A comprehensive look at irrigation management for processing vegetable production

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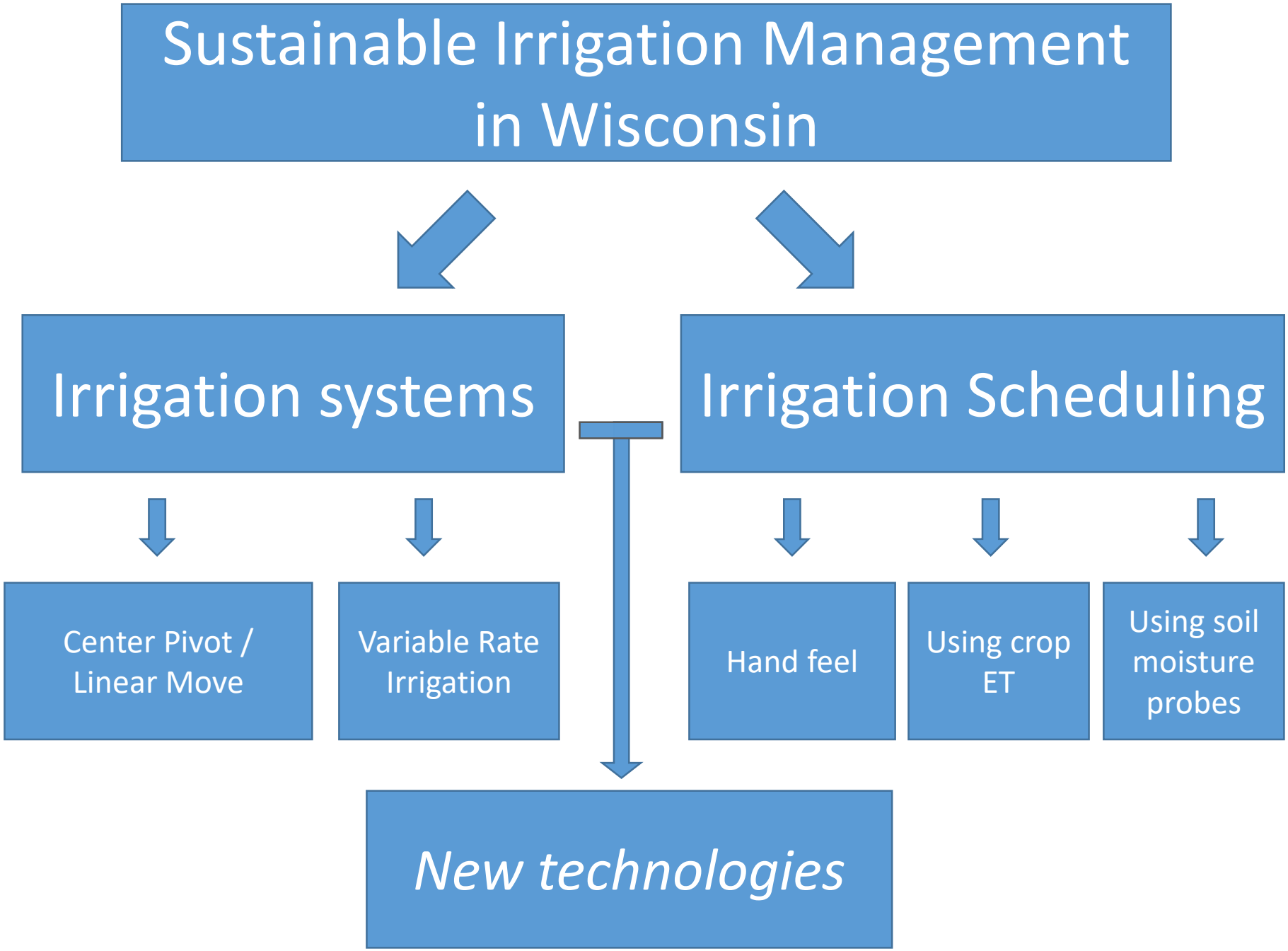
Irrigation management

