Migration as a Geographical Path to Agricultural Sustainability

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Agriculture

Southeastern Irrigation

Migration of Agriculture as an Adaptation to Climate Change

NIFA-NSF EASM Project*

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U.S. Forest Service

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Funded by NIFA Climate Change Program –L.Tupas, M.Bowers, N. Cavallaro

Southeastern Irrigation

Strategies for Sustaining Agriculture in the Face of Climate/Water Threats to Production

1. Conservation – low pressure nozzles, drip irrigation, irrigation scheduling etc.

2. Improved genetics – drought and salt tolerant cultivars

3. Building of additional water storage and water transfer projects

Here we propose that a fourth strategy - migration of agriculture to where it is more sustainable should be evaluated.

While almost everyone in the climate change community has expressed concern about the impact of climate change on agriculture, less has been discussed about agricultural change in the last century in the U.S. which makes agriculture vulnerable to climate.

The drought of 2012 in the Midwest and the current Western drought expose this vulnerability

Southeastern Irrigation

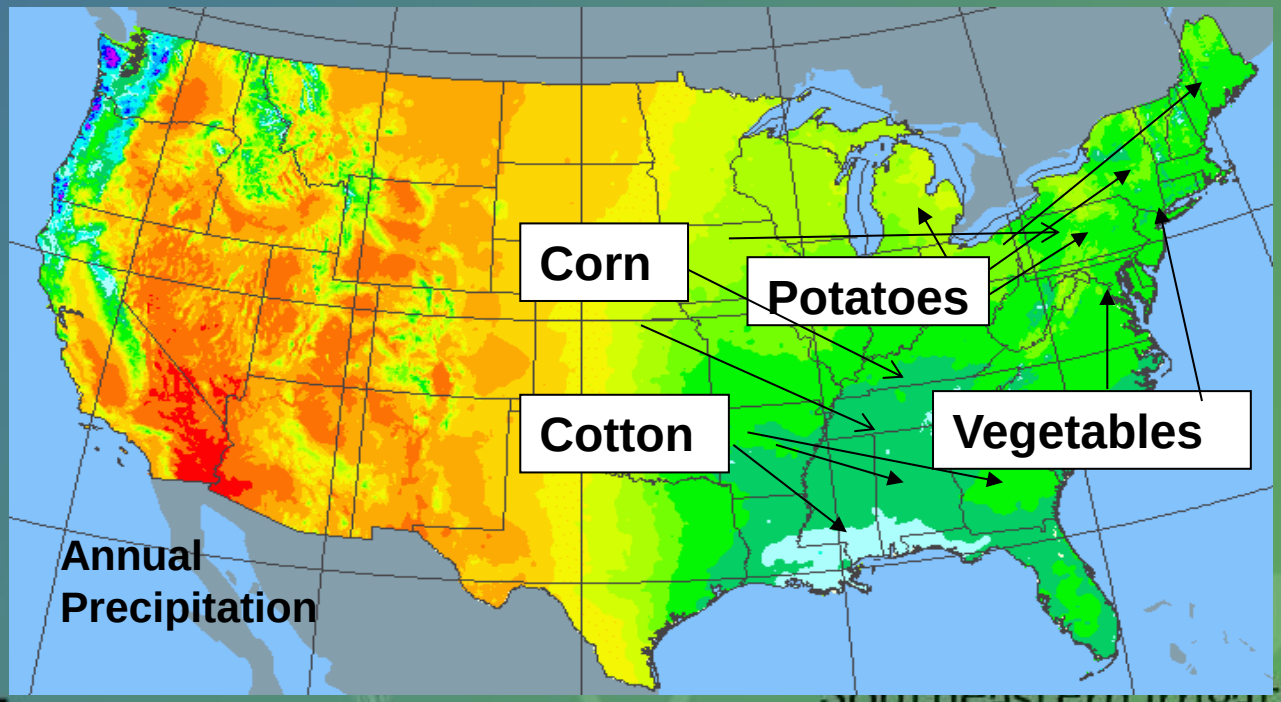
Since 1940 there has been a major migration of agricultural production in this country driven by water and transportation

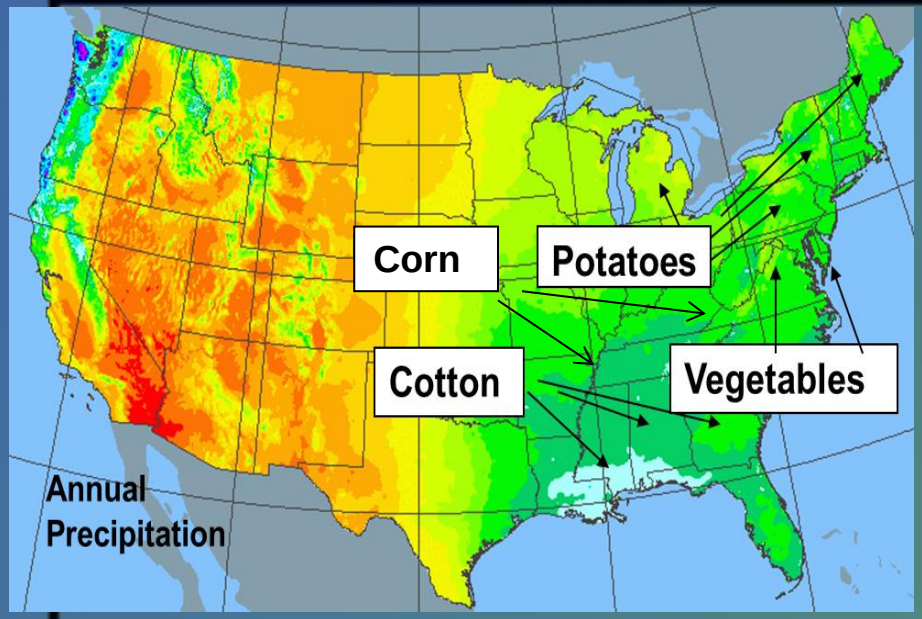
Prior to 1940 Maine ,Pennsylvania and New York led the nation in potato production

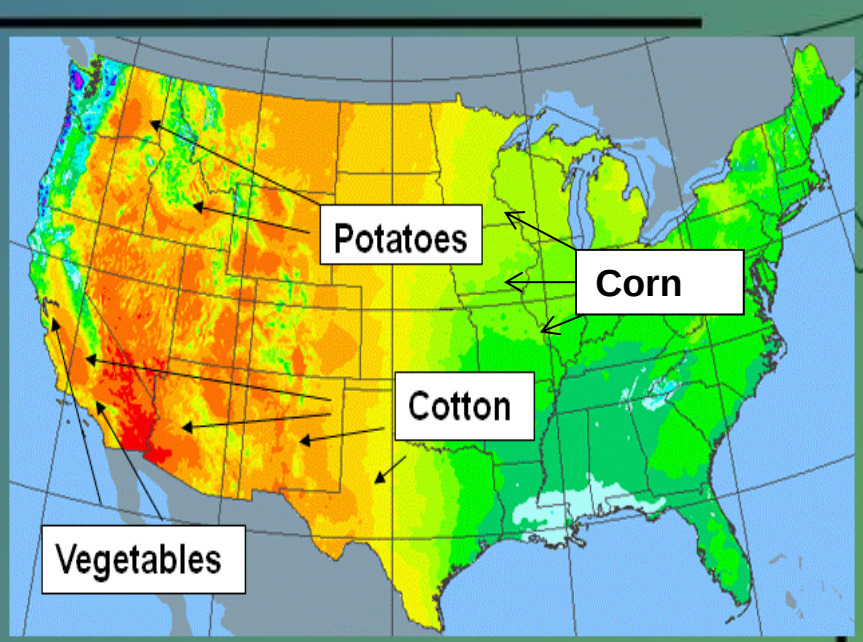
Cotton was King in the Southeast

Northeast provided produced a substantial fraction of vegetable production

Corn was grown in almost every State for local use







1930 **2013**

The underlying map shows precipitation.

We have moved production away from the Nation's water and concentrated grain production in a small part of the upper Midwest.

Is this a sustainable geography for U.S. agricultural production?

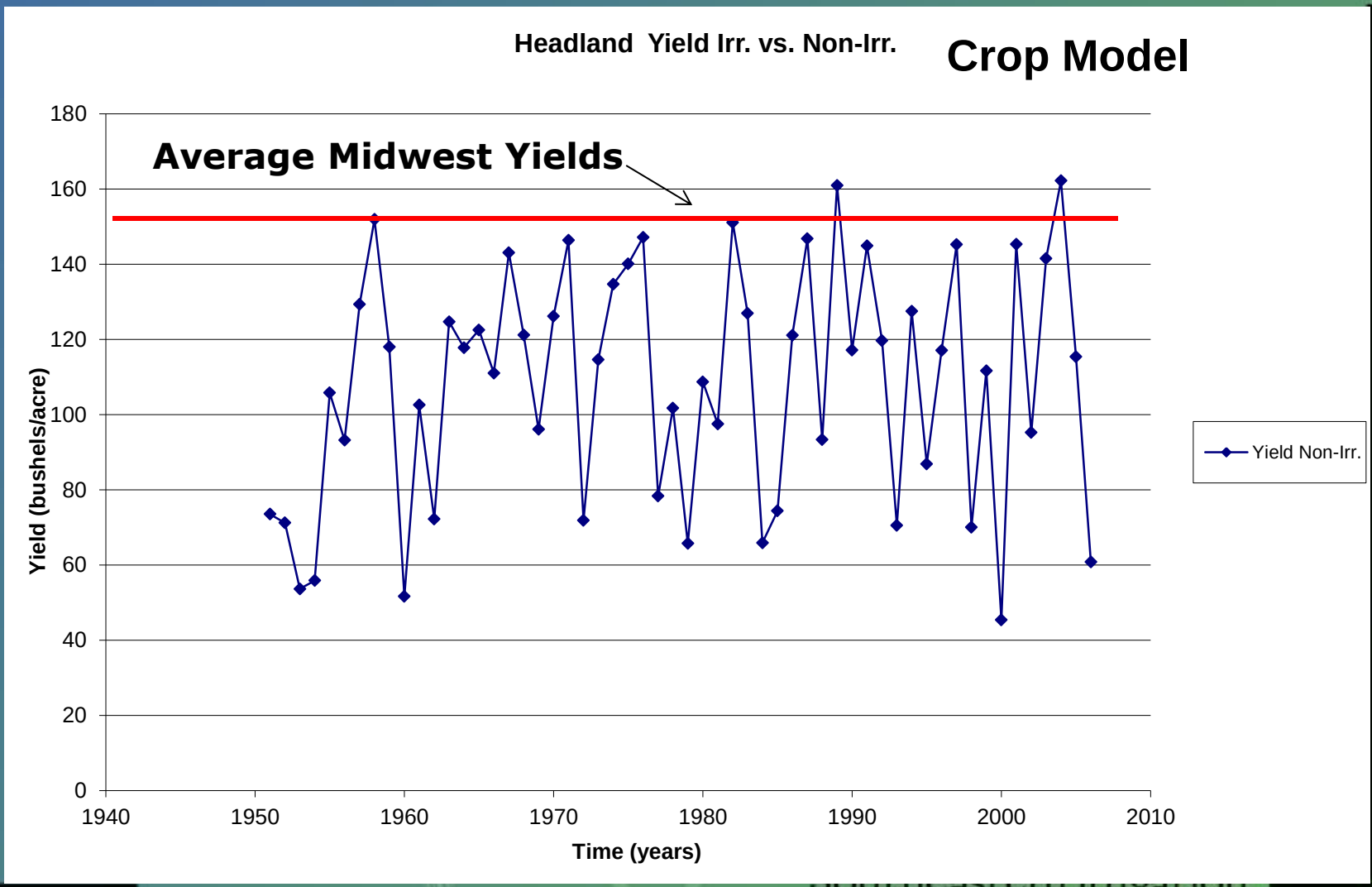
What drove this dramatic shift in agricultural production ?

Search for Consistent Water for Production and Transportation

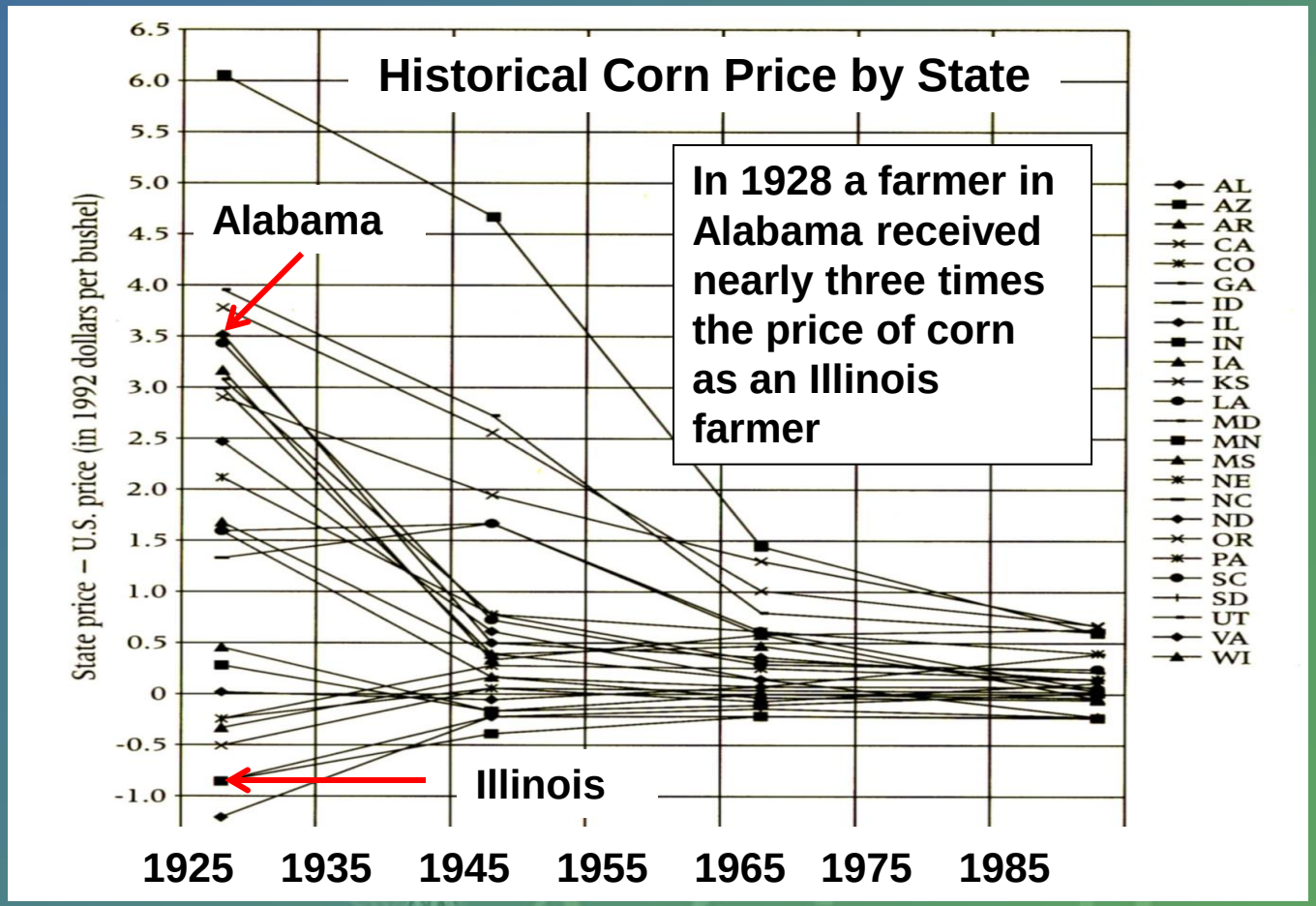
Agriculture

Southeastern Irrigation

Deep water holding soils in the Midwest largely insulated farmers from short-term losses that plagued the other parts of the East

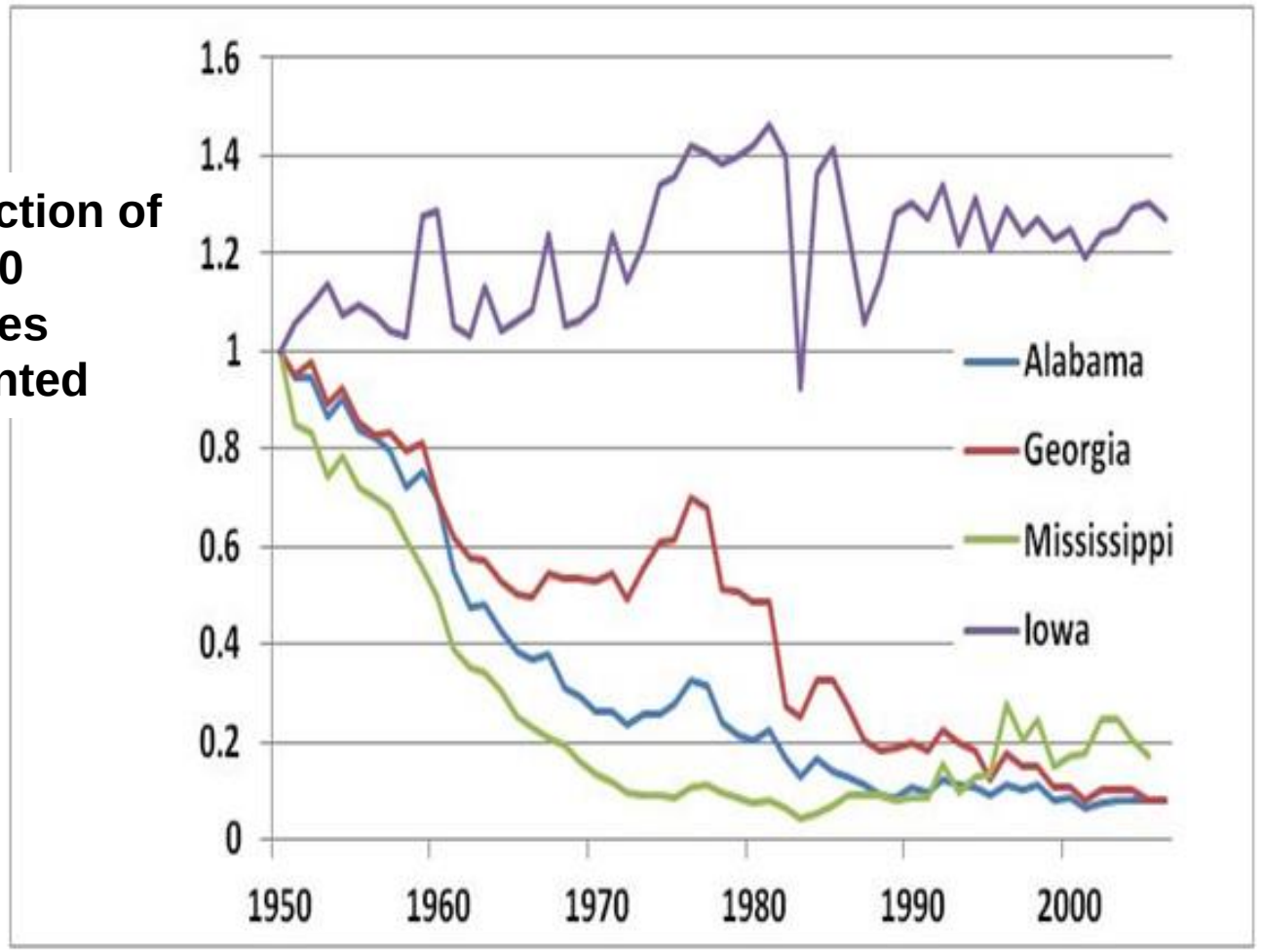


Transportation Improvements Intruded into Regional Markets that had Functioned for Generations

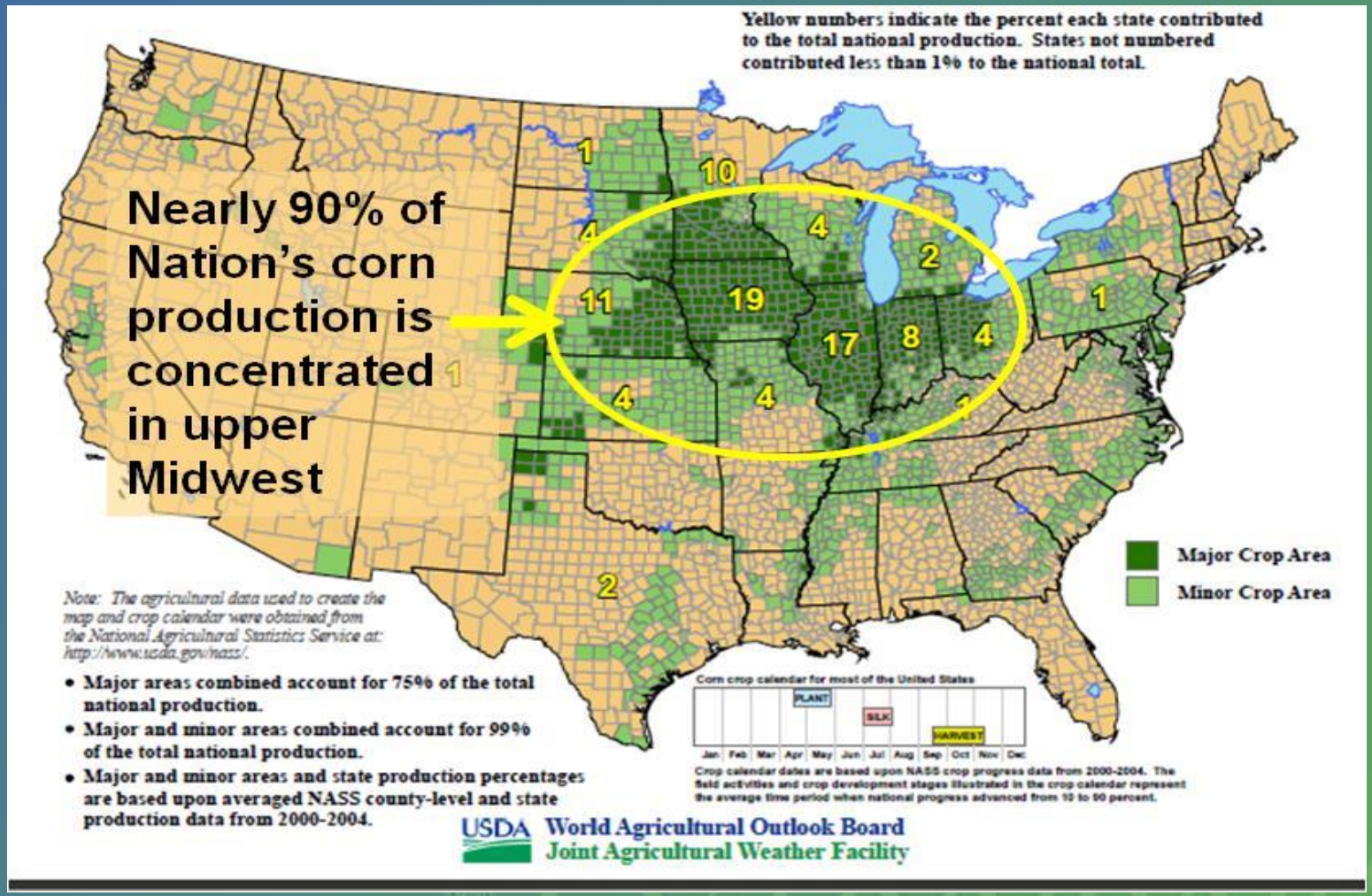


Corn prices by state from 1928 to 1988. From Gardner 2002.

