Leave it to Beaver

Rethinking Drainage Management

Presentation to the 2009 Minnesota Lakes and Streams Conference

Rochester, MN

Terry Lee, Olmsted County Environmental Services
2116 Campus Drive SE
Rochester, MN 55904
(507) 328-6723
lee.terry@co.olmsted.mn.us

Beaver Hypothesis

Beaver are ecosystem engineers capable of completely altering stream ecology.

Beaver dominated all but the largest streams in North America during most of the last million years.

Most native stream and riparian species are still genetically programmed to lifecycles dependent upon, or at least adapted to, beaver-created habitat.

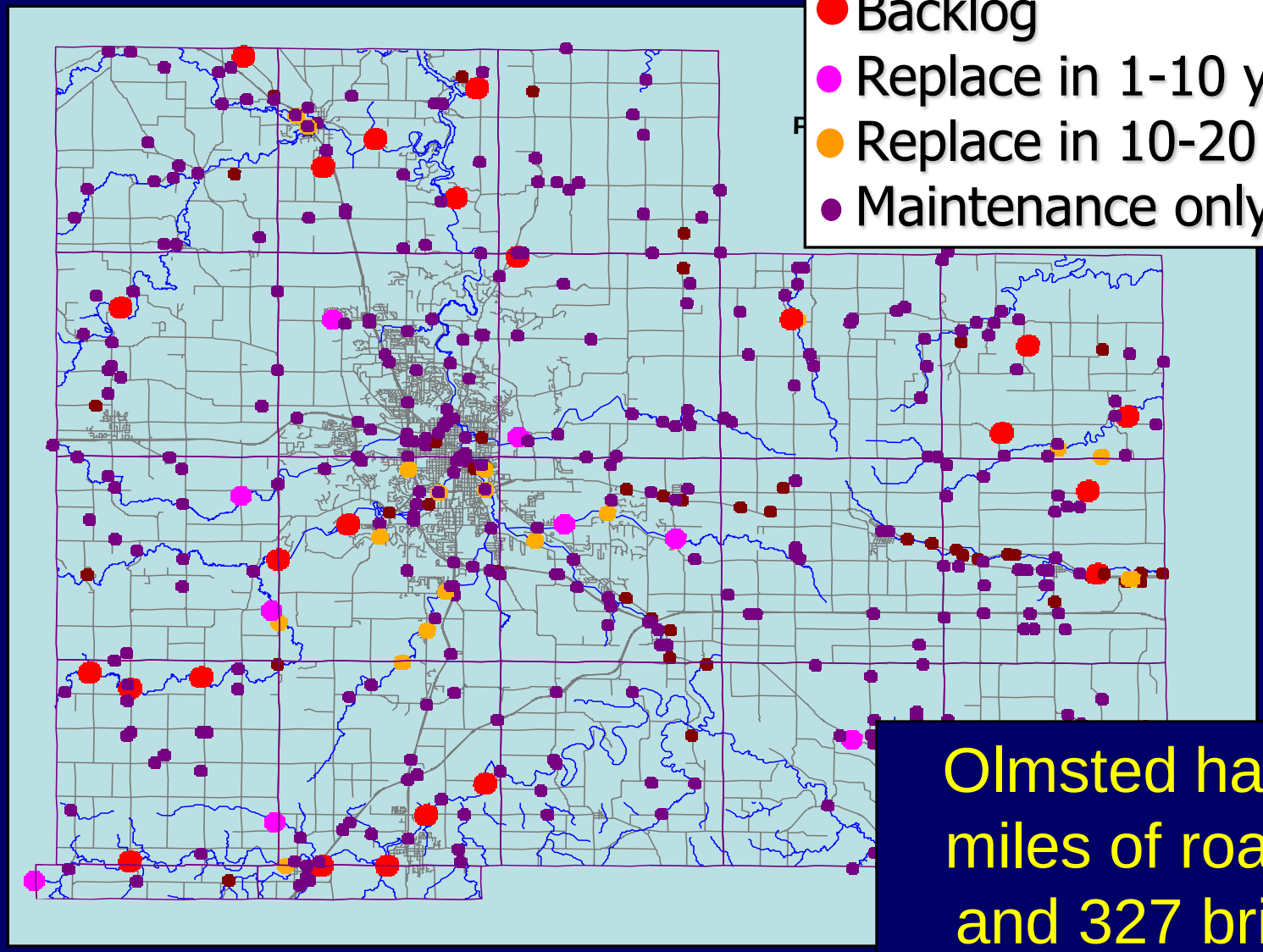
Restoration of native stream ecosystems requires beaver.

Beaver have historically and continue to provide essential ecosystem services for the benefit of humans.

Olmsted County's Problem

- Many bridges and culverts are outdated
- Replacements must be larger and more expensive to accommodate trends in increased precipitation and flooding

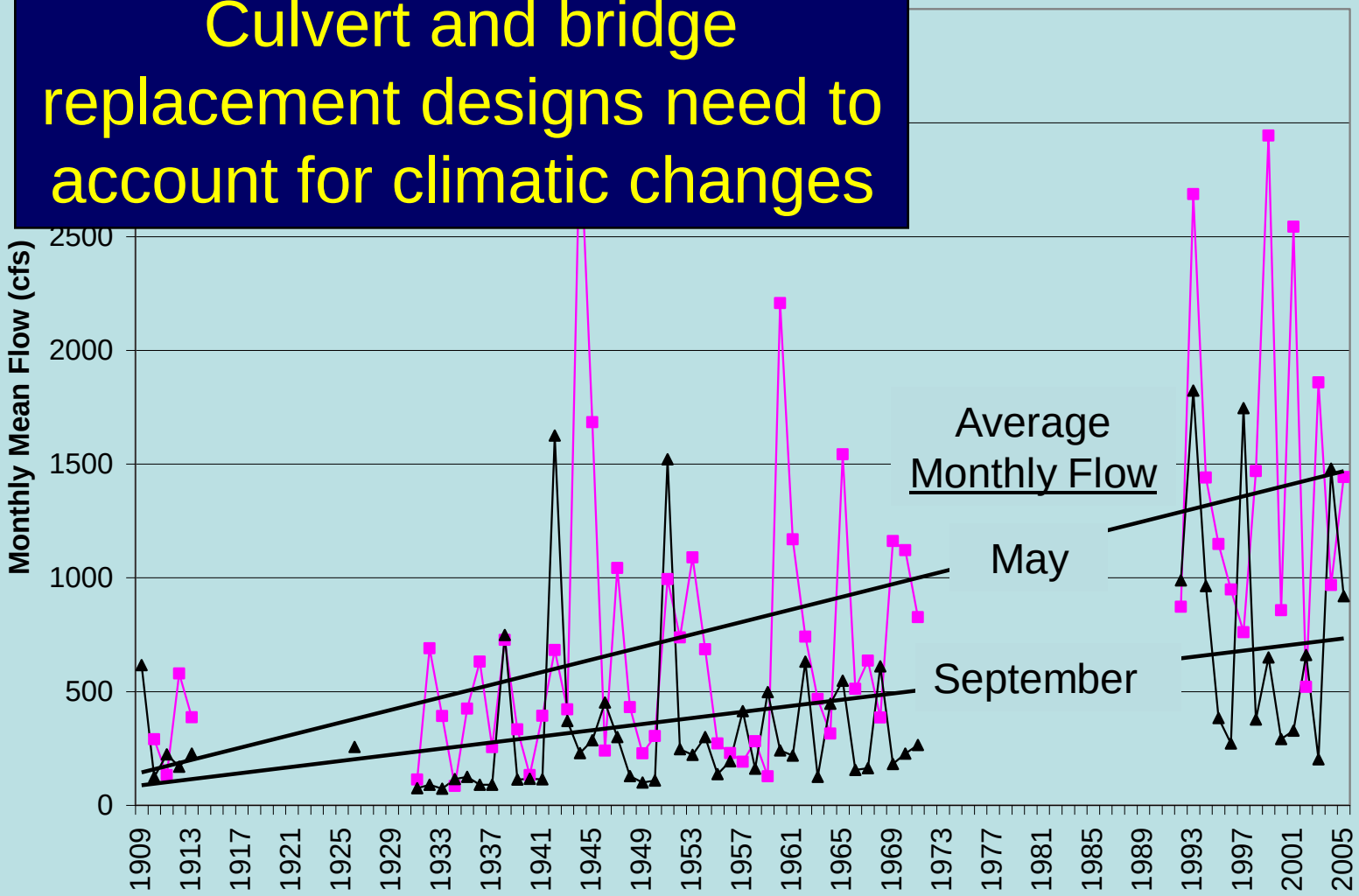
$8 Million Needed to Replace Bridges & Culverts in the Next Five Years



Olmsted has 522 miles of roadway and 327 bridges

Long Term Stream Discharge Trends

Culvert and bridge replacement designs need to account for climatic changes



Source: Minnesota Pollution Control Agency (Welch Creek)

Options for Fixing the Problem

- Increase flood conveyance
- Increase flood storage

Hydrology Management Options

Hydrology management has two variables:

- conveyance
- storage

If conveyance is limited, storage increases.

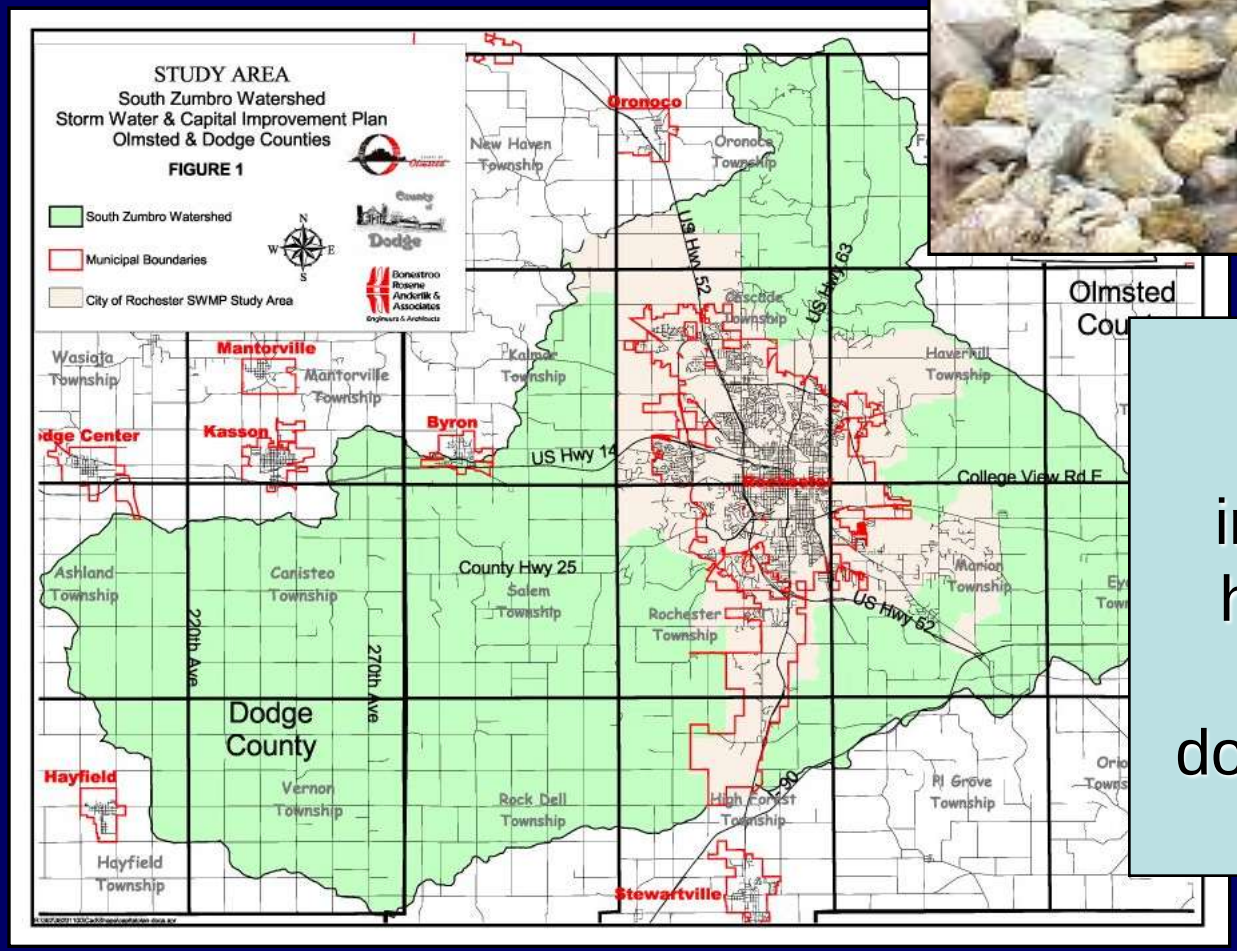
If storage is limited, conveyance increases.

Source: Donald Hey, 2001

Proposed Fix

A Watershed Plan that focuses on increasing flood storage

A plan was developed to store upland flood waters as an alternative to increasing the conveyance capacity of bridge and culvert replacements



Both increased conveyance and increased storage have a cascading impact on all downstream culverts and bridges

Benefits expected from implementing the Watershed Plan:

- Reduced runoff flow volumes and velocities
- Lower transportation construction and maintenance costs
- Improved road safety (reduce flood risk)
- Improved downstream water quality
- Stabilized drainage and stream corridors
- Reduced sediment and flooding damage
- Reduced streambank erosion
- Restored/created wetlands
- Improved fish and wildlife habitat
- Connected wildlife corridors

$1.20

Return

Funding to Get Started

$1.00

Investment

Decrease Conveyance

Increase Storage

Problems with the Proposed Plan

- No sources of capital to get started,
- Natural and cheap storage on floodplains is being lost,
- DNR won’t allow flow control structures on the stream

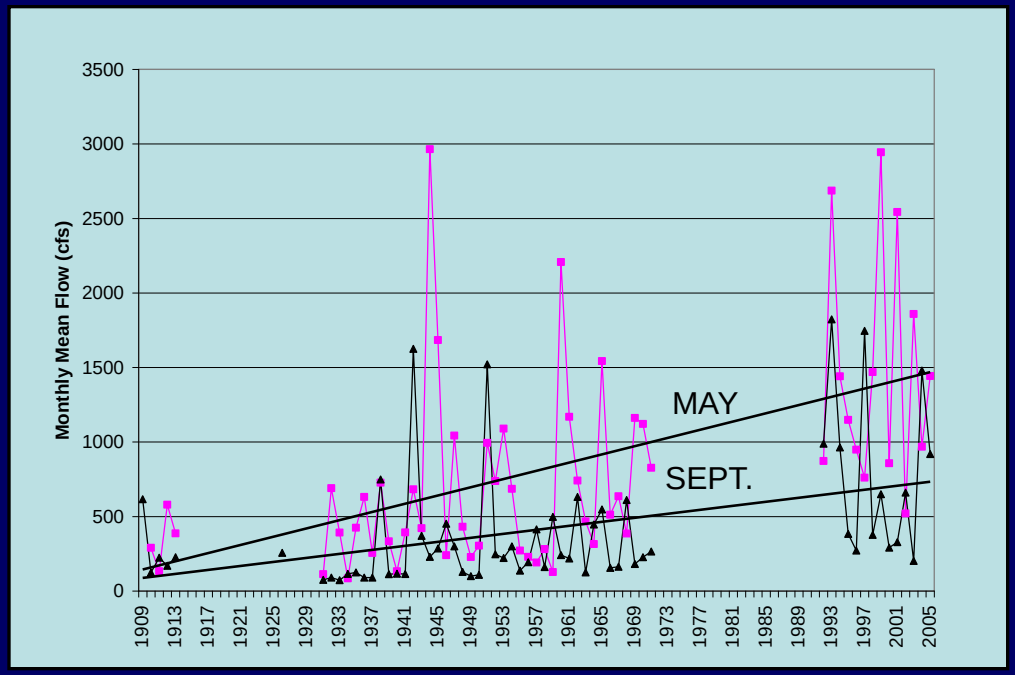
Constructed flood storage is estimated to cost at least $10,000/acre foot.

Far less expensive is restoring natural storage on floodplains.

