Hydrology & Water Quality

November 17-19, 2008
Asheville, NC

Greg Jennings, PhD, PE
Professor & Extension Specialist
Biological & Agricultural Engineering
jennings@ncsu.edu

Biological & Agricultural Engineering

National Water Program
A Partnership of USDA CSREES & the Land Grant System
Applying knowledge to improve water quality

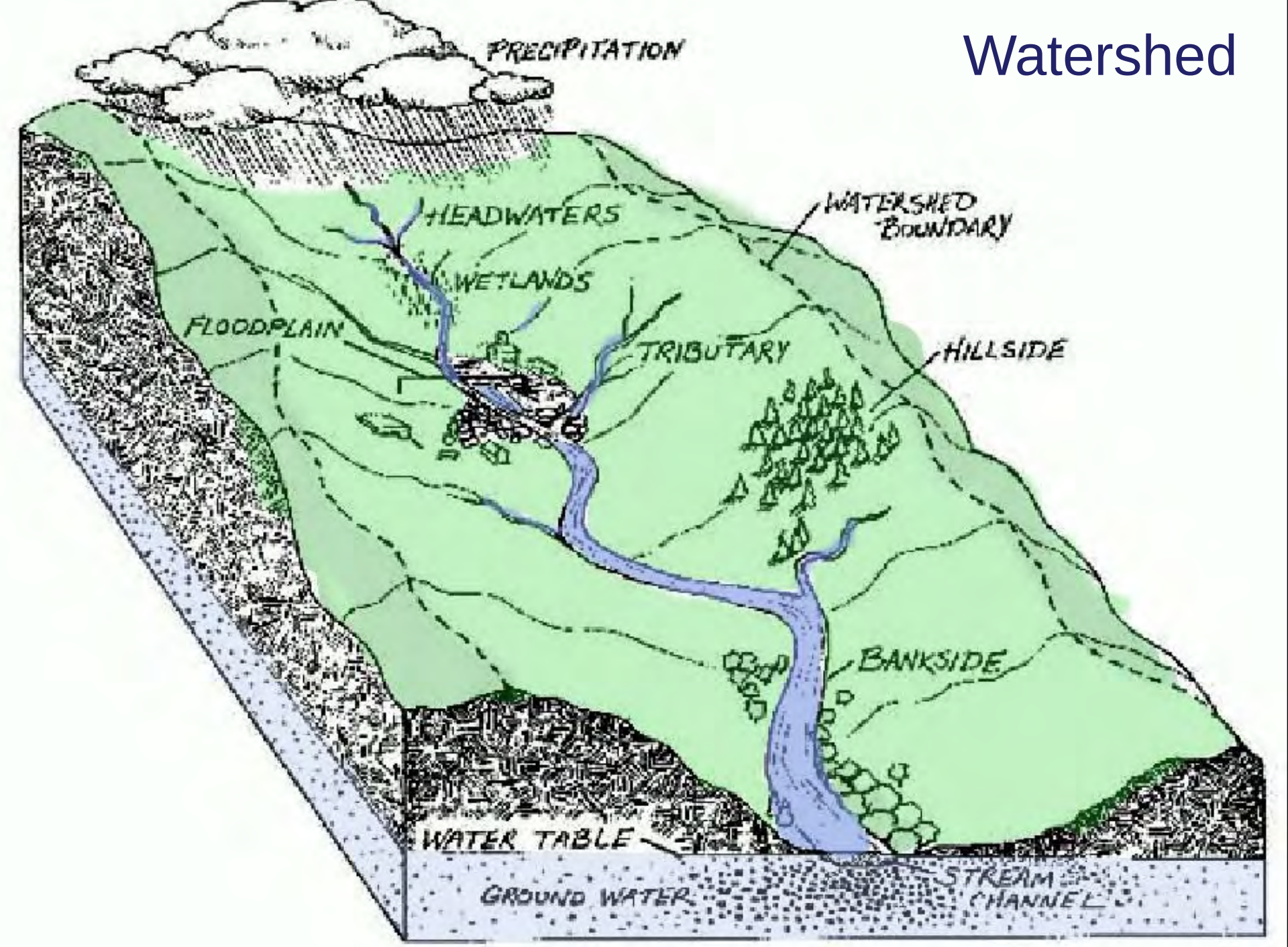
USDA CSREES Education Research Extension

NC STATE UNIVERSITY

NC State University
A&T State University
NC COOPERATIVE EXTENSION
Empowering People · Providing Solutions

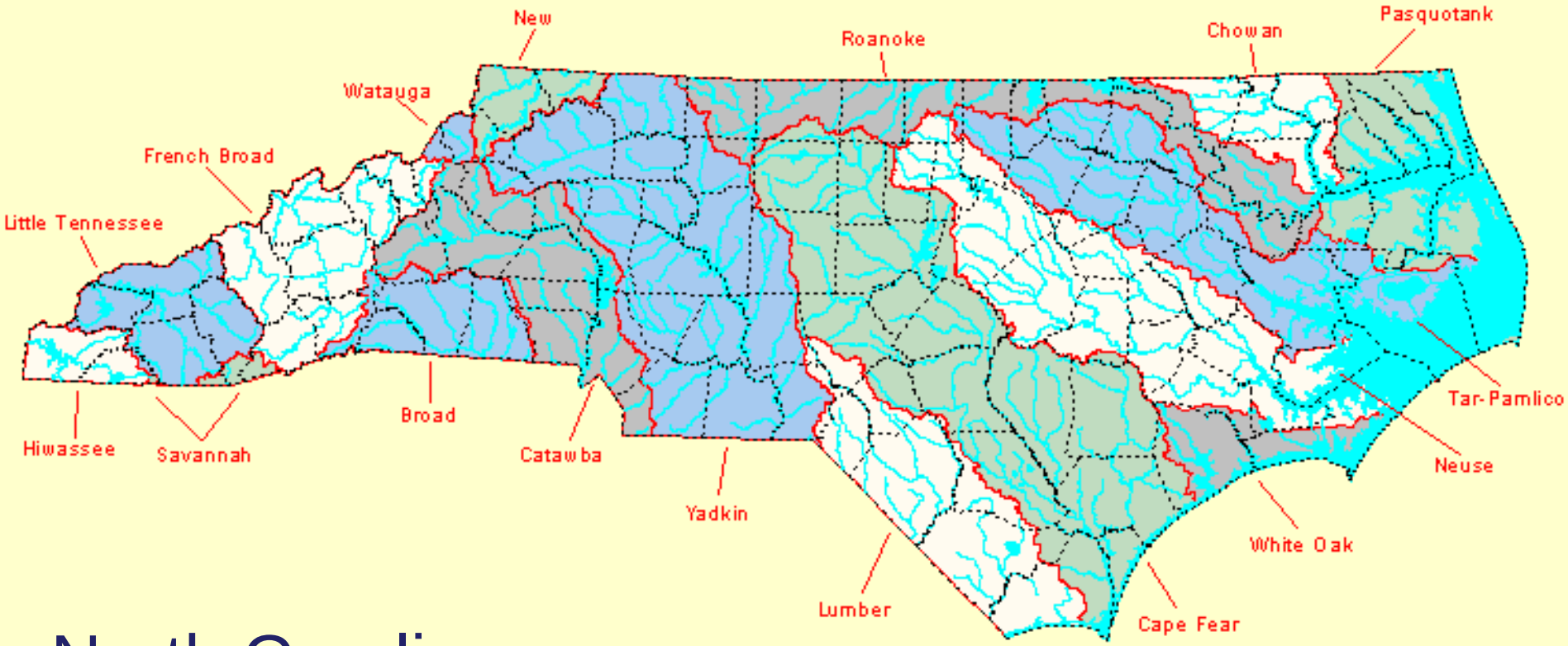
NC STATE UNIVERSITY
Stream Restoration Program

Watershed


PRECIPITATION
HEADWATERS
WATERSHED BOUNDARY
WETLANDS
FLOODPLAIN
TRIBUTARY
HILLSIDE
BANKSIDE
WATER TABLE
GROUND WATER
STREAM CHANNEL

Watershed:

Land area draining to a point on a river, lake, or estuary



North Carolina:

17 river basins for water quality management

NC STATE UNIVERSITY

From Webster's Revised Unabridged Dictionary (1913) :

Watershed, n [Cf. G. *wasserscheide*; *wasser* water + *scheide* a place where two things separate, fr. *scheiden* to separate.]

1. The whole region or extent of country which contributes to the supply of a river or lake.

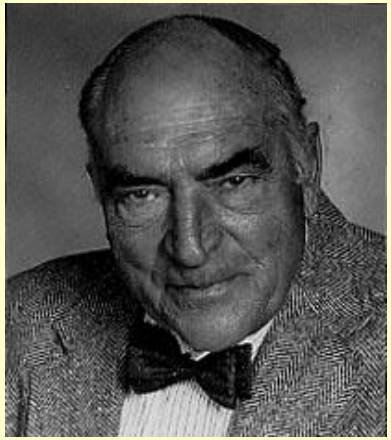
2. The line of division between two adjacent rivers or lakes with respect to the flow of water by natural channels into them; the natural boundary of a basin.

