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Floridan Aquifer Collaborative Engagement for Sustainability

FACETS: Floridan Aquifer Collaborative Modeling for Sustainable Management

Presentation by Kristin Rowles to FACETS Georgia Water School, September 27, 2022

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USDA United States Department of Agriculture | National Institute of Food and Agriculture | University of Georgia | Auburn University | Albany State University, University System of Georgia | UF Water Institute, University of Florida

What if....?

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- What would happen to the aquifer all irrigation systems upgraded to the high efficiency equipment and practices?
- What would happen to stream flows if we paid farmers incentives to stop irrigating during drought?
- What would happen to the economy if we shifted critical areas of the aquifer from farms to forestry?
- What would happen to the region if the drought of 2011-2012 had lasted one year longer?

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Floridan Aquifer Collaborative Engagement for Sustainability

FACETS Brings together scientists and stakeholders to:

- develop new knowledge needed to explore tradeoffs and synergies between the regional agricultural economy and environmental quality;
- understand changes needed to achieve agricultural water security and environmental protection; and
- develop tools, incentives and educational programs for improved decision making

PROJECT VISION

Promote economic sustainability of agriculture and silviculture in N Florida and S Georgia while protecting water quantity, quality, and habitat in the Upper Floridan Aquifer and the springs and rivers it feeds.

The Floridan Aquifer

- **~10 million people** depend on Upper Floridan Aquifer (UFA) for water
- **~$9B in agriculture**-related economic activity; corn, cotton, peanuts, timber
- Among largest & most productive aquifers; **vital *regional* resource**
- **Many uses** – sometimes competing: urban, agriculture, forestry, & environmental water uses
- **Unique aquatic ecosystems**

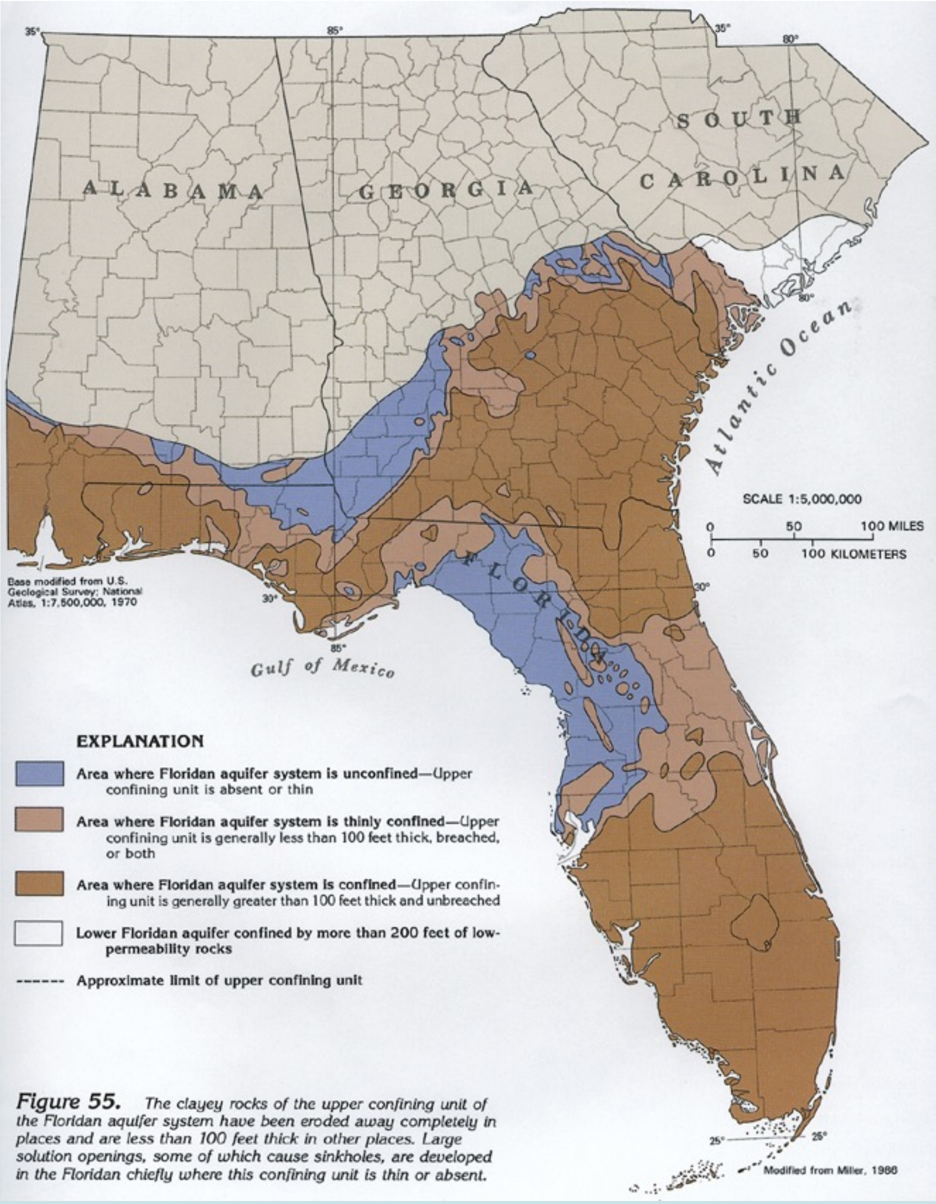
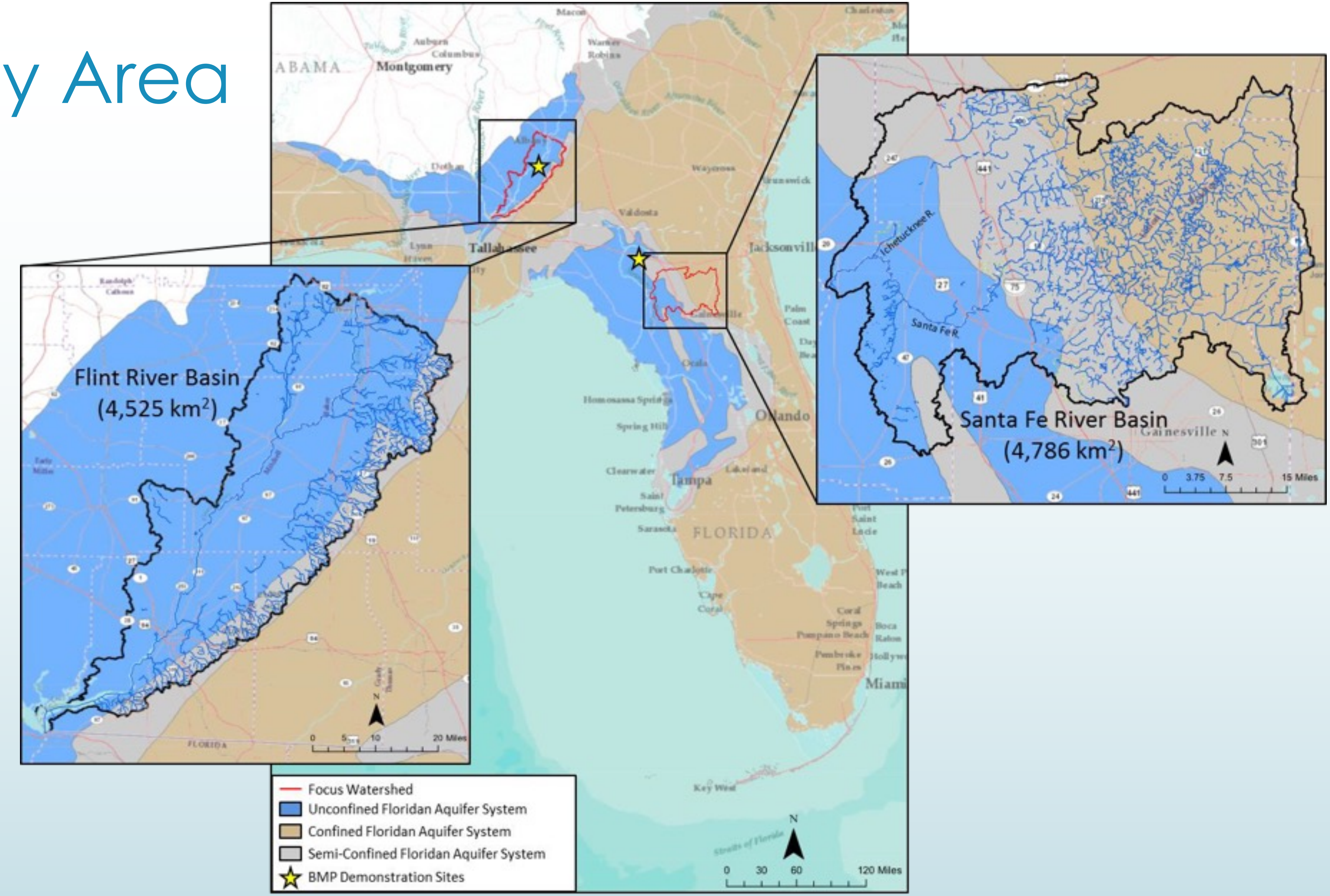


Figure 55. *The clayey rocks of the upper confining unit of the Floridan aquifer system have been eroded away completely in places and are less than 100 feet thick in other places. Large solution openings, some of which cause sinkholes, are developed in the Floridan chiefly where this confining unit is thin or absent.*

- Increasing **water use**
- Reduced **spring and river flows**
- Increases in **nitrate concentration** in surface and groundwater
- **In the context of** climate variability, environmental standards, history of interstate conflict

Study Area

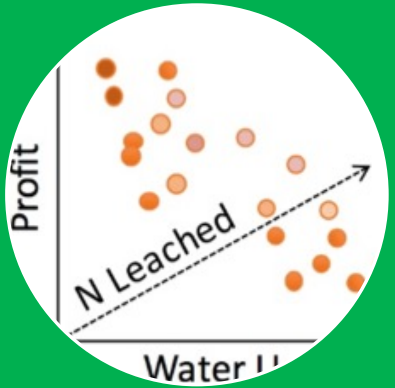


Flint River Basin
(4,525 km²)
Santa Fe River Basin
(4,786 km²)
Ichetucknee R.
Santa Fe R.
0 5 10 20 Miles
0 3.75 7.5 15 Miles
0 30 60 120 Miles
Montgomery
Tallahassee
Jacksonville
Valdosta
Waycross
Brunswick
Ocala
Orlando
Tampa
Clearwater
Saint Petersburg
Sarasota
Port Charlotte
Cape Coral
Lakeland
Homosassa Springs
Spring Hill
Palm Coast
Gainesville
Miami
Key West
FLORIDA
Focus Watershed
Unconfined Floridan Aquifer System
Confined Floridan Aquifer System
Semi-Confined Floridan Aquifer System
BMP Demonstration Sites

PROJECT ACTIVITIES AND OUTPUTS

Field Research

- Water use, quality, yield impacts of Best Management Practices (BMPs) for irrigation & nutrient management
- Digital decision toolkit



Modeling

- Land use & management impacts on water quantity & quality, crop & forest production, and regional economy
- Best Management Practice supply and demand curves

Stakeholder Engagement

- Co-develop models
- Scenarios (baseline and future)
- Tradeoffs & synergies
- Communication tools

Extension

- On-farm Best Management Practice demos
- In-Service Training programs
- Water Schools

collaborative research and Extension

BMP Research

- Florida
  - Corn, Carrot, Peanut
  - Corn, Cover Crop, Peanut
- Georgia
  - Corn, Cotton, Peanut
- BMPs
  - Fertilizer rates/application methods, irrigation scheduling methods, cover crops







