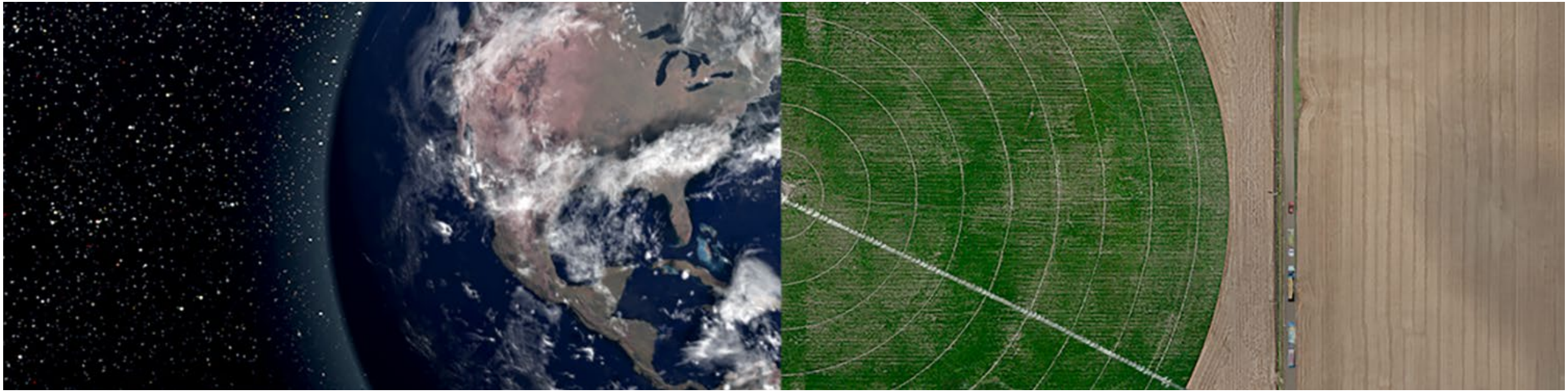


Indigo Sustainability Science & Quantification Overview

Russell Booth, Commercial Program Manager

rbooth@indigoag.com

March 1, 2023


CARBON CROP II

Our integrated business platform is built on a rigorous foundation of science, technology and data to enable agricultural sustainability

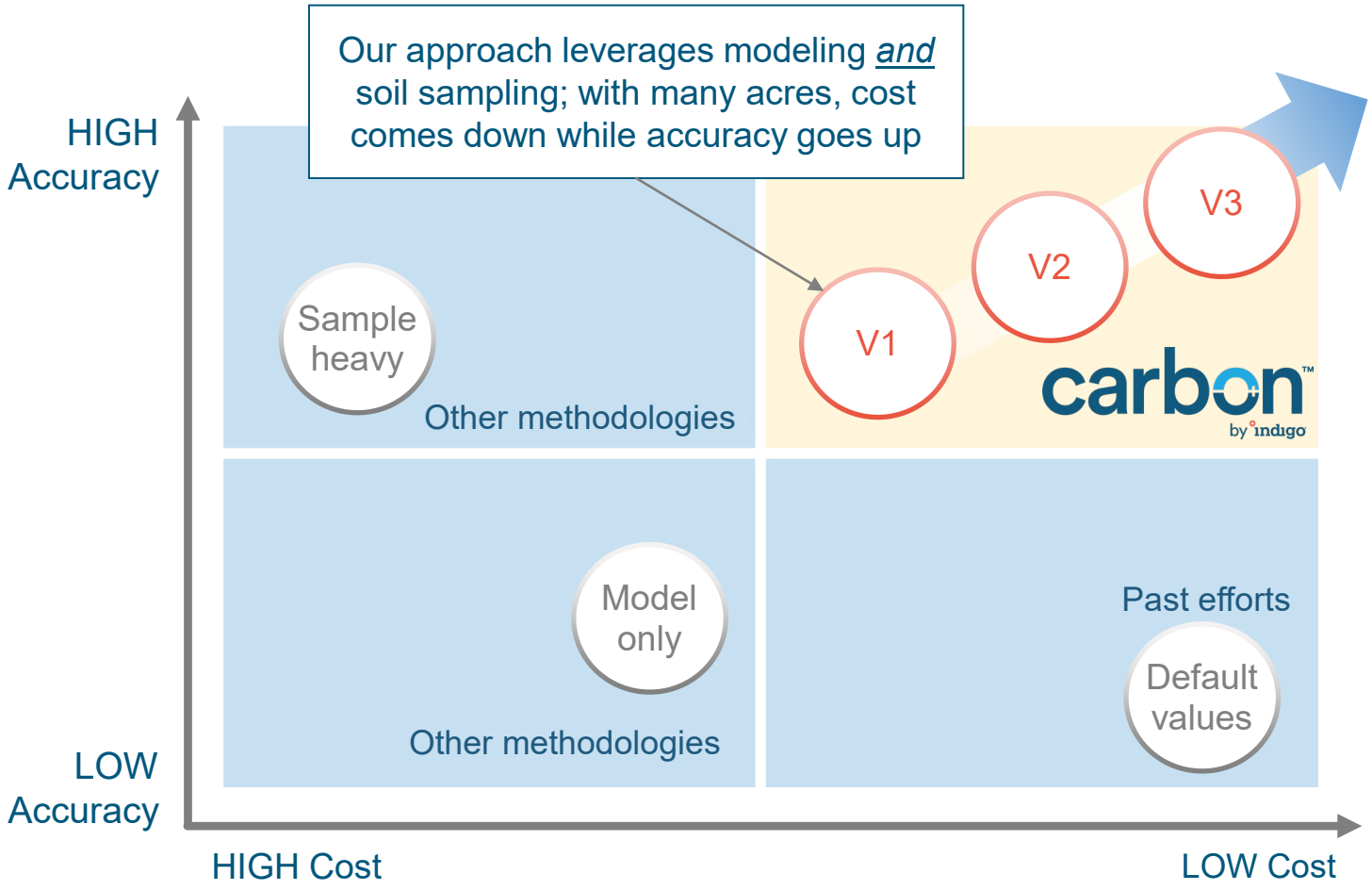
Standards and Registries are critical for the strength of carbon markets

Indigo's work meets Verra and CAR requirements, resulting in the highest value carbon offsets for sale into voluntary carbon markets

Key criteria for carbon credits

1. **Realness**
   GHG reductions must be conservatively and completely measured
2. **Additionality**
   Credits can only be issued for practices that are in addition to business as usual
3. **Permanence**
   Carbon stocks must be maintained for the long-term

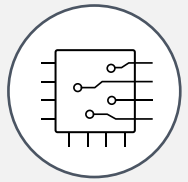
The foundation of our methodology is a dual approach of modeling and direct measurement through soil sampling



Carbon by Indigo is unlocking the full potential of agriculture as a climate solution for the first time

