Historical Changes in Erosion and Sedimentation along Driftless Area Channels and Floodplains

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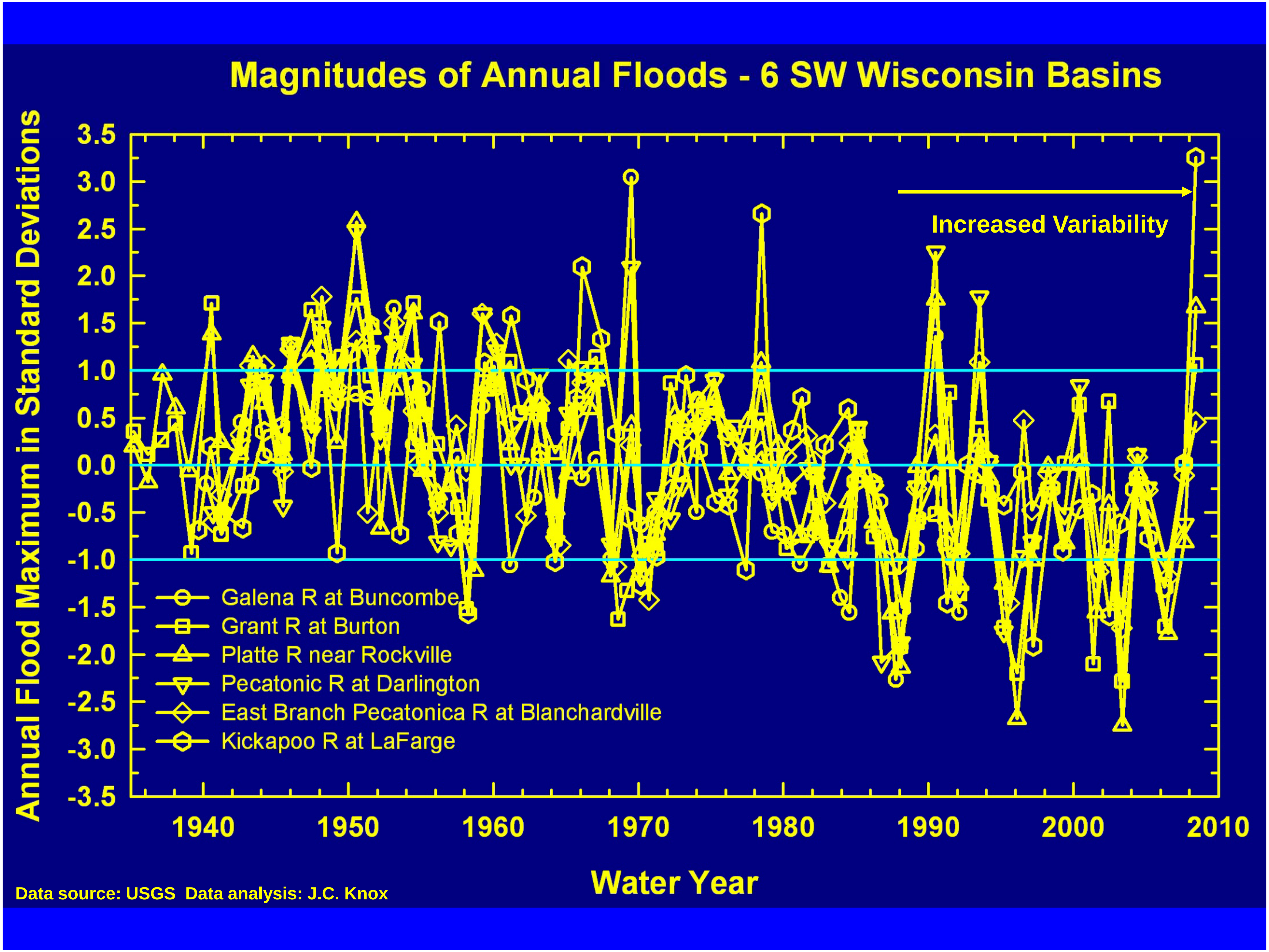
Acknowledgements: U.S. National Science Foundation & Many Graduate Students

Frequent heavy early summer rains in recent years have been increasing runoff and soil erosion from agricultural cropland in the upper Mississippi River valley.



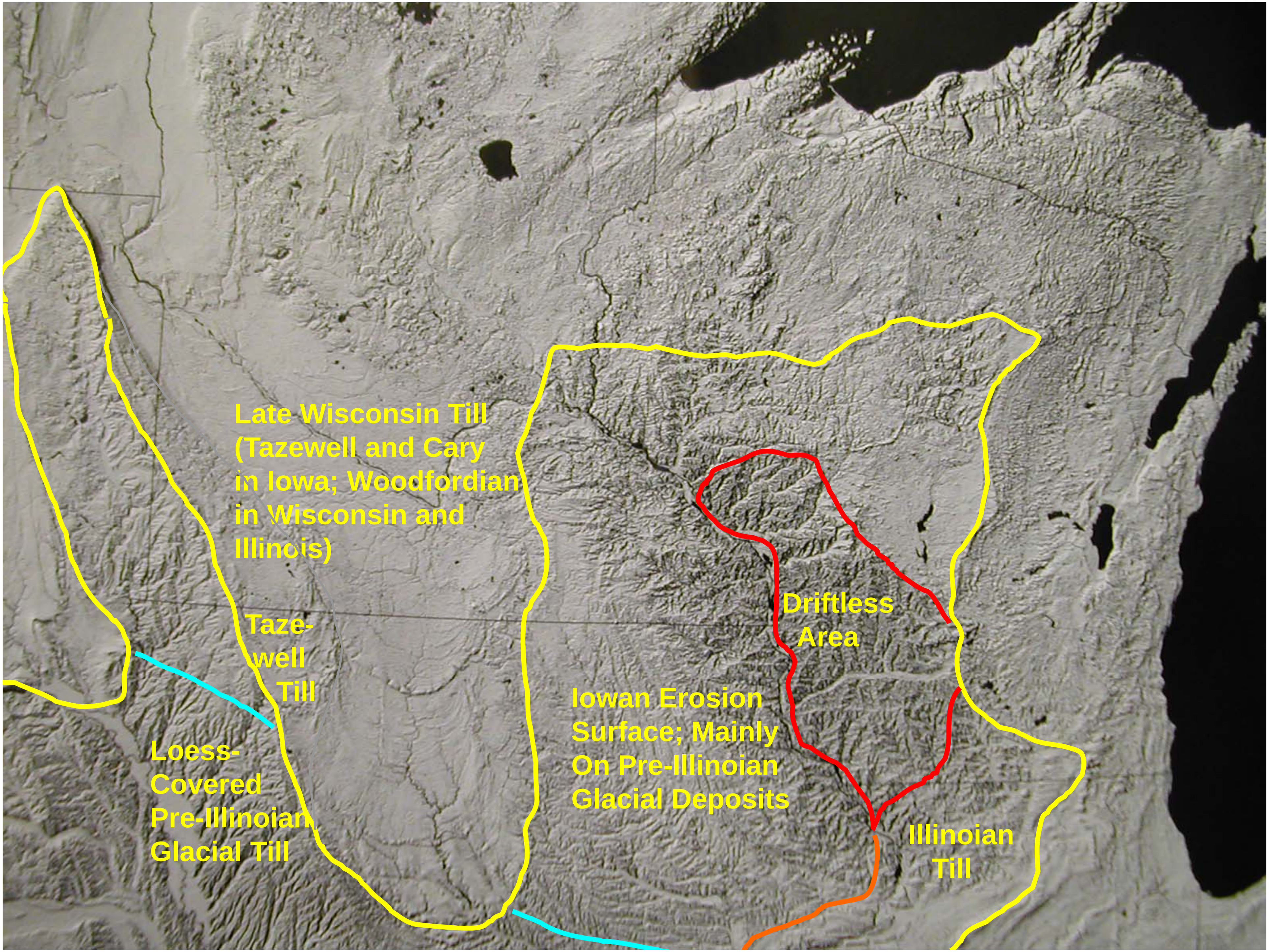
Magnitudes of Annual Floods - 6 SW Wisconsin Basins
Annual Flood Maximum in Standard Deviations
Water Year
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
1940
1950
1960
1970
1980
1990
2000
2010
Increased Variability
Galena R at Buncombe
Grant R at Burton
Platte R near Rockville
Pecatonic R at Darlington
East Branch Pecatonica R at Blanchardville
Kickapoo R at LaFarge
Data source: USGS Data analysis: J.C. Knox

Grant River – View Upstream
from Burton, WI Gage Site
September 25, 2007

Photo: J.C. Knox

Grant River – View Upstream
from Burton, WI Gage Site
April 25, 2008

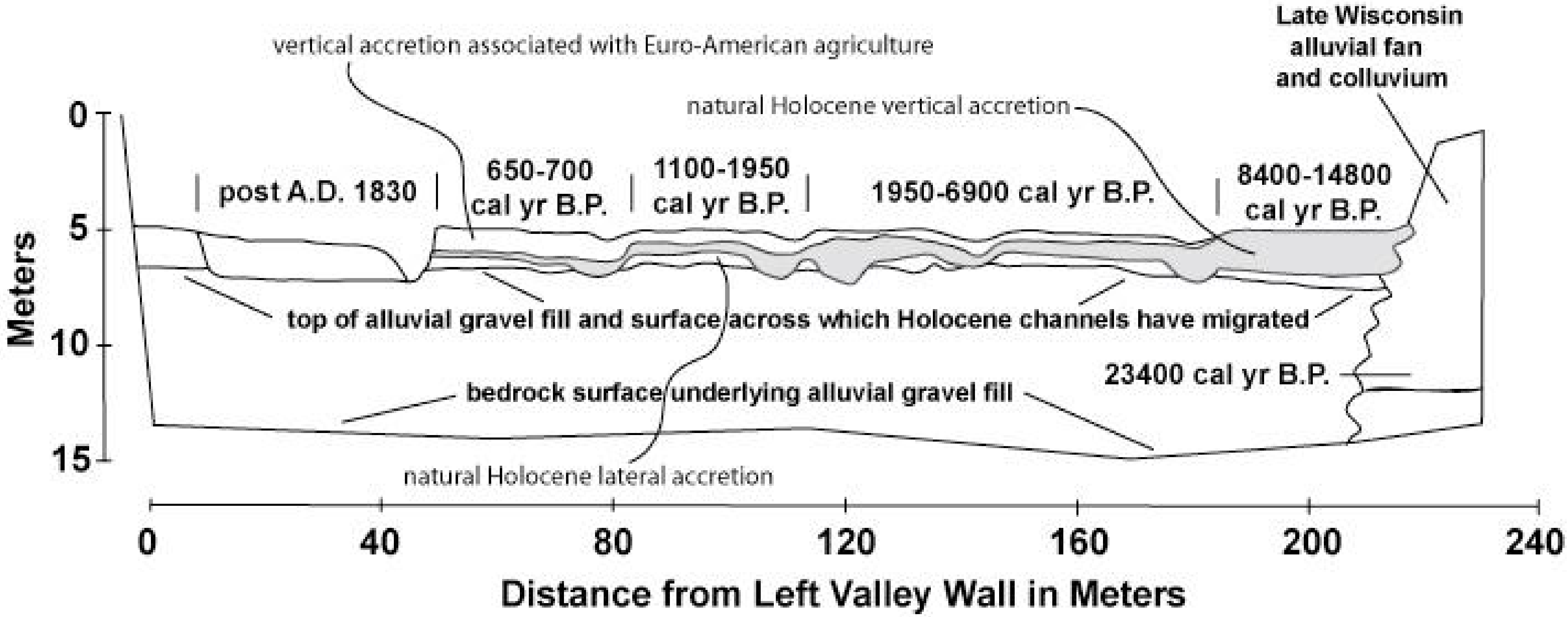
Photo: J.E. Rawling



Late Wisconsin Till
(Tazewell and Cary
in Iowa; Woodfordian
in Wisconsin and
Illinois)
Taze-
well
Till
Loess-
Covered
Pre-Illinoian
Glacial Till
Iowan Erosion
Surface; Mainly
On Pre-Illinoian
Glacial Deposits
Driftless
Area
Illinoian
Till

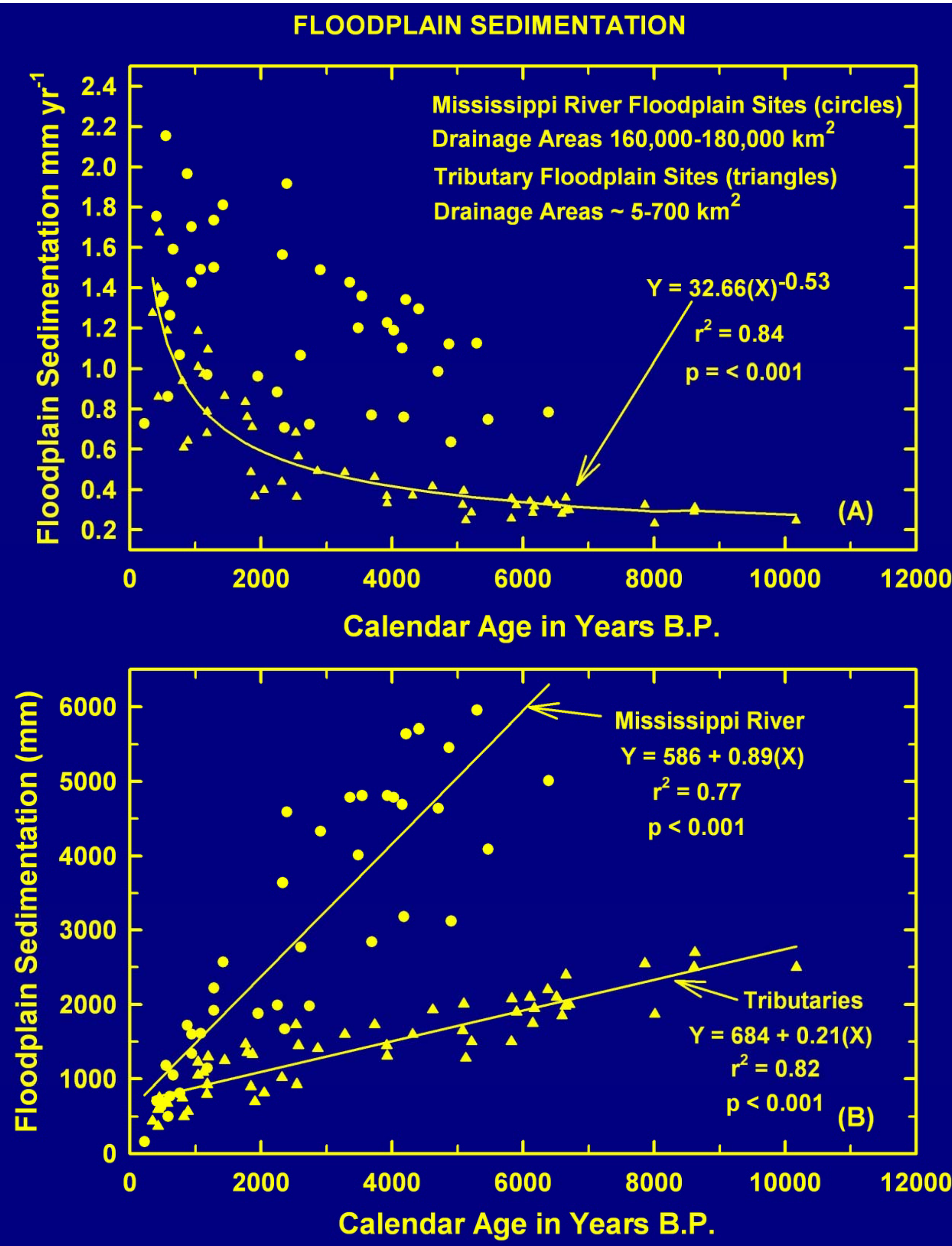
Richman Tributary to Snowden Branch, Grant County, WI.

Photos: J. C. Knox



Bollant-Michek Site: Platte River Headwaters, Grant County, Wisconsin
Data Source: J. C. Knox

Radiocarbon Dates From Upper Mississippi Valley Floodplains



Natural Rates of Sedimentation Prior to Agricultural Influence

Source: Knox, 2006

Palzkill Site, Pecatonica River near Mineral Point, Wisconsin

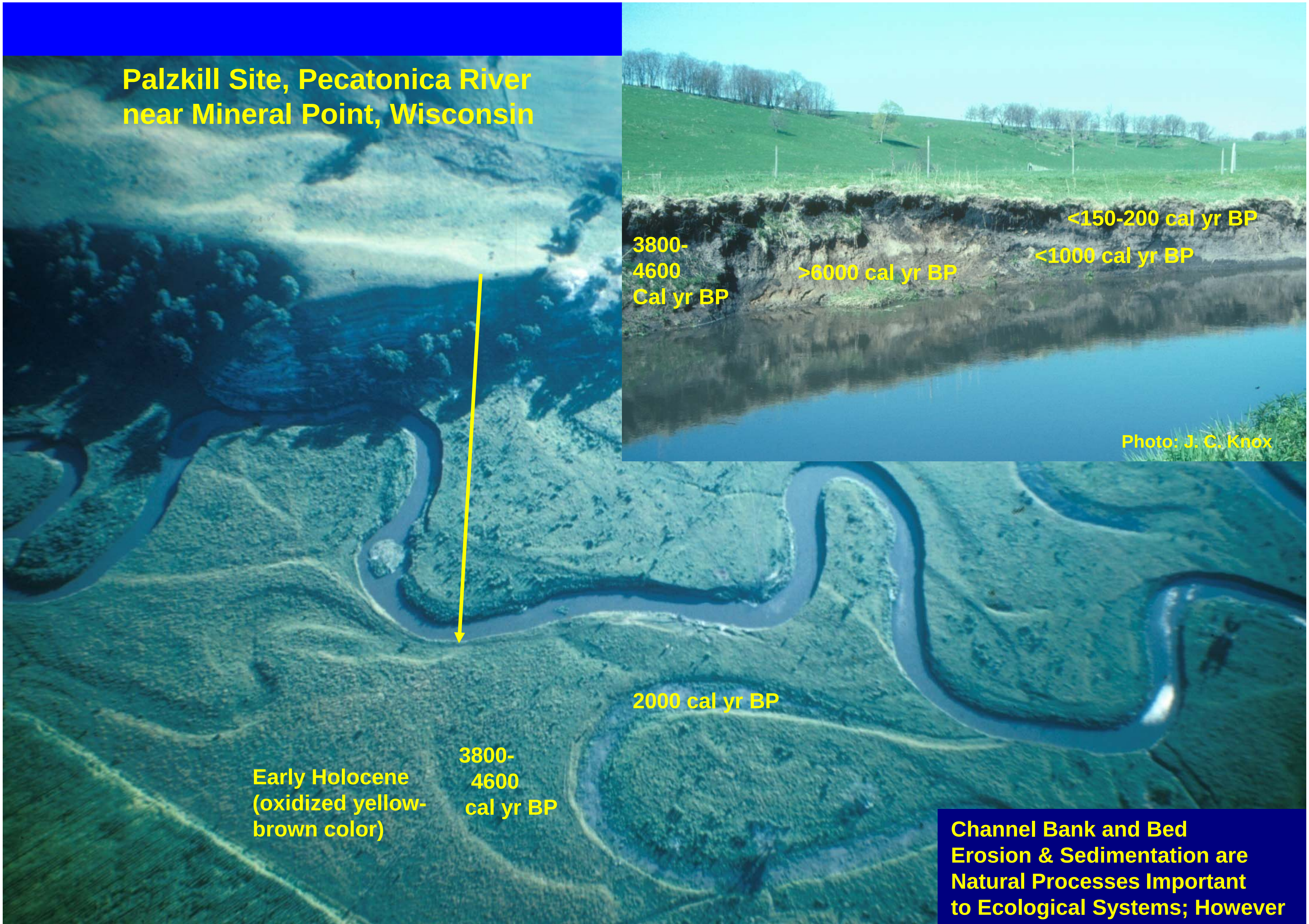
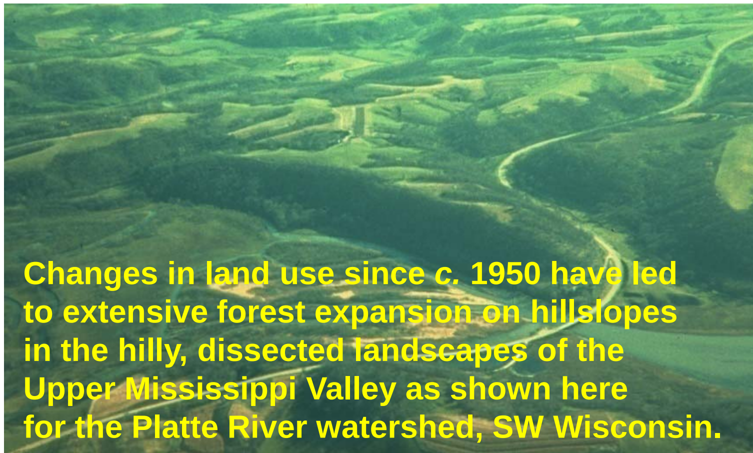


