Soil Health: Recent Advances and Future Directions

Wayne Honeycutt

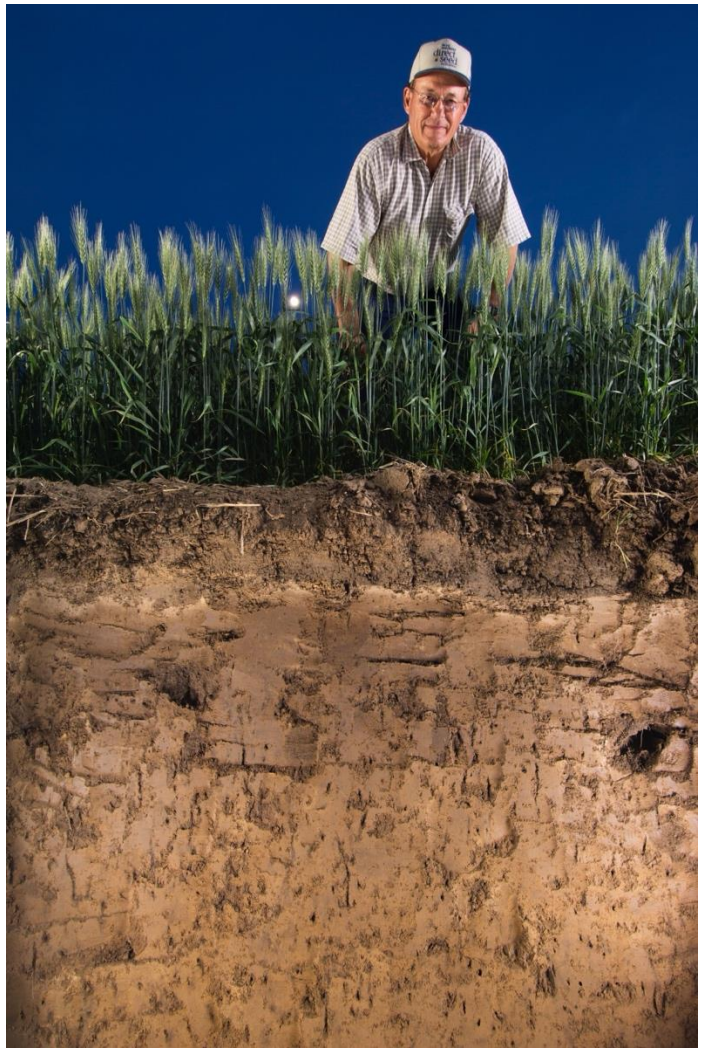
Soil Health is About Soil Functioning

SOIL HEALTH INSTITUTE

Soil Health is the Foundation for Regenerative Agriculture

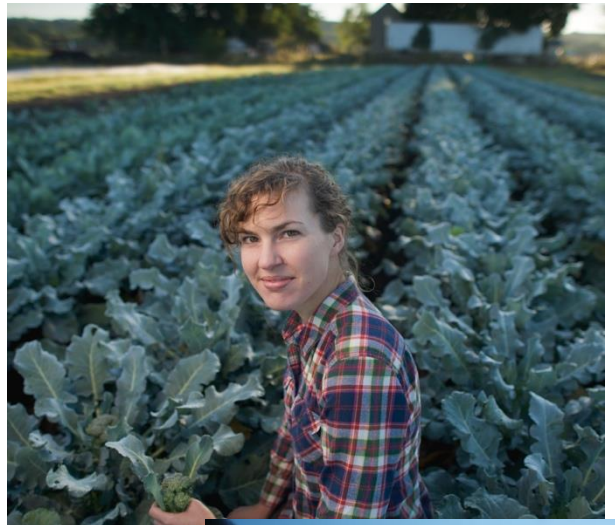
Benefits of Healthy Soils

- Drought Resilience
- Yield Stability
- Profitability
- Nutrient Availability
- Disease Suppression
- Carbon Sequestration
- Reduced GHG Emissions
- Improved Water Quality



SOIL HEALTH INSTITUTE

THE MOST CRITICAL INGREDIENT:



SOIL HEALTH INSTITUTE

SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

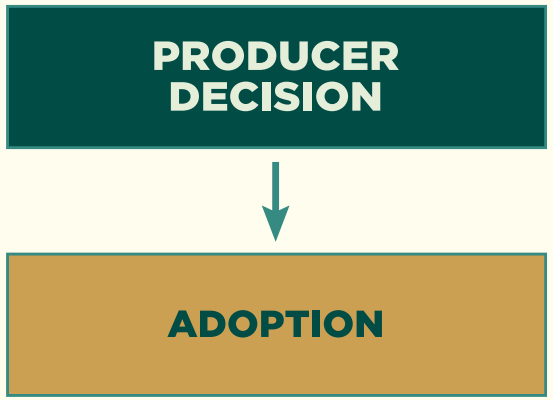
COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS

ADOPTION

SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

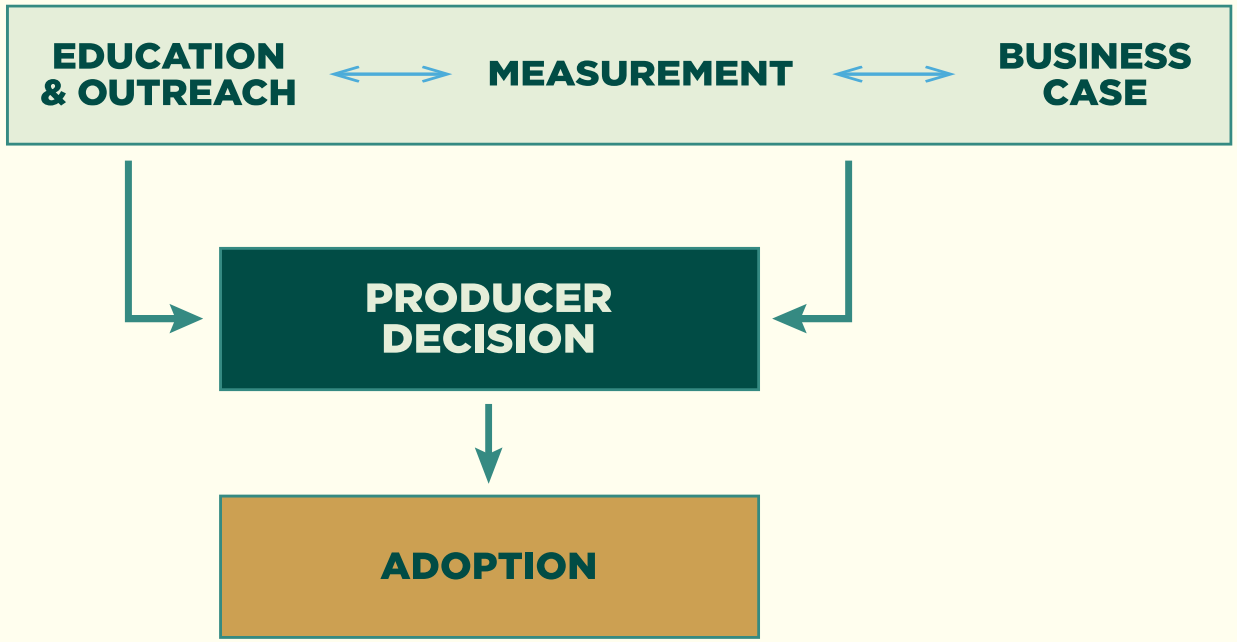
COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS



SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

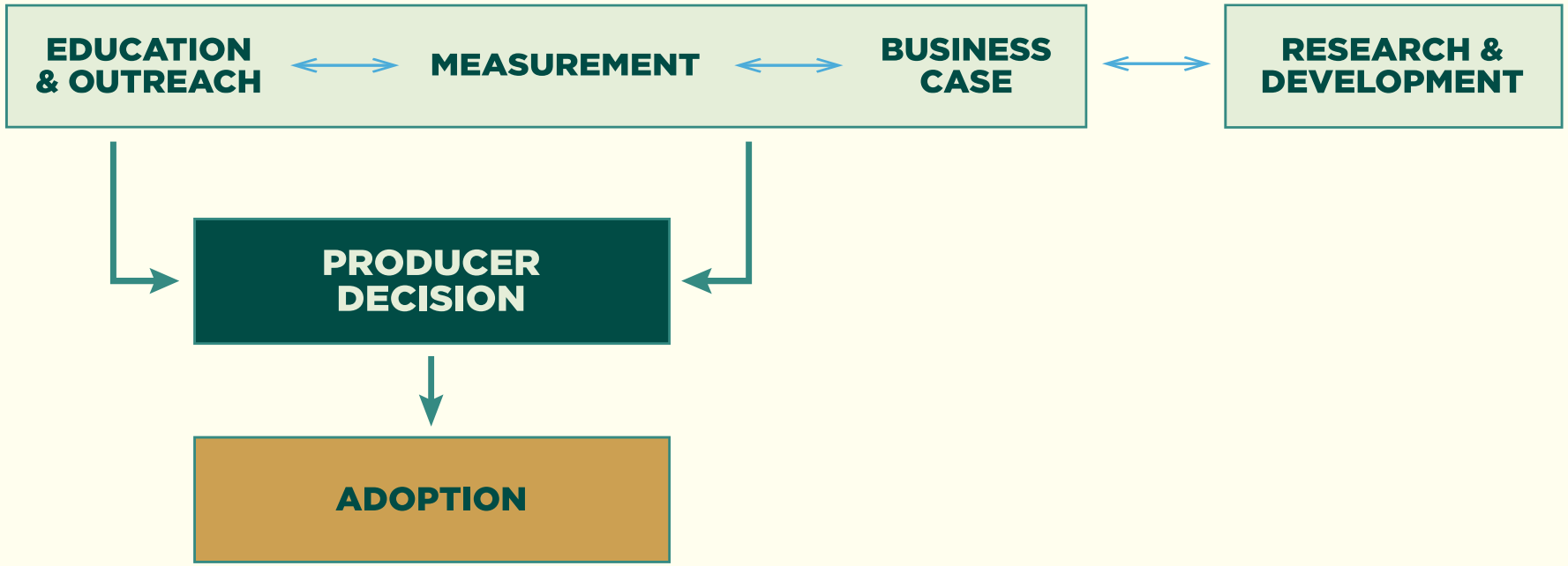
COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS



SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

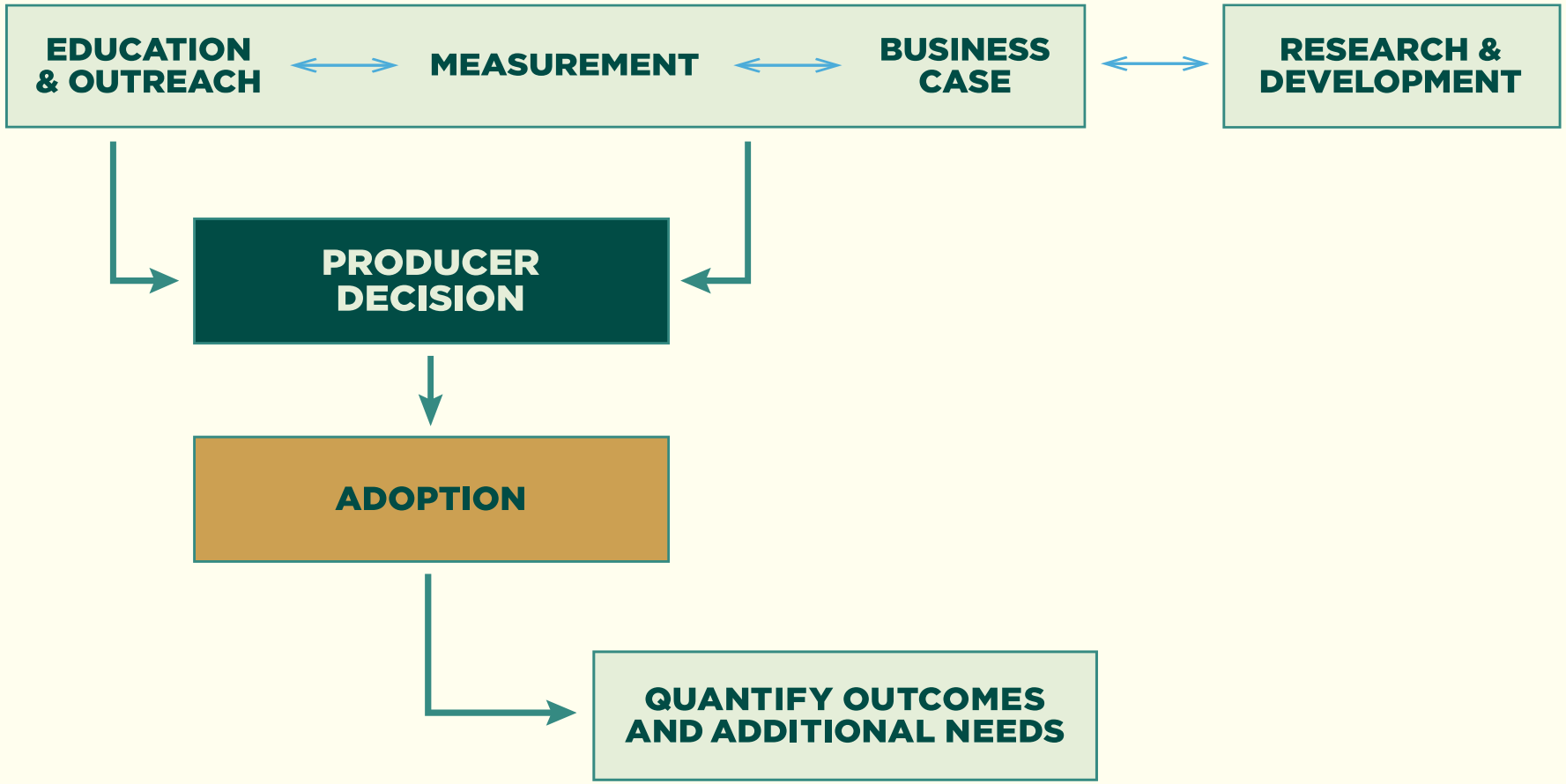
COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS



SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

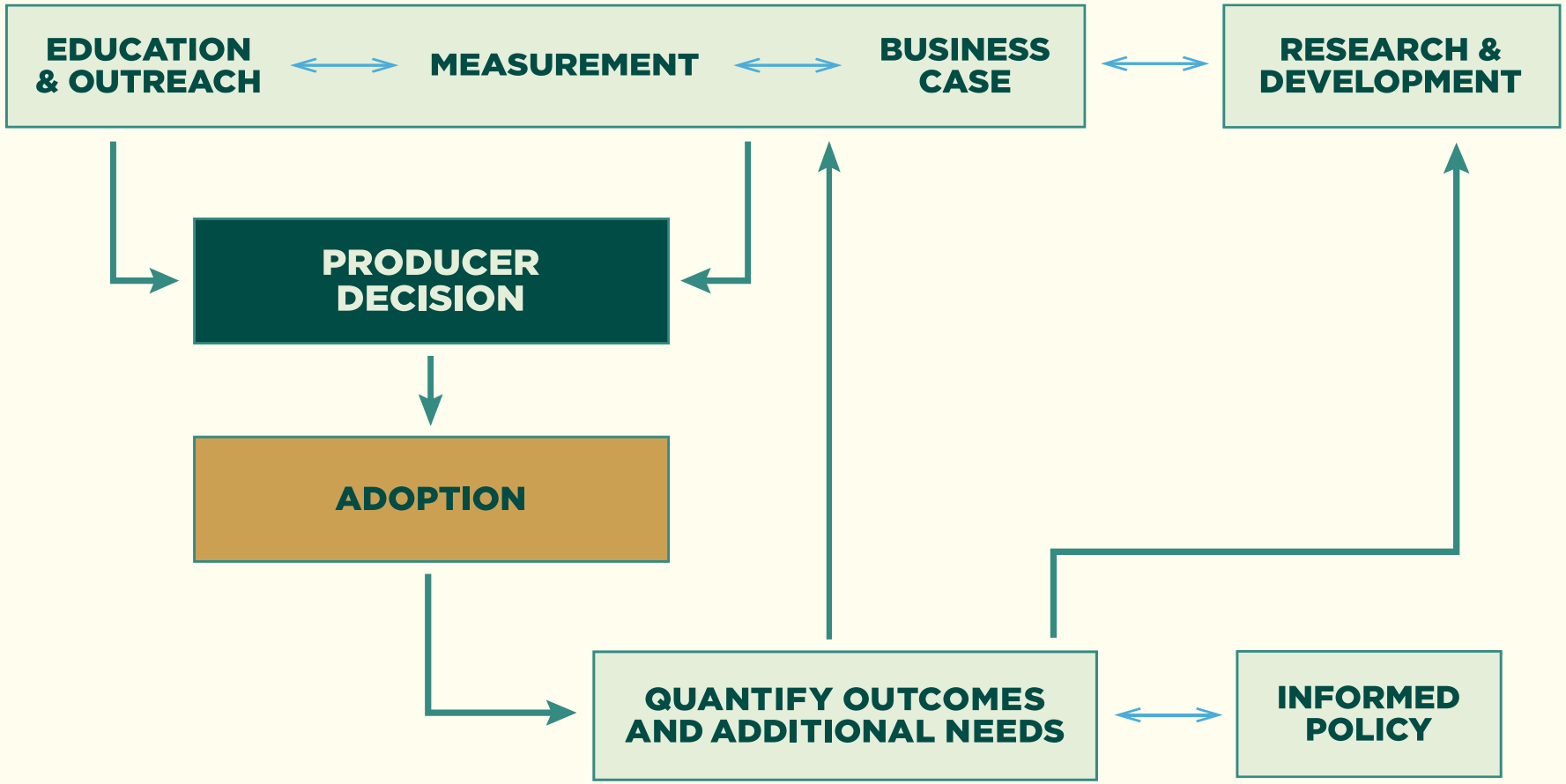
COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS



SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

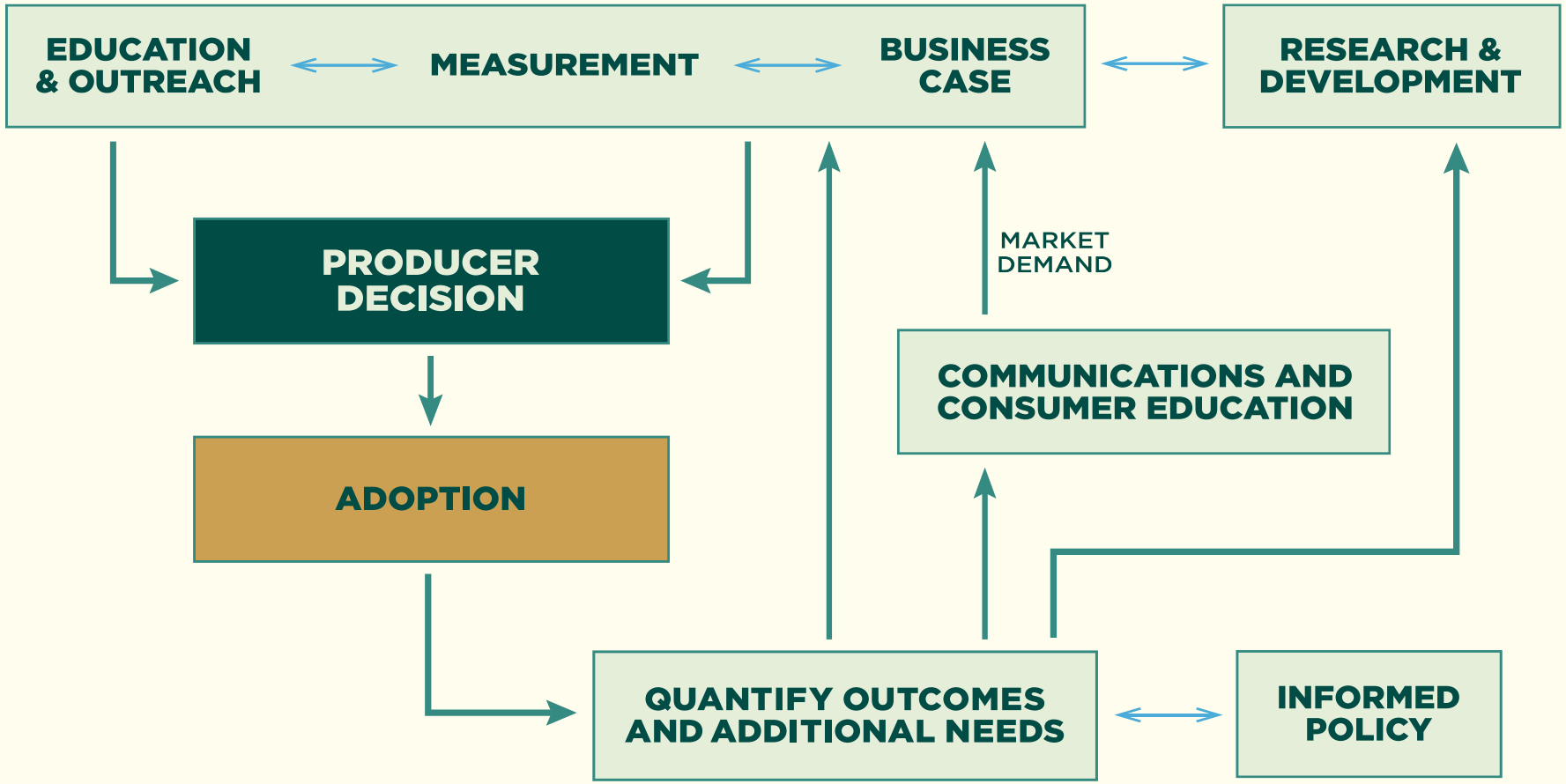
COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS



SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

COMPREHENSIVE STRATEGY TO INCREASE ADOPTION OF SOIL HEALTH MANAGEMENT SYSTEMS

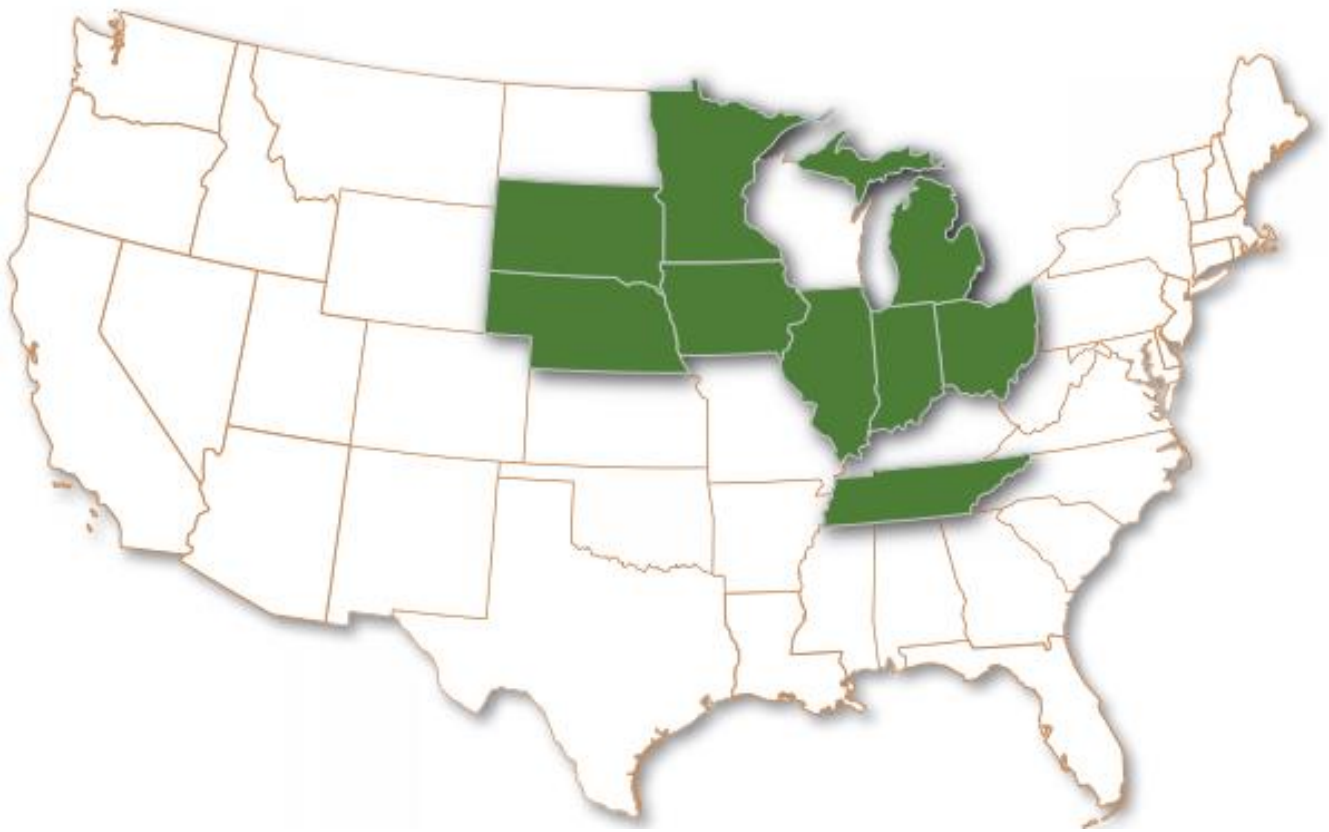


SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

LEVER OF CHANGE #1. BUSINESS CASE

ADVANCEMENT: Evaluated the Business Case for Soil Health

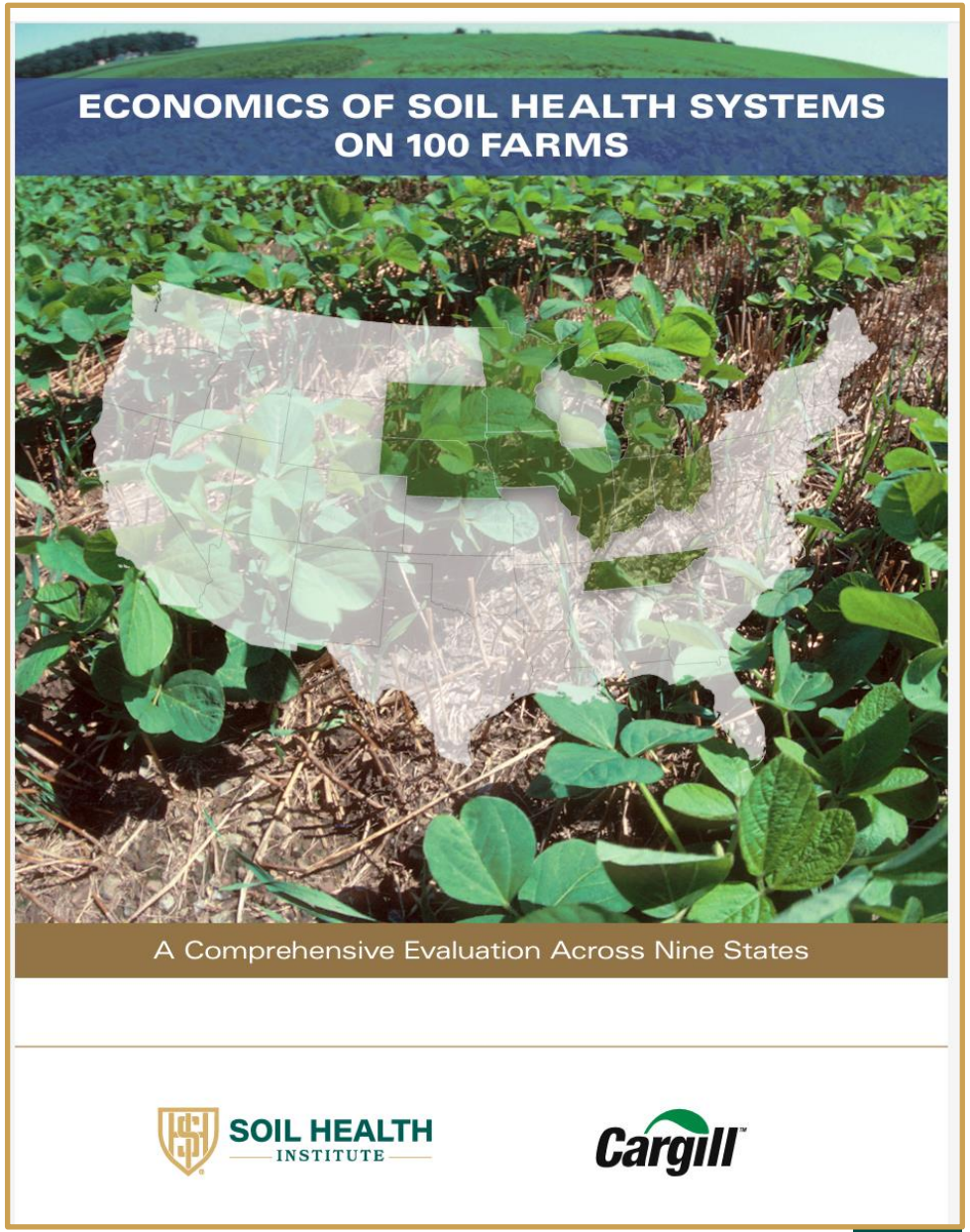


- 100 Farms
- 9 States
- 71% Corn in U.S.
- 67% Soybean in U.S.
- MAP: 20 – 55 in. (51 – 140 cm)
- MAT: 43 – 61°F (6 – 16°C)
- GDD: 2400 – 4000
- Average 1940 crop acres/farm
- Average No-Till for 19 years
- Average Cover Crops for 9 years

Funder: Cargill

Summary of Findings from 100 Farms

- SHMS reduced average production costs by:
  - $24/acre for corn
  - $17/acre for soybean
- SHMS increased net farm income for:
  - 85% of farmers growing corn
  - 88% of farmers growing soybean
- SHMS increased average net farm income by:
  - $52/acre for corn
  - $45/acre for soybean
- Additional benefits reported by farmers:
  - 83% reduced fertilizer inputs
  - 93% increased access to their fields
  - 97% increased resilience to extreme weather
- Based on current adoption rates in these 9 states (41% no-till; 6% cover crops) more farmers could increase net farm income with SHMS



SOIL HEALTH INSTITUTE

ADVANCEMENT: Business Case of Soil Health Mgmt. System Adoption

Average Net Income Increase from SHMS

DIVERSE SYSTEMS

↑ $65/acre

across 29 farms in 20 states

CORN AND SOYBEAN

↑ $52/acre

↑ $45/acre

across 100 farms in 9 states

COTTON

↑ $150/acre

across 19 farms in 5 states

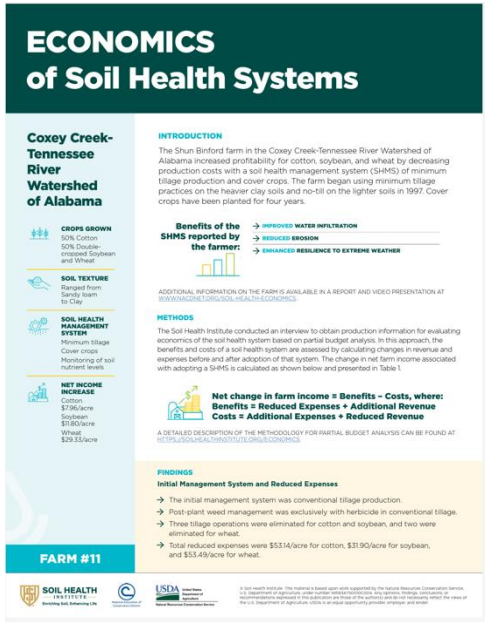
SMALL GRAINS

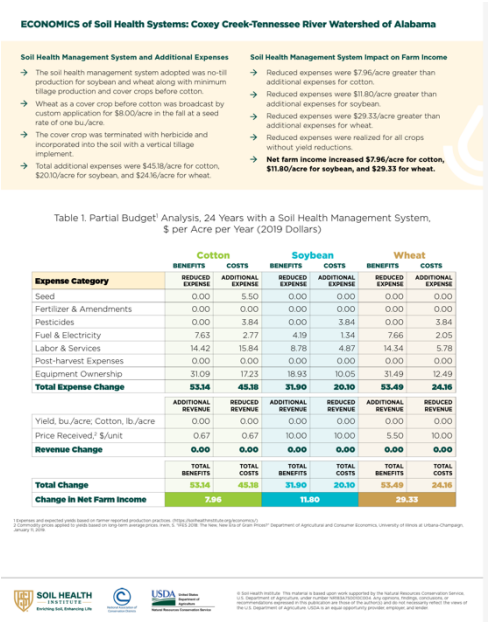
↑ $19/acre

across 10 farms in North Dakota and Kansas

↑ US$31/acre

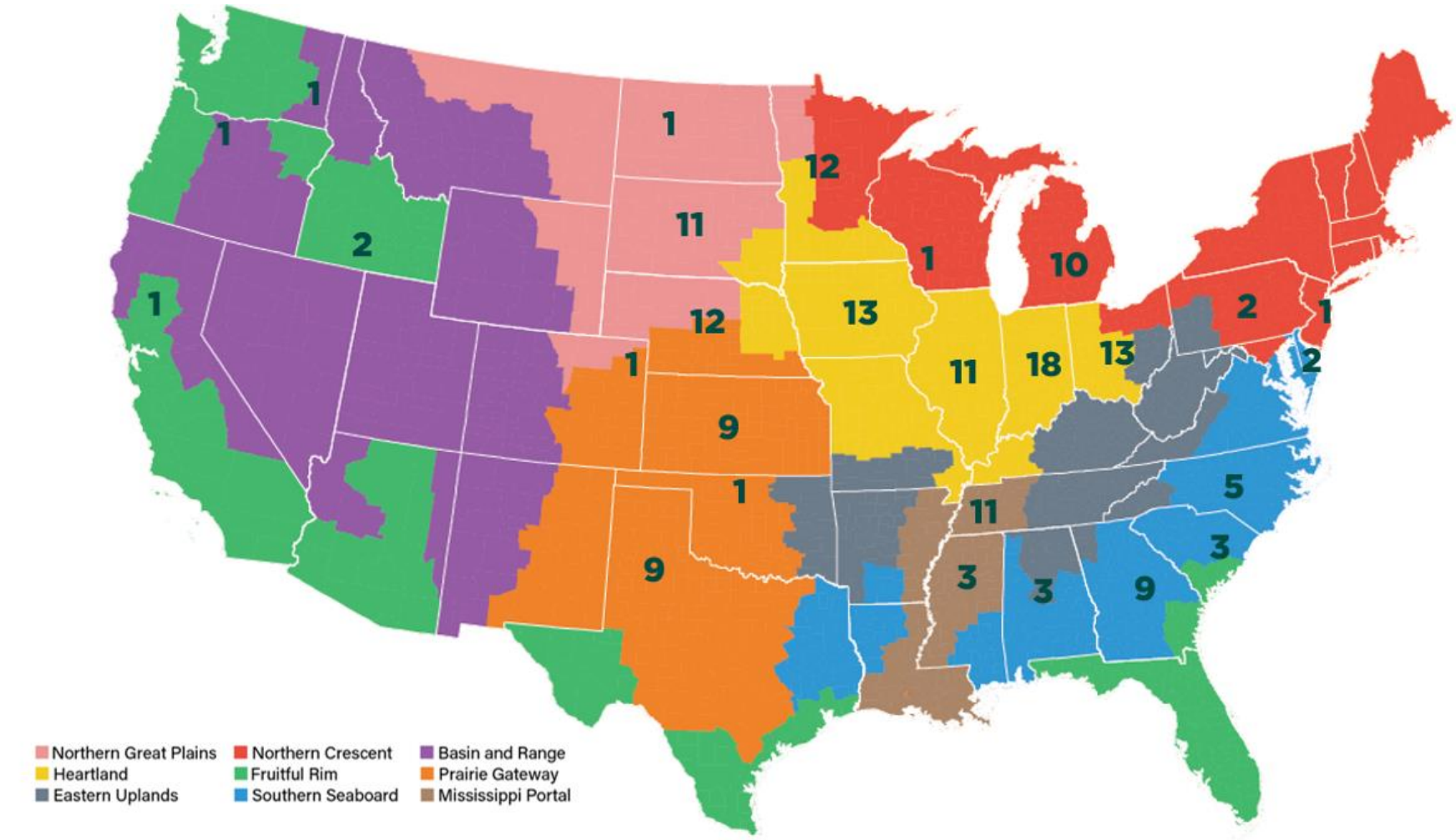
across 5 farms in Canada





SOIL HEALTH INSTITUTE

FUTURE DIRECTIONS: 1) Expand Evaluations of Long-Term Business Case 2) Develop Predictive Tool of Short-Term Changes in Economics



SOIL HEALTH INSTITUTE

Region map: USDA, Economic Research Service

SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

LEVER OF CHANGE #2. MEASUREMENT

Workshops to Identify Effective Soil Health Measurements

Organizer/Sponsor	Date	Location
Noble Foundation, Farm Foundation	Nov. 2014	Ardmore, OK
Noble Foundation, Farm Foundation	Apr. 2015	Ardmore, OK
Noble Foundation, Farm Foundation	Oct. 2015	Dallas, TX
Noble Foundation, SHI, NRCS	Feb. 2016	Ardmore, OK
Soil Health Institute – Measurement Straw Papers & Survey (Tier 1, 2, 3 Measurements Followed)	July 2016	Louisville, KY