CHALLENGES

High cost of measurement and verification



Lack of technology and expertise to guide a change to regenerative practices

No financial incentive for farmers to change behaviors

INDIGO CARBON INNOVATIONS

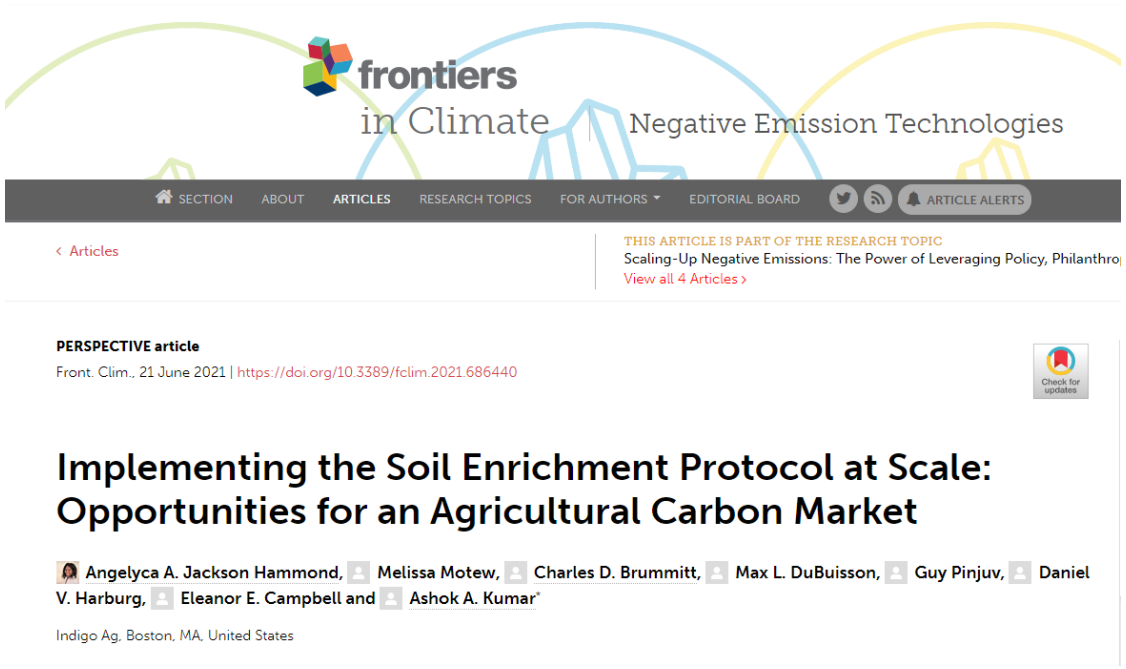
Utilizing Indigo's technology, investments, and data collection and algorithms to drive scale and reduce costs

Deploying hybrid soil sampling + modeling approach in line with Verra and CAR methodologies

Building technology and conducting experiments that will enable Carbon to support farmers that are transitioning to regenerative practices

Accelerating the adoption of regenerative agricultural practices by creating carbon credits, to pay farmers to sequester carbon

The CAR Soil Enrichment Protocol enables credits at scale



frontiers in Climate | Negative Emission Technologies

SECTION ABOUT ARTICLES RESEARCH TOPICS FOR AUTHORS EDITORIAL BOARD ARTICLE ALERTS

‹ Articles

THIS ARTICLE IS PART OF THE RESEARCH TOPIC
Scaling-Up Negative Emissions: The Power of Leveraging Policy, Philanthro
View all 4 Articles ›

PERSPECTIVE article

Front. Clim., 21 June 2021 | https://doi.org/10.3389/fclim.2021.686440

Check for updates

Implementing the Soil Enrichment Protocol at Scale: Opportunities for an Agricultural Carbon Market

Angelyca A. Jackson Hammond, Melissa Motew, Charles D. Brummitt, Max L. DuBuisson, Guy Pinjuv, Daniel V. Harburg, Eleanor E. Campbell and Ashok A. Kumar*

Indigo Ag, Boston, MA, United States

Key advances of the Soil Enrichment Protocol:

1. Flexibility in biogeochemical model use enabled by explicit performance requirements

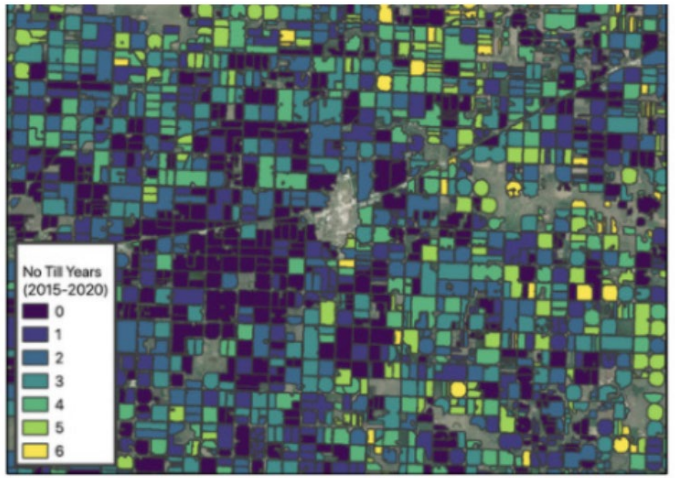
2. A new approach to field-level, modeled baselines that is both dynamic and adaptive

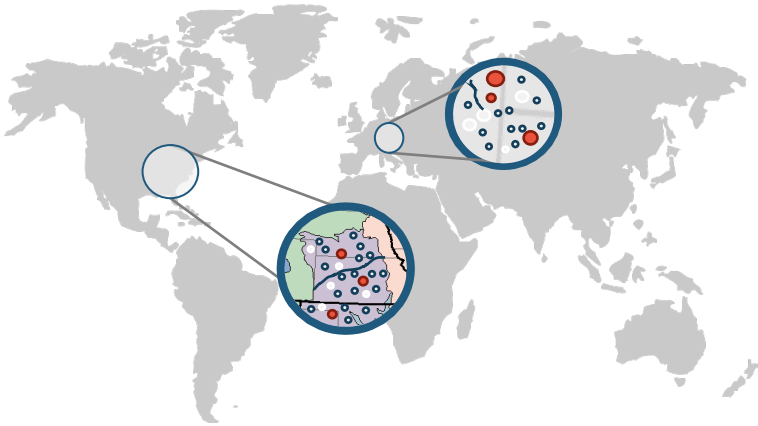
3. A hybrid approach to credit generation using soil measurements, modeling, and default equations

4. Requiring a new type of uncertainty quantification that accounts for multiple sources of uncertainty:
   - Sampling design uncertainty
   - Model uncertainty

