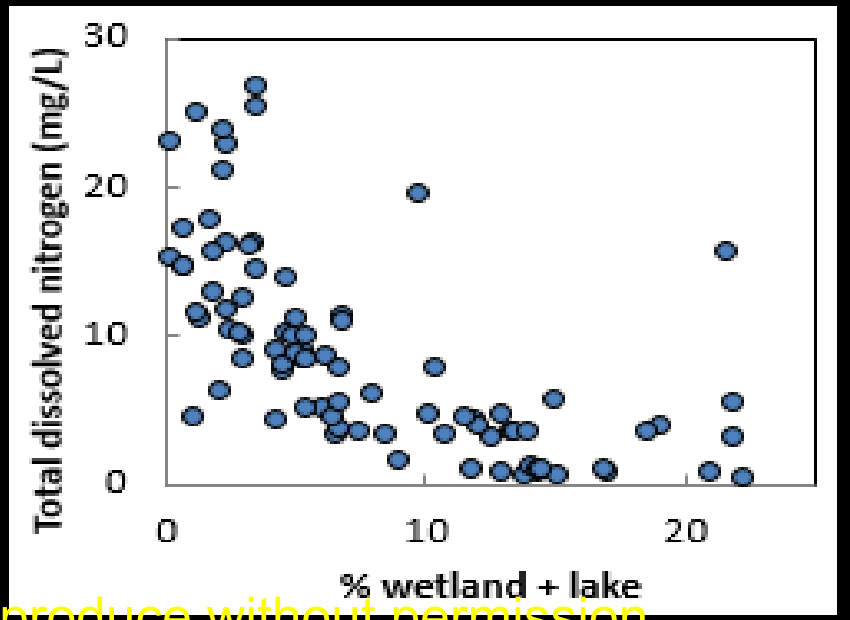
# Wetlands also decrease nitrogen concentrations in ditches during most critical season




- Reduces N during highest flows
- Apr-June flux sets size of Gulf Hypoxic Zone (Turner et al. 2012)

June decreases in TDN correlate with wetland coverage:

- 94 sites in 3 HUC-8 basins, sampled same week in June 2014
- Drainage areas: 3 to 5800 km$^2$
- Correlation with % wetland + lake holds when control for % cropland (85% cropland +/- 2.5%, $r^2 = 0.30$, $p = 0.009$, $n = 22$)




J. Finlay, A. Hansen

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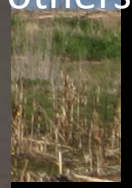
# We have some great examples to follow

Swift County JD 8 Restoration Project, Kriter, Magner and others





BE County Ditch 57 Restoration Project, Duncanson, Brandel, BEC

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# What needs to happen?

1. **Slow the flow!** Store more water in the landscape.
   - Make better use of existing water storage sites
   - Install new water detention basins
   - Controlled drainage
   - Increase soil carbon

   1a. Water needs to be detained long enough to not add to peak.

   1b. Make the most of that dedicated land.
   Habitat benefits? Nutrient reduction? Hay in dry years?

   1c. Make the improvements 'permanent'.

2. Continue to maintain and improve field practices.

3. Provide incentives with minimal red tape.

Coordinate efforts…the collective, downstream impacts matter.



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