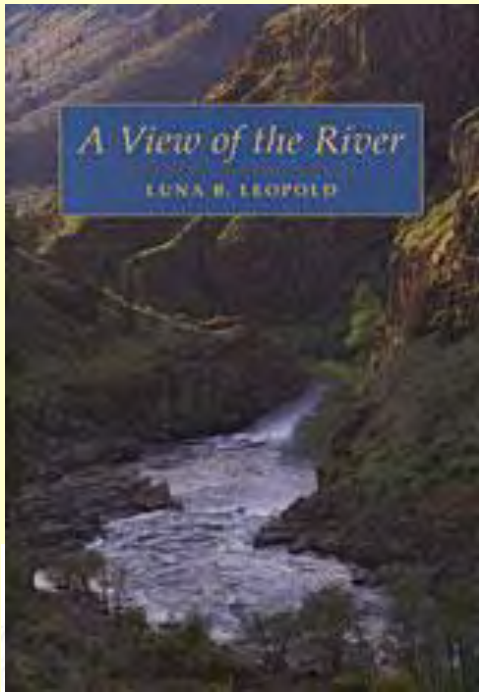
Other Terms: Catchment, Drainage basin, River basin

"We have to teach the general public to appreciate water - clean water - both in quality and quantity. The American people take it for granted. We can't take it for granted.“

"We can solve many of our problems in water quality by good land management, taking care of the watershed.“

Luna Leopold, 2002
Retired Chief Hydrologist, U.S. Geological Survey





Watershed:

"Area of land that drains water, sediment, and dissolved materials to a common outlet at some point along a stream channel"

Dunne and Leopold, 1978

Watershed form is influenced by:

1. Climate
2. Geology & Soils
3. Fluvial Geomorphology
4. Vegetation
5. Land Uses

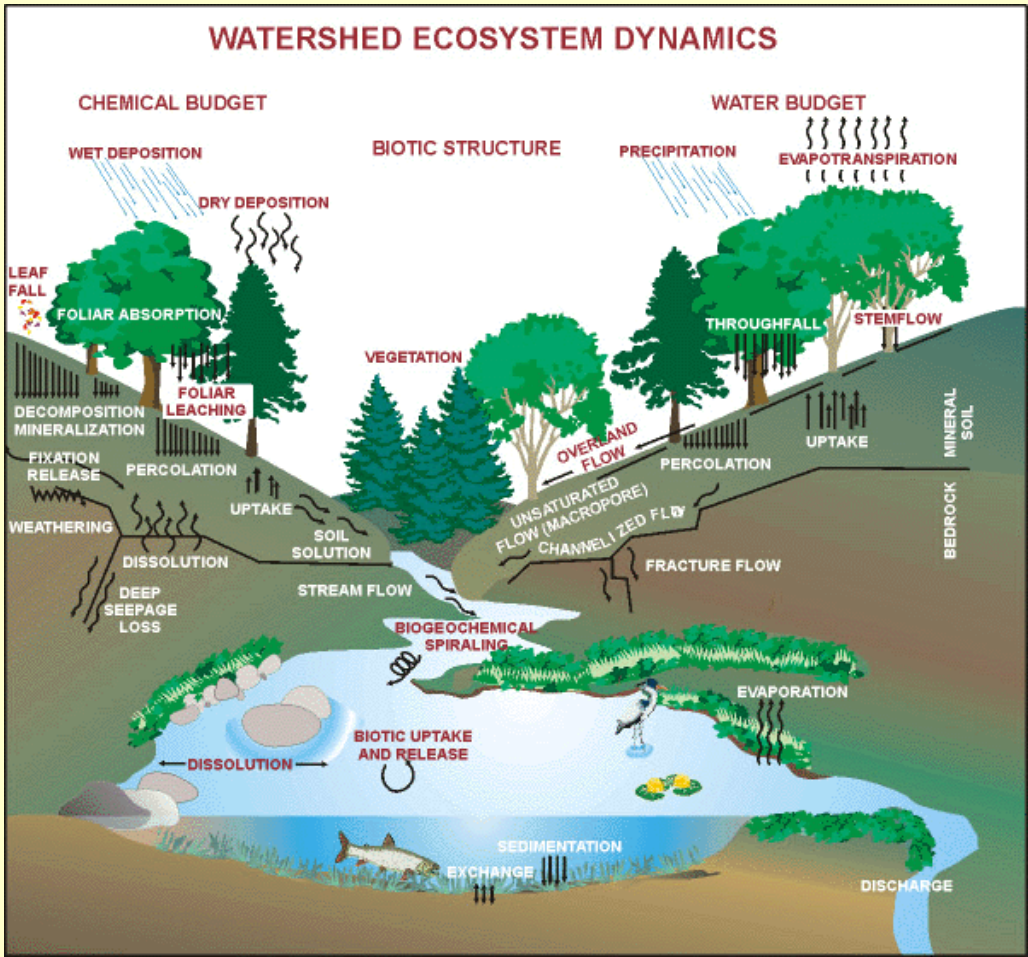
Watershed Functions:

Transport & Storage:

1. Water
2. Sediment
3. Dissolved Materials

Habitat:

1. Animals
2. Plants
3. Humans



Water Transport & Storage

Hydrology: The study of the flow of the earth's waters through the hydrologic cycle.

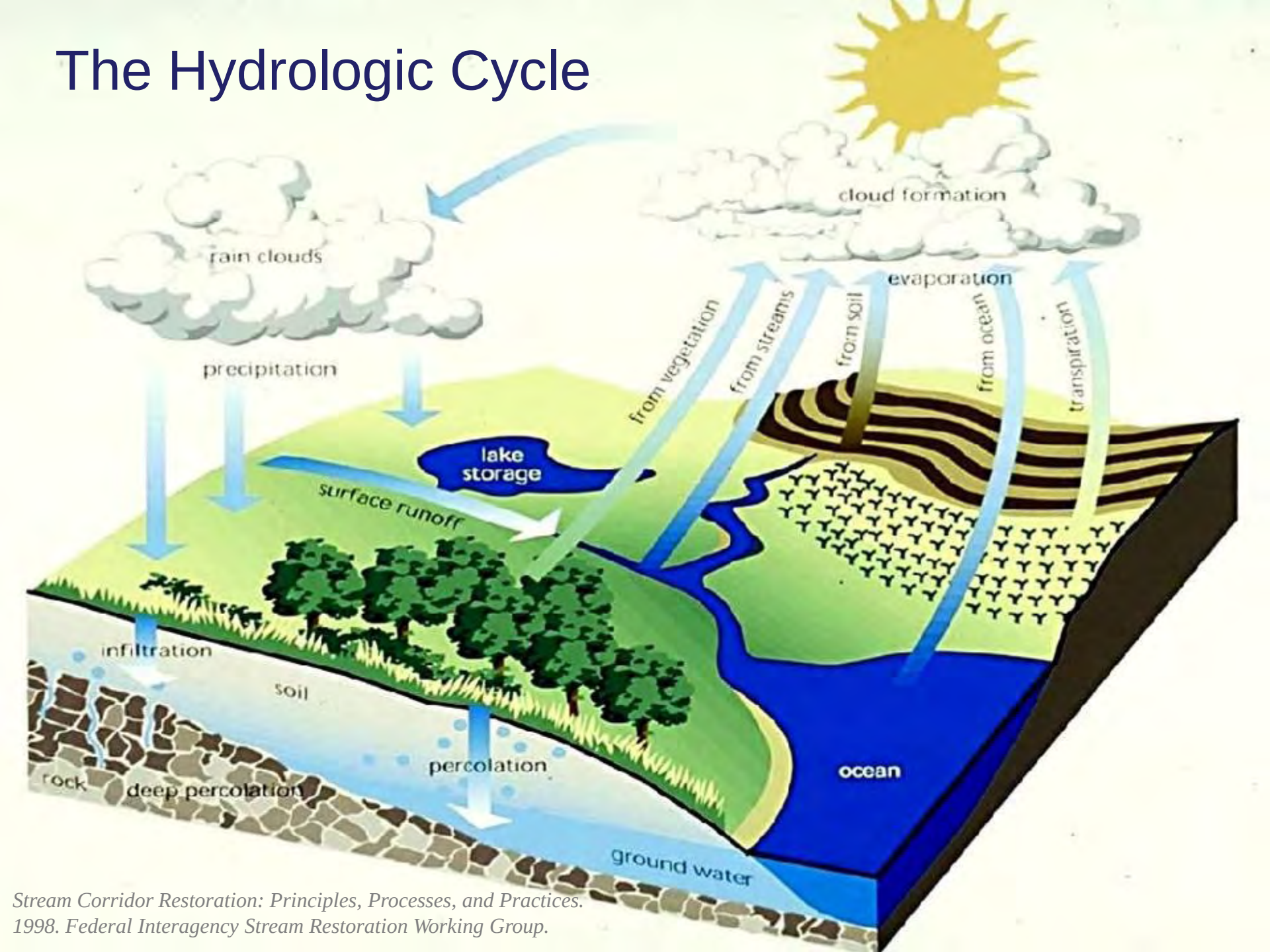
Total Water on Earth: 326 million cubic miles

97.2% oceans

2.15% ice caps and glaciers

.65% lakes, streams, ground water, atmosphere

The Hydrologic Cycle



Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

Hydrologic Cycle

The flow of water through the earth's system, powered by gravity and solar energy.