Our quantification engine integrates data across scales

MEASURE | **MONITOR** | **MODEL**





DATA COLLECTION

SOIL SAMPLING

CORTEVA agriscience

JOHN DEERE OPERATIONS CENTER

REMOTE MONITORING

telluslabs

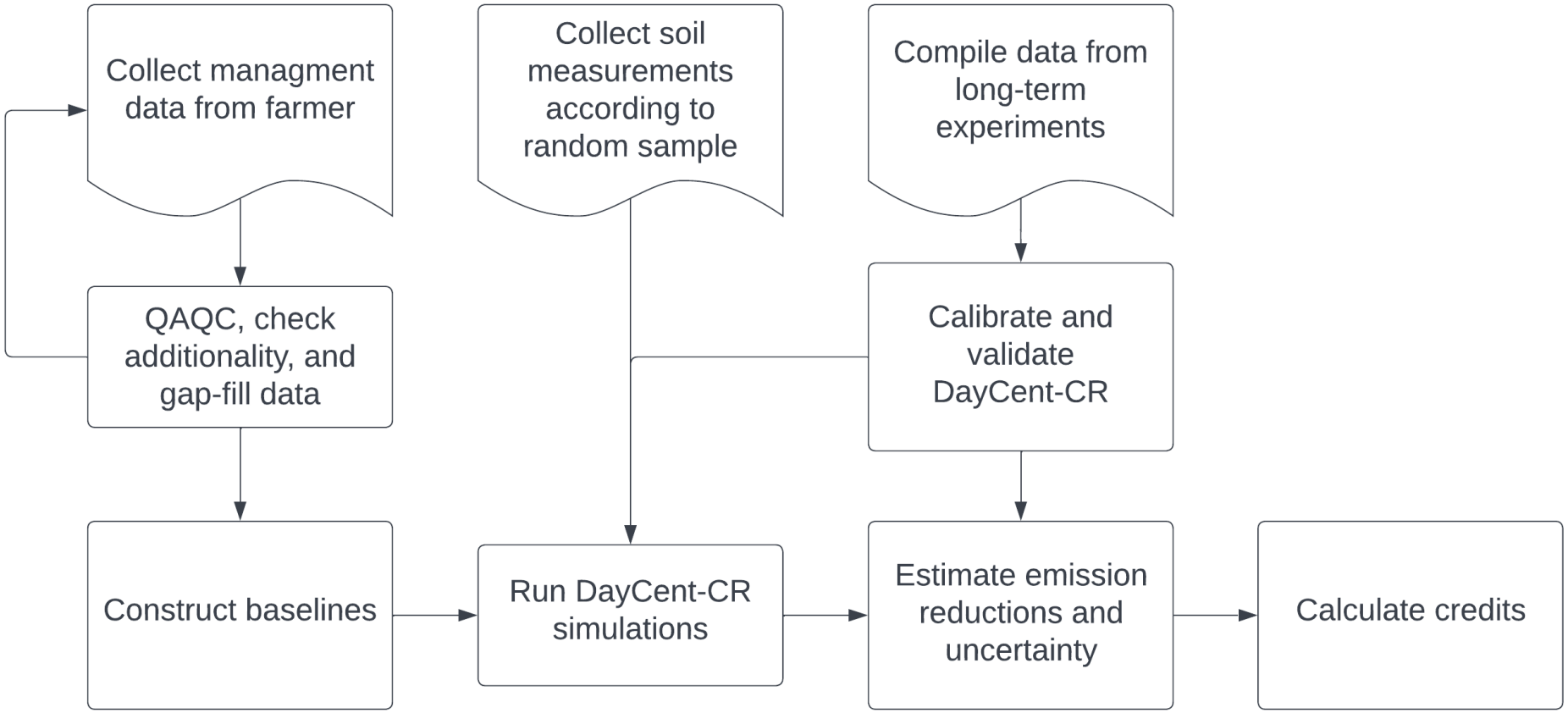
BIOGEOCHEMICAL MODELING

SoilMetrics

Century 100 DayCent

indigo

Carbon Quantification Overview

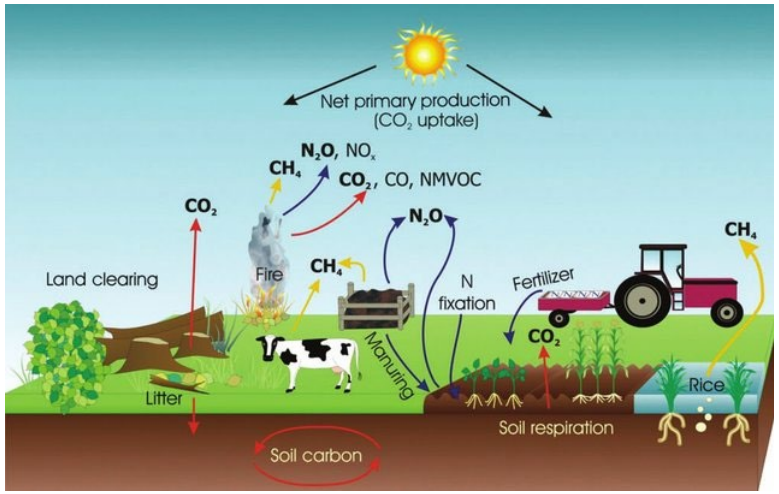


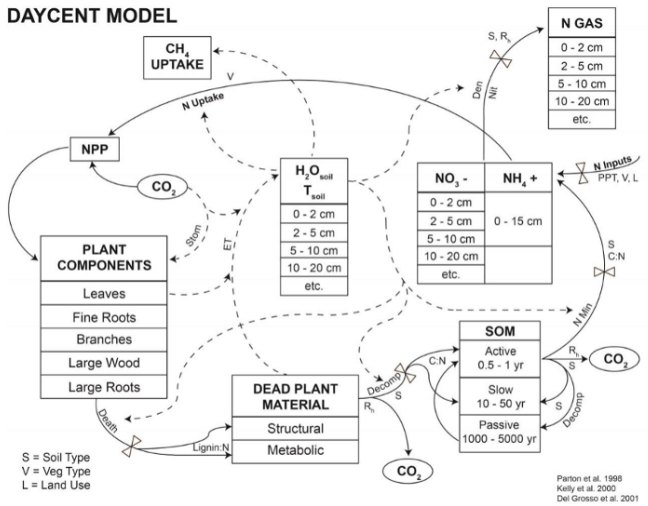
Not shown:

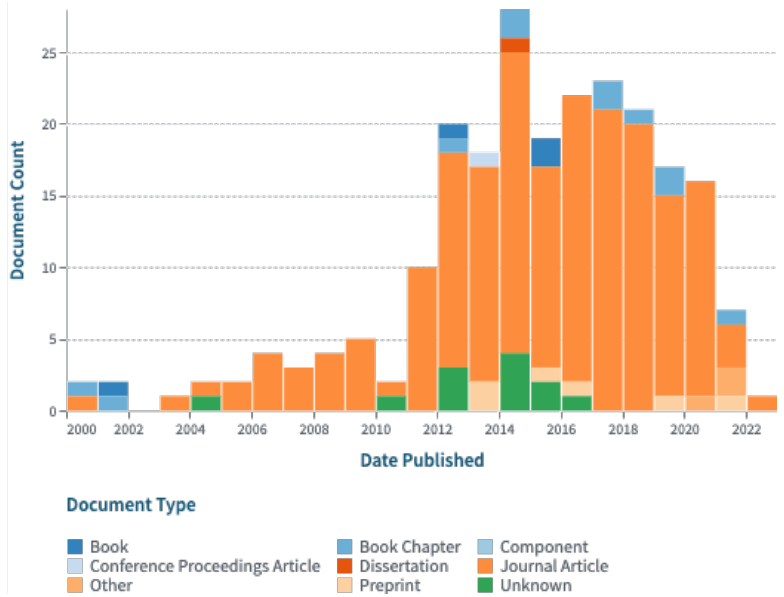
- Using farmer data to estimate N_2O and CH_4 emission reductions, and CO_2 emission reductions from fossil fuels
- Leakage deduction and buffer pool contributions

Quantification engine: modeling

DayCent-CR is based on DayCent, the world's leading biogeochemical modeling software for soil organic carbon and greenhouse gas emissions in land use. Used on every continent but Antarctica, DayCent is also used each year to produce the national inventory for the EPA and Paris Climate Accords.