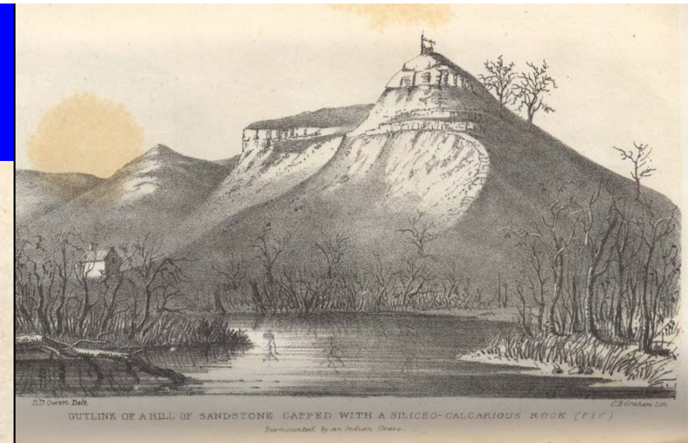
Photo: J. C. Knox

Air Photo: L. J. Maher

Channel Bank and Bed Erosion & Sedimentation are Natural Processes Important to Ecological Systems; However Human Activities Can Greatly Impact the Natural Rates



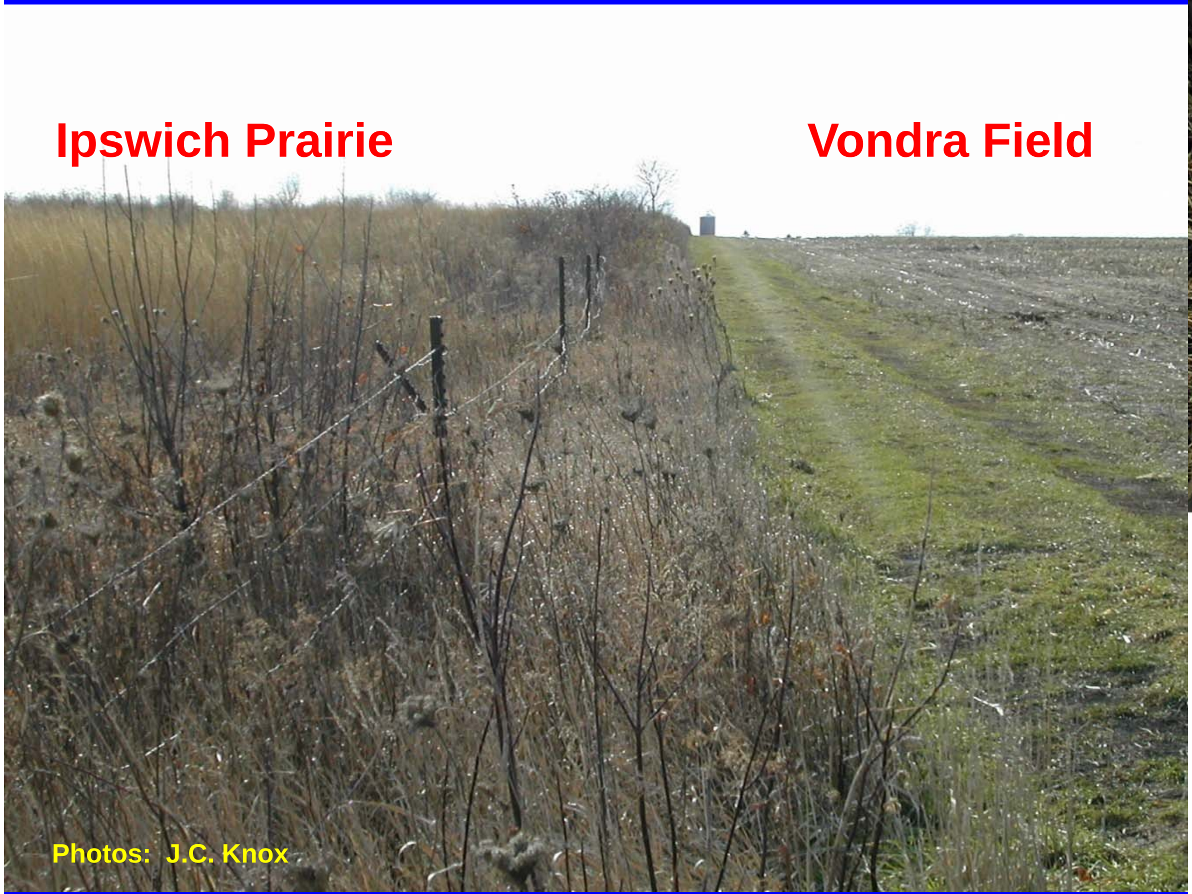
Changes in land use since *c.* 1950 have led to extensive forest expansion on hillslopes in the hilly, dissected landscapes of the Upper Mississippi Valley as shown here for the Platte River watershed, SW Wisconsin.



David Dale Owen Sketch of Lower Kickapoo River Valley.

The Lower Kickapoo River Valley, Crawford County, SW Wisconsin, *c.* 1839-1846

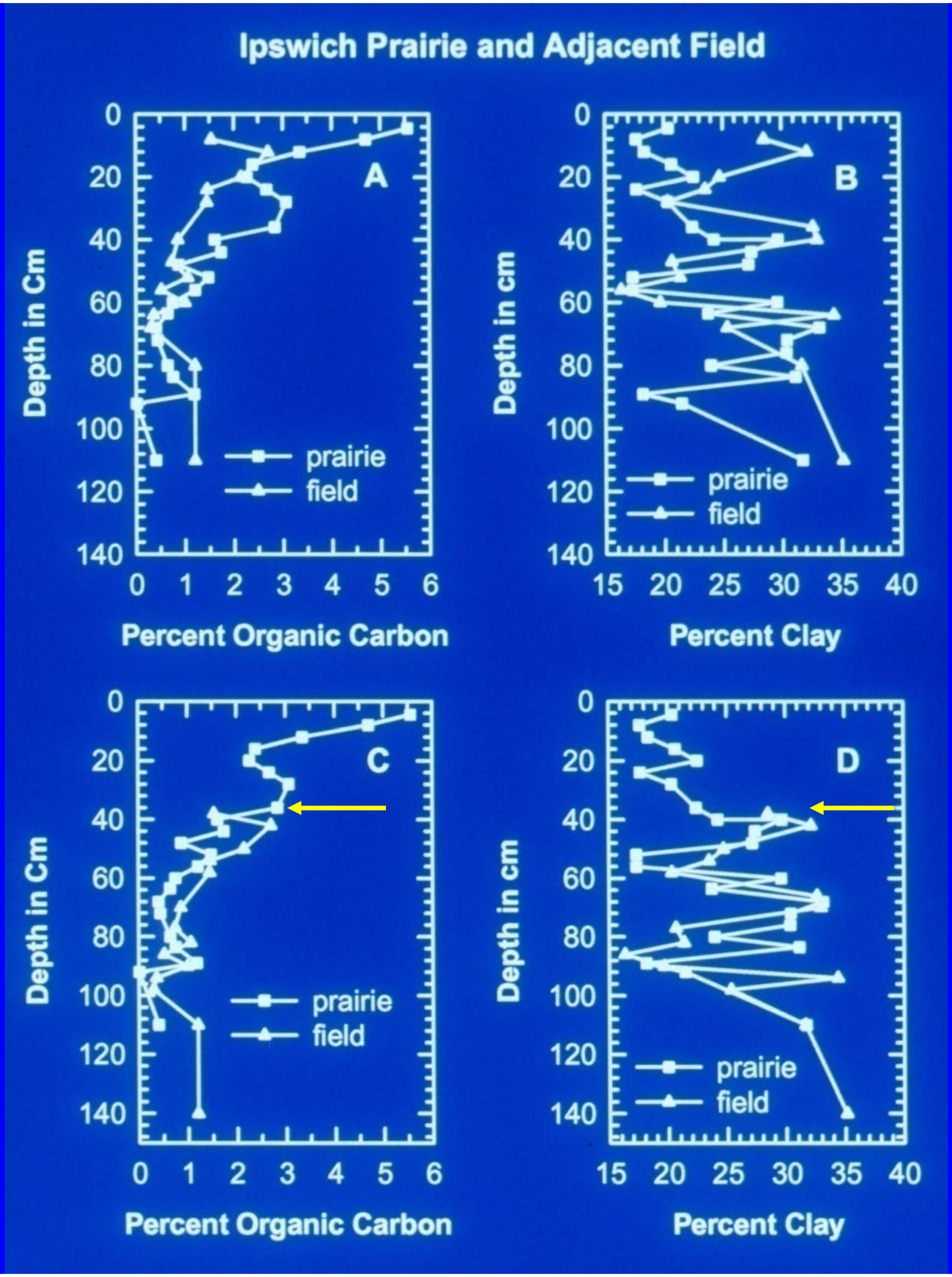
Platte River – Galena River Upland Drainage Divide, SE Grant County, Wisconsin



U.S. Government Land Patent: 1839

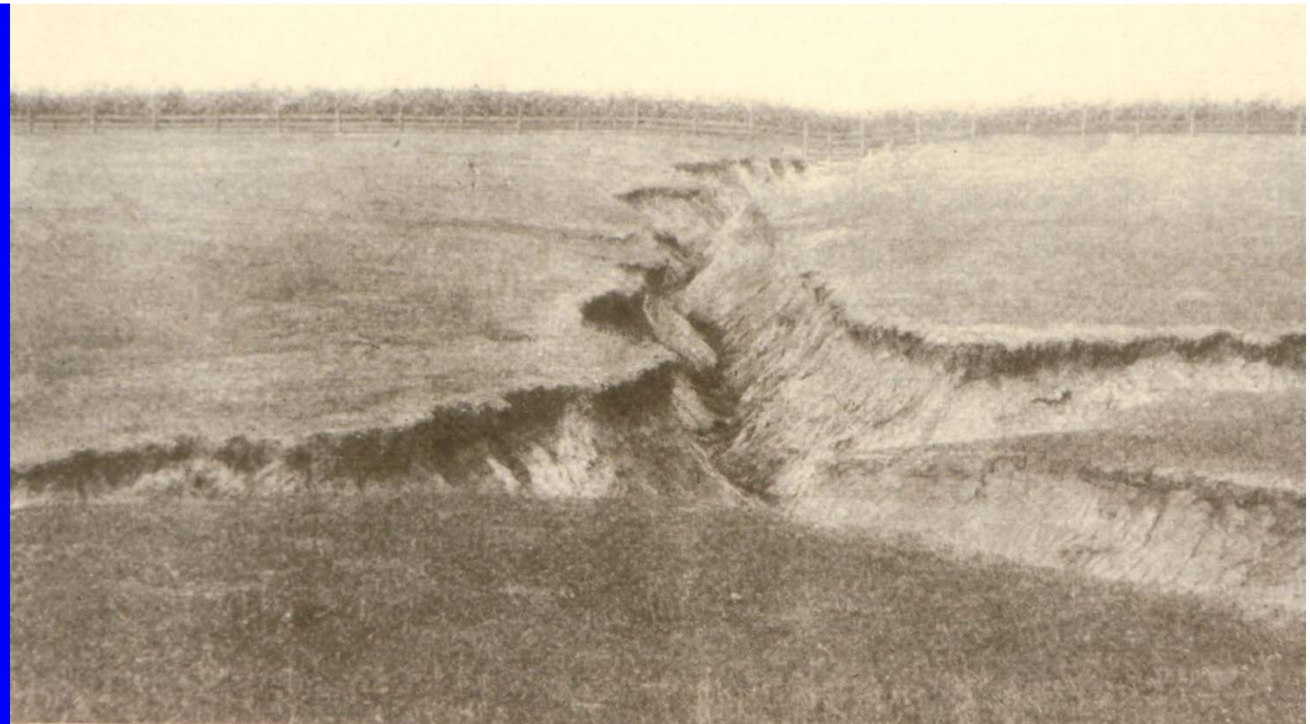
Southeast Grant County Wisconsin Upland Sites

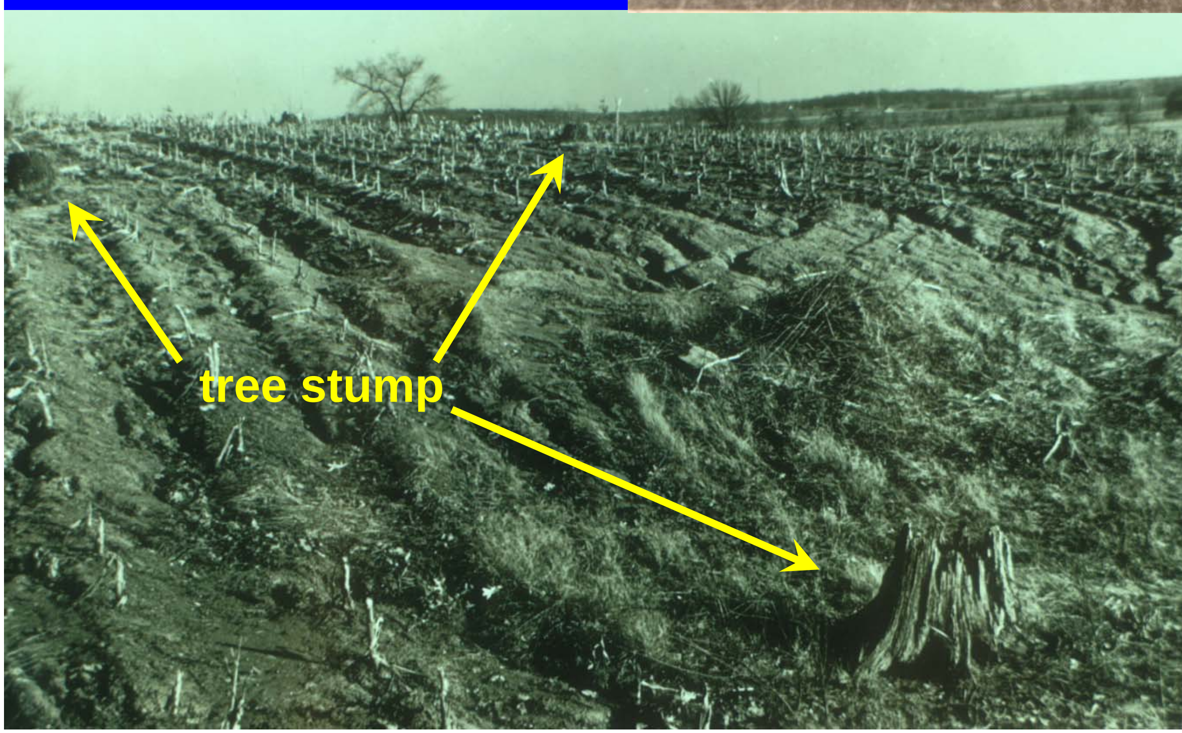
Approximately 38 cm of topsoil erosion occurred during the past 175 years of agricultural land use.



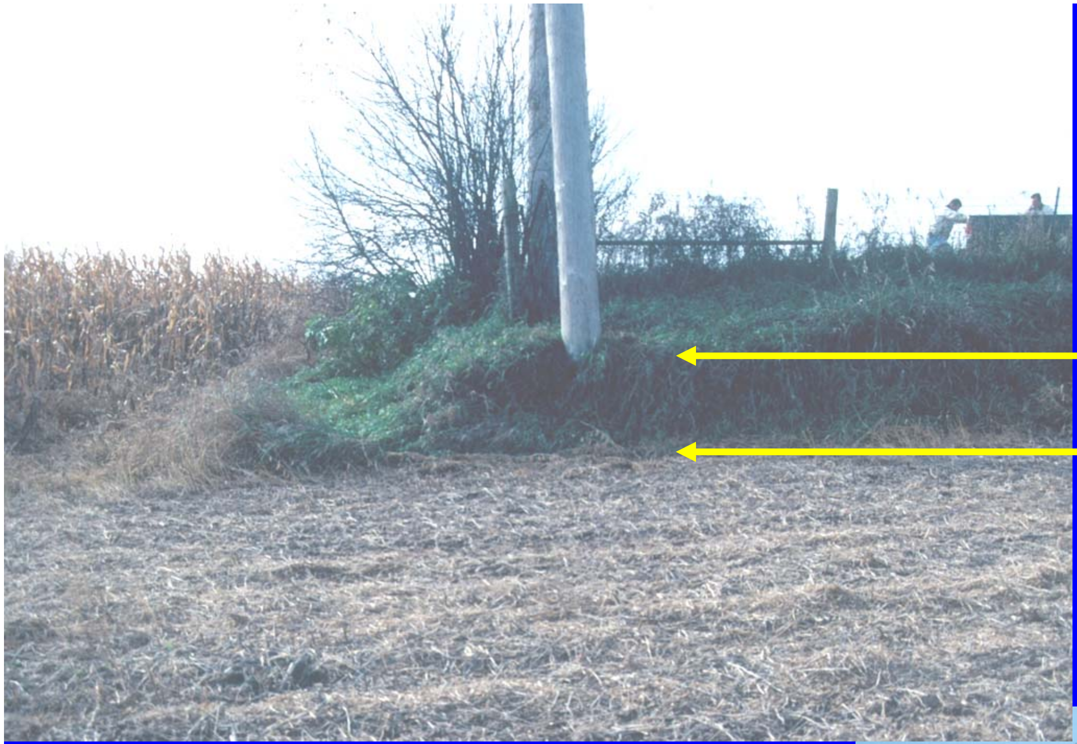
(Source: Knox, 2001)

Jo Daviess County, Illinois, Gully Below Ridge-Top Corn Field; Described as Typical of Early 1910s Tributary Drainages in Jo Daviess County. (Trowbridge and Shaw ,1916).



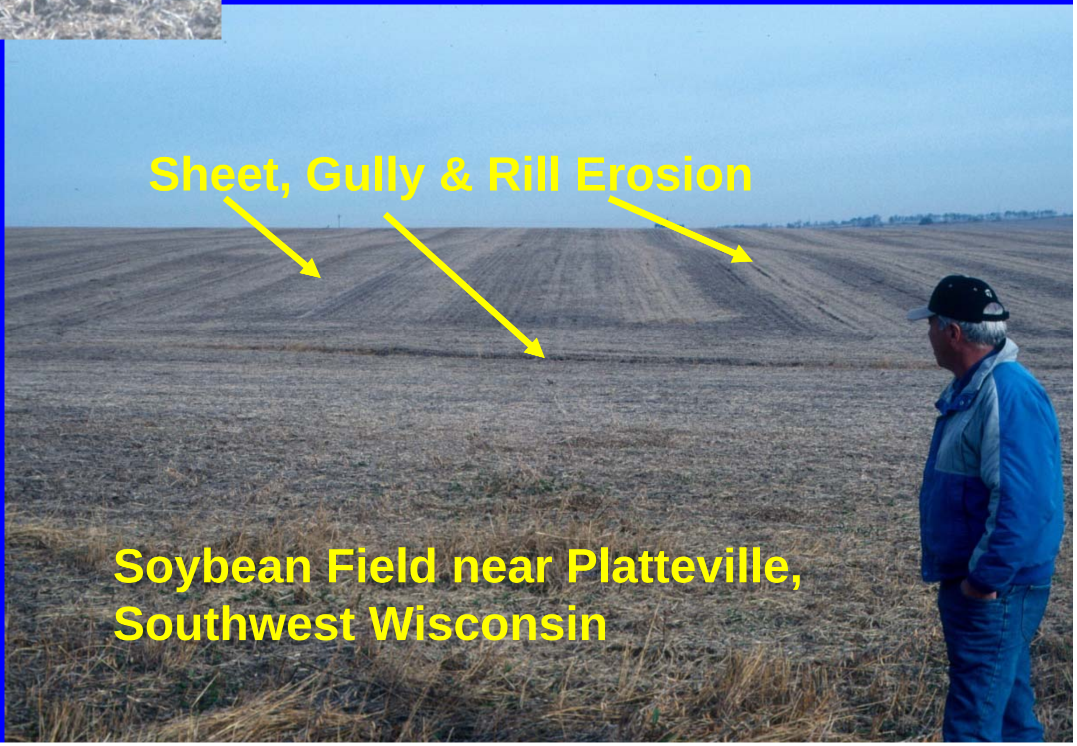


Severe Rill Erosion in Late 19th Century NW Illinois Corn Field.
Photo Source: Wisconsin State Historical Society.



