Florida Agricultural Soil Moisture Sensor Network

Engaging growers, agents, and technology industry to conserve and protect water resources

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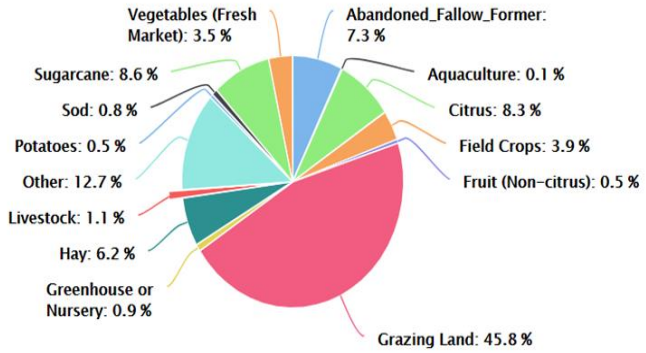
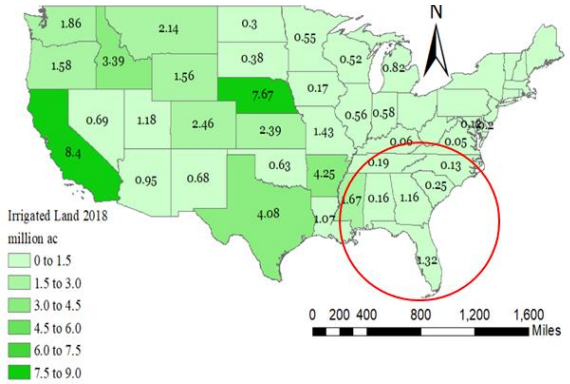
Outline

- **Florida Water Management Challenges**
- **Why and What is Precision Irrigation Management**
- **Irrigation Scheduling Methods**
- **Soil Moisture Sensor Technologies:**
- **Other Practical considerations**
- **Florida Agricultural Soil Moisture Sensor Network**

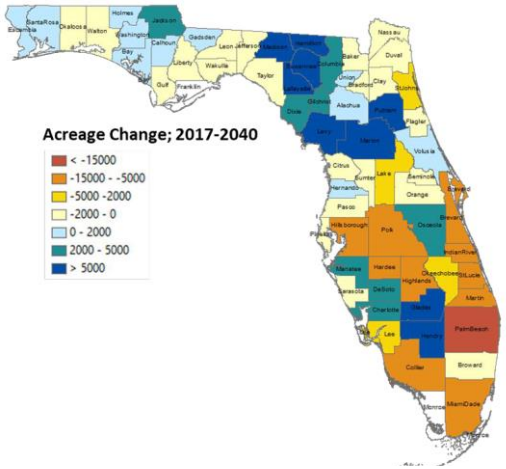
Florida Irrigated Agriculture

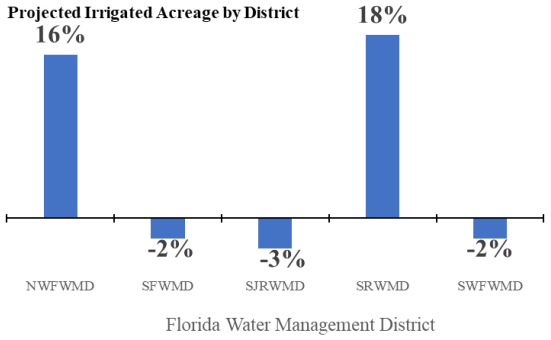
Specialized crops and Irrigated Ag





Water Quantity Challenges

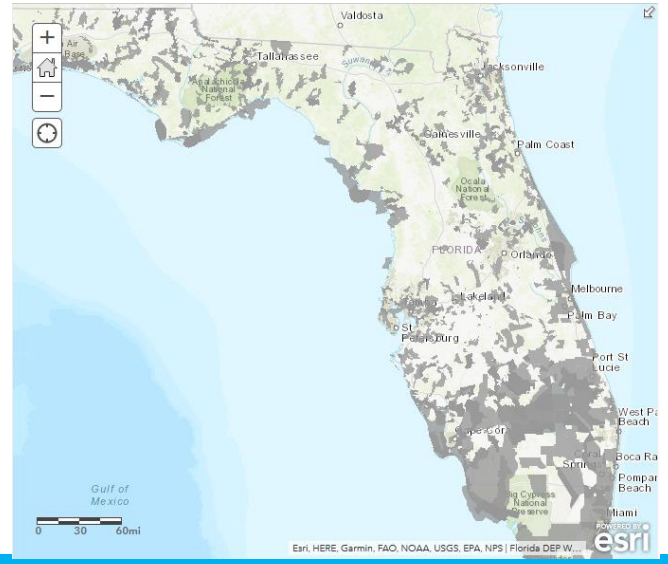




Florida Water Management District

4% increase in Florida Water use by 2040

Water Quality Challenges



Increased nitrate-nitrogen (NO^3-N) concentrations, Impaired waterbodies, harmful algal bloom

Extreme year to year variability in irrigation requirements

Source: (NASS, FDACS, FDEP, Springs Eternal Project, by InDepth)

Precision Irrigation Management

- Maximizing the benefit of irrigated agriculture through well designed Ag water management network is critical in Florida.
- 5th R – closing the loop

When to irrigate? (timing)

How much water? (amount)

Where to irrigate? (where)

:

- Anaerobic Soil Conditions (Yield Penalty)
- Increased Pumping Cost (i.e., energy cost)

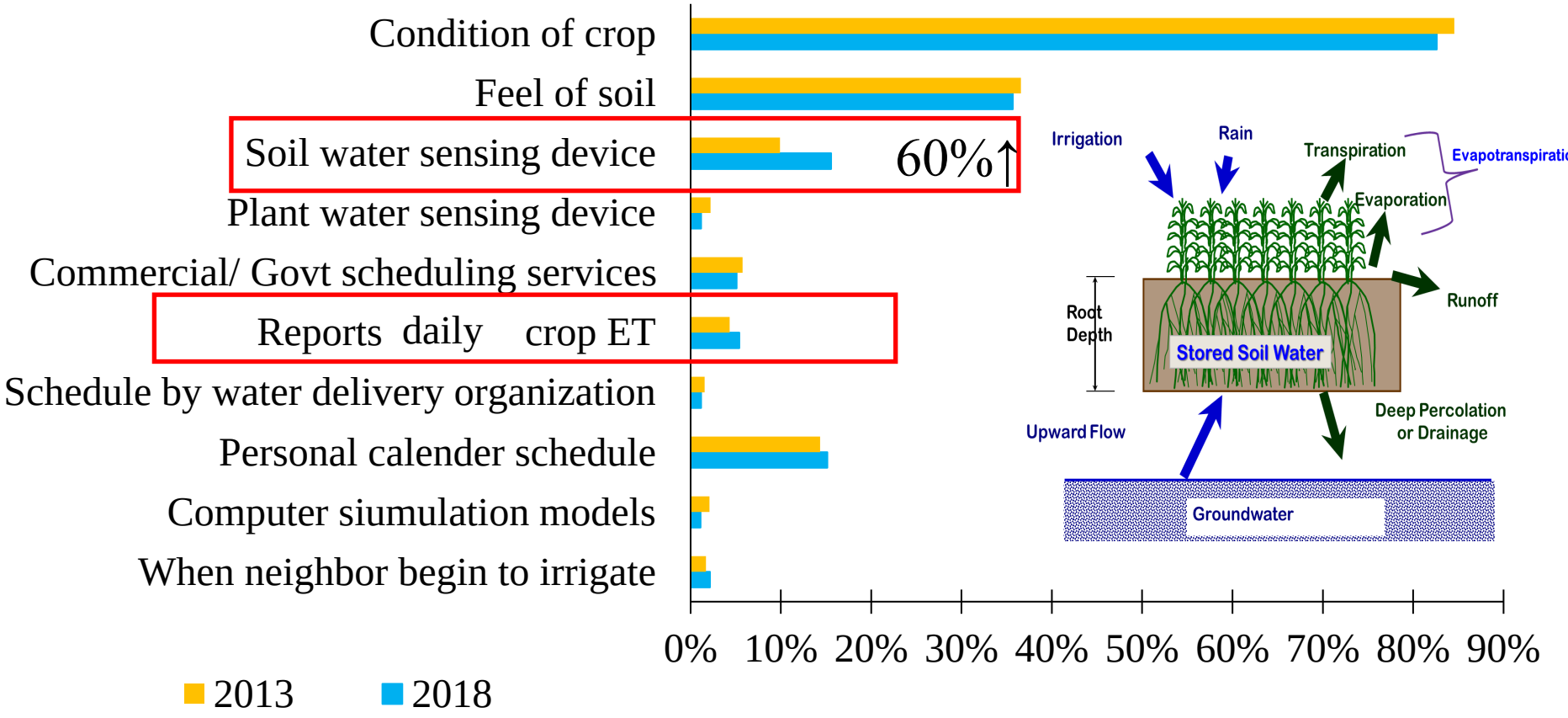
- Net Return ($ per acre)