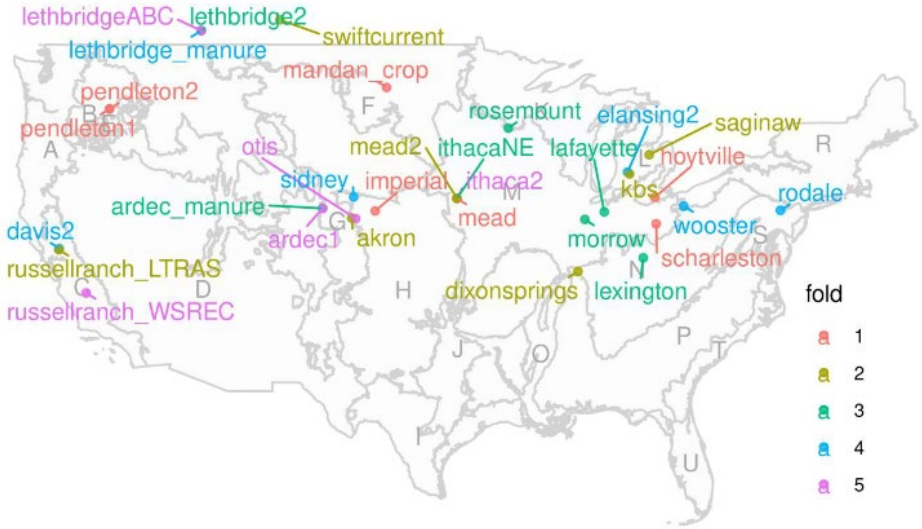


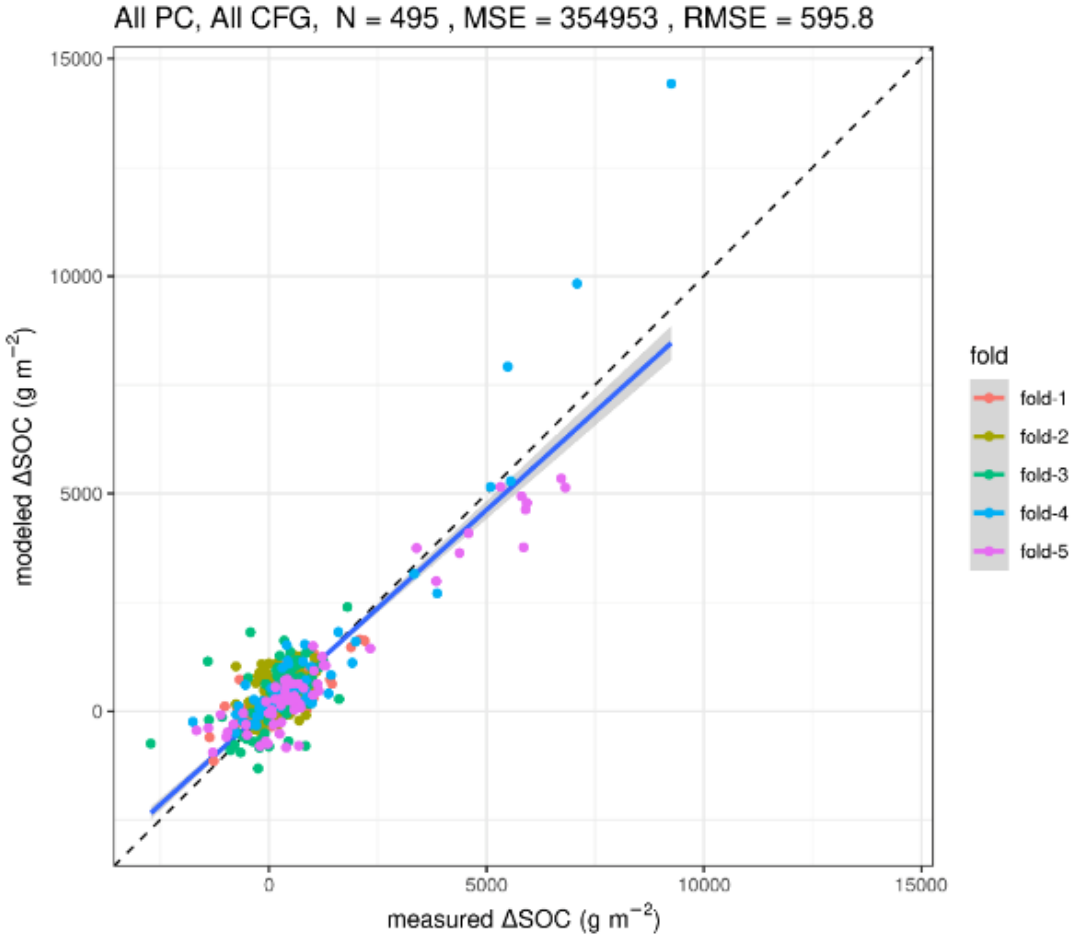


Validation criteria must be met for each practice change (PC) by crop function group (CFG) category

Validation Criteria:

- Experimental data must be **representative** of land in the project
- **Out-of-sample predictions** of **emission reductions** must perform well:
  - Sufficiently unbiased
  - 90% prediction intervals must contain the truth 90% of time





See:

- Requirements and Guidance for Model Calibration, Validation, Uncertainty, and Verification for Soil Enrichment Projects, v1.1a
- Validation Report for DayCent-CR version 1.0

Indigo invests in research to further enable sustainability at scale

Research workstreams are tied to at least one of three key drivers for Indigo Carbon

1 Generate High-Quality Credits at Scale

- Reduce uncertainty through improved sampling designs
- Increase effect size through ground-truth data
- Ground-truth and vet new models to expand domain
- Provide first-hand proof of regen success to growers

2 Minimize Grower Data Burden

- Establish scientific partnerships to access ground-truth data for remote sensing models
- Validate technologies that reduce grower data collection requirements