- Sustainable agricultural production requires more efficient use of irrigation water resource
- More extreme weather conditions cause increased peak crop water use / evaportranspiration (ET) during the growing season
- Drying up of some water body in the state has drawn attention to sustainable irrigation management
- *What does sustainable irrigation management mean?*


Sustainable Irrigation Management in Wisconsin
Irrigation systems
Irrigation Scheduling
Center Pivot / Linear Move
Variable Rate Irrigation
Hand feel
Using crop ET
Using soil moisture probes
New technologies

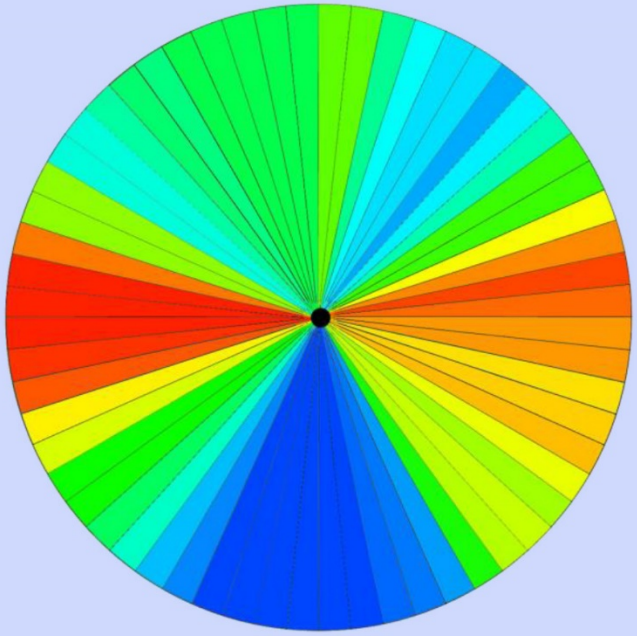
Irrigation systems

- Maintenance of existing irrigation systems
  - Fixing leaky irrigation systems (pivot pressure regulators and nozzles)
  - Turning off end guns of pivot
  - Applying newer nozzles that can generate larger water droplet sizes to reduce evaporative loss
- Variable Rate Irrigation (VRI) might be a future trend
  - Optimize irrigation on every acre by adjusting water application site-specifically to account for spatial variability → increase in crop yield and quality
  - VRI might increase irrigation water productivity (yield produced per water drop) and water quality
  - VRI will not reduce crop ET
  - $$ is the hurdle to VRI adoption
  - Speed control vs Zone or Nozzle control

Type	Description	Considerations	Examples uses
Speed control	• Varied by changing the speed of the pivot; • Irrigation management zones are “pie slice” shaped	• Relative inexpensive – many existing pivot panels are capable without additional investment; • No special hardware on the sprinklers	• If spatial variation lines up well with “pie slices”; • Multiple crops or varieties under one pivot
Zone or nozzle control	• Sprinklers are turned on and off and pivot speed may also vary; • Irrigation management zones may be any shape or size	• Greatest flexibility in application; • More expensive; • May require additional maintenance and management	• Avoid application on irregularly-shaped uncropped areas or water surfaces; • Vary irrigation on irregularly-shaped management zones as needed to maximize yield and profits

