Modification of Indiana's Hydrologic Cycle

Indiana Watershed Leadership Academy Webinar
April 25, 2012

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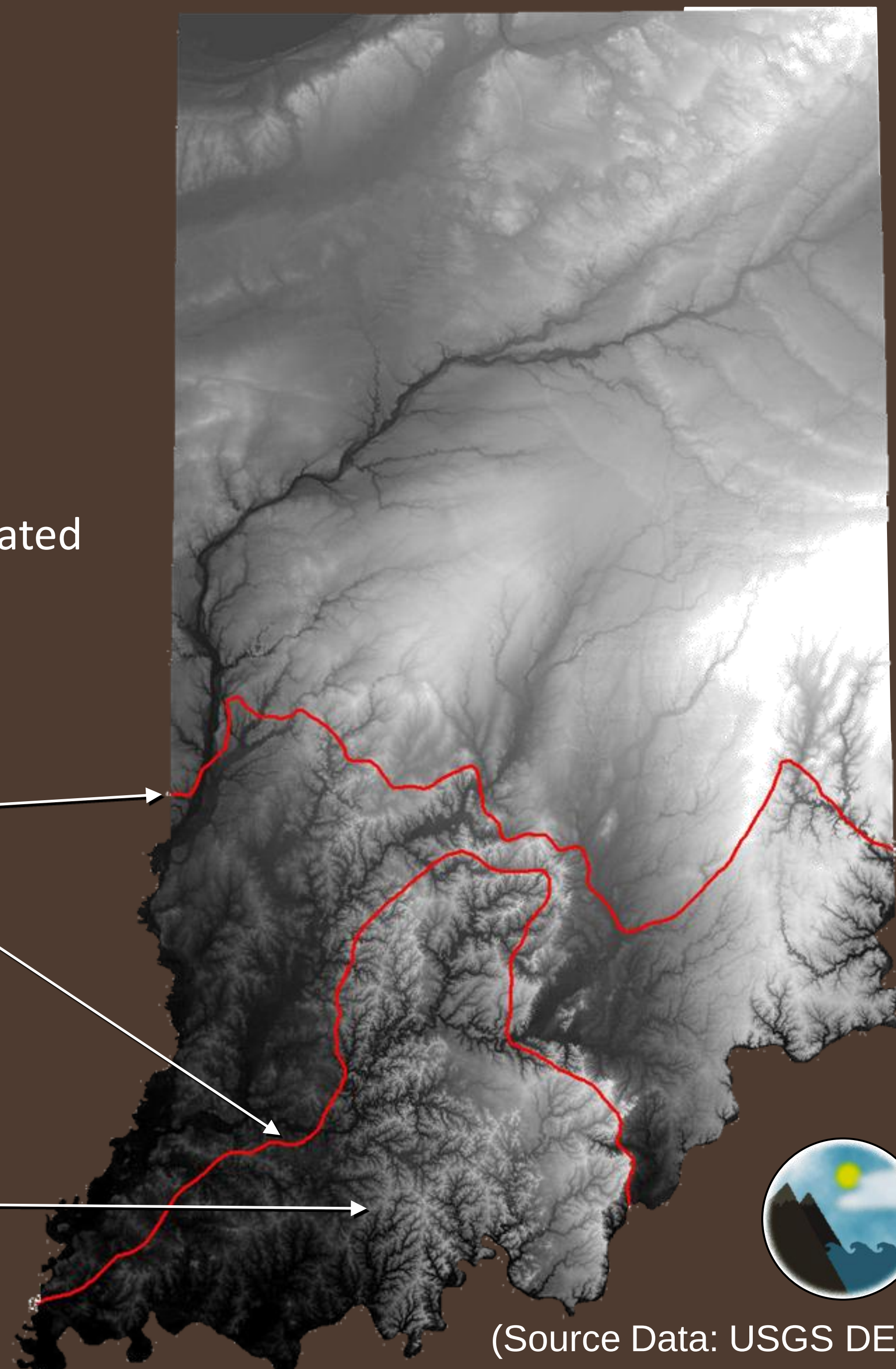
Indiana's Physical Setting

Tipton Till Plain
Recently Deglaciated
(<20,000 yrs)

Glacial
Maximums

Older Glacial Terrain (and
non-glaciated)



(Source Data: USGS DEM)

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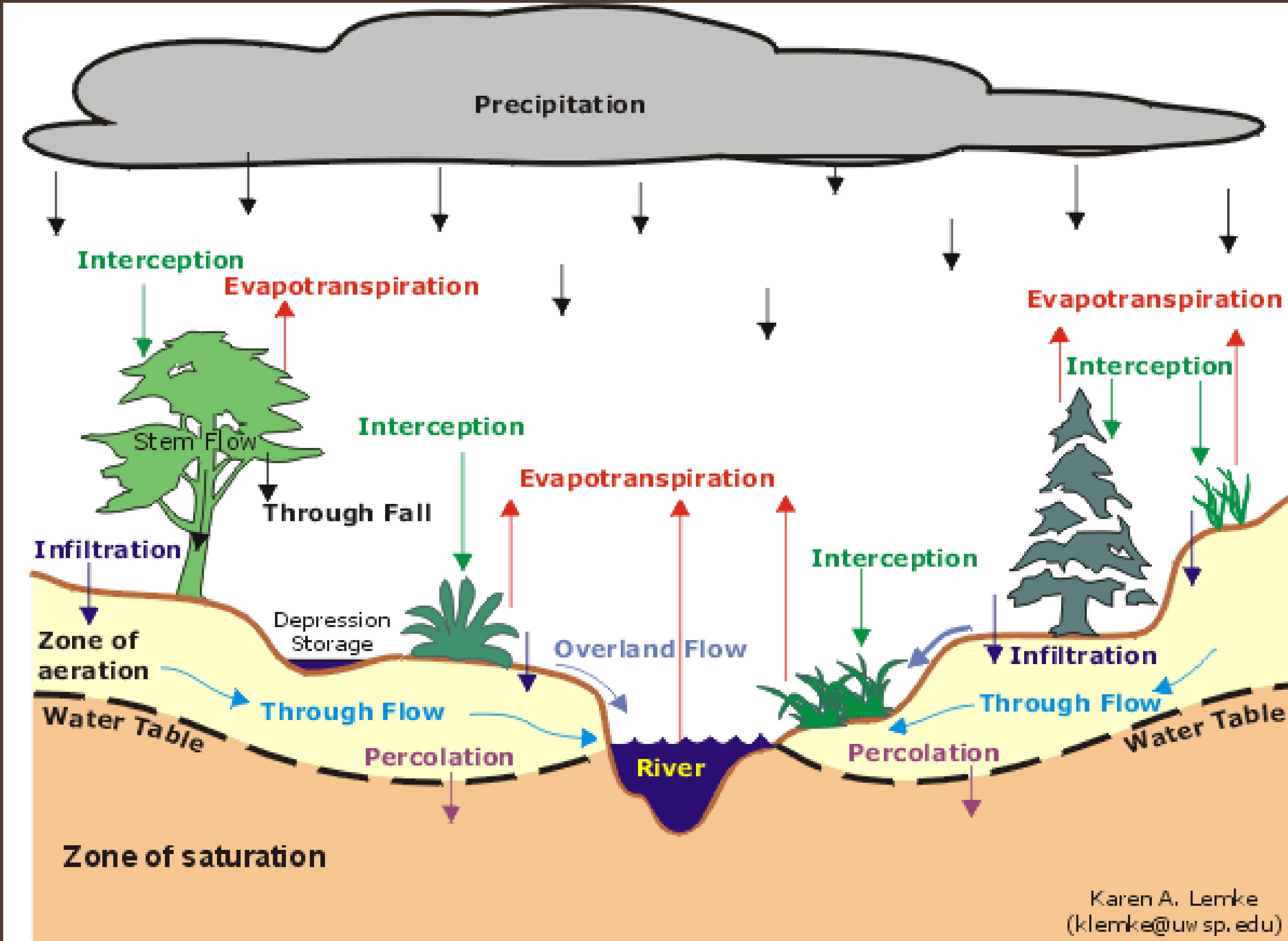


Precipitation
Interception
Evapotranspiration
Stem Flow
Through Fall
Interception
Evapotranspiration
Infiltration
Depression Storage
Zone of aeration
Overland Flow
Through Flow
Water Table
Percolation
River
Interception
Evapotranspiration
Interception
Infiltration
Through Flow
Water Table
Percolation
Zone of saturation
Karen A. Lemke
(klemke@uwsp.edu)

