# Forest Water Resource Research Needs:

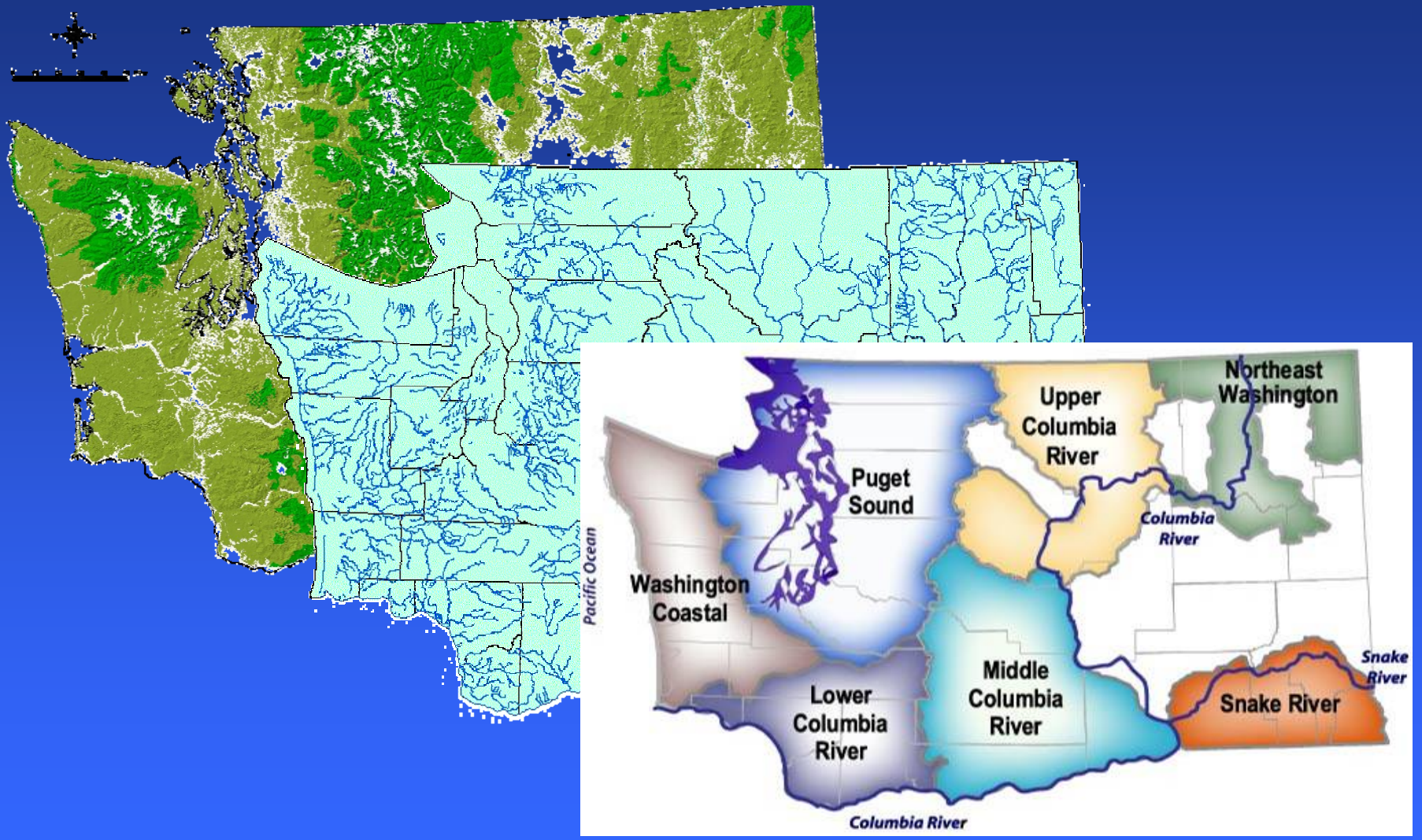
## The Forest Water Research Cycle

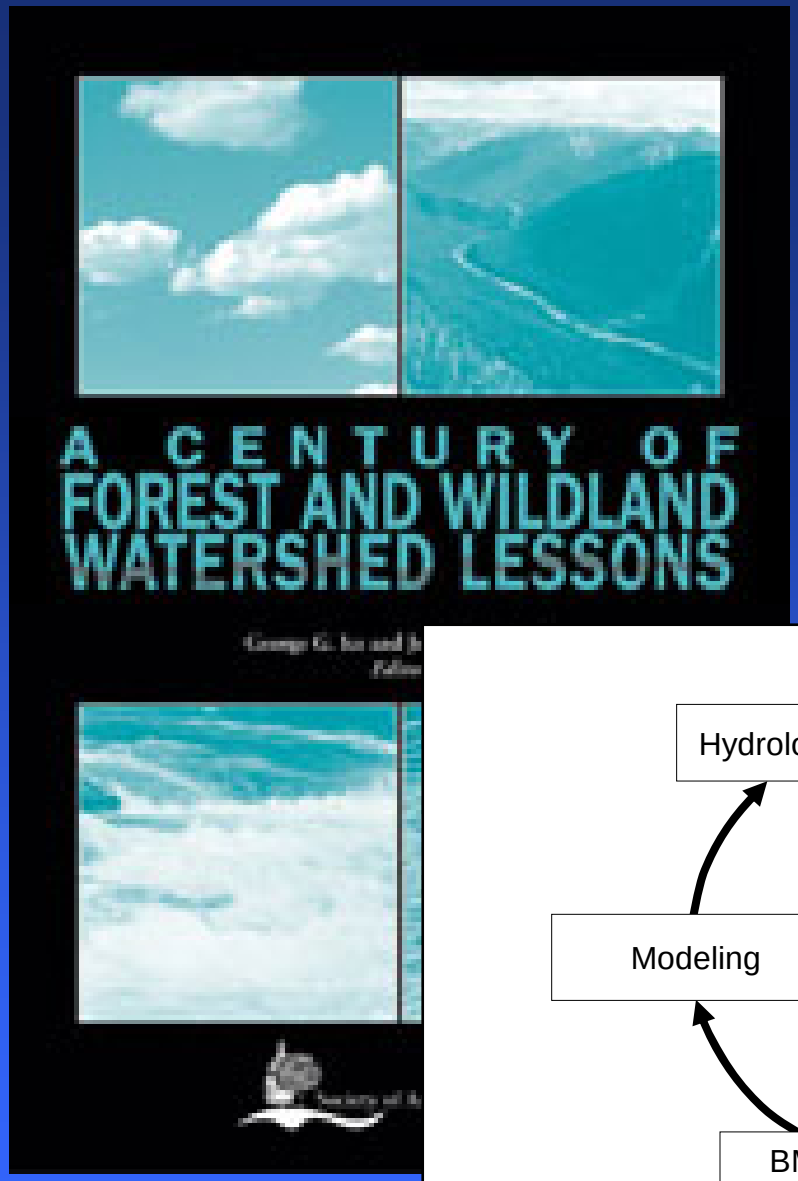
George Ice, NCASI

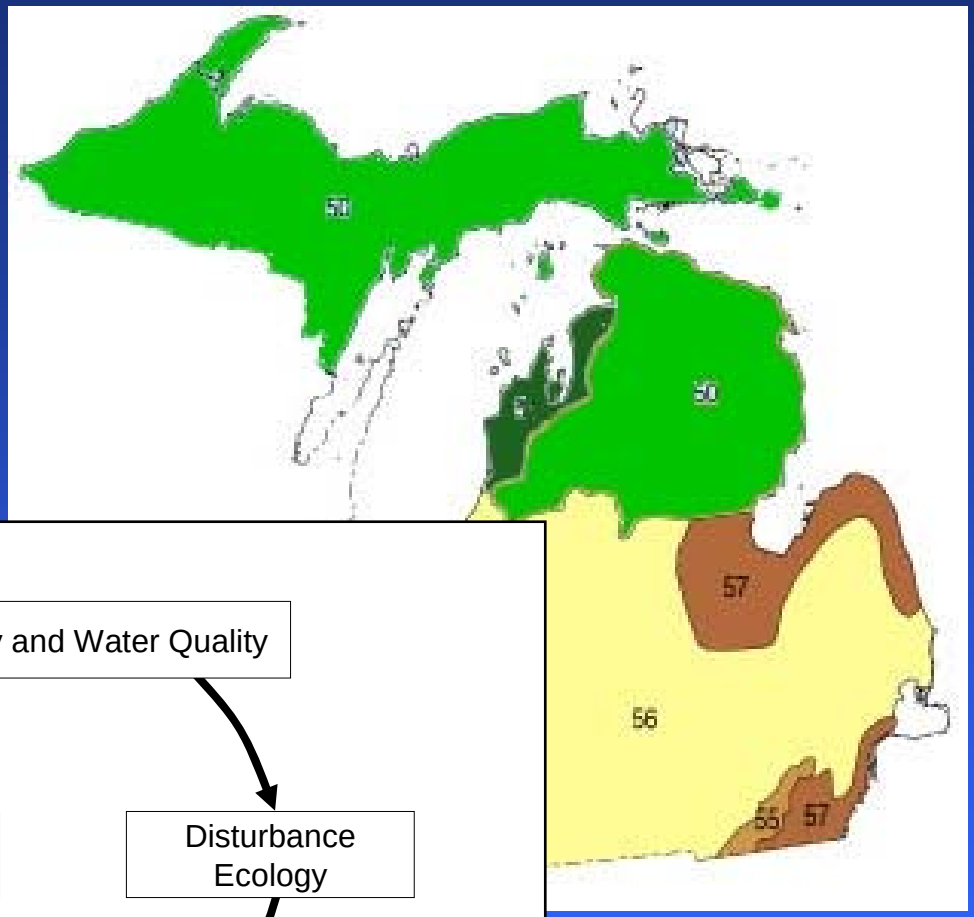
Sustainable Water Resources Roundtable Workshop and Symposium on Research Needs

April 5-6, 2005

# Forests and Water Concerns




A CENTURY OF
FOREST AND WILDLAND
WATERSHED LESSONS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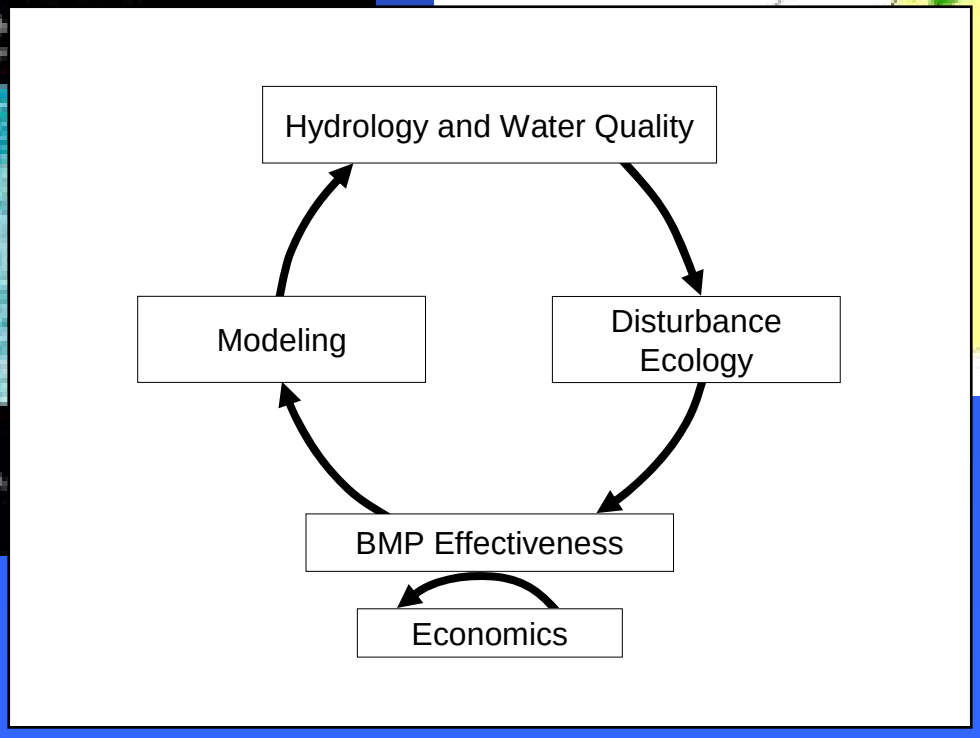
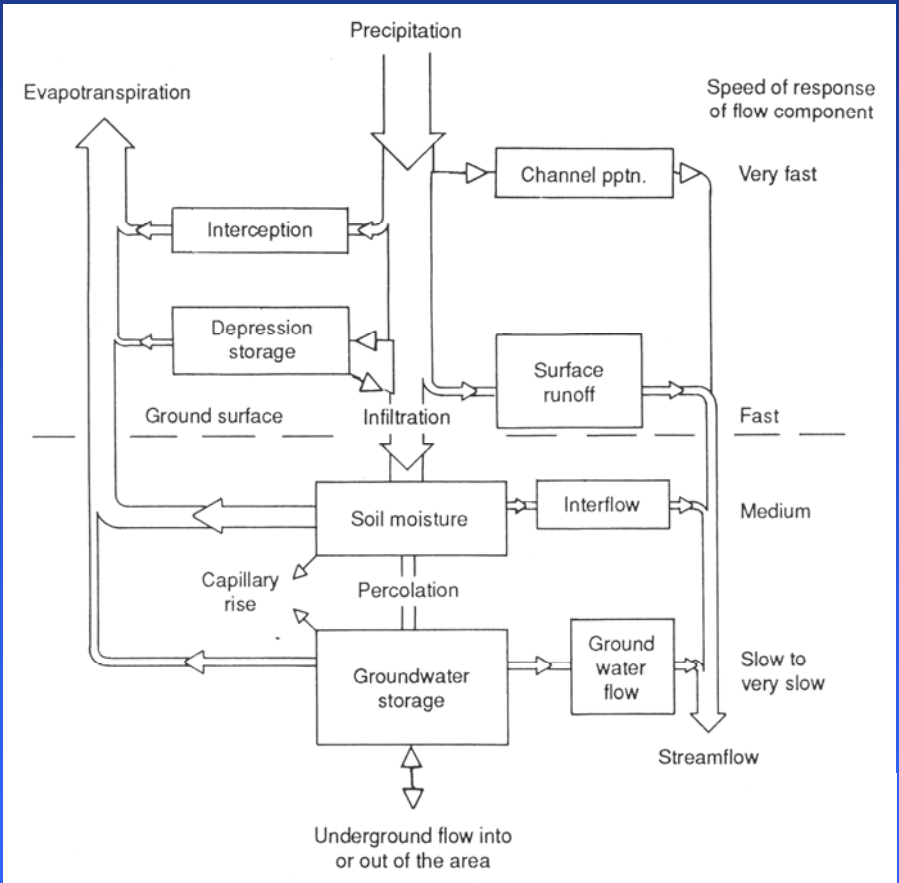
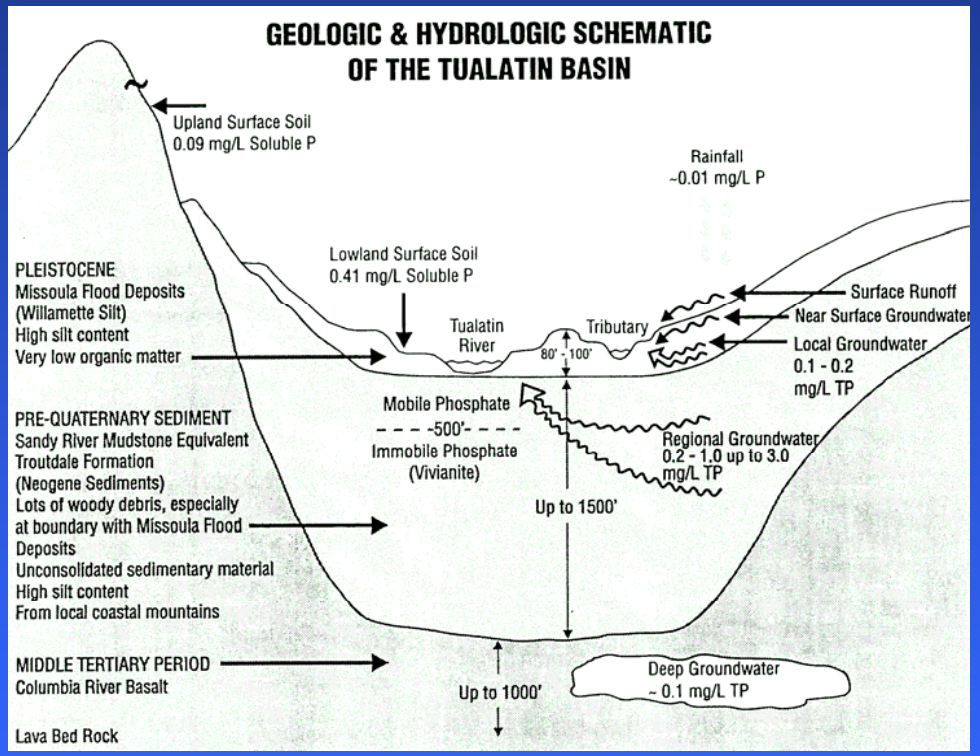