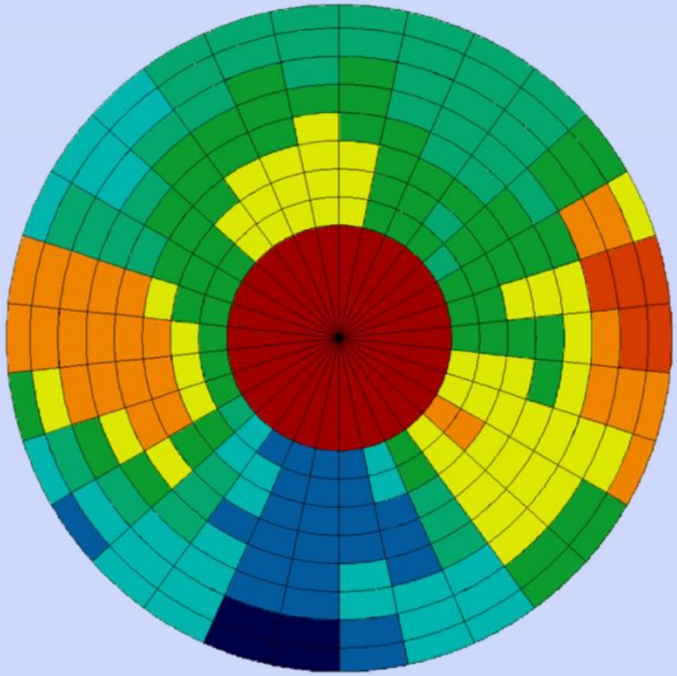
Source: University of Nebraska - Lincoln

Speed control



Total Cost: ~$3,000
(free with some new panels)

