Hydrological and hydro-illogical cycles: managing short-term droughts in the southeast

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Southeastern Irrigation

In the coming century the United States will be faced with two critical agricultural issues

Food Security

Can the US maintain its agricultural output in the face of potential declines in production due to water pressures in the West and High Plains?

Energy Security

Can the US expand its agricultural output to meet biofuel needs and not impact food supplies?

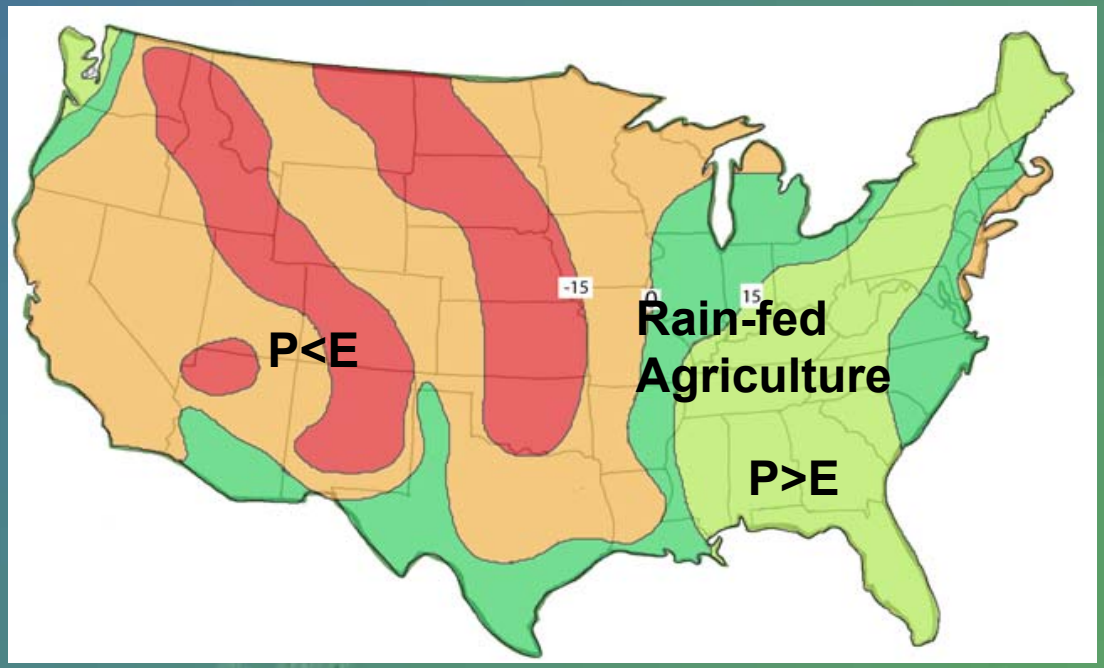
US must also be a leader in developing sustainable strategies for increasing the world's food supply.

We believe that developing irrigated assisted rain-fed agricultural systems in the Eastern U.S. harvesting winter water is the key to Food Security and Energy Security for the U.S. and is a sustainable strategy.

It is all about water!

Rain-fed Agriculture in the Eastern U.S.

- At the turn of the 20th century most of the U.S food and fiber production was found in the East and Midwest based on rain-fed agriculture



Precipitation minus Evaporation

from NCEP 1963-2002

The Associated Press

With an adequate supply of rainfall, there would be no dirt visible between the rows of peanuts in this Dale County field near Headland. Rainfall for the year is almost 20 inches below normal, similar to other parts of South Alabama and adjacent northwest Florida.

Corn crops vanishing in South Alabama

Current drought makes farm risk that much greater

By BOB JOHNSON
The Associated Press

HEADLAND – Kris Balkcom shakes his head as he stands in a dusty field surrounded by waist-high, brown and barren corn plants that by this time of year should be taller than him and filled with ears of tasty sweet corn.

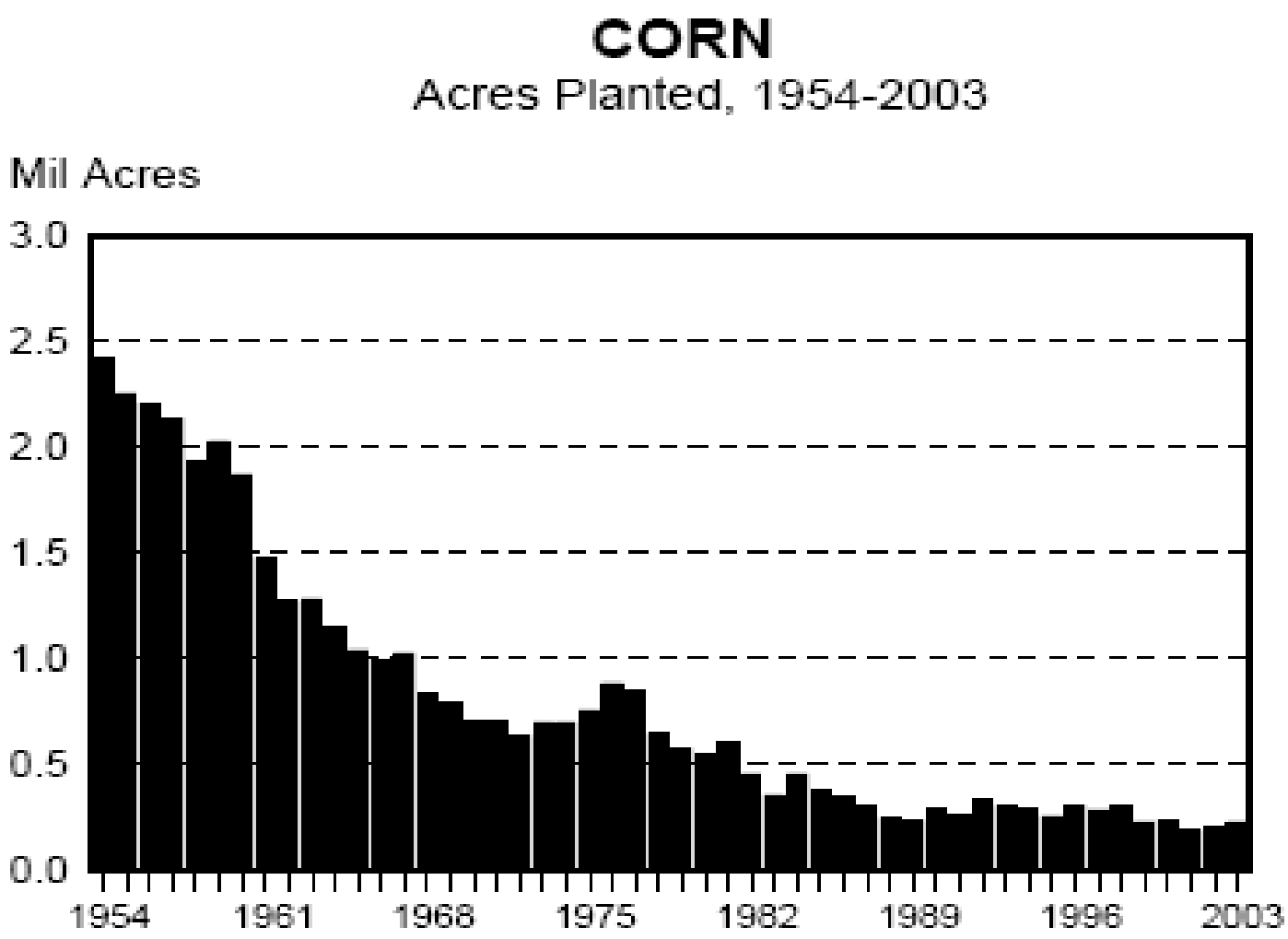
Rainfall for the year is almost 20 inches below normal, similar to other parts of South Alabama and adjacent northwest Florida. As wide sections of the Southeast bake, National Weather Service forecasters say a combination of factors, including a high pressure system parked over the

rabbits, Christmas trees and llamas. In southeast Alabama, some farmers are hoping that blueberries might be the answer.

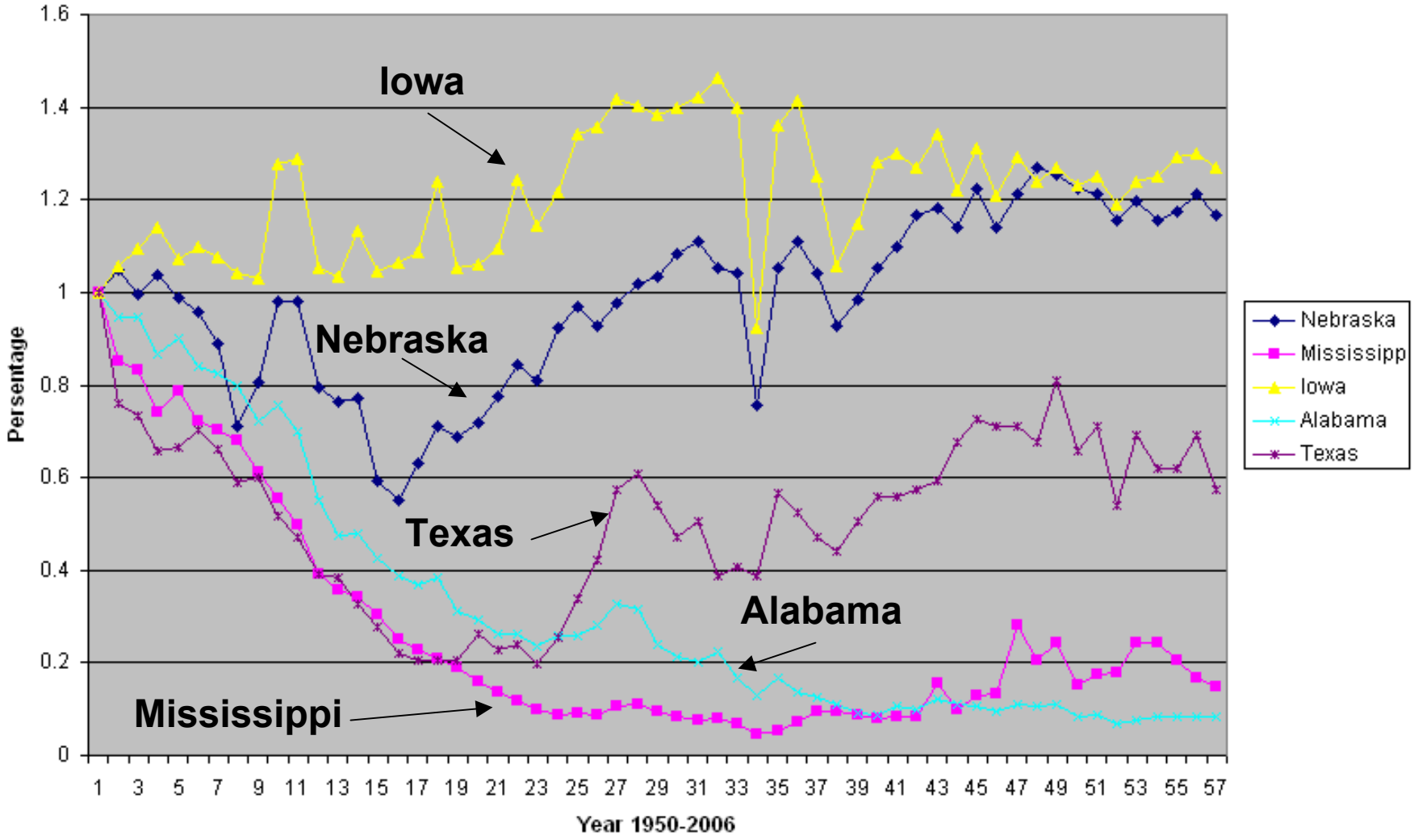
Parker said some of his neighbors are planting blueberries on what used to be corn, cotton or peanut fields. Blueberries must be irrigated, but require fewer acres to produce a profitable crop.

"It takes a small enough acreage that maybe a family can make a living at it," Parker said.

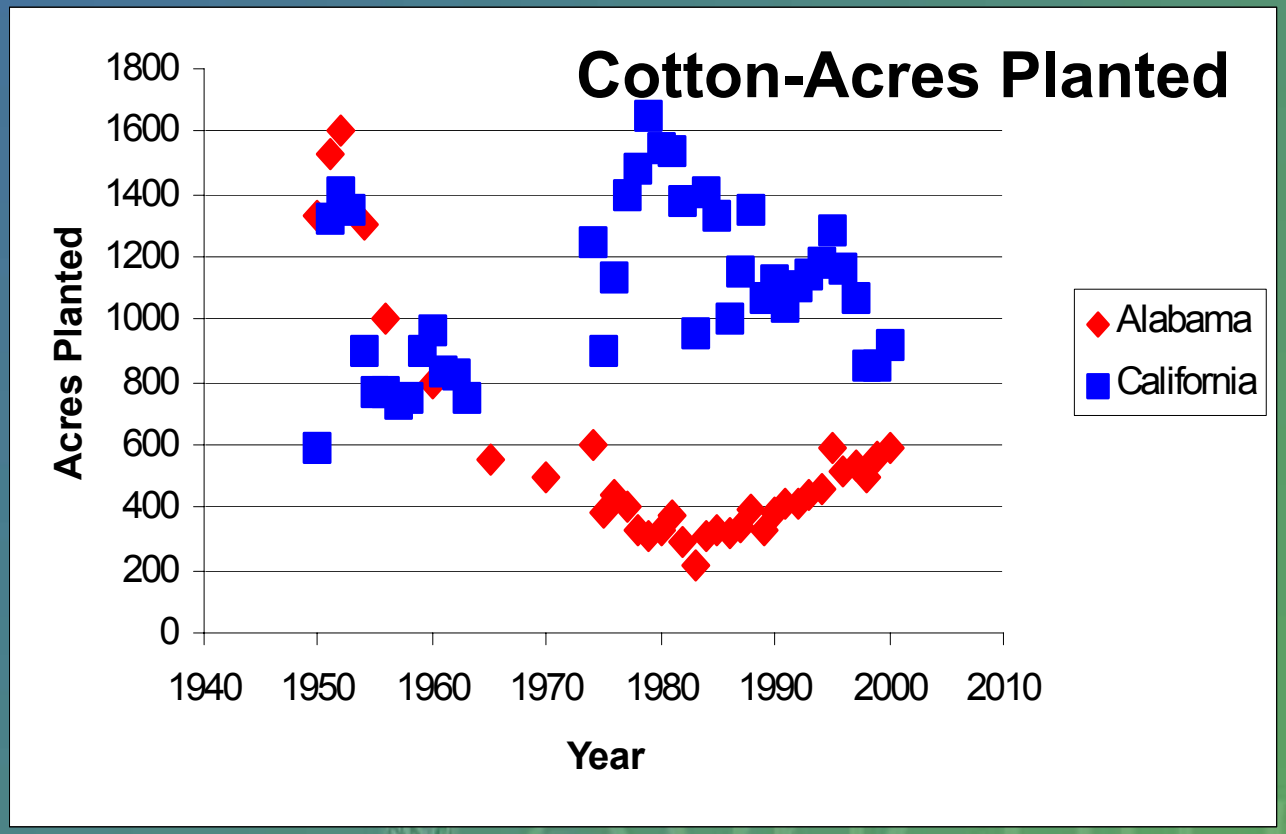
Agriculture officials and farmers say the recent succession of dry spells in a region historically considered one of the wettest in the country is joining other factors – low prices, the high cost of insurance, fuel costs, trade deficits and government regulations among them


