DESIGNING DECISION SUPPORT TOOLS FOR SUSTAINABLE AGRICULTURE

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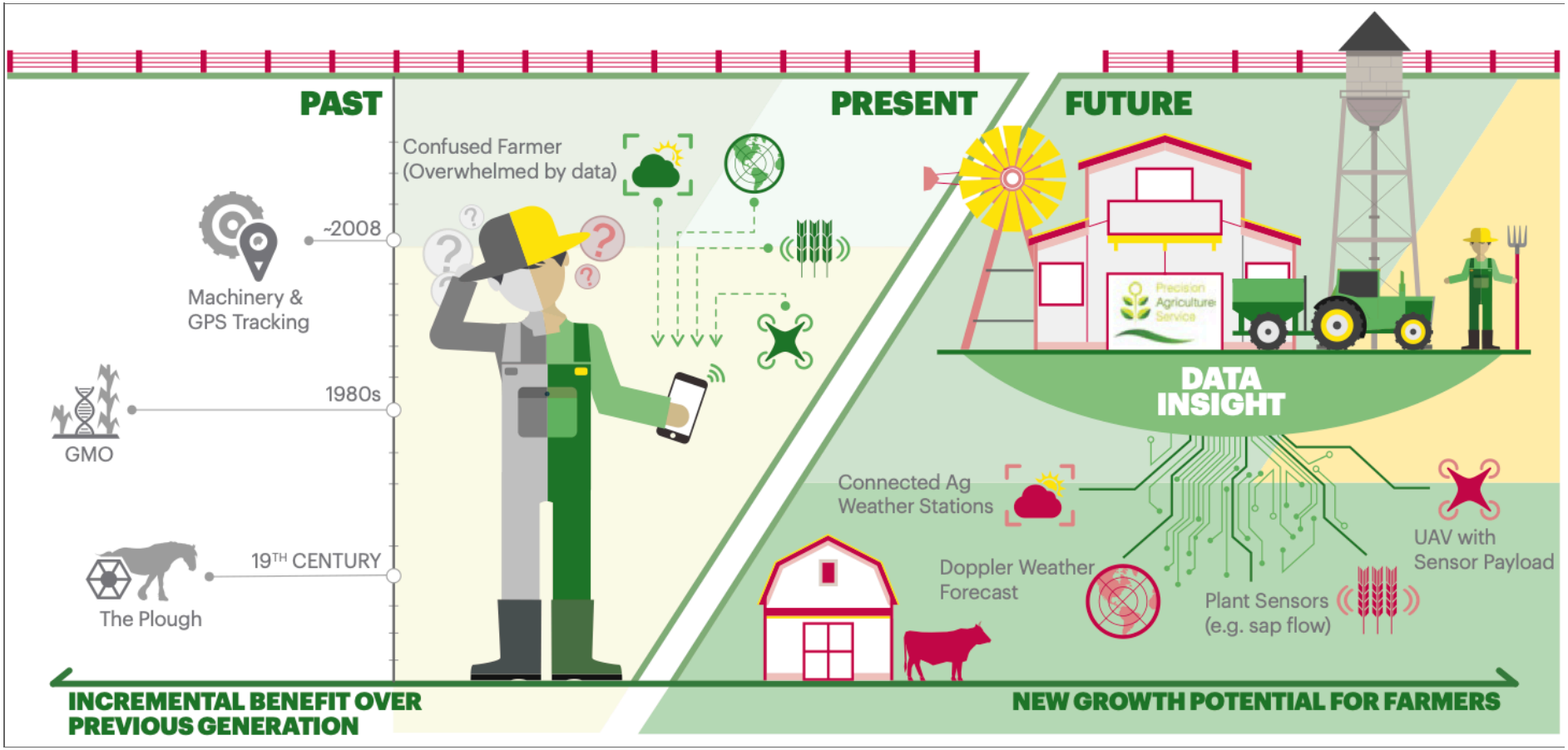
THE DIGITAL REVOLUTION



img src: Accenture, 2017

SOFTWARE GIVES US THE ABILITY TO
MANAGE AGRICULTURAL COMPLEXITY ACROSS SCALES.

img src: Studio Ghibli, Laputa Castle in the Sky, 1986

CHALLENGES

Handling in-field spatial variability
Identifying weeds & pests
Improving soil health quality
Adaptive farm management
Empowering stakeholders
Enhancing food security

EXPLORATIONS

with variable rate technologies
via computer vision
through geospatial analytics
using realtime, site-specific data
with decision-support tools
by connecting people through tech

TEASING APART TECHNOLOGY

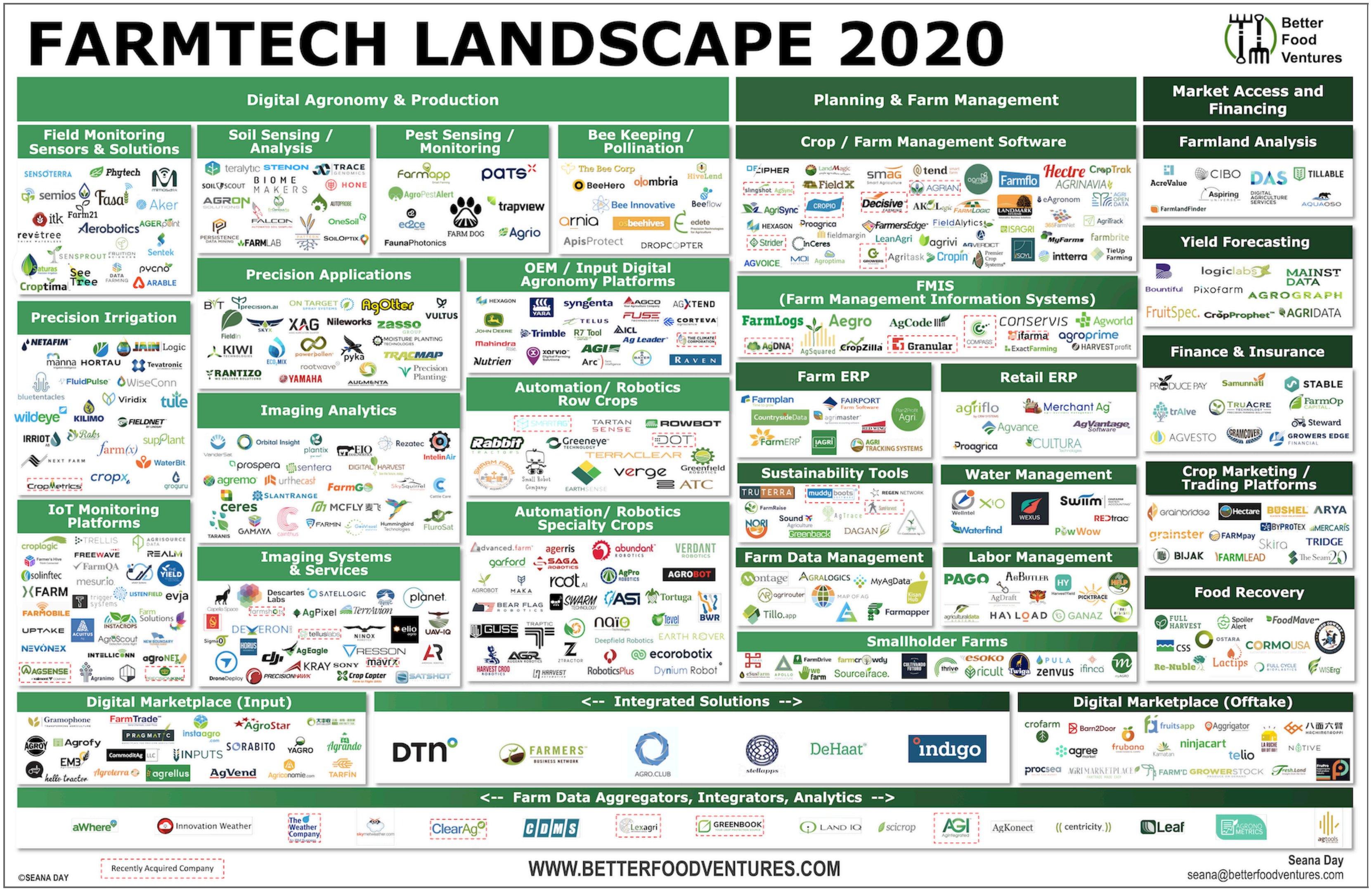
HARDWARE

Manipulate the world
Manipulate reality
Physical interactions
Augment human action

SOFTWARE

Manipulate information
Manipulate models
Hypothetical interactions
Augment human thought
predictive analytics, real-time monitoring, problem diagnosis, decision support, data driven insights, system-level analysis, communication, coordination, and collaboration

img src: PascalCrimson @ DeviantArt, Neo from Matrix, 2016



FARMTECH LANDSCAPE 2020
Better Food Ventures
Digital Agronomy & Production
Planning & Farm Management
Market Access and Financing
Field Monitoring Sensors & Solutions
Soil Sensing / Analysis
Pest Sensing / Monitoring
Bee Keeping / Pollination
Crop / Farm Management Software
Farmland Analysis
Precision Applications
OEM / Input Digital Agronomy Platforms
FMIS (Farm Management Information Systems)
Yield Forecasting
Precision Irrigation
Automation/ Robotics Row Crops
Imaging Analytics
Farm ERP
Retail ERP
Finance & Insurance
IoT Monitoring Platforms
Automation/ Robotics Specialty Crops
Sustainability Tools
Water Management
Crop Marketing / Trading Platforms
Imaging Systems & Services
Farm Data Management
Labor Management
Food Recovery
Smallholder Farms
Digital Marketplace (Input)
<-- Integrated Solutions -->
Digital Marketplace (Offtake)
DTN
FARMERS BUSINESS NETWORK
AGRO.CLUB
stellapps
DeHaat
indigo
<-- Farm Data Aggregators, Integrators, Analytics -->
aWhere
Innovation Weather
The Weather Company
ClearAg
DTN
Lexagri
GREENBOOK
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seana@betterfoodventures.com

https://usfarmersandranchers.org/wp-content/uploads/2021/02/USFRA-

Transformative-Investment-Report.pdf

Key Findings

Farmer Perspectives on Data Collection and Sharing

With cost barriers addressed, precision technology use could increase significantly.

79% responded that they would start or increase their use of precision farm management technologies if they could acquire the equipment needed (software, sensors, etc.) at no charge or incentivized discount.

Trust issues are significant, but lenders are the most trusted data holders.

73% of respondents don't trust private companies with their data, and 58% don't trust the government with it; conversely, 71% do trust their financial institutions with their data.

Farmers have transparency concerns.

65% said their customers do not have a right to know how the crop was produced; this sentiment is shared equally among FMIS users and non-users.

Significant differences in FMIS usage exist across crop marketing outlets.

The respondents who primarily market their harvest to a food or fuel company are more likely to use FMIS as compared to respondents who market to other outlets, especially those who use their harvest for animal feed on their own operations.

Slattery et al., 2021, https://www.trustinfood.com/wp-content/uploads/2021/05/Farmer-Perspectives-on-Data-2021.pdf

EVALUATING AG TECH QUALITY

1. **Utility:** how useful is it for users (farmers, managers, workers, etc)?
2. **Usability:** how easy is it to use?
3. **Interoperability:** can we move data across tools, devices, systems?
4. **Trust:** do users trust the tech with their data?
5. **Resilient:** are the tools robust, reliable, and adaptable? Will they stand the test of time?

HOW CAN WE DESIGN EFFECTIVE DECISION SUPPORT TOOLS THAT EMPOWER FARMERS AND ADVISORS TO IMPROVE SUSTAINABILITY IN AGRICULTURE?

KNOWLEDGE WORK

Using historical sales data
Taking soil core samples
Viewing satellite imagery
Tracking cattle movements
Scanning in-field camera footage
Using photos #localfood at market

to choose what to plant this season.
to determine water availability.
to assess crop quality and quantity.
to calculate grazing capacity.
to evaluate wildlife buffers.
to understand consumer sentiment.

USING DATA TO
LEARN SOMETHING,
SOLVE A PROBLEM,
OR MAKE A DECISION.

WHAT IS DATA?

"Data are symbols that represent the properties of objects and events."
Ackoff, From Data to Wisdom, 1989
"[R]ecorded information of any kind regardless of the form or method of the recording[.]"
DEVCOM Army Research Lab, Legal Definition in General CRADA, 2020.
DATA ARE OBSERVATIONS!

Data: Observations

- Data Collection Tools, Transaction Processing Systems

Information: Processed data, i.e., *formatted, structured, organized, and contextualized*

- Management Information Systems

Knowledge: Explicit (know what). Tacit (know how). *"[A] mix of information, understanding, capability, experience, skills and values"*

- Decision Support Tools, Recommender Systems, Machine Learning

Wisdom: *"[E]xpert knowledge and judgement about important, difficult and uncertain questions[.]"* What makes us human? Intelligence?

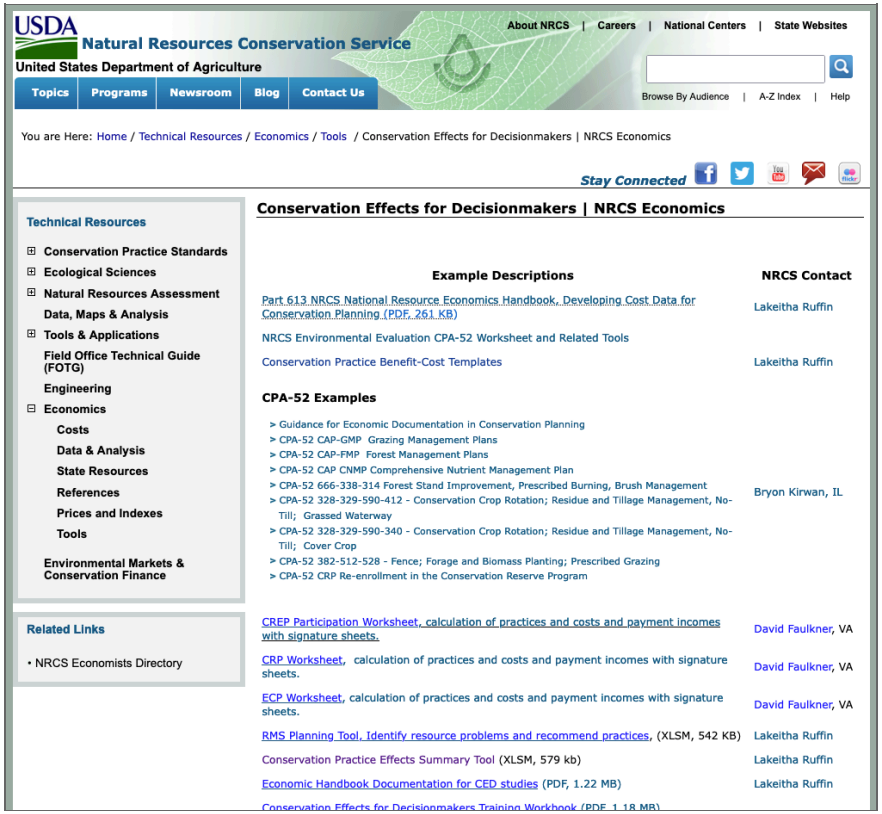
- Expert Systems, Artificial Intelligence

Rowley, The wisdom hierarchy: representations of the DIKW hierarchy, 2006.

"Decision Support Tools are interactive software tools used by decision-makers to help answer questions, solve problems, and support or refute conclusions."

U.S. EPA, "Decision Support Tools - Development of a Screening Matrix for 20 Specific Software Tools". Available at: https://frtr.gov/decisionsupport/PDF/DST%20Matrix%20Report.pdf

DST EXAMPLES: NRCS WORKSHEETS



USDA Natural Resources Conservation Service
United States Department of Agriculture

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Stay Connected

Technical Resources

- Conservation Practice Standards
- Ecological Sciences
- Natural Resources Assessment
- Data, Maps & Analysis
- Tools & Applications
- Field Office Technical Guide (FOTG)
- Engineering
- Economics
  - Costs
  - Data & Analysis
  - State Resources
  - References
  - Prices and Indexes
  - Tools
- Environmental Markets & Conservation Finance

Related Links

- NRCS Economists Directory

Conservation Effects for Decisionmakers | NRCS Economics

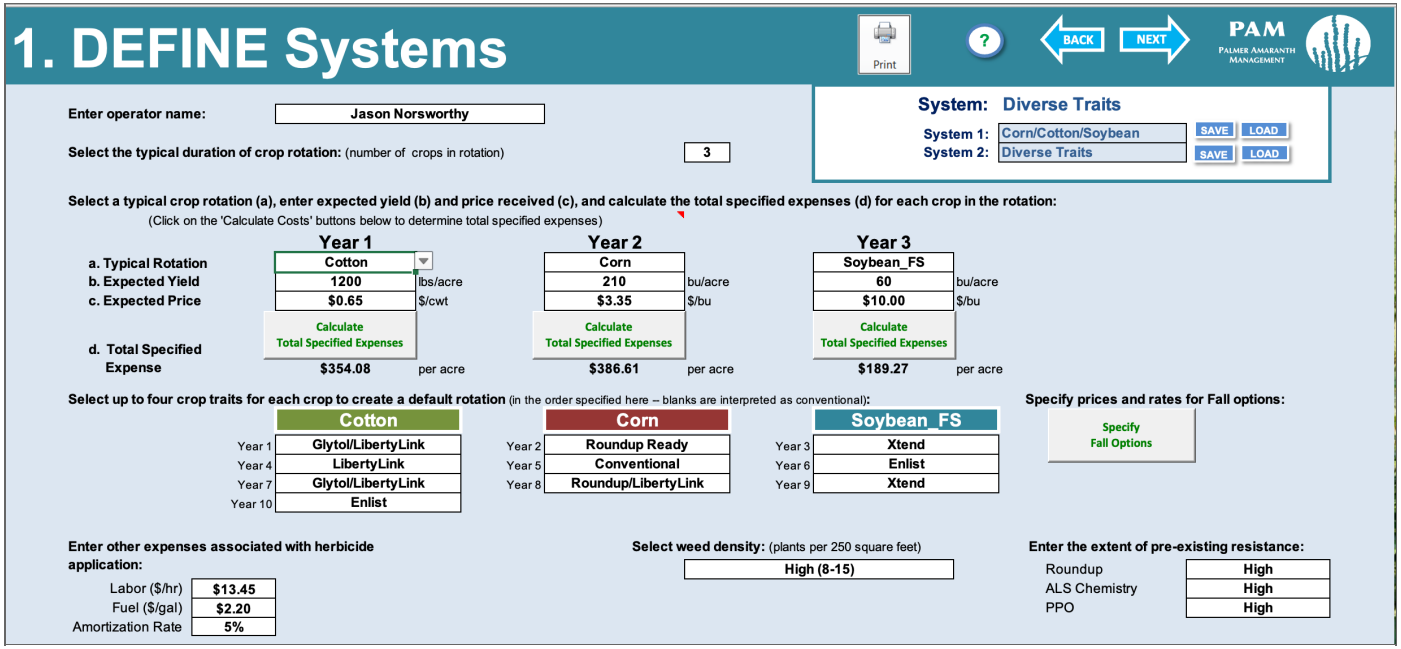
Example Descriptions	NRCS Contact
Part 613 NRCS National Resource Economics Handbook, Developing Cost Data for Conservation Planning (PDF, 261 KB)	Lakeitha Ruffin
NRCS Environmental Evaluation CPA-52 Worksheet and Related Tools	
Conservation Practice Benefit-Cost Templates	Lakeitha Ruffin
CPA-52 Examples	
> Guidance for Economic Documentation in Conservation Planning > CPA-52 CAP-GMP Grazing Management Plans > CPA-52 CAP-FMP Forest Management Plans > CPA-52 CAP CNMP Comprehensive Nutrient Management Plan > CPA-52 666-338-314 Forest Stand Improvement, Prescribed Burning, Brush Management > CPA-52 328-329-590-412 - Conservation Crop Rotation; Residue and Tillage Management, No-Till; Grassed Waterway > CPA-52 328-329-590-340 - Conservation Crop Rotation; Residue and Tillage Management, No-Till; Cover Crop > CPA-52 382-512-528 - Fence; Forage and Biomass Planting; Prescribed Grazing > CPA-52 CRP Re-enrollment in the Conservation Reserve Program	Bryon Kirwan, IL
CREP Participation Worksheet, calculation of practices and costs and payment incomes with signature sheets.	David Faulkner, VA
CRP Worksheet, calculation of practices and costs and payment incomes with signature sheets.	David Faulkner, VA
ECP Worksheet, calculation of practices and costs and payment incomes with signature sheets.	David Faulkner, VA
RMS Planning Tool. Identify resource problems and recommend practices, (XLSM, 542 KB)	Lakeitha Ruffin
Conservation Practice Effects Summary Tool (XLSM, 579 kb)	Lakeitha Ruffin
Economic Handbook Documentation for CED studies (PDF, 1.22 MB)	Lakeitha Ruffin
Conservation Effects for Decisionmakers Training Workbook (PDF, 1.18 MB)	

Data: User-inputted, work through this with an advisor.

Decisions: Conservation planning with a focus on environmental and economic tradeoffs

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/econ/tools/?cid=nrcs143_009735

DST EXAMPLES: PAM SPREADSHEET

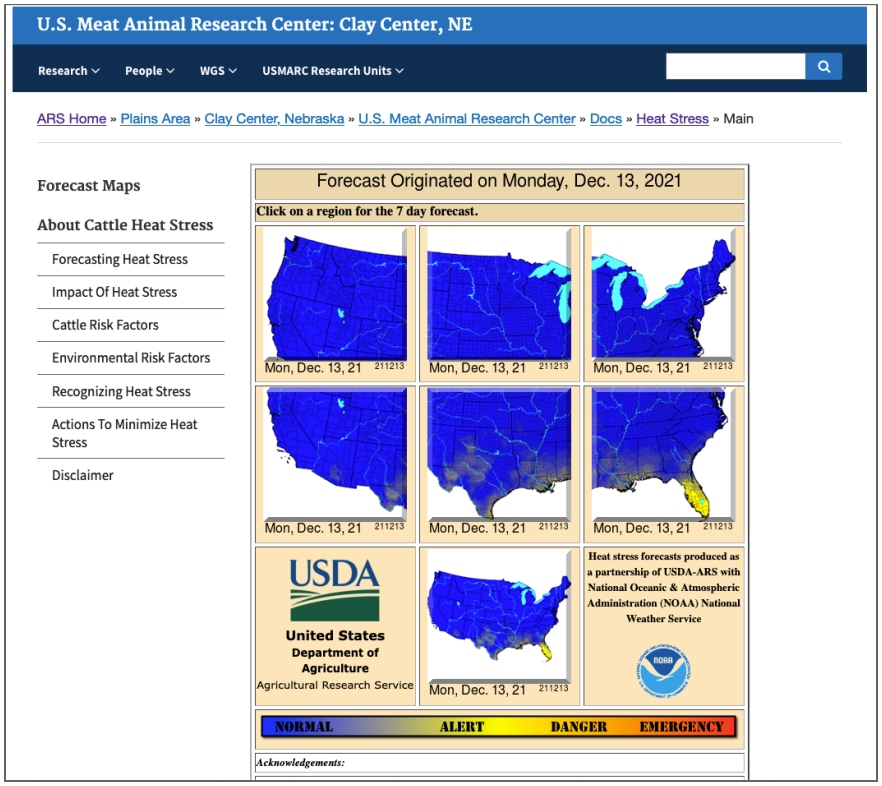


Data: User-inputted, work through this with an advisor.

Decisions: Palmer amaranth management decisions and herbicide interactions to enable weed management.

https://agribusiness.uark.edu/decision-support-software.php

DST EXAMPLE: CLIMATE STRESS MAPS



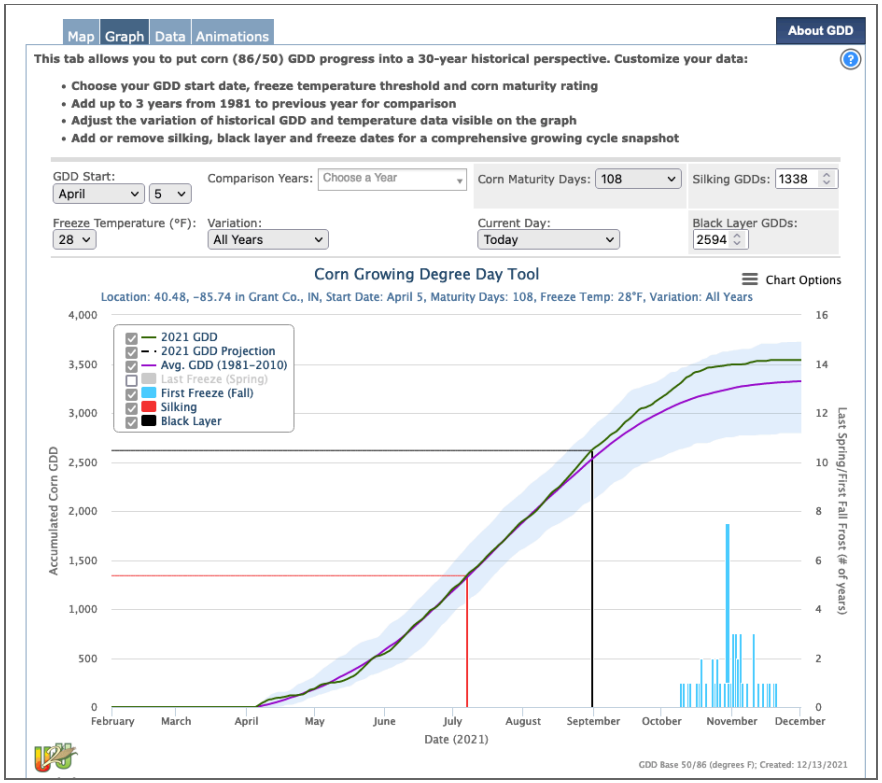
Data: Public climate data, consult only

Decisions: Likelihood of heat stress on cows to enable livestock management

https://www.ars.usda.gov/plains-area/clay-center-ne/marc/docs/heat-

stress/main/

DST EXAMPLE: CORN GDD WEB TOOL

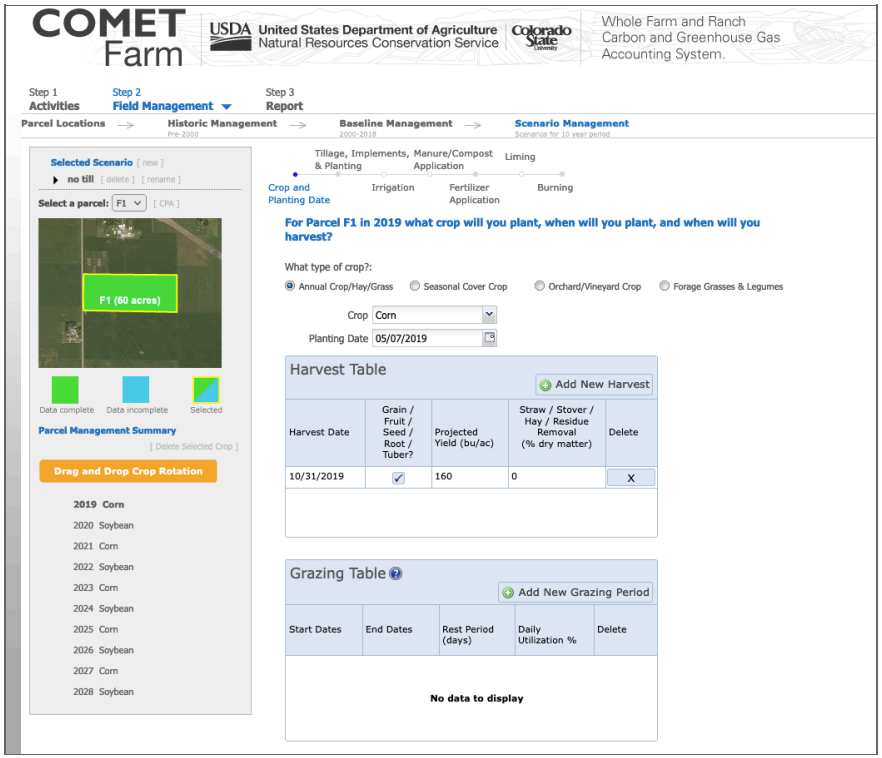


Data: public data, research data, user input data

Decisions: growing degree day trend projections to enable activity planning, climate risk assessment, and marketing.

https://mrcc.purdue.edu/U2U/gdd/

COMET-FARM MODELING TOOL

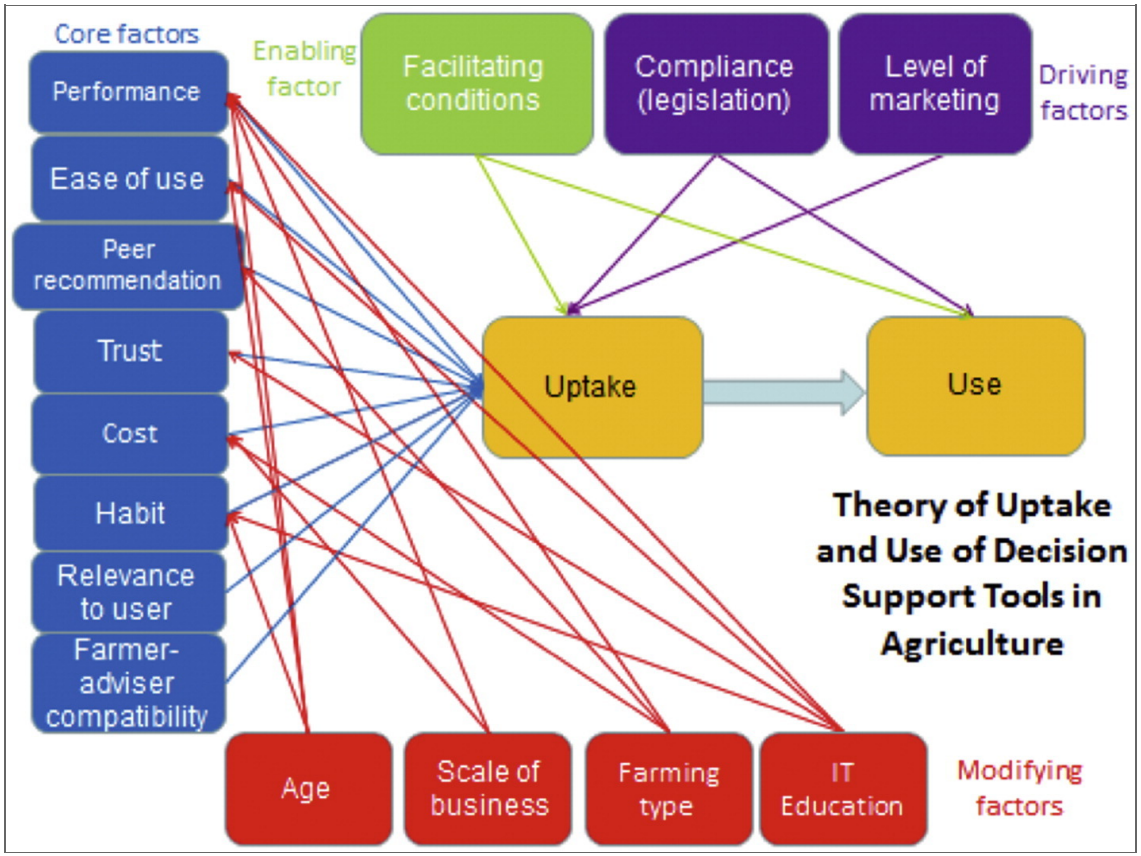


Data: public data, research data, user input data

Decisions: farm management history enables whole farm carbon and GHG accounting.

https://www.comet-farm.com

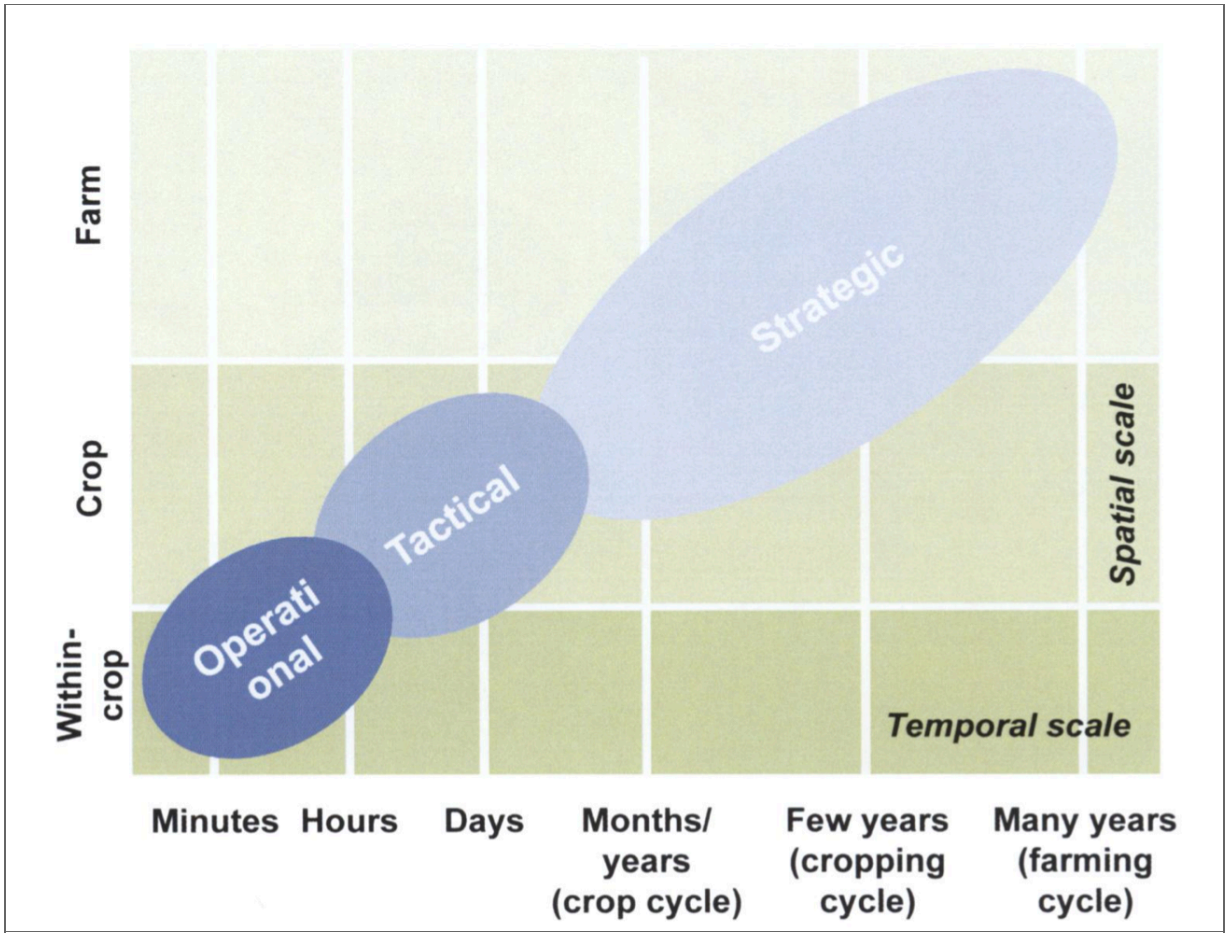
FACTORS OF DST UPTAKE & USE



Rose et al., 2016, "Decision support tools for agriculture: Towards effective design and delivery". Available:

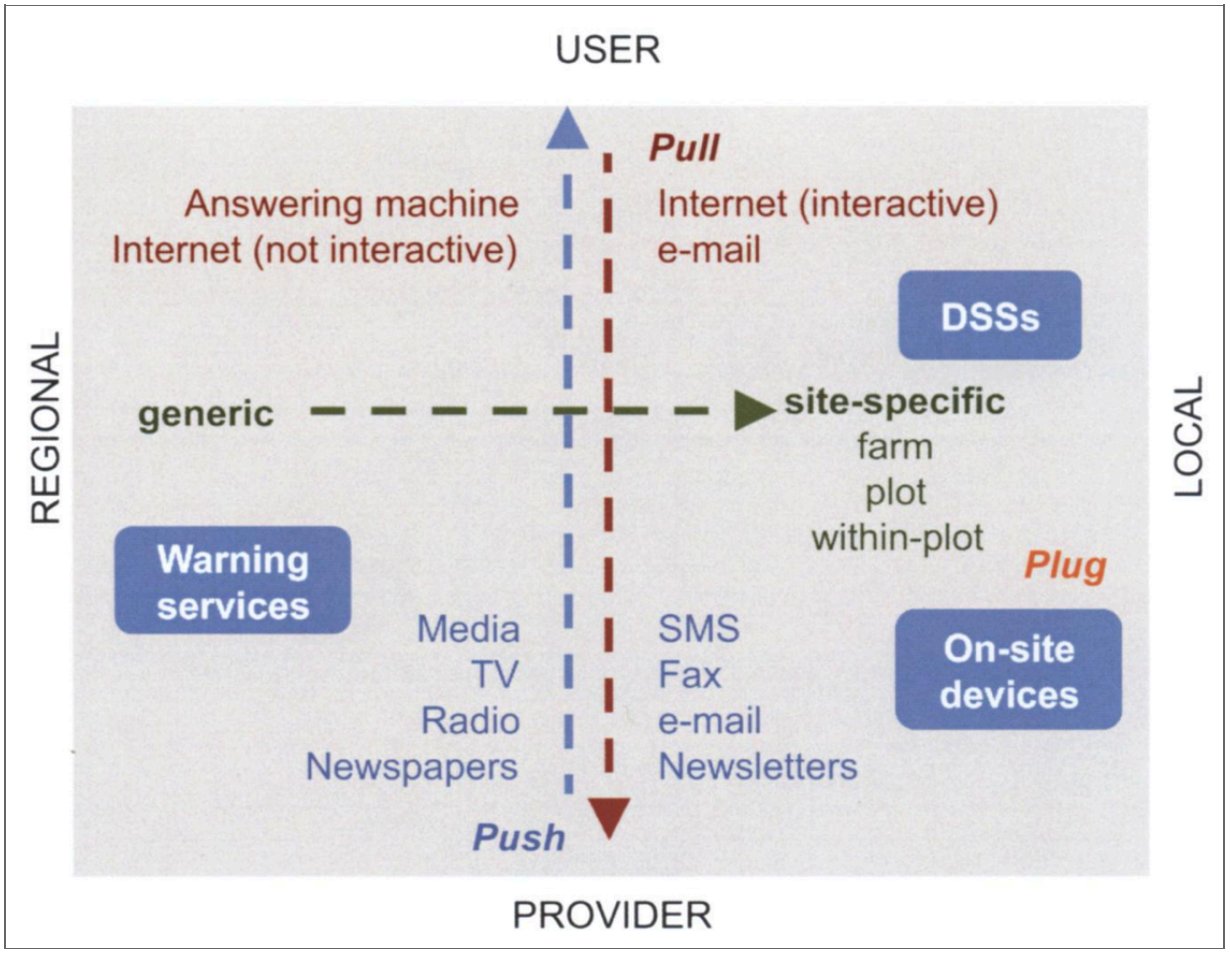
https://www.sciencedirect.com/science/article/pii/S0308521X16305418

SPATIO-TEMPORAL SCOPE OF DECISIONS



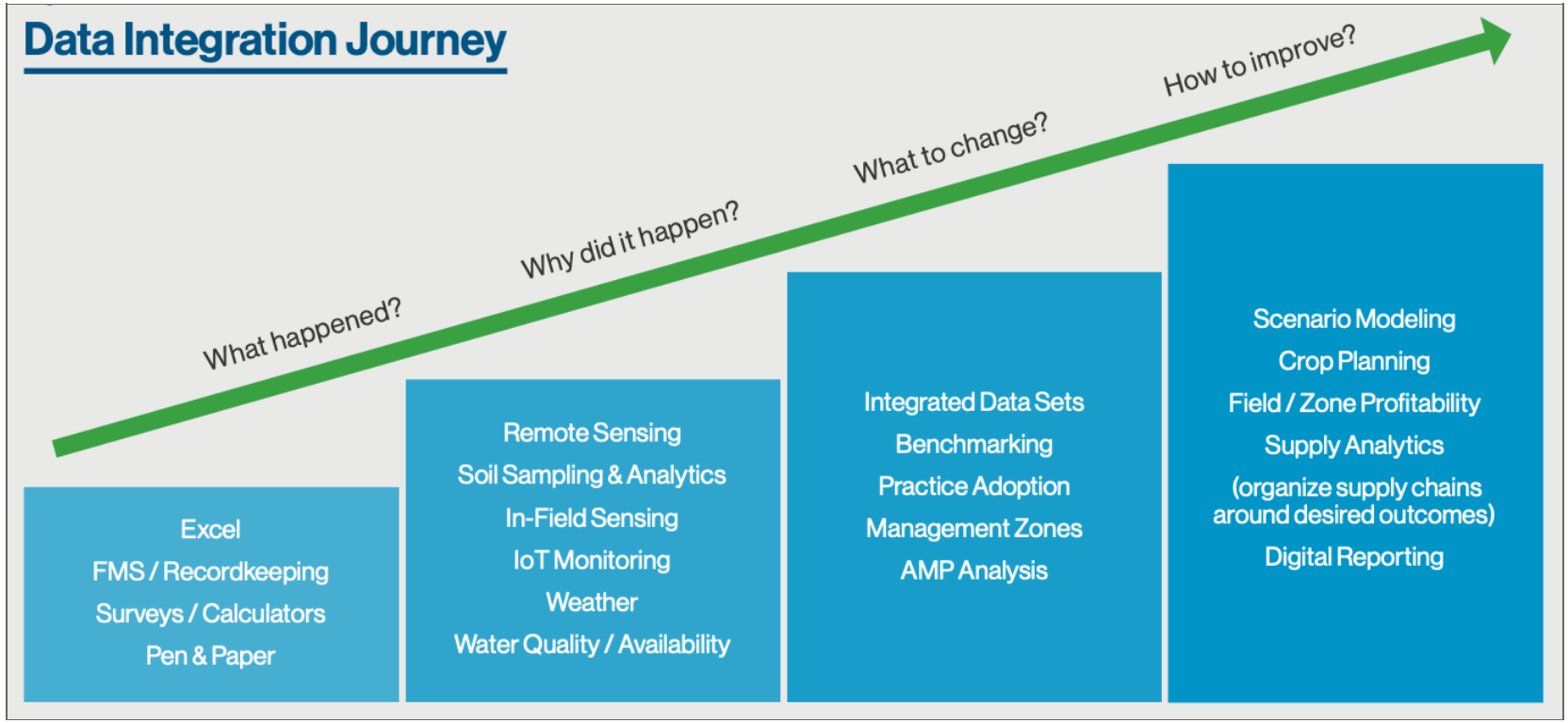
Rossie et al., 2012, "Helping farmers face the increasing complexity of decision-making for crop protection", Available: https://www.jstor.org/stable/43872334

INFORMATION DELIVERY MECHANISMS



Rossie et al., 2012, "Helping farmers face the increasing complexity of decision-making for crop protection", Available: https://www.jstor.org/stable/43872334

THE DST DREAM!



https://usfarmersandranchers.org/wp-content/uploads/2021/02/USFRA-Transformative-Investment-Report.pdf

CASE STUDY: COVER CROP DECISION SUPPORT TOOLS

SOIL HEALTH DECISION SPACE

Management Practices

Covex Crops

Crops planted to prevent soil erosion by covering the ground with living vegetation and roots that hold on the soil (Magdoff 1942).

Crop Rotations

Growing different crops on the same land on alternating years or season. E.g : soy-bean rotation.

Intercropping

Crops planted in the same space and time, so that both crops can benefit each other.

Composting

Combining available and appropiate organic wastes, so that they decompose and make a uniform product for fertilizing.

Manure Application

Apply manure as fertilizer, nutrient amount of it may vary depending on the time of the year, application time, storage and soil type.

Biological Pest Mngmt

Use of arthropods, or other living predators of the pest, or certain fungus and pathogens to combat a disease. Also includes the use of biofumigation (plant residue with biocidal compounds)

Chem Pest Mngmt

Use of fungicides and pesticides for pest management.

Reduced Tillage

Use of disk or chisel plow instead of moldboard plow. Restricted Tillage: Includes no-till or strip tillage.

Also refers to reducing the amount or times that tillage is done.

Can also be mentioned as mulch till that does not disturb residue.

Perennial Systems

Perennial systems are those that regrow after a single harvest, and is the intentional integration of perennialized crops (grains, legumes, oil seeds etc) in diverse farming systems. (FAO, 2011)

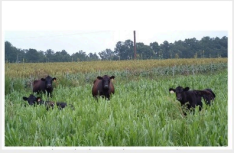
Residue Mngmt

Can also be mentioned as mulching which is to apply plant residues to compensate loss due excessive tillage.

Under residue management is to leave crop residue for the next planting season, or using cover crop with high residue content.

Livestock Integration

Integrating productive crops with livestock and forage crops for grazing (which can serve as cover cropping)and for livestock feed.



Controlled Traffic

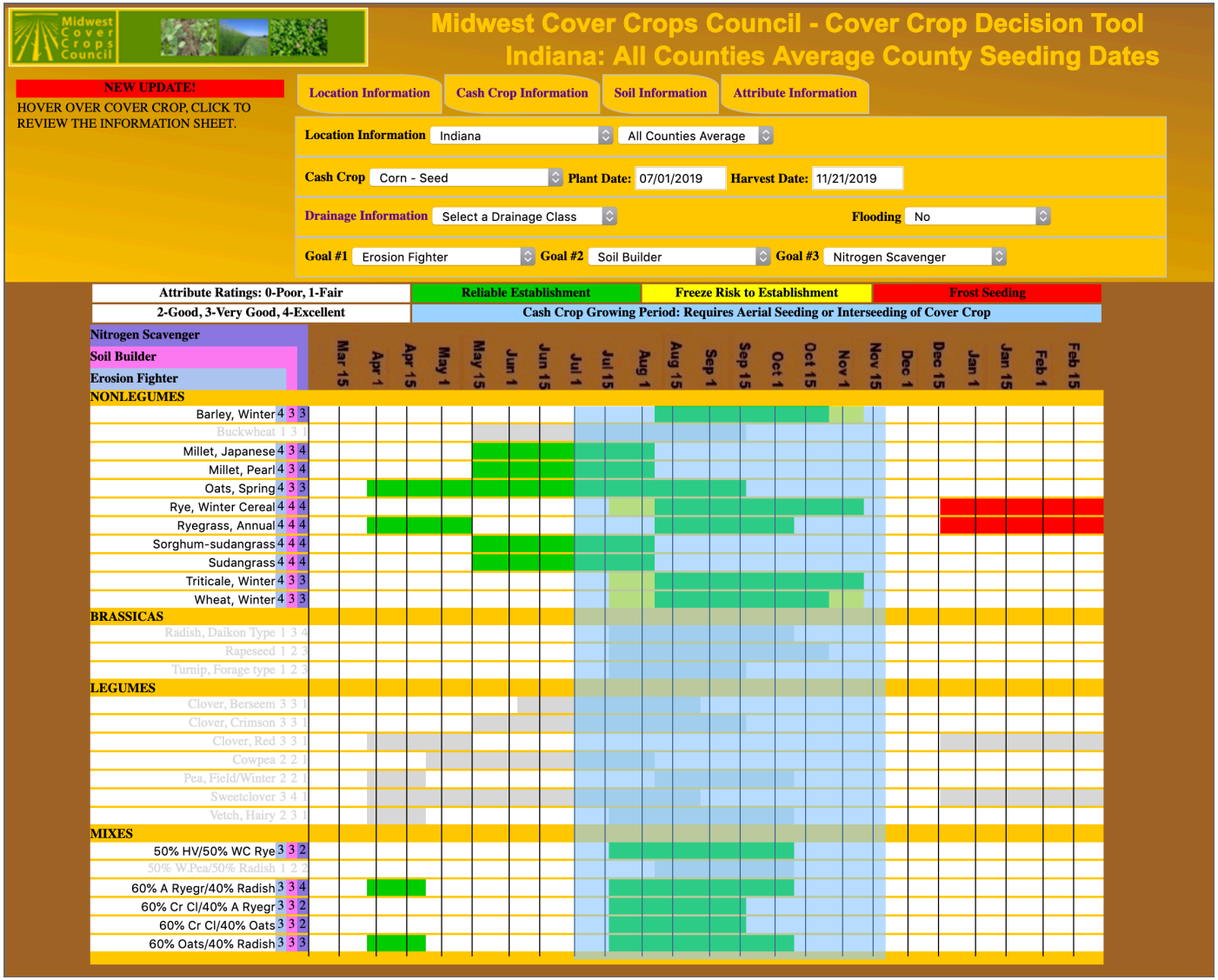
Running farm machinery over the same paths in the field to lessen compaction and disturbed the smallest proportion of soil. Crop zones and traffic lanes are permanent separated. Also known as tramline farming.

COVER CROPS SERVICES

Erosion protection
Nutrient cycling
Good grazing
Improved water quality
Pollinator habitats
Increased soil organic matter
...and more.

OXFORD, MARYLAND - Aerial view of cover crops sitting next to the Chesapeake Bay © Edwin Remsberg, SARE Cover Crop Image Library

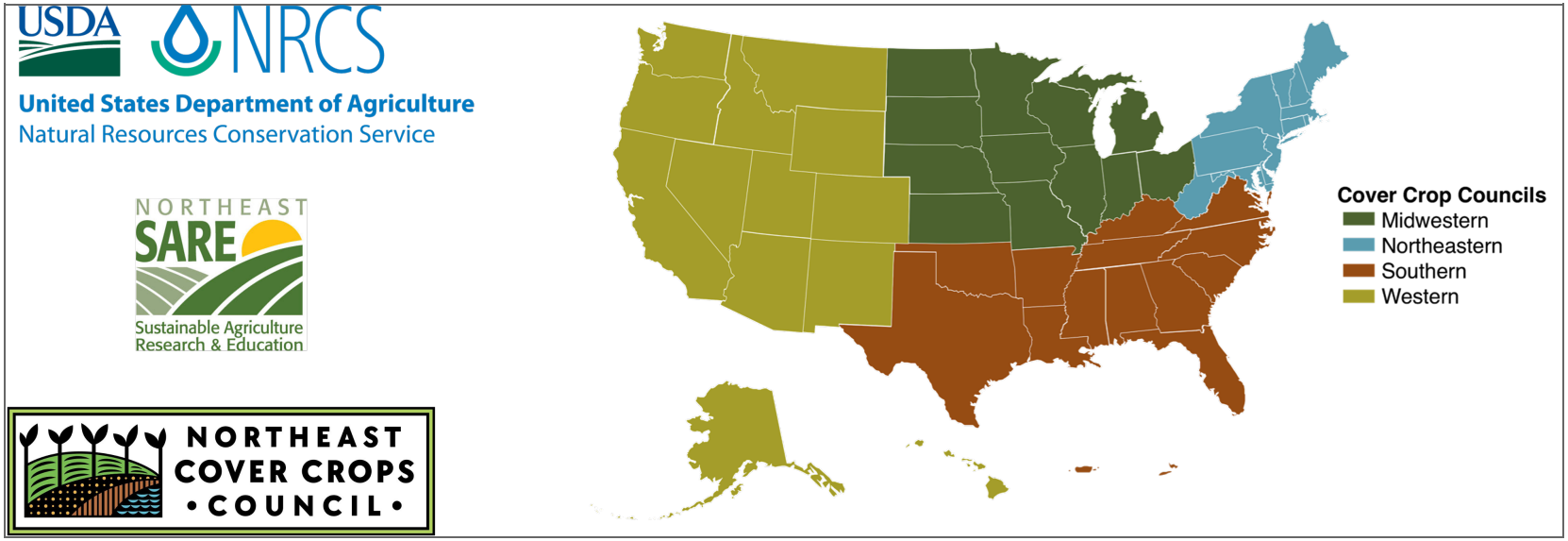
Effective Cover Cropping is Knowledge Intensive



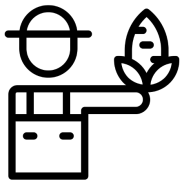
"DON'T BOTHER CORN FARMERS WITH POTATO QUESTIONS"

In conversation w/Chris, MyFarms.com

COMMUNITIES OF PRACTICE



COVER CROP DST USER GROUPS



Grower

Goal: find a cover crop to meet my farming goals

Advisor

Goal: advise a grower on cover cropping, including selection & management

Explorer

Goal: learn about cover crops!

DESIRE: FULL-STACK DECISION MAKING

1. Select species
2. Create mixes
3. Calculate seeding rates
4. Cost-share & economic evaluation
5. Plan termination
6. Nutrient management
7. Weed management
8. Assess performance of cover crops

GOAL: MODULAR ARCHITECTURE

WHAT LEADS TO *EFFECTIVE* COVER CROP DECISION SUPPORT?

DATA

High quality regional cover crop performance data + local field conditions

Behind the scenes

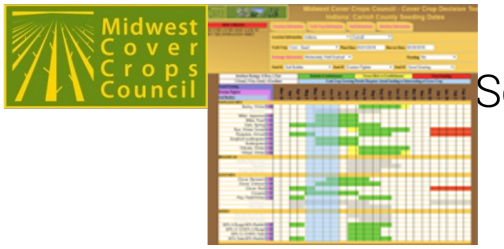
DESIGN

An improved user experience that reduces information overload

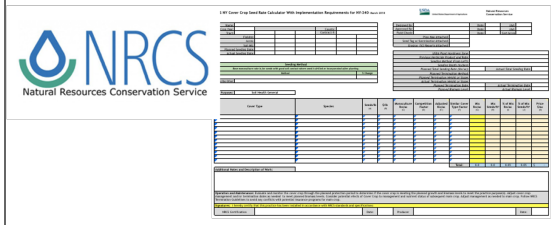
What you see on the screen

EXISTING DATA & TOOLS

Cover Crop Data



MCCC Selector Tool



NRCS NY Seeding Rate Tool

Plant & Environmental Data

Integrated Taxonomic Information System -> Plant Names

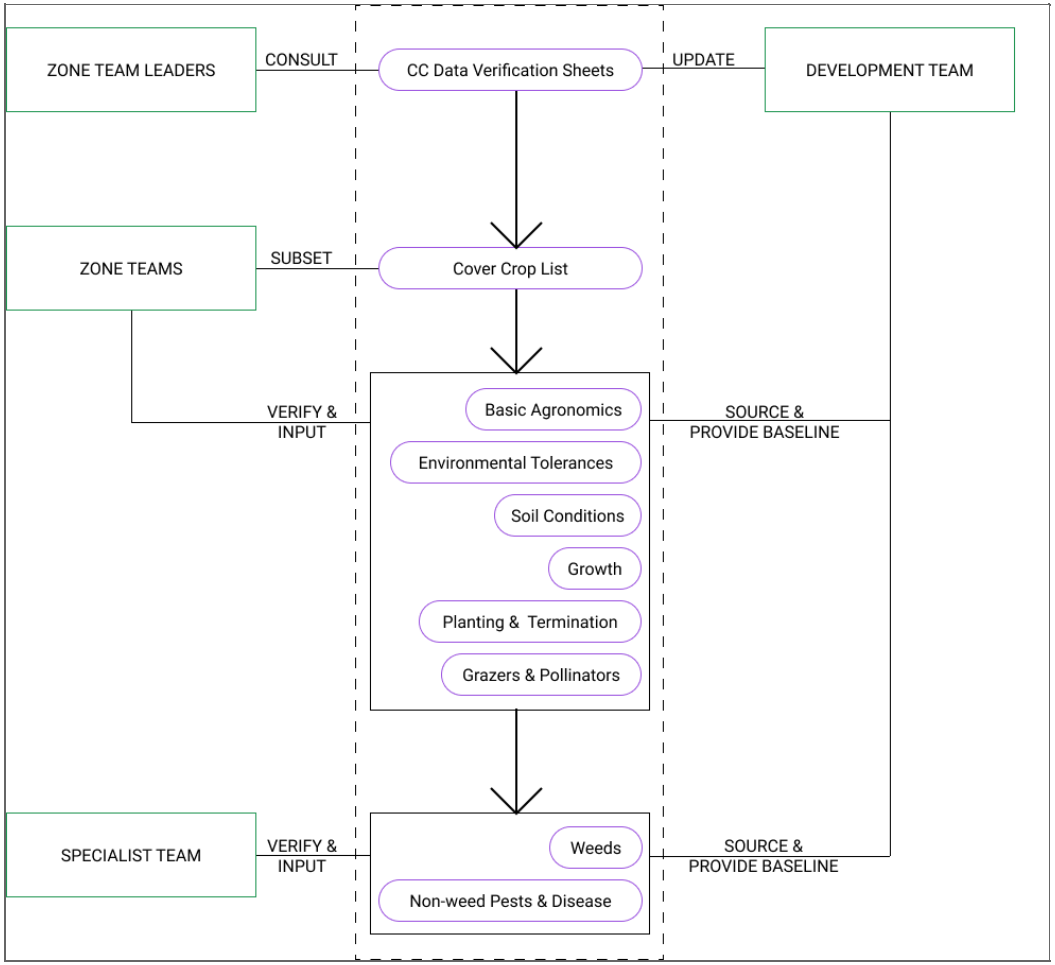
USDA PLANTS Database -> Agronomics, growth, morphology, etc.

-> Soils Data

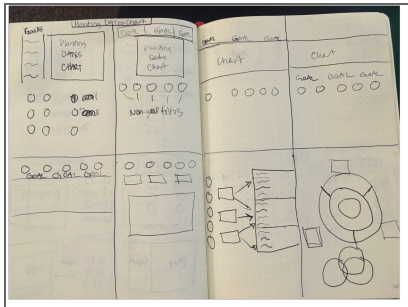
-> Weather Data

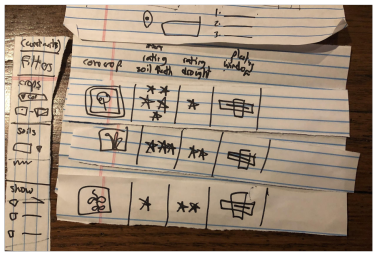
DATA CURATION

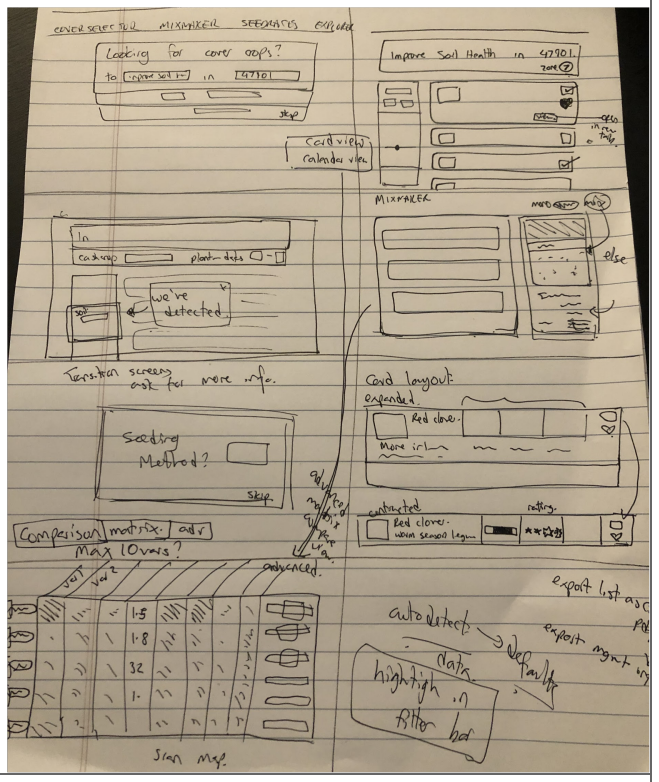
50+ cover crop experts: Farmers, crop advisors, researchers, and more.

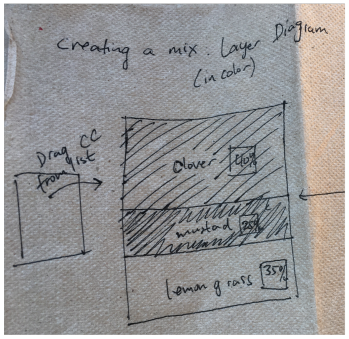


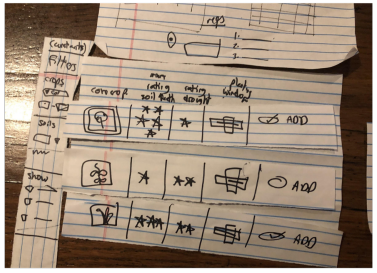
USER-CENTERED DESIGN

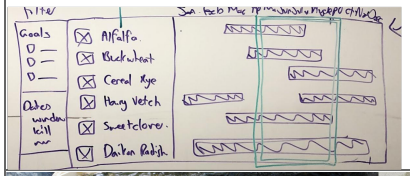


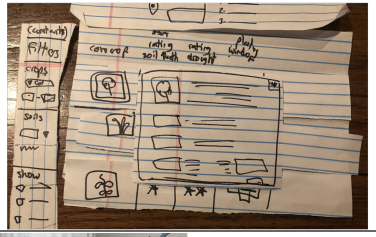




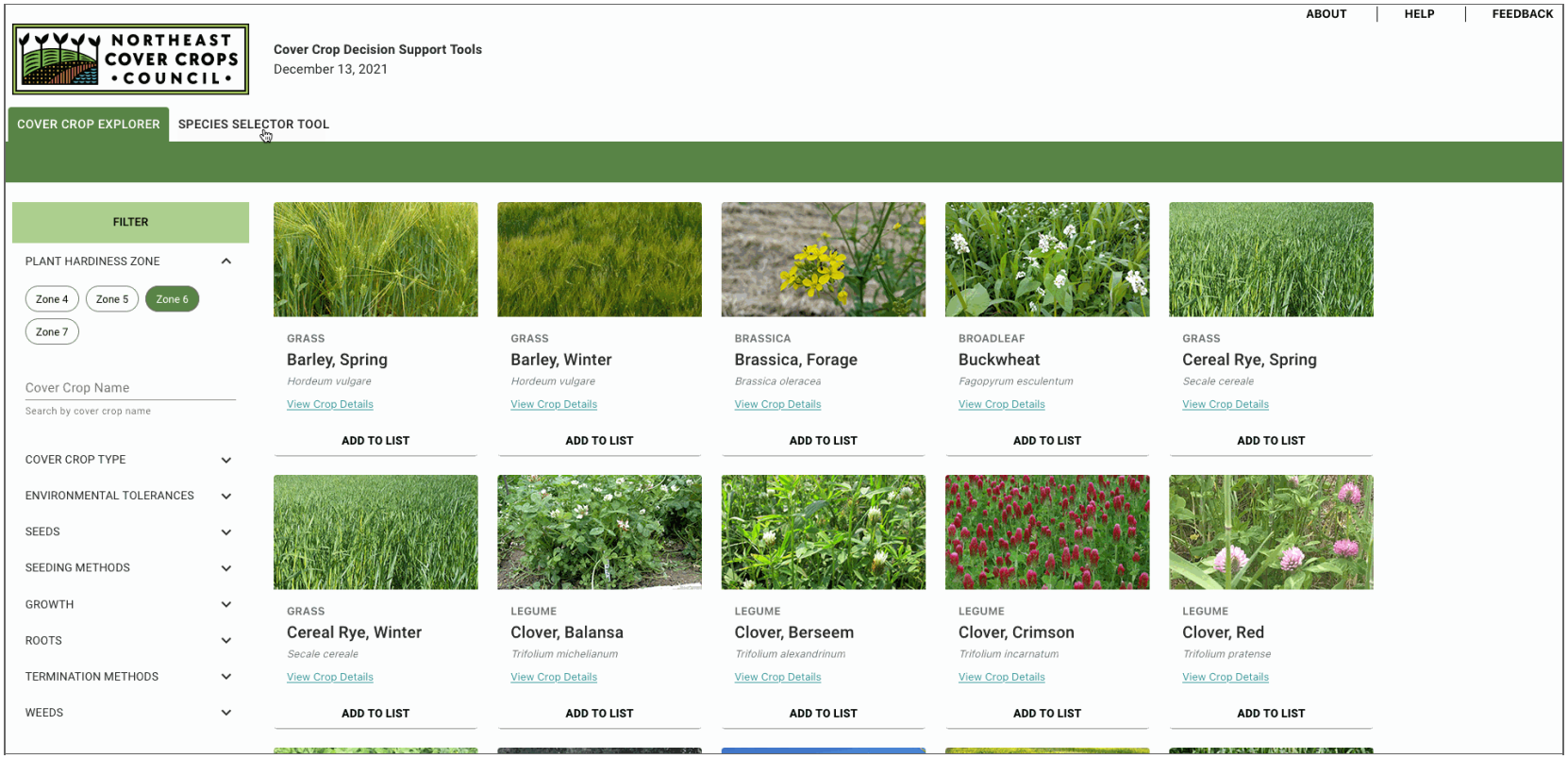






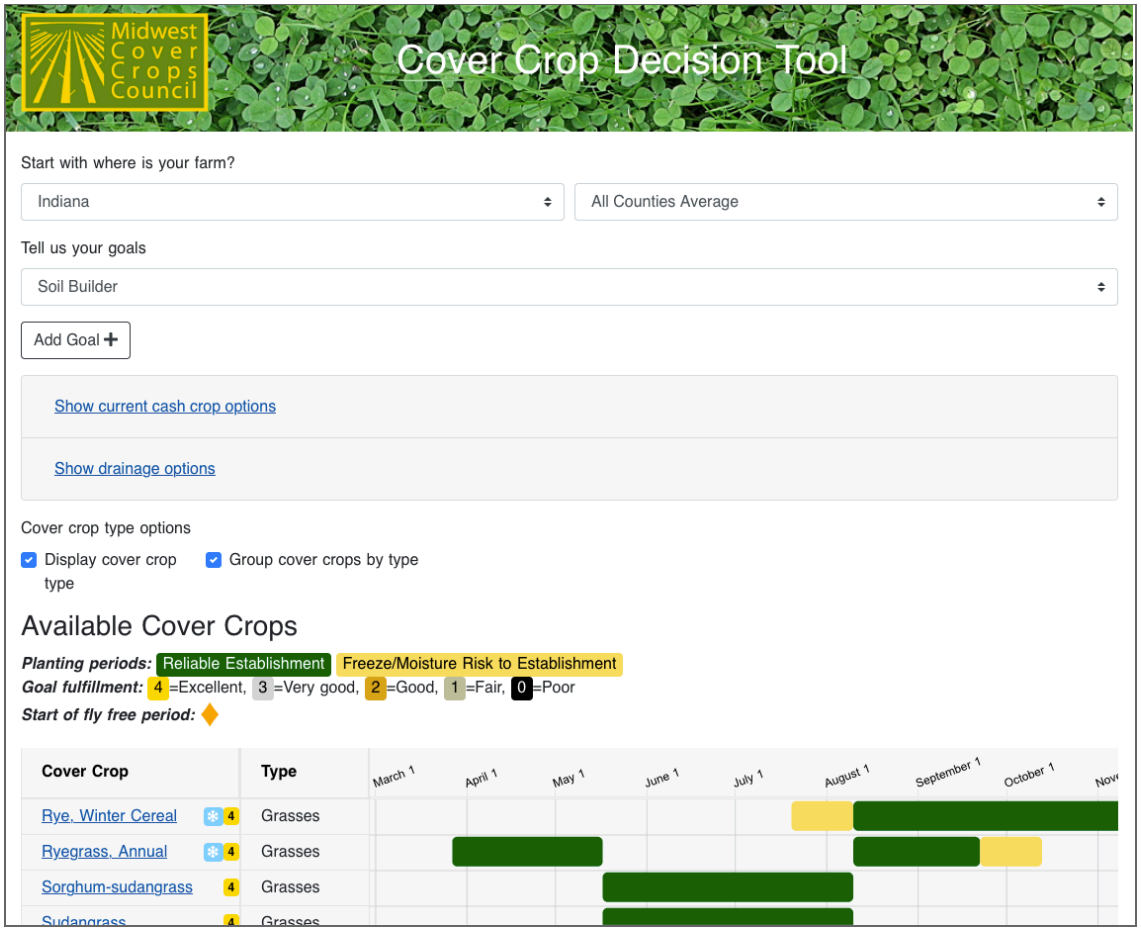


SPECIES SELECTOR TOOL: NECCC



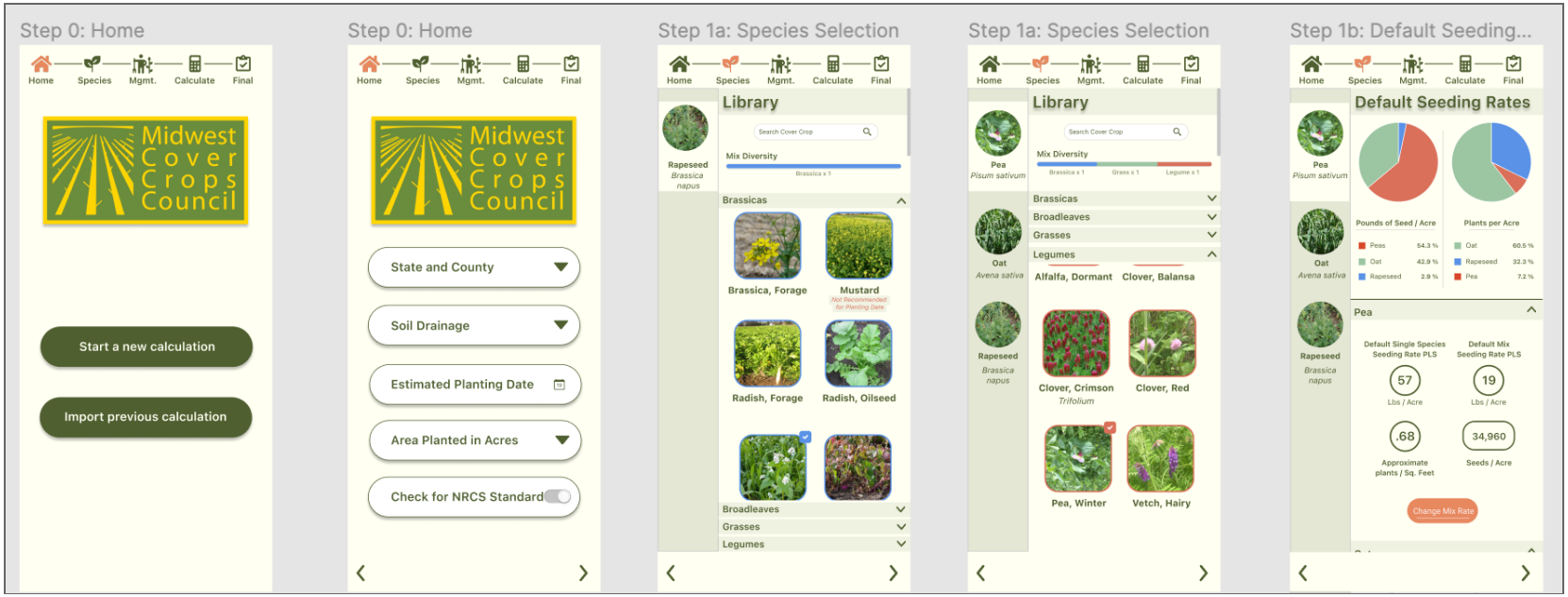
http://covercrop.tools/

PARTNERS IN THE MIDWEST: MCCC TOOL



https://mccc.msu.edu/covercroptool/

SEEDING RATE CALCULATOR



MCCC + NECCC, a unified design effort.

Tool ETA: 2022.

AN INVITATION TO COLLABORATE

THE AGRICULTURAL INFORMATICS LAB

axilab

PURDUE UNIVERSITY

Thinking about how
people
design, build, and use
technology to...
grow and distribute food & ag products,
manage natural systems,
coordinate and organize work, &
strategize for food & ag system resilience.

THE DESIGN FOR AGRICULTURAL SOIL HEALTH INFORMATION (DASHI) PROJECT

Problem: How can we create seamless user experiences as farmers collect, manage, and use agricultural, environmental, and operational data to improve soil health outcomes?

Current Status: Design research (w/Farmers & Ranchers, Tool Developers, Data Curators) to inform future development of appropriate technologies.

Project Partners: Farmer & Buyers (e.g., via Stoneyfield) Open Source AgTech (e.g., OurSci, FarmOS), Model Developers (e.g., Cool Farm Tool, Comet Farm), and an interdisciplinary team of researchers.

THE DESIGN FOR AGRICULTURAL SOIL HEALTH INFORMATION (DASHI) PROJECT

What does it involve?

- Farmer interviews and data mapping to explore data life cycles
- Farmer reflection worksheets to understand technology context
- Speculative design workshops w/soil health data stakeholders (farmers, advisors, researchers) to envision next gen soil health tools.

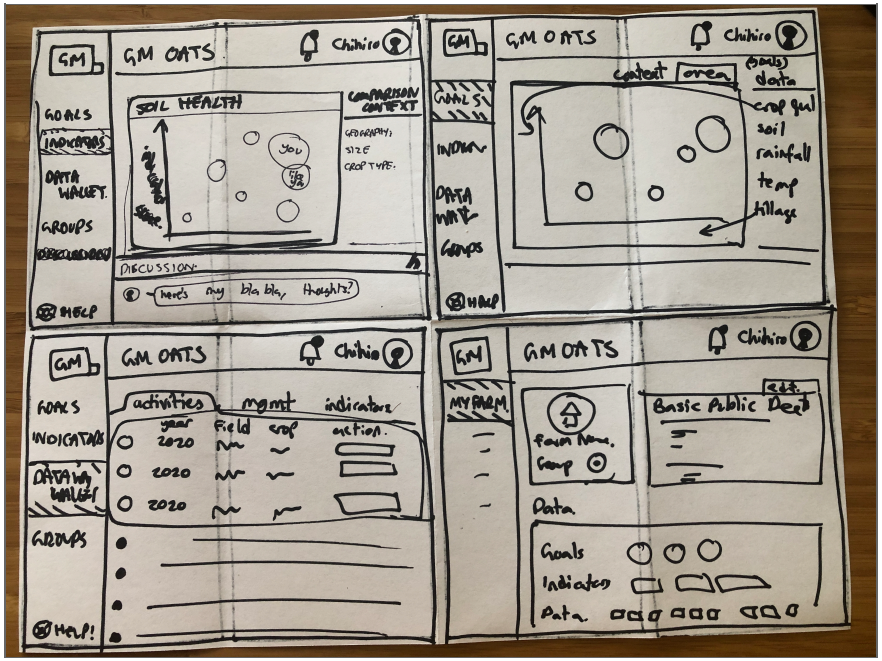
Express interest: https://bit.ly/dashi-interest

Learn more: dashi.aginformaticslab.org

CO-DESIGNING DECISION TOOLS

How can we better support farmers and crop advisors in Indiana?
Imagine your at your favourite farm. You’re in the field, it’s a great day, but your grower has a really hard problem that they’ve called out here for. As you're talking, you get to the point where you whip out your phone and do what? Do you calculate something? Look for information about what you see in the field? Draw something? **What is it you want this digital portal to provide?**

Draw out a storyboard and share it with us!


GM
GM OATS
Chihiro
GOALS
INDICATORS
DATA WALLET
GROUPS
HELP
SOIL HEALTH
COMPARISON CONTEXT
GEOGRAPHY
SIZE
CROP TYPE
YOU
DISCUSSION
Here's my bla bla, thoughts?
context
area
(goals) data
crop
soil
rainfall
temp
tillage
activities
mgmt
indicators
year
Field
crop
action
2020
2020
2020
MY FARM
Basic Public Data
edit
farm Name
Comp
Data
Goals
Indicators
Data

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	• Virtual community for resilient partnerships: **forum.goatech.org** • Bringing together developers, designers, farmers, researchers • Coordinating grassroots development of open ag tech • Hackathons! GOAT:Hacks @ conferences, USDA, universities, and more!		

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THANK YOU!

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