Levels of Irrigation Scheduling

- Three general approaches or philosophies for scheduling irrigation are:
  - Maintain soil water content within desired limits,
    - Direct measurement
    - Moisture accounting
  - Use plant status indicator to signal the need for water
    - Wilting, leaf rolling, leaf color
    - Canopy-air temperature difference
  - Irrigate according to calendar date or other fixed schedule
    - Irrigation district delivery schedule
    - Watching the neighbors

Irrigation Scheduling in Florida

- Irrigated lands are limited in the adoption of newer technologies/tools.



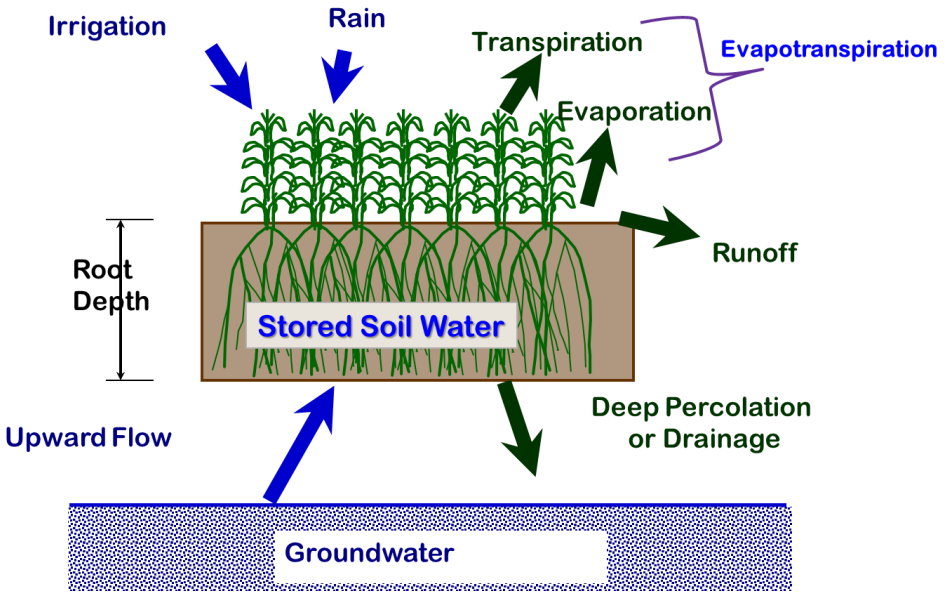
Industry support

Irrigation Apps/IoTs

Cost Share programs

Sour ey

Scientific Irrigation Scheduling



- **Soil-moisture based irrigation scheduling.**
  - Directly measure the soil moisture. (Soil moisture sensors).

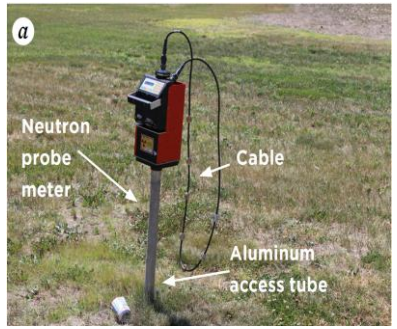
- **Checkbook/Climate based irrigation scheduling.**
  - Use climate data to estimate change in soil moisture. (Climate data from weather station + crop coefficients).