CORN
Acres Planted, 1954-2003
Mil Acres
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1954
1961
1968
1975
1982
1989
1996
2003

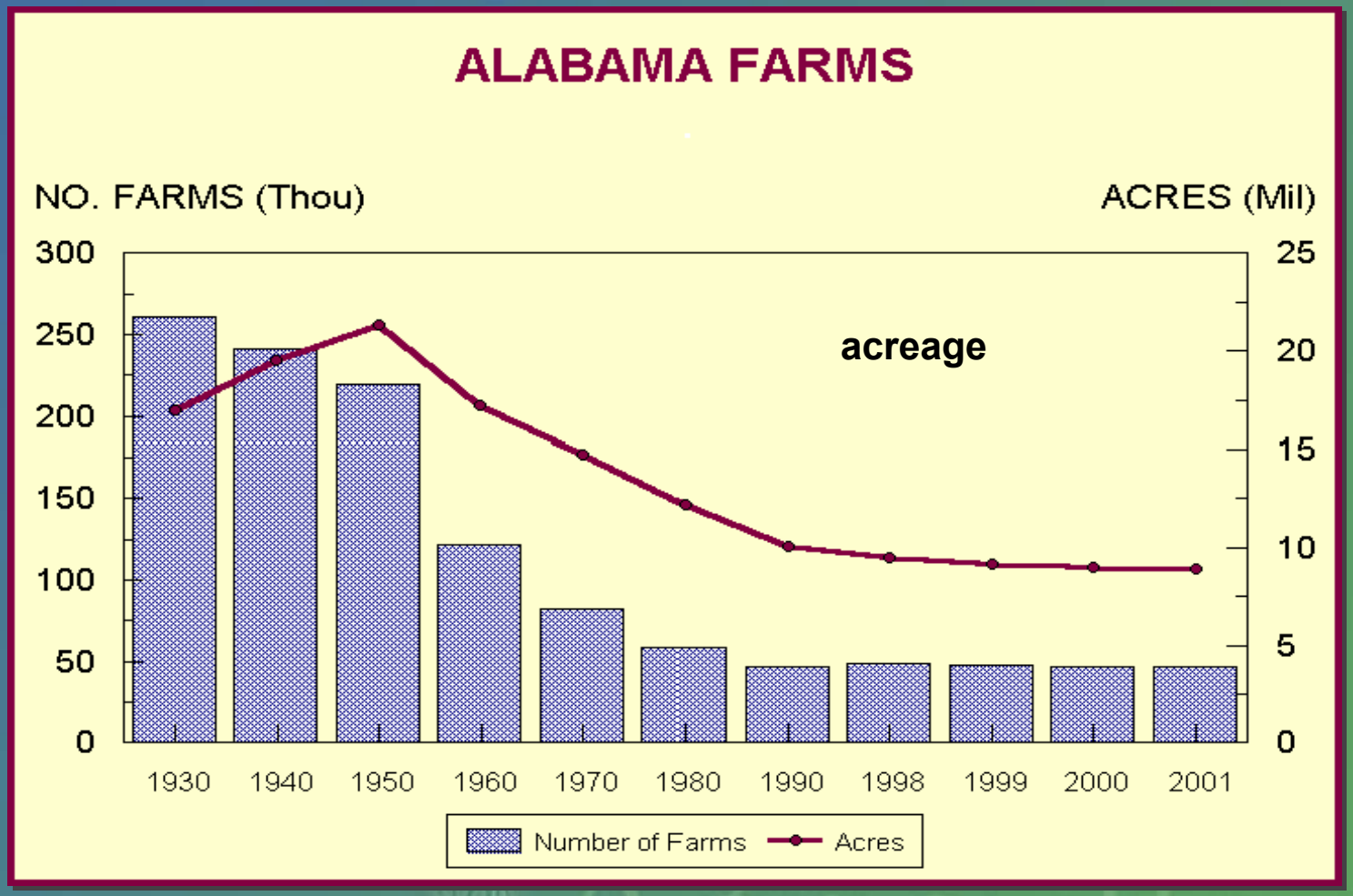
Corn Acres Planted As Fraction of 1950



During the the same period that Alabama, Georgia and Mississippi were losing cotton - California and Arizona were gaining cotton



Since 1950 Alabama has lost over ten million acres of farm land



The loss of agriculture devastated rural economies

Landowners faced with the competition of Western subsidized irrigated agriculture and deep water holding soils in mid-west resorted to accepting government set asides or timber farming.

Land is now in timber or low intensity pasture.

When a farmer is farming he is turning over $500-$750 per acre per year which is part of the local economy

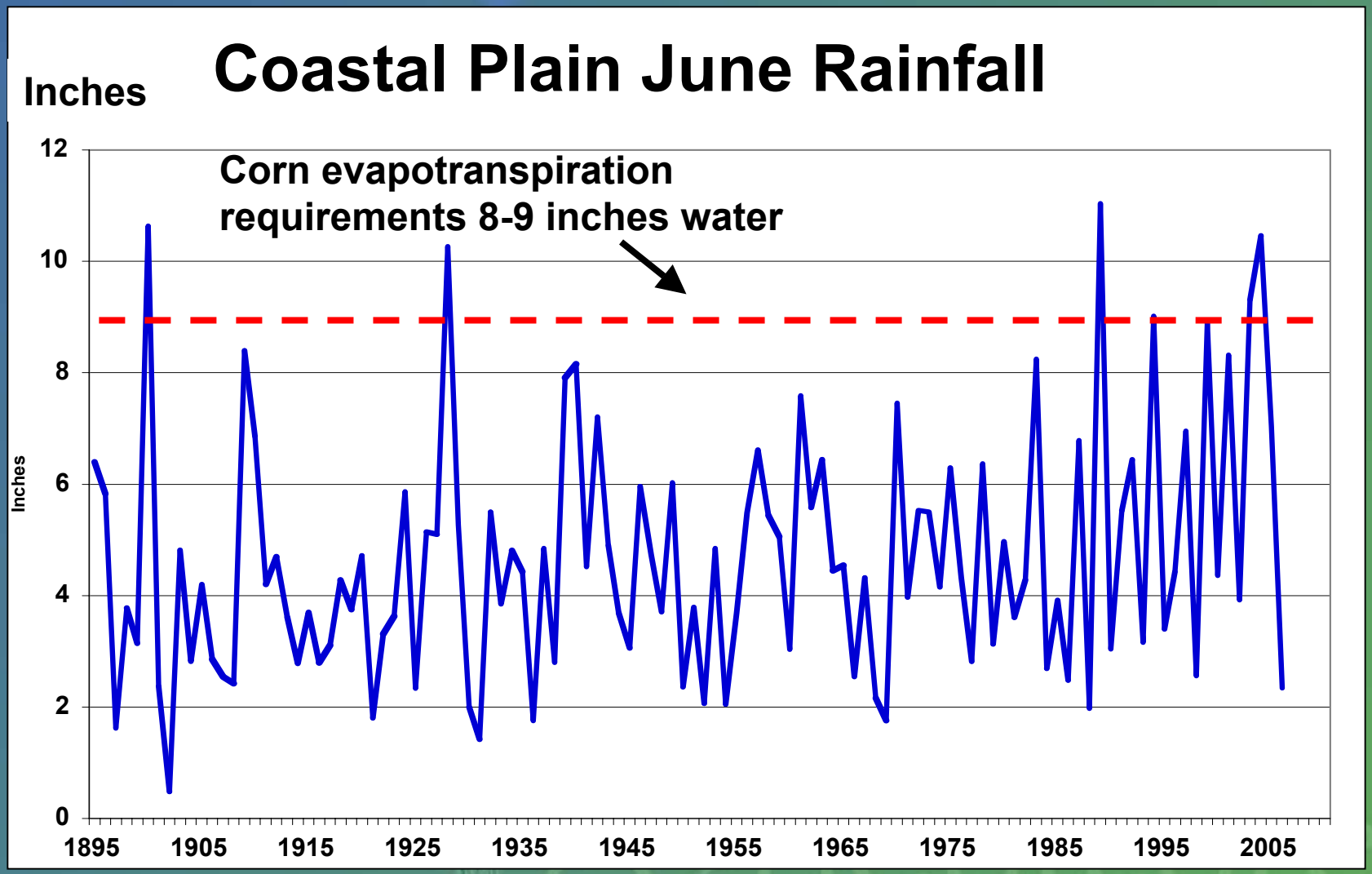
With timber production he is only turning over $18-22 per acre per year.

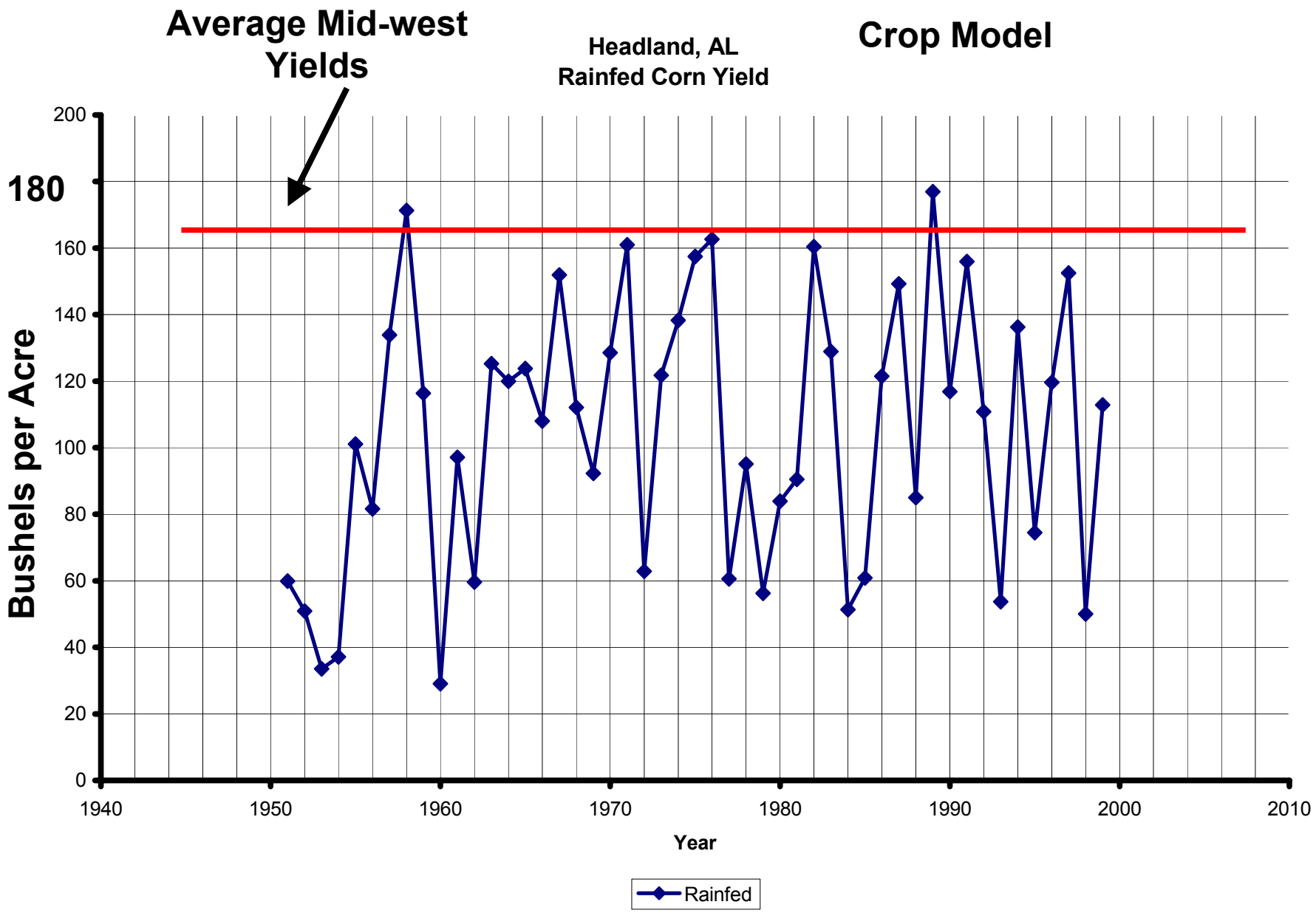
Rural towns dependent on farming business died out.

