



Wireless Sensing for Monitoring and Control in Horticulture

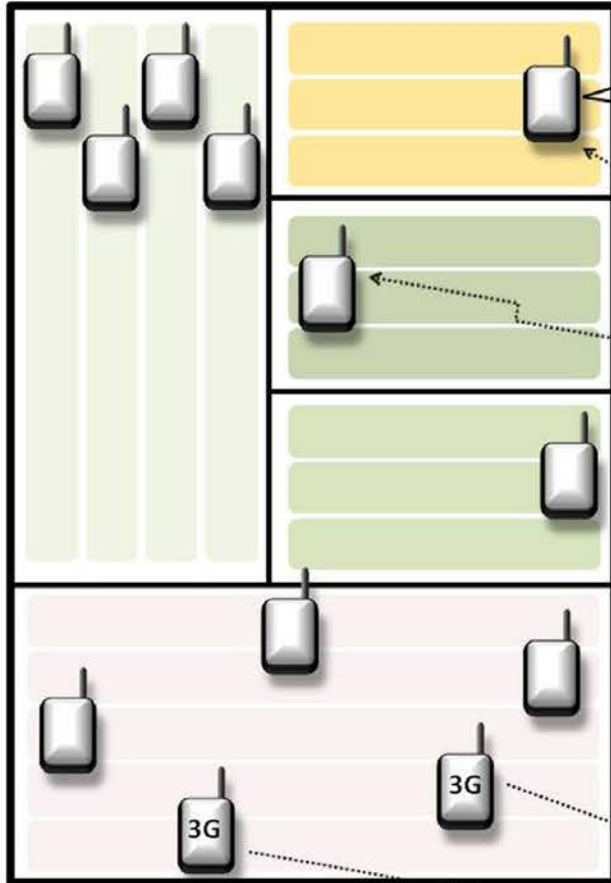
George Kantor
CMU Robotics Institute

IFTA
25 February 2013

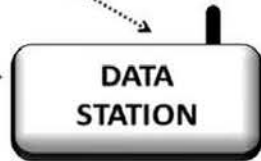
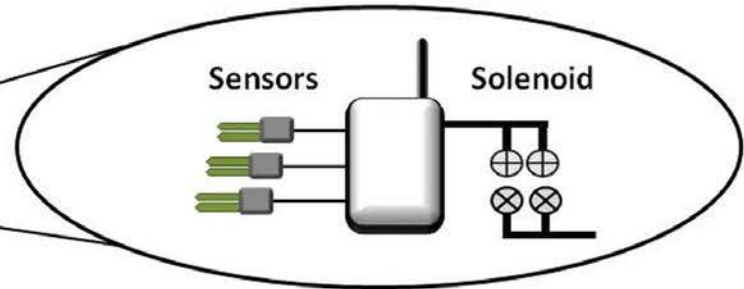


