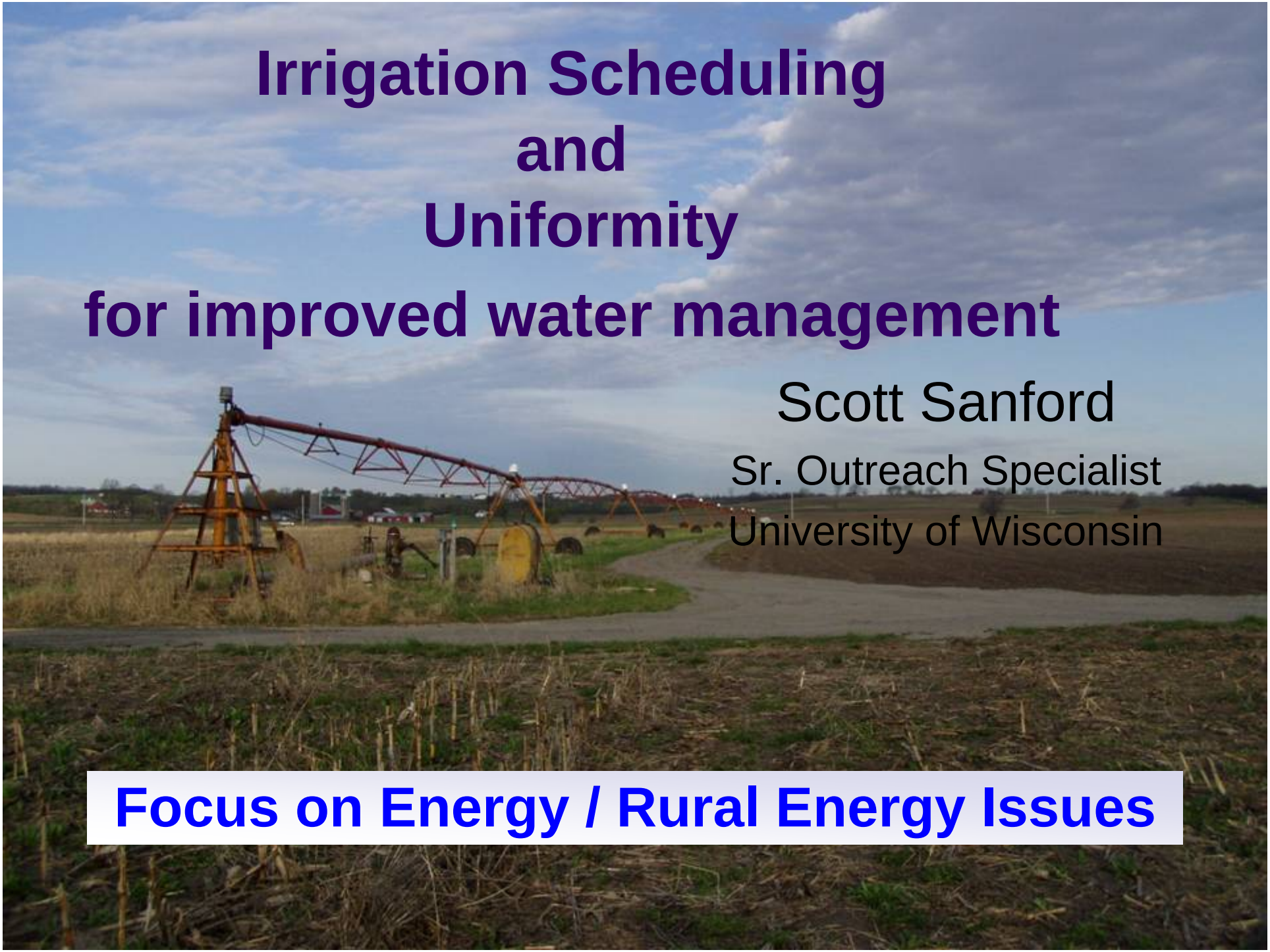
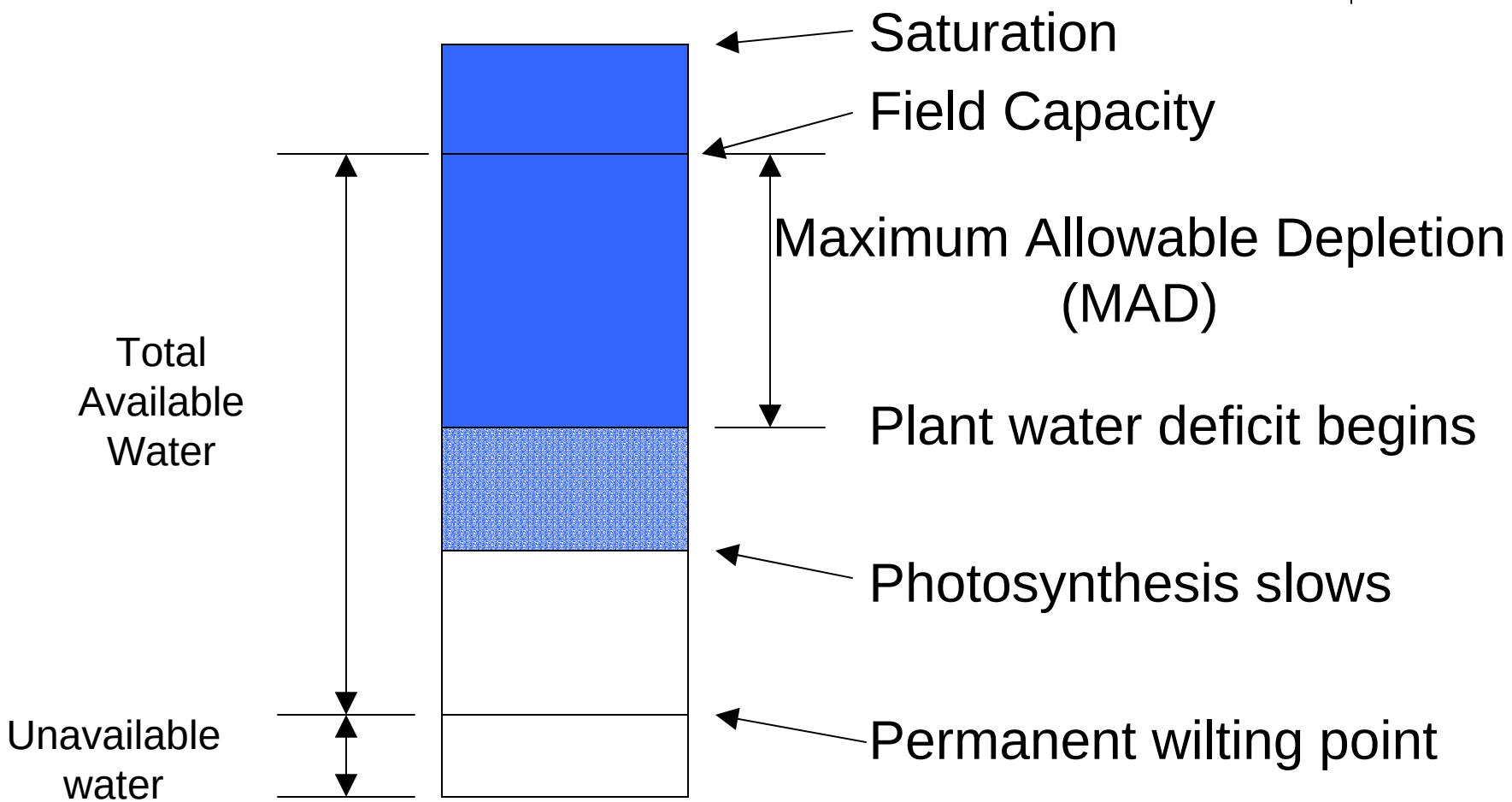


