Dual Use Solar PAC Inaugural Meeting: Agronomic Summary

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Acknowledgement

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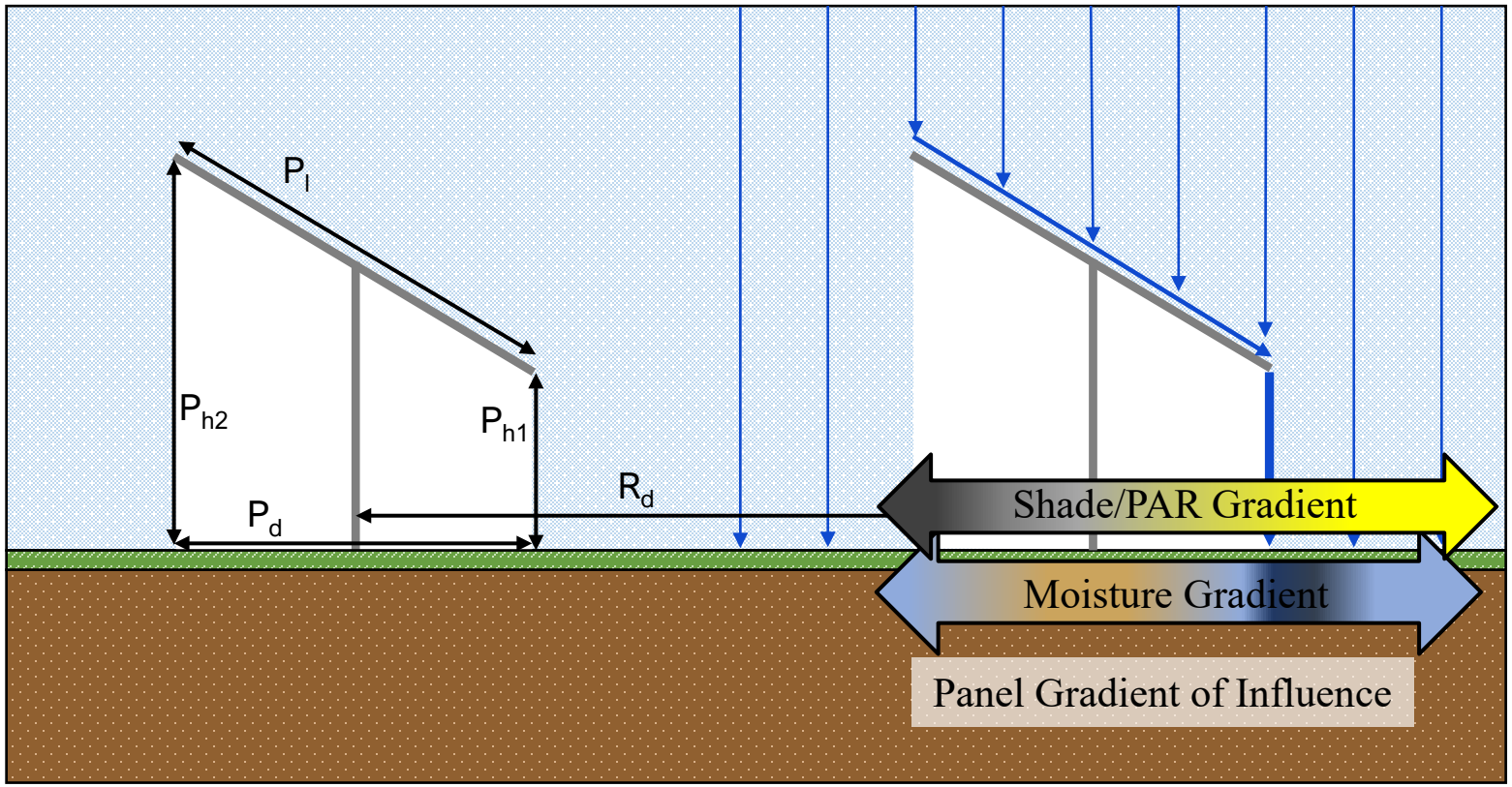
About the Solar Energy Technologies Office

The U.S. Department of Energy Solar Energy Technologies Office supports early-stage research and development to improve the affordability, reliability, and domestic benefit of solar technologies on the grid. Learn more at energy.gov/solar-office.