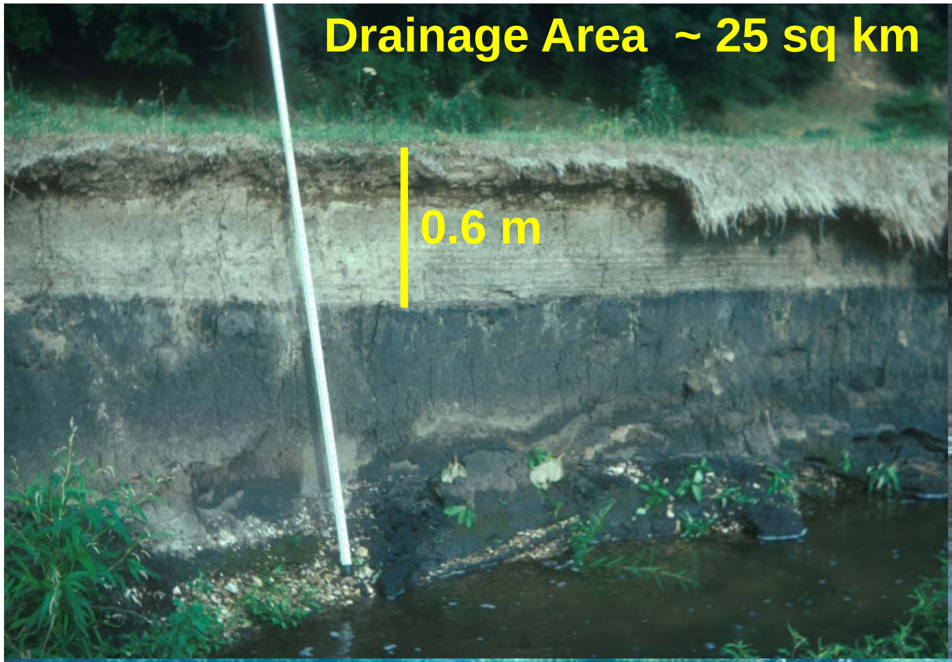
Ground Surface *c*. 1830

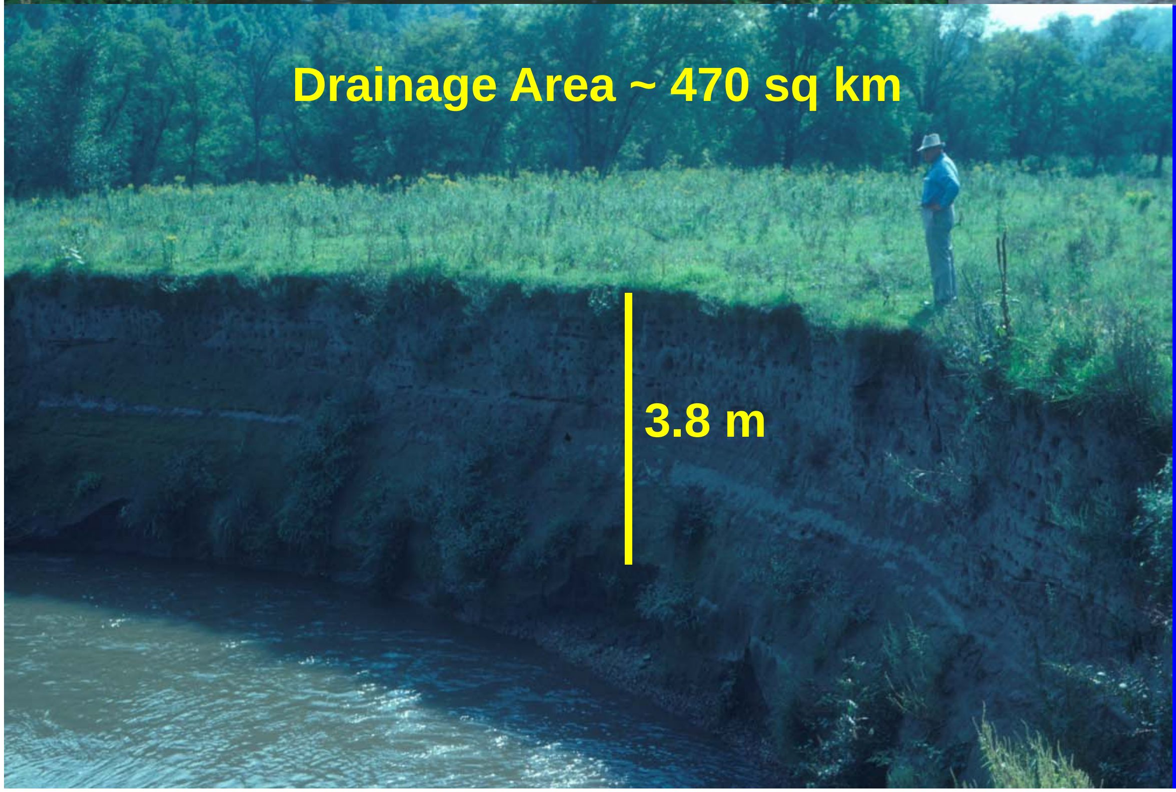
Ground Surface *c*. 2005



Historical Soil Erosion in Upland Fields Since *c*. 1840

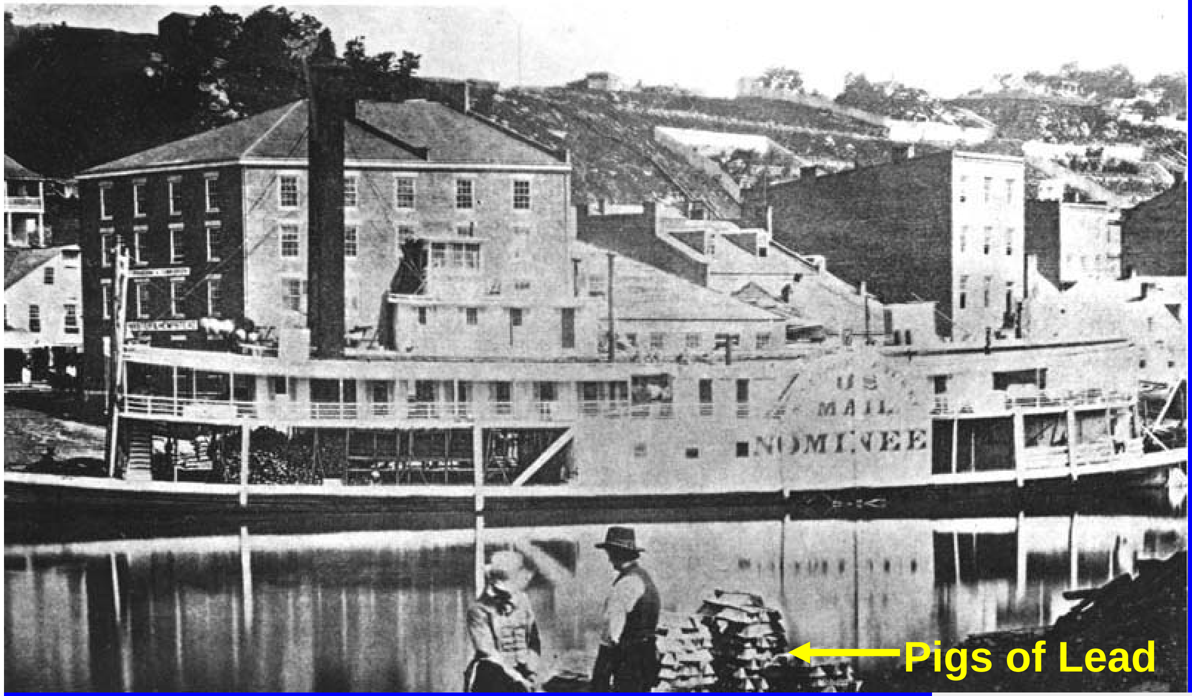
Photos: J.C. Knox





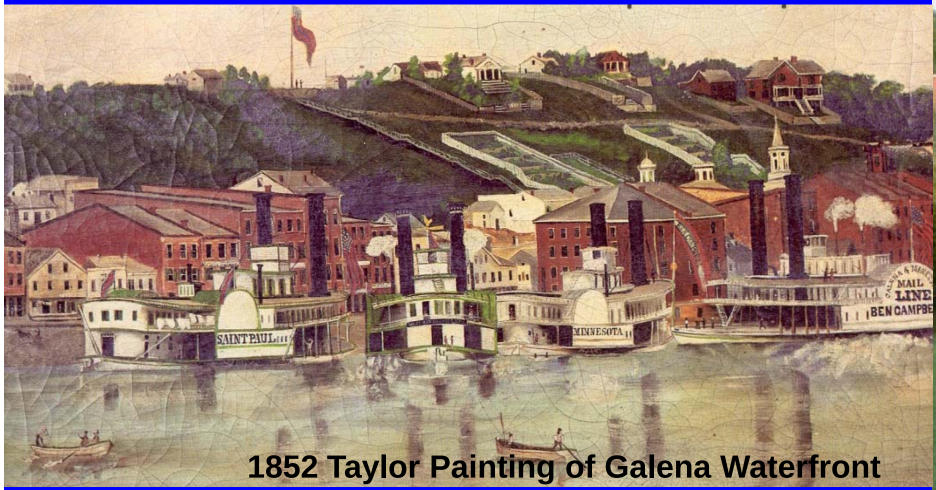
Pre-Euro-American Agriculture Floodplain Surface is Denoted by Mollisol Paleosol Whose Depth of Burial Increases Downstream

Photos: J.C. Knox



Pigs of Lead

Steamboat Nominee Docked at Galena, Illinois *c.* 1847-1853.

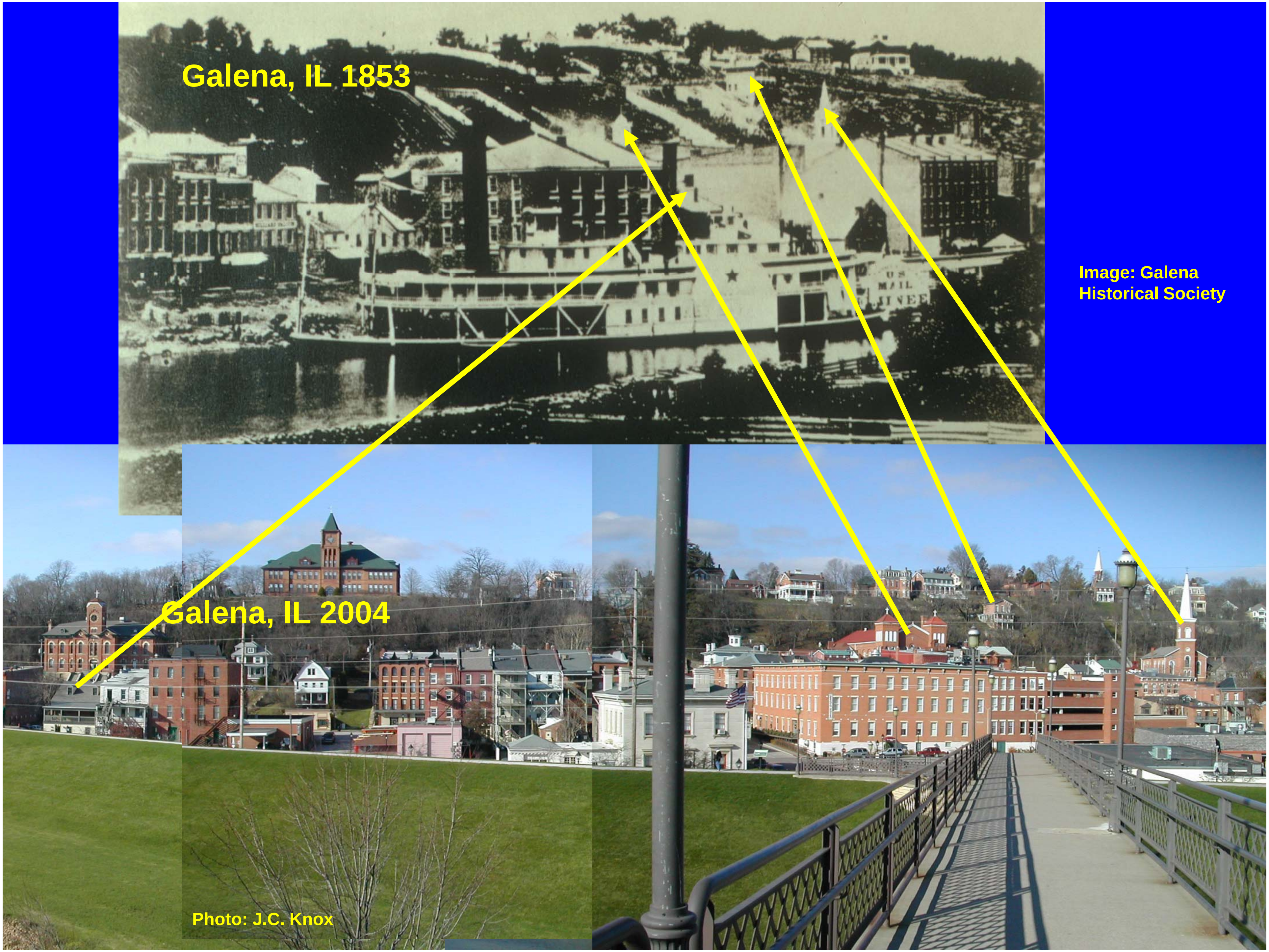


1852 Taylor Painting of Galena Waterfront

Images: Galena Historical Society

View of Galena River 2 October 2005 from Right Bank Position of the Docked Steamboat Nominee

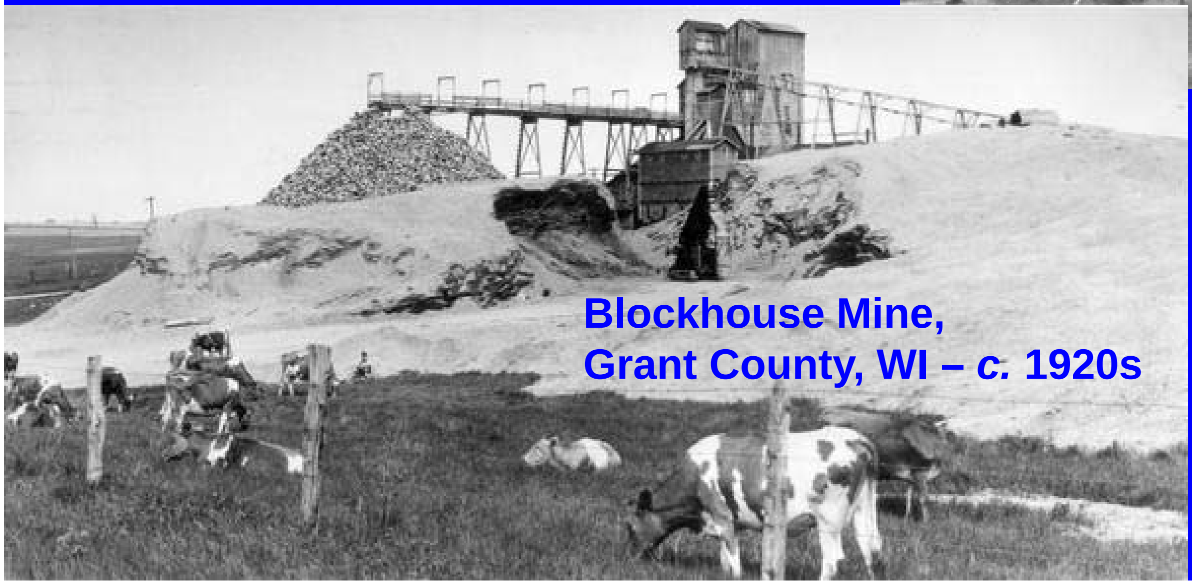
Photo: J.C. Knox


Galena, IL 1853
Image: Galena Historical Society
Galena, IL 2004
Photo: J.C. Knox

Photos: J. C. Knox

Mullen Mine, Lafayette Cty, WI
1925 -1952 (intermittent)

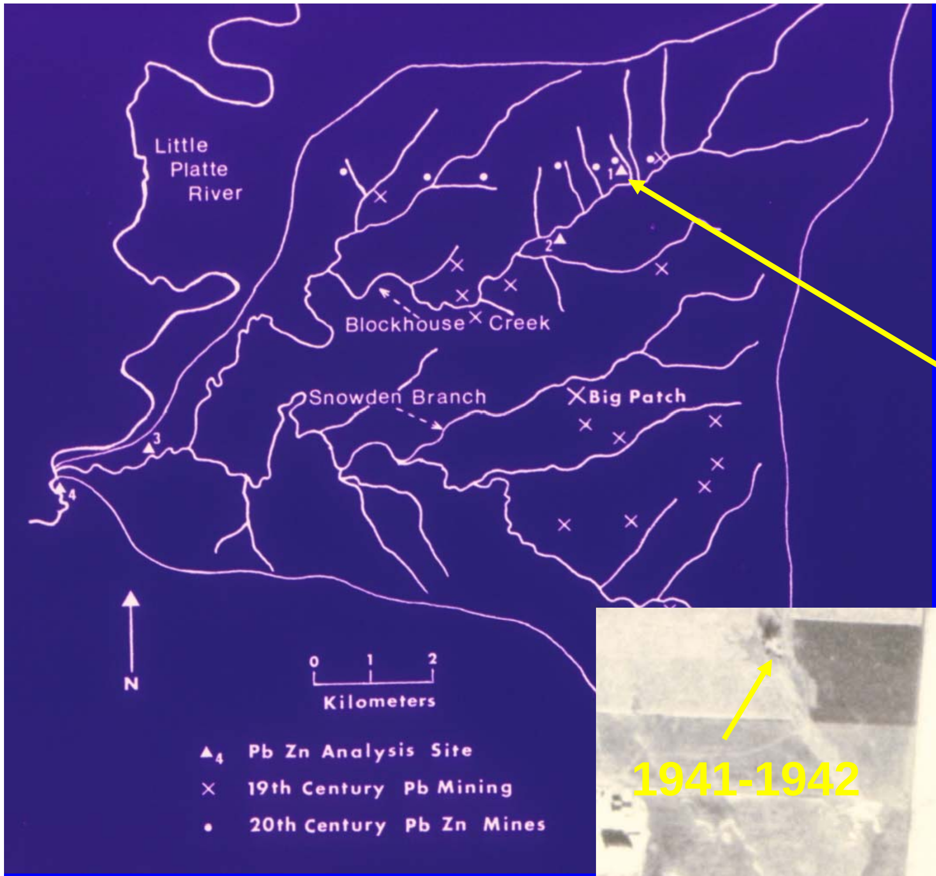
Hughlett's Lead Furnace,
Galena, IL – *c*. 1850

