Consequences of Increased Low and Mean Streamflow in Midwestern Agricultural Watersheds on Geomorphic - Ecological Interactions

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Importance of “below bankfull” flows

1. Geomorphic and engineering focus has been on channel-forming flows & floods
2. Lower, below bankfull flows are important ecological and can impact sediment load
3. TNC Ecological flows initiative has increased interest

Ecological flow studies- Major focus has been impacts of low flow on fish

This study focused on sandbar ecology: turtle nesting and vegetation colonization

Vegetation feedback on channel width

Hydrologic changes in southern MN

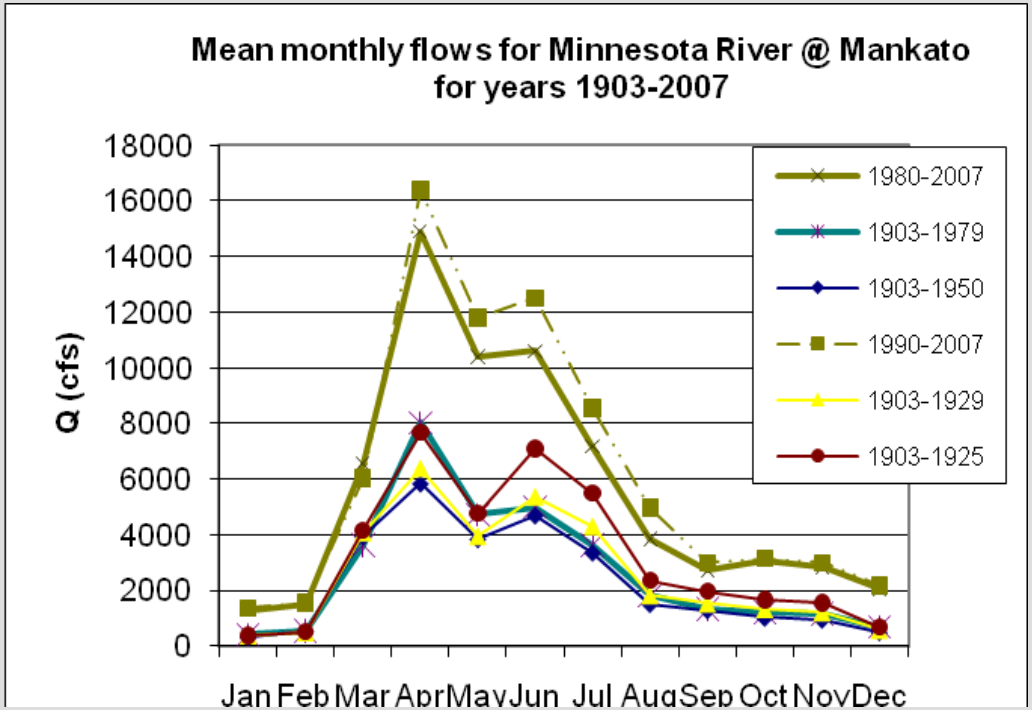
Increased stream flow in agricultural watersheds of the upper Midwest

Northern forested watersheds (Minnesota, Wisconin, Michigan)have not experienced dramatic hydrologic shifts

Greatest changes in low to 75% flows (IHA analysis)

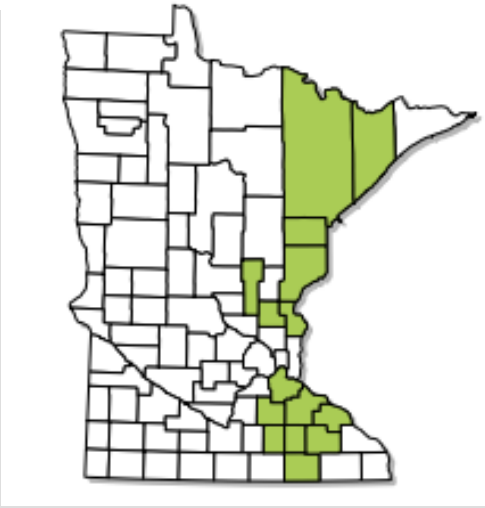
Duration has increased

No sig. change in the magnitude of small and large floods (2, 10 year recurrence



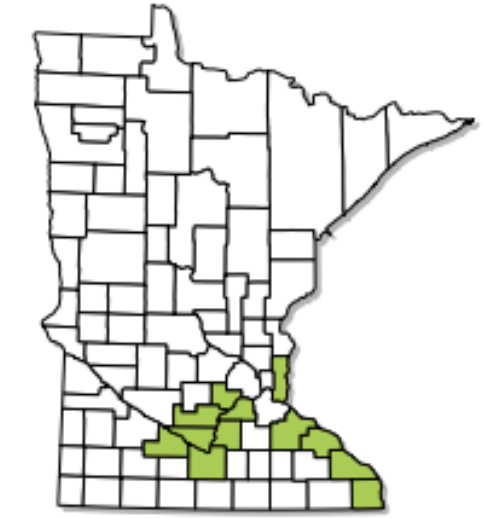
Lenhart, C. ,Petersen, H. and Nieber, J. 2011. Watershed response to climate change in the upper Midwest: The importance of low and mean flow increases for agricultural watershed management. *Watershed Science Bulletin*, Spring 2011: 25-31.