Soil Moisture Sensor Technology

Manual

Gravimetric Method

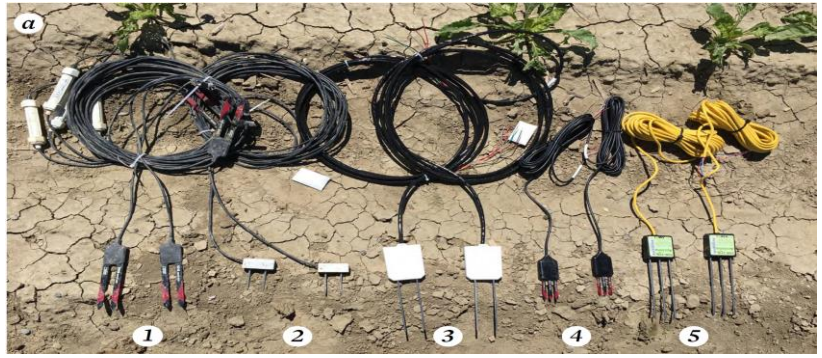
Tensiometer



Neutron Probe

Dataloggers

Watermark



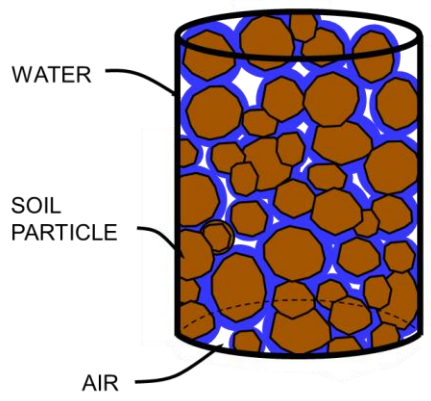
Single depth sensor

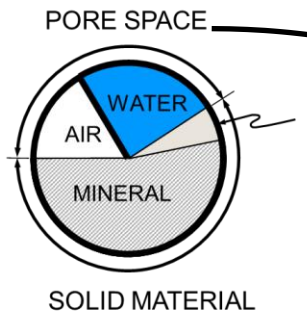
IoTs

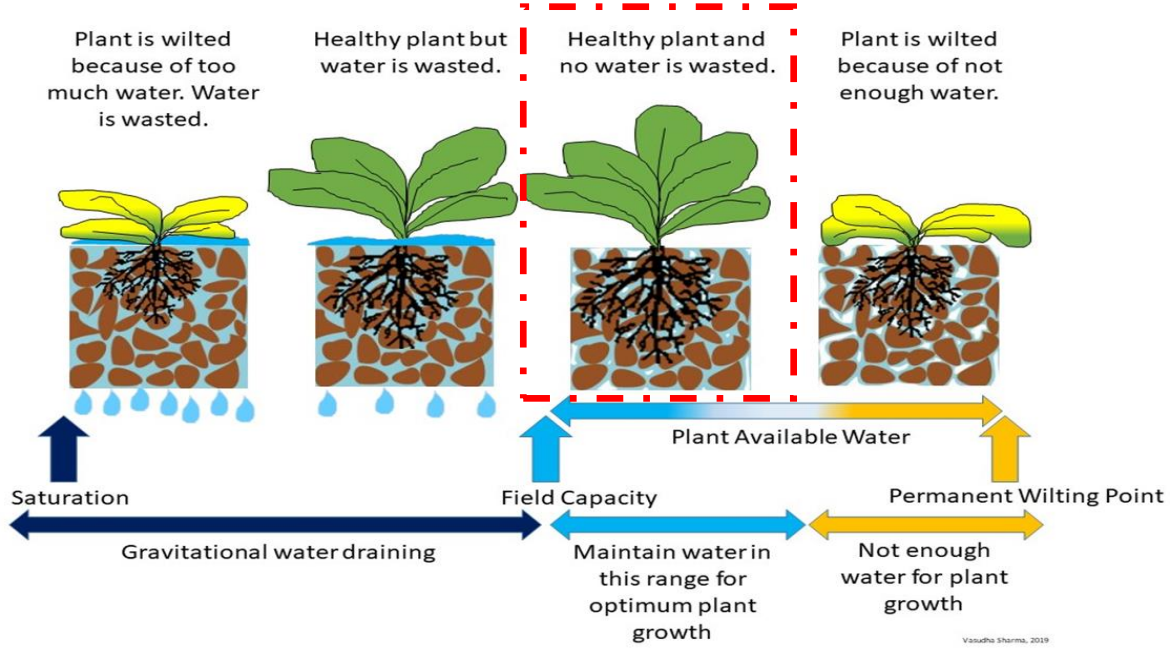
Sentek Probe

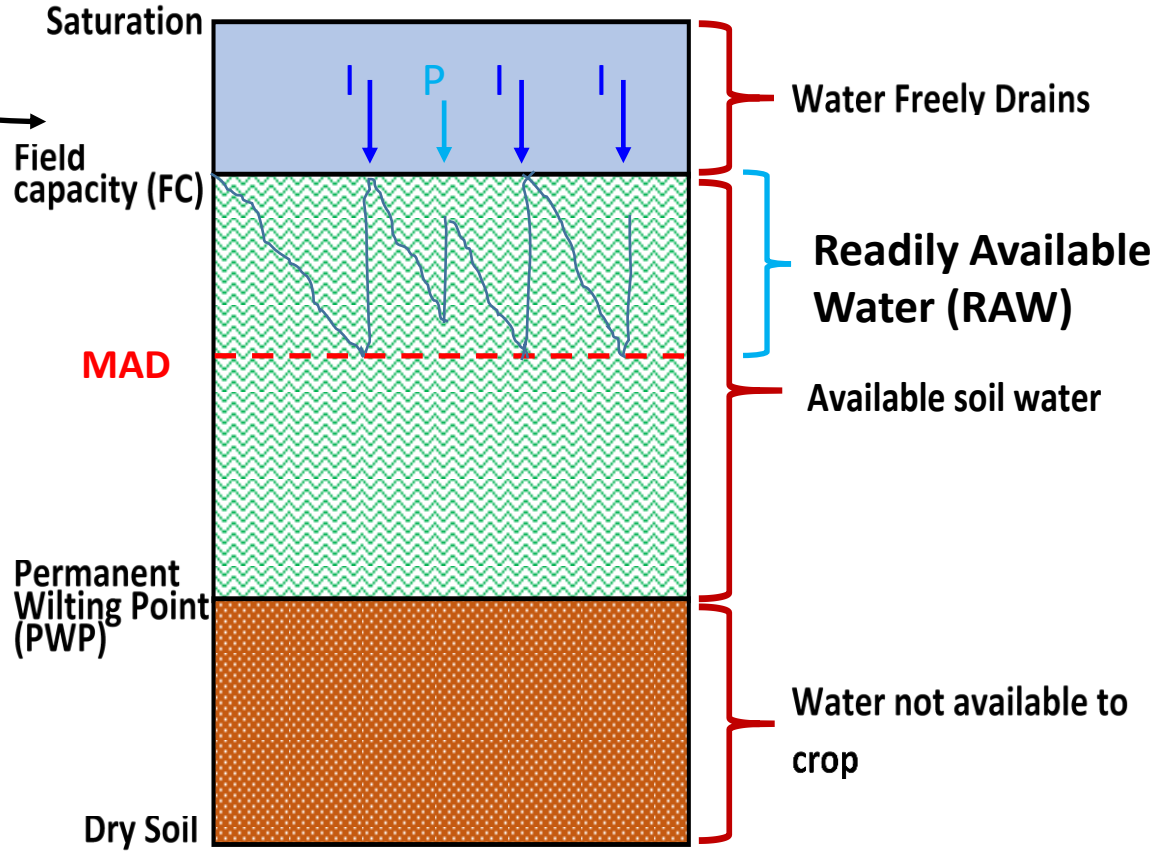
BMP logic

Irrigation Scheduling Using Management Allowable Depletion (MAD)







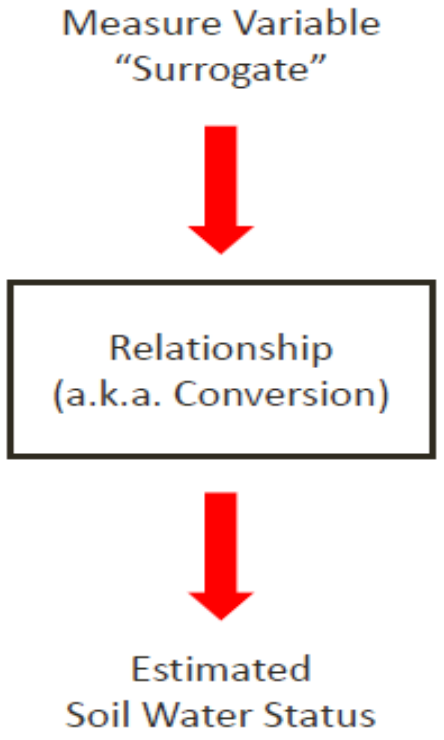


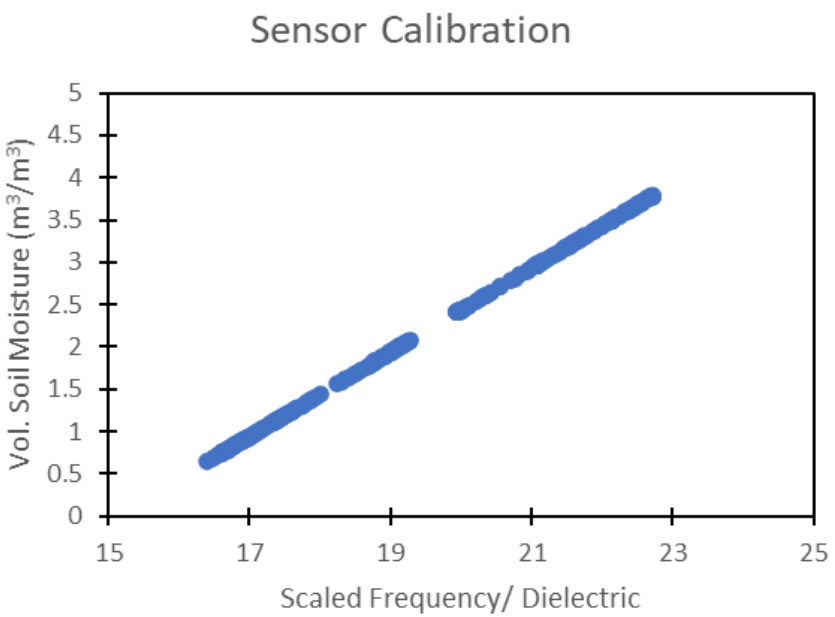
Conceptual "bucket" of plant available water

Goal: keep water contents within this range to avoid crop water stress and minimize drainage below the root zone