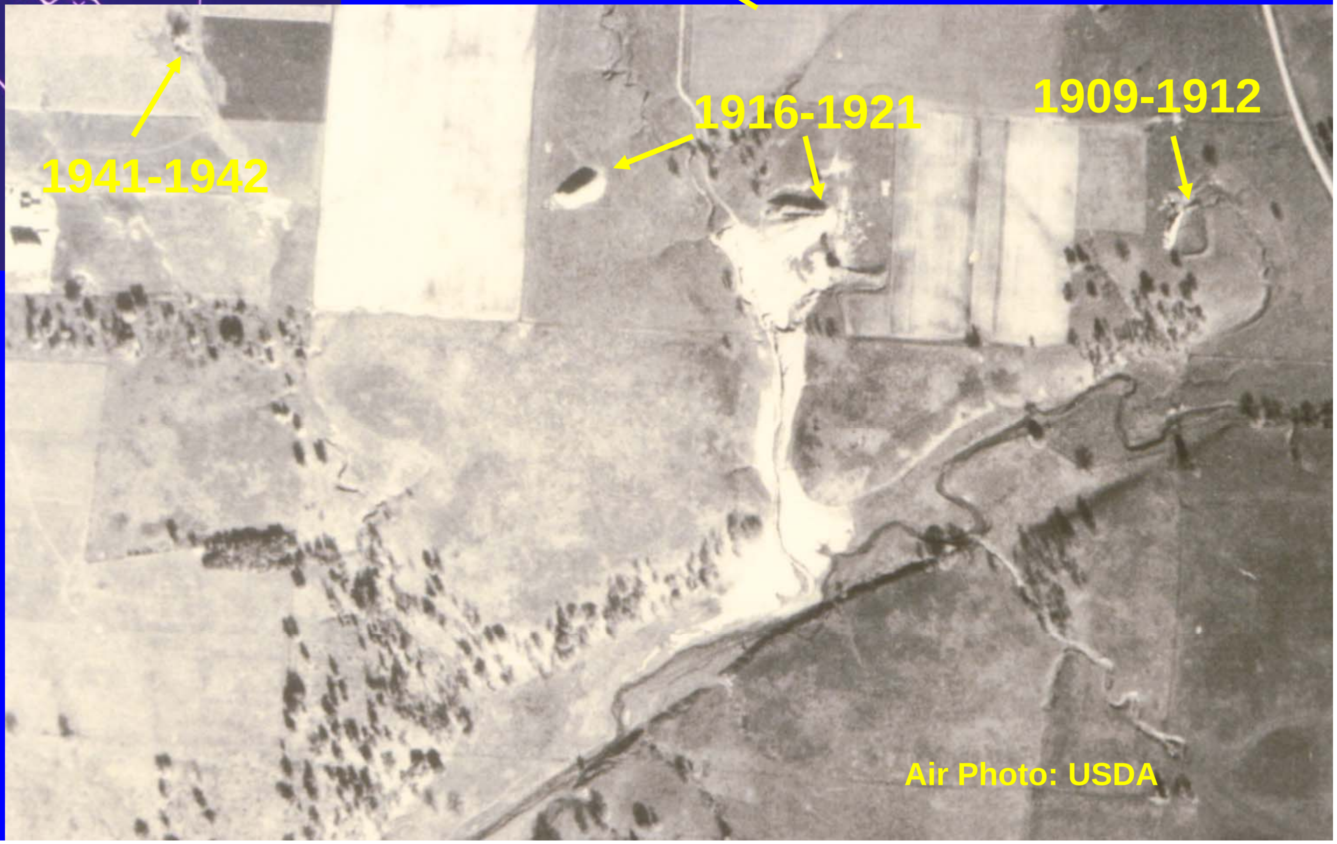


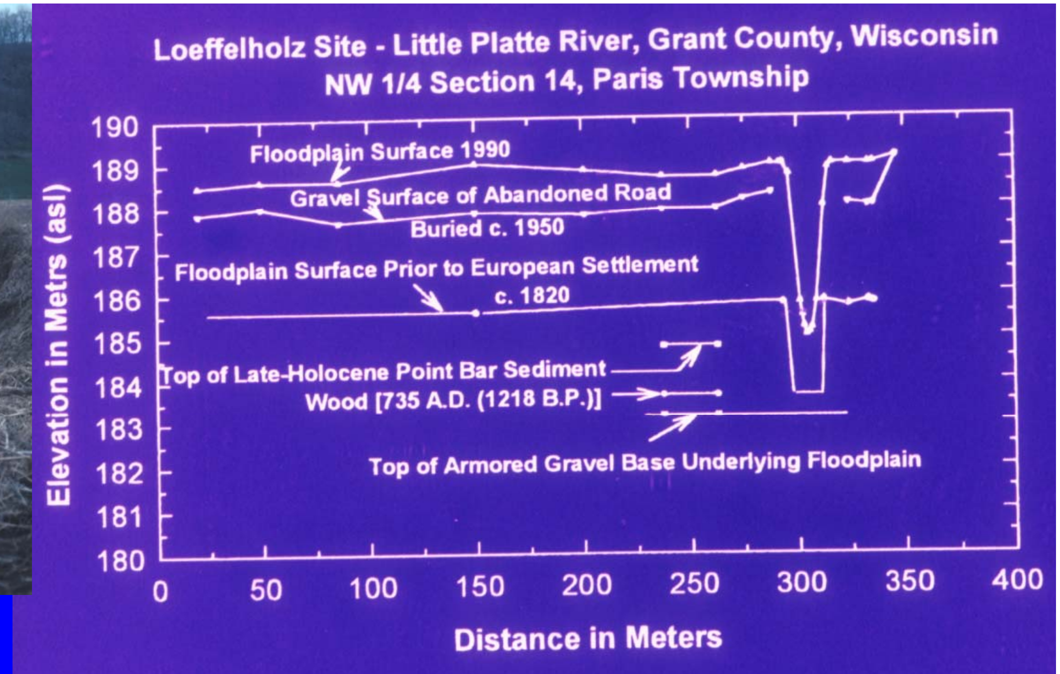
Blockhouse Mine,
Grant County, WI – *c.* 1920s

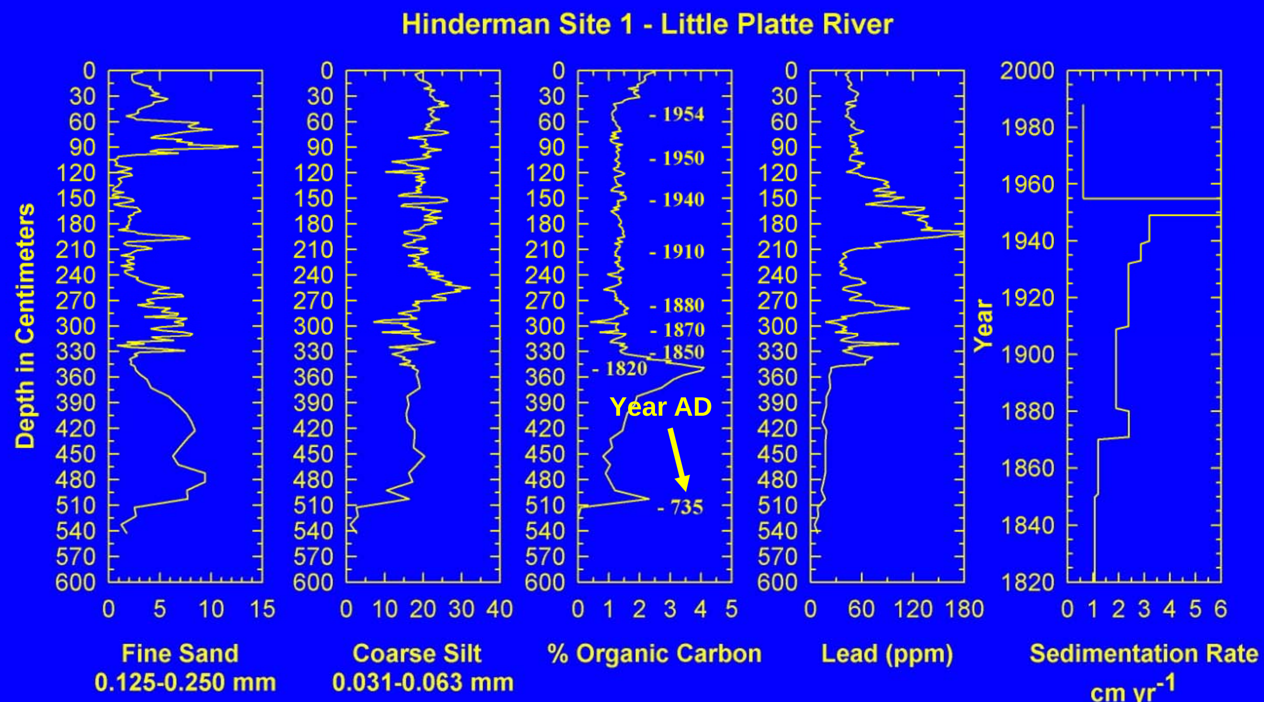
Photo Sources: Wisconsin State Historical Society

Mining Sites in the Platte River Watershed, Southwestern Wisconsin

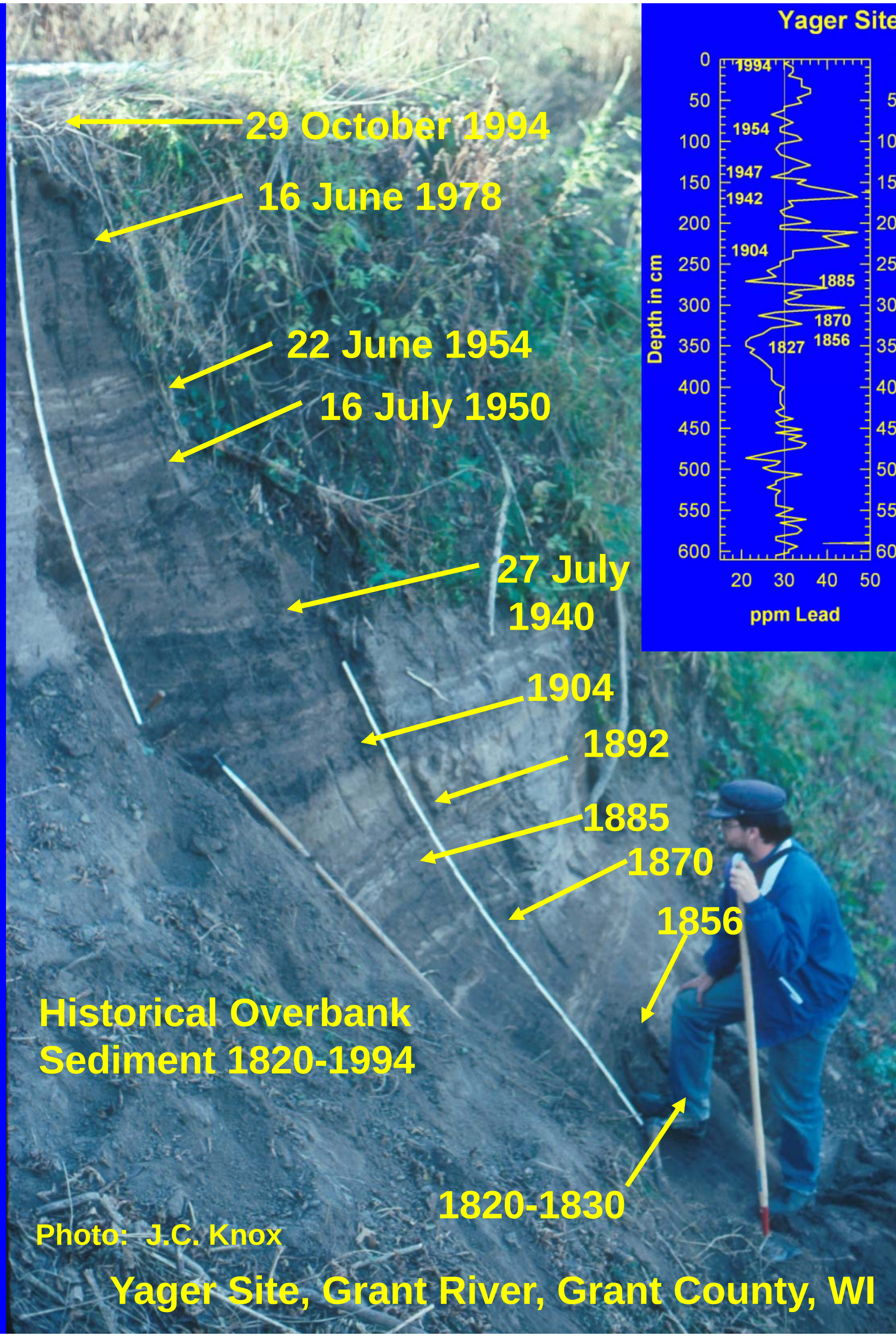


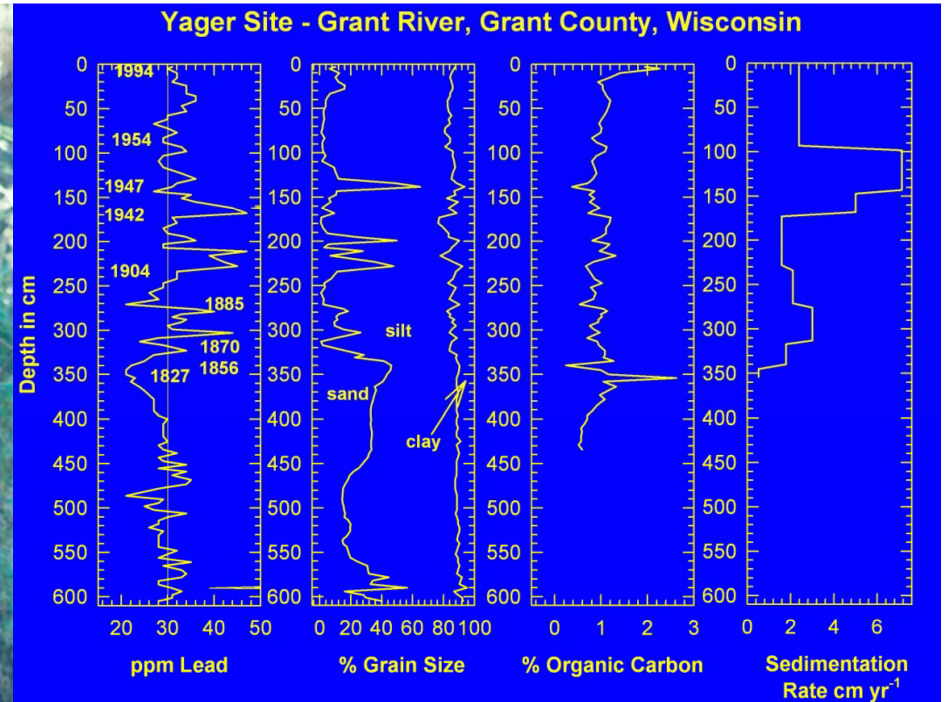


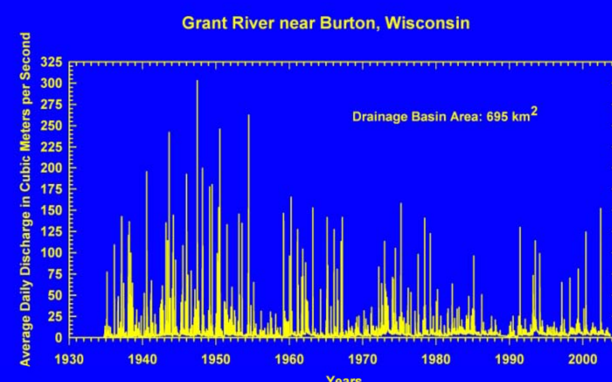




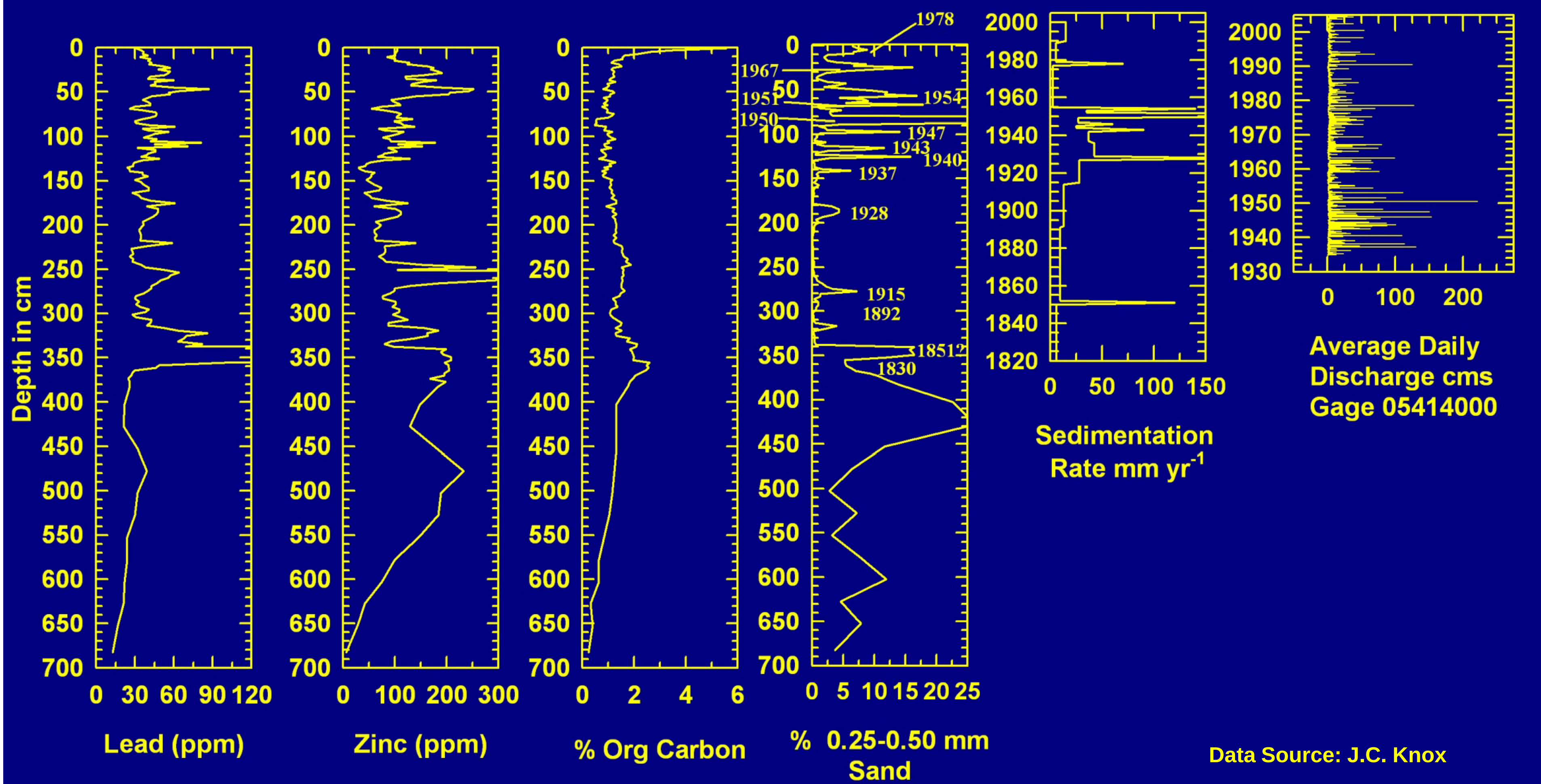
Source: Knox, 2001, *Catena*, v. 42, p. 193-224.


29 October 1994
16 June 1978
22 June 1954
16 July 1950
27 July 1940
1904
1892
1885
1870
1856
1820-1830
Historical Overbank Sediment 1820-1994
Photo: J.C. Knox
Yager Site, Grant River, Grant County, WI


Yager Site - Grant River, Grant County, Wisconsin
Depth in cm
1994
1954
1947
1942
1904
1885
1870
1856
1827
silt
sand
clay
ppm Lead
% Grain Size
% Organic Carbon
Sedimentation Rate cm yr^{-1}

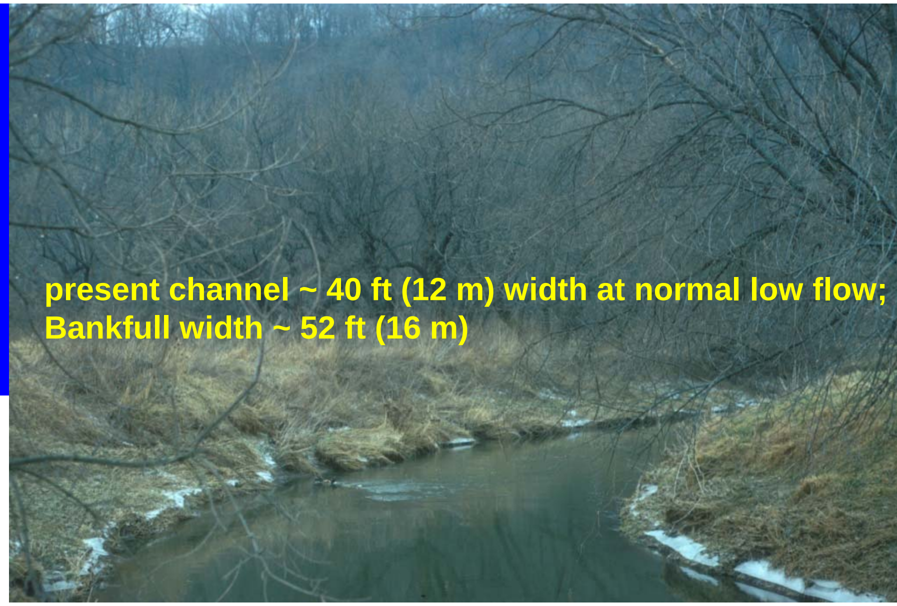

Grant River near Burton, Wisconsin
Drainage Basin Area: 695 km^2
Average Daily Discharge in Cubic Meters per Second
Years

Floodplain Sedimentation Stelpflug Site 2 - Platte River, Grant County, Wisconsin



Metamorphosis of the lower Platte River, Grant County Wisconsin since *c.* 1833, mainly in response to agricultural land use and backwater effects of Lock & Dam 11

