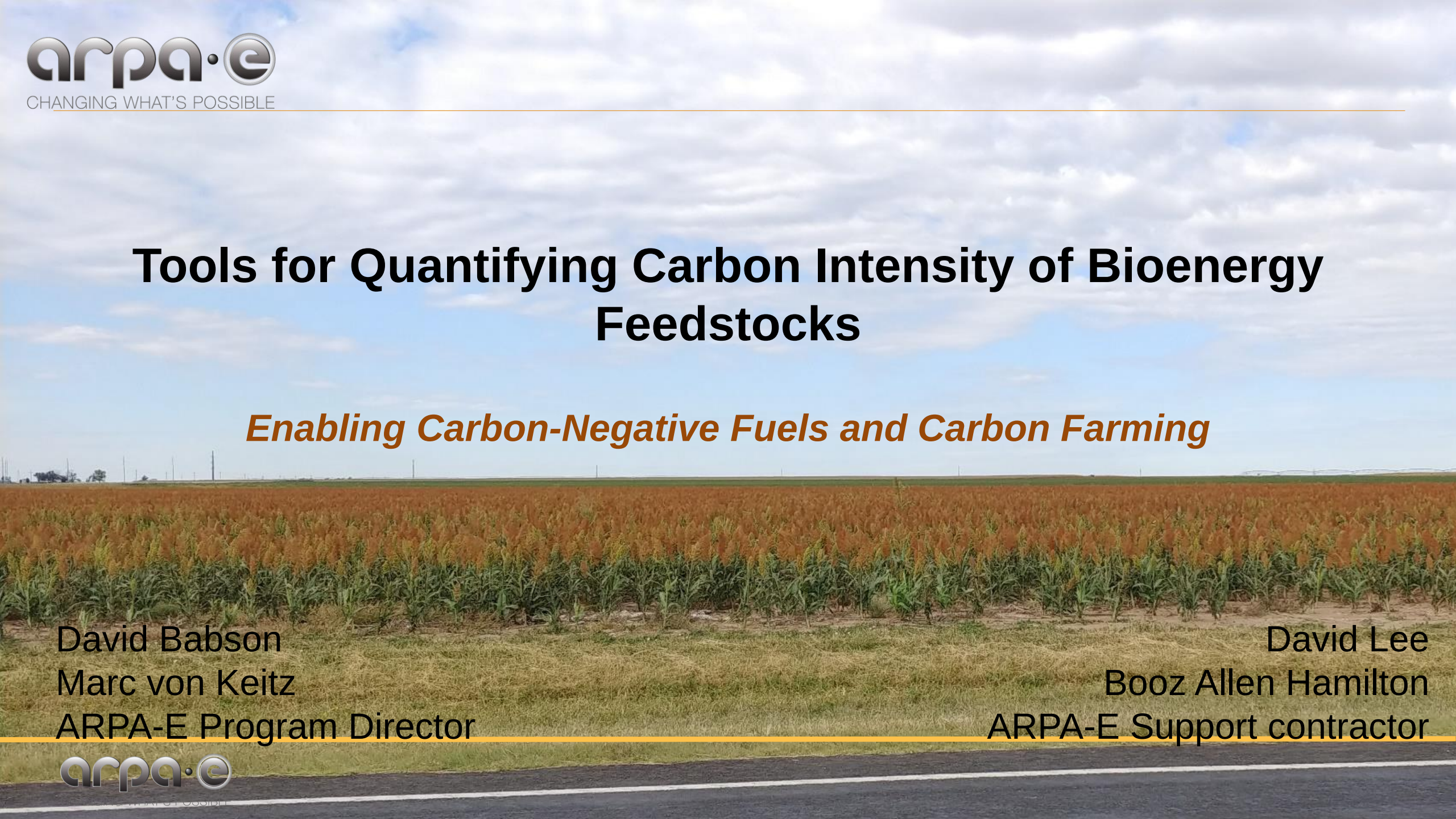


Tools for Quantifying Carbon Intensity of Bioenergy Feedstocks

Enabling Carbon-Negative Fuels and Carbon Farming

David Babson
Marc von Keitz
ARPA-E Program Director

David Lee
Booz Allen Hamilton
ARPA-E Support contractor

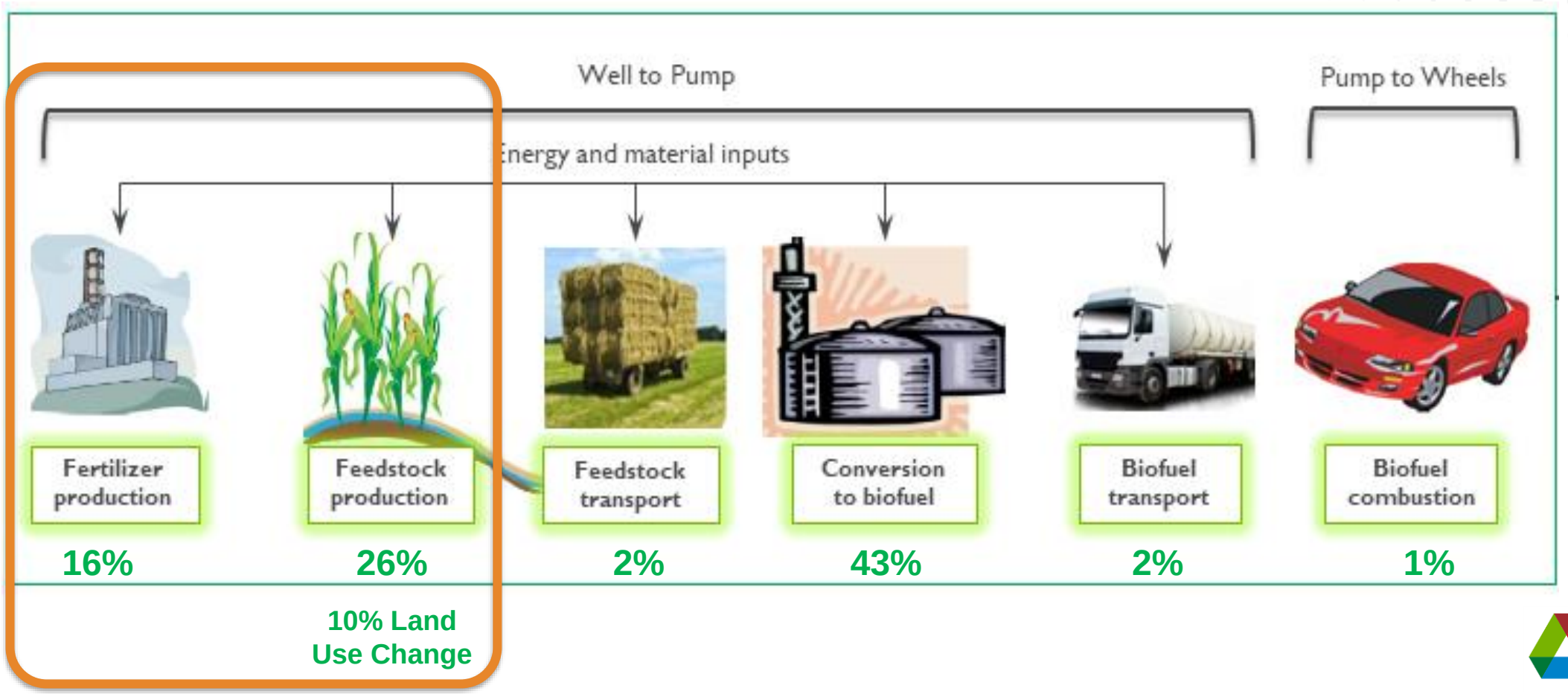
ARPA-E Mission Thrusts

Mission: To overcome long-term and high-risk technological barriers in the development of energy tech

Current Corn Ethanol Carbon Intensity: 50-80 g CO_2e/MJ

>40% of well-to-wheel emissions originate upstream

Low visibility; revenue streams are limited to yield



Emissions Breakdown

Range based on GREET and Industry Life Cycle Analyses (LCAs)

Data framework for farm-level carbon accounting

Primary output: **CO_2e/bu**

Components of **CO_2e/bu**

Components based on:

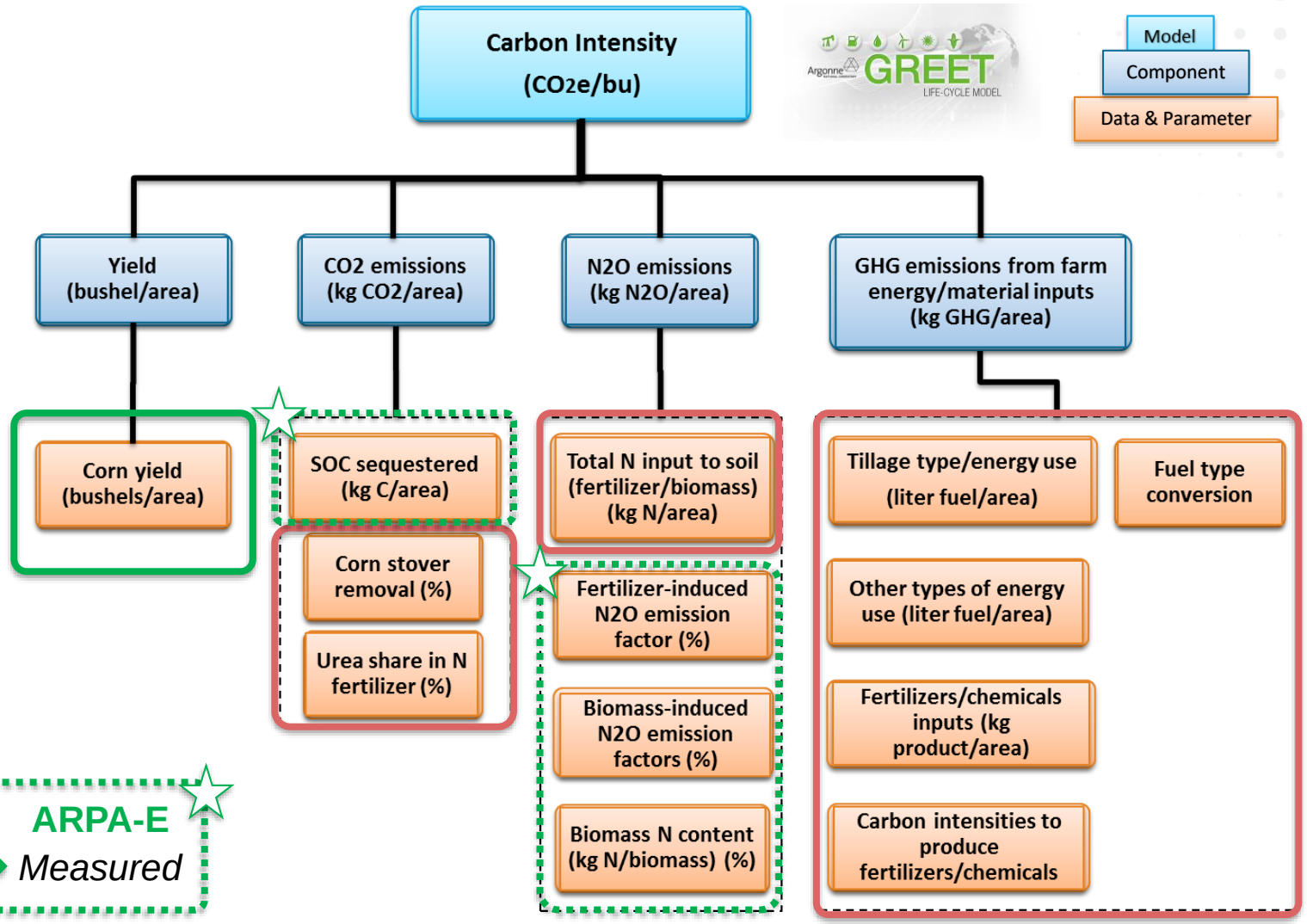
Management

Rotation
Tillage/Cover crop
Irrigation
Genetics (e.g. ROOTS)
Chemical inputs (e.g. REFUEL)