Irrigation Scheduling and Uniformity for improved water management

Scott Sanford
Sr. Outreach Specialist
University of Wisconsin

Focus on Energy / Rural Energy Issues

Soil Moisture Primer



Plant Water Extraction Pattern

Figure 3–2 Typical water extraction pattern in uniform soil profile

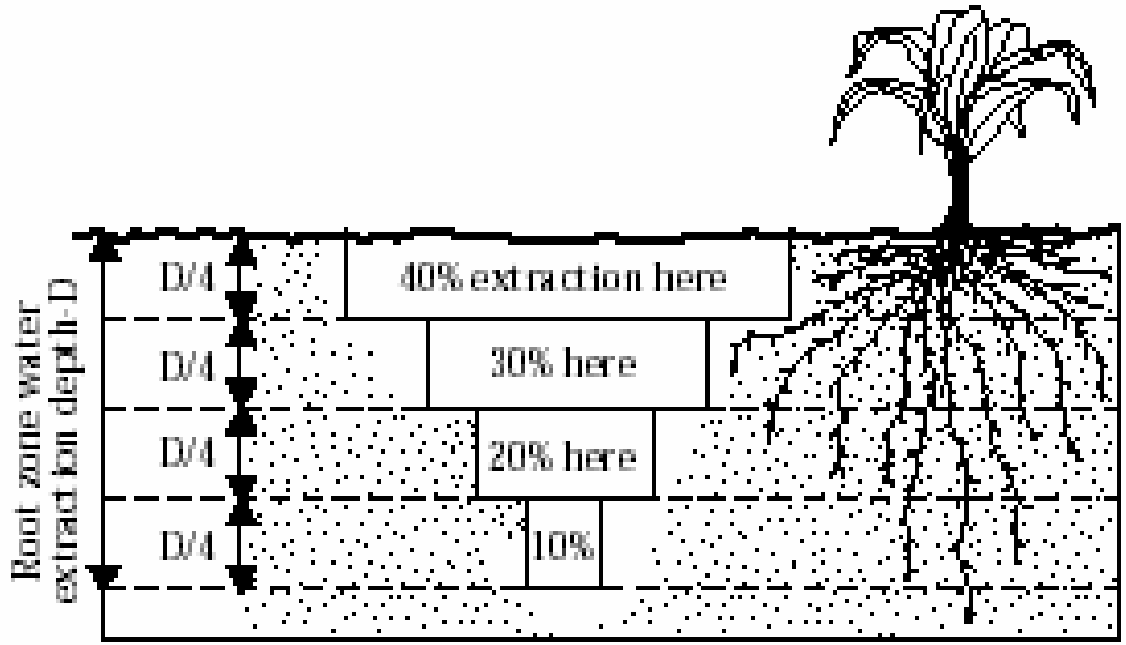
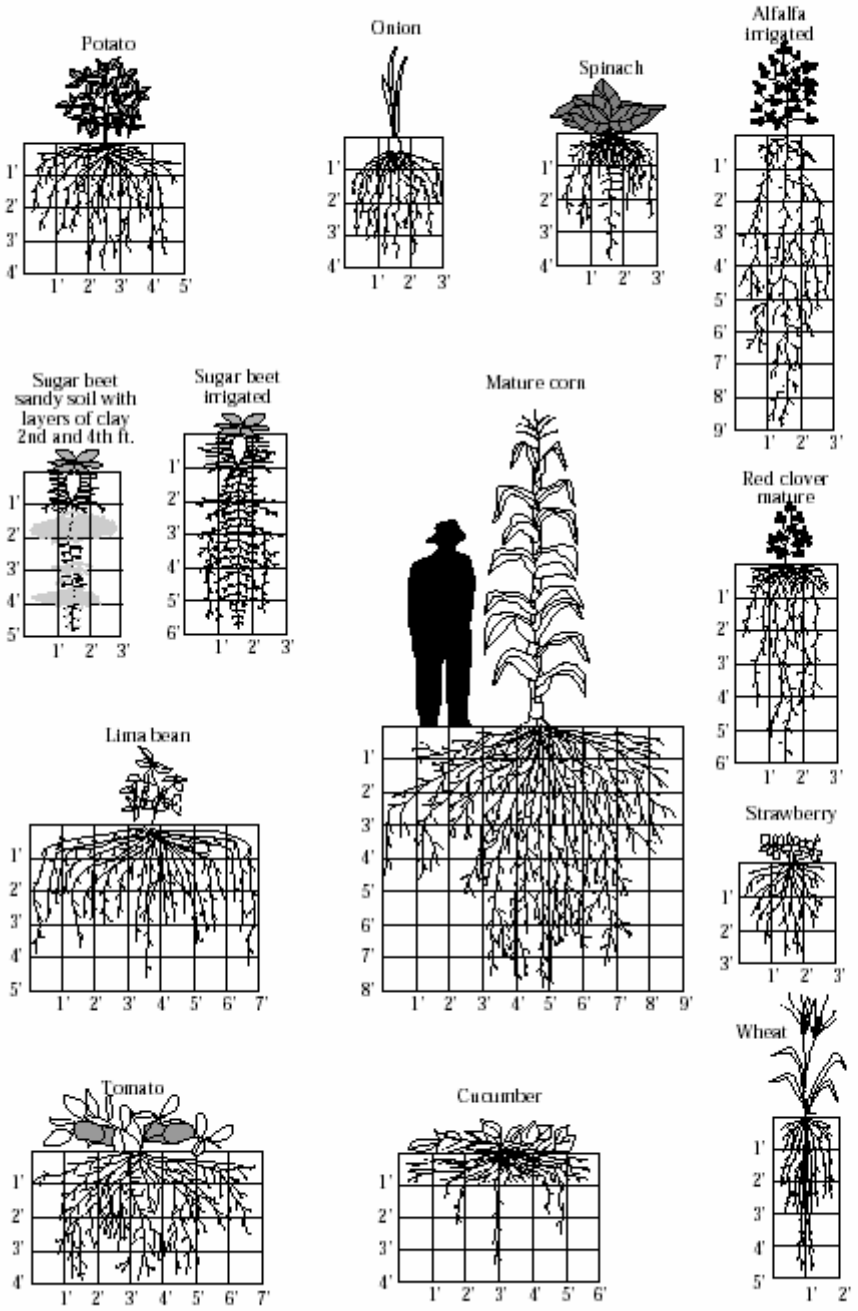


