

ENVIROATLAS USE CASE Evaluating Potential for Water Transfer Markets in the US Southeast

March 2019



- 1. Introduction**
- 2. Methodology**
- 3. Potential Drought Impacts on Agriculture**
- 4. Potential Motivators for Trading**
- 5. Results**
- 6. Learn More**

Introduction

Every few years, the Southeast US experiences a major drought – the most recent occurring in 2016, when soil moisture reached the 2nd lowest ever recorded between October to November.¹ During these times, the increased frequency of above-normal temperatures and below-normal rainfall during the growing season can result in major agricultural impacts, including:

- row-crop losses (e.g. corn, soybeans);
- severe pasture stress;
- supplemental feeding requirements for livestock;
- surface water shortages in ponds and streams; and
- increased risk of wildfire.

Water transfer markets provide a way for various water users to buy and sell their use rights to water, creating a market-based system for water use. At least a dozen countries have water rights systems in place to manage allocation and allow trading of those rights. Most trading takes place between agricultural producers or as agriculture-to-urban transfers. But rights can also be purchased or leased and dedicated to environmental use, known as “instream buybacks.”

Developing water transfer markets to minimize the impact of localized drought on the agricultural community has been widely discussed, but additional supporting information about where to promote the development of water transfer markets is needed.

¹ <https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2017JD027523>

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Methodology

This use case explores a method for evaluating potential for agricultural water transfer markets in the US Southeast (Alabama, Georgia, Florida, North Carolina, and South Carolina).

Regions with high vulnerability of agriculture to drought and high demand from different water users are places where we should look more closely at for developing water transfer markets. In our model, we would expect to see potential for water transfer markets to be particularly useful in mitigating drought under the following conditions:

- **Potential Drought Impacts on Agriculture:** Current crop and soil moisture conditions are likely to impact agricultural productivity.
- **Potential Motivators for Trading:** Agricultural water use and pricing, the presence of multiple water users in the watershed, and the presence of major urban areas or endangered aquatic species can all influence demand for water.

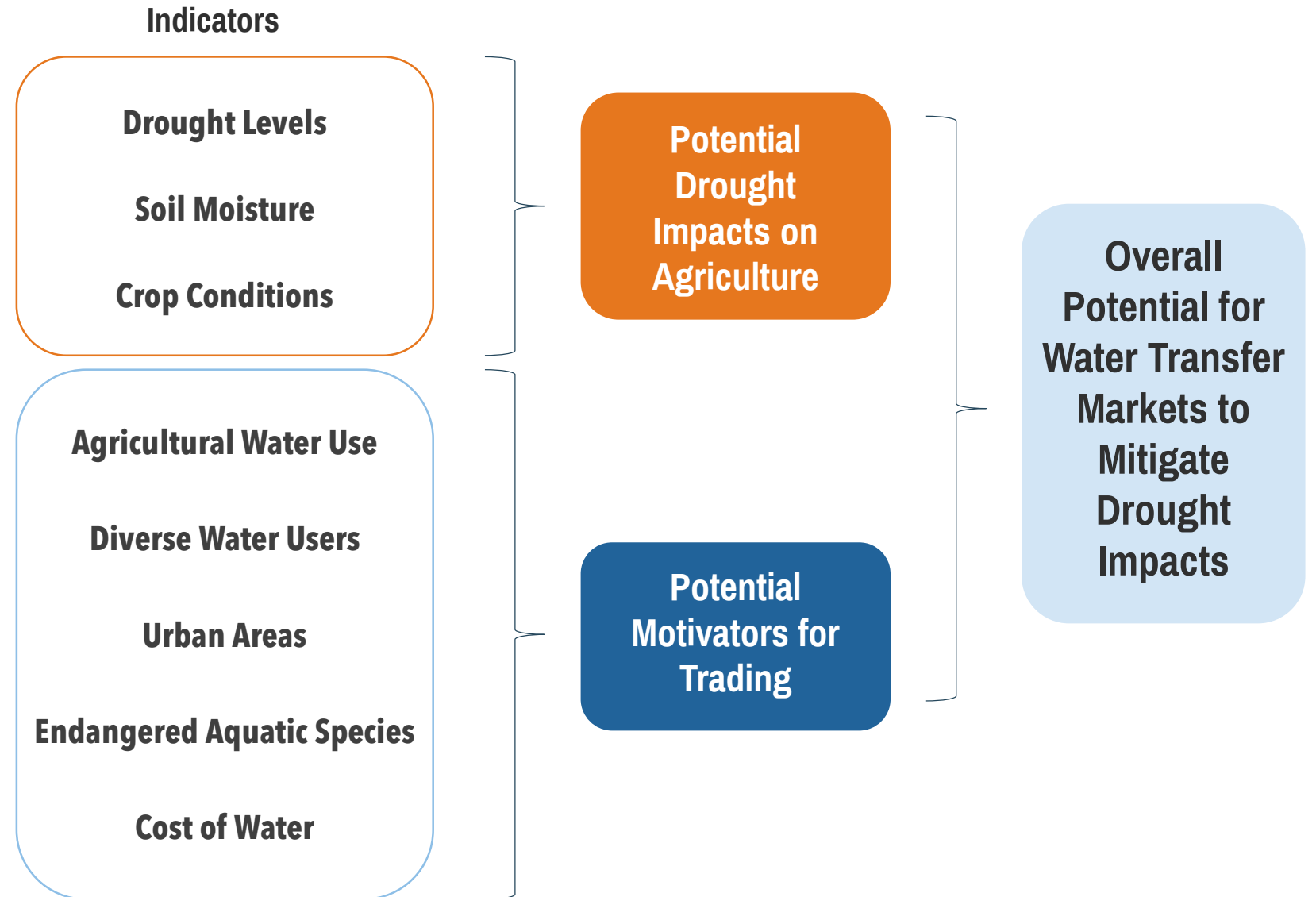
Summary of Sub-indices, Datasets, and Data Sources

Index	Datasets	Data source
Potential Drought Impacts on Agriculture <i>A high score for this index suggests a high potential for drought to impact agricultural productivity.</i>	Drought levels	US Drought Monitor
	Soil moisture	NASA GRACE
	Crop conditions	USDA NASS Crop Conditions and Progress
Potential Motivators for Training <i>A high score for this index indicates many competing water uses in a basin, suggesting greater benefits to be obtained from trading.</i>	Agricultural Water Use	EnviroAtlas
	Diverse Water Users	EnviroAtlas
	Urban Areas	US Geological Service
	Endangered Aquatic Species	US Fish and Wildlife Service
	Cost of Water for Agricultural Users	USDA NASS - Census of Agriculture - 2013 Farm and Ranch Irrigation Survey