Outcome

Yield
Measured

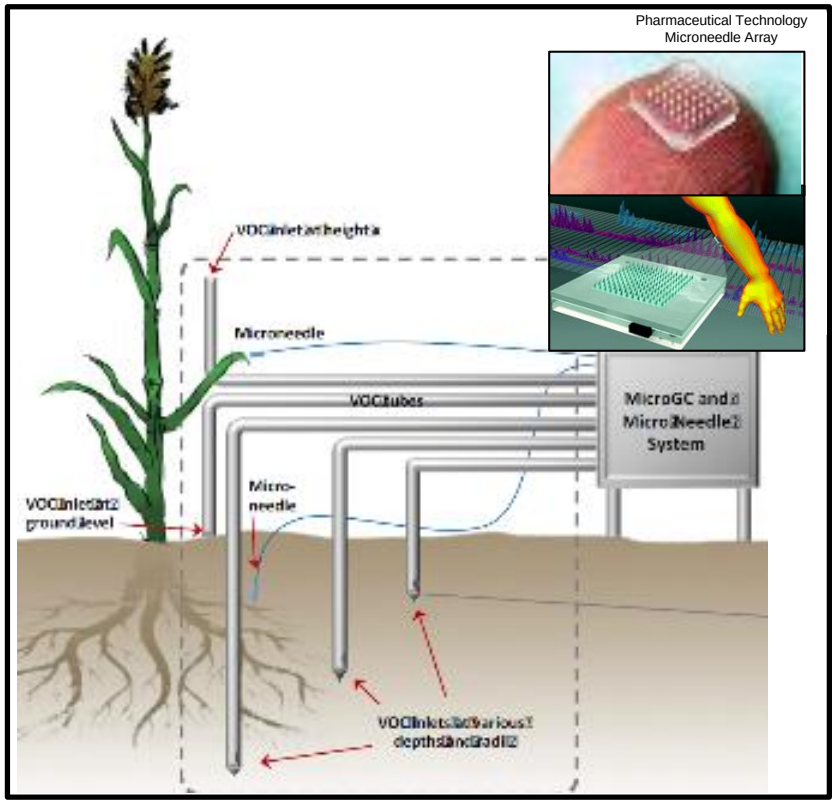
CO_2e
U.S. avg → **ARPA-E** *Measured*

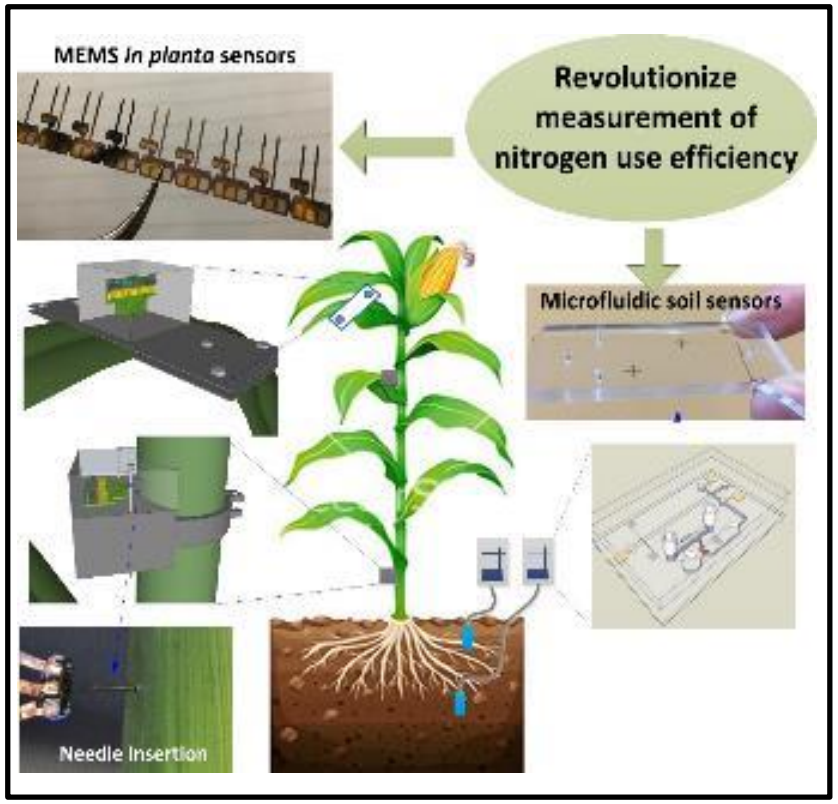


Advanced Field Based Sensing Tools

ROOTS
Soil Carbon Capture

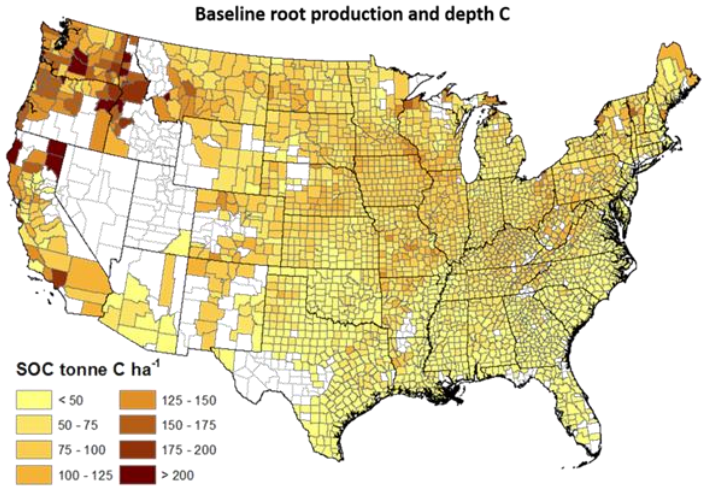
- In field physiological monitoring – plant, soil and microbial
- Plant level monitoring products of photosynthesis
- Soil sensors measure gas release and nitrate