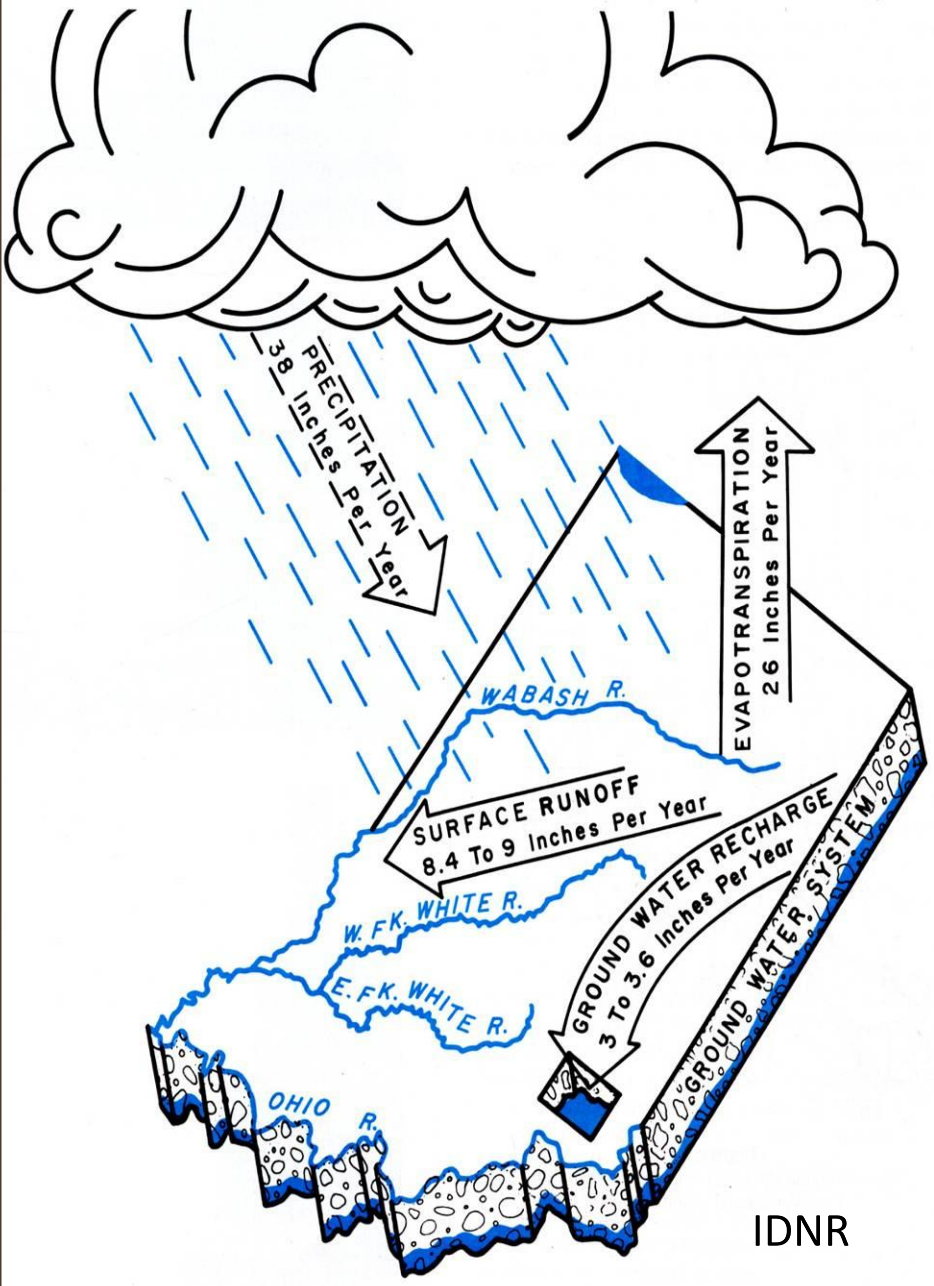
Indiana's Hydrologic Cycle

P: 38 in/yr

E / T: 26 in/yr

I : 3.0 - 3.6 in/yr

R: 8.4 - 9.0 in/yr



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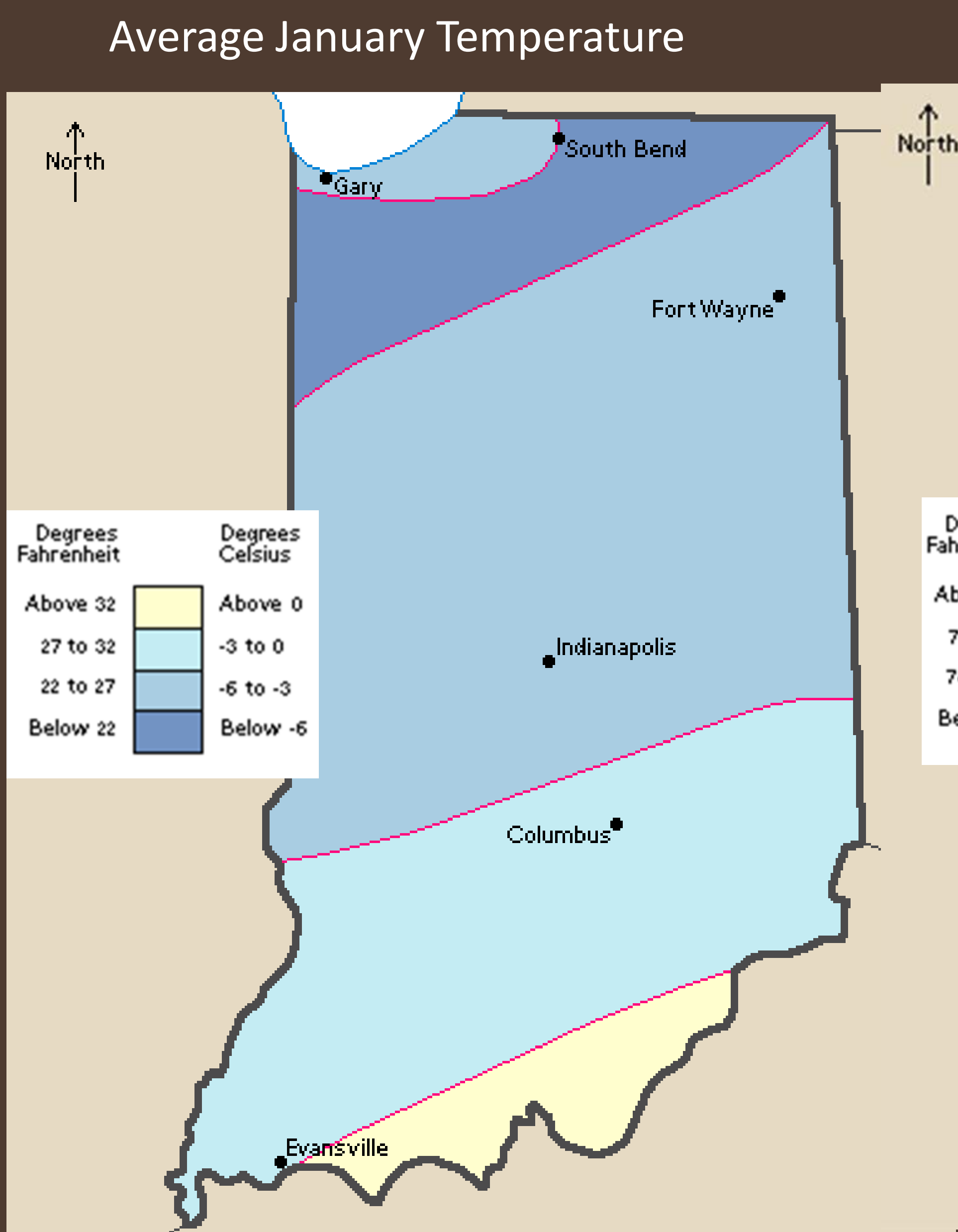
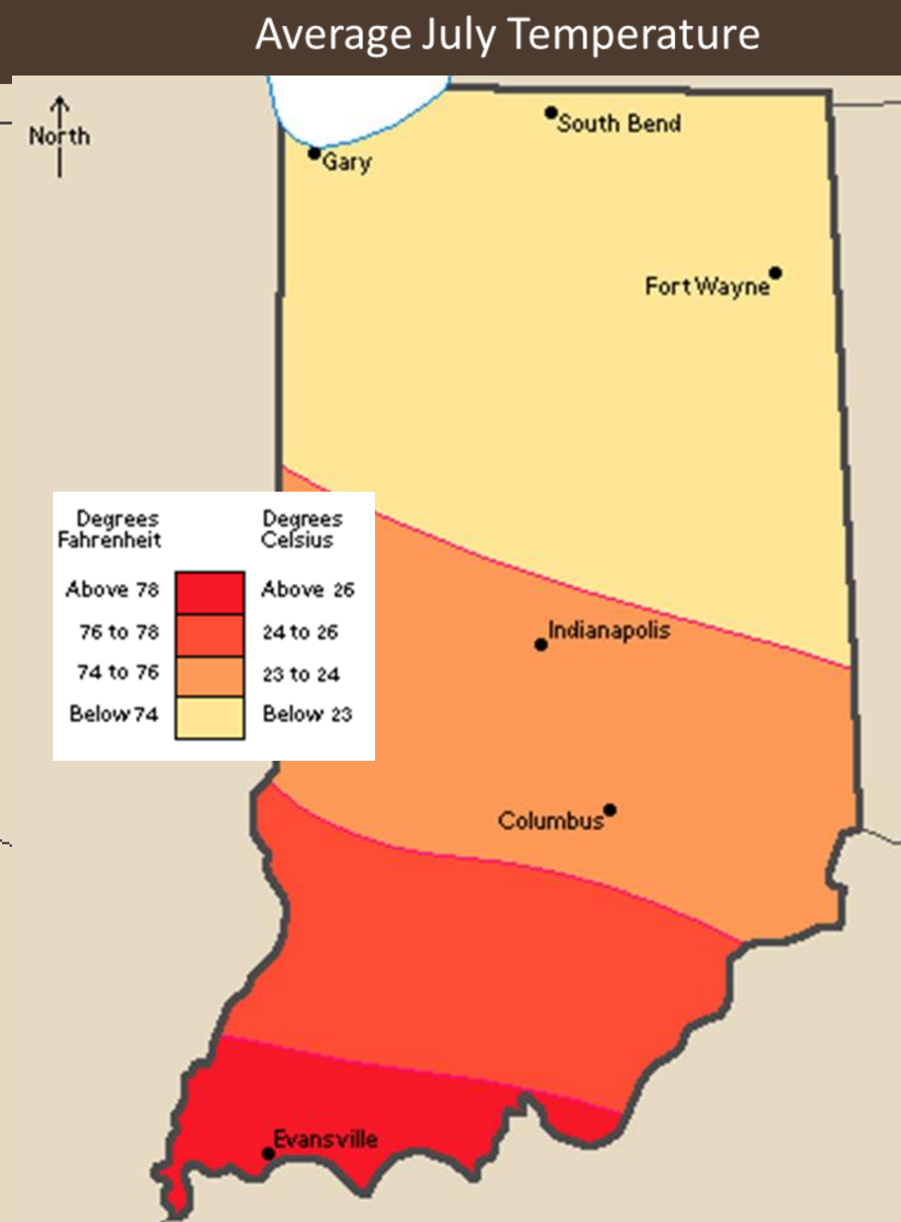
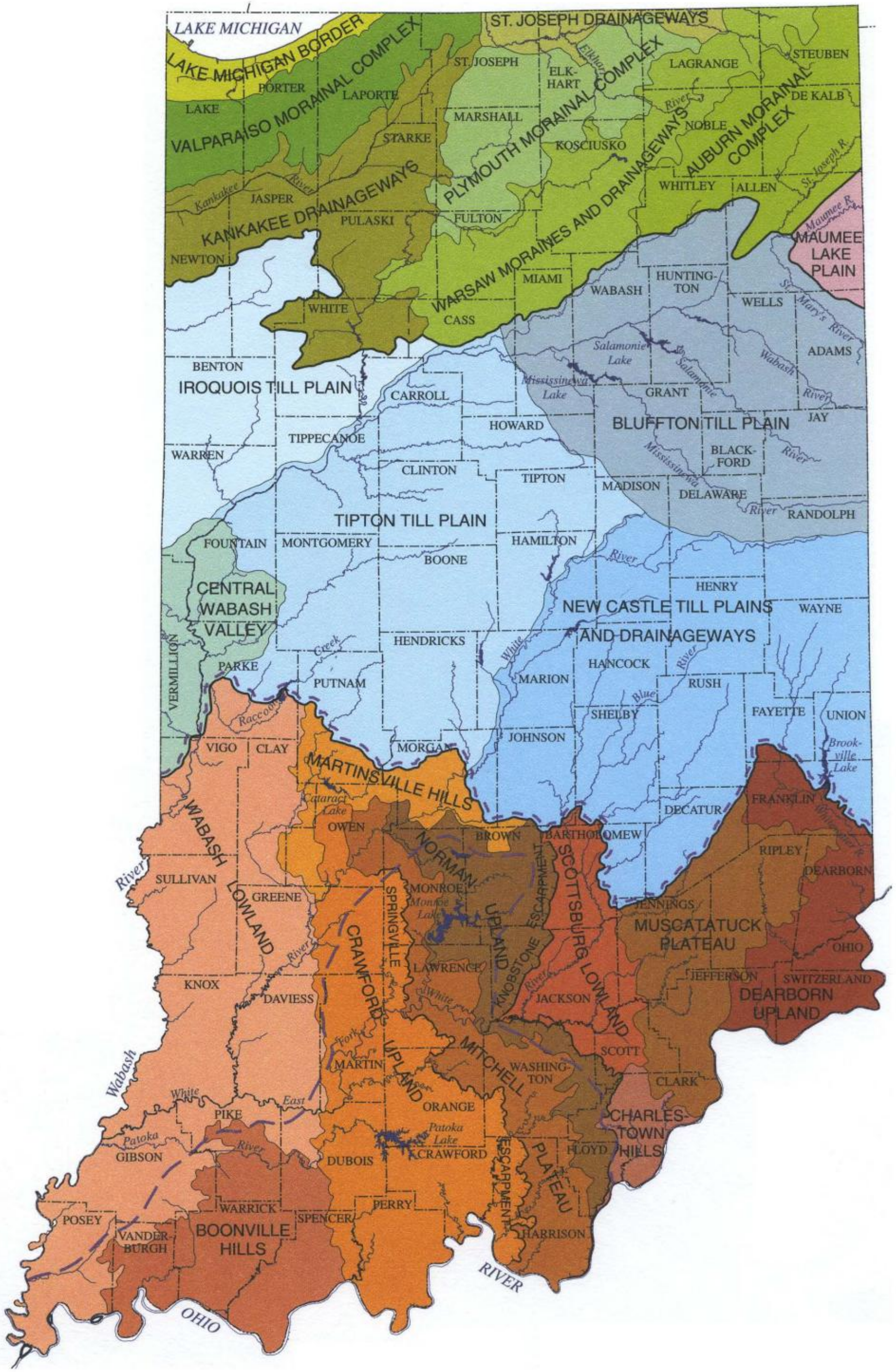




www.worldbook.com



Henry H. Gray, 2001, Map of Indiana Showing Physiographic Divisions, IGS Misc. Map 69

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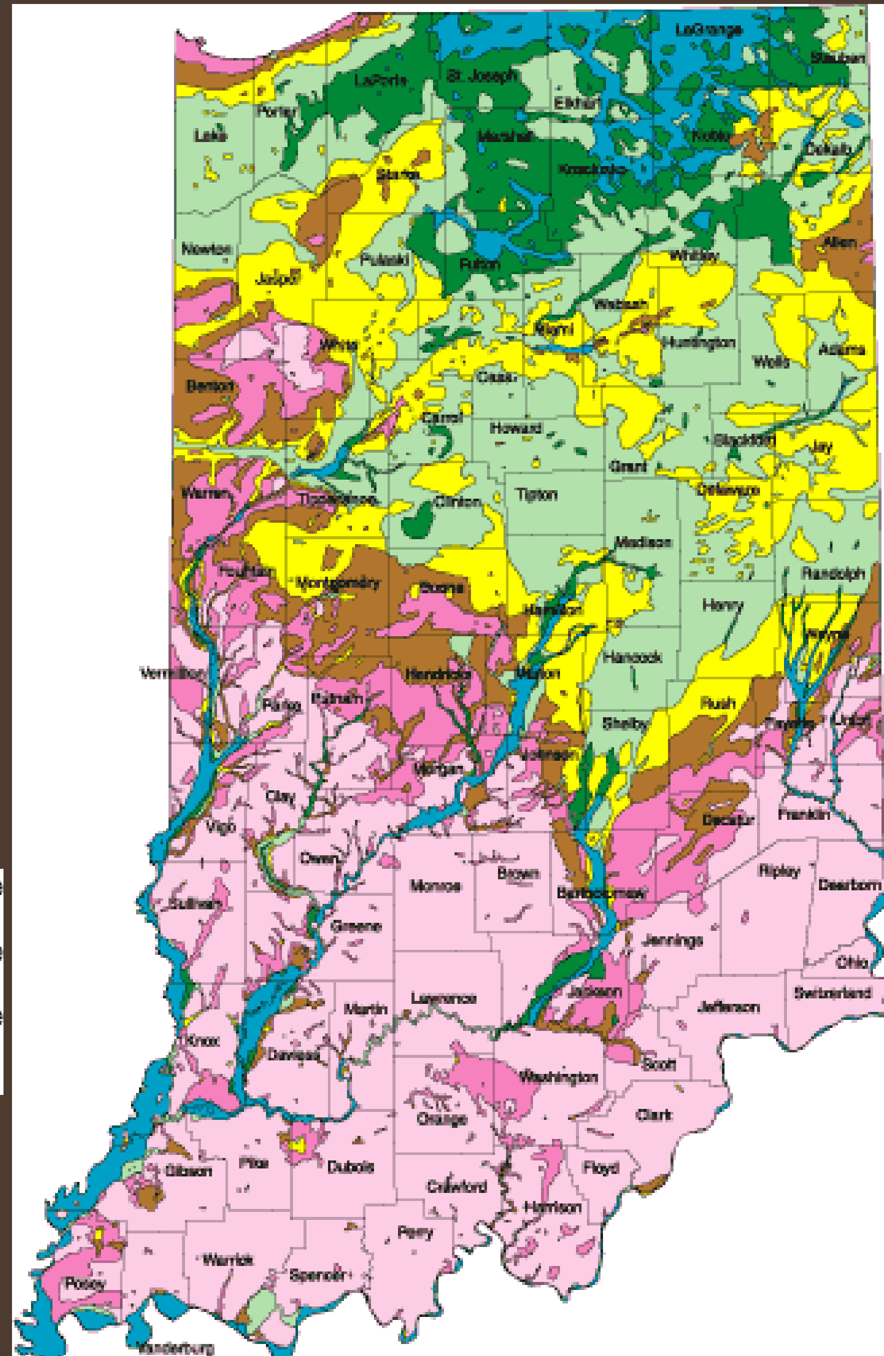
Indiana Ground Water Resources