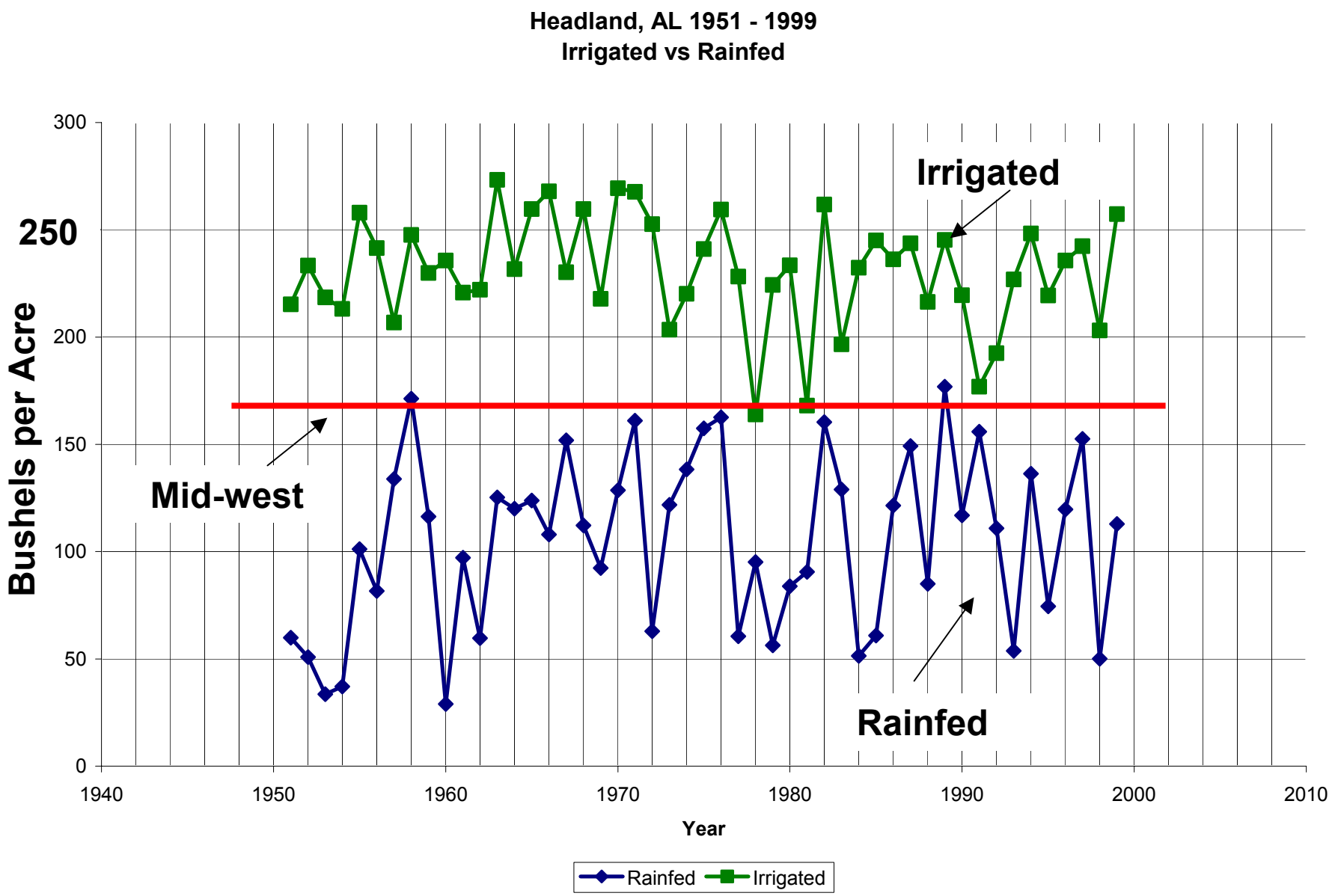
(Birmingham News.Bernard Troncale)

Many parts of these rural areas are third world in terms of poverty and infant mortality. State and Federal governments have huge welfare burdens and community assistance costs.

The problem with crop production in the SE




Average Mid-west Yields
Headland, AL
Rainfed Corn Yield
Crop Model
180
Bushels per Acre
200
160
140
120
100
80
60
40
20
0
1940
1950
1960
1970
1980
1990
2000
2010
Year
Rainfed


Headland, AL 1951 - 1999
Irrigated vs Rainfed
Irrigated
Mid-west
Rainfed
Bushels per Acre
250
300
200
150
100
50
0
1940
1950
1960
1970
1980
1990
2000
2010
Year
Rainfed
Irrigated

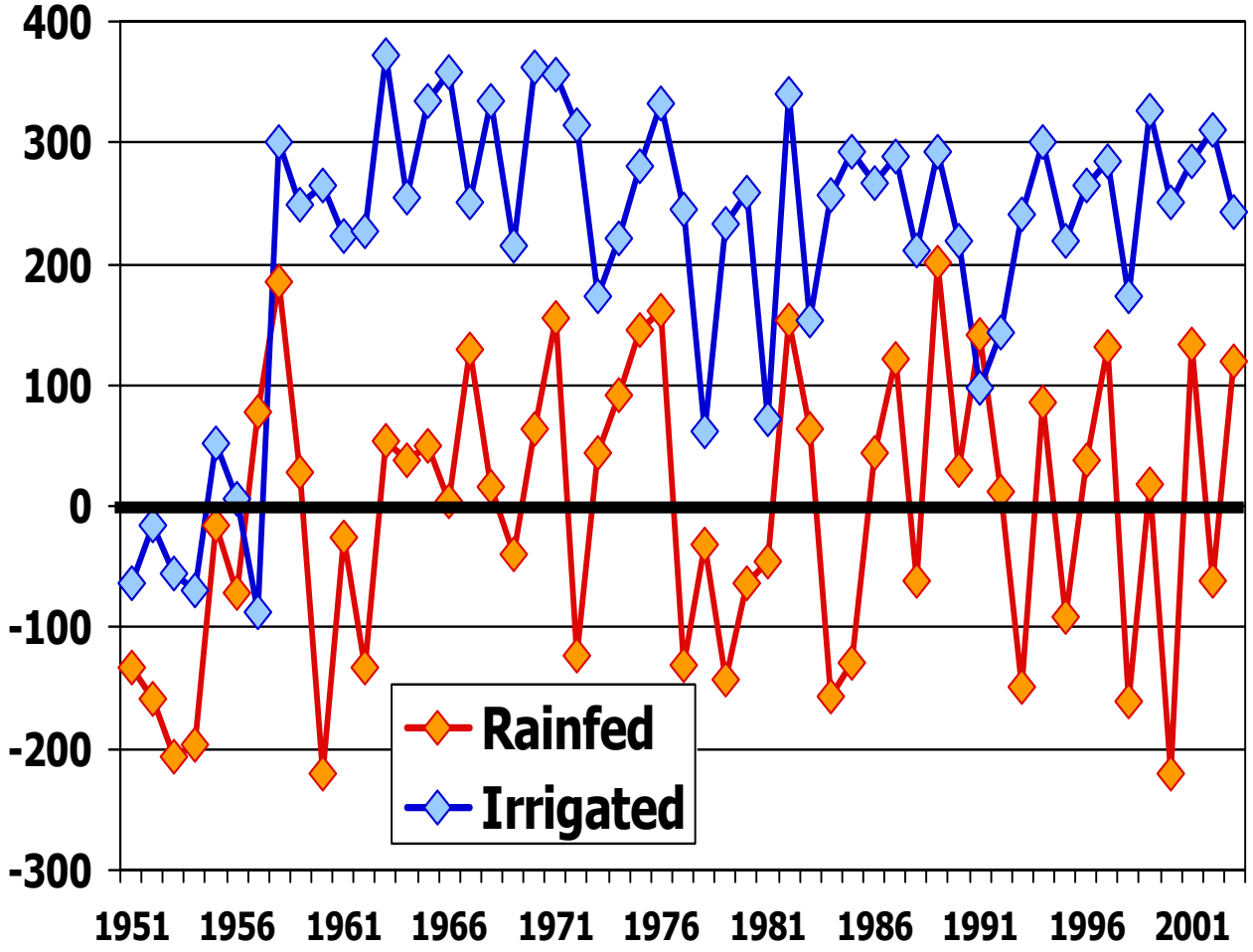
Net Profit Per Acre

(2003 dollars/ 2003 Genetics)

Average Profit/Acre

Irrigated $ 217

Rainfed $ -4



Base production costs from NASS - $303/ac

Additional Irrigation costs

Infrastructure 1000/ac amortized over 7 years (1951-1958 at 7%)

Electric costs - $40/ac

Fertilizer $20/ac

Labor - $48/ac

Reduced insurance $5 per acre

Alabama and the East lost its cotton production because it couldn't deal with droughts as well as its western irrigating competitors and it lost its corn production because it couldn't deal with droughts as well as deep water holding soils farmed in the mid-west.

In effect the market and competition worked – rain-fed production in Alabama was inefficient relative to its competitors.

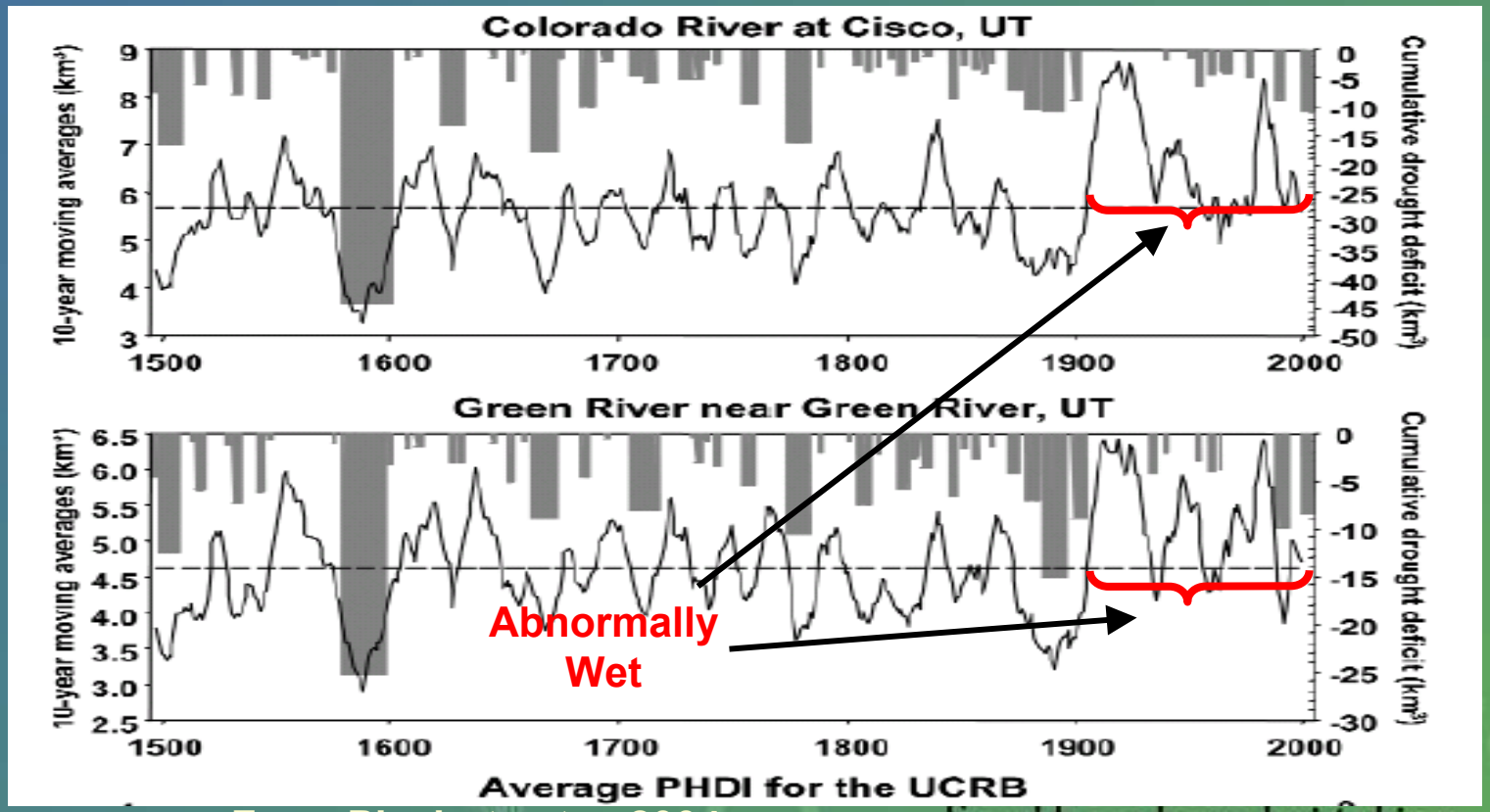
Can Alabama and the East regain its agricultural position if it embraces irrigation?

There is tremendous pressure on Western and High Plains agricultural systems due to water

- Ground water overdrafts from pumping
- Water demand from rapid urban growth
- Silting of reservoirs
- Salt and selenium surface poisoning
- River restoration and endangered species initiatives

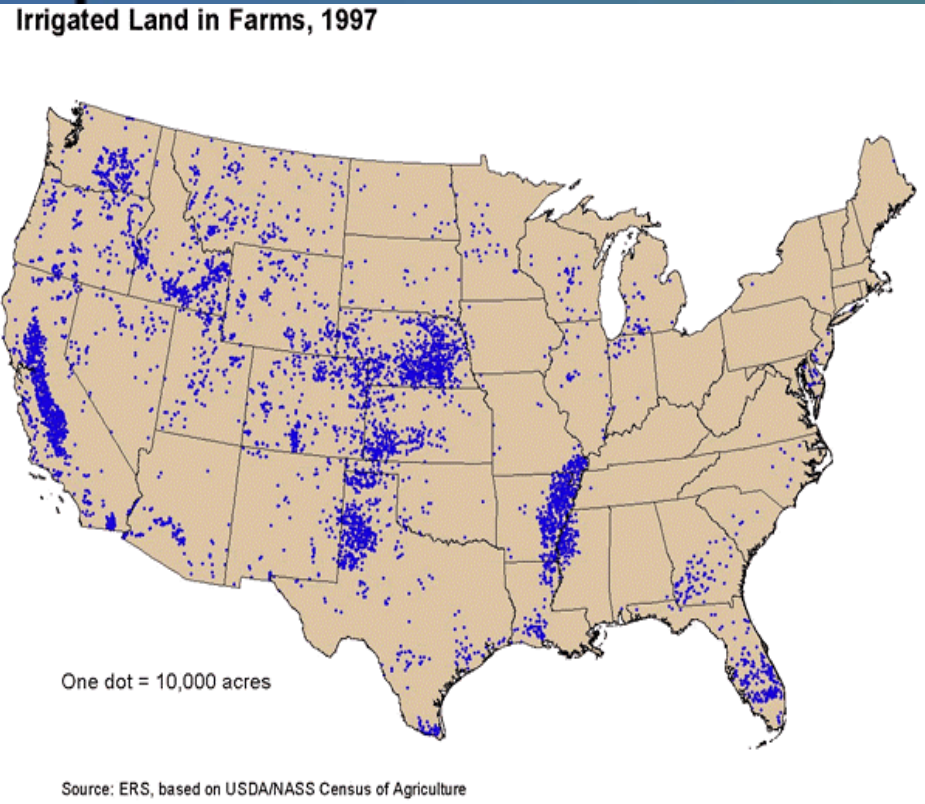
Demand for water by growing populations may not be the biggest issue facing the west. Rather, it may be supply.