3 Improve Unit Economics

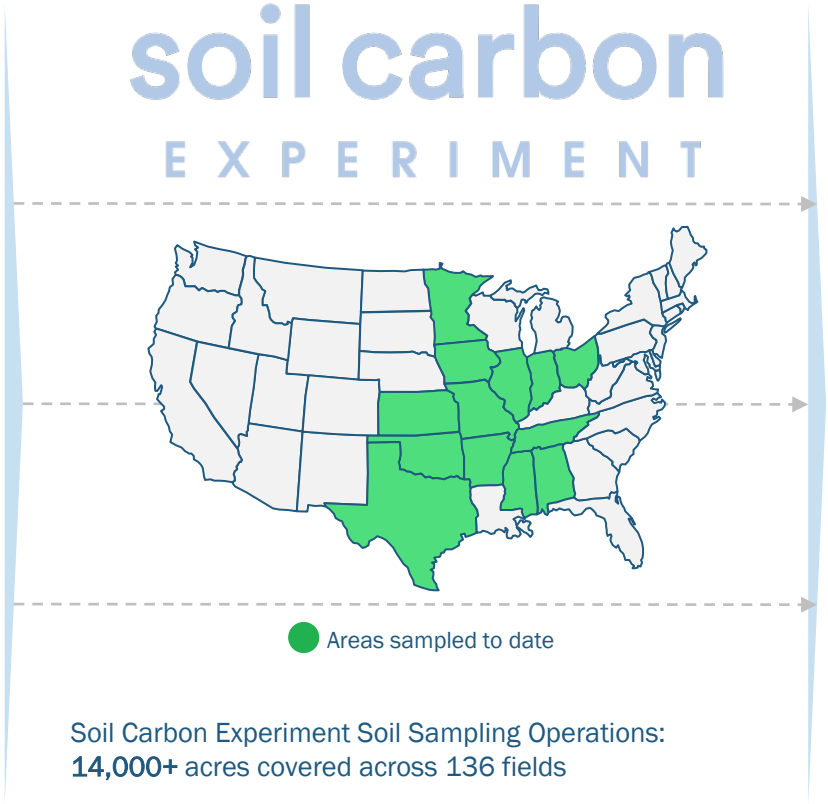
- Reduce number of soil samples required
- Reduce labor needed in-field or in-lab
- Improve modeling across multiple parameters

Indigo is at the leading edge of research to advance carbon models

Our soil carbon, agronomic, economic, and behavioral dataset keep our models, agronomic tools, offerings, & support, at the cutting edge of soil carbon science

Critical questions

- Can we incorporate multiple data types to **improve Carbon models**?
- What are the **best sampling and evaluation methods** for Indigo Carbon?
- How can we better understand **barriers in regen practice adoption**?
- Are **profits greater than average** on regenerative operations?
- What are **the best local management practices** to maximize carbon sequestration?



Soil Carbon Experiment Soil Sampling Operations:
14,000+ acres covered across 136 fields

How we're helping answer these questions

- Our dataset is being used to **test and refine models against real-world data**
- Our analyses have led to **improvements in sampling protocols**
- Our grower interviews helped **define grower personas** to better support our grower adoption
- Our profitability data **calibrates our profitability model** that helps show growers' potential returns in addition to carbon payments
- Our first years of trials already have highlighted **management practices that can be effective in specific settings**

The Soil Carbon Experiment is our primary research focus

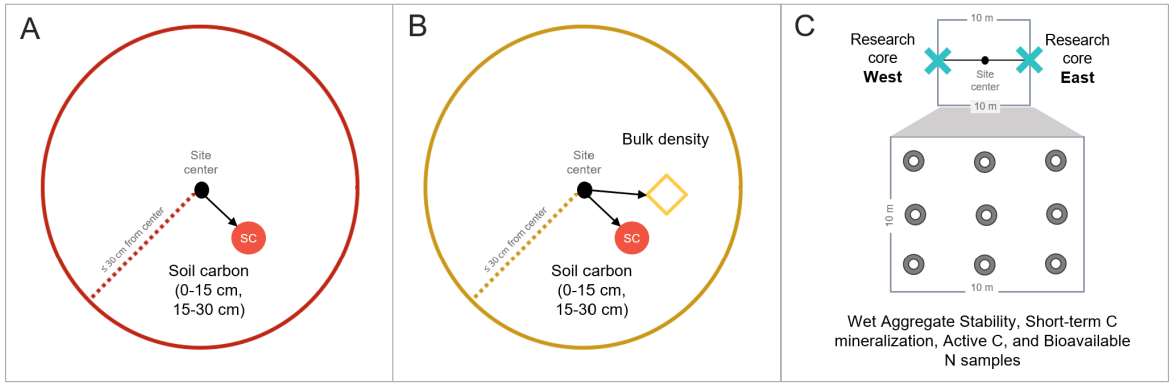
Four cohorts provide multiple “shots on goals” to answer complex questions

1	2	3	4
Regen Transitions	**Carbon Sentinel**	**Carbon Trailblazers**	**Legacy Pairs**
Interventional Split-field experiments on Indigo Research Partner acres; with ½ of each field having a steep on-ramp to regen practices to test regen interventions	*Observational* Selected Carbon by Indigo growers sampled with full research protocol to generate a deeper carbon accounting dataset	*Observational* Growers who have deployed highly-regenerative practices on their operations for years and do not meet additionality requirements	*Observational* Continued sampling of the best field pairs from our 2019 cohort to deliver high-quality data set

We follow consistent field protocols for every experimental field, producing a comprehensive soil and grower history dataset

Protocol	Data Produced
SOIL CARBON	Soil Organic C (SOC) and Total C
BULK DENSITY	Bulk Density
SOIL CARBON to 1 METER	SOC and Total C, Texture, Total N, pH, CEC, Macronutrients, Micronutrients, Bulk Density
SOIL HEALTH	pH, Nutrients, OM, Soil Respiration, Wet Aggregate Stability
GROWER INTERVIEWS	Agronomic Management History, Production, Profitability, Qualitative Insights