Soil Moisture Sensor Method for Irrigation

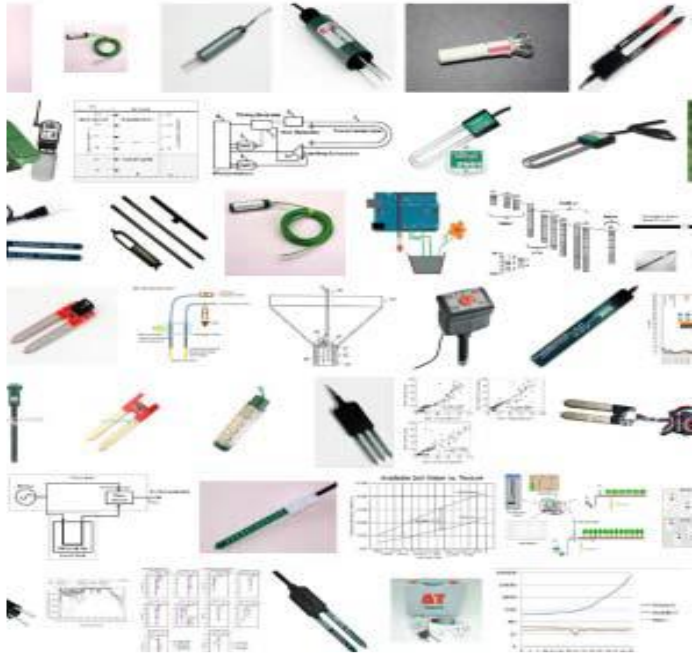
- **Direct soil moisture monitoring** (e.g., gravimetric methods).
- **Indirect soil moisture monitoring methods:**
  - Indirect methods measures a surrogate soil property and relate it to soil water content or potential.
  - Indirect methods:
    - Hand feel
    - Neutron probe
    - Capacitance
    - Time domain reflectometry
    - Frequency domain reflectometry
    - Electrical resistance
    - Tensiometer
    - Thermal (i.e., heat dissipation)





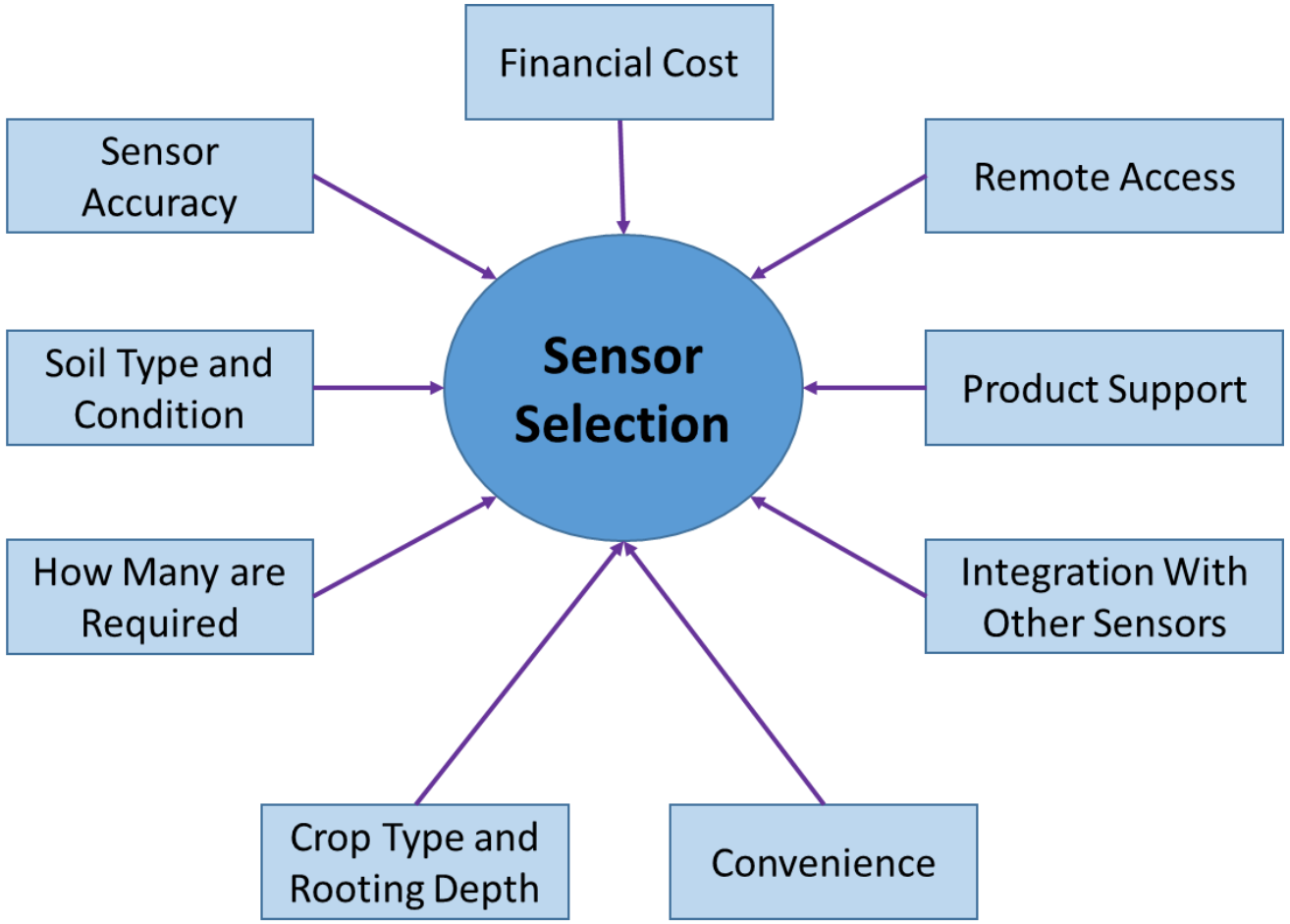
Soil Moisture Sensors

- Vast array of soil moisture sensors that respond differently across soils, fields, and irrigate conditions.

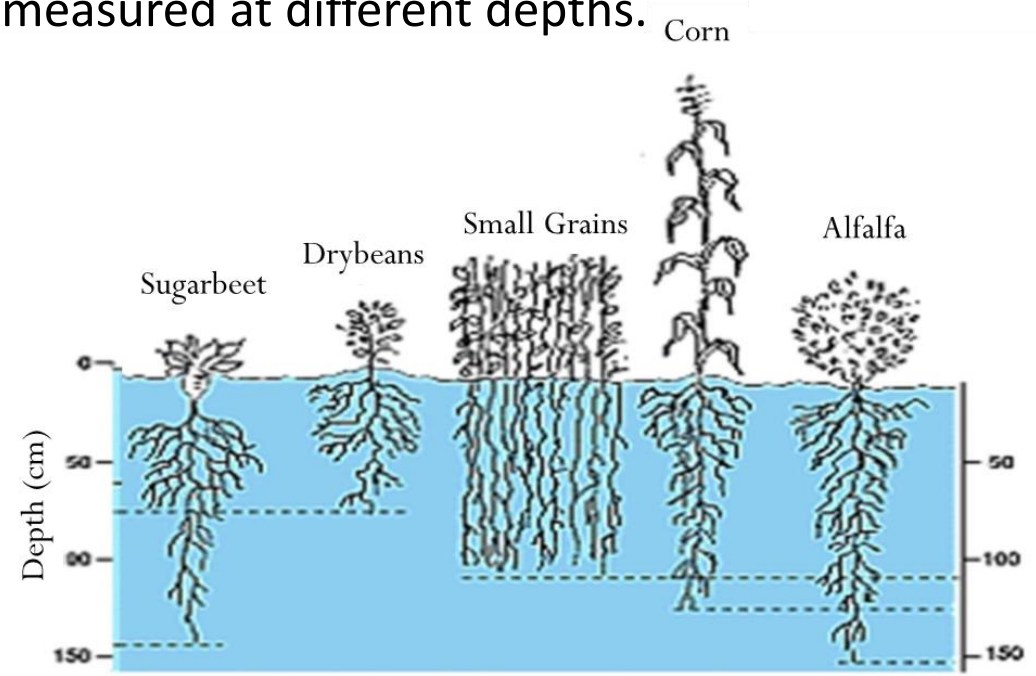


- **All sensors are not created equal**
- **Moisture contents measured by sensors may not represent the field scale.**
- **Development of accurate and affordable sensors is difficult and a work in progress**

Things to Consider When Selecting the Soil Moisture Sensor



- Crop with different root architecture (e.g. density and depth), which can affect water and nutrient availability and uptake.
- Consequently, soil moisture will have to be measured at different depths.