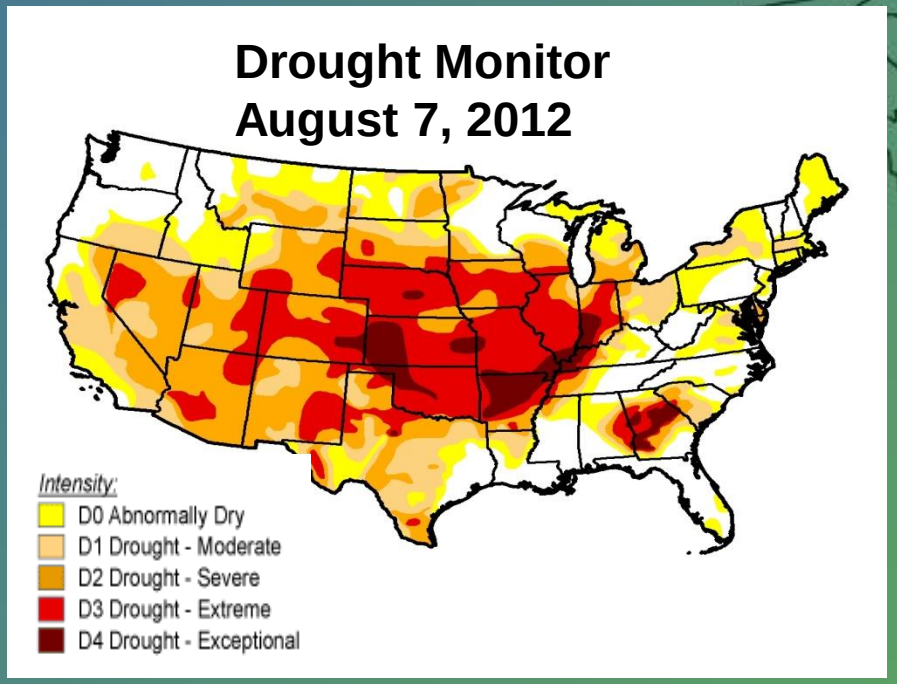
Most areas could not compete with Midwest yields so that areas like the Southeast gave up on corn.



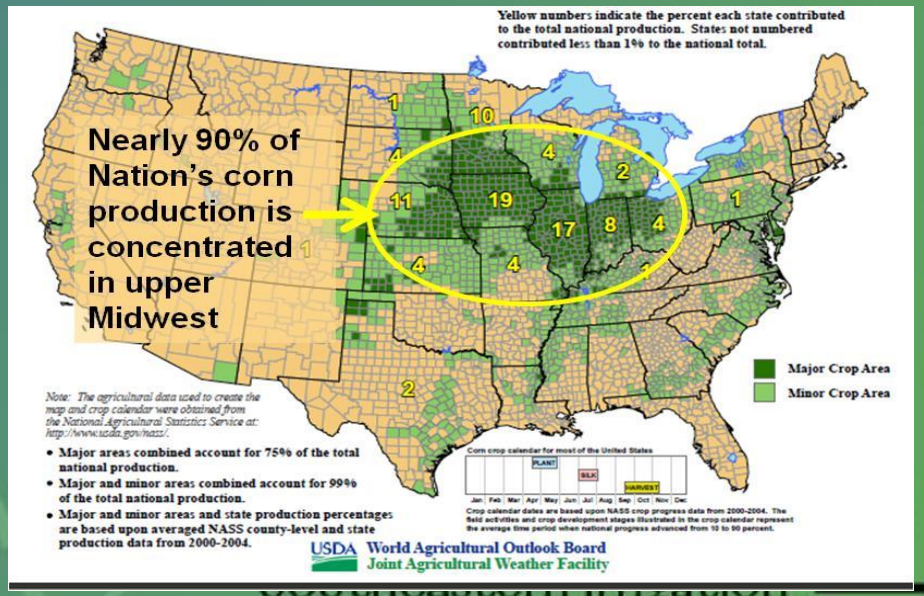
The end result is that we have concentrated nearly 90% of the nation's corn production in an area not much bigger than the State of Texas



Midwest Drought of 2012 shows the danger of concentration too much of the Nation's agricultural production in one region

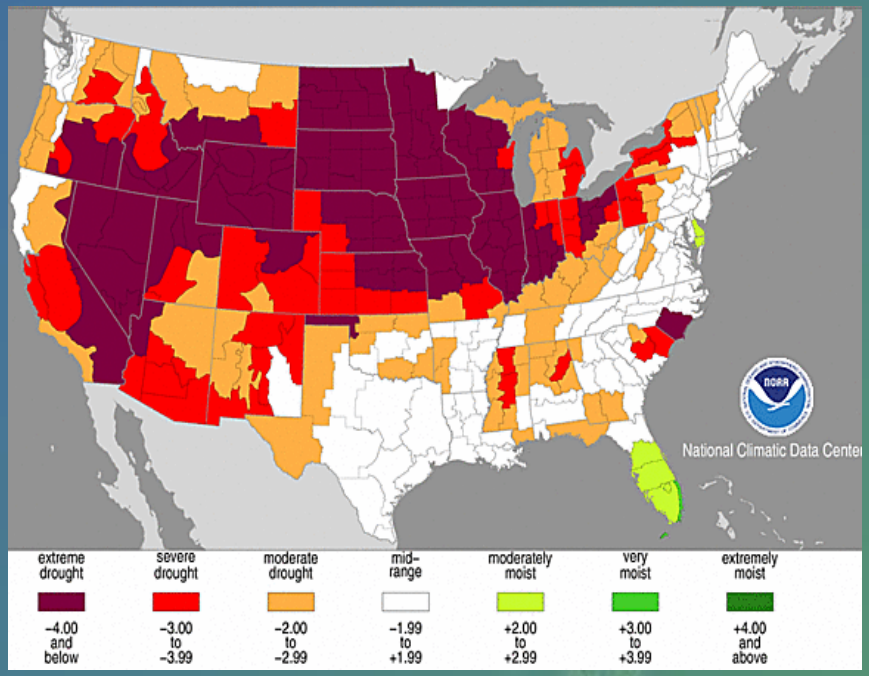


The impact could have been much worse because this drought was short-lived and was not centered on the corn production region



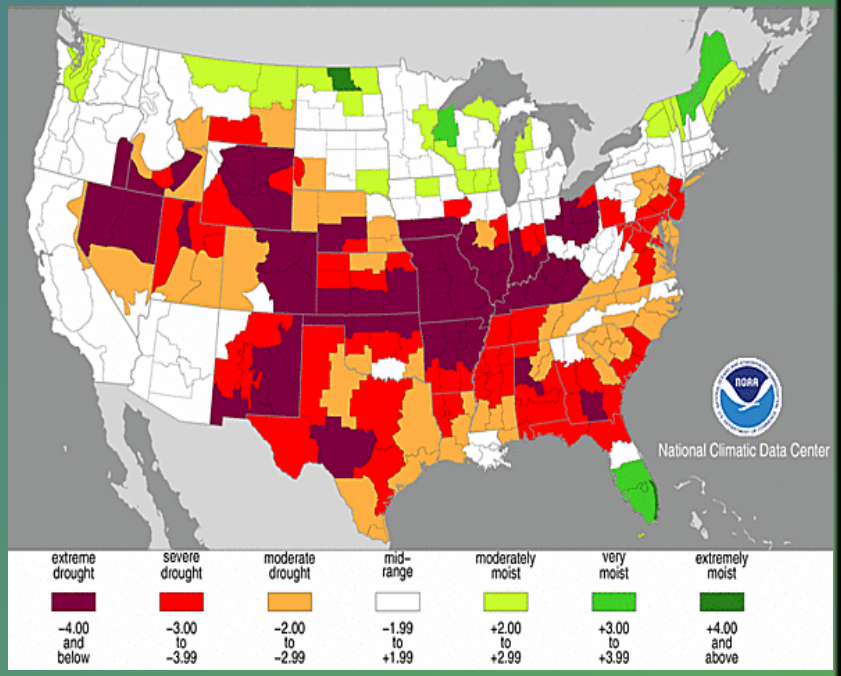
While Some Droughts Can be National in Scope that is Usually the Exception

1934
July



Palmer Drought Severity Index

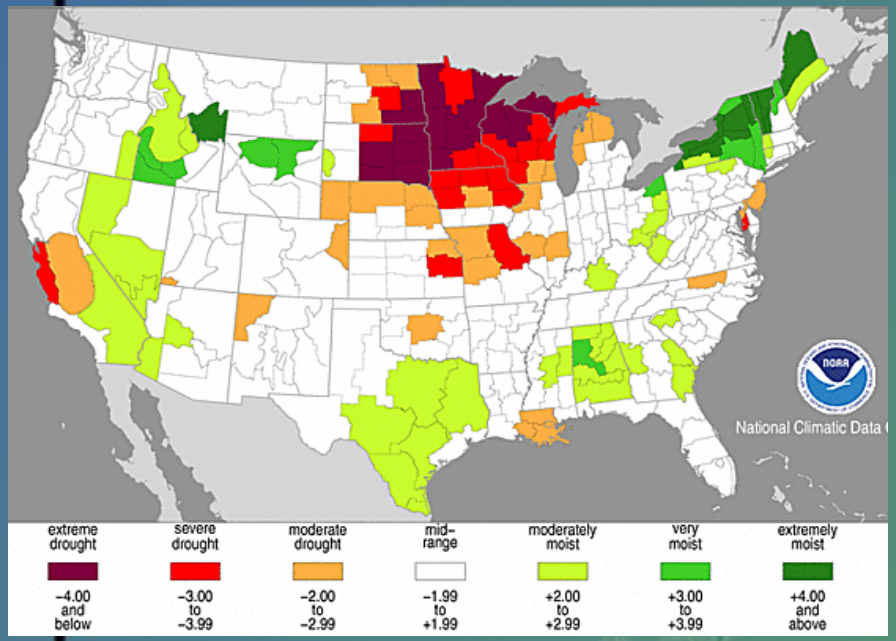
1954
July



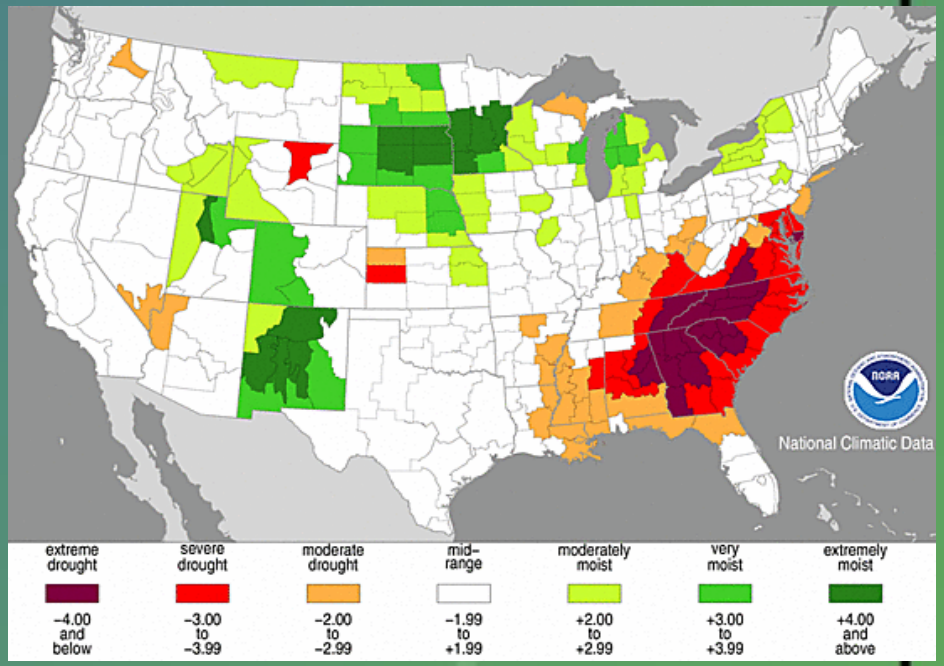
Palmer Drought Severity Index

More often droughts in the U.S. occur on a smaller scale In fact due to stationary weather patterns (synoptic scale) that Midwest and Southeast droughts are often out of phase.

September 1978



July 1986



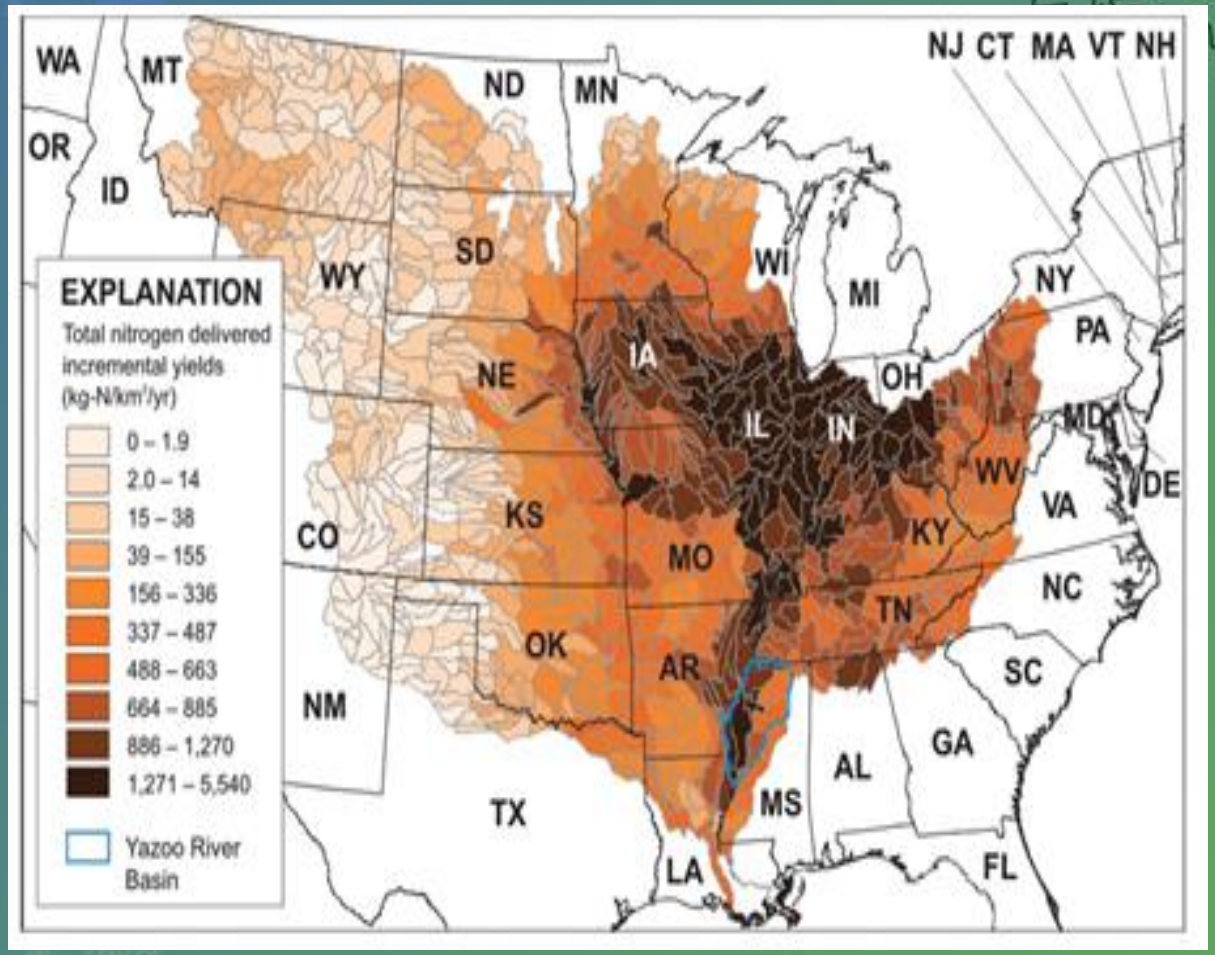
This argues for a more distributed geographical production in agriculture.

Southeastern Irrigation

Nutrient Loading in the Mississippi Basin

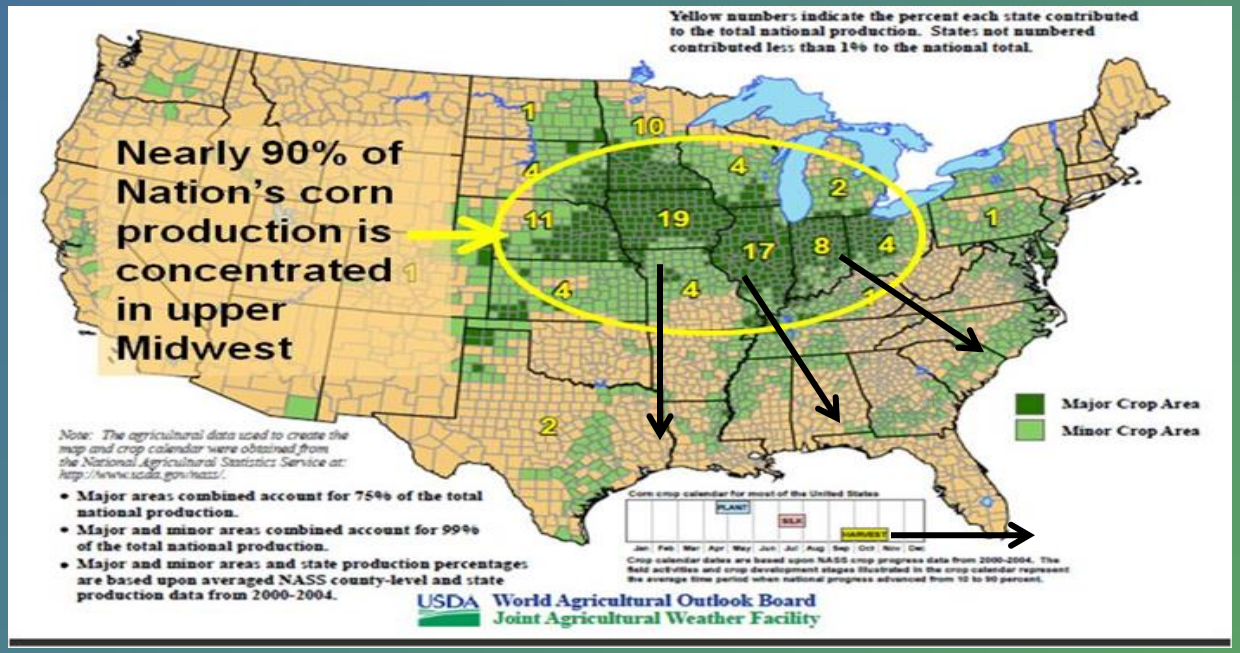
EPA is setting reduction targets for the basin (Rabalais 2011).

For Iowa the strategy, which is voluntary for farmers, calls for a 45 percent reduction in nitrogen and phosphorus pollution leaving the state.



Nutrient Loading is also related to drought

It is proposed that a more distributed geography of grain production should be evaluated in terms of economic viability, energy use and environmental impact.

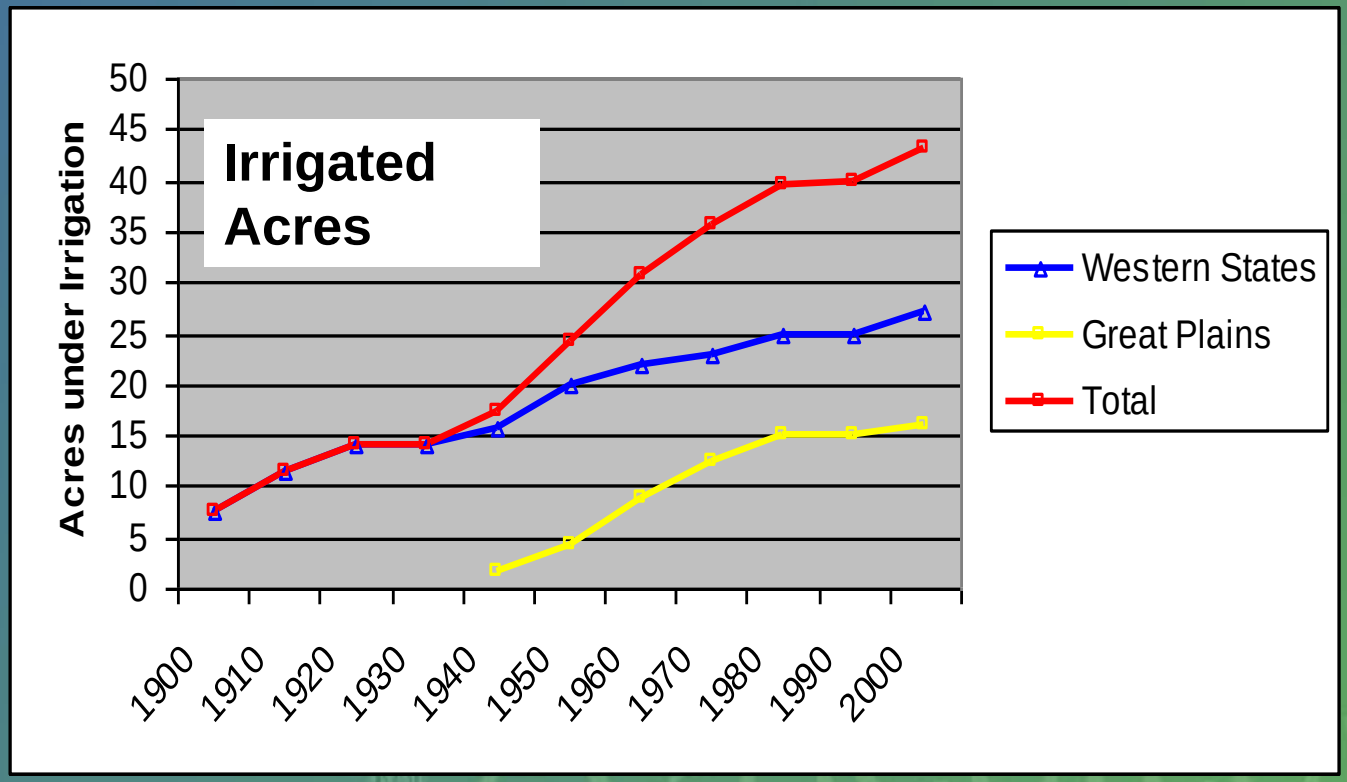


This would reduce impacts of future regional droughts in the Midwest and potentially help solve some nutrient loading on the Mississippi and perhaps future disease concerns.