Natural flood storage is lost when streams become incised and disconnected from their floodplains

Primary Incision Factors

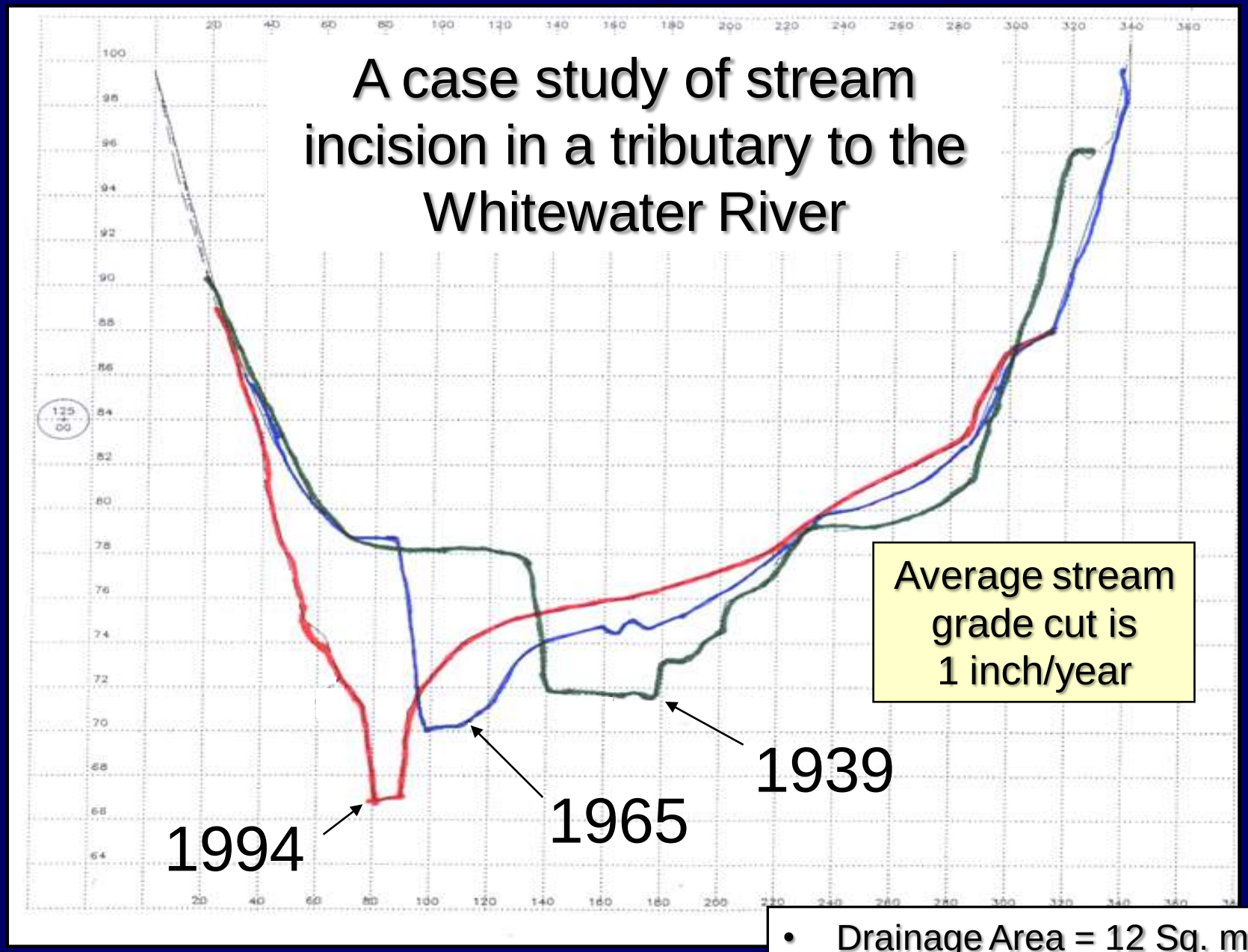
- Flows increased
- Sediment loads decreased



Stream Discharges

Conservation Tillage

A case study of stream incision in a tributary to the Whitewater River



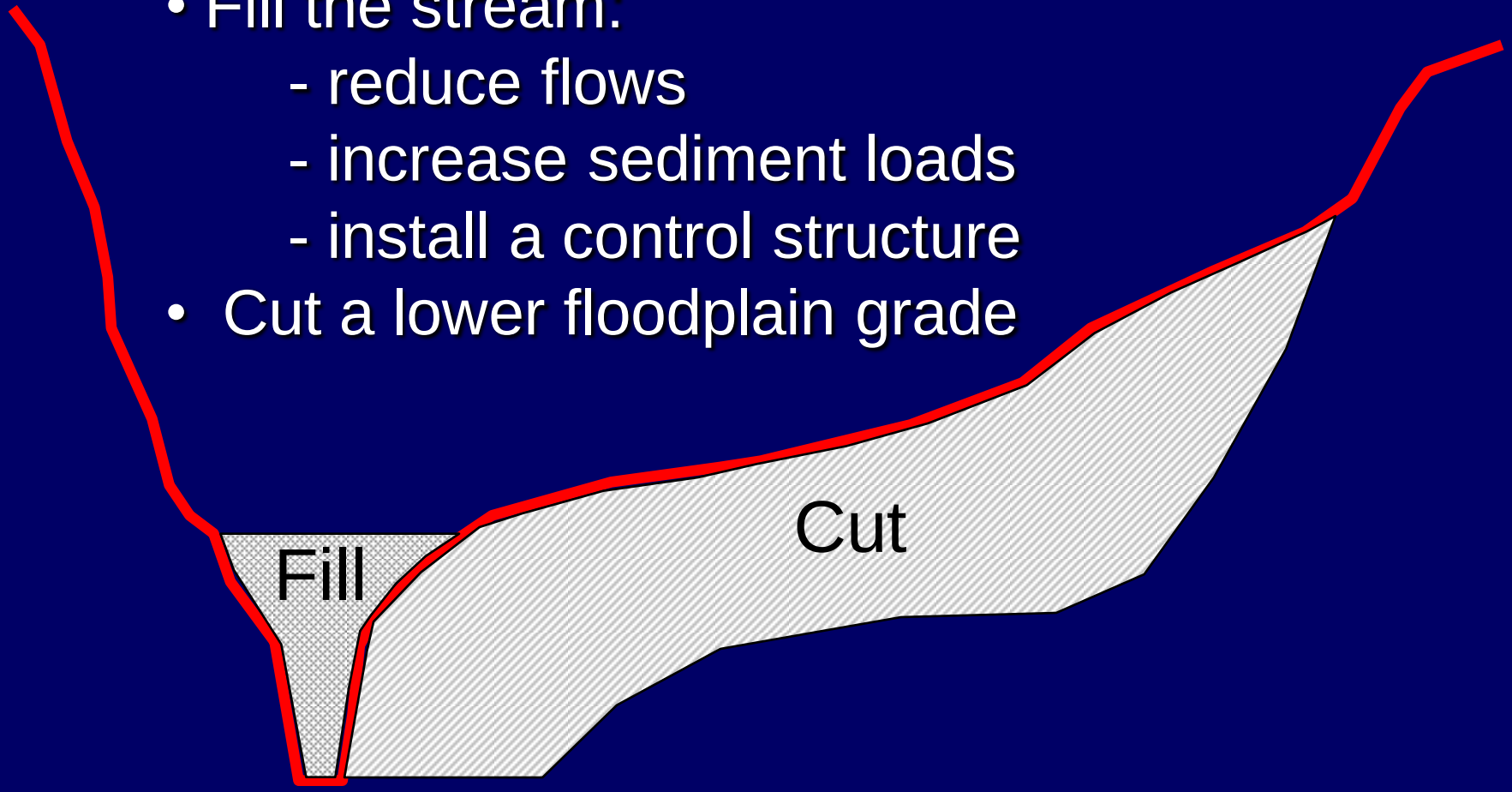
Average stream grade cut is 1 inch/year

- Drainage Area = 12 Sq. miles
- Vertical Exaggeration X 10

Source: Natural Resources Conservation Service – Trout Creek

How can this stream be reconnected to its floodplain?

- Fill the stream:
  - reduce flows
  - increase sediment loads
  - install a control structure
- Cut a lower floodplain grade

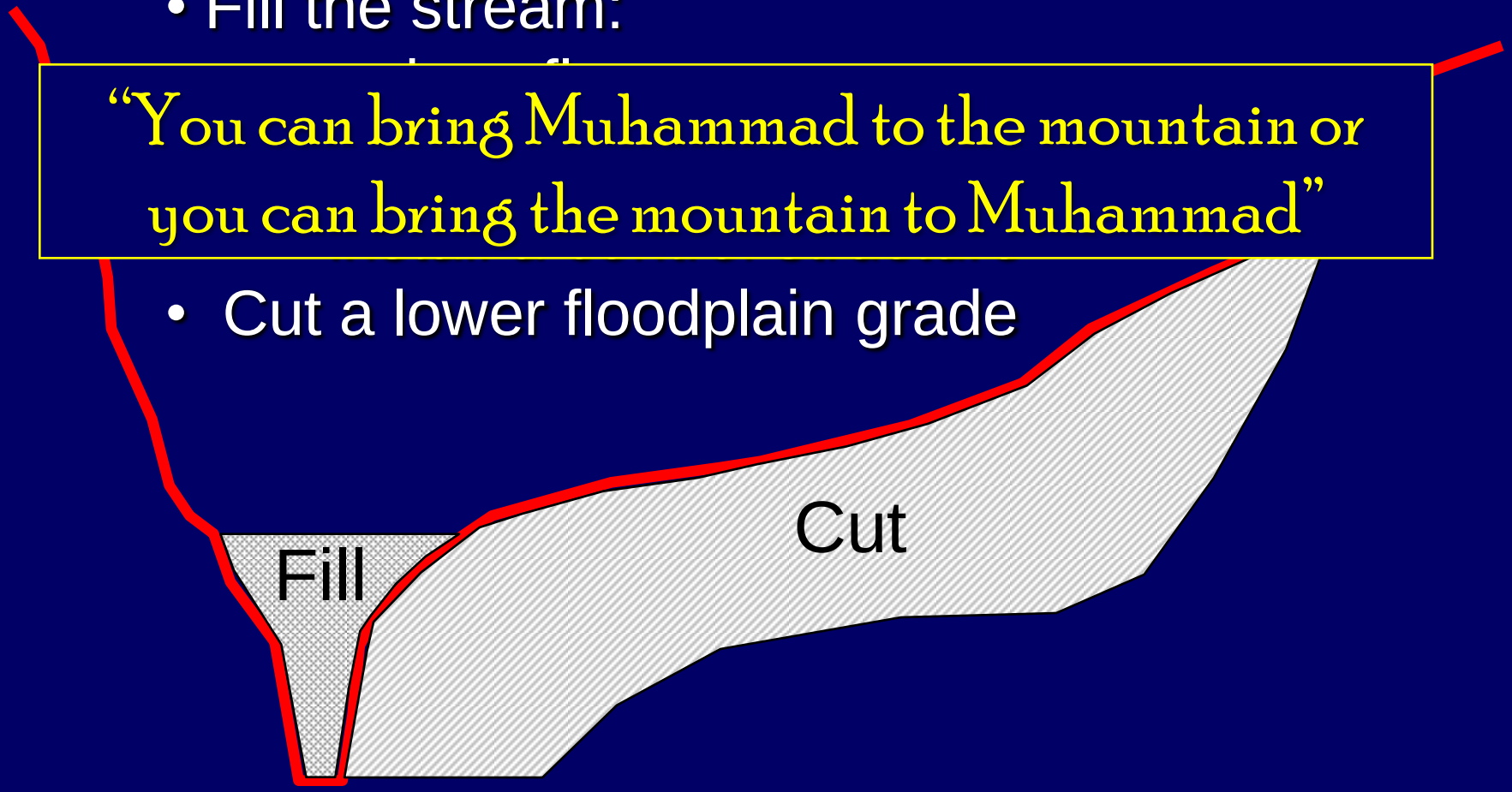


How can this stream be reconnected to its floodplain?

- Fill the stream:

"You can bring Muhammad to the mountain or you can bring the mountain to Muhammad"

- Cut a lower floodplain grade



August 2007 Flood

Whitewater River

Mountains were moved when new floodplains were cut

The Zumbro Plan Specified Flow Control Structures on Cascade Creek

Alternative Plan

Restore floodplain storage using natural dams

Beaver Dams as an Alternative

- Costs for *site* design, easements, engineering, *construction,* maintenance, and *replacement*
- Requires access and *permits*
- Requires support from land owners, fishing groups, and resource managers

- Costs for *corridor* design, easements, engineering, *wildlife plantings,* maintenance, and *damages*
- Requires access as well as *beaver harvest constraints*
- Requires support from land owners, fishing groups, resource managers, and *trappers*

Problem with the Alternative

- It hasn’t been done before,
- There are a lot of questions about whether it should be done and can be done

Should it be done?

Are the dams really natural in this region?

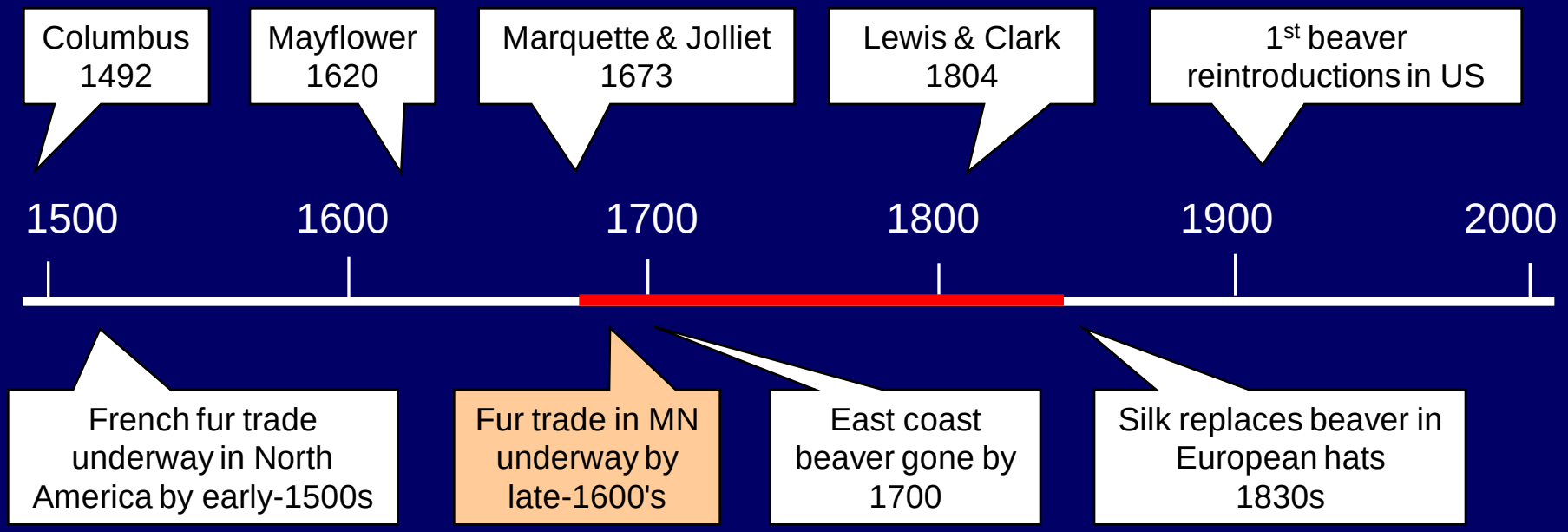
Beaver in Regional Native American Archeological Study Sites

- Of the 190 species found, only Whitetailed Deer (32 sites) and Three Ridge Mussels (25 sites) were found at more sites than beaver.

- Beaver were found at 24 of 32 study sites.
  - 11 Oneota sites: AD 1250 – AD 1650
  - 10 Woodland sites: AD 1 – AD 1200
  - 3 Archaic sites: 9,000 BC – 1 BC

Source: Theler, 2000

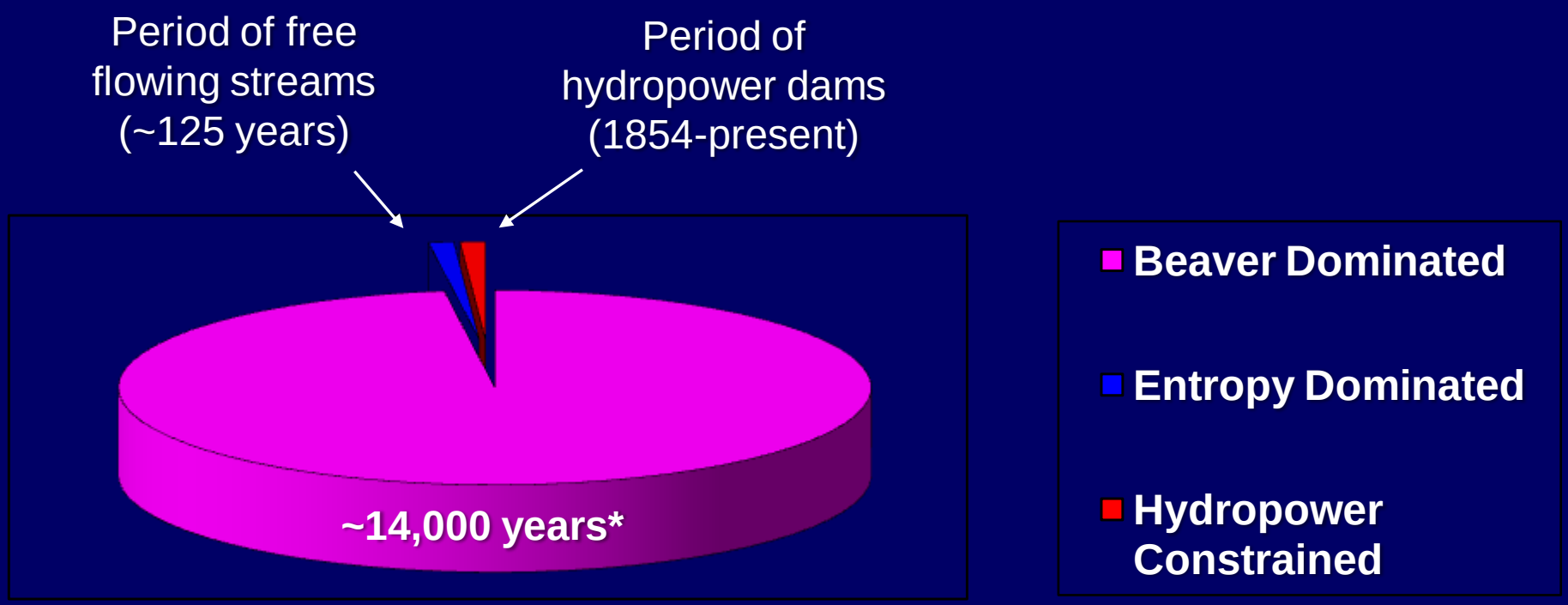
Chronology of Events Associated with the Harvest of Beaver in North America