Legend

10 gallons per minute	200 gallons per minute
50 gallons per minute	400 gallons per minute
100 gallons per minute	600 gallons per minute
> 1000 gallons per minute	

IDNR

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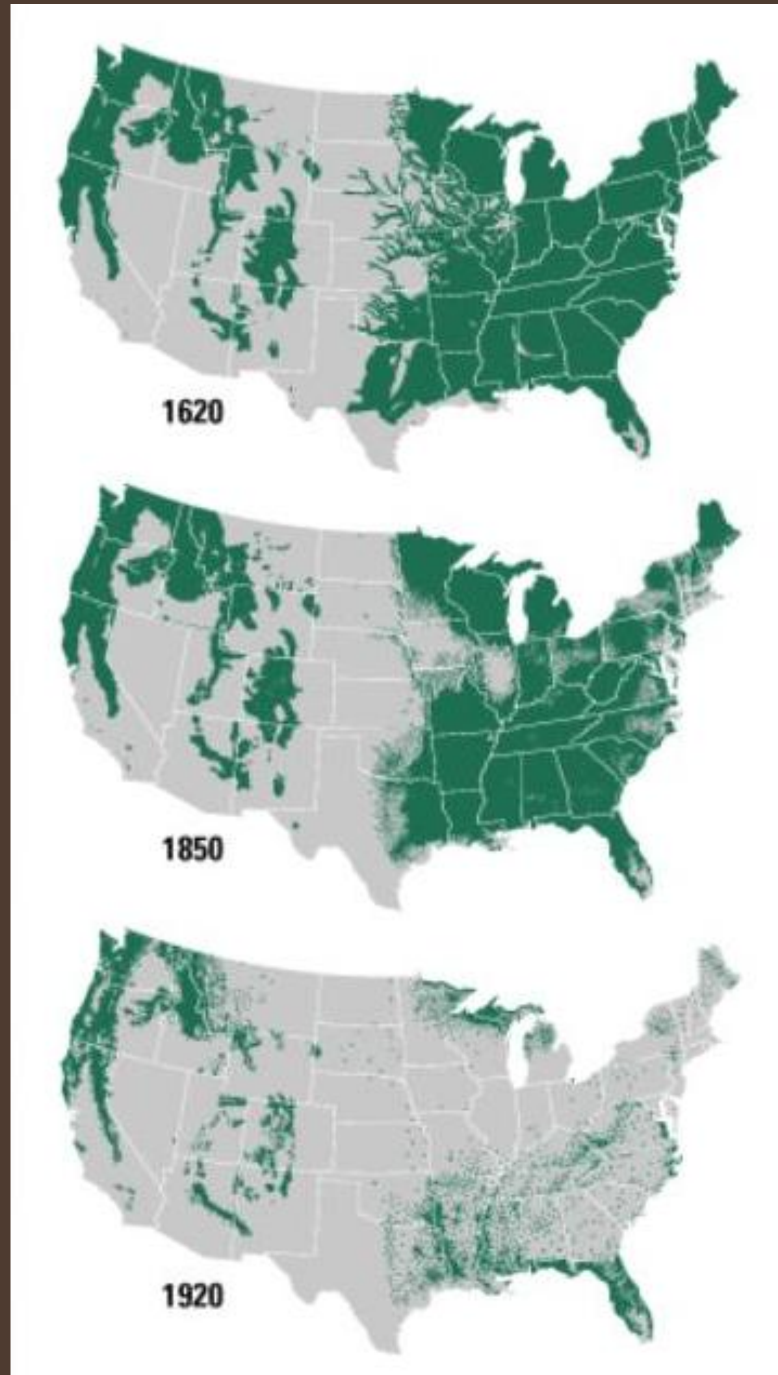
Approximate location of virgin old-growth forest



Meyer, 1995

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“On the Banks of Fall Creek”

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C. Deam, 1922,
Clark State Forest
IDNR

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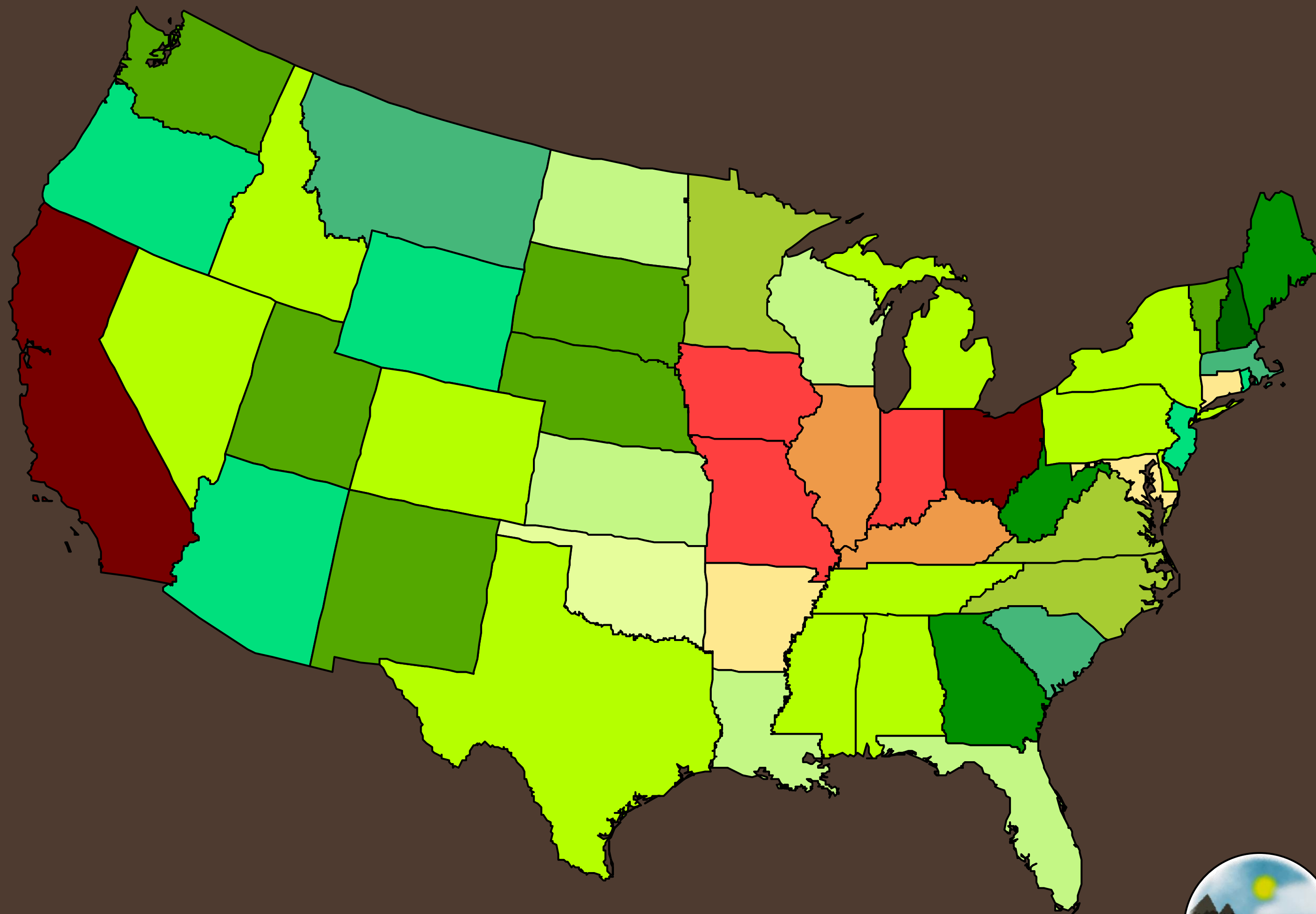
Wetland Loss from Time of European Settlement

Percentage of wetland loss

- 0 - 11
- 12 - 24
- 25 - 29
- 30 - 35
- 36 - 39
- 40 - 45
- 46 - 49
- 50 - 65
- 66 - 69
- 70 - 75
- 76 - 79
- 80 - 85
- 86 - 89
- 90 - 100



Source - U.S. Environmental Protection Agency

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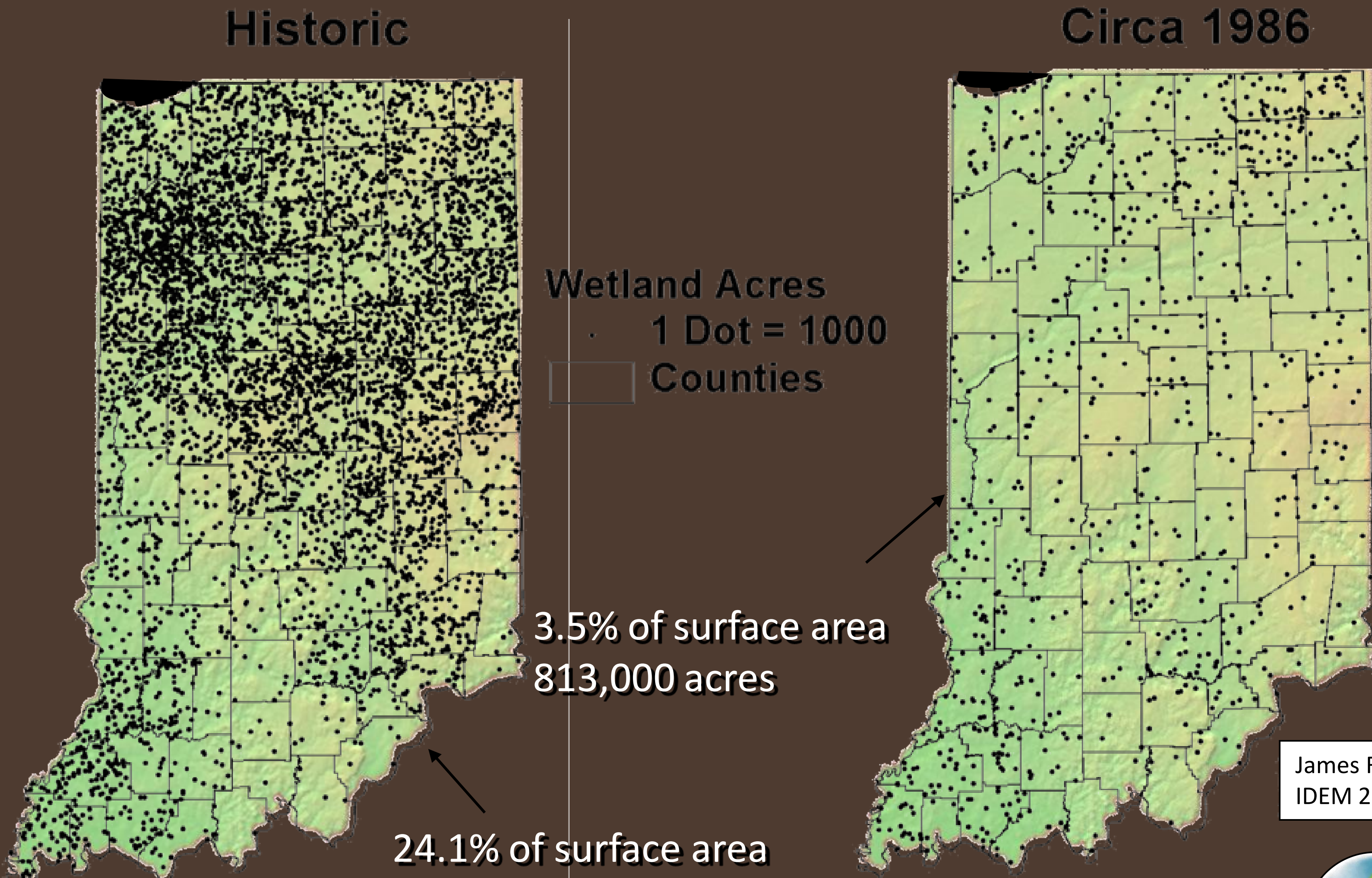
Indiana Wetland Loss



3.5% of surface area
813,000 acres

24.1% of surface area
5.6 million acres

James Robb
IDEM 2002

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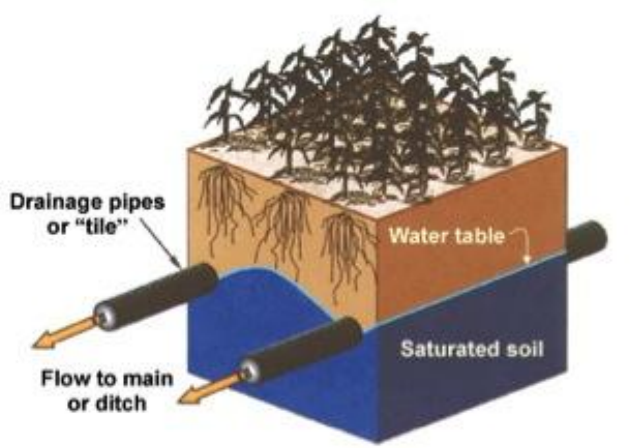
Agricultural Drainage System

- 75-80% of the agricultural areas on the till plain are tile drained
- Tile drains function much like urban storm water drains
  - Effect is the same
    > peak flows,
    < base flow
- Riparian buffer strips are short-circuited by tile drains
- Results in relatively high chemical loading to streams