SOIL HEALTH INSTITUTE

LIMITATIONS OF LITERATURE TO IDENTIFY EFFECTIVE MEASUREMENTS

Data from Multiple Studies Combines Different:

- measurements,
- methods,
- labs,
- sampling intensity & methodology,
- sample handling & shipping,
- sample storage,
- sampling times in relation to management practices,
- unknown inherent soil properties,
- inconsistent and unknown management histories
- …

NORTH AMERICAN PROJECT TO EVALUATE SOIL HEALTH MEASUREMENTS

GOAL: Identify Effective, Widely Applicable Measurements of Soil Health to Scale Soil Health Assessment

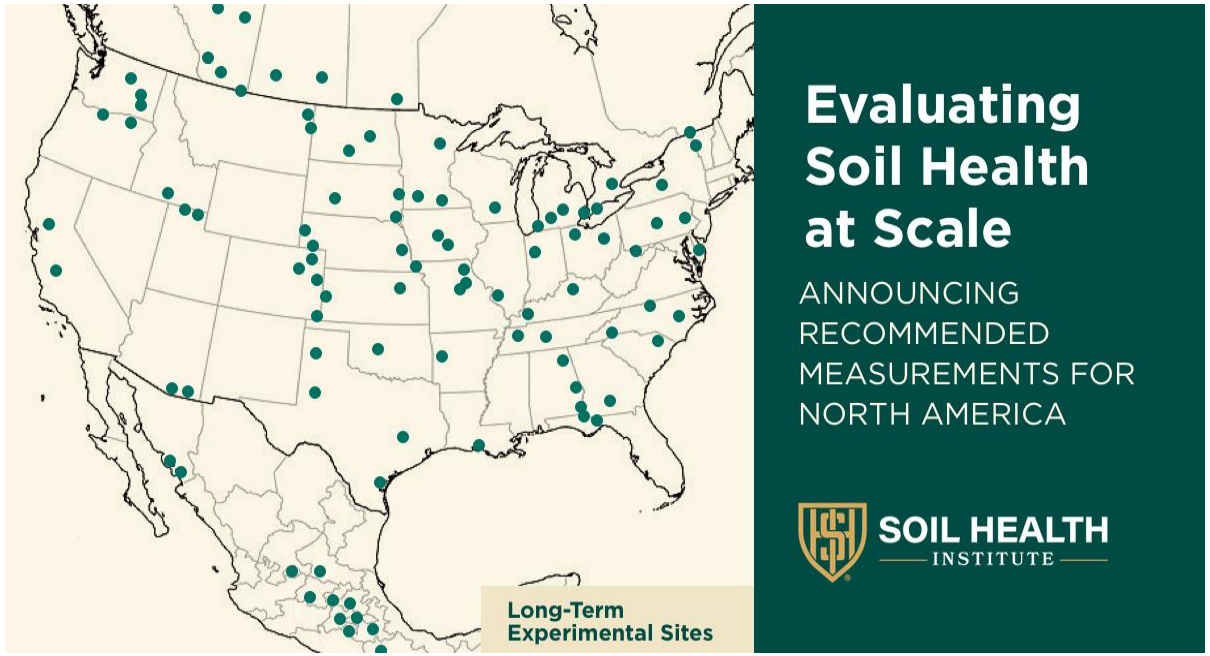
SOIL HEALTH INSTITUTE

SOIL HEALTH (AND RELATED) MEASUREMENTS EVALUATED

pH
Electrical Conductivity
Cation Exchange Capacity
Total Nitrogen
Extractable Phosphorus
Extractable Potassium
Percent Base Saturation
Sec./Micro. (Ca, Mg, S, Fe, Zn, Cu, Mn)
Organic Carbon
Short-Term C Mineralization
Nitrogen Mineralization
Enzymes: B-Glucosidase, Phosphatase, B-Glucosaminidase, Arylsulfatase
Soil Protein Index - Autoclave Citrate Ext.
Extractable non-nutrient elements Al, As, B, Ba, Cd, Co, Cr, Mo, Ni, Pb, Si, Sr
Soil Stability Index
Water Stable Aggregation

Particle Size
Bulk Density
Available Water Holding Capacity
Crop Yield
Erosion Rating
Penetration Resistance
Infiltration Rate
Saturated Hydraulic Conductivity
Sodium Adsorption Ratio
Active Carbon – Permanganate Oxidizable C
Phospholipid Fatty Acid (PLFA)
Ester-Linked Fatty Acid Methyl Ester (EL-FAME)
16S rRNA Amplicon Sequencing
Shotgun Metagenomic Sequencing
VisNIR & MIR Reflectance
Soil Management Assessment Framework (SMAF)
Cornell (CASH)
Haney

ADVANCEMENT: Evaluated > 30 Soil Health Measurements Across North America



Evaluating Soil Health at Scale

ANNOUNCING RECOMMENDED MEASUREMENTS FOR NORTH AMERICA

SOIL HEALTH INSTITUTE

30+

Soil Health Measurements Evaluated

124

Long-term Research Sites

688

Production System X Management Practice Combinations

29

Peer-reviewed Publications

7

Laboratory Standard Operating Procedures

MAP=6-70 in/yr; MAT=37-77 F; Consistent Sampling, Shipping, Lab Protocols

$6.5M, 3-yr.
FFAR, Noble Fdn., General Mills, Walton Family Fdn.

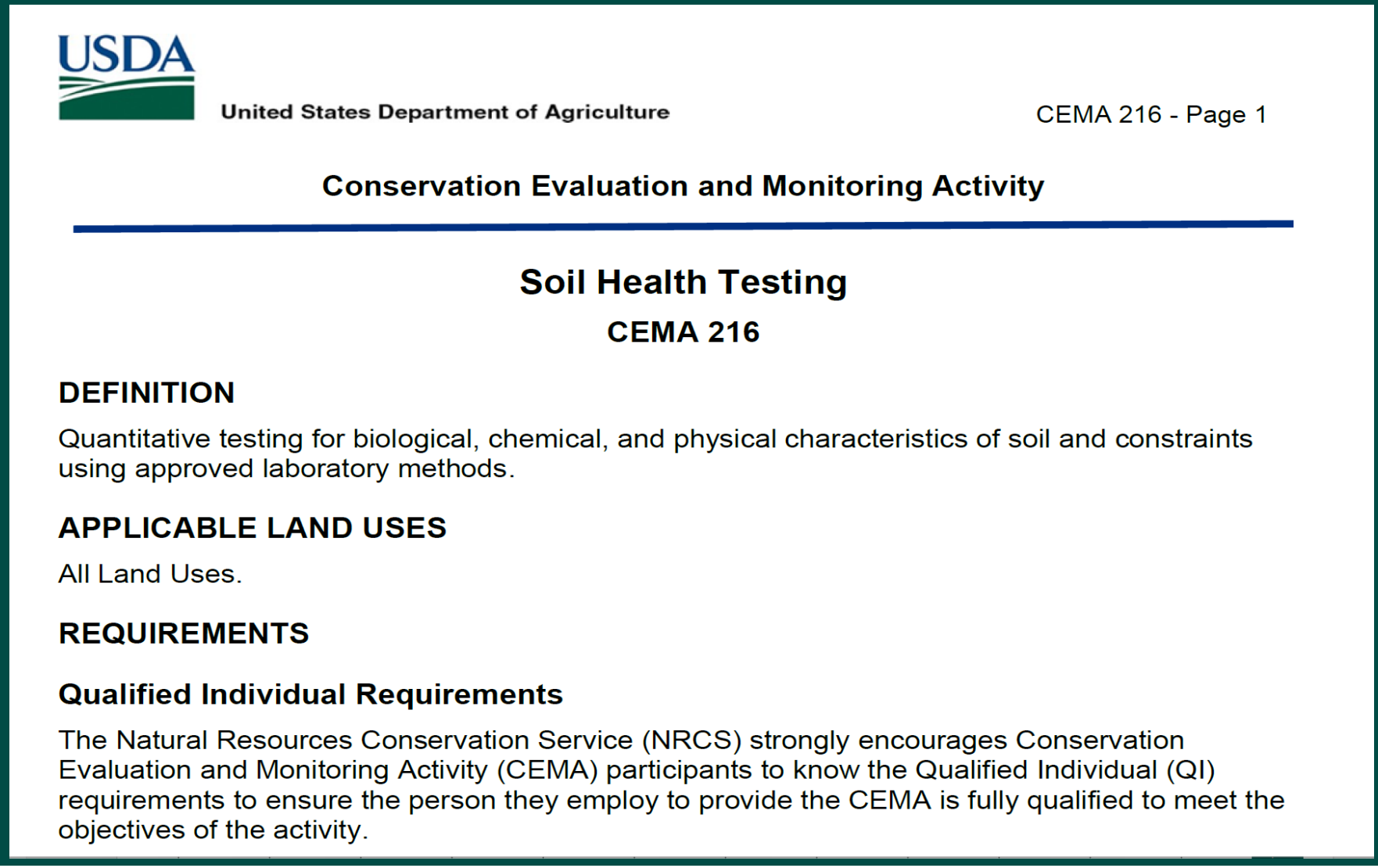
SOIL HEALTH INSTITUTE

ADVANCEMENT: Recommended Essential Suite of Soil Health Measurements for North America and Beyond

1. Soil Organic Carbon Concentration
2. Carbon Mineralization Potential
3. Aggregate Stability
4. *Predicted Available Water Holding Capacity*

(Bagnall et al. 2022. Soil Sci. Soc. Am. J. https://doi.org/10.1002/saj2.20395)

ADVANCEMENT: USDA-NRCS ADOPTION



USDA

United States Department of Agriculture

Conservation Evaluation and Monitoring Activity

Soil Health Testing

CEMA 216

DEFINITION

Quantitative testing for biological, chemical, and physical characteristics of soil and constraints using approved laboratory methods.