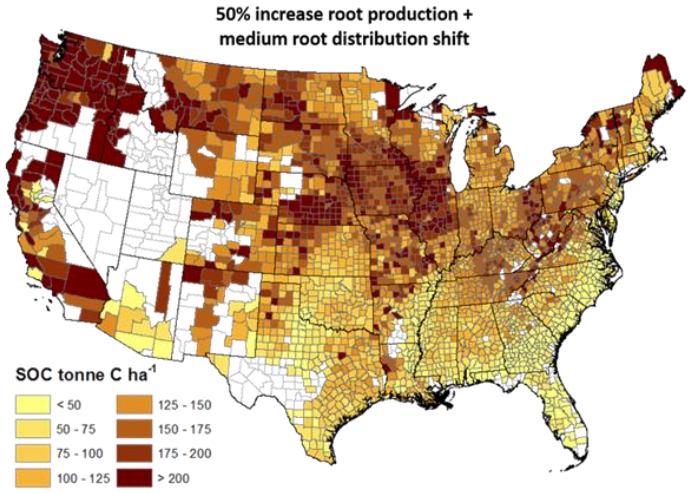


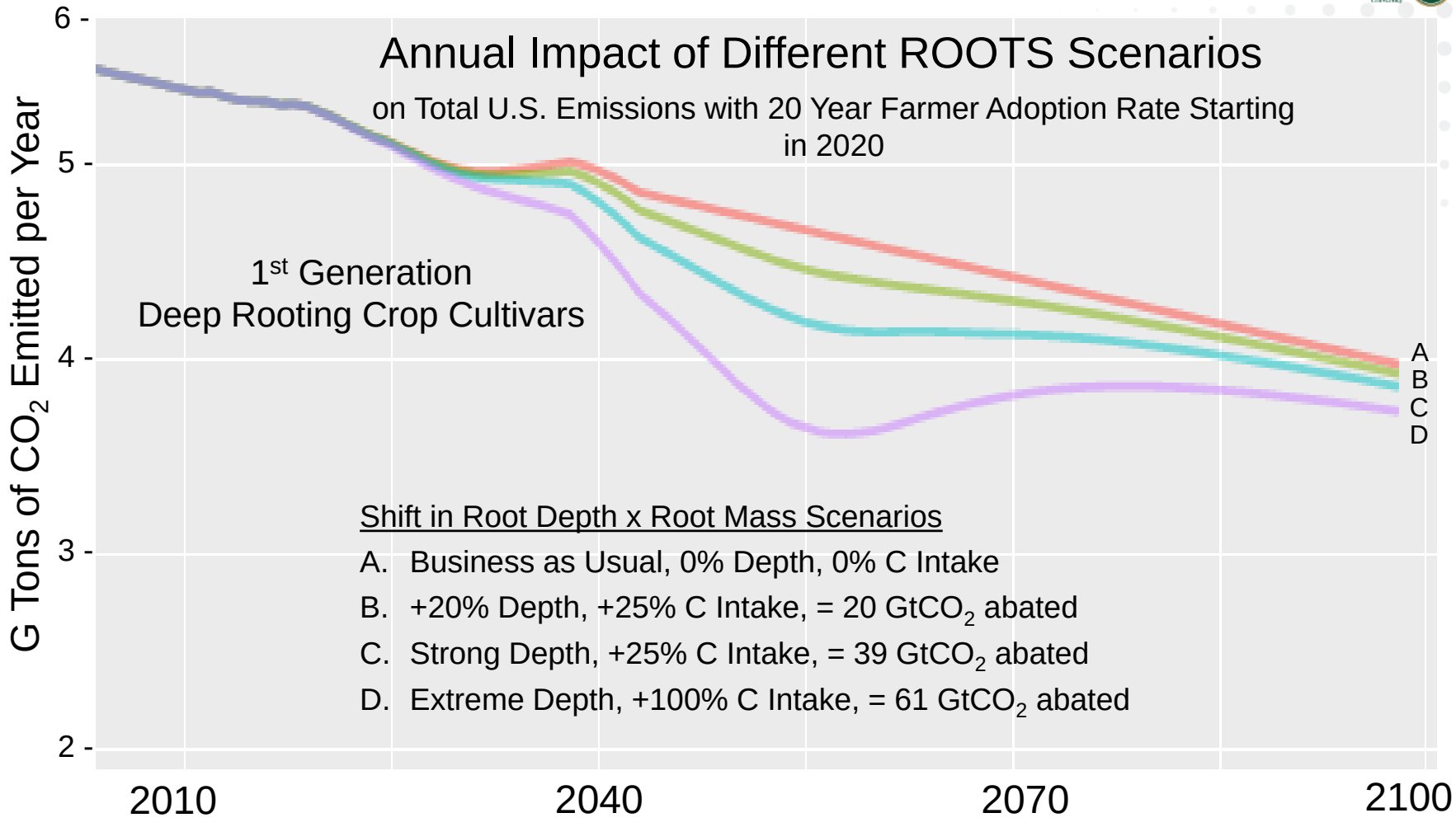


Potential CO_2 Emissions Captured

with Improved Crop Roots





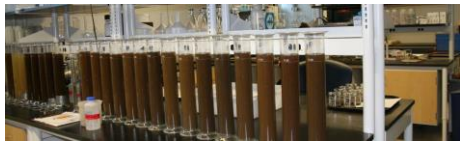


"If it Works, Will it Matter?"