Soil & Microclimate Research



The goal is to document and understand changes across the **panel gradient of influence**

- Soil chemical characteristics
- Soil Temperature
- Soil Moisture
- Soil Compaction
- Surface Vegetation
- Soil Health Indicators
- Relative Humidity
- Air temperature
- Photosynthetically active radiation
- Precipitation

Slide adapted from Emily Cole

Grafton Fixed Tilt – Squash & Lettuce

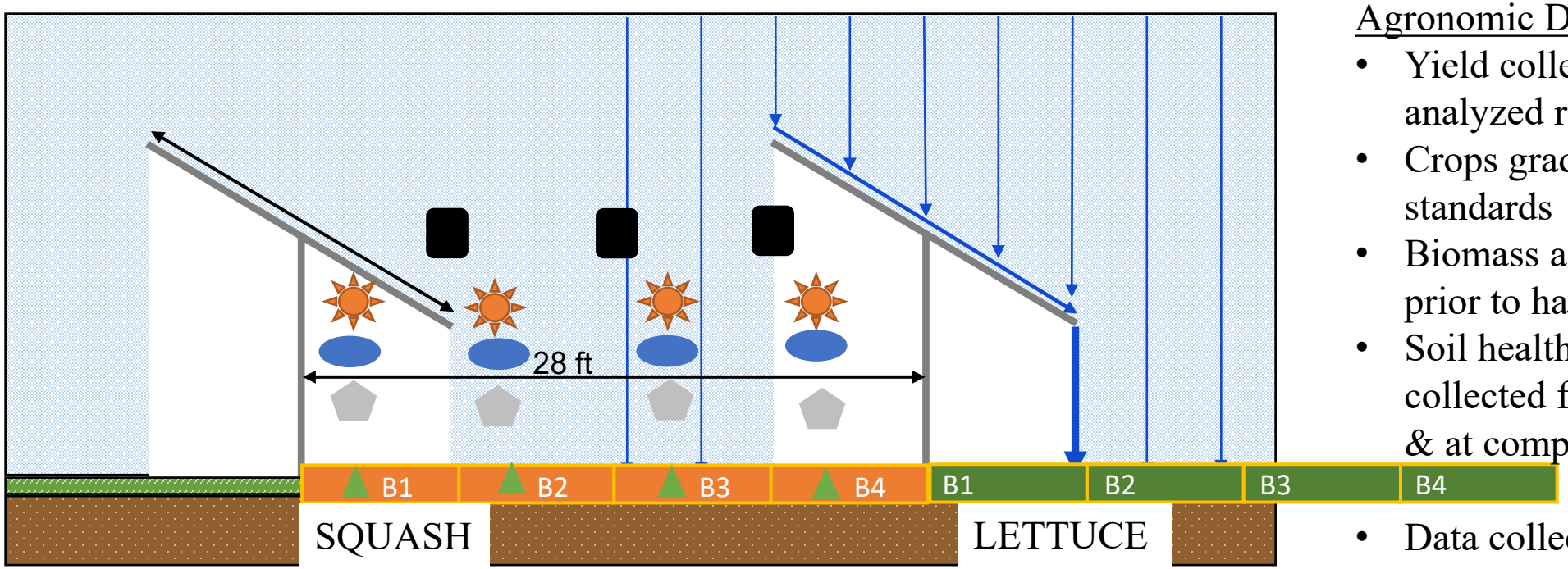
Harvested product is fruit. High energy requirement to produce.

Heat tolerant, sun loving.