APPLICABLE LAND USES

All Land Uses.

REQUIREMENTS

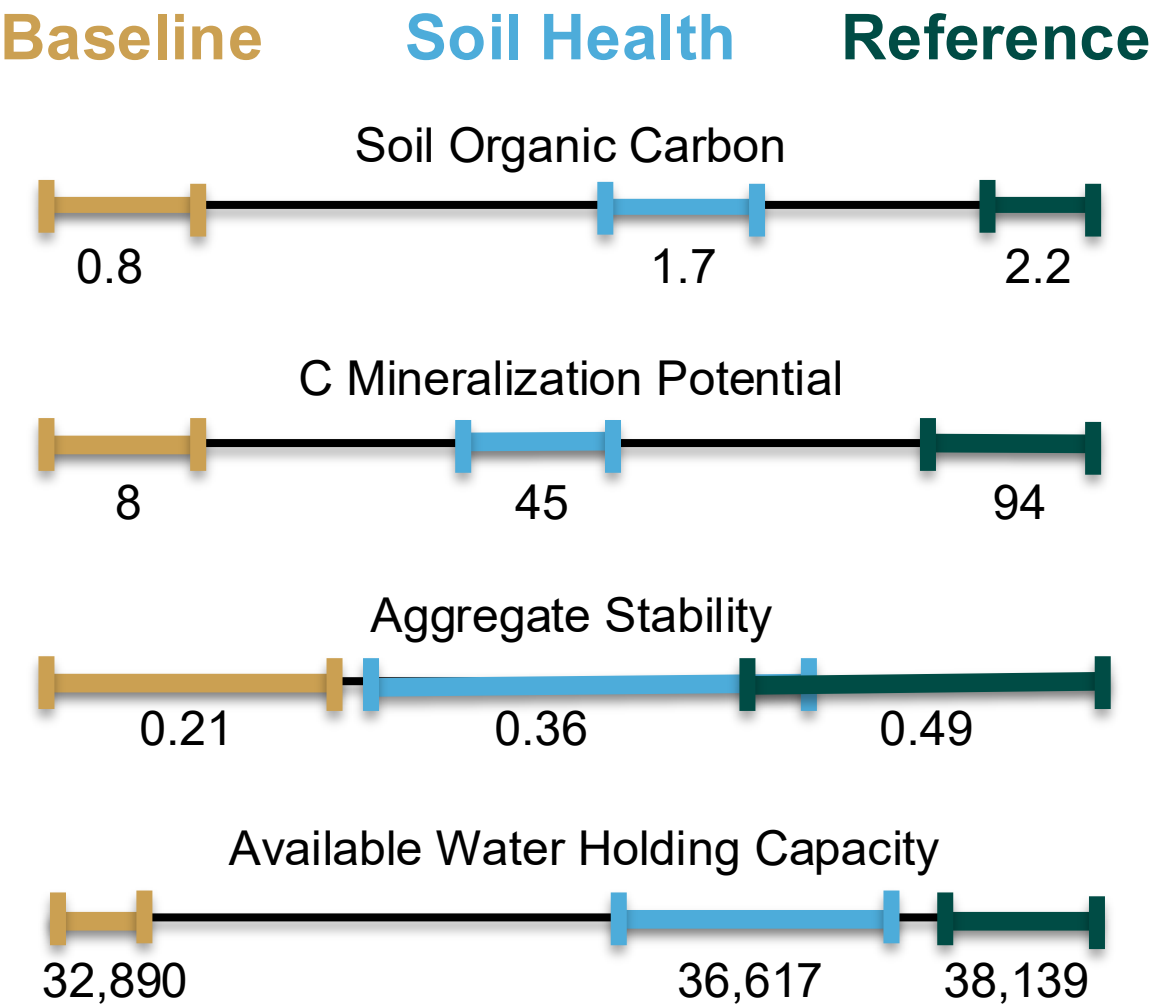
Qualified Individual Requirements

The Natural Resources Conservation Service (NRCS) strongly encourages Conservation Evaluation and Monitoring Activity (CEMA) participants to know the Qualified Individual (QI) requirements to ensure the person they employ to provide the CEMA is fully qualified to meet the objectives of the activity.

https://www.nrcs.usda.gov/sites/default/files/2023-09/FY24-CEMA-216-Soil-Health-Test-10-23.pdf

ADVANCEMENT: Local Soil Health Interpretations with Benchmarks

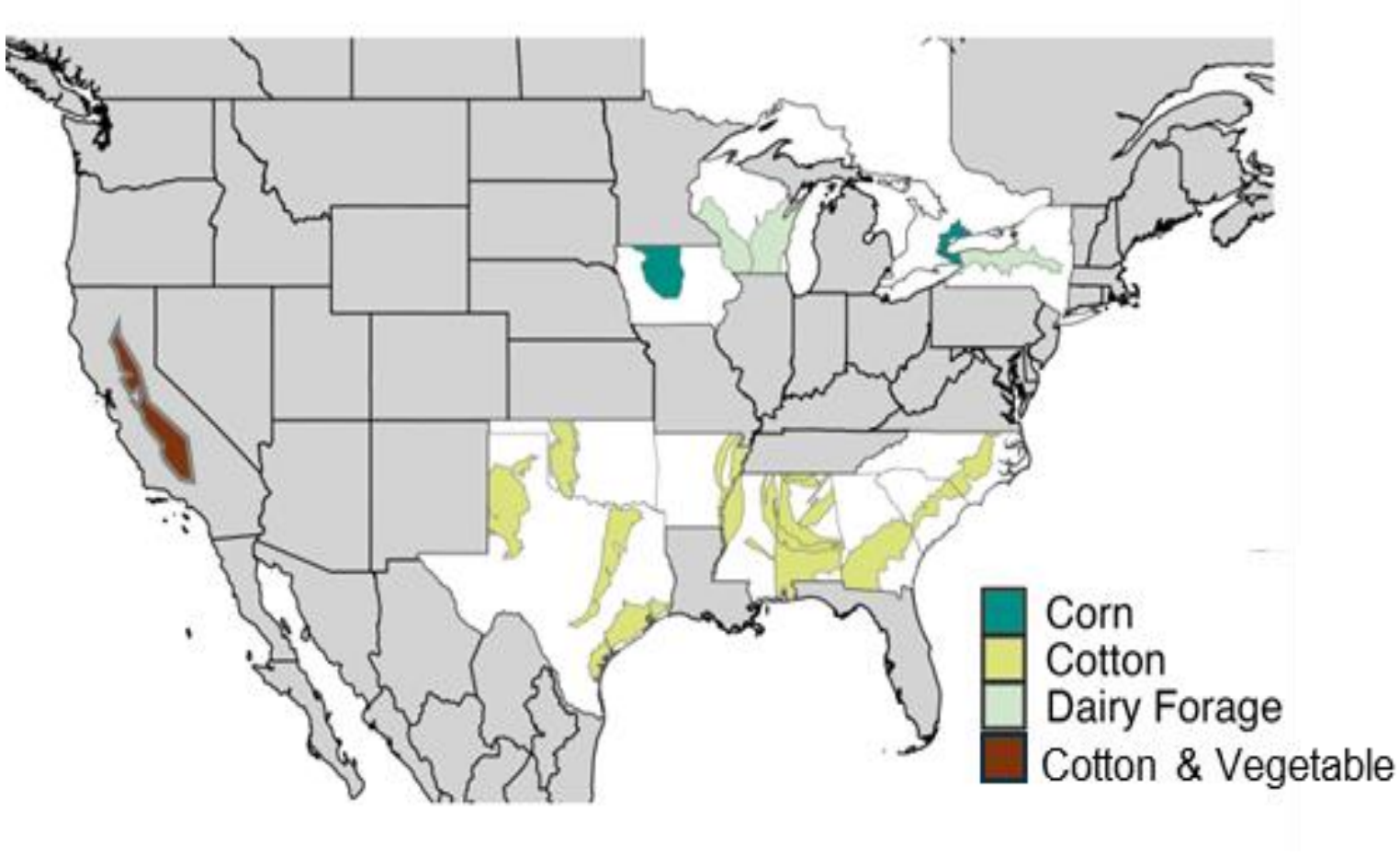
Management Systems

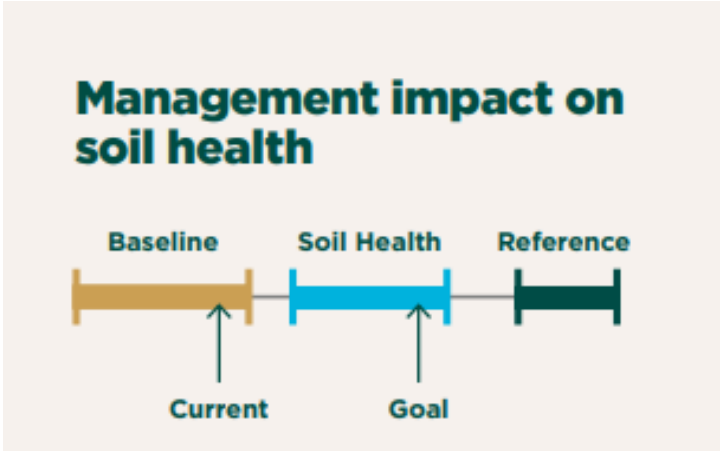


SOIL HEALTH INSTITUTE

SOIL HEALTH INSTITUTE

ADVANCEMENT & FUTURE DIRECTION: Establishing Soil Health Benchmarks





19M

Acres with established benchmarks

508

Farmer reports

Funders:
Ralph Lauren Foundation, Walmart Foundation, Dairy Mgmt. Inc., FFAR, VF Foundation, Levi's, Wells Fargo, Cotton Inc.