Hydrology and Water Quality
Disturbance Ecology
BMP Effectiveness
Economics
Modeling

# Flow Pathways and Hydrology




# Intrinsic Water Quality Potential

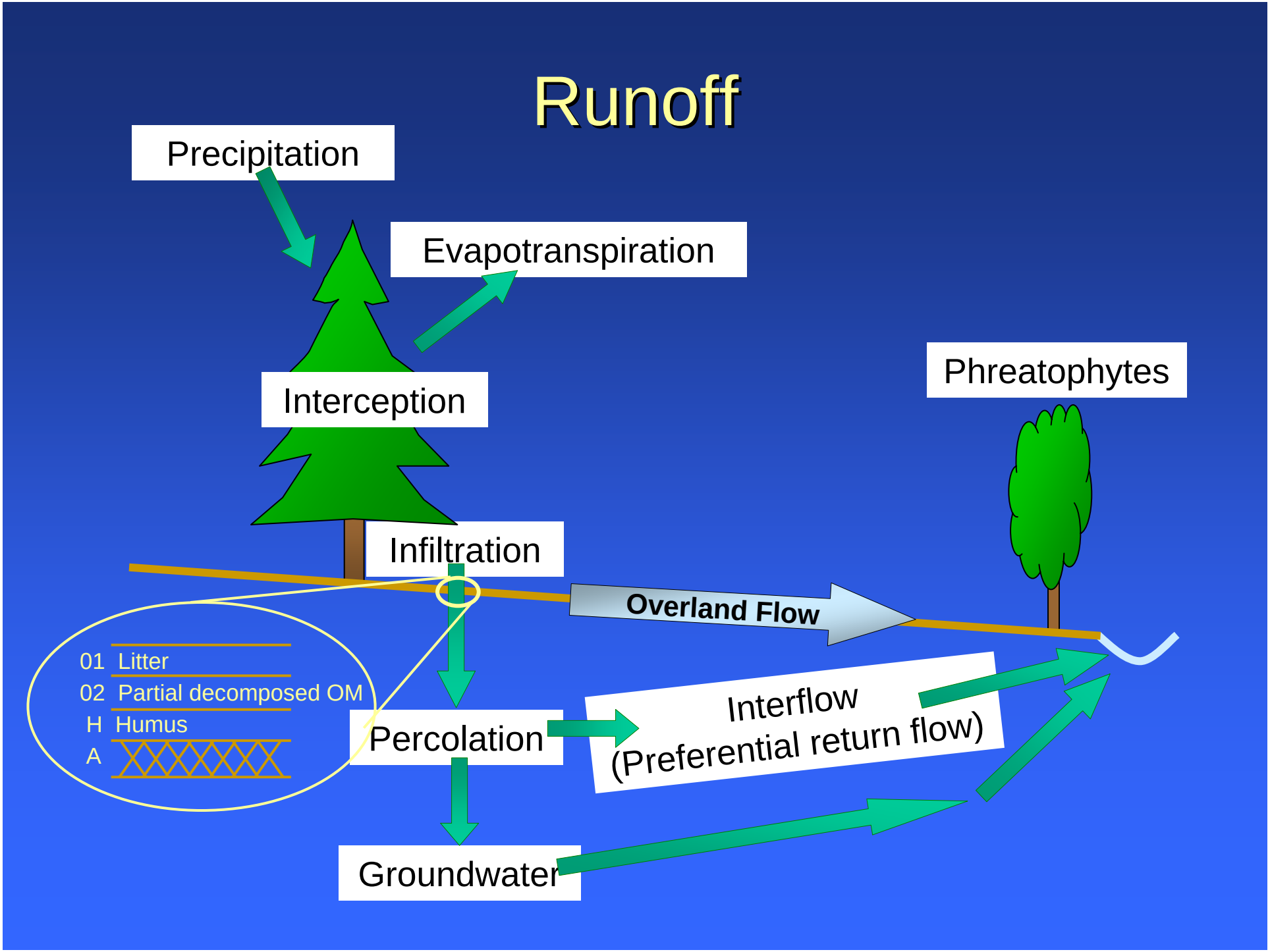
- Dissolved oxygen in least-impaired streams of northern Louisiana
- Nutrient concentrations in forest streams
- Temperature in the Pacific Northwest
- Sediment in northern California



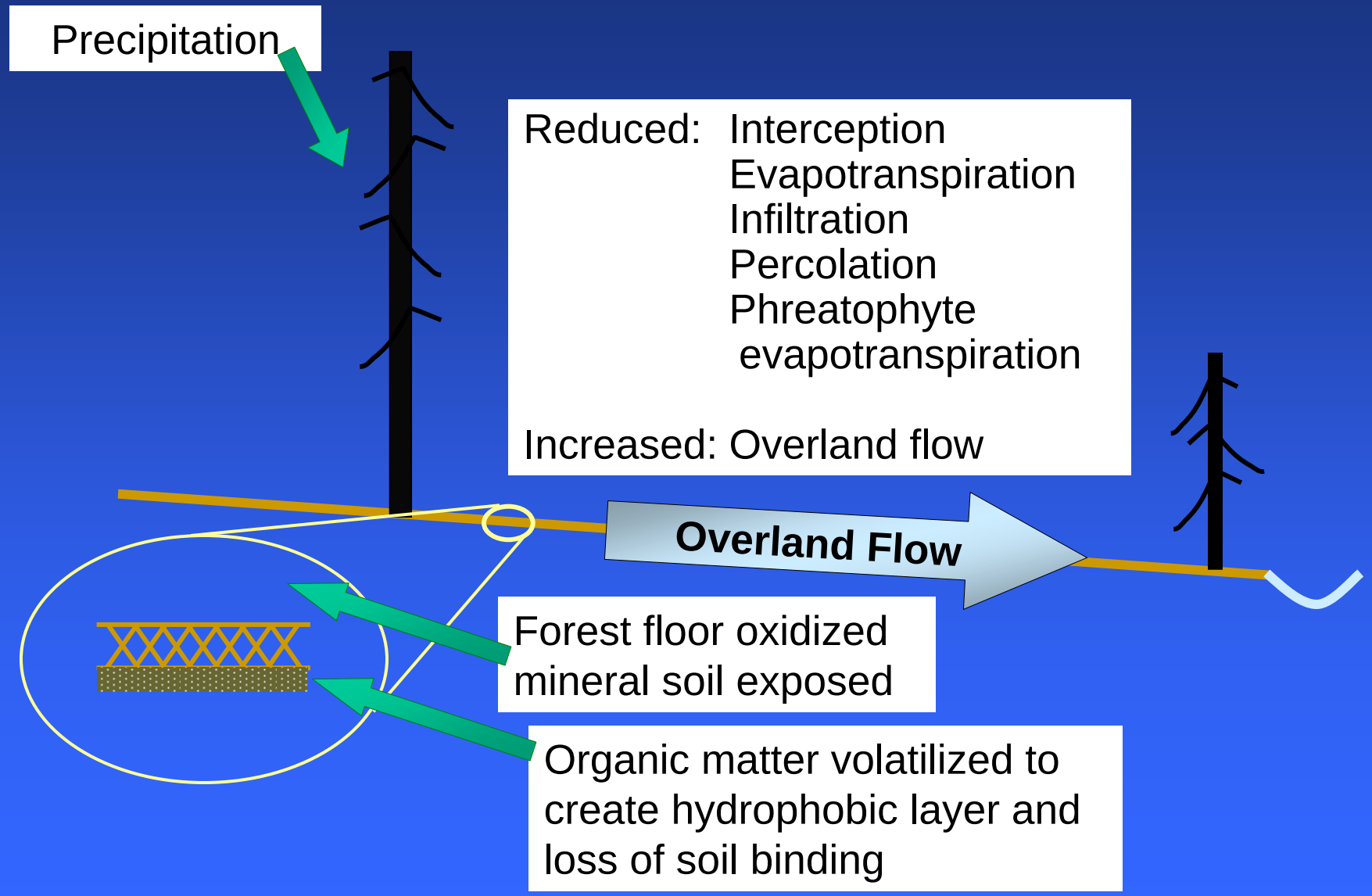
# Disturbances Shape Forest and Watersheds

- Key disturbances: wildfire, windthrow, insect and disease outbreaks, ice storms and ice flows, floods and droughts
- Disturbance can be both negative and positive
- Management implications

Mt. St. Helens Eruption 1980


Runoff
Precipitation
Evapotranspiration
Interception
Phreatophytes
Infiltration
Overland Flow
01 Litter
02 Partial decomposed OM
H Humus
A
Percolation
Interflow
(Preferential return flow)
Groundwater

# Runoff after Severe Fire Attacks



# Wildfire

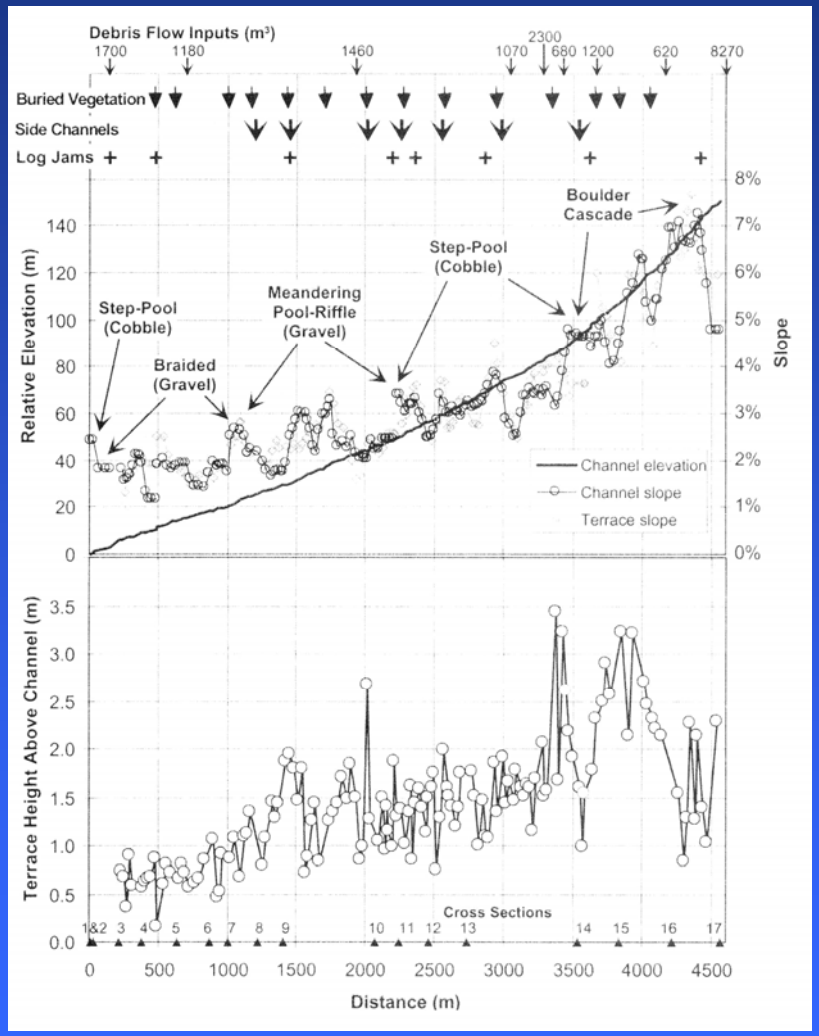

North Fork Boise Wildfires, Boise National Forest

# Miller and Benda: Sediment Wedges

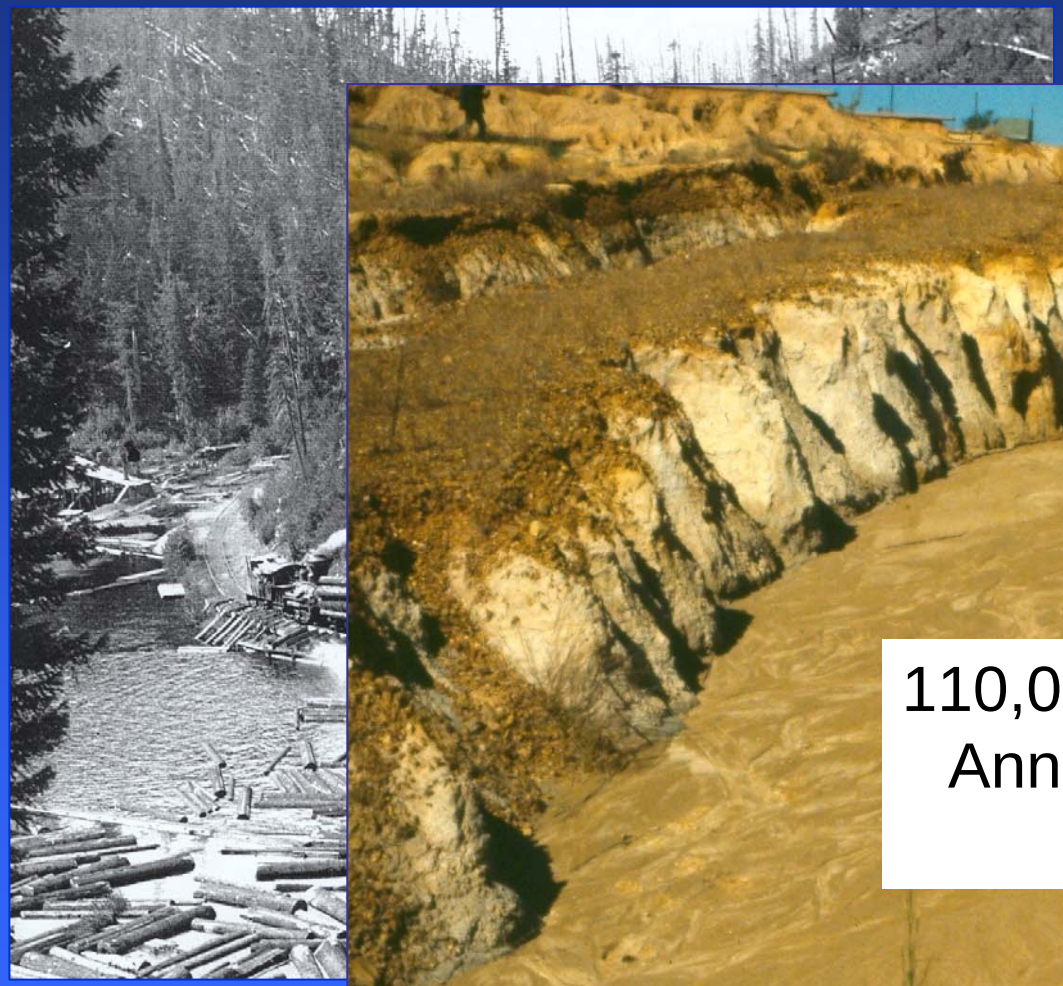
Fish Creek, Oregon
(George G. Ice)

"…disturbance is a prerequisite for maintaining high-integrity ecosystems…"

Everett et al. 2002



# Legacy of Past Abusive Management





110,000,000 Mg in storage
Annual export 40,000 Mg
Martin et al. 1999

Murder Creek Watershed Study, Georgia

# Best Management Practices (BMPs)

Mulching and seeding can be used to create a cover and reduce erosion from exposed soils. Water bars and streamside management zone are other commonly used BMPs.