Potential SmartFarm Programs for Quantifying and Optimizing Ag Practices

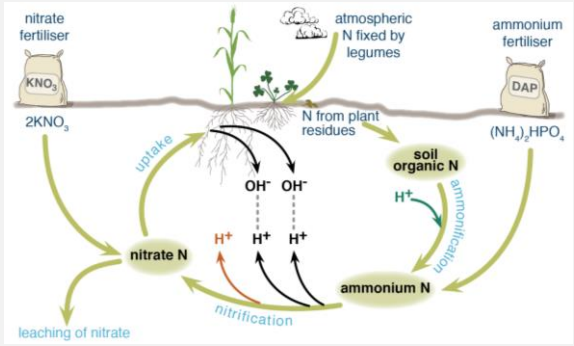
Systems for Monitoring and Analytics for Renewable Transportation Fuel from Agricultural Resources and Management

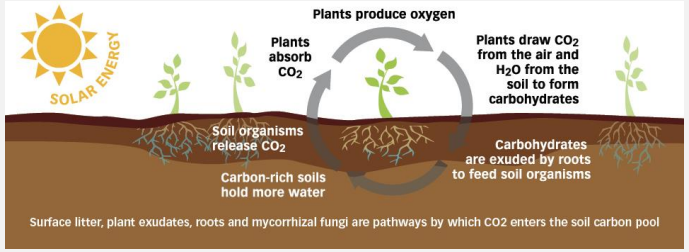
1. Set a Baseline



- Establish ground truth in real-world conditions
- Pilot market mechanisms
- Higher cost, higher resolution

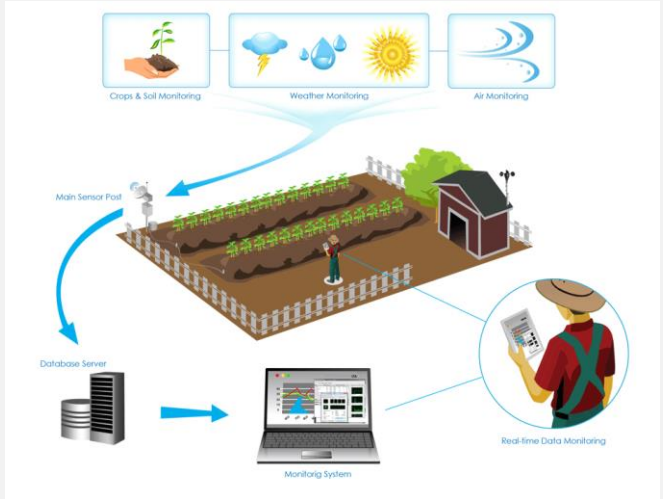
2. Develop New Methods





- Directly measure N & C flux
- Increase reliability, resilience
- Reduce cost and footprint
- Incorporate IoT hardware

3. Provide Decision Support



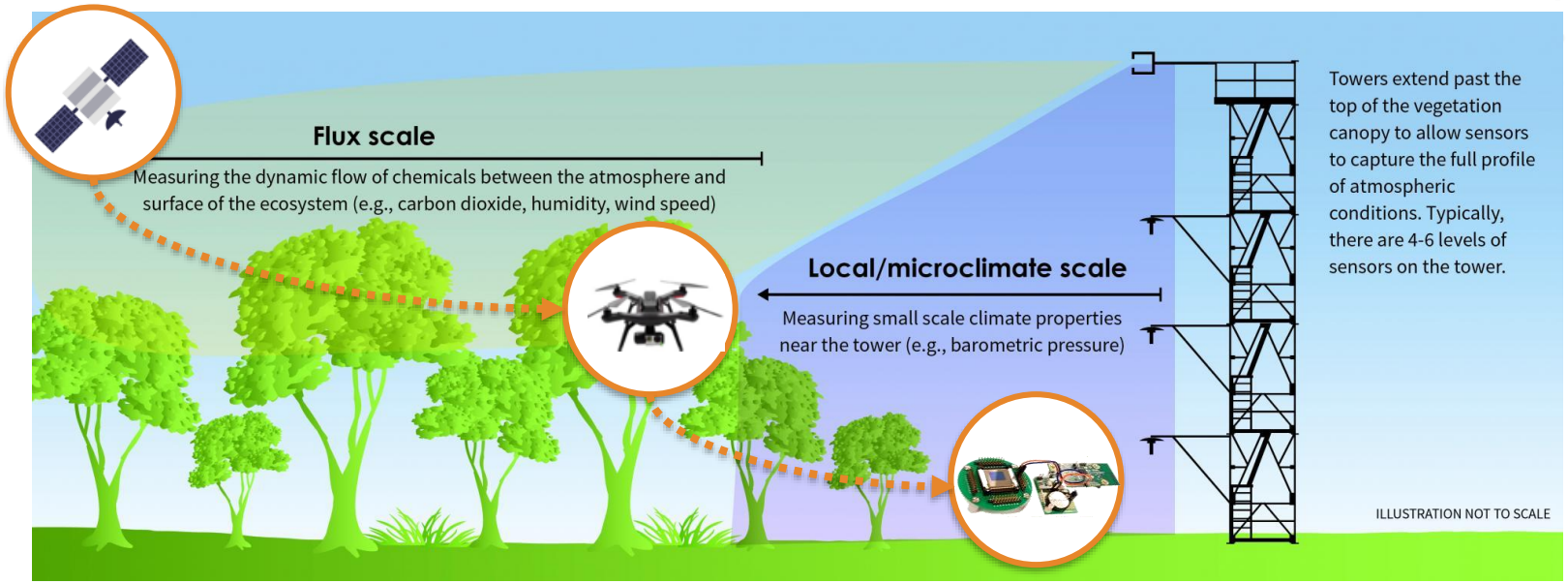
- Management ⟺ Outcomes
- Aggressive cost targets
- System optimization
- Field-level data product

