Basics of Irrigation Scheduling

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Outline

- Objectives of irrigation management.
- Factors affecting irrigation scheduling.
- Effect of Florida's population increase on state water use.
- Crop water use calculations.
- Irrigation requirements.
- Overview of soil water status sensors.
- Demonstration of web and site-specific irrigation scheduling tools.

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Objectives of Irrigation Scheduling

- Maximum yield per acre
- Maximum yield for amount of water applied
- Maximum yield per unit of fuel or electricity
- Maximize nutrient uptake.
- Minimize nutrient leaching.

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6 key questions in irrigation scheduling

- How deep to irrigate?
- How deep do my roots grow?
- How much water does the soil contain now?
- How dry does the soil need to be to irrigate?
- How long do I wait to irrigate?
- How much water do I need to apply?

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Factors affecting irrigation scheduling

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Factors that affect irrigation depth and timing

- Soil type – water holding capacity, hydraulic conductivity.
- Where and how deep do my roots grow?
- Depth to water table.

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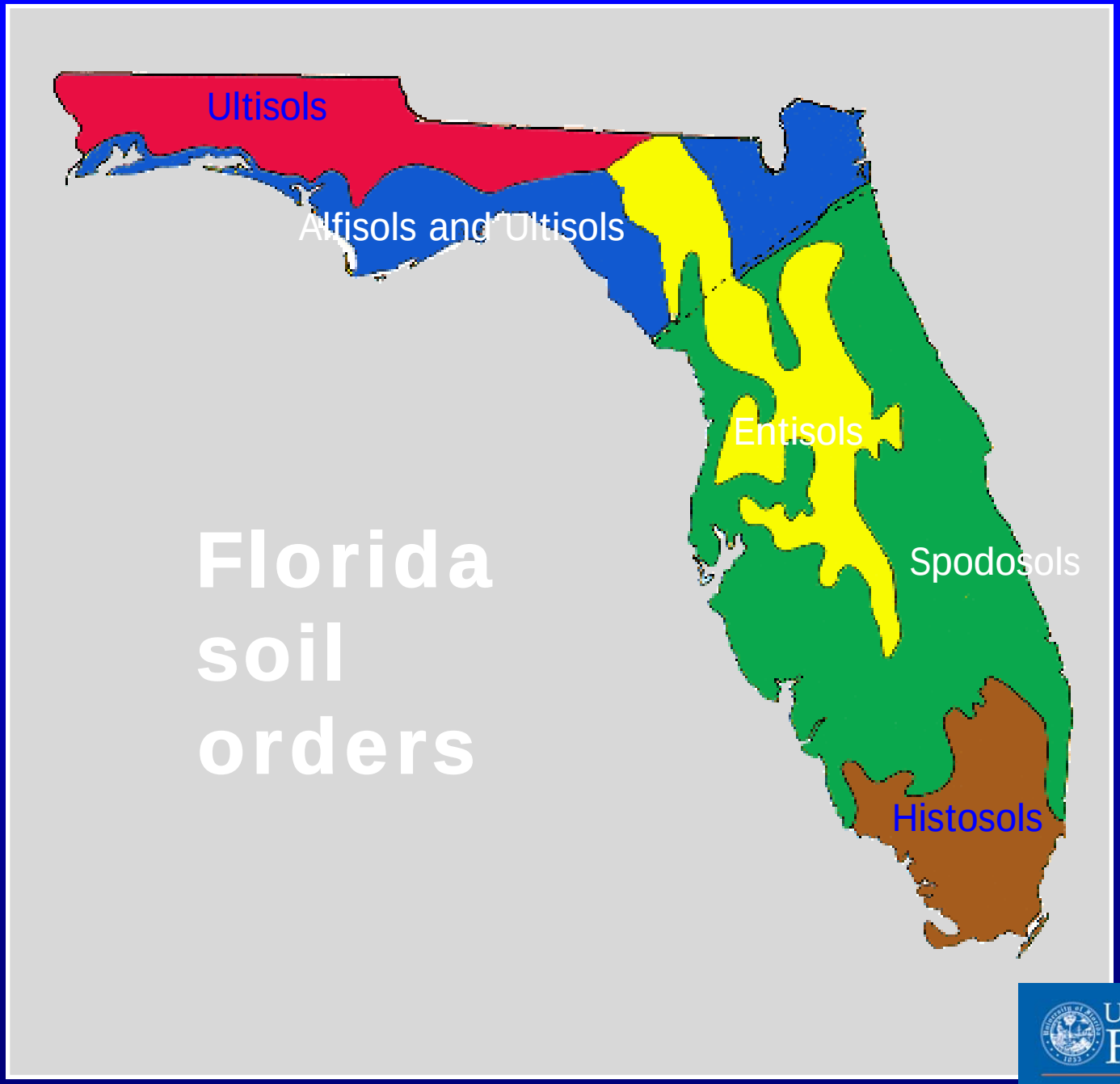

Florida soil orders

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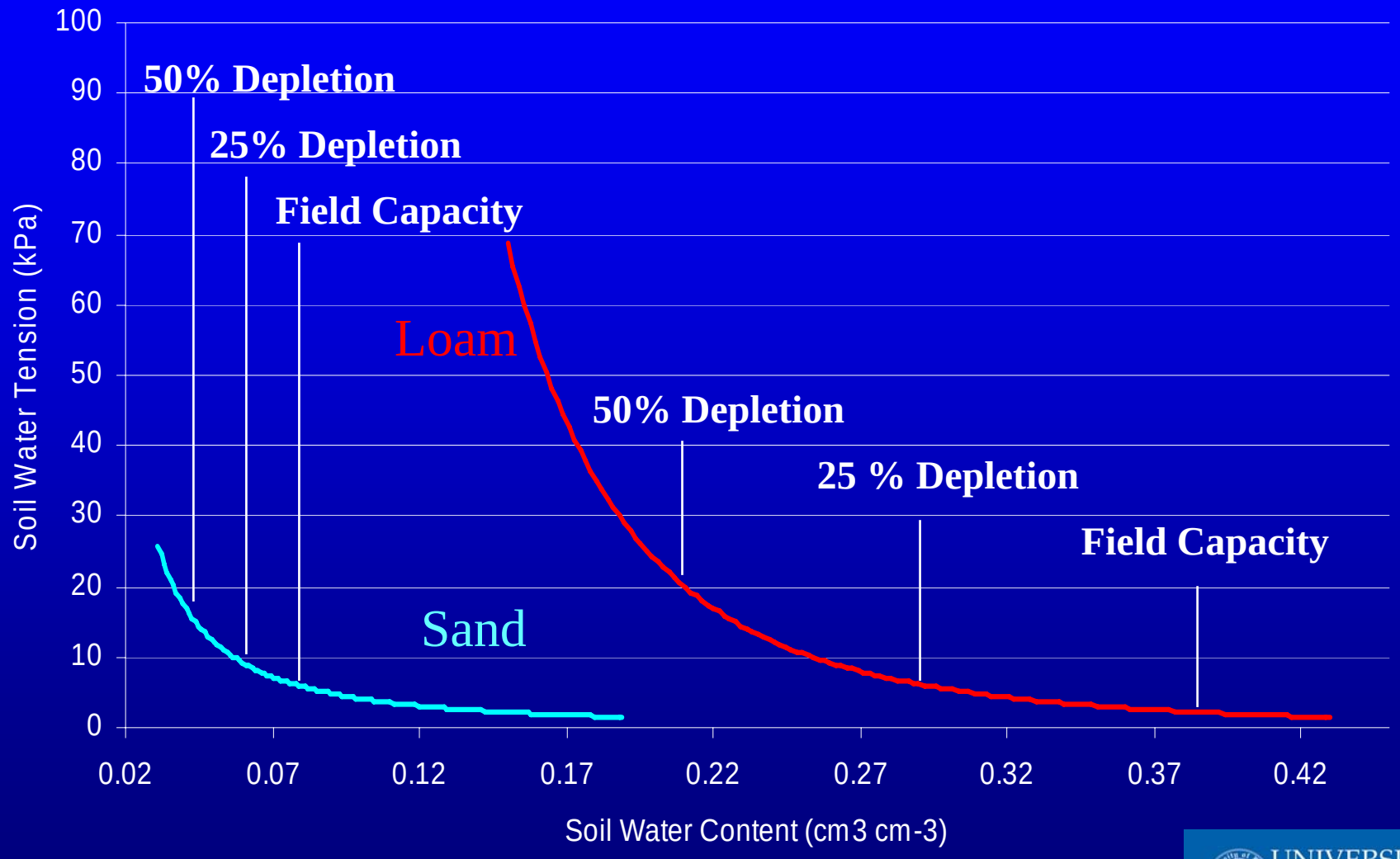
Florida Sandy Soils



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Soil Types

Entisol

Spodosol

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Spodosols (Bassinger, Immokalee, Myakka)

Soil Layer	Thickness (Inches)	Organic Matter	Clay Content	Available Water	Permeability (in/hr)
A horizon	3-6	0.5-2%	< 5%	7-10%	6-20
E horizon	18-30	< 0.5%	< 5%	5-7%	6-20
Bh horizon	6-12	2-8 %	1-8%	12-26%	0.6-2

Source: USDA, NRCS, Soil Survey of Hendry County, Florida

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Entisols (Candler, Tavares, Zolfo, Pomello)

Soil Layer	Thickness (Inches)	Organic Matter	Clay Content	Available Water	Permeability (in/hr)
A horizon	3-6	0.5-2%	< 3%	4-8%	6-20
C horizon	> 80	< 0.5%	< 3%	2-6%	6-20
B horizon	None				

Source: USDA, NRCS, Soil Survey of Polk County, Florida

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Soil Effects on Root Density (Spodosol)

- Citrus trees form dense mat of fibrous roots immediately below the soil surface
- Generally one-third of root system on furrow side of bed, remaining two-thirds on crown side
- The A horizon appears to play the most important role in root size and quantity
- Thickness of the A horizon critical in defining thickness of root system

Source: Rootstock and Soil Interactions Project, Bauer, Castle, Boman, and Obreza

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Soil Effects on Root Density (Entisol)

- Root density decreases with distance from the tree and depth
- Changes in rooting pattern is predictable with increase in tree size
- Citrus trees form dense mat of fibrous roots 12 to 18 inches below the soil surface

Source: Morgan et al. 2005

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Effect of Florida's population increase on state water use.