Impacts of hydrologic alteration on river turtle nesting



Wood Turtle – a MN Threatened species

Smooth Softshell – MN Special Concern

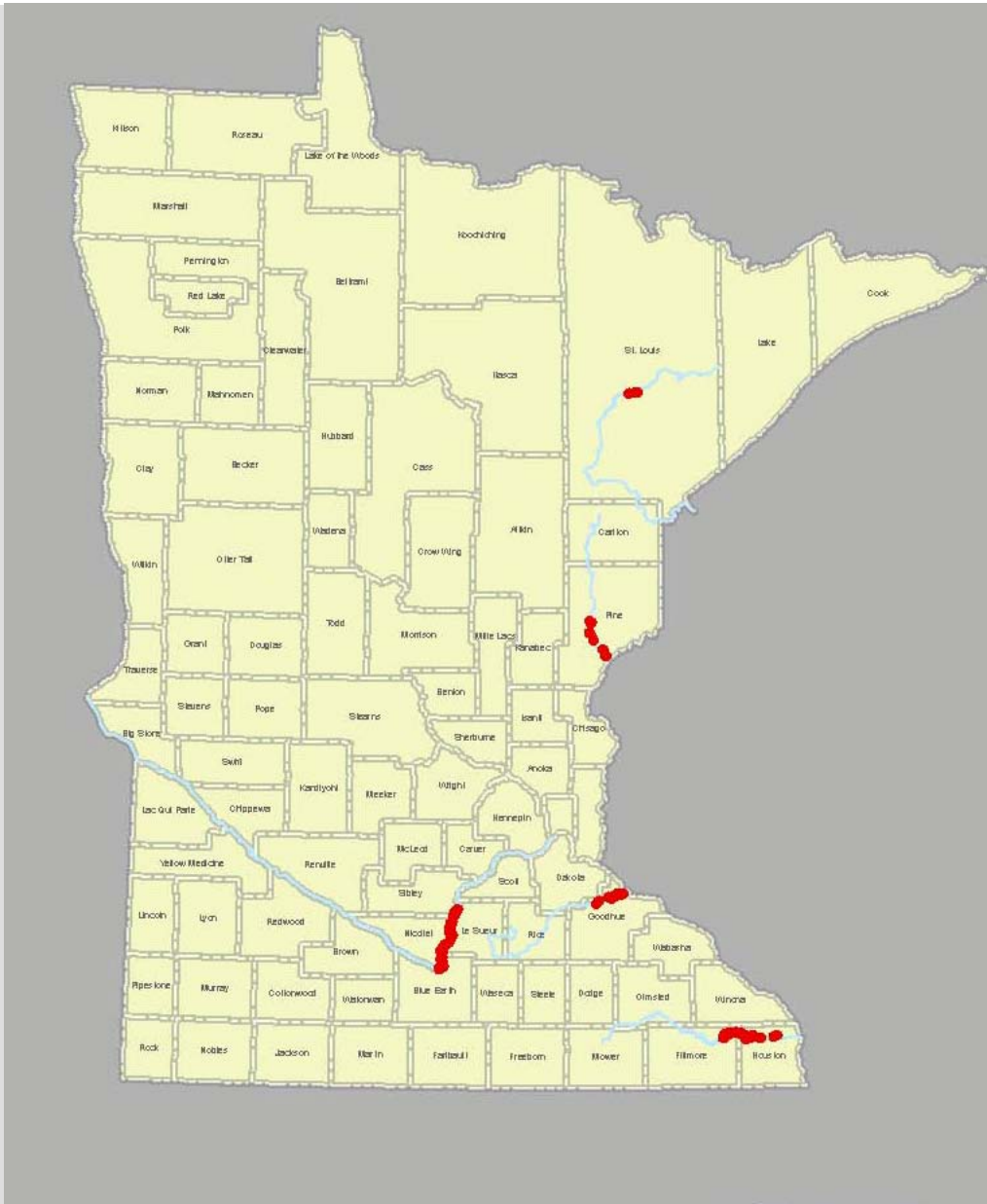


Hypotheses

1. The increased low flow level and duration in summer have reduced the areal extent and duration of sandbar exposure in southern Minnesota Rivers
2. The above impacts have reduced riverine turtle nesting opportunity
3. Channel evolution lags by decades to hydrologic changes

Research Sites

River	Characteristics
Root River	Driftless area Mississippi River tributary (smooth softshell)
Minnesota River	Largest tributary to Mississippi with largest sediment load (smooth softshell)
Cannon River	Trib to Mississippi River, (wood and smooth softshell) (only wood turtle reserve in state)
Kettle River	Northern forested region (wood turtle)
St. Louis	Northern forested (wood turtle)



Turtle lifecycle and hydrology relationships

Nesting
Feeding
Basking
Overwintering
Dispersal to uplands

Bodie (2001) Human impacts

1. **reduced logjams/woody debris**
2. **drainage or riparian wetlands/side channels**
3. **channelization**
4. **impoundment and flow regulation**
5. **reduction of sandbars or beaches**
6. **human use of riparian zone**
7. **pollution/siltation**