Harvested product is stem and leaf. Less energy intensive for the plant to make.

Heat sensitive, shade tolerant.

Grafton Fixed Tilt – Squash & Lettuce



Photosynthetically Active Radiation (PAR)

Leaf Wetness

Air Temp & Relative Humidity

Soil Moisture & Temp

Rain Gauge

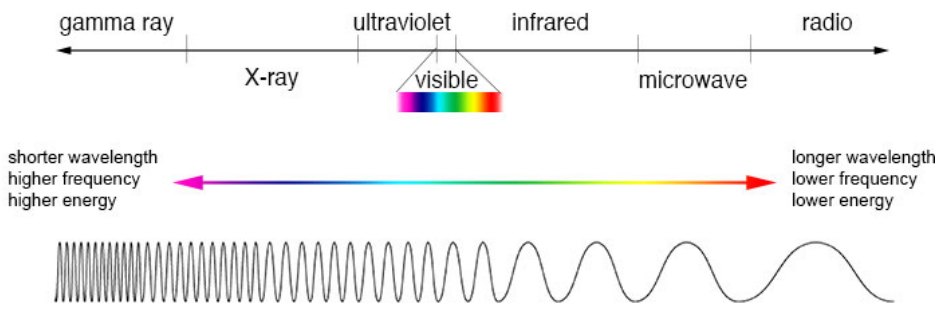
Agronomic Data Collection

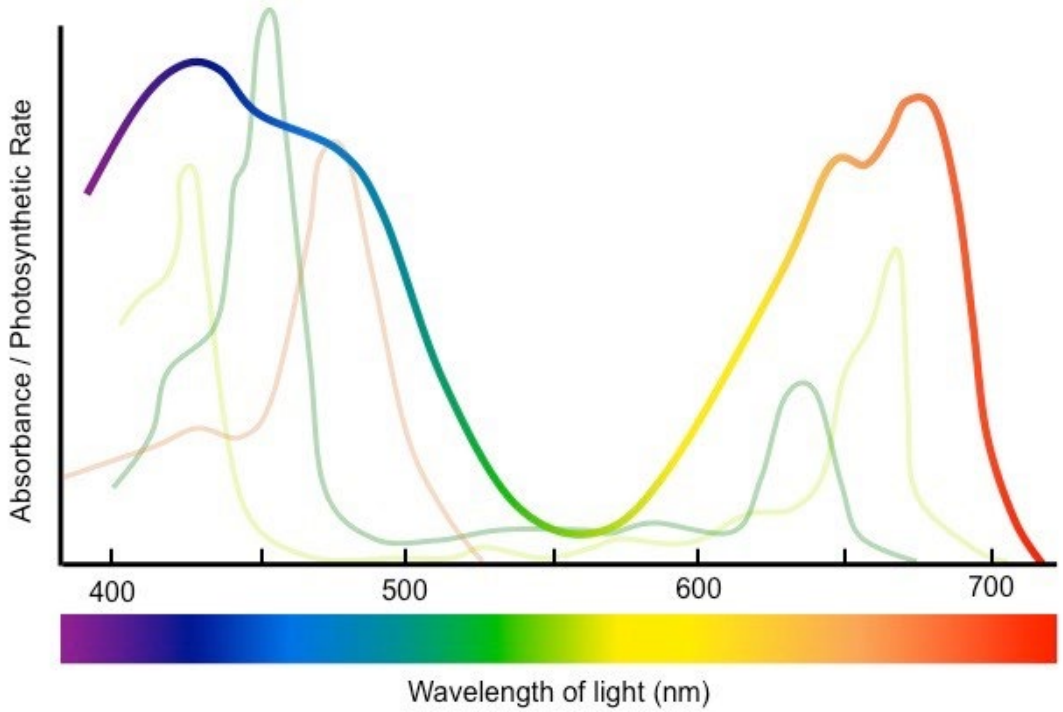
- Yield collected from both crops, analyzed relative to bed number
- Crops graded according to USDA standards
- Biomass also collected from squash prior to harvest stage
- Soil health and fertility samples collected from each bed as a baseline & at completion of project
- Data collection for both crops replicated three times, compared to control (not replicated).
- Sensors in squash beds only
  - Note: 3 rain gauges in the transect; all other sensors = 1 sensor/bed