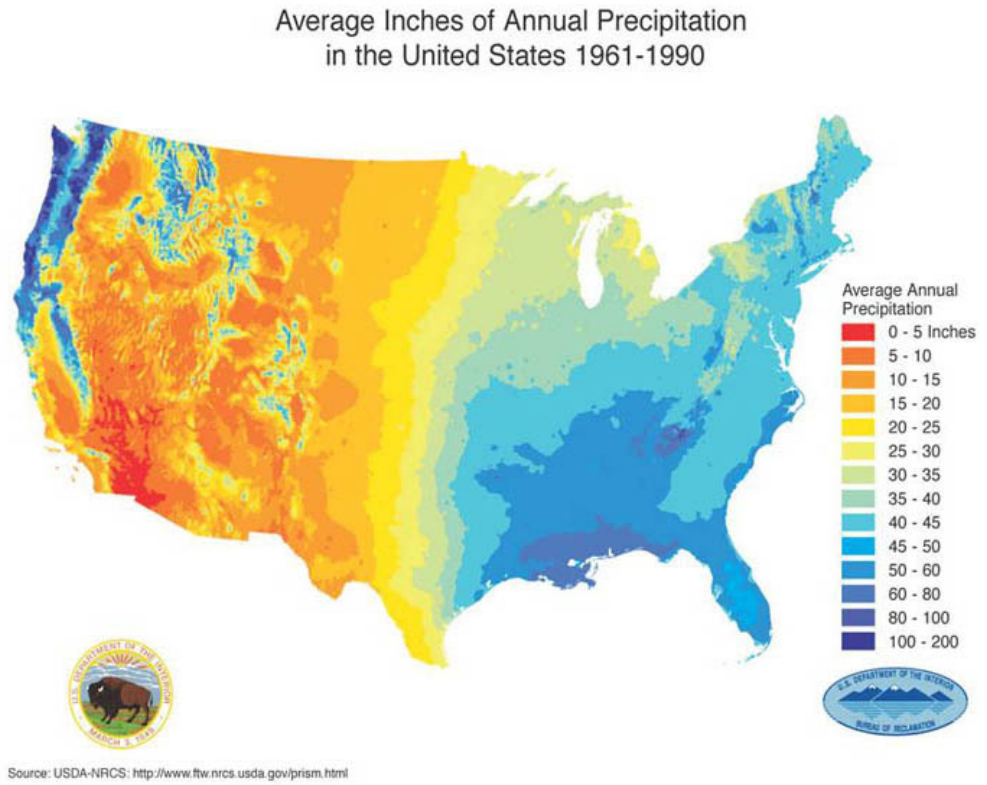
Recent reconstruction of climate indicate that the past 70 years may have been abnormally wet and future supply could be much less. The recent drought may be the norm.



From Piechota et a. 2004

U.S. irrigating where water is limited





Expanded irrigation in the Southeast could help energy and food security issues as well as address rural poverty

President Bush in 2006 proposed replacing Arabian Oil (500 million barrels/yr) with bio-fuels.

A 1000 gal water is needed to produce one gallon of ethanol

To replace Arabian oil with ethanol would require 60 million acre-ft water/yr

Where can we find this much water? Not west of the Mississippi!

For the U.S. to achieve these goals of increased ethanol production without adversely impacting food supply it must put land back into production where there is water.

Does the Southeast really have enough water to expand irrigation?

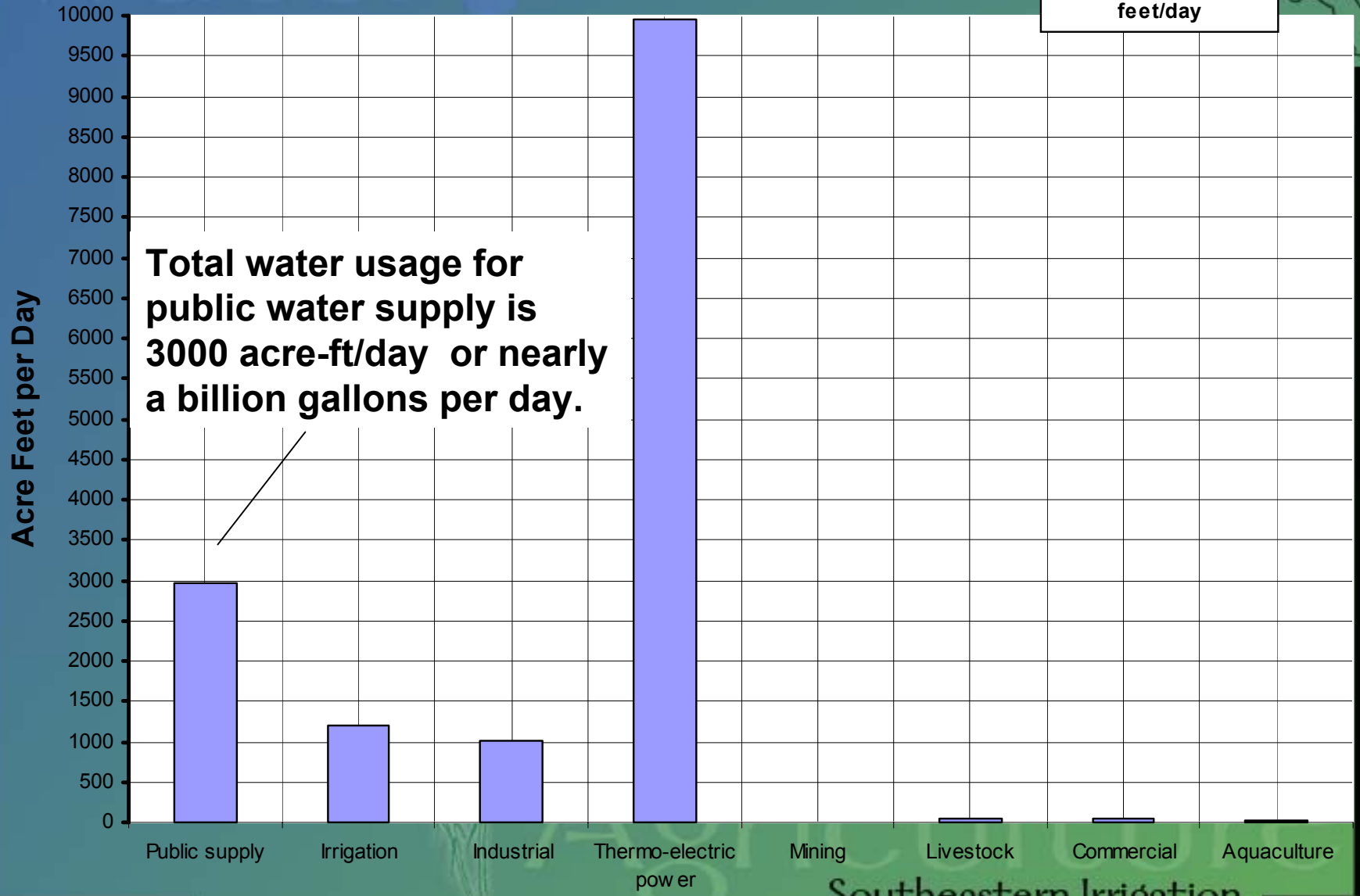
If you see headlines in papers and words of politicians and lawyers related to water wars in the Southeast or environmental activists trying to curtail urban growth or public utilities trying to control water in "their reservoirs"

you might perceive the answer is no!

Putting aside well intentioned agendas let's examine how much of this is based on hydrological facts as opposed to hydro-illogical perceptions.

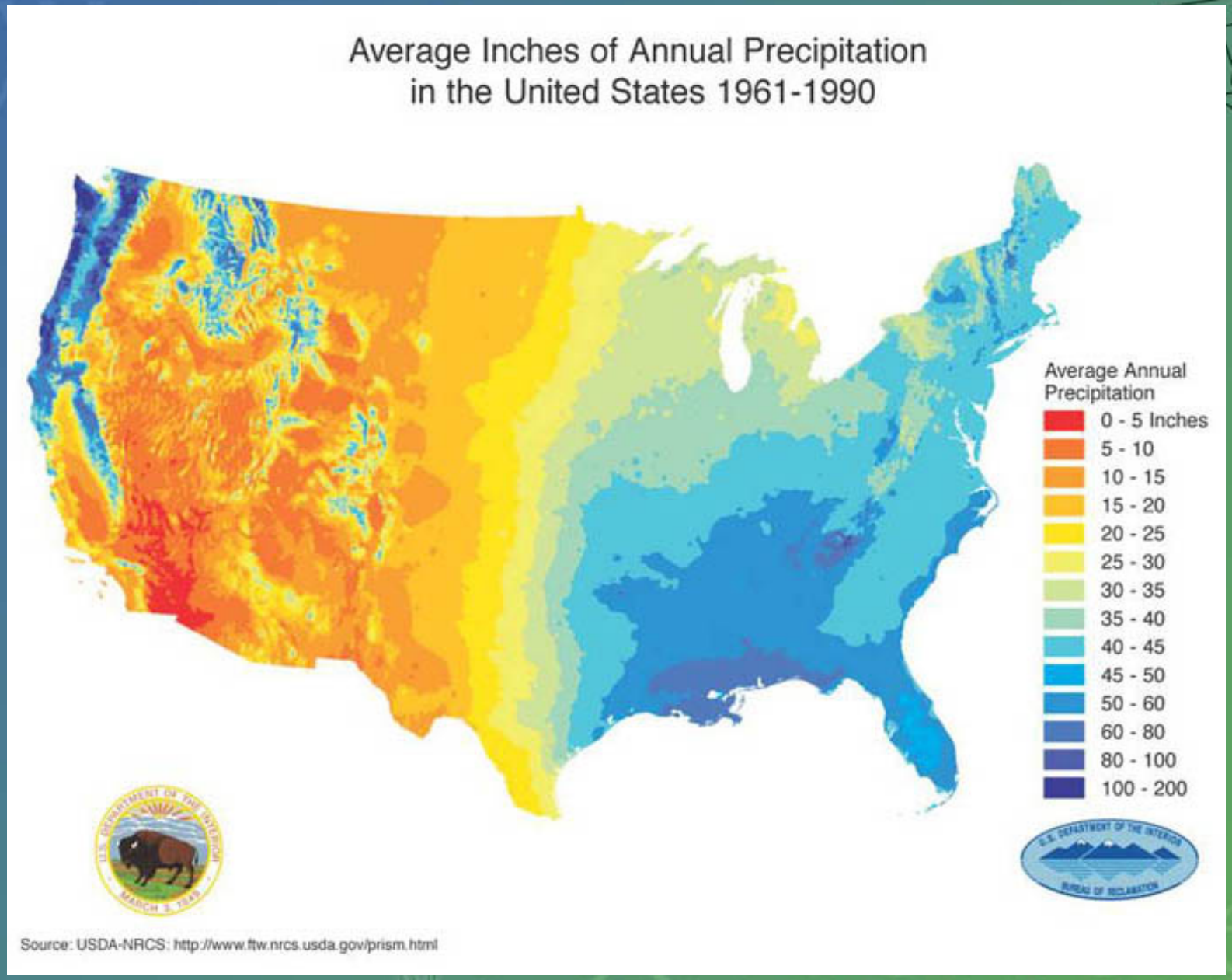
Hydro-illogical Perception: Urban growth is draining rivers dry

Water Usage for Georgia



Total water usage for public water supply is 3000 acre-ft/day or nearly a billion gallons per day.