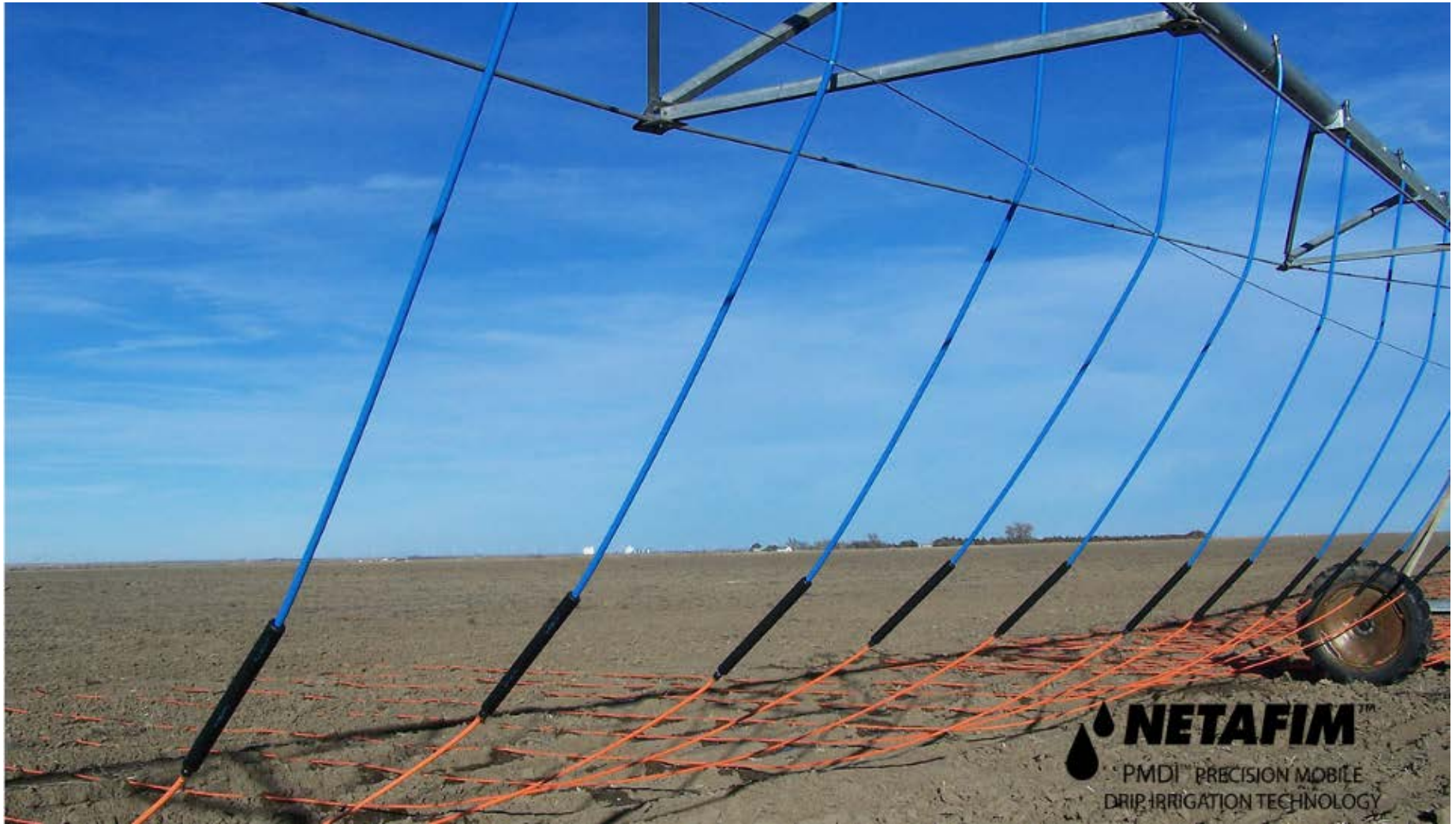
Zone or nozzle control



Total Cost: ~$16,000+

Irrigation systems – new technology

- PMDI (Precision Mobile Drip Irrigation): uses in-line drip tubing in place of nozzles or sprinkler heads