SOIL HEALTH INSTITUTE

ADVANCEMENT & FUTURE DIRECTION:
Soil Health Reports for Farmers, Conservationists, & Consultants

2025 Soil Health Report

Farm/Farmer Name

US REGENERATIVE COTTON FUND
SOIL HEALTH INSTITUTE

YOUR REGION

Your results were compared to soil health indicator values for similar soils under different management systems throughout the Georgia Southern Coastal Plain (shaded region below).

59 farmers participated

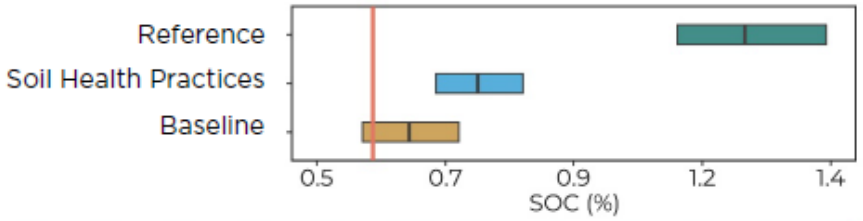
129 fields sampled

149 soils sampled

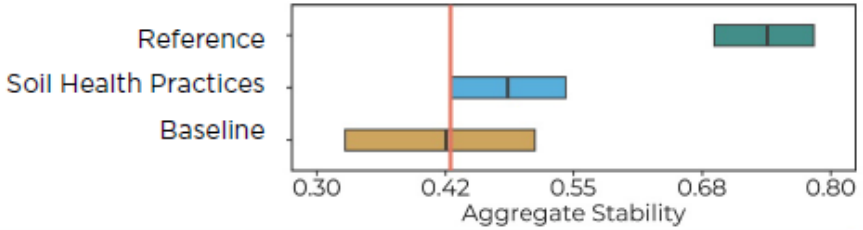
YOUR SOIL

Soil texture: Loamy sand
Crop at sampling: Cotton
Soil Survey map unit: Tifton loamy sand, 2 to 5 percent slopes

Soil Organic Carbon (SOC) measures the carbon contained in soil. Increasing SOC promotes soil structure, microbial activity, available water, and available nutrients. Soil organic matter can be estimated by multiplying SOC by 1.72.



Aggregate Stability measures soil structure and resistance to disturbance. Soils with greater aggregate stability are more resistant to erosion and have improved aeration and water filtration and storage.



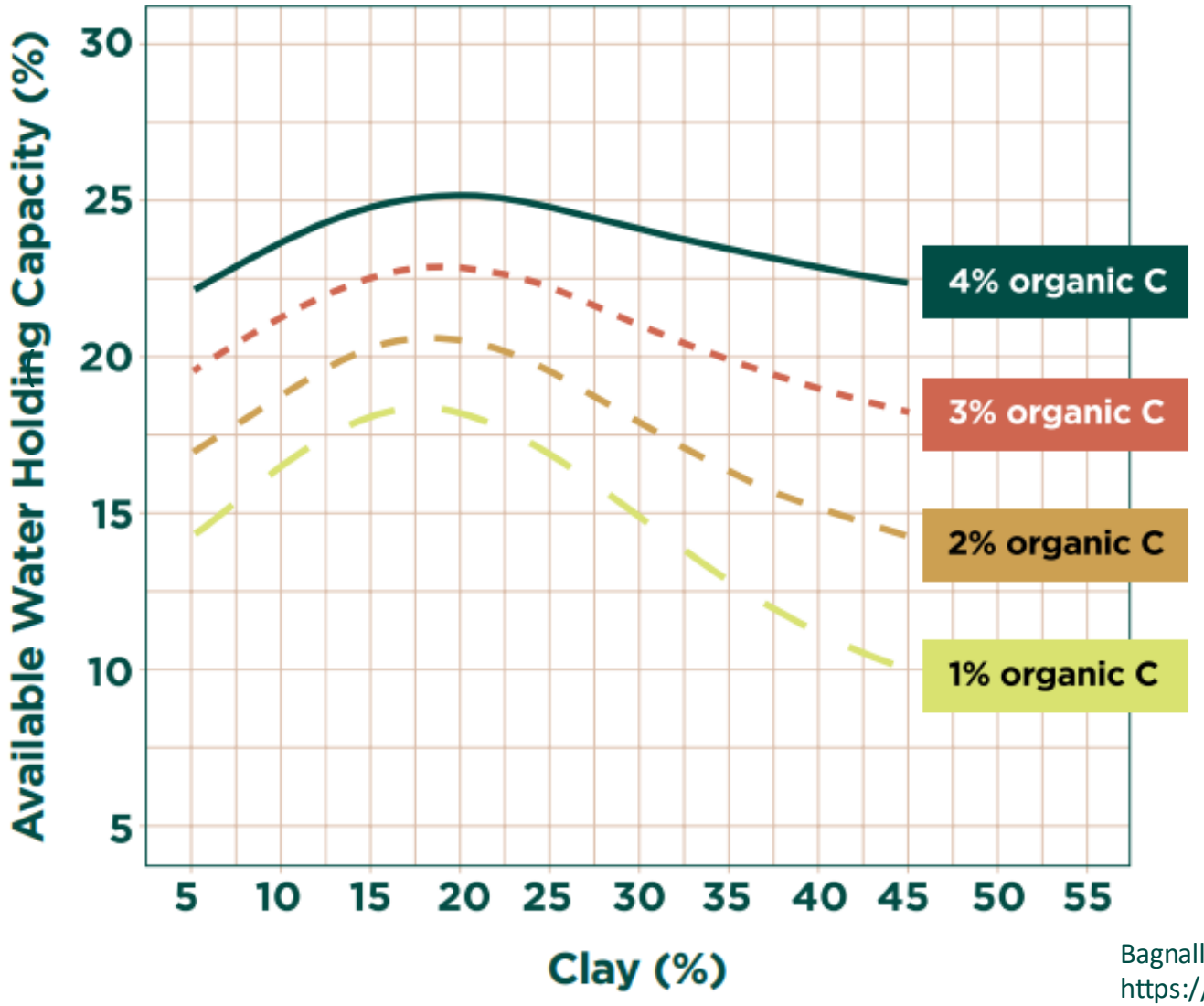
SOIL HEALTH INSTITUTE

SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

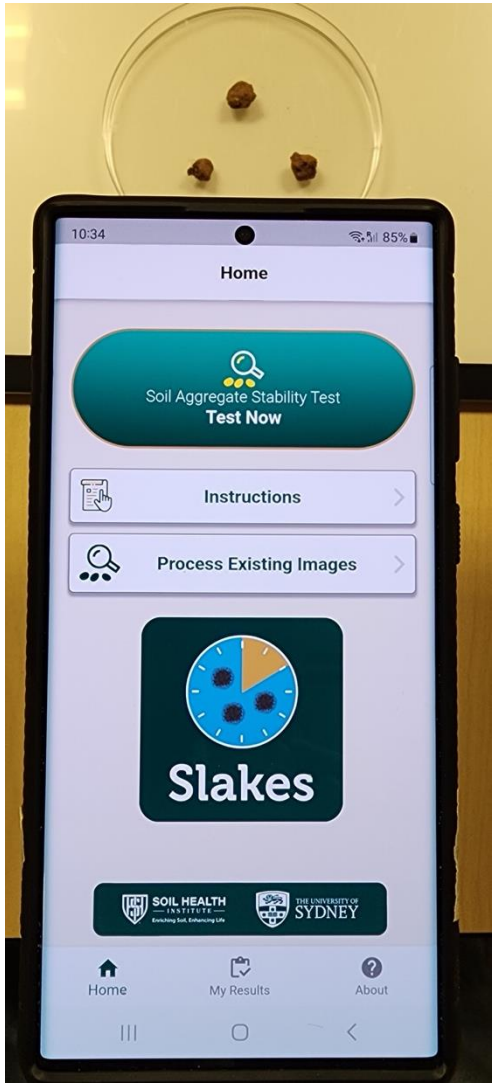
LEVER OF CHANGE
#3. RESEARCH & DEVELOPMENT

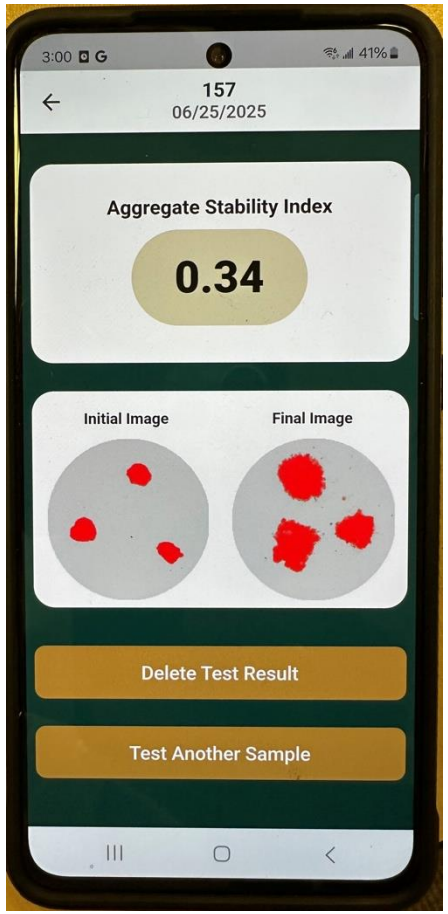
ADVANCEMENT: Equations to Predict Increases in Available Water Holding Capacity from Increasing Soil Organic Carbon