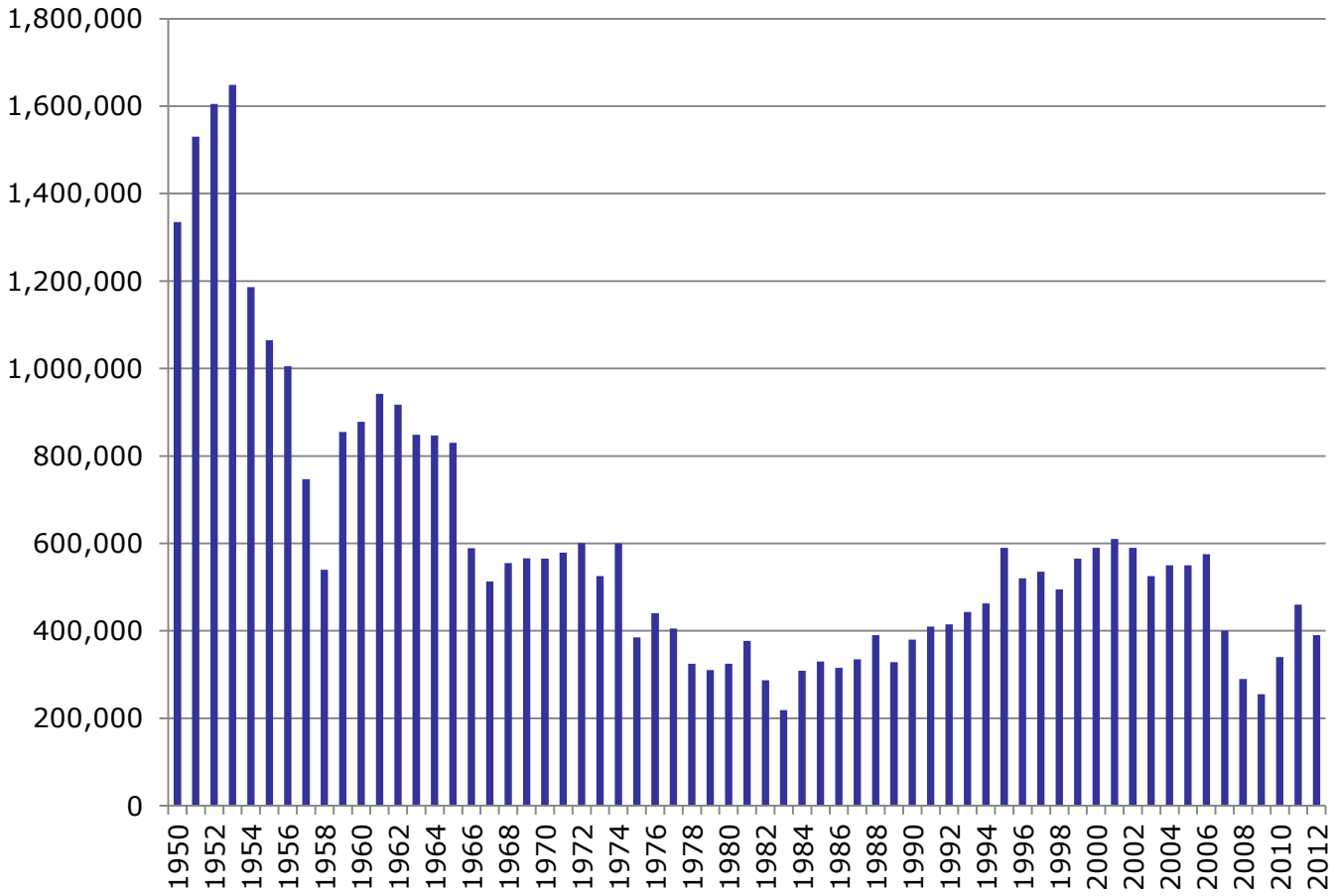
Irrigation also drove the migration of agriculture

Potato production became concentrated in the Snake River Valley so that Maine, New York and Pennsylvania lost their production.

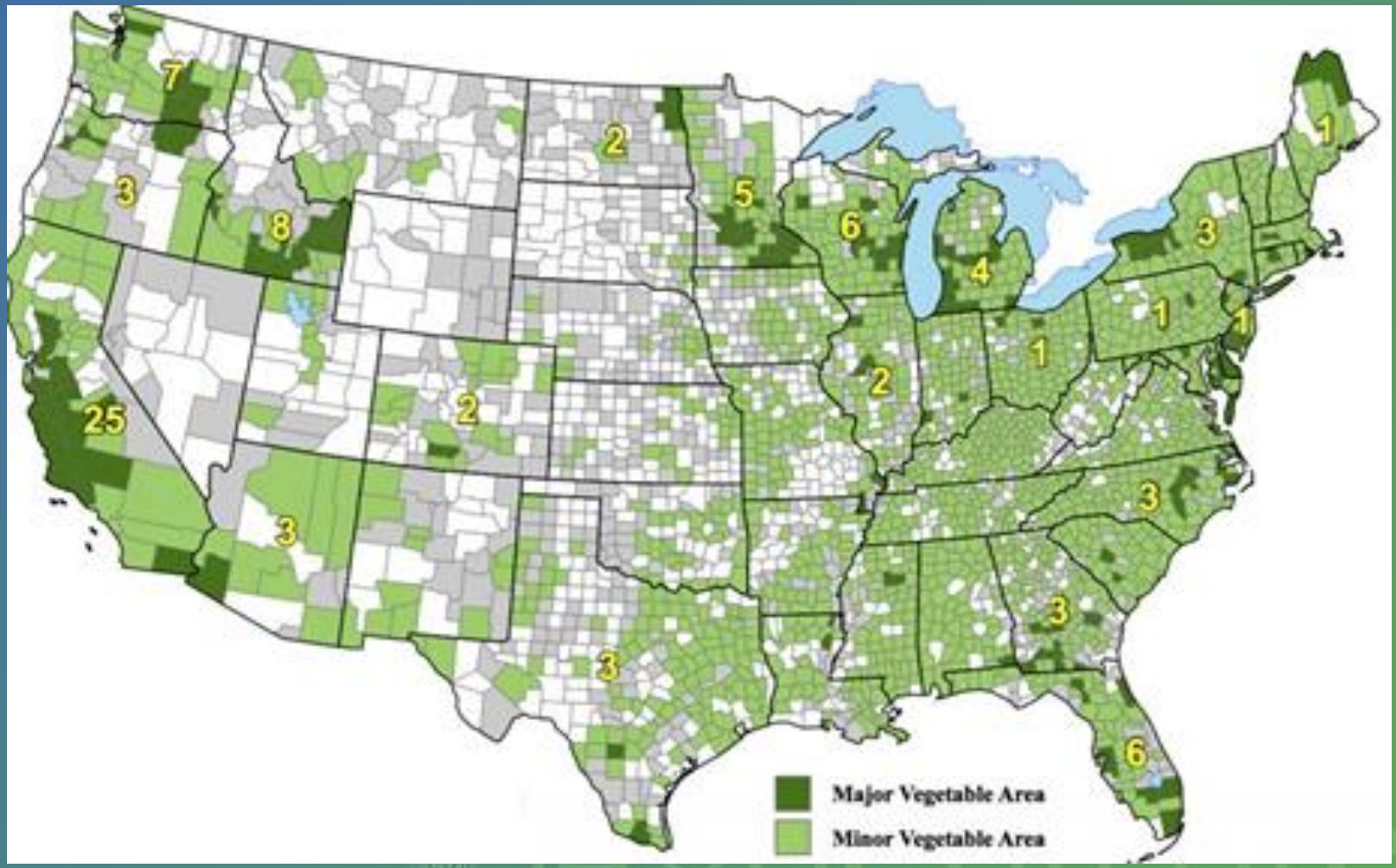
Irrigated cotton in California, New Mexico and Arizona drove Southern Cotton farmers out of business.



Planted Acres of Cotton - Alabama



Fruit and vegetable production has been concentrated in the river basins of the arid west



Fraction of national production (California Agricultural Resource Directory 2010)

99 percent of the artichokes	83 percent of Romaine lettuce
44 percent of asparagus	83 percent of fresh spinach
67 percent of carrots	86 percent of lemons
89 percent of cauliflower	90 percent of avocados
94 percent of broccoli	84 percent of peaches
95 percent of celery	88 percent of fresh strawberries
90 percent of the leaf lettuce	97 percent of fresh plums

In 1950 the Northeast Produced ~ 21% of Commercial Fresh Vegetables – about what California does today.

By 1980 it had been reduces to 7%

1984

The Economic Viability of Commercial Fresh Vegetable · Production in the Northeastern United States
John W. Wysong, Mary G. Leigh, and Pradeep Ganguly

Even as recently as 1950, USDA data indicated that the Northeast region accounted for 21 percent of the total U.S.commercial vegetable production. However, by 1980, that proportion was down to only seven percent

Table 1. Commercial Vegetable Production, U.S., Northeast, and Selected States, 1950, 1960, 1970 and 1980

State Ranked by 1980 Output	1950	1960	1970	1980	Percent Change 1950–1980
	Tons				(percent)
1. New York	1,338,500	1,130,650	974,250	959,800	−29
2. New Jersey	643,900	694,400	602,950	306,070	−52
3. Maryland	388,700	325,950	254,950	160,070	−59
4. Pennsylvania	417,200	329,150	283,150	151,700	−64
5. Delaware	92,000	101,550	97,700	71,980	−22
6. Massachusetts	118,600	98,400	76,100	59,020	−50
7. Connecticut	48,400	56,750	40,350	19,800	−59
8. Maine	42,100	35,150	13,650	8,380	−80
9. West Virginia	1,500	1,800	400	160	−89
10. New Hampshire	14,400	10,650	5,750	*	−89
11. Rhode Island	11,800	7,750	*	*	N.A.
12. Vermont	2,400	300	*	*	N.A.
Northeast Total	3,119,500	2,792,500	2,349,160	1,736,980	−44
U.S. Total	15,038,800	18,276,100	20,510,900	24,012,770	+60
N.E. Percent of U.S. Total	20.7	15.3	11.5	7.2	

Source: U.S.D.A., Agricultural Statistics; various issues, 1951 to date.
* Insignificant acreage reported in recent years.

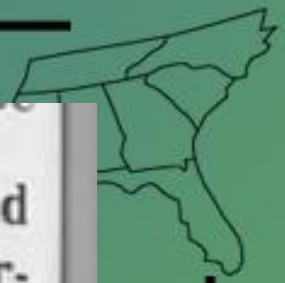
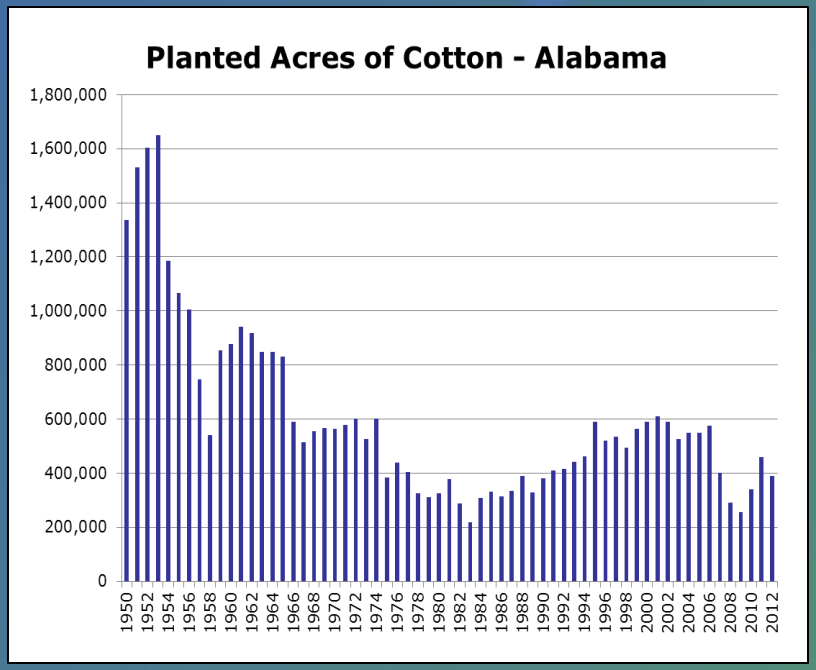
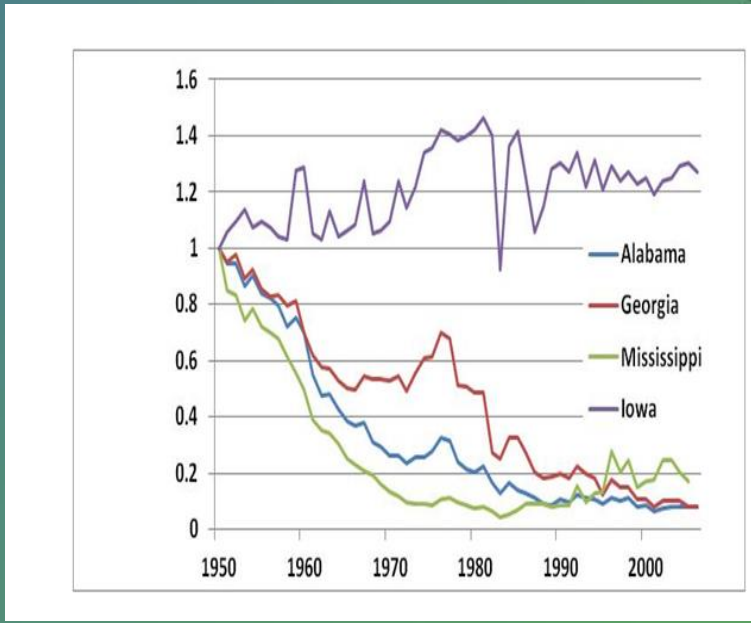


Table 3. Estimated Per Acre Yields and Variable Costs for Fresh Tomatoes in California Counties and Central Maryland

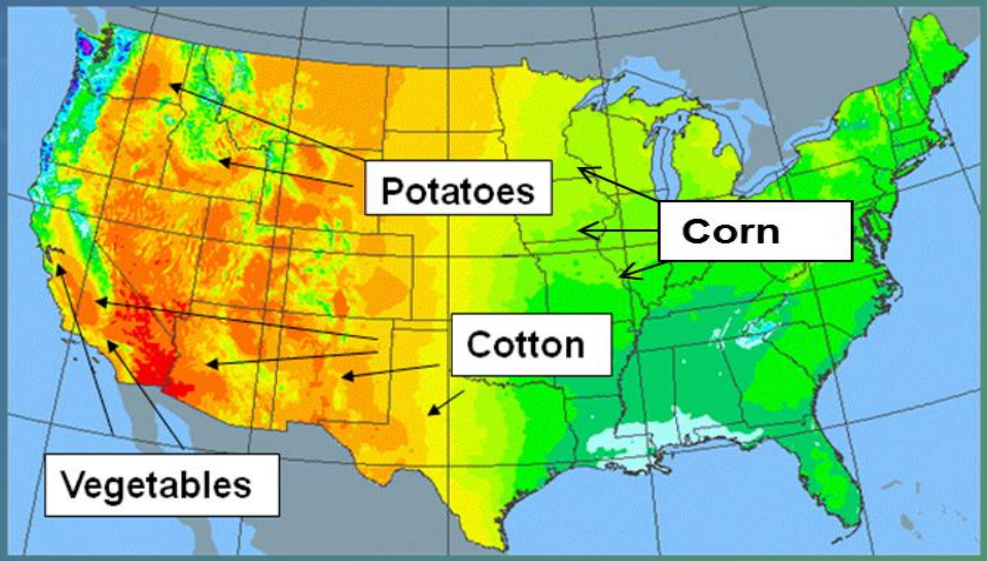
	Yield cwt.	Total Variable Cost	Cost per cwt.
Tulare Co., CA	500	$9,414	$18.83
Fresno Co., CA	360[a]	2,571	7.14
Santa Clara Co., CA	320	3,425	10.70
Central Maryland	300	2,540	8.46

Source: *California Cooperative Extension Service*, County Agricultural Agents developed tomato crop budgets for each county.
[a] 200 cwt. of the 360 cwt. in the Fresno County, California budget total was assumed to be used for canning and only 160 cwt. for fresh market purposes.





Loss of row crops in the East also reduced ancillary vegetable production – almost all row crop farmers grew a vegetable garden for extended families and friends and also sideline cash.



2015

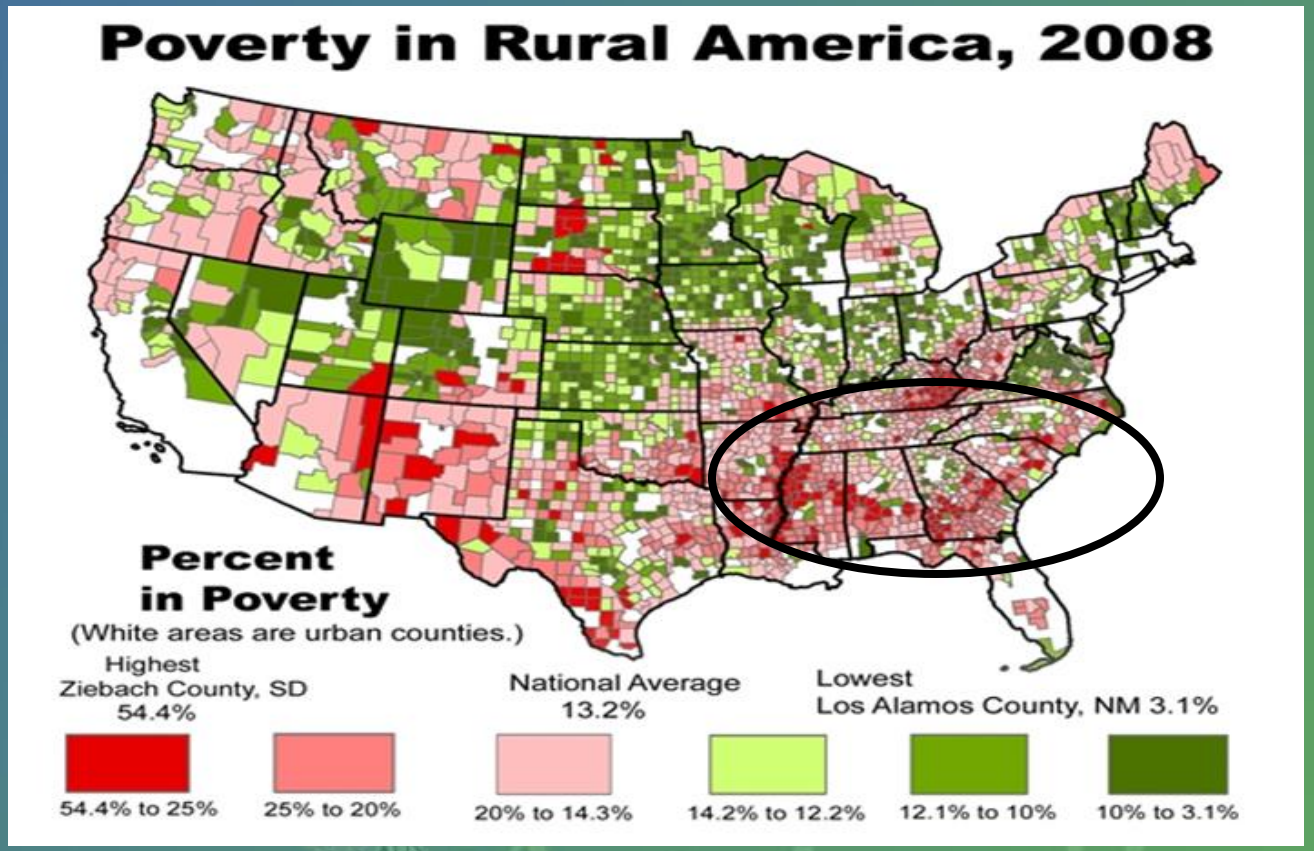
The migration of production that evolved in the last century produced a bonanza of cheap quality food for the American consumer. But left in its wake potential vulnerabilities dislocation and poverty.

Migration in the last century was largely unplanned and did not foresee potential issues of sustainability.

This massive shift in agriculture was highly subsidized. The Federal government spent billions of dollars on Western water projects for agriculture. This included massive dams, canals, piping to provide water to farmers. Grain transportation via rivers and highways was made possible through dams and interstates built in large part by the federal government.