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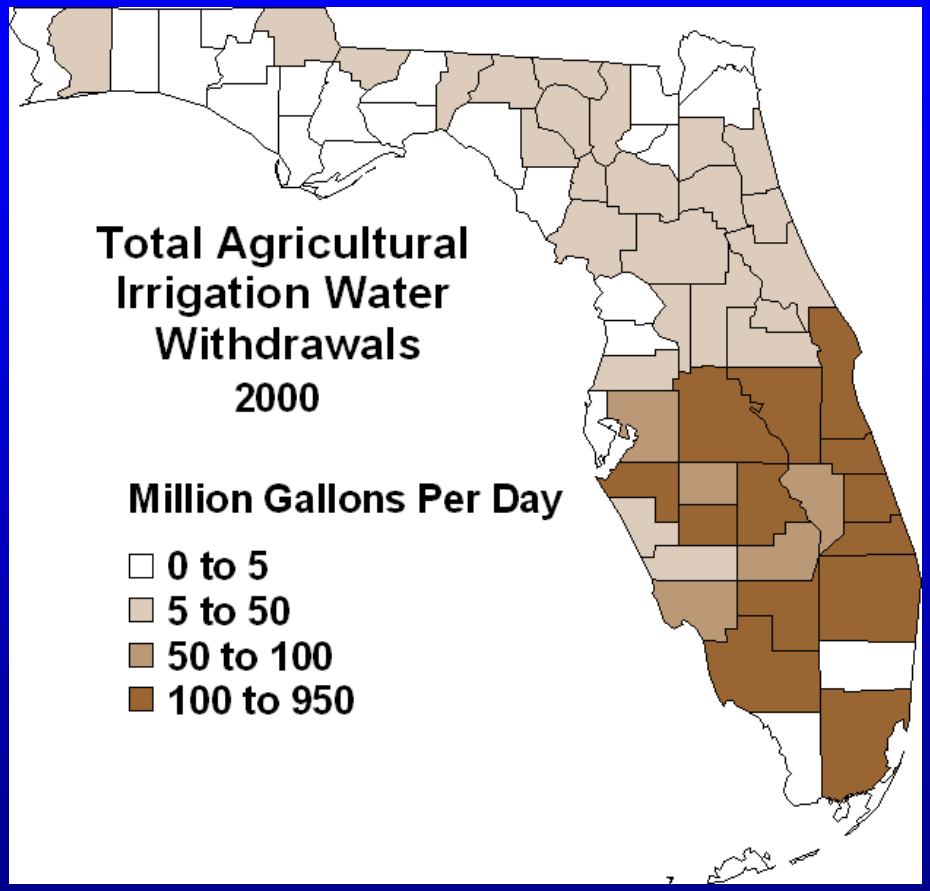

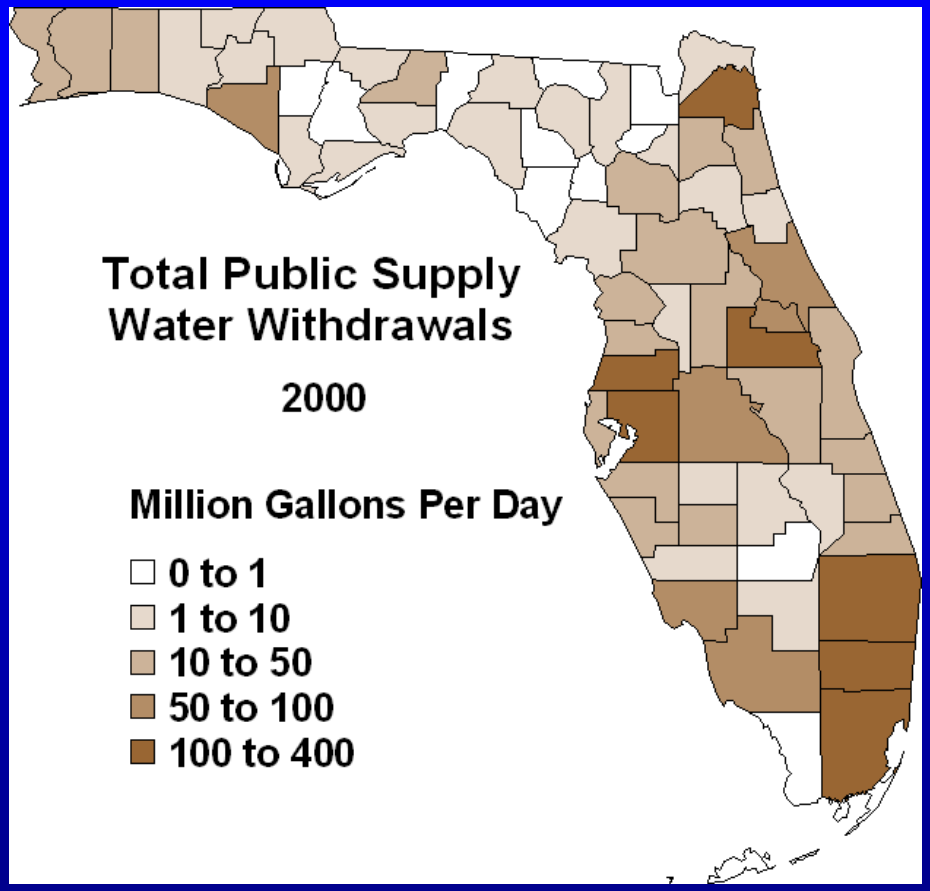

USGS Florida Integrated Science web site http://fl.water.usgs.gov/WaterUse/

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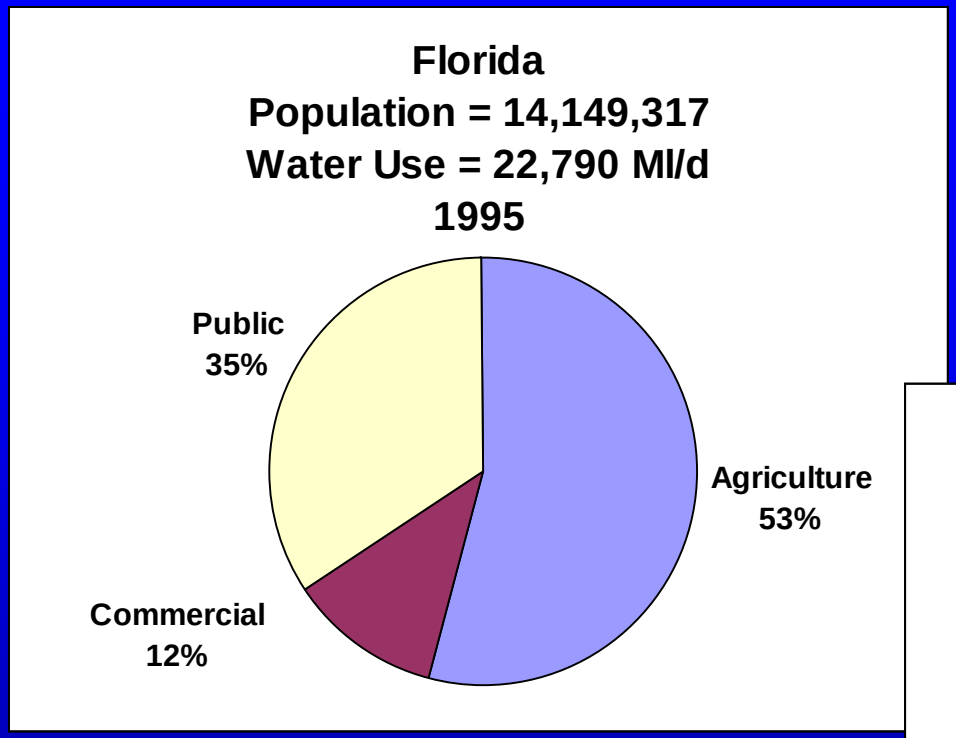

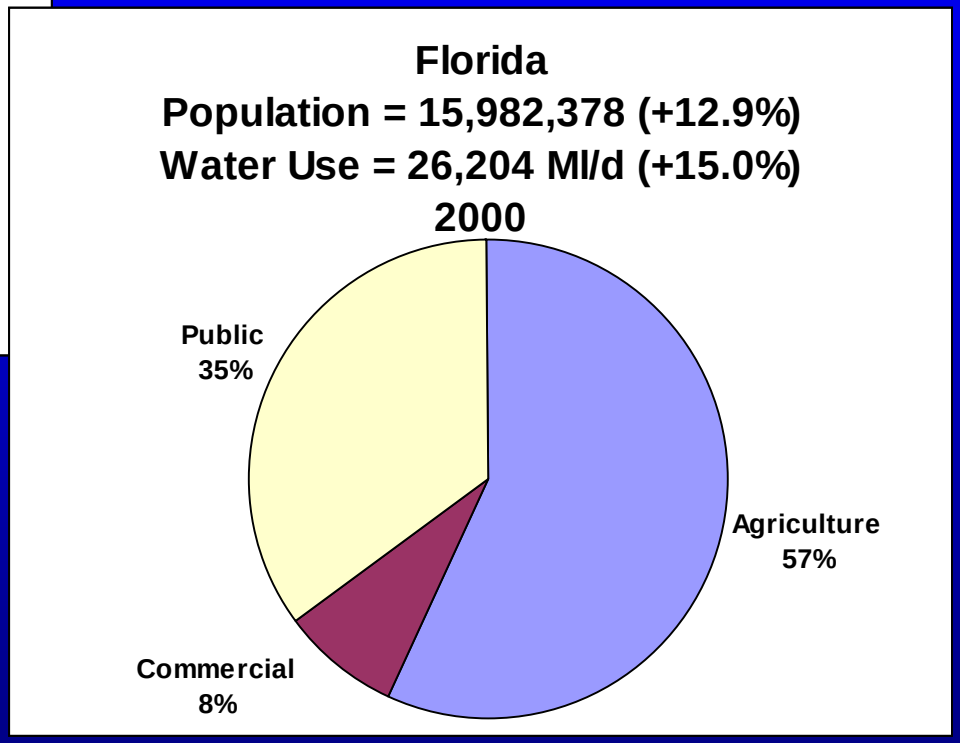

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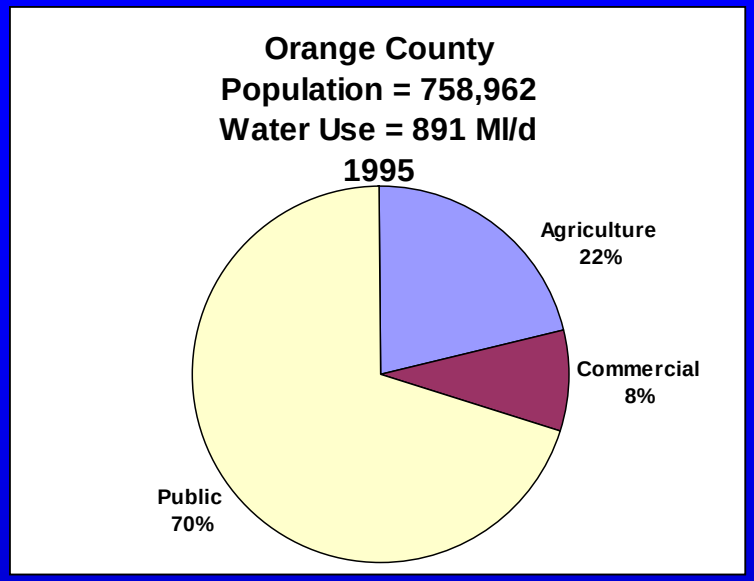