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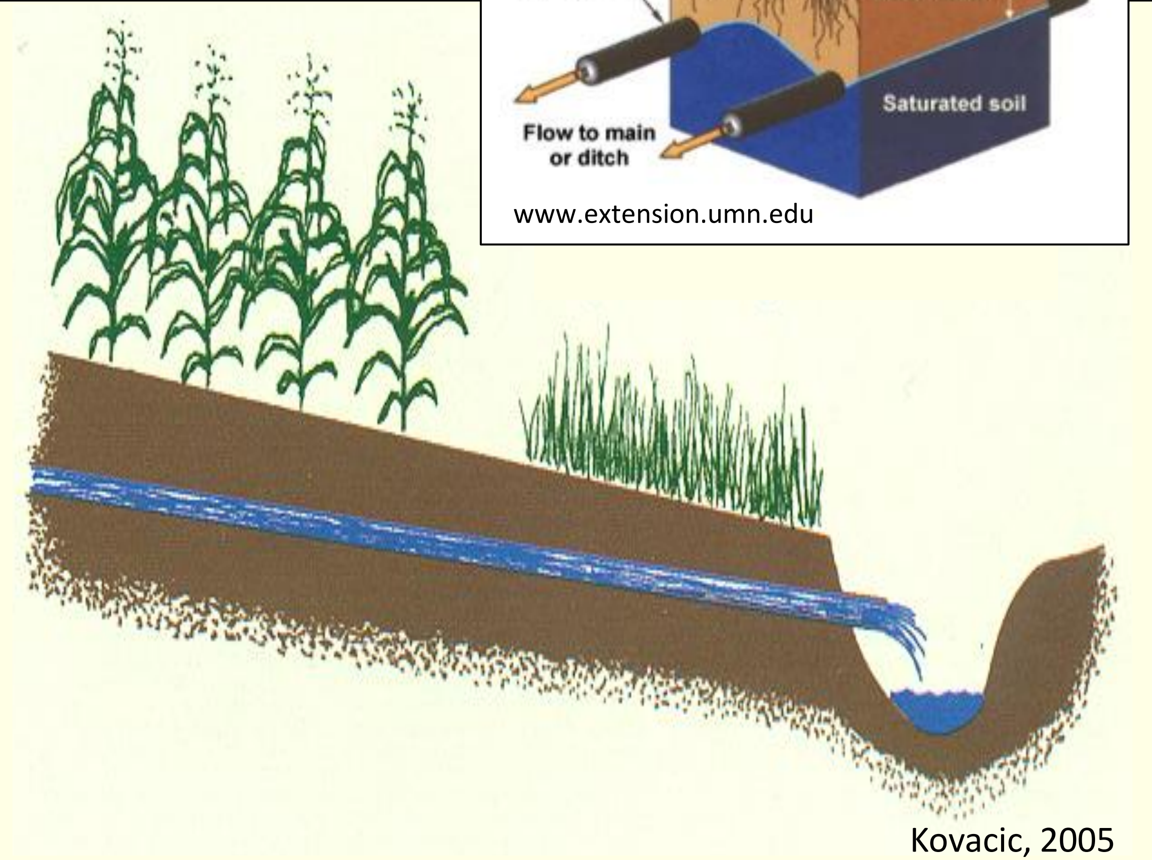
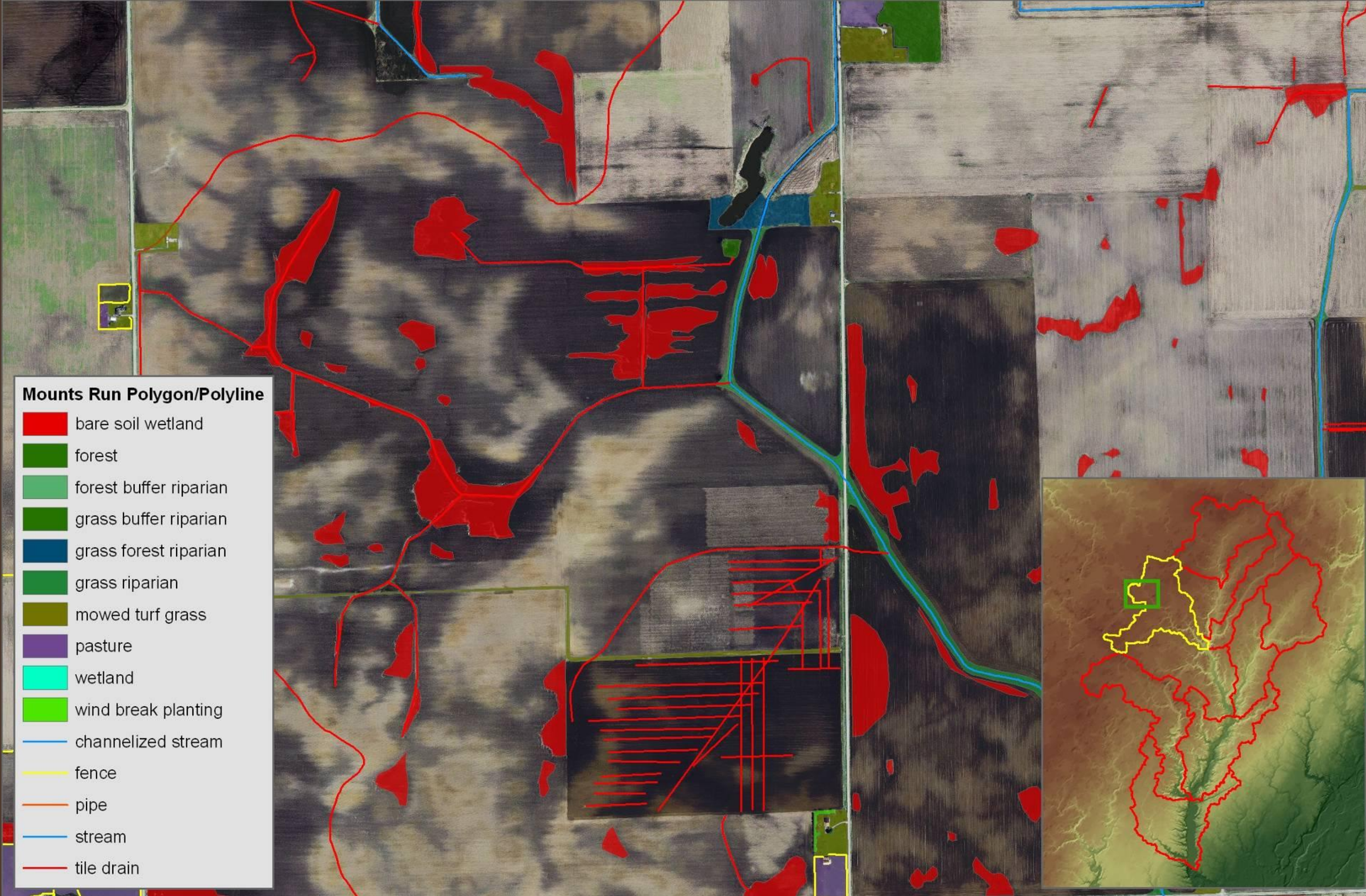

Kovacic, 2005



USDA Conservation Effects Assessment Project (CEAP)
Visual Interpretation Digitizing Example
Upper Mounts Run - ECW

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Department of Earth Sciences ~ IUPUI
www.cees.iupui.edu

Source: 2005 Indiana Orthophotography Project

0 0.25 0.5 1 Kilometers

0 0.125 0.25 0.5 Miles

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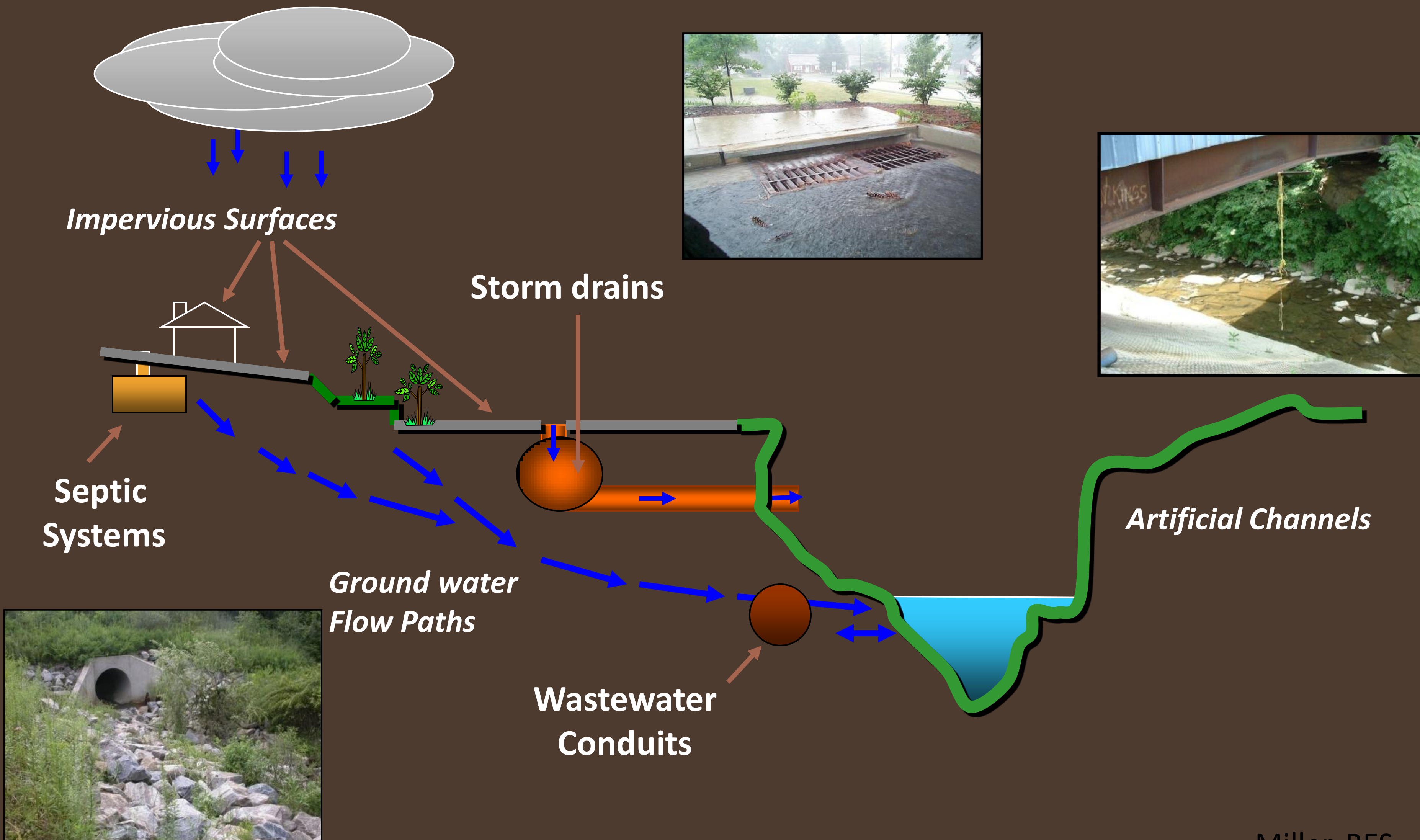
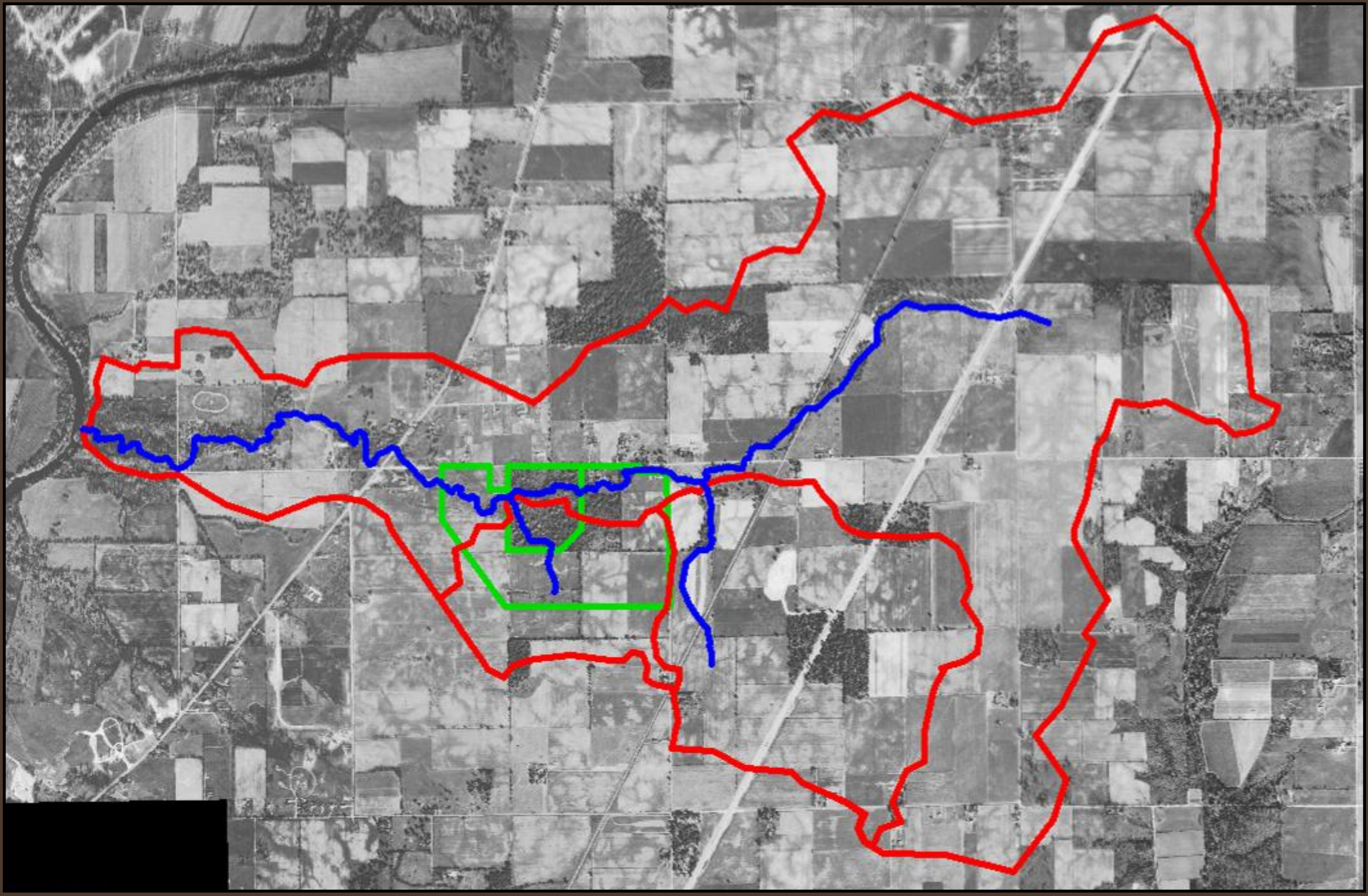
Mount’s Run, Eagle Creek Watershed