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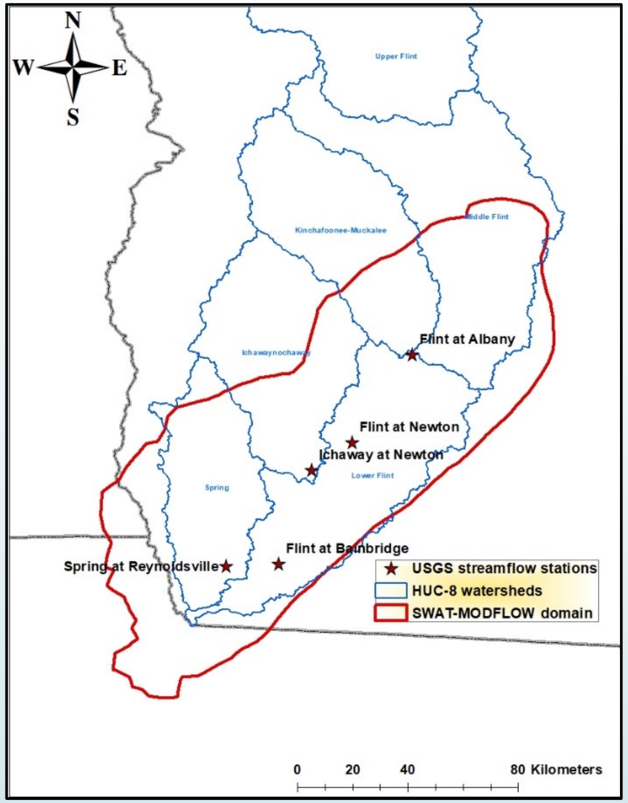
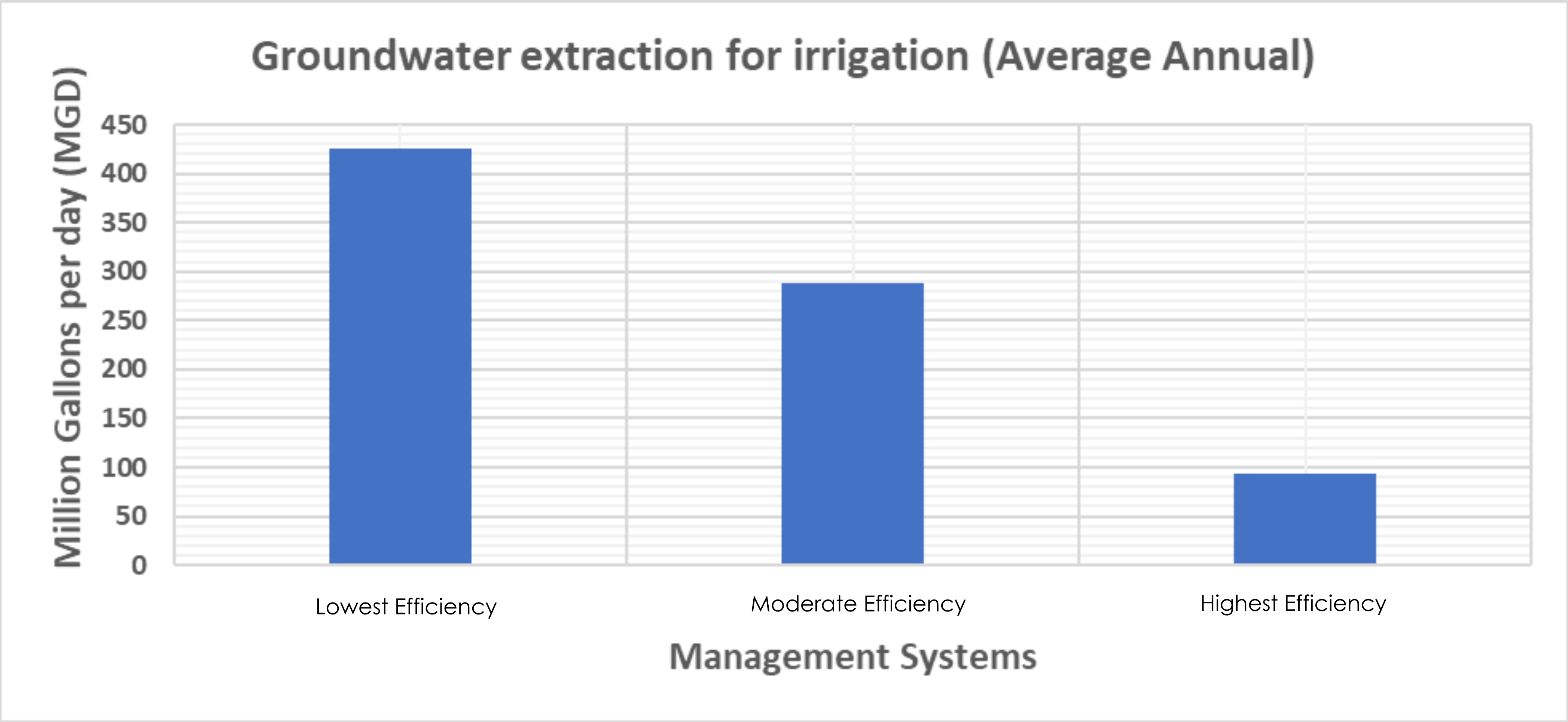
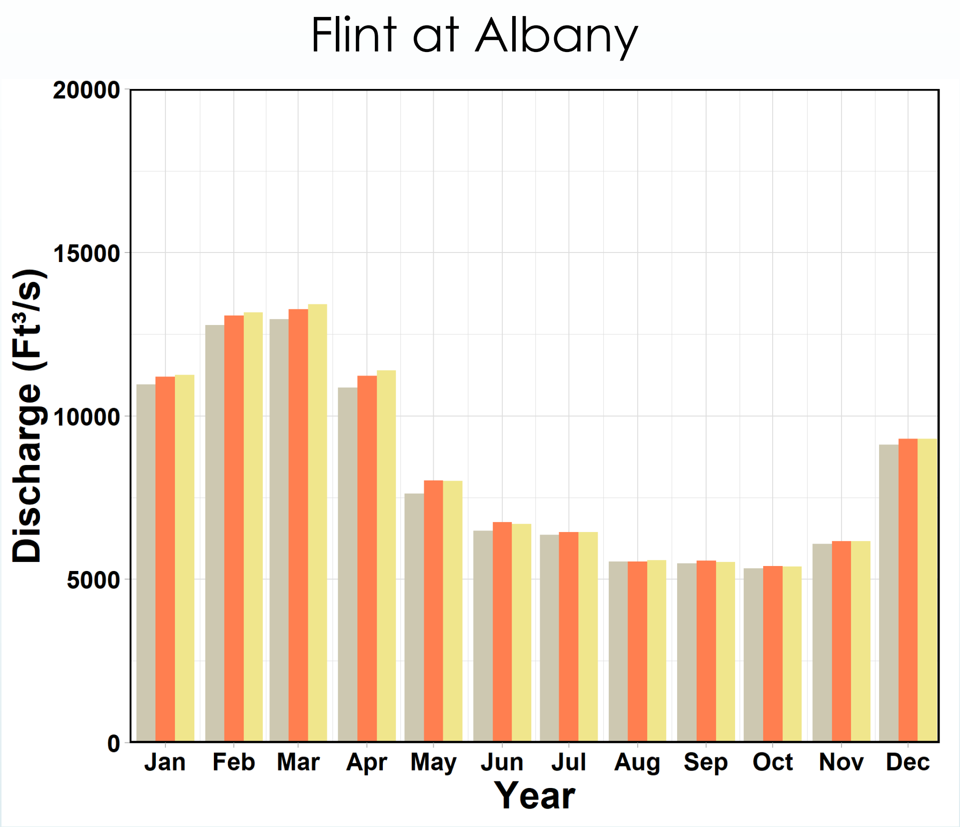


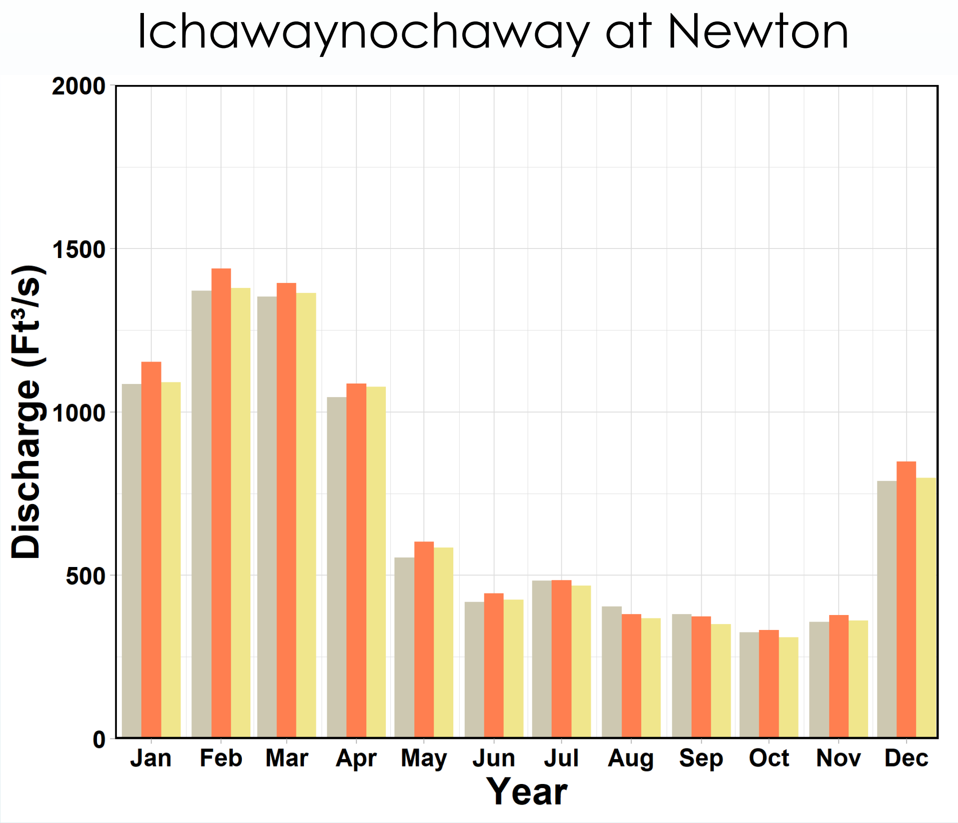
What would happen if all irrigation systems upgraded to high efficiency equipment and practices?