Southeastern Irrigation


Average Inches of Annual Precipitation
in the United States 1961-1990
Average Annual
Precipitation
0 - 5 Inches
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 45
45 - 50
50 - 60
60 - 80
80 - 100
100 - 200
Source: USDA-NRCS: http://www.ftw.nrcs.usda.gov/prism.html

Run-off

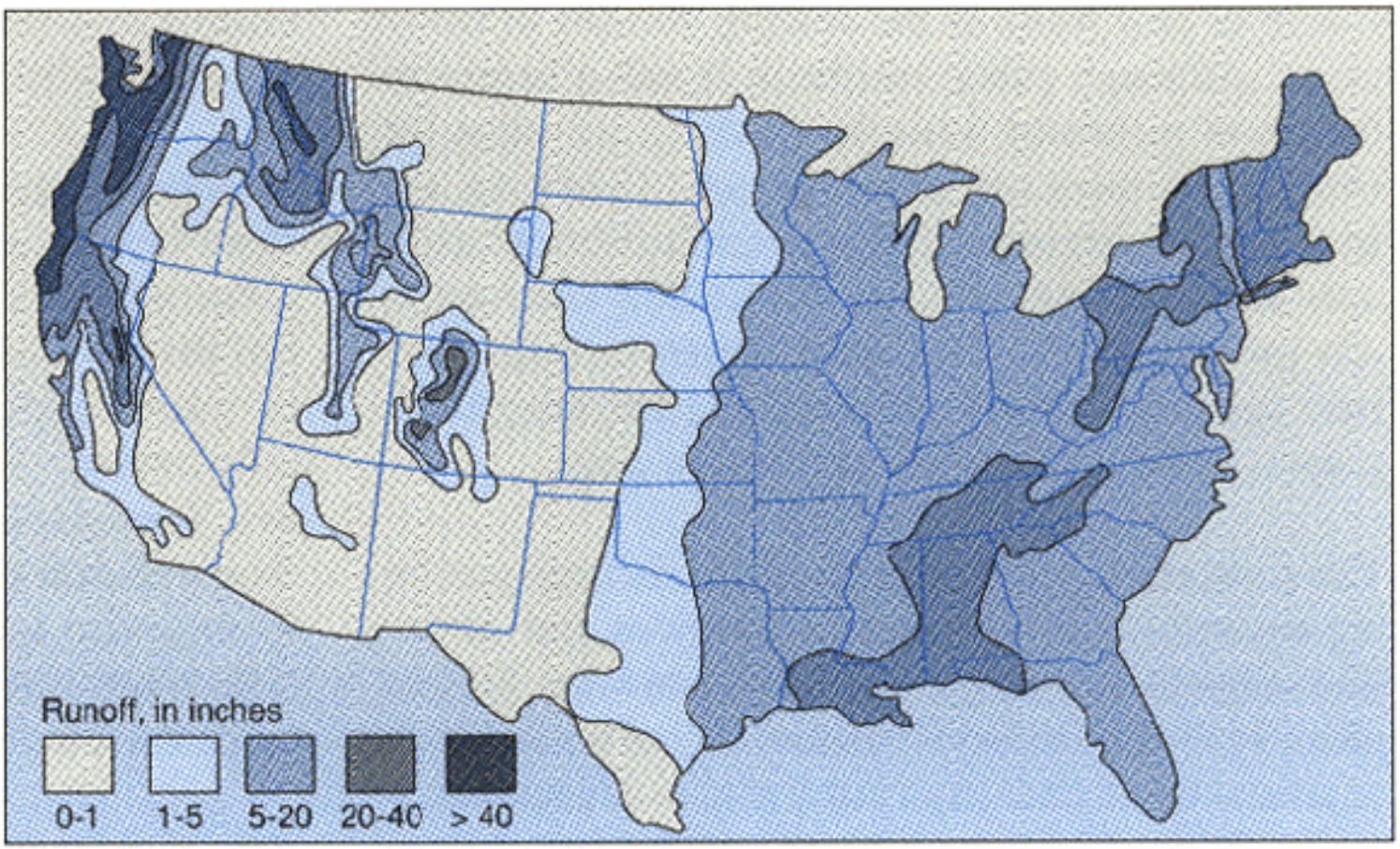
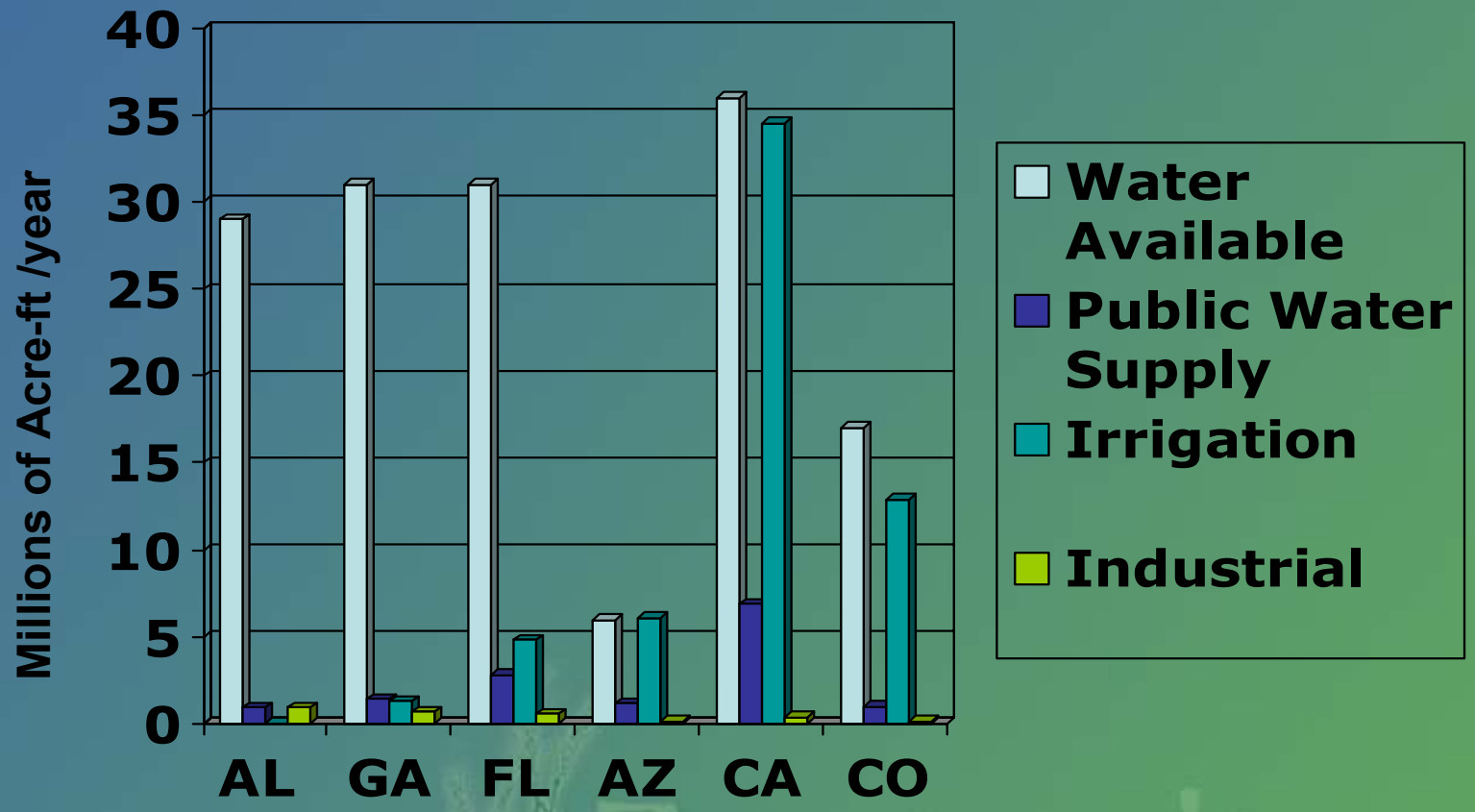


Figure 3 Average annual runoff in the conterminous U.S., from U.S. Geological Survey, National Water Summary 1983—Hydrologic Events and Issues: USGS Water-Supply Paper 2250 (1983).

Annual Fraction of Water Withdrawal in Southeast is Extremely Low



Based on Withdrawals

Water Consumption Versus Water Withdrawal

The fraction of water actually consumed (evaporated) by urban water use is small.

Atlanta withdraws approximately 1. million acre-ft/year (USGS)[1]

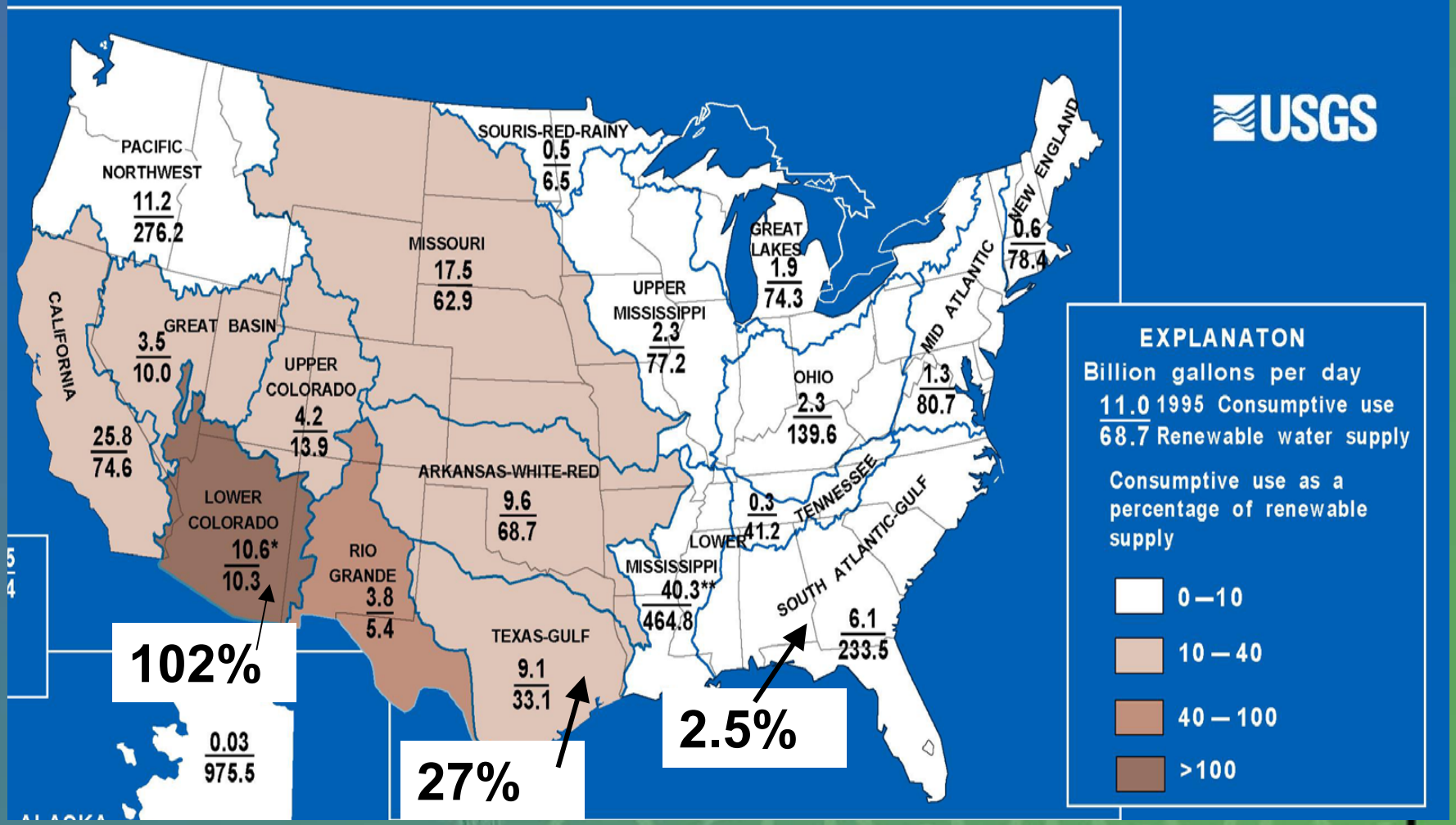
Fraction consumed (0.15 -0.2) – 150,000-200,000 acre-ft/year

Increased consumption since 1973 - 75,000-100,000 acre-ft/year

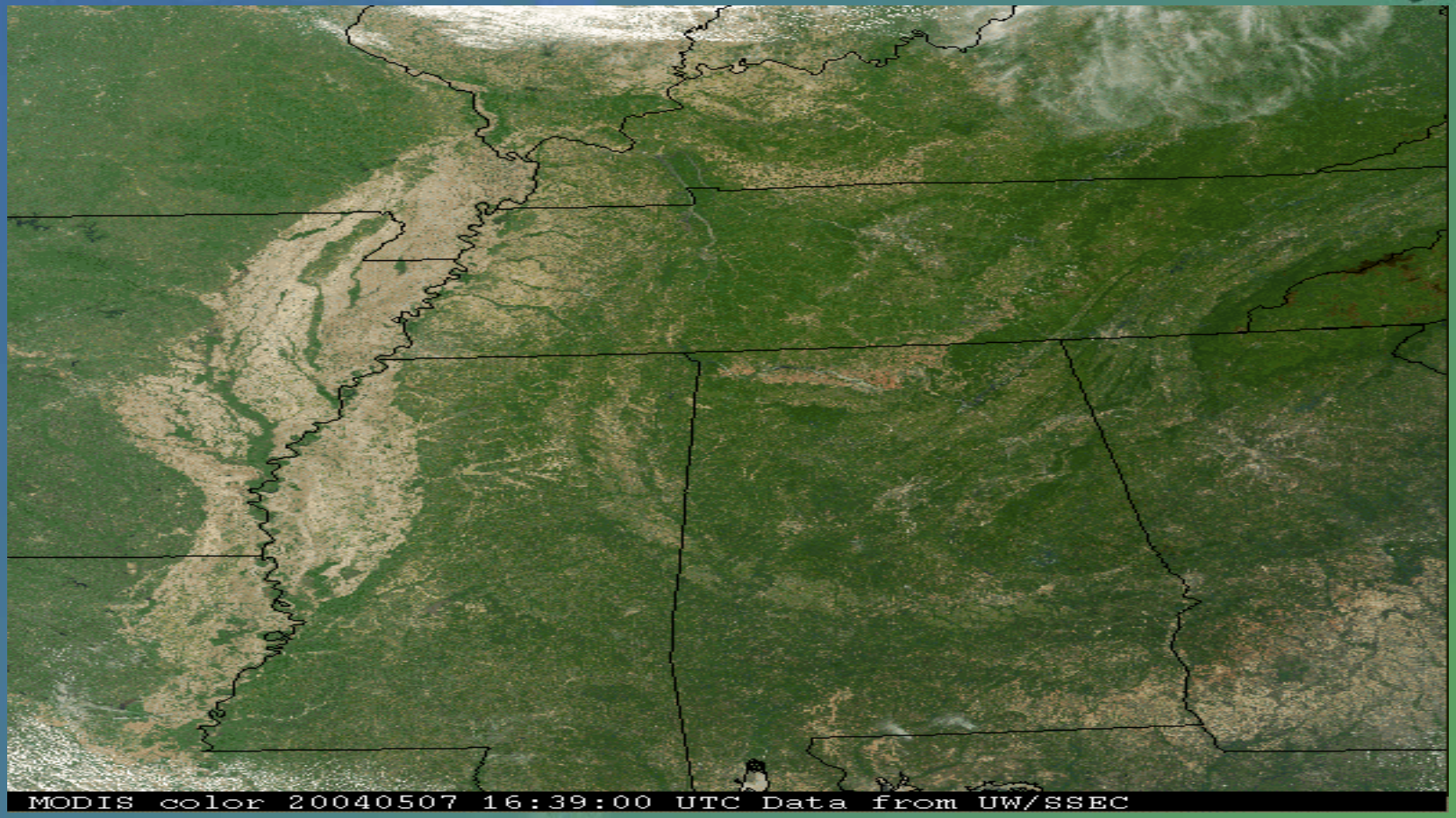
Estimated based on Georgia total withdrawals for public water supply