Sensor Networks

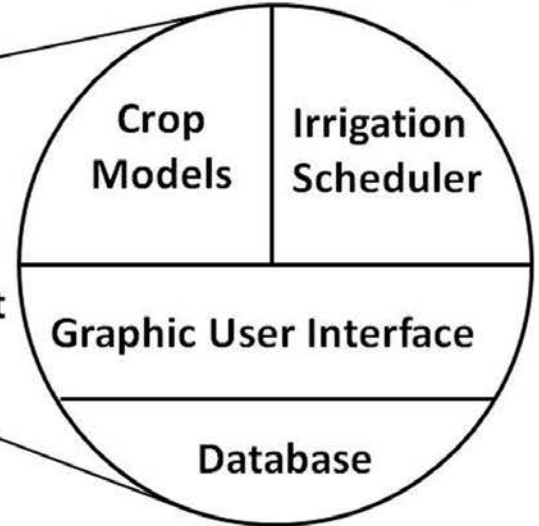
Production Area / Irrigation Zone



Local Irrigation Control



Global Irrigation Control



Local Computer

Grower Input



Remote Server

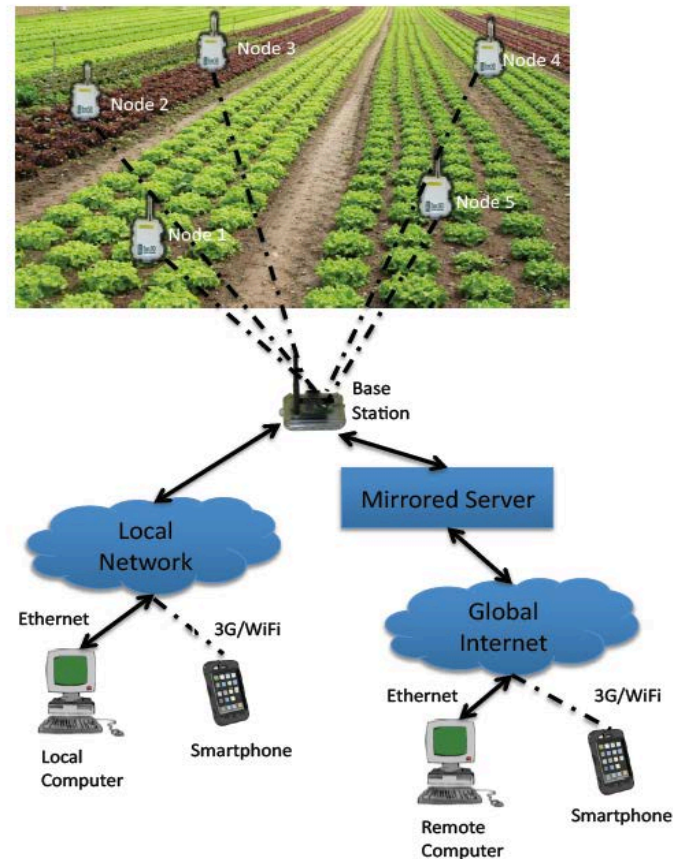


Smartphone or Handheld Device

(Via Secure Internet Connection)

Wireless Sensor Network

- Three primary components
 - **Nodes:** Inexpensive devices that read from sensors and transmit the data to a central basestation
 - **Sensors:** Devices that sense the environment (e.g., soil moisture)
 - **Basestation:** Used to configure nodes, and work with node sensor data



New nR5-Control Node: (Field tested during 2012)



- ✓ **nR5 Node** – This wireless node allows us to both monitor sensors and control irrigation events, based on sensor readings
- ✓ **Node measures data every minute** and then logs the data at an interval specified by the user (1, 2, 5, 15, 30, 60 minutes etc.)
- ✓ **Monitoring Mode:** Batteries logging at 15 minutes typically last 12+ months
- ✓ **Control mode:** Batteries are lasting 4-6 months, depending on the # irrigations initiated per day.



Sensing

- Three types
 - **Canopy Environment:** Air temperature, RH, light, etc.
 - **Root Environment:** Water content, temperature, salt
 - **Irrigation System Health:** Flow meters, line pressure, in-tank EC



Environmental Sensors

(we work with the **Decagon** product line)



light



temperature, RH



rainfall



leaf wetness



wind speed and
direction



Root Zone Sensors



soil moisture



soil moisture, temp,
EC



Irrigation System Sensors



line/tank EC



line pressure



Flow meter



Viewing Data

- Web-based interface (accessible from anywhere)
- Instantaneous overview (red-yellow-green)
- Detailed time series plotting
- Grower tools (VPD, DLI, physiological models, etc.)