Figure adapted from Emily Cole

Grafton Fixed Tilt – Squash & Lettuce

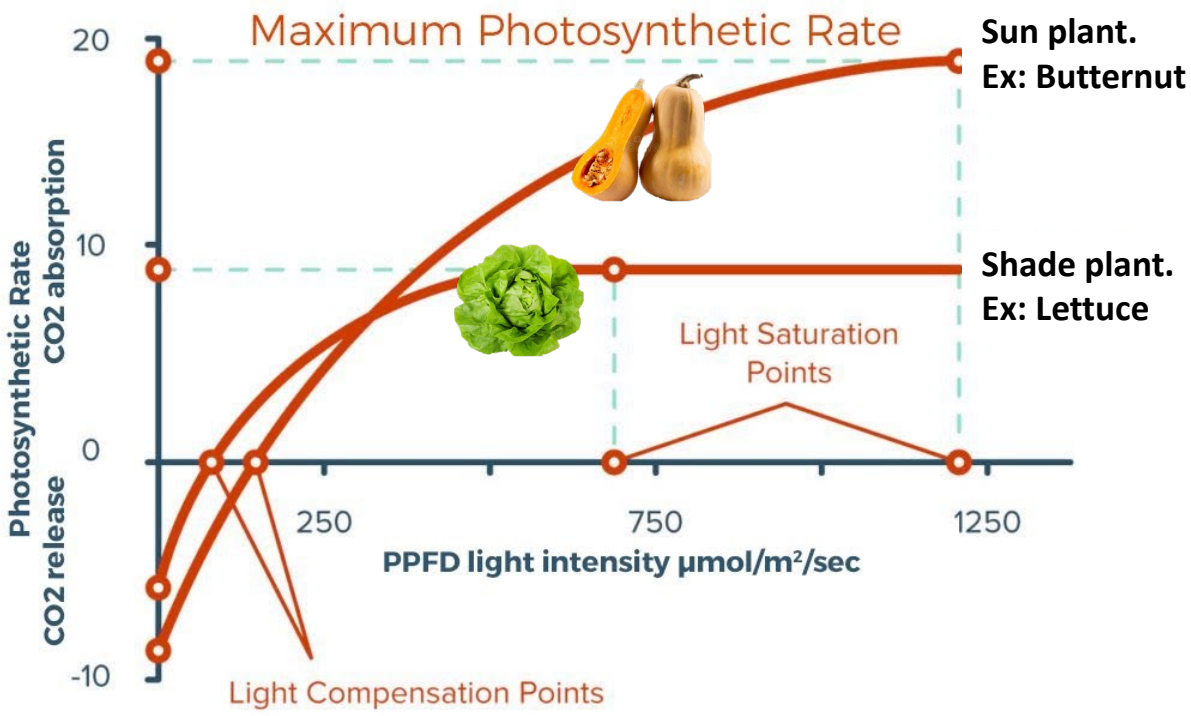
- "Light" is measured in quality, intensity/quantity, and duration.
- Light that plants can use is called **PAR,** which stands for **photosynthetically active radiation (that's all the useable light for photosynthesis).** *This is* ***quality.***
    - Plants are best able to absorb and use red light and blue light; Green light is not absorbed by chloroplast and is not used for photosynthesis
- *Light* ***intensity*** refers to the **quantity** of light that strikes a leaf per unit of time.
- *Light* ***duration*** is how long a plant receives light over a period of time. I.e. 8 hrs versus 12 hrs.
- **Our sensors** measure the intensity (quantity) of light in the photosynthetically active spectrum (quality) at 15 minute intervals (duration).