Each sample type and is taken in a prescribed manner for all program fields

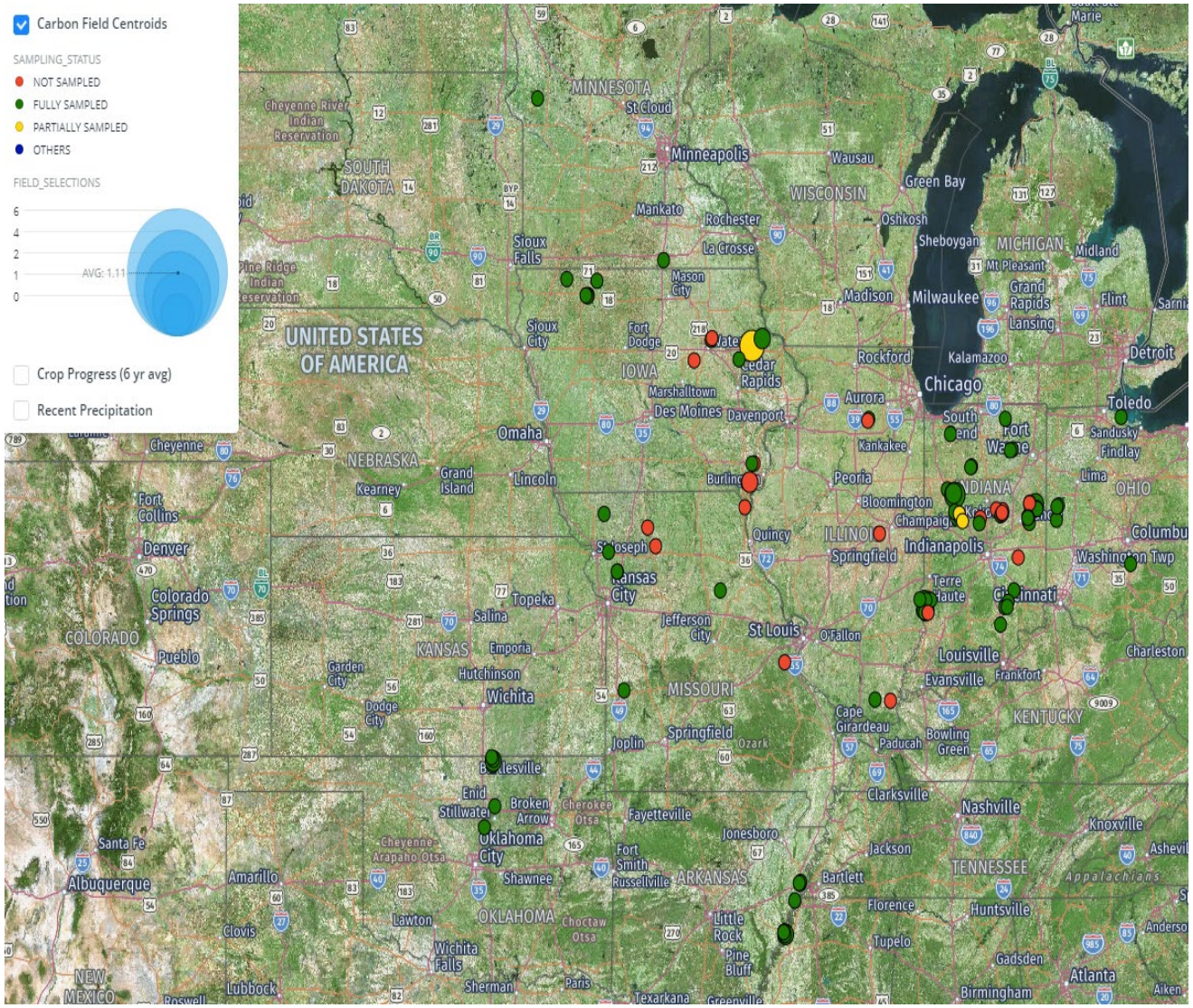


Vendor Spring 22 Metrics

Vendor		Review Date	June 24, 2022

Vendor KPI(s)	Best of Peers		Target
% Fields Confirmed	100%	99%	100%
# Samples Collected	1,278	1,278	1,649
# Field Selections Sampled	106	106	123
% Field Selections Sampled	82%	80%	90%

Vendor & Lab Quality KPI(s)	Best of Peers		Target
Vendor Defects	1.74	1.74	3.5
Vendor & Lab	0	0	0



RAG Legend: Target Achievement % — 0-69% | 70-89% | 90%-100%

- Quality Defects are tracked per 100 samples taken and processed

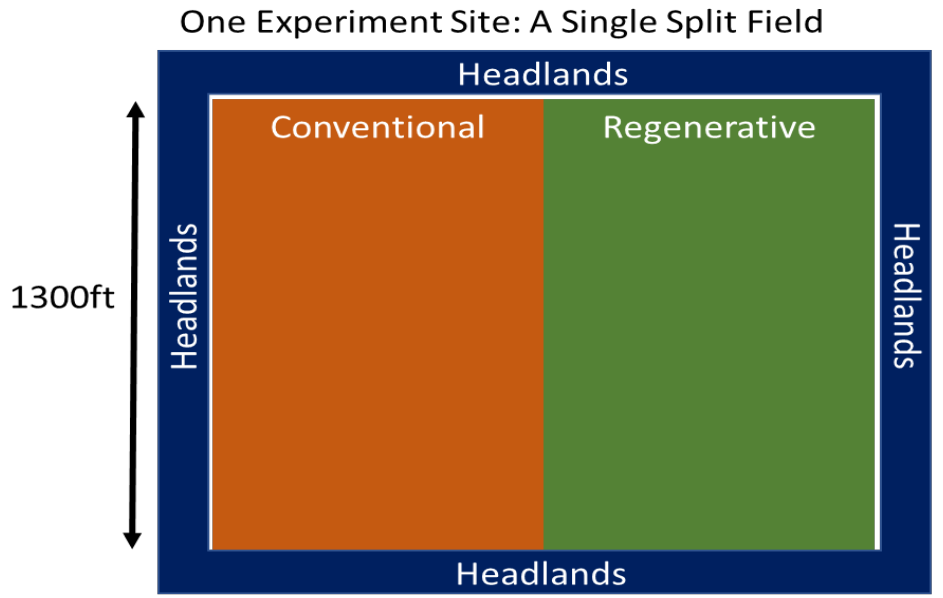
Regenerative Transitions Experiment

Experimental Goal: 1. Demonstrate increased profitability during a three-year transition to regenerative practices: both cover crops and no-till, in addition to input reduction where possible 2. Demonstrate that a transition to regen practices is profitable from different baseline production systems. 3. Demonstrate that a transition to regen practices increases SOC and nutrient concentrations. 4. Identify specific scenarios in which regen practices are more profitable and/or increase SOC/ nutrient concentrations in field.

Value to grower:	Generate increased returns by lowering input costs without incurring yield losses and improving resiliency to water stress, weed & pest pressure over time.	
Products, Practices or Variables Being Tested	Conventional A	Standard Practices of Herbicide, Standard Nutrient use, Soil Cultivation and **NO** cover crops usage
	Conventional B	Standard Practices of Herbicide, Standard Nutrient use, No-Till Planting and **NO** cover crops usage
	Regenerative	**10%** Reduction of Herbicides **15%** Reduction of Nutrients (N mainly) No-Till Planting, and Minimum of 3 Species Cover Crop
Grower Capability Requirements:	*Precision planting system capable of capturing variety/hybrid, treatment, seeding rate, and planting date either from own machines or custom applicator*	
	Yield monitor system capable of capturing yield, moisture, speed, elevation, header up/down	
	Cloud data transfer via my JohnDeere or AgFiniti is preferred, USB transfer is acceptable provided IRP staff has prompt access to capture data immediately following field operations	
	*Ability to continue experiment for **minimum** of 3 and up to 5 years*	
Keys to Trial Success	*Fast and accurate planting data capture*	
	Treatment size of 20 acre minimum; 40 acres minimum in total	
	Single, uniform population, variety, and base seed treatment across all trial blocks	
	Success in multiple species CC establishment with a reduction in Nutrients and Herbicides rates	

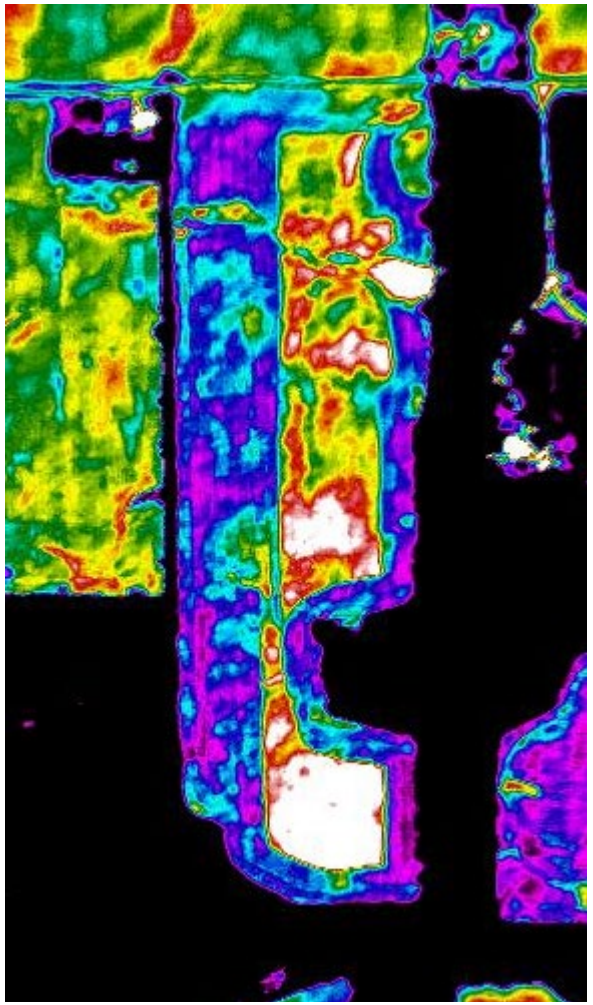
Value to Indigo:	Improved understanding of agronomic recs, ability to test a wide range of hypotheses on regen. Expansion of spring cohort enables increased geographic coverage and practice diversity. Key data set for updating/building BGC models.