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Our Analytical Workflow



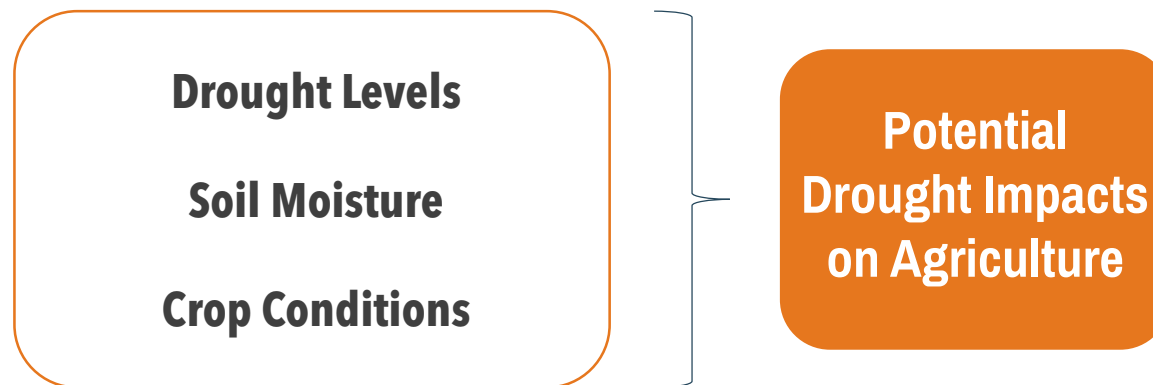
Potential Drought Impacts on Agriculture

Potential Drought Impacts on Agriculture

The first sub-index developed was for the potential impact of drought on agriculture.

We looked at the following indicators:

1. Drought levels, itself a composite indicator reflecting the number of nonconsecutive weeks in drought at level D2 (as defined by the US Drought Monitor) or higher, by county, for the period 2014-2018.
2. Soil moisture, in terms of root zone soil moisture by percentile, October 2018*
3. Crop conditions, in terms of cotton crop conditions ratings as of October 2018*



1. Introduction
2. Methodology
3. **Potential Drought Impacts on Agriculture**
4. Potential Motivators for Trading
5. Results
6. Learn More

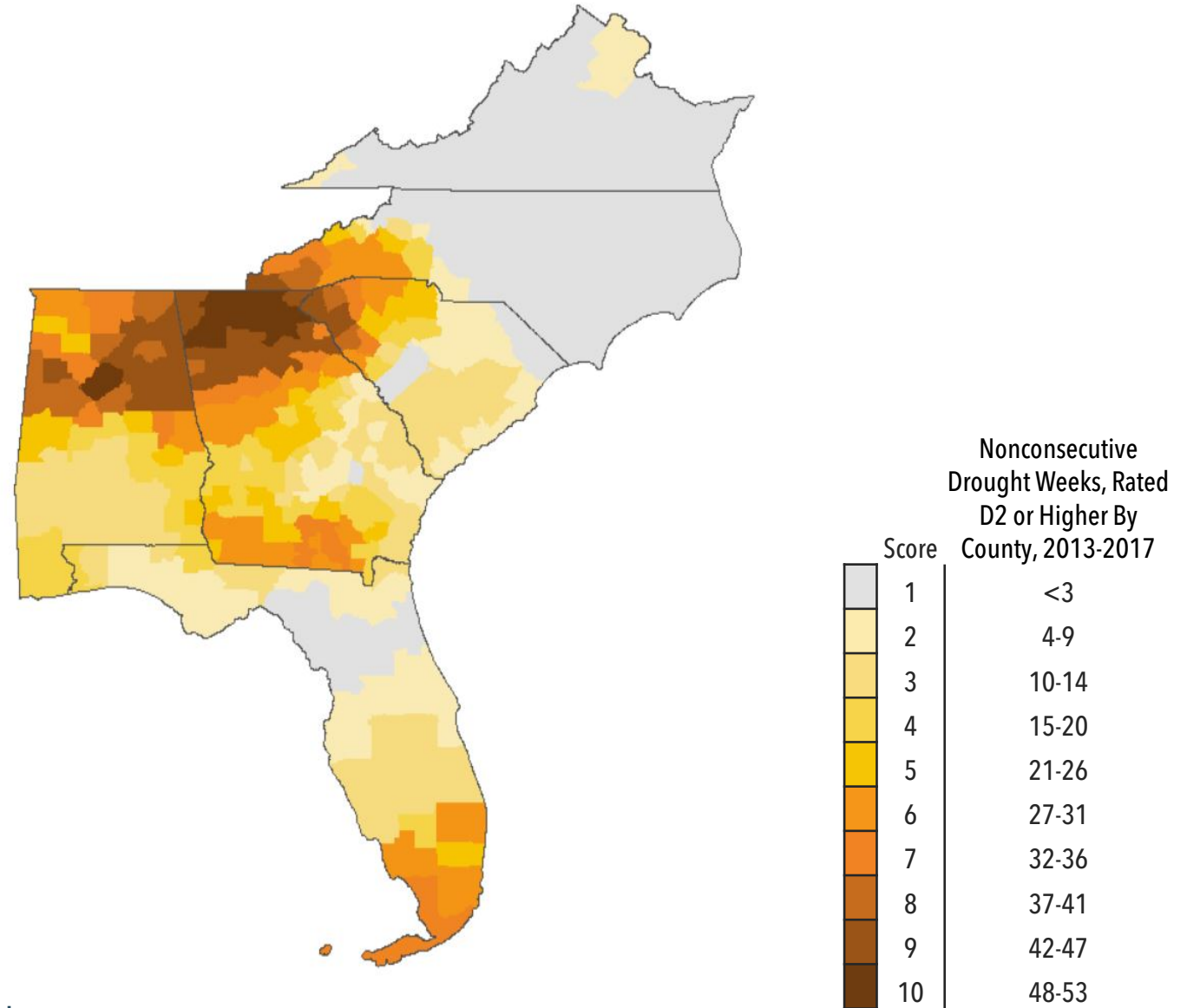
*For the purposes of this study, we use October of 2018 as the time period for analysis. It is an important month for harvest, and the month with the most recent comprehensive data available at the time of this writing. However, we would expect the data to change significantly during drought years.

ENVIROATLAS USE CASE

Note: In this analysis, we make the assumption that nonconsecutive weeks of drought will have a linear impact on agriculture. We only collected data around D2 ("severe drought") levels; assuming that moderate (D1) or moderately dry (D0) conditions would not affect agricultural production.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More