High Efficiency Scenario: Groundwater Use



High Efficiency Scenario: Streamflow





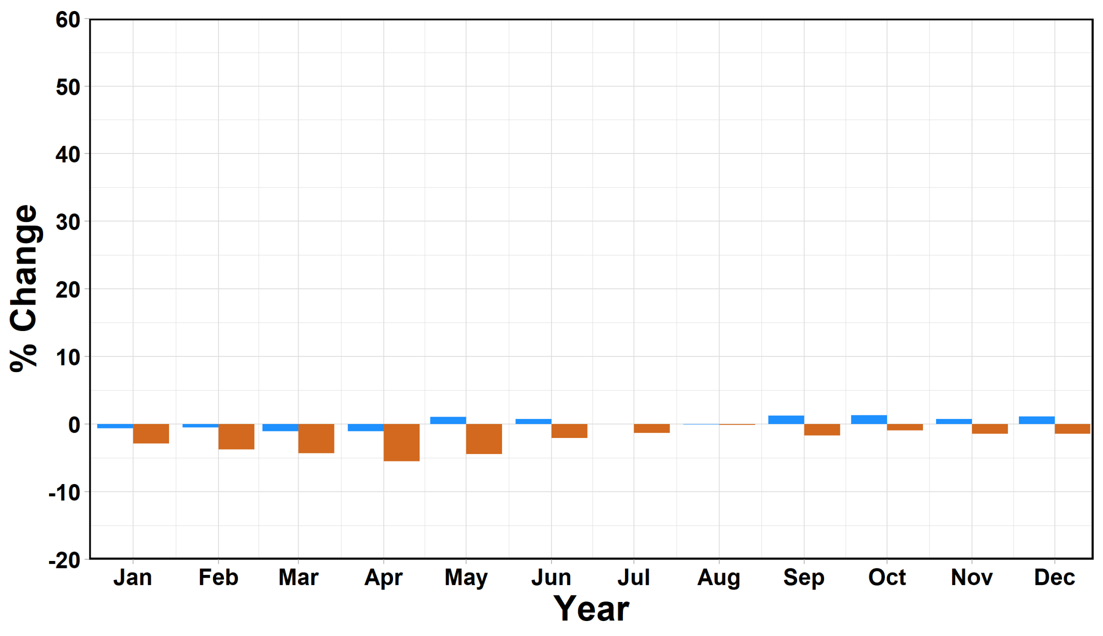
Highest efficiency

Moderate efficiency

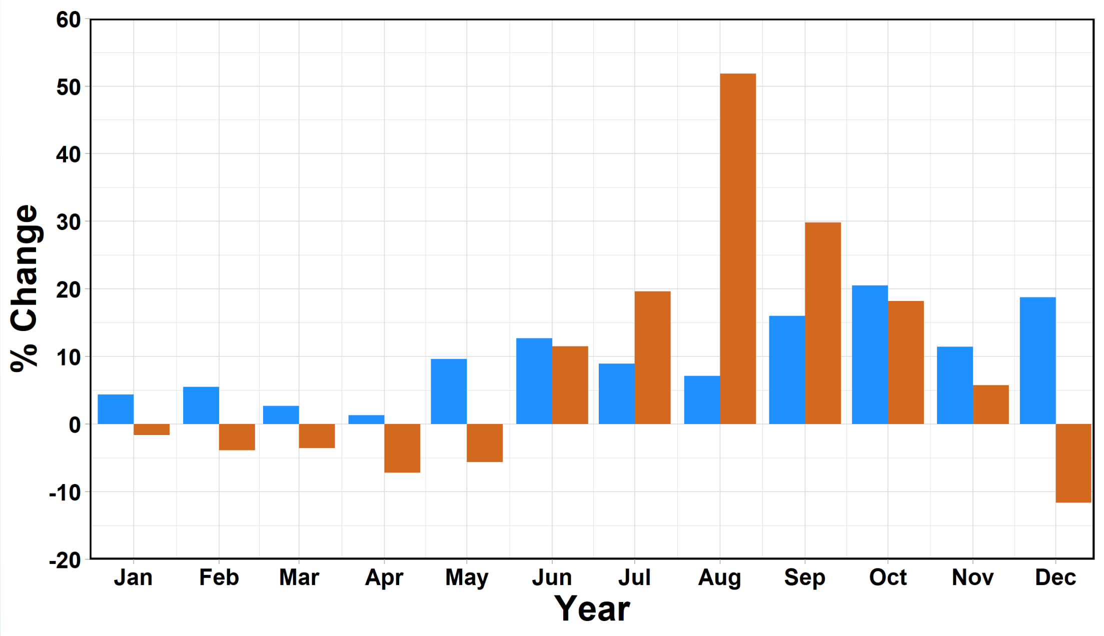
Lowest efficiency

High Efficiency Scenario: Streamflow Impacts in Drought Years

Flint at Albany



Ichawaynochaway at Newton

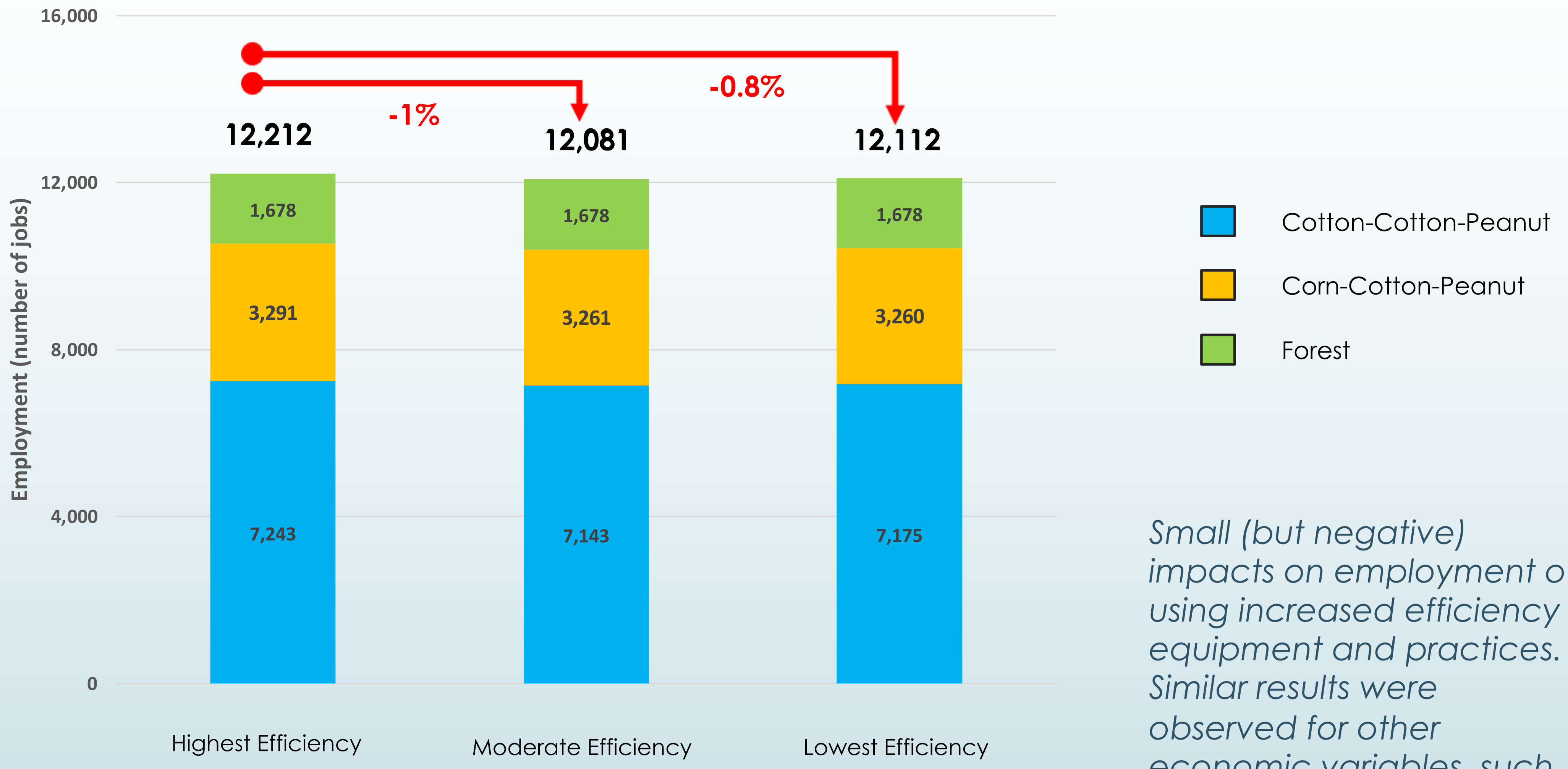


- Highest efficiency (vs. lowest)
- Moderate efficiency (vs. lowest)

Increased efficiency of equipment and practices improves flows in dry summer months in Ichawaynochaway (and Spring Creek), but not in the mainstem Flint River.

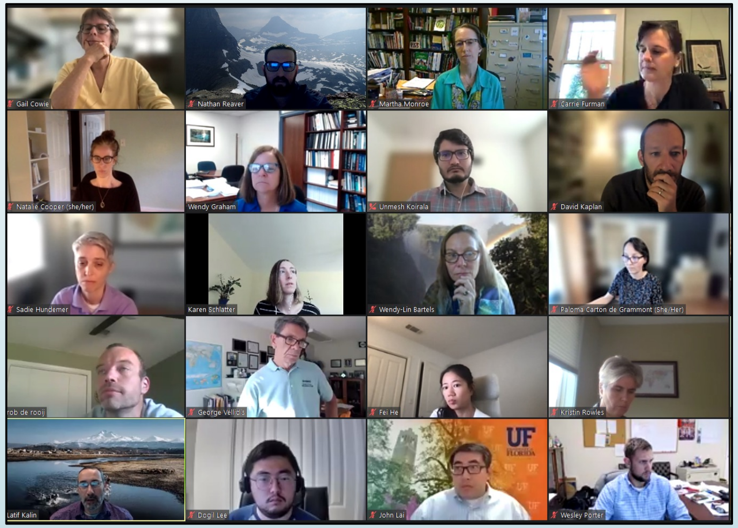
Drought Years Only

High Efficiency Scenario: Employment



Small (but negative) impacts on employment of using increased efficiency equipment and practices. Similar results were observed for other economic variables, such as local taxes.

Participatory Modeling Process (PMP)



PARTICIPATORY MODELING PROCESS (PMP) MEMBERS

Lesley Bertolotti, The Nature Conservancy

Kirk Brock, Brock Farms

Jason Chandler, Grimmway Farms

Kevin Coyne, Florida Dept of Env Protection

Stacie Greco, Santa Fe Springs Protection Forum

Eric Handley, Usher Land and Timber, Inc.

Hugh Thomas, Suwannee River Water Mgmt District

Lucinda Merritt, Ichetucknee Alliance

Dan Roach, Rayonier Inc

Charles Shinn, Florida Farm Bureau Federation

Jacqui Sulek, Audubon

Kathryn Holland, Florida Department of Agriculture and Consumer Services

Perri Campis, Flint River Soil & Water Conservation District

Chase Cook, UGA Sustainable Forestry Initiative

Michael Dooner, Southern Forestry Consultants

Bert Earley, Georgia Forestry Commission

Steve Golladay, Jones Ecological Center

Sara Gottlieb, The Nature Conservancy

Connie Hobbs, Baker County

Elliott Jones, Flint Riverkeeper

Greg Murray, Dollar Farm Products

Mike Newberry, Hillside Farms

Steve Sykes, City of Thomasville, GA

Anna Truszczynski, Georgia Environmental Protection Division

Participatory Modeling Process

- Models grounded in "real world"
- Input to modeling team on baseline information and research questions
- Envisioning scenarios that help us to understand the system
- Interpreting results collaboratively: What are the tradeoffs & implications? What else do we want to know?
- New channels and approaches for science communication
- Interstate partnership building

PARTICIPATORY MODELING PROCESS

Co-Develop Management Systems
Represent the Range of Current Practices

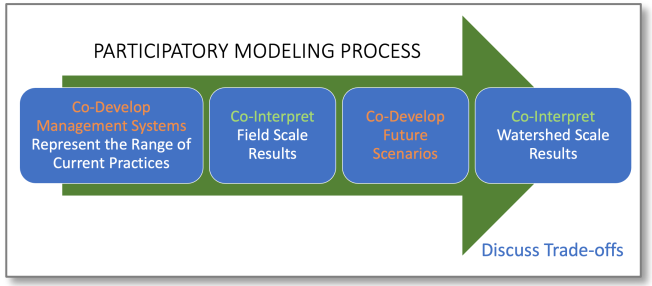
Co-Interpret
Field Scale Results

Co-Develop
Future Scenarios

Co-Interpret
Watershed Scale Results

Discuss Trade-offs

Management Systems



Current Production Systems

CROPS Cotton-cotton-peanut

Corn-cotton-peanut

FORESTS Longleaf

Loblolly

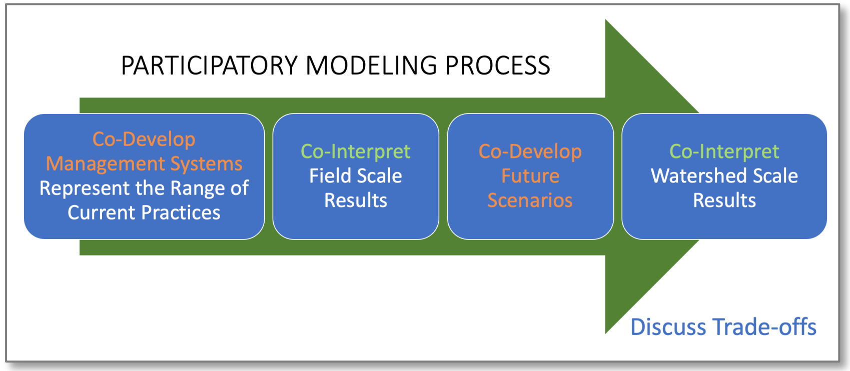
Slash pine

GEORGIA

Management System Summaries

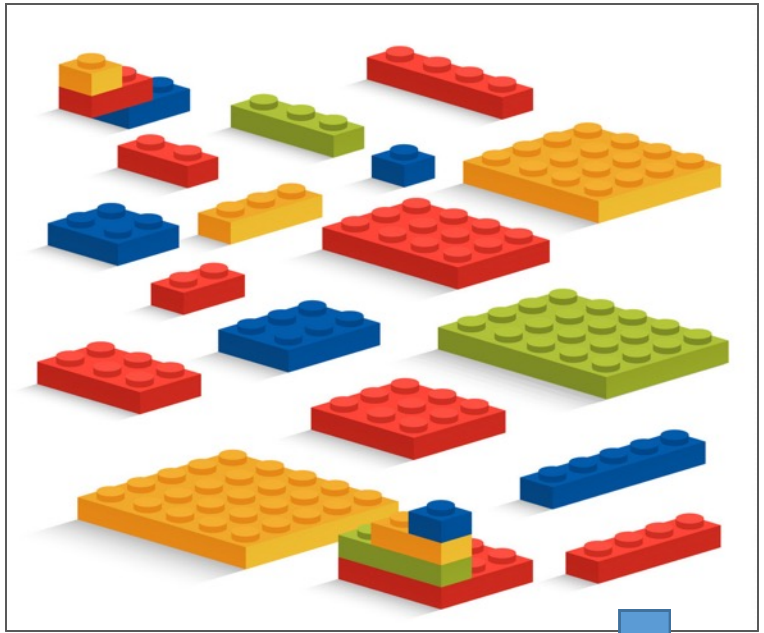
Management Increases (Crops) ↑ | Management Increases (Forest) ↓ | Inputs Increase (All land uses) ↓

	Crop	Forests
MS1	• SMS based irrigation • Lowest fertilization • Cover crops • Strip tillage	• No thinning • No fertilization • Longer rotation age • Lower initial planting density
MS2	• Checkbook irrigation • Medium N rate • No cover crops • Conventional tillage	• Thinning • Medium N rate • Medium rotation age
MS3	• Least efficient irrigation • Highest fertilization • No cover crops • Conventional tillage	• Thinning • Highest N rate • Shortest rotation age



Modeling at Two Scales

Field-Scale Models



Regional/Watershed-Scale Models

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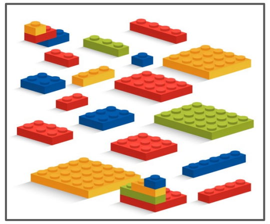
Model Input and Outputs



Inputs → "Levers or Scenarios"

- Cropping/forest systems (e.g., corn-cotton-peanut; slash pine plantation)
- Management systems (e.g., practices used for nutrient management, water management)
- Soil types
- Weather/climate data and scenarios

Field Scale Model Outputs

- Net returns ($)
- Yield
- Leached N
- Water use
- Net recharge

Watershed Scale Model Outputs

- Regional Economy
- Regional crop and forest production
- Aquifer/stream N concentrations
- Spring & stream flows
- Aquifer water levels

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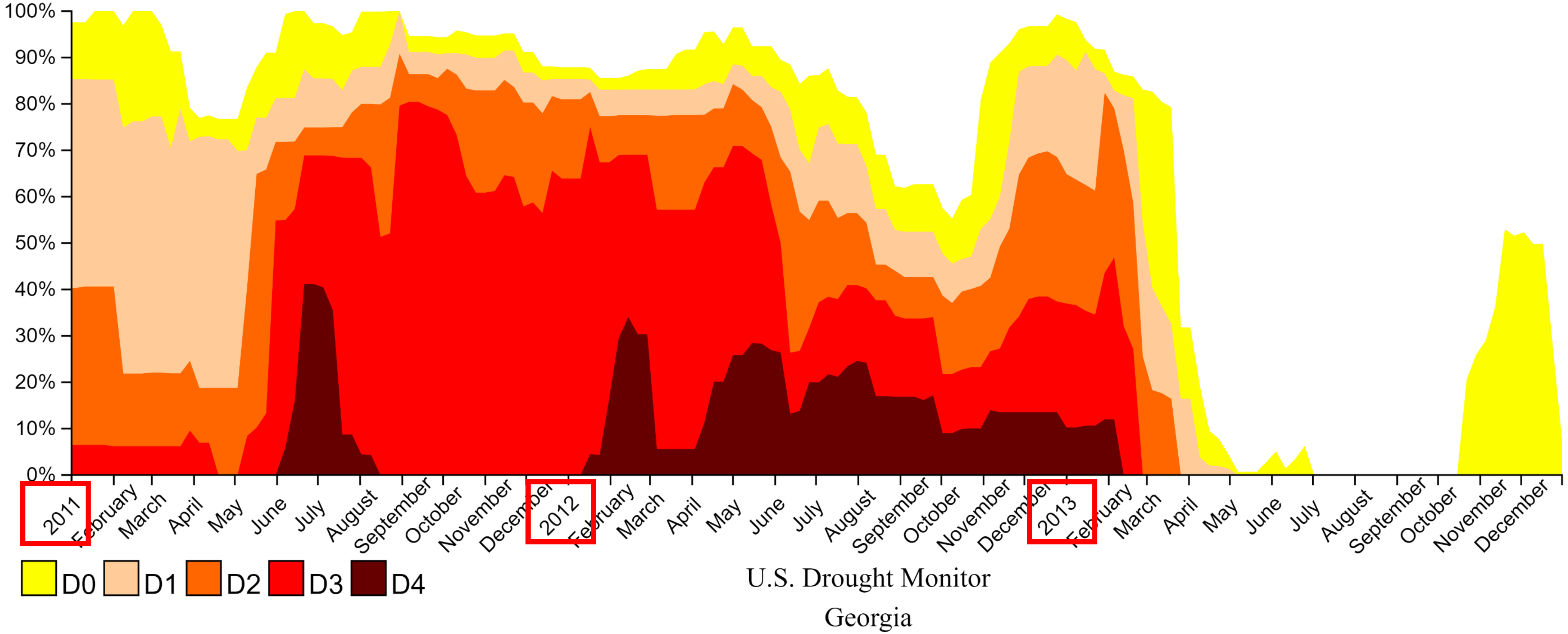
Georgia Scenarios