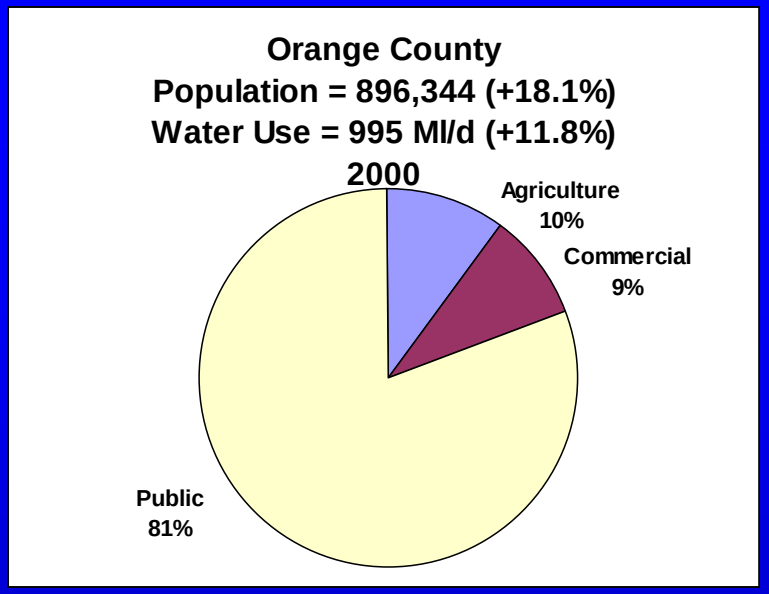

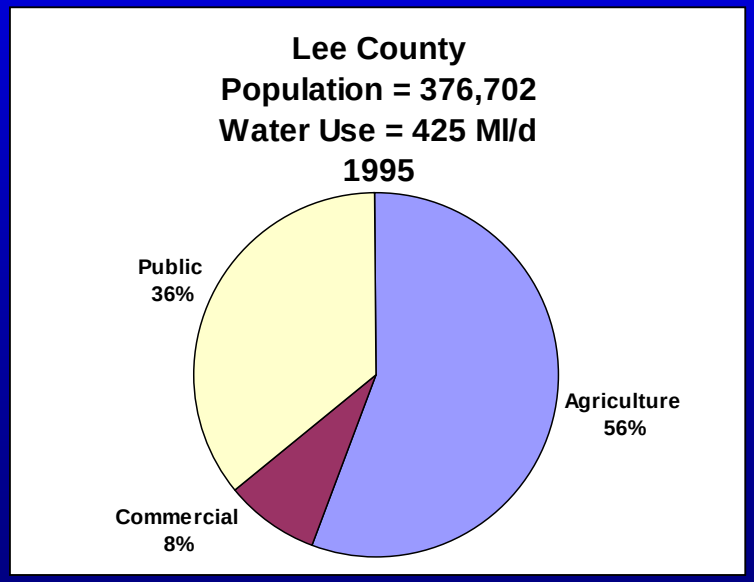

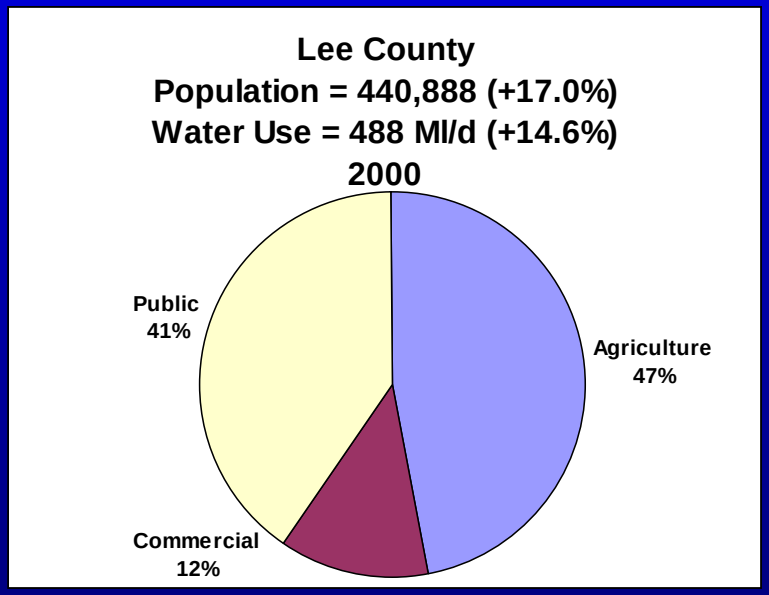

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Crop water use calculations.

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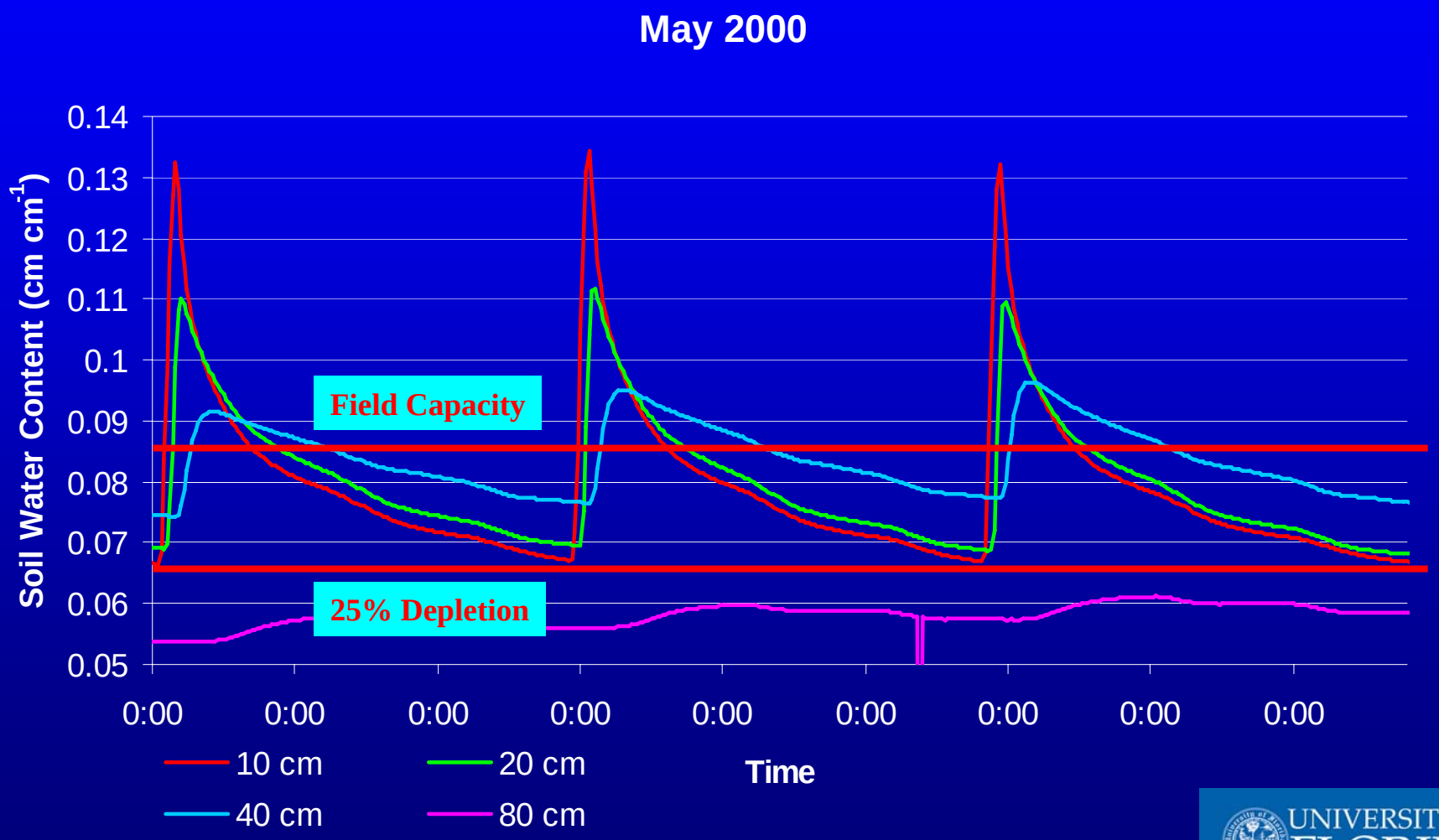
Reduction of Soil Water Content with Time after Application



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Crop Evapotranspiration (ET_c)

$$ET_c = ET_o * K_c * K_s$$

Where,

ET_o = Reference ET.

K_c = Crop Coefficient,

K_s = Soil water extraction factor.

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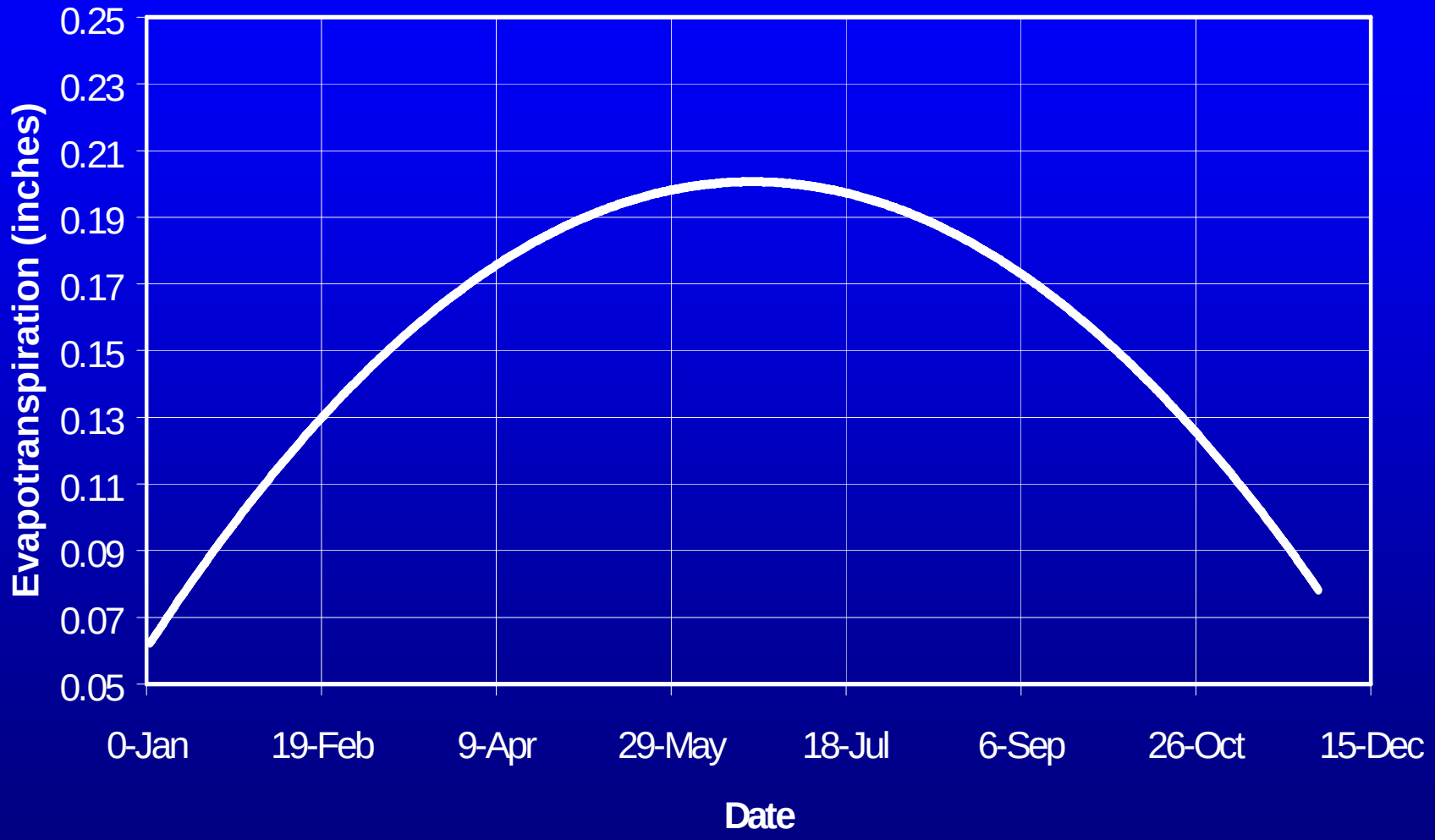
Reference Evapotranspiration (ET_o)