Background: Hydrology-turtle nesting relationships

- **Duration, timing and frequency of flow key for successful nesting**
- **Temperature of sand effects development**
- **> 2 days submergence- no survival** (Plummer 1976)
- **Reduced nesting time and/or delayed emergence = less reproductive success**

Methods

Field survey data:

Nesting locations

Presence of turtles

Sandbar traits

- slope,
- direction orientation
- soil particle size,
- nest elevation above river
- Temperature (0, 15cm, water surface)

Hydrologic analysis

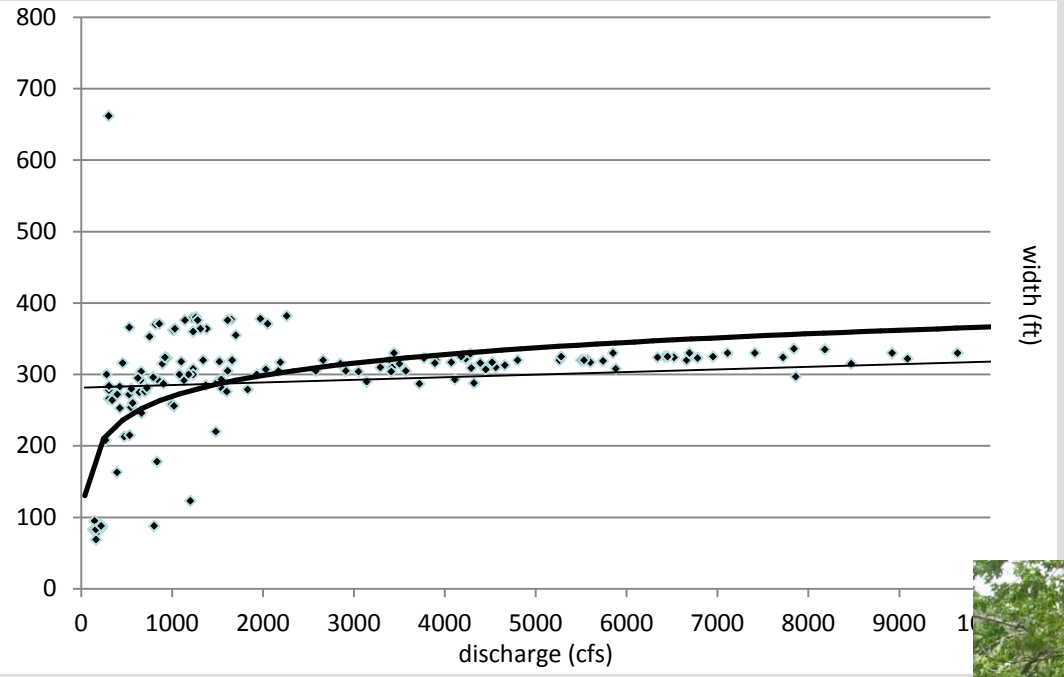
Indicators of Hydrologic Alteration (IHA) - flow metrics of ecological importance including duration, frequency, timing, magnitude