Photo: J.C. Knox



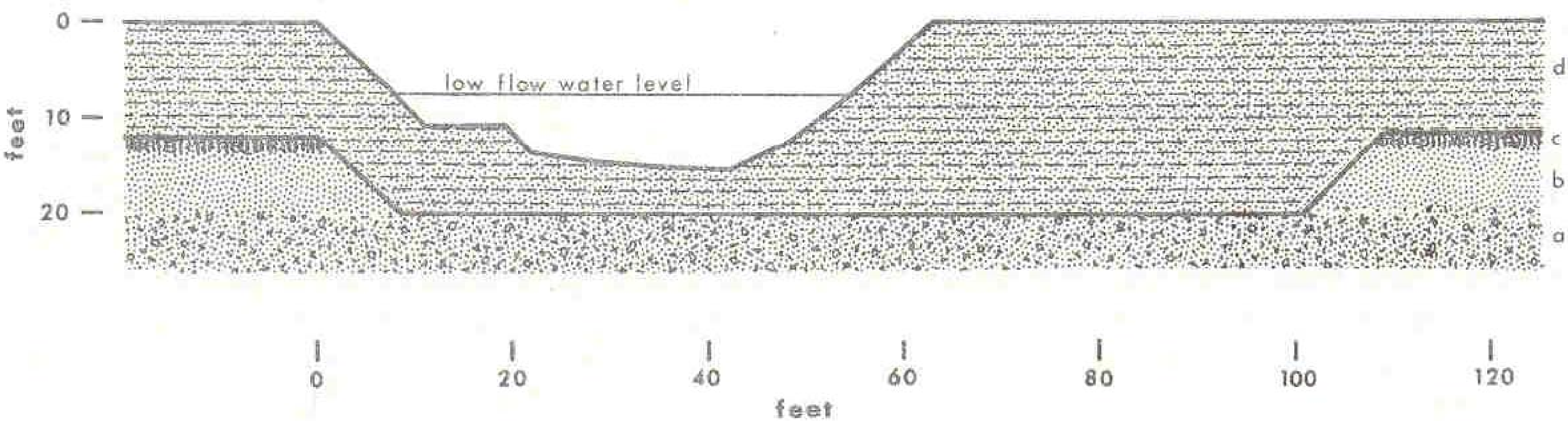
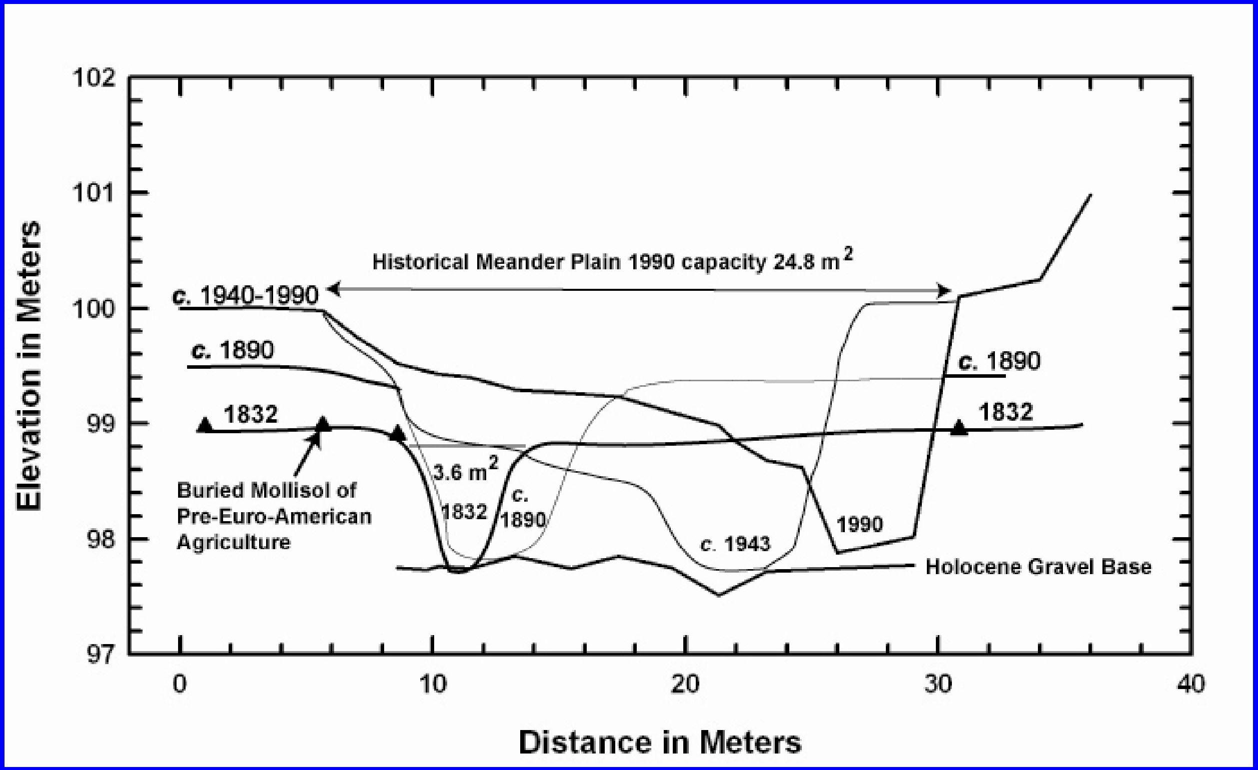


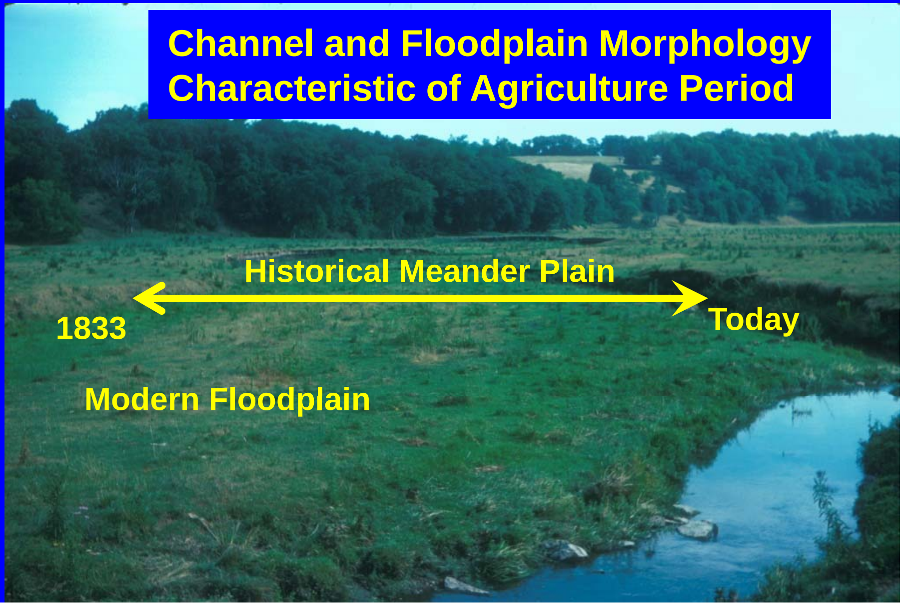
FIG. 12. Typical historical channel metamorphosis in the lower reach of the Big Platte River, downstream of mile thirty-five (km 56). Unit "a" consists mainly of sandy gravels; the top of the unit correlates with the base of the presettlement channel that is identified in the profile at the base of unit "d." Unit "b" mainly is silt and it is capped by a paleosol, unit "c," that was the presettlement surface soil. Unit "d" is represented by silts and sandy silts that have accumulated in response to conversion of the natural vegetation to agricultural land use.

(Source: Knox, 1977)

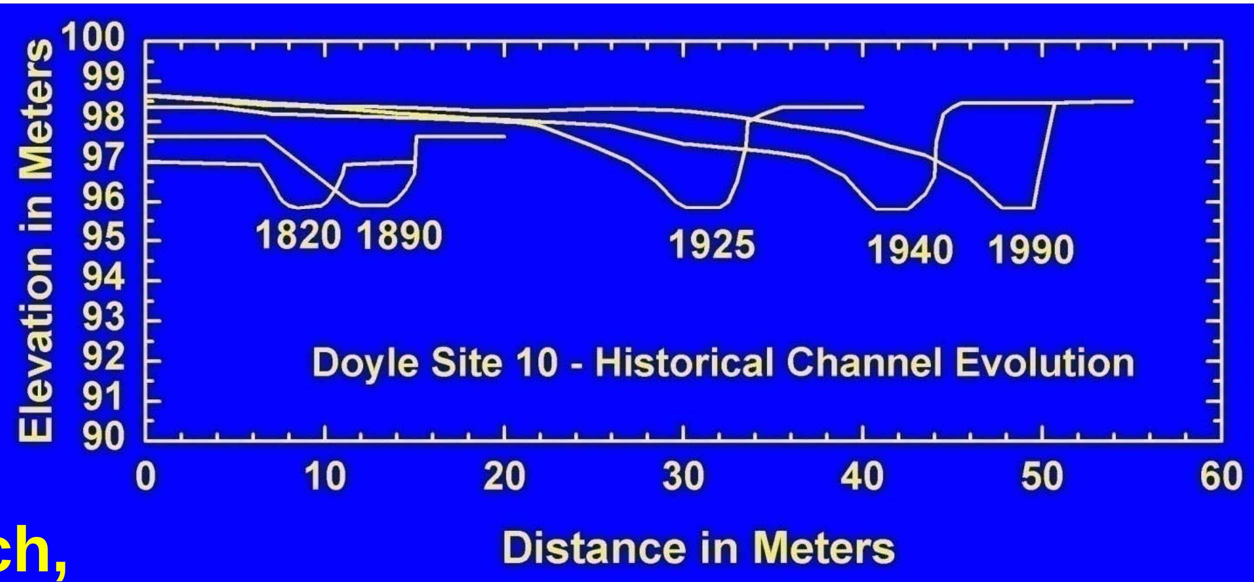
Doyle Site 9 – Strickland Branch, Lafayette County, Wisconsin



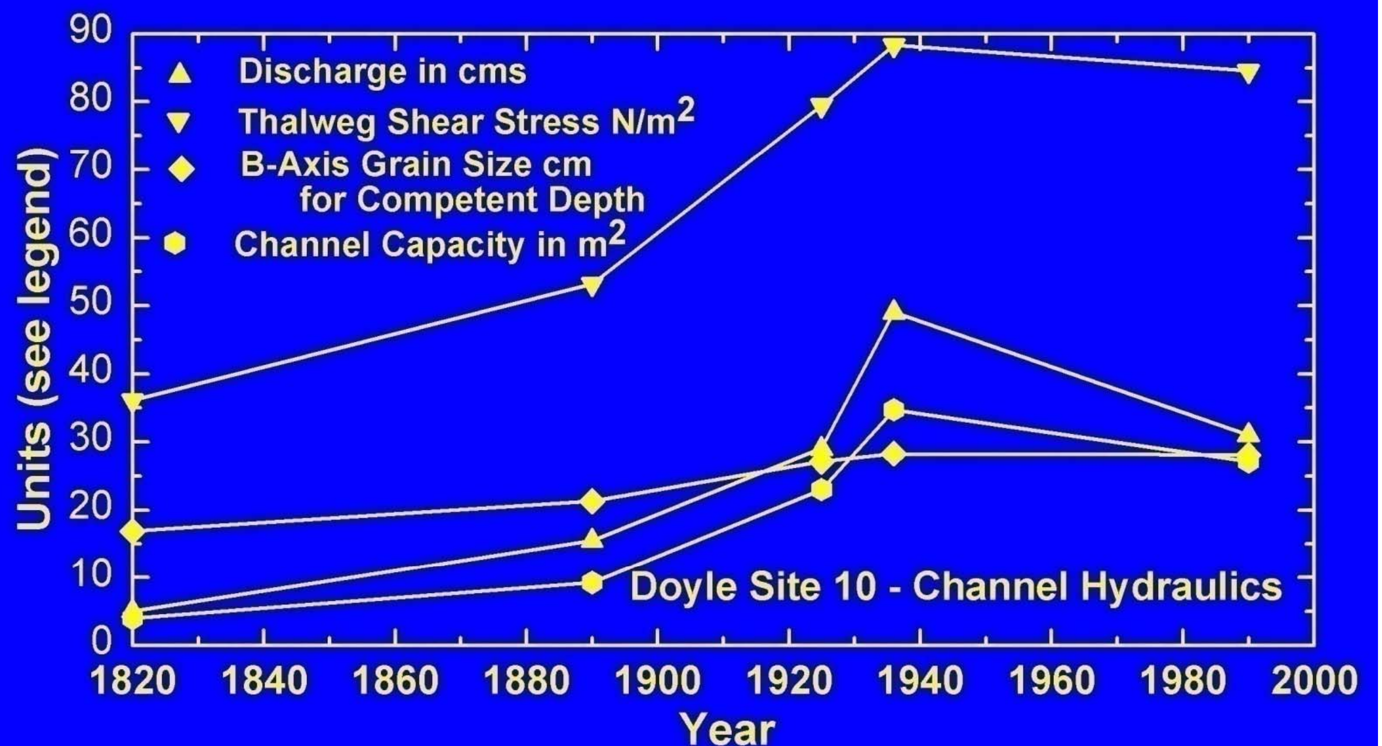
Photos: J.C. Knox



Historical Channel Metamorphosis

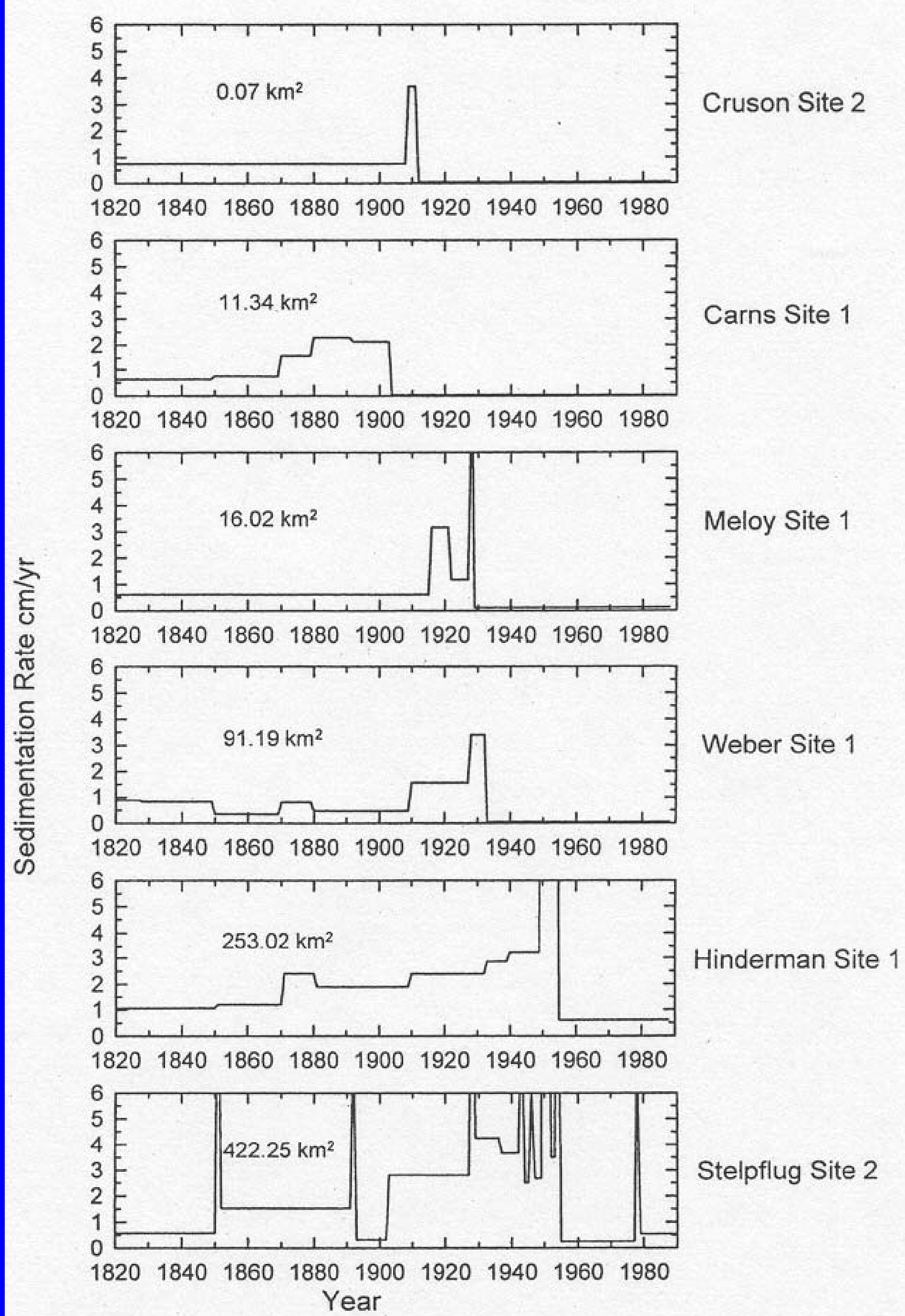


Shullsburg Branch, Lafayette County, SW Wisconsin



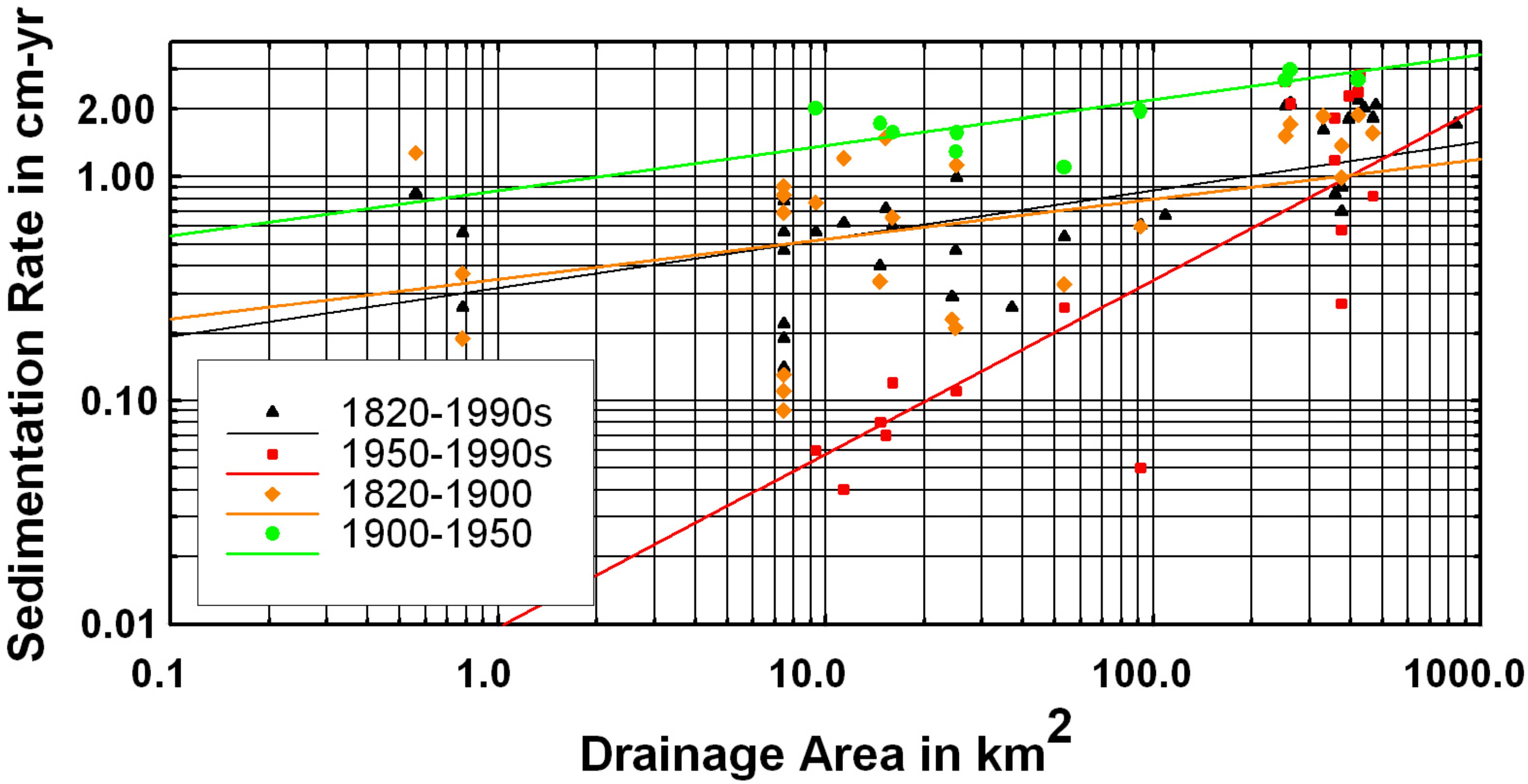
Source: Knox, 2001 *Catena*, v. 42, p. 193-224)

Floodplain and Valley Bottom Sedimentation Rates vs Drainage Area: Platte River System Grant County, WI