Southeastern Irrigation

The Migration of Agriculture Left behind a Swath of Poverty where Southern Agriculture Collapsed

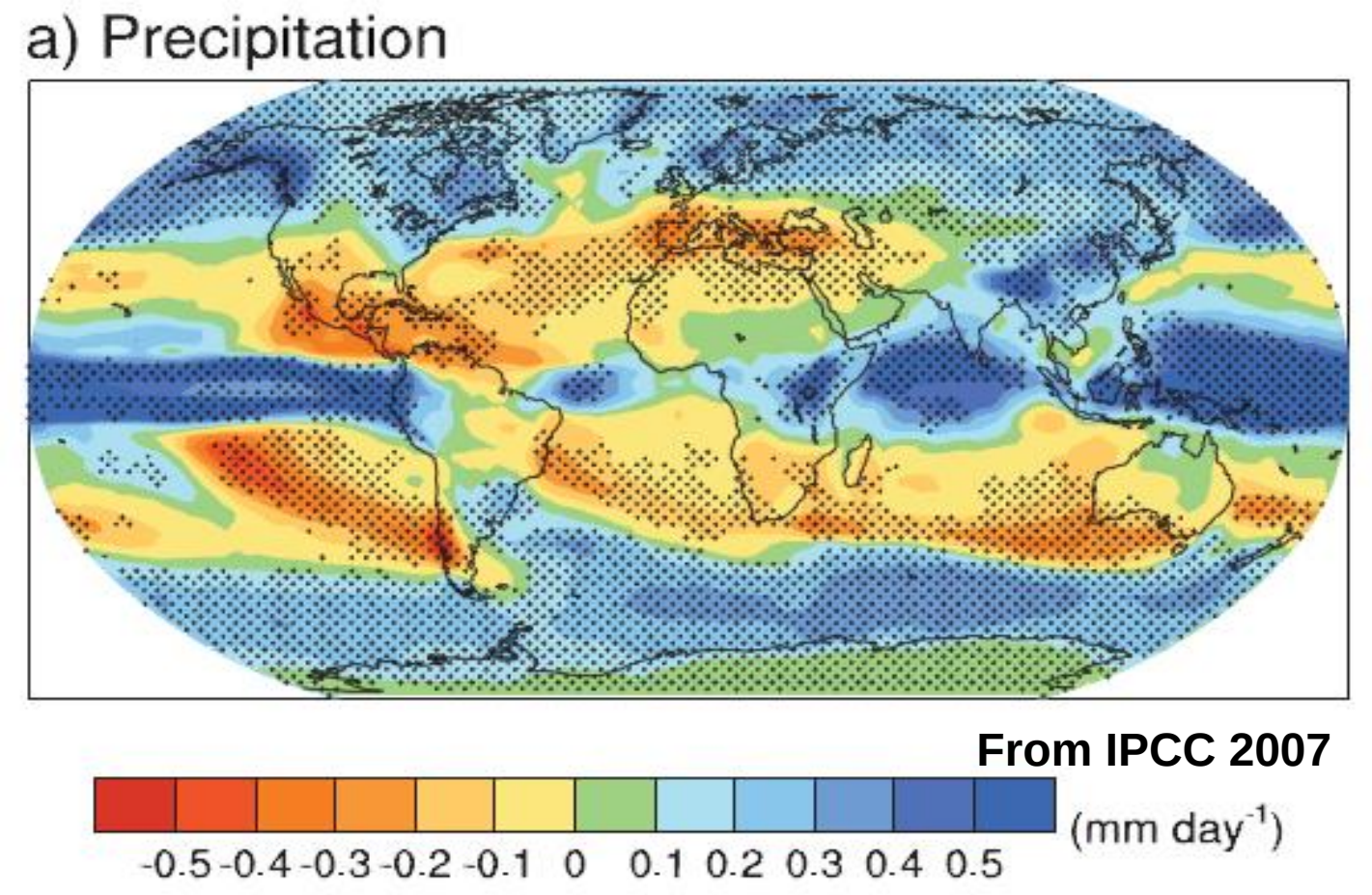


In the descriptions of Selma when President Obama's visited Selma for the 50Th anniversary of the Selma to Montgomery March the most common was the shocking poverty.

However, there was little discussion of the roots of this poverty – poor water holding soils and the collapse of agriculture!

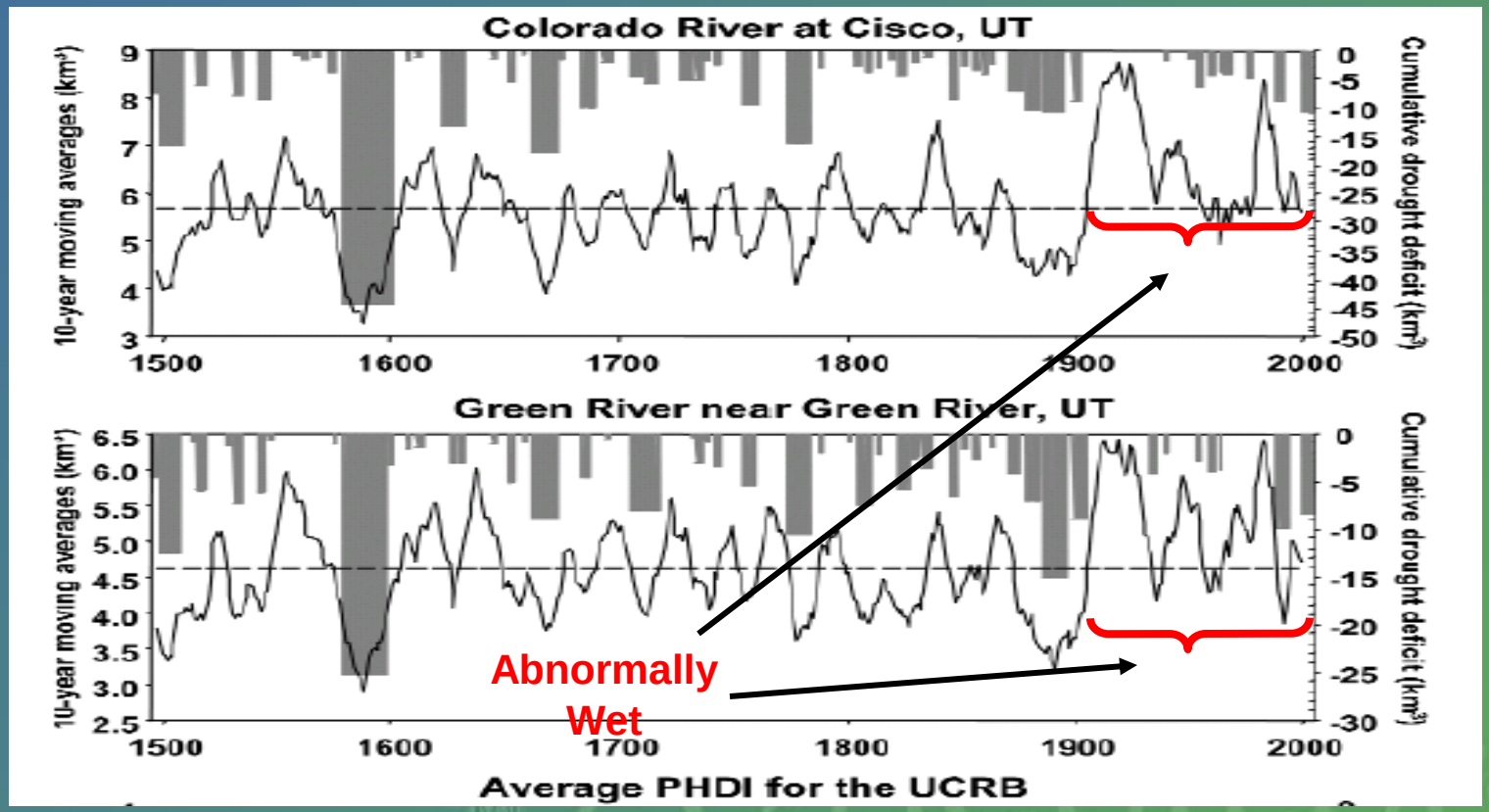
The Honorable Andrew Young - "The farmers who let us stay in their homes, who bonded us out of jail, are old guys now. They still own land but they can't make a living on the land."

Aggregate of climate models predict drying in the Southern High Plains and Southwest but no change or an increase in precipitation in the East and Southeast.



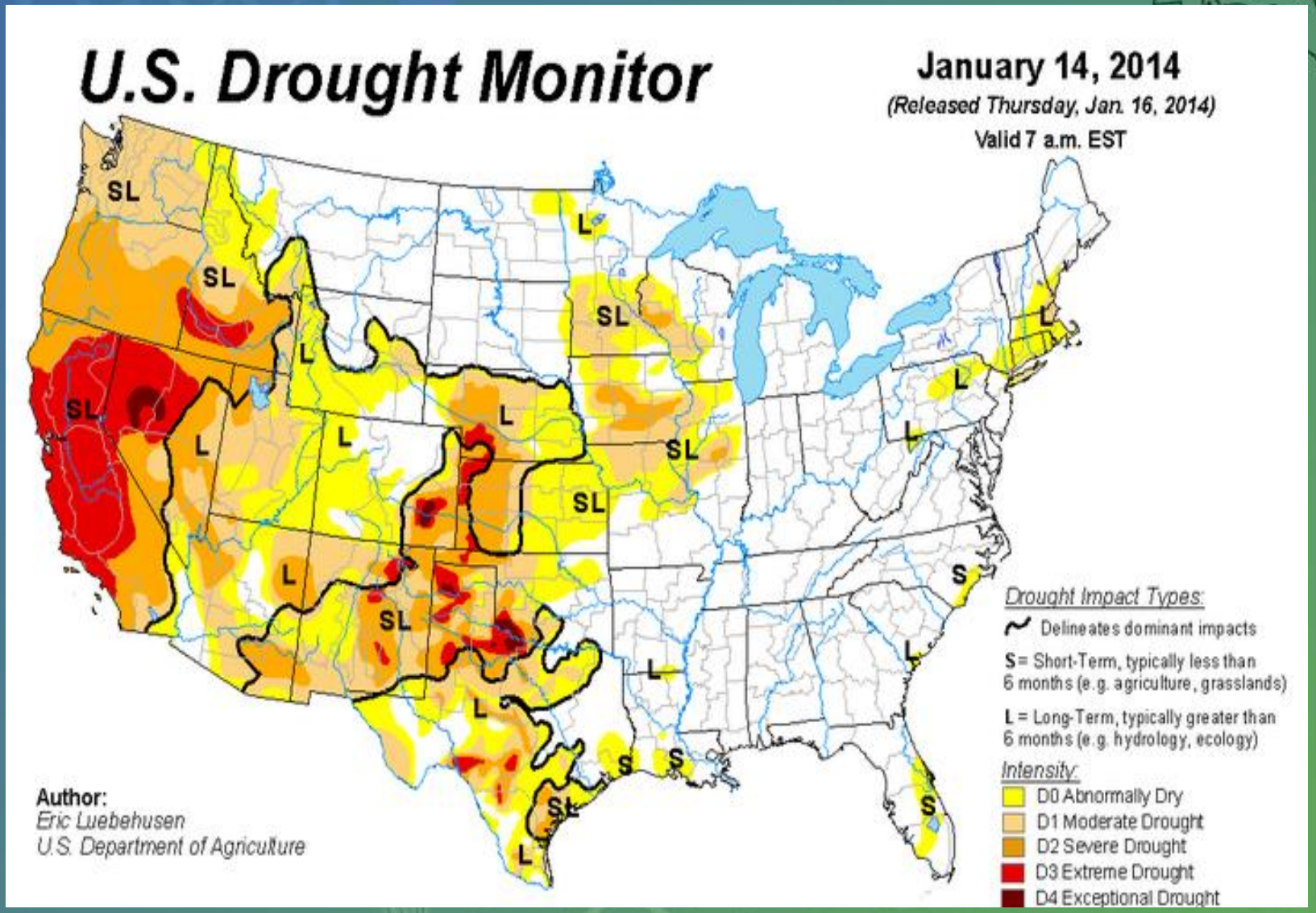
Even if anthropogenic climate change does not occur the West may be in trouble.

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



From Piechota et a. 2004

Piechota, T., J.Timilena, G.Tootle and H.Hidalgo, 2004:The western drought: How bad is it? *EOS*, 85, 3 p301

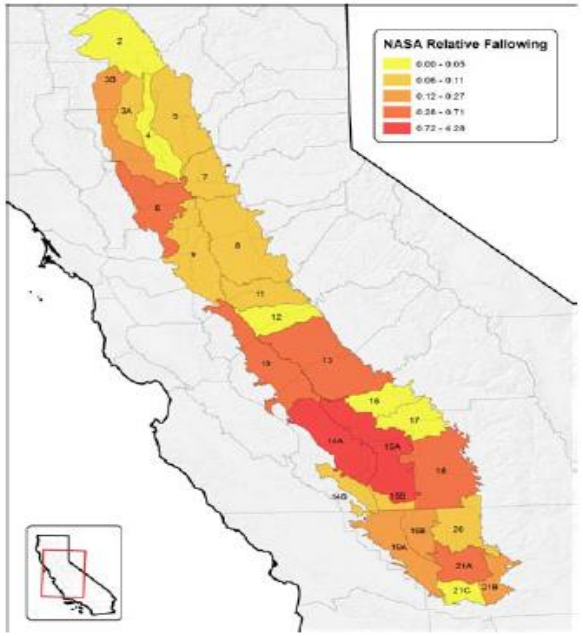

U.S. Drought Monitor
January 14, 2014
(Released Thursday, Jan. 16, 2014)
Valid 7 a.m. EST
Author:
Eric Luebehusen
U.S. Department of Agriculture
Drought Impact Types:
Delineates dominant impacts
S = Short-Term, typically less than 6 months (e.g. agriculture, grasslands)
L = Long-Term, typically greater than 6 months (e.g. hydrology, ecology)
Intensity:
D0 Abnormally Dry
D1 Moderate Drought
D2 Severe Drought
D3 Extreme Drought
D4 Exceptional Drought

Economic Analysis of the 2014 Drought for California Agriculture

Richard Howitt
Josué Medellín-Azuara
Duncan MacEwan
Jay Lund
Daniel Sumner

Center for Watershed Sciences
University of California, Davis
UC Agricultural Issues Center
ERA Economics, Davis, Calif.

July 15, 2014



Nearly One Million Acres Expected to be Fallowed Due to Water Shortage. Fallowed land is mainly in cotton, grains and seed oils not high value crops.

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August 17, 2015

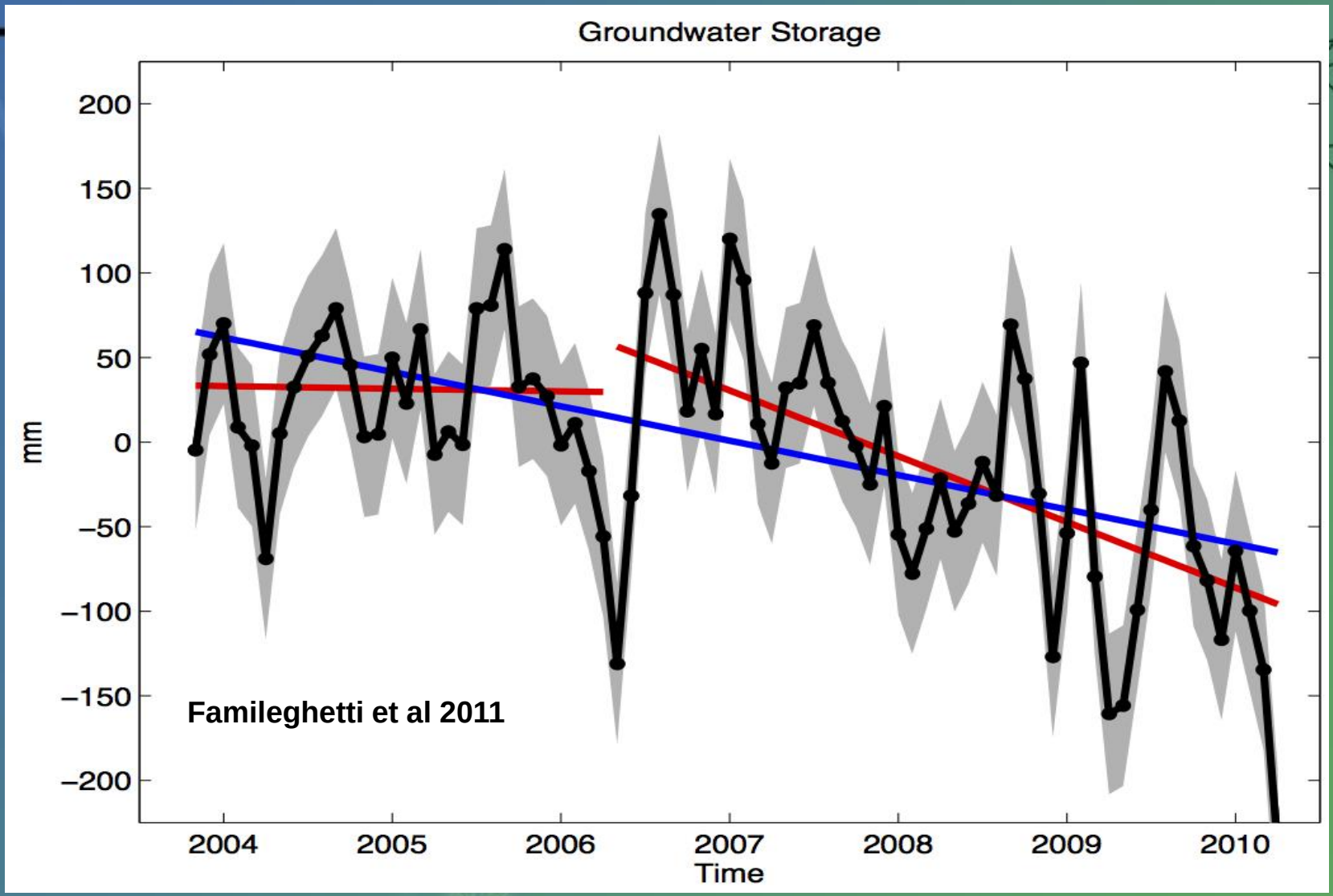
Funded by
California Department of Food and Agriculture

Impact of California Drought -2015 by Richard Howitt et al.

Description	Impact	Base year levels	Percent change
Surface water shortage (million acre-ft)	8.7	18.0	-48%
Groundwater replacement (million acre-ft)	6.0	8.4	72%
Net water shortage (million acre-ft)	2.7	26.4	-10%
Drought-related idle land (acres)	540,000	1.2 million*	45%
Crop revenue losses ($)	$900 million	$35 billion	2.6%
Dairy and livestock revenue losses ($)	$350 million	$12.4 billion	2.8%
Costs of additional pumping ($)	$590 million	$780 million	75.5%
Direct costs ($)	$1.8 billion	NA	NA
Total economic impact ($)	**$2.7 billion**	NA	NA
Direct job losses (farm seasonal)	10,100	200,000#	5.1%
Total job losses	**21,000**	NA	NA

* NASA-ARC estimate of normal Central Valley idle land.

Total agriculture employment is about 412,000, of which 200,000 is farm production.



Groundwater storage changes in California from 2003-2010. 1. Blue line shows overall decreasing trend, about 3 cubic kilometers per year. Red line shows piecewise trends, and that most of the depletion occurred during the drought of 2006-2010

California is not the only place where ground water is being depleted

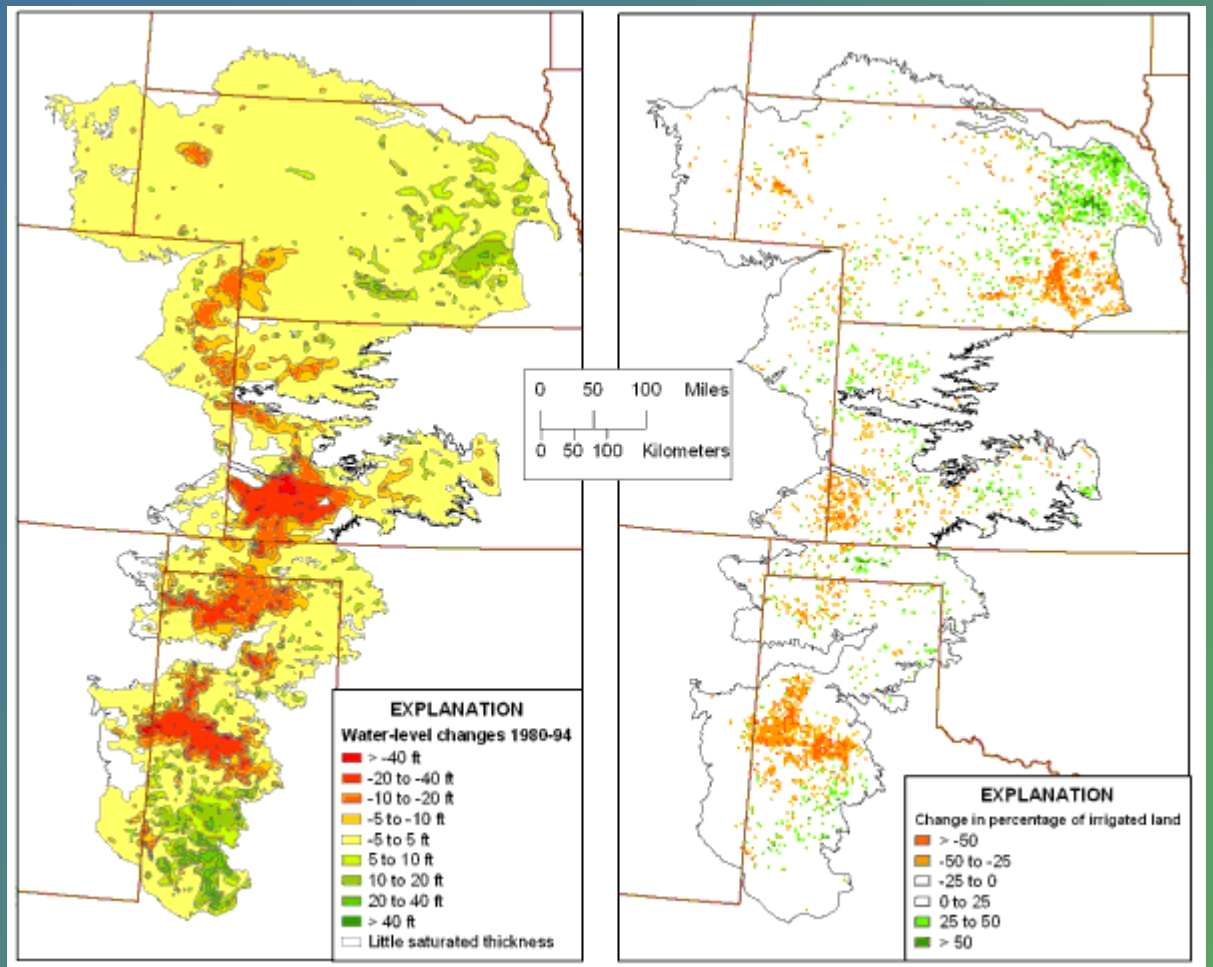


Figure 12. Water-level changes from 1980 to 1994 and change in percentage of irrigated land from 1980 to 1992