Sandbar exposure-discharge relationship

Change in frequency, timing and duration of exposure

Presumed impact on nesting success

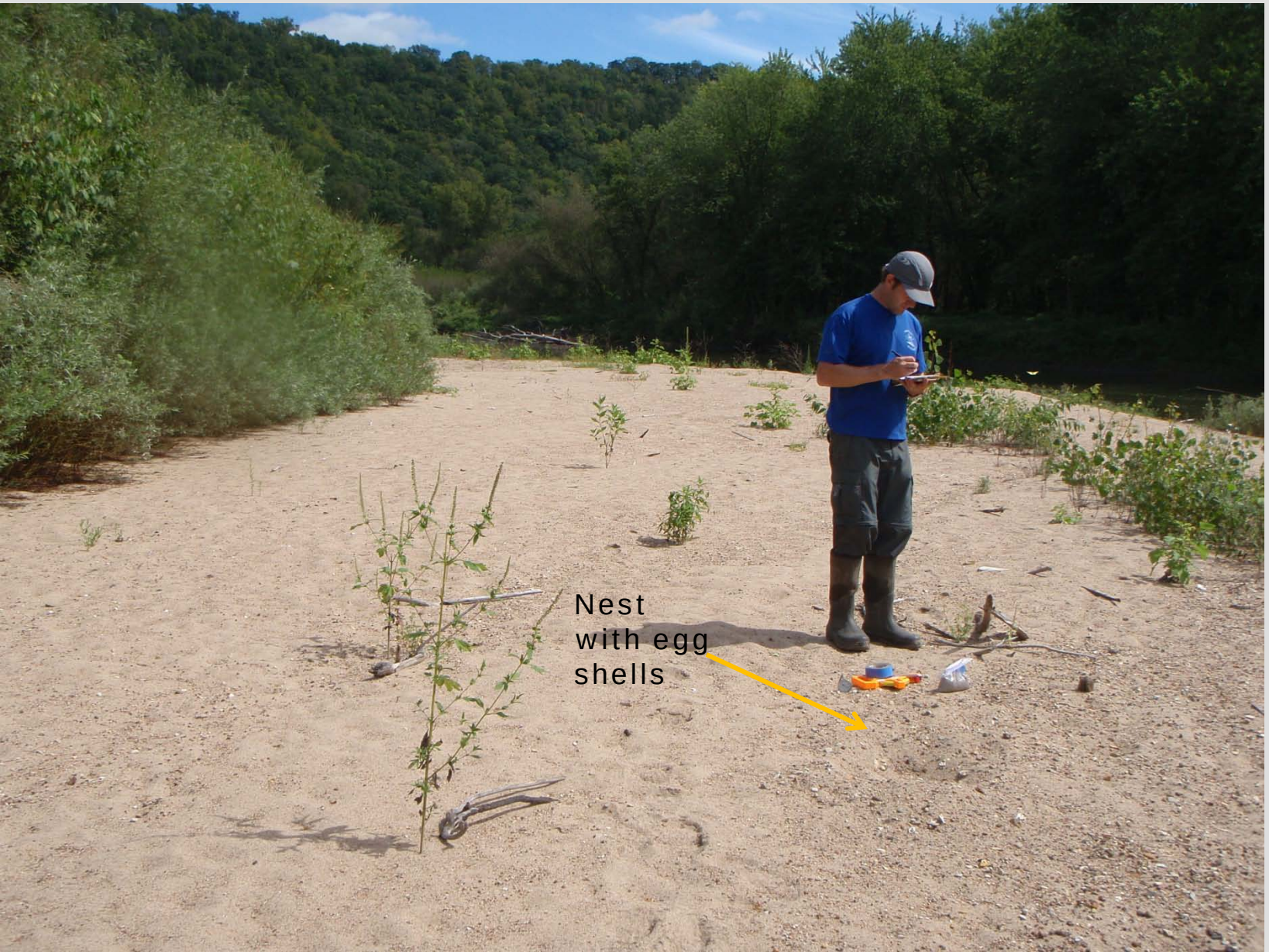
Flow-sandbar emergence relationship



1. aerial photos used to obtain sandbar area at different flow levels

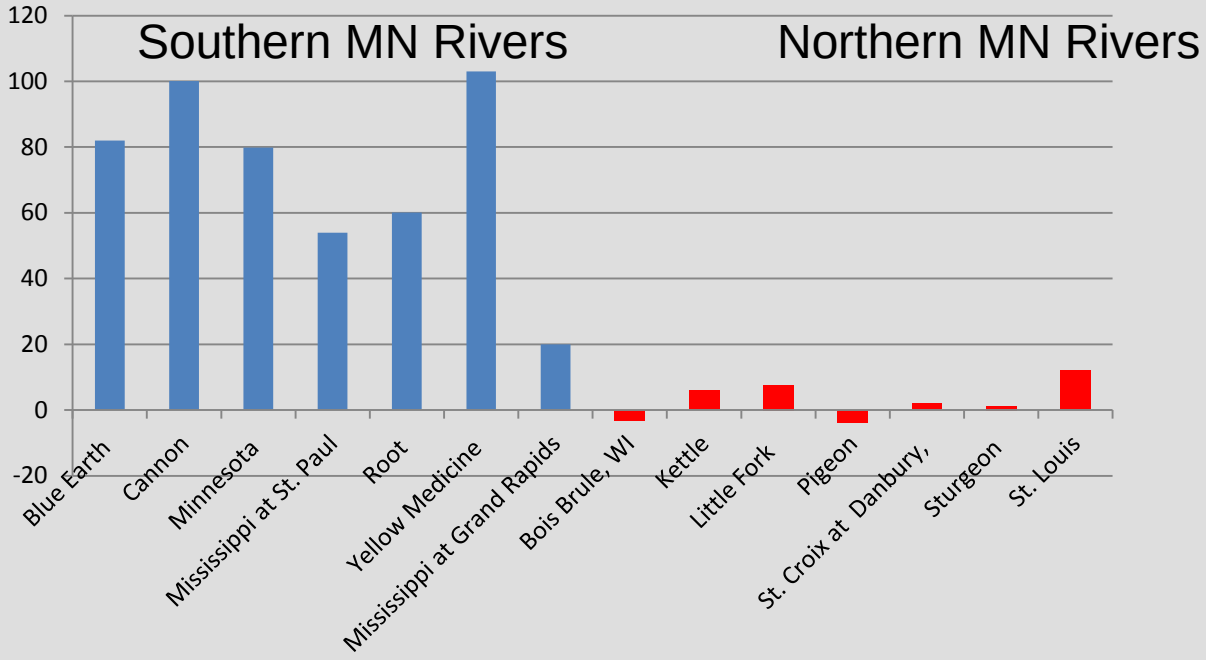
2. Compared to USGS width/discharge measurements at stream gauges