The Urban Hydrologic System

infrastructure driven pathways

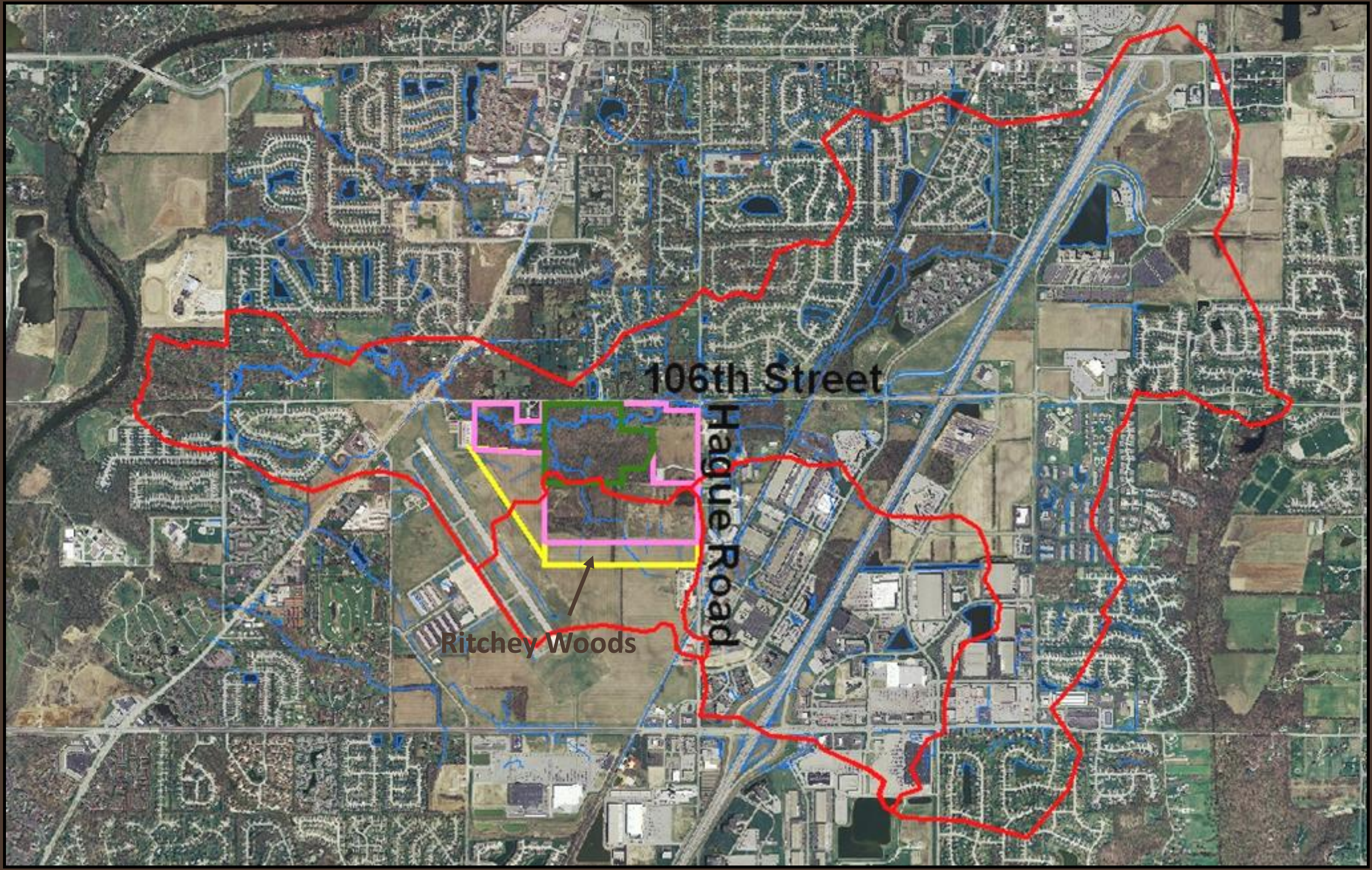


Miller, BES



Hamilton County NRCS, 1956

Historic Land Use, Cheeney Creek Watershed 1956



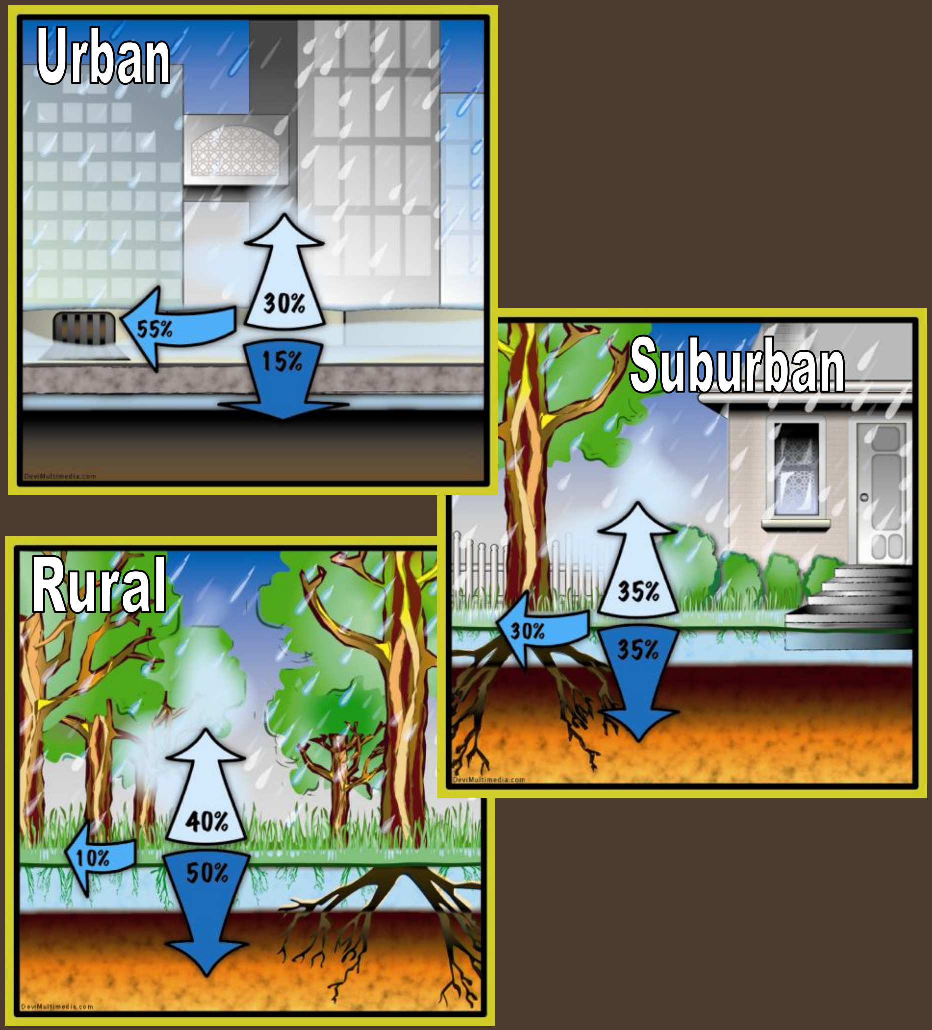
IGIC, 2005

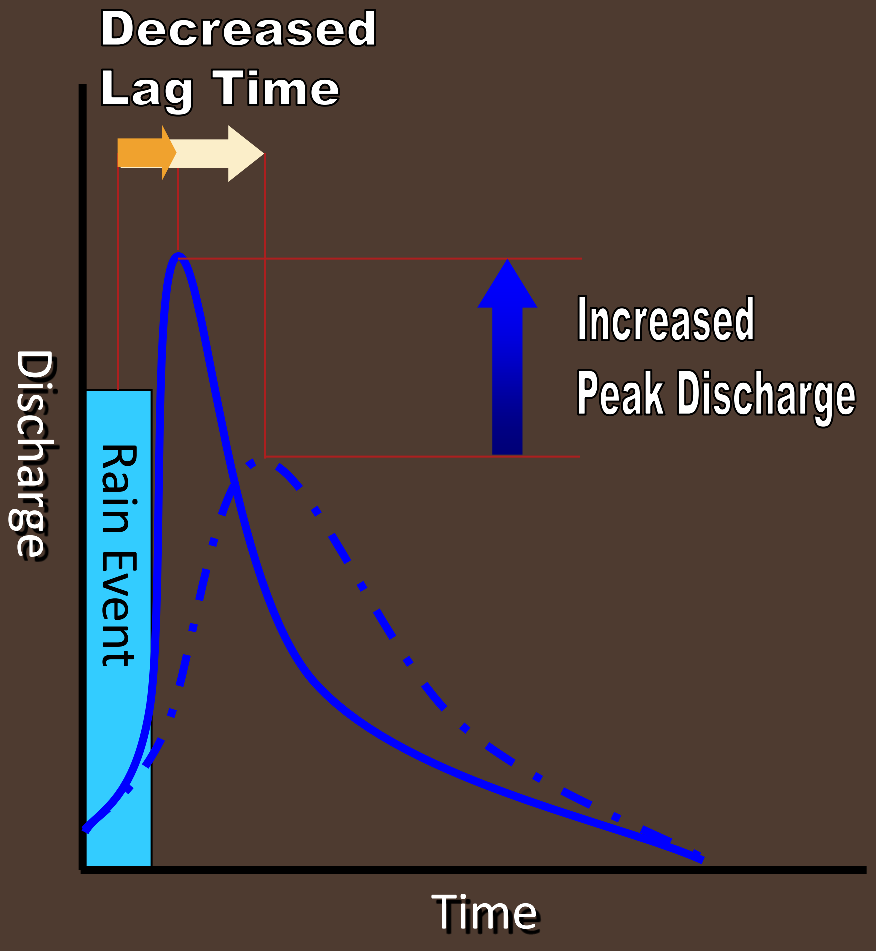
Hamilton County

Land Use, Cheeney Creek Watershed, 2005

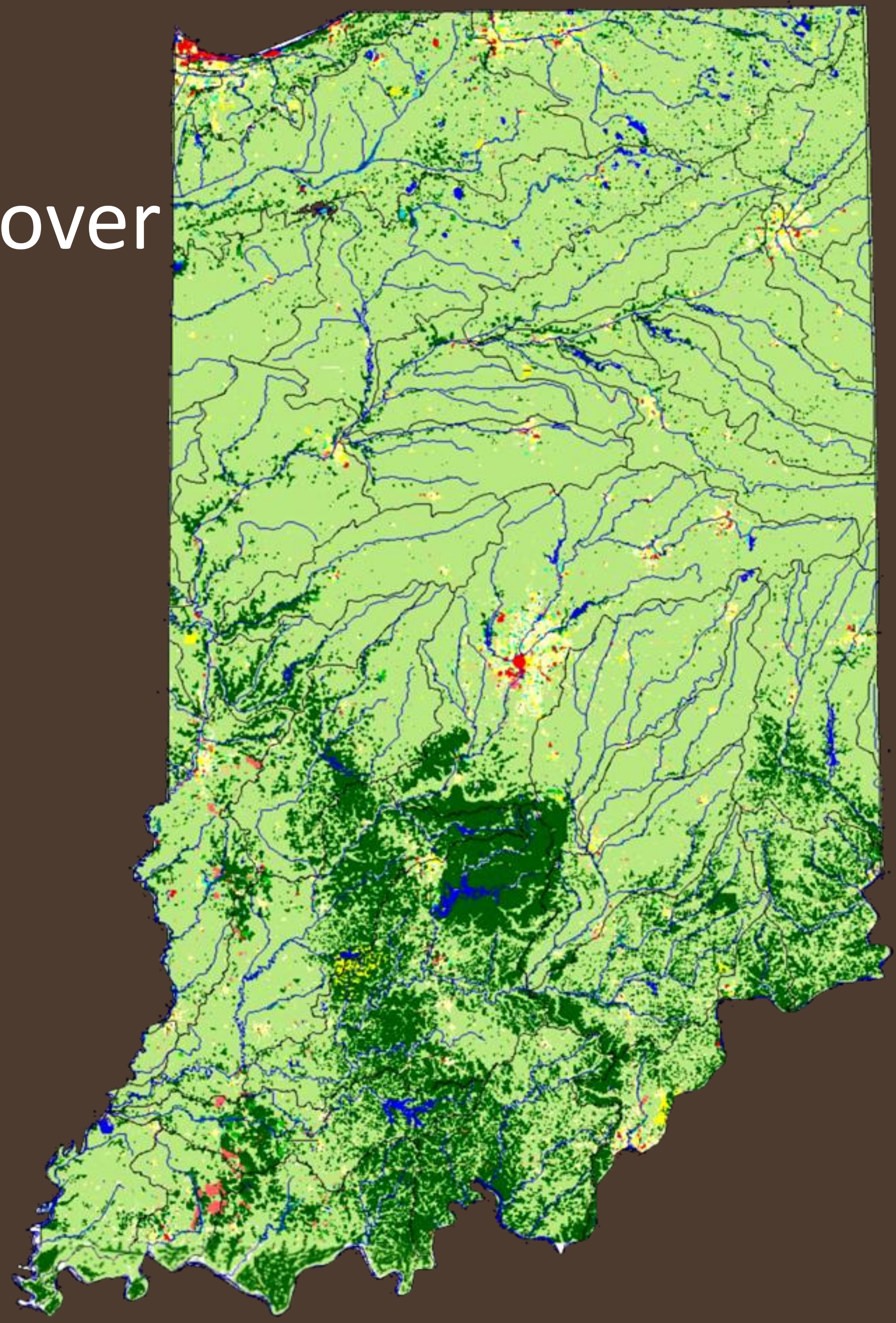
Headwaters of Cheeney Creek, Fishers. IN