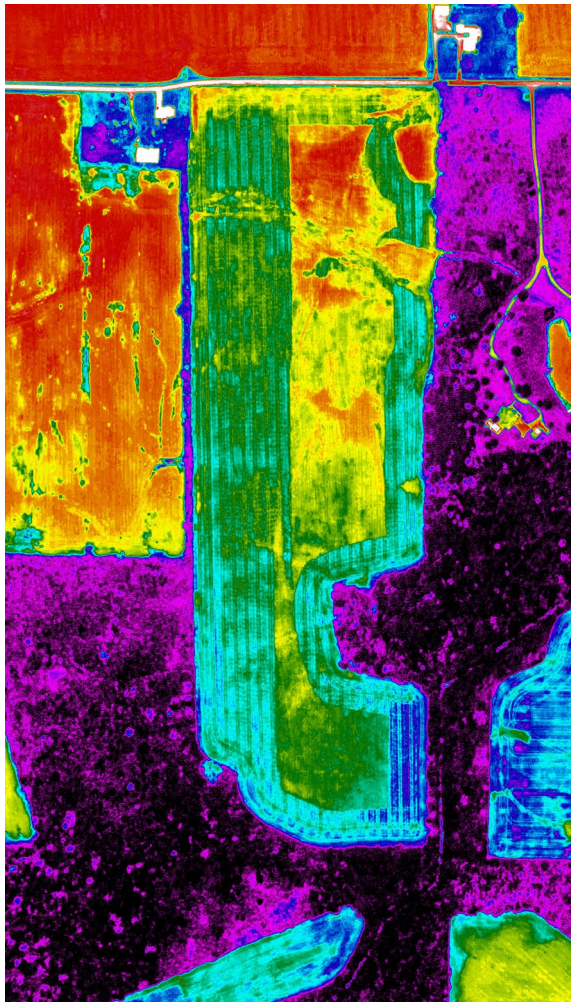
Experimental Layout:



We collect multiple layers of imagery and other sensor data at our trial sites

Imagery of IRP grower near Muncie, IN.
Images taken at end of May 5/31/2021.



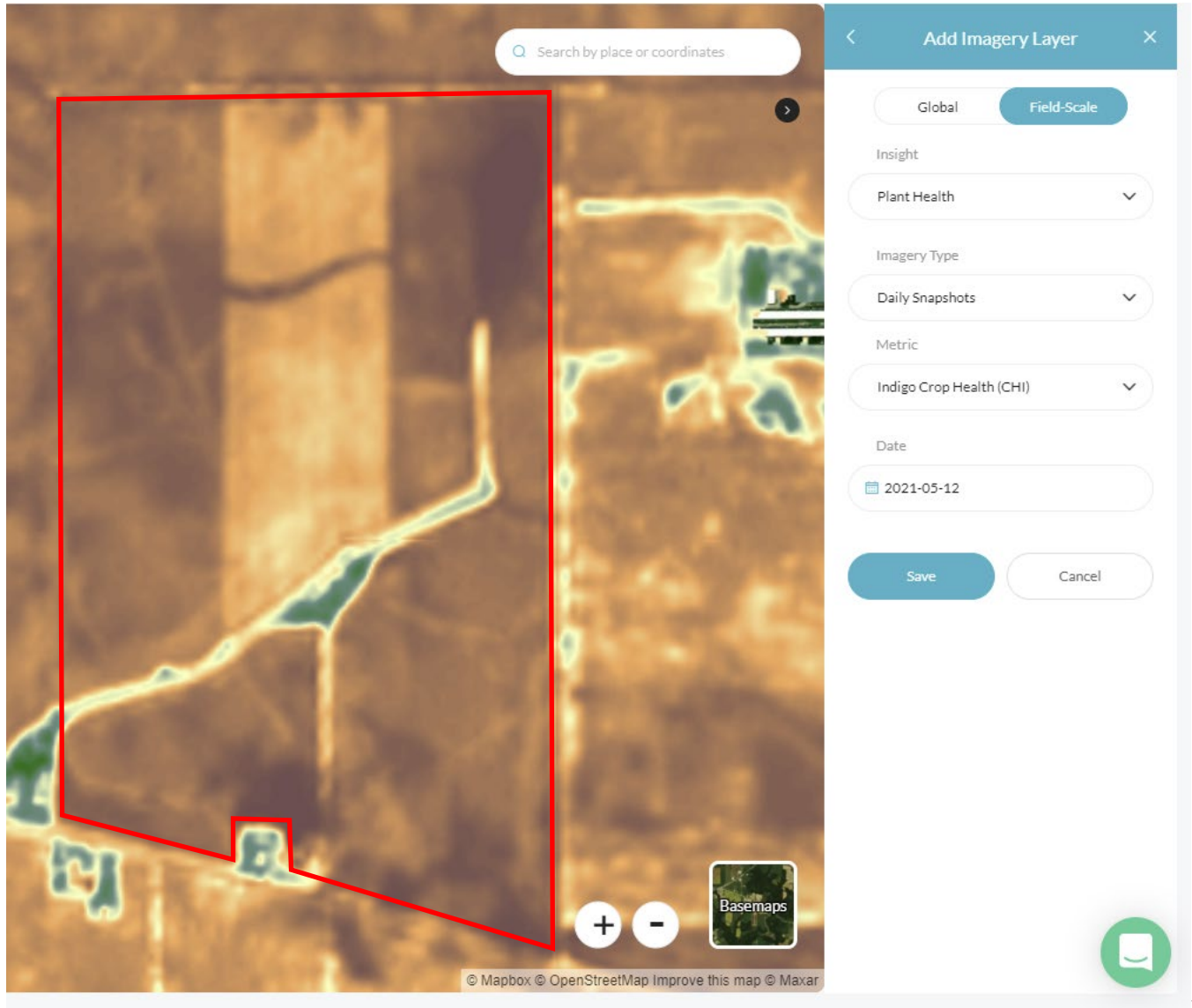


Left image: RGB of site with cover crop on the Left side of the field bare ground on Right

Middle Image: Thermal of site with cover crop on the Left side of the field bare ground on Right. The cover cropped area is much cooler indicating the water retention and the accumulated plant matter.

Right image: NDVI of site with cover crop on the Left side of the field bare ground on Right.