Drought Levels, by County



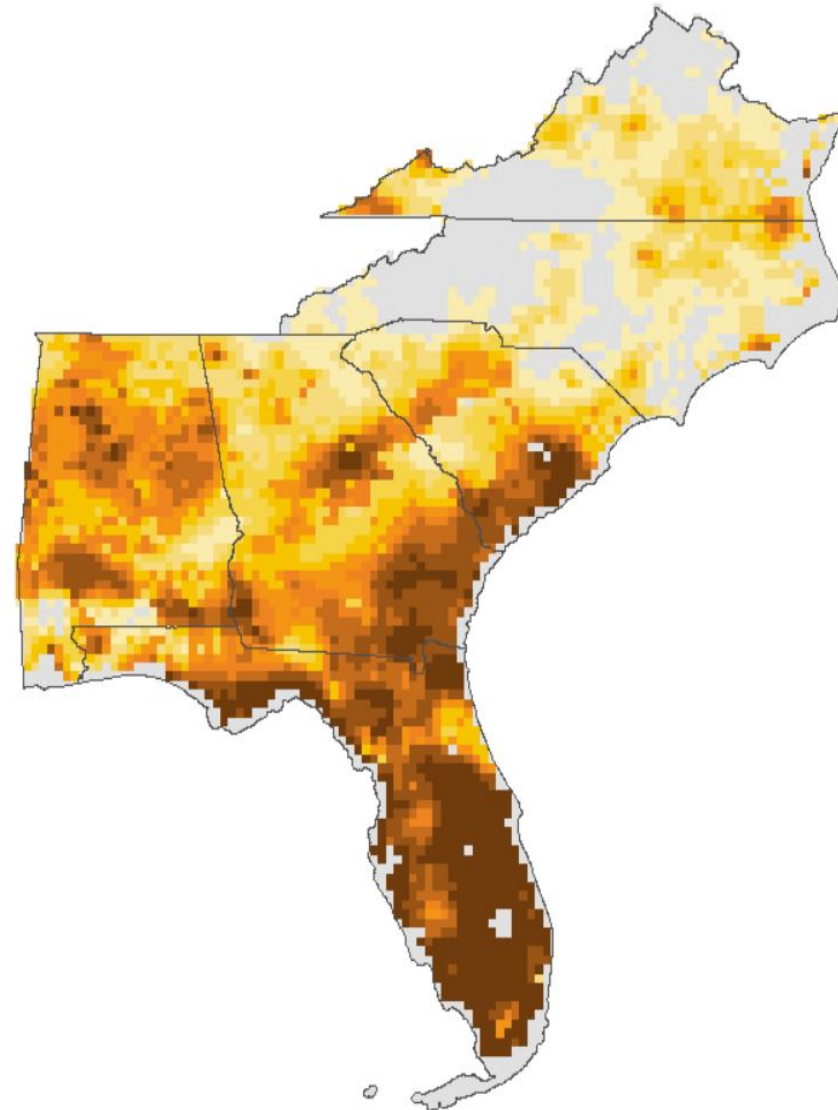
Data source: [US Drought Monitor](#)

ENVIROATLAS USE CASE

Soil Moisture

Note: Data provided by NASA's Gravity Recovery and Climate Experiment (GRACE) satellites. The satellites' spatial resolution, >150,000 km², is combined with additional precipitation, solar radiation and other data to increase the resolution of soil moisture and groundwater storage seen in the map here.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More



Score	Root Zone Soil Moisture, Percentile
1	92.68 - 100
2	84.70-92.68
3	76.14-84.70
4	66.79-76.14
5	56.65-66.79
6	46.43-56.65
7	35.34-46.43
8	22.98-35.34
9	10.53-22.98
10	0.099-10.53

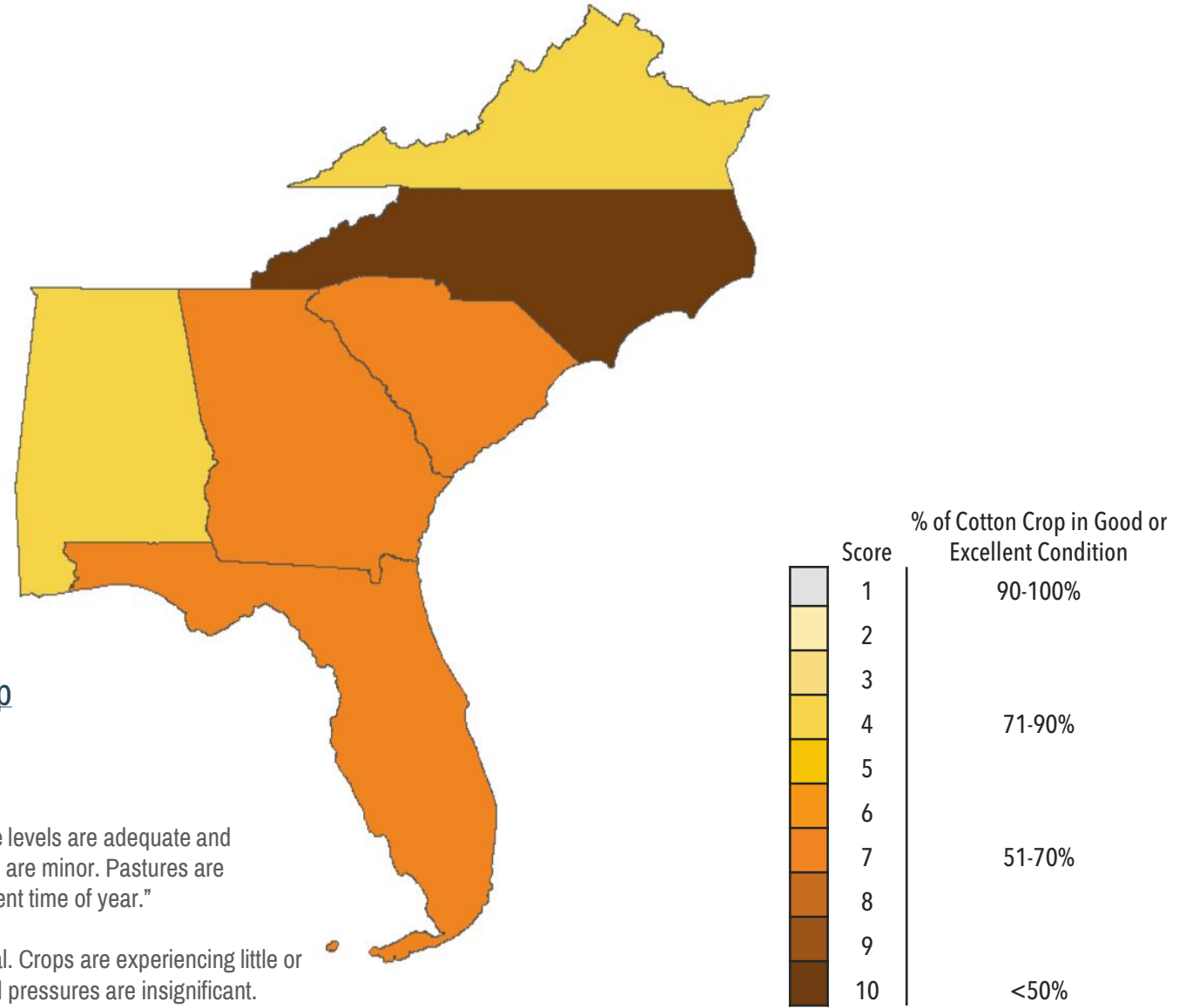
Data source: NASA GRACE

ENVIROATLAS USE CASE

Note: The USDA NASS dataset provides crop conditions for specific crops on a monthly basis. We have presented the data for cotton here, as it was the most up-to-date crop data available for the SE US. Future studies could examine other crops, emphasizing those with a reliance on irrigation and at a more-detailed spatial level.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More

Crop Conditions



Data source: [USDA NASS Crop Conditions and Progress](#)

Definitions:

Good – “Yield prospects are normal. Moisture levels are adequate and disease, insect damage, and weed pressures are minor. Pastures are providing adequate feed supplies for the current time of year.”