Change in Hydrology after Urbanization



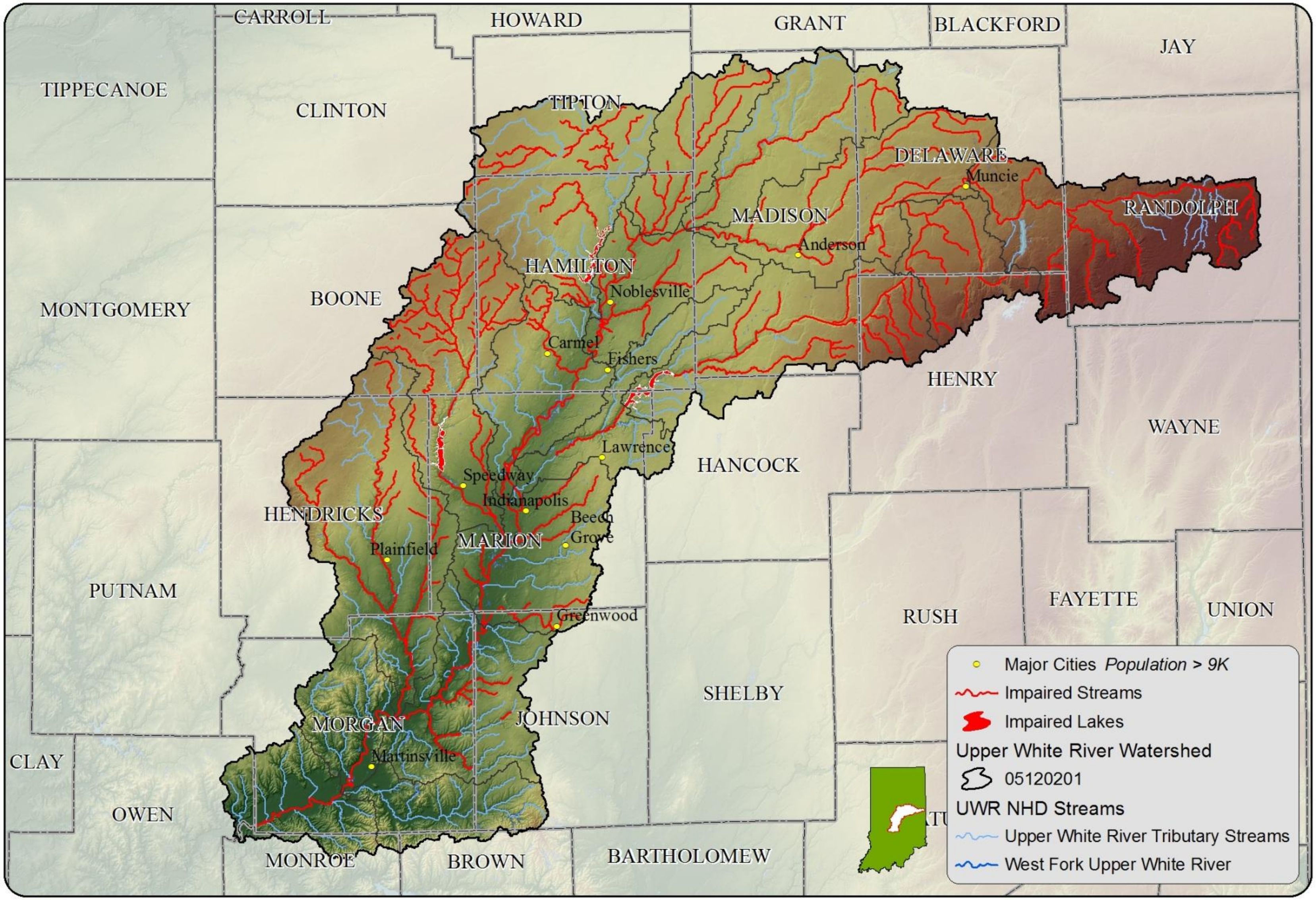


Indiana
Land Use/Cover



Industrial
Residential
Cropland
Forested

US EPA 1994



Impaired Streams and Lakes

Center for Earth and Environmental Science
Department of Earth Sciences
www.cees.iupui.edu

CEES

Source: Impaired Streams and Lakes (IDEM 303D List, 2006), Streams and Waterbodies (Medium Resolution NHD, USGS), Cities (USGS), Watersheds (NRCS), Background (30M DEM, USGS), Projection: UTM NAD83 Zone 16 Cartography: J. Jeremy Webber

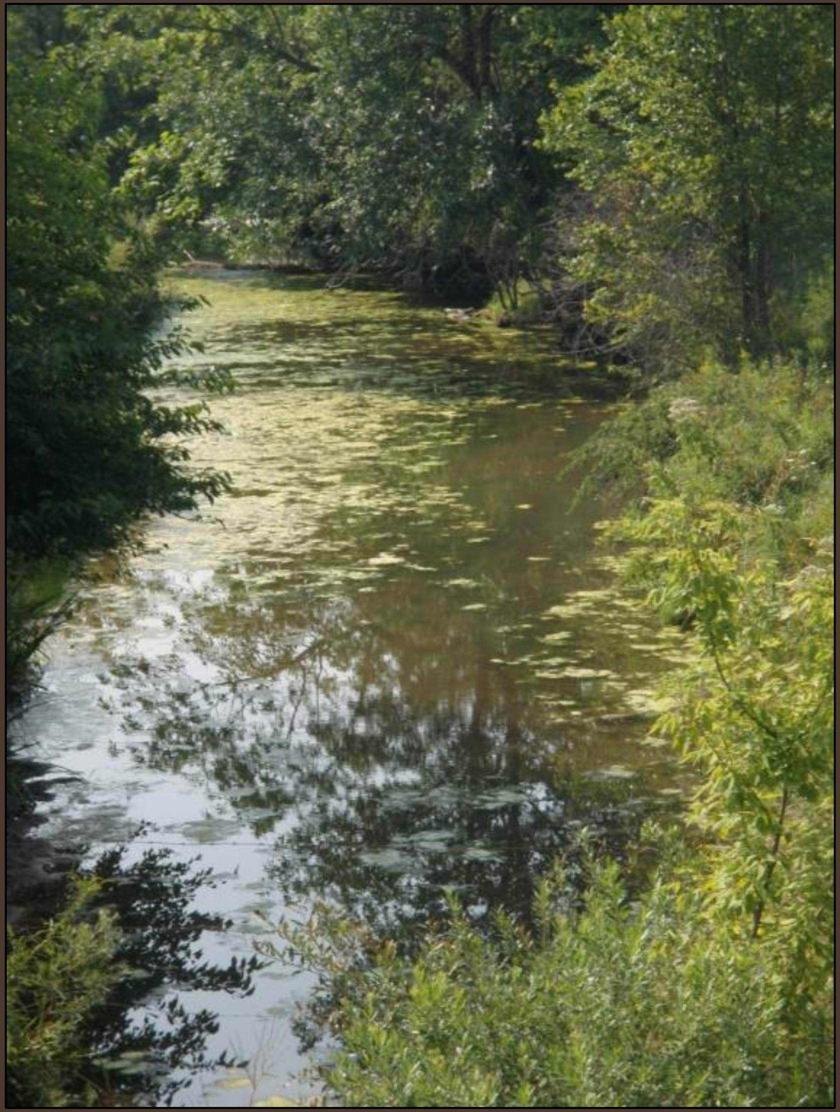
0 7.5 15 30 Kilometers

0 5 10 20 Miles

N

Alteration of Hydrologic Cycle

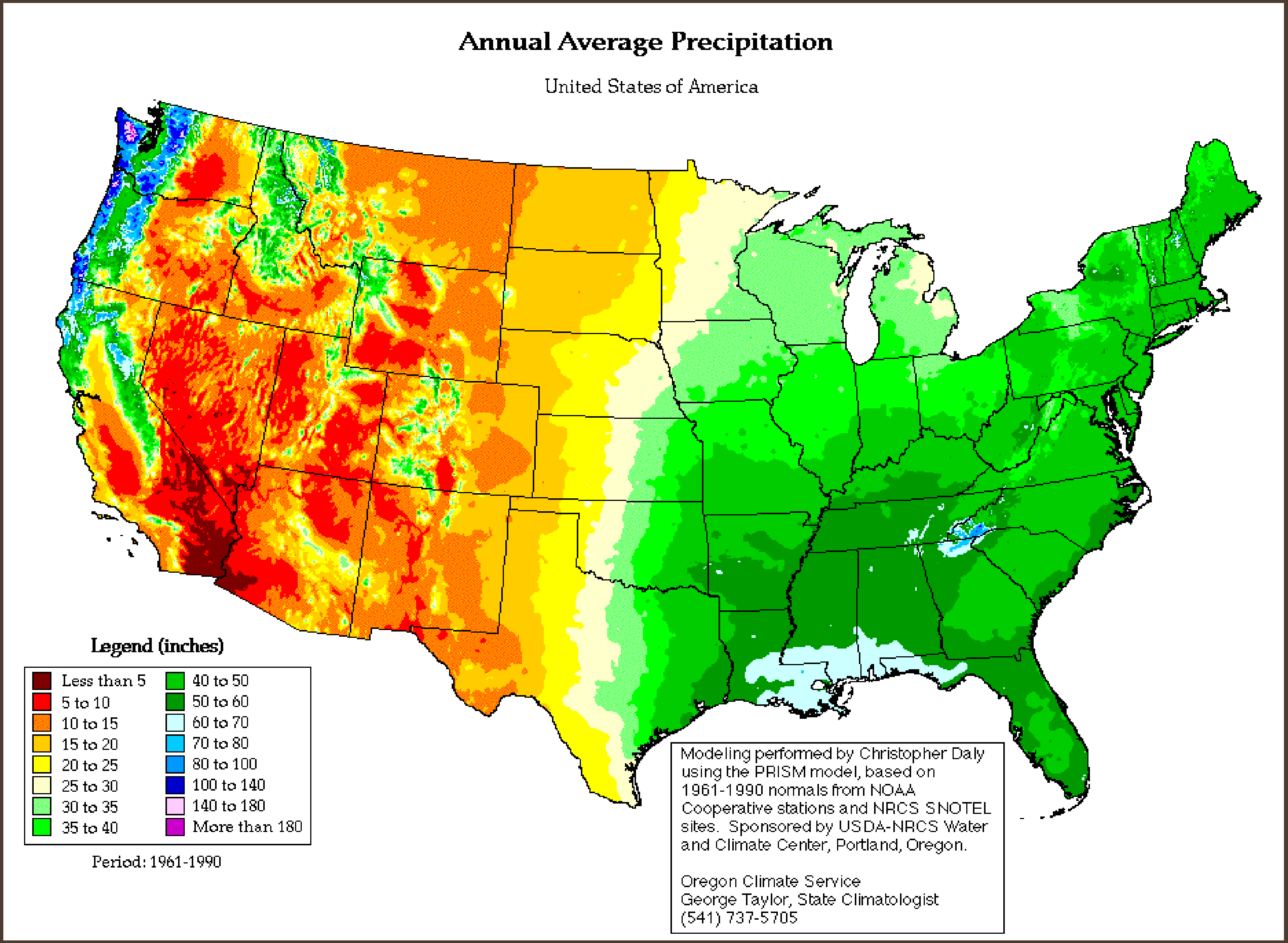
- Extensive Alteration of Hydrologic Processes Has Led to the Degradation of Water Resources
  - Increased Peak Flows and Decreased Base Flows in Streams
  - Increased Flooding and Increased Overall Discharge
  - Decrease in Water and Sediment Storage Upstream
  - Sediment, Nutrient, and Pathogen Loading Downstream
- High and Variable Contaminant Loads Impacting Both Recreational and Drinking Water Uses of Surface Water



Climate Change

“The likely increase in precipitation in winter and spring, more heavy downpours, and greater evaporation in summer will lead to more Global Climate Change Impacts in the United States - periods of both floods and water deficits.”