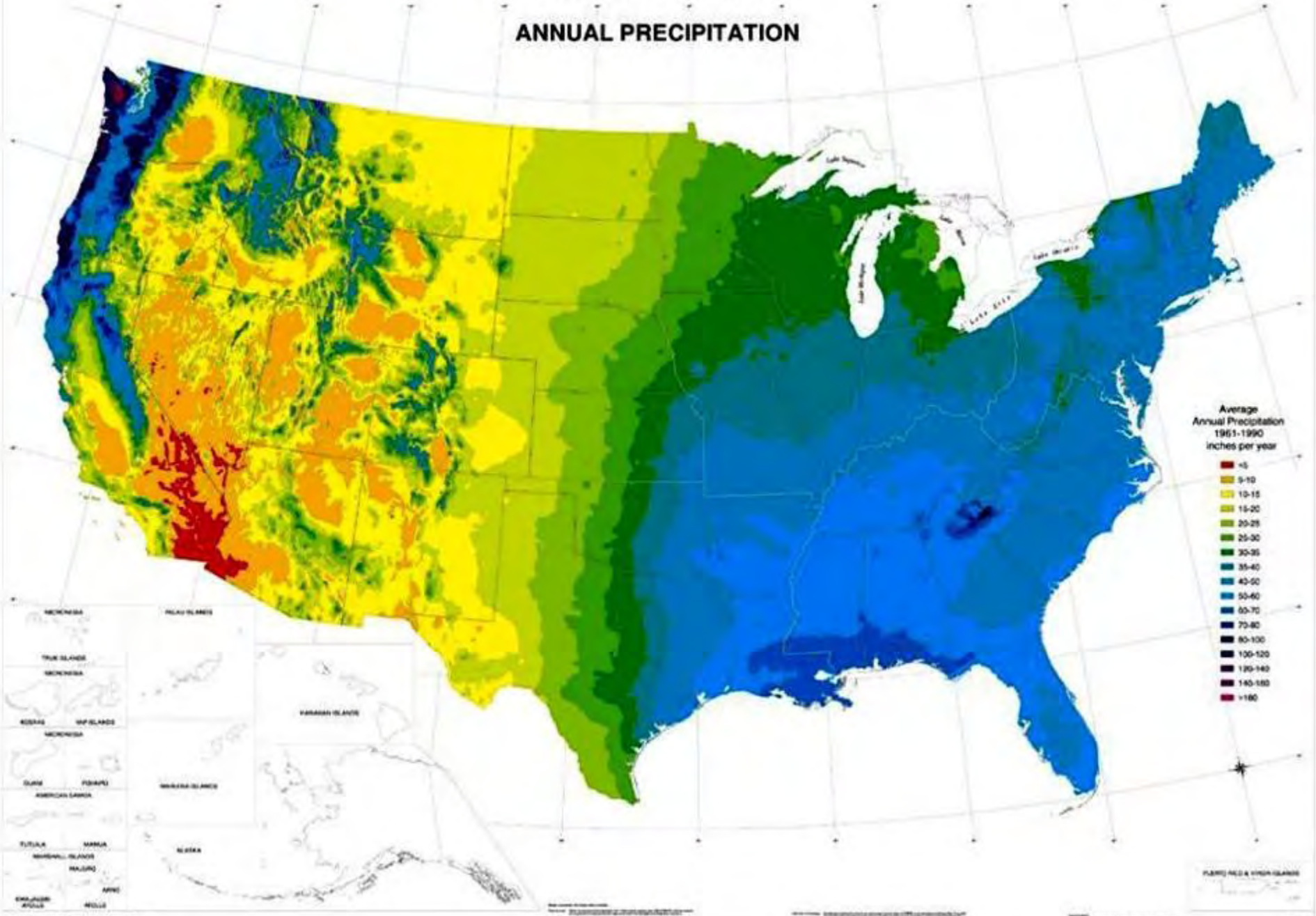
1. Precipitation
2. Evaporation
3. Evapotranspiration
4. Surface Runoff
5. Stream Flow
6. Infiltration
7. Subsurface Flow
8. Ground Water Flow

U.S. DEPARTMENT OF AGRICULTURE

NATURAL RESOURCES CONSERVATION SERVICE

UNITED STATES

ANNUAL PRECIPITATION

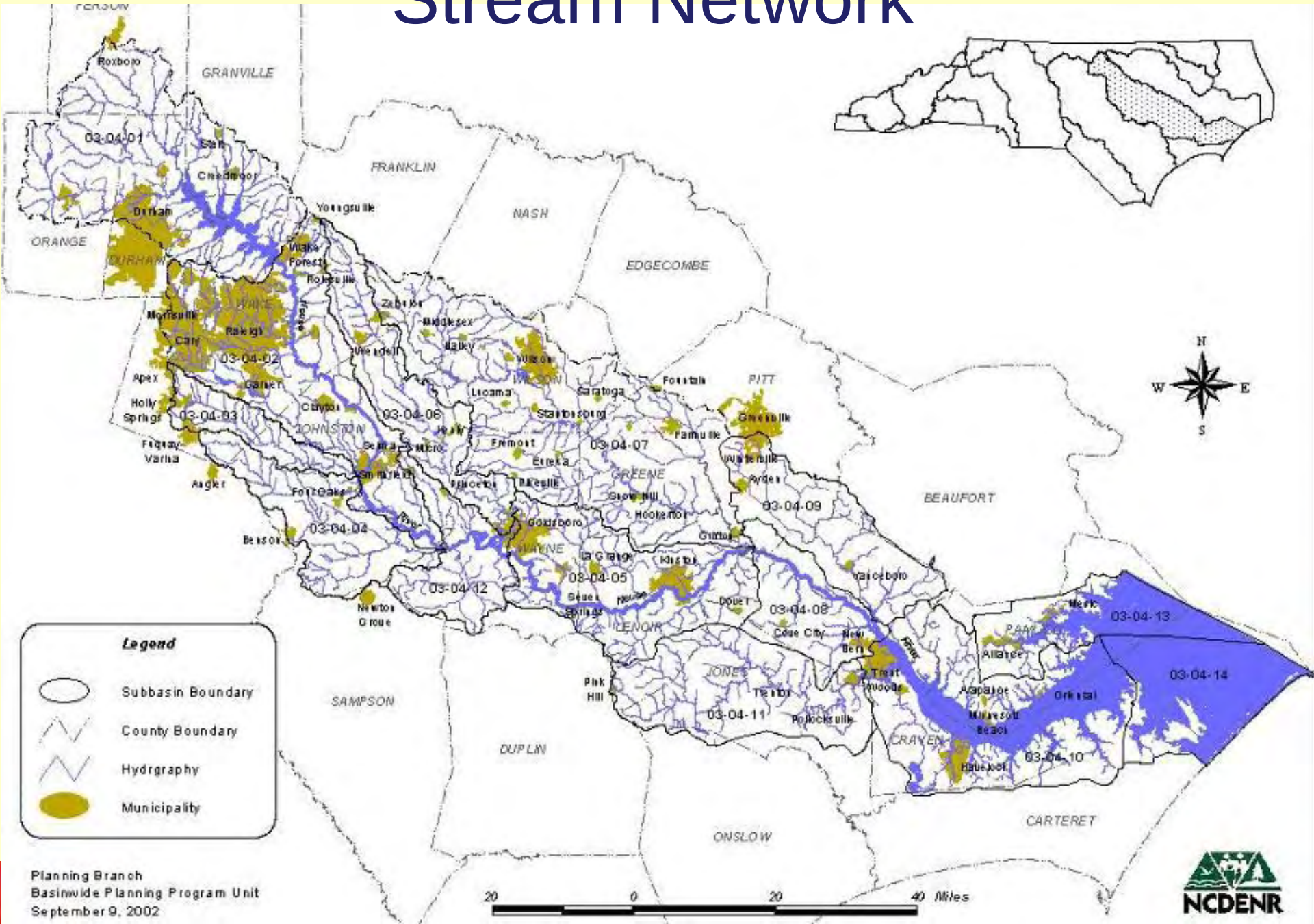


Extreme Weather!