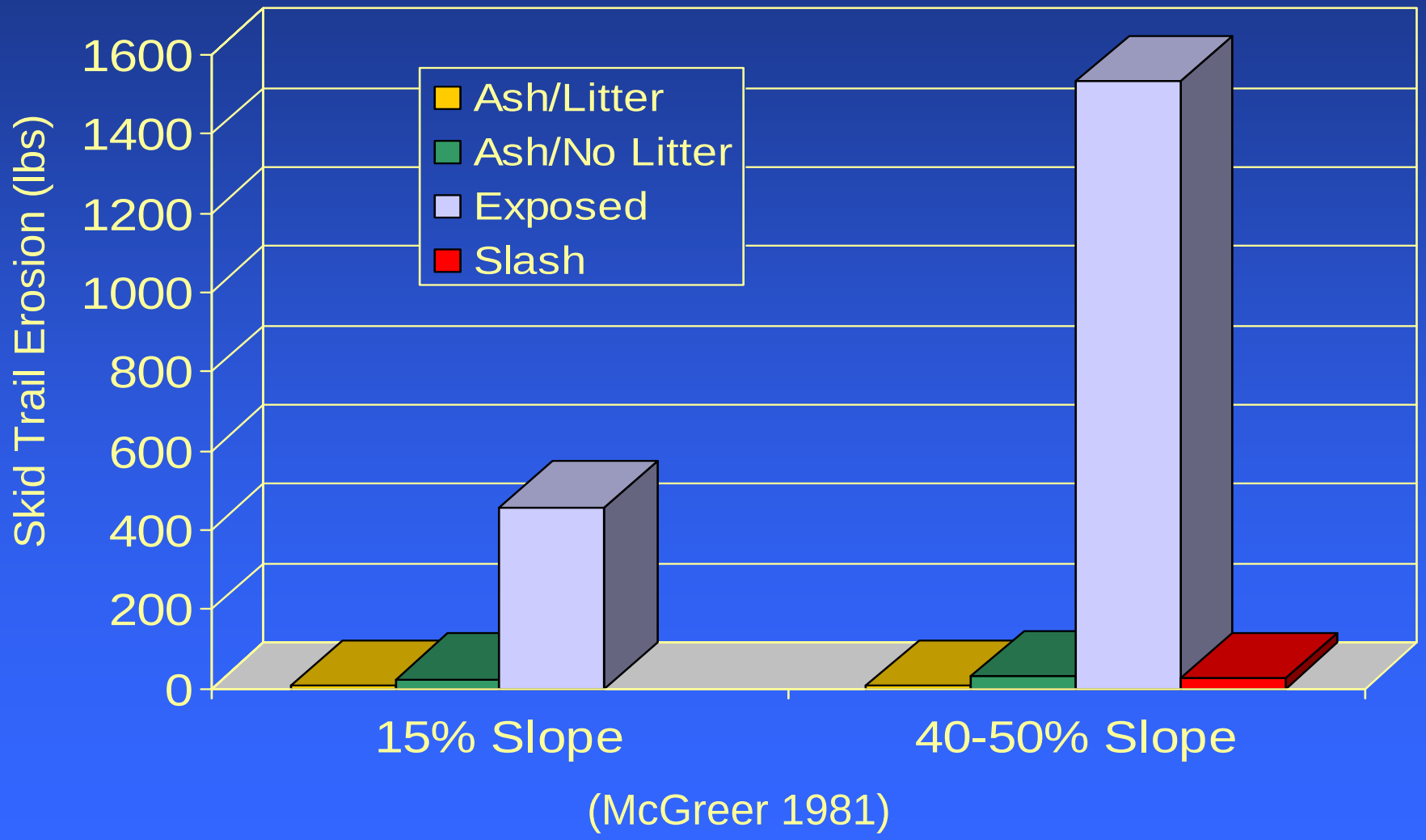
http://www.ncasi.org/Publications/Detail.aspx?id=2621

# Skid Trail Erosion, Idaho

Highly disturbed skid trail

Sediment trap

# Erosion w/without BMPs




(McGreer 1981)

# Economics

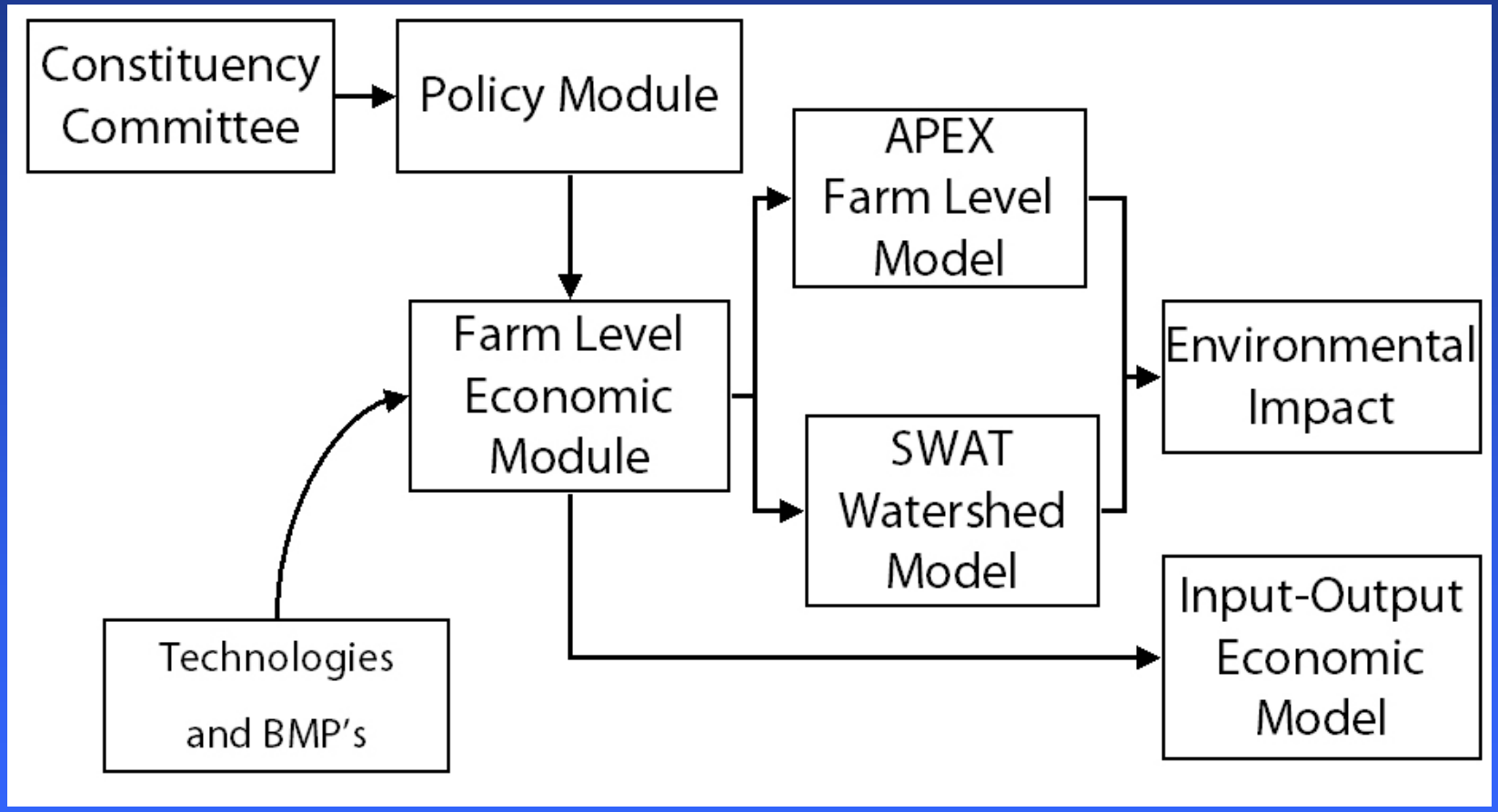
"We are loosing 4,000 acres (of forestland) every day to forest development."

Dale Bosworth, Chief
USDA Forest Service

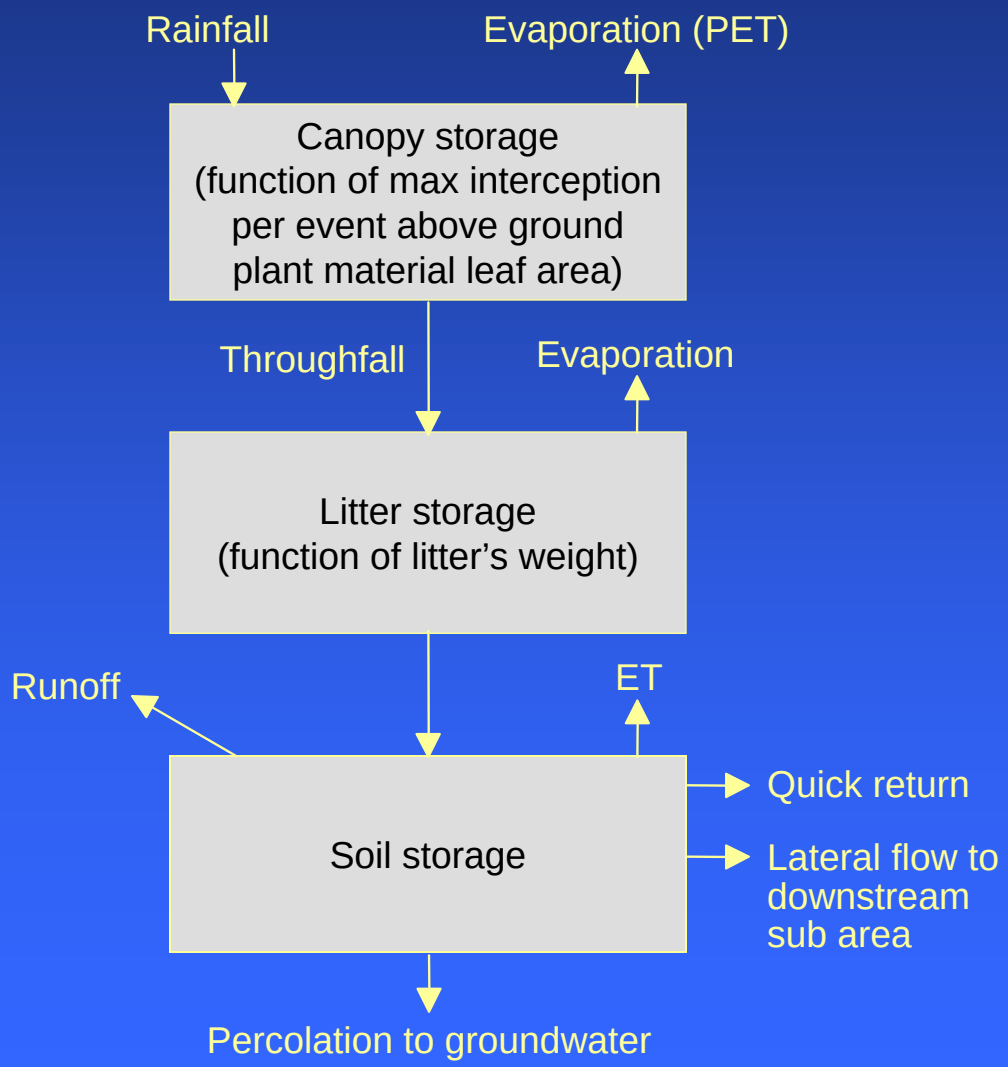
"A significant problem with current regulations is unsustainable economics… At the same time, there are missed opportunities to better protect aquatic resources…"

Zobrist et al. 2005

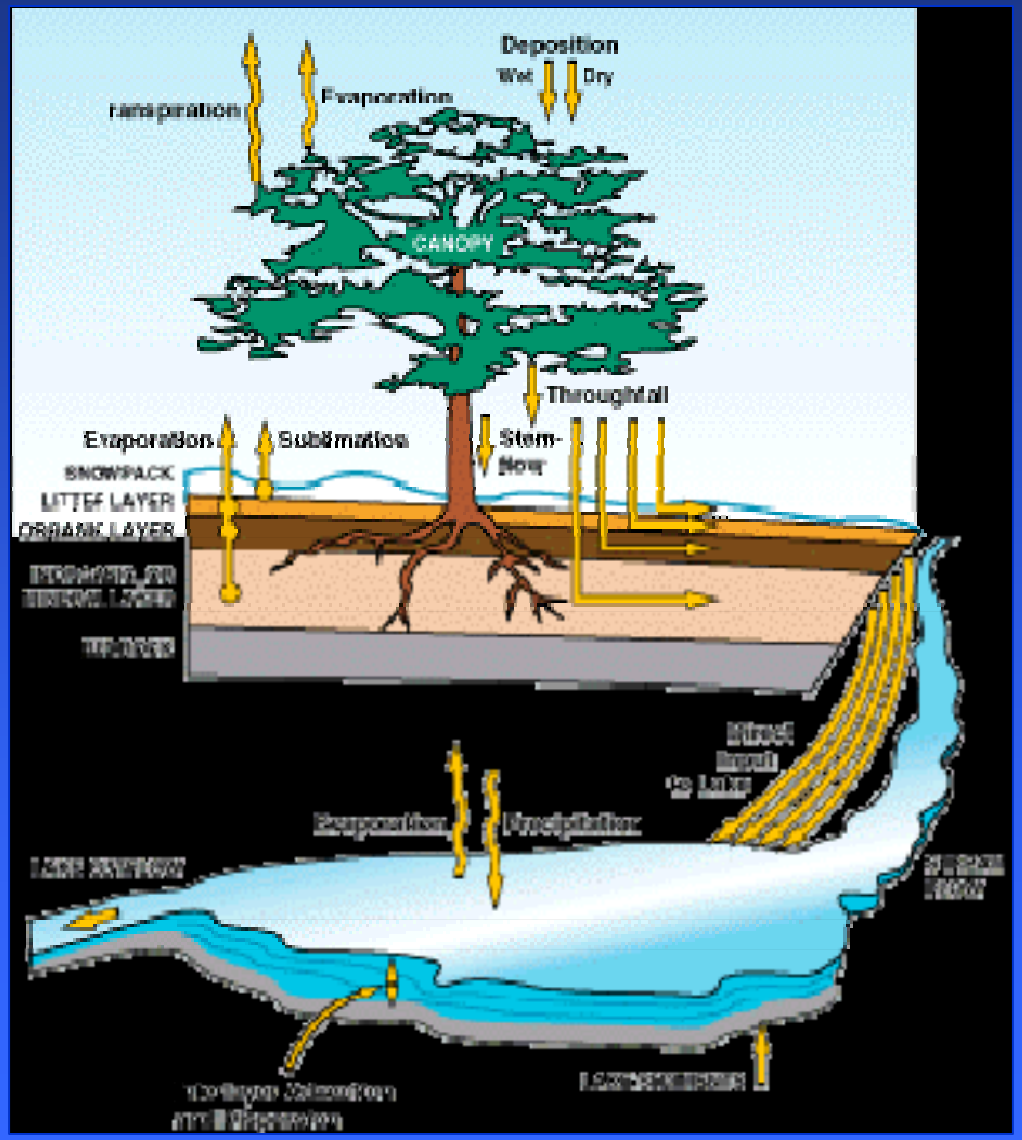
# Major Components of CEEOT



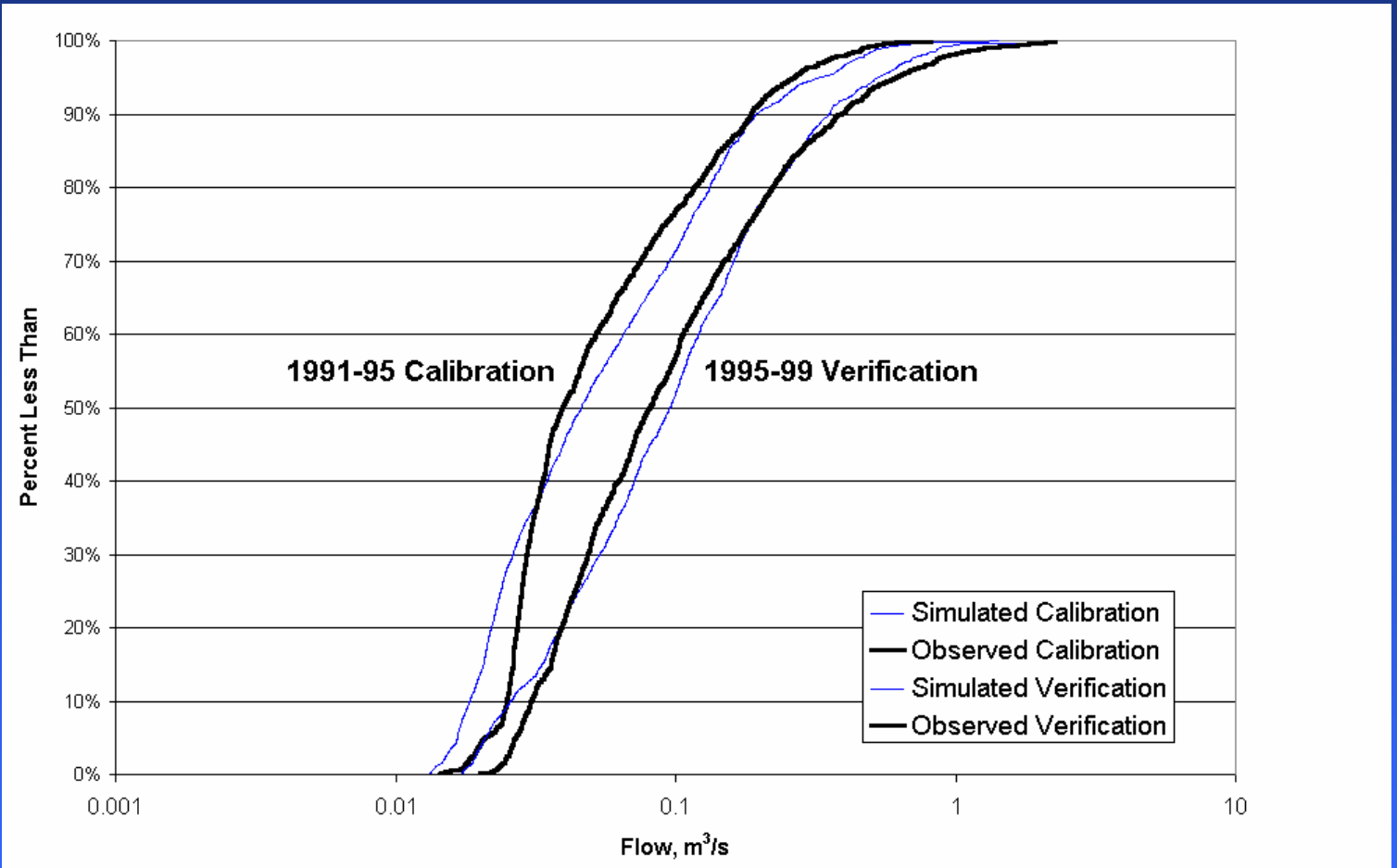
# Schematic of Forest Watershed Modification in APEX



# Watershed Analysis Risk Management Framework (WARMF)



# WS5 Calibration/Verification WARMF- Mica Creek




Need to validate internal processes and pathways - Dr. Jeff McDonnell, OSU

# Conclusions

- Forest watershed research involves cycle between topics
- What are the basic pathways and intrinsic potential of forest waterbodies?
- How does disturbance shape forests and watersheds?
- How effective are BMPs?
- Are BMPs economically sustainable?
- How can we model forest watersheds?