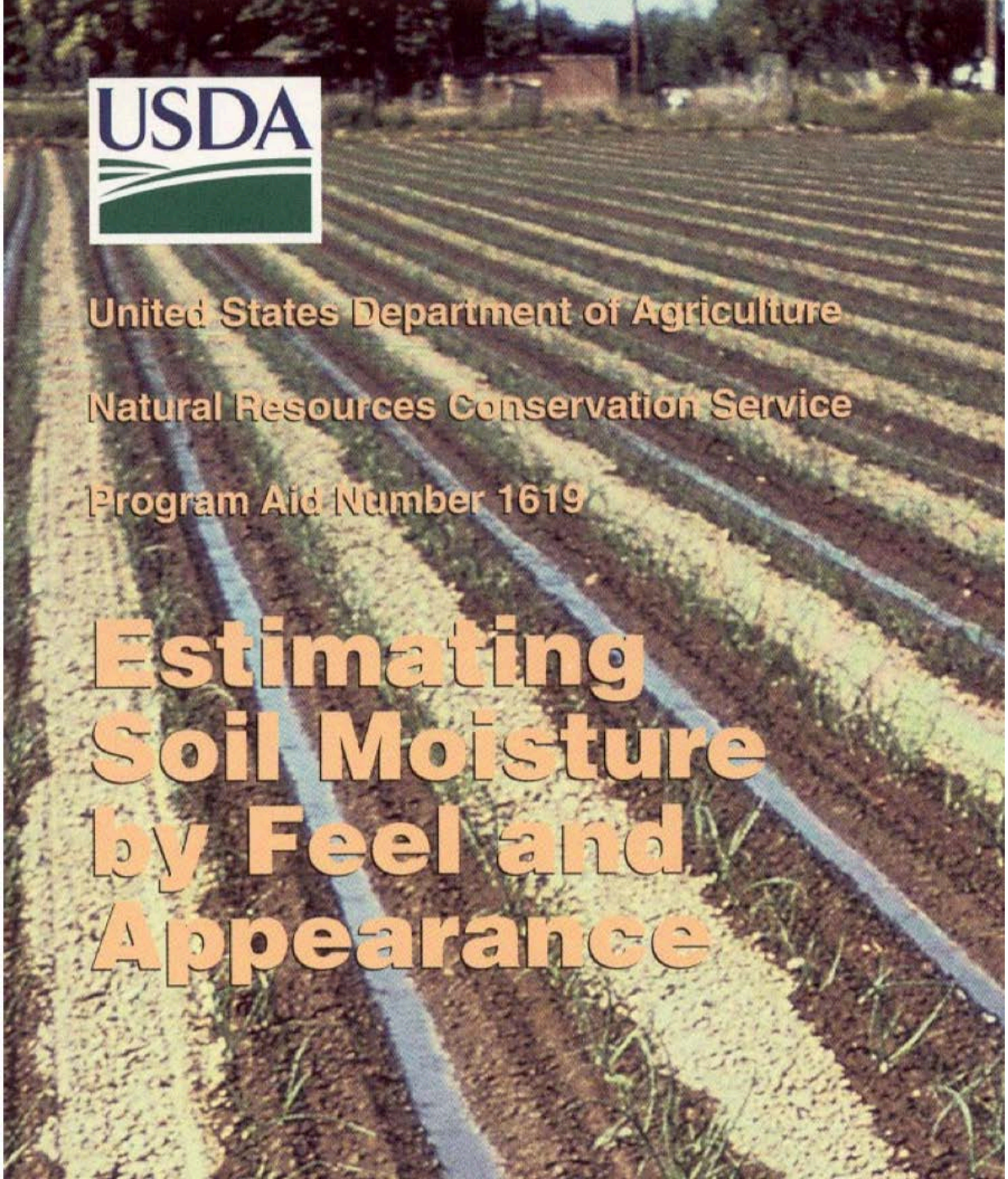


Irrigation systems – new technology

- T&L pivot with Netafim heavy-duty drip tubing
- On pivots, flow at each drop is controlled by length (number of emitters) of drip tubing
- Canopy stays dry to help reduce diseases and evaporative loss, no concern of foreign material, up to 95% irrigation efficiency, and pivot rutting can be avoided – dry wheel tracks
- Very costly: $20-25K/pivot for groundwater irrigation
- Drip tubes bitten by animals or damaged by winter winds
- Is recommended for areas with severe drought issues

Irrigation scheduling

- The “hand feel” method (or subjective method) is the most commonly used
- Soil moisture conditions can be estimated, with experience, to an accuracy of about 5 percent
  - Soil moisture is typically sampled in one-foot increments to the root depth of the crop at three or more sites per field
  - Squeeze the soil sample in your hand and refer to USDA-NRCS Program Aid #1619 to determine when to irrigate and how much water to apply
- This method is labor-intensive and time-consuming, and requires many years of experience to apply



USDA

United States Department of Agriculture

Natural Resources Conservation Service

Program Aid Number 1619

Estimating Soil Moisture by Feel and Appearance

Irrigation scheduling

- Refer to daily crop water use – evapotranspiration (ET)

$$ET_c = ET_0 \times Kc$$

  - ET_c: crop ET
  - ET_0: ET of a reference crop (alfalfa). Function of weather conditions – solar radiation, temperature, wind speed, relative humidity
  - K_c: crop coefficient. Function of the crop growth
- Main difficulty of estimating ET is to quantify ET_0 and K_c
- Inaccurate ET estimate will cause over- or under-irrigation

Irrigation scheduling

- Use soil moisture probes to indicate the soil water status
- Different soil moisture probes are available on the market
  - Tension-based probes
    - Tensiometer
    - WaterMark sensor
  - Electromagnetic probes
    - Time-domain reflectometer (TDR)
    - Capacitive sensor
- Drawbacks of using soil moisture probes:
  - cannot indicate spatial variability within fields
  - labor- and time-intensive to install and remove

Tensiometer

Sensor	Advantage	Disadvantage
Tensiometer	• Capable of highly frequent sampling • Inexpensive • Large sensing area (8-inch diameter)	• Limited range • Maintenance is necessary especially for sandy soils • Less intuitive due to negative relationship between volumetric water content and tensiometer reading