Hale and Hines Nursery home - Mozilla Firefox
_ □ ×

File Edit View History Bookmarks Tools Help

69.8.161.221:3000
☆ ↻ Google

Hale and Hines Nursery home

Hale and Hines Nursery Sensorweb

Sunrise 4:22, Sunset 18:13
Current time: 2012 Apr 29 12:31:06 CDT

Navigation

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Welcome to the Hale and Hines Nursery sensorweb



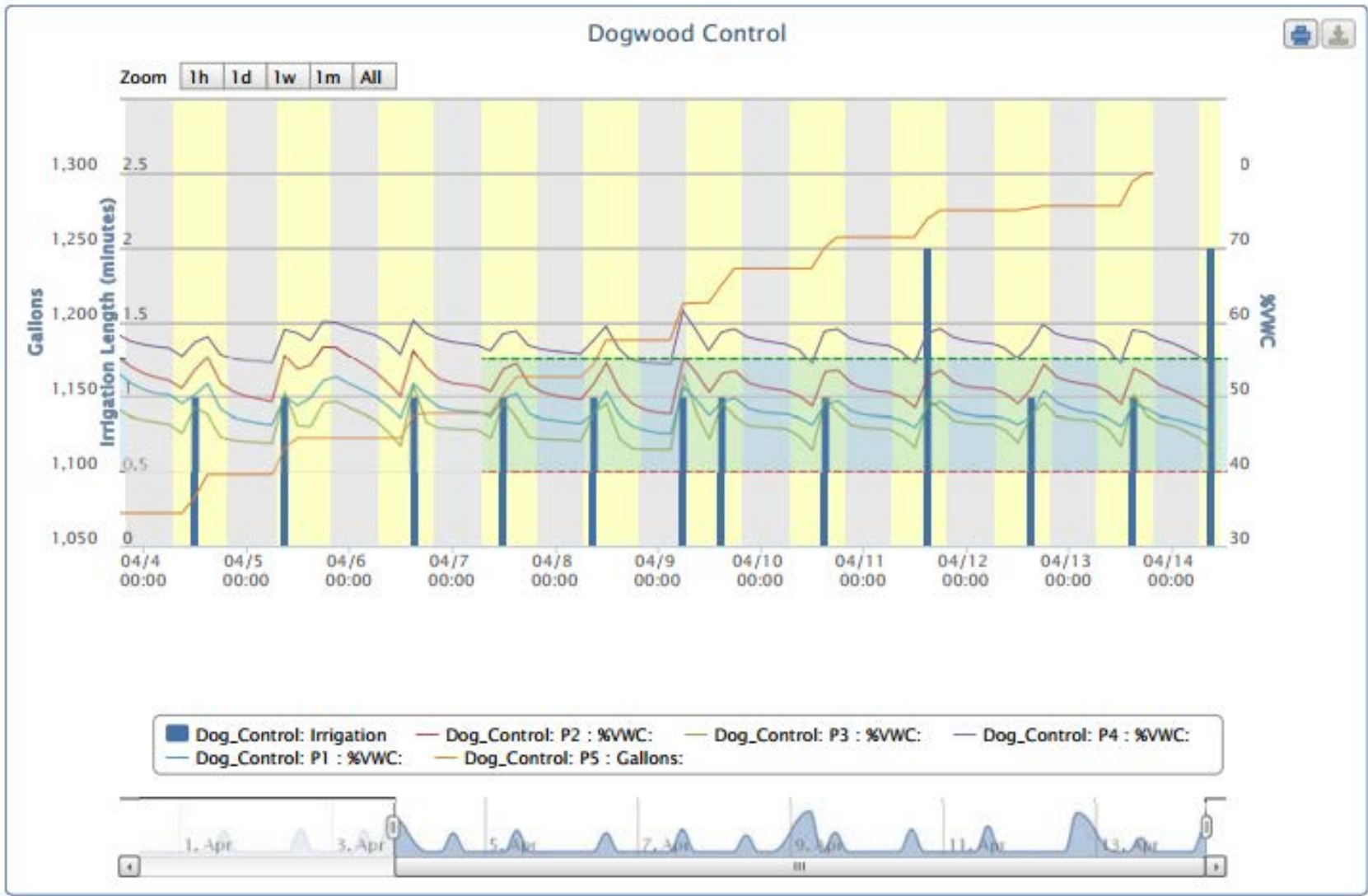
Place mouse over location for details?

Legend?