Technology Adoption?

- **What prevents more growers from adopting water saving technologies?**

Concerns with cost, risk, & effort hinder technology transfer

Growers need to see the value of the technology, recognize it as low-risk and low-effort, and receive help getting started.

How do we increase technology adoption?

Growers need to understand the outputs from soil moisture sensing devices. They need to see first-hand how they can save capital and improve yield by using the technology to better manage irrigation and fertilizer.

Florida Agricultural Soil Moisture Sensor Network

- The premise of the network is to educate producers and extension agents and to work with FDACS to increase producer adoption of irrigation BMPs throughout the state to conserve water.
- The project facilitates in-depth, one-on-one educational opportunities between agents and growers about this beneficial and cost-saving technology. Specific objectives include:

  - Continuous expansion of Florida Ag. soil moisture sensor network
  - Assisting the agents and growers in investigating soil moisture sensors as a water-conserving technology
  - Quantify the operational and financial benefits and challenges of soil moisture sensor technologies in different management practices.
  - Providing information on sensor costs and cost-share funding availability.

Technology Transfer Model

Agent joins network

Agents self-select to participate and begin learning about the technology.

Farmer recruitment

Agents recruit participating farmers.

Applied learning

Agents, specialists, & farmers discuss sensor data & how it can be applied real-time.

Integrating knowledge

Farmers use sensor data to modify irrigation management.

Outcomes

Farmers & agents increase KASA
Farmers adopt technology
Improved water use efficiency
Improve water quality

Training Program

- One-on-One training
- Workshops
- In-Service Training (ISTs)

In 2019-2020 :
- 3 field days,
- 4 workshops and
- 37 one-on-one or group trainings

In 2020-2021 :
- 2 IST workshops (online) and
- Multiple one-on-one or group trainings (online)

In 2021-2022 :
- 3 invited sessions (online)
- Multiple online one-on-one or group trainings (online)

In 2022-2023:
- 3 IST
- 4 invited sessions (online)
- Multiple zoom meeting with extension faculty

Sensor Technologies

- The project seeks to use the most appropriate, cost-effective, and advanced technology to expand the soil moisture network in the state of Florida.

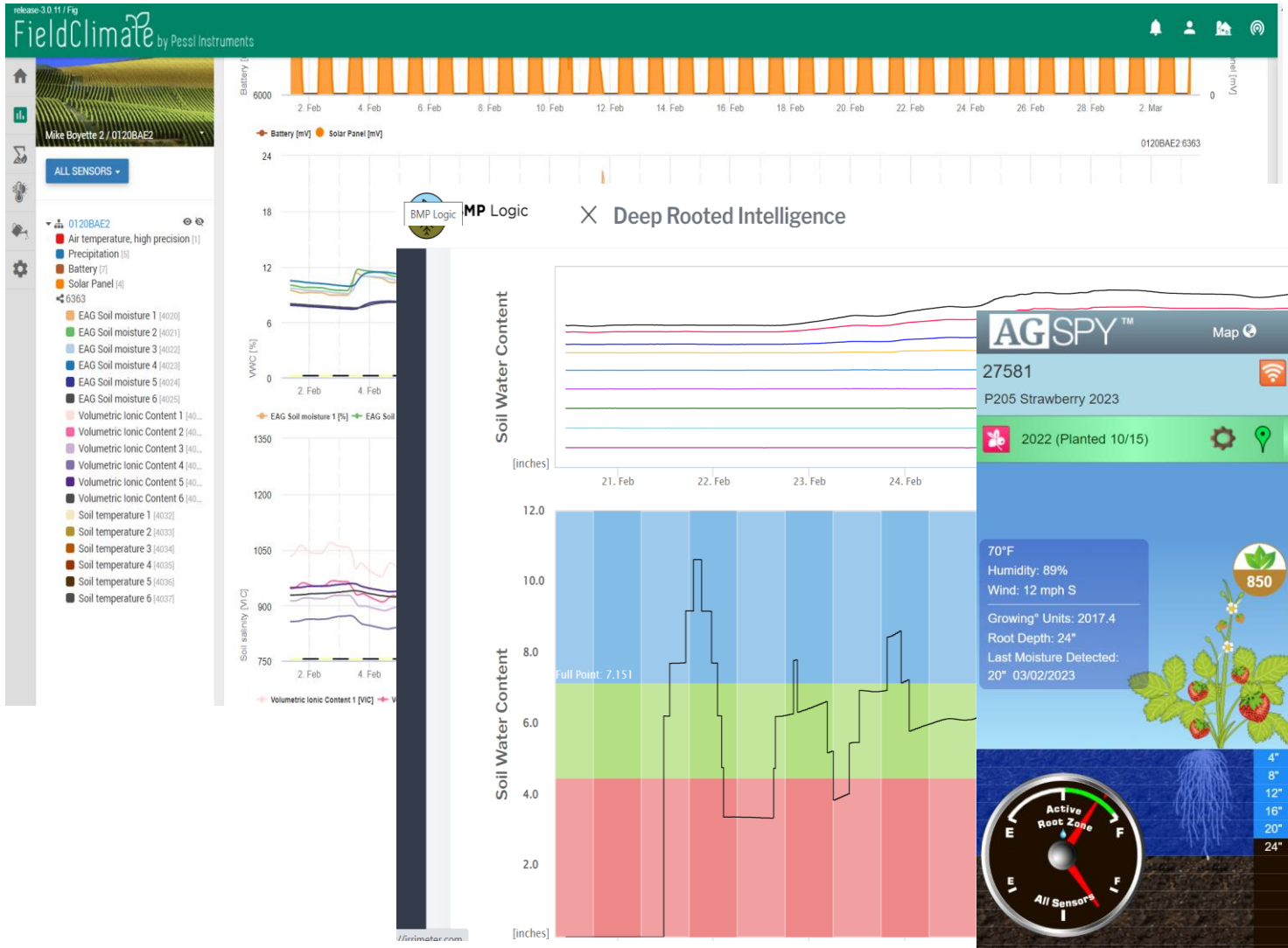
Sentek Drill and Drop Sensors

BMP Logic

AquaSpy

Delta-T Devices
Sentek technologies
CPN
Acclima
CropMetrics
Yield Optimization Technology
AquaSpy
AquaCheck
CAMPBELL SCIENTIFIC
DECAGON DEVICES
Stevens
Water Monitoring Systems, Inc.
Spectrum Technologies, Inc.
IRROMETER
TROXLER
METER