Bagnall et al. 2022. Soil Sci. Soc. Am. J. https://doi.org/10.1002/saj2.20395

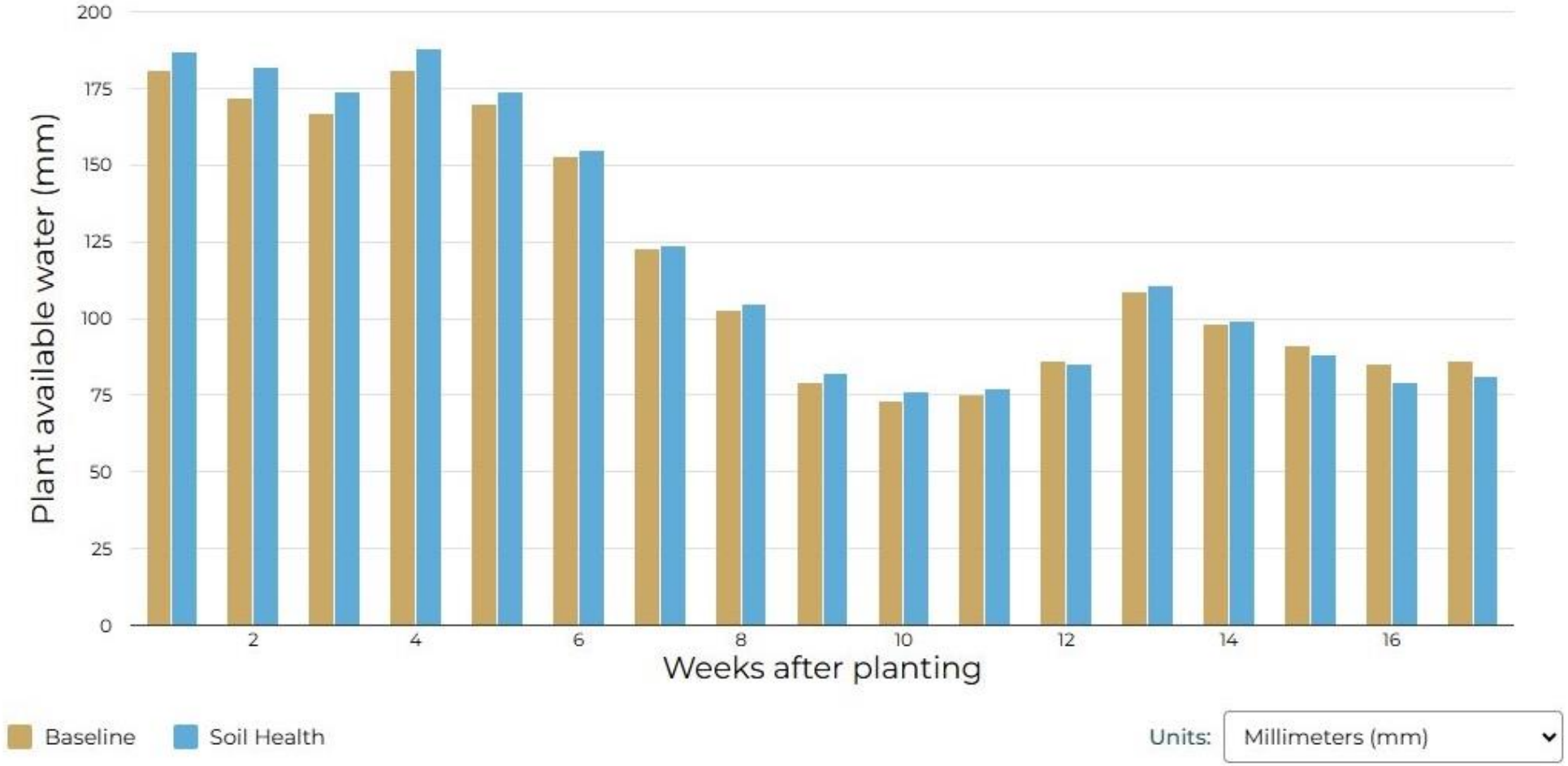
ADVANCEMENT: Slakes App for Measuring Aggregate Stability





SOIL HEALTH INSTITUTE

ADVANCEMENT & FUTURE DIRECTION: Drought Resilience Calculator



SOIL HEALTH INSTITUTE

Funder: Cargill

SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

LEVER OF CHANGE #4. EDUCATION

ADVANCEMENT: Established Education Programs for Farmers

Approach:

- Continuous Engagement
- Local Hub & Spoke Farmer-to-Farmer Networks
- Local Farmer Mentors & Technical Specialists
- In-person Field Days & Workshops
- Webinars, Videos, Fact Sheets
- Integrate Economics, Measurements, Benchmarks, Decision Support Tools

ADVANCEMENT: Implemented Education Programs for Farmers

8
Soil Health Educators

38
States and Provinces

10
Local Technical Specialists

100+
Education Sessions

14
Local Farmer Mentors

25K+
Stakeholders Reached








SOIL HEALTH INSTITUTE

FUTURE DIRECTION: Expand Farmer Education Programs & Partnerships

- In-Person, Local Farmer-to-Farmer Networks
- Educational Webinars
- Farmer-to-Farmer Videos
- Virtual Field Days
- Train the Trainer Program & Certification
- Closed Captioning for the above
  (multiple languages)

SOIL HEALTH INSTITUTE

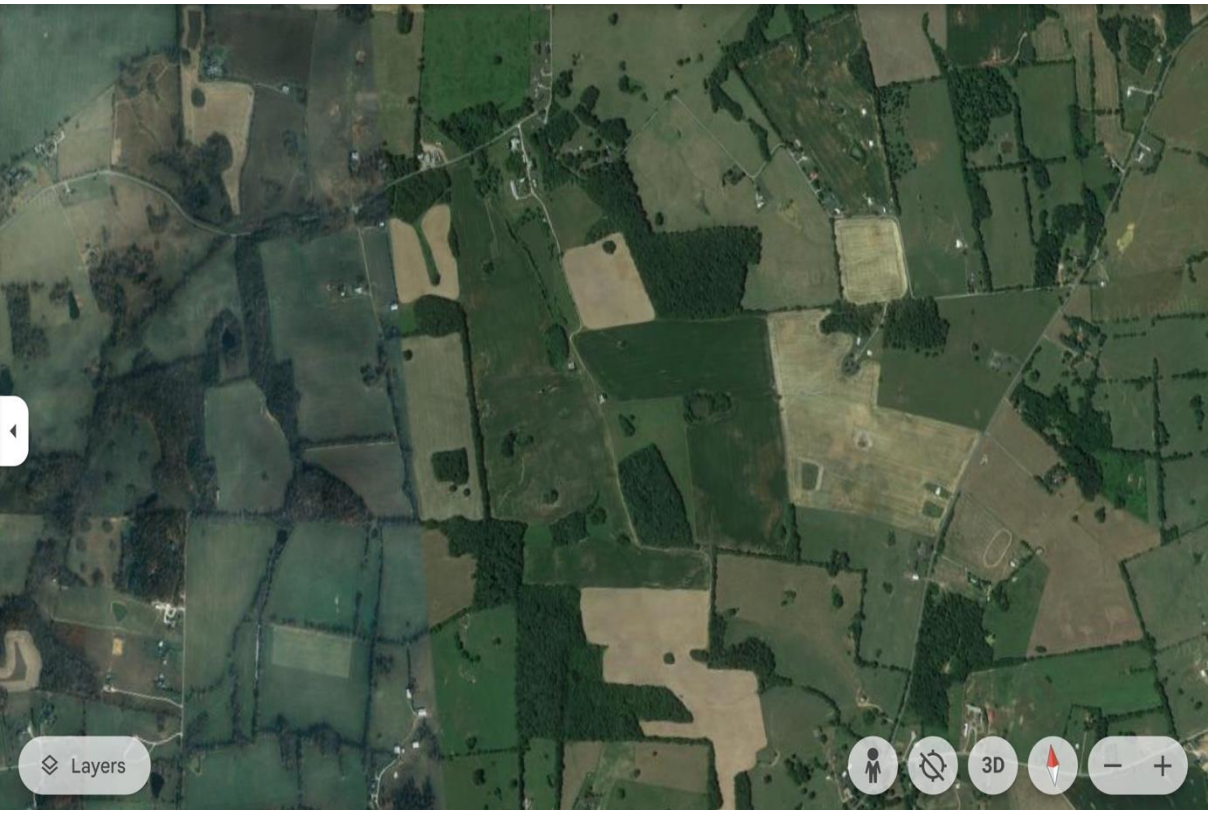
SOIL HEALTH INSTITUTE

Enriching Soil, Enhancing Life

FUTURE DIRECTION:

INTEGRATE ALL LEVERS OF CHANGE INTO A PRODUCER PORTAL

FUTURE DIRECTION: Integrate All Levers of Change into A Producer Portal: A Place-Based, Science Translation & Delivery Tool



Google Earth Type Interface with Locally Relevant Resources:

- Business Case
- Soil Health Benchmarks
- Educational Materials for Measuring Soil Health
- Educational Materials for Improving Soil Health
- Local Farmer Mentors & Technical Specialists
- Field Days / Workshops
- Option for Farmers to Share their Soil Health Data with SHI

THANK YOU!