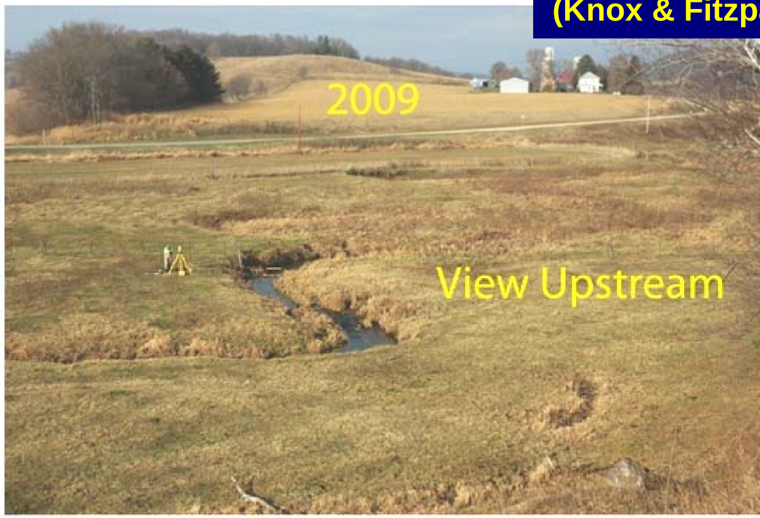
Data Source: Knox, 2002

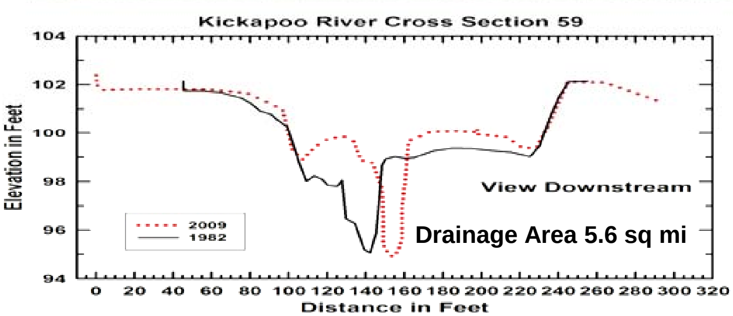
Historical Overbank Sedimentation Rates in the Lead-Zinc District

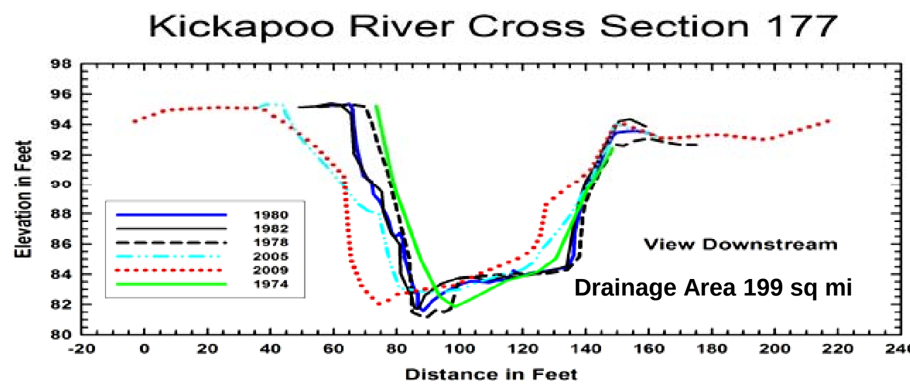


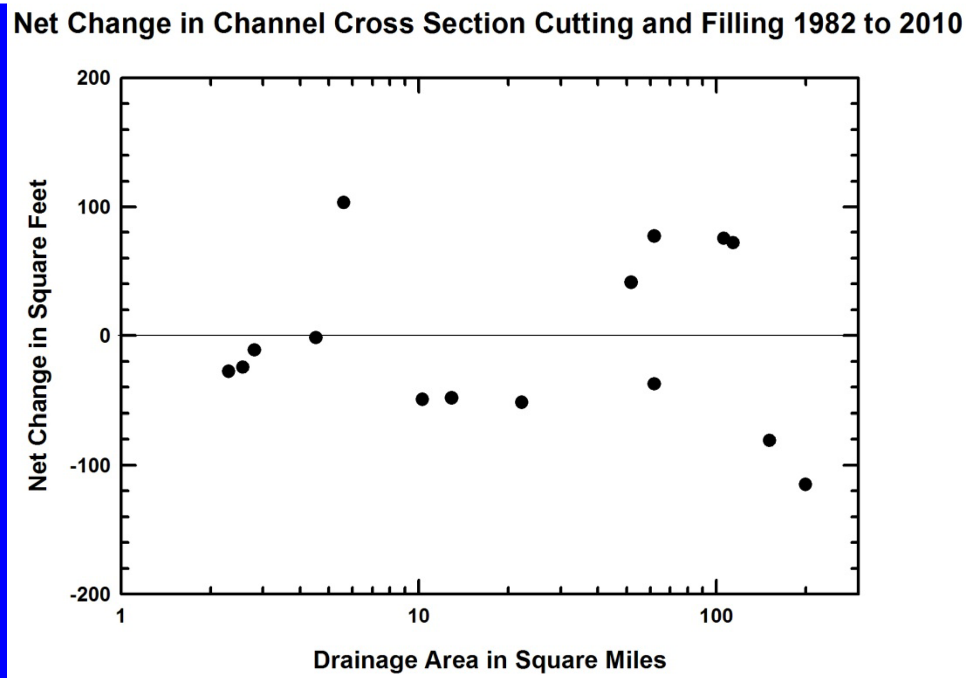
Data: J. C. Knox (2006) *Geomorphology*

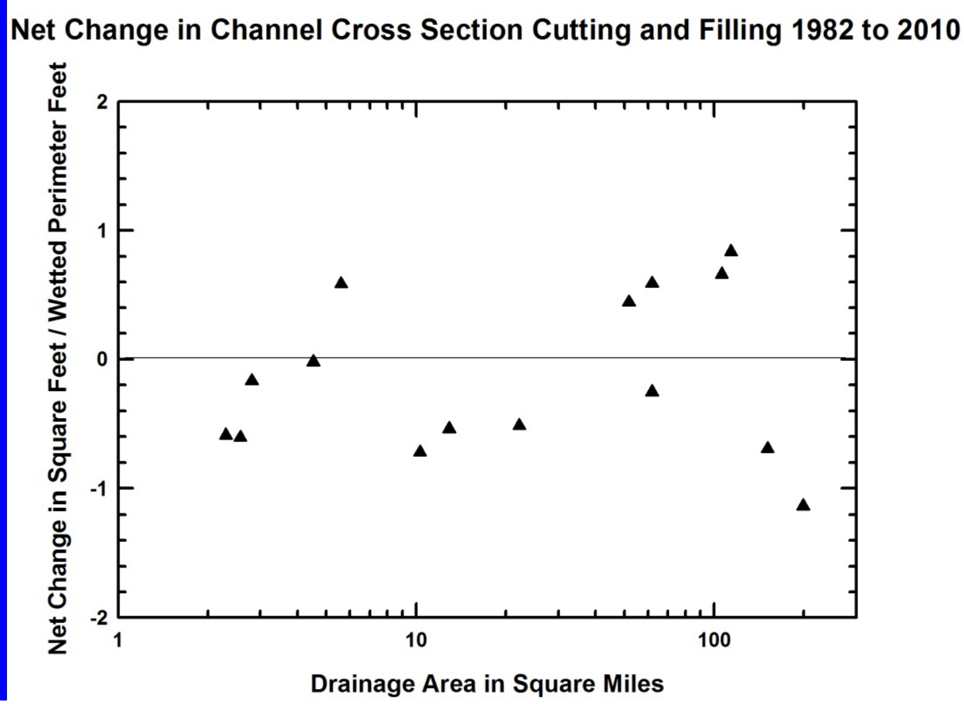
(Knox & Fitzpatrick, in progress)



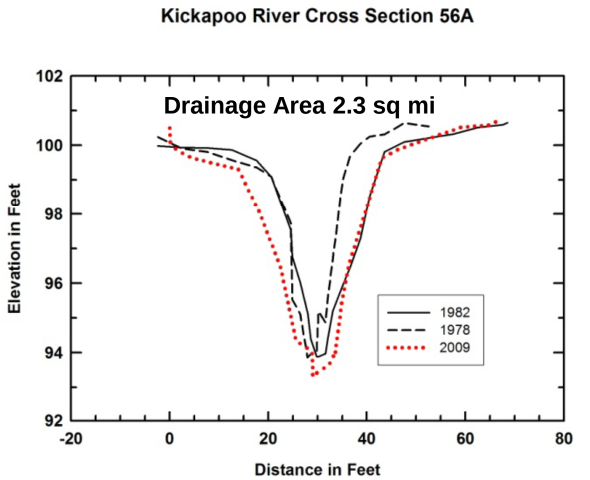


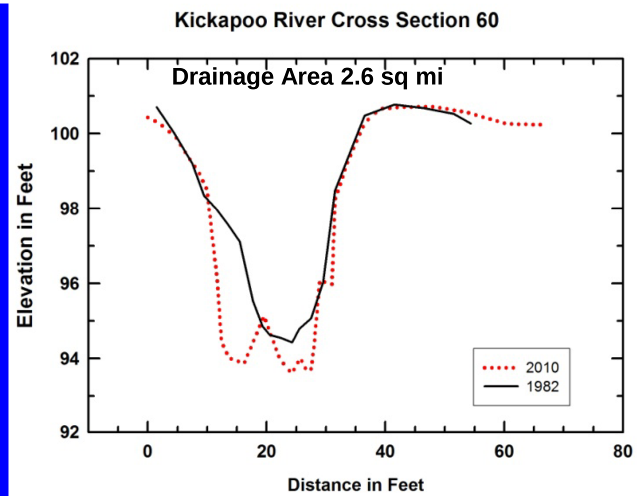


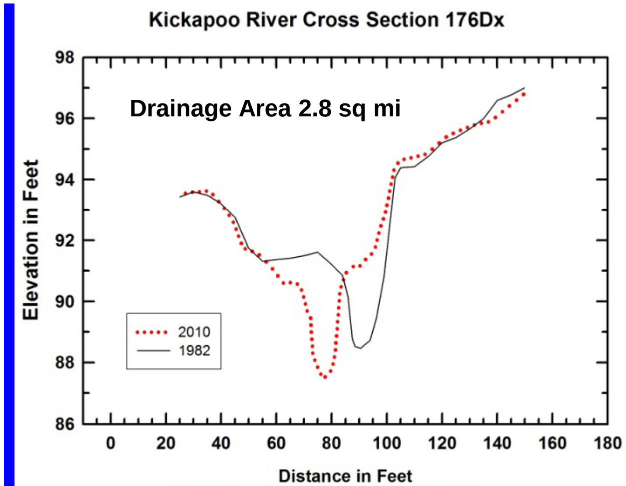


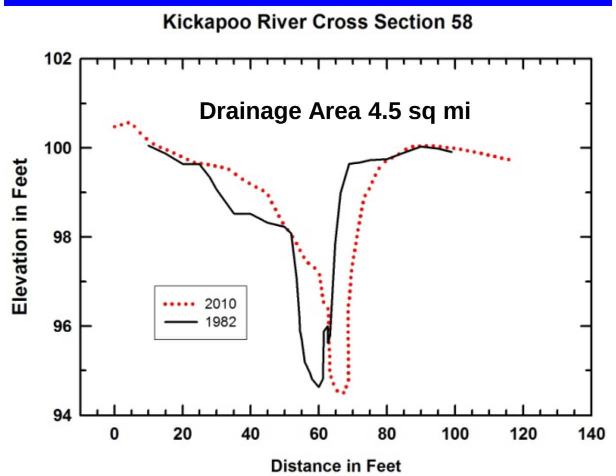


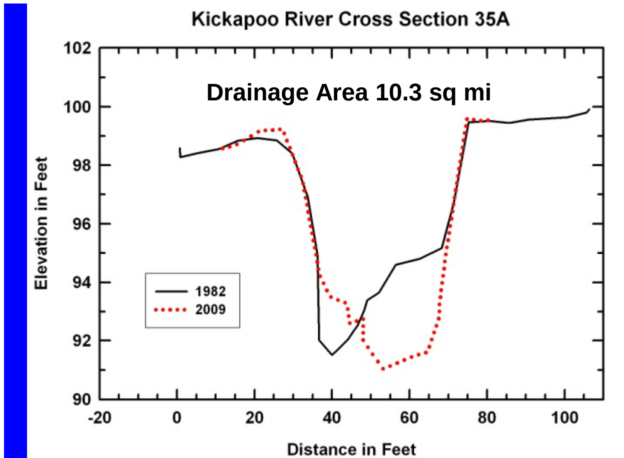
(Data Source:
Knox & Fitzpatrick, in progress)

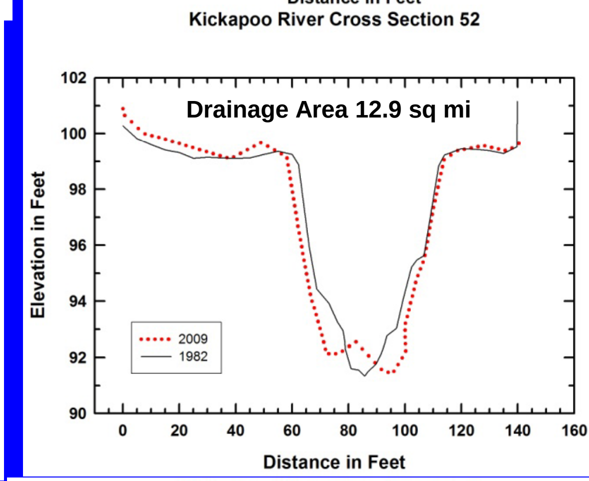

Kickapoo River Cross Section 56A
Drainage Area 2.3 sq mi
Elevation in Feet
Distance in Feet
1982
1978
2009

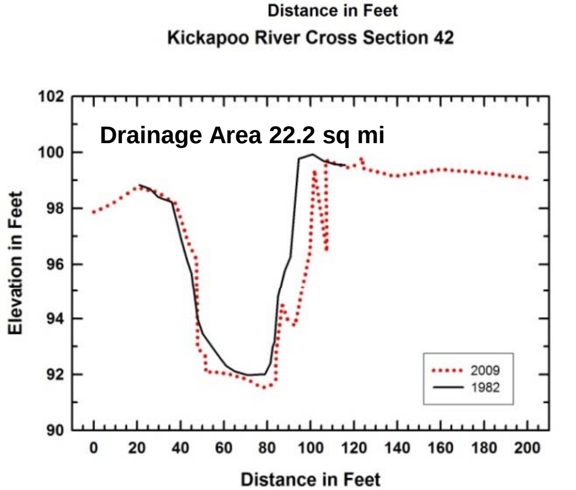

Kickapoo River Cross Section 60
Drainage Area 2.6 sq mi
Elevation in Feet
Distance in Feet
2010
1982

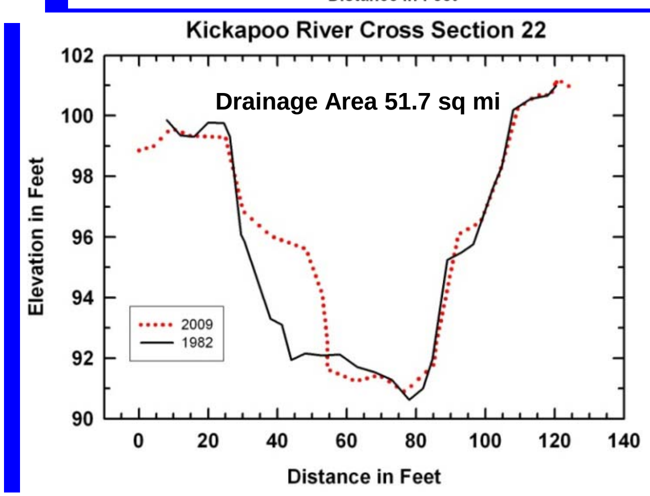

Kickapoo River Cross Section 176Dx
Drainage Area 2.8 sq mi
Elevation in Feet
Distance in Feet
2010
1982

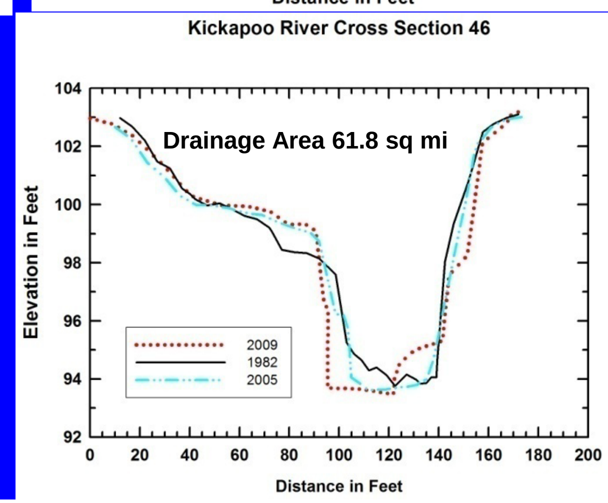

Kickapoo River Cross Section 58
Drainage Area 4.5 sq mi
Elevation in Feet
Distance in Feet
2010
1982

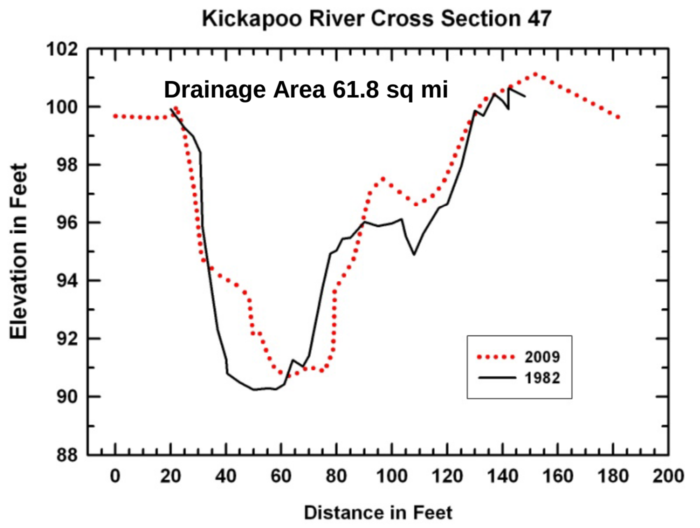

Kickapoo River Cross Section 35A
Drainage Area 10.3 sq mi
Elevation in Feet
Distance in Feet
1982
2009

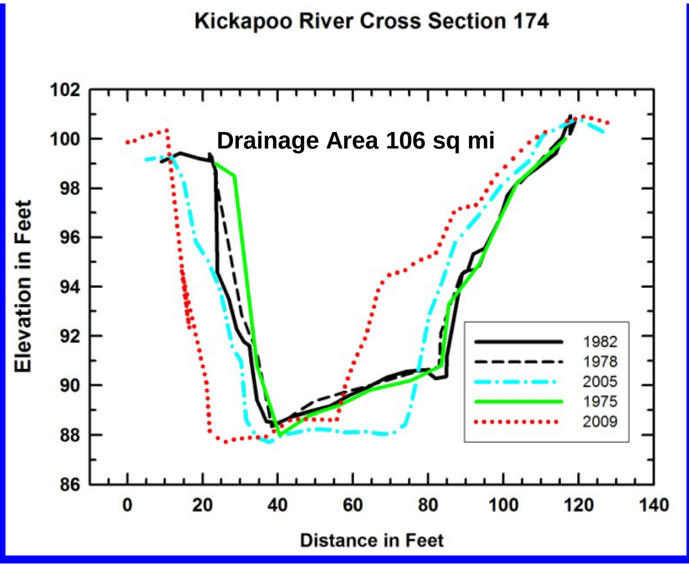

Kickapoo River Cross Section 52
Drainage Area 12.9 sq mi
Elevation in Feet
Distance in Feet
2009
1982

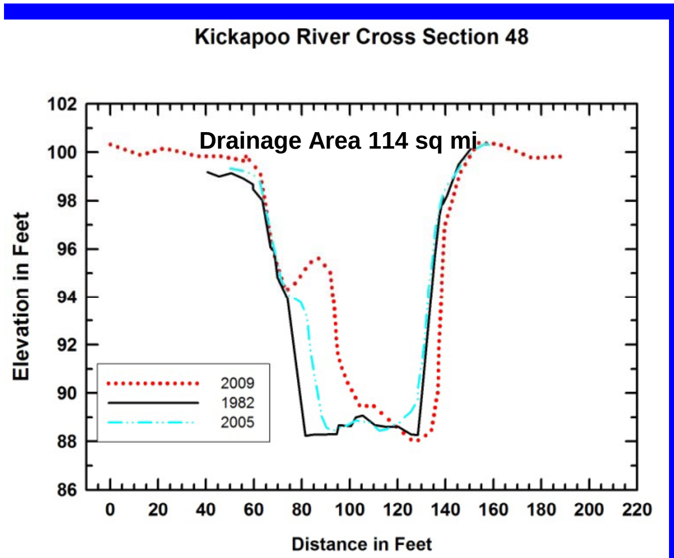

Kickapoo River Cross Section 42
Drainage Area 22.2 sq mi
Elevation in Feet
Distance in Feet
2009
1982