The West may be caught in the “The Perfect Storm “

Short-term Drought

Reductions in snowpack and increased temperatures are driving seasonal flows to record low levels

Ground Water Pumping

Ground water throughout the West is being depleted

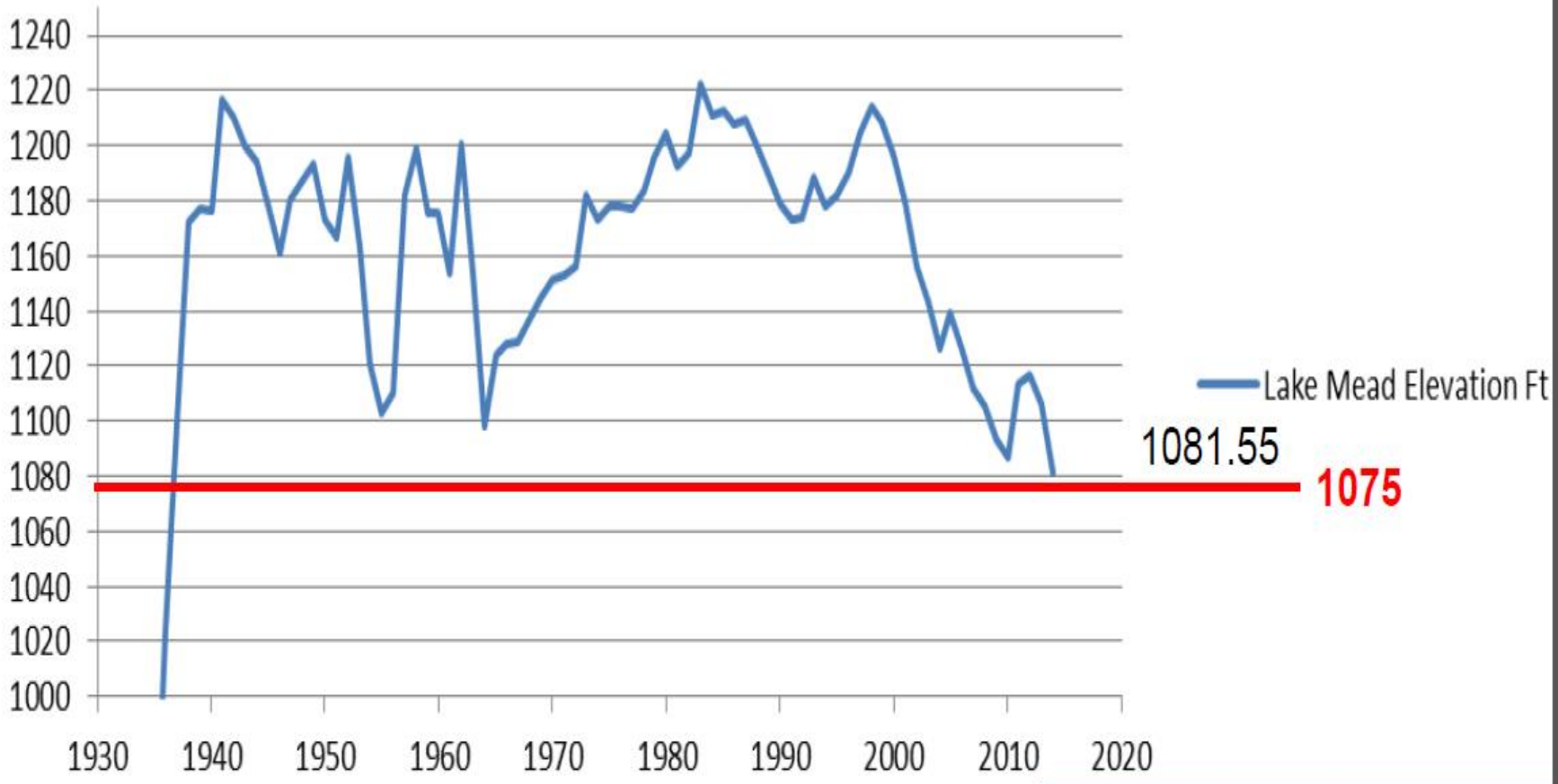
Exhausted Water Storage

The major southwestern reservoirs - Lakes Powell and Mead, fell nearly 50 percent between 1999 and 2004 and have not risen significantly since.

Population Growth

Population continues at an accelerating pace in parts of the West

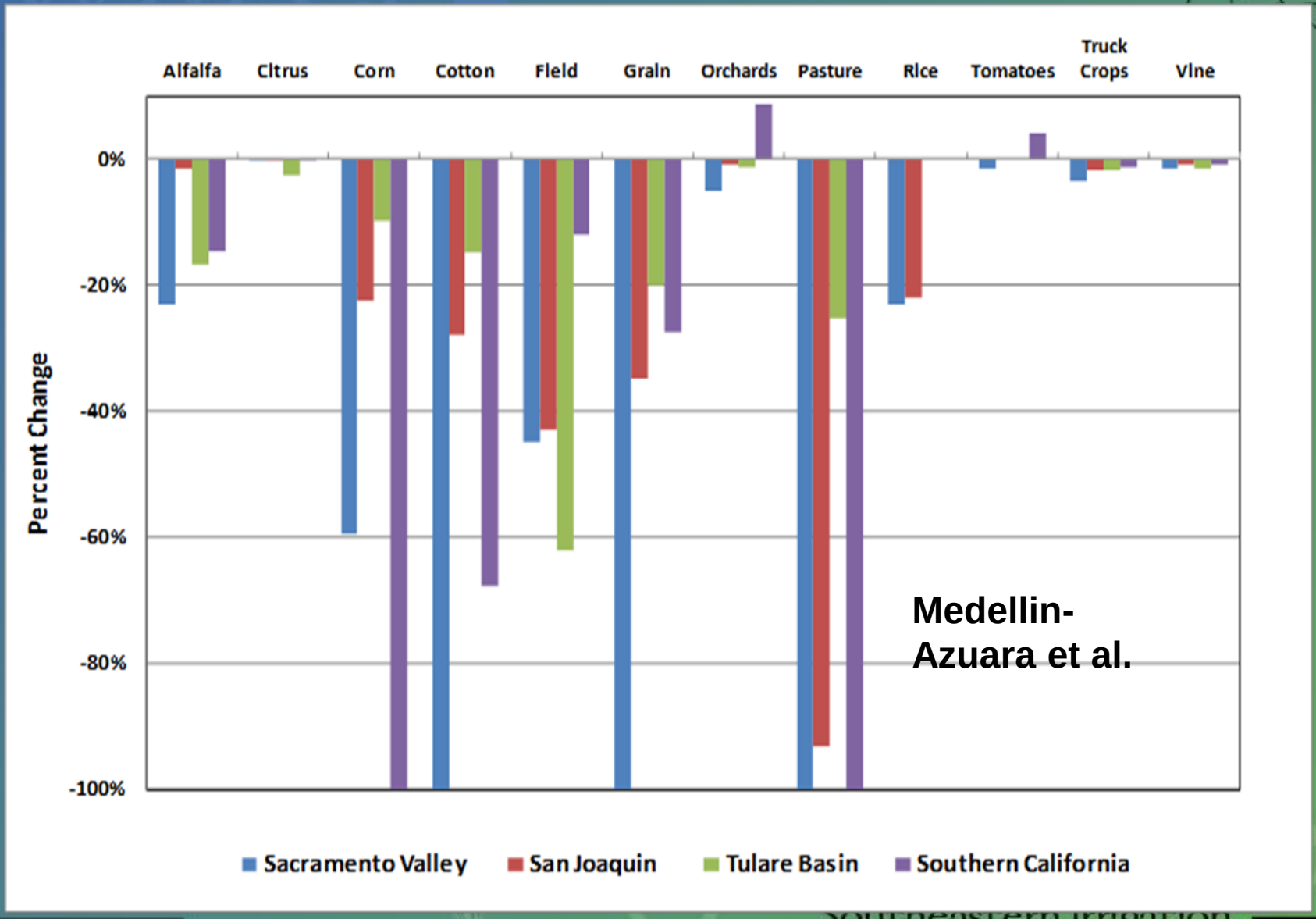
Lake Mead Elevation Ft



1,075 ft elev. Federal Water Shortage Declaration

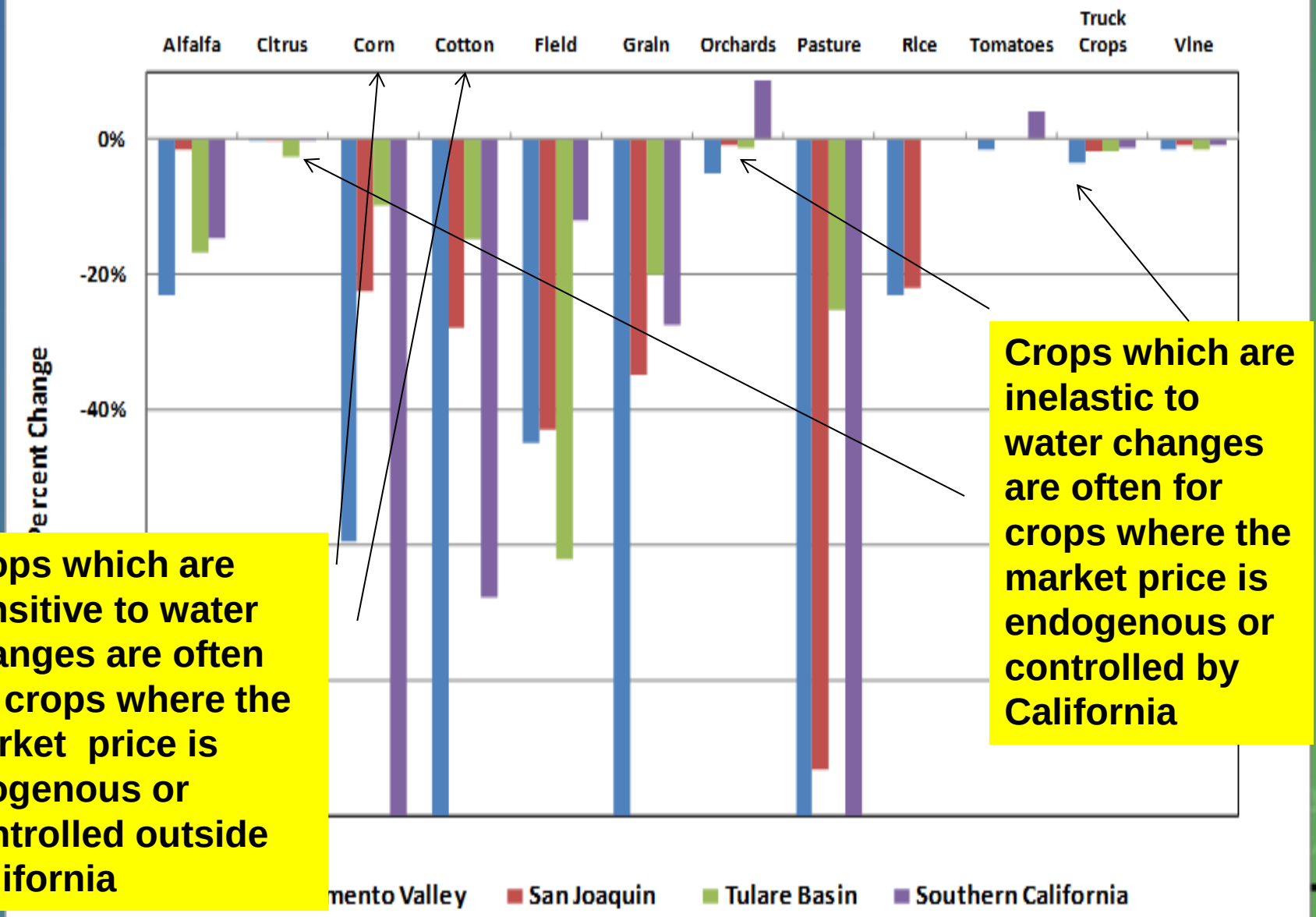
- Water cut by 4.4 percent in the three Lower Basin

Shifts in Crops Due to Water Reductions



Medellin-Azuara et al.

Nutrition Danger of Reduced Water in California



Crops which are sensitive to water changes are often for crops where the market price is exogenous or controlled outside California

Crops which are inelastic to water changes are often for crops where the market price is endogenous or controlled by California

Where can the Nation Replace This Lost Production?

Should we let it move offshore?

Water

Agriculture

Southeastern Irrigation

- **There should be consideration of migrating some of the Southwest's agriculture back to the East or Northwest.**

  This would protect the nation's vegetable production in a region which will likely be water limited in the future.

  It would allow continued environmental restoration.

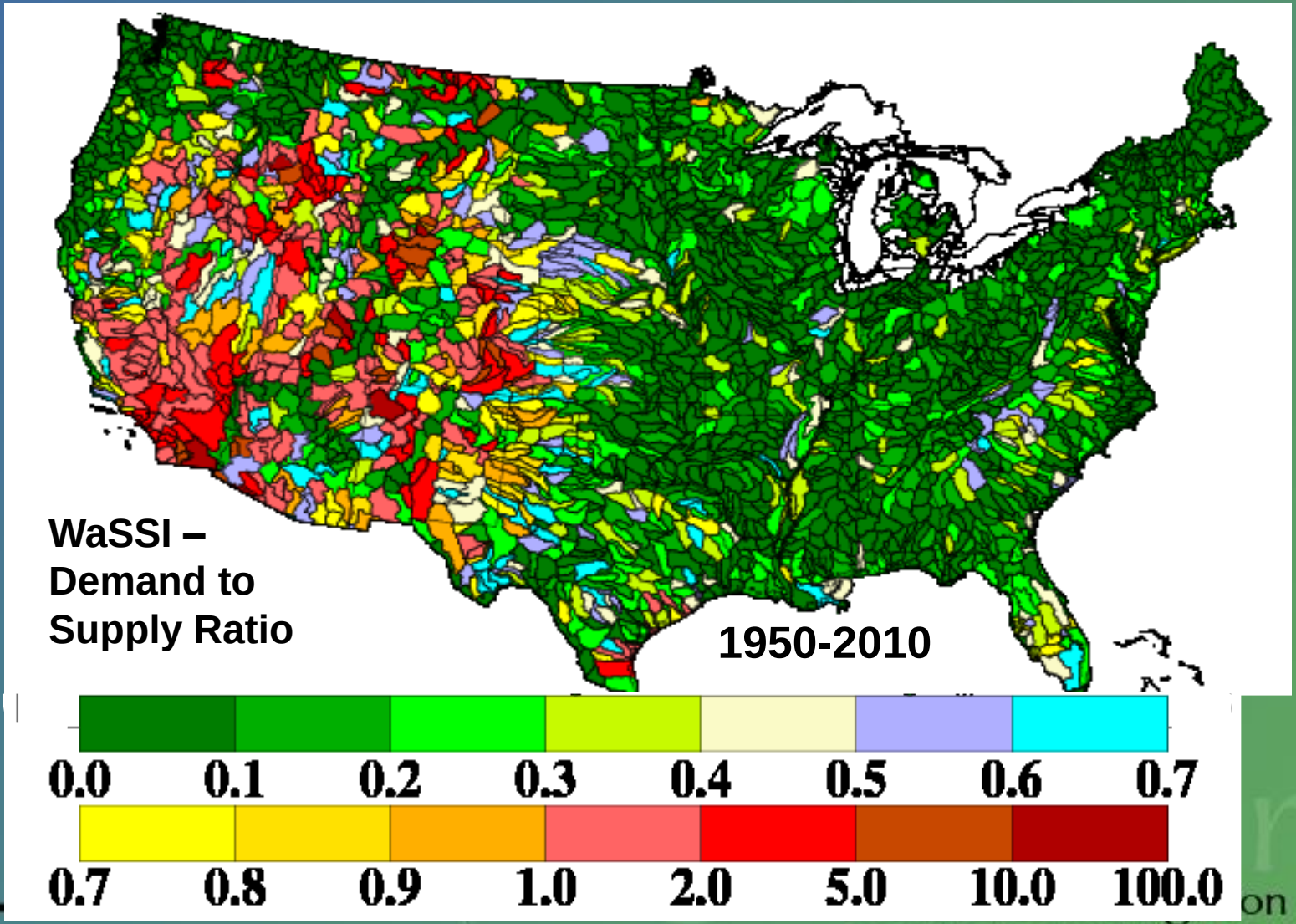
We believe the nation must be careful about expensive investment in wringing the last drops out of western water.

In building western water projects should cost benefits of equivalent production in the East be considered?

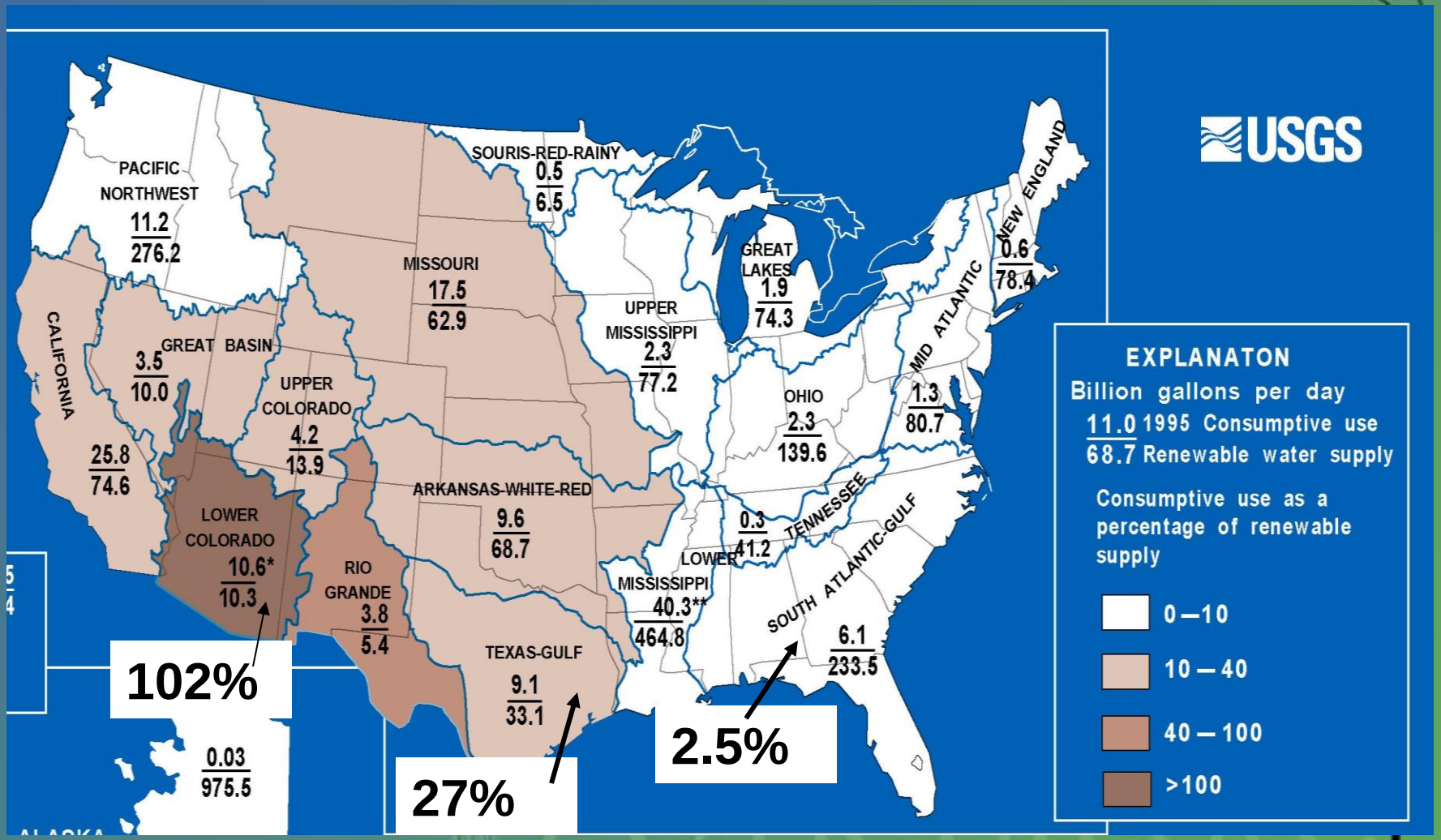
The Temperance Flat Dam Project has been proposed as a solution to catch more water in the San Joaquin Basin near Fresno, CA. The cost is estimated to be $2.5 billion. It would yield 77,000 acre-ft of additional water which would serve up to 30,000 irrigated acres.

About 20% of the monetary benefits of this of the project are attributed to agriculture – so that cost for the agricultural portion would be about $500 million. In the East this would support 180,000 acres (on-farm storage and center pivots)

Considering all uses of water – the Eastern U.S. has far more available water



Net Consumption of Water - Tennessee River is one of the laest consumed Rivers in the U.S.