Field survyes: Locating nesting sites

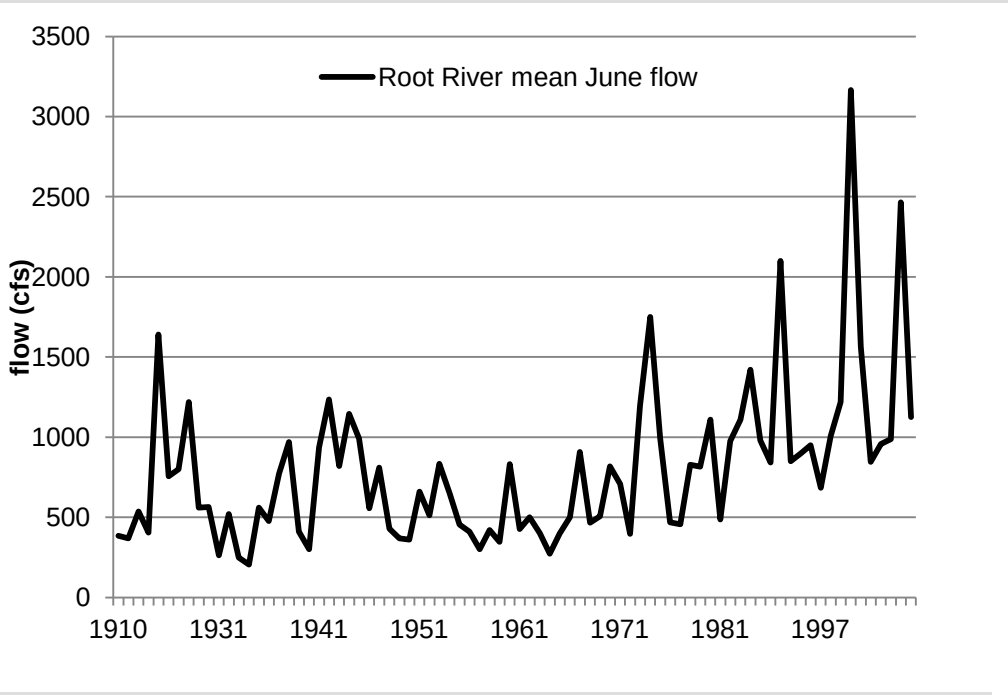


Hydrologic analysis results: mean annual flow

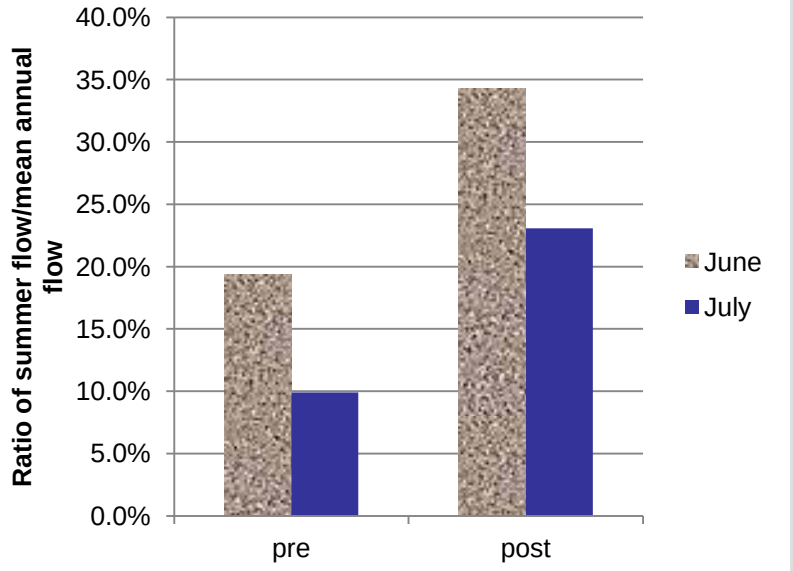
% change to mean annual flow
(1940-1979 vs 1980-2009)



Changes to mean flow in nesting period



Summer flow as a percent of the mean annual flow has increased.