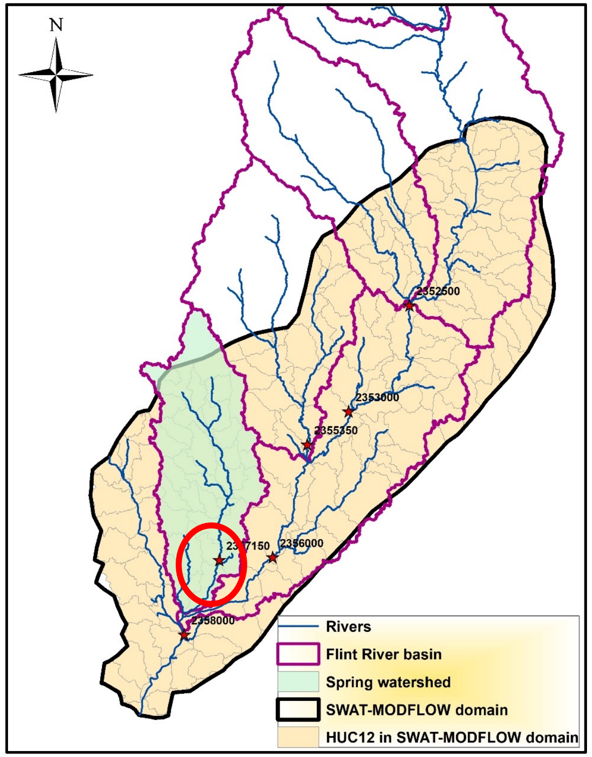
Scenario	Description
Scenario 1 Current/Baseline Conditions	• Forestry and crops approximate current conditions
Scenario 2 Multi-Year drought	• Multi-Year drought applied to Current/Baseline conditions (Scenario 1) • Extends 2011-2012 drought into a 3-year drought
Scenario 3 Land Use Change	• Converts acres irrigated from Floridan Aquifer from Capacity and Restricted Use Areas (identified by GAEPD) to forestry
Scenario 4 Drought Year Irrigation Suspension (voluntary)	• Suspends irrigation in Capacity and Restricted Use Areas for Floridan Aquifer withdrawals (full season) in drought years.

Georgia Drought – 2011-2012

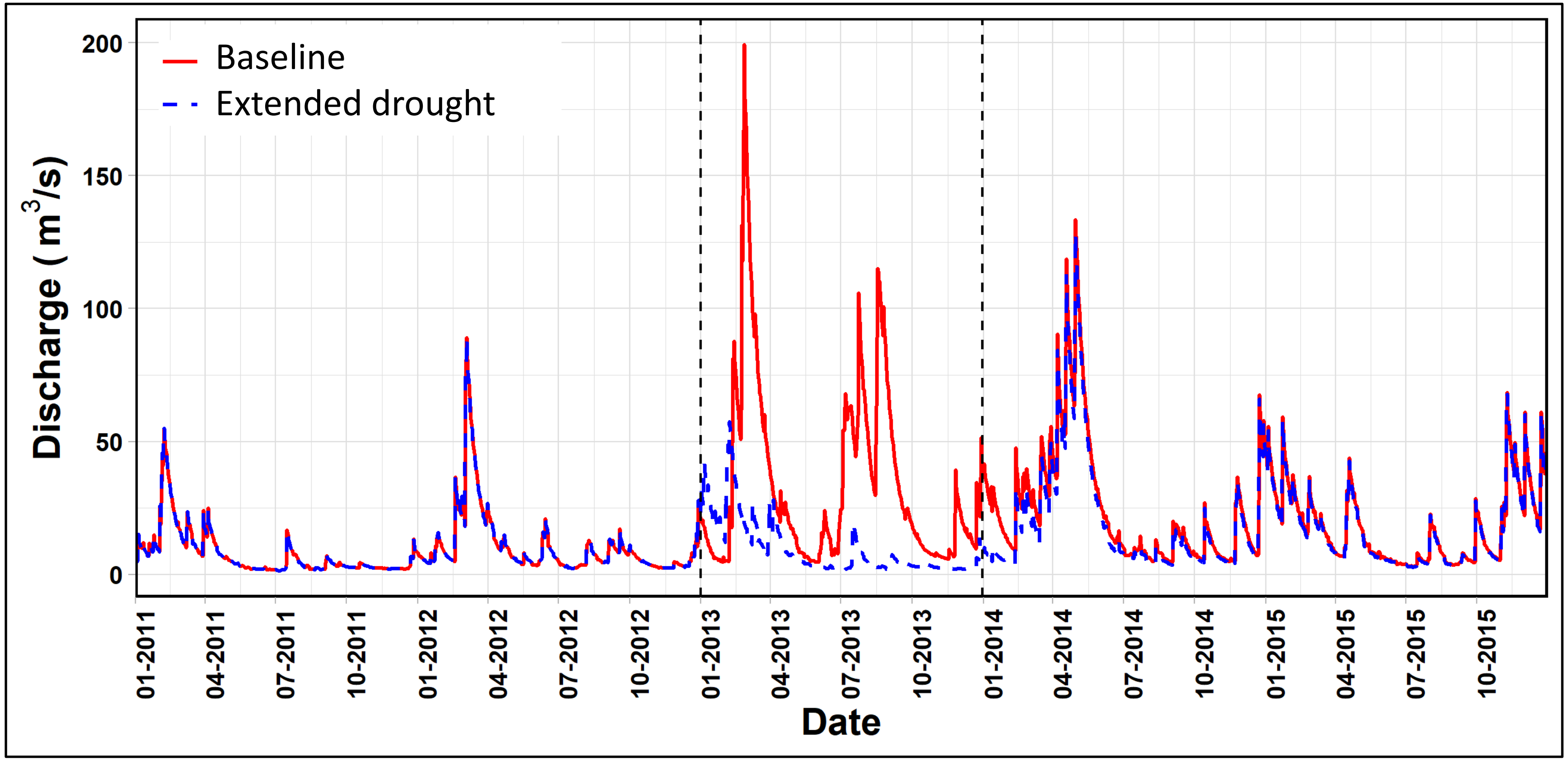


Multi-Year Drought Scenario: Streamflow

Scenario 2



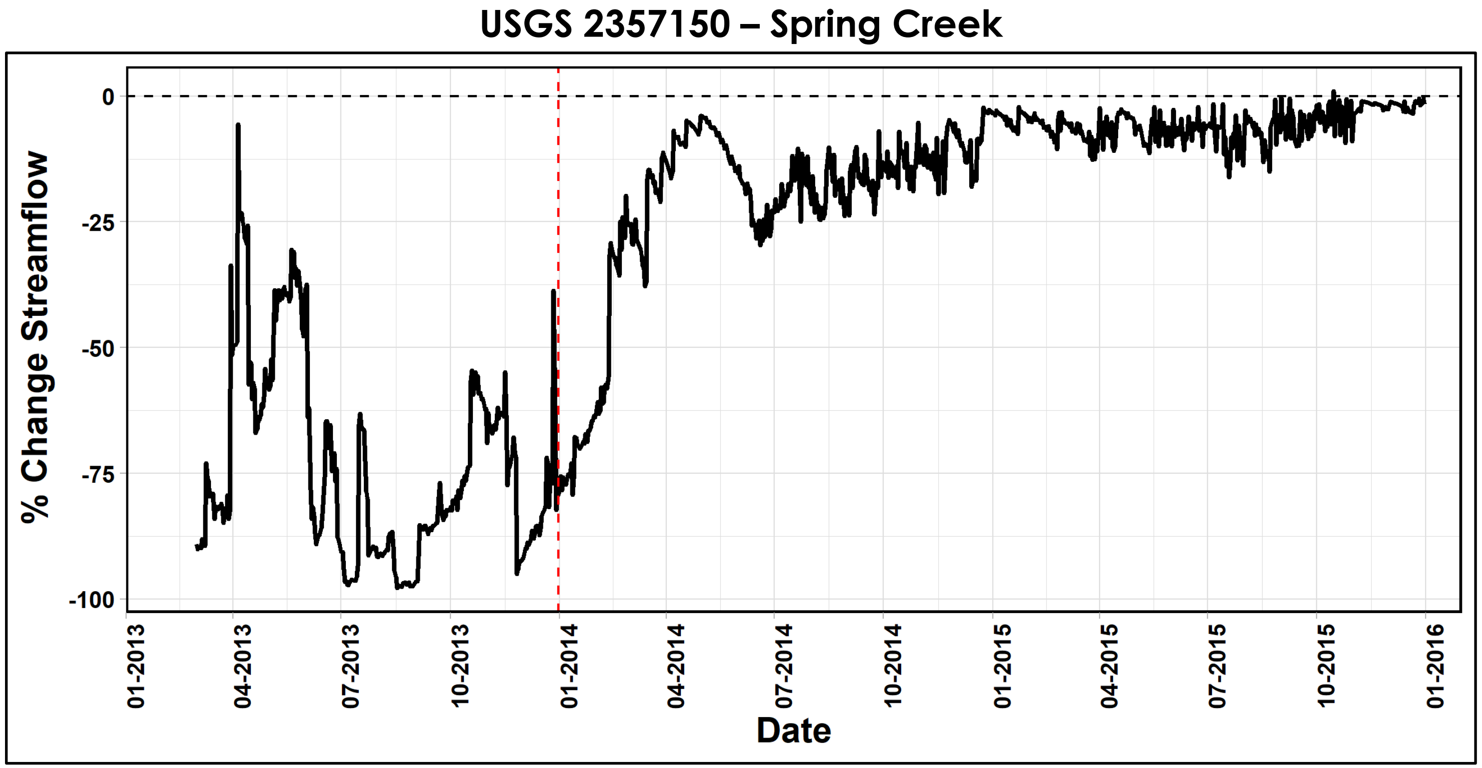
USGS 2357150 – Spring Creek



An extended drought to 2013 would result in low flow conditions observed similar to 2011 and 2012.

Multi-Year Drought Scenario

- It would take close to two years (until late 2015) for the system to return to flows and groundwater levels observed under current/baseline conditions.

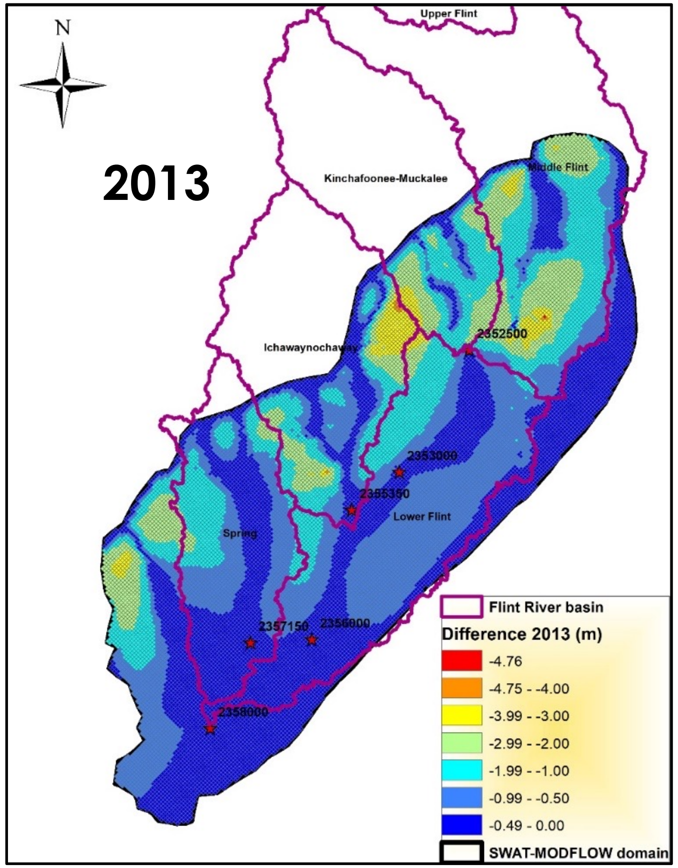


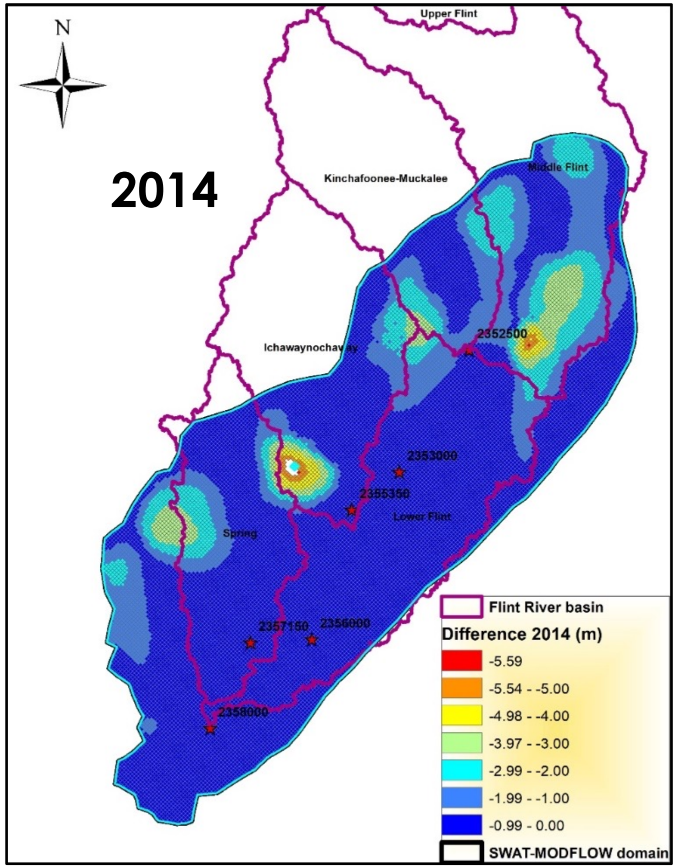
Multi-Year Drought Scenario: % Change in Streamflow from Baseline, 2013-2015