Stream Functions

1. Transport water
2. Transport sediment
3. Habitat (aquatic & terrestrial)
4. Recreation
5. Aesthetics
6. Safe Water Supply

Stream Network



Strahler Stream Order

Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

Ephemeral

Intermittent

Perennial

NC STATE UNIVERSITY

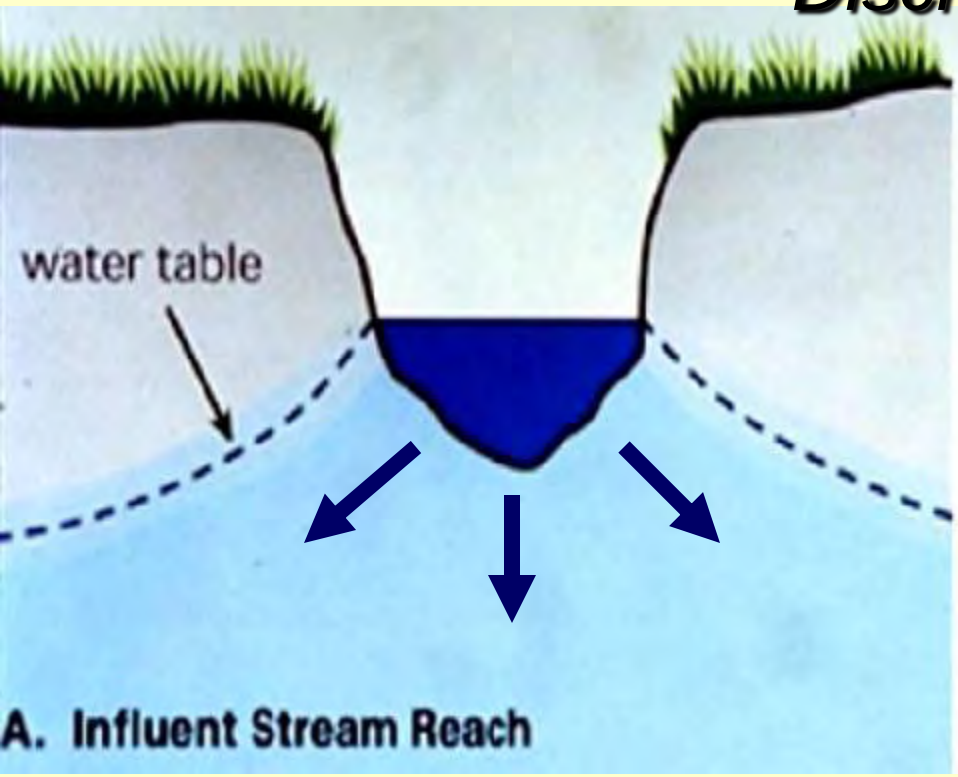
Groundwater Influences Streamflow

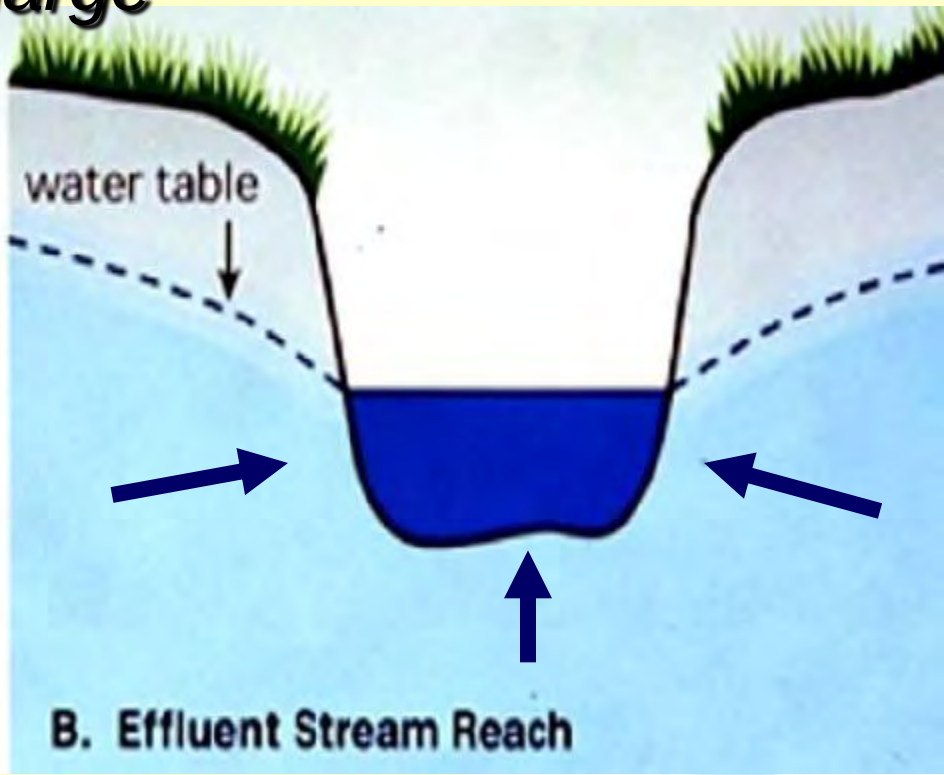
Losing Stream

Groundwater Recharge

Gaining Stream

Groundwater Discharge





Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

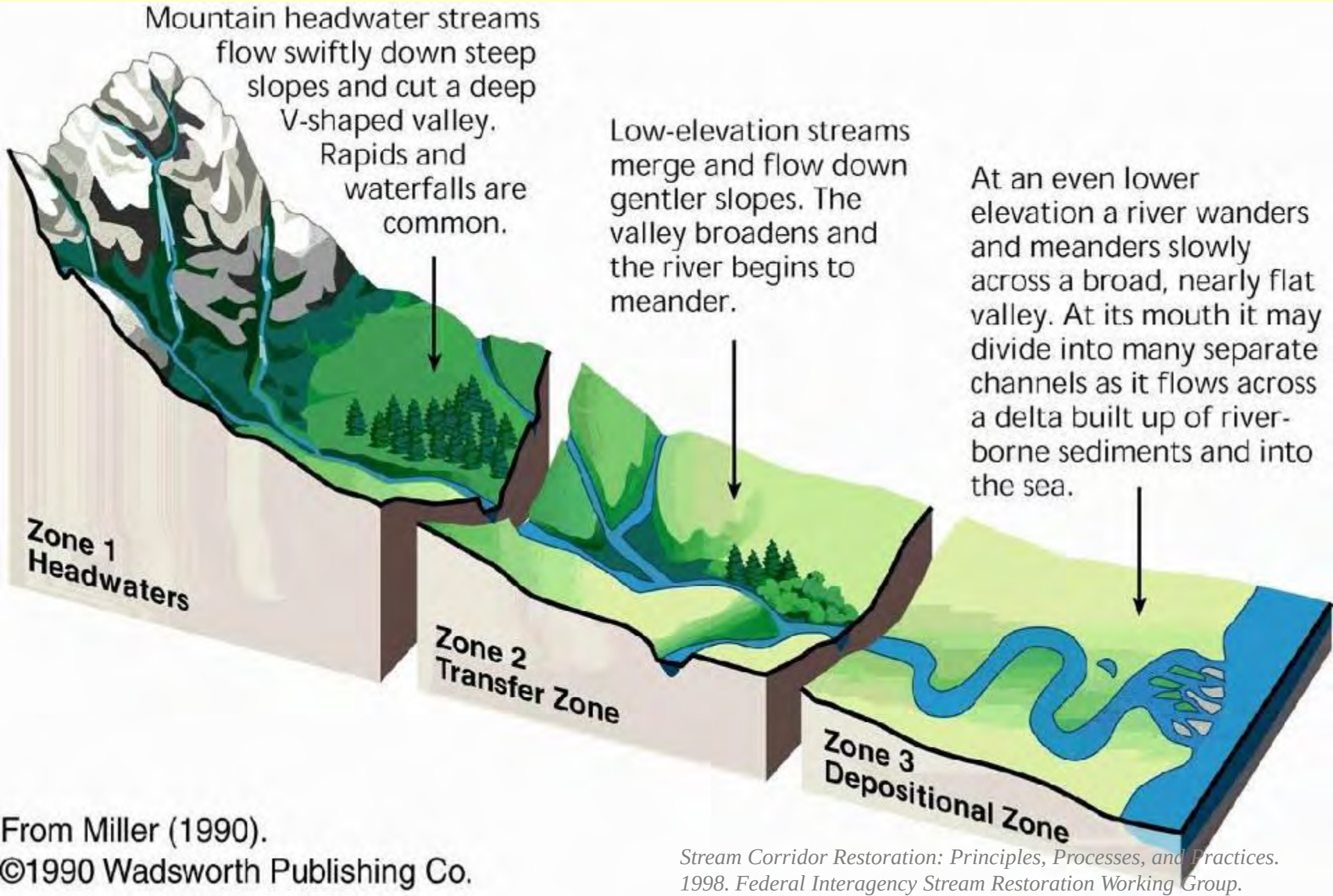
Stream Channel Morphology

size and shape of the channel

Influenced by:

- Watershed area
- Land use and land cover
- Soils and geology
- Topography
- Climate
- Human impacts (intentional or not)