https://arpa-e-foa.energy.gov/

New tools for above- and below-ground verification

ARPA-Hard: Sensor accuracy, reliability and deployment

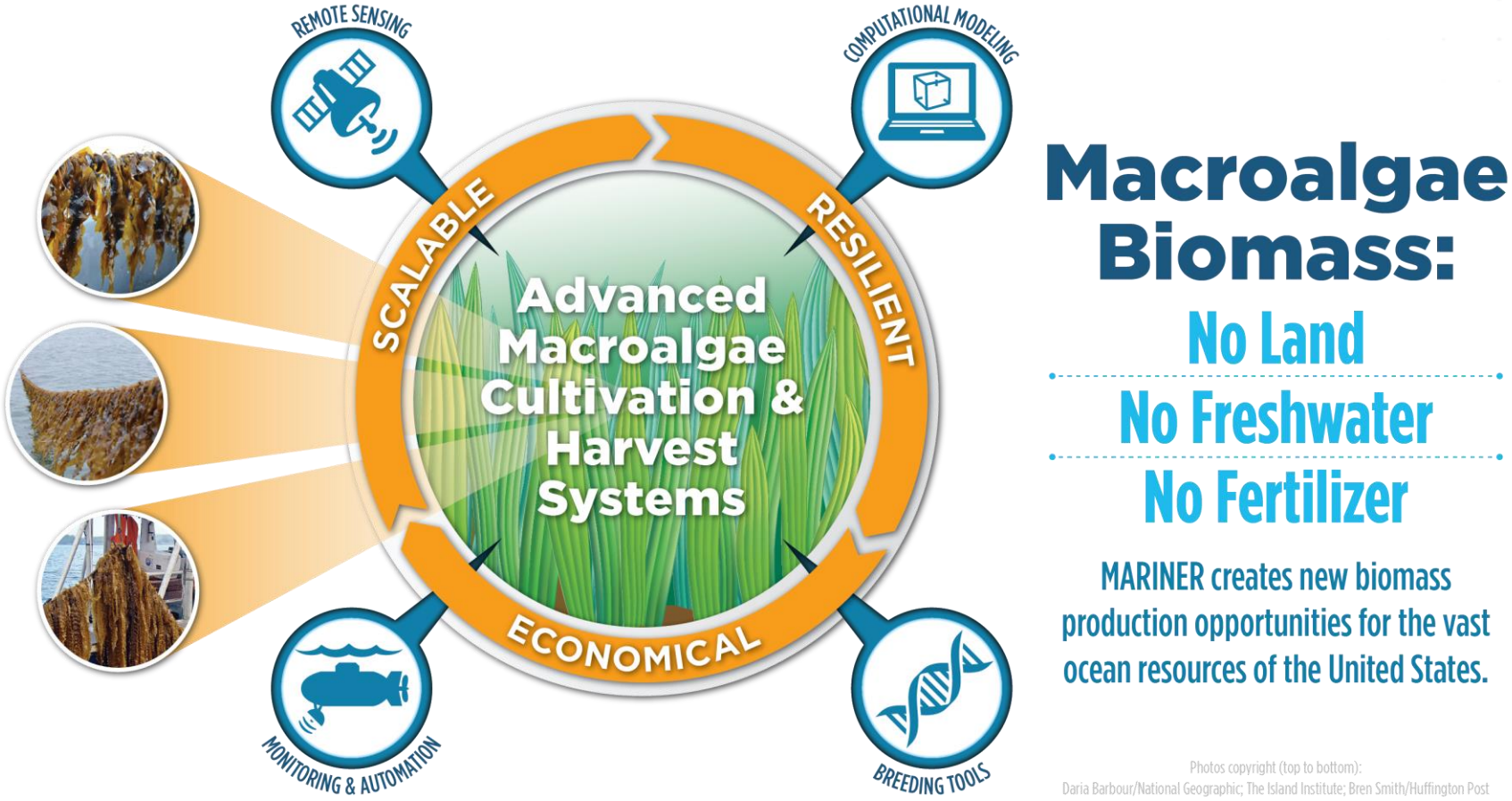
Aboveground monitoring of N_2O, CO_2, CH_4 flux