Excellent – “Yield prospects are above normal. Crops are experiencing little or no stress. Disease, insect damage, and weed pressures are insignificant. Pastures are supplying feed in excess of what is normally expected at the current time of year.”

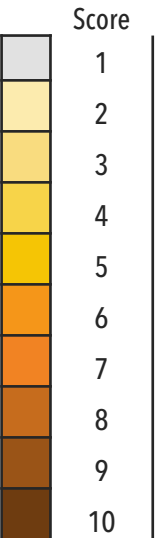
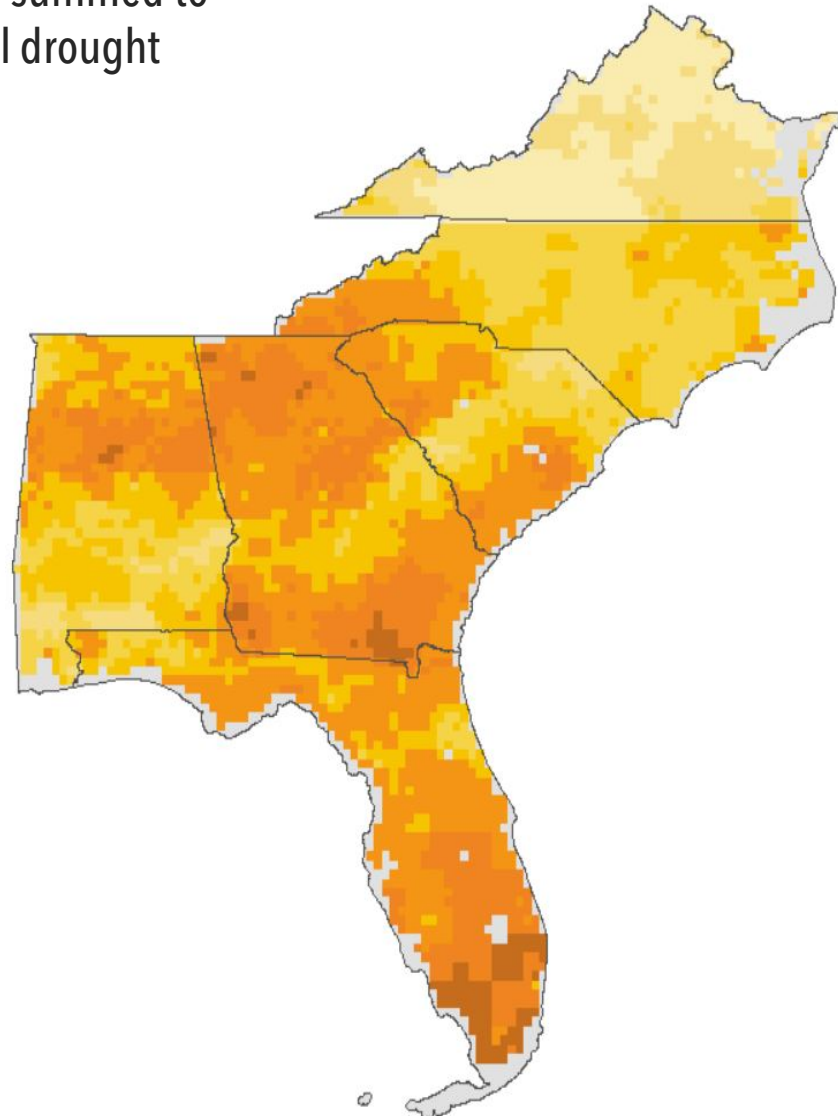
ENVIROATLAS USE CASE

Note: Because most of the raster data collected is at the state or county scale, the findings would improve with more detailed on-the-ground data.

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Potential Drought Impacts on Agriculture in the Absence of Irrigation: Combined Score

Scores for each indicator were summed to generate an index of potential drought impacts on agriculture.



Potential Motivators for Trading

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Potential Motivators for Trading

Many areas within the Southeastern US are home to competing water users such as cities (for drinking water), agriculture (for irrigation water), and natural environments (for recreational water use and species habitat). In cases where there is not enough water available, or water is inefficiently managed, water transfer markets can help ease the cost and quantity of water available to these various users.

What determines an ideal site for water transfer markets? We developed a sub-index of potential motivators for trading, summarizing scores for the following indicators:

1. **Agricultural Water Use:** areas with higher water use (in terms of gallons of water) are more likely to experience supply constraints.
2. **Cost of Water for Agricultural Users:** a low cost of agricultural water can lead to overuse and low supply
3. **Diverse Water Users:** If users don't communicate with each other, there could be inefficient use of available water
4. **Urban Areas:** Highly-concentrated or growing urban areas means a strong water user competitor to agricultural water users (see #3).
5. **Endangered Aquatic Species:** The presence of endangered aquatic species also represents the presence of a strong competing water user (see #3).