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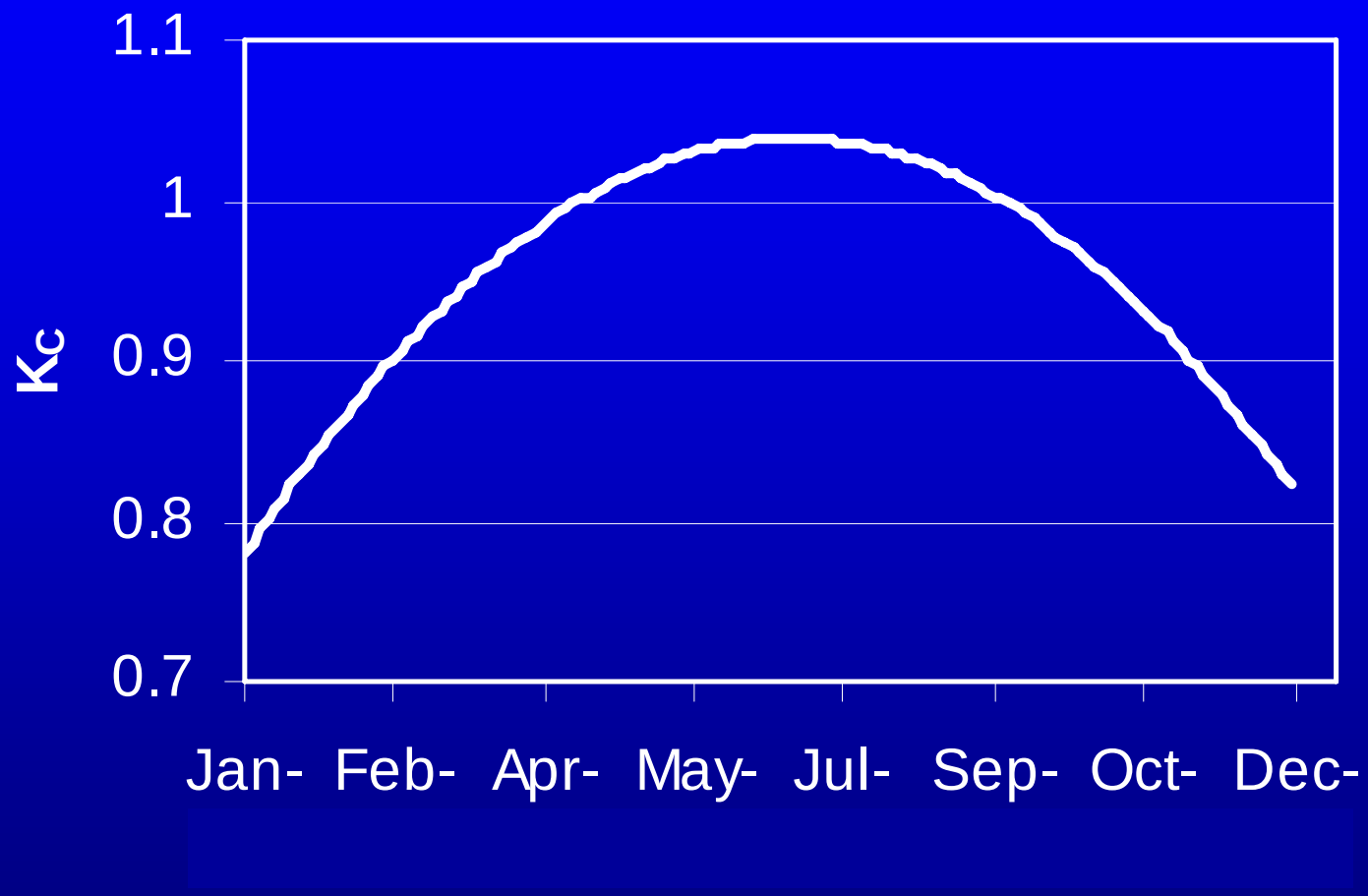
Effect of Time of Year



Source: Morgan et al. 2005

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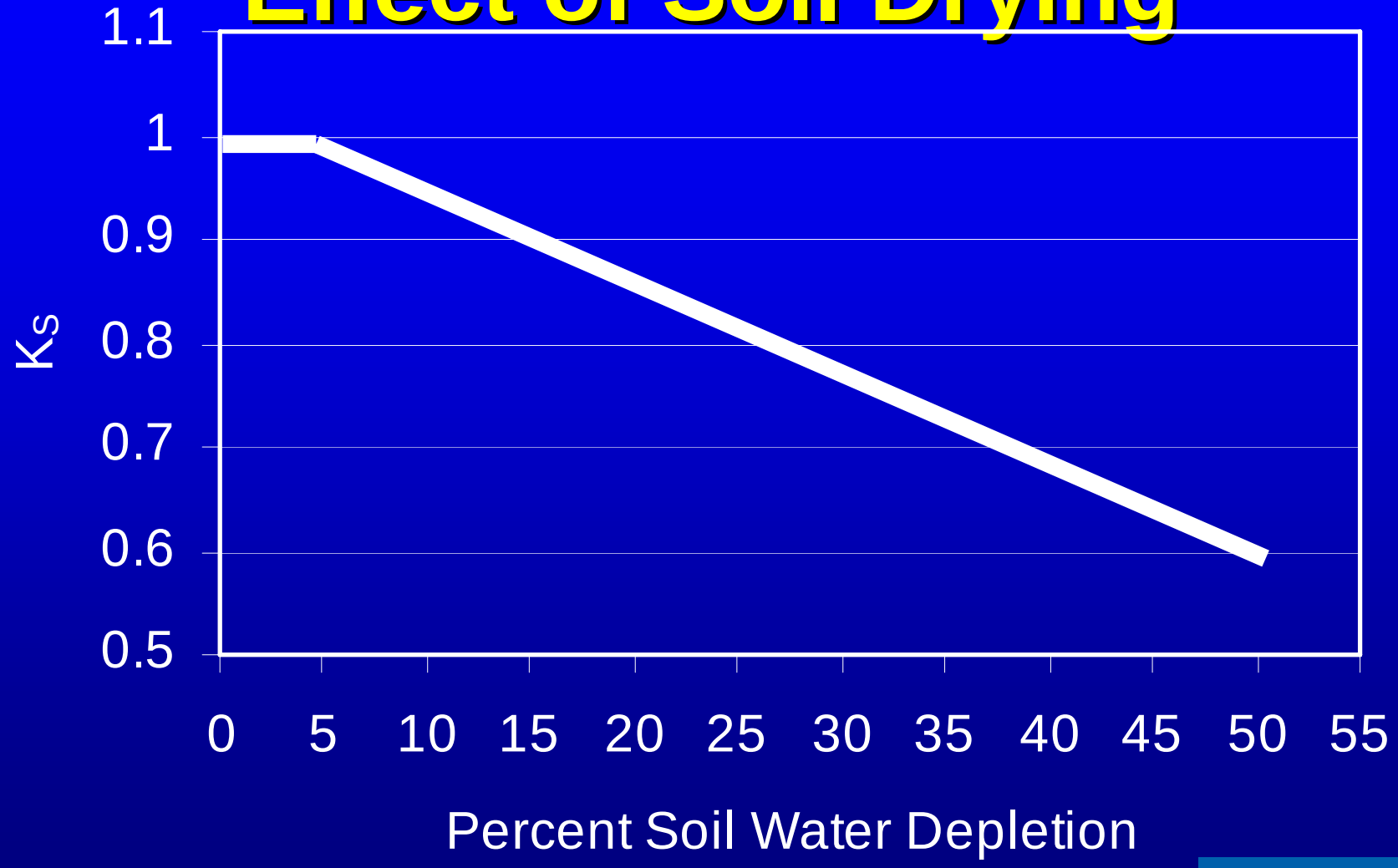
Effect of Soil Drying



Source: Morgan et al. 2005

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Irrigation requirements.

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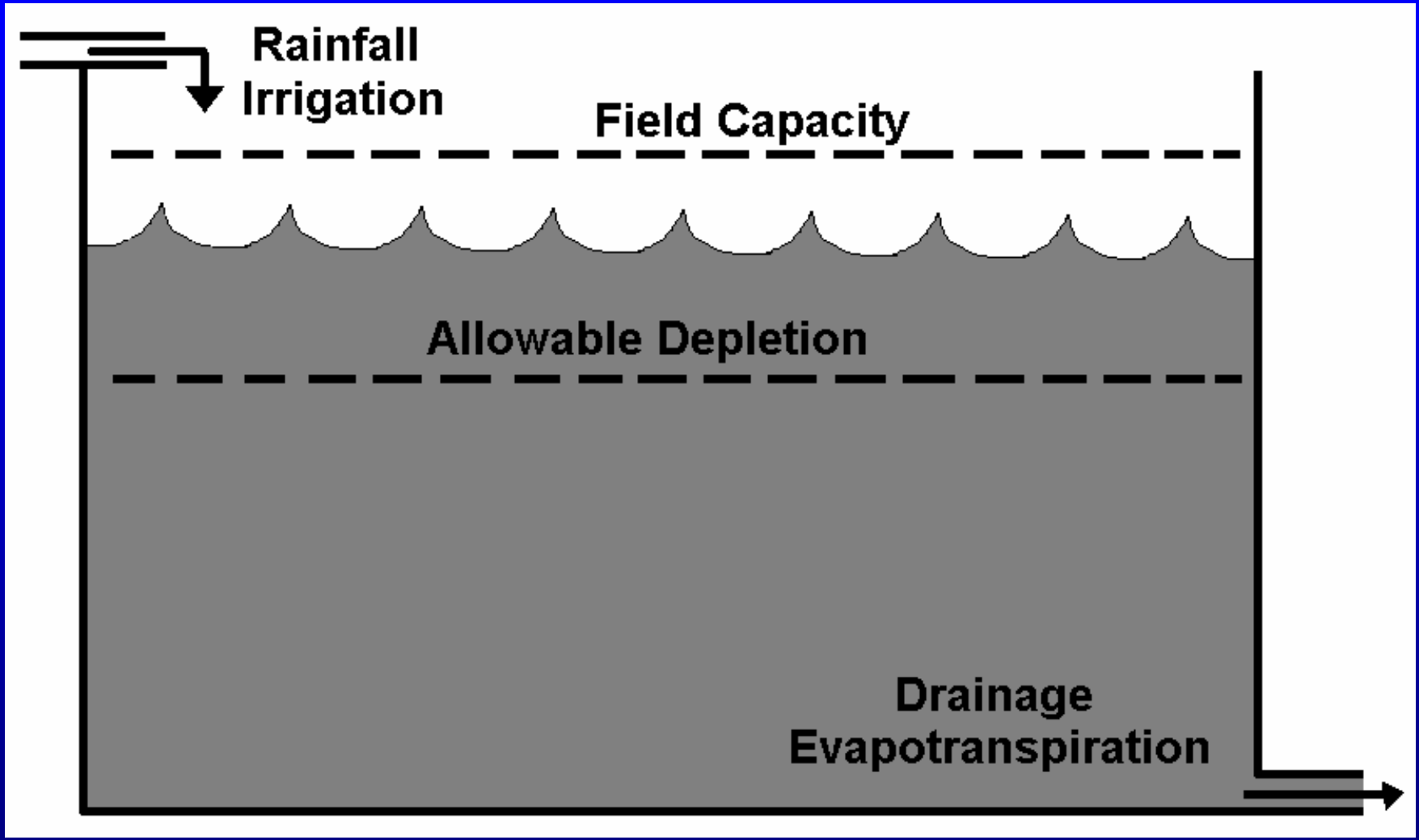

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Irrigation Trigger Point

- Irrigation should be started at a specific soil water content.
- The soil water content used depends on the stage of crop growth.