	Min	Max
<small>ens0</small>	0.0	10.0
<small>ens0</small>	10.0	60.0
<small>ens0</small>	60.0	100.0
<small>ens0</small>	100.0	600.0
<small>ens0</small>	Not in ranges above	

Measurements?

- Battery Life
- Daily Irrigation
- Electro-Conductivity (EC)
- PAR
- Sun Power
- Rainfall (Precipitation)
- Rainfall (Volume)
- Soil Moisture (cubic meters)
- Soil Moisture (%VWC)
- Temperature (Celsius)
- Temperature (Fahrenheit)



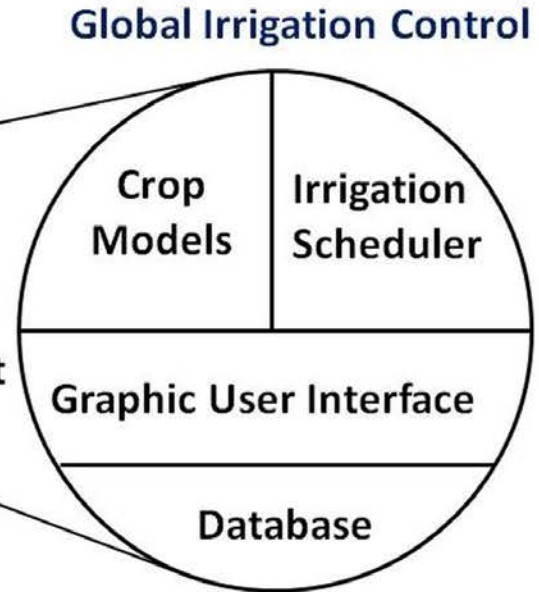
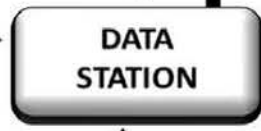
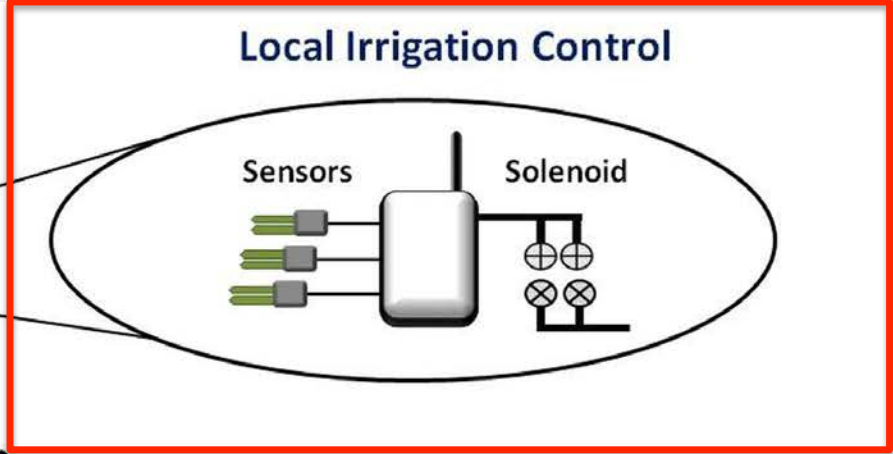
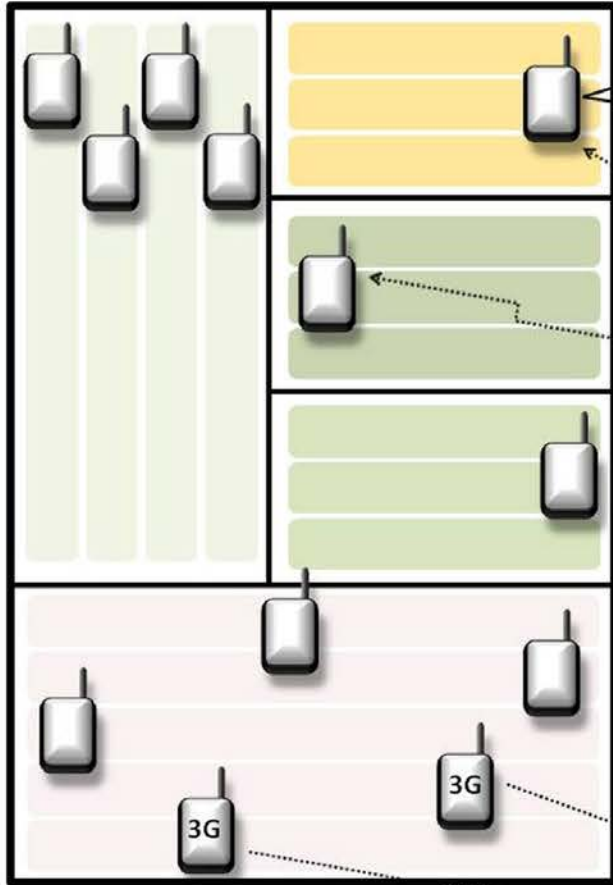
Alerts