# Agricultural Water Conservation for Irrigated Agriculture

Terry A. Howell

USDA-Agricultural Research Service

Conservation & Production Research Laboratory

Bushland, Texas

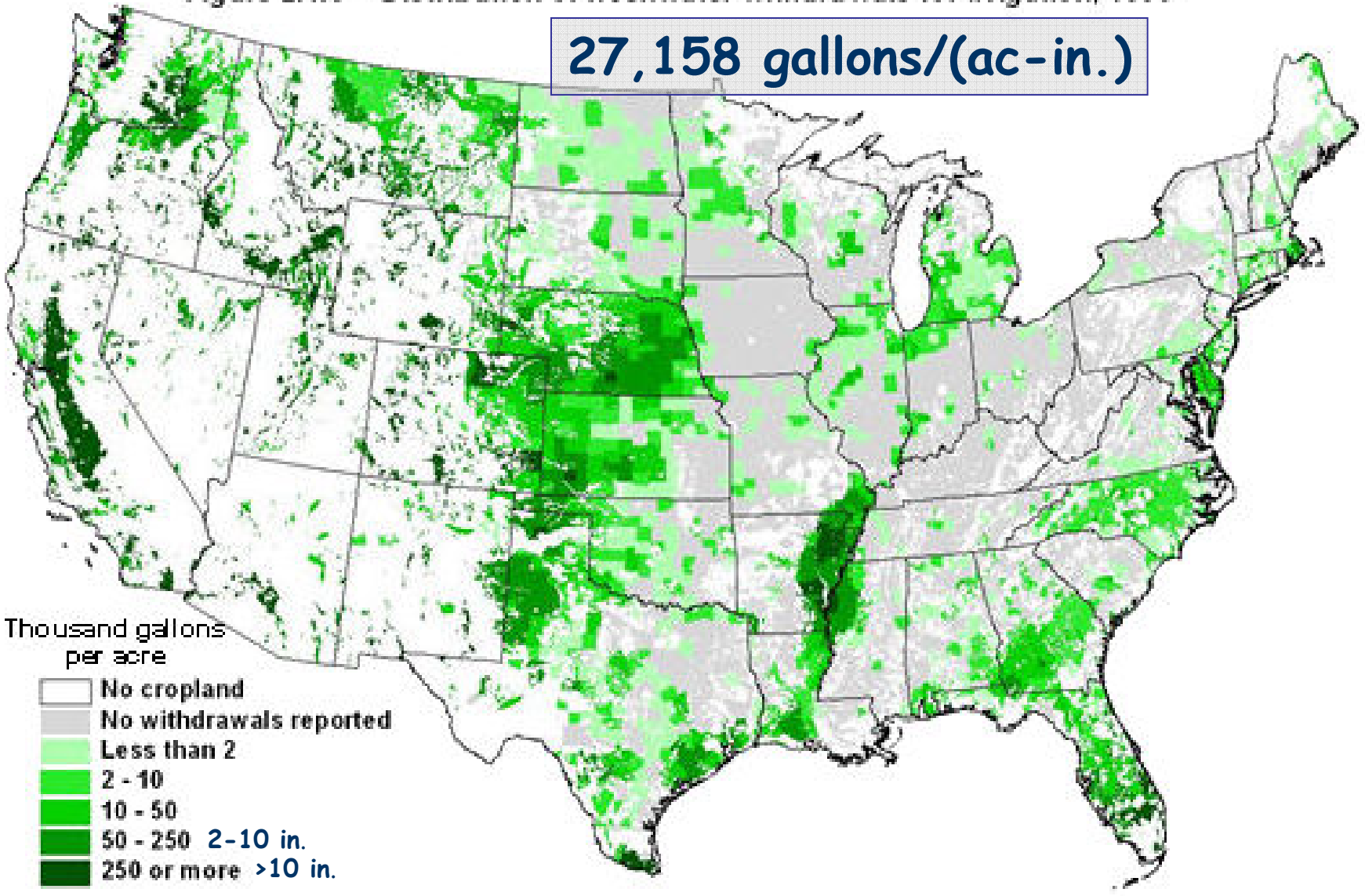
# Overview

- Irrigated agriculture remains the dominant use of fresh water in the United States
  - although irrigation's share of total consumptive use is declining
- National irrigated cropland area has expanded over 40 percent since 1969
  - field water application rates (volume/unit area) have declined about 20 percent
- The total quantity [or volume] of irrigation water applied increased about 15 percent since 1969. Nationally, variable irrigation water costs for ground water averaged $32 per acre and off-farm surface water about $41 per acre
  - Neither *reflects* the full costs of water (subsidizes for publicly developed off-farm surface water supplies)

Source: USDA-ERS AH 722, 2003

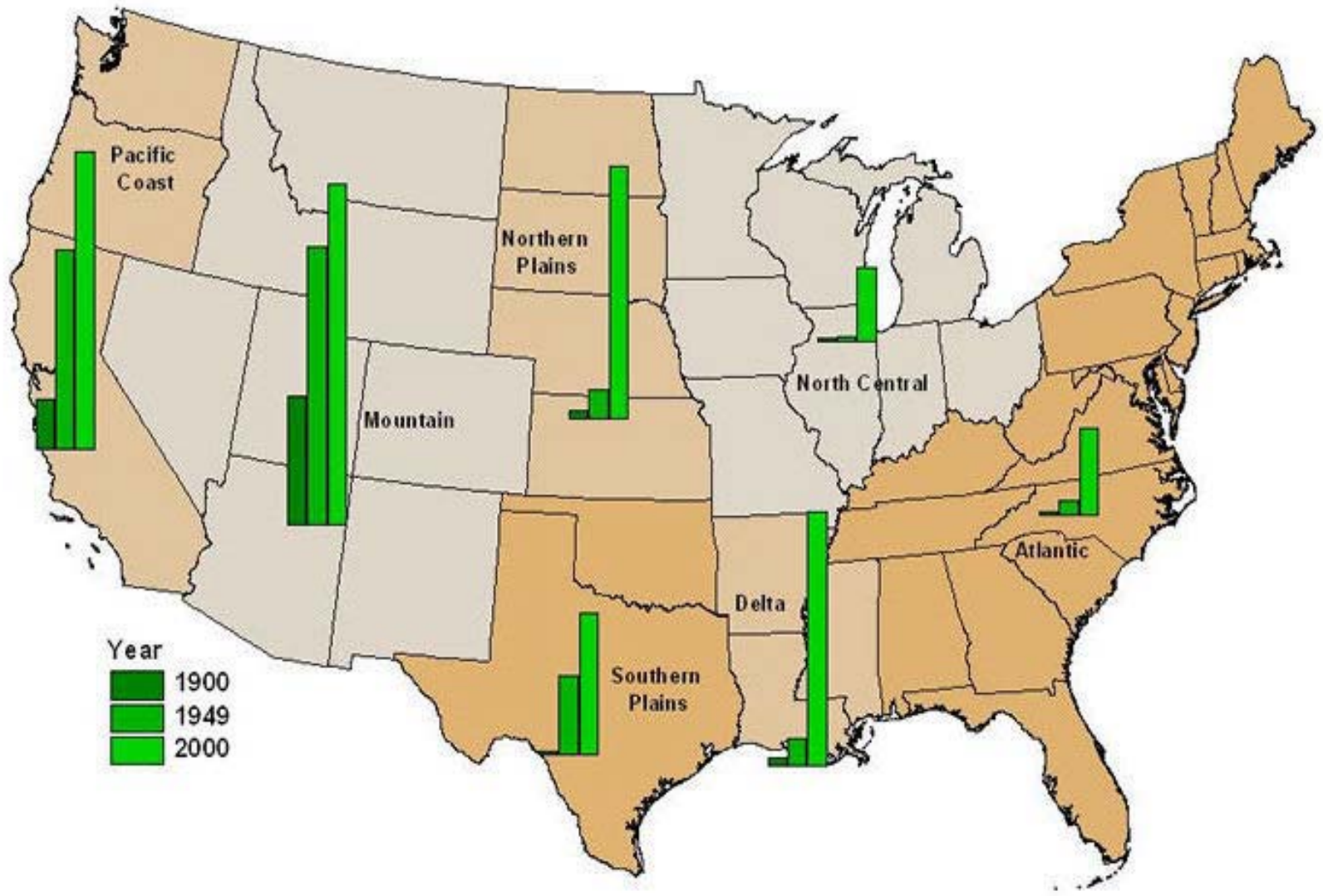
Figure 2.1.3 -- Distribution of freshwater withdrawals for irrigation, 1995

**27,158 gallons/(ac-in.)**



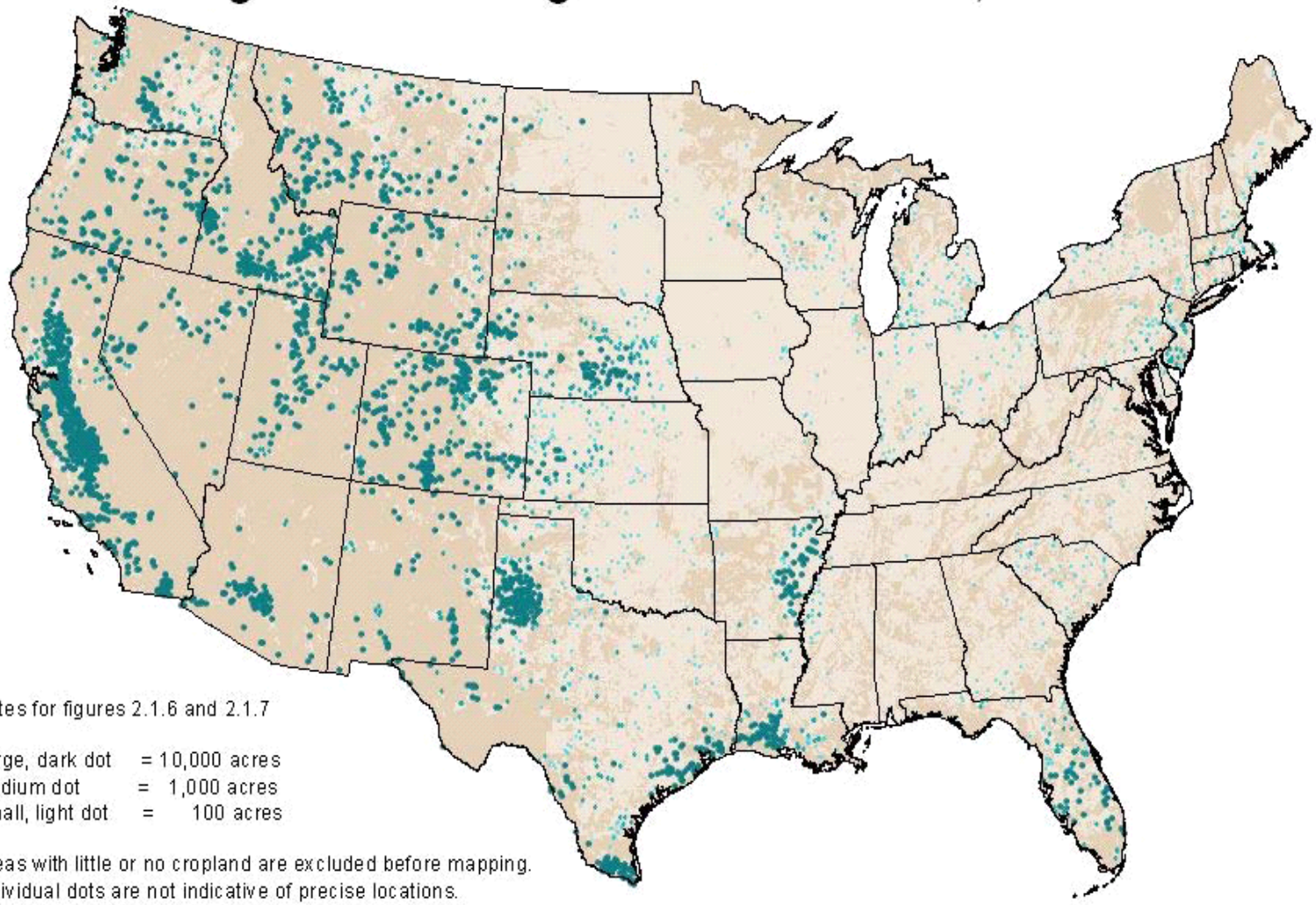

Source: USDA, ERS based on Solley et al, 1998. Total county volumes of withdrawal are averaged over the mapped area segments of each county. Mapped segments are those identified as having significant cropland

## Figure 2.1.4 -- Irrigated area by region for 1899, 1949, and 2000




Source: Census of Agriculture: USDOI/U.S.Census Office (1902); USDOC/Bureau of the Census (1952); USDA/ERS estimates, Table 2.1.2

# Figure 2.1.6--Irrigated land in farms, 1949



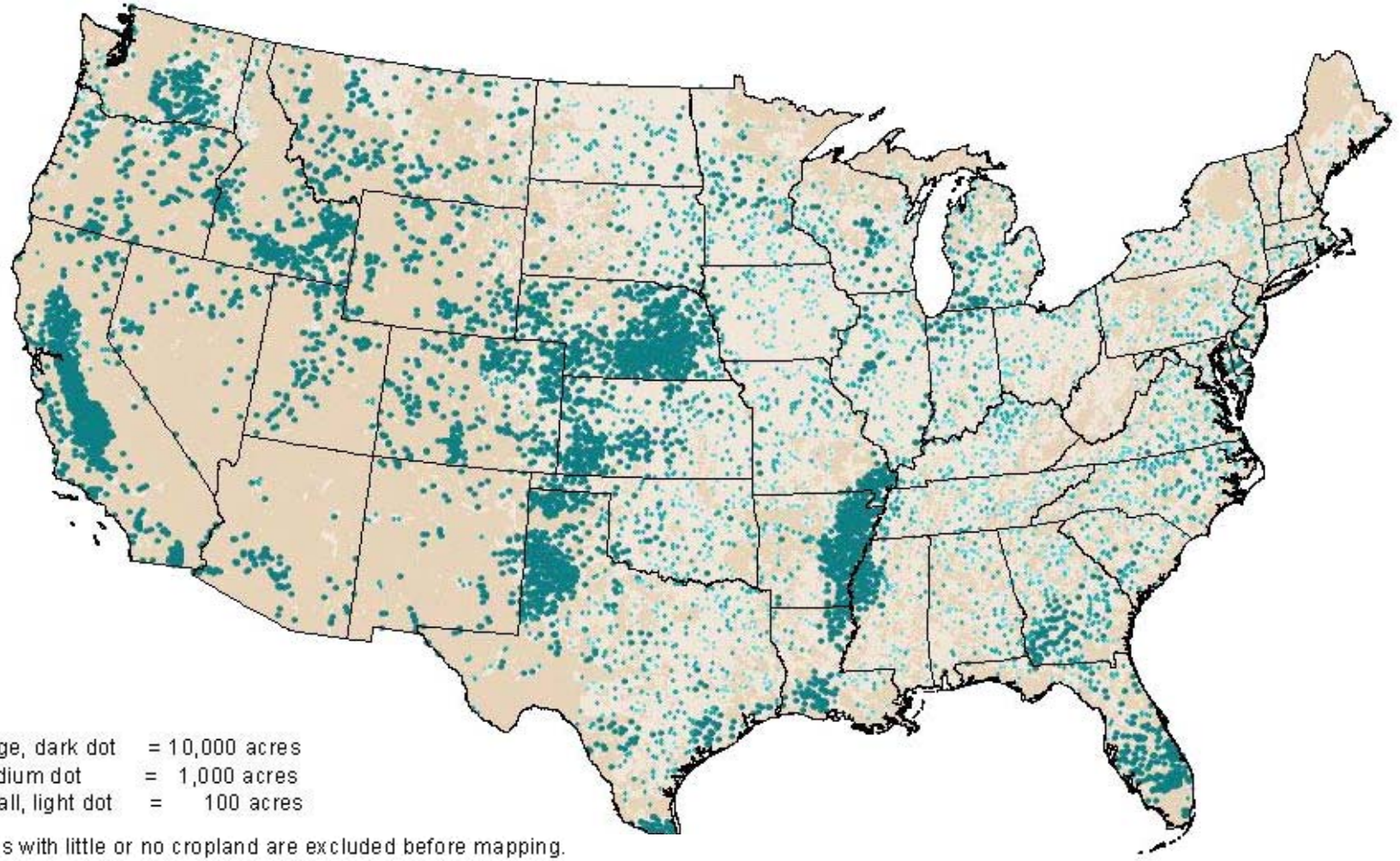
Notes for figures 2.1.6 and 2.1.7

Large, dark dot = 10,000 acres
Medium dot = 1,000 acres
Small, light dot = 100 acres

Areas with little or no cropland are excluded before mapping.
Individual dots are not indicative of precise locations.