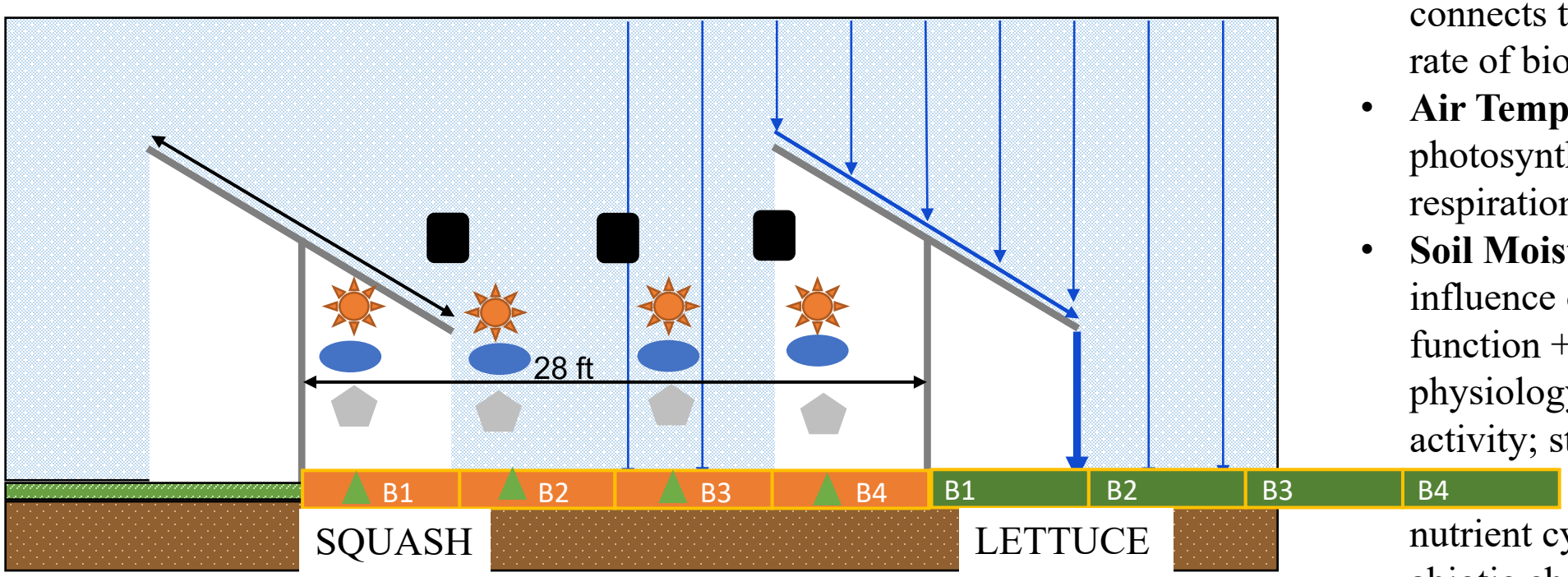


Grafton Fixed Tilt – Squash & Lettuce

- Light quality AND intensity (PAR) changes relative to clouds, season (earth's tilt), longitude…and shade!
- **Different plants can use different amounts of light – what's the best fit for the system?**



Grafton Fixed Tilt – Squash & Lettuce



Photosynthetically Active Radiation (PAR)