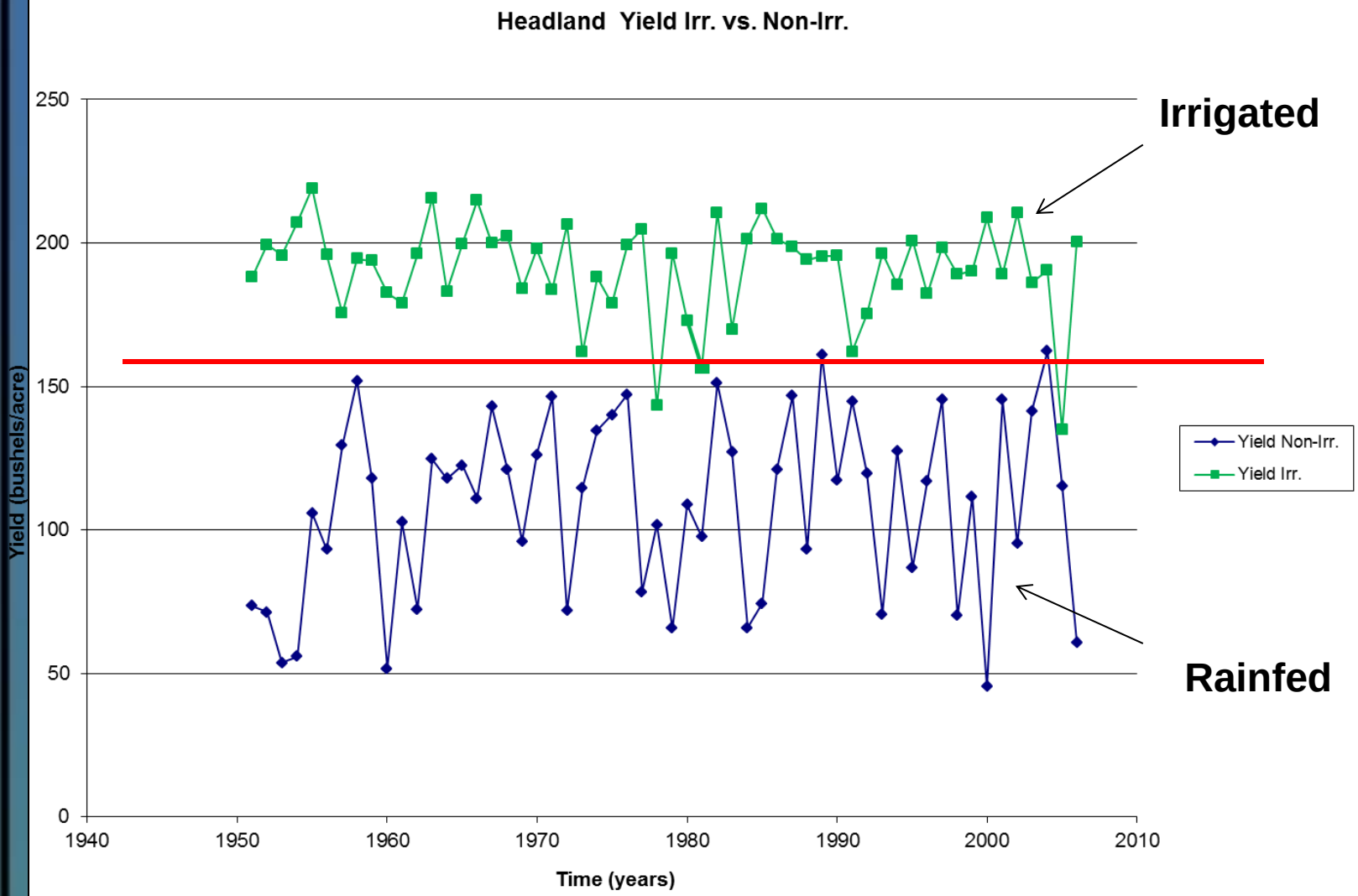
Can migrating agriculture to the East/Southeast or to the Northwest with expanded irrigation be a sustainable solution for the Nation's future agricultural security ?

Is it economically viable?

Is it environmentally sustainable?

- **Will expanded irrigation harm the region's water resources?**
- **Will water quality be harmed?**

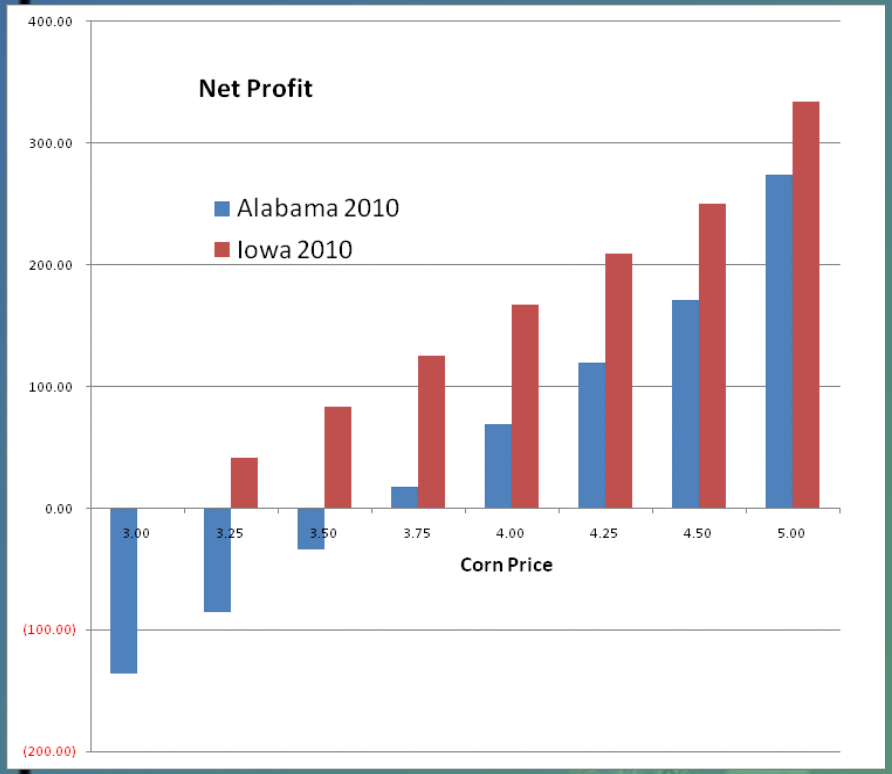
Corn Yield Estimated by DSSAT Crop Model for Coastal Plain Soils in South Alabama

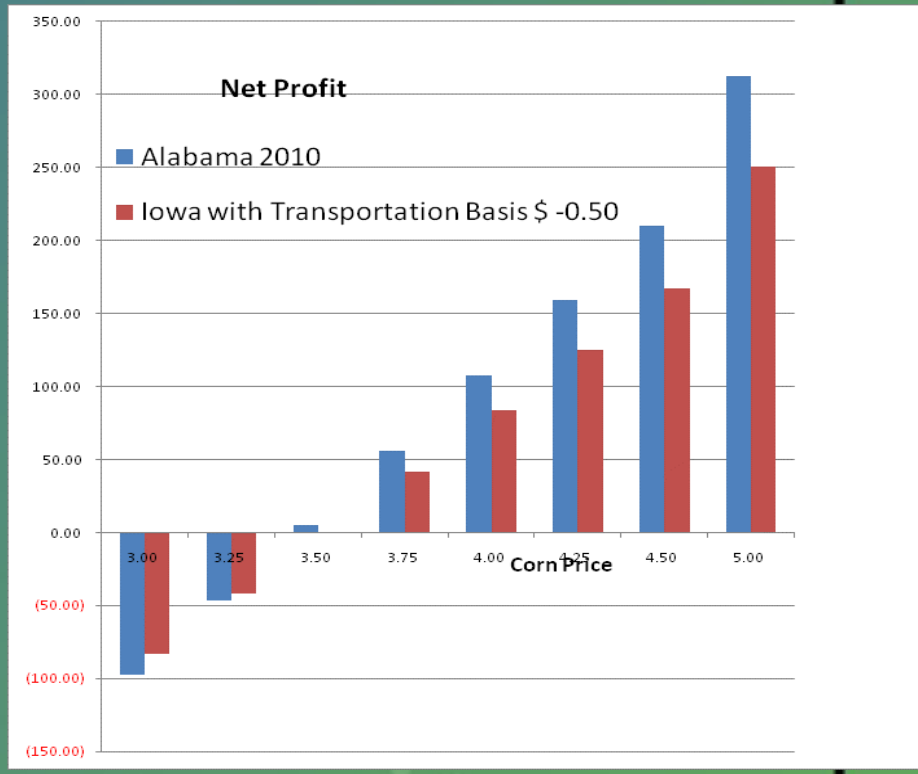


Economics

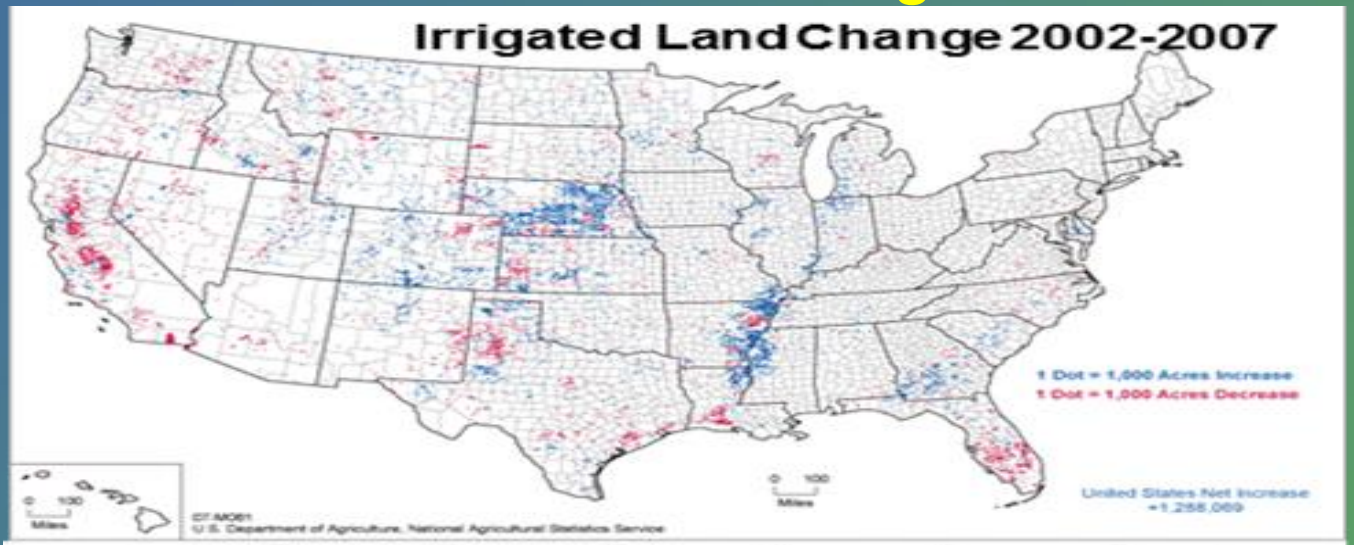
Can Southeast really compete with Iowa in grains?

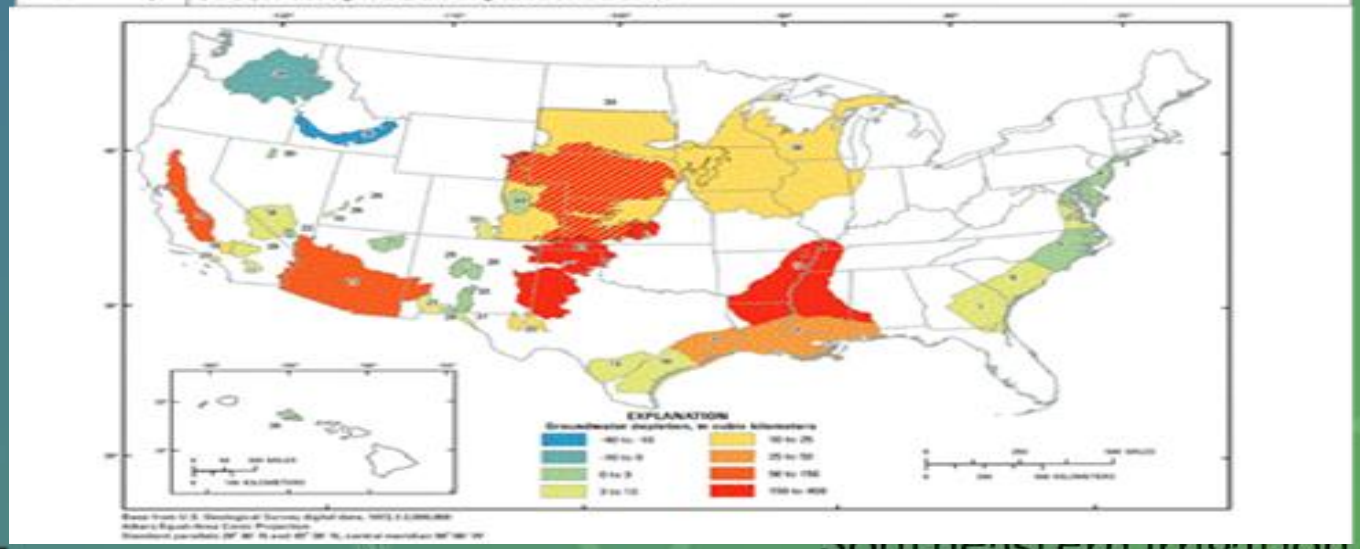
If we include transportation cost – Yes!



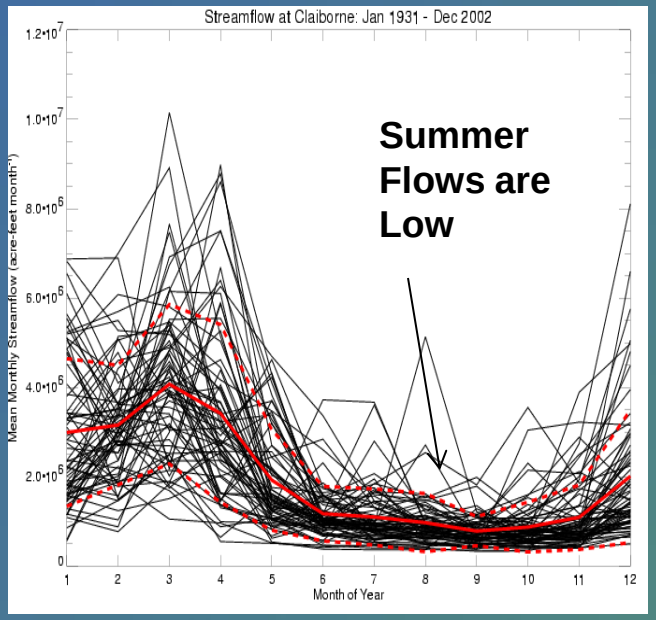


Southeast has also in depleted ground water in some locations. In part, because of Riparian Rertrictions on moving water



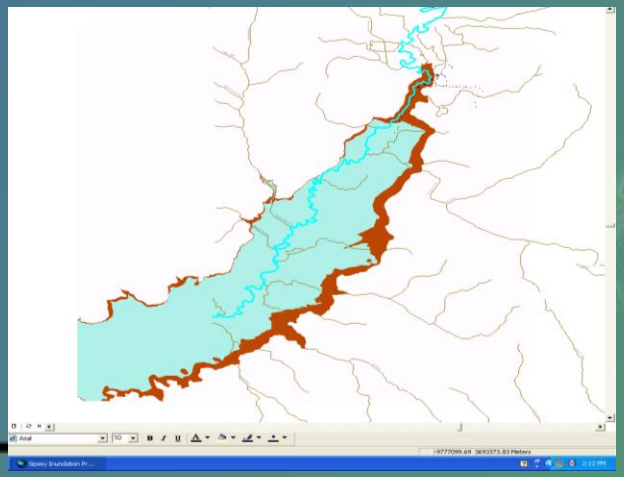


Environment – while East has much more water than the west its ecosystems evolved based on large amounts of water



Use on Farm storage ponds

Irrigation Model



How will flood Plains be Impacted?

Southeastern Irrigation

East also faces challenges in terms of nutrient export and pesticide application

For vegetables quality and marketability are challenges

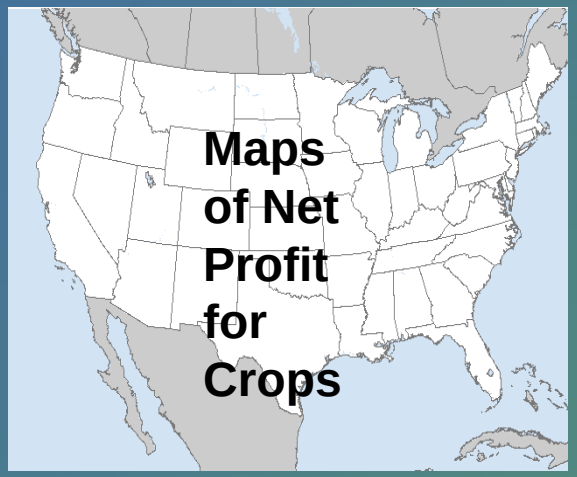
Eastern Broccoli Project

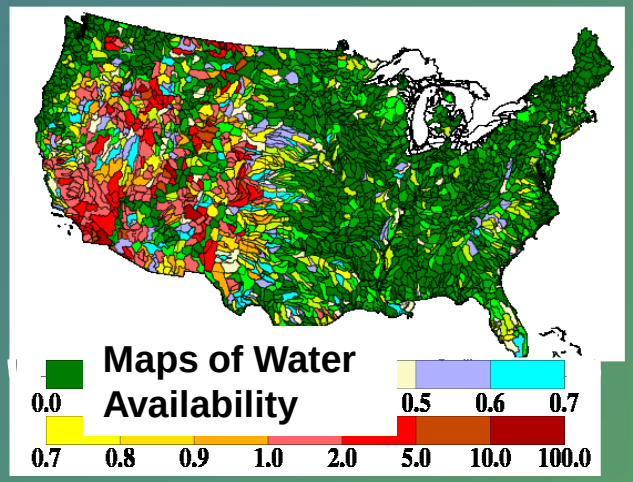
Building a Better Broccoli

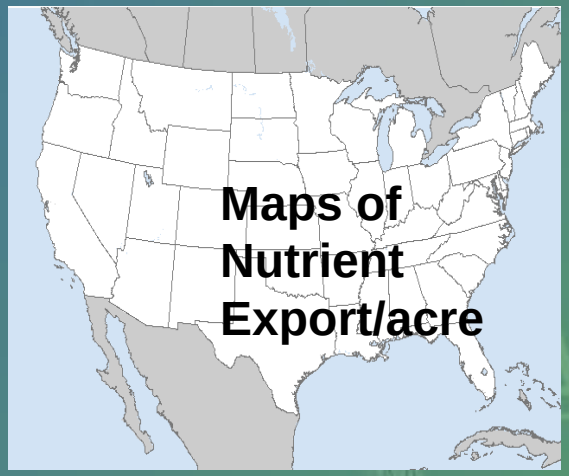
Researchers aim to launch an East Coast industry, from seed to supermarket

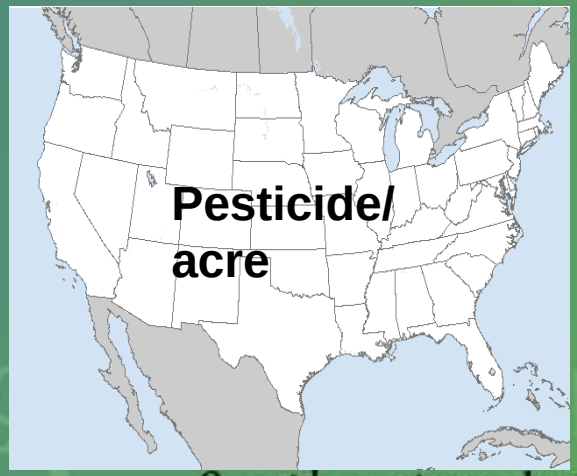
A couple of years ago, the *New York Times* conducted a tongue-in-cheek thought experiment aimed at getting more Americans to eat their greens. It recruited a prominent ad agency to give broccoli an "extreme makeover," applying to that cruciferous vegetable the same marketing acumen it offers major food brands like Coca-Cola. The resulting pseudo-campaign declared broccoli "the alpha vegetable," dubbed it "43 percent less pretentious than kale," and suggested that macho men could give bunches of it to

Can we define maps and metrics for economic and environmental sustainability.