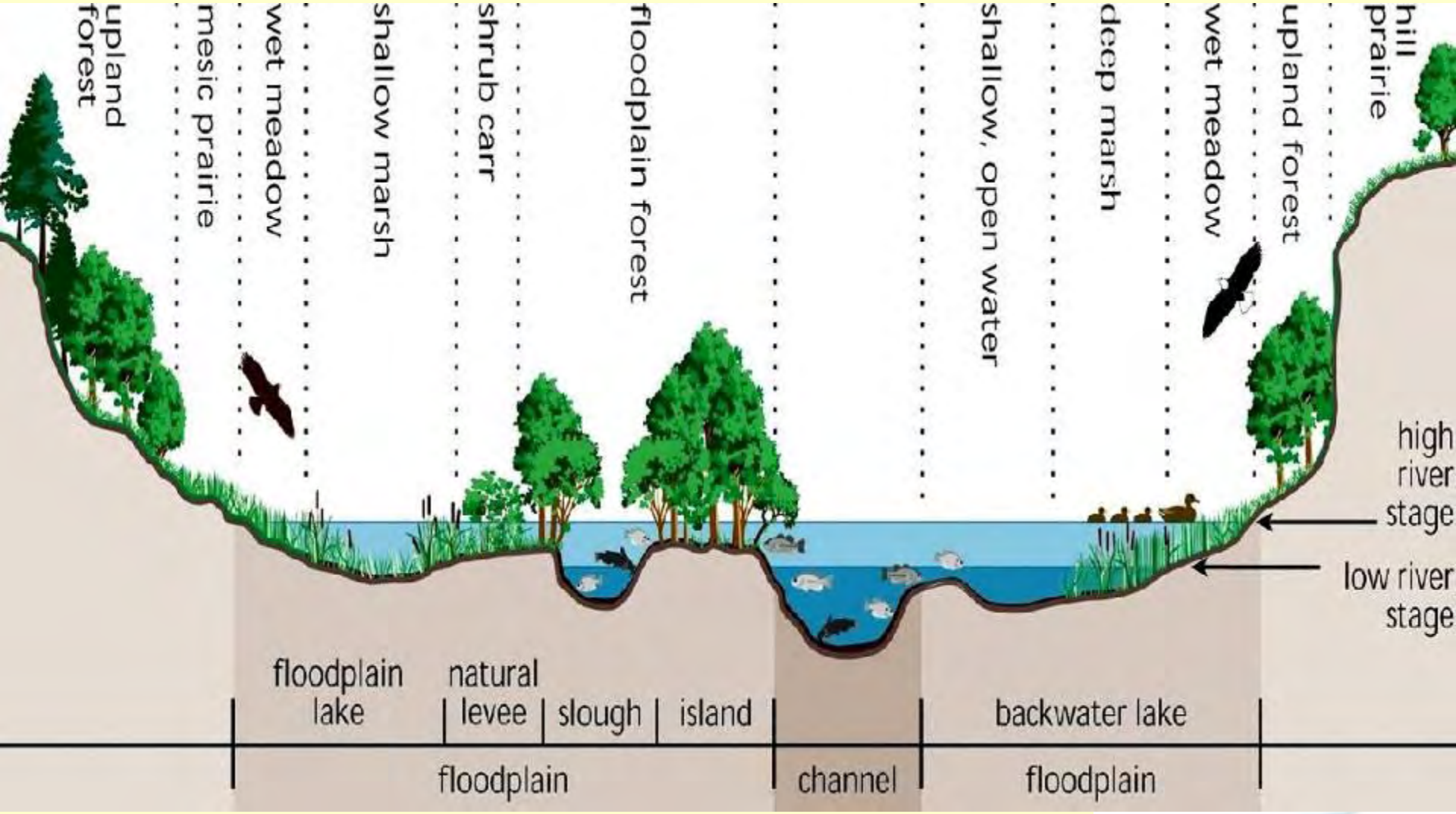
Stream Corridor Longitudinal Profile



From Miller (1990).

Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

Stream Corridor Lateral Profile



Stream Corridor Restoration: Principles, Processes, and Practices.
1998. Federal Interagency Stream Restoration Working Group.

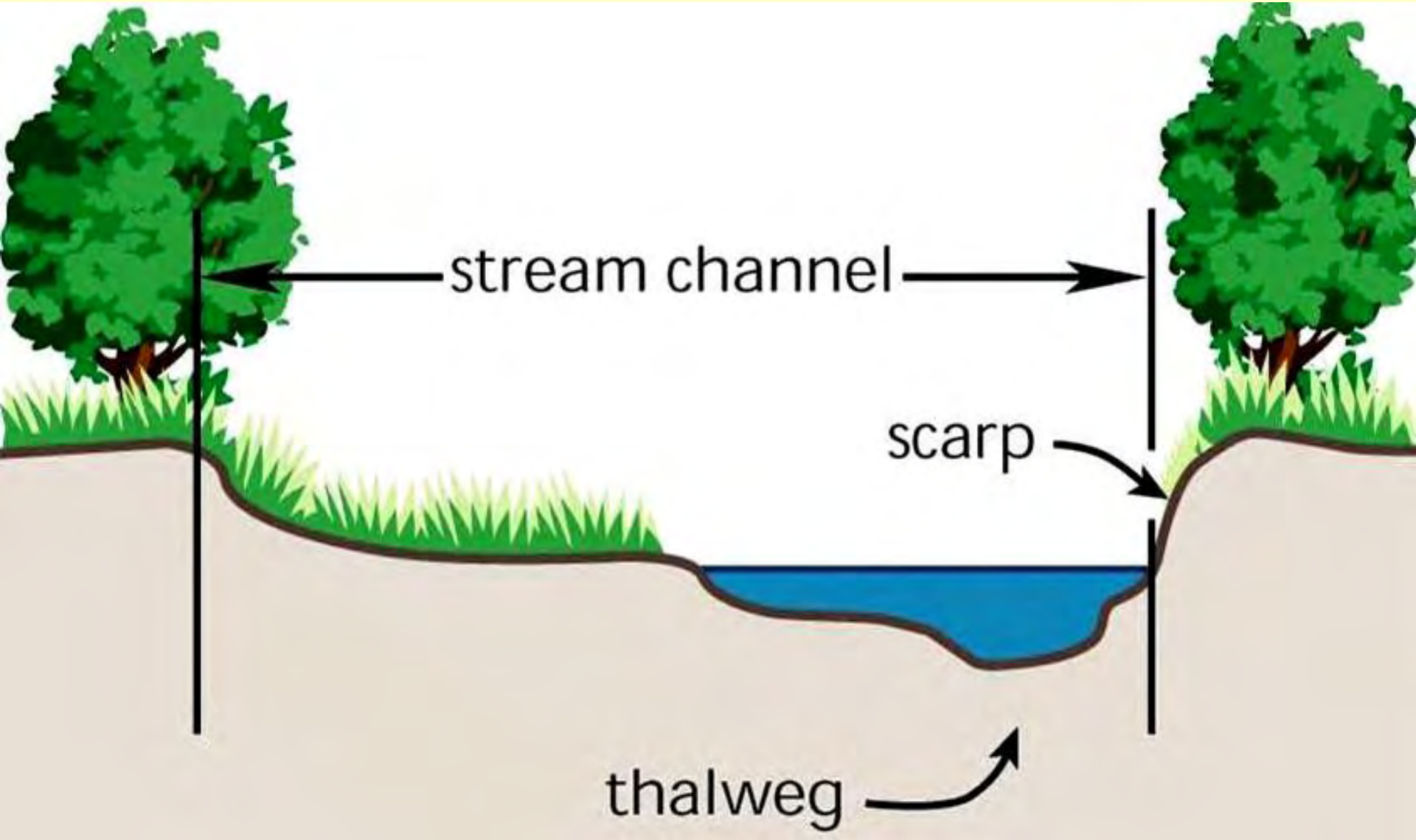
NC STATE UNIVERSITY
Stream Restoration Program

Stream Systems Include Their Floodplains

NC STATE UNIVERSITY

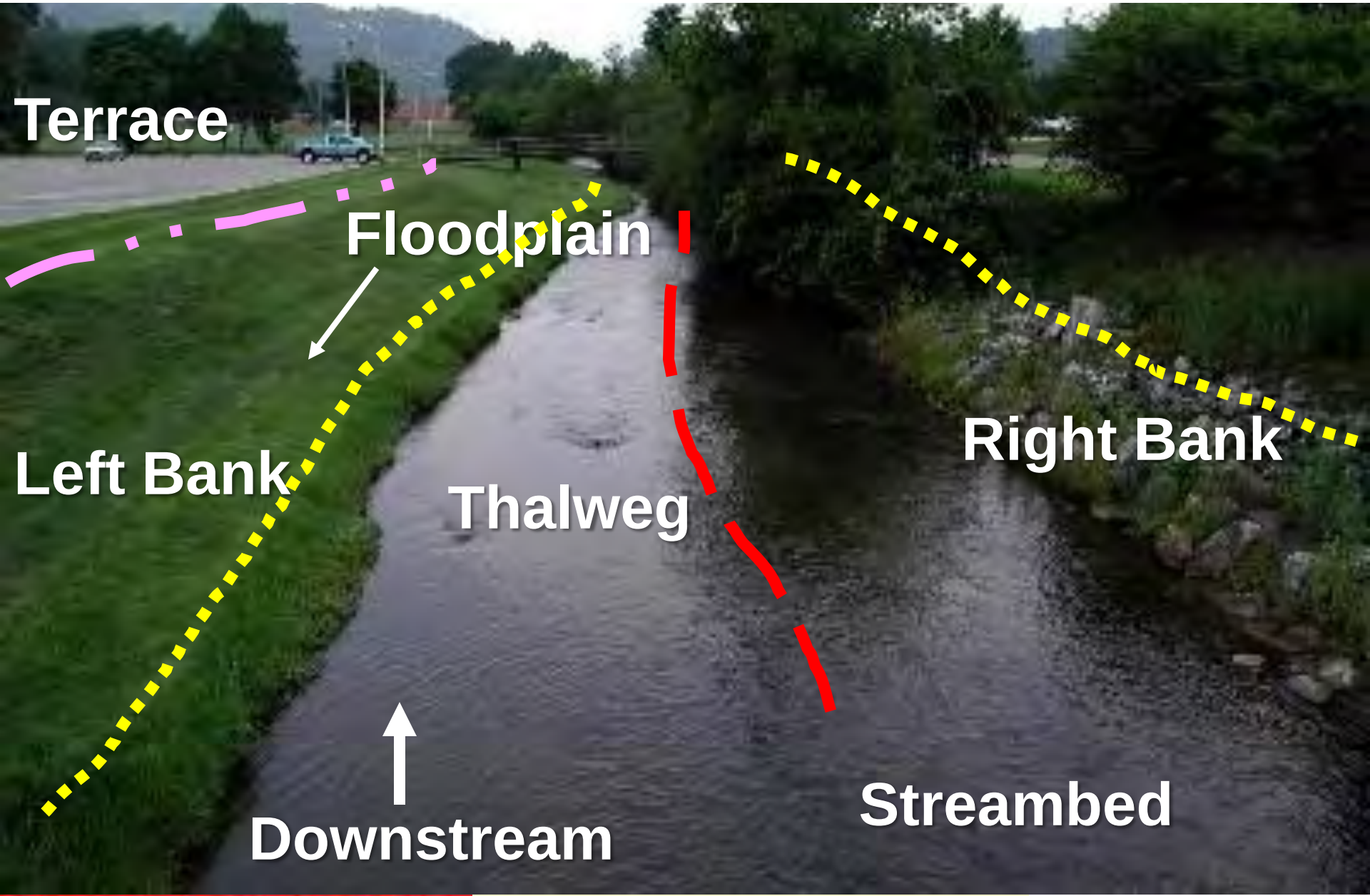
NC STATE UNIVERSITY
Stream Restoration Program