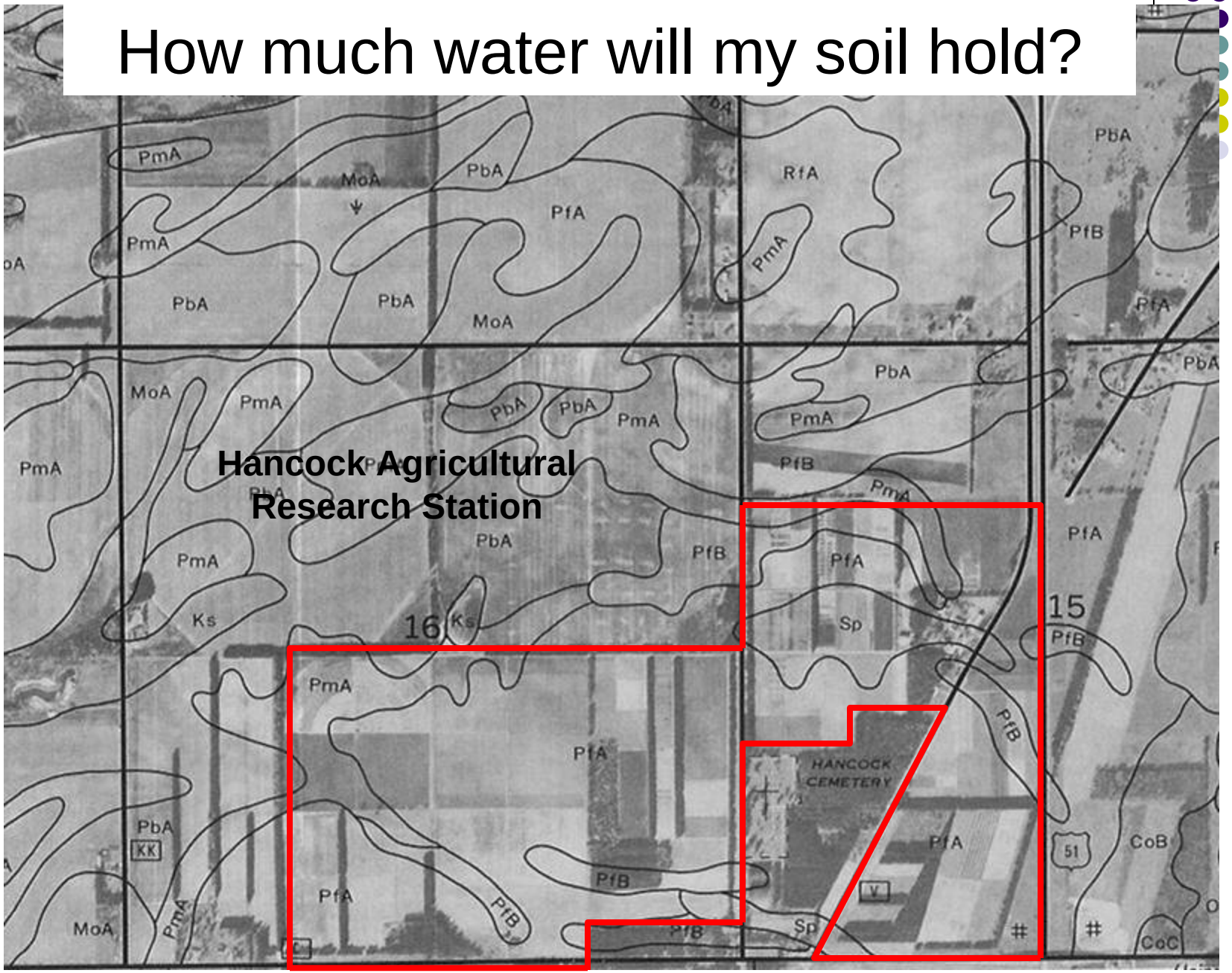
Figure 3–1 Root distribution systems—deep homogenous soils with good water management and no soil restrictions