Source: USDA, ERS based on Census of Agriculture:
USDoC, Bureau of the Census, 1949 and USDA, NASS, 1997

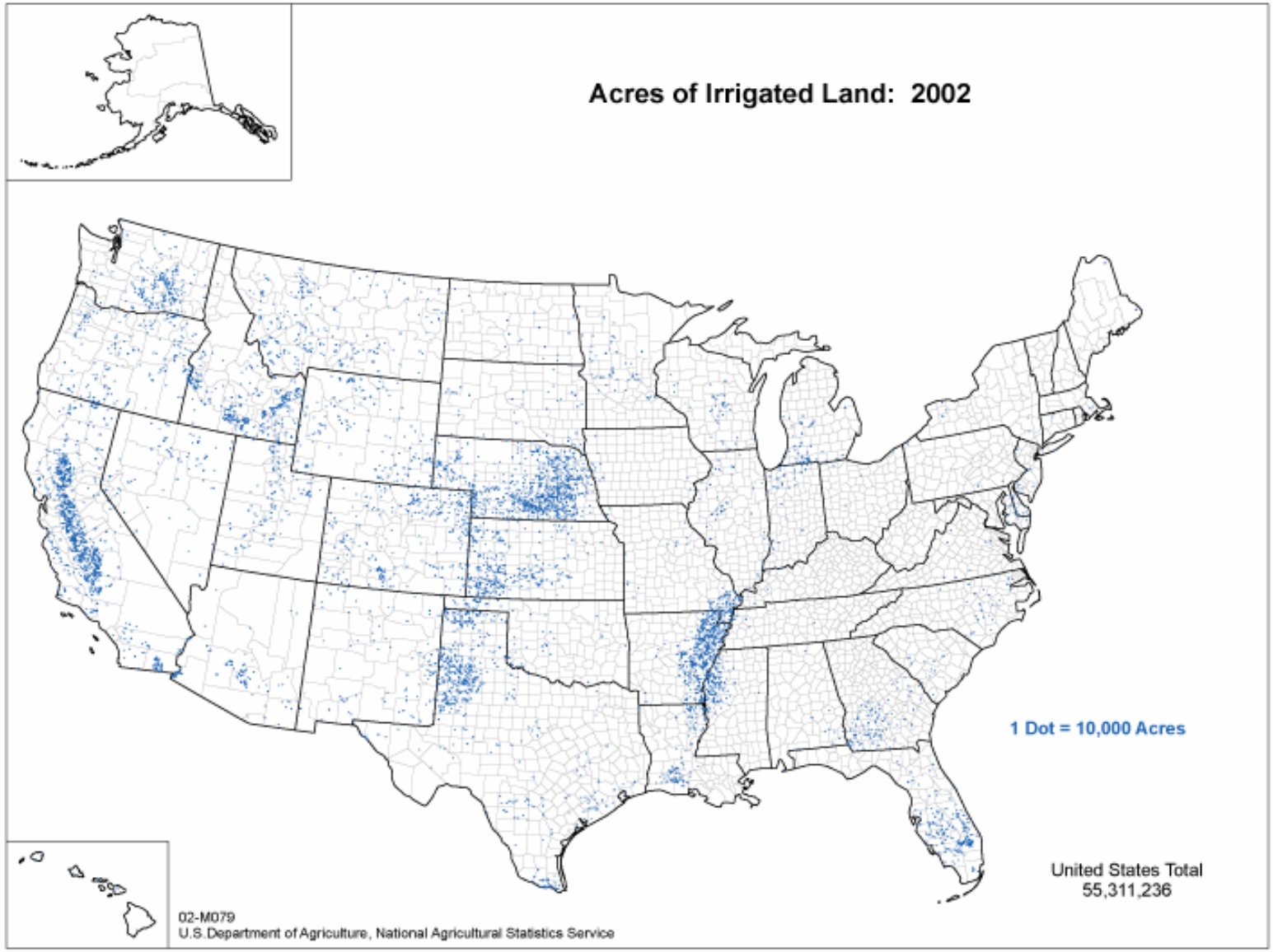
# Figure 2.1.7--Irrigated land in farms, 1997

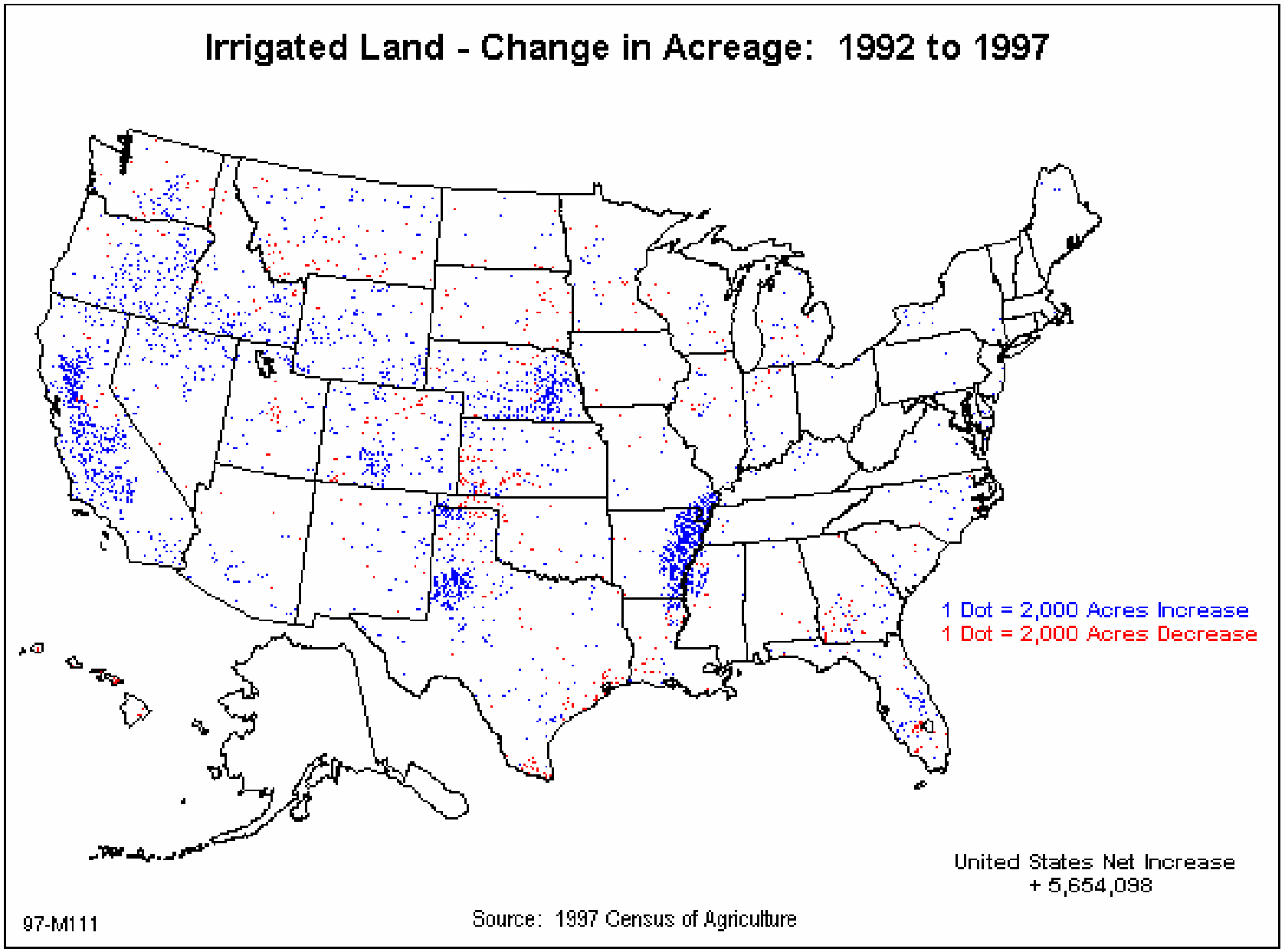


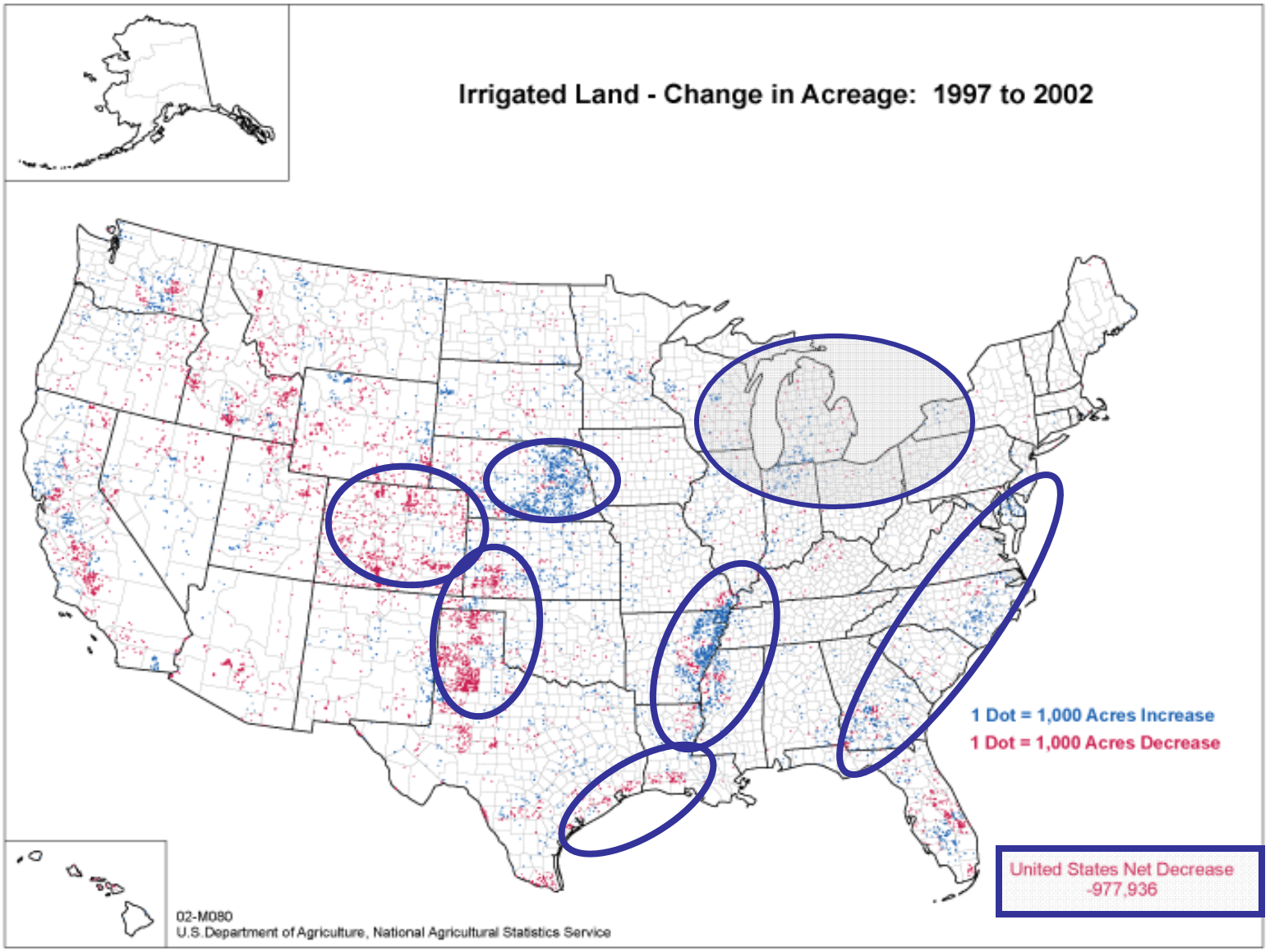
Large, dark dot = 10,000 acres
Medium dot = 1,000 acres
Small, light dot = 100 acres

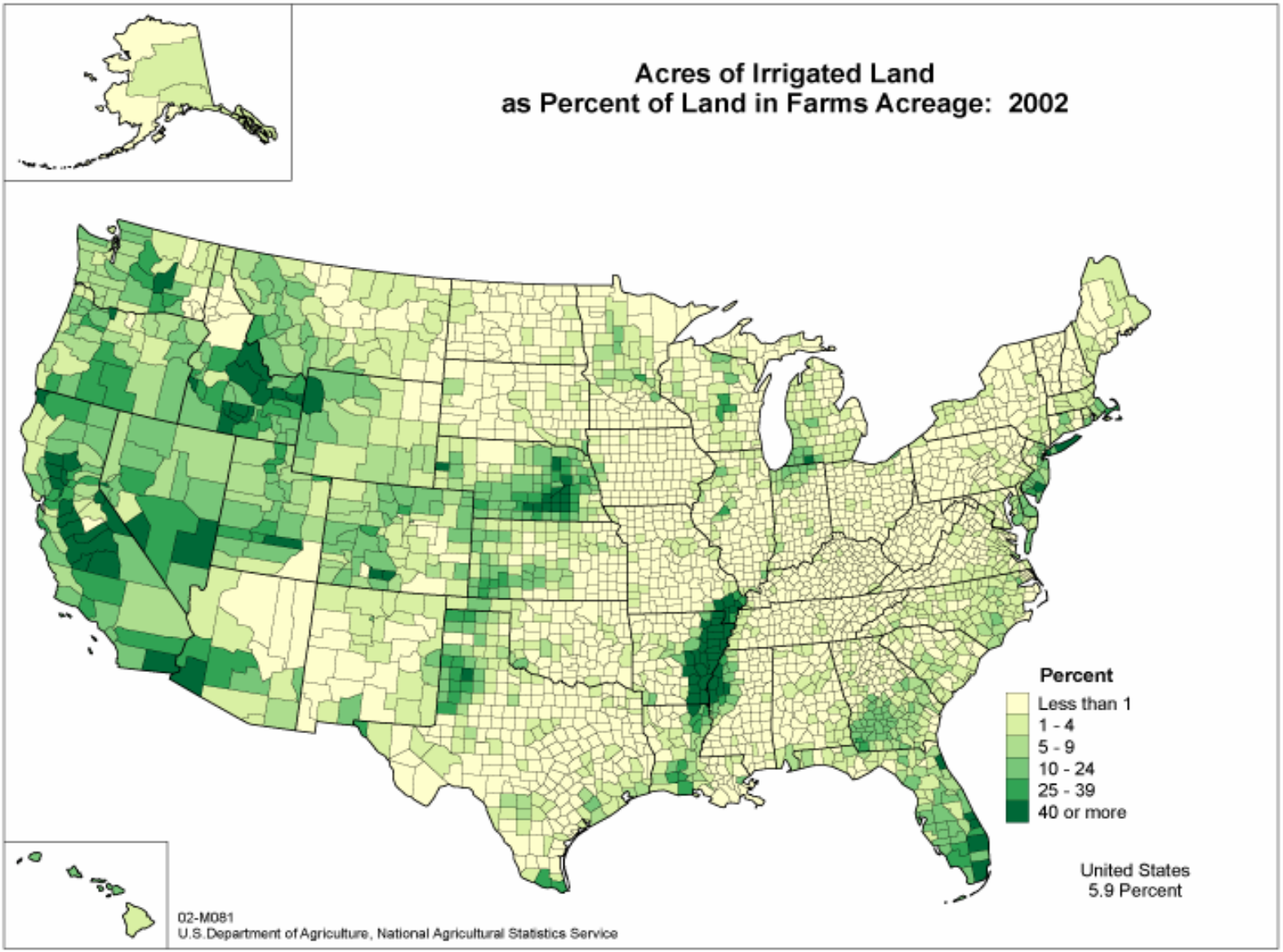
Areas with little or no cropland are excluded before mapping.
Individual dots are not indicative of precise locations.