Leaf Wetness

Air Temp & Relative Humidity

Soil Moisture & Temp

Rain Gauge

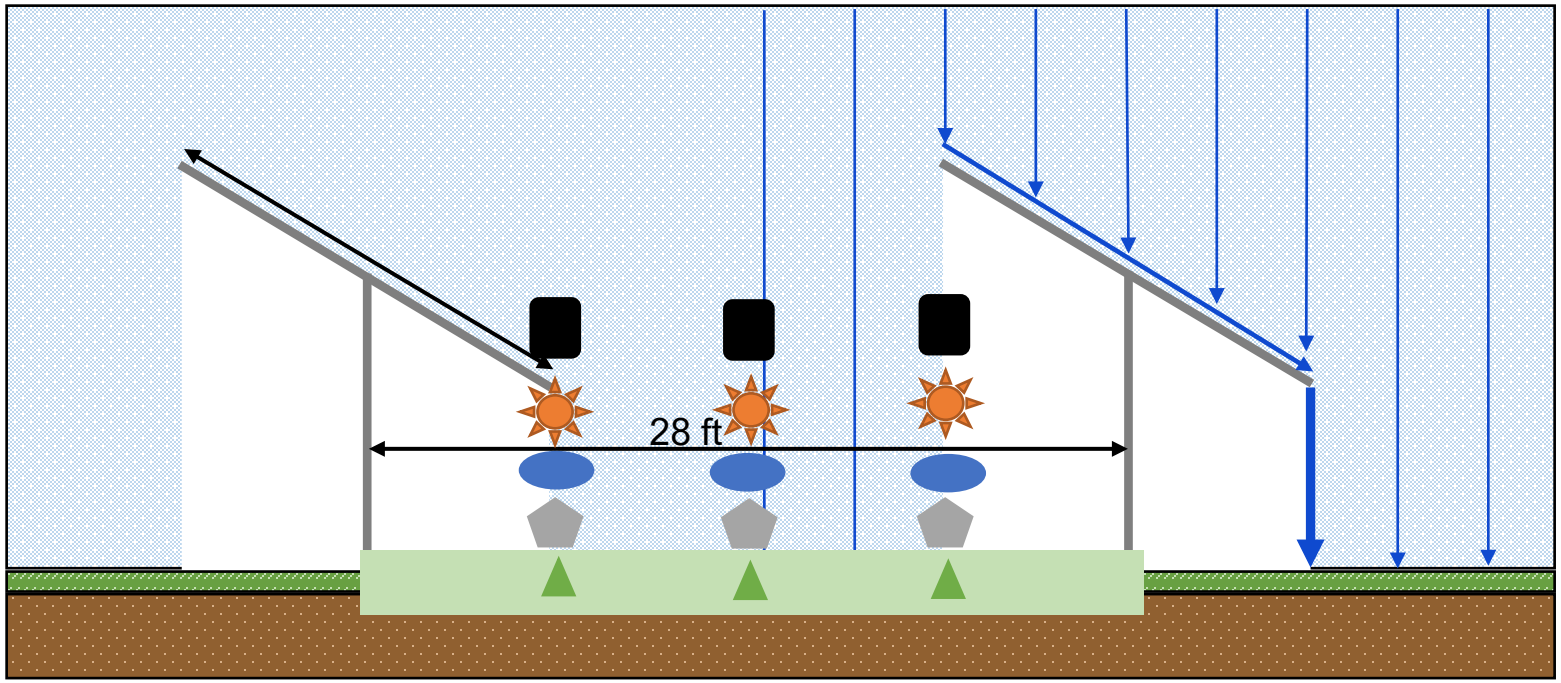
Sensor Data

- **Leaf Wetness** – strong connection to pathogen development. Also connects to leaf temperature at the rate of biological reactions.
- **Air Temp & RH** – affects photosynthesis, transpiration, respiration, disease incidence, etc.
- **Soil Moisture & Temp** – major influence on root health and function + above ground physiology; impacts soil microbial activity; strong influence on nutrient cycling and soil biotic and abiotic chemistry
- **Rain Gauges**: captures dripline effect (increase), back of panel impermeable surface effect (decrease), and center bed (neutral)

Figure adapted from Emily Cole

Grafton Fixed Tilt – Graze

Design is the same for the hay site



Photosynthetically Active Radiation (PAR)