Beaver skins were the principal export of New York City until 1700

Source: Outwater, 1996

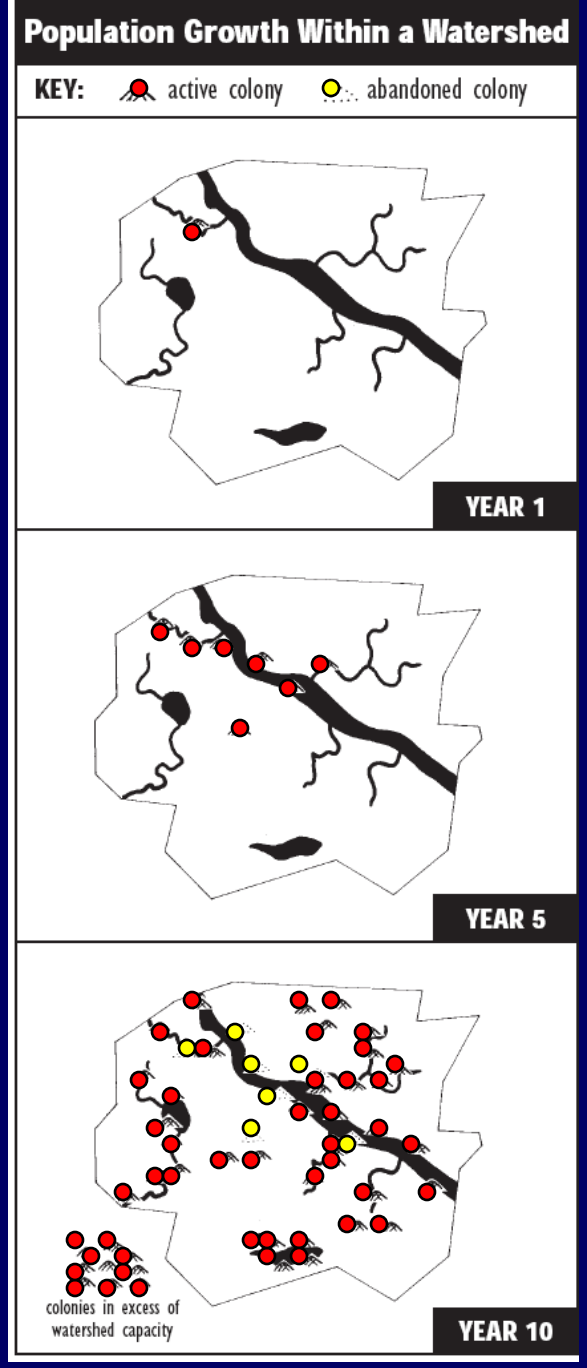
Period of Influence on Stream Ecology in Olmsted County Since the Last Glaciation



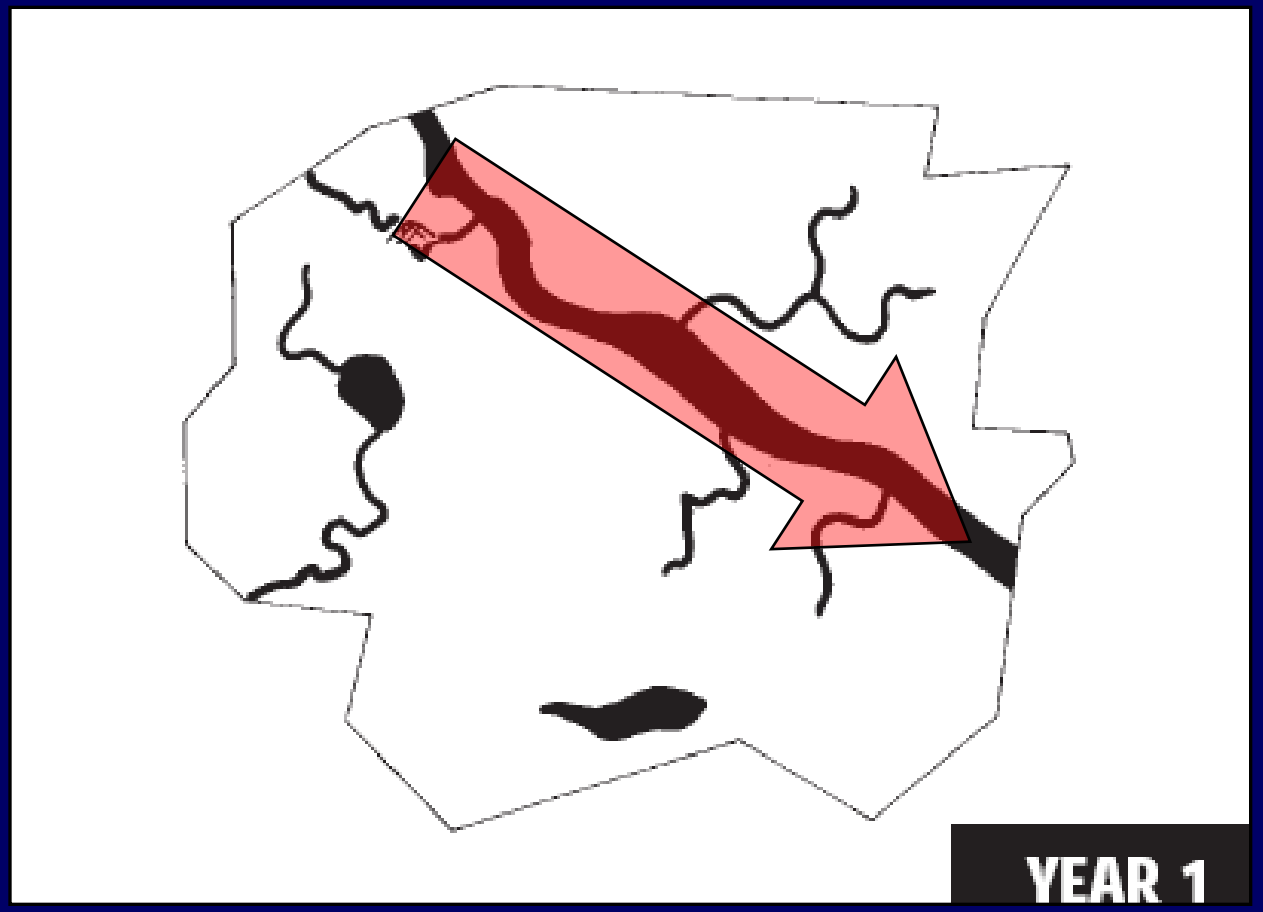
* The principal predators of beaver during this period were humans and wolves.

Keystone Species

- A species that so alters its environment that most other native species have adapted to it.



Beaver dams retard the free flow of water, nutrients, sediment, and energy out of the upper and middle reaches of the watershed.



Source: Jackson & Decker, Univ. of Massachusetts

Hydrology Impacts of Beaver Extirpation

"Extirpation" means locally extinct

- Streams become free flowing
- Streams degrade (sediment is removed)
- Streams become incised (deeper and narrower)
- Water tables are lowered
- Wetlands are drained
- Landscapes become drier
- Stream base flows decrease and peak flows increase

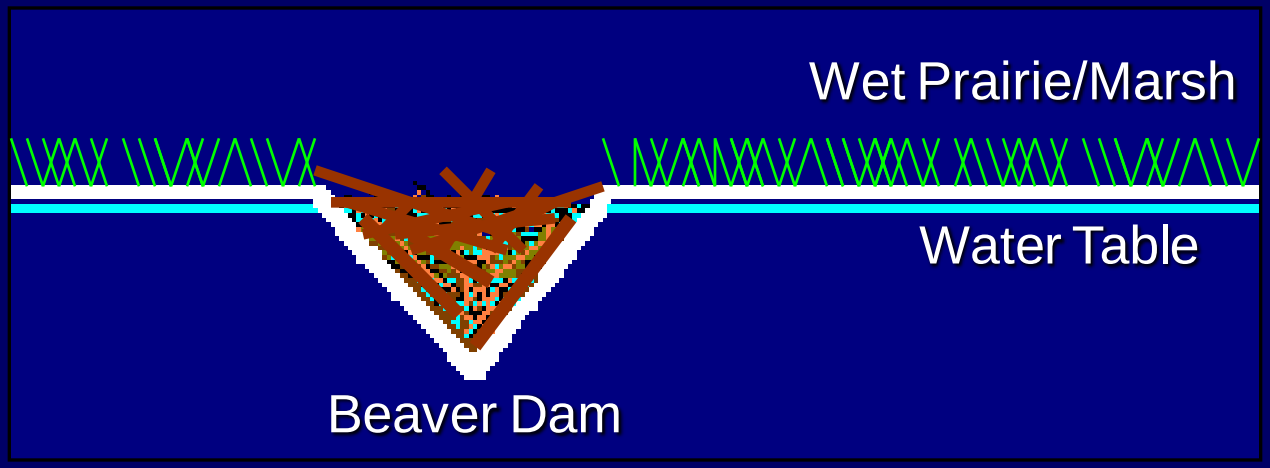
Hydrology Impacts of Beaver Extirpation

- Streams become free flowing
- Streams degrade (sediment is removed)

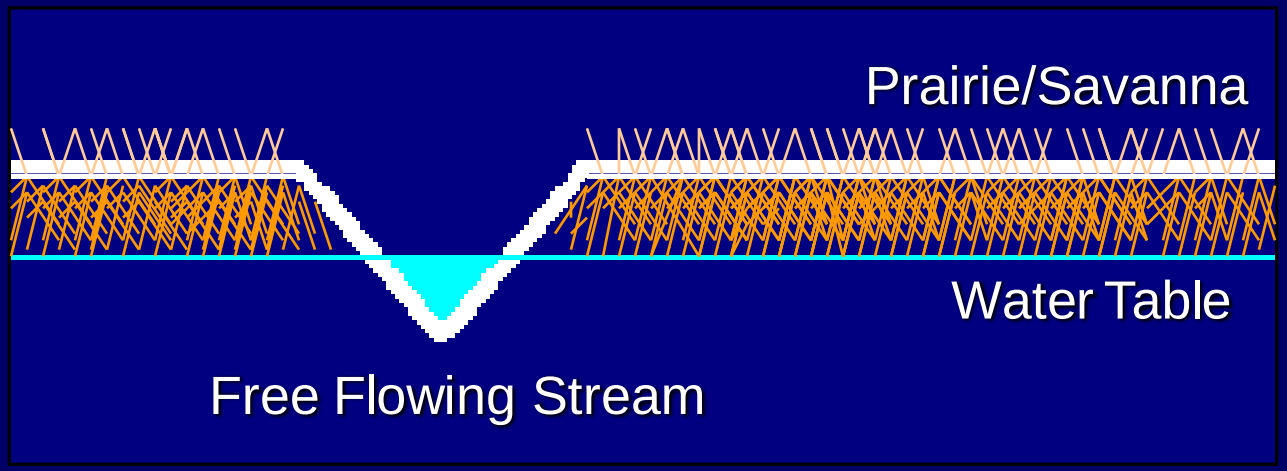
This entropic feedback loop continues to challenge stream restoration efforts

- Wetlands are drained
- Landscape becomes drier
- Stream base flows decrease and peak flows increase

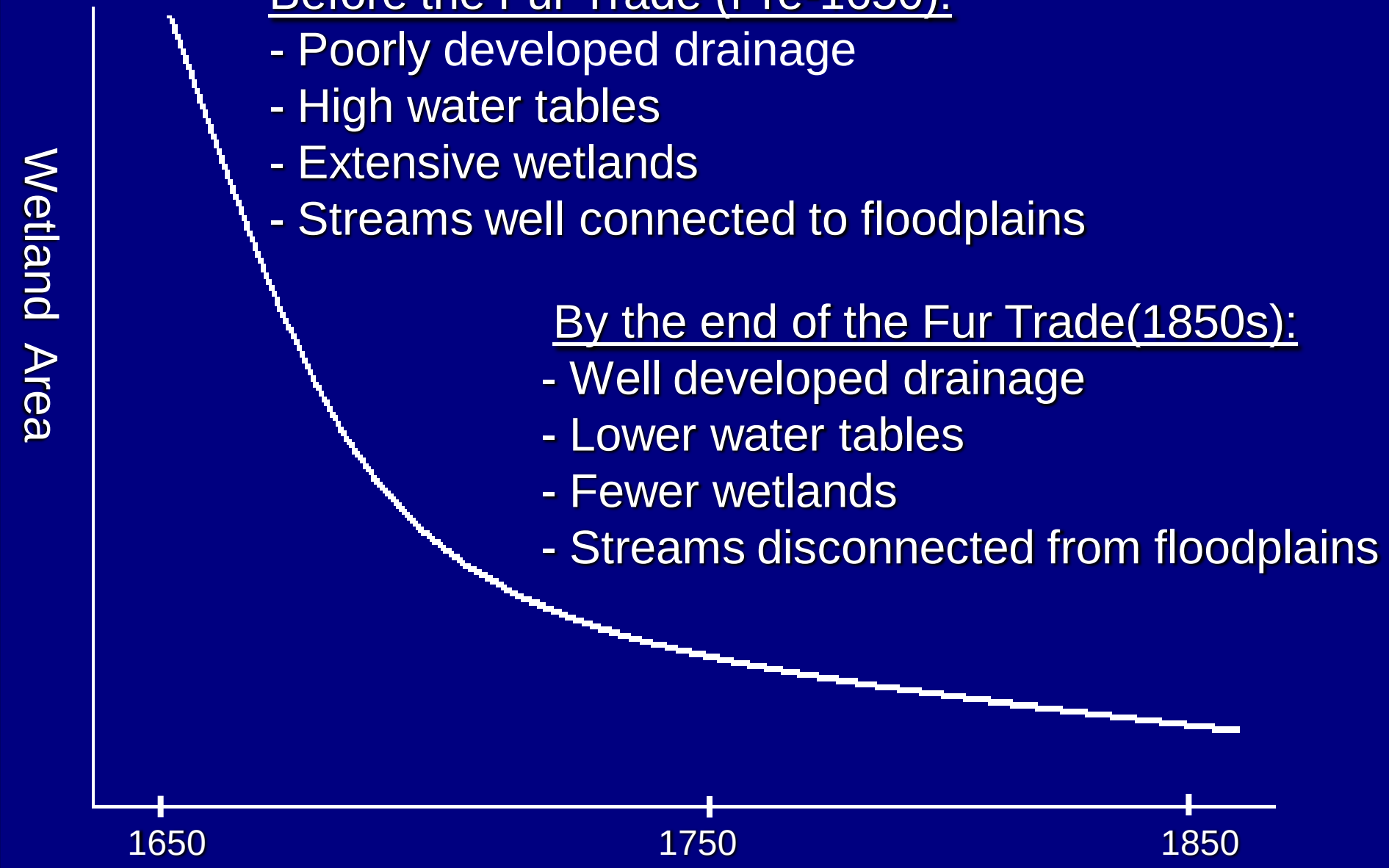
Landscape Impacts of Beaver Extirpation



Beaver dams enhance groundwater recharge and storage



What Happened?