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Irrigation Trigger Point

- Spring (Feb.- May) Flowering, Flush, and Fruit set.
- Summer, Fall, and Winter (June - Jan.) Flush and Fruit Enlargement.
- Citrus recommendation are:

  25-33% Depletion Feb. - May

  50-66% Depletion June - Jan.

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Soil Water Now =
Soil Water Yesterday - ET

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Example of Irrigation Scheduling Month = June

	Historic ET_c	AW at Field Capacity	Depletion	Days between irrigations
	Inches			
25% Depletion	0.21	1.65	0.41	1.95
50% Depletion	0.21	1.65	0.83	3.95

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Irrigation Scheduling Methods

- Published Guidelines.
  - Not Specific to Grove
- Soil Water Status.
  - Can be Expensive
  - High Labor Requirement
- Soil Water Balance Models.
  - Requires Information about field and irrigation system
  - Computer Based

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Irrigation Schedule

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept	Oct.	Nov.	Dec.
ET (in/day)	0.07	0.11	0.13	0.18	0.20	0.21	0.20	0.19	0.16	0.12	0.09	0.06
Interval (days)	7-10	3-4	3-4	2-3	2-3	2-3	3-4	3-4	3-5	4-6	5-8	7-10
Duration (hours)	5-6	3-4	3-4	3-5	4-5	4-5	4-6	4-6	4-6	4-6	4-6	4-6

Source: HS 958 “Management of Microsprinkler Systems for Florida Citrus”, L.R. Parsons and K.T. Morgan.

Assumptions:

Field Capacity = 0.08 to 0.10 in/in
Rooting Depth = 18 inches
Application Rate = 0.1 to 0.15 in/hr
Depletion = 25% Spring, 50% summer - Winter

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Effect of Rooting Depth

	12 in. depth	18 in. depth	24 in. depth
Field Capacity (in/in)	0.09	0.09	0.09
	Available Soil Water (in)		
Feb. – June. (25%)	0.27	0.41	0.54
July- Jan. (50%)	0.54	0.81	1.08
	Irrigation Schedule		
Jan. (ET= 0.08)	6-7 days	10-11 days	13-14 days
	3-4 hours	5-6 hours	7-8 hours
May (ET=0.20)	1-2 days	2-3 days	2-3 days
	1-2 hours	2-3 hours	3-4 hours
August (ET=0.22)	2-3 days	3-4 days	4-5 days
	3-4 hours	5-6 hours	7-8 hours

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Overview of soil water status sensors.

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Soil Water Status

- Soil Water Content – Electronic Sensors
  - Most accurate method to determine irrigation scheduling and application amount
  - Highest cost
- Soil Water Tension - Tensiometers
  - Measures status not soil water content
  - Must know soil characteristic to determine irrigation schedule and application amount

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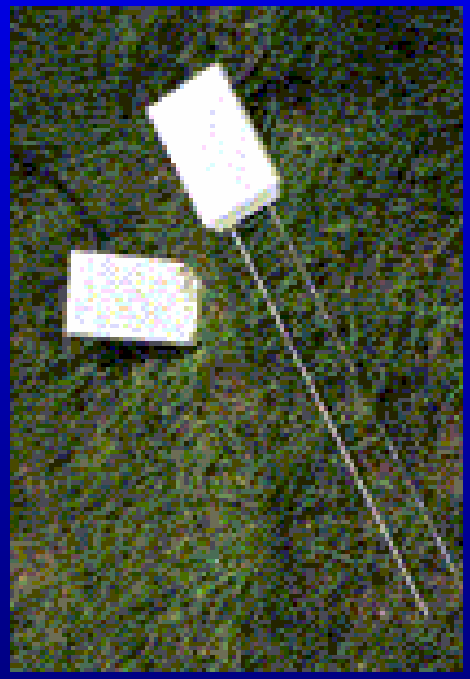
Soil Water Content

Multi Sensor Arrays

Single Sensor Probes

Time Domain Reflectometry



Access Tube Sensor

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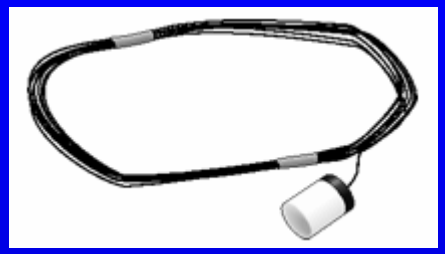
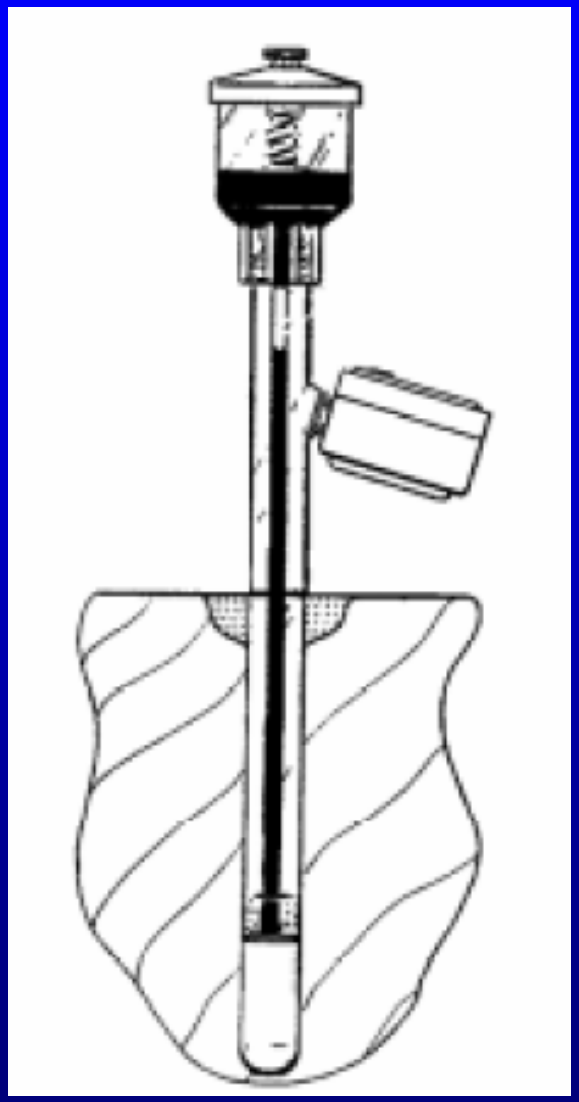
Soil Water Potential



Resistance Sensors



Tensiometers

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Web and site-specific irrigation scheduling tools.

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Soil Water Balance

- Daily Soil Water Loss – Evapotranspiration (ET).
  - Evaporation from soil surface.
  - Transpiration from citrus trees.
- Calculate ET for the crop.
  - Table of historic ET values for the crop.
  - Calculate from reference ET (FAWN)

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Computer Programs

- Web based
  - schedule based on nearest station
  - Enter: Field capacity, tree spacing, irrigation specifications
- PC Irrigation program
  - Select FAWN site
  - Same information required
  - Stores irrigation data
  - Print reports

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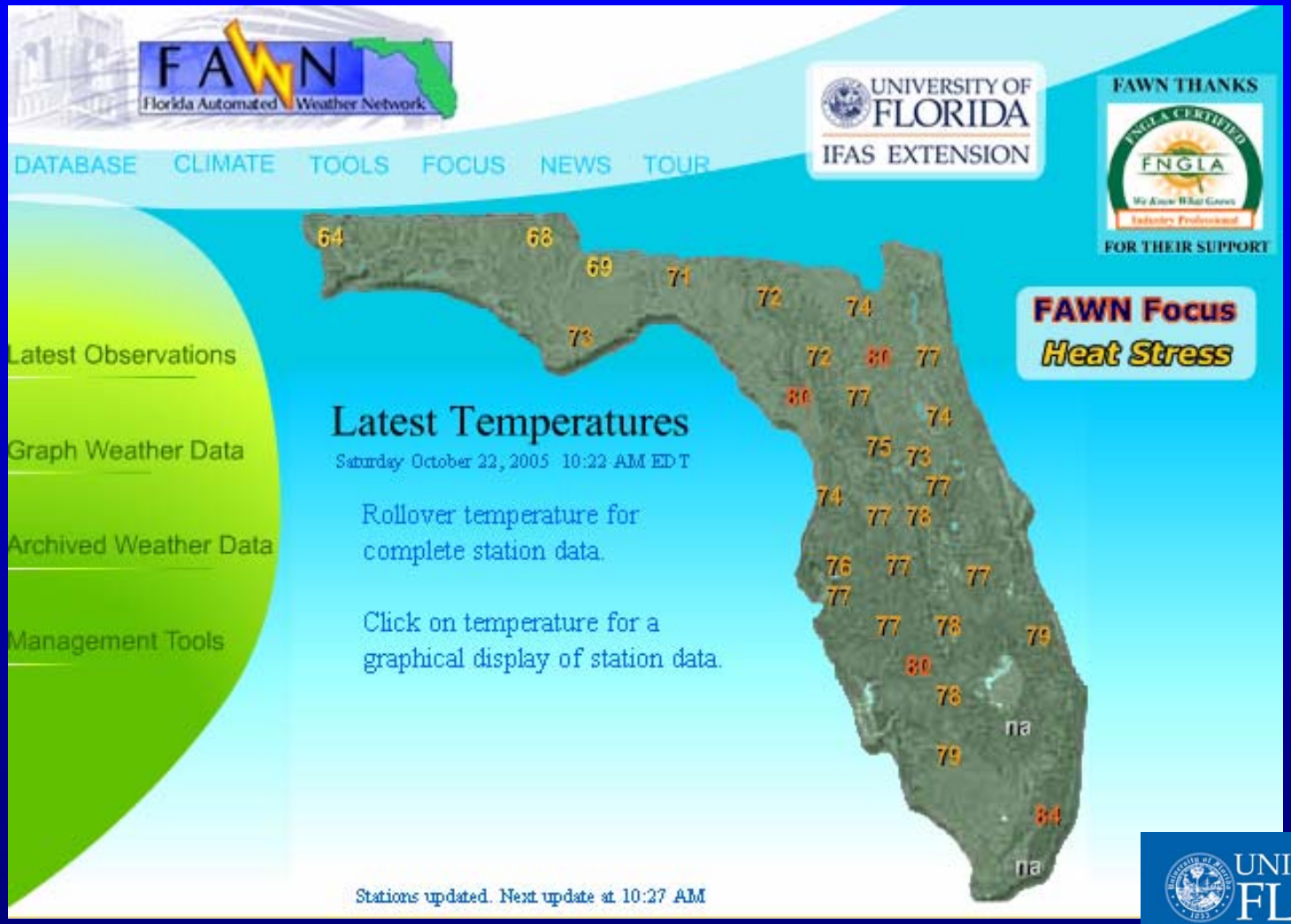
Florida Automated Weather Network (http://FAWN.IFAS.UFL.EDU)



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Web-based Tool

- Required Information
  - FAWN station for ET.
  - Tree spacing, irrigation depth, irrigation specifications.
  - Soil field Capacity (can be selected from list).
  - Allowable seasonal depletion (can select default values).
- Outputs
  - Crop ET.
  - Interval between irrigations.
  - Duration of irrigation.