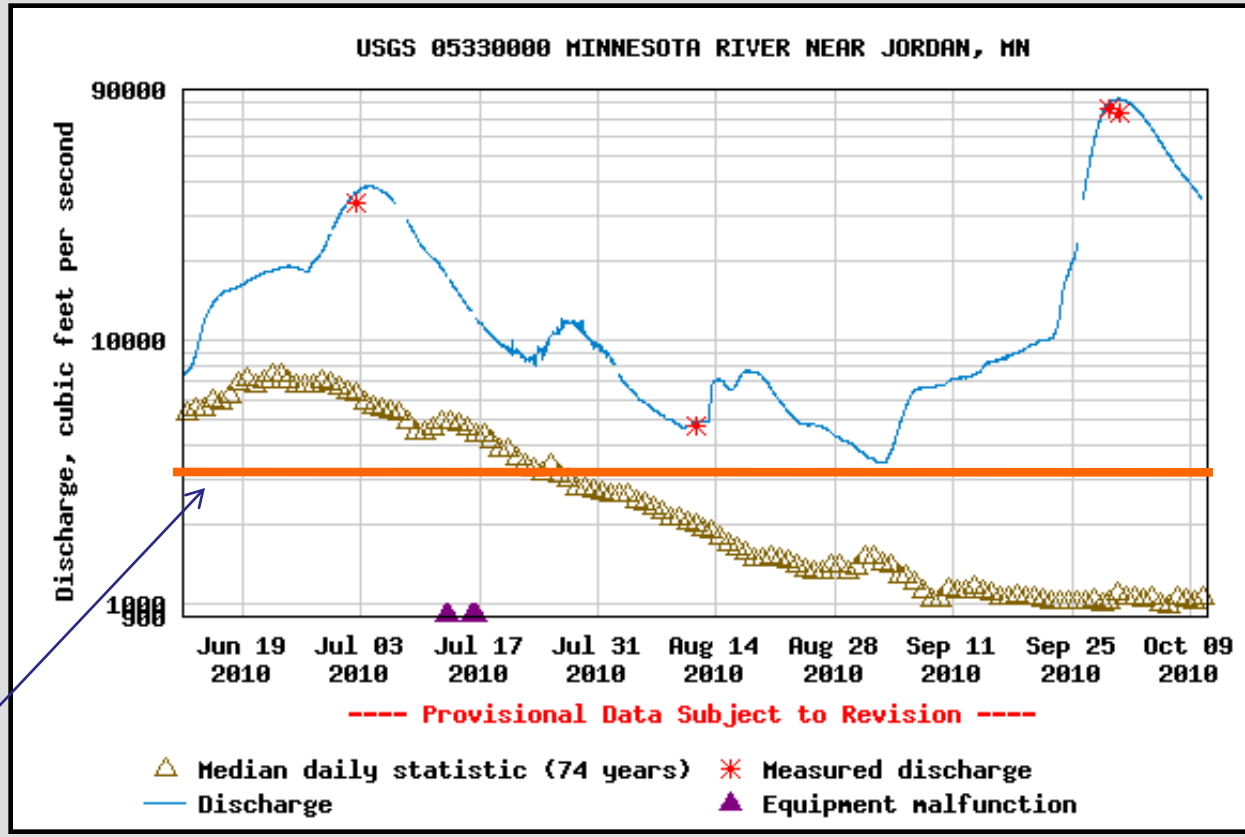


Duration of prolonged high summer flow (Minnesota River in 2010)

Duration of moderately high flows has increased in summer

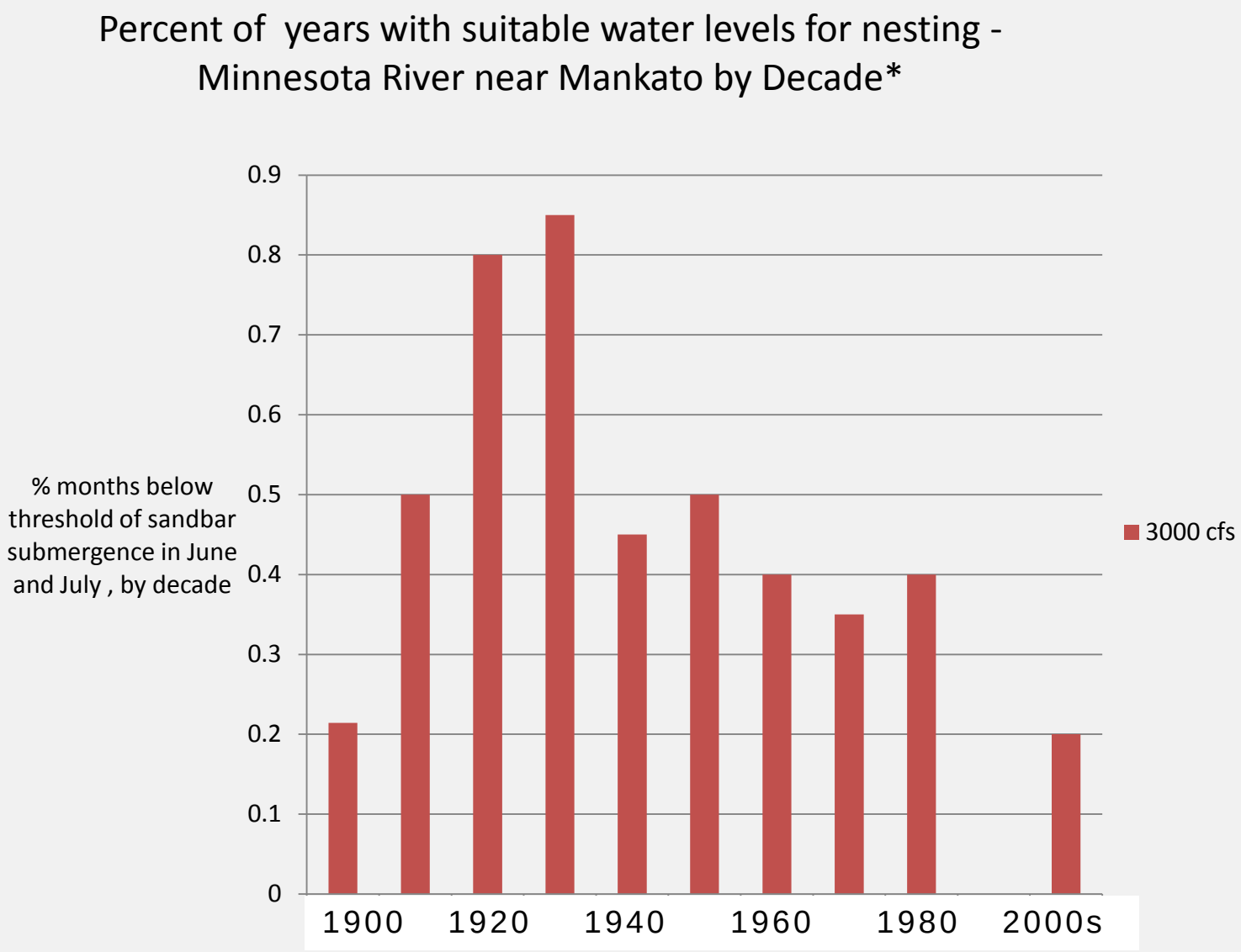
“Drawdown” duration is reduced, less frequent