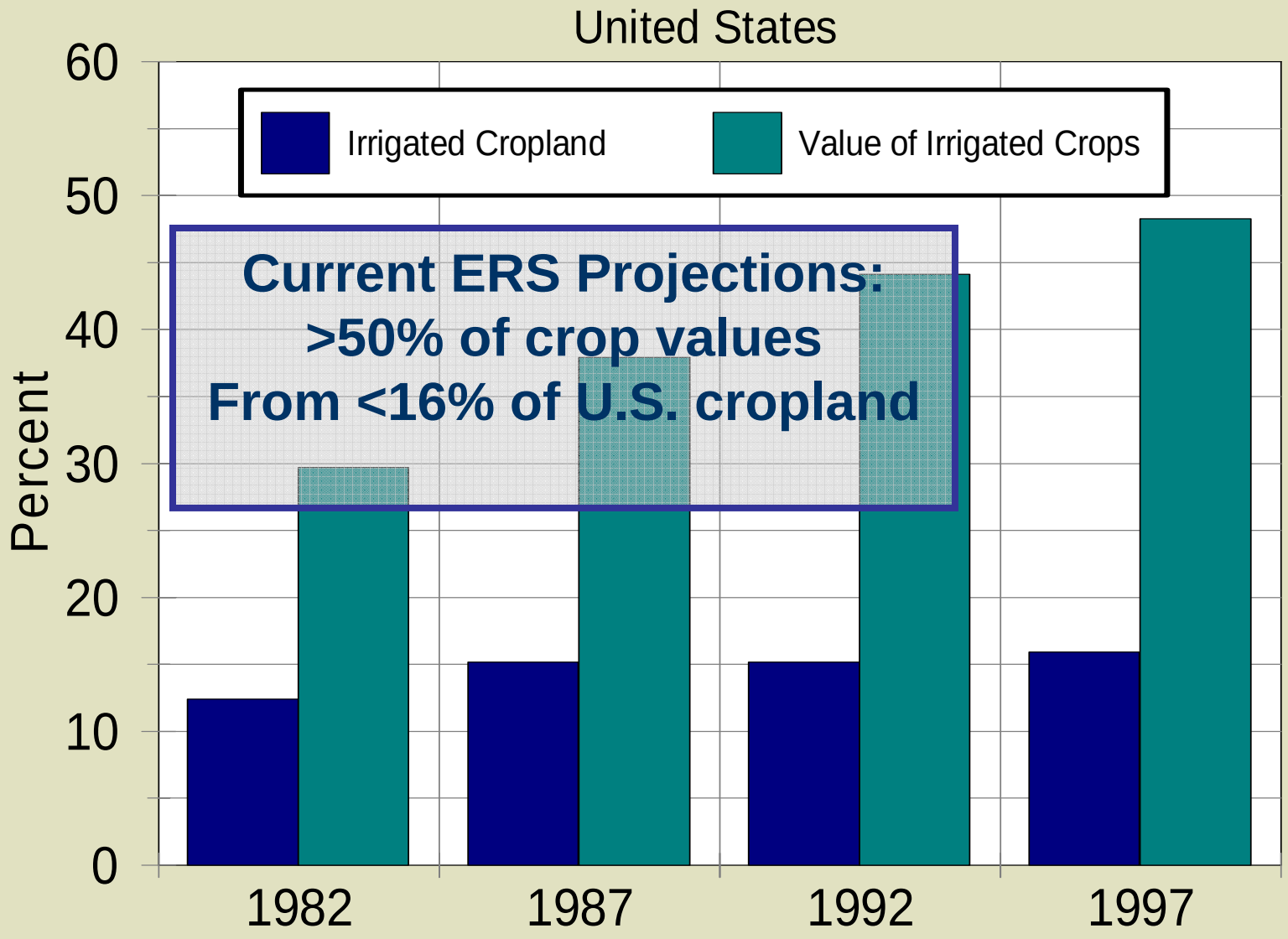
Source: USDA, ERS based on Census of Agriculture:
USDoC, Bureau of the Census, 1949 and USDA, NASS, 1997


Acres of Irrigated Land: 2002
1 Dot = 10,000 Acres
United States Total
55,311,236
02-M079
U.S.Department of Agriculture, National Agricultural Statistics Service


Irrigated Land - Change in Acreage: 1992 to 1997
1 Dot = 2,000 Acres Increase
1 Dot = 2,000 Acres Decrease
United States Net Increase
+ 5,654,098
97-M111
Source: 1997 Census of Agriculture

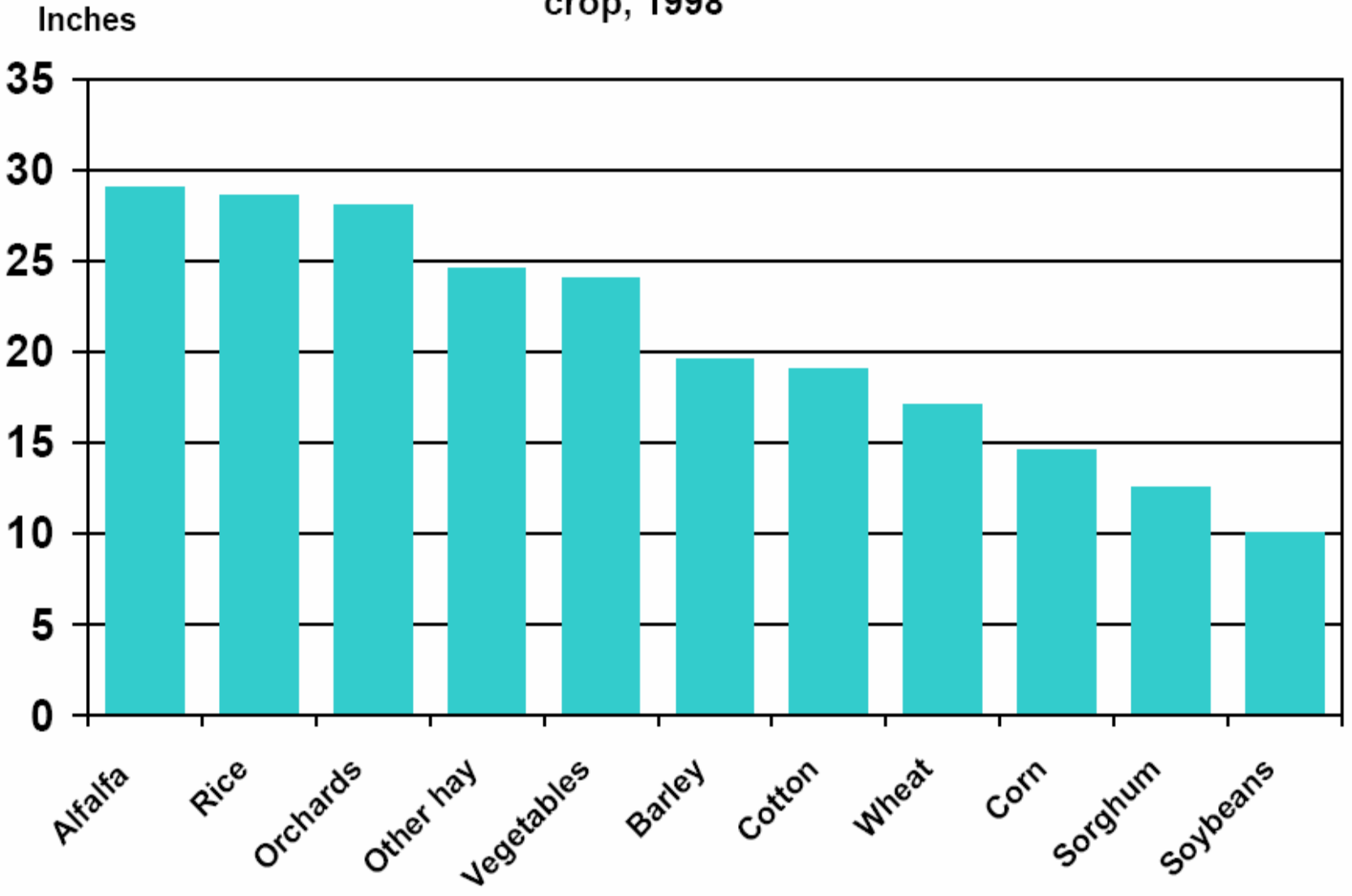

Irrigated Land - Change in Acreage: 1997 to 2002
1 Dot = 1,000 Acres Increase
1 Dot = 1,000 Acres Decrease
United States Net Decrease
-977,936
02-M080
U.S.Department of Agriculture, National Agricultural Statistics Service


Acres of Irrigated Land
as Percent of Land in Farms Acreage: 2002
Percent
Less than 1
1 - 4
5 - 9
10 - 24
25 - 39
40 or more
United States
5.9 Percent
02-M081
U.S.Department of Agriculture, National Agricultural Statistics Service




Source: 1997 Census of Agriculture (1999)

## Figure 2.1.8 -- Average depth of irrigation water applied by crop, 1998




Source: USDA/NASS, 1998 Farm and Ranch Irrigation Survey

# Implications ?

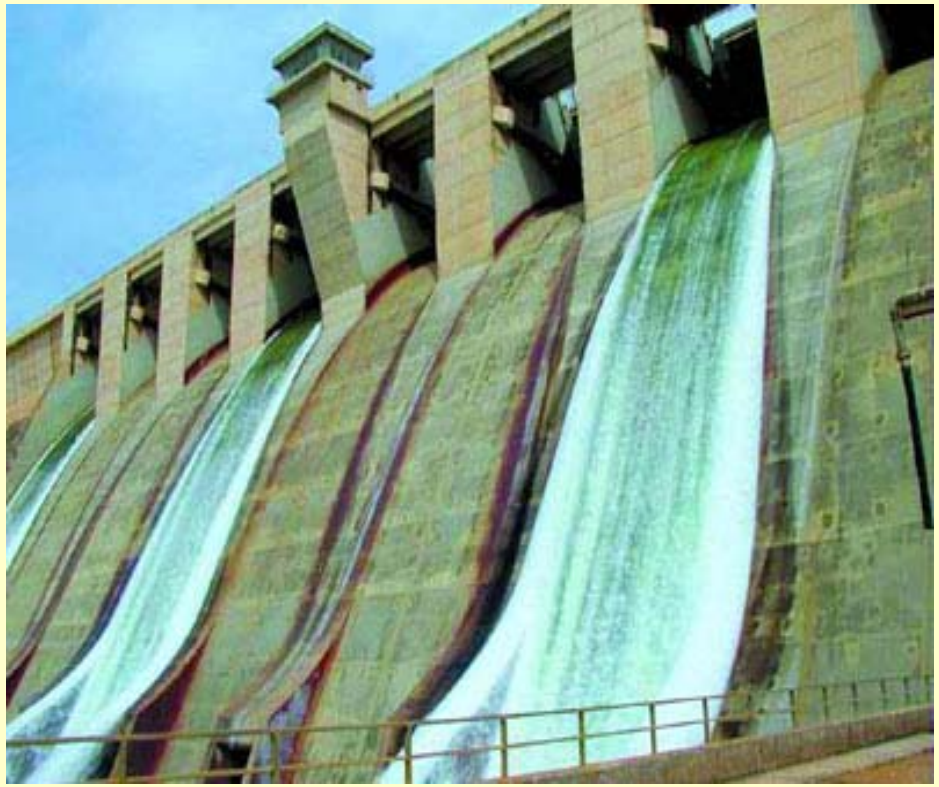
- U.S. Food security
  - Quantity
    - Also, worldwide implications
  - Quality
    - (Homeland security issues)

# Is Water Abundant?

- There's plentiful annual renewable freshwater in the U.S.
  - ~1,500 million acre-feet/year
- ONLY about 90% of the total U.S. water use is renewable, however
  - 10%+ comes from depleting ground water resources

# Meeting the Growing Demand

- Dam construction
  - Slowed and negative (i.e., dam removals) in some cases
    - Lack of funding
    - Environmental issues
- Interbasin Transfer
  - Growing in importance and frequency, particularly for urban needs



# Future Water Demands

- Met by reallocation of existing supplies
  - Water markets
  - Water transfers
- Since Agriculture is THE largest water user (of high quality and inexpensive water), it will be the most likely segment to be impacted

# U.S. Irrigated Agriculture

- Growing economic significance
- Growing significance in national food security
- Under pressure from other water consumption and needs
- Developing national education and training need

# THANKS

- If there's time for questions, I'll address them now or catch me during breaks or visit our web site at http://www.cprl.ars.usda.gov.

- If you don't receive our unit news, the *Wetting Front*, leave me a card or contact me (806) 356-5746 or email (tahowell@cprl.ars.usda.gov). The *Wetting Front* is available via "snail" mail (by subscription) and on the web.

# Status of Research and Challenging Issues: Agriculture

**Sandra S. Batie**

**MSU**

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# Agriculture, Sustainability, and the GLB

- Issues are huge!
- Only 10 minutes!
- What a challenge!

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# Sustainability

- **Sustainability is about informed thinking about the future**

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# What would a sustainable agriculture sector look like in a restored GLB?

- Do we even want agriculture in the GLB?
- What changes and what research will improve our prospects of obtaining this future?

? ? ?

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# Do we want agriculture in the GLB?

- Yes
- It is a key component of a system

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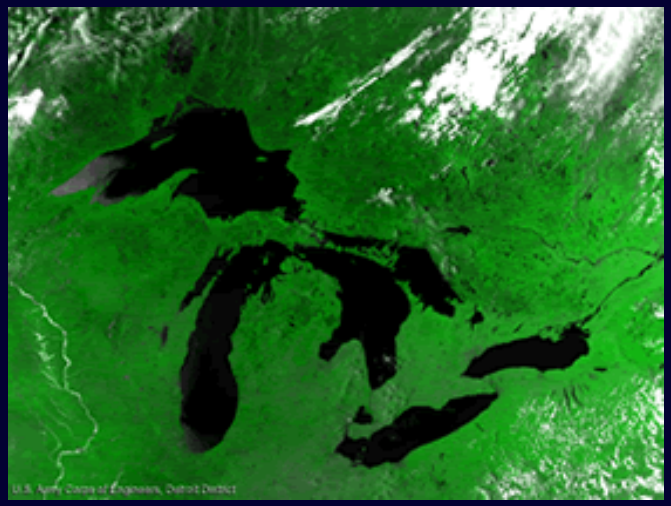
# Great Lakes Basin

- Agriculture land use dominates the southern portions of the basin
- 24 % of the entire basin
- 35 % of the terrestrial area



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# Agriculture

- **Land use/open space**
- **Habitat**
- **Water Quality**
- **Hydrologic Cycle**
- **Carbon Sequestration**
- **Economic Sector**
  - Food and Fiber
  - Agro-Tourism

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# What would a sustainable agriculture sector in a restored GLB look like?

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# A Possible Future

- Populated countryside
- Healthy, vibrant communities
- Inhabited with friendly people who are good stewards
- A safe and welcoming landscape
- Good livings for farmers and workers

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# A Possible Future

- **Clean, unpolluted, unpolluting, uncrowded**
- **Produces healthy, safe food**
- **Provides excellent wildlife habitat**
- **Attractive to visit, appealing visual amenities**

» Nassauer, 1997

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# Changes and Research?

