

State Technical Committee Meeting
November 14, 2019 at 10:00 a.m.
NRCS State Office Conference Room

AGENDA

10:00 – 10:05	Welcome, Opening Remarks	Jack Bricker, NRCS
10:05 – 10:45	Highlights of the 2018 Farm Bill RCPP – what we know so far CSP Interim Final Rule highlights	Julie Hawkins, NRCS
10:45 – 11:45	Soil Health Assessment & Measurement	Chris Lawrence, NRCS
11:45 – 12:45	Chesapeake Bay Program’s science panel report on cropland irrigation	Mark Dubin, UMD Extension

Adjourn



Next Meeting – TBA

State Technical Committee Meeting

NRCS State Office, Richmond, Virginia

Thursday, November 14, 2019 @ 10:00 a.m.

Name (Please print.)

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State Technical Committee Meeting
Thursday, November 14, 2019, at 10 a.m.
NRCS State Office, Richmond, Virginia
Large Conference Room

Those in attendance were:

Ebonie Alexander, Black Family Land Trust (BFLT), by phone
Jill Auburn, Virginia Association for Biological Farming (VABF)
Kristen Saacke Blunk, Headwaters LLC
David Bryan, Department of Conservation and Recreation (DCR)
Seth Coffman, Trout Unlimited (TU)
Dean Cumbia, Virginia Department of Forestry (VDof)
Mark Dubin, University of Maryland Extension (UMD)
Lauren Fox, Pamunkey Indian Tribe
Emily Francis, Agua Fund
Todd Groh, Virginia Department of Forestry (VDof)
Leticia Jackson, NRCS, Easement Program Specialist
Elliott Kellner, West Virginia University (WVU)
Marilyn Knight, U.S. Fish & Wildlife Service (USFWS)
Matt Kowalski, Chesapeake Bay Foundation (CBF)
Sylvia Malm, Source Water Collaborative by phone
Jen Perkins, Virginia Department of Agricultural and Consumer Services
Mark Schonbeck, Virginia Association for Biological Farming (VABF)
Reggie Tupponce, Upper Mattaponi Indian Tribe
Jack Bricker, NRCS, State Conservationist
Julie Hawkins, NRCS, Assistant State Conservationist-Programs
Diane Dunaway, NRCS, Easement Specialist
Chris Lawrence, NRCS, Cropland Agronomist
Patrick Vincent, NRCS, Farm Bill Program Specialist
Chad Wentz, NRCS, State Resource Conservationist
Ron Wood, NRCS, Farm Bill Program Specialist
Kathleen Anderson, NRCS (Recorder)

Julie Hawkins, NRCS Assistant State Conservationist-Programs, welcomed everyone to the meeting.

The meeting participants introduced themselves by stating their names and agencies/organizations.

Jack Bricker, NRCS State Conservationist, began the meeting by stating that there are new features of the 2018 Farm Bill. Some highlights:

- There is an interim rule/guidance for hemp production requiring a state plan be approved by the USDA.
- We will cover the Regional Conservation Partnership Program (RCP) update today.

- We will go into detail with the Conservation Reserve Program (CRP) at a later time, as there are new responsibilities in this program.
- The budget is initially 17 million dollars for the Environmental Quality Incentive Program (EQIP).
- The Conservation Stewardship Program (CSP) is no longer acreage-based, but now it funding-based. The funding for this program is 8 million dollars.
- NRCS Virginia is at historic lows in hiring. We are currently at 135 employees; we need 185. We especially need more field staff.
- There are two new tools that our staff will use for conservation planning and Farm Bill delivery, Conservation Desktop, and Conservation Assessment Ranking Tool (CART), a new tool for ranking. This is a big change for the organization. There are a lot of new things to learn in using these, with a big learning curve. This should be in use by the second quarter.

Julie Hawkins began the first part of her presentation, “**Highlights of the 2018 Farm Bill.**” (*See the PowerPoint entitled “What’s New: Natural Resources Conservation Service (NRCS) and the 2018 Farm Bill,” from slide numbers one through nine.*) There are changes for Programs in the new Farm Bill.

There were no new programs established in this Farm Bill, and none were eliminated. The Bill increased the funding for both the Agricultural Conservation Easement Program (ACEP) and EQIP, and direct funding for RCPP. There is an update to the definition of a military veteran farmer. Priorities in this Bill include soil health, water quality, and pollinators.

ACEP was authorized for up to 450 million dollars per year. Now, an authorized trust can own the land, then transfer it to a landowner after a few years. The ALE plan is no longer required and the minimum plan must address Highly Erodible Land (HEL).

Conservation Innovation Grants (CIG) expanded to classic and to on-farm trials (helps farmers to develop innovative practices). The definition of what a tech service provider is has been clarified. There was an increase in funding for VPA-HIP. This program now allows for public access and recreational activities. The application period is through November 27.

The hemp rule has removed this crop as controlled substance. There are two fact sheets that have been handed out today. (*See the handouts entitled “Hemp and Farm Bill Programs” and “U.S. Domestic Hemp Production Program.”*)

Urban farms (such as indoor farms, etc.) are a priority. NRCS is expected to expand on this important topic.

Nationally, we are devoting 10% of total program funding towards source water protection (SWP) as required in the new statute. States were to identify priority areas by September 30. Two areas in Virginia are Luray and Shenandoah. We relied on our partners to help identify this. We now have a GIS specialist to help with future analyses regarding source water protection priority areas.

In response to a question on why EQIP is on hold, Julie Hawkins explained the rule for EQIP has not yet been published. The Farm Bill gave transitional authority until September 30, 2019, so we are on hold until the EQIP interim final rule is published.

At this point, Jack Bricker elaborated why is staffing so low at NRCS in response to a question about staffing. This low employment rate is recent history. There had been 11,000 NRCS employees nationwide. Recently, there was

downsizing for all, resulting in between 8,700 and 9,800 nationwide. Our cap will be raised again to 11,000. We hope that some hiring will take place. Hiring has not kept up with attrition (retirement, etc.). We cannot keep up with attrition, but we hope that we will increase our numbers, by way of the Pathways program. This program is about bringing students on board during their junior year in college, looking toward converting some to full time employment after graduation. Question: Do people go around and check on the results of the practices implemented? Answer: The 9th step of our planning process is follow-up, but since we have a shortage of employees, we fall short on this step. This is part of our business model, though.

There was a question on the agency's new software. Julie Hawkins explained there was training on using the Conservation Assessment Ranking Tool in Norman, Oklahoma, a few months ago, for a roll-out of CART. There was a demo of the ranking tool. The agency is excited for this, though more functionality will become evident as time goes on. We look forward to things being connected in usage. Virginia has participated in user acceptance testing for the fund manager portion of CART.

Julie Hawkins proceeded to the second part of her presentation, **"Conservation Stewardship Program."** (*See the PowerPoint entitled "What's New: Natural Resources Conservation Service (NRCS) and the 2018 Farm Bill," beginning at slide number ten.*)

On Tuesday, November 12th, the Interim Final Rule was published. This provides the necessary regulatory language for how the agency intends to implement the statute. Training for Programs staff members begins on December 9th. More information is coming out for us. Even with the interim final rule published, we cannot hold sign-up yet, until we have our training.

There are excellent changes provided by the statute and this new regulation. It is now required that CSP should be more streamlined. The program must be managed to promote soil health and includes regulatory changes to now include public land (mostly applies to western lands). It clarifies definitions; expands on bundling; and provides for separate ranking and funding for organic producers and growers transitioning to organic production, instead of just beginning farmers. Early start waivers are now allowed even though there is no guarantee that they will get funding for this. In the fifth year of current contract, participants were opting to not renew (as they had to be held to a higher standard in conservation) and would just reapply to start a new contract. But now, if participants opt-out, they have a cooling-off period of 2 years until they can apply again. Also, the operator of record is no longer needed. The main highlights are that the payment deadline will be removed and implementing enhancements by third year only were removed. The NRCS Associate Chief wants to hear feedback from partners, whether it is positive or negative feedback during the comment period.

NRCS had sent out information to staff and partners on "Myth-busters," namely the Existing Activity Payment (EAP), known as the forgotten payment by the programs staff. This credits people for the conservation thresholds where they are, by using a formula. It is not easy to make a comparison between EQIP and CSP. As an example, a comparison was made between a cow-calf operation in EQIP and in CSP. In this instance, CSP had seven resource concerns, and showed a 50% higher reward from it (the CSP) over the EQIP. Think of other programs, more than just EQIP!

Next, **Julie Hawkins** presented **"RCPP – What We Know so Far."** (*See the PowerPoint entitled "Regional Conservation Partnership Program (RCPP)." These are from Stacy Bradshaw, Soil Conservationist/Water Resource Operations Team. Stacey is currently away on training.*)

The Regional Conservation Partnership Program (RCPP) is a collaborative program that co-invests with partners. The premise is that the whole is greater than the sum of the parts. It began under the 2014 Farm Bill, then was authorized later to be its own program. We do not have the regulation yet on this. There are 5 major steps in getting this to the federal register. *(Make sure to see the red print on slide number two regarding ongoing changes with this.)*

RCPP has four major pillar principles: impact, partner contributions, innovation, and partnership and project management. NRCS prioritizes projects that integrate multiple programs and conservation approaches, and, with innovation to use the multiple authorities, flexibility is allowed.

There are significant changes for RCPP in the 2018 Farm Bill. There are now 15 Alternative Funding Arrangements that will be more grant-like and will be announced in an upcoming announcement of program funding. The three funding pools have been reduced to two, state/national and CCAs. There is a new emphasis on project outcomes. There are faster timelines and a new, streamlined approach. NRCS is required to report to partners now. Even though we did keep current with this information to report, it is now required.

There is a project maximum of 10 million dollars and a minimum of 250K. The application period ends December 3. There is no longer a two-phase application process, which had required a pre-proposal.

There is a timeline available *(see slide number six)* showing the RCPP actions for Fiscal Years 2019 and 2020. Alternate Funding Alliance (AFA) awards will be announced in the summer of 2020.

Funding pools for RCPP in Virginia are part of two Critical Conservation Areas (CCA), the Chesapeake Bay and the longleaf pine.

The lead partner eligibility was expanded. The lead partner is responsible for executing the project to completion. Non-lead partners can contribute and can be third party individuals or organizations.

The agency is doing a better job to explain how the technical assistance (TA) funding works. The slides illustrate this with 70% going to FA and 30% to TA. There is a non-negotiable 5% TA going to NRCS and 18% implementation TA is negotiable between the partner and NRCS depending on who is doing what. Enhancement TA is up to 7% and covers things that were prohibited under the 2014 Farm Bill like outreach and project management. There is a useful chart giving examples of activities and what type of TA or contribution is applicable as well as a chart that shows RCPP conservation activities and the associated covered program authorities. Also, there are lists and explanations of the different aspects of RCPP funding, application, partnership agreements, reporting, reimbursement requirements, among other helpful information.

Chris Lawrence, NRCS Cropland Agronomist, gave his presentation on **“Soil Health Assessment and Measurement.”** *(See the slides entitled “Chris’s pitch on SH Assessment and Measurement,” “Comprehensive Strategy to Increase Adoption of Soil Health Management Systems,” and “On-Farm Research...Nitrogen Fertilizer.”*

Chris began with one quote, “You can’t manage what you can’t measure.” Then, he countered this concept with a second quote, “It’s not about the numbers. It’s about the understanding.” This second idea seems to work better in evaluating soil health. We need to have some assessment, too, not just measurement.

Six years ago, in 2013, the Soil Health management program “Unlock the secrets of the soil” began. There are important principles for healthy soils:

- Keep the soil covered as much as possible.
- Disturb the soil as little as possible.
- Keep plants growing throughout the year to feed your soil.
- Diversify as much as possible using crop rotation can cover crops.

We are now ready to add another step to soil management.

Core resources to rely on:

- Building Soils for Better Crops
- The Nature and Properties of Soils
- Caring for the Soil as a Living System

We need to prioritize our efforts and attention. We must correlate what we get out of the lab with what we see in the field. Beware of the under-read and the over-read. Get current information. Keep it simple in soil health. We can get delayed by “paralysis by analysis.”

There are many things to measure. We can assess test results for chemical, physical and biological properties. But there are components within each of the three topics. We are to assess the indicators, and then summarize the indicators.

Soils have inherent and dynamic properties. Some things we cannot really do anything about. Some soils really cannot become another soil! In a soil, we can see some qualities, and some are more subtle. There are ephemeral, intermediate, and permanent properties. We should narrow our attention and focus on the intermediate.

What should we measure? Soil indicators from different online sources have various listings. One chart may have five indicators, and another may have as many as 78 indicators. There are several lists from NRCS. Cornell University has a list of twelve indicators (4 each of chemical, physical and biological properties) called the Comprehensive Assessment of Soil Health (CASH). (The Cornell assessment is good, but it is from the northeastern United States. We want our soil health to be the best in each field, here in Virginia.) There are many methods for assessing. There are too many options to even understand, much less implement. Some are evaluated in the lab, but often the overlooked qualities are observable in the field.

We must be selective and put nitrogen, namely potentially mineralizable nitrogen (PMN), and bioavailable nitrogen (BAN), at the top of our list. We have limited amount of time to improve soil health, and we need to focus on a few things at a time. Be selective and start with one criterion, the nitrogen. We can use the many lab assessments, but there are almost too many to deal with at a time. We need to keep this simple.

We have already been doing a lot to calculate soil health. But we can enhance our efforts by adding some points. Start by looking at the soil, count the earthworms, look for soil erosion, and reflect on crop yields. Then explore laboratory testing. Focus on the indicator, nitrogen, rather than the methods. See how soil health relates to an increase in soil BAN/PMN and how it correlates to what is going on the field.

It is very important to focus on bioavailable nitrogen, especially how it relates to crop yield. But more isn't always better; don't waste any. Too much nitrogen can adversely affect water quality. We need to be effective in our use of nitrogen.

Organic matter is living, dead and very dead. Mineral matter, organic matter, very dead—complex molecules that have been processed by biology on the soil that they cannot be broken down.

There is often no assessment of BAN/PMN in traditional soil tests. Most lab methods take too long and are too expensive. And, typically, degraded soils are very low in BAN/PMN. Nitrogen dynamics are complex. Therefore, there is just not a workable test for BAN. Our starting point for nitrogen recommendation is to make sure that you apply enough. We need a test for BAN, but there is no correlation from the lab to what is happening here in Virginia.

Alan Frans Huber from 2014 is taking soils from Virginia and putting on different rates of Nitrogen. When nitrogen goes up (1 lb. per bushel), we need less of it because there is more organic matter in the soil. Soil-tested biological activity (STBA) is independent of soil type. It is on the farms that we can see the improvements.

Improving soil health is done incrementally. We must be realistic as we address this. We need to keep it simple. Nitrogen is only one out of many indicators, but a very important one!

Mark Dubin, University of Maryland Extension, gave his presentation on the “**Chesapeake Bay Program’s Science Panel Report on Cropland Irrigation.**” (*See the slides entitled, “Cropland Irrigation Management as a Best Management Practice: Findings from a Scientific Review.”*)

Mr. Dubin has been with the Bay program since 2006 and has been working on many best management practices (BMP) during this time. He now is addressing research needs in Ag Extension. This current project, cropland irrigation in the mid-Atlantic region, does not apply to everyone. Just what does irrigation do? And, what does it not do?

Irrigation is adding water by artificial means. Water is one of the most important substances on earth. Irrigation water sources are either from surface water or groundwater. The main, broad categories of irrigation methods include surface/flood by gravity, sprinklers, trickle, and subsurface. However, not all methods, such as gravity, are used in the study area of the Chesapeake Bay and the Delmarva Peninsula.

Irrigation encompasses a third of all the water use across the nation. The six Bay states use only .3 of 1% of this water and make up .9 of 1% of total irrigated land. Irrigation is used on about 63,000 acres in Virginia. Virginia irrigates mostly berries, grain, corn, and silage. According to the 2012 agricultural census, one in five Delaware farms are using irrigation.

The Chesapeake program’s science panel studied if cropland irrigation management is an interim BMP. The panel consisted of people from the Delmarva area (from Virginia Department of Conservation and Recreation, USDA-Natural Resources Conservation Service, USDA-Agricultural Research Service, United States Geological Survey, and from several universities (U. of Delaware, U. of Maryland, and Virginia Tech.)

Different aspects were considered during this study:

- The type of crop grown on the field. A field is not just a bare field, but specifically what kind of crop will be grown on it.

- The variation of yields on irrigated fields vs. non-irrigated fields.
- Soil moisture management. Run-off will occur if the irrigation is in operation all the time.
- Water only vs. additives put in the water. The panel only looked at water only.
- Research papers. The panel examined research papers, including some from the western United States. Some of the research projects were still in progress, and the panel needed to wait until these projects were done.

There were a lot of weather changes during the study. There was a lot of rain during this time; in fact, the non-irrigated fields did better than irrigated!

The soils in question were coastal plains soils, rather than piedmont and highlands soils. Conclusions, of the panel. The study yielded the most information on growing corn (row crops).

The main focus was on nitrogen. Nitrogen deficiency did not find a positive value, but rather a neutral value. There were lots of variation. Looking at long-term with these systems, if we want to see a change in this, we need to see more research, but not from a water quality or engineering standpoint. It is creating a benefit. If there are high nitrates, it is being recycled back through the soil as a filtration system. Should we reduce nitrogen application? Or, should we pull nitrogen back to the surface with the Irrigation?

There needs to be more future research. The panel could not find a value and is in the process of final review.

Q. Chris- how is this connected to the funding process for research? A. linking funding sources, scientific research projects, hiring staff, peer review. Is engaged in research projects in Virginia. Virginia is more nutrient efficient than other parts of the country is! What is our ag production here in VA vs. the rest of the country?

Q. Use of cover crops as a best management practice. A. Some people that do practice irrigation don't use cover crops. There are many mitigating factors on whether or not to use a cover crop. Until we went through the process, we really did not know what the answer was. We still don't, but we are closer.

Julie Hawkins **concluded the meeting**, and Jack Bricker said a final closing.

What's New: Natural Resources Conservation Service (NRCS) and the 2018 Farm Bill



Virginia
State Technical Committee Meeting
November 14, 2019

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Conservation Overview

- No new NRCS programs were added, and none were eliminated. We will continue to offer the same types of assistance that producers have come to expect, and even improve upon them.
- The Conservation Title increases funding for EQIP, ACEP, and creates direct funding for RCPP.
- Robust support for CSP remains, despite a reduction of funding levels over a budgetary baseline, essentially replacing an acreage cap in favor of yearly funding authorizations.
- New Veteran Farmer definition now includes who “first obtained veteran status during the most recent 10-year period”.
- Maintains the ‘locally led’ process of prioritizing resource concerns.
- Prioritizes soil health, water quality and quantity, and enhancement of pollinator habitat across all programs.

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Environmental Quality Incentives Program

- Adds “expected” resource concerns related to operation changes as eligible resource concerns for financial assistance.
- Raises cap for organic producers to \$140,000 over six years.
- Requires advance payment notification to all historically underserved producers.
- Increased targeting of wildlife habitat funds to 10%
- Decreased targeting of livestock related fund to 50%

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Environmental Quality Incentives Program

- Increased incentives for practices that address local priority resource concerns.
- Progressive implementation of CNMPs.
- Creates new EQIP Incentives
- Continuation of Working Lands for Wildlife offering producers who voluntarily install conservation practices for candidate species up to 30 years of certainty for related to protections from incidental take under the Endangered Species Act

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Conservation Stewardship Program

- Increases payment rates for adoption of cover crop rotations and advanced grazing management activities.
- Authorizes contract extensions to facilitate renewal under new program authority.
- Transforms funding mechanism for program contracts, going from an acre-based program to a dollar-based program with an annual allocation.
- Provides specific support for organic and transitioning to organic production activities.
- Includes special grassland conservation initiative for certain producers who have maintained cropland base acres. Eligibility is determined by FSA. \$18/ac/year payments to address grassland resource concerns.

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Agricultural Conservation Easement Program

- Authorizes assistance to partners who pursue 'Buy-Protect-Sell' transactions - where the entity owns the eligible land subject to the ag land easement and then transitions it to a farmer within 3 years.
- Requires a conservation plan for highly erodible land that will be protected by an agricultural land easement.
- Increases flexibility for partners to meet cost-share matching requirements (now includes cash contribution, charitable donation, or other non-USDA federal source).
- Prioritizes water quality improvement on wetland reserve easements.
- Expands wetland types eligible for restoration and management under wetland reserve easements.

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Regional Conservation Partnership Program

- Simplifies funding authorities for program implementation.
- Authorizes Regional Conservation Partnership Program contracts rather than requiring enrollment through other program authorities – now a stand-alone program.
- Expands flexibility for alternative funding arrangements with partners from only 2 per year nationally to up to 15 per year.
- Expands availability of watershed program authorities to projects outside critical conservation areas.
- Eliminates the National funding pool.
- Noncompetitive process for renewing successful projects.

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Other Farm Bill Programs/Changes

Strengthens conservation assistance framework through support for—

- Conservation Innovation Grants – a new “farmer-centric” approach and introduction of “innovation trials” to include Soil Health trials.
- Technical Service Providers – definition clarified to include “commercial” entities and allows for a third-party (non-federal) certification of TSPs.
- Voluntary Public Access and Habitat Incentive Program (VPA-HIP) – increased funding and incentives for private landowners to allow public recreation on wetland reserve easements.
- Removal of hemp from the controlled substances list
changing how USDA works with hemp producers.

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Other Farm Bill Programs/Changes

- Addition of eligibility for operators on heirs property land to obtain a farm number and be eligible for FSA/NRCS/RMA programs.
- Incorporation of “urban farms” (rooftop farms, indoor farms and other urban farms)
- Feral swine eradication and control pilot program – joint effort between NRCS and APHIS
- Source Water Protection – requires 10% of total funding to be used in priority SWP areas specifically targeting water quantity and quality practices.

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Conservation Stewardship Program

Interim Final Rule published on November 12th

- Provides the regulatory language by which NRCS will implement the statutory CSP provisions of the 2018 Farm Bill
- Policy under development
- Signups not authorized yet
- National training for programs staff December 9-13, 2019

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Excellent Changes to CSP

Statutory Changes:

- **Converts CSP to a funding-based program**
- **Defines a new term of conservation activities**
- **Expands the definition of stewardship threshold**
- **Simplifies ranking criteria**
- **Authorizes high payments for cover crop (125%)**
- **Authorizes higher payments for advanced grazing systems (150%)**
- **Authorizes a 1-time payment to participants to develop a comprehensive conservation plan**
- **\$200,000 payment limitation**

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Excellent Changes to CSP

Statutory Changes Continued:

- Requires a separate allocation to support organic production
- Establishes the new CSP Grassland Conservation Initiative to protect grassland resource concerns on base acres
- Requires CSP be streamlined and aligned with EQIP including applications, contracting, planning, practices, etc.
- Requires to the greatest extent practicable, the program should be managed to enhance soil health
- Requires renewals to be ranked

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Excellent Changes to CSP

Regulatory Changes:

- Adds definitions of advanced grazing management, comprehensive conservation plan and management-intensive grazing
- Expands Eligible land to include public land
- Clarifies some definitions
- Expands the potential scope of bundles
- Adds organic producers or producers transitioning to organic as a category for a targeted ranking pool
- Clarifies annual payment structure
- Allows for 12 months to commence first activity
- Allows for early start waivers

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Excellent Changes to CSP

Regulatory Changes continued:

- **Allows for contract increases due to minor adjustments**
- **Provides greater consideration to a participant's operational changes**
- **Renewal opportunity provided in first half of 5th year of a contract**
- **Eligibility restriction for renewal-eligible participants who choose not to renew in favor of competing for new**
- **Removed operator of record requirement**
- **Allows application determinations throughout the year**

Expected Policy changes

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CSP – EAP (the forgotten payment)

Conservation payments for CSP include an Existing Activity Payment (EAP) for every acre enrolled as well as additional payments for enhancements, bundles (multiple enhancements) and practices.

The EAP payment is calculated for each land use using the following formula:

- **(AxB) + (CxD)** Where—
- A = the number of resource concerns met at the time of application
- B = a standard rate that is the same for all resource concerns
- C = the acres in the land use
- D = a standard rate that is determined for each land use (\$7.50 per cropland acre, \$3.00 per pasture acre, \$0.50 per forest/associated agricultural land acre)

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Myth Busters & Communications Strategy

Scenario 1																			
cow/calf operation with 300 acres and 6 paddocks at 50 acres each;																			
participant already has all infrastructure, exclusion, prescribed grazing plan paid through EQIP																			
applicant wants Endophyte-infected fescue conversion to cool season grass and legume mixture on one 50 acre paddock																			
Option	Activity	payment rate	acres	years	Total payment														
EQIP	512	\$ 303.82	50	1	\$ 15,191.00														
				TOTAL	\$ 15,191.00														
Participant meets 7 resource concerns of water quality, soil erosion, soil quality, degraded plant condition, insufficient water, excess water and inefficient energy use																			
Option	Activity	payment rate	acres	years	Total payment														
CSP	EAP	\$ 3,350.00	300	5	\$ 16,750.00														
	512	\$ 20.62	50	1	\$ 1,031.00														
	E528140Z1	\$ 3.28	300	5	\$ 4,920.00														
				TOTAL	\$ 22,701.00														
49% higher financial award under CSP than EQIP, even if you drop the 528 enhancement it's still 17% higher than EQIP																			

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Questions?



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United States Department of Agriculture

Regional Conservation Partnership Program (RCPP)

Julie Hawkins

State Technical Committee Meeting

November 14, 2019



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Background

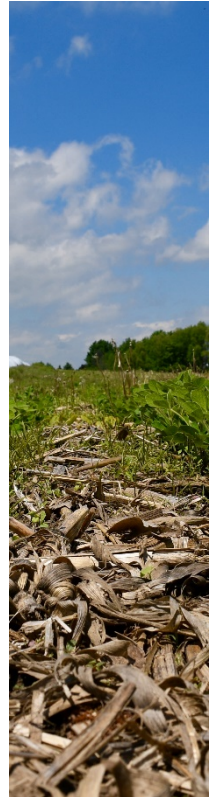


The Regional Conservation Partnership Program (RCPP) promotes coordination of NRCS conservation activities with partners that offer value-added contributions to expand our ability to address natural resource concerns.

Through RCPP, NRCS seeks to co-invest with partners to implement projects that demonstrate innovative solutions to conservation challenges.

The specifics of what I am sharing today is only applicable to funds made available with the FY19 APF.

The 2018 Farm Bill requires the development of a program regulation and program changes are expected as part of the rule making.



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RCPP Pillar Principles

- **Impact** - effective and compelling solutions that address one or more natural resource priorities
- **Partner Contributions** - combination of cash and in-kind value-added contributions to leverage NRCS's RCPP investments. Partner contributions at least equal the NRCS investment
- **Innovation** - integrate multiple conservation approaches or implement innovative conservation approaches or technologies
- **Partnership and Project Management** - experience, expertise, and capacity to manage the partnership and project, provide outreach to producers, and quantify the environmental (and when possible, economic and social) outcomes of an RCPP project



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2018 Farm Bill - Significant Changes

- **Standalone program with \$300 million annually**
- **RCPP contracts, RCPP easements and RCPP programmatic agreements**
- **Enhanced Alternative Funding Arrangement provision**
- **Three funding pools reduced to two**
- **Noncompetitive project renewals**
- **Emphasis on project outcomes**
- **Customer service provisions**



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2019 Funding Announcement



- **Consistent with the forthcoming Interim Final Rule**
- **Makes available \$300 million**
 - 50% dedicated to CCA projects and 50% to state/multistate projects
- **Maximum of \$10 million, minimum of \$250k (FA & TA)**
- **Application period is 90 days – Ends December 3**
- **No pre-proposal phase to application process**
- **Applications entered into the RCPP Portal**



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RCPP FY 19/20 Timeline



RCPP Action	Timeline
RCPP FY 2019 funding announcement released	September 3, 2019
RCPP renewals awards announced	By November 15, 2019
Application period closes	December 3, 2019
RCPP Interim Final Rule released	Late 2019/Early 2020
AFA funding announcement released	Soon after IFR release
RCPP award announcement	Week of March 9, 2020
FY 2019 RCPP partnership agreements (including renewals) executed	By mid-June 2020
Next funding announcement released	July 1, 2020
AFA awards announced	Summer 2020



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RCPP Funding Pools



1. Critical Conservation Areas (CCA) –

- A. Chesapeake Bay
 - Water Quality Degradation
 - Inadequate Habitat for Fish, Wildlife and Invertebrates
- B. Longleaf Pine Range (AL, FL, GA, LA, MS, NC, SC, TX, VA). CCA projects must take place wholly within a CCA.
 - Inadequate Habitat for Fish, Wildlife and Invertebrates
 - Degraded Plant Condition
 - Water Quality Degradation

2. State/Multistate – project must be carried out within either a single state or in multiple states. For multistate, priority is given to those projects with a reasonable and manageable number of states.



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Lead Partner Eligibility

The lead partner submits the application and negotiates and executes the RCPP partnership agreement with NRCS.

It is the lead partner that is responsible for ensuring completion of project deliverables.

Lead partners may be:

- Ag or Silviculture Producer Association
- State or Unit of Local Government
- Indian Tribe
- Farmer Cooperative
- Water, Irrigation or Rural Water District Association
- Municipal Water or Wastewater Treatment Entity
- Institution of Higher Education
- Conservation District
- An organization with a history of working with producers



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Contributing Partners



RCPP projects may also include direct or in-kind contributions from “contributing partners”

Non-lead eligible partners from the list may provide contributions

Third-party individuals or organizations (including non-USDA Federal agencies) that would not qualify as an eligible party can also provide contributions



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Producers/Landowners Eligibility

Ag producers and landowners receiving RCPP funding must be in compliance with Farm Bill eligibility including:

Highly Erodible Land (HEL)

Wetland Conservation Provisions (WC)

Adjusted Gross Income (can apply for a waiver)

RCPP projects must be carried out on ag or NIPF or associated land

NOTE: Any cost share provided to a producer/landowner CANNOT be counted as partner contribution (match)



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RCPP Conservation Activities



RCPP Activity Type	Associated Covered Program Authorities
Land improvement / management/ restoration	EQIP, CSP, ACEP-Wetland Reserve Easements (WRE) (restoration), HFRP (restoration), Public Law 83-566
Land rental	CRP
Easement (U.S.-held)	ACEP-WRE, HFRP (easement), Public Law 83-566 (floodplain easement); expanded to include land uses other than those traditionally eligible under the covered programs (e.g. grasslands, agricultural lands, riparian areas)
Easement (entity-held)	ACEP-ALE (currently); expanded to include easements on land uses other than those traditionally eligible under the covered programs (e.g., wetlands, floodplains, forest lands)
Public works/watersheds	Public Law 83-566



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RCPP Project Funding



RCPP Funding is in two categories with a 70/30 split:

- 1. Financial Assistance (FA) – at least 70% of RCPP funds requested must be FA and are held by NRCS for eligible producer contracts.**
- 2. Technical Assistance (TA) - up to 30% of RCPP funds requested must be TA and may be retained by NRCS or split between NRCS and the partner to support project implementation.**



*** Application budgets must be consistent with this split to be considered for funding.**

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RCPP Project Funding

Technical Assistance is broken into (3) categories:

- 1. Implementation TA (I) – planning, design, installation, checkout, easement due diligence (title reviews, valuation, survey reviews, closing services, monitoring)**
- 2. Enhancement TA (E) – outreach to producers/landowners, project management, environmental monitoring, communications activities, calculation of project outcomes)**
- 3. Potential Partner Contribution (C) – partner “match”**



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RCPP Project Funding



The 30% Technical Assistance is broken down as follows:

**1. Implementation TA = 23% (fixed percentage), of that:
5% = NRCS TA (fixed percentage and non-negotiable)**

**18% = Implementation TA to partner and/or NRCS
(fixed percentage and subject to post
selection negotiations)**

**2. Enhancement TA = 7% (maximum allowed and
negotiable).**

***If enhancement TA isn't requested by the partner, total TA maxes
out at 23%.**

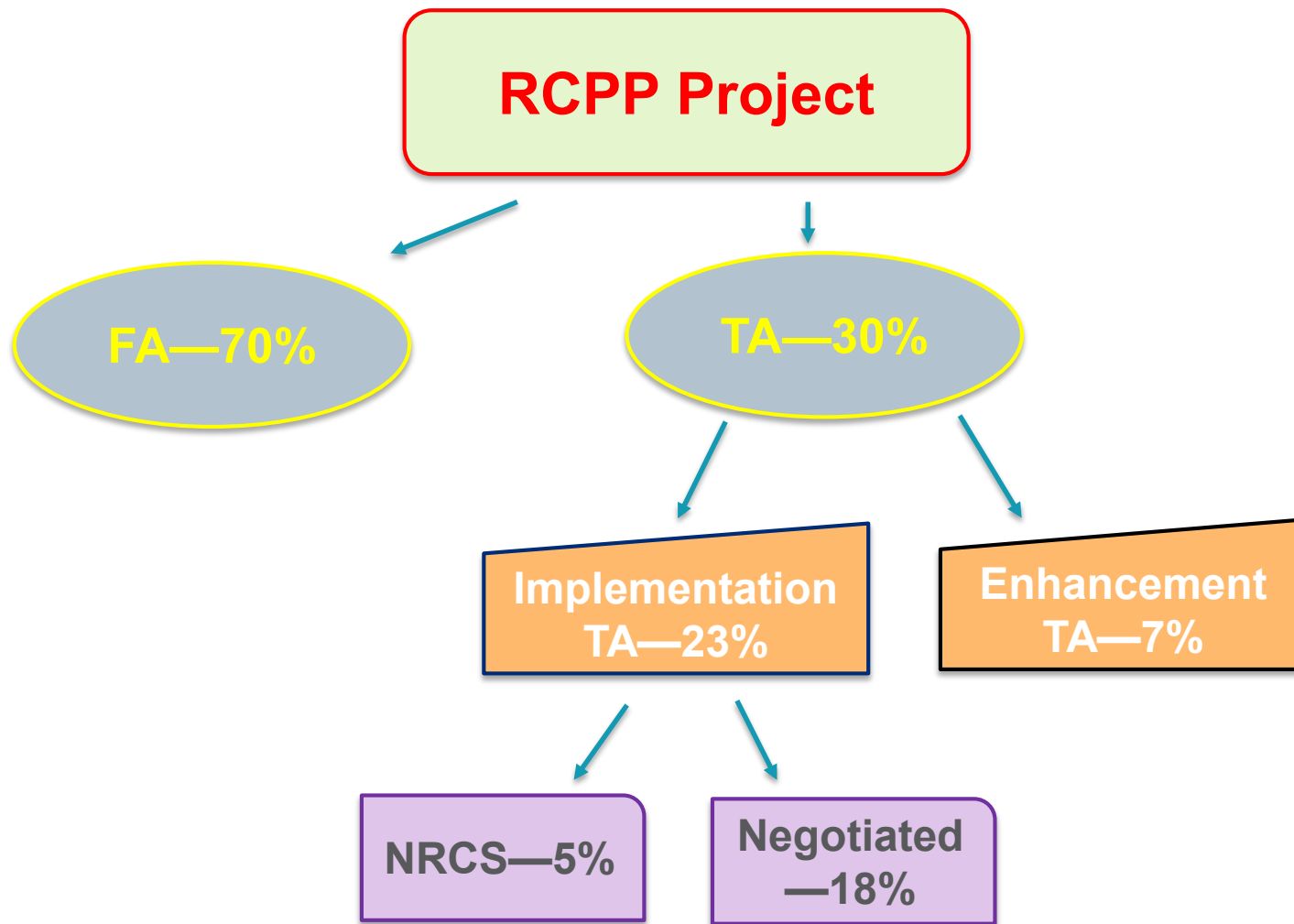


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RCPP Project Funding



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RCPP Project Funding

- **Proposal budgets must explicitly identify partner requests for implementation and enhancement TA.**
- **All TA awards are negotiated between the lead partner and NRCS**
- **Funding from non-USDA Federal agencies CAN be counted as partner contribution**
- **Outreach activities carried out by partners between the time of project selection and agreement execution CAN be counted toward partner contributions IF identified in the proposed budget**
- **Implementation TA and enhancement TA are reimbursable activities awarded through supplemental agreements following the execution of the partnership agreement.**



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RCPP Project Funding

- **Administrative Costs (overhead/indirect costs) are prohibited from being reimbursed**
 - Examples include: rent and utilities, durable equipment and software acquisitions, space used by staff, copiers, phones, IT support, etc.
- **Administrative Costs CAN be counted as partner contributions**
- **Organizations with an active NICRA must use the rate identified in that agreement in determining indirect costs to be included as contributions (upload with application)**
- **Entities without a NICRA may use a 10% indirect cost rate**



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Project Application Content

1. **Basic Project and Information**
2. **List of Project Partners**
3. **Project Questionnaire – in the RCPP Portal**
4. **Project Outcomes – guidance document on the RCPP website**
5. **Deliverables and Contributions – two tables in the Portal**
6. **Contribution Commitment Letters – letters are required from each NON-LEAD partner or other third-party providing contributions, including cash and in-kind services**
7. **Project Map**
8. **Dun and Bradstreet (DUNS) number**
9. **System for Award Management (SAM) number**



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Application Review Criteria

Ranking uses the 4 RCPP Pillar Principles:

Impact – 25%

Partner Contributions – 25%

Innovation – 20%

Partnerships and Management – 30%

- **All RCPP technical reviews occur at the State Level.**
- **NRCS STC will consult with the State Technical Committee, as necessary, on the RCPP review process.**
- **A NRCS leadership review board will evaluate the results of the state review and make recommendations for funding to the Chief.**



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RCPP Partnership Agreements

After a project application is selected to become an RCPP project, the lead STC will negotiate with the LEAD partner to define the final scope and partner responsibilities.

The RCPP partnership agreement serves as the agreement guiding the project. There is no funding obligated through the partnership agreement. It includes lead partner deliverables, timelines, and expectations for future RCPP awards.

RCPP applicants should anticipate a project start date of June 15, 2020.



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RCPP Partnership Agreements

After the partnership agreement is executed, future awards associated with the agreement may include RCPP producer contracts and supplemental agreements with eligible partners

- TA Agreements, Easement Agreements, Public Works/Watershed Agreements

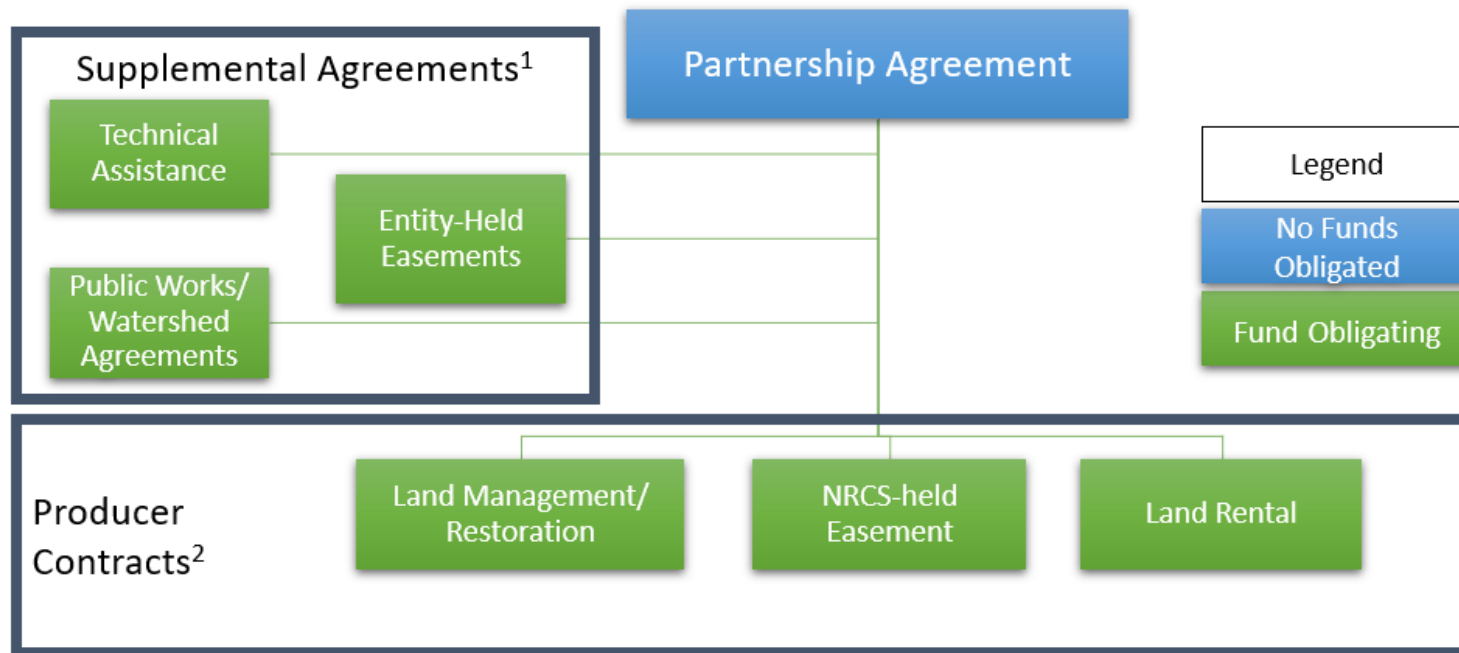
Supplemental agreements are not subject to lead partner negotiation and will be managed according to NRCS developed terms and conditions.



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RCPP Programmatic Agreement Structure



1 – Agreements with partners for public works/watershed activities, technical Assistance, and entity-held easement agreements.

2 – Contracts with a producer may contain one or more of the components listed in this section.

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Reporting and Reimbursement Requirements

- Lead partners are required to submit annual progress reports through the RCPP Portal
- Lead partners are required to submit a final project report and fact sheet that can be shared with the public
- RCPP partners that are recipients of a supplemental agreement are responsible for requesting reimbursement from NRCS
- Documentation required for reimbursements will be based on agreement deliverables and activities.
- Documentation of both reimbursable expenses and partner contribution expenditures are required to be maintained for 3 years beyond the expiration of a supplemental agreement.
- NRCS will conduct random audit samples of RCPP projects annually.



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Sample Activities for Potential Partner Contributions/TA

Potential Partner Contributions

- Develop and manage RCPP agreements with NRCS (C, E)
- Other RCPP project-related outreach and education, including inventories, analyses, and tools needed to inform outreach (C,E)
- Inventories and data to support environmental evaluations (C, I)
- Providing information or tools needed by NRCS to support Agency eligibility determinations, evaluation, and ranking (C, I)
- Develop and enter into financial assistance (FA) contracts or agreements to implement RCPP eligible activities with non-NRCS funds (C)
- TA to producers or landowners for planning directly related to installation or management of eligible conservation activities (C, I)

C= Contribution

I = Implementation TA

E = Enhancement TA



Sample Activities for Potential Partner Contributions/TA

Potential Partner Contributions

- Other non-inherently governmental FA contract support services (e.g., securing and managing contracts for third-party services like engineering studies, surveys, appraisals to satisfy NRCS requirements) (C, I)
- Project related communications and coordination activities (C, E)
- Environmental monitoring to support partner responsibility to track and report on project outcomes (C, I)
- Development and calculation of quantifiable project outcomes (C, E)
- Manage leveraging of other funds related to the RCPP project goals and objectives (C)
- Development of innovative conservation approaches (C, E)
- Project management and partnership development to accomplish project goals (C, E)
- Staff development/training/capacity building (C)
- Developing/maintaining connections to related conservation efforts (C)
- Any other project-related administrative (indirect) costs** (C)

C= Contribution

I = Implementation TA

E = Enhancement TA



Questions?



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“You can’t manage what you can’t measure.”

- Dr. Wayne Honeycutt, Soil Health Institute (SHI) President & CEO, 2018

“It’s not about the numbers. It’s about the understanding .”

- Bob Shindelbeck, Cornell Soil Health Lab Director & Extension Associate, 2018

Virginia NRCS State Technical Committee Meeting, Nov. 14, 2019

Soil Health Assessment & Measurement in Virginia: Options and Opportunities

Chris Lawrence, State Cropland Agronomist, Virginia

USDA-NRCS (Natural Resources Conservation Service)

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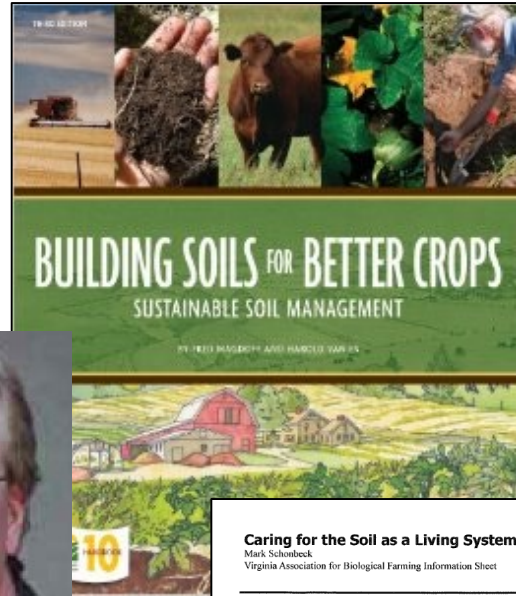


VA NRCS Soil Health Management Principles

- Keep Soil