Chattahootchee has 1.7 million acre ft/yr

Net Consumption of Water

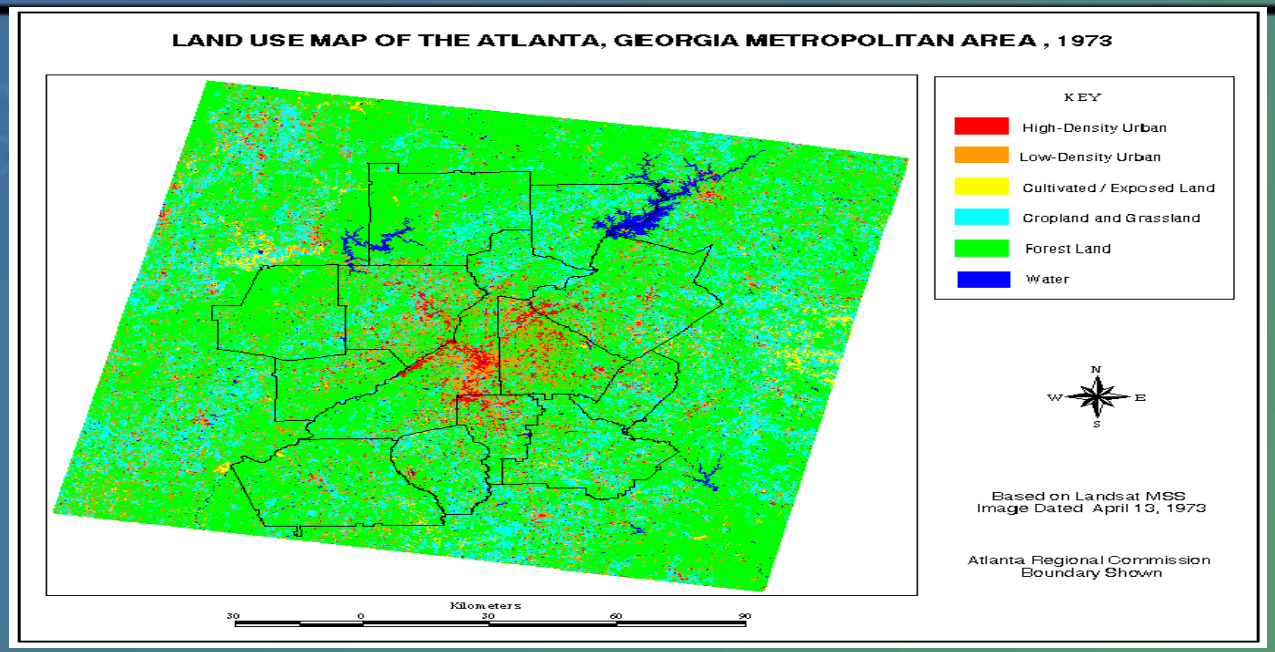


In humid environments substantial water is consumed by vegetation in the warm season

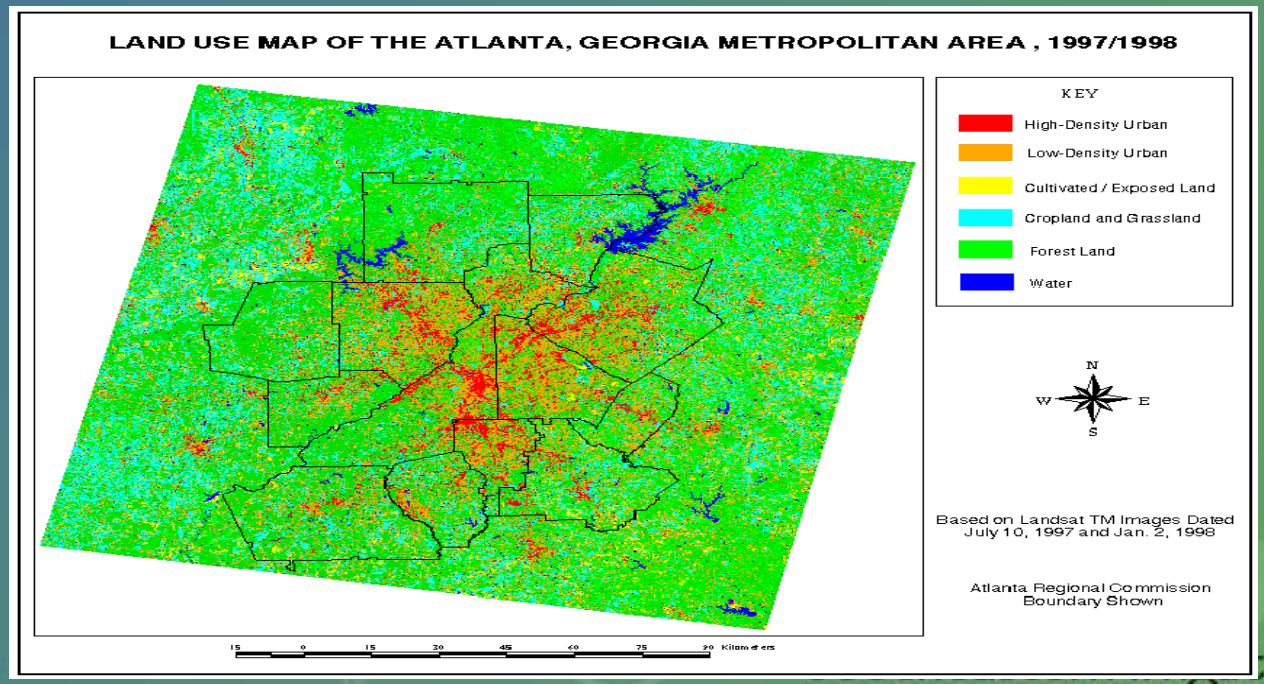


Forests transpire (consume) 20-26 inches per year (USGS)

1972

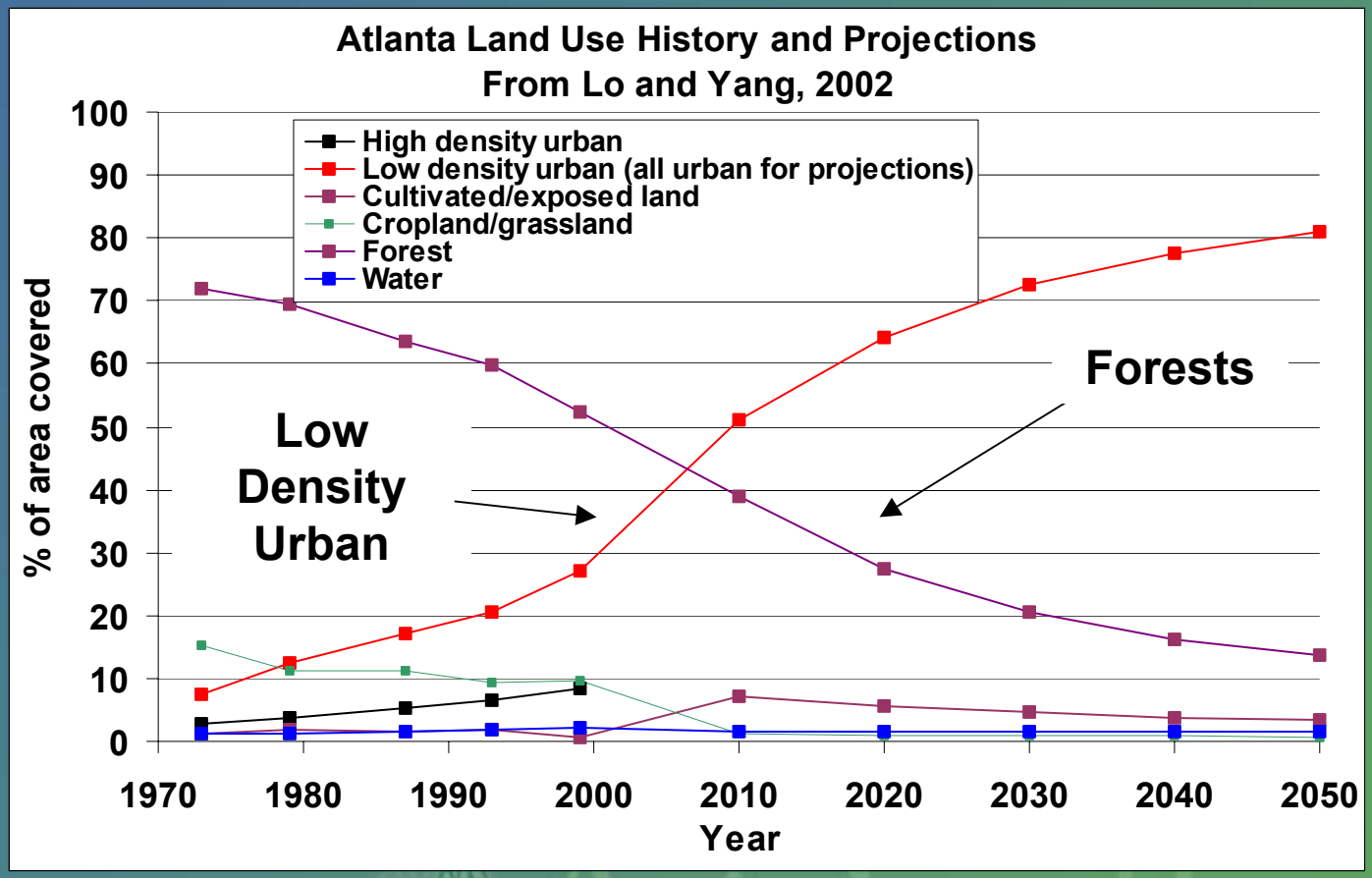


1998



Courtesy Dale Quatrocchi, NASA MSFC

Estimate of Consumption Change Due to Land Use in Atlanta



Coweta Watershed Forest Cut in 1939

Year	Years since treatment	Annual precipitation	Estimated increases in streamflow: Observed minus normal runoff	By regression on time	±95 percent confidence limit
	(1)	(2) *Inches*	(3) *Inches*	(4) *Inches*	(5) *Inches*
1940-41	1	54.56	14.45	14.68	2.36
1941-42	2	61.35	10.89	12.04	1.81
1942-43	3	80.99	10.94	10.50	1.55
1943-44	4	76.97	9.76	9.41	1.41
1944-45	5	63.44	7.88	8.56	1.35
1945-46	6	75.22	9.93	7.87	1.31
1946-47	7	66.68	7.93	7.28	1.30
1947-48	8	73.37	7.30	6.78	1.31
1948-49	9	89.91	5.19	6.33	1.33
1949-50	10	84.99	5.17	5.93	1.36
1950-51	11	72.75	5.59	5.57	1.39
1951-52	12	83.70	5.78	5.24	1.42
1952-53	13	64.98	4.99	4.93	1.45
Average		72.99	8.14	8.09	1.49

From Kovner 1957 Proceedings of American Foresters, 1957 Memphis,Tennessee

Estimated evapotranspiration decreased by 10 inches after cutting forest.

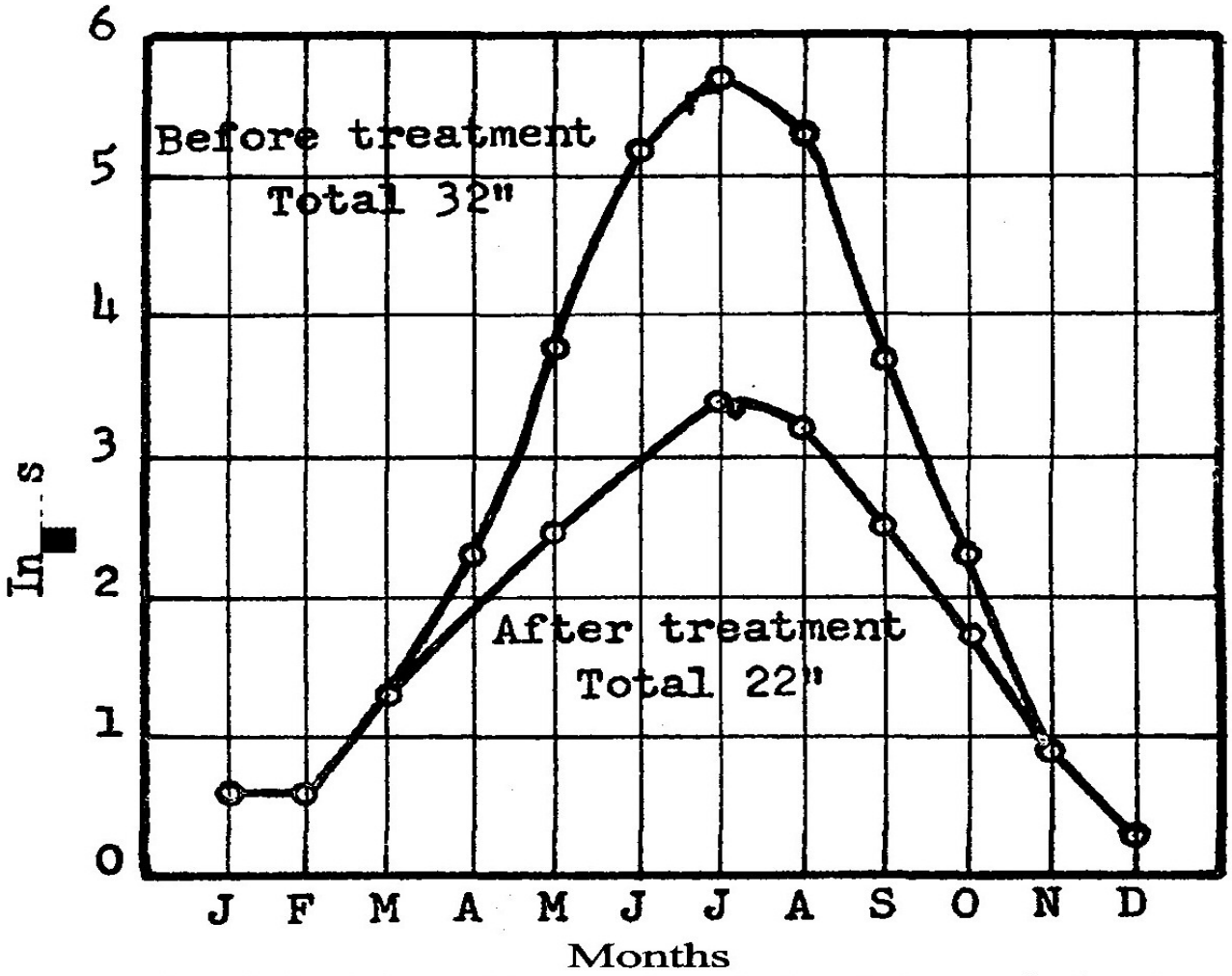


FIGURE 3. *Estimated monthly evapotranspiration before and after treatment Watershed 17.*