Time-domain Reflectometer

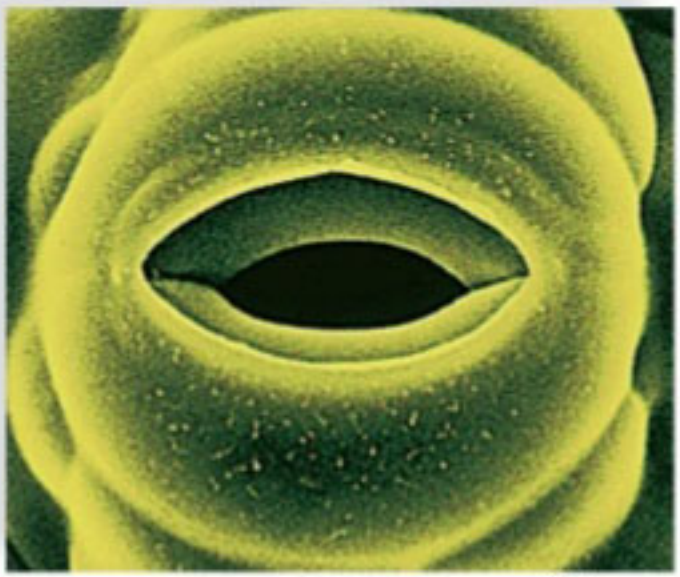
Sensor	Advantage	Disadvantage
TDR	• Highly accurate (±1%) • Can be used without calibration to specific soils, however it reduces accuracy • Minimal soil disturbance	• Need good contact between sensor and soil • Small sensing area (2-inch diameter)

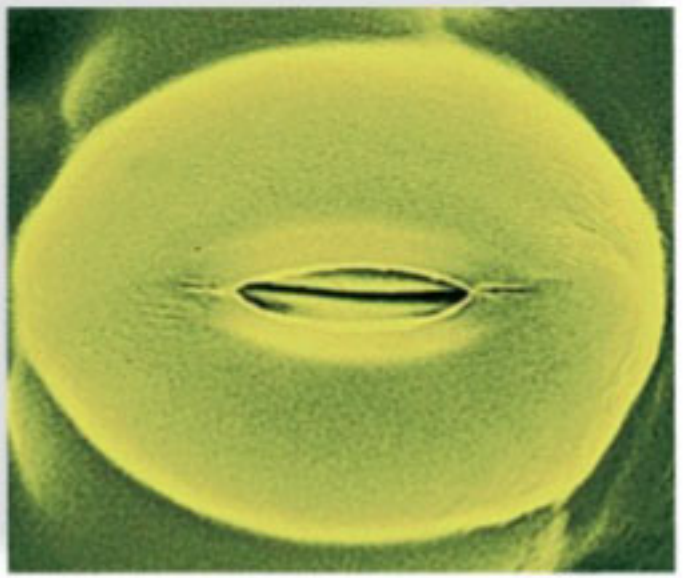
Selection of soil moisture probes

- Crop type
- Soil type
- Irrigation systems
- Available labor
- How durable are the probes
- How much maintenance they need
- Financial budget