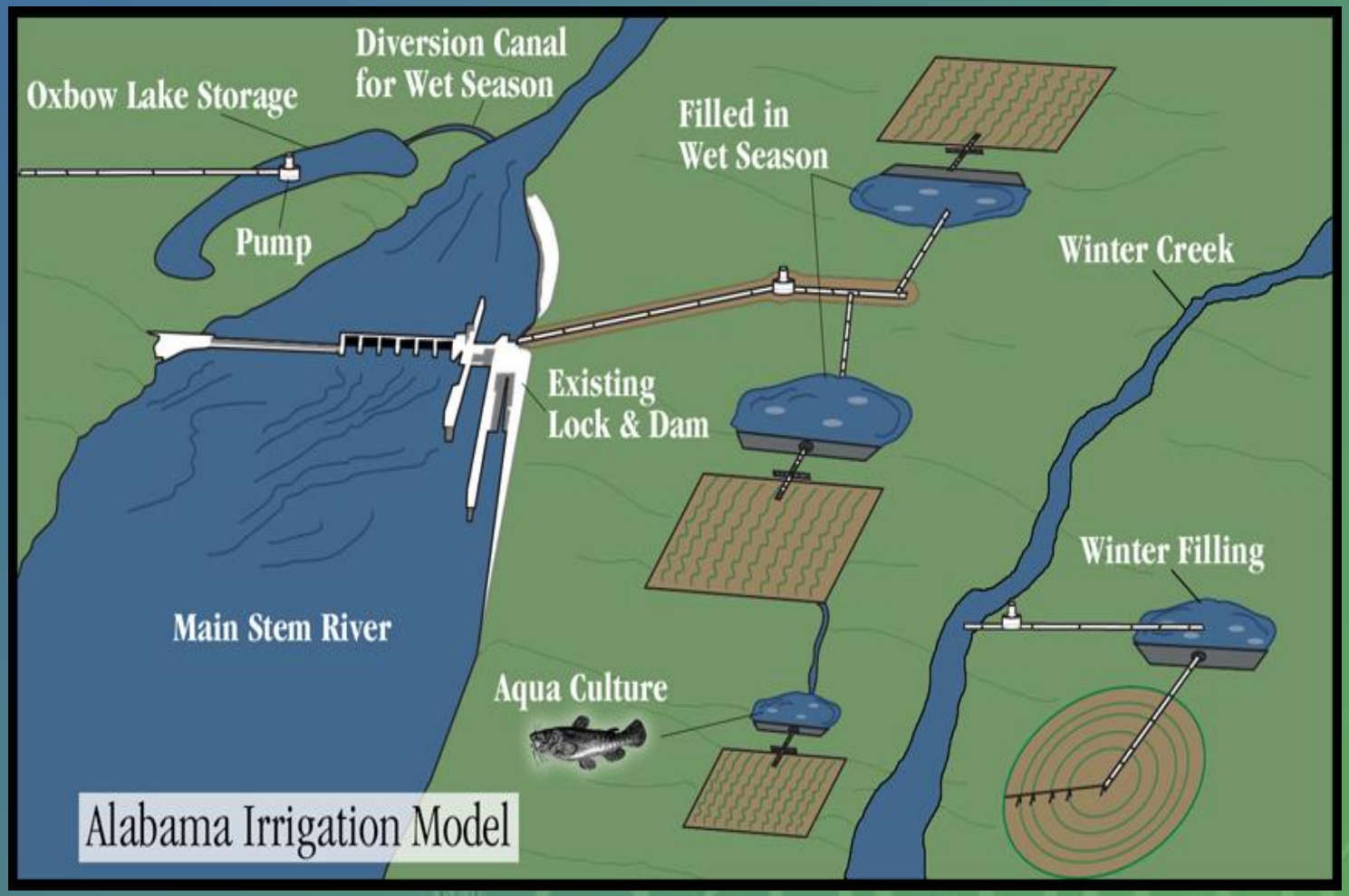


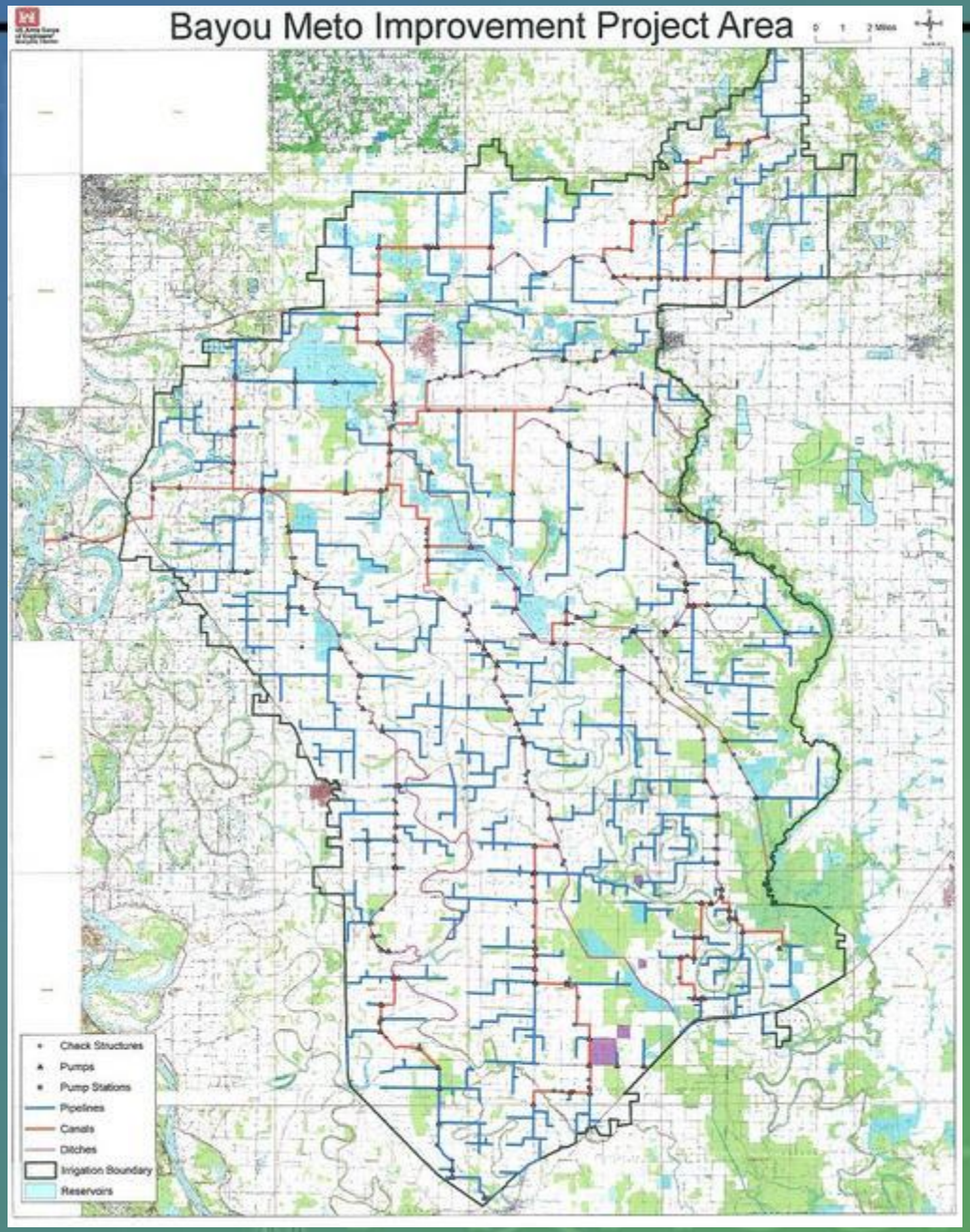






Building Irrigation Infrastructure Support in the East





Southeastern Irrigation

Questions

Is migration a path that can sustain agricultural production?

Can metrics/maps needed to define economic, environmental and societal geographical sustainability be defined?

If so, how can these maps be used to encourage shifts in agriculture ?

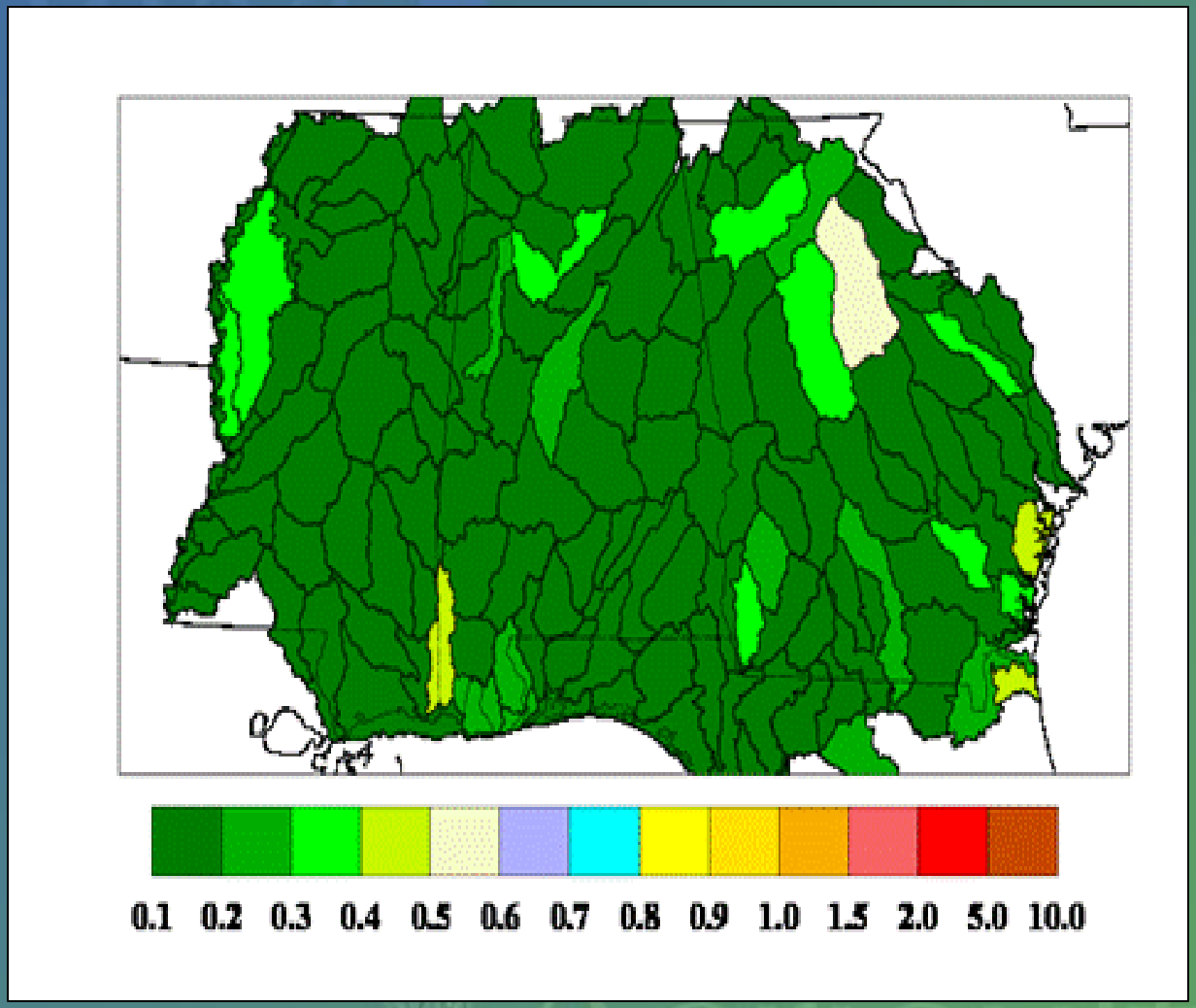
Supplemental Slides

Water

Agriculture

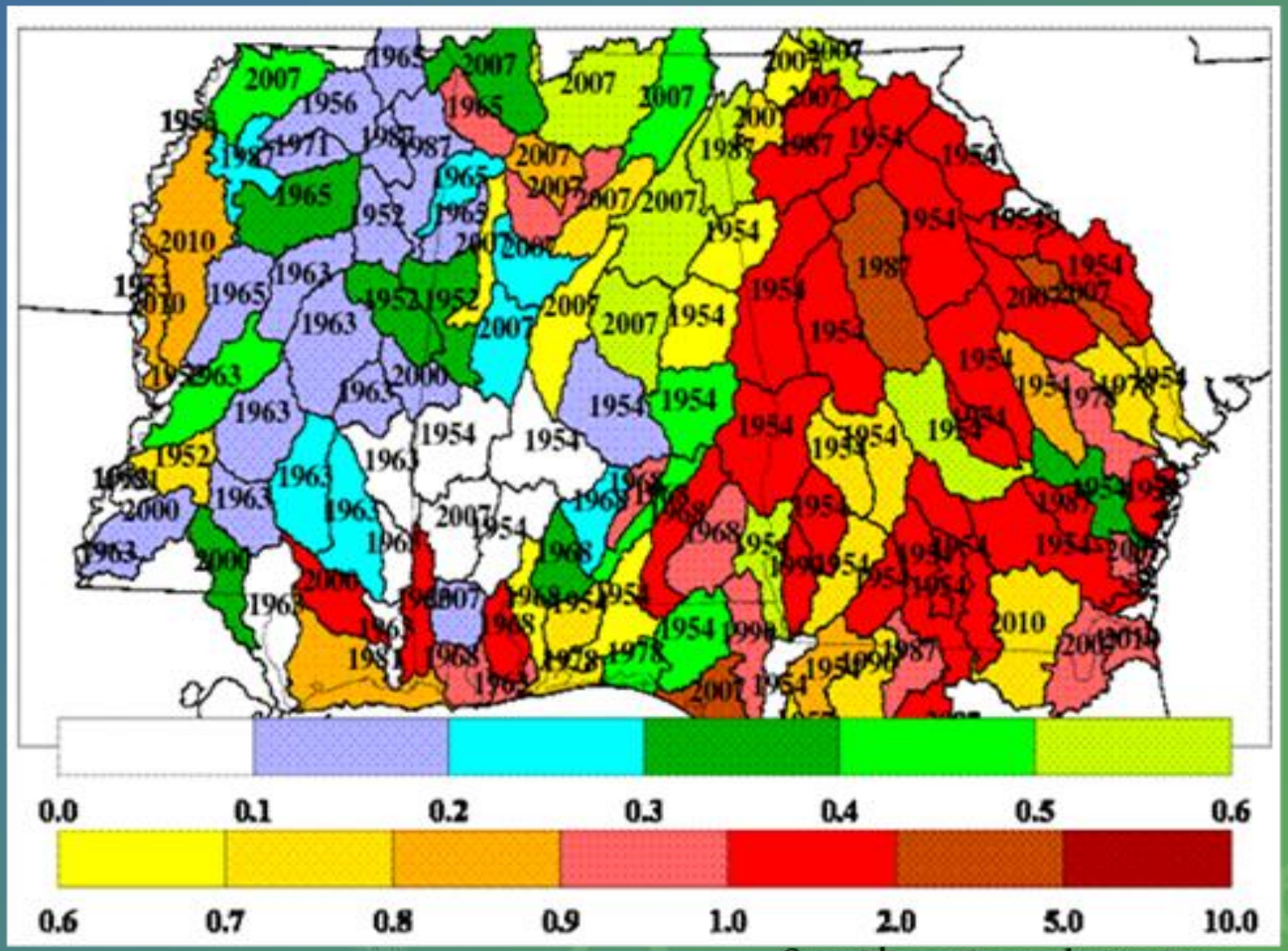
Southeastern Irrigation

Mean Demand to Supply Ratios – 1950-2010



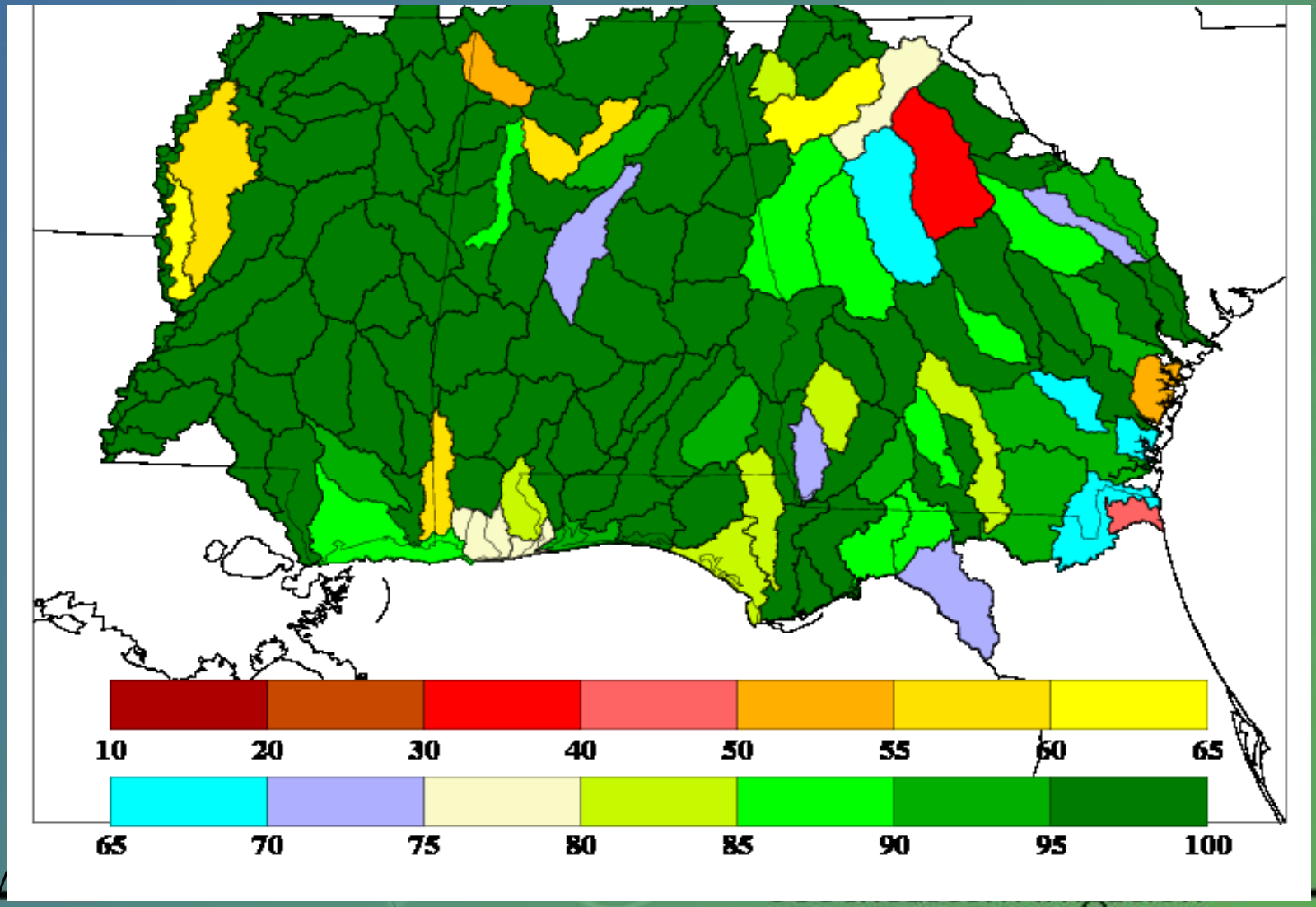
Extreme Events

Maximum Demand to Supply Ratios and Year (1951-2010)

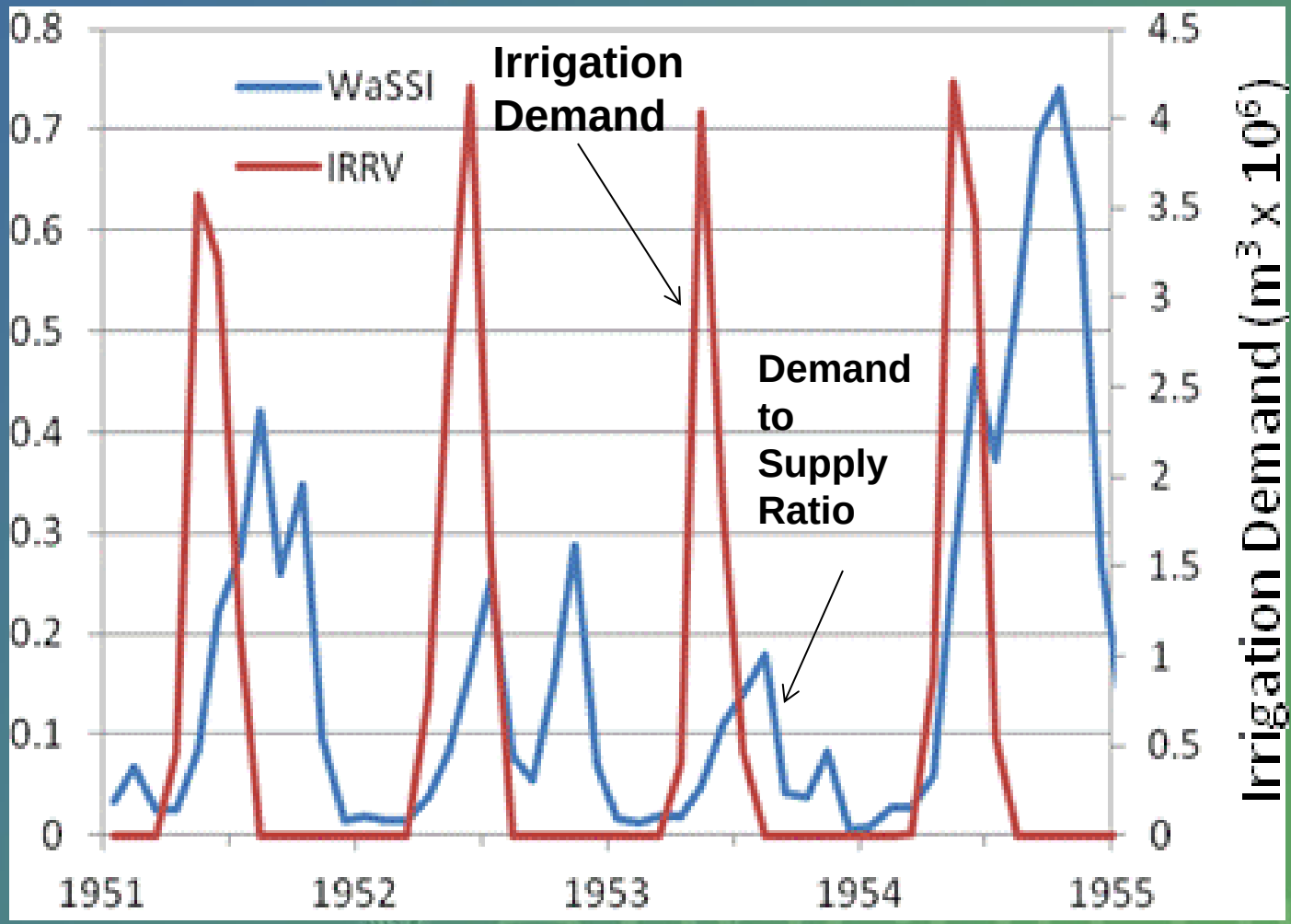


Southeastern Irrigation

Percent of Time Watersheds Are Not Stressed (1951-2010)



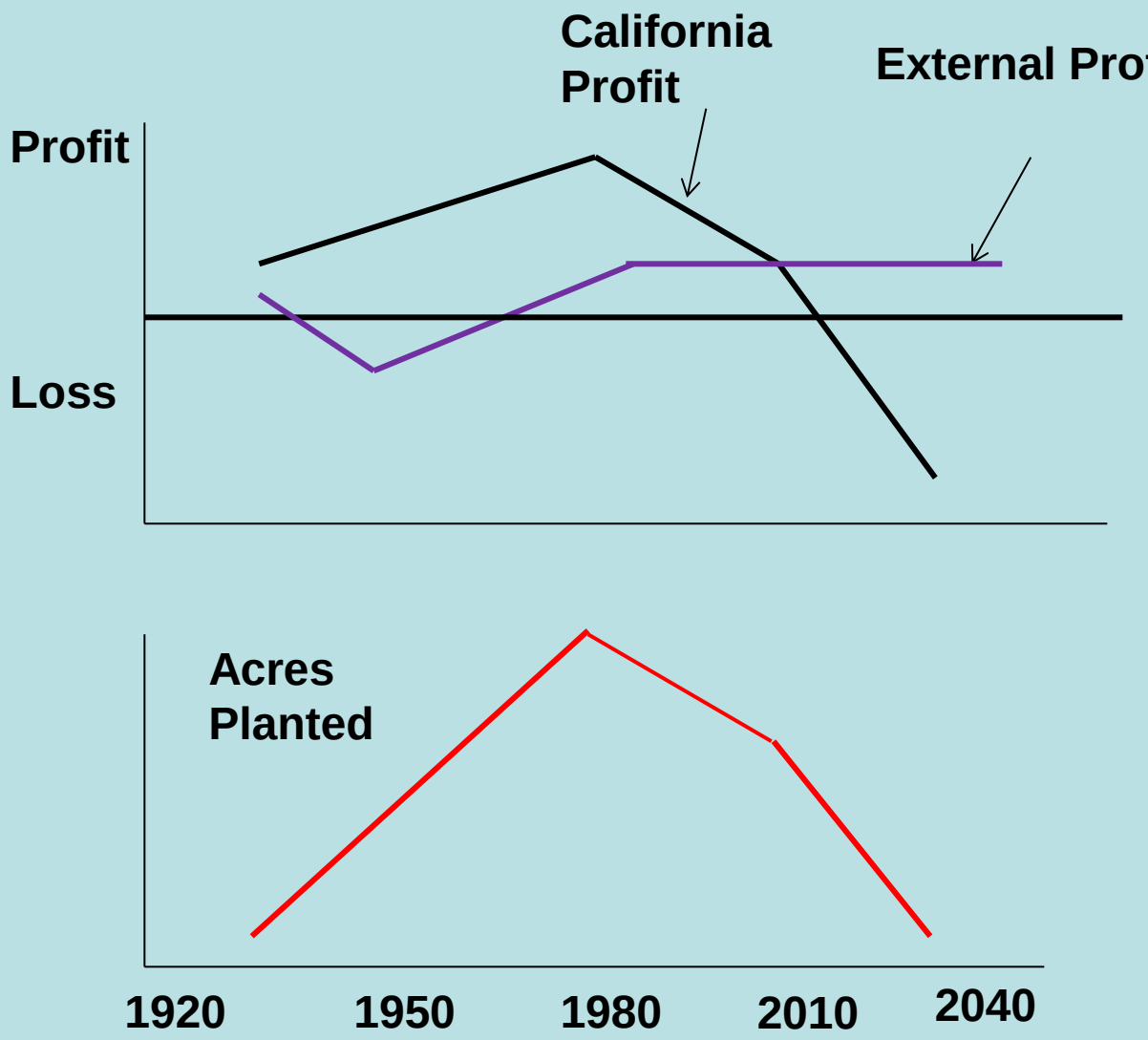
Is water available for irrigation during times when crops need water?