Delays or reduces nesting opportunity



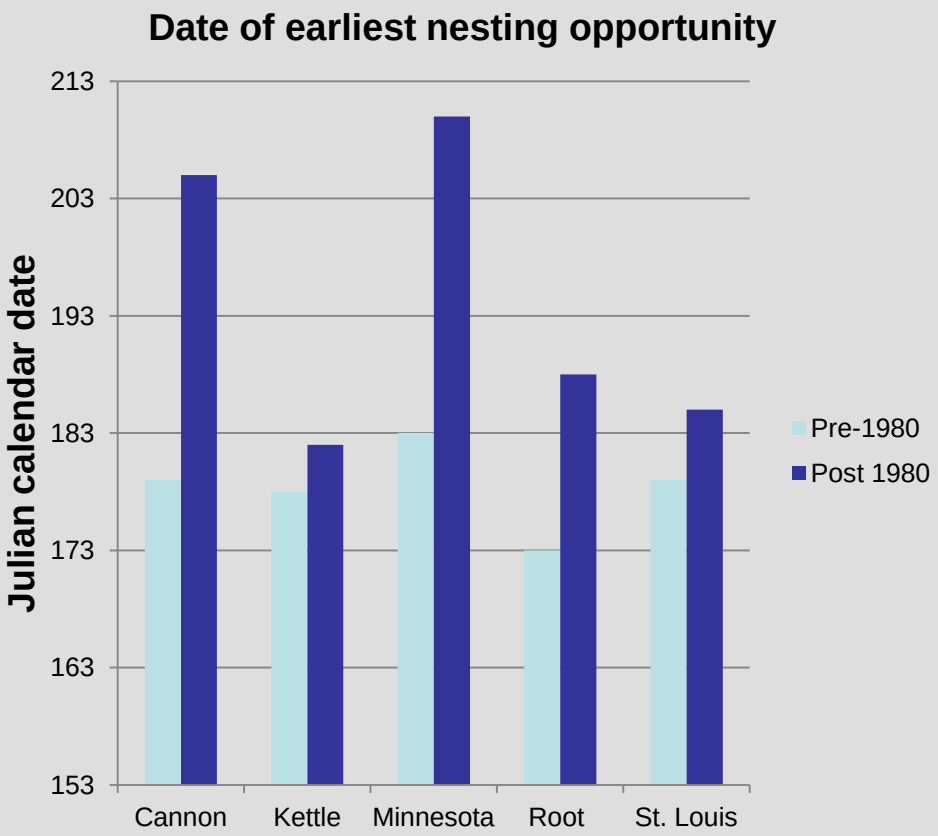
Sandbar inundation flow level

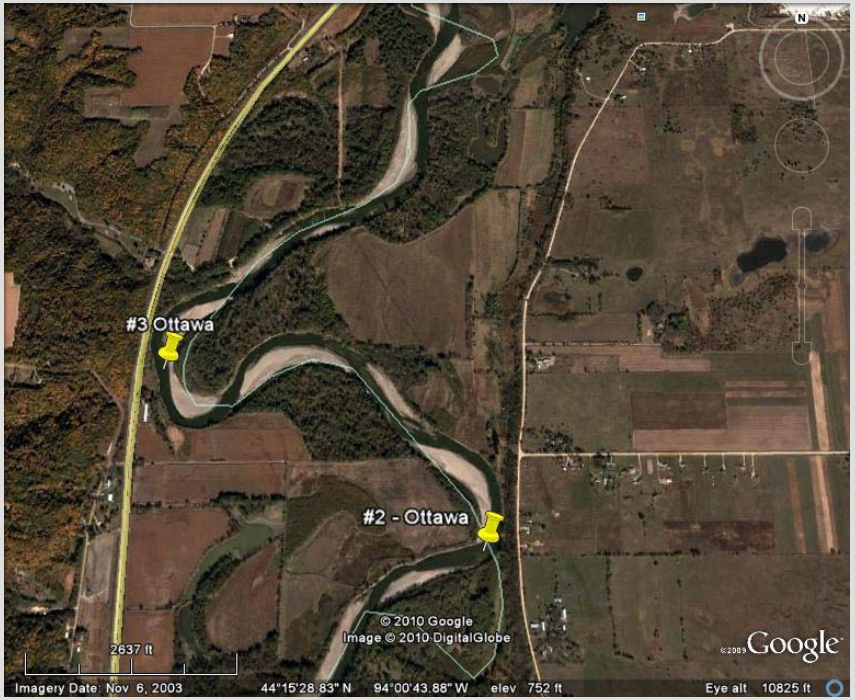
Sandbar emergence analysis (decadal)



Timing of sandbar availability/nesting

Earliest date of nesting availability after June 1st, followed by 75 flood free days, (< 2 days submerged)