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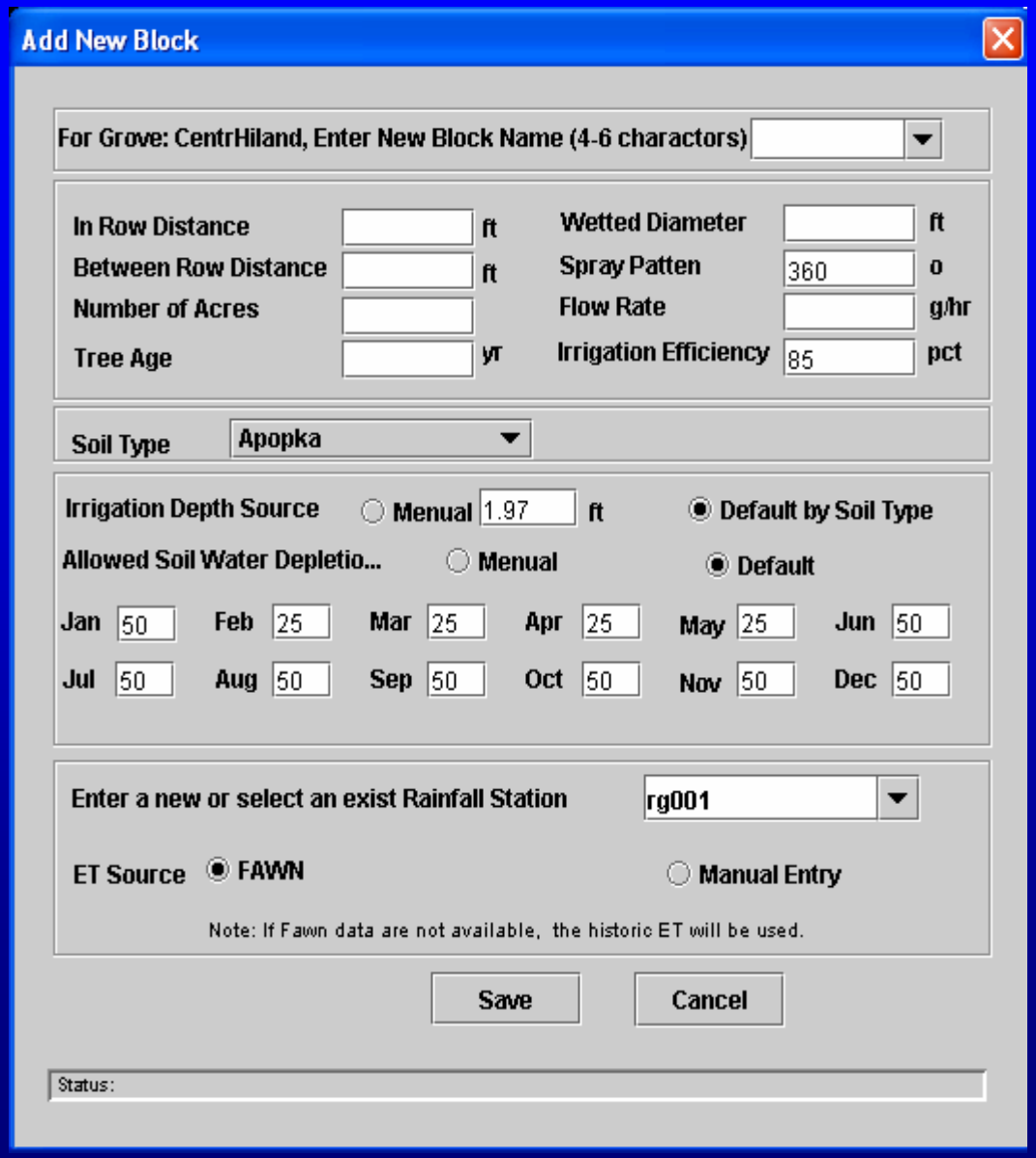
PC-based Site Specific Management System



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PC-based Site Specific Management System

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PC-based Irrigation Management System

- Site Specific (Multiple Fields) Information
  - Estimated soil water content by soil layer.
  - Crop water uptake and stress index.
  - Field specific irrigation schedule.
  - Water use by field.
- Irrigation Schedule
  - Date specific.
  - Duration to fill each soil layer to irrigation depth to field capacity.
  - Alternate irrigation dates and durations

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Conclusions

- Soil type is key to root distribution.
- Depth of rooting is key to irrigation scheduling decisions.
- Water quantity and quality issues will impact agricultural water use in areas of increasing development.
- Irrigation scheduling varies seasonally by weather conditions.
- Three methods of irrigation scheduling are: tables, sensors, and models.

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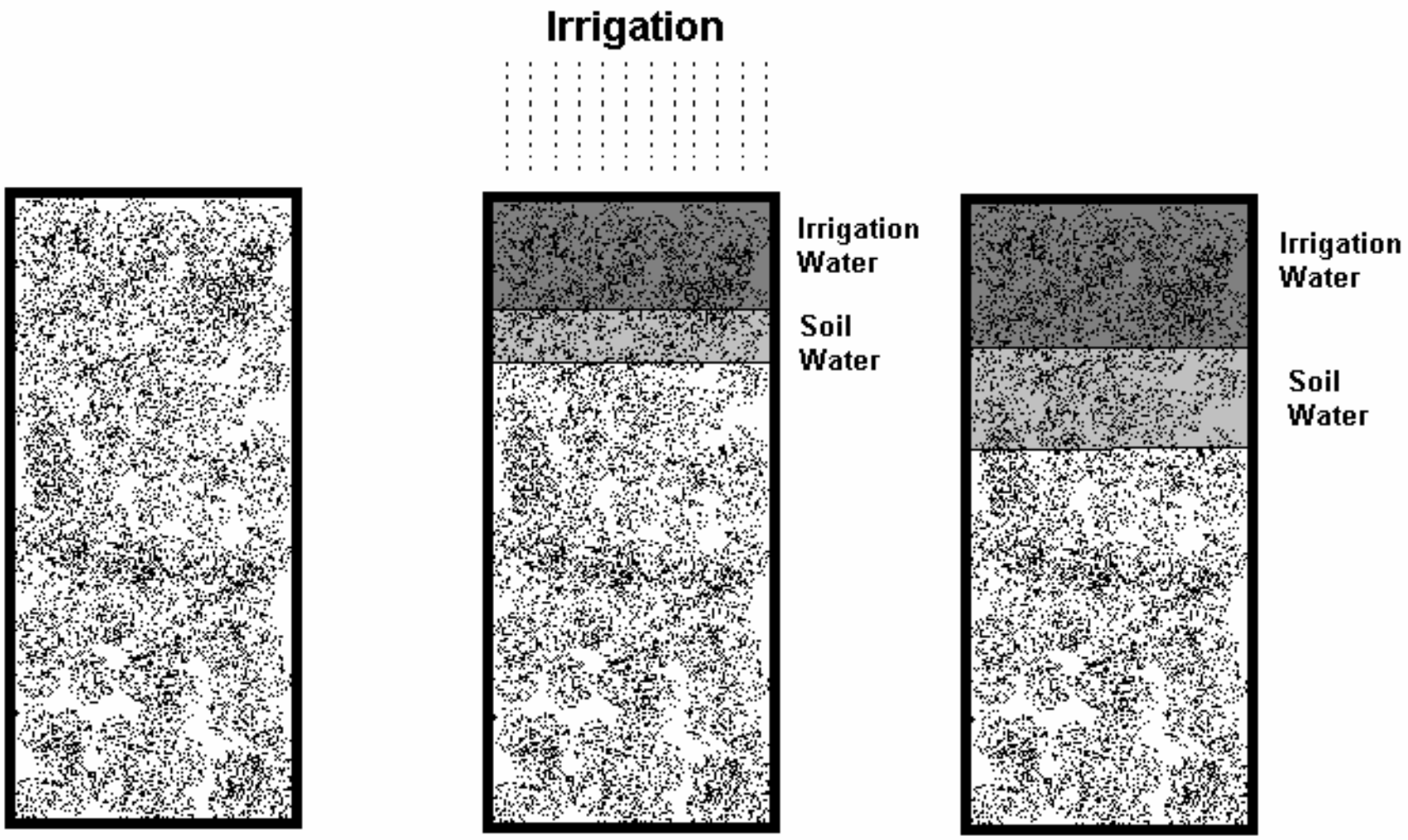

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Infiltration Depth of Water Applied

$$I = \frac{A}{FC}$$

Where: I = Infiltration depth of applied water (in)

A = Depth of water applied (in)

FC = Field capacity of soil (in/in or % divided by100)

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Total Soil Depth to Field Capacity

$$I_t = \frac{A + W}{FC}$$

Where: I_t = Total water depth to field capacity (in)

A = Depth of water applied (in)

W = Depth of water to infiltration depth (in)

FC = Soil field capacity (in/in or % divided by 100)

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Depth of 1.0 inch of Rainfall

Assume:

- **Candler Fine Sand – FC = 8%**
- **Soil Water Content – 6% (1/3 depletion)**
- **Rainfall - 1.0 Inches**

$$I = \frac{A}{FC} = \frac{1.0}{0.08} = 12.5 \text{ inches}$$

$$W = I * SWC = 12.5 * 0.06 = 0.75 \text{ inches}$$

$$I_t = \frac{A + W}{FC} = \frac{1.0 + 0.75}{0.08} = 21.87 \text{ inches}$$

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Depth of 0.5 inch of Irrigation

Assume:

- **Candler Fine Sand – FC = 8%**
- **Soil Water Content – 6% (1/3 depletion)**
- **Irrigation Depth - 0.5 Inches**

$$I = \frac{A}{FC} = \frac{0.5}{0.08} = 6.25 \text{ inches}$$

$$W = I * SWC = 6.25 * 0.06 = 0.375 \text{ inches}$$

$$I_t = \frac{A + W}{FC} = \frac{0.5 + 0.375}{0.08} = 10.94 \text{ inches}$$

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Weak Tree with Damaged Root System

Healthy Tree with Normal Root System

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Weak Tree with Damaged Root System