Leaf Wetness

Air Temp & Relative Humidity

Soil Moisture & Temp

Rain Gauge

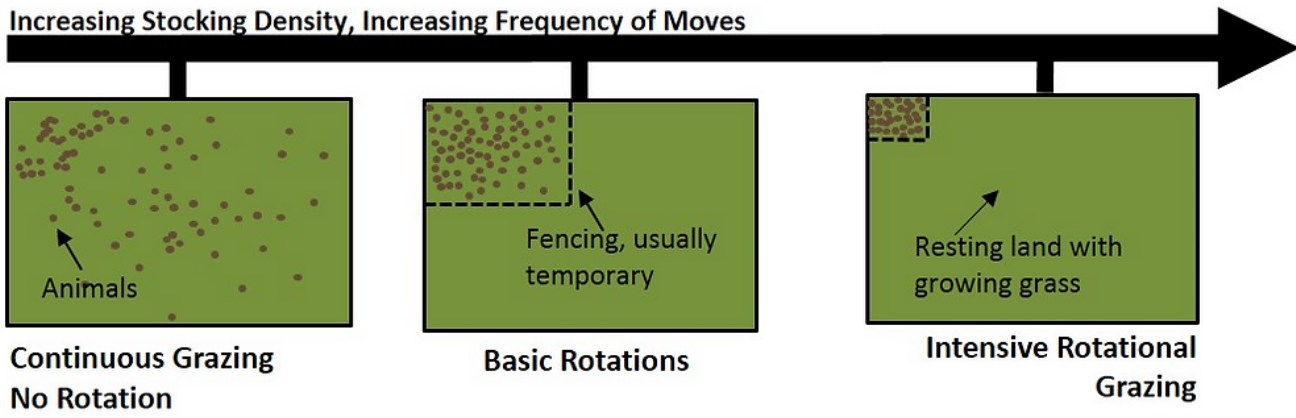
Agronomic Data Collection

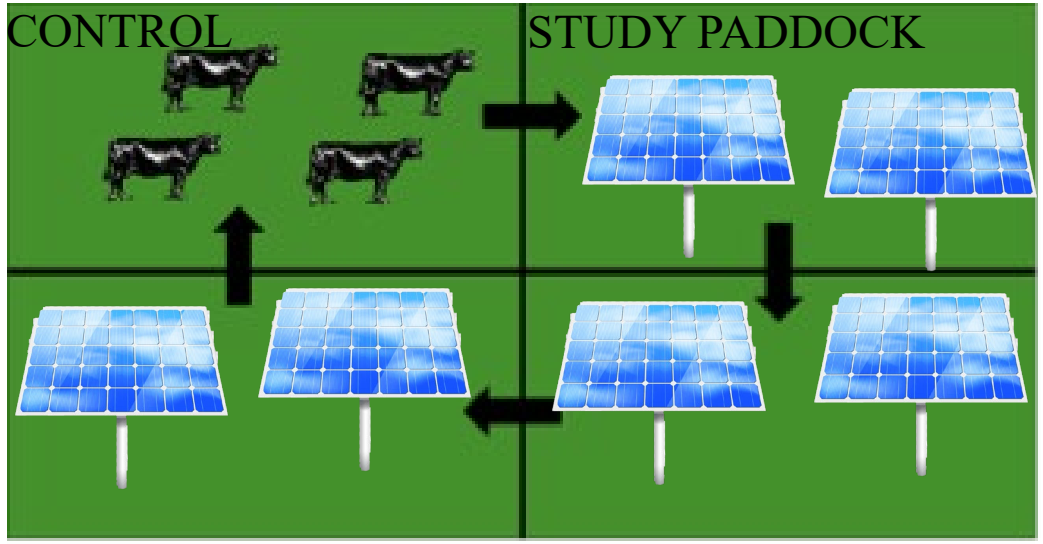
- Sensors in a three position transect from panel to panel.
- Yield collected from 1x1 meter areas to the desired grazing height.
  - Will be submitted for forage quality analysis.
- Soil health and fertility samples collected from each experimental paddock as baseline & at completion of project
- Sensor data replicated twice in solar array, twice in control area; yield data replicated in three locations.
- Data collected from a control paddock and one solar array paddock.