- Configurable alerts can be sent via email or text message
- Alerts can be generated when a sensor value, irrigation, or growing tool; go above or below a value
- Alerts can also be used to send daily messages to the user. Such as total irrigation.



Sensor Networks

Production Area / Irrigation Zone



(Via Secure Internet Connection)

Smart-Farms.net — Managing Irrigation and Nutrition via Distributed Sensing

Remote Server

Smartphone or Handheld Device



Solenoid Control in the Field



24 VAC solenoid



12 VDC latching solenoids

Sensorweb: Macro-Scheduling Tool

Allows for real-time monitoring and adjustment of irrigation events, for blocks of times during the day, using sensor-based or schedule-based control

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Irrigation Settings Saved
Irrigation Scheduler

Maple Block

Dogwood Block

Select Node: Dog_Control

Relay Mode: Disabled Schedule based control ? Local setpoint control ? Global setpoint control ?
Select which moisture sensor ports to use for control (selected sensors must be the same type and will be averaged together):
 Port 1 Port 2 Port 3 Port 4 Port 5

Low Setpoint (0-55%VWC): 46

Pulse Type: MicroPulse_2 [Edit pulse types here](#)

Click on start and end point to create (or delete) schedule below: ? [Click here to view all schedules](#)

6am 9am noon 3pm 6pm

Maximum irrigation time per day is 3 hours

Sensorweb: Micro-pulse Tool

Allows a “time-out” for sensors to measure between pulse events, reducing leaching fractions (and nutrient loss) to minimal amounts

Hale and Hines Nursery Sensorweb

Sunrise 4:49, Sunset 19:52 Current time: 2012 Jun 16 09:07:50 CDT


Relay Pulse Configuration Tool

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	Name	Pulse Duration(s)	Time Between Pulses(s)	Number of Pulse Cycles	Total Time of Event
<input type="radio"/>	Standard	300	0	1	300
<input type="radio"/>	MicroPulse	20	40	5	300
<input checked="" type="radio"/>	MicroPulse_2	120	180	1	300
<input type="radio"/>	MicroPulse_3	90	210	1	300
<input type="radio"/>	MicroPulse_4	180	120	1	300

Name:

Pulse Duration(s):

Irrigation On - 

Irrigation Off -


Time Between Pulses(s):

Number of Pulses:

Sensorweb: Local Set-Point Irrigation

Augments Scheduling and Micro-pulse tools with soil moisture sensor feedback: irrigation is disabled with set-point is exceeded

Irrigation Scheduler



Select Node

Relay Mode: Disabled Schedule based control ? Local setpoint control ? Global setpoint control ?