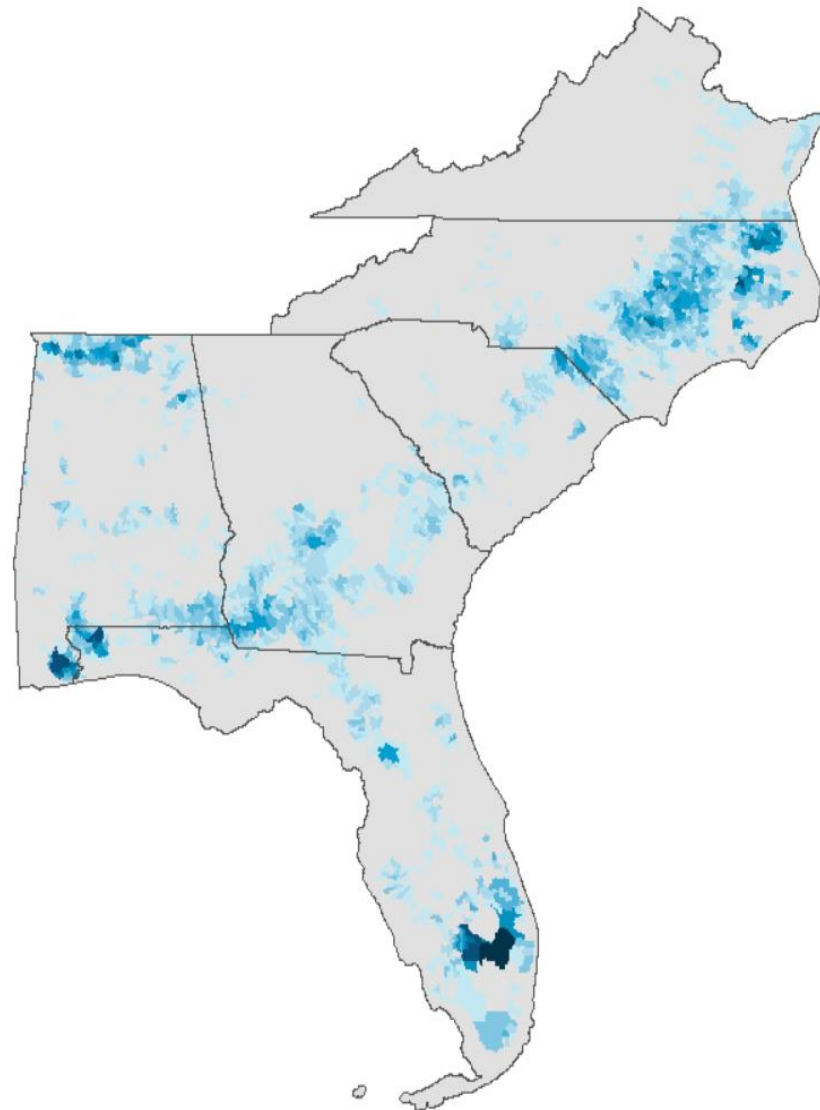
Potential
Motivators for
Trading

ENVIROATLAS USE CASE

Agricultural Water Use

Note: This map estimates water use for agricultural irrigation, including estimates of self-supplied surface and groundwater, and water supplied by irrigation water providers. The data is provided at the HUC level.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More



Score	Gallons per Day per HUC 12
1	<274,386
2	274,387-909,600
3	909,601-1,853,378
4	1,853,379-3,210,036
5	3,210,037-4,921,948
6	4,921,949-7,214,306
7	7,214,307-10,077,302
8	10,077,303-14,937,739
9	14,937,740-48,892,680
10	>48,892,681

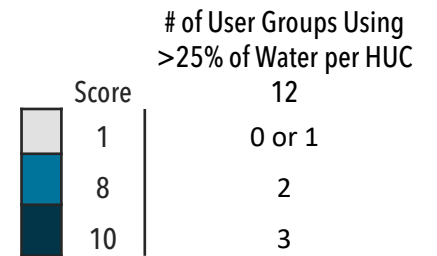
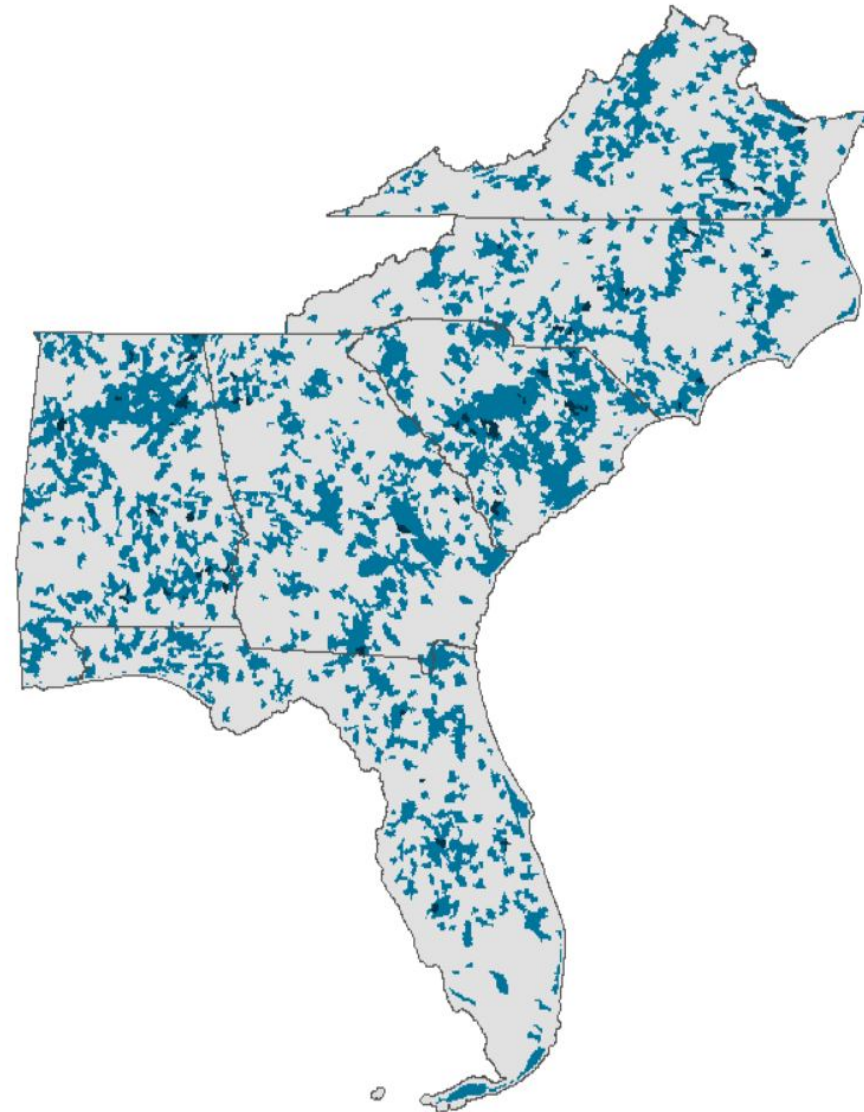
Data source: EnviroAtlas

ENVIROATLAS USE CASE

Multiple Major Water Users

Note: We combined three data layers from EnviroAtlas: daily agricultural water use, industrial water use, and thermoelectric water use. "High demand" for water was defined as 25% or more of water used in HUC12 by each of the user groups.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More