Stream Channel Cross-Section



Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Federal Interagency Stream Restoration Working Group.

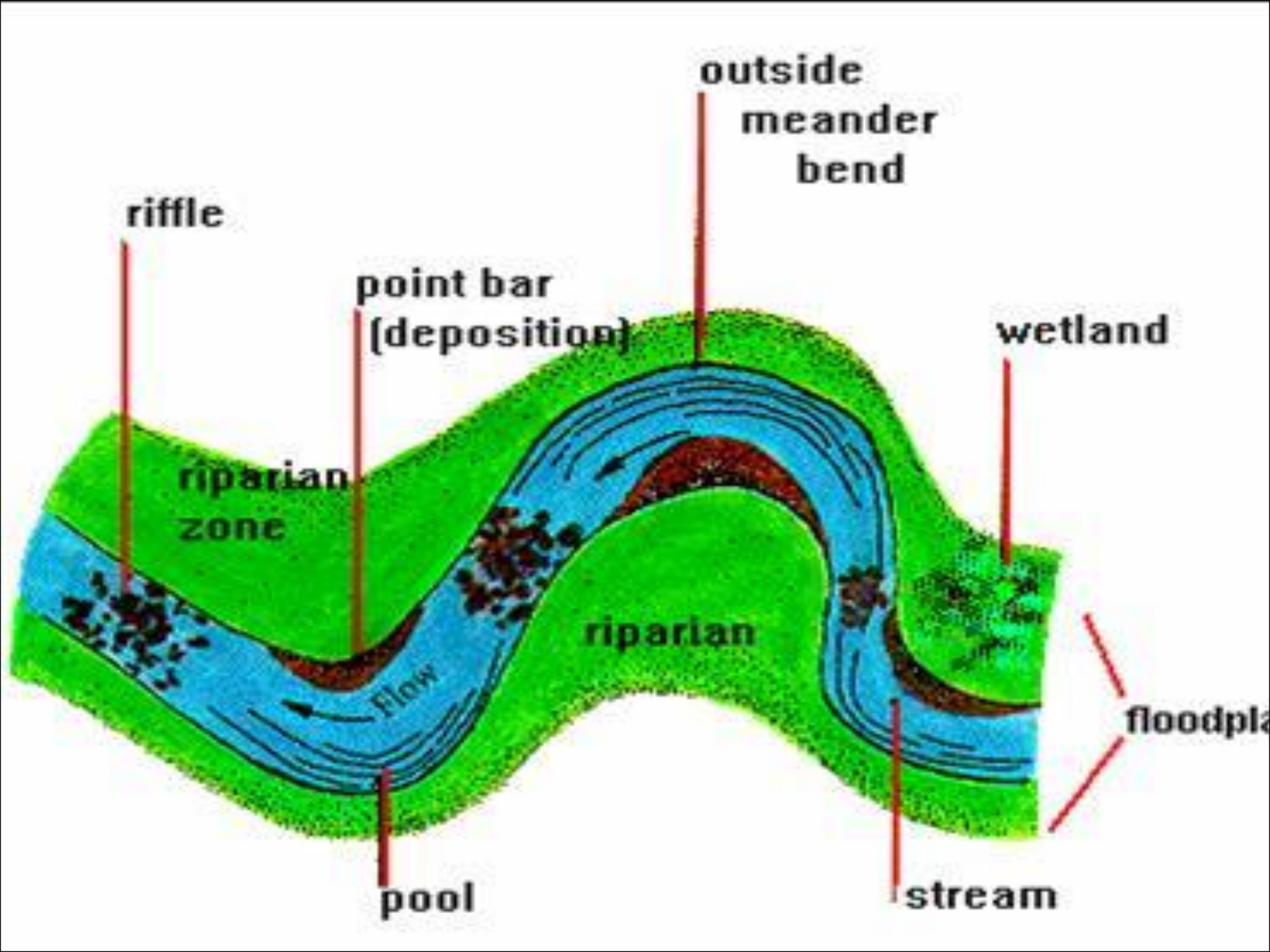
Stream Components




Terrace
Floodplain
Left Bank
Right Bank
Thalweg
Streambed
Downstream

Flow diversity improves habitat:

- Riffles
- Steps
- Pools


outside
meander
bend
riffle
point bar
(deposition)
wetland
riparian
zone
riparian
Flow
floodpla
pool
stream

Riffles

NC STATE UNIVERSITY
Stream Restoration Program

Importance of Riffles

- Areas of oxygenation
- Highly diverse substrate and habitat
- Diverse macroinvertebrate population

NC STATE UNIVERSITY
Stream Restoration Program

Pools

NC STATE UNIVERSITY
Stream Restoration Program

Importance of Pools

- Refuge for fish during low flow, drought periods
- Rest stop and food area for fish
- Predator refuge for young fish

NC STATE UNIVERSITY
Stream Restoration Program

Runs and Glides

NC STATE UNIVERSITY
Stream Restoration Program

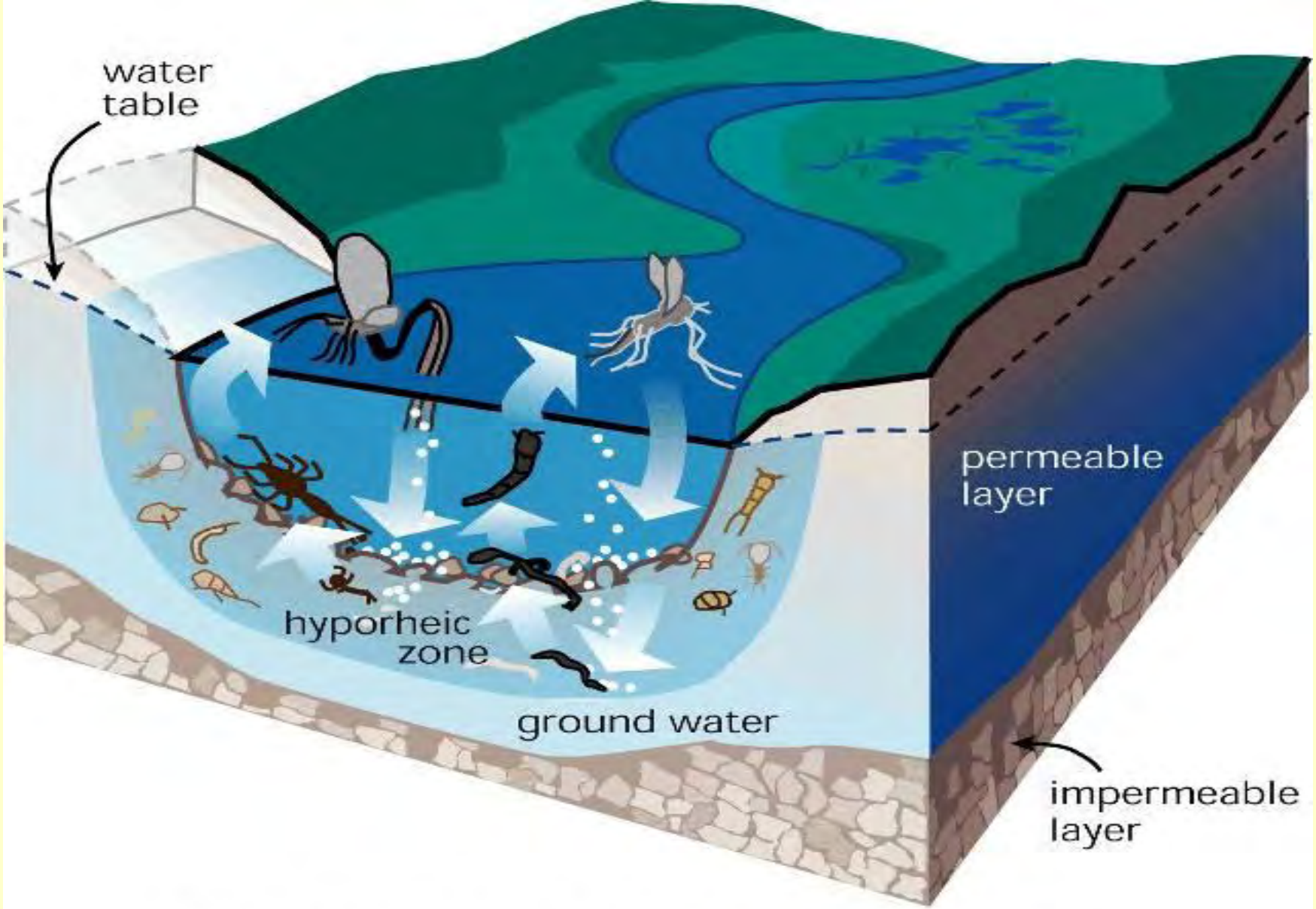


Fig. 2.35 -- Hyporheic zone. Summary of the different means of migration undergone by members of the stream benthic community.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Natural Stream Channel Stability