Soil Moisture Management

	Managed Root zone	Max. Allow Depletion	Critical Period
Potatoes	18-24”	35% - 50% 50%@ vine kill	Flowering and tuber formation to harvest
Peas	24”	50%	Start of flowering and when pods are swelling
Green beans	24”	40%	Blossom through Harvest
Sweet Corn	24”	50% @ estabish 40% until harvest	Tasseling thru silk stage until kernels are firm
Grain Corn	36-48”	50%	Tasseling thru silk stage until kernels are firm

How much water will my soil hold?



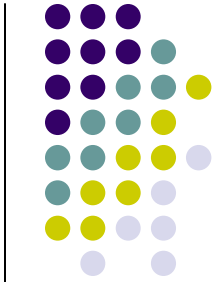
Soil Water Holding Capacity

Soil type	Depth (in)	AWC (in/in)	AWC 18 in.	AWC 24 in.	AWC 48 in.
Sp (Sparta)	0-18 18-27 27-60	0.09-0.12 0.05-0.11 0.04-0.07	1.89	2.37	3.76
PfA PfB (Plainfield)	0-7 7-36 36-60	0.04-0.09 0.04-0.07 0.03-0.07	1.06	1.39	2.65
PmA (Plainfield)	0-7 7-53	0.07-0.09 0.04-0.08	1.22	1.58	3.02

Max Allowable Depletion (inches)

Soil type	AWC 18 in.	MAD 35% 50%	AWC 24 in.	MAD 35% 50%	AWC 48 in.	MAD 50%
Sp (Sparta)	1.89	0.66 0.94	2.37	0.83 1.18	3.76	1.88
PfA PfB (Plainfield)	1.06	0.37 0.53	1.39	0.48 0.70	2.65	1.32
PmA (Plainfield)	1.22	0.42 0.61	1.58	0.55 0.79	3.02	1.51

Evapo-transpiration Values



- UW Crop ET Values
  - www.soils.wisc.edu/wimnext/water.html
  - Based on Priestley & Taylor equation
    - Inputs – Solar radiation, Temperature, soil heat flux
    - Accuracy : +/- 15-20%
  - Correct for % of canopy coverage under 80%.
    - Refer to Appendix Table C in UW Extension bulletin A3600 “Irrigation Management in Wisconsin”

- Other methods
  - Based on Grass or Alfalfa Reference
  - K-factors - Correction of reference ET value for specific crop