- It depends on how we frame the issues

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# My Points

- **Our concepts of sustainability underlies how we frame issues and problems with respect to agriculture's impact on environmental health, community health, and human health**

- Paul Thompson

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# If

- **Focus on a farm field—look at soil, water, nutrients**
- **Focus on farms, groups of farms, or watersheds—look at landscape features, riparian corridors**
- **Focus on the farmer-- look to banks, markets, cultural influences, institutions**
- **Focus on water-- look to temperature, toxics, habitat. biodiversity**

» Paul Thompson

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# The Land Manager: The Farmer

- The choices made as to land management are critical
- Achieving sustainable outcomes requires influencing these choices

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# Influences on the Farmer

Inputs
$$
Land
Water

Government Programs

Market Forces
Supply Chain

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# Farmer's Influences

Water Quality and Quantity

Amenities

Human and Animal Health

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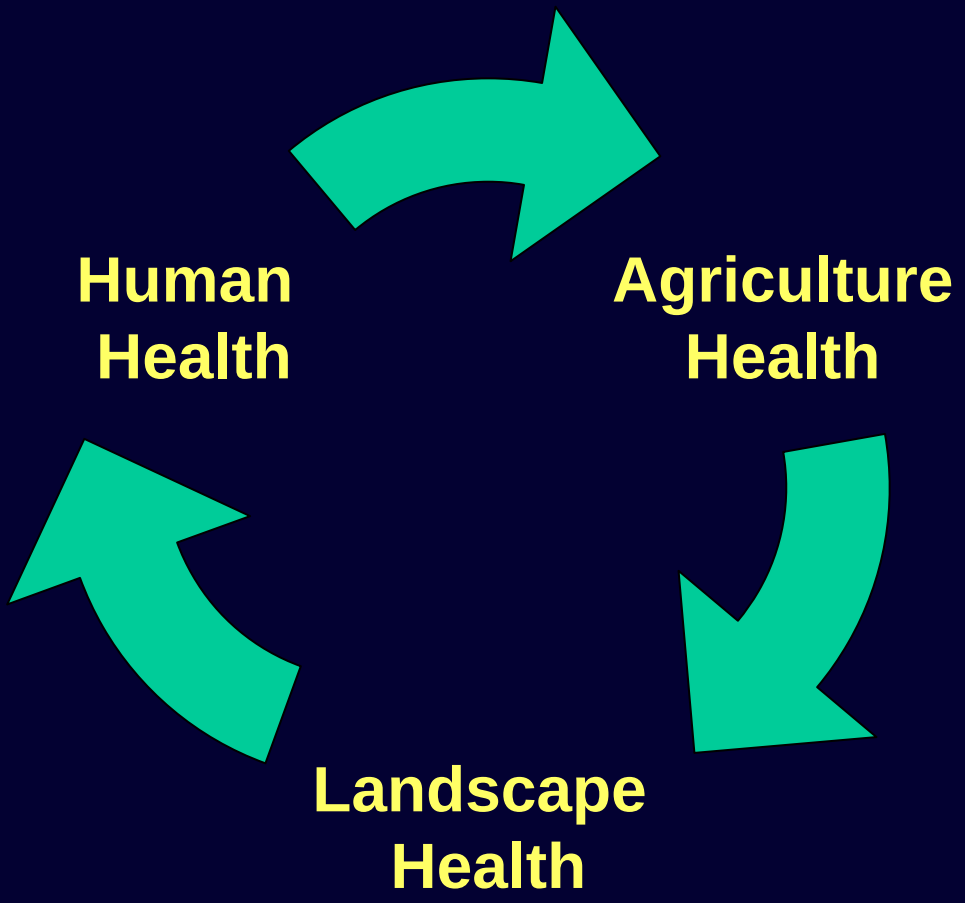
# The System

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# Research—"Systems Equilibrium"

- **Social Institutions and Systems**
  - Appropriate policies
    - Market-based
    - Cost-effective: target, tailor, transparent
    - Agency capacities

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# Research

- **Ecological systems**
  - Restoration science
    - Soil
    - Water
    - Habitat
  - Impacts on human and animal health

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# Research

- **Cultural identity**
  - Community vitality

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# Examples:

- Conserve and enhance soil quality including carbon sequestration capabilities
- Develop complementary technologies
- Improve efficiency of inputs
- Reduce risks of environmental damage
- Design market-based programs that protect resources

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# Examples:

- Increasing the resistance and resilience of agricultural landscapes
- Identifying the spatial and temporal variability of water pollutants
- Improved institutions to change land managers' behaviors
- Invest in complementary technologies

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# Examples:

- Identify tradeoffs in the pursuit of objectives
- Identify substitution possibilities
- Identify uses of manure that reflect understanding of mass balance concepts—thinking larger that a farm field
- Drawing lessons from other large scale restoration efforts for improved policy

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# A Final Point

- Developing sustainable indicators is a challenge for the restoration of the GLB
- Developing institutions that can receive and cost-effectively act on sustainable indicators is even a bigger challenge
- Incorporating the principles of sustainability into everyday actions is a huge challenge

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# All of these challenges

- **Will not be achieved without specific attention to them**

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# Great Lakes Water Research in the USDA Forest Service


Randy Kolka

**Project Leader & Research Soil Scientist**


North Central Research Station

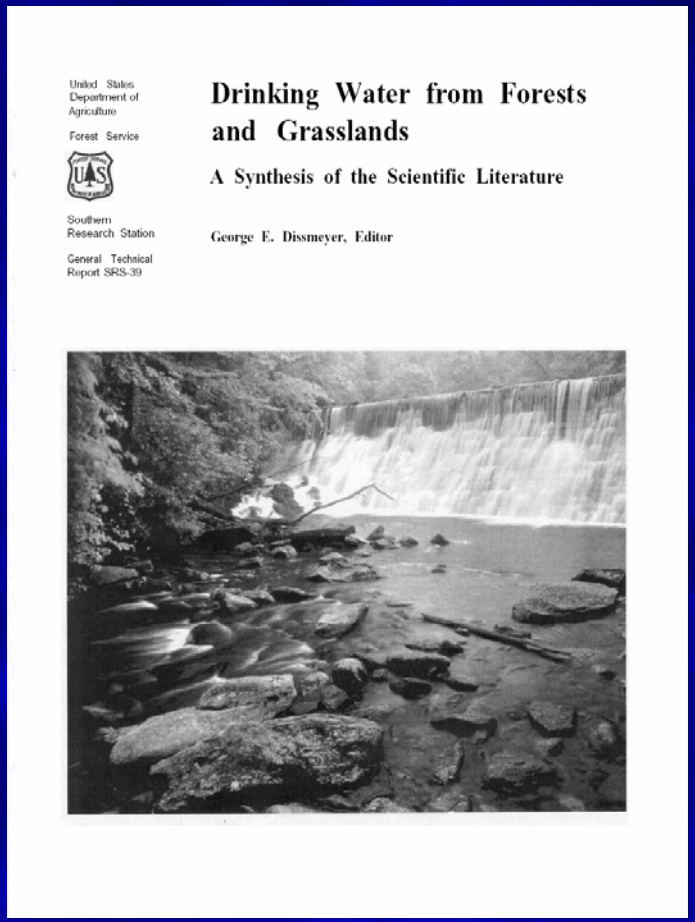
USDA Forest Service

# Background – Forest Service Structure

- National Forest System
- State and Private Forestry
- Research and Development

# National Forests

- National Forest System
  - 10 Regions
  - 15 National Forests in Northeast
  - ~12 million acres



United States Department of Agriculture

Forest Service

Southern Research Station

General Technical Report SRS-39

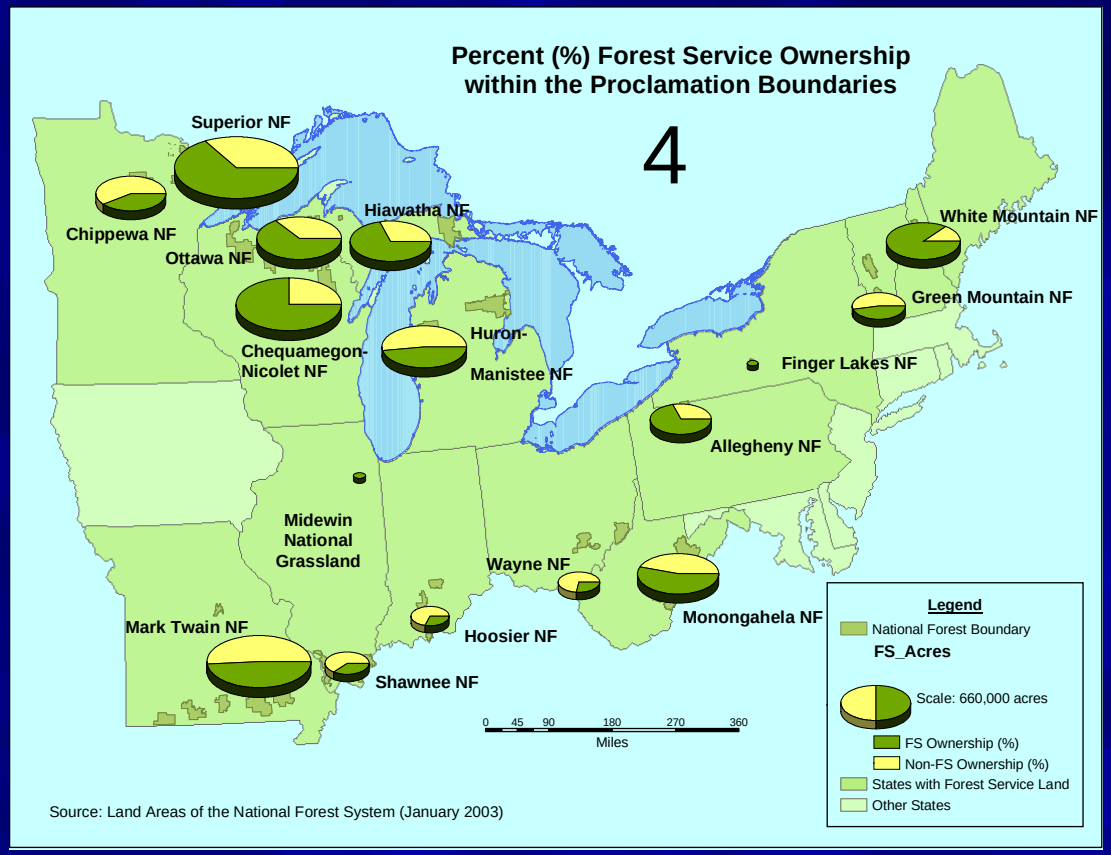
**Drinking Water from Forests and Grasslands**

A Synthesis of the Scientific Literature

George E. Dissmeyer, Editor

# National Forest Issues

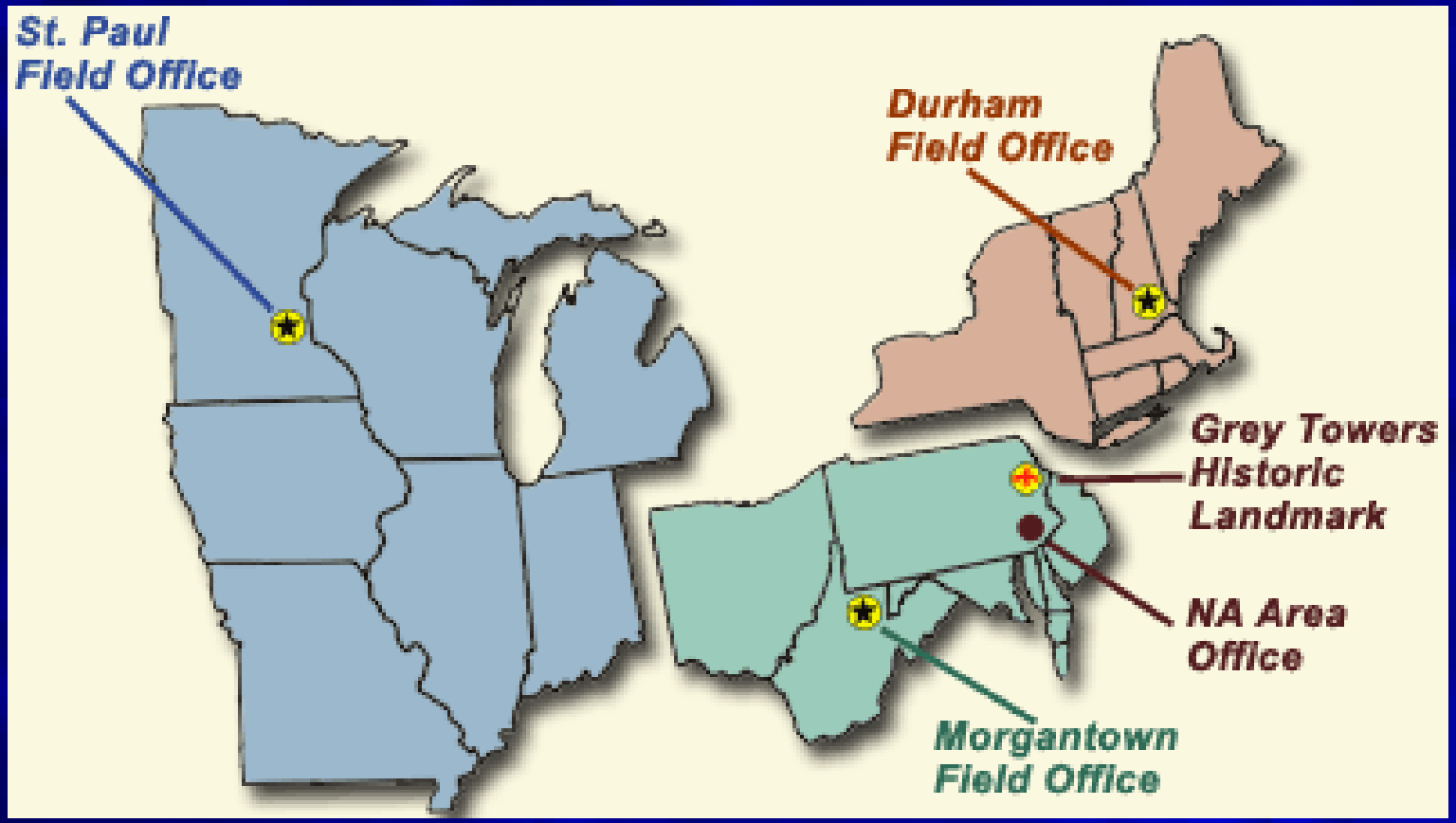
- **Watershed Health & Assessment**
  - **Physical**
  - **Chemical**
  - **Biological**
  - **Pollutants (Hg)**
  - **Invasive Species**