Healthy Tree with Normal Root System

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Severely Damaged Roots

Recovering Root System

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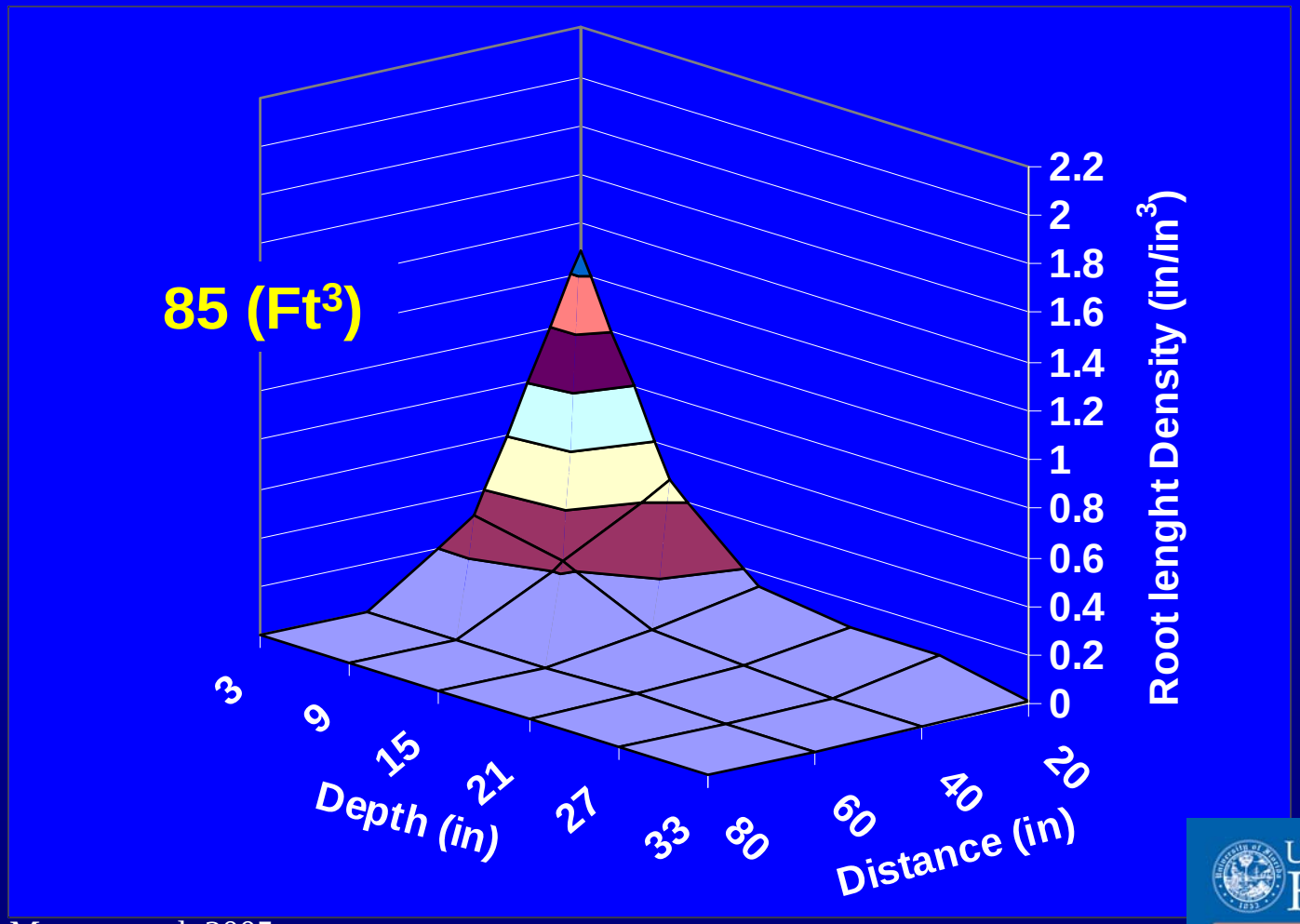
Effect of Canopy Volume on Root Length Density



Source: Morgan et al. 2005

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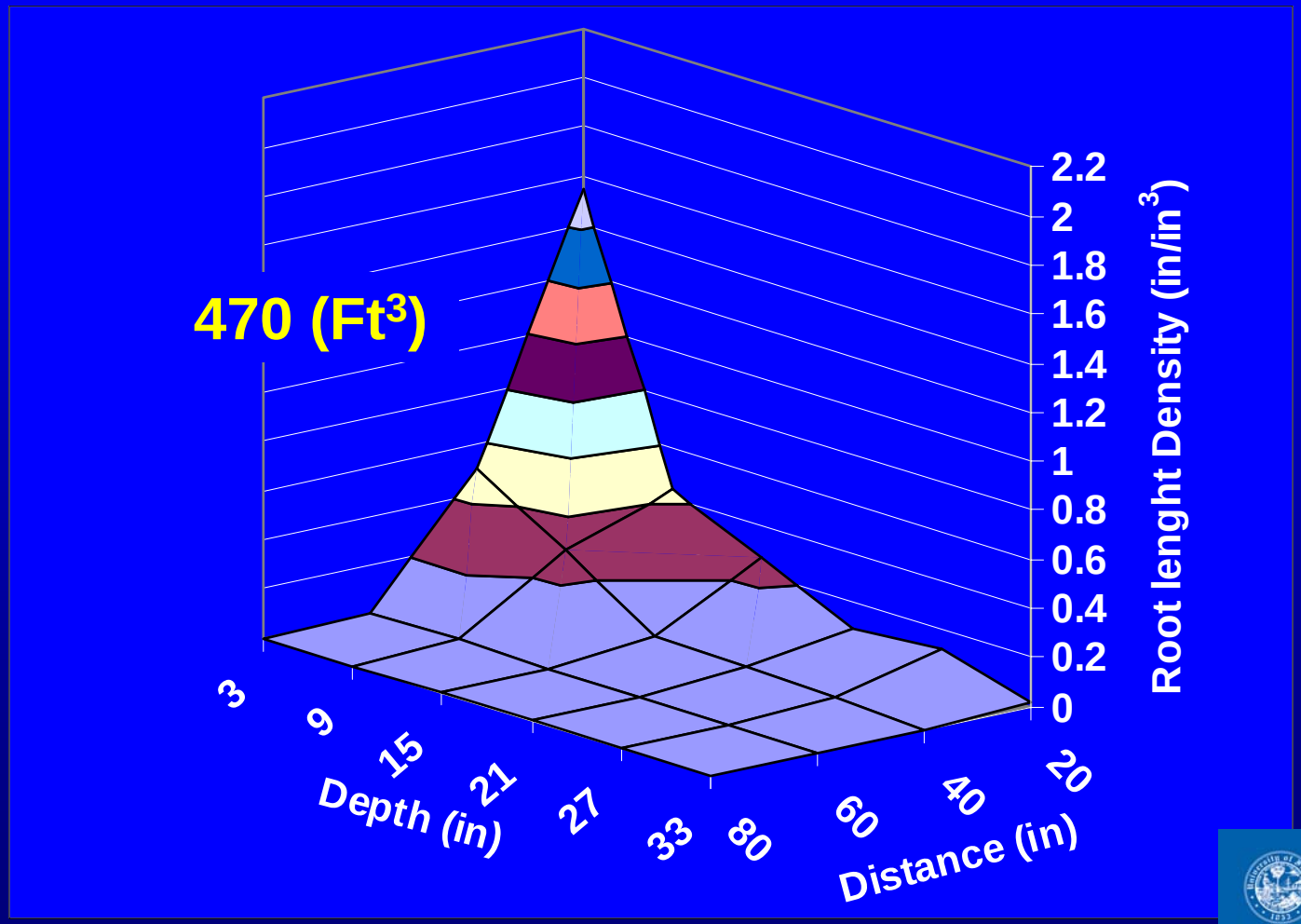
Effect of Canopy Volume on Root Length Density



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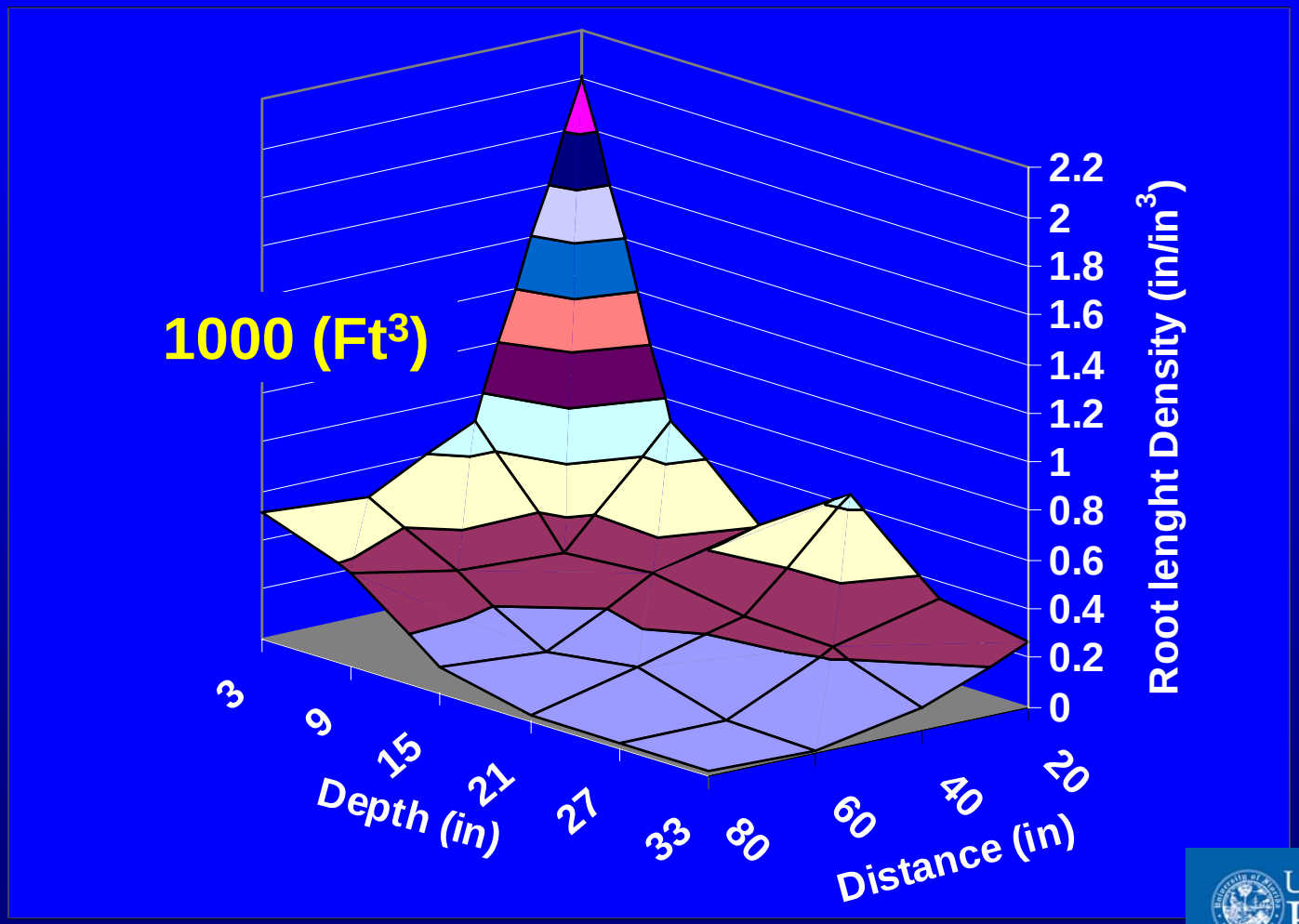
Effect of Canopy Volume on Root Length Density