Data Visualization

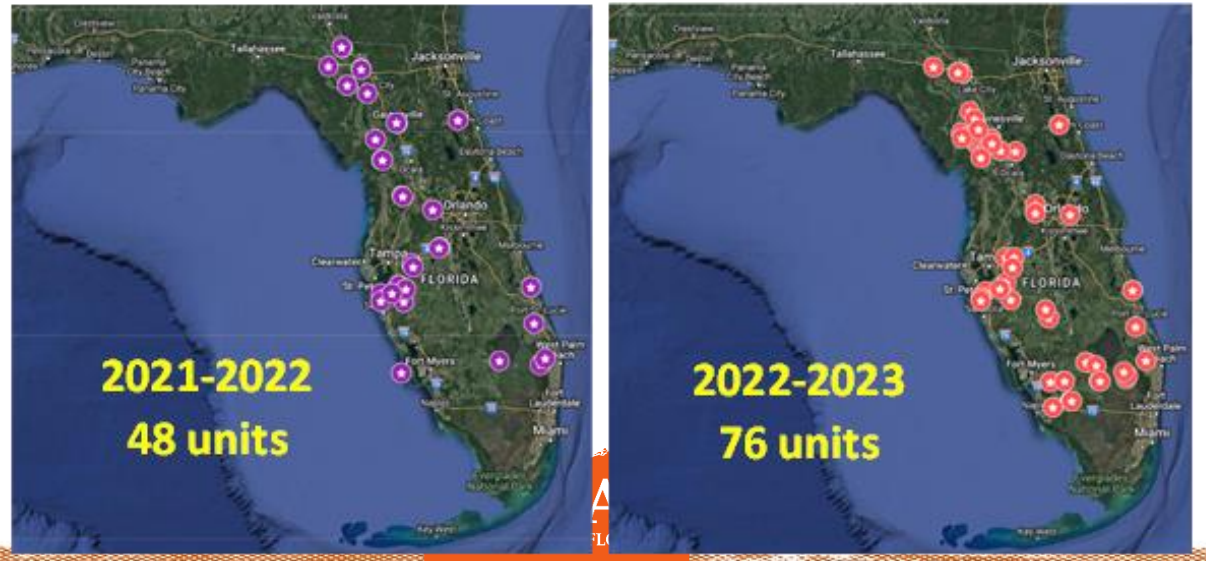


Field Climate

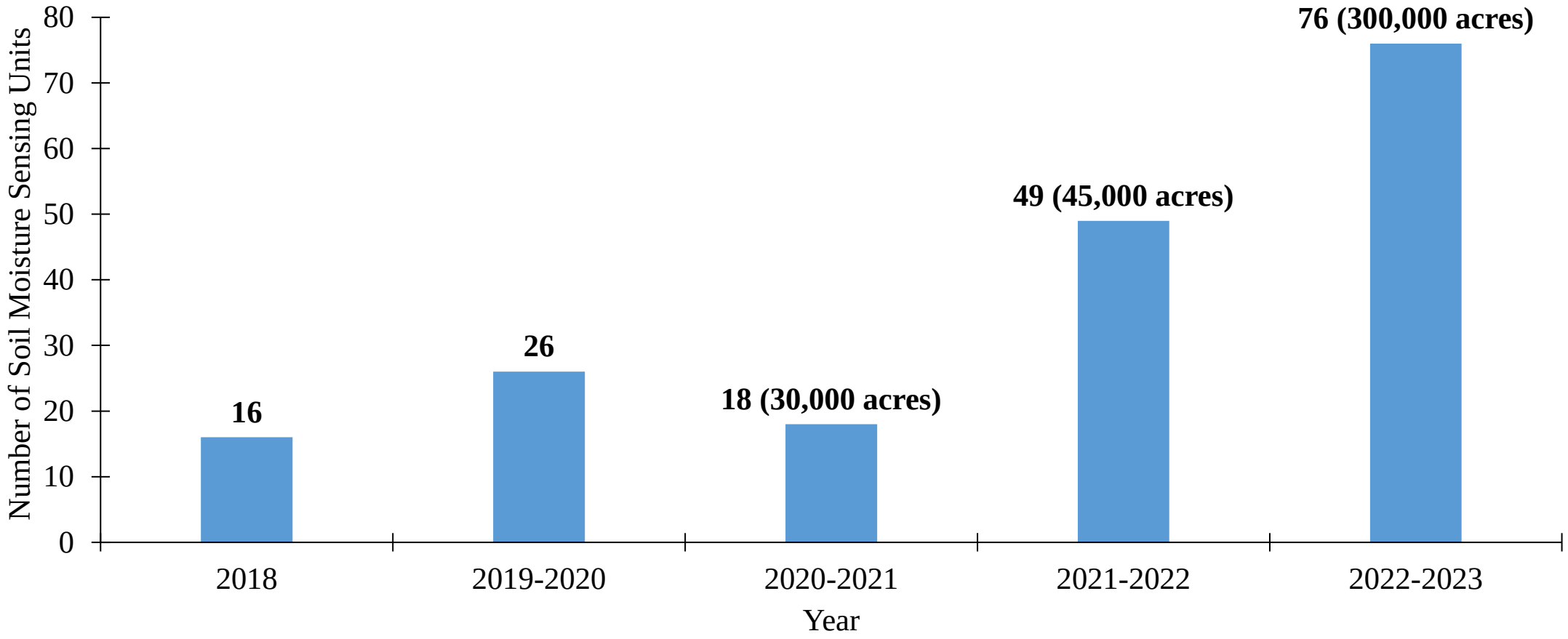
Irrimeter

AquaSpy

Network Expansion



Network Expansion



Crops Covered

- Corn
- Peanuts
- Peaches
- Watermelon
- Strawberry
- Citrus
- Nursery
- Cabbage
- Tomatoes
- Potatoes
- Blueberry
- Mango
- Dragon fruit
- Beans
- Cilantro
- Spinach
- Pepper
- Sugarcane
- Squash
- Pumpkin
- Stevia
- Sod