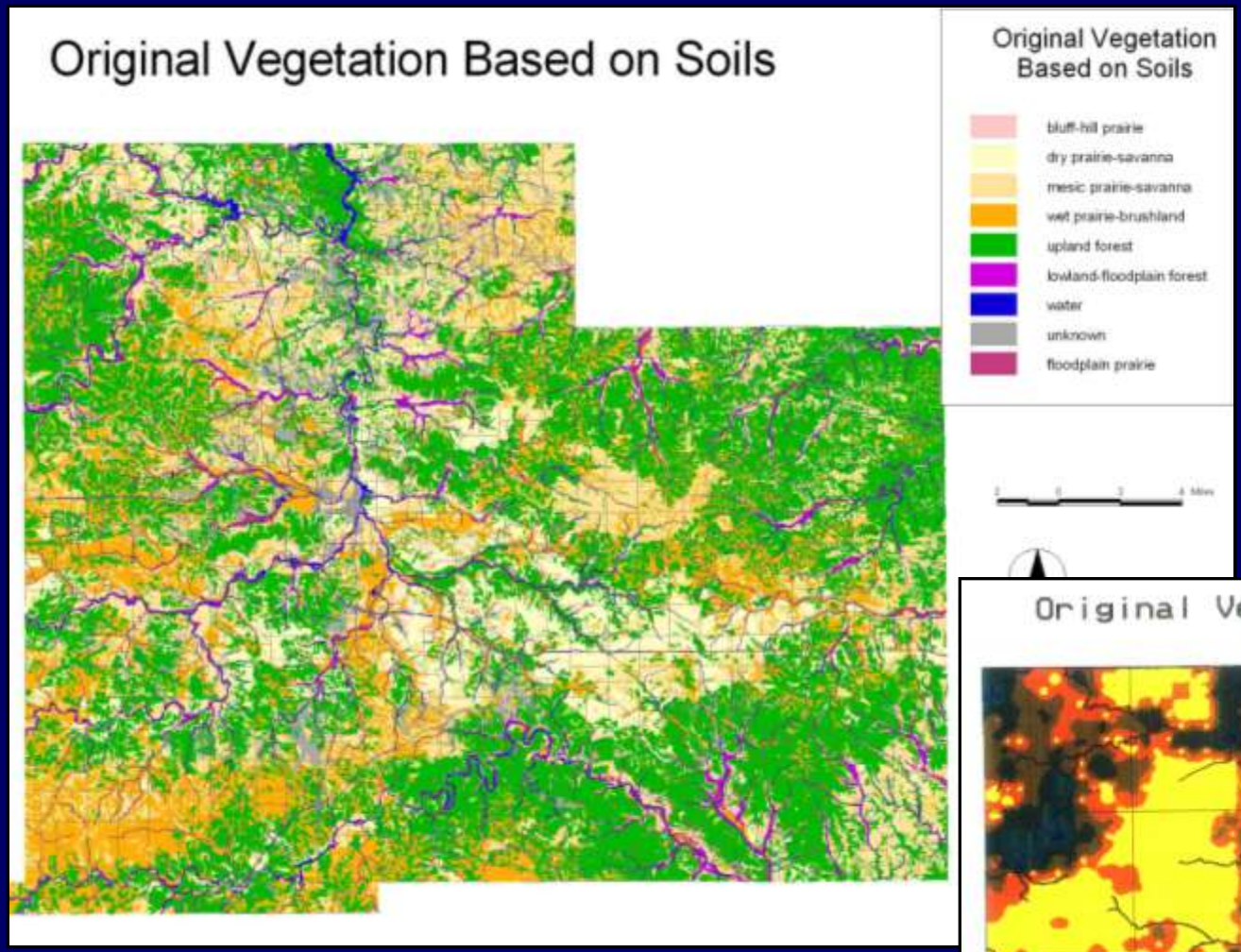
Before the Fur Trade (Pre-1650):

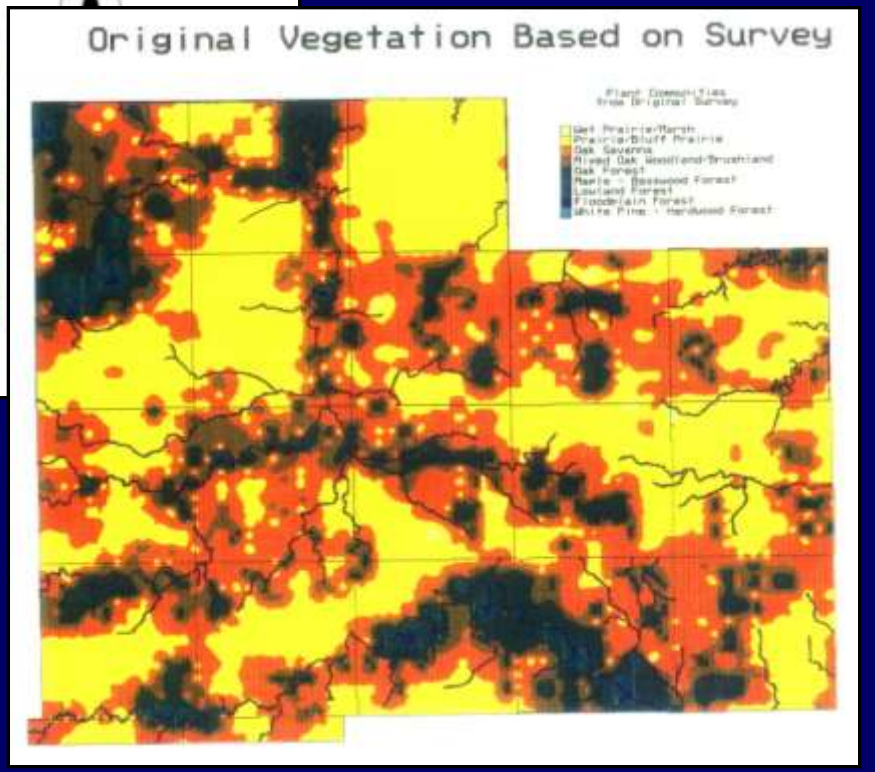
- Poorly developed drainage
- High water tables
- Extensive wetlands
- Streams well connected to floodplains

By the end of the Fur Trade(1850s):

- Well developed drainage
- Lower water tables
- Fewer wetlands
- Streams disconnected from floodplains

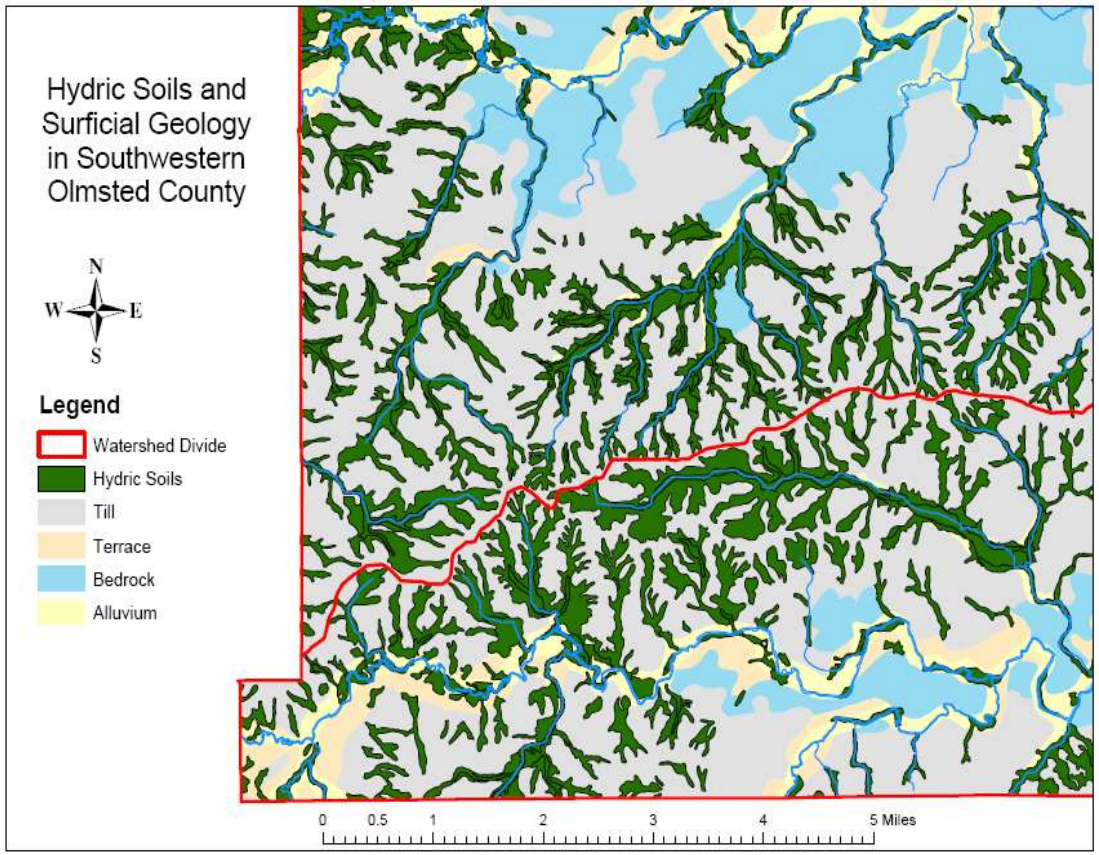
Pre-European Vegetation in Olmsted County

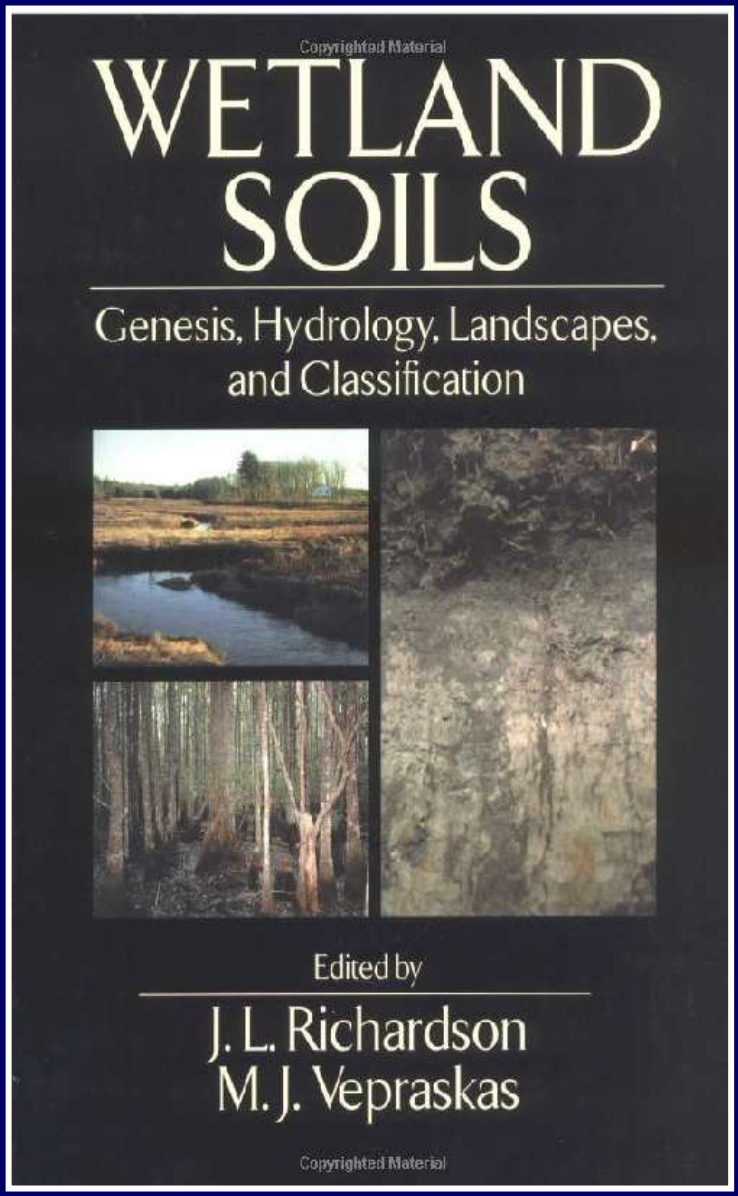




By the time of the 1853-54 Federal Land Survey, the landscape of Olmsted County had been largely drained.

Beaver Created Soils in Olmsted County?

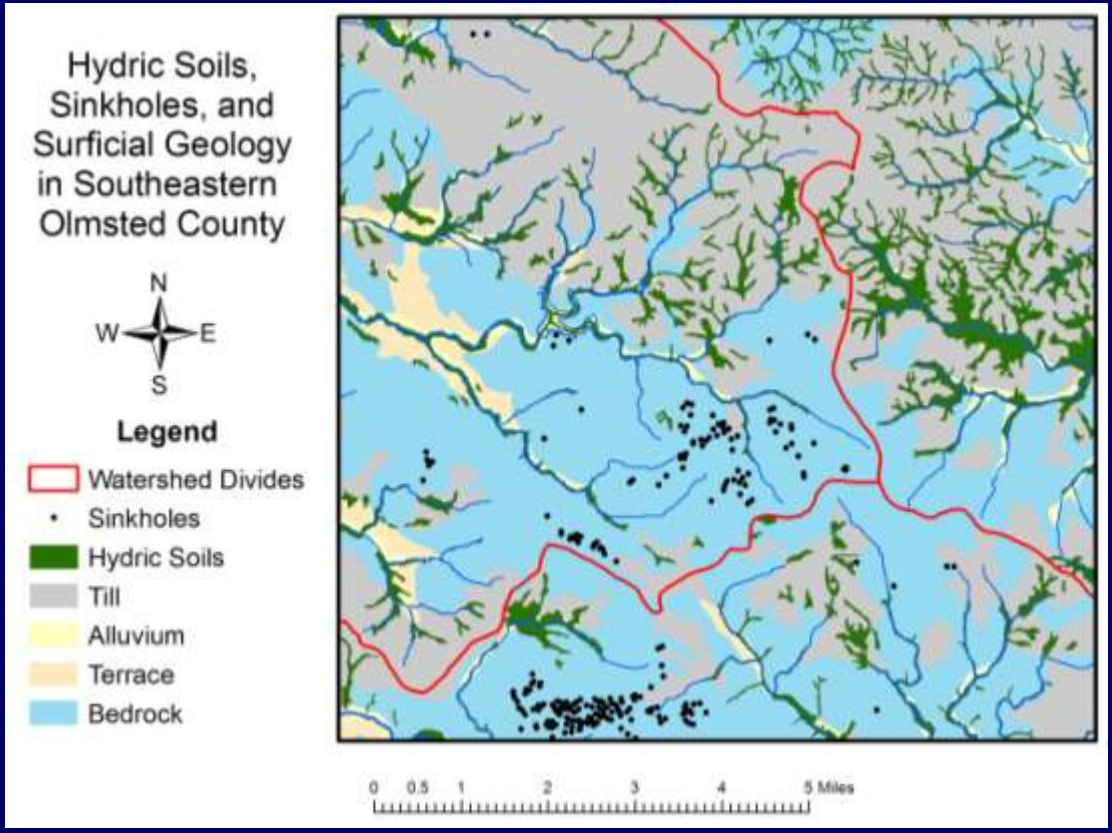


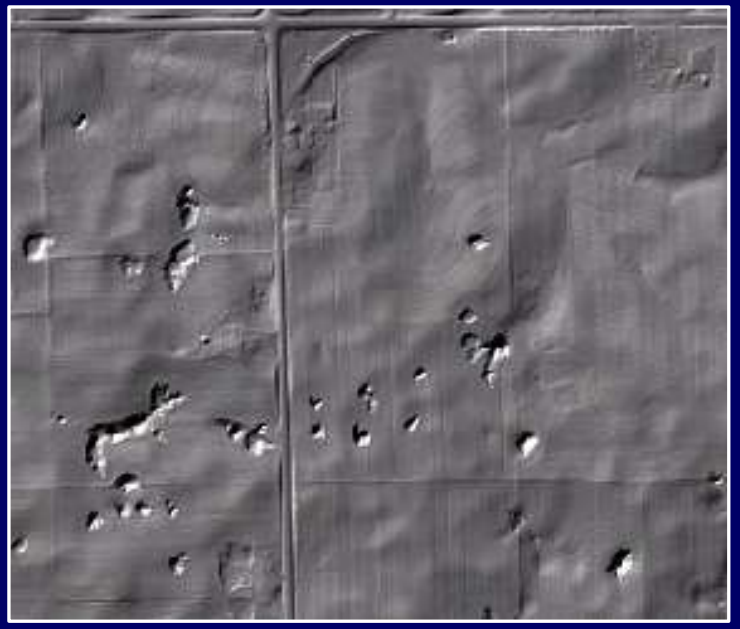


Chapter 19: Wetland Soil and Landscape Alteration by Beavers.

Carol A. Johnston, author

Beaver Created Sinkholes in Olmsted County?





Sinkholes formed in beaver ponds in Pine County, MN (1988).

Iowa LIDAR mapping shows pattern of sinkholes formed in drainageways.

Should it be done?

Are natural dams compatible with the current stream flora and fauna?