Belowground validation of carbon sequestration

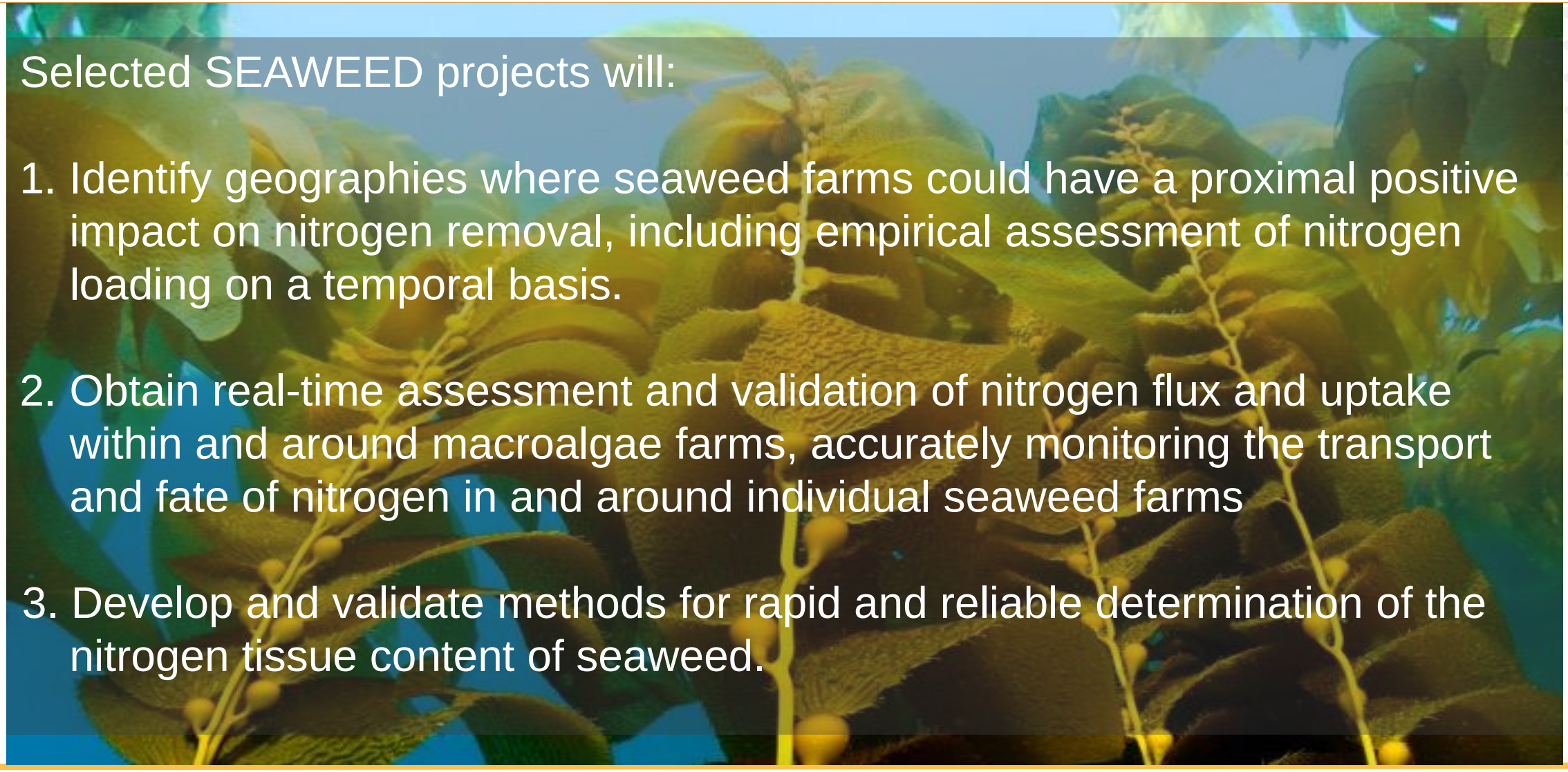
CHANGING WHAT'S POSSIBLE

The ARPA-E MARINER Program



MARINER kicked off in 2018, and Phase II deployment started in 2019.

Tools for Remediation of Marine Environments



Selected SEAWEED projects will:

1. Identify geographies where seaweed farms could have a proximal positive impact on nitrogen removal, including empirical assessment of nitrogen loading on a temporal basis.

2. Obtain real-time assessment and validation of nitrogen flux and uptake within and around macroalgae farms, accurately monitoring the transport and fate of nitrogen in and around individual seaweed farms

3. Develop and validate methods for rapid and reliable determination of the nitrogen tissue content of seaweed.

CHANGING WHAT'S POSSIBLE

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THANK YOU

CHANGING WHAT'S POSSIBLE