Change in consumption due to land use change in Atlanta

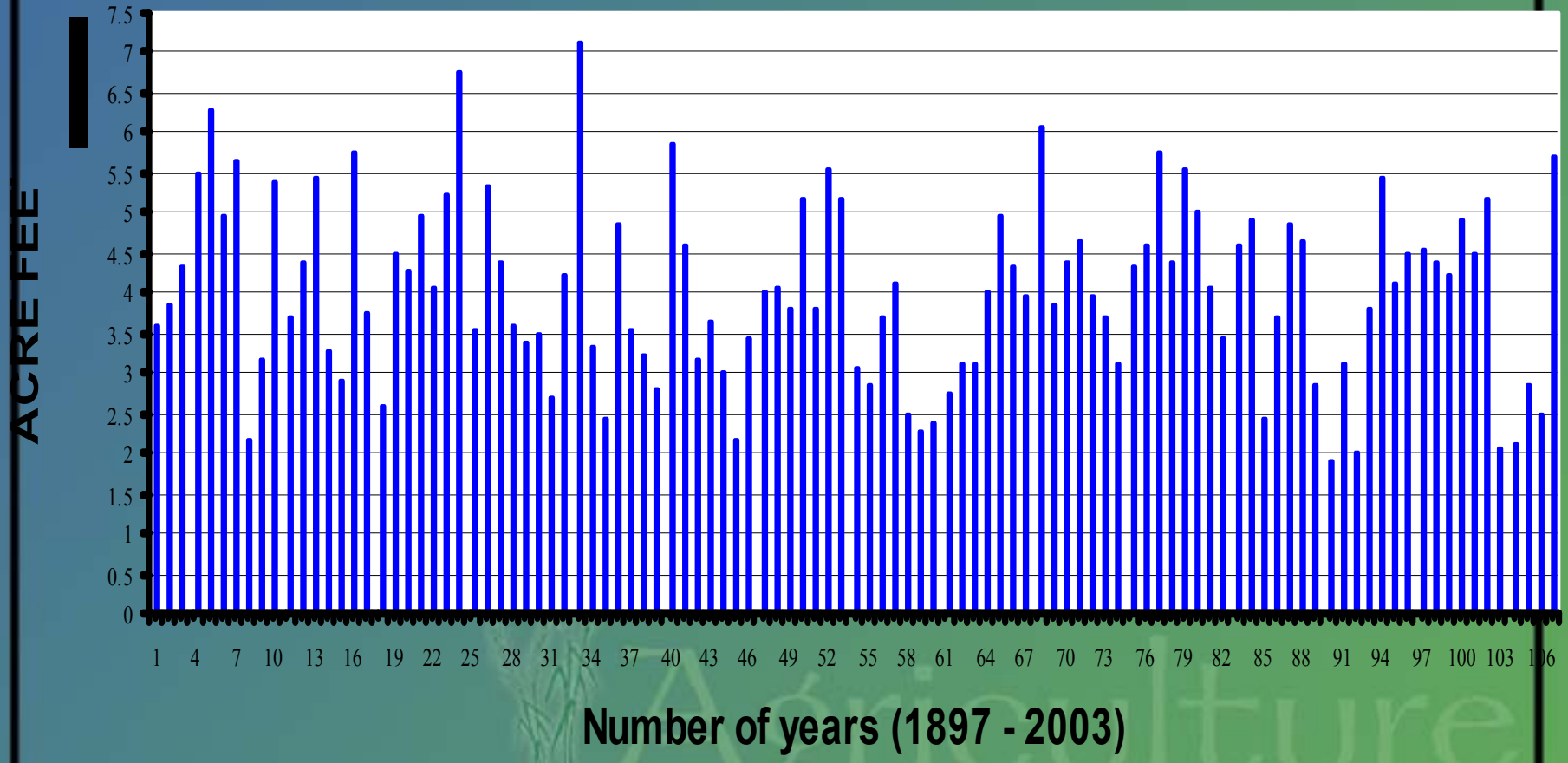
1973-1999 decrease in forests 2200 sq.km or 518,000 acres

For a 10 inch decrease in evapotranspiration based on Coweta experiment this yields 431,000 acre-ft of reduced consumption of water in Atlanta area

Compare to increased consumption by urban use 75,000-100,000 acre-ft per year.

Thus, the net result is that in humid environments urban development actually increases annual stream flows

CHATTAHOCHEE RIVER : WEST POINT
AVERAGE ANNUAL VOLUME



Southeastern Irrigation

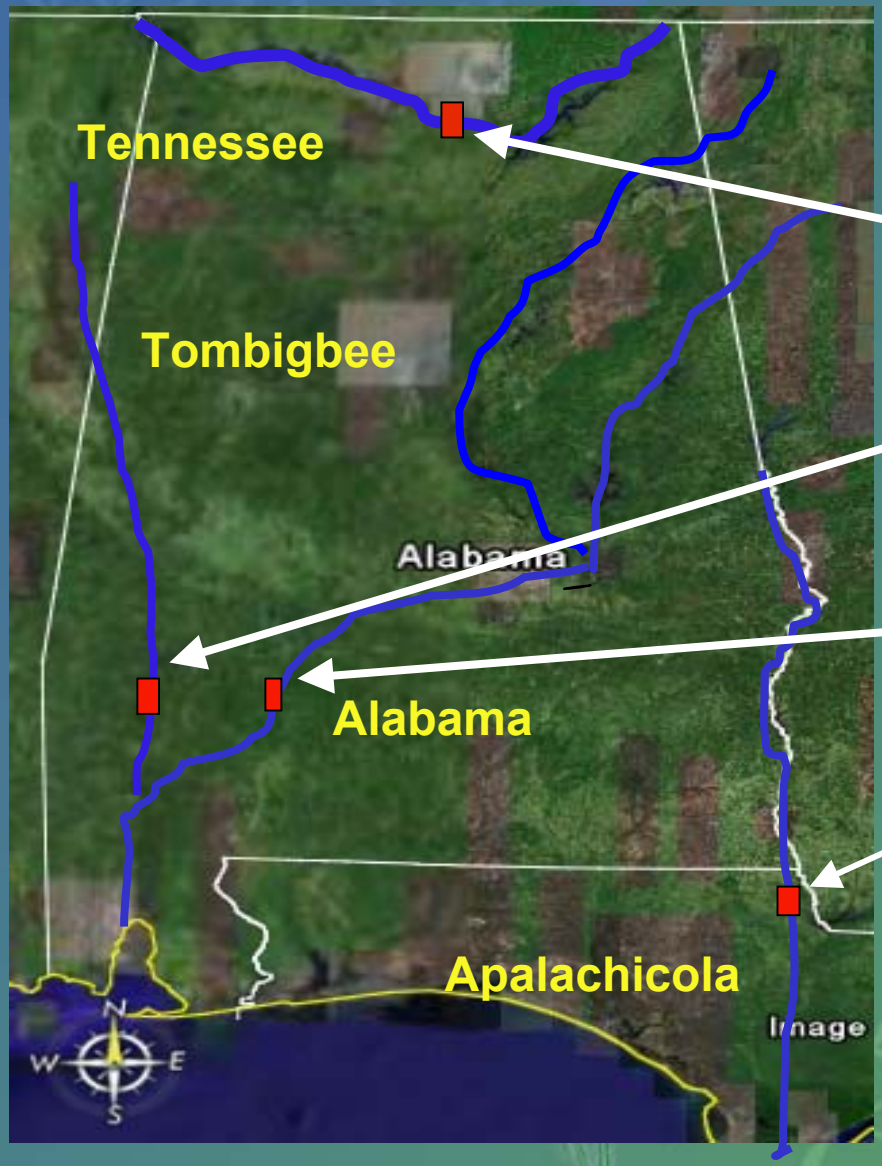
While consumption of water for public water supply in Atlanta may not be adversely impacting water resources in the southeast, water consumption for food in Atlanta may be an issue.

For an average person in Atlanta consuming 2500 calories/day in food (20% of calories as meat) this represents 1000 gallons of water per day consumed for this food production per day. This consumption is from the plant transpiration in producing this food.

By comparison 50 gallons per day per person is consumed for public water supply in the Atlanta region.

In effect, we are transporting scarce water from the west to water rich Atlanta – this is hydro-illogical.

River Flows Are Huge in SE



Colorado River – Glen Canyon
10 million acre-ft/yr

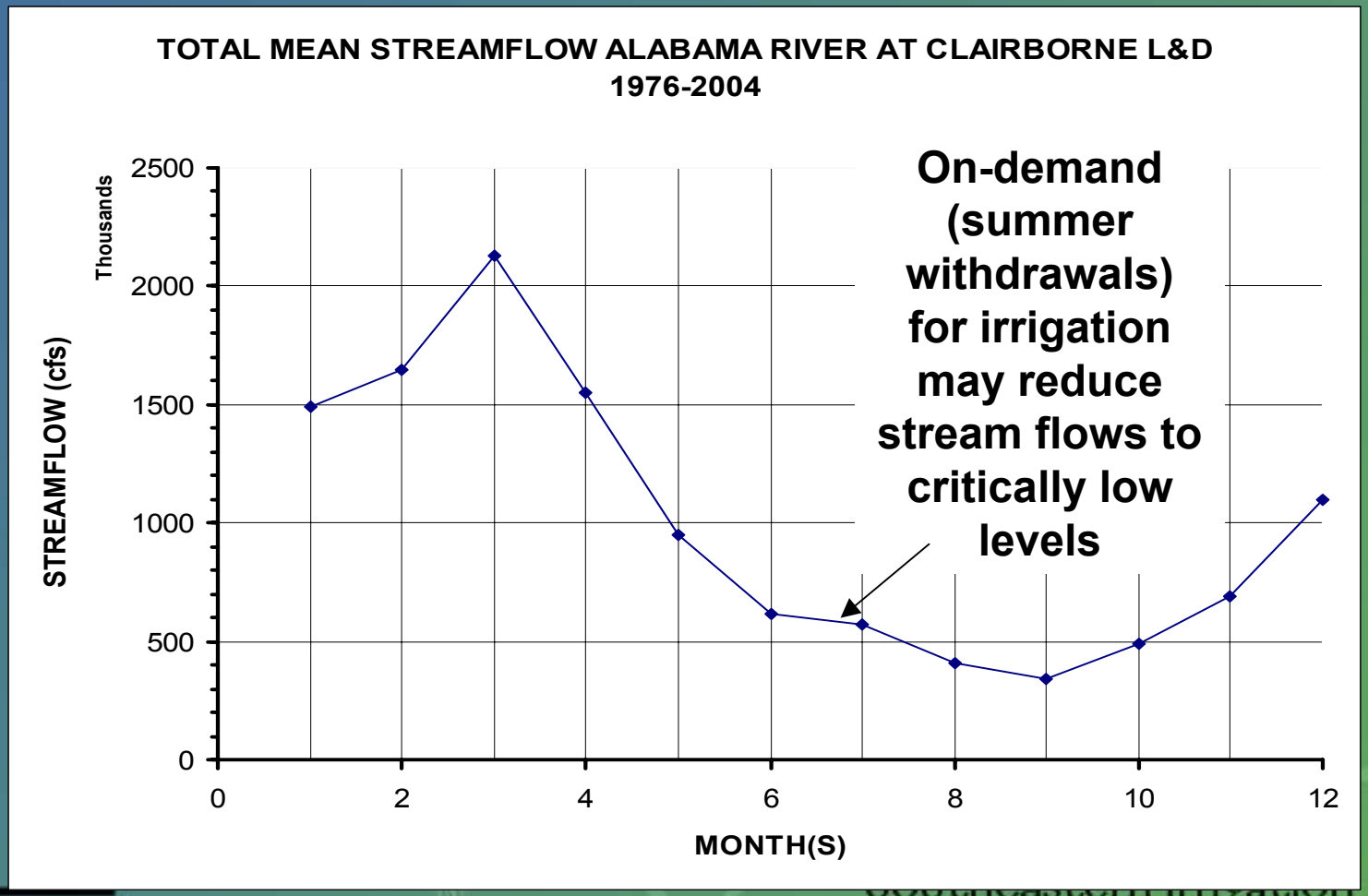
Tennessee –Huntsville
30 million acre-ft/yr