Components needed to define maps of economic and sustainable geography

1. Crop Models to determine yields and production costs (including water costs) in different geographical regions.
2. Hydrologic Models to determine impact and sustainability of water resources considering all competing uses of water.
3. Nutrient loading models to examine impact of production
4. Transportation Models to explicitly consider movement of agricultural goods
5. Nutrition/freshness models to examine time cost of transport to consumer.
6. Social costs of geographical production

Cotton as Example



Vegetable as Example

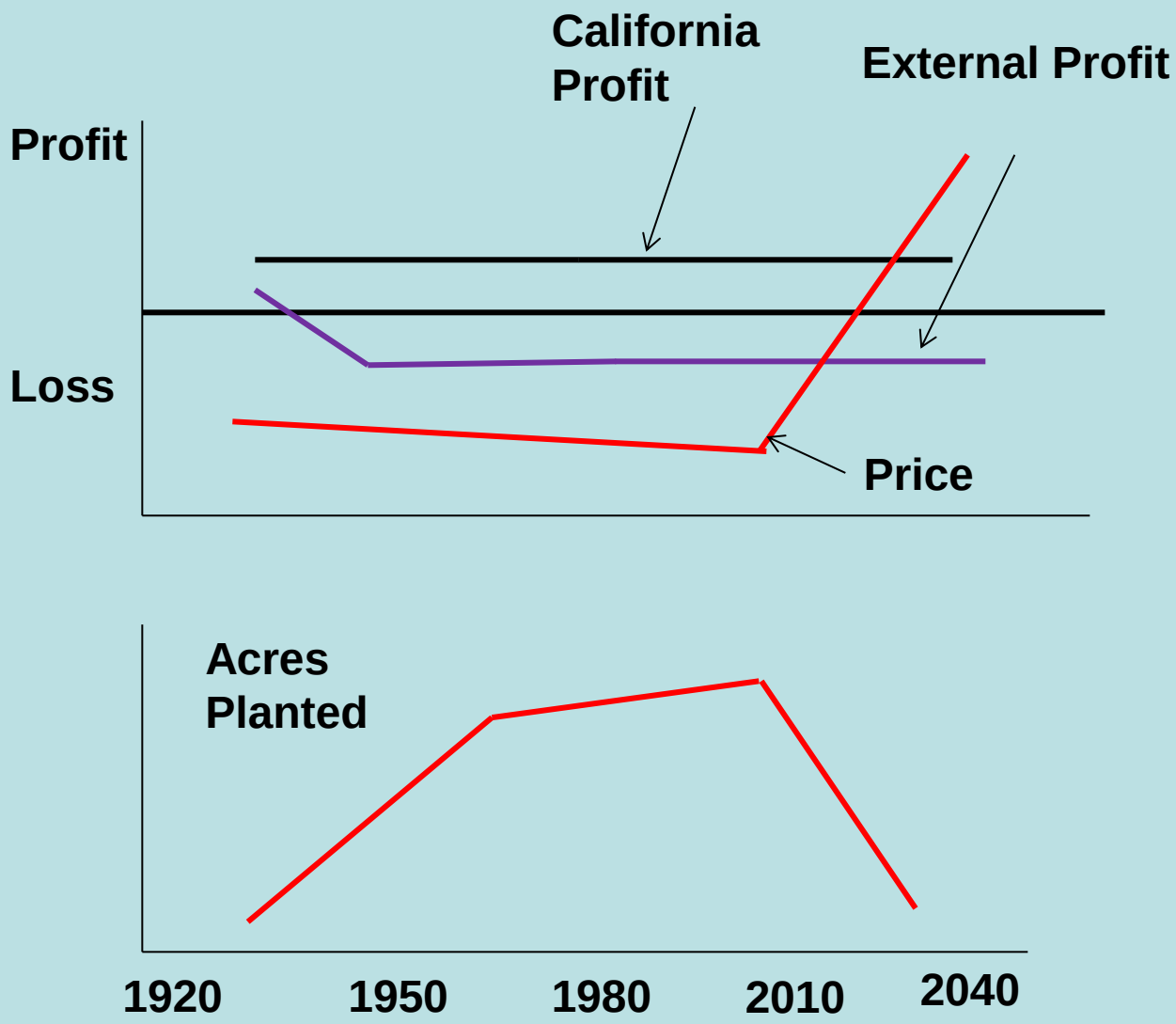


Table ES-1. 2014 Drought and California Agriculture Summary

Drought impact	Loss quantity
Water supply	
Surface water reduction	6.6 million acre-feet
Groundwater pumping increase	5 million acre-feet
Net water shortage	1.6 million acre-feet
Statewide costs	
Crop revenue loss	$810 million
Additional pumping cost	$454 million
Livestock and dairy revenue loss	$203 million
Total direct losses	**1.5 billion**
Total economic cost	**$2.2 billion**
Total job losses	**17,100**

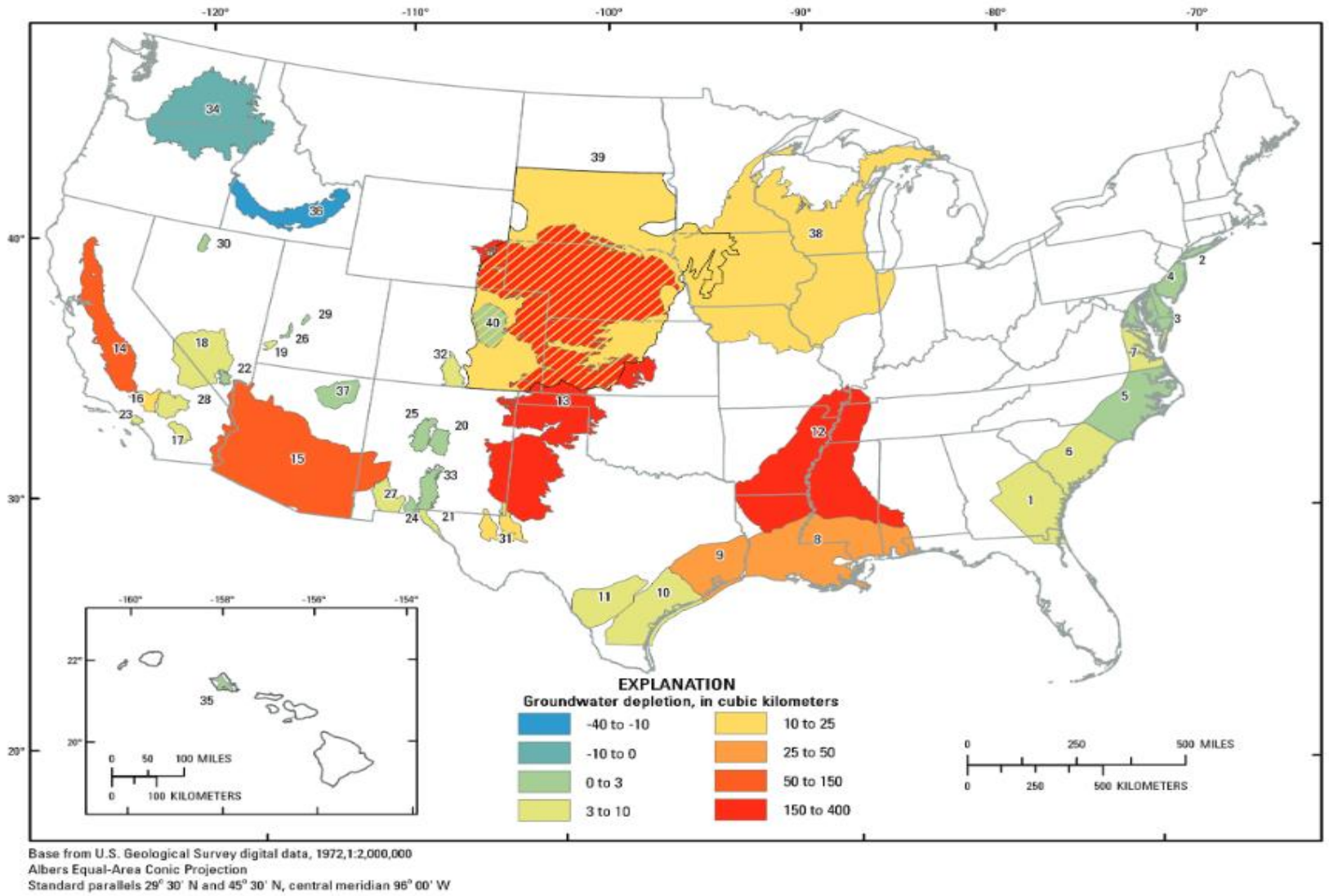
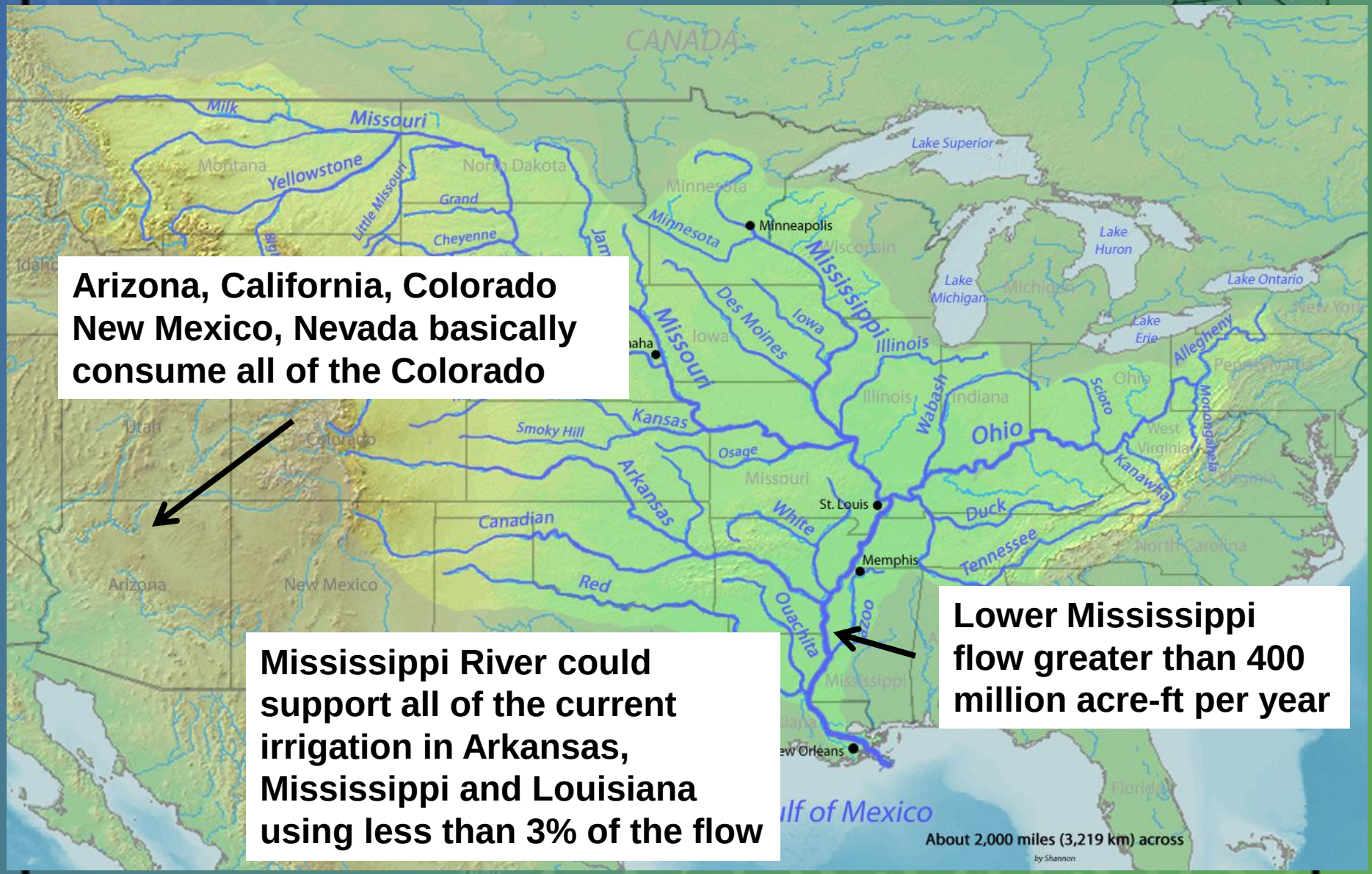
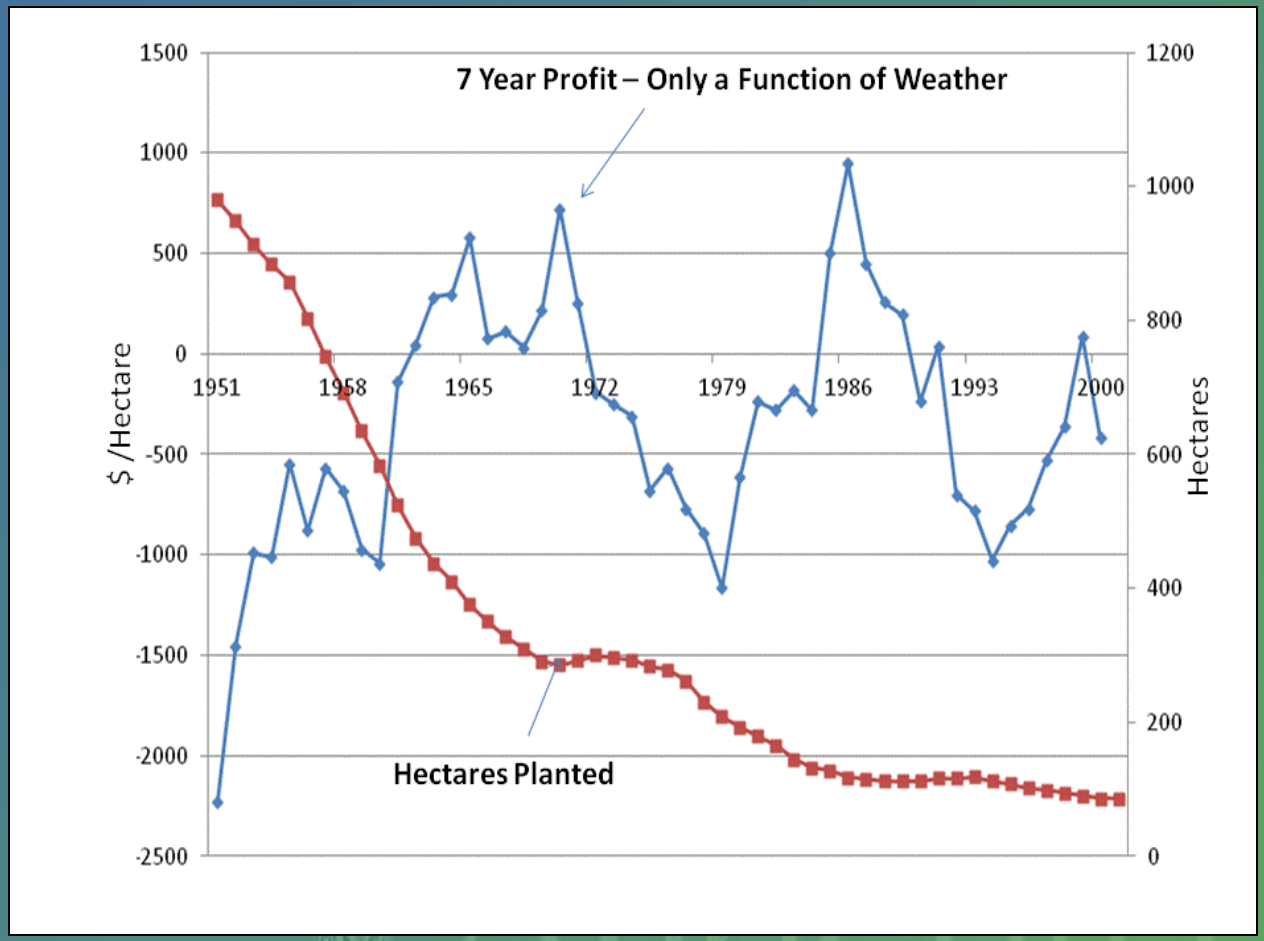


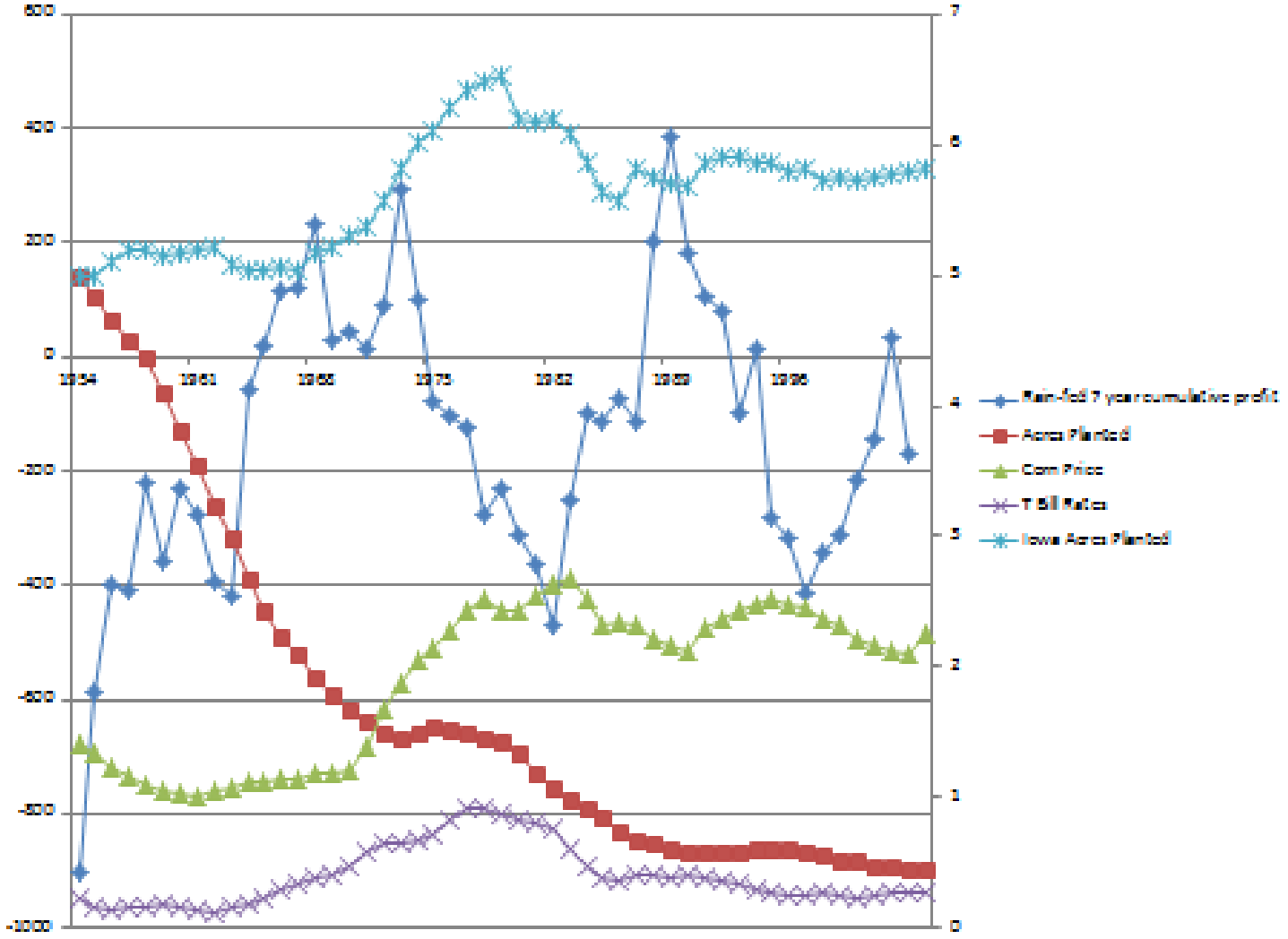
Figure 2. Map of the United States (excluding Alaska) showing cumulative groundwater depletion, 1900 through 2008, in 40 assessed aquifer systems or subareas. Index numbers are defined in table 1. Colors are hatched in the Dakota aquifer (area 39) where the aquifer overlaps with other aquifers having different values of depletion.



Southeastern Irrigation

Climate can totally change agriculture and society





Southeastern Irrigation