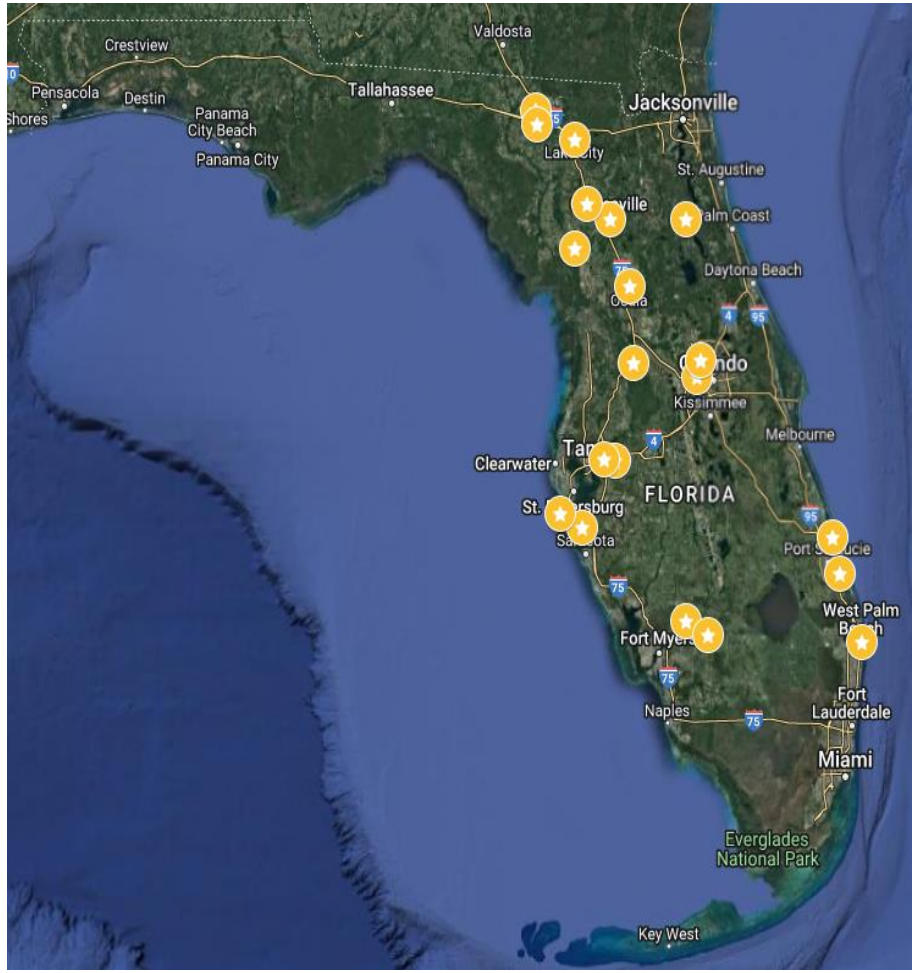
Extension Agent Network



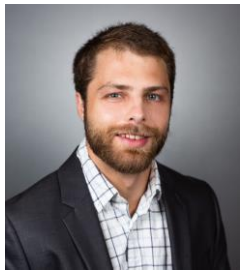








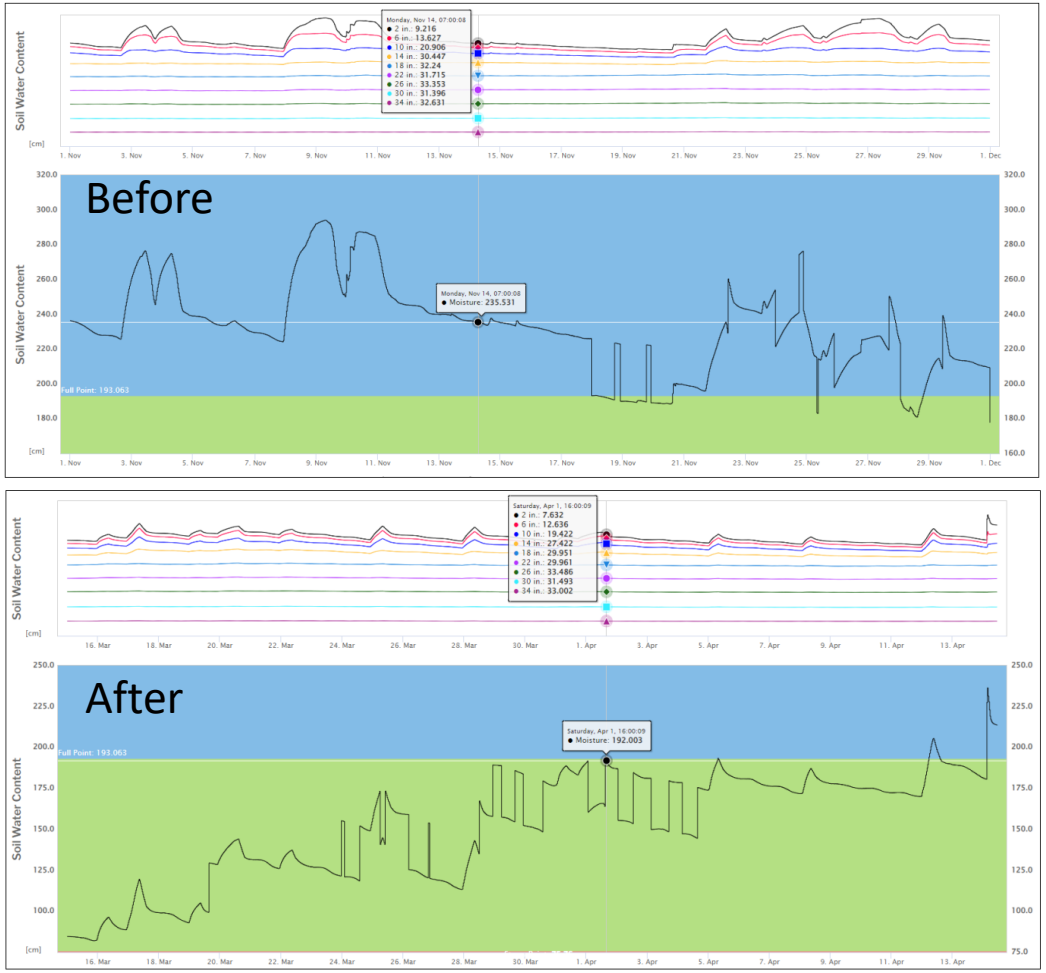






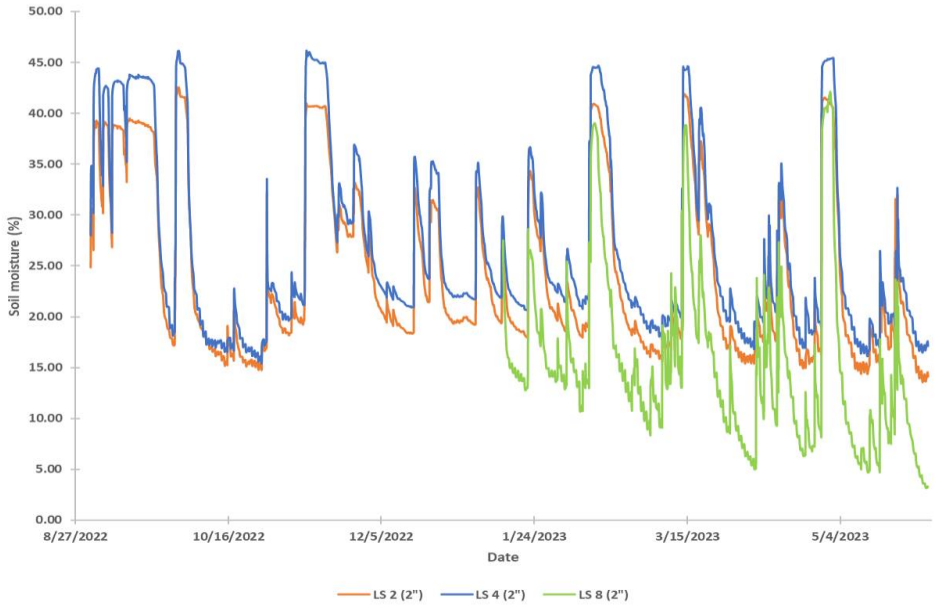
Success Story 1

- **Manatee County,** (Christine Russo)
- Soil moisture sensors was installed in sod farm
- By checking the SMS graphs daily, the producer was able to adjust irrigation time to promote deeper root growth and reduce overall soil moisture, thereby reducing total water usage.
- The SMS graphs for initial vs. current data, revealed the increased activity of the 14” sensor from November to April, suggesting deeper root growth in response to improved soil moisture



Success Story 2

- **Putnam County** (Wendy Mossuline)
  - Six automated soil moisture sensors were installed for continuous monitoring as one of the advanced BMP technologies integrated into a compost application project at a commercial sod farm.
  - Incorporation of compost at a rate of 4t/ac, increases the soil water holding capacity of soil.



- Soil moisture sensor was installed in citrus field - closely monitoring the air and soil temperatures in his groves for freeze protection.
- Growers **saved 1.1 million gallon** of water by monitoring the probe and choosing not to irrigate for freeze protection.