Tombigbee River - Coffeeville
19 million acre-ft/yr

Alabama River -Monroeville
24 million acre-ft/yr

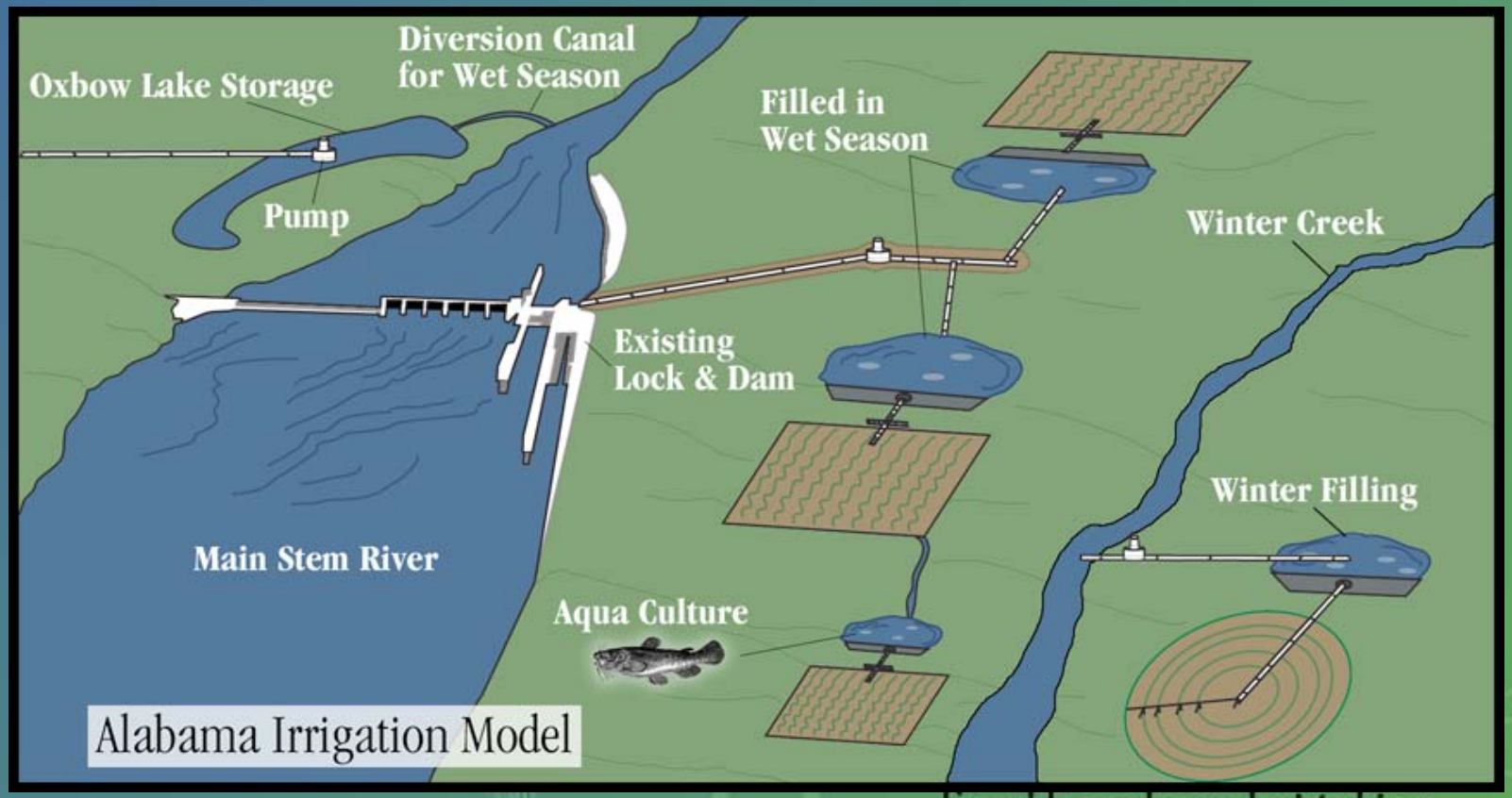
Apalachicola – Blountstown
16 million acre-ft/yr

The Southeast has plenty of water availability on an annual basis. Even in the driest years rivers have huge flows compared to western rivers. However, during the summer the consumption of water by the vegetation of the region reduces stream flows to critically low levels.

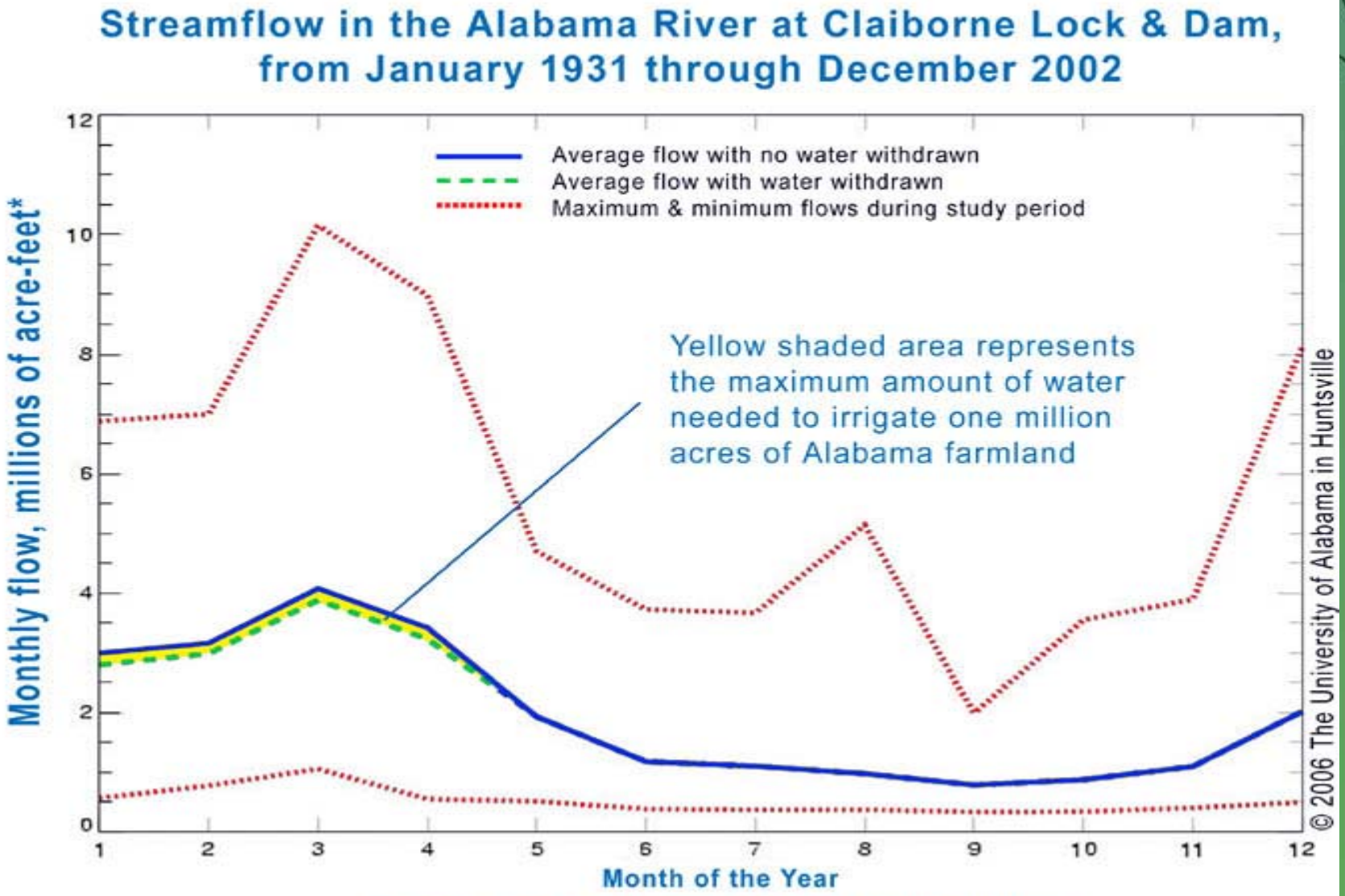


Sustainable Southeastern Model - Storage of Winter Surface Water

Even in dry years crops need less than a foot of water. Irrigation can be supported with a fraction of the winter river flow removed.



How much water can be withdrawn?



In the East irrigation can be supported using only a fraction of the available water. In the West many streams are almost totally consumed.

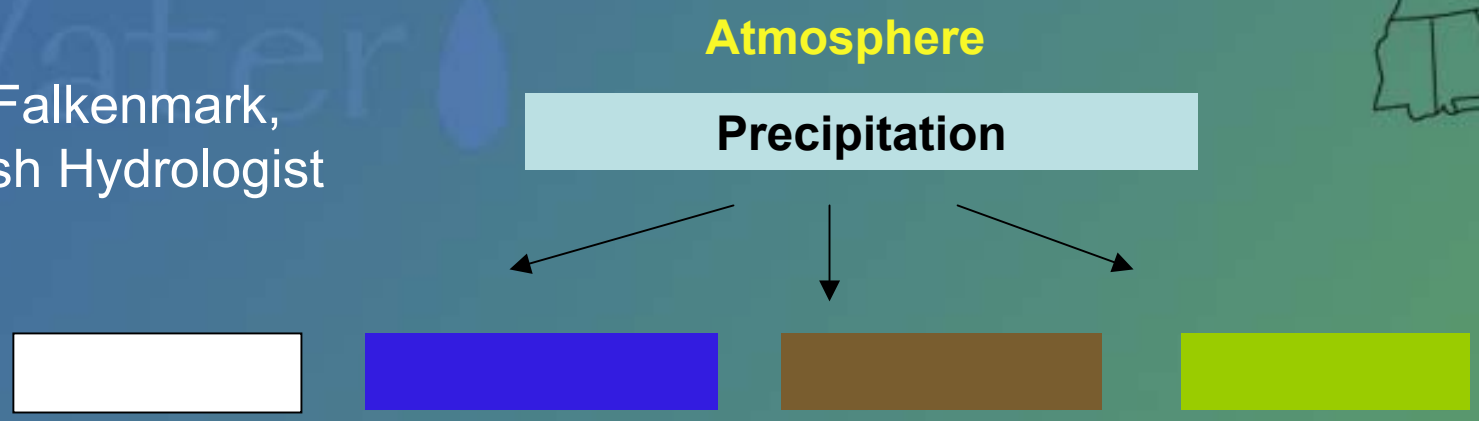
For example in California tremendous environmental damage was done as rivers were totally depleted destroying salmon runs and wetlands.

East needs help for investment in storage infrastructure

Wringing the final drops of water out of the western system will be incredibly expensive. Catching and storing water in the east is easy and inexpensive. Rather than big multi-year storage reservoirs needed in the west, simple on-farm storage ponds can be filled with excess winter water from small streams and catchments.

In many areas a 15 acre pond ten feet deep (enough to irrigate nearly 300 acres) can be constructed for less than $100,000.

Marin Falkenmark,
Swedish Hydrologist



White Water
Ice caps / Glaciers

Blue Water
Rivers / lakes

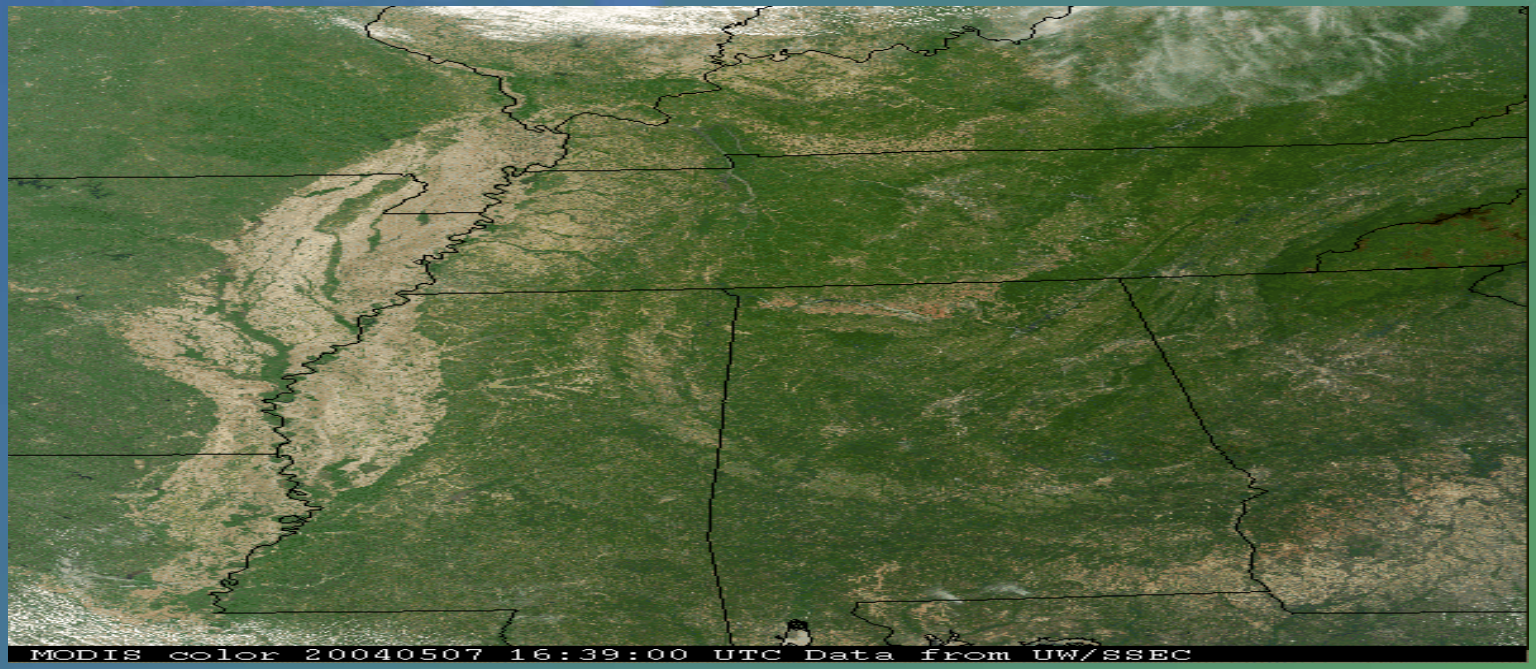
Brown Water
Ground Water

Green Water
Water transpired by plants back into the atmosphere

In the Southeast we not only have a large amount of blue water in the winter but we have a large amount of green water during the summer.

What role can this green water have on water policy in the Southeast?

In humid environments water will be consumed by vegetation even if not in agricultural production



Corn rain-fed – 12-15 inches

Corn irrigated 18-20 inches

Forests 20-26 inches (USGS)

Natural forests or farmed forests may consume more water over a season than irrigated corn

In the South agriculture can be expanded using green water rather than blue water.

Transitioning of forests back to agriculture will use green water consumed by forests for agricultural production.

Thus the U.S. may increase its agricultural output for food security and energy security without impacting water availability.

20th Century: Move Water to Agriculture

The western belief that it was a crime to let water flow into the sea lead to the financing of colossal projects to divert water onto deserts. Moving water is expensive and long term problems are now apparent.

Friant Dam near Fresno CA
0.5 to 3 million ac-ft/year

21st Century: Move Agriculture to Water

Coffeeville Lock and Dam in Alabama
11 to 35 million ac-ft /year

In wet climates, only inches per year of irrigation are needed to supplement natural rainfall. The most cost effective and sustainable solution for U.S agriculture is to bring it back to water.

This will enable food security and allow expansion of agriculture for bioenergy needs.