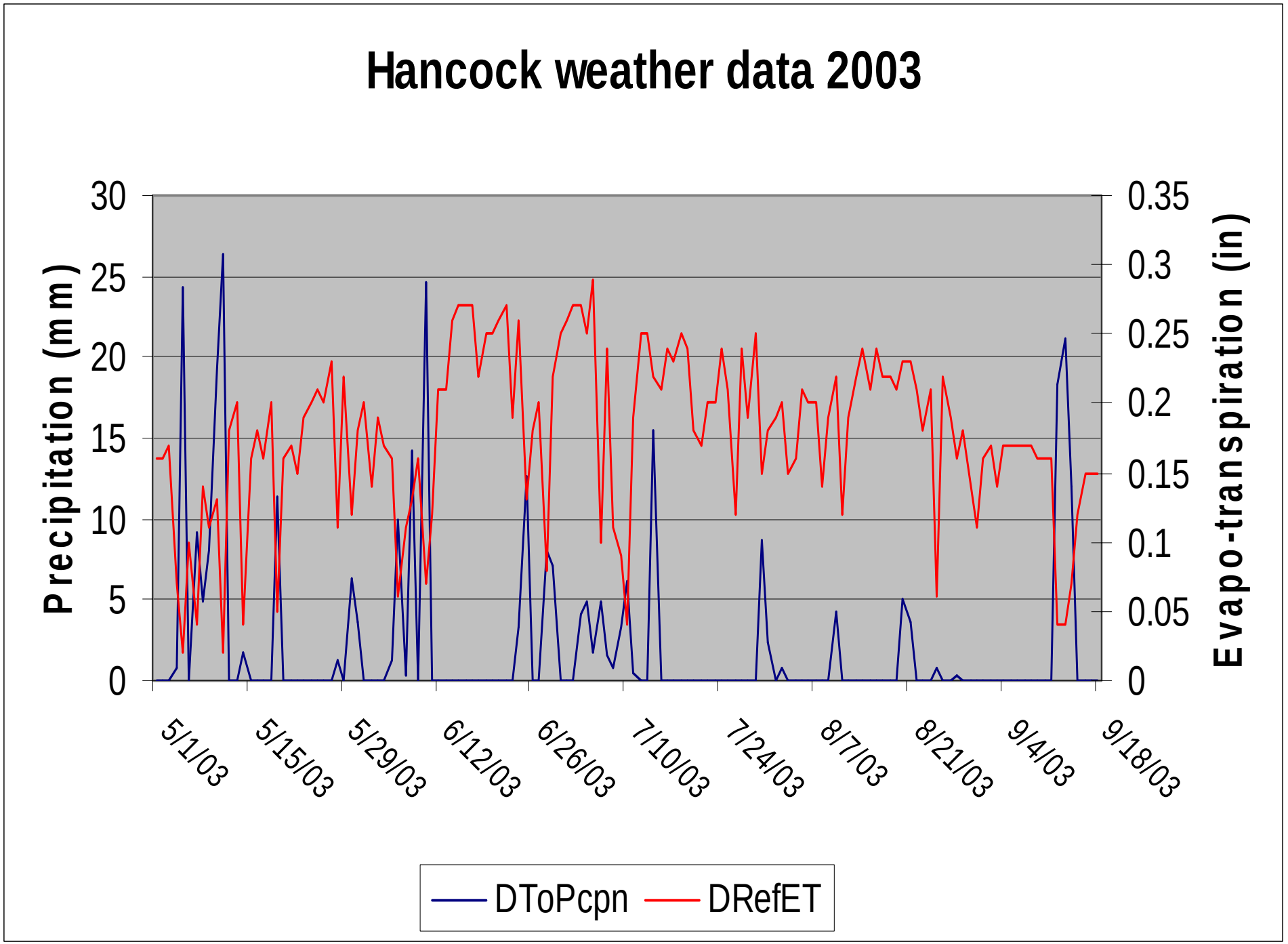
ET adjustment table

Appendix Table C. Evapotranspiration (ET) estimates adjusted for % crop canopy cover (for use with WISP)

ET estimate in inches	% crop cover								
	0	10	20	30	40	50	60	70	80
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02
0.04	0.00	0.00	0.01	0.02	0.03	0.03	0.04	0.04	0.04
0.06	0.00	0.01	0.02	0.03	0.04	0.05	0.05	0.06	0.06
0.08	0.00	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.08
0.10	0.00	0.02	0.04	0.05	0.07	0.08	0.09	0.10	0.10
0.12	0.00	0.03	0.05	0.06	0.08	0.09	0.11	0.11	0.12
0.14	0.00	0.03	0.05	0.07	0.09	0.11	0.12	0.13	0.14
0.16	0.01	0.04	0.06	0.08	0.11	0.13	0.14	0.15	0.16
0.18	0.01	0.04	0.07	0.09	0.12	0.14	0.16	0.17	0.18
0.20	0.01	0.05	0.08	0.11	0.13	0.16	0.18	0.19	0.20
0.22	0.01	0.05	0.08	0.12	0.15	0.17	0.19	0.21	0.22
0.24	0.01	0.06	0.09	0.13	0.16	0.19	0.21	0.23	0.24
0.26	0.01	0.06	0.10	0.14	0.17	0.20	0.23	0.25	0.26
0.28	0.01	0.06	0.11	0.15	0.19	0.22	0.25	0.27	0.28
0.30	0.01	0.07	0.12	0.16	0.20	0.23	0.26	0.28	0.30
0.32	0.02	0.07	0.12	0.17	0.21	0.25	0.28	0.30	0.32
0.34	0.02	0.08	0.13	0.18	0.23	0.26	0.30	0.32	0.34
0.36	0.02	0.08	0.14	0.19	0.24	0.28	0.32	0.34	0.36

*To use this table, you must have an estimate of the current % crop canopy cover and the ET estimate provided by University of Wisconsin-Extension, Cooperative Extension. You can obtain the ET estimate by calling the toll-free IPM PEST Phone at (800) 236-4264. Outside Wisconsin, call (608) 262-4264.

To adjust the ET estimate for canopy cover, select the appropriate % crop cover value. Move right to the column headed by the ET estimate. The value at the intersection is the adjusted ET estimate.

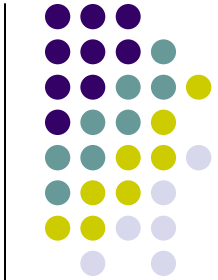

Hancock weather data 2003
Precipitation (mm)
Evapo-transpiration (in)
30
25
20
15
10
5
0
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5/1/03
5/15/03
5/29/03
6/12/03
6/26/03
7/10/03
7/24/03
8/7/03
8/21/03
9/4/03
9/18/03
DToPcpn
DRefET

Rain Gauges

- Accurate measurements of field conditions
- Install 3 in every field
  - Records rain and irrigation
- Low evaporation rates
  - < 1% per week

Figure 1: Irrigage built from thin-walle
PVC pipe and plastic bottle

Irrigation Scheduling



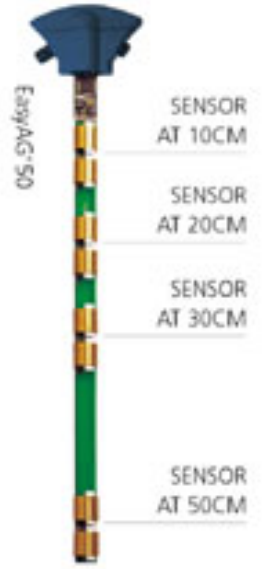
- Check book method
  - Only water when necessary
  - Use enough to grow a high quality crop
  - ET (evapo-transpiration) values available from UW
    - Can be e-mailed to you daily

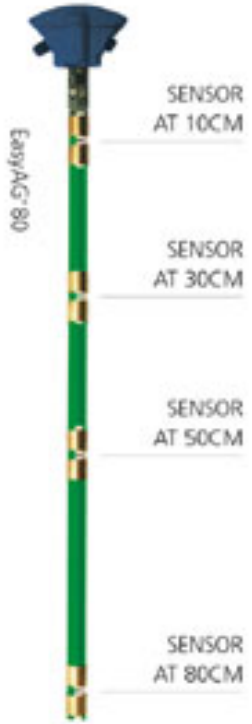
- Program or manually
  - Manually - Extension Bulletin A3600 – Irrigation Management in Wisconsin
  - WISP – WI Irrigation Scheduling Program
    - Real Toolbox – Farm Management System
    - Excel spreadsheet
      - http://www.soils.wisc.edu/wimnext/water.html


CS615


ECH2


DIVINER


EasyAG'50
SENSOR AT 10CM
SENSOR AT 20CM
SENSOR AT 30CM
SENSOR AT 50CM


EasyAG'80
SENSOR AT 10CM
SENSOR AT 30CM
SENSOR AT 50CM
SENSOR AT 80CM

What soil moisture sensors tell.