Satellite Imagery with in-built analytical tools such as our Crop Health Index



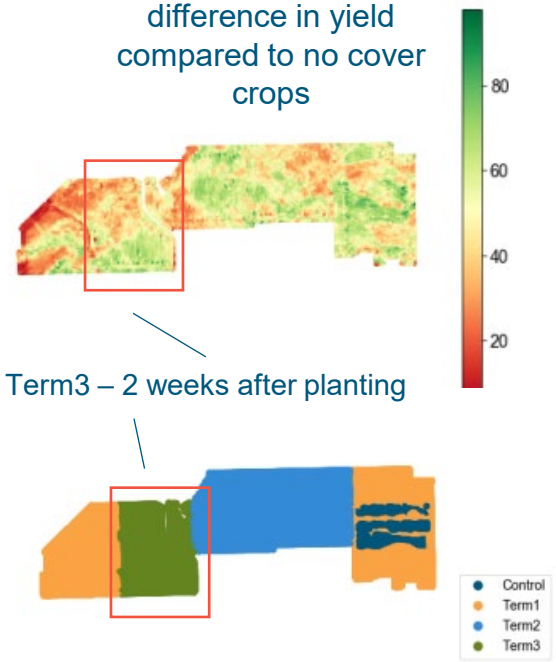
Sensors for in-field real-time monitoring

Our research also helps growers push systems to maximize carbon without sacrificing yield

Example: a grower in Indiana maintained yield while terminating cover crops 2 weeks after planting soybeans, enabling greater biomass and water infiltration

Yield (bu/ac)

No statistically significant difference in yield compared to no cover crops



Term3 – 2 weeks after planting

Ground cover & Biomass

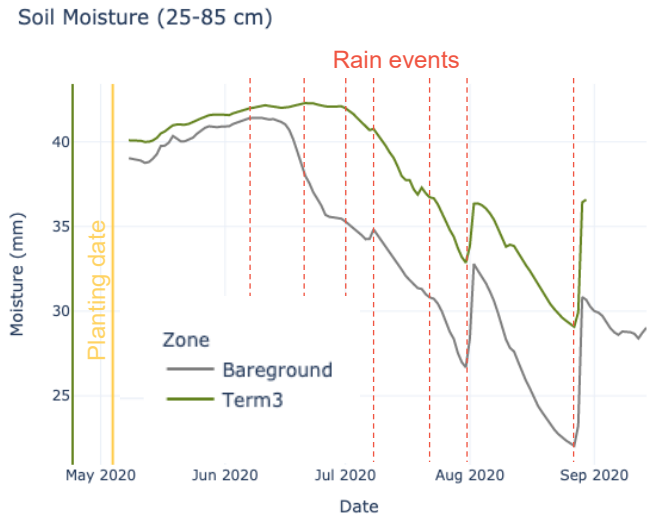
Normal termination (2 weeks before planting) had more bare ground visible

Late termination had carryover residue

Border showing additional biomass from 2 weeks of spring growth (~1,400 lbs/acre of additional biomass)

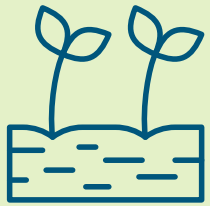
Water Infiltration

Cover cropping and late termination led to greater collection of moisture at depth throughout the growing season



Our tech exploration is focused on three technology classes to enable our mission

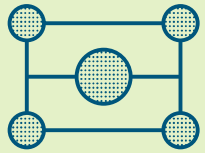
1 Sequester & Abate



Technology aimed at increasing sequestration rates or accelerating emissions reduction

Examples: biochar, biological products, enhanced rock weathering

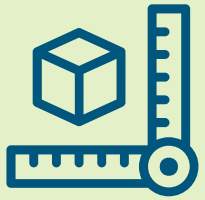
2 Model & Compute



Soil & ecosystem models and computational methods

Examples: stratification algorithms, biogeochemical models, crop models

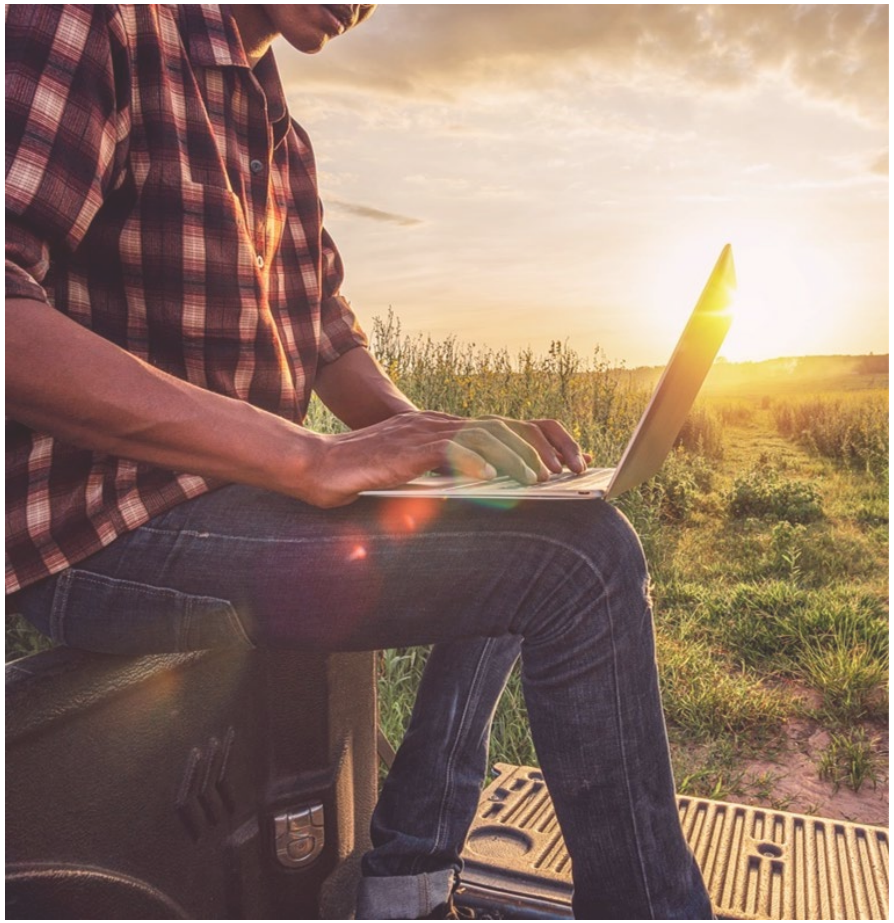
3 Measurement



Technology that helps improve speed, accuracy, precision, and cost of quantifying Carbon

Examples: in-field soil probes, in-field lab tech, trace gas emissions measurement methods

Where to learn more – documents published with CAR:



Some aspects of the methods and systems are the subject of one or more pending patent applications.

We've published several documents through CAR, including:

- Model Validation Report for DayCent-CR
- Verification Report & Statement
- Annual Monitoring Plan & Report
- Attestations of Voluntary Implementation, Regulatory Compliance & Title
- Project Submittal forms, including area map
- Additional supporting documents that Indigo voluntarily made public, including:
  - *Soil sampling & testing procedures*
  - *Practice change assessments*
  - *Statistical methods*
  - *Baseline logic*
  - *Model sensitivity & implementation*
  - *And more…*

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