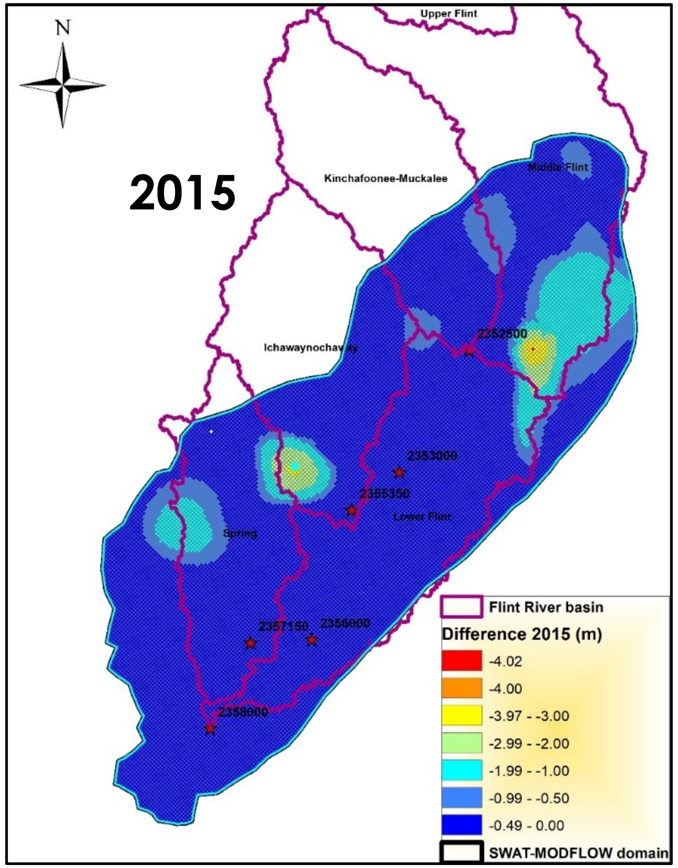
Multi-Year Drought Scenario: Groundwater Levels Difference from Baseline, 2013-2015

Scenario 2

- **Groundwater levels would not rebound to observed under current/baseline conditions until 2015**





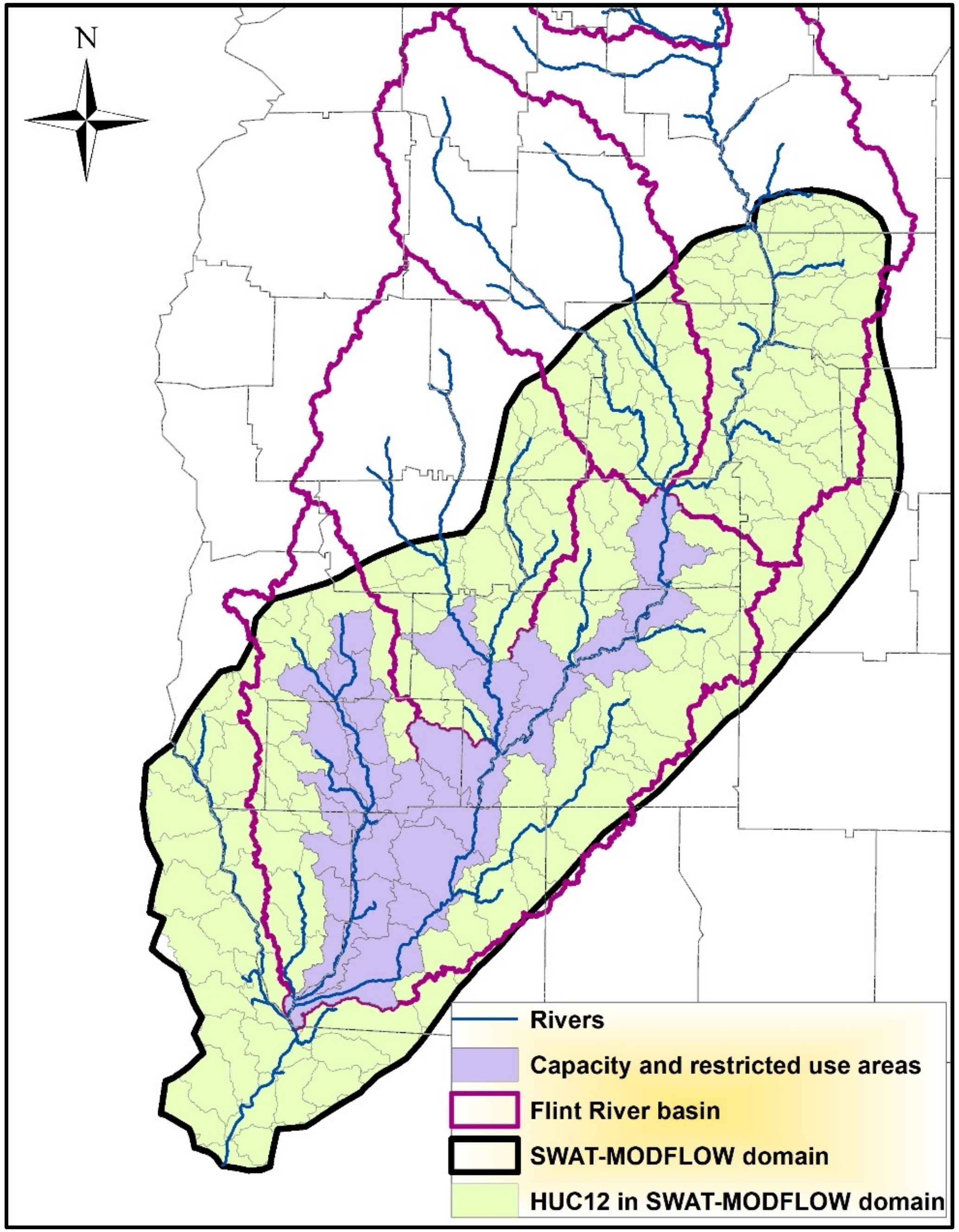


Groundwater levels for the multi-year drought compared to baseline scenario

Land Use Change Scenario

Scenario 3

Shift agriculture to forestry in capacity and restricted use areas



Reduced irrigated crop acreage from

799,508 acres

to

568,860 acres

Land Use Change Scenario
Model Results Summary

Scenario 3

Streamflow

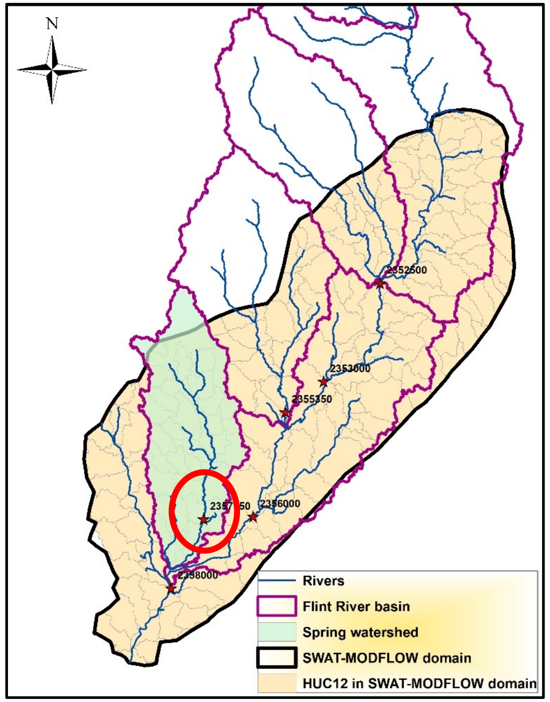
- Low flows are consistently higher than baseline scenario. Effect was bigger in tributaries than in mainstem of Flint River.
- Biggest % increase in daily streamflow was observed during drought.
- Some tributary peak flows were lower.
- Mean daily flow increased in the Ichawaynochaway and Lower Flint (8% and 2% respectively) but reduced by 0.5% in the Spring watershed

Groundwater levels

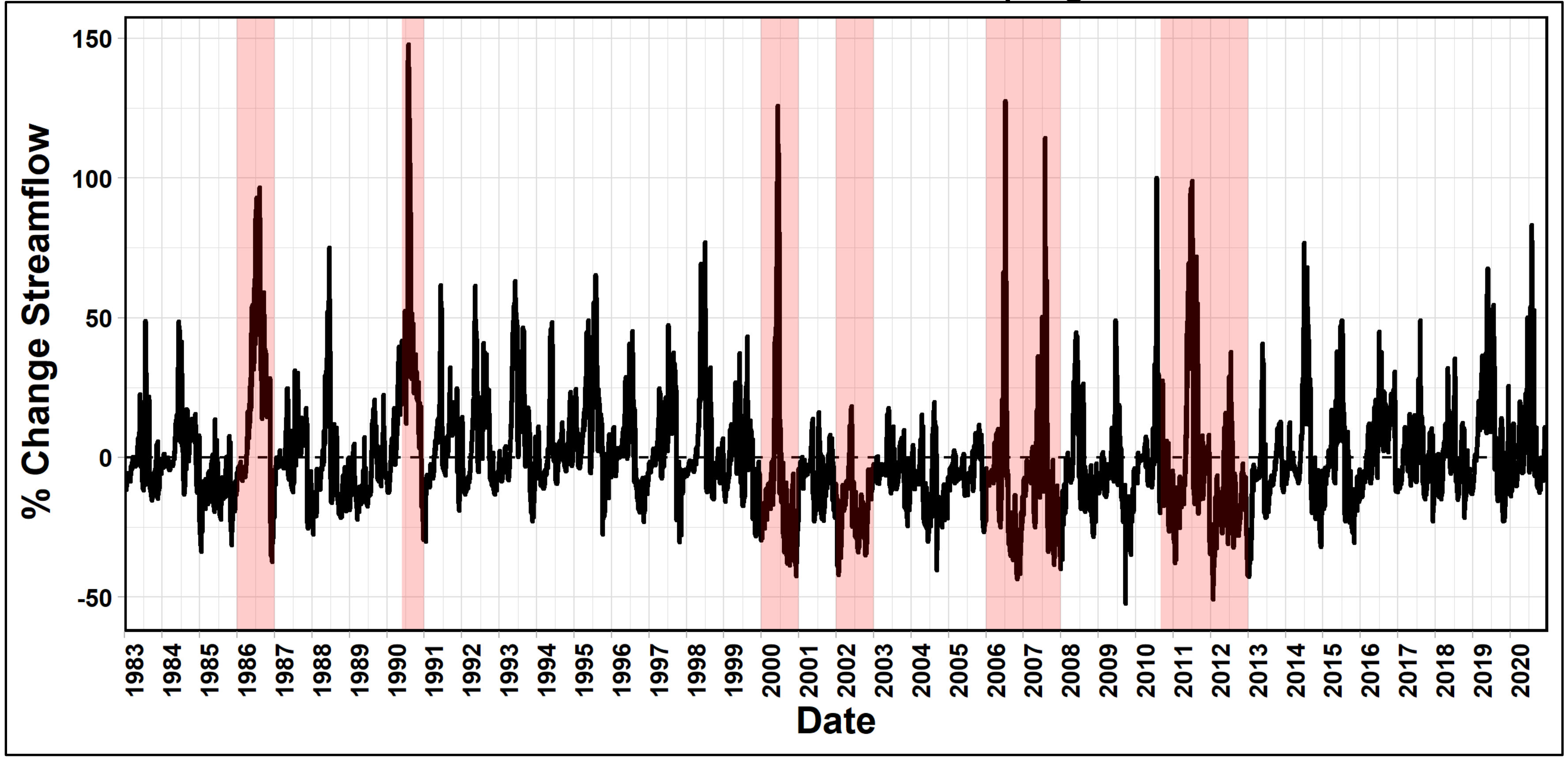
- Average annual increase in groundwater levels was observed in parts of the Spring and Ichawaynochaway Basins (tributaries).
- Groundwater level increase was less than one meter in most of the region.

Land use change scenario: Streamflow Impact
% change in Streamflow vs. Baseline

Scenario 3



USGS 2357150 – Spring Creek



For the land use change scenario:

- Biggest % increase in daily streamflow was observed during drought periods (highlighted in red) – as high as 150%.
- Mean daily flow (1983-2020) decreased by 0.5%. *But in Ichawaynochaway, mean daily flow increased by 8%.*