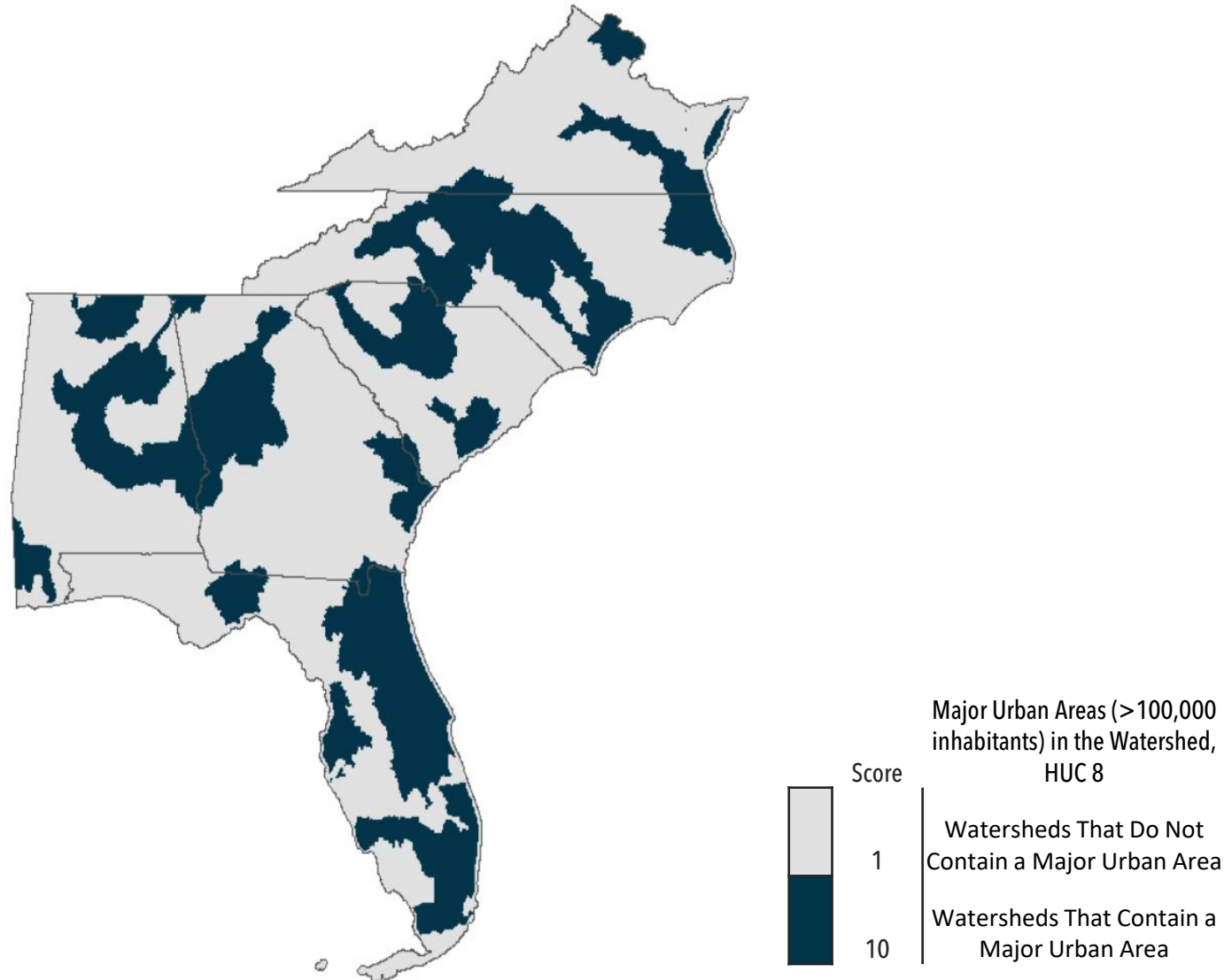
Data source: EnviroAtlas

ENVIROATLAS USE CASE

Note: We identified cities with populations of 100,000+ (defined as a "major urban area") and identified which HUC8 watersheds they are part of.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More

Major Urban Areas in the Watershed



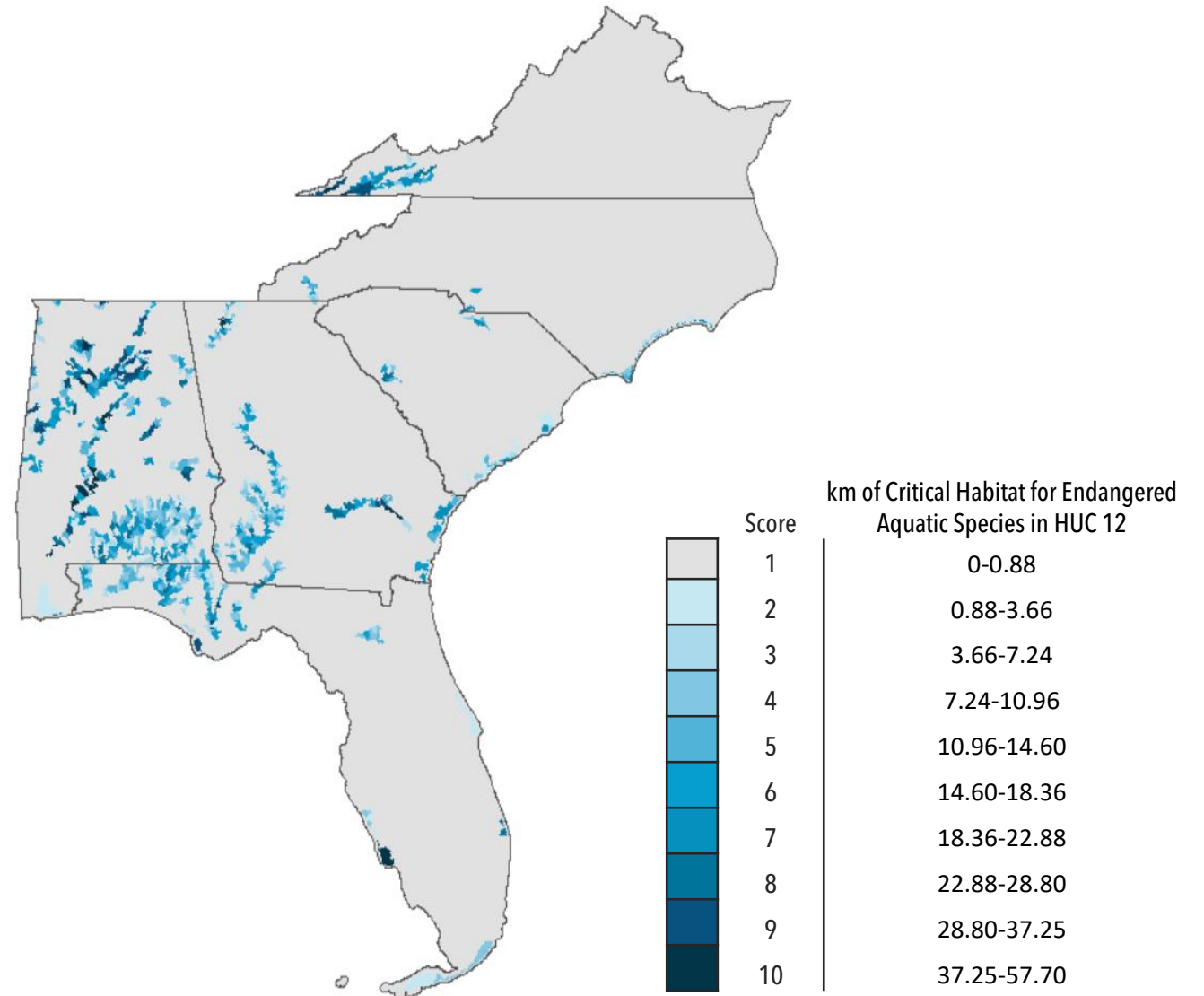
Data source: US Geological Service (Population)

ENVIROATLAS USE CASE

Note: In this analysis, we make the assumption that the presence of an endangered aquatic species represents a competing use of water, increasing the potential benefits of water transfer markets. However, readers should be aware that the presence of endangered aquatic species in some circumstances could be a *limiting* factor, if critical habitat area designations preclude the use of transfer markets driven by concerns about potential negative impacts on flows from trading.