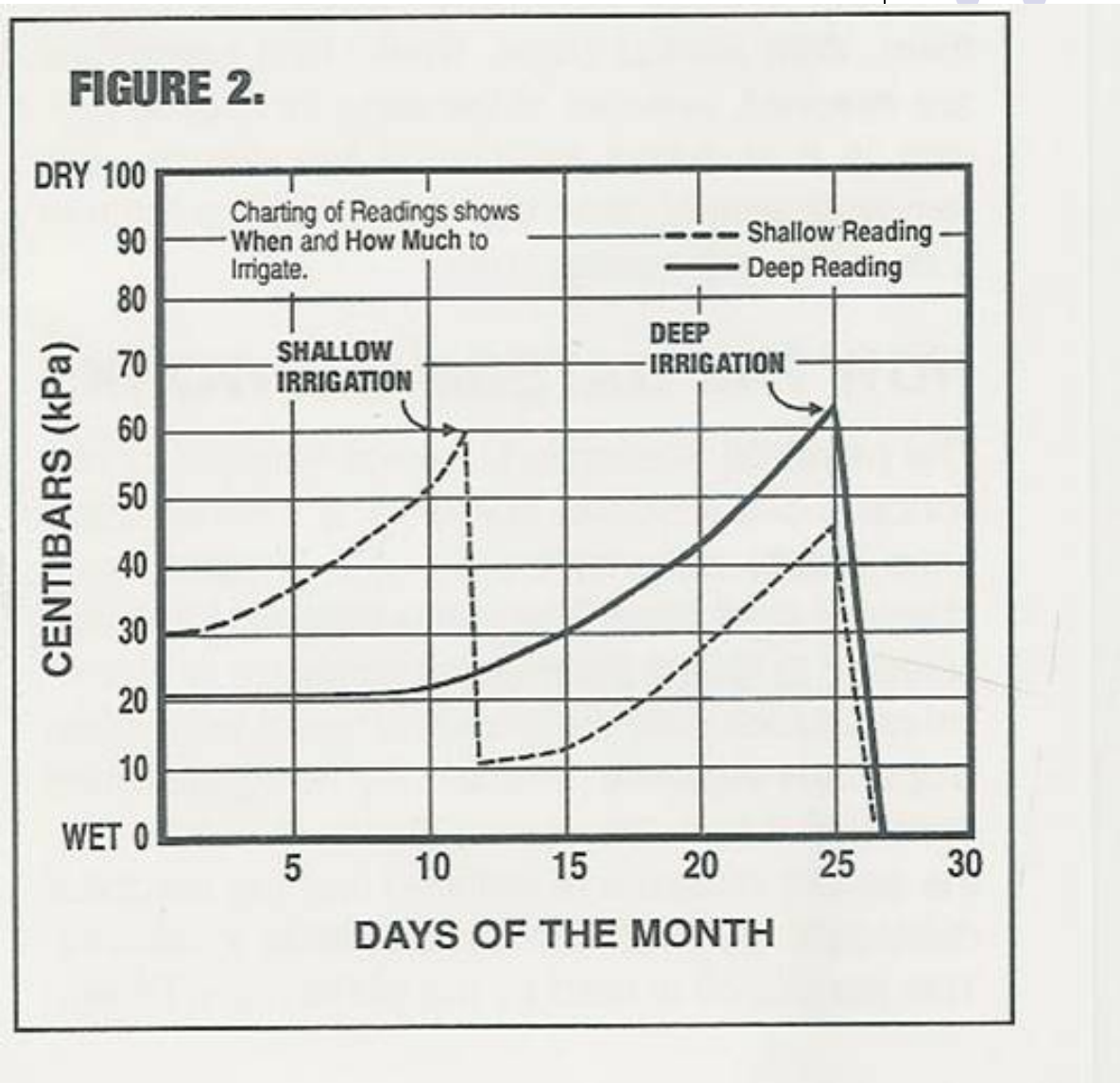
Moisture Sensor Location

-Shallow location

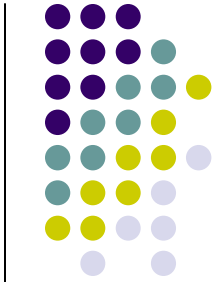
~ 20-25% of root zone depth

-Deep location

~ 80% of root zone depth



Irrigation Management Summary
Corn vs Potatoes



- Deeper Root zone
  - High water holding capacity
  - More days possible between irrigation applications
  - Increased ability to utilize rainfall
  - Reduced number of leaching events

- Deeper Roots > Deeper irrigation water percolation
  - Need to increase depth per application
  - Swallow irrigation
    - Root pruning
    - Increase in lodging

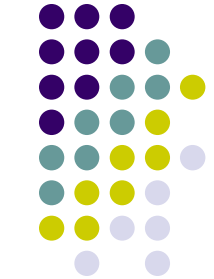
Does your Center Pivot apply water uniformly?

Sprinkler Uniformity Testing

- Measure water applied to soil – not soil moisture.
- Indirectly checks sprinklers for wear, restrictions, proper rotation.
- Check installation of new sprinklers for correct order

- Life of sprinklers is generally 10-15 years
- Test for uniformity every 3 - 5 years or sooner
- Need lots Rain gauges or cans

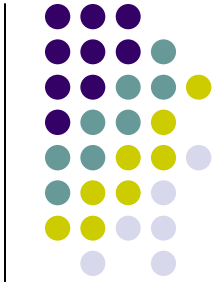
Factors that affect uniformity



- Nozzle / sprinkler maintenance
- Pressure variations
  - Endguns – On/Off - Spoking
  - Corner systems
- Wheel slippage
- Wind