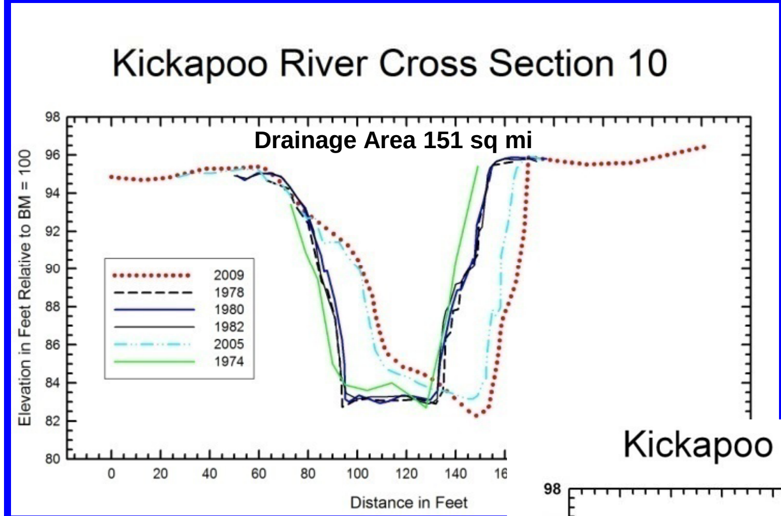

Kickapoo River Cross Section 22
Drainage Area 51.7 sq mi
Elevation in Feet
Distance in Feet
2009
1982

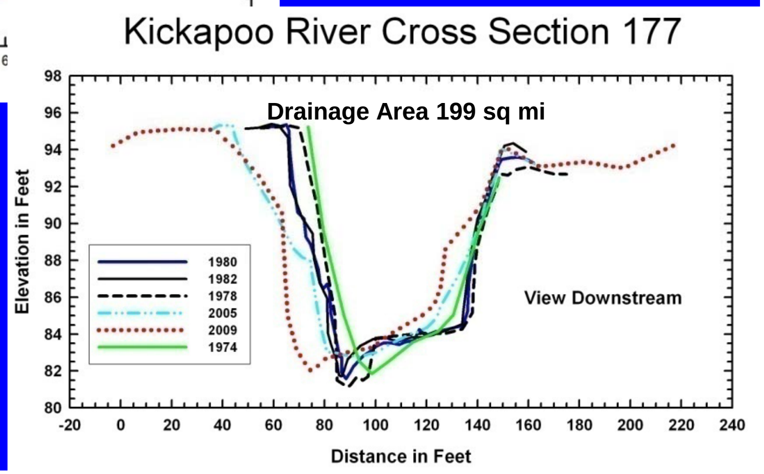

Kickapoo River Cross Section 46
Drainage Area 61.8 sq mi
Elevation in Feet
Distance in Feet
2009
1982
2005

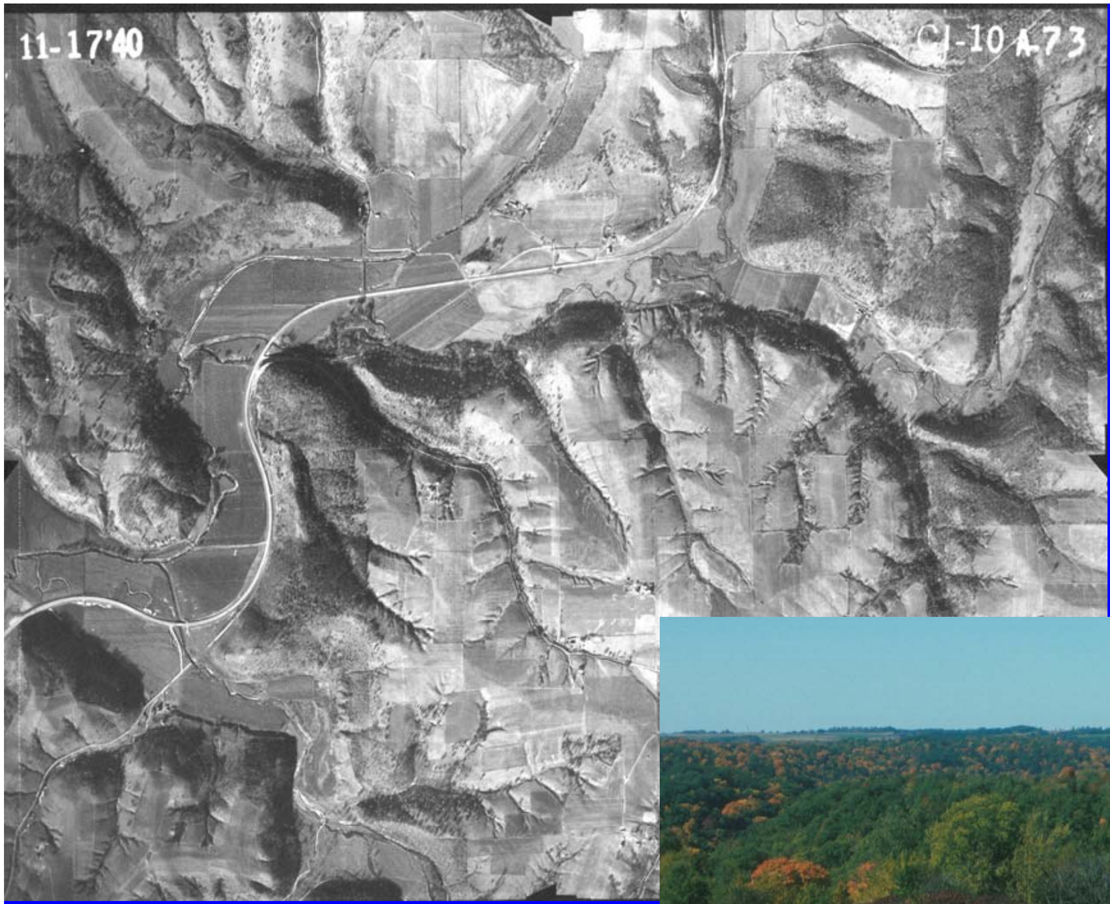

Kickapoo River Cross Section 47
Drainage Area 61.8 sq mi
Elevation in Feet
Distance in Feet
102
100
98
96
94
92
90
88
0
20
40
60
80
100
120
140
160
180
200
2009
1982


Kickapoo River Cross Section 174
Drainage Area 106 sq mi
Elevation in Feet
Distance in Feet
102
100
98
96
94
92
90
88
86
0
20
40
60
80
100
120
140
1982
1978
2005
1975
2009


Kickapoo River Cross Section 48
Drainage Area 114 sq mi
Elevation in Feet
Distance in Feet
102
100
98
96
94
92
90
88
86
0
20
40
60
80
100
120
140
160
180
200
220
2009
1982
2005


Kickapoo River Cross Section 10
Drainage Area 151 sq mi
Elevation in Feet Relative to BM = 100
Distance in Feet
98
96
94
92
90
88
86
84
82
80
0
20
40
60
80
100
120
140
16
2009
1978
1980
1982
2005
1974


Kickapoo River Cross Section 177
Drainage Area 199 sq mi
Elevation in Feet
Distance in Feet
View Downstream
98
96
94
92
90
88
86
84
82
80
-20
0
20
40
60
80
100
120
140
160
180
200
220
240
1980
1982
1978
2005
2009
1974



Poor Land Conservation Was Common Until the Mid- and Late 1940s for Much of the Driftless Area and Adjacent Areas.

Contour Strip Cropping and Other Conservation Measures Were Promoted and Practiced Beginning in the Late 1940s and Early 1950s.

Photo: J.C. Knox

Figure 5

Photos taken on June 12, 2001, of (a) conventional tillage and (b) no-tillage plots during a light-intensity rain and immediately after 38 mm of rainfall.

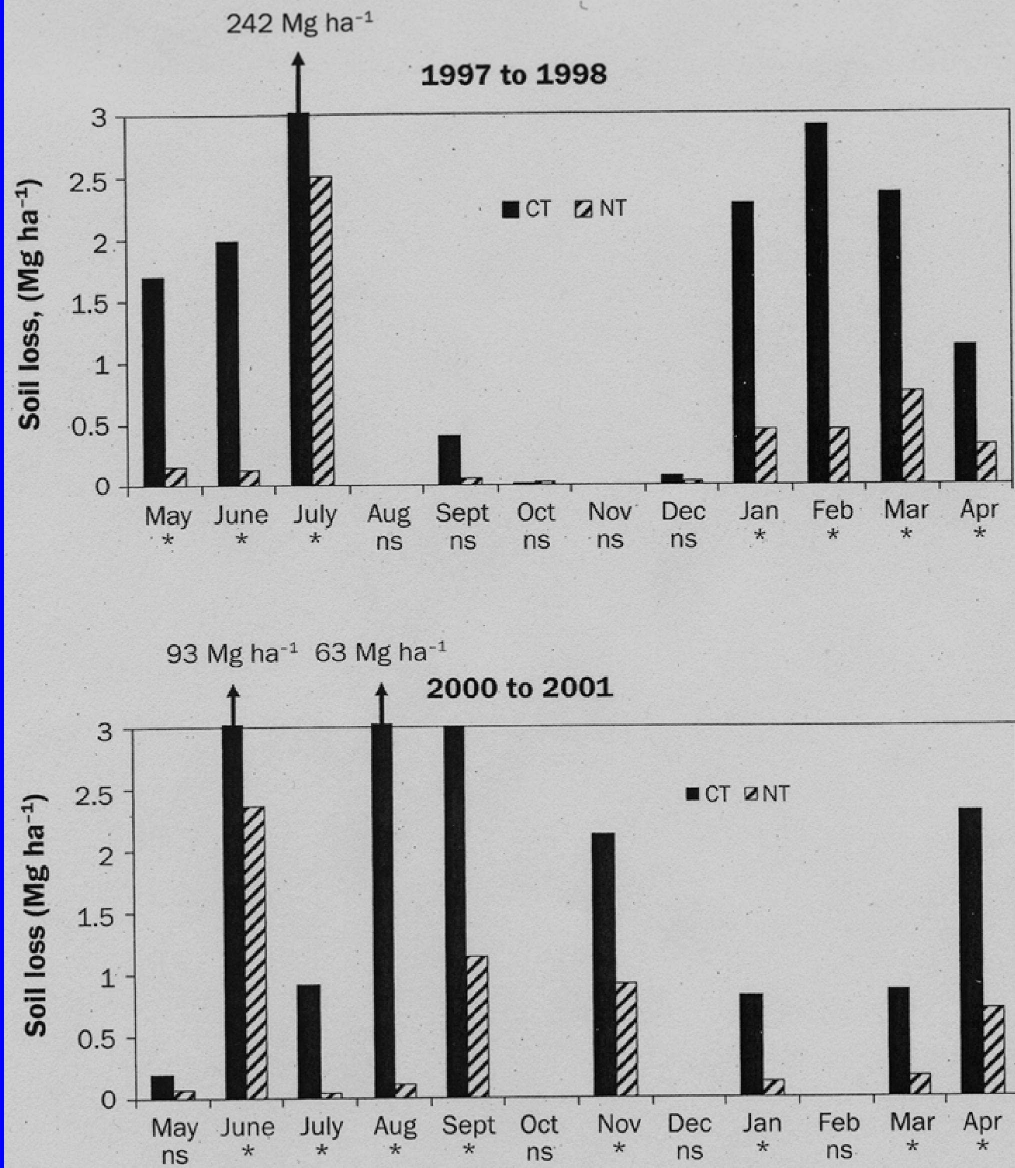
(a)

(b)

Notes: The conventional tillage photo shows an almost completely sealed soil surface, the occurrence of runoff (see free water on the soil surface), and zones with washed sediment in wheel-traffic areas. The no-tillage photo shows a soil surface almost entirely covered by crop residue and no evidence of wash or runoff.

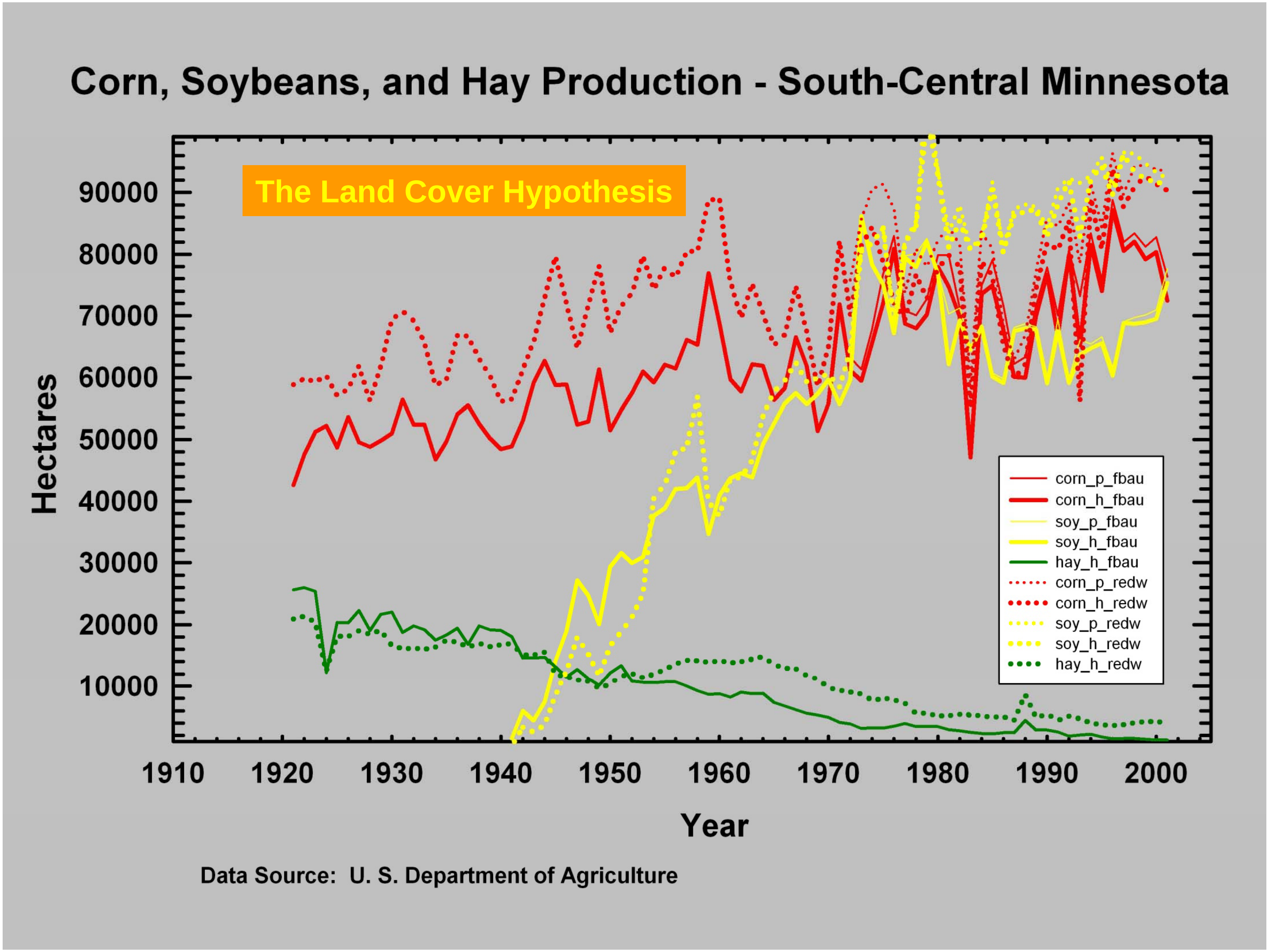
Figure 4

Monthly soil loss totals in conventional tillage (CT) and no tillage (NT) treatments during the 1997 to 1998 and 2000 to 2001 study years.

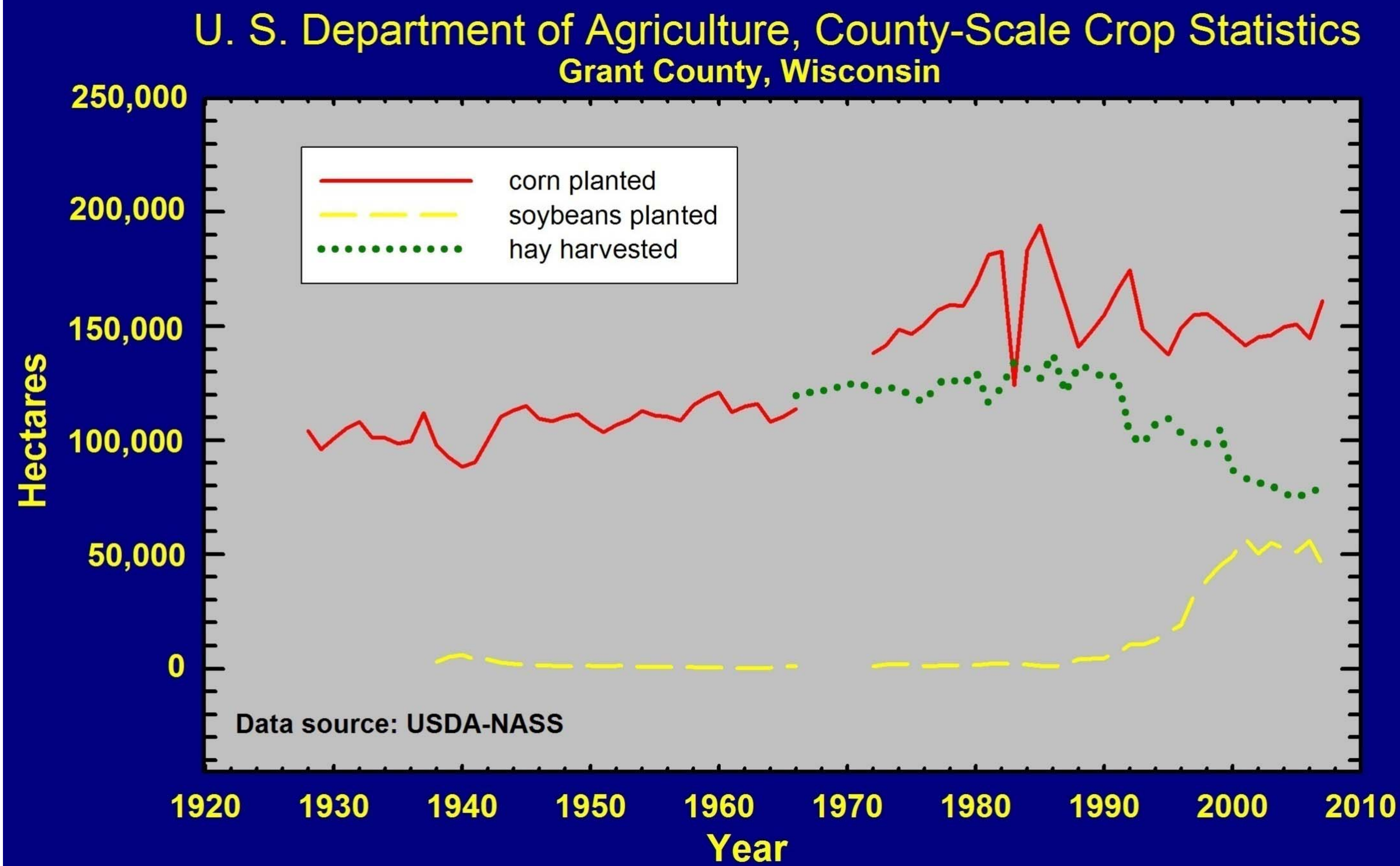


Note: For each month, a significant difference (p = 0.0500) between CT and NT treatment means is denoted as "*" while non-significance is indicated as "ns."