Global Climate Change Impacts in the United States, 2009

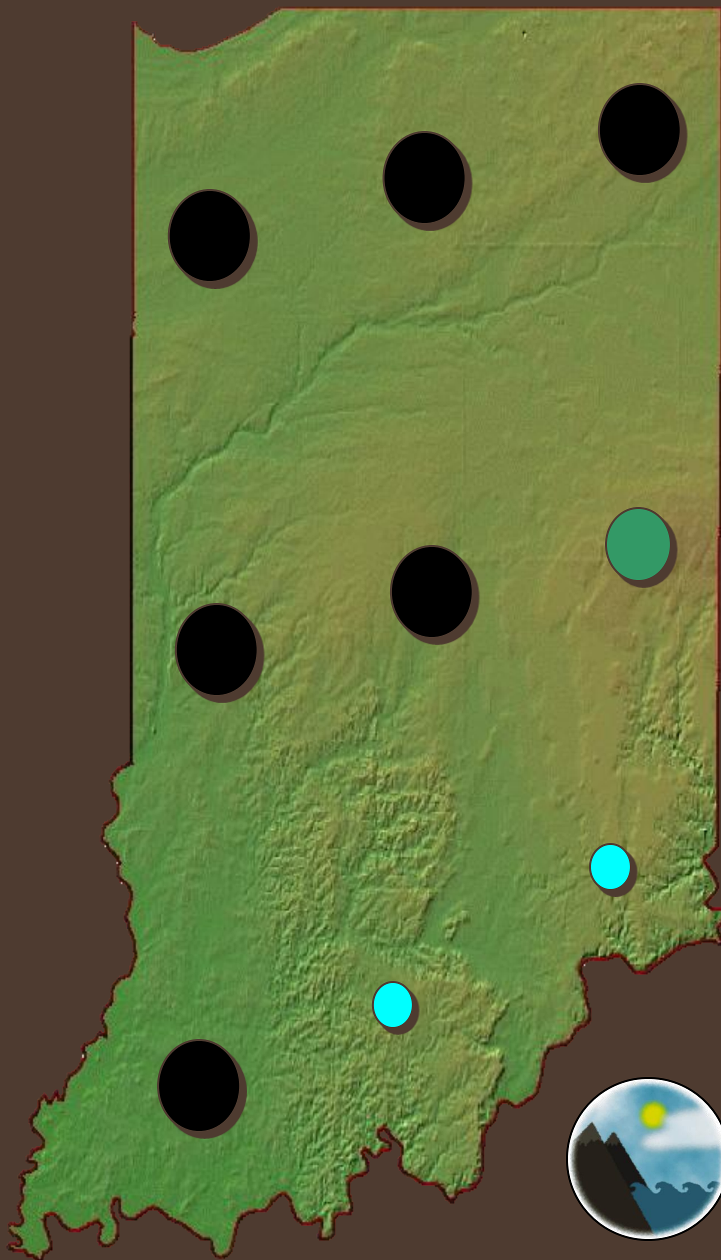


Annual Average Precipitation
United States of America
Legend (inches)
Less than 5
5 to 10
10 to 15
15 to 20
20 to 25
25 to 30
30 to 35
35 to 40
40 to 50
50 to 60
60 to 70
70 to 80
80 to 100
100 to 140
140 to 180
More than 180
Period: 1961-1990
Modeling performed by Christopher Daly using the PRISM model, based on 1961-1990 normals from NOAA Cooperative stations and NRCS SNOTEL sites. Sponsored by USDA-NRCS Water and Climate Center, Portland, Oregon.
Oregon Climate Service
George Taylor, State Climatologist
(541) 737-5705

Precipitation Trends from 1900 – 2000

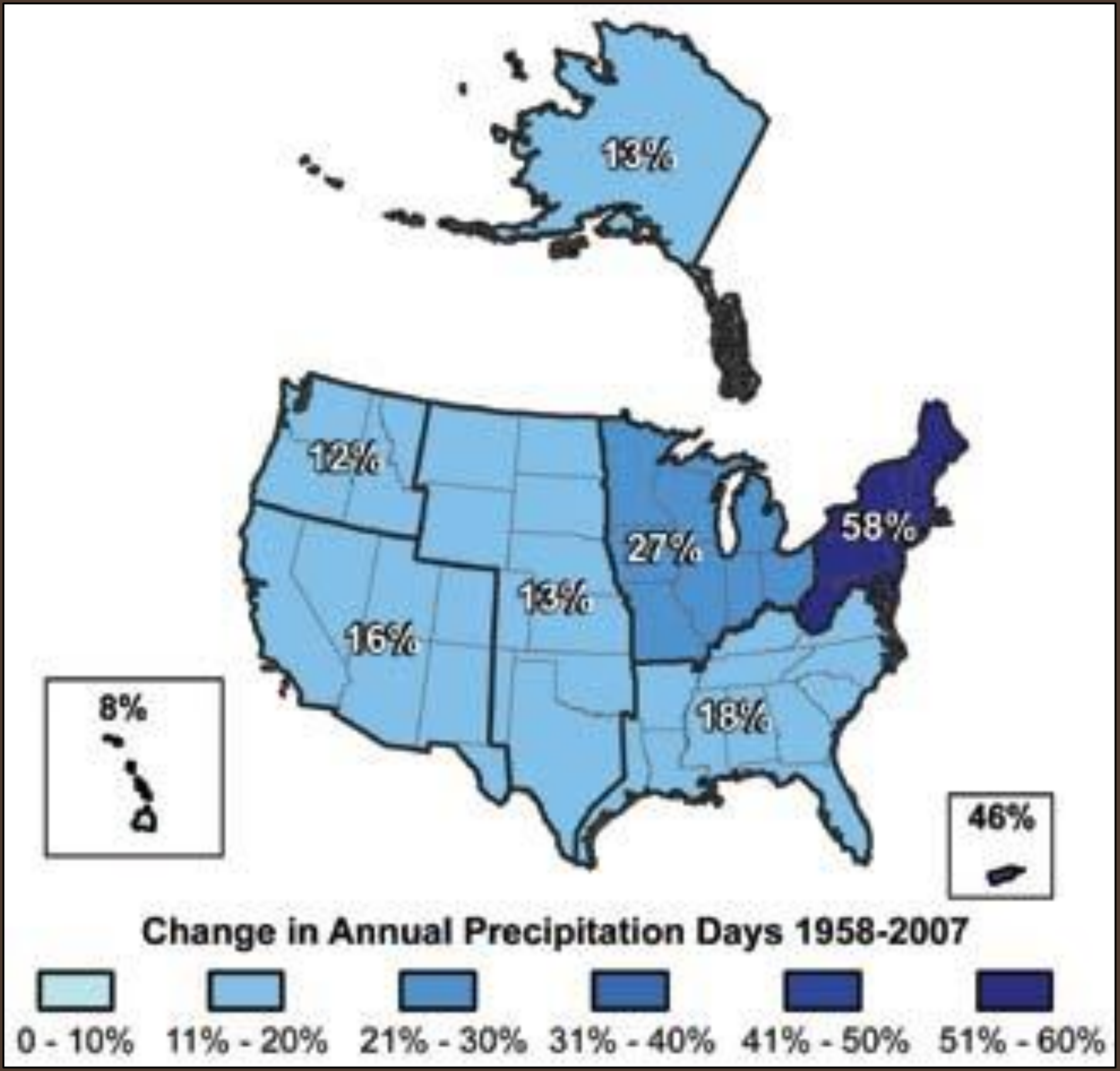
Trends per 100 years

- Black circle: + 20 %
- Green circle: + 10 %
- Cyan circle: + 5 %
- Yellow circle: - 5 %
- Orange circle: - 10 %
- Red circle: - 20 %



Source: Karl et al. (1996)

Increases in Average # of Days with Very Heavy Precipitation (>2”), 1958-2007



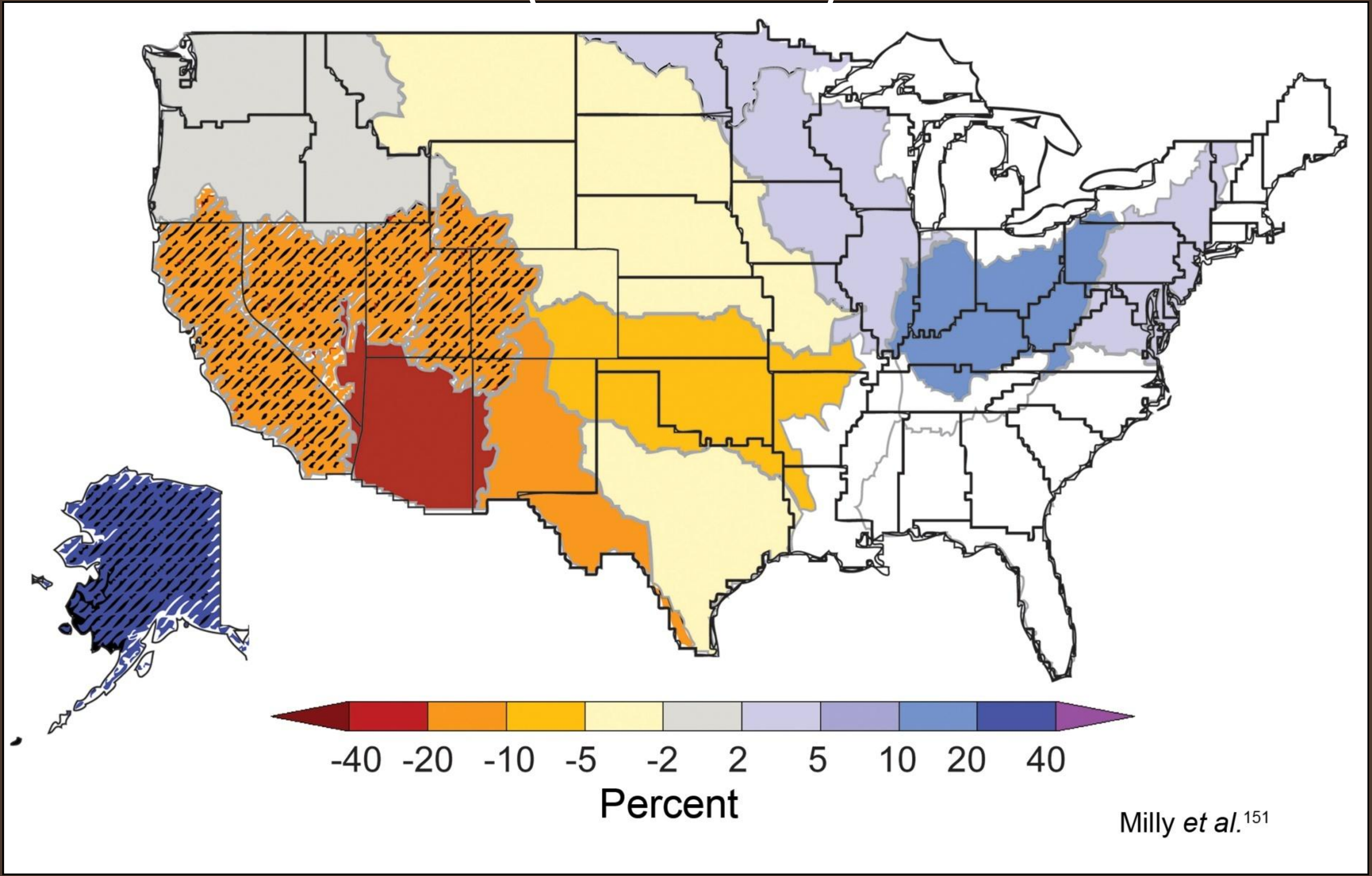
Global Climate Change Impacts in the United States, 2009

(Updated from Groisman *et al.* 2004)

Weather Patterns

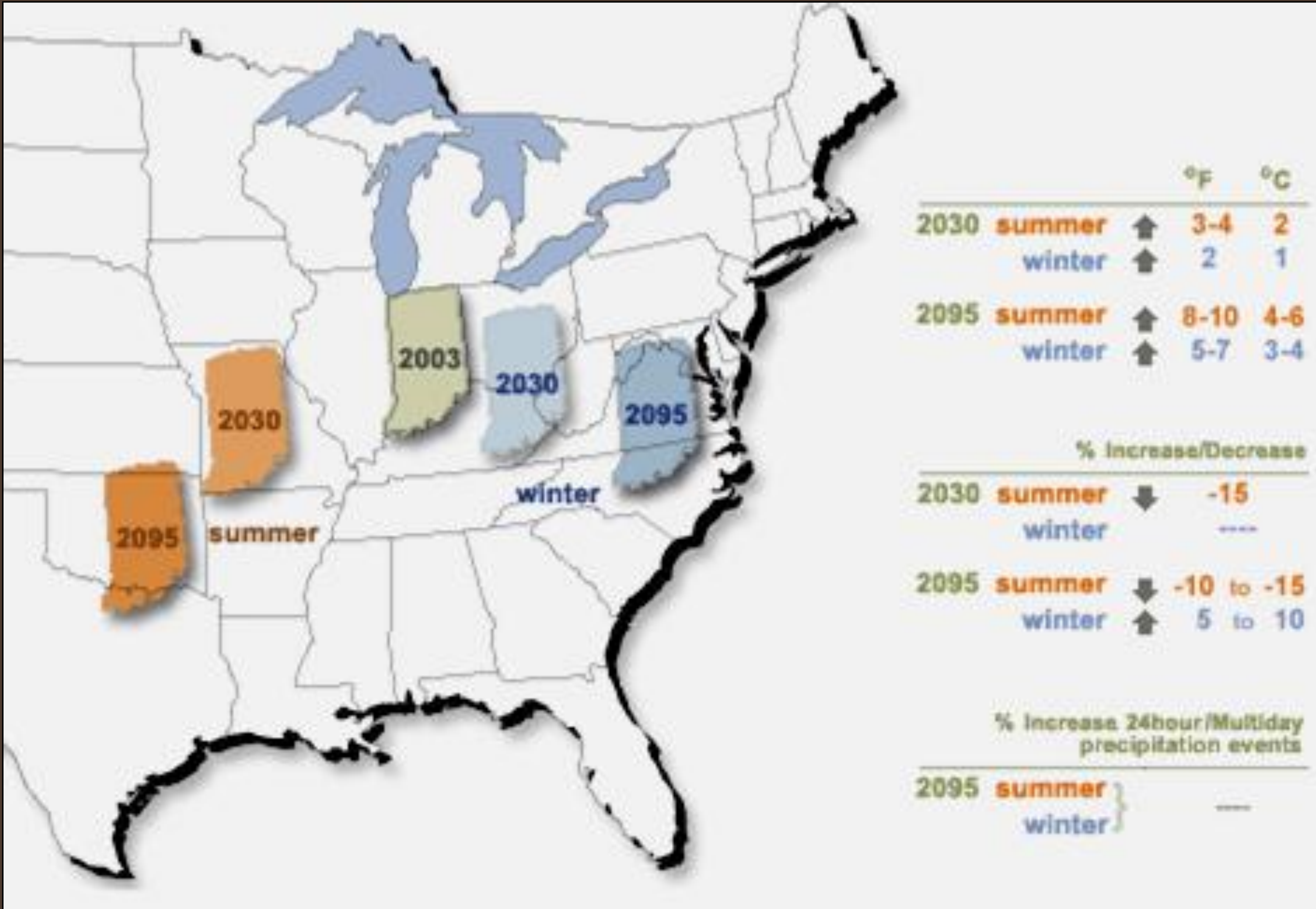
- Extreme heat will be more common, and the frequency of heavy rainstorms will increase.
- Winter and spring rainfall events are expected to increase in quantity and intensity, resulting in flooding and more municipal and farm runoff.
- The frequency of heavy rainstorms, both 24-hour and multiday, is projected to increase over the next century. These trends are already evident in the region

Project Change in Median Runoff (2041-2060)



Projected changes in median runoff for 2041-2060, relative to a 1901-1970 baseline, are mapped by water-resource region. Colors indicate percentage changes in runoff.