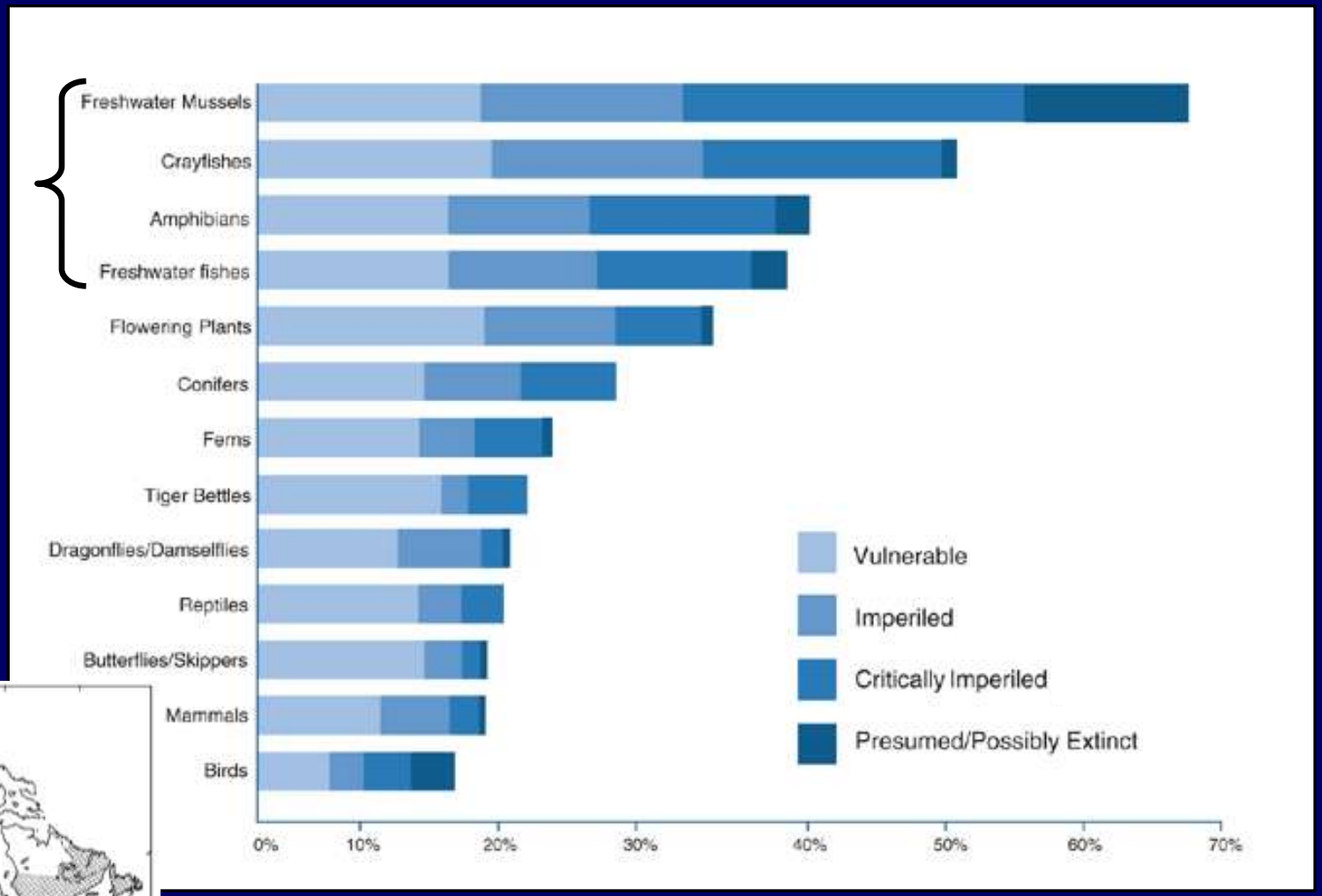
Animals that rely on beaver-created habitats:

- salamanders
- frogs
- turtles
- water snakes
- swallows
- herons
- grebes
- ducks
- rails
- hawks
- owls
- flycatchers
- kingfishers
- minks
- muskrats
- bats

Source: Jackson & Decker, Univ. of Massachusetts

Species at Risk in the United States

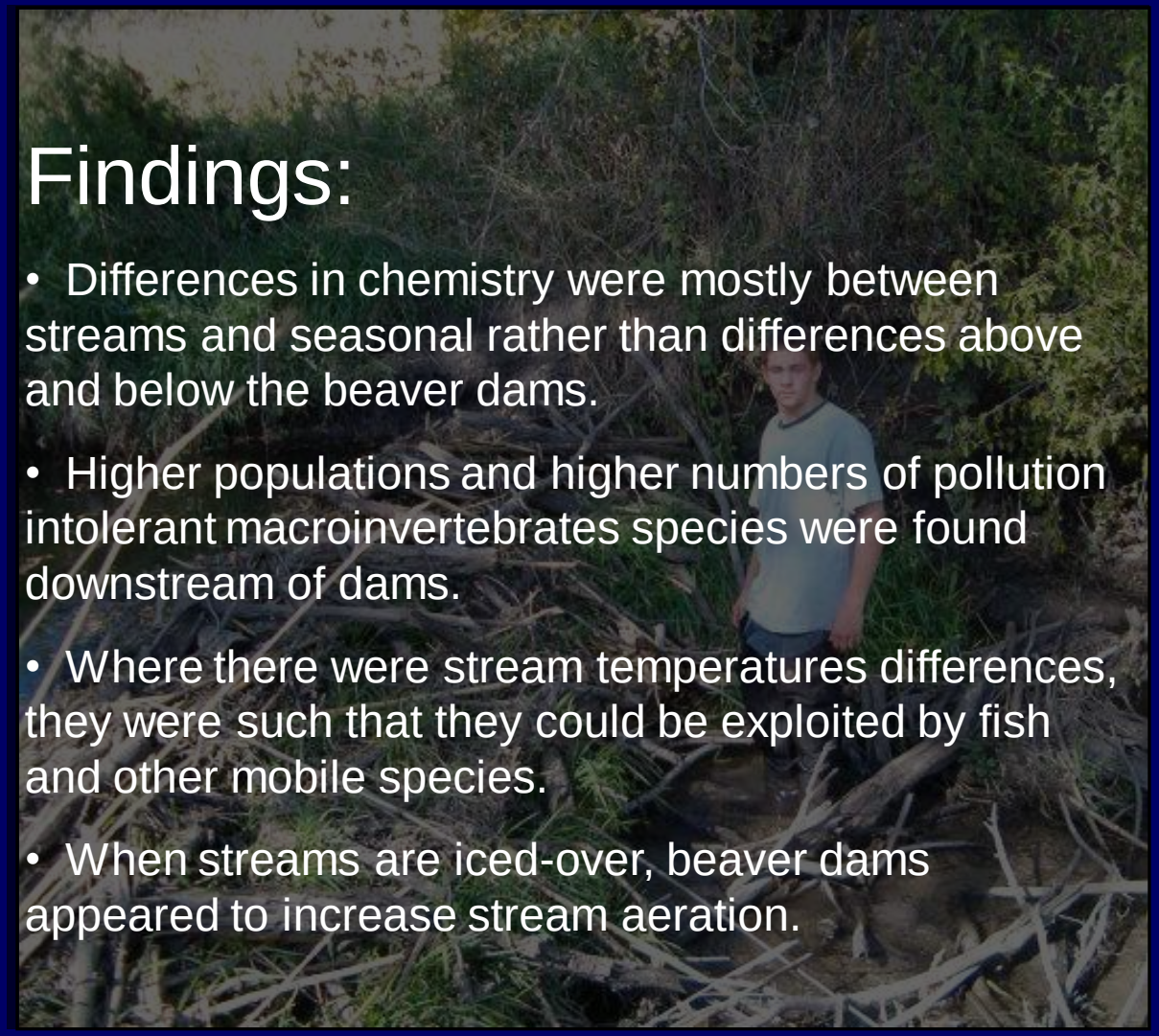
Species directly affected by beaver impoundments



US EPA

Historic range of Beaver in North America (Novak)

2006 Beaver Dam Study in SE Minnesota



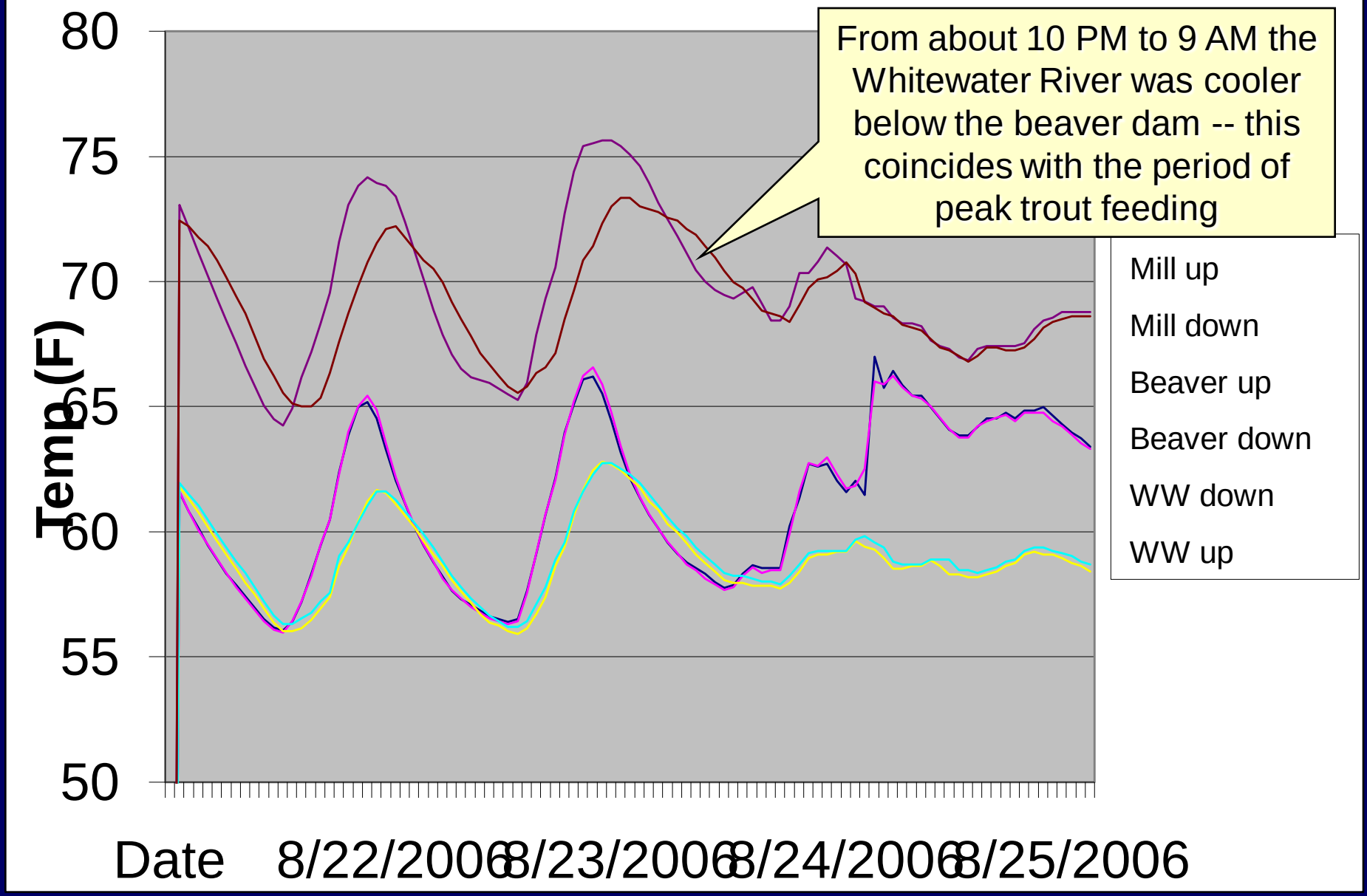
Findings:

- Differences in chemistry were mostly between streams and seasonal rather than differences above and below the beaver dams.
- Higher populations and higher numbers of pollution intolerant macroinvertebrates species were found downstream of dams.
- Where there were stream temperatures differences, they were such that they could be exploited by fish and other mobile species.
- When streams are iced-over, beaver dams appeared to increase stream aeration.

Greg Thompson

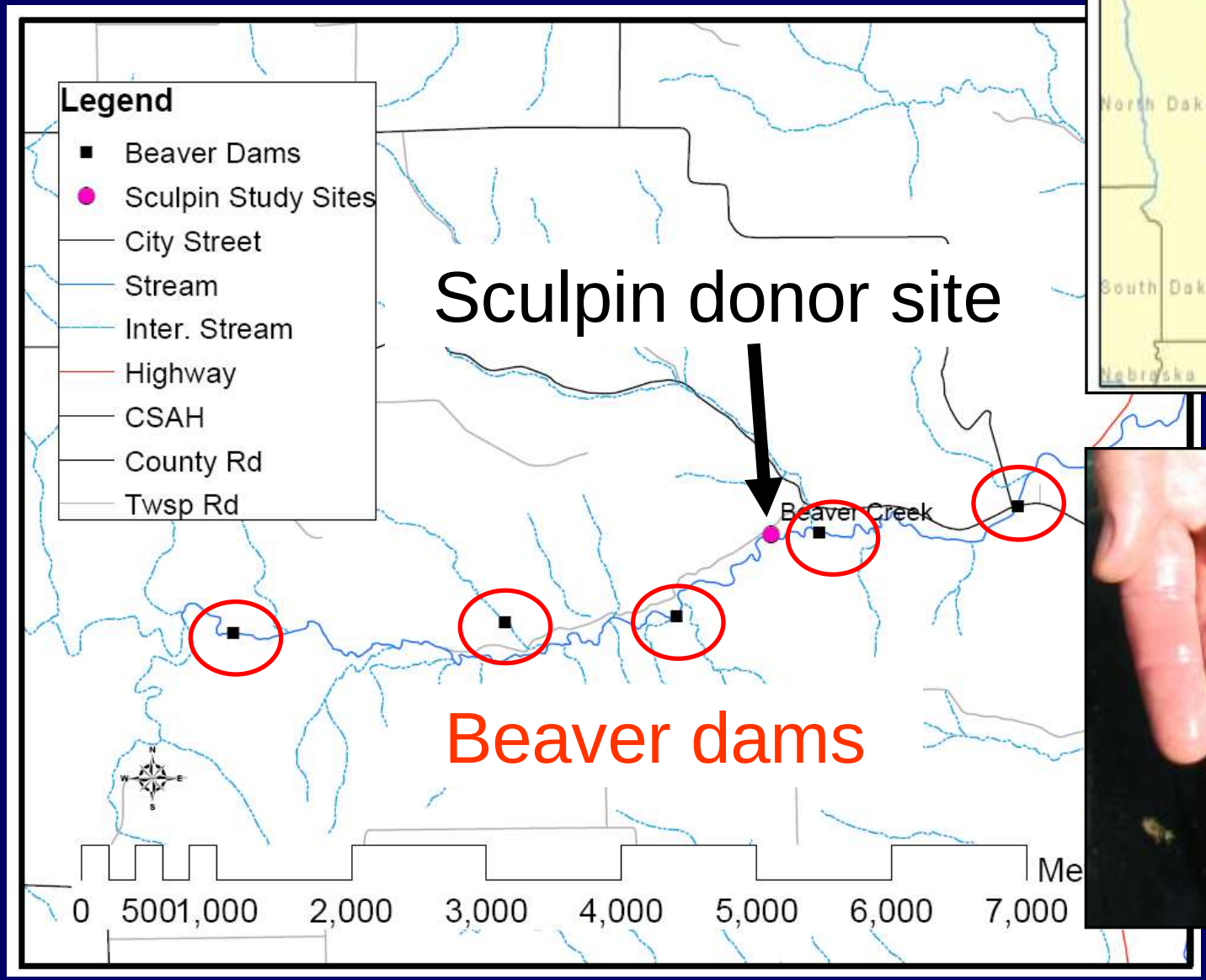
18 physical, chemical, and biological parameters were sampled at 3 beaver dam sites on Beaver Creek, Mill Creek, and the South Branch of the Whitewater River

Temperature Monitoring Results

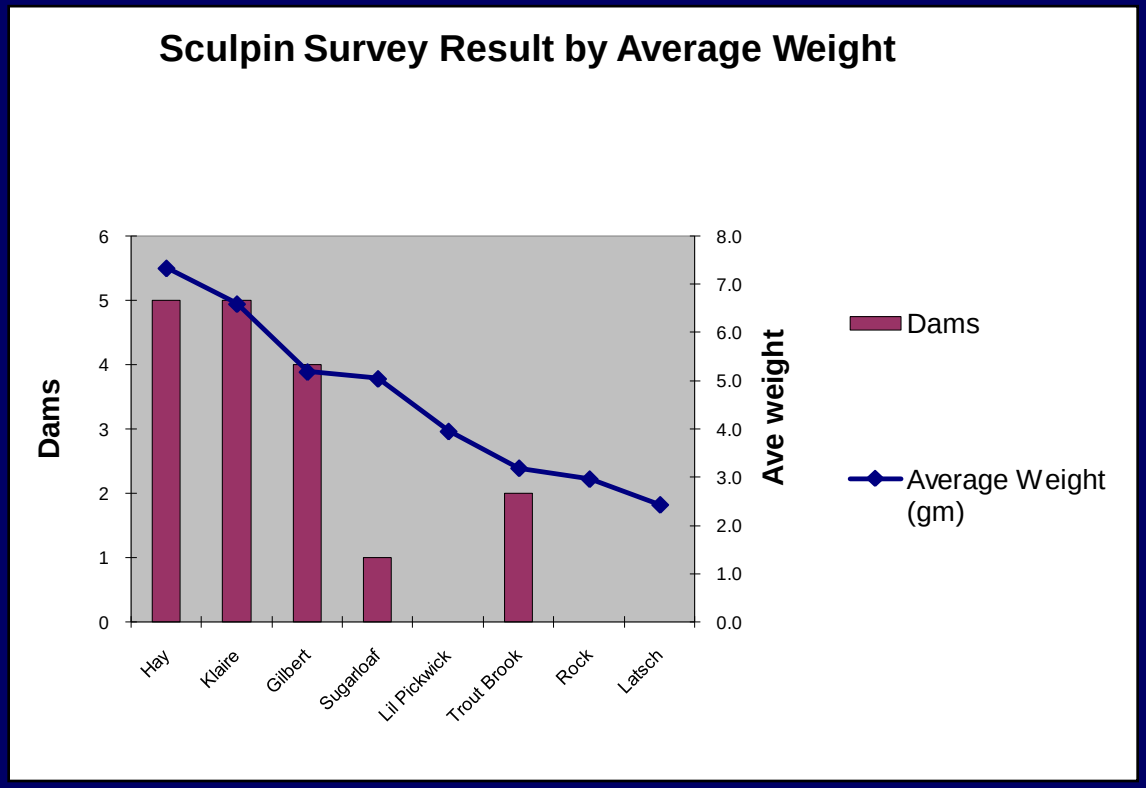


2007 Fish Survey Downstream of Two Beaver Dams on Cold Spring Brook

Sculpin Reintroduction Project



Southeast Minnesota sculpin grow larger on streams that have beaver dams*



* Beaver dam survey – G. Thompson & D. Huff, 2007
Sculpin reintroduction study – D. Huff, UofM, 2007

California salmon grow larger when they have access to floodplains

Salmon from California's Cosumnes River field experiment. The larger fish were reared on a floodplain, the smaller ones in a river.

