Root traits and soil health: Prospects for Control, Observation and Value

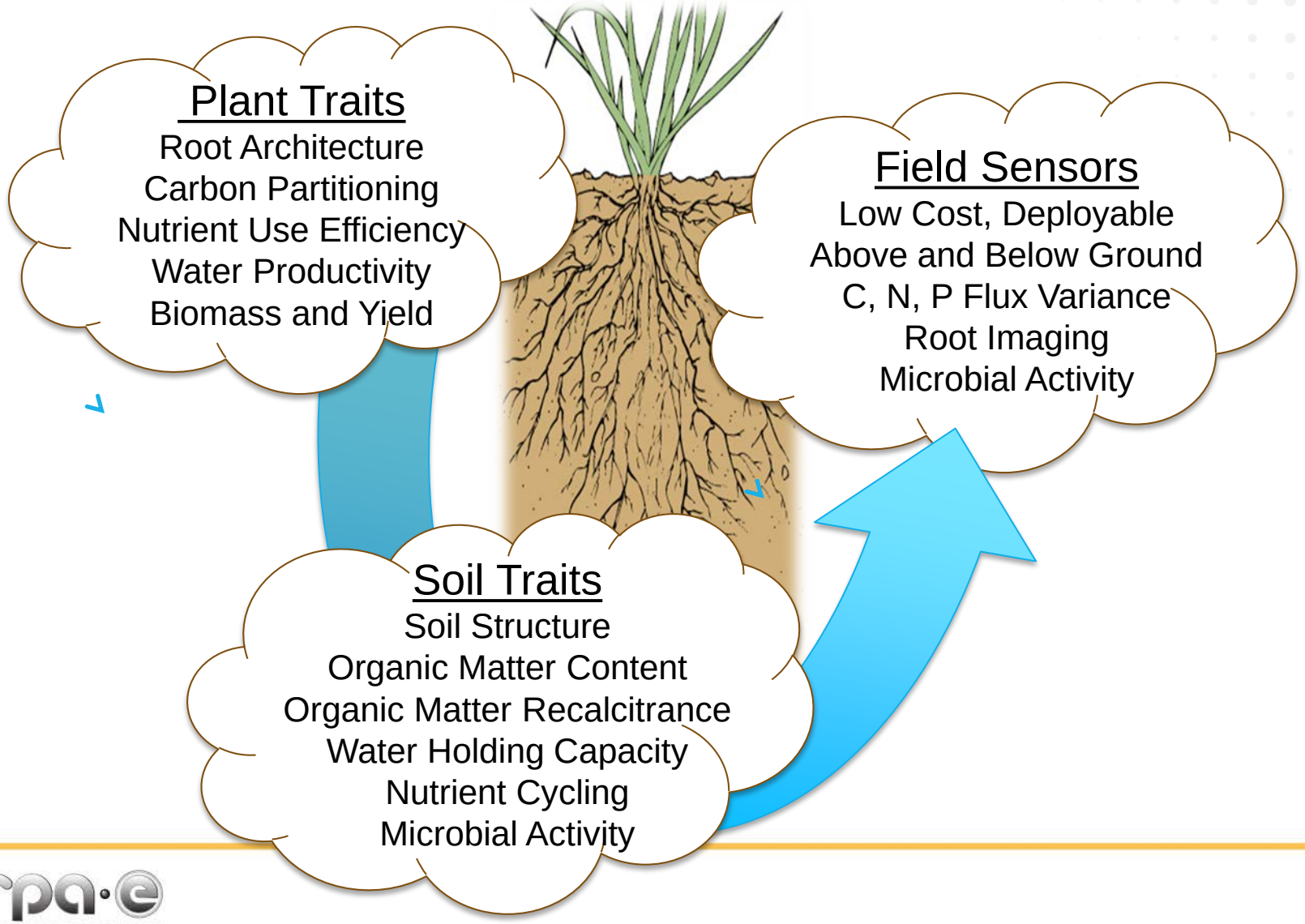
Designing a Program for ARPA-E

Workshop Readout

ARPAE Biogeochemistry Workshop Feedback

Biogeochemistry = Chemical, Physical and Biological Processes that Govern Composition of Natural Environment

BIOGEOCHEMISTRY WORKSHOP CONDUCTED 23-24 JULY 2015, CHICAGO IL



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CHANGING WHAT'S POSSIBLE

Potential New ARPAE Program

Enhancing Biogeochemistry Systems for Agricultural Productivity

Objective (Our 'New Horizon')	Deliverable	Impact	Long term Goal (Our 'Pluto')
Identify and measure plant, soil, microbial *traits of interest* above and below ground. Enable crop breeders to select germplasm and monitor subsurface physical and biological processes in the FIELD. Value traits that allow sustainability in production agriculture, forestry, and rangeland.	Advanced chemical, physical and biological sensor technologies, computational tools and robotic platforms. Data sets with scale and resolution to permit genetic association studies for high value traits that improve sustainability and yield. Identify genes and alleles that contribute to useful phenotypes.	With potential to: • Increase biomass yield (above or below ground) • Improve crop resilience • Enhance nutrient cycling (C, N, P) • Improve water use efficiency • Enhance soil structure	That contribute toward value added carbon productivity. e.g. • Increased crop yields (Food-Fuel-Feed-Fiber) • Reduced fertilizer inputs • Reduced GHG emissions • Increased soil organic carbon flux • Improved land use management

ARPA-E lessons from workshop

- Land use has the potential to be a great carbon source or sink depending on management and represents a great opportunity
- ARPA-E currently working to develop models and life cycle analysis for a potential program area to ensure that interventions are encouraged in the most effective areas
  - Establish that improved root architecture and trait development contributes to increased soil carbon and sustainable practices
  - Need to identify the key interactions in carbon, nitrogen, and water cycles. It's likely that some interventions will lead to progress in multiple areas.
- Any interventions must be accompanied by precise monitoring nutrient and water monitoring that is currently done with expensive equipment and not widely accessible
- Correlations between lab measurements and field observations may be low for below ground phenotypes – optimize technologies in the lab, but prepare for the field
- Medical imaging and plant breeding communities are well suited for collaborations
- Pay equal attention and devote equal resources to data collection and processing, signal processing is critical to success
- Over the next several months ARPA-E will continue shaping a program, targeting an early winter call for proposals.

Advanced Soil/Root Analysis Program

Preliminary goals and metrics

GOAL: Doubling Carbon per unit time/space/water/nutrient input

Phenotypic Traits of Interest:

Photosynthate Flux, Root Depth, Branching Rate and Extent, Fine Root Turnover/Exudates, Root Mass, Microbial Biomass

Soil Traits of Interest:

C Stocks at Depth, Organic Matter, Respiration Rate, Nitrogen Cycling, Water-Holding Capacity

Ag/Bio Requirements:

- Environment Diversity: 3+ Soil Types.
- Crop Choice:. Economically Important
- Genetics: Characterized Genome
- Selectivity: Discriminate top 10%

Instrument Requirements:

- Platform: In-Field & Maintains Root/Soil Viability.
- Data Turnaround Time: 48 hours
- Accuracy: Validate to 10% against ground truth
- Sample Rate: 1x/day, once per week, over 1 acre.
- T2M: Deployable Cost (TBD)