Results represent work in progress and are not yet peer reviewed

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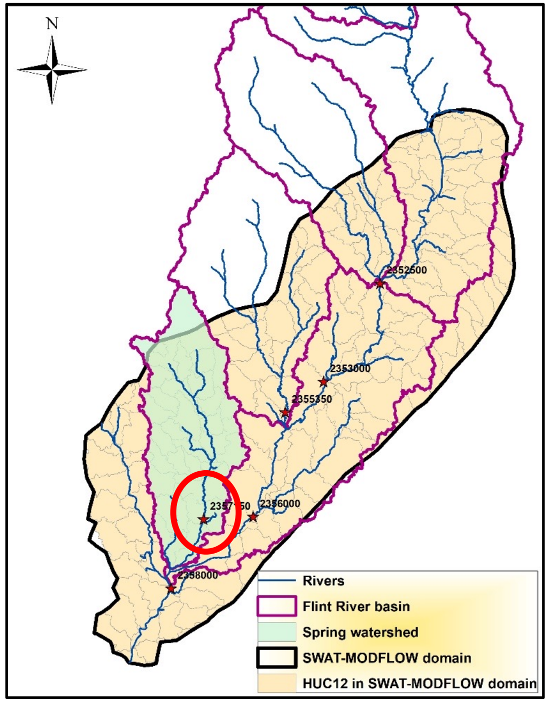
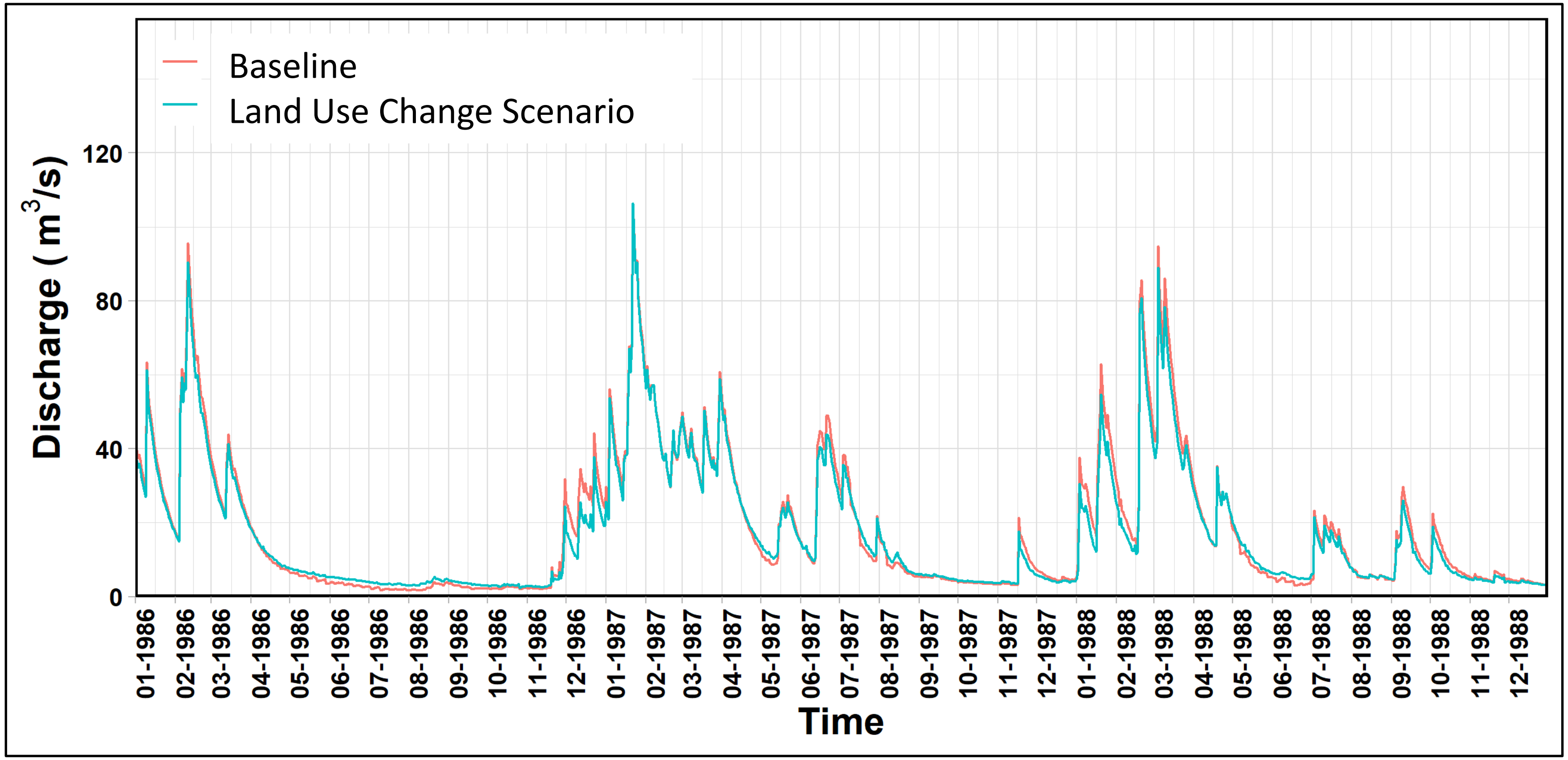
Land use change scenario: Streamflow

Scenario 3



USGS 2357150 – Spring Creek, 1986-1988



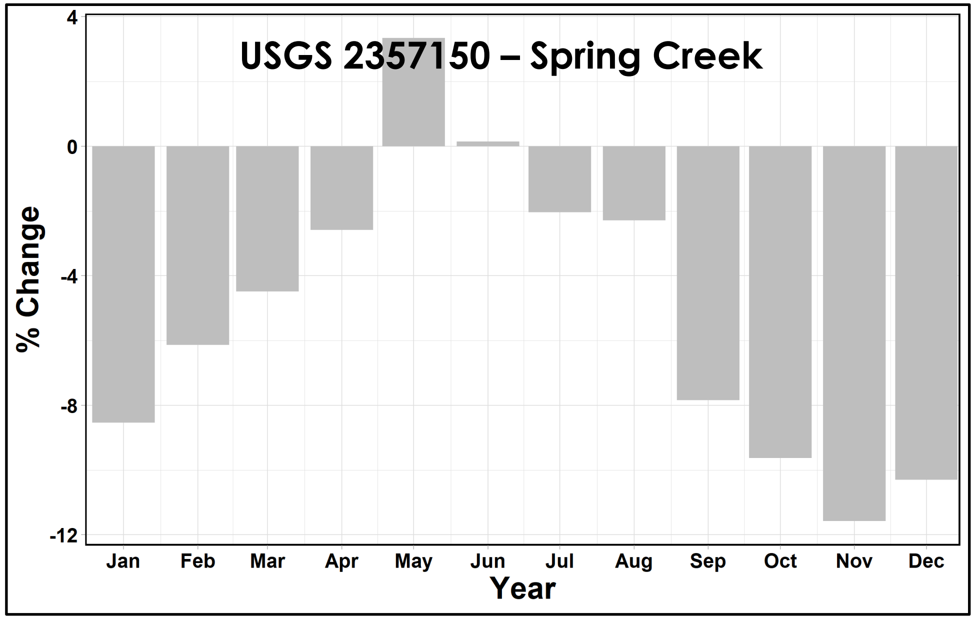
For the land use change scenario:

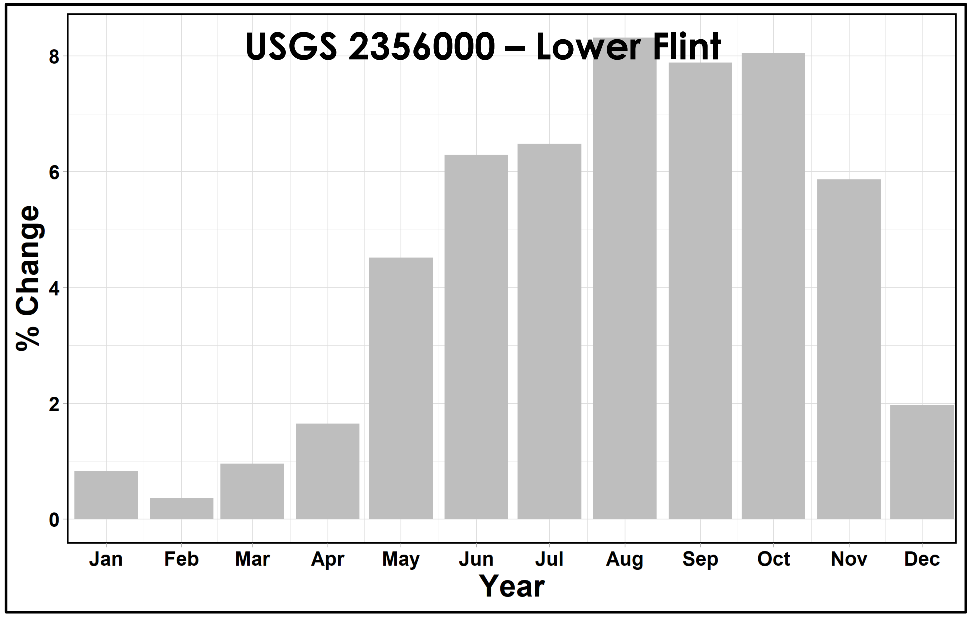
- Low flows are consistently higher than baseline scenario.
- Peak flows are lower.
- Similar results observed for Ichawaynochaway Creek.

Land Use Change Scenario: Streamflow Impact

Scenario 3

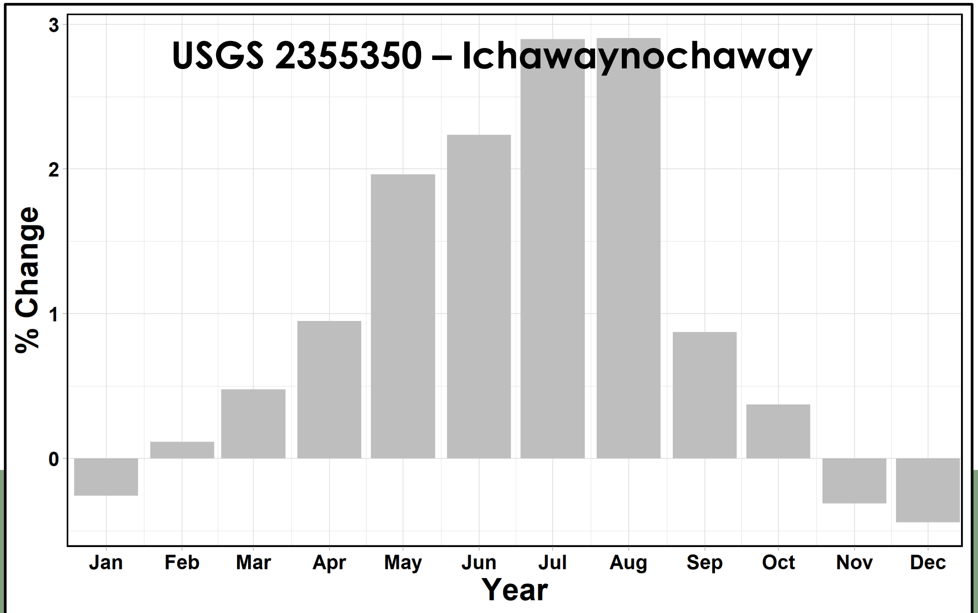
Change in monthly mean flows due to land use change compared to current conditions





Changes in monthly streamflow varied by location

- Spring Creek Increased flows in May and June but decreased flows in other months
- Ichawaynochaway Increased flows in all months of the year
- Lower Flint mainstem Increased flows for February through October and decreased in other months



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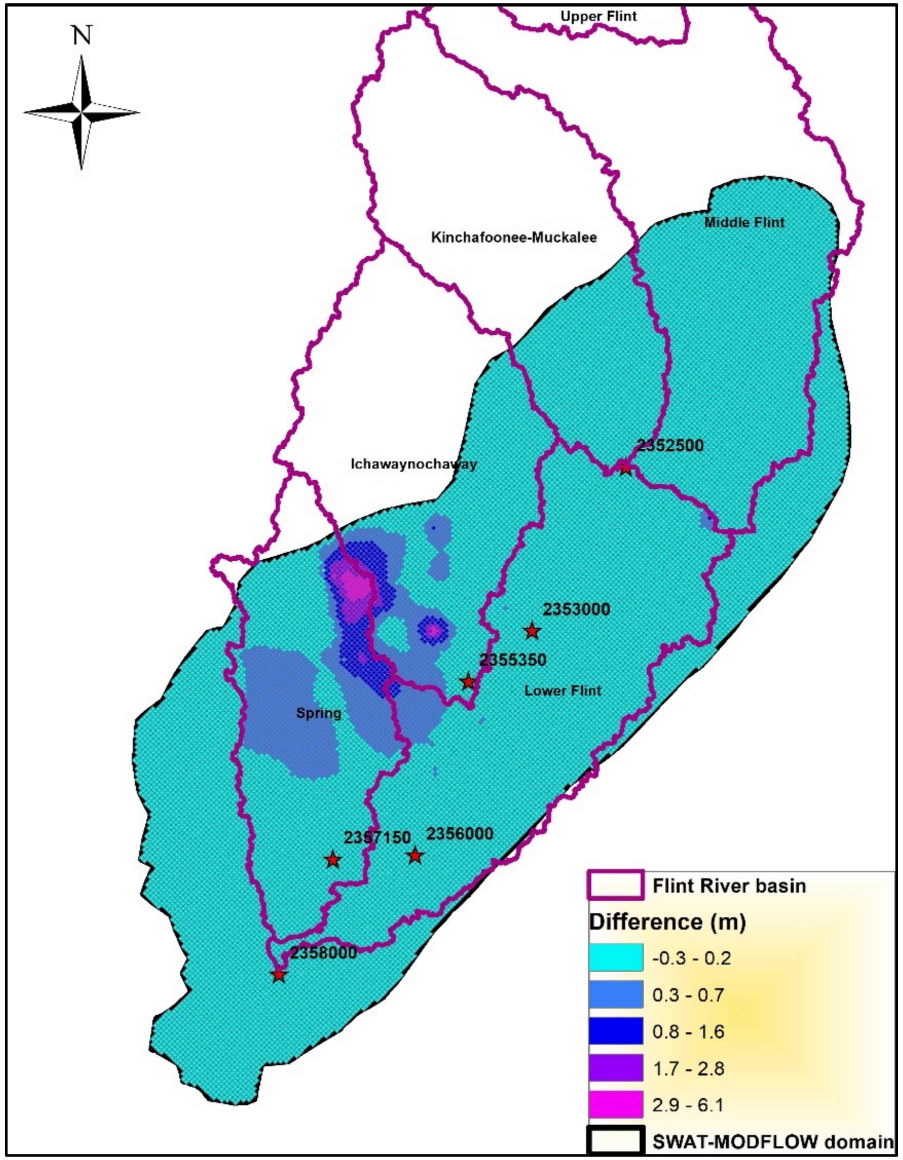
Land Use Change Scenario: Impact on groundwater levels

Scenario 3

Change in Groundwater Levels (average)