Beaver and log dam removal impacts on brook trout in the Pemebonwon River in NE Wisconsin

546 dams were removed from 33 miles of stream:

- Brook trout populations declined in the river but increased in the tributaries,

- Because the tributaries were inaccessible to anglers, the sport fishery significantly declined.

*1982-86 WI DNR Study, Avery

Beaver and log dam removal impacts on brook trout in the Pemebonwon River in NE Wisconsin

546 dams were removed from 33 miles of stream:

SUMMARY AND CONCLUSIONS

Beaver dams did not prevent movement of brook trout either upstream or downstream in the PR. There appeared to be no way brook trout could move in either direction through primary beaver dams on most tributaries to the PR.

- Because the tributaries were inaccessible to anglers, the sport fishery significantly declined.

*1982-86 WI DNR Study, Avery

Trout vs Beaver on Little Hay Creek

1919 - 1.4 mile long brook trout stream

1960s - beaver clogged stream unsuitable for brook trout

1970-80s - restored as a trout stream

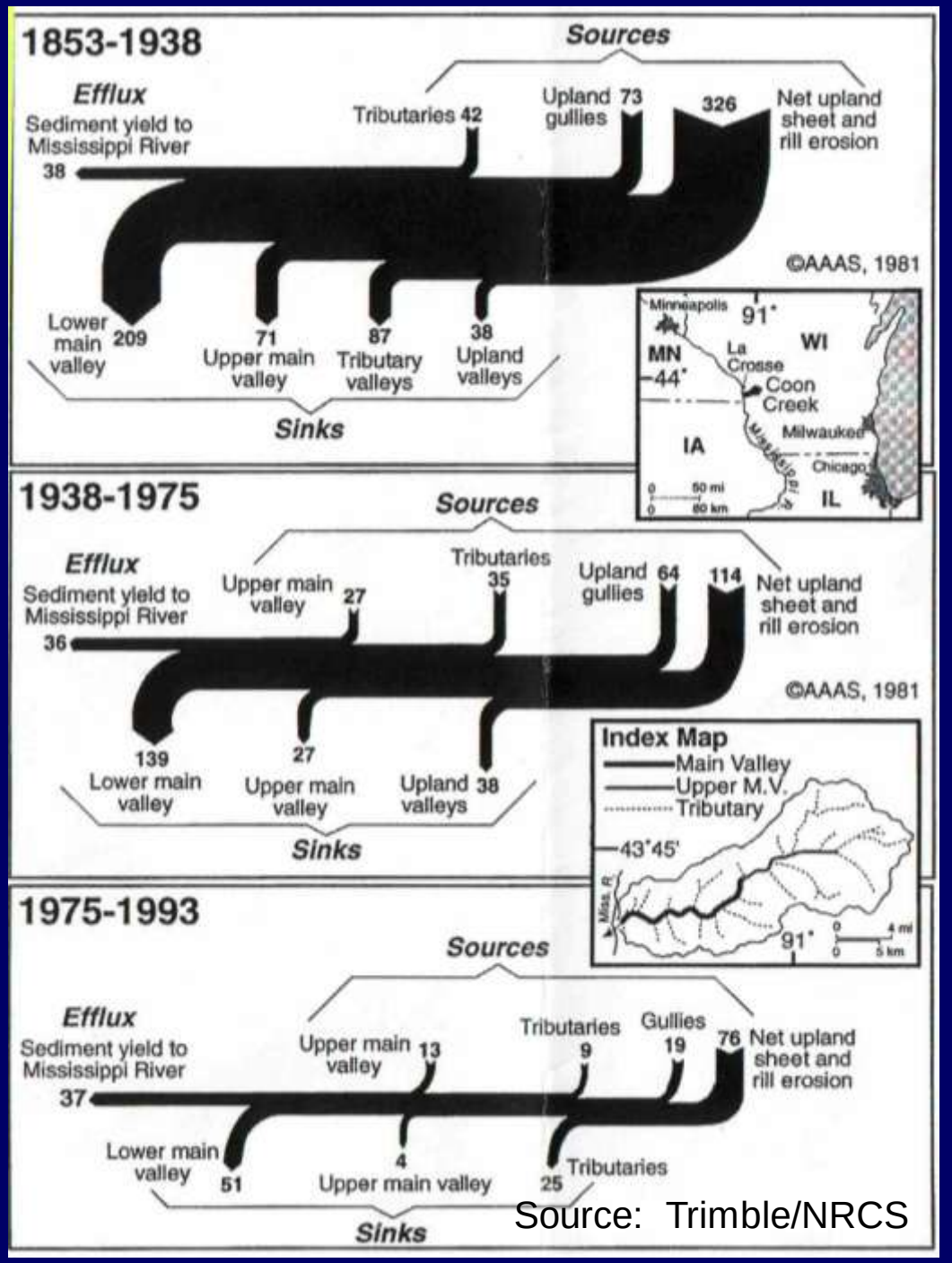
1990s - beaver clogged

Currently – restored as a trout stream

Small streams are converted to wetlands.

Source: MN DNR

Erosion and sedimentation rates have declined to the point that stream bank erosion is now identified as the major source of sediment in streams.



Source: Trimble/NRCS

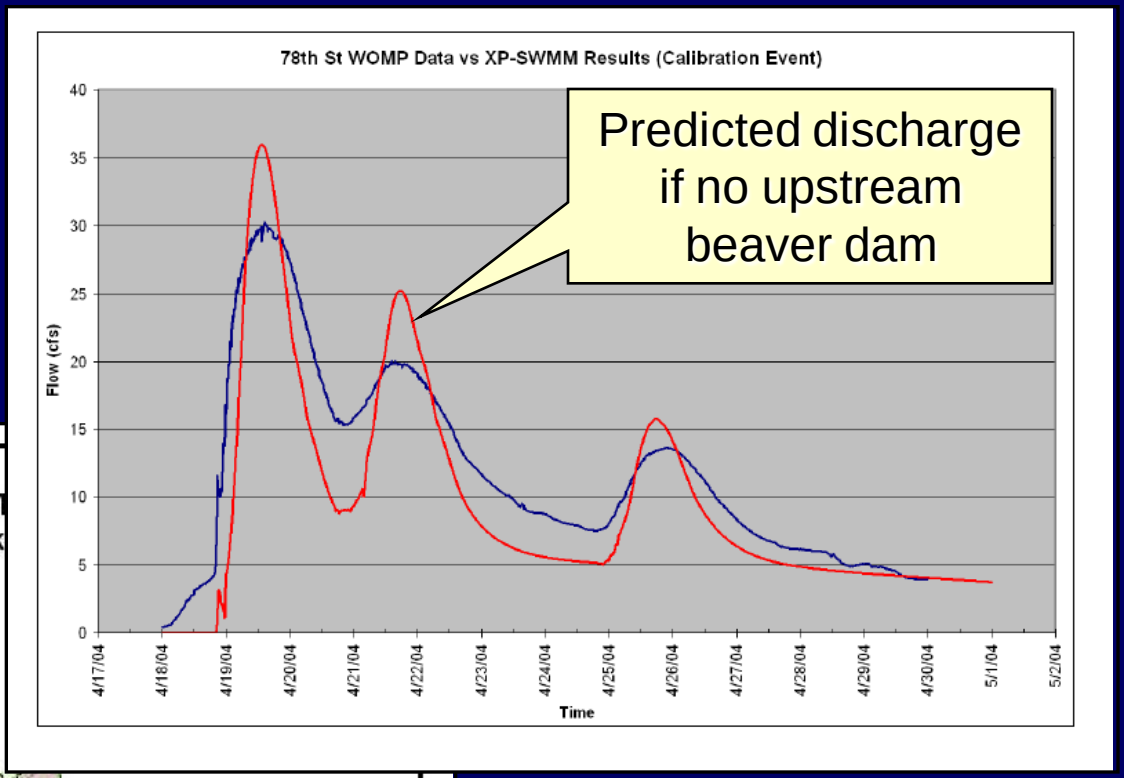
From: Knudsen & MacDonald, Sustainable Fisheries Management - Pacific Salmon

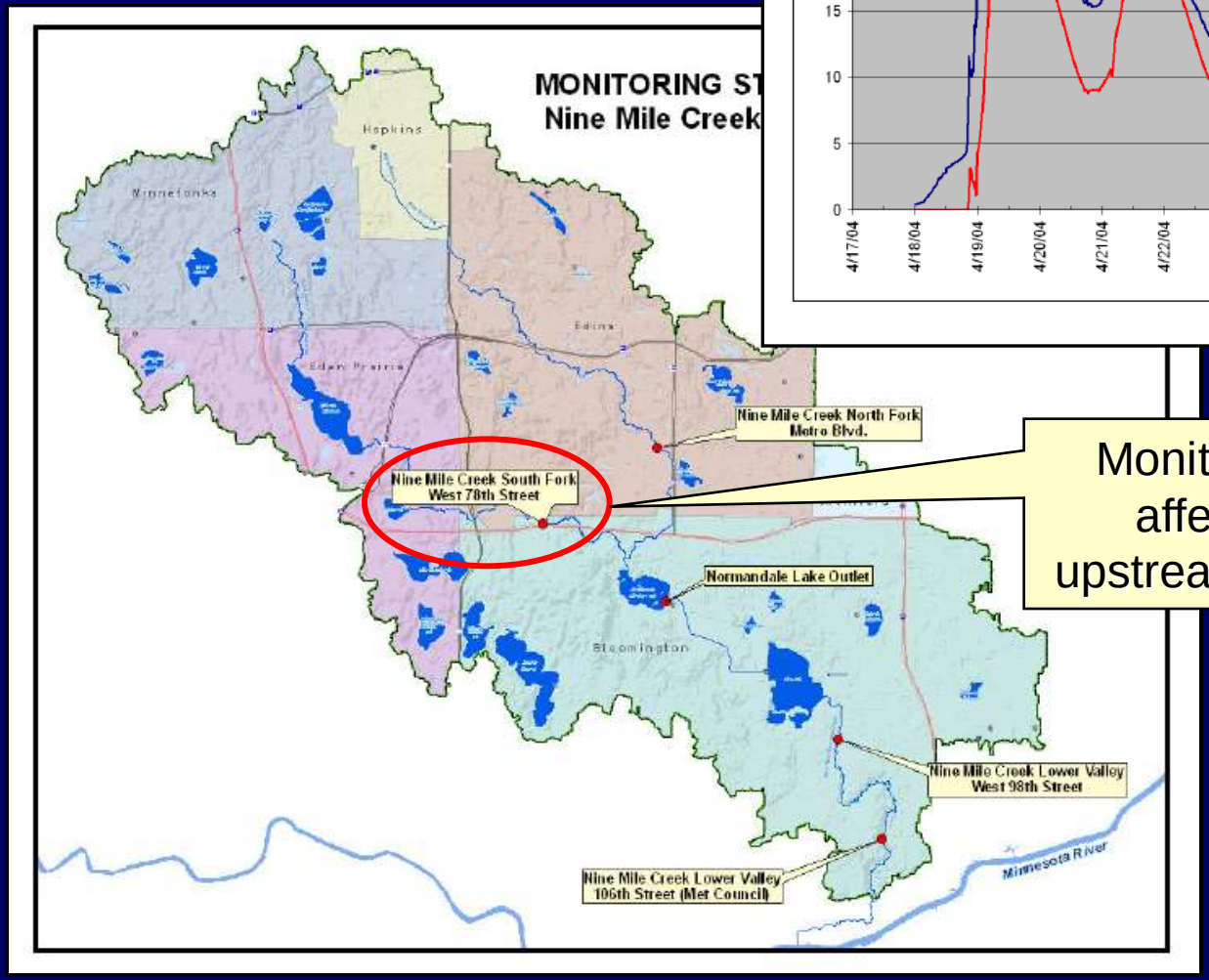
Should it be done?

Are natural dams effective?

March 2004 Rain Event

Nine Mile Creek





Monitoring station affected by an upstream beaver dam

BARR

August 2007 Flood

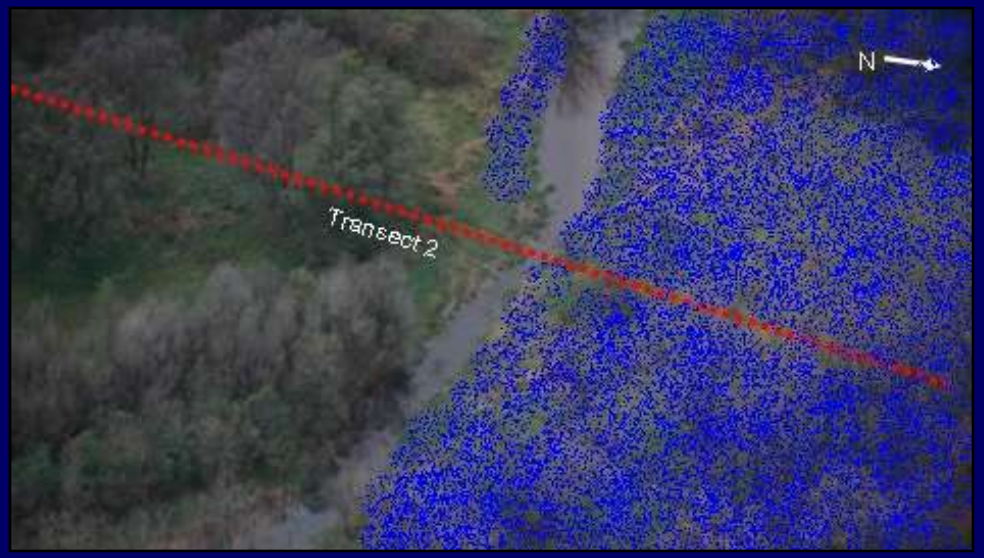
Cold Spring Brook

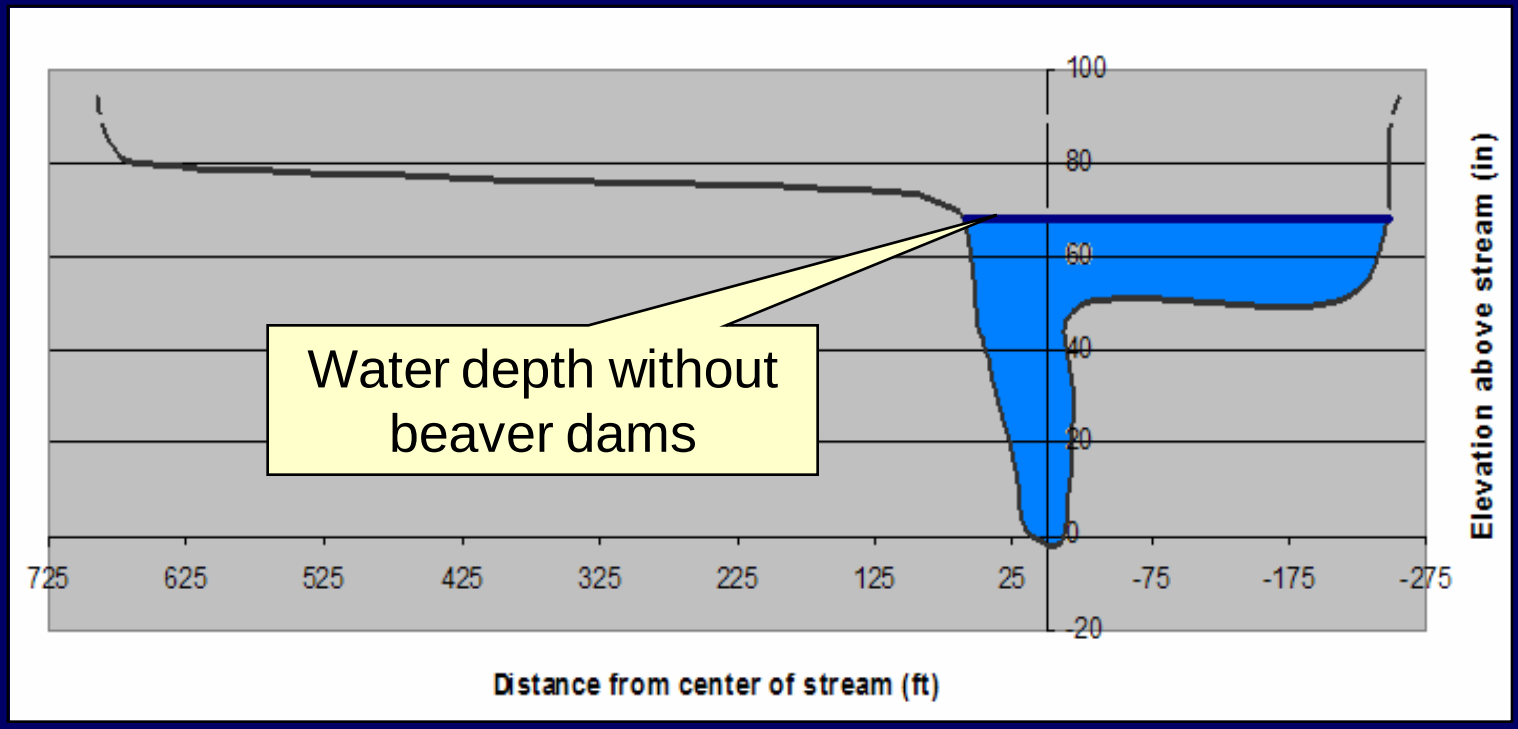
Beaver dam and pond

Flood crest was 90 inches above normal

The beaver dam increased stream depth by about 20 inches at the flood crest -- significantly increasing its connection to the floodplain