Source: Morgan et al. 2005

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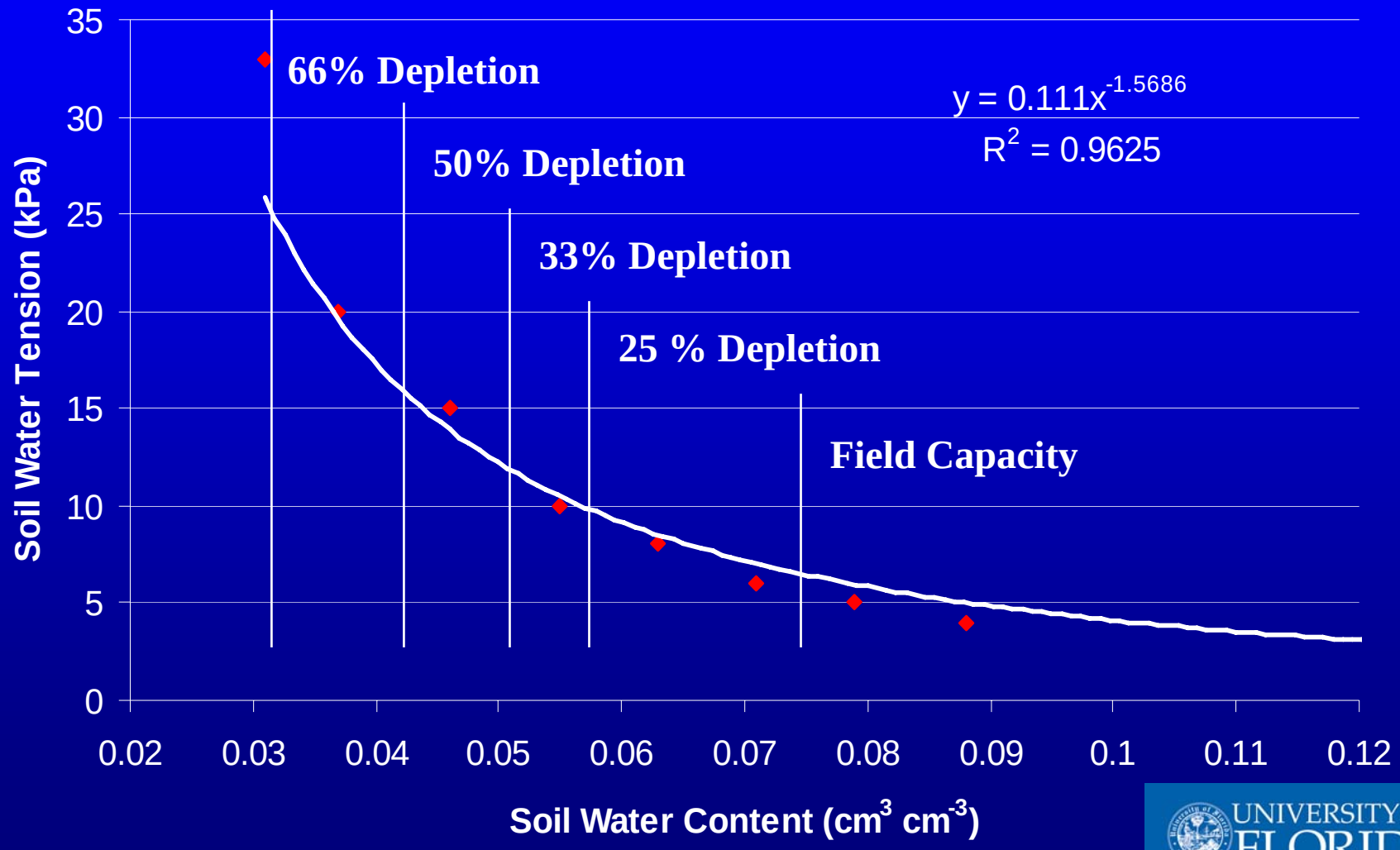
Soil Water Retention



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Alfisols (Pineda, Riviera, Wabasso, Winder)

Soil Layer	Thickness (Inches)	Organic Matter	Clay Content	Available Water	Permeability (in/hr)
A horizon	3-6	1-4%	< 5%	7-10%	6-20
E horizon	18-24	< 0.5%	< 5%	5-7%	6-20
Bt horizon	12+	< 0.5%	10-30%	12-16%	< 0.2

Source: USDA, NRCS, Soil Survey of St. Lucie County, Florida

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Ridge Soil Types

Entisol

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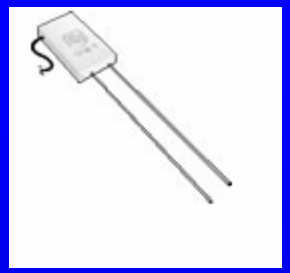

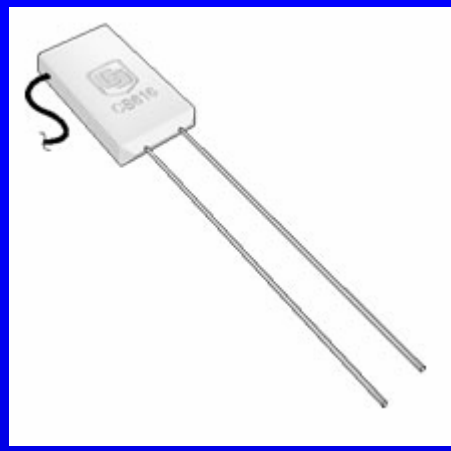

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Water Table Depth Monitoring

- Soil water status
  - Tensiometers
  - Soil water content sensors
- Water table wells
  - Recording depth measurement devices
  - Manual (float) gauges

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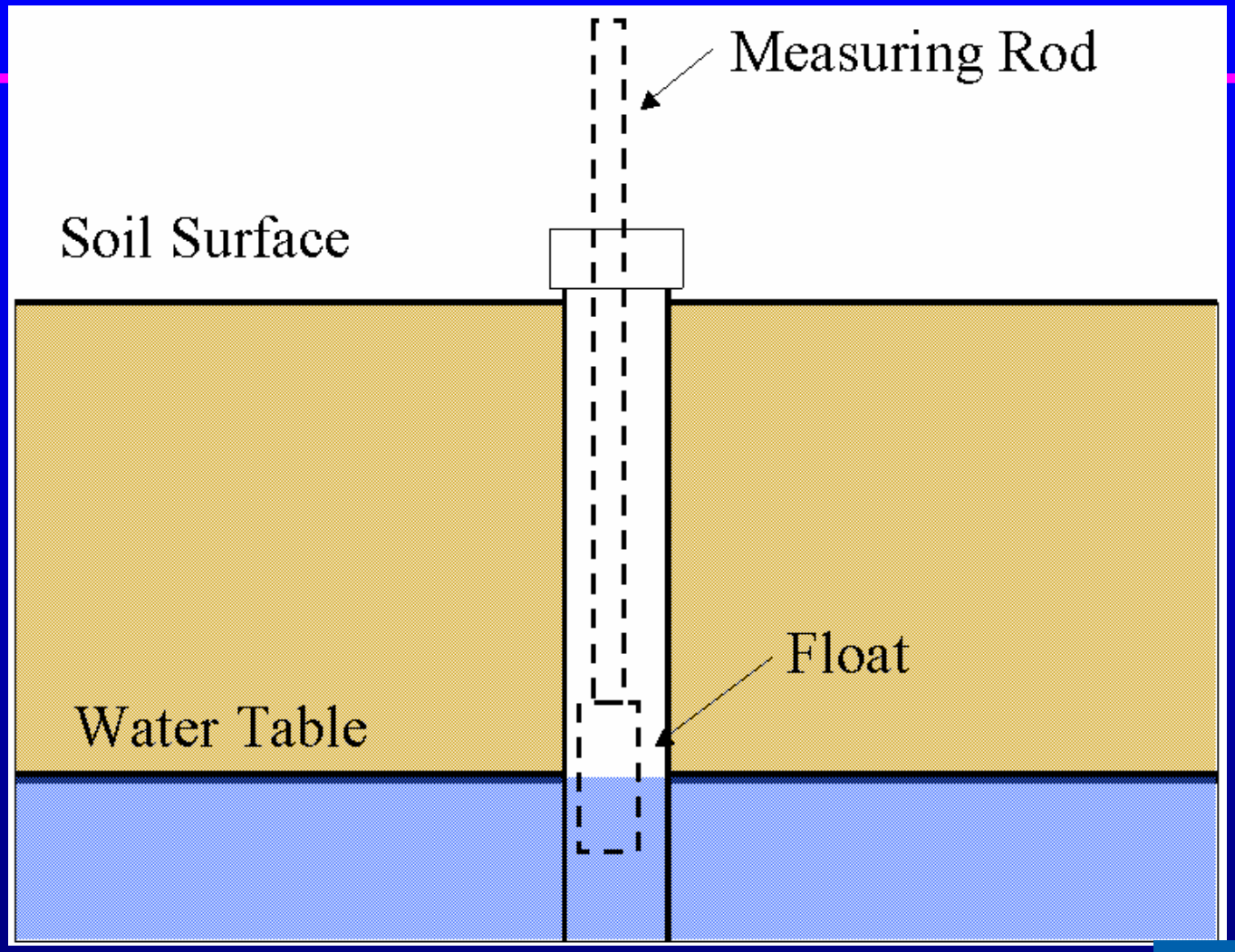
Water Table Observation Well



Source: Circular 1409, Florida Cooperative Extension Service, IFAS, University of Florida, Boman and Obreza

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Simulation Report

Result Table | Result Chart : Total Layers | Result Chart : Experiment vs Model

CWMS Report Center

BlockID : Grove 1Block1 Day : 23 Month : 10 Year : 2005 Refresh

Total Root Length : 7181638.790 Today Date on Simulation : 10-23-2005

Daily Report | Monthly Report | Yearly Report

Area : Irrigated Area Refresh Daily Data

Soil Profile#	Layer#	Root Section#	RootLength pct	WC(%)	NH4 Concnetra...	NO3 Concnetrat...	Ks used
1	1	-	1.95	0.06952	-	-	0.3659
1	2	-	1.95	0.06952	-	-	0.3659
1	3	-	1.95	0.06952	-	-	0.3659
1	4	-	0.68	0.07504	-	-	0.6255
1	5	-	0.68	0.07504	-	-	0.6255
1	6	-	0.68	0.07356	-	-	0.6051
1	7	-	0.37	0.08105	-	-	0.7538
1	8	-	0.37	0.08105	-	-	0.7538
1	9	-	0.37	0.08105	-	-	0.7538
1	10	-	0.44	0.07654	-	-	0.6981
1	11	-	0.44	0.07654	-	-	0.6981
1	12	-	0.44	0.07654	-	-	0.6981
1	13	-	0.41	0.08785	-	-	0.7538
1	14	-	0.41	0.08785	-	-	0.7538

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CWMS Daily Report for February, 2005

BlockID g1b1z1 | Day 1, Month Feb., Year 2005 | Total Root Length :_

Irrigation Zone							Non-Irrigation Zone						
Soil Profile#	Layer#	Root Section#	Root Length pct	WC (%)	NH4 Concentration (%)	NO3 Concentration (%)	Soil Profile#	Layer#	Root Section #	Root Length pct	WC (%)	NH4 Concentration (%)	NO3 Concentration (%)
1	1	1											
1	2	1											

Monthly Report for February, 2005

BlockID g1b1z1 | Month Feb., Year 2004

Day	Interval (day)	Duration (hours)	ETo Source	ETo Used (inches/day)	Ks used	Kc Used	ETc Used (inches/day)
Feb. 1	3	0.8					
Feb. 2							

Yearly Report (Monthly data used) for year 2005

BlockID g1b1z1 | Year 2004

Month	Set Point Depth Source	Set Point Depth (cm)	Irrigation Depth Source	Irrigation Depth (cm)
Jan.				

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Decision Support Systems

Add New Block

Grove | Block | Zone

In Row Distance		ft	Wetted Diameter		ft
Between Row Distance		ft	Spray Patten	360	o
Number of Acres			Flow Rate		g/hr
Tree Age	>15	yr	Irrigation Efficiency	85	%

Soil Series: Apopka

Irrigation Depth: 3 ft

Allowed Soil Water Depletion

Jan	50	Feb	25	Mar	25	Apr	25	May	25	Jun	50
Jul	50	Aug	50	Sep	50	Oct	50	Nov	50	Dec	50

Crop Coefficient

Jan	0.85	Feb	0.80	Mar	0.90	Apr	0.95	May	1.10	Jun	1.15
Jul	1.15	Aug	1.10	Sep	1.05	Oct	0.90	Nov	0.85	Dec	0.85

Rainfall Station

ET Source: (•) FAWN ALACHUA ( ) Manual Entry ( ) Historic Data

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