Figure adapted from Emily Cole

Grafton Fixed Tilt – Graze

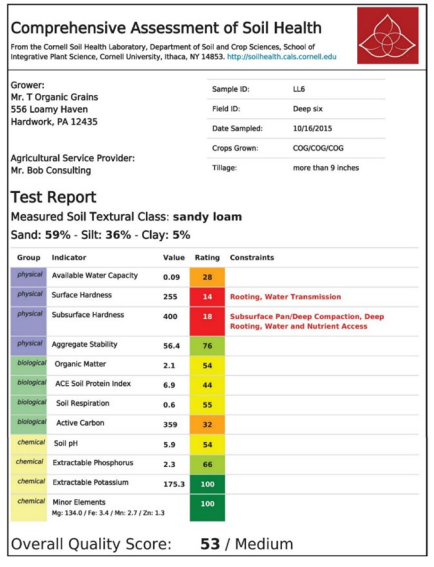
- Animals will graze in the control paddock and array paddock back to back.
- Animal daily water intake will be recorded in each paddock using a marked trough.
- Ungrazed areas around posts and fence lines will be subtracted from total yield
- Animal behavior will be noted
    - Ex: preferential/overgrazing underneath panels on a hot day?





Additional Information

- **Monson, hayfield tracking panel site:** will receive all the same assessments minus the animal influence. Yield and quality data will be taken at each cutting.



Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. http://soilhealth.cals.cornell.edu

Grower:
Mr. T Organic Grains
556 Loamy Haven
Hardwork, PA 12435

Agricultural Service Provider:
Mr. Bob Consulting

Sample ID:	LL6
Field ID:	Deep six
Date Sampled:	10/16/2015
Crops Grown:	COG/COG/COG
Tillage:	more than 9 inches

Test Report

Measured Soil Textural Class: **sandy loam**

Sand: **59%** - Silt: **36%** - Clay: **5%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.09	28	
physical	Surface Hardness	255	14	Rooting, Water Transmission
physical	Subsurface Hardness	400	18	Subsurface Pan/Deep Compaction, Deep Rooting, Water and Nutrient Access
physical	Aggregate Stability	56.4	76	
biological	Organic Matter	2.1	54	
biological	ACE Soil Protein Index	6.9	44	
biological	Soil Respiration	0.6	55	
biological	Active Carbon	359	32	
chemical	Soil pH	5.9	54	
chemical	Extractable Phosphorus	2.3	66	
chemical	Extractable Potassium	175.3	100	
chemical	Minor Elements Mg: 134.0 / Fe: 3.4 / Mn: 2.7 / Zn: 1.3		100	

Overall Quality Score: **53** / Medium

- **Advanced soil health testing**
  - Soil texture – contextualizes all other soil health observations
  - Active carbon – fast response to management practices; source of food for soil microbes
  - Wet aggregate stability – indication of resistance to erosion
  - Soil respiration – indication of microbial activity
  - Total carbon & total nitrogen – indication of nutrient cycling and carbon sequestration
  - Autoclave-citrate extractable protein test – measures soil organic nitrogen, a pool of nitrogen that responds to both seasonal changes and management practices
  - Predicted available water capacity - indication of how much water a field can hold, and therefore drought resistance
  - Surface, sub-surface hardness – indication of compaction, which influences water infiltration from rainfall and run off and affects rooting depth, root function, and root health

- **Sorbed metals determination**: lead, nickel, cadmium, chromium, zinc, selenium, copper
  - Proposed concern: solar panels may be leaching heavy metals into soil beneath the panels.
  - Experimental response: There is very little experimental data so support or refute this concern. Some studies have shown metals residual after panels have been damaged by tornadoes/hurricanes, but it is necessary to study this question under **intact panels.**