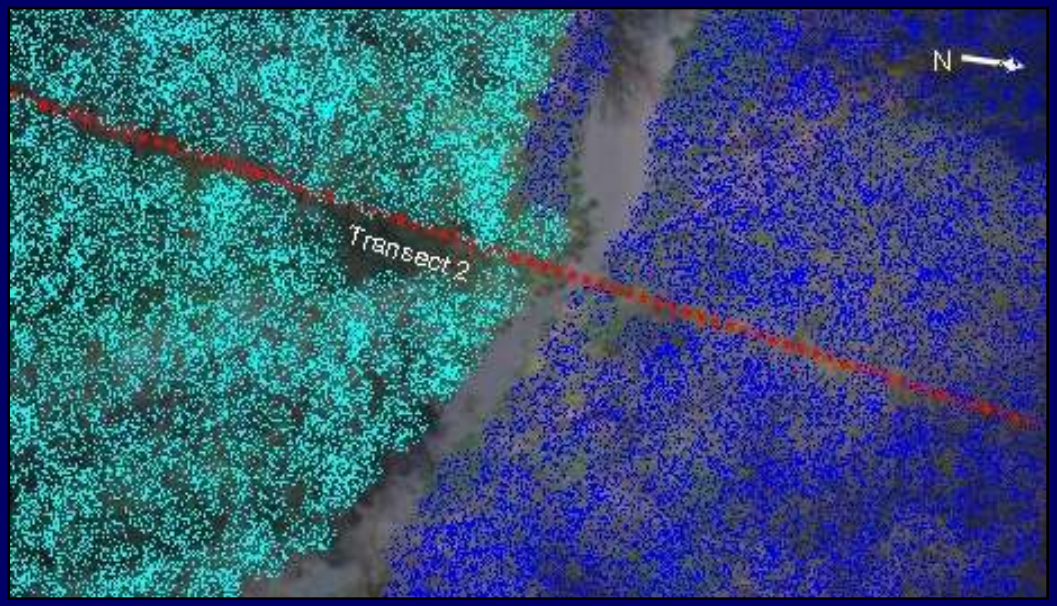
Projected water depth during August 2007 flood if there were no beaver dams*

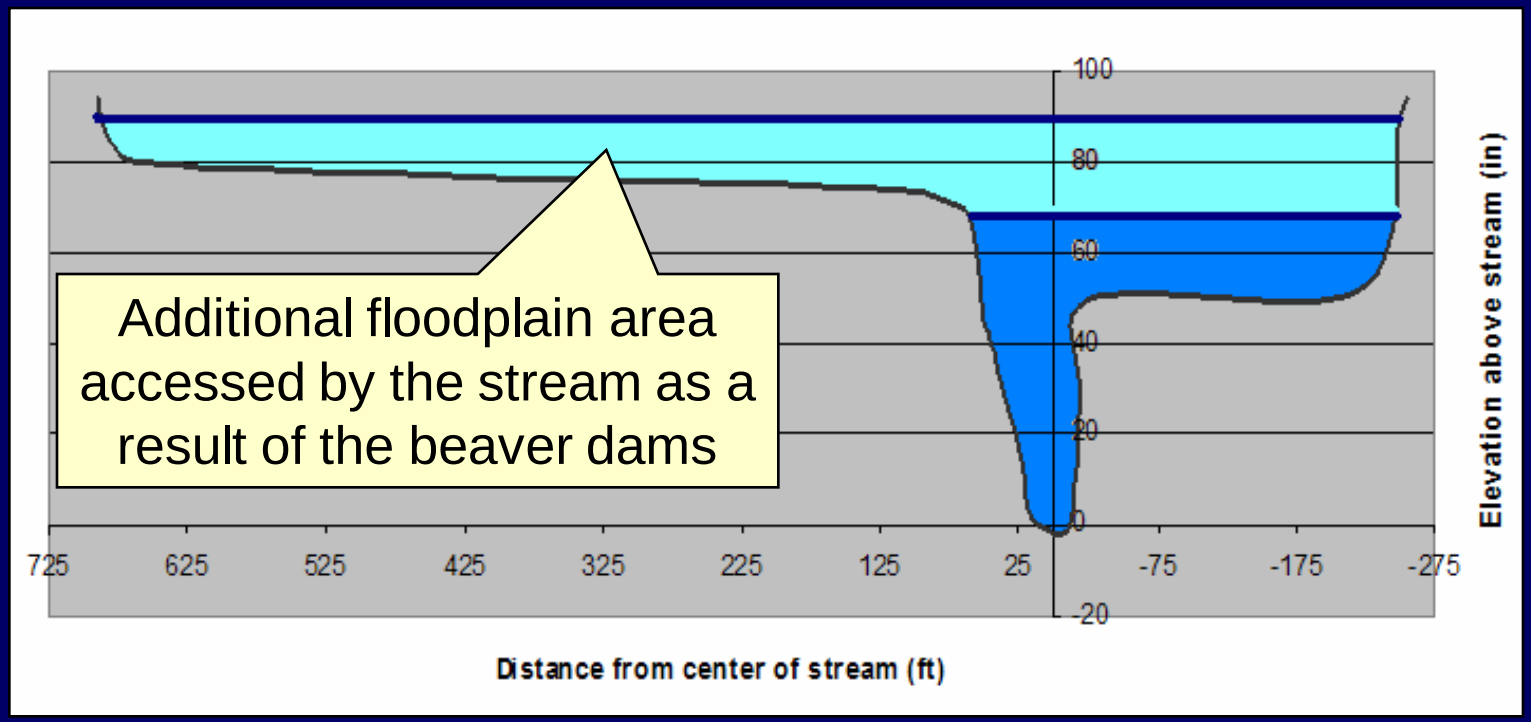




* Based on measured flood crests on stream reaches above and below the beaver dams

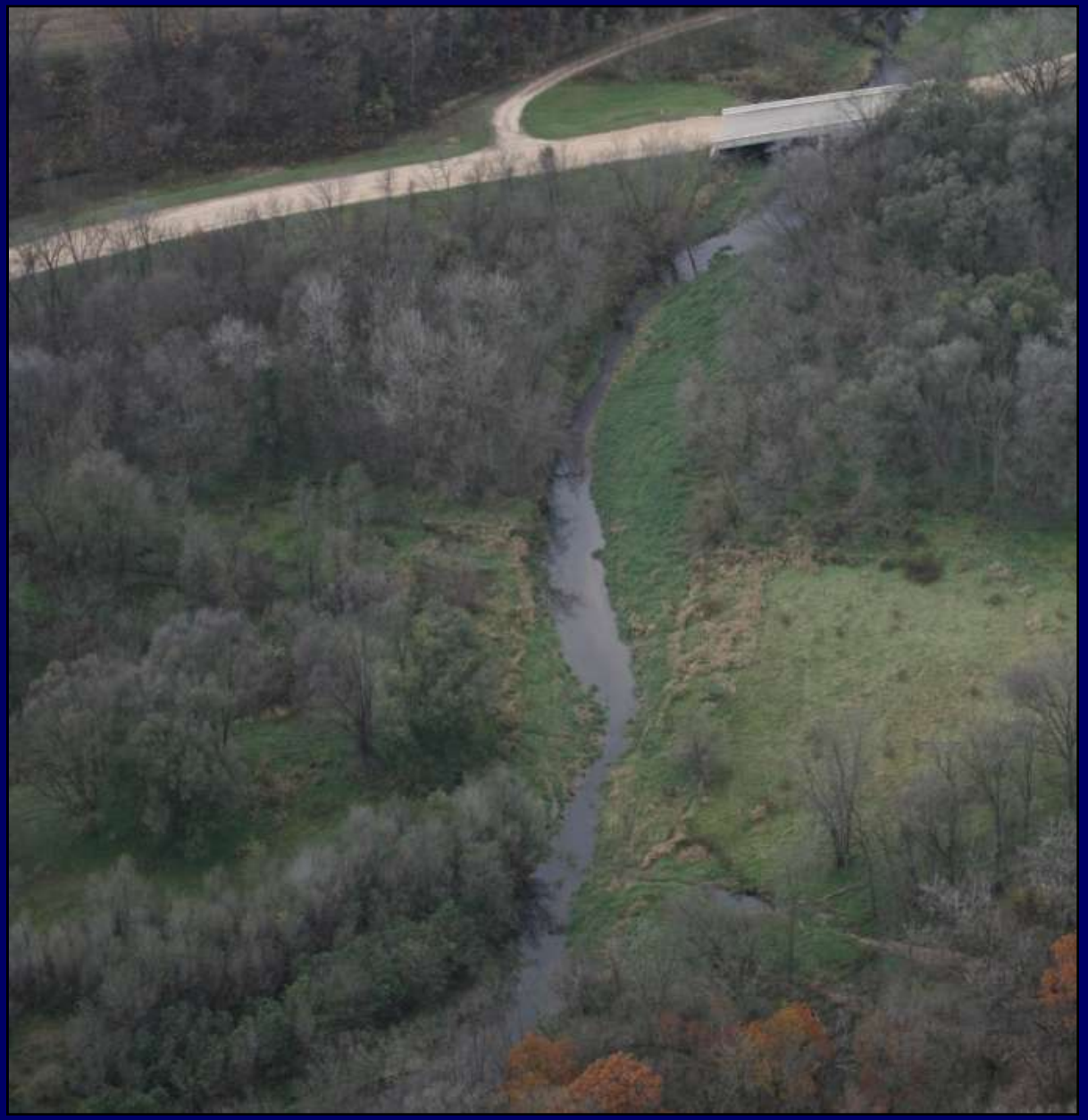
Actual water depth and floodplain accessed by the stream during August 2007 flood





Water area was doubled and velocity halved.

The two beaver dams on Cold Spring Brook increased flood storage by about 7 acre-feet providing an estimated $70,000 worth of additional flood storage



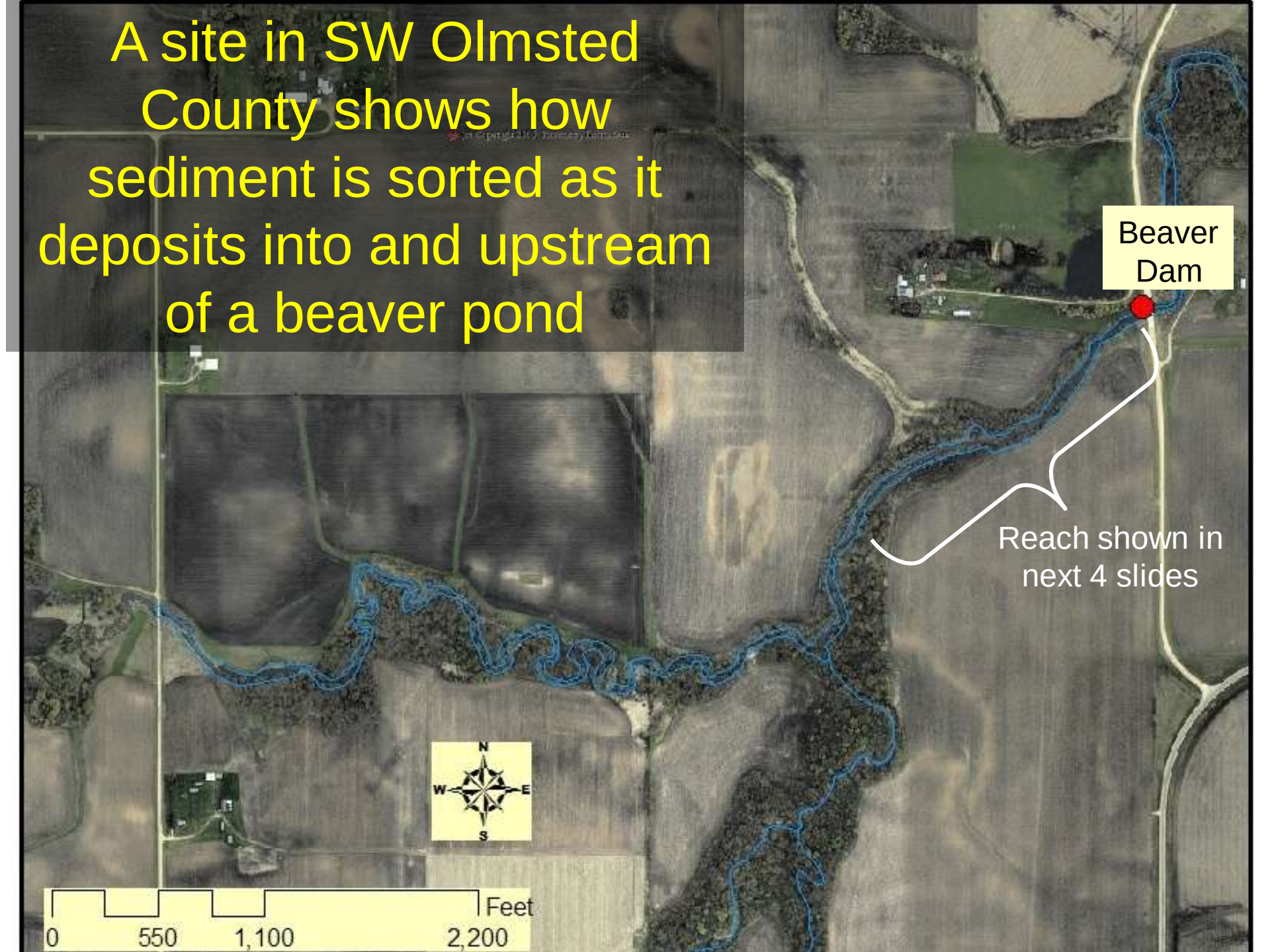
Should it be done?

Will natural dams last?

A 12-year study in Nebraska found streams with beaver dams accumulated over 300 tons of sediment/mile/year increasing stream grades by about 2 inches/year

The cost of removing sediment from downstream reservoirs is about $10/ton

From: McCullough, 2006


A site in SW Olmsted County shows how sediment is sorted as it deposits into and upstream of a beaver pond
Beaver Dam
Reach shown in next 4 slides
N
W
E
S
Feet
0
550
1,100
2,200

August 2008

Baseflow

Stream Habitat Creation on the North Branch Root River

Silt is deposited in the pond created by the beaver dam

Consistent with Stokes' Law, sand and small gravel is deposited at the upstream end of the beaver pond –

Large gravel is deposited upstream of the beaver pond creating an earthen dam and riffle

Pool formed above pond

Above the earthen dam, the stream grade is restored, a pool is created, and the stream is reconnected to its floodplain.

The cost of constructing a similar stream restoration at this scale would be tens of thousands of dollars.

Should it be done?

Are natural dams compatible with current land uses?

Storing floodwaters in the upper reaches of streams is not only compatible with current land use, it is essential in preventing catastrophic flooding.

Beaver can reduce bridge clogging hazards by controlling tree growth on shorelines and by removing branches from downed trees

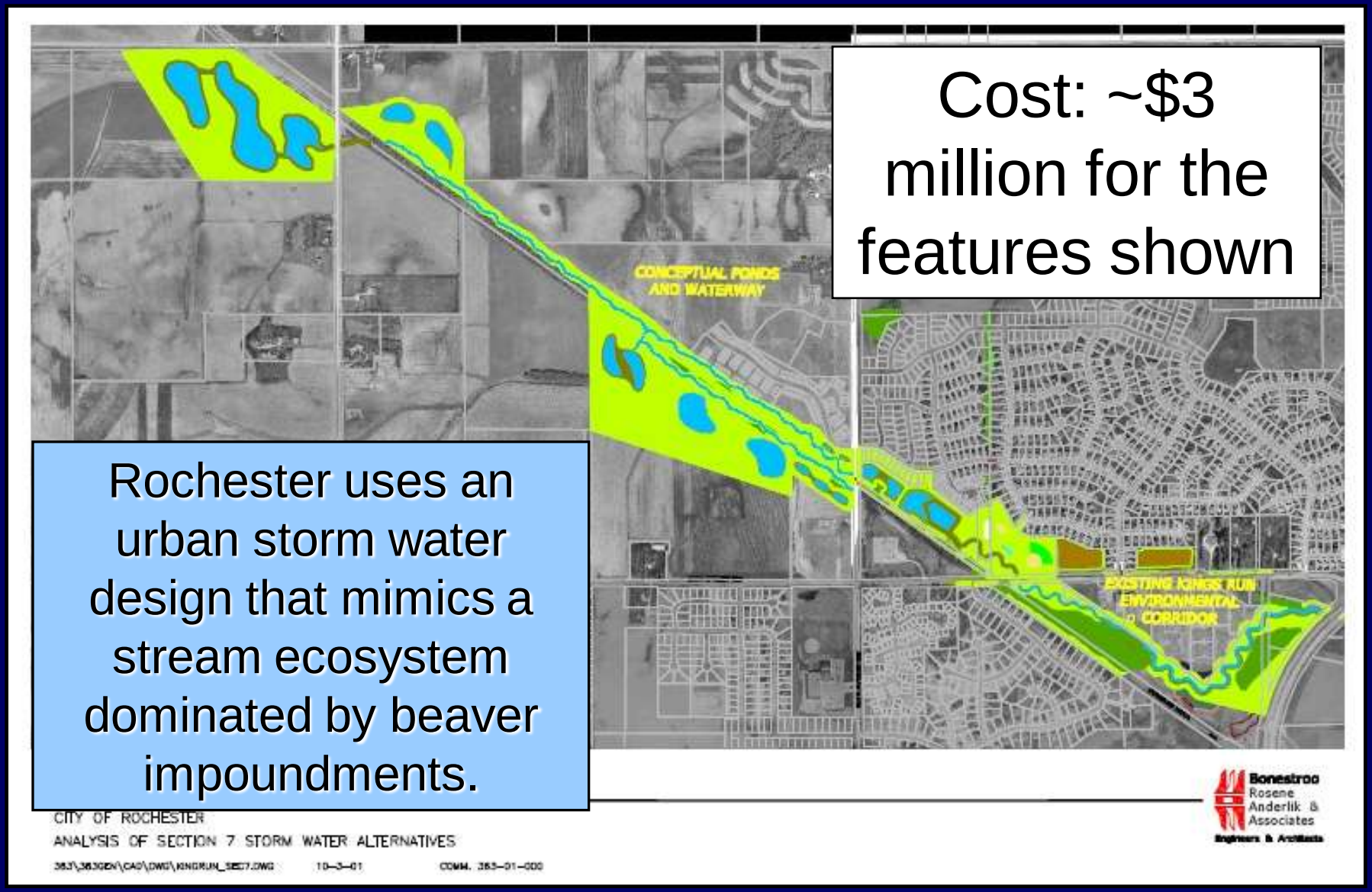
Bridge on the Middle Branch Whitewater River after August 2007 flood

Tangled branches and roots prevented the trees from moving downstream – the bridge was damaged and required replacement.