Global Climate Change Impacts in the United States, 2009



Union of Concerned Scientists (2003)

Restoration of Indiana's Hydrologic Cycle

- Naturalizing Flow Patterns
  - Increase Upland Storage
    - Increase Groundwater Recharge
    - Stabilize Base Flow
  - Reduction of Overland Flows – or Interception Prior to Reaching Stream Network

- Reestablish Ecosystem Functions
  - Reconnect Floodplains
  - Restore Streams and Riparian Corridors
  - Reestablish Wetland Complexes

Reestablish Upland Water Storage

- Focus on Premise that Agricultural and Storm Water Management should NOT be Water Disposal
- Improve Agricultural Water Management Practices
- Improve Storm Water Management Practices (LID Practices)

Reestablish Stream Functions

- Stream naturalization that combines flood storage with flow naturalization
- Requires upland storage and enhanced infiltration
- Link urban LID stormwater practices with stream mitigation

(Pleasant Run G.C., Indianapolis, IN)

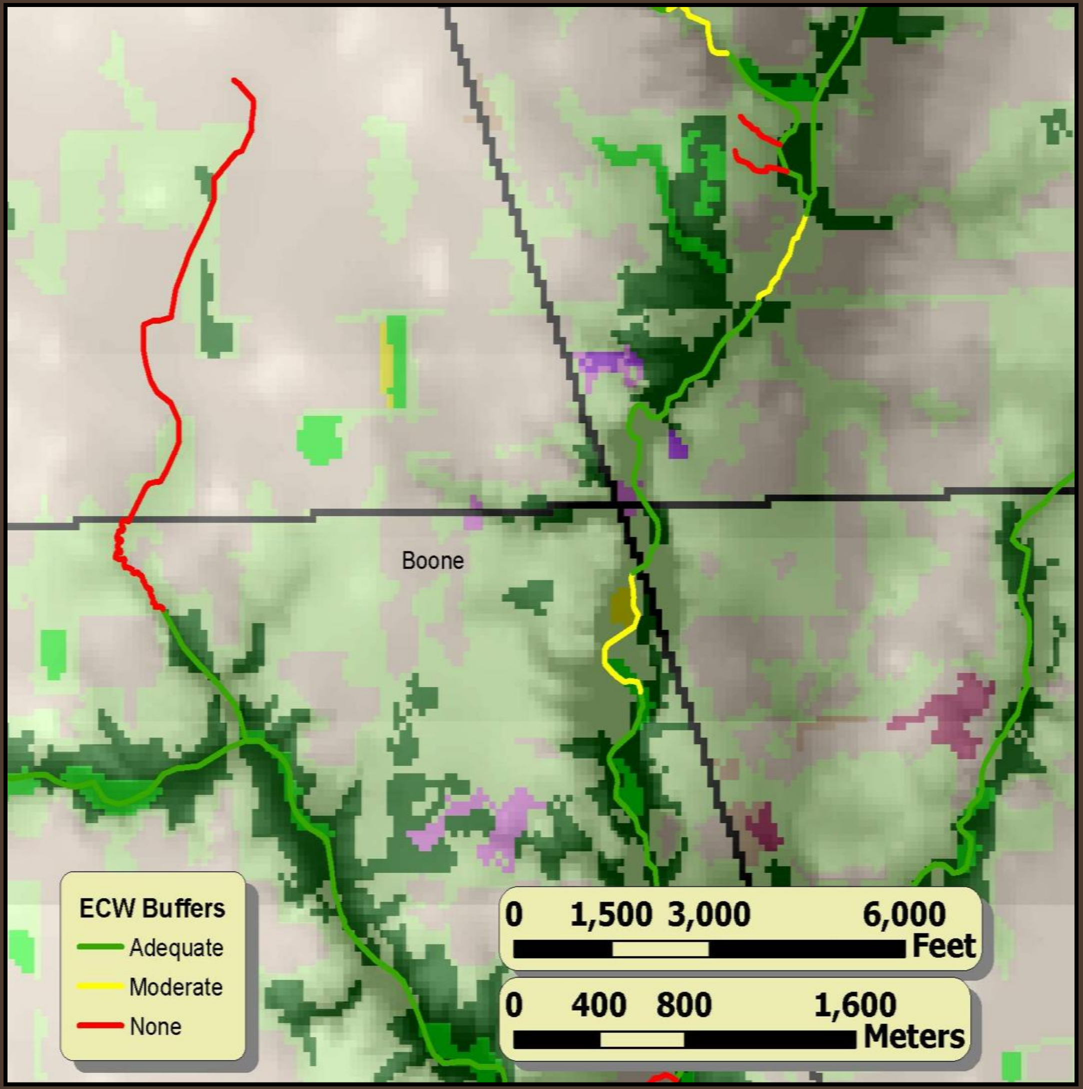
Utilizing Natural Storage

- 80-day flood of 1993 on the Mississippi River generated 39 million acre-feet of floodwaters (at St Louis)
- Conservative estimate of available flood storage in the watershed indicates that approximately 40 million acre-feet of water could be stored within the existing levees and outside the levees on existing or drained wetlands.
- Spent >$55 million in levee repair

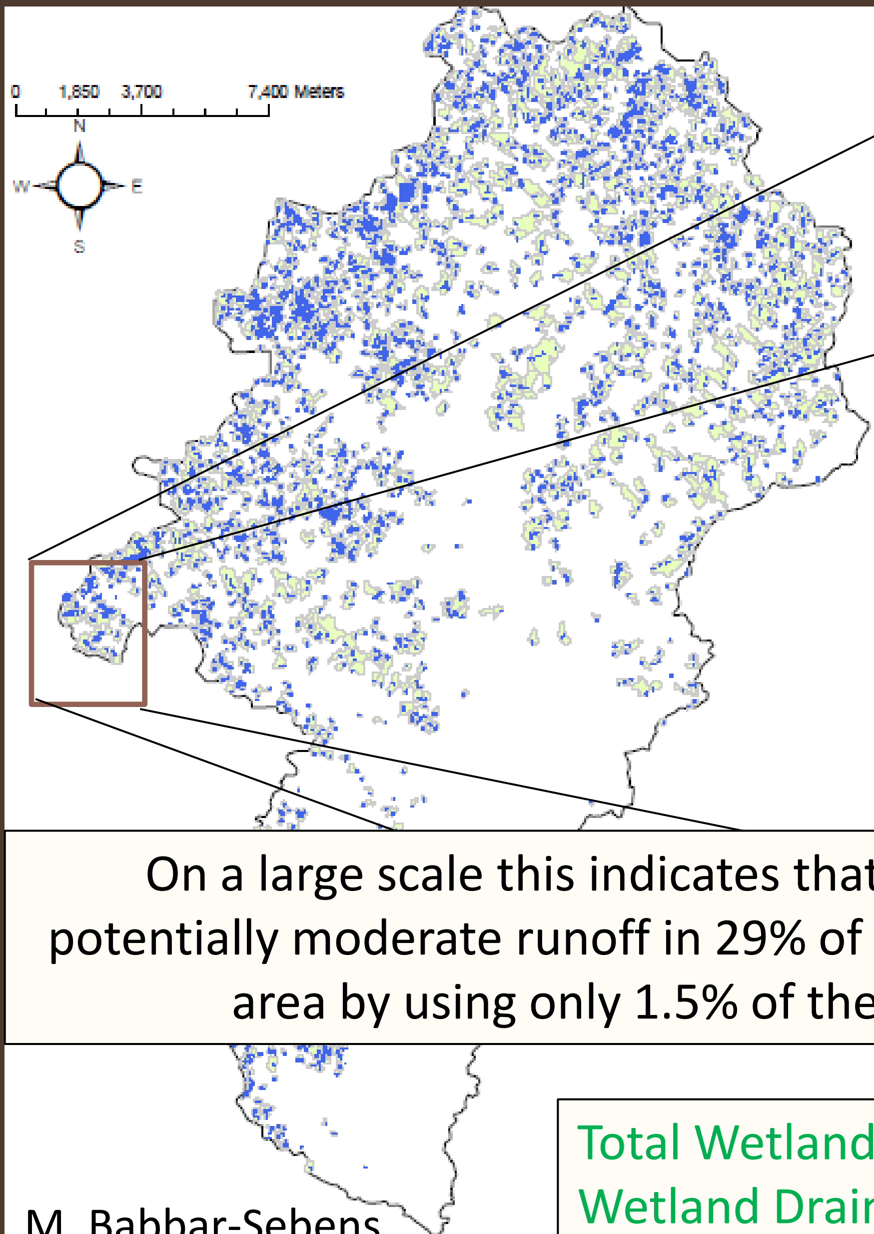
Hey and others, 2004

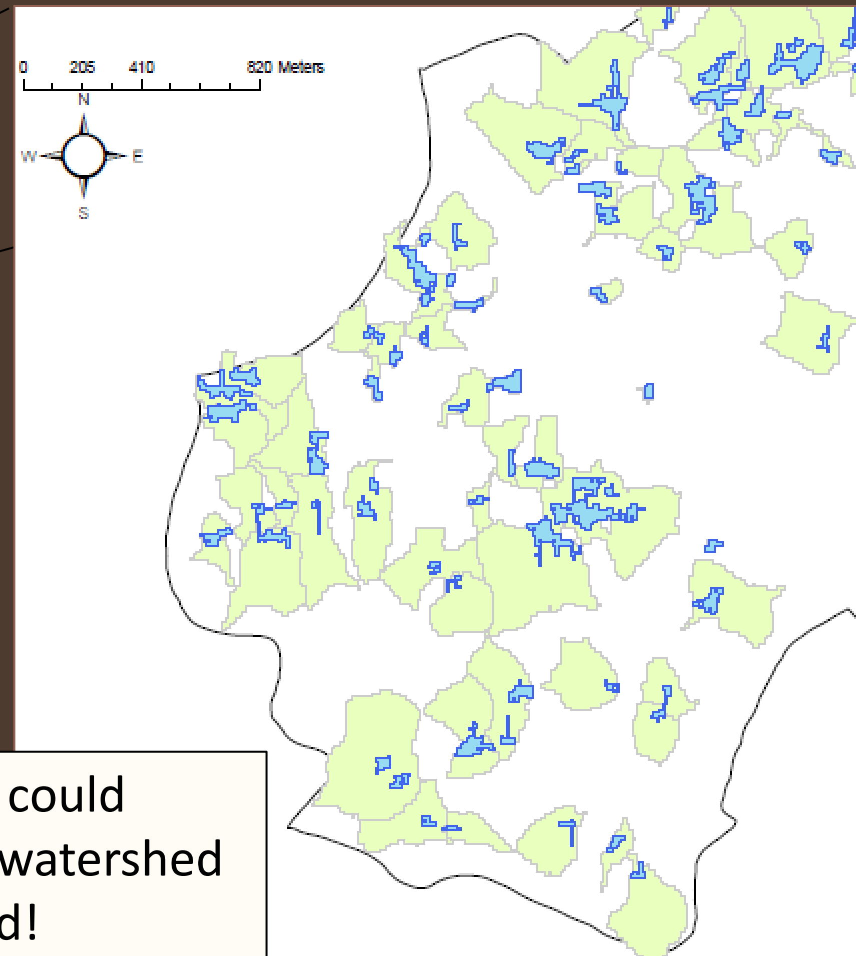
Identifying Potential Storage Areas

- GIS-based Tool
- Utilizes
  - Land Use/Land Cover
  - Soil Drainage Class
  - Digital Elevation Models
  - Flow Path Modeling



Potential Upland Water Storage Sites: Eagle Creek Watershed





On a large scale this indicates that we could potentially moderate runoff in 29% of the watershed area by using only 1.5% of the land!

Total Wetland Area = 1.5% of Watershed Area
Wetland Drainage Area = 29% of Watershed Area

M. Babbar-Sebens

Increase Field Capacity – NRCS Soil Health Initiative

Challenges for Improving Water Resources

- Agricultural and Urban Storm Water Management Must Go Beyond Water Disposal
- Recognize that Water Resources are All Part of the Same Cycle and Manage Them Together
- Water Cycle Needs to be Managed for both Quality AND Quantity


William's Creek, 2007
Webber