- 1. Introduction
- 2. Methodology
- 3. Potential Drought Impacts on Agriculture
- 4. Potential Motivators for Trading
- 5. Results
- 6. Learn More

Critical Habitat for Aquatic Species in the Watershed



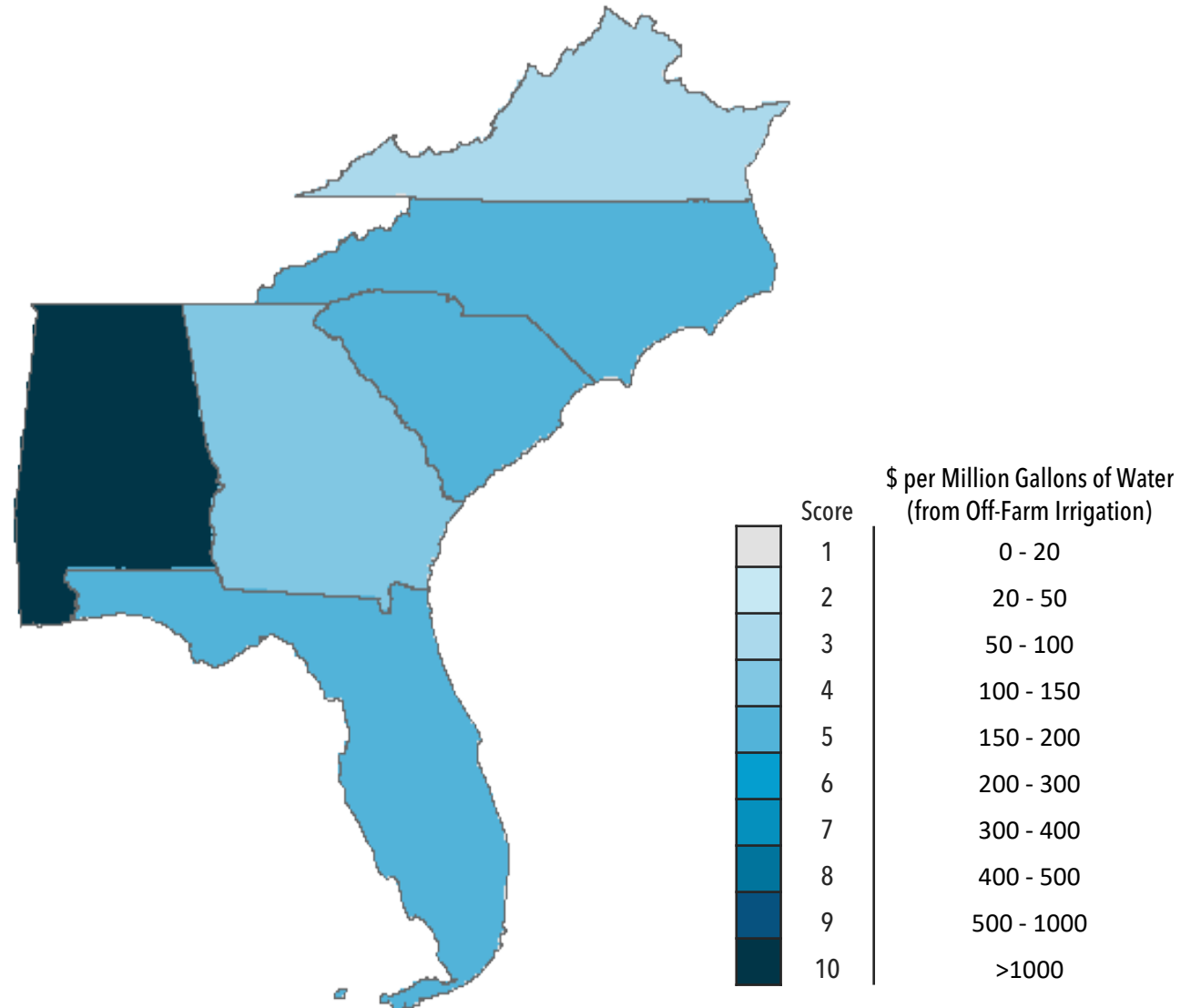
Data source: US Fish and Wildlife Service

ENVIROATLAS USE CASE

Note: We used USDA NASS data that collected the average cost per acre foot, by state. We then converted those volumes to a price per million gallons.

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

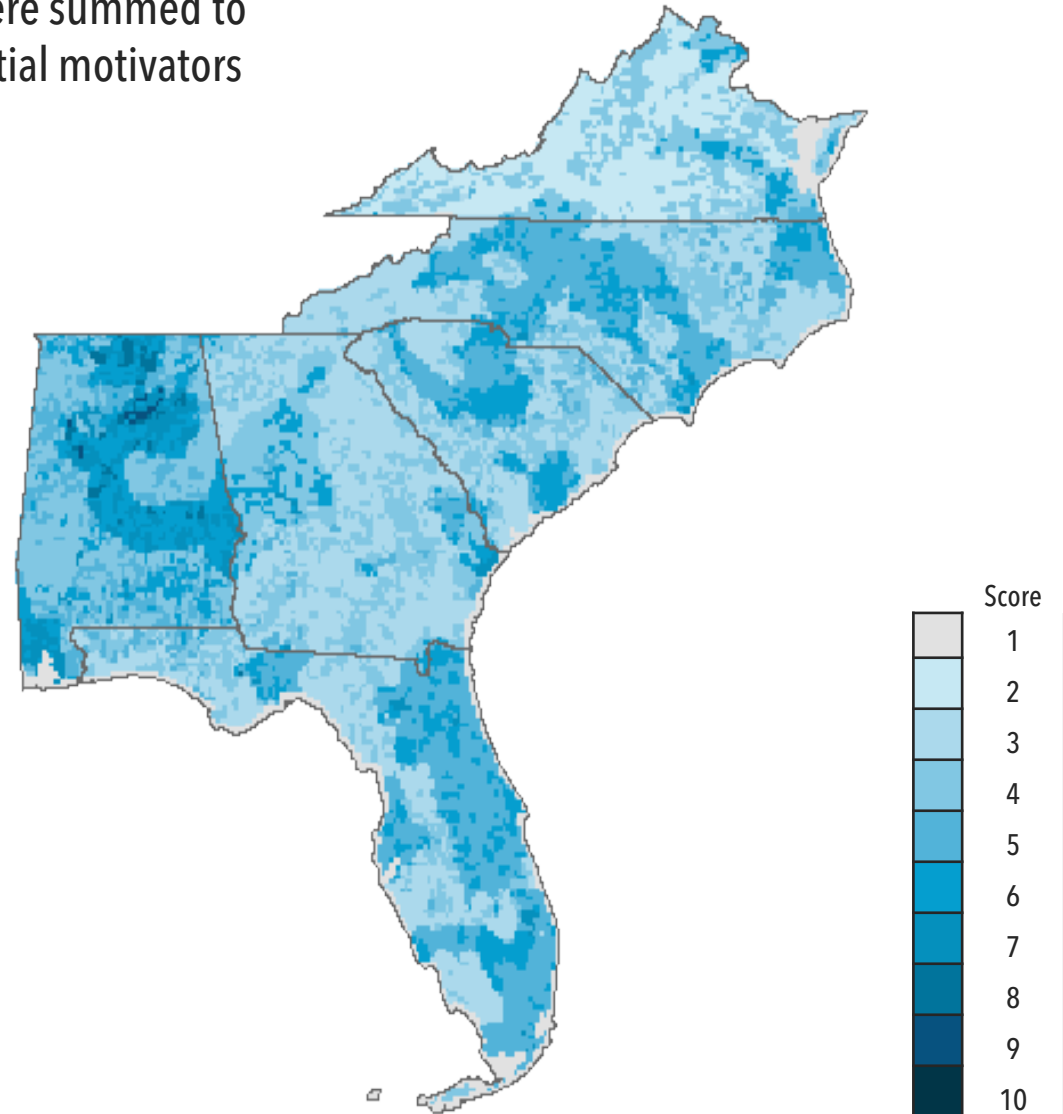
Cost of Water for Agricultural Users



Data source: USDA NASS - Census of Agriculture - 2013 Farm and Ranch Irrigation Survey - Expenses for Irrigation Water from Off-Farm Suppliers

Potential Motivators for Trading: Combined Score

Scores for each indicator were summed to generate an index of potential motivators for trading.