Special culverts and control structures can be used to prevent culverts from being clogged or dammed and to limit water levels

Can it be done?

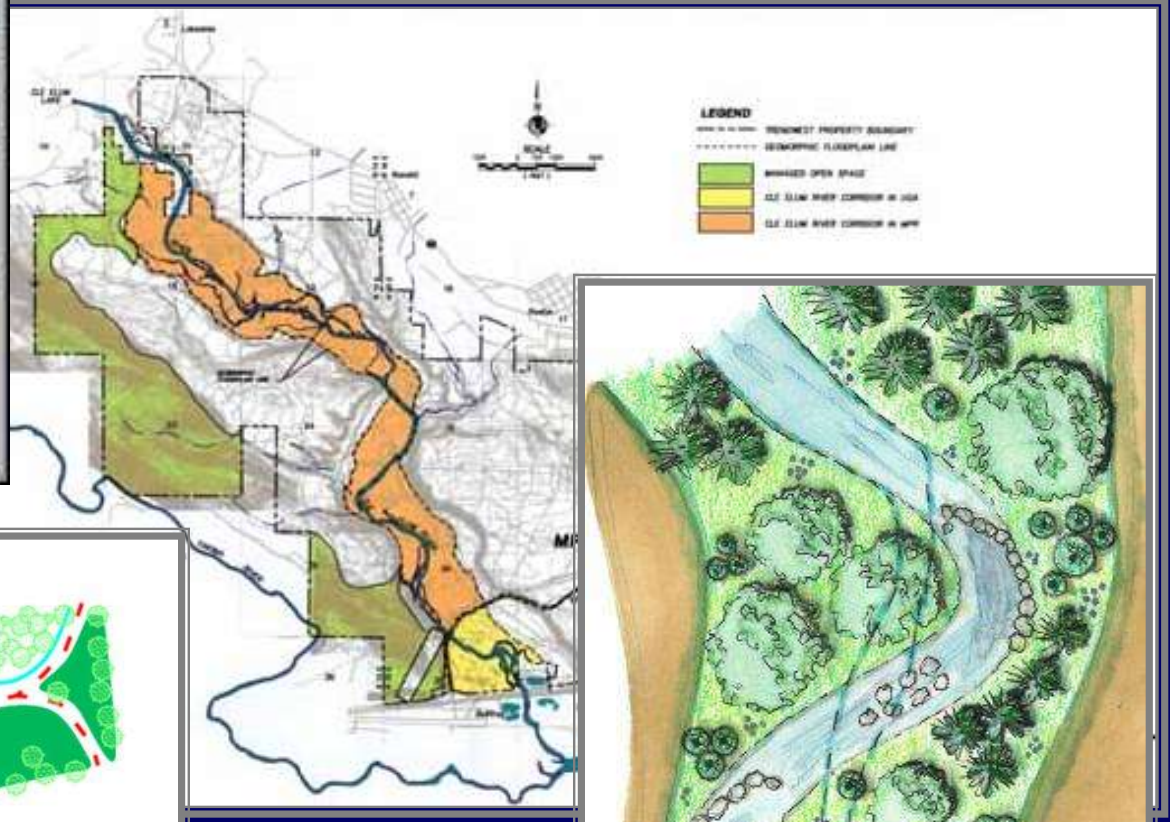
Urban Storm Water Management Corridor

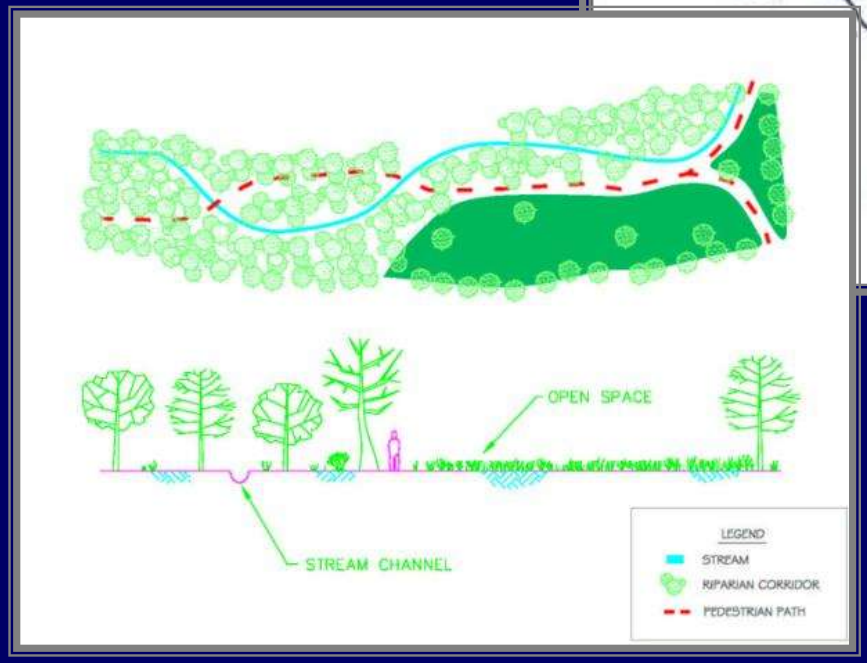


Cost: ~$3 million for the features shown

Rochester uses an urban storm water design that mimics a stream ecosystem dominated by beaver impoundments.

Beaver Management Corridors/Linear Parks



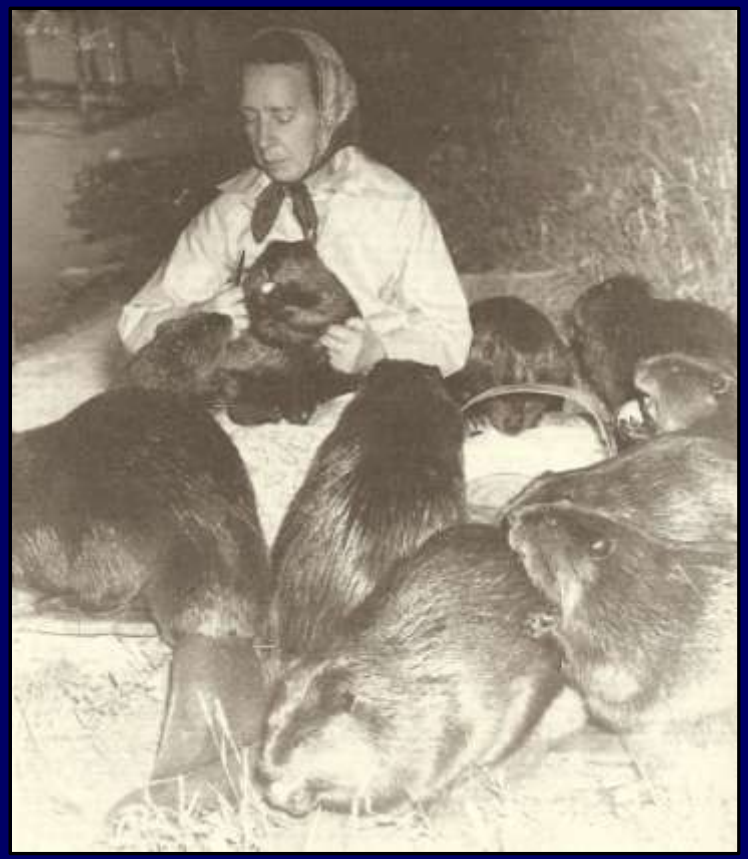


Beaversprite

My Years Building an Animal Sanctuary

by Dorothy Richards

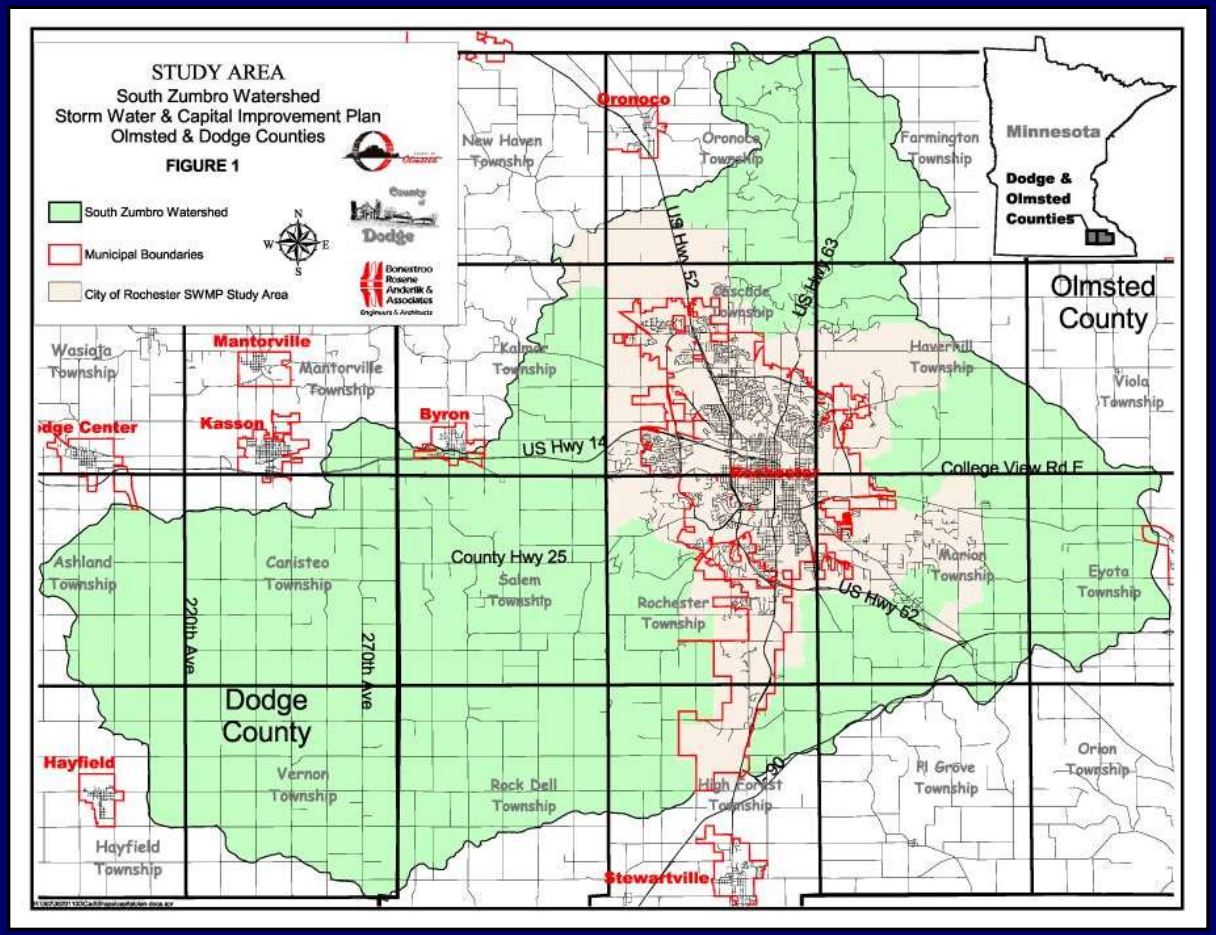
with Hope Sawyer Buyukmihci



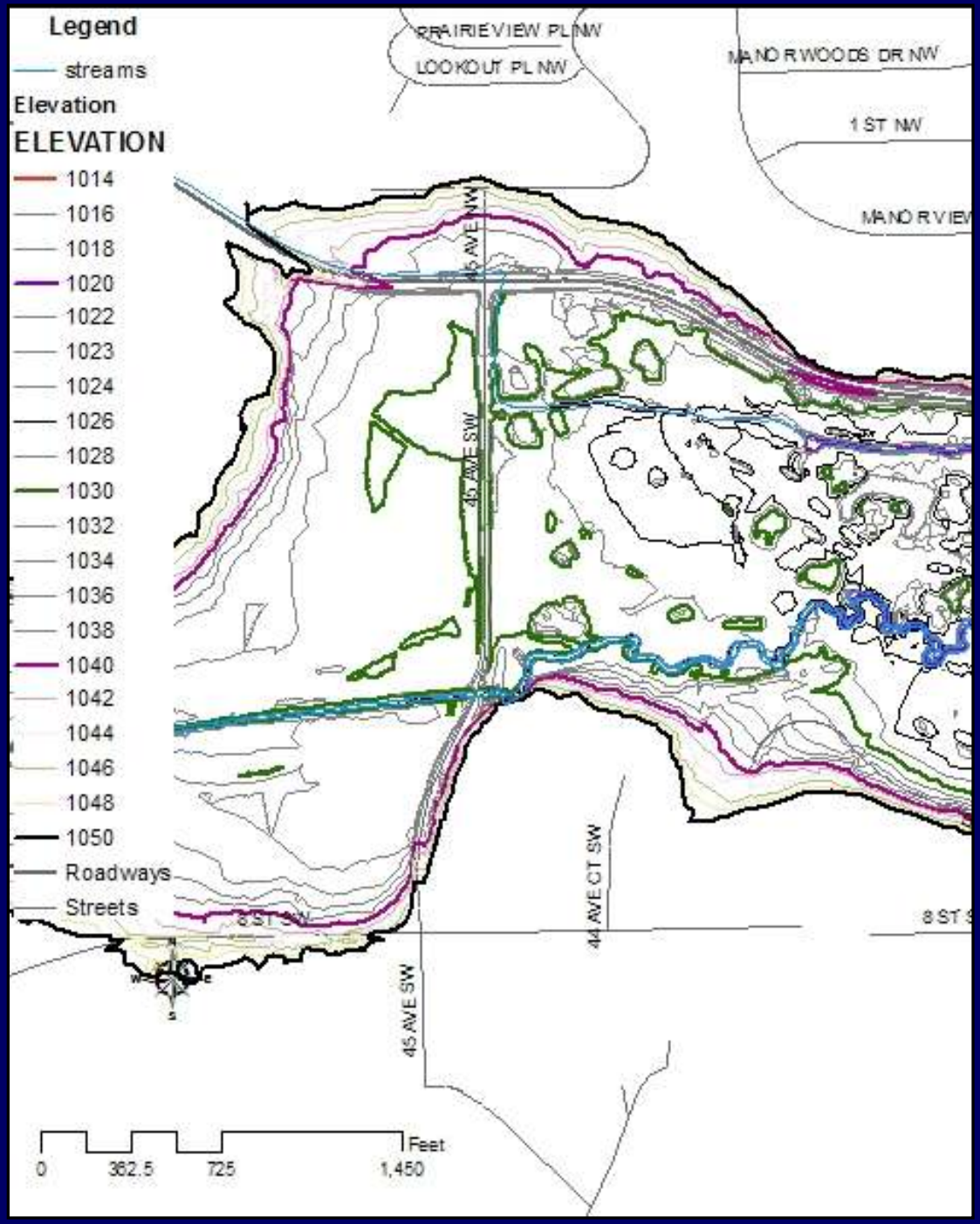
The Alternative Plan

What's next?

Complete a landscape-scale feasibility study of the potential for utilizing beaver corridors to meet flood storage and conveyance objectives



The detailed contour maps needed to complete the study will be available in July of 2009



Credits

- Barr Engineering, Inc.
- Bonestroo, Rosene & Anderlik, Inc.
- George Poch
- Greg Thompson
- Kimm Crawford
- MN Board of Water and Soil Resources
- MN Dept. of Natural Resources
- MN Pollution Control Agency
- Olmsted County Planning Department
- University of Nevada
- Olmsted County Public Works Department
- U.S. Animal Control
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service
- U.S. Forest Service
- University of Massachusetts
- Winona County Soil and Water Conservation District
- Wisconsin Dept. of Natural Resources
- Zumbro Watershed Partnership