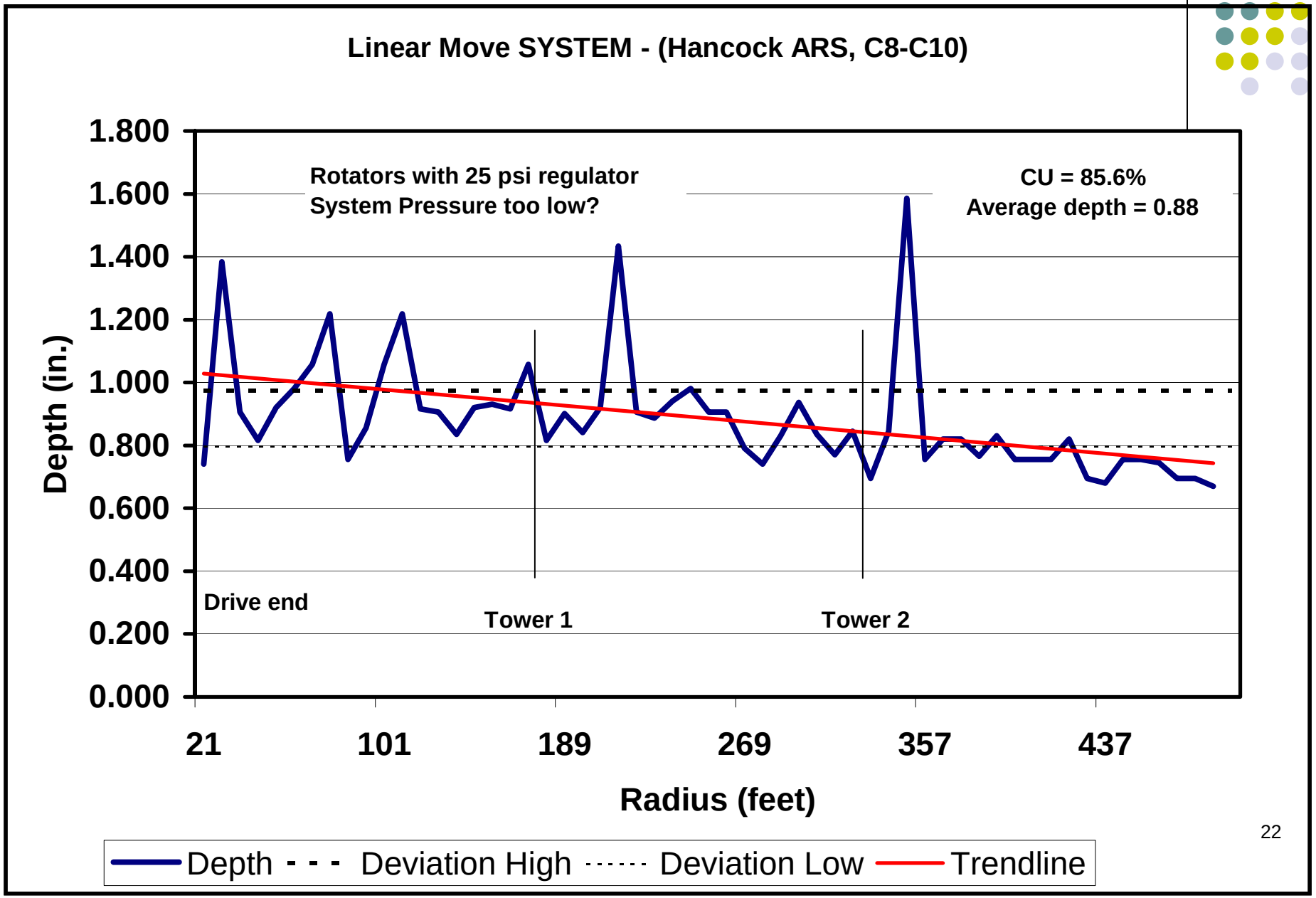
- Non-Uniform application affects:
  - Crop yield variations
  - Fertilizer utilization
  - Pest control chemicals (weeds, bugs and disease)
  - Localized leaching