- **Mixed Land Uses**
  - **Need to Build Partnerships**

# State and Private Forestry

- **Northeastern Area**
  - **States, Tribes, Communities, Landowners**

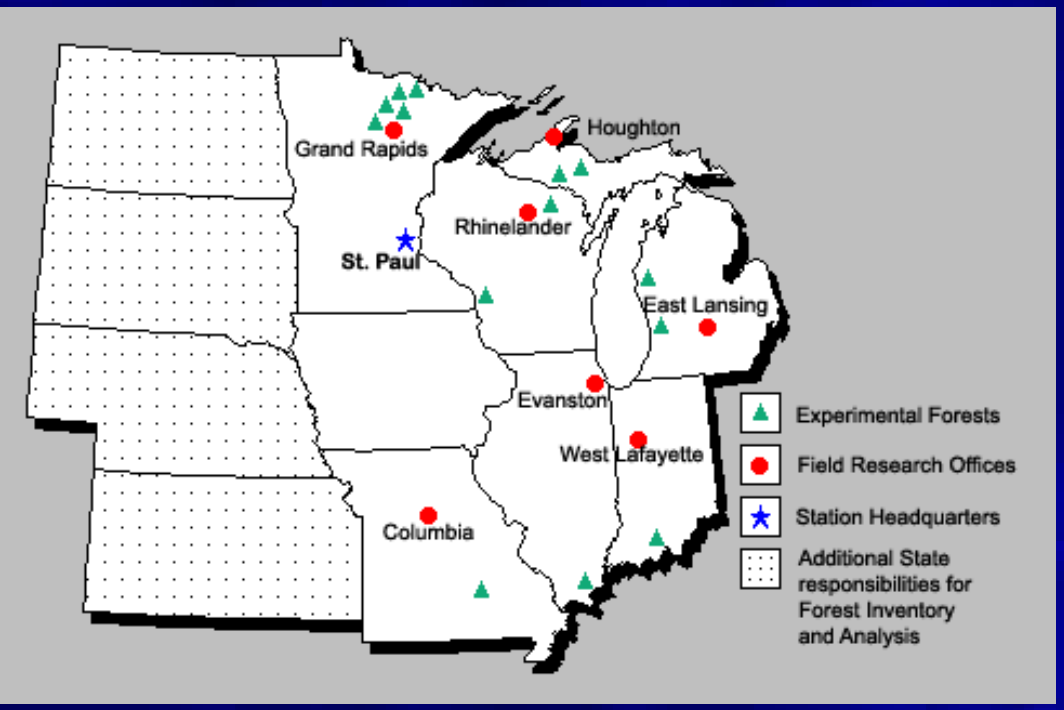


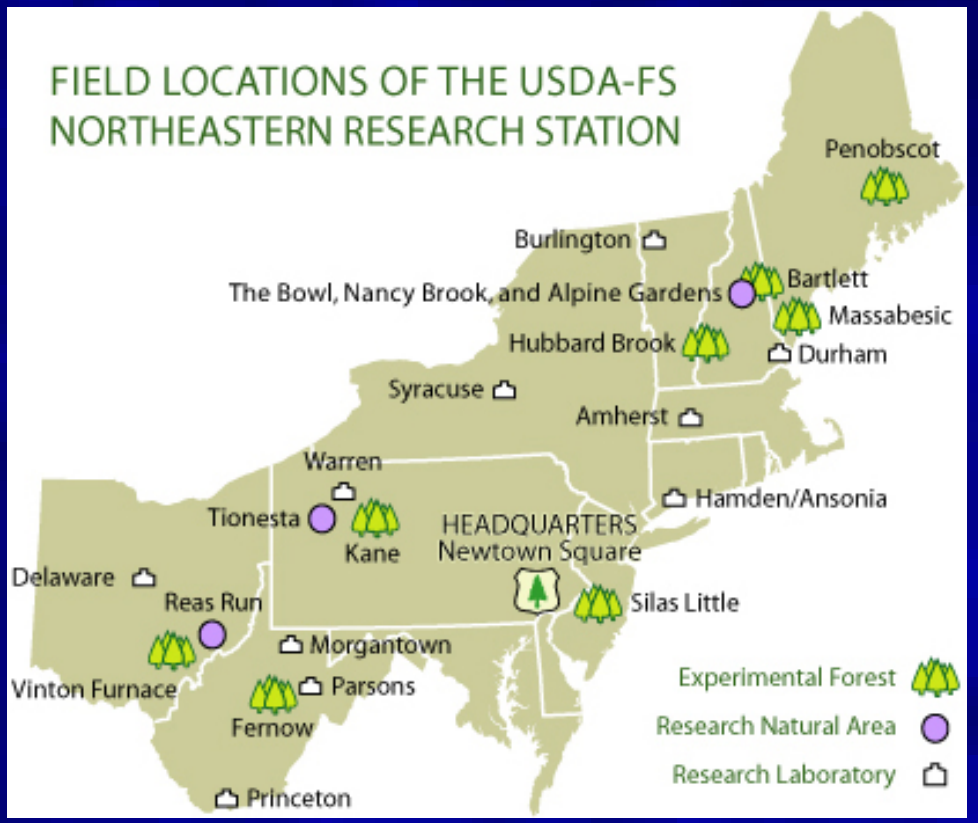
# State and Private Issues

- **Watershed Management**
  - **Mixed Use or Changing Use**
  - **Assessment of Change**
  - **Cumulative Effects**
  - **Riparian and Shoreline Management**

# Forest Service Research

- **Research and Development**
  - **Two Research Stations (NE & NC)**
  - **NE – 20 Research Work Units**
  - **NC – 14 Research Work Units**

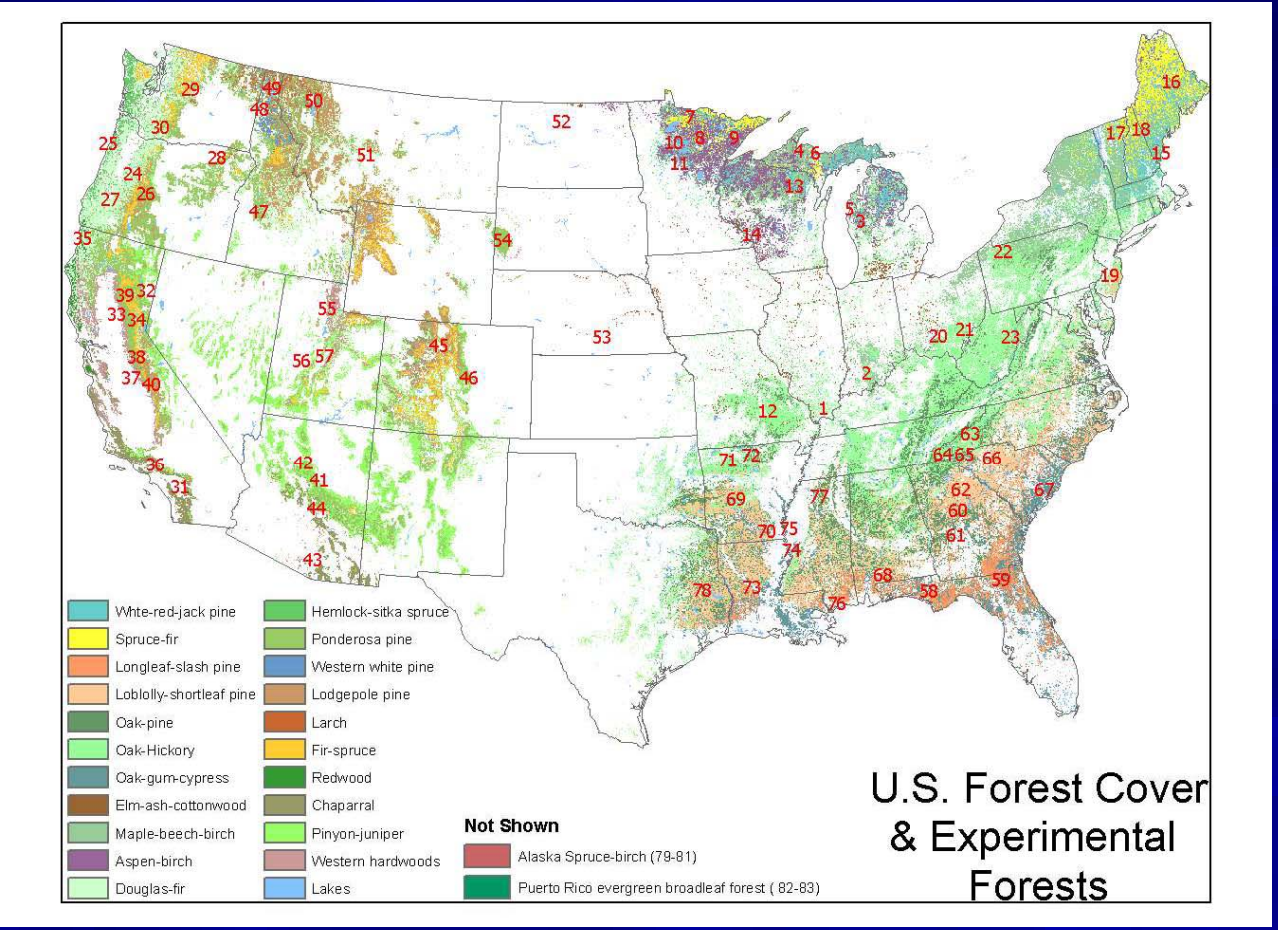



- **Water Research Units**
  - **Grand Rapids, MN; Amherst, MA; Parsons, WV; Durham, NH**

# Forest Service Research

- **Experimental Forests**
  - **23 in Great Lakes Region**
  - **Long-term Research**
  - **3 Active Water Related**
  - **Marcell, Hubbard Brook, Fernow**



# Experimental Forest Research

- Long-term Data Bases
- Reference Systems
- Manipulative Experiments
- Watershed Scale

# Hydrologic Data Bases
# HydroDB


(http://www.fsl.orst.edu/climhy)

# Long-term Hydrologic & Climate Data

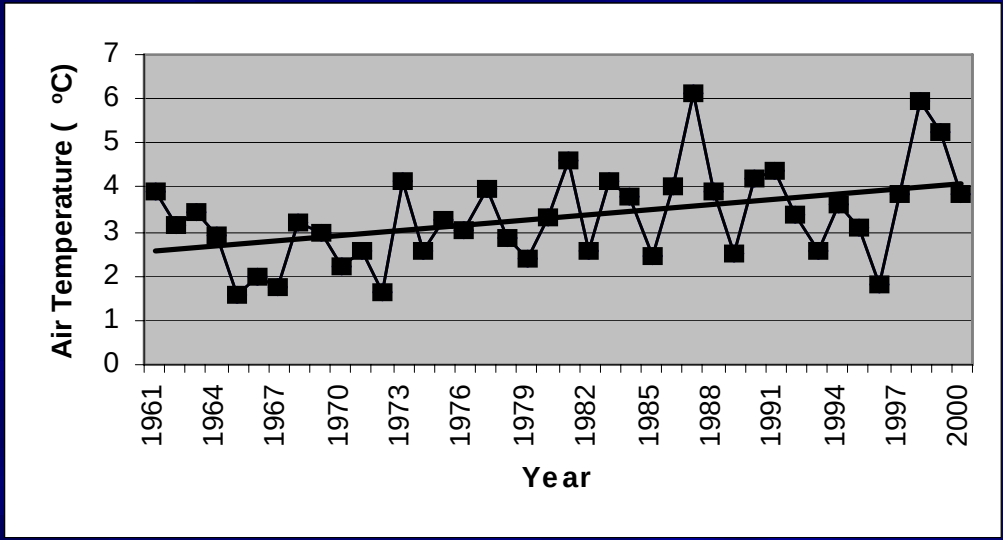



Figure 1. Forty-year trends in mean annual air temperature at the MEF.

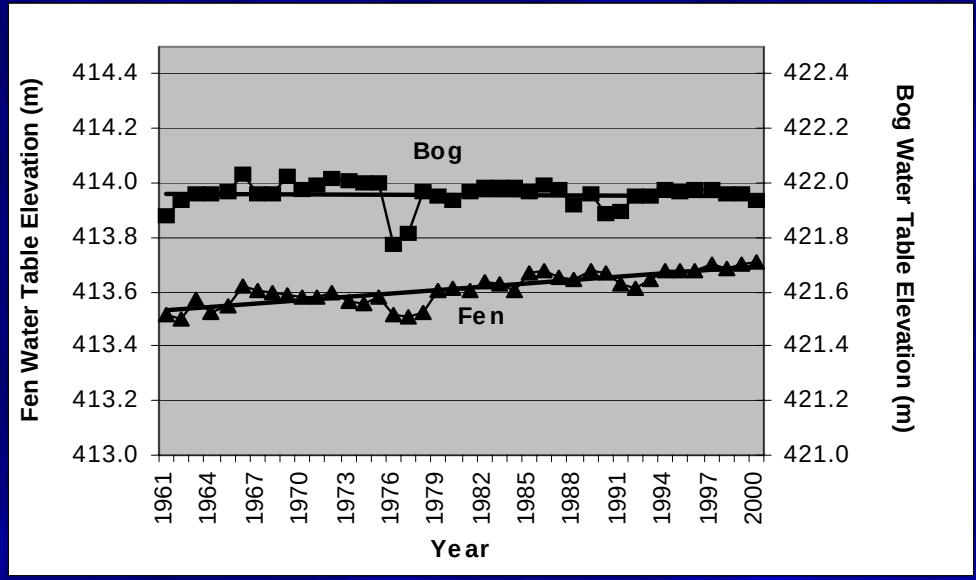


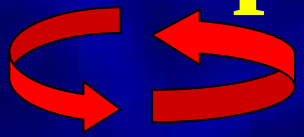

Figure 2. Forty-year trends in mean annual water table elevation for the S2 bog and S3 fen at the MEF.

# Forest Service Research

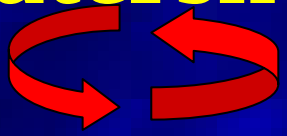
- Traditionally Forested Landscapes
  - BMPs for Forest Management
  - Streams, Lakes, Wetlands
  - Water Quantity, Quality, Biota
- New Research – Mixed Use Landscapes
  - Landscape Change/Fragmentation
  - Agricultural to Urban
  - Social Sciences
  - Modeling
- Restoration
  - Stream
  - Wetland

# Forest Service Research

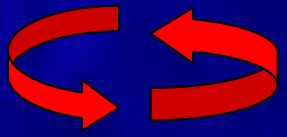
**Landscapes**



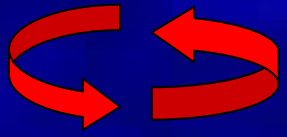
**Watersheds**



**Upland Areas**

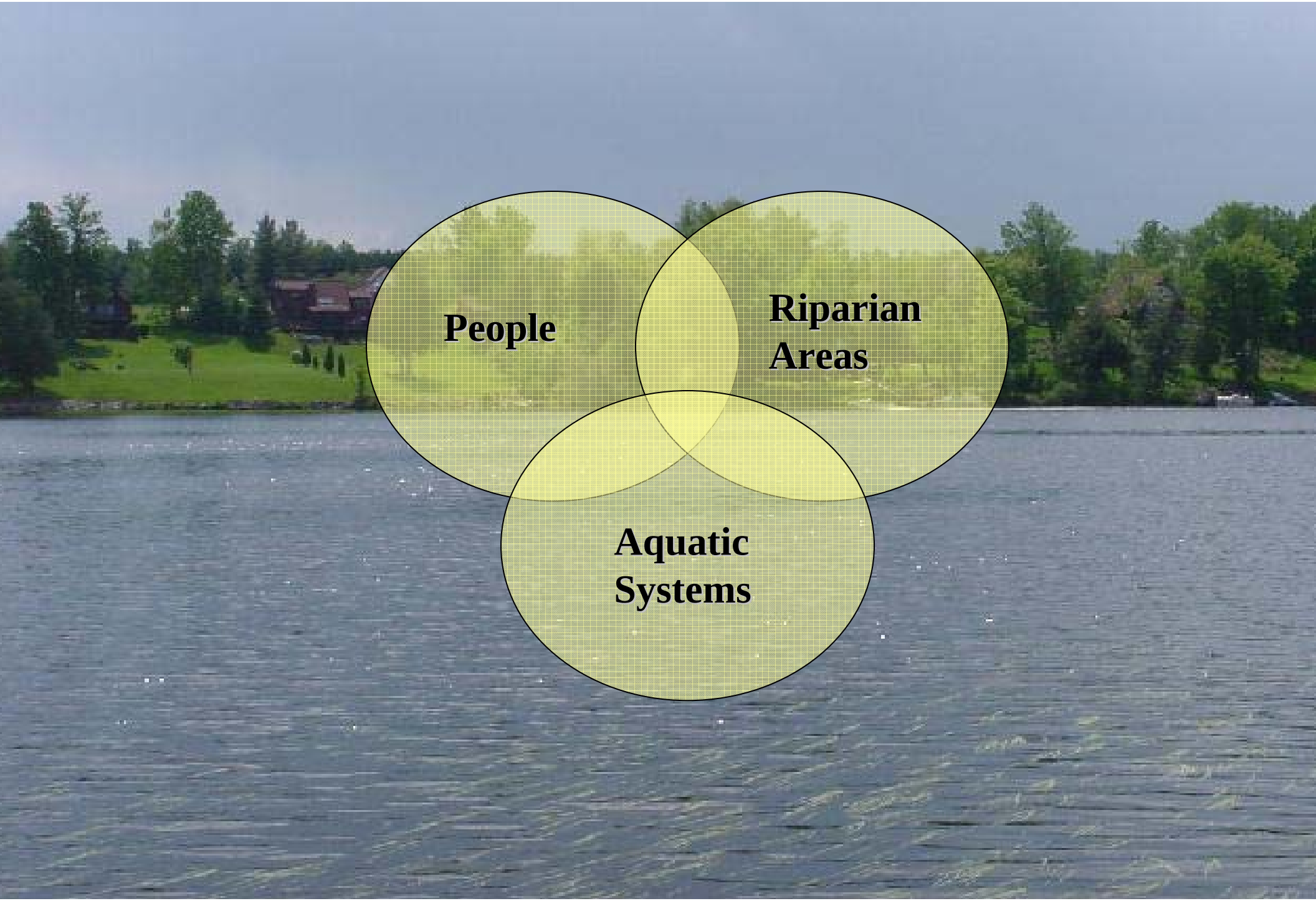


**Riparian Areas**



**Streams/Lakes/Wetlands**

- **Issues of Scale**
- **Cumulative Impacts**
- **Terrestrial/Aquatic Interactions**


People
Riparian Areas
Aquatic Systems

# Thank You!