Channel response: Widening in southern agricultural streams

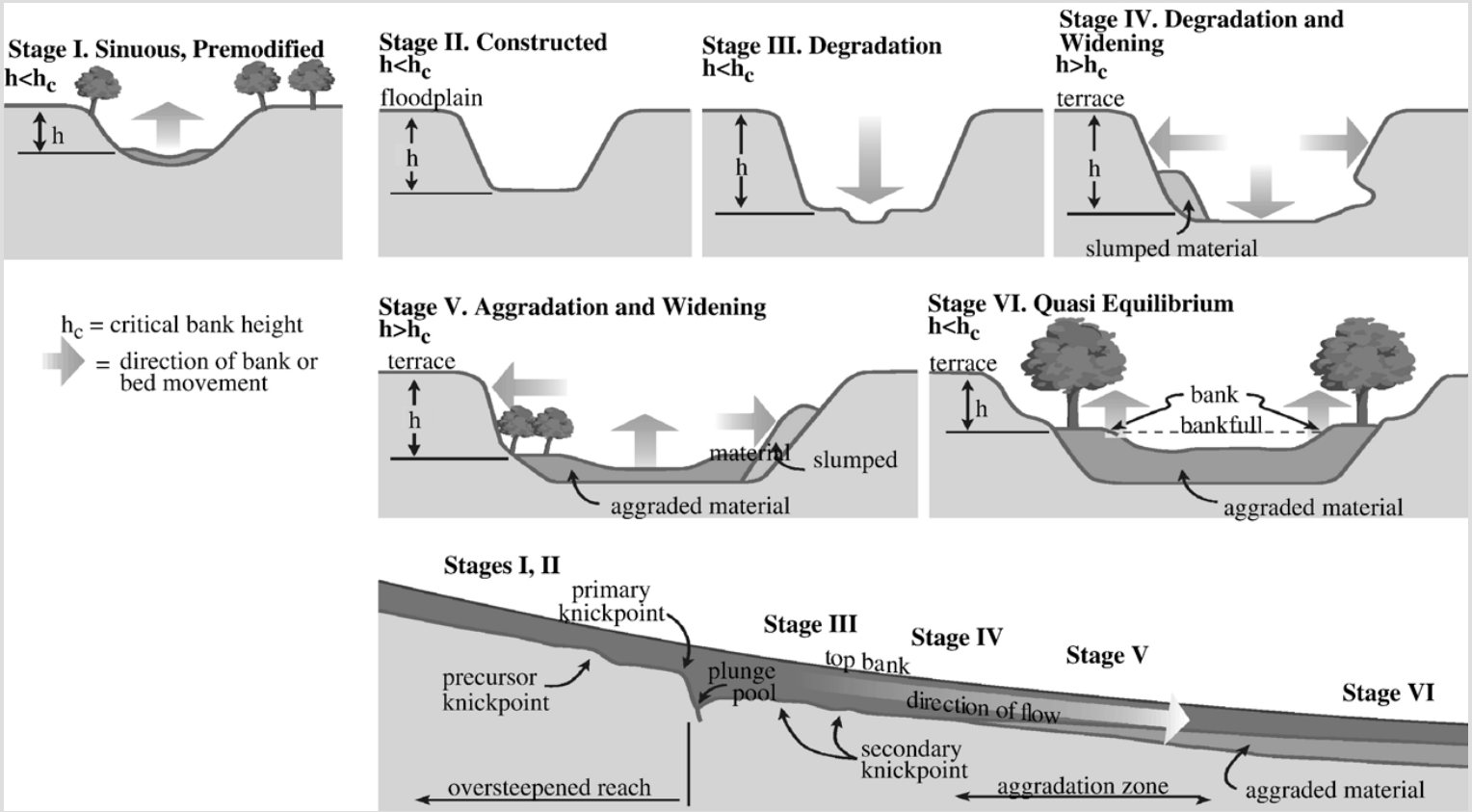
Widening on southern rivers, but not northern rivers.

Lower MN River has widened by > 50%. Kettle and St. Louis are stable.

But sediment deposition rates on sandbars is unkown?

Channel evolution

- **At what stage of evolution are the southern MN Rivers ?**



Simon and Rinaldi 2006

A vegetative hydro-geomorphic model of channel widening

- Hydrology, geomorphology and plants width
- Typical model only geomorphic
- Changes to magnitude & duration of summer flows effect plant establishment & growth

Woody plant establishment impacts

Vegetation colonization line moves up & out from increased summer flows

Outer bend erosion continues

Plant colonization line on point bar: primarily willows & cottonwood (Noble 1979)

Management

- Consequences of elevated nesting zones: more nest predation, human disturbance and further migration
- Impacts on overwintering habitat?
- Feeding impacts of higher turbidity/food web alterations
- Watershed management needed flow volume reduction
- Instream: undo channelization (lower Root and MN Rivers); other?

Further questions

- **Is streamflow regime shift permanent?**
- **Impact of different types of hydrologic change on channel evolution**
- **Future research on restoration prioritization.**

Summary

Hydrologic change (as calculated by IHA) has reduced time and extent of nesting habitat in southern MN Rivers further stressing river-nesting turtles

Low and mean flow changes are key for ecological interactions

Further research needed on actual nesting survival, other life cycle components

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