Irrigation scheduling – new technology

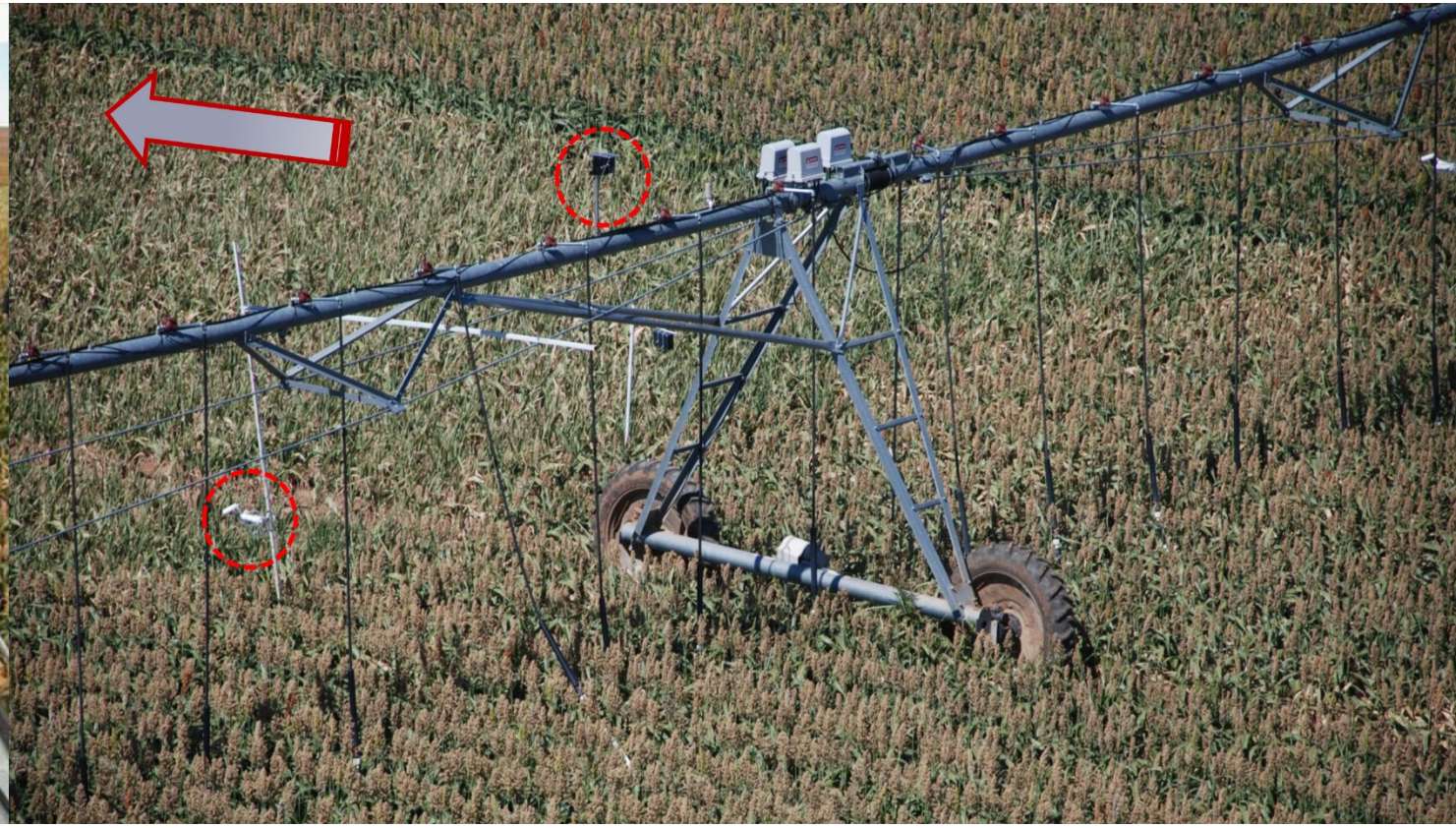
- Use canopy temperature to indicate crop responses to environmental water conditions
- Stomata close during water deficit → plant transpiration reduces → canopy temperature increases