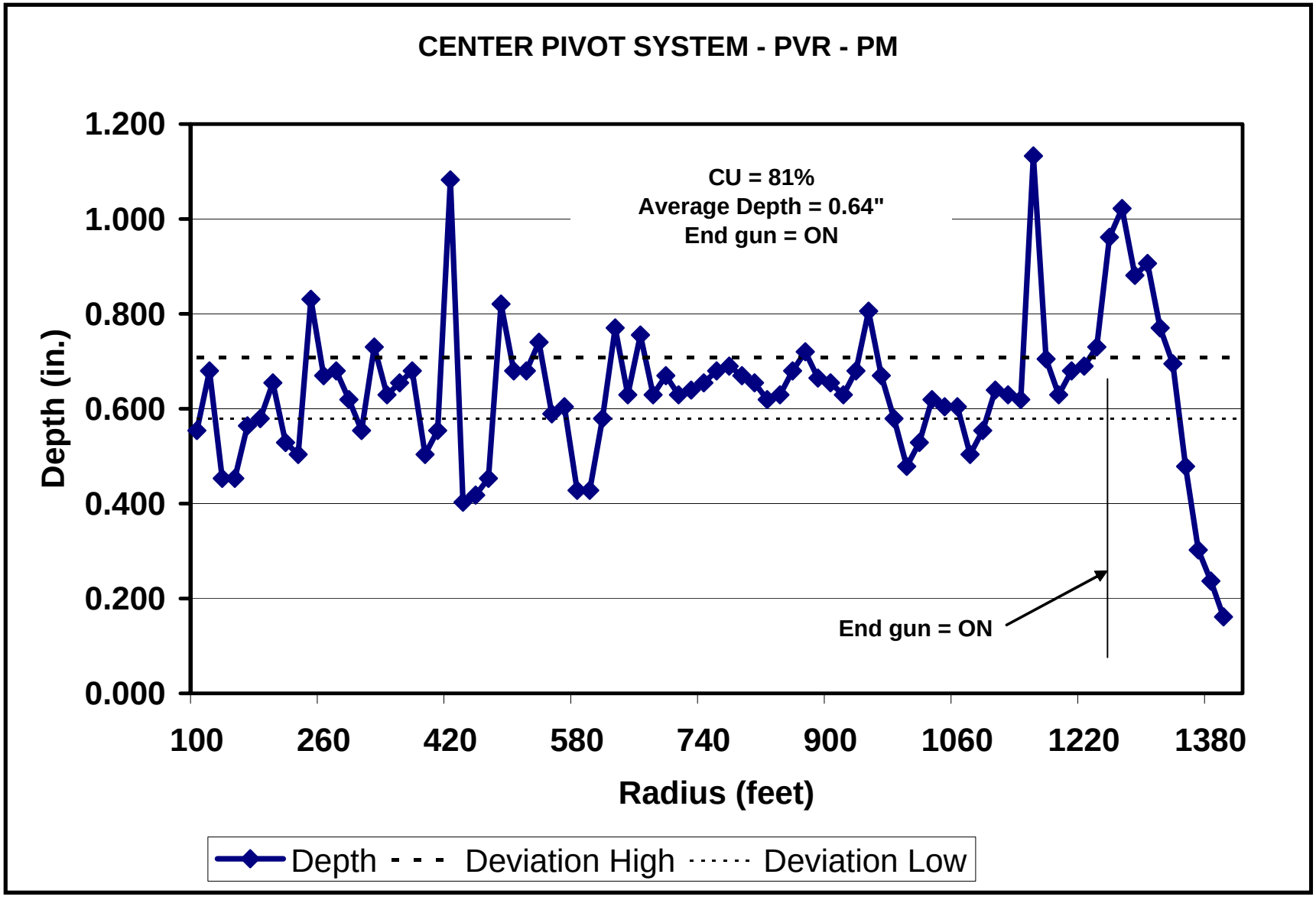
Coefficient of Uniformity



- Target Coefficient of Uniformity > 90%
  - Excellent 95%
  - Very Good $\geq$ 90%
  - Good $\geq$ 85%
  - Fair $\geq$ 80%
  - Poor $\leq$ 79%
- Testing during Summer 2004
  - 16 systems
  - CU ranged from 72% to 90%
  - Mean: 84%

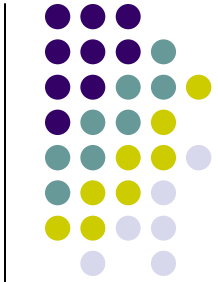
Uniformity Testing


Linear Move SYSTEM - (Hancock ARS, C8-C10)
Rotators with 25 psi regulator
System Pressure too low?
CU = 85.6%
Average depth = 0.88
Drive end
Tower 1
Tower 2
Depth (in.)
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
21
101
189
269
357
437
Radius (feet)
Depth
Deviation High
Deviation Low
Trendline


CENTER PIVOT SYSTEM - PVR - PM
CU = 81%
Average Depth = 0.64"
End gun = ON
End gun = ON
Depth (in.)
1.200
1.000
0.800
0.600
0.400
0.200
0.000
100
260
420
580
740
900
1060
1220
1380
Radius (feet)
Depth
Deviation High
Deviation Low

Irrigation Uniformity Test Kit

Test Kit Contents



- 150 Irrigages in totes & Stakes
- Measuring wheel and 300’ tape
- Hammer and driver
- Wind, Thermometer, % RH meter
- Pressure gauge
- Graduated cylinder
- Instructions
- Clip board & Worksheets
- Shipping container 40” x 48” x 46” high
  - Approximate weight: 450 lbs.

Uniformity Test Kit

- Available for anyone in WI to borrow at N/C
- Housed at Hancock ARS
- Contact Jeff @ 715-249-5961 to reserve

Sponsors

- WI Focus on Energy program
- WI Potato & Vegetable Grower Association
  - Associate Division
- WI Rural Energy Issues Foundation

Maintenance

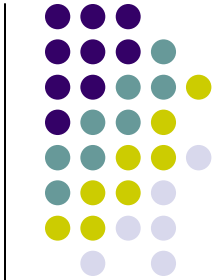
- Pump / Well Testing
  - Determine if pump / well is meeting design specification
    - Pressure versus gallons per minute
  - Worn Impeller
  - Pump depth – Net positive suction head (NPSH)
  - Well capacity
  - Test every 2-3 years
  - Cost: $150-$300

  - 1995 study – WI pumping system on average 25% less efficient than Nebraska standards
  - 1993 – KSU – “about 40% more fuel than necessary”
  - Nebraska study – adjustments saved 14% in energy costs on 57% of 180 systems tested

Other Cost Saving Opportunities

- Convert to lower pivot pressures :
  - 80+ to 30 psi system pressure
  - Up to 40% energy savings
  - Same application rate

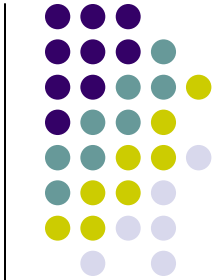
Focus on Energy Grants



- State Public Benefits Energy Conservation Program
- Agricultural Program
  - Free energy audits
  - Educational materials
  - Grants
  - Utility must be participating in program

- www.focusonenergy.com
- Contact Agricultural consultant – Fred Daniels
  - 1-800-762-7077 or 608-310-6910 / 273-0182

Other Grant programs



- USDA – EQIP – Irrigation Water management grants
  - Adams, Portage, Waushara
  - Contact local FSA office for more information

- USDA 2002 Farm Bill
  - 9006 energy efficiency grants
  - Applications typically May to June with awards in Sept or October.
  - Maximum grant – 25% of project cost
  - 15% minimum energy savings
  - Minimum grant $2500 ($10,000 project cost)

Focus on Energy

Scott Sanford
Senior Outreach Specialist
Biological System Engineering
University of Wisconsin
sasanford@wisc.edu
608-262-5062