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Low Setpoint (0-55%VWC):

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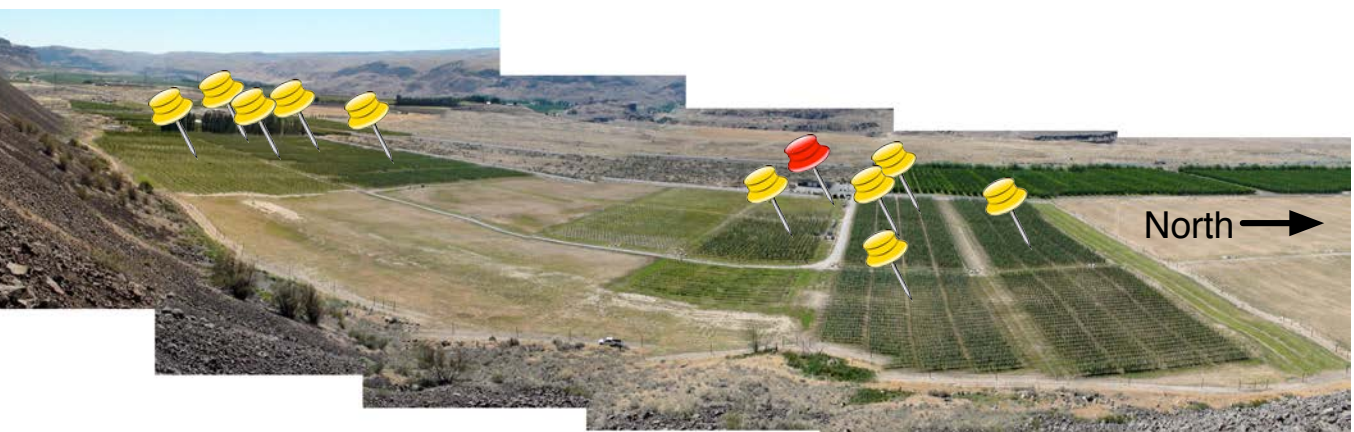


Dogwood Monitoring vs. Control (Lea-Cox)

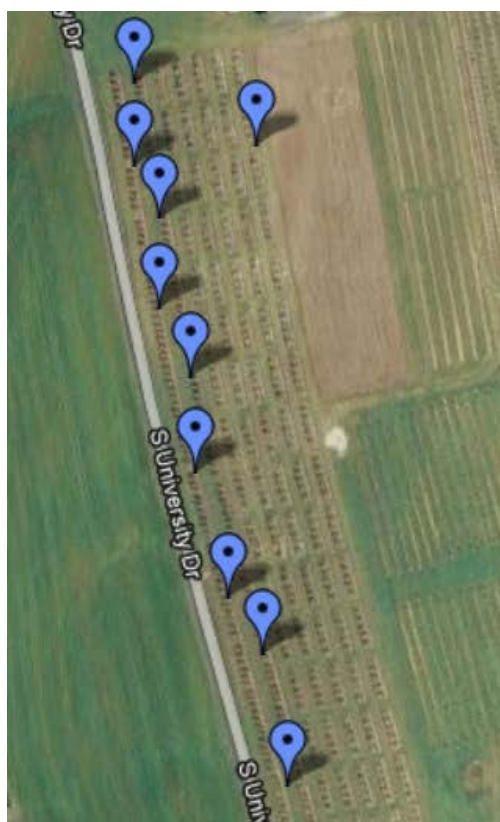
Water Use: April – October, 2012

Irrigation Method	Total Water Use (Gals / Row)	Average Water Application (Gals/ Tree /Day)	Av. Efficiency (Timed vs. Control)	Water Savings (Control vs. Timed)
Grower: Timed, Cyclic	28,334	0.922	0.371	2.69
Sensor: Setpoint Control	10,521	0.342		





WSU Sunrise Orchard



PSU FREC Orchard



Auvil Vantage Orchard (WA)

Thanks CASC and WTFRC





Conclusion

- Wireless sensing and control is available, reliable, and expensive
- Flexible system easily retrofitted to existing infrastructure
- These technologies can be used to push research into production environments
- Potential uses in orchards
 - Irrigation control
 - Disease prediction
 - Pest monitoring and prediction
 - Plant stress detection



Thank You Questions?

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And Thanks to all MINDS partners!

For more information visit us online at <http://smart-farms.net/>