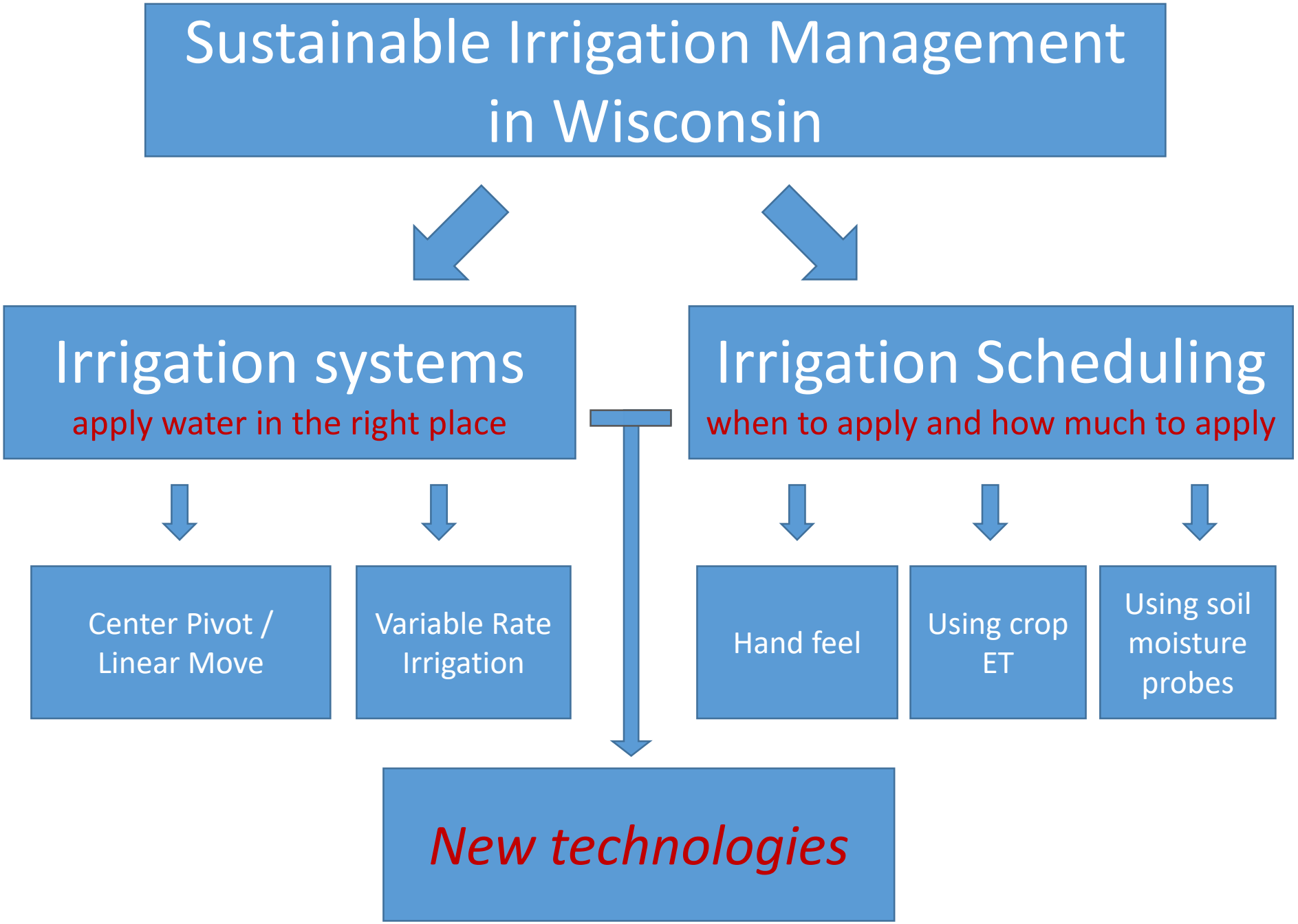


Irrigation scheduling – new technology

- Center pivot mounted with canopy temperature sensors can measure real-time crop water status across the fields (not destructive)
- Irrigation scheduling based on canopy temperature sensors can produce equal or higher yield of cotton, corn and sorghum on research plots
- However, challenge is background temperatures cause noises
- And it is a very costly technology, not used for commercial production yet



METHODS	ADVANTAGES	DISADVANTAGES
Feel and appearance	Straightforward, easy application, and low cost	Labor-intensive and requires many years of experience
Based on ET	Easy application; sufficient robustness under a wide range of environmental conditions	Lower accuracy compared with soil moisture-based method, estimation of ET is needed, inaccurate estimation can cause over- or under-irrigation
Based on soil moisture	Easy application; accuracy; availability of many irrigation controllers that are interfaced to soil moisture sensors	Labor and cost-intensive for installation and removal, might not be sufficient to indicate spatial variability
Based on canopy temperature	Directly measures the plant's response to soil moisture level and climate conditions; promising with remote sensing technology development	Background signals can cause errors, scarcely used yet for routine irrigation scheduling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THANK YOU