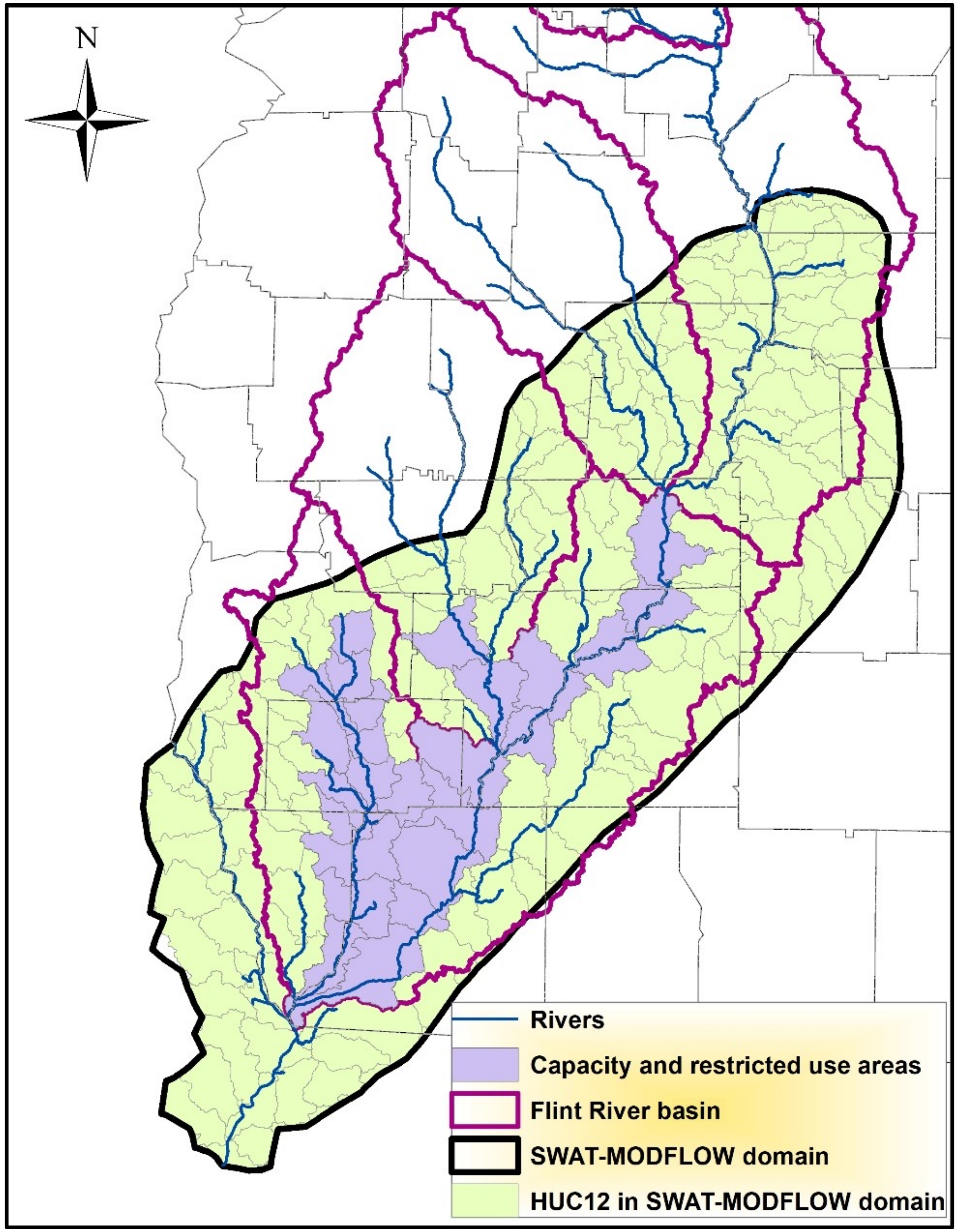
Increase in average annual groundwater level was observed in parts of Spring and Ichawaynochaway watersheds.

Voluntary Irrigation Suspension Scenario

Scenario 4

Pay incentives to farmers in Capacity and Restricted Use Areas to suspend use of the aquifer in drought years

Reduced irrigated crop acreage during drought years from 799,508 acres to 568,860 acres



For this scenario, irrigation was suspended in these areas in the following years:

1986
2000
2002
2006
2007
2011
2012

Voluntary Irrigation Suspension Scenario

Results were very similar to the Land Use Change Scenario

Streamflow impacts

- Impacts were observed only during drought years
- In drought years, low flows increased. The impact on low flows was similar to that observed for the Land Use Change Scenario.
- Overall, mean flows in Spring Creek and Ichawaynochaway Creek increased by 2% and 0.5% in the Flint River mainstem.

Groundwater levels

- Similar increases observed to those seen for the Land Use Change Scenario (in drought years).

Economic Results

Land Use Change Scenario 3

- Significantly decreases agriculture while increasing timber production
- May significantly harm the regional economy
- Losses of approximately $450 M in sales revenues, $160 M in wages, profits, and taxes and almost 3,000 jobs
- Positive effects in forestry production do not compensate for the decline in agriculture and in the overall economy

Voluntary Irrigation Suspension (drought years) Scenario 4

- Some negative impacts in agricultural industries.
- Losses of $6.4 M in corn production and around $2 M in the cotton and peanut production.

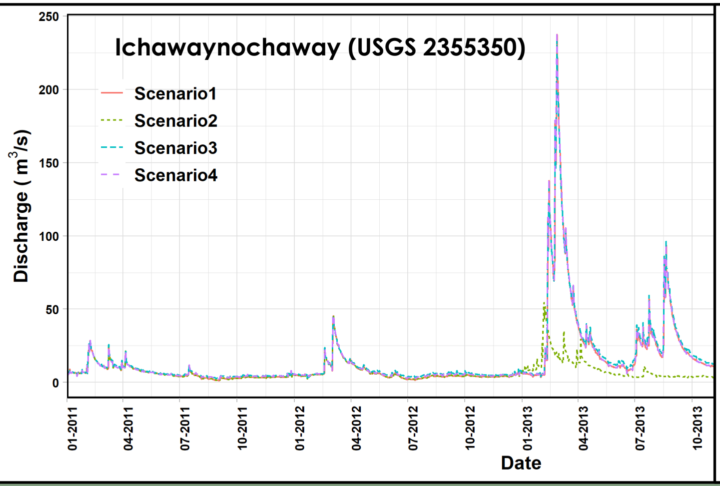
What's Next? More Scenarios

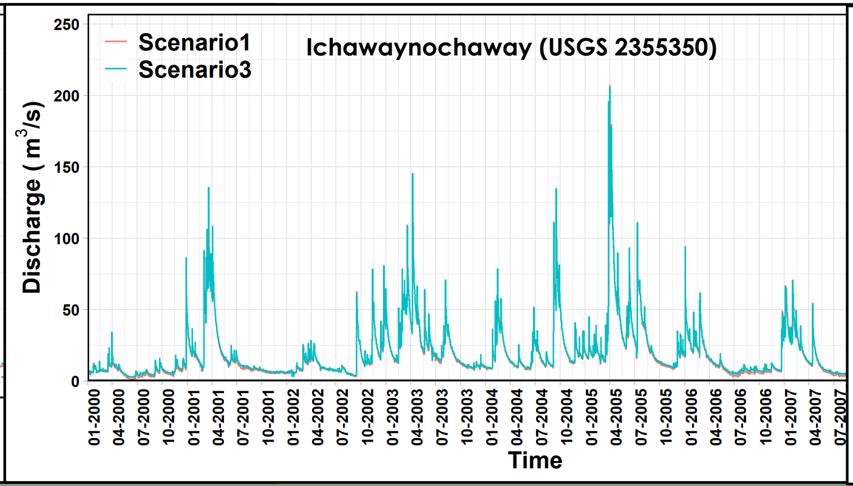
- Restoration longleaf pine
- Solar farms

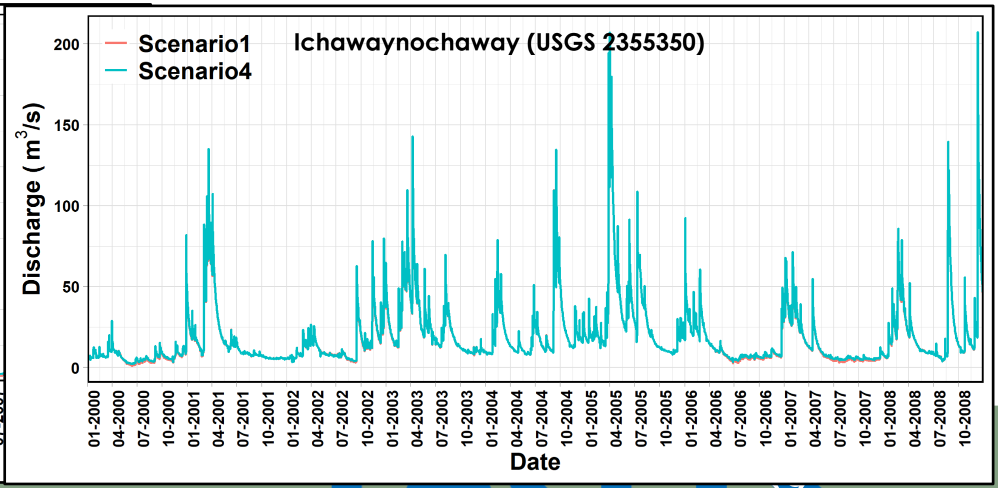
What if….?

Streamflow comparison across all scenarios

	Description	Streamflow impacts
Scenario 1 (Current/baseline conditions)	MS2 Simple Scenario (row crops and forests) with historical climate data	
Scenario 2 (Multi-Year Drought)	Multi-Year Drought applied to MS2 Simple Scenario	• **Reduction in streamflow** – comparable to levels of 2011 and 2012 • **Streamflow recovery would take multiple years**
Scenario 3 (Land Use Change)	Remove irrigated agriculture (source: Upper Floridan) from Capacity and Restricted Use Areas (identified by GAEPD) – Assume converted areas are loblolly MS2 forestry	• Annual irrigation reduction by an average of 26%. • Increase in streamflow **(biggest among the three scenarios) – mostly during drought periods.** • **Mean daily flow increased in the Ichawaynochaway and Lower Flint (8% and 2% respectively) but reduced by 0.5% in the Spring watershed** • **Possible reduction in peak flows during high flow periods.** • **Ichawaynochaway showed a more consistent increase in low flows** than spring watershed.
Scenario 4 (Drought Year Irrigation Suspension)	Suspend irrigation in Capacity and Restricted Use Areas for Floridan Aquifer withdrawals (full season) in drought years.	• Annual irrigation reduction by an average of 21%. • **Streamflow increase was observed only during drought years** (low flow periods) of irrigation suspension. • **No reduction in peak flow.** • Mean daily flow increased by 2%, 2%, and 0.5%, respectively (Spring, Ichawaynochaway, and Lower Flint).

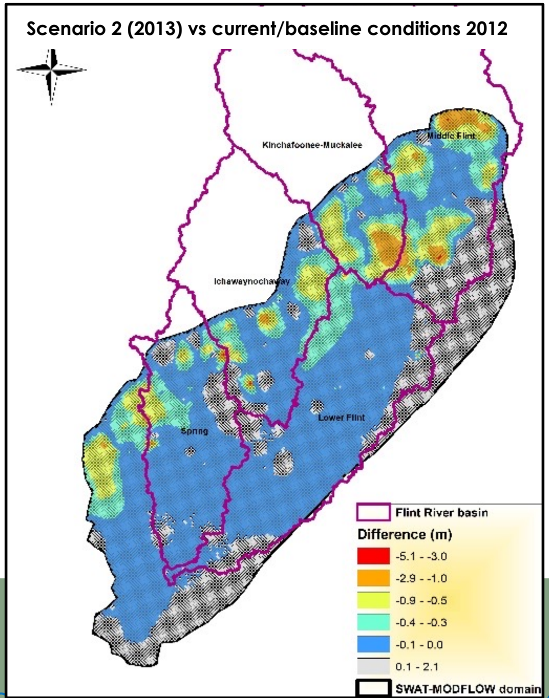


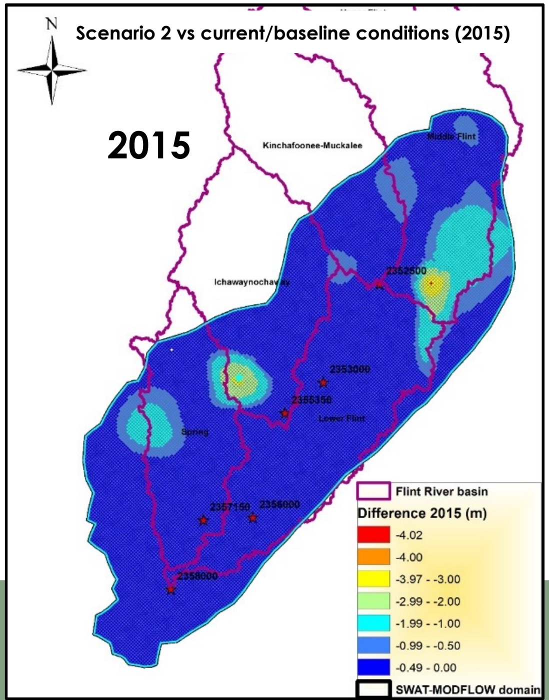


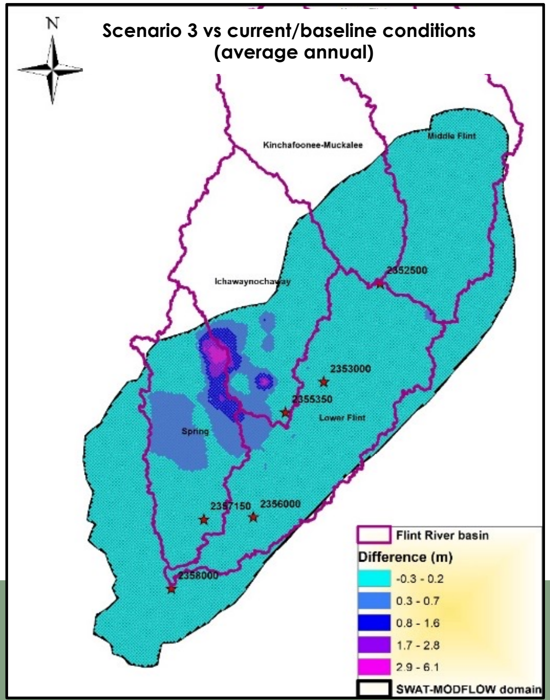


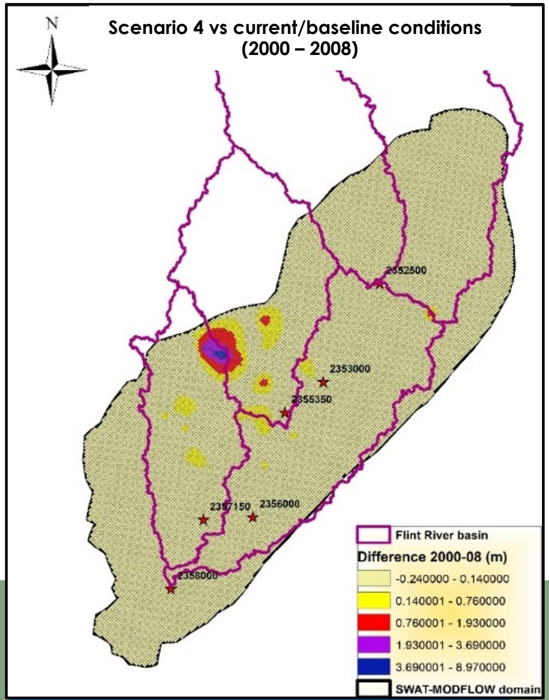
GW level comparison across all scenarios

	Description	Groundwater level impacts
Scenario 1 (Current conditions)	MS2 Simple Scenario (row crops and forests) with historical climate data	
Scenario 2 (Multi-Year Drought)	Multi-Year Drought applied to MS2 Simple Scenario	• **Reduction in GW levels by close to 3 m** in the north-western end of the aquifer when compared to 2012 levels. • **Most reduction in the Kinchafoonee and Middle-Flint watersheds.** • GW levels rebound to current/baseline condition levels would not occur till 2015.
Scenario 3 (Land Use Change)	Remove irrigated agriculture (source: Upper Floridan) from Capacity and Restricted Use Areas (identified by GAEPD) – Assume converted areas are loblolly MS2 forestry	• **Average annual increase in GW levels was observed in parts of the Spring and Ichawaynochaway watershed.** • GW level **increase was less than 1 m in most of the sensitive region**.
Scenario 4 (Drought Year Irrigation Suspension)	Suspend irrigation in Capacity and Restricted Use Areas for Floridan Aquifer withdrawals (full season) in drought years.	• **Increase in GW level was similar in space and magnitude as observed under Scenario 3** during the drought years when irrigation was suspended.