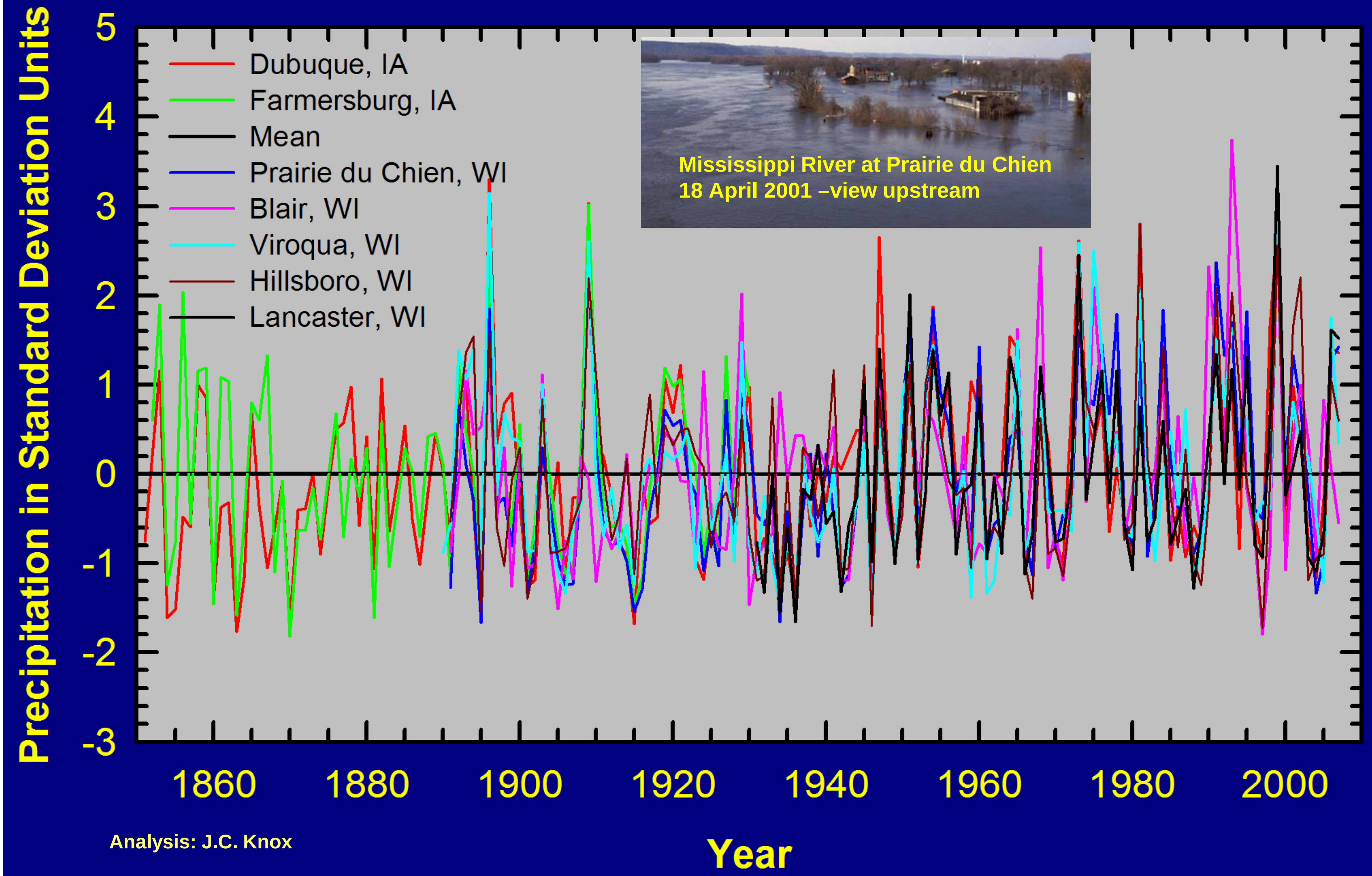
Source: Raczkowski et al., 2009, Jour. Soil & Water Cons., v. 64.


Corn, Soybeans, and Hay Production - South-Central Minnesota
The Land Cover Hypothesis
Hectares
90000
80000
70000
60000
50000
40000
30000
20000
10000
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
Year
corn_p_fbau
corn_h_fbau
soy_p_fbau
soy_h_fbau
hay_h_fbau
corn_p_redw
corn_h_redw
soy_p_redw
soy_h_redw
hay_h_redw
Data Source: U. S. Department of Agriculture

Land Use Change in SW Wisconsin's Hilly, Driftless Area, Grant County



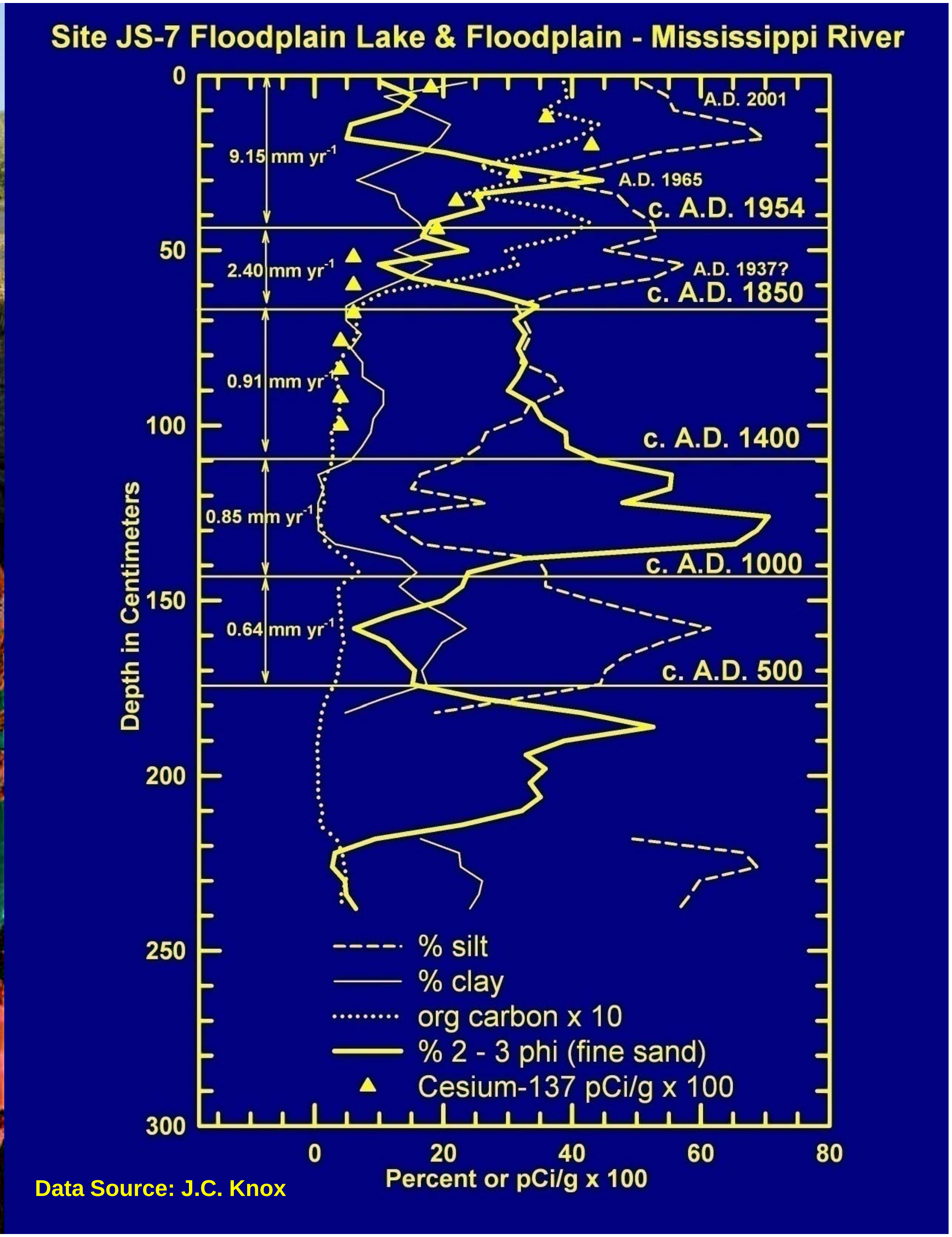
April Precipitation - Upper Mississippi Valley Stations



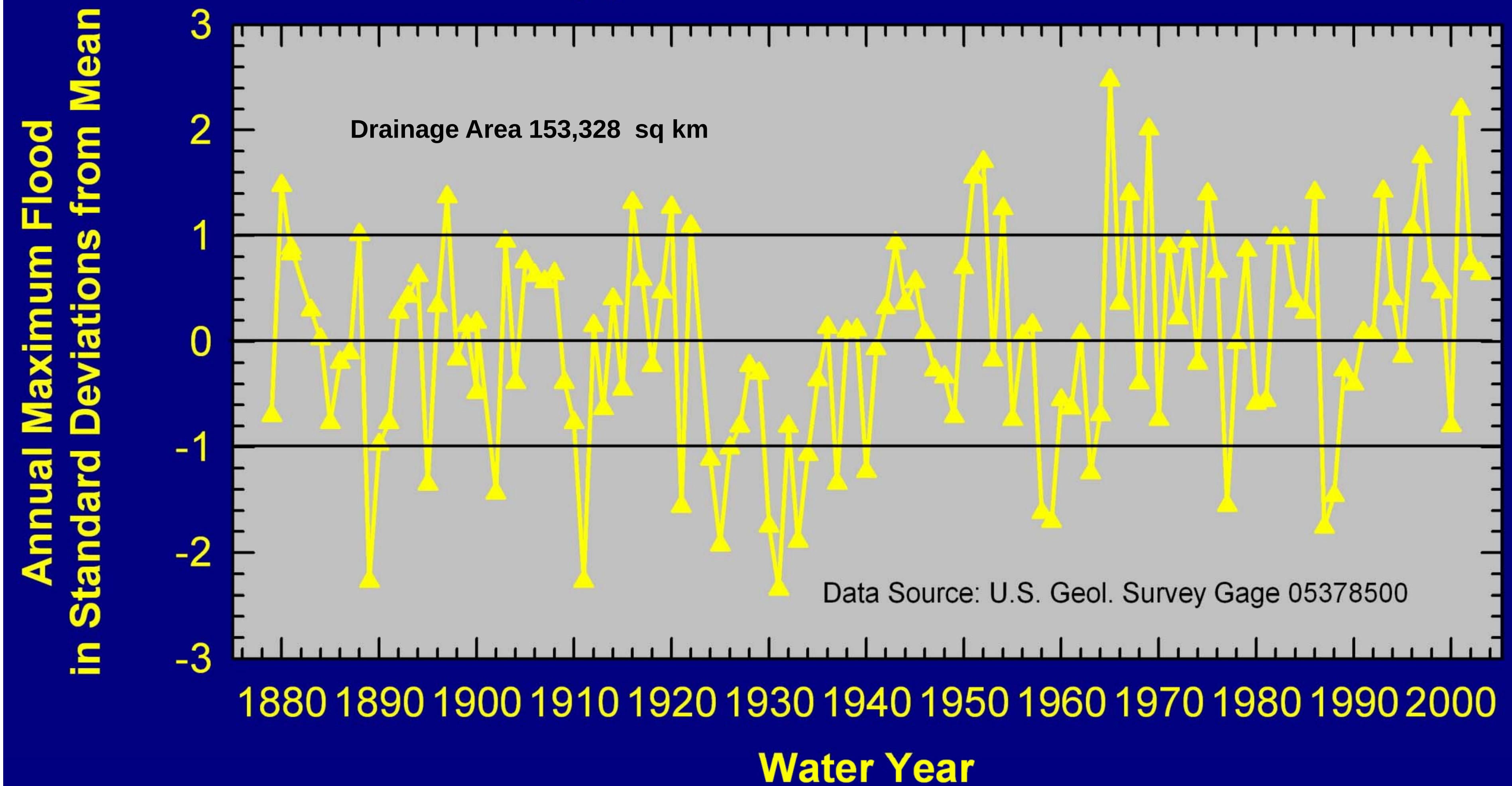
Analysis: J.C. Knox


Floodplain Lake
Site JS-7


Site JS-7
Mississippi R

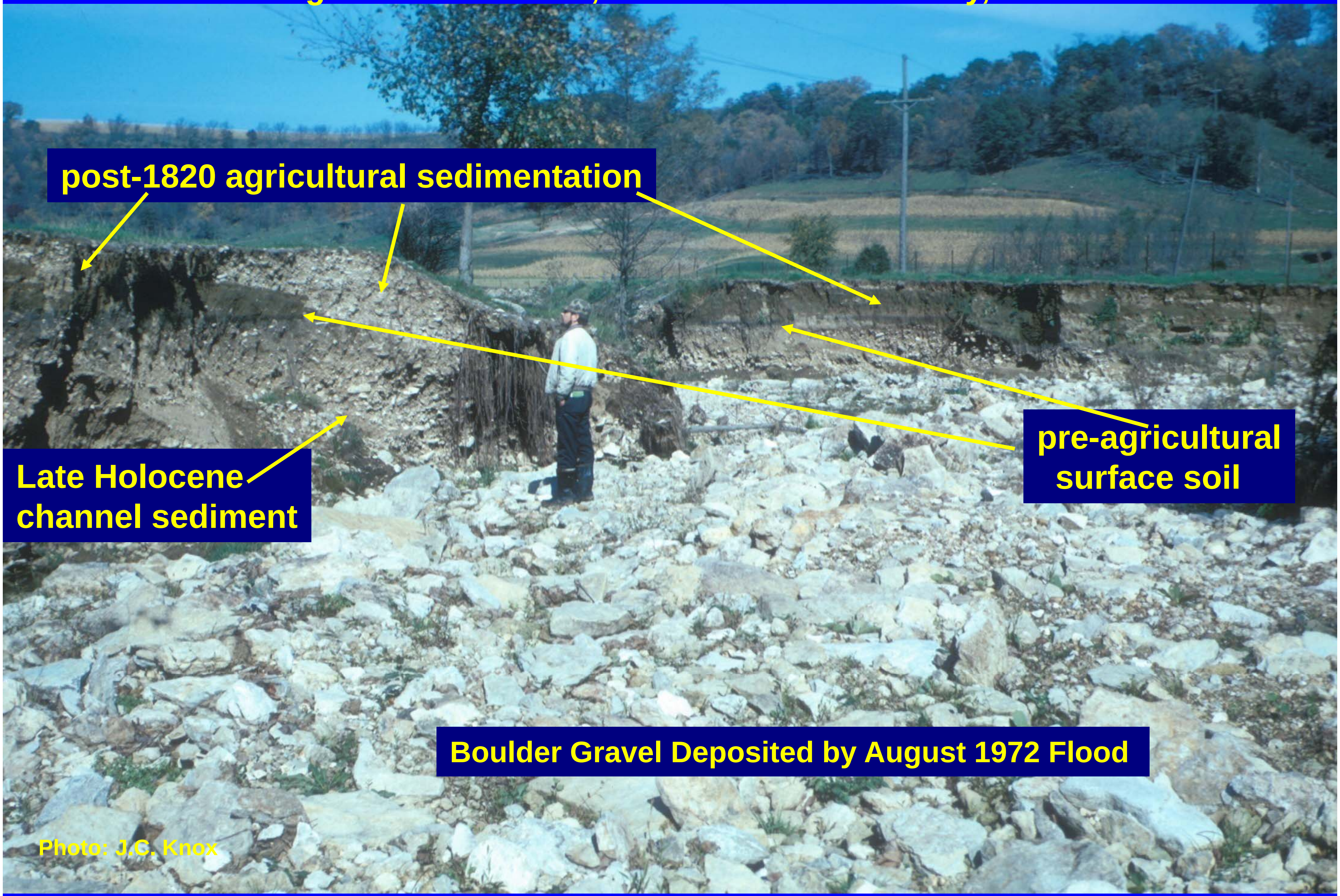

Site JS-7 Floodplain Lake & Floodplain - Mississippi River
Depth in Centimeters
Percent or pCi/g x 100
A.D. 2001
9.15 mm yr-1
A.D. 1965
c. A.D. 1954
2.40 mm yr-1
A.D. 1937?
c. A.D. 1850
0.91 mm yr-1
c. A.D. 1400
0.85 mm yr-1
c. A.D. 1000
0.64 mm yr-1
c. A.D. 500
% silt
% clay
org carbon x 10
% 2 - 3 phi (fine sand)
Cesium-137 pCi/g x 100
Data Source: J.C. Knox

Mississippi River at Winona, Minnesota

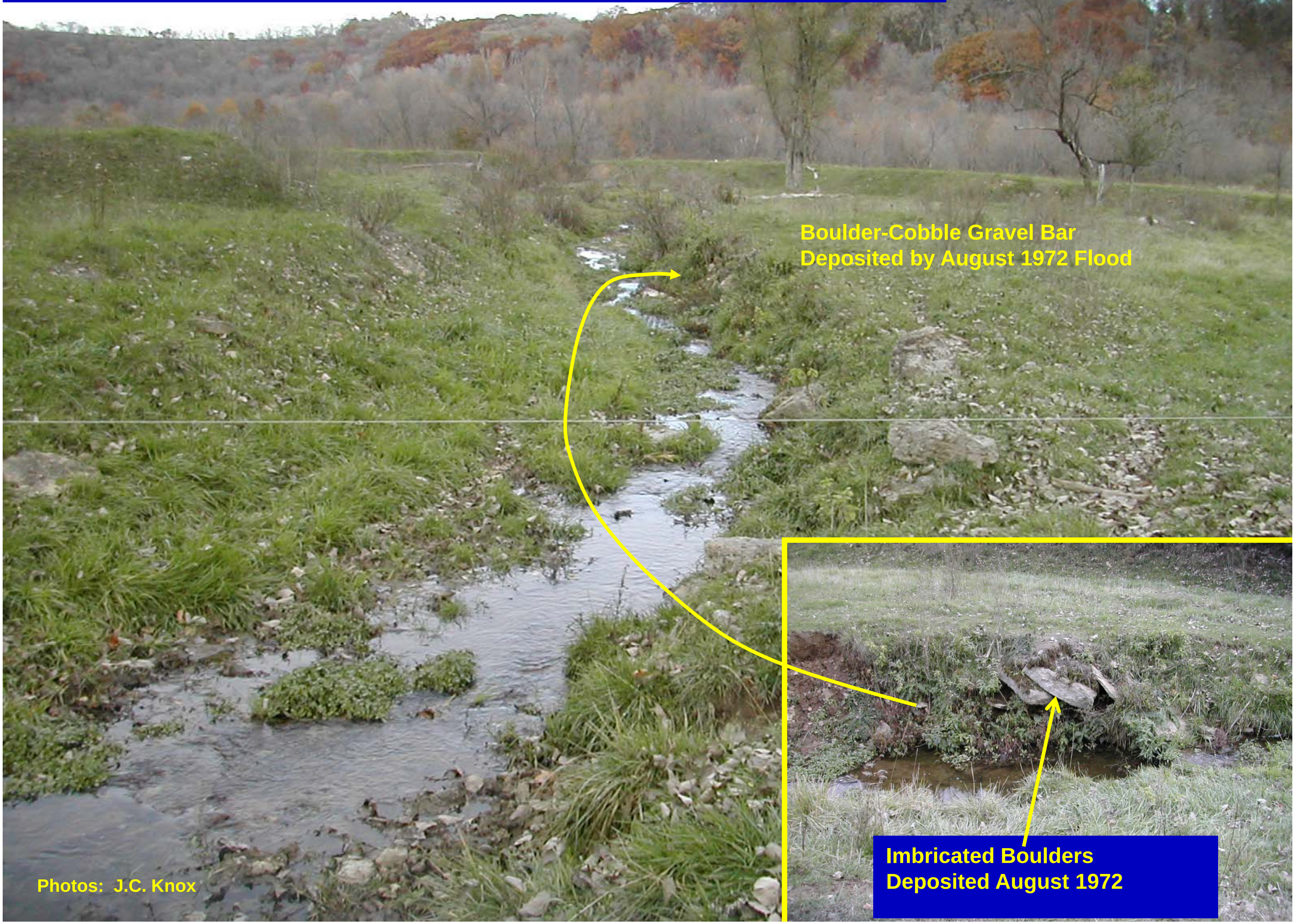


Analysis: J.C. Knox

Historical Change in Flood Power, L. Platte River Tributary, SW Wisconsin



McAdam Branch Tributary, Grant County, Wisconsin, October 2003



Conclusions Re: Historical Changes in Erosion and Sedimentation

1. Human imprint on floodplain morphology and sedimentation during last ~200 years greater than any influences of natural environmental changes of last 10,000 years;

2. River system responses to changes in upland watershed runoff and soil erosion reflect both positive and negative feedbacks involving temporal and spatial scales of sensitivity to environmental change; tributaries experiencing net erosion today?

3. Agriculturally accelerated valley-bottom flooding and sedimentation lasted:
   - about 50-70 yrs on valley floors of tributaries 1-10 sq km;
   - an additional 30-50 years on early floodplains of 10-50 sq km drainages;
   - until about 1950 on early floodplains with drainages as large as 150-200 sq km;

   Since 1950, floods smaller than 50-100 yr recurrence frequencies generally do not exceed capacity of historical meander belt for drainages less than 150-200 sq km;

4. Long-term average floodplain sedimentation rates:
   Tributaries: 0.2 mm per year natural vs 2-20 mm per year Euro-American;
   Mississippi: 0.9 mm per year natural vs 5-20 mm per year Euro-American;

5. Large floods are major contributors to alluvial environment erosion and deposition;
   - frequency of large floods on tributaries generally decreased after about 1950, but short-term variability in magnitudes increased since 1988;
   - frequency and magnitudes of large floods generally increased after about 1950 on the upper Mississippi River

6. There is a high probability that high short-term hydrologic variability involving anomalous high frequencies of large floods will continue in the early 21st century.