Success Story 3

- **Southwest Florida** (Craig Frey, Anna Meszaros, Christian Kammerer)
  - **28 sensors** in different crop including dragon fruit, beans, cilantro, celery, baby spinach, pepper, watermelons, sugarcane, squash, and pumpkin were installed in 2023.
  - Covered over approximately **200,000 acres**.
  - Participant growers purchased/cost-share **30 new sensors.**
  - One grower save approximately **3 million gallon of water.**

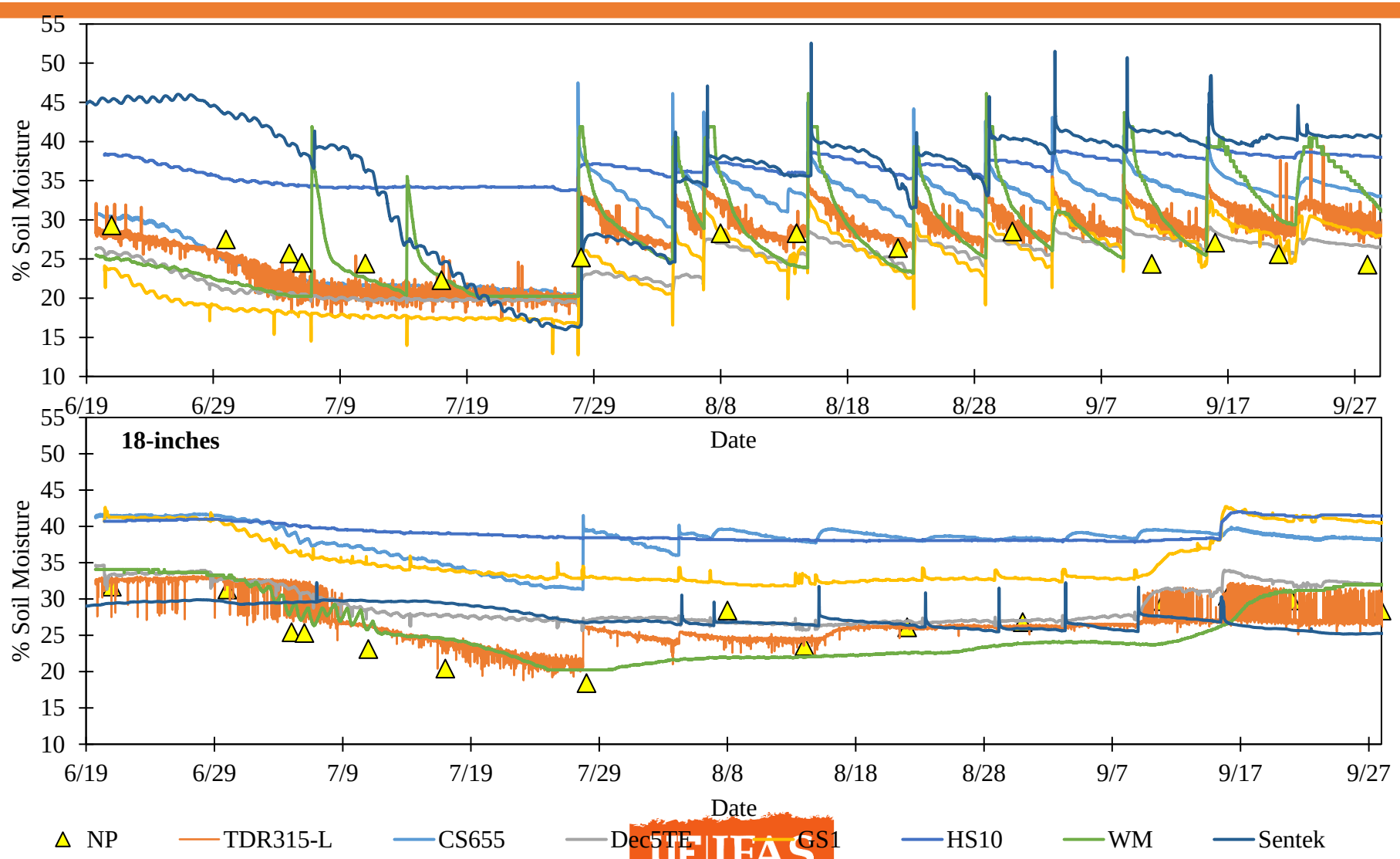



Success Story 4

- **Marion County** (Gabriel Vicari)
  - Sensors were installed in passion fruit
  - Careful monitoring of soil moisture help growers to optimize irrigation and resulted in saving of 1690 gallon of water per day.

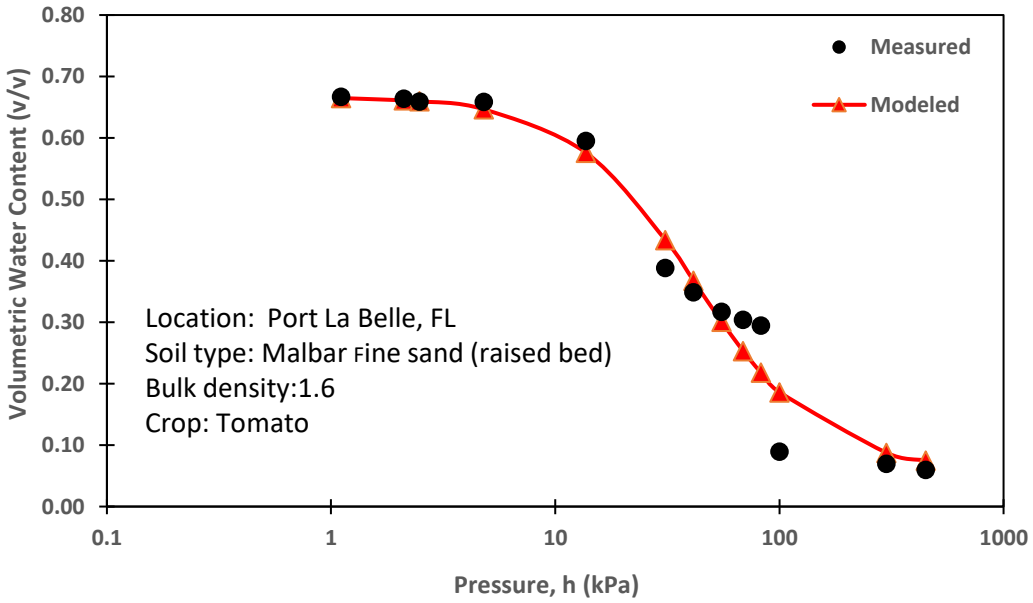

AquaSpy
Neutron Probe
Crop Metric
Teton Technology
John Deere
Irrometer Watermark
Delta T, PR2 Soil Moisture Probe
Campbell Scientific CS655
Acclima TDR315-L
Decagon 5TE
Decagon HS10
Decagon GS1

Sensor Calibration



Sensor Calibration

- **Development of Soil Characteristic Curves to determine field capacity and permanent wilting point for different soil types in Florida.**



Florida Agricultural Soil Moisture Sensor Network

- The network is bringing cultural and behavioral changes in technology implementation resulting in water conservation, nutrient, and energy savings.

- About **80% of the participants** who participated (**around 1026 since 2020**) in extension activities have gained additional knowledge on soil moisture technologies and irrigation management.

- Because of the continuous educational effort by the network, since 2020, the Suwannee River Water Management District alone has approved funding for **601 soil moisture probes** as a part of the cost-share programs, **representing 49,000 acres**.

- Since 2020, the St. Jones River Water Management District has approved **207 soil moisture sensor** probes as a part of the cost-share program.

- On average, the water conservation that was observed/reported by network ranged from **0.5 inches to 1.5-inchs per growing season** depending on the crop type and climatic conditions.

Take-home Message

- Good management of irrigation water will increase crop yields, improve crop quality, conserve water, save energy, decrease fertilizer requirements, and reduce nonpoint source pollution.
- Using soil moisture measurements is one of the best and simplest ways to get feedback to help make improved water management decisions.
- Irrigation scheduling based on a refill point (MAD) will work given the “right” sensor and in certain soils.
- There is no universal calibration. Field accuracy is typically less than the laboratory.
- Sensor Installation is the KEY!

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Thank you for your attention!
Questions

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