PROJECT ADVISORY COMMITTEE (PAC)

Del Bottcher, President, Soil & Water Engineering Technology
Casey Cox, Longleaf Ridge Farms
Tommy Dollar, CEO, Dollar Farm Products
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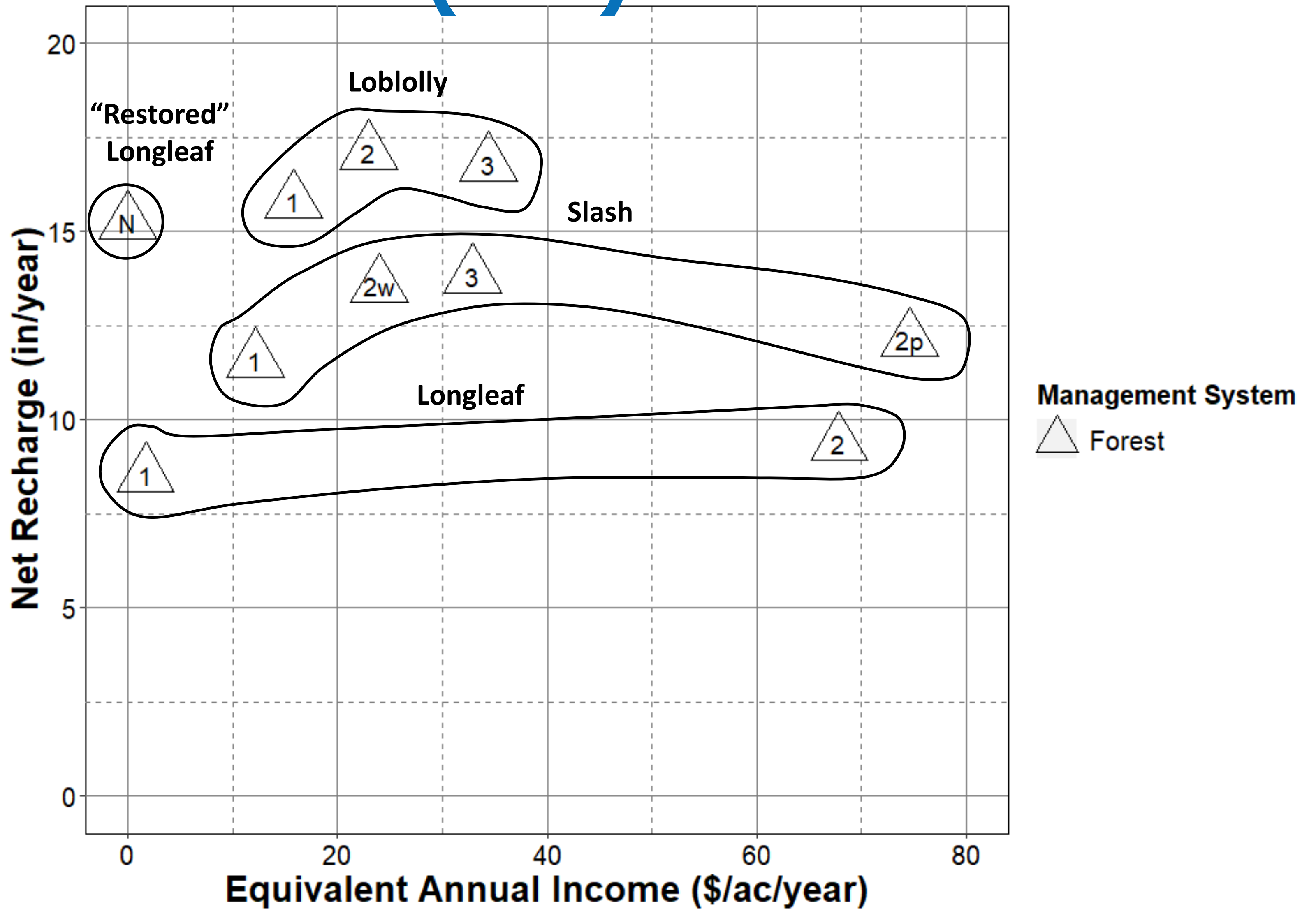
Michael Roth, President, Our Santa Fe River, Inc.
Scott Thackston, Forester, Georgia Forestry Commission
Hugh Thomas, Executive Director, Suwannee River Water Management District

Regional Model: Simple scenarios

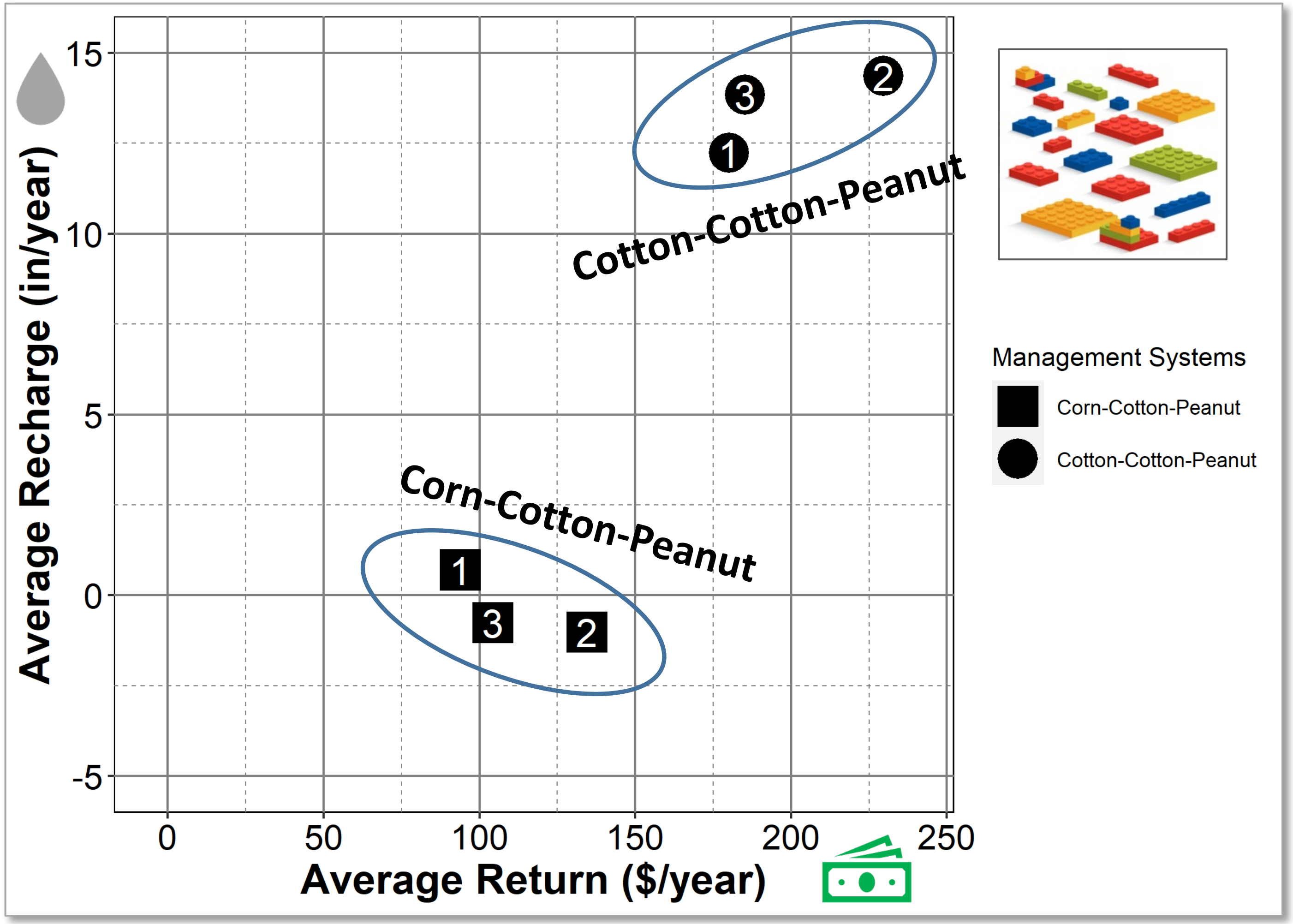
Scenario	Management Systems
<u>All Ag MS1</u> **Row crops:** corn-cotton-peanut cotton-cotton-peanut **Forest:** Loblolly	All row crops use MS1, Forests MS1
<u>All Ag MS2</u> **Row crops:** corn-cotton-peanut cotton-cotton-peanut **Forest:** Loblolly	All row crops use MS2, Forests MS1
<u>All Ag MS3</u> **Row crops:** corn-cotton-peanut cotton-cotton-peanut **Forest:** Loblolly	All row crops use MS3, Forests MS1

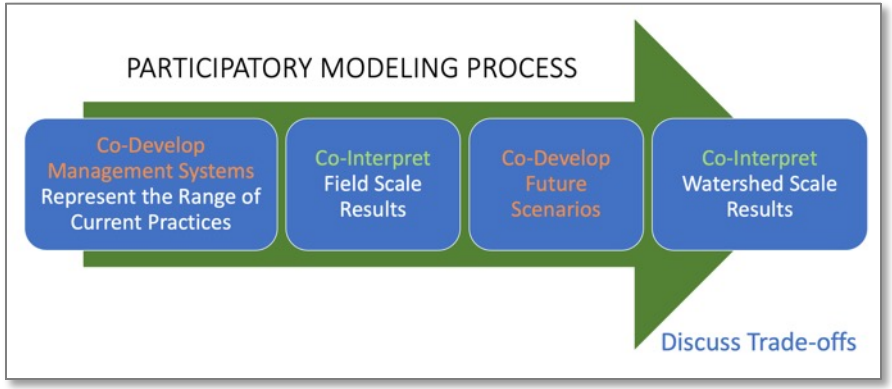
GEORGIA

Regional Modeling Results – Tradeoffs (GA)



Field-Scale Results: Georgia





Georgia focused on:

Net Recharge

Net Returns

More Inputs

MS1: Most efficient irrigation, lowest N rate, cover crop, strip till

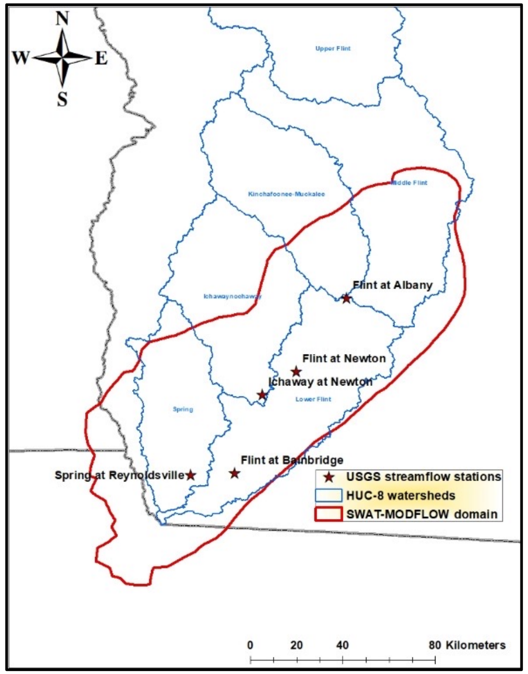
MS2: Efficient irrigation, medium N rate, no cover crop, conventional till

MS3: Least efficient irrigation, highest N rate, no cover crop, conventional till

FACETS

Floridan Aquifer Collaborative Engagement for Sustainability

Scenarios Focused on Ag Practices
(high, moderate, low levels of management & efficiency)



Net recharge of the aquifer

- Minimal differences (MS1, MS2, MS3), especially when evaluated for the whole basin

Groundwater levels

- Minimal difference between MS2 and MS3
- Comparison of scenarios identified critical areas

Streamflow

- All management approaches had minimal impact on the Flint River mainstem
- Impact on streamflow was significant during drought years in the two tributary streams.

Economics

- Negative impact on economic variables (state and local taxes, gross regional product/value-added, employment) as practices shift from MS3 to MS1

Management System	Efficiency & Environmental Management
MS1	Highest
MS2	Moderate
MS3	Lowest