Migration of Agricultural Production Back to the Southeast as a Climate Change Adaptation Strategy

Richard McNider¹, Gerrit Hoogenboom², Richard Marcus³, Grover Ward⁴, Amelia Ward⁴, Lee Ellenburg¹, John Christy¹, Jeff Mullen⁵, James Cruise¹, Cameron Handyside¹

in collaboration with
Steve McNulty, Gee Sun and Peter Caldwell
U.S. Forest Service

University of Alabama in Huntsville¹, Washington State University², California State University Long Beach³, University of Alabama⁴, University of Georgia⁵
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.
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. New Jersey/Del Marva Peninsula provided vegetables for urban areas. Corn was grown in almost every State for local use.
Deep water holding soils in the Midwest largely insulated farmers from short-term losses that plagued the Southeast.

Average Mid-west Yields

Headland, AL
Rainfed Corn Yield

Crop Model

Deep water holding soils in the Midwest largely insulated farmers from short-term losses that plagued the Southeast.
Transportation Improvements Intruded into Regional Markets that had Functioned for Generations

In 1928 a farmer in Alabama received nearly three times the price of corn as an Iowa farmer.

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.
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.
1930
The underlying map shows precipitation.

2013
We have moved production away from the Nation’s water
In many parts of the West tree rings show the 20th Century was likely the wettest century in the last 500 years.

Climate models generally predict drying in the Southern High Plains and Southwest but no change or an increase in precipitation in the East and Southeast.
While this shift was supported by market efficiencies that provided a kings fare of meat and fresh vegetables to the American people, it was not exactly a free market. And in this case President Obama was correct – business was enabled by government infrastructure.

The Federal government spent billions of dollars on Western water projects for agriculture. This included massive dams, canals, piping to provide basically free water to farmers. Transportation via rivers and highways was made possible through dams and interstates built in large part by the federal government.
Role of climate variability in agricultural migration

Because precipitation change under climate change scenarios in the East is not large – they may not be the most threatening climate agricultural scenario.
Climate can totally change agriculture and society

7 Year Profit – Only a Function of Weather

Hectares Planted

Hectares
Unaccounted Externalities - The tremendous increase in market efficiency in western agriculture due to irrigation and concentration of grain production in the upper Mississippi Basin came with additional costs beyond what the market and federal government paid.

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

Concentration of production and reduction of Mississippi flood plains has produced apoxia problems in Gulf of Mexico.

See Cadillac Desert
Social Costs

These old agricultural areas of the South – once the richest are now the poorest.
The concentration of grain production in the Midwest and dependence on agricultural production in the arid West leaves the country’s food and fiber production vulnerable to climate change.

Solution we propose is to migrate agriculture back to the East and Southeast under an irrigation-assisted rain-fed system for a more distributed production.
Positive values indicate areas with irrigation adaptation potential and negative values indicate irrigation constrained areas. Dark green FPUs are saturated at 50 km3/y. From Elliot et al. 2013 PNAS.
Corn Yield Estimated by DSSAT Crop Model for Coastal Plain Soils in South Alabama
Can migrating agriculture back to the Southeast with expanded irrigation be a sustainable solution for the Nation’s future agricultural security?

Is it economically viable?

Will expanded irrigation harm the regions water resources?

Will winter withdrawals reduce flood plain inundation?

Will water quality be harmed?
Our Team is Using Climate Information to Build and Run

• Crop models
• Regional Hydrologic Models
• Nutrient Loading and Uptake models
• Ecosystem Flood Plain Models
• Economic Models
• Energy Consumption Models
• Also Examining Social, Legal and Economic Barriers to Expanding Irrigation in the Southeast
Is there available water considering both anthropogenic demands and ecosystem needs?

We are employing the WASSI Model (developed by USDA/USFS) a continental scale water balance model for projecting climate and population change impacts on water supply stress in the conterminous U.S.

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\text{WASSI} = \frac{\text{Total Water Demand}}{\text{Water Supply}}
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Water Demand is sum of uses from 7 private sectors plus public use.

Water Supply is computed from the hydrologic model plus groundwater supplies plus return flows.

Return flows are taken as percentages of withdrawals for the use sectors.
Considering all uses of water – the Eastern U.S. has far more available water.
Mean Demand to Supply Ratios – 1950-2010
Maximum Demand to Supply Ratios and Year (1951-2010)
Hydrologic Modeling especially for Low Flows Must Include Reservoirs

Chattahoochee at West Point without Reservoirs
We have added reservoirs using the operating rule curves and reservoir capacity. Have completed Alabama and nearly complete for Georgia.
Irrigation demand in the Southeast is highly dependent on weather as is water availability. It is thus important to consider both irrigation demand and water availability together.

We have coupled regional hydrologic model (WaSSI) to regional crop model (GRiDSSAT).
DSSAT Irrigation Demand is coupled to WaSSI Hydrological model
How many irrigated acres can watersheds support before streams are stressed?

Number of warm months 1951-1999 that Demand to Supply Exceeded 0.4

Non-irrigation withdrawals

Additional impact with 10% of crop land irrigated

Additional impact with 25% of crop land irrigated

Additional impact with 50% of crop land irrigated

From McNider et al 2014
Is water available for irrigation during times when crops need water?
Environment: How does irrigation impact nitrogen run-off in humid climates?

Used models and on-farm studies.

Irrigation pushes soils closer to saturation thus increasing run-off potential.

Irrigation takes nutrients to root zoned decreasing potential for flash run-off.

In drought years irrigation allows full uptake of applied nitrogen leaving less residual.

In model and on-farm experiments irrigation does not change total nitrogen export.

Per weight of yield reduces nitrogen by export by nearly 50%.
Economics

Can Alabama really compete with Iowa in grains? If we include transportation cost – Yes!

Also examining total economic multiplier impact of increased agricultural production and optimal water rates for economic gain.
Environment
Winter /Spring Withdrawal

Summer Flows are Low

Use on Farm storage ponds

How will flood Plains be Impacted?
Our project has impacted water and agricultural policy

Farm Bill language to build on-farm reservoirs introduced

Irrigation Tax Credit bill with water protection language passed and signed by Governor