1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

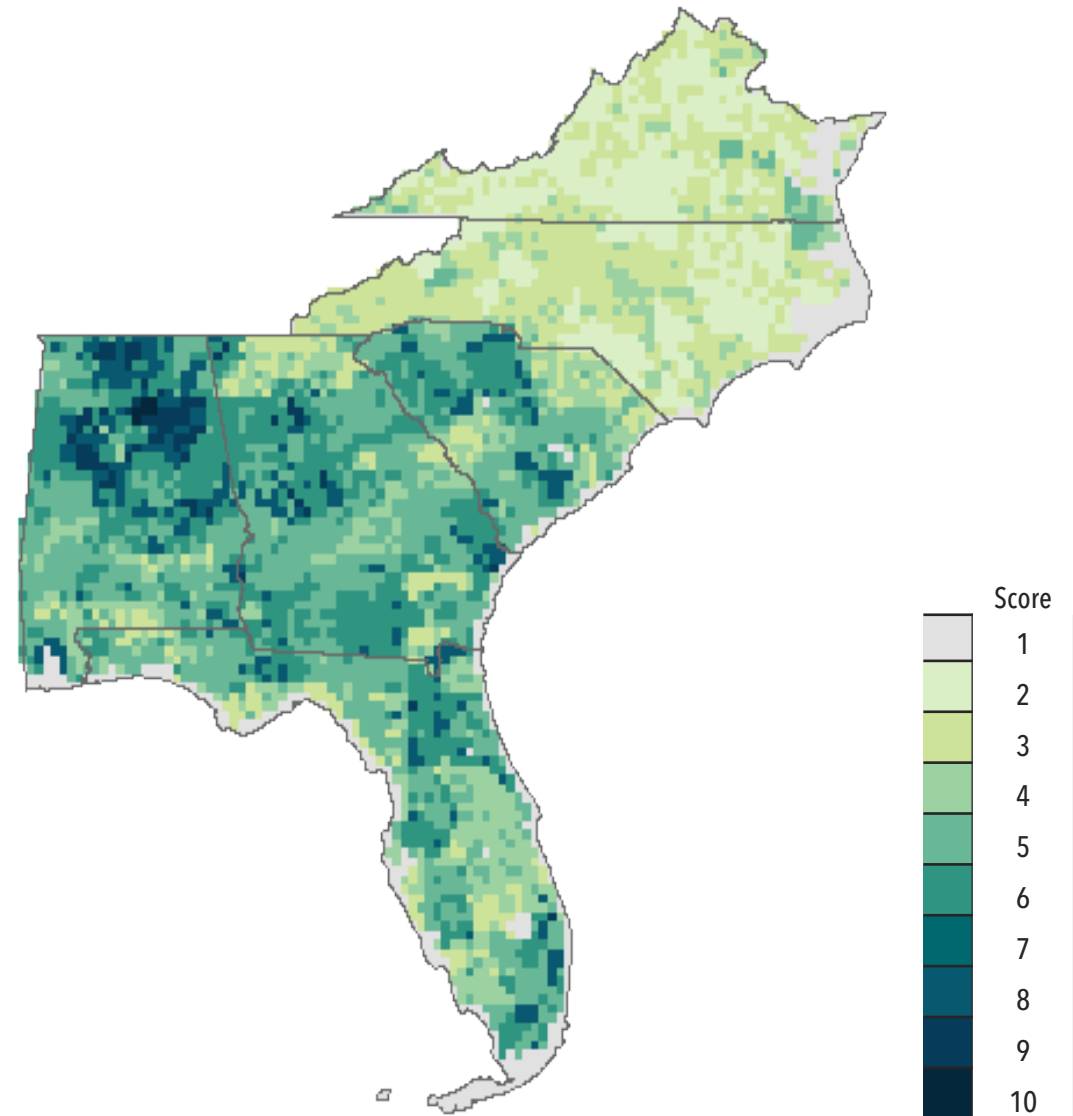
Results and Conclusions

ENVIROATLAS USE CASE

Note: Our analysis presents the potential need for water transfer markets. However, these markets can only exist in areas with irrigation infrastructure. Further analysis would be necessary to find the areas with the most potential for water transfer markets to mitigate drought impacts.

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Combined Score: Overall Need for Water Transfer Markets to Mitigate Drought Impacts



1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Summary

- Water transfer markets provide a way for various water users to buy and sell their use rights to water, helping to re-allocate water during times of drought to where it is most needed. Developing water transfer markets to minimize the impact of localized drought on the agricultural community has been widely discussed, but additional supporting information about where to promote the development of water transfer markets is needed.
- This use case provides a simple screening method to identify areas that could particularly gain from water transfer markets to mitigate impacts of drought, based on high vulnerability of agriculture to drought and the presence of many competing water users who may see benefits in selling water use rights to agricultural users during periods of drought. Two sub-indices were developed reflecting each of these conditions, which were normalized and combined to produce an overall composite score.
- Our results based on this preliminary analysis that potential benefits from water transfer markets for agricultural producers during periods of drought are particularly high in many areas in Florida, Georgia, and Alabama, as well as in parts of the Carolinas.
- Further analysis evaluating potential gains from trading would benefit from more fine-grained data on costs of agricultural water, and from the addition of data on price of water for other uses: industrial, urban, and non-consumptive (i.e., for minimum flows for habitat or recreation), which were unavailable at the time of this study. Further analysis would also benefit from the inclusion of data on conveyance of water, in order to quantify whether water can be moved to where it is needed.

1. Introduction
2. Methodology
3. Potential Drought Impacts on Agriculture
4. Potential Motivators for Trading
5. Results
6. Learn More

Learn more about:

Markets for watershed investments:

- [State of Watershed Investment 2016: Alliances for Green Infrastructure](#)

Water transfer markets in the US:

- [Water Share: Using Water Markets and Impact Investment to Drive Sustainability](#)
- [Agricultural Water Transfers in the Western United States](#)

Other EnviroAtlas Use Cases from Ecosystem Marketplace:

- [Mapping Potential Demand for Water Quality Trading in the United States](#)
- [Screening New Market Opportunities for Sustainably Managed State, Private and Tribal Working Forests](#)
- [Assessing Ecosystem Markets Opportunities on Public and Private Lands: New Tools and Data for Decision-Making](#)