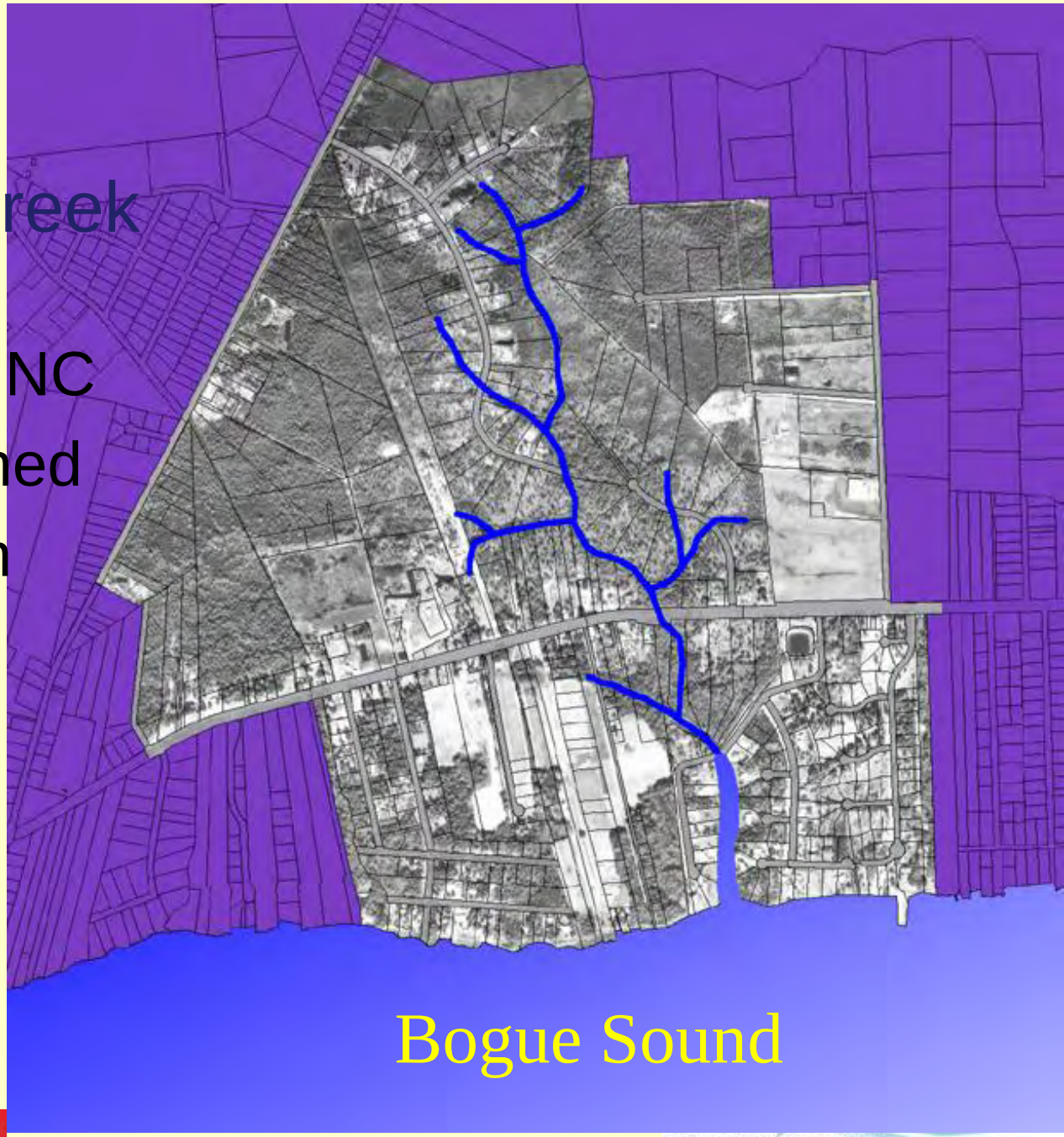
(from Leopold)

- River has a stable *dimension, pattern and profile*
- Maintains channel features (riffles, pools, steps)
- Does not aggrade (fills) or degrade (erodes)

Watershed Land Use Changes

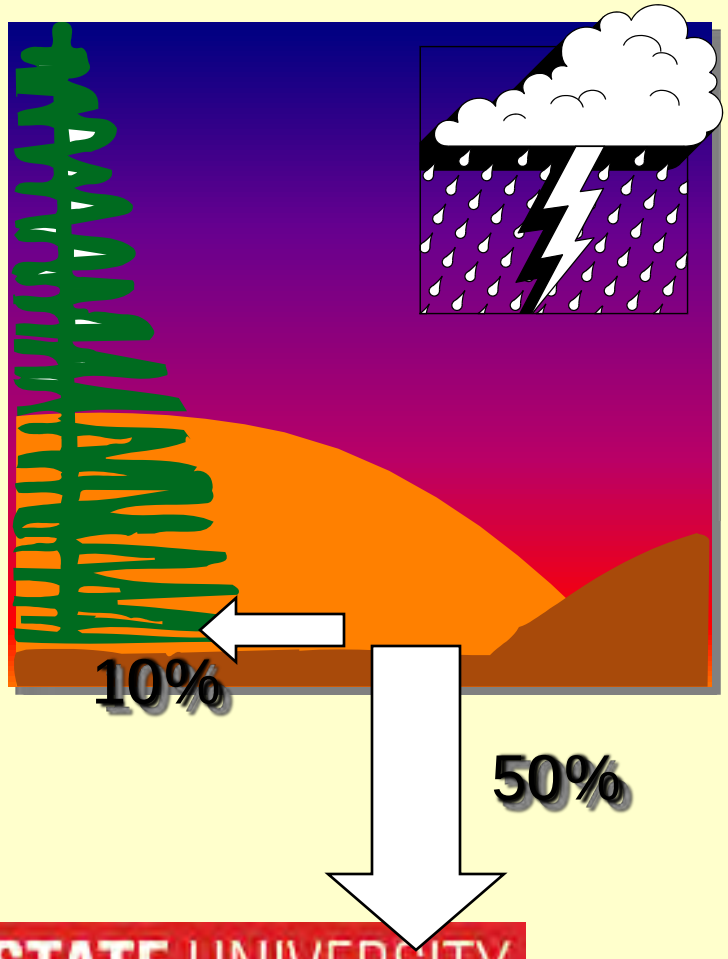
Jumping Run Creek

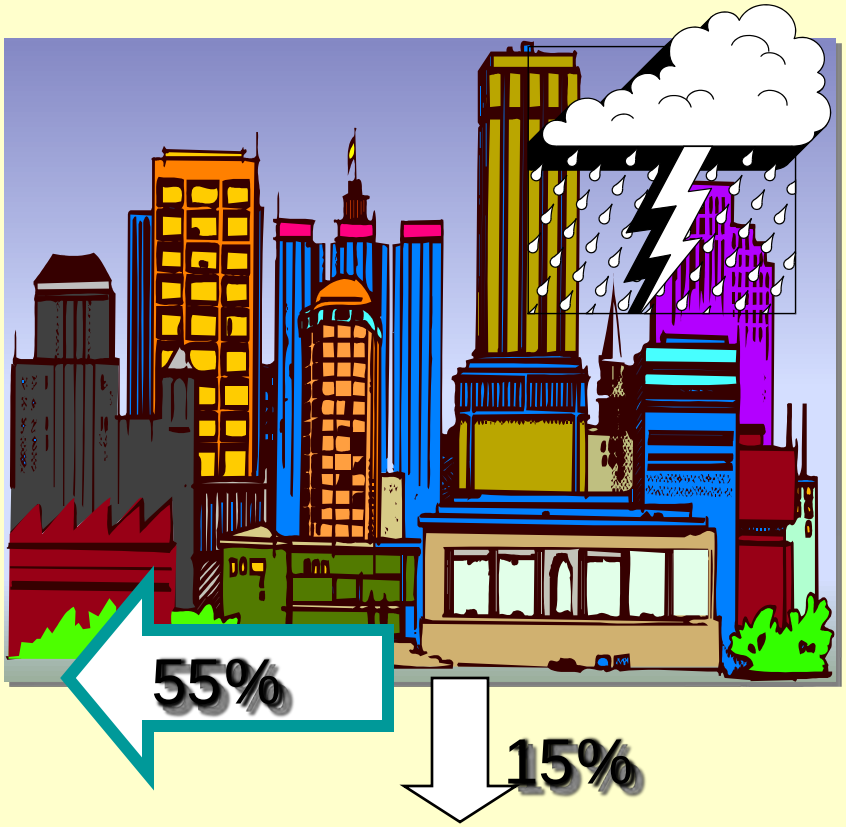
- Carteret County, NC
- 800-acre watershed
- Need for shellfish restoration



Land Use Change

Development Impacts on the Water Cycle





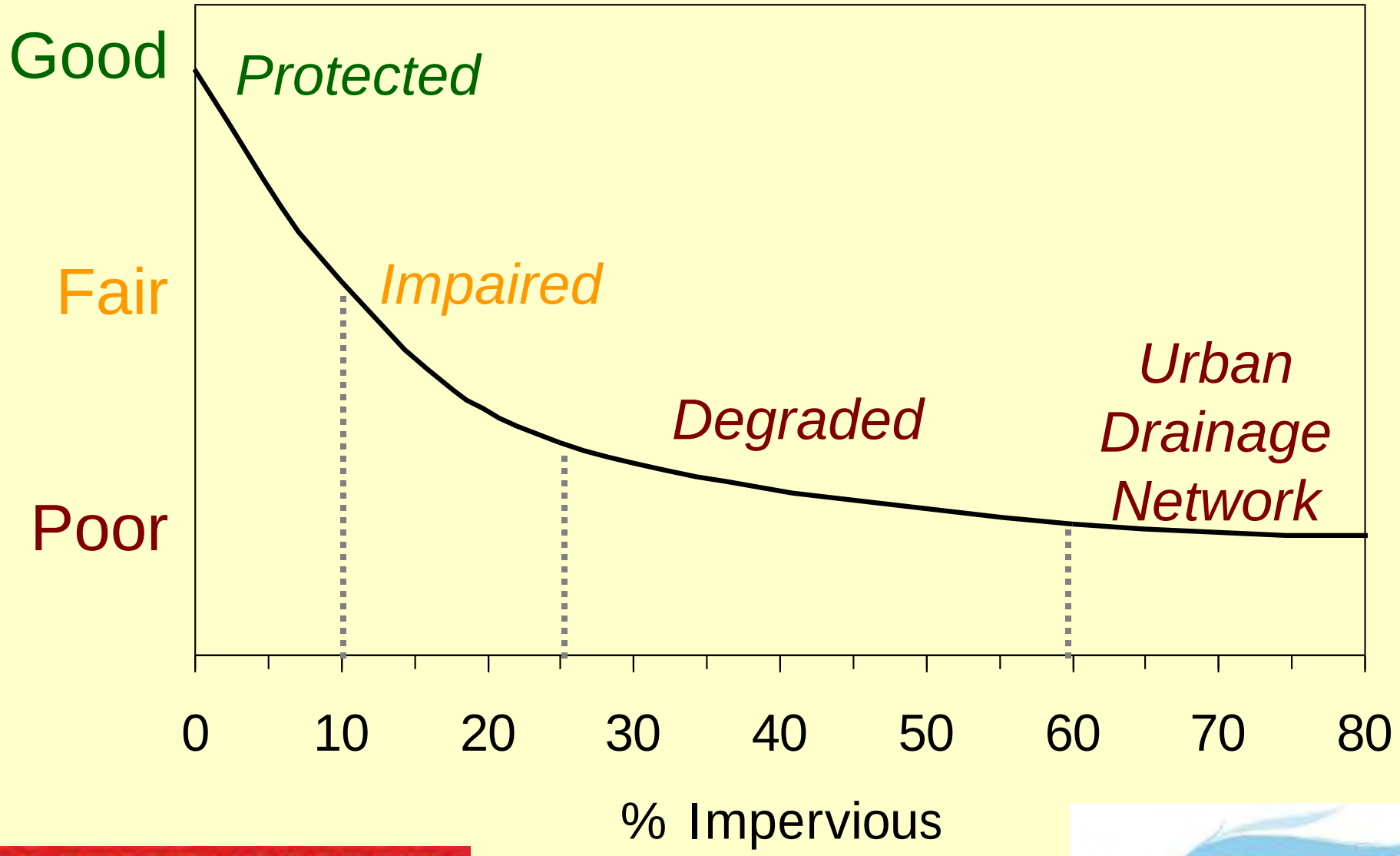
NC STATE UNIVERSITY

NC STATE UNIVERSITY
Stream Restoration Program

Hydrologic Responses to Urbanization

1. Increased discharge
2. Increased peak discharge
3. Increased velocities
4. Shorter time to peak flow
5. More frequent bankfull events
6. Increased flooding
7. Lower baseflow
8. Less ground water recharge

Stream Condition Related to Impervious Surface



Source: Center for Watershed Protection

NC STATE UNIVERSITY
Stream Restoration Program

Development Impacts on Water Quality

Increased quantity

Decreased quality

Nutrients

Pathogens

Sediment

Toxic Contaminants

Debris

Thermal Stress

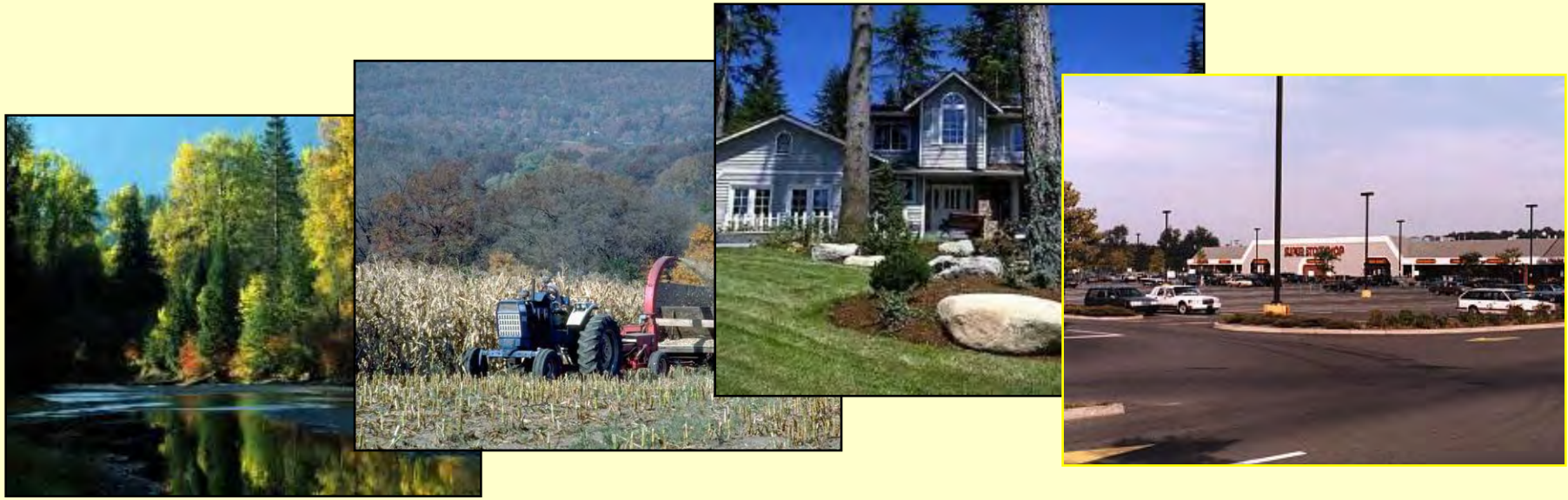
NC STATE UNIVERSITY
Stream Restoration Program

Stream Impairment Causes (EPA, 2000)

1. Sediment
2. Pathogens
3. Nutrients
4. Metals
5. Dissolved Oxygen
6. Habitat Alterations
7. Temperature
8. pH
9. Impaired Biology
10. Pesticides
11. Flow Alterations
12. Mercury

Sediment Sources

1. Land Disturbance
2. Channel Erosion
3. Bedload Transport



INTENSITY OF LAND USE

IMPERVIOUS SURFACE

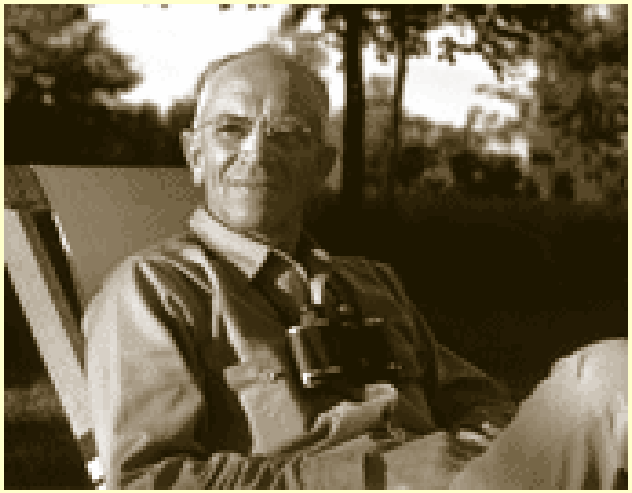
WATER QUALITY PROBLEMS

NC STATE UNIVERSITY

NC STATE UNIVERSITY
Stream Restoration Program

"The oldest task in human history: to live on a piece of land without spoiling it. "

-Aldo Leopold



Charge for the week:

"Pay attention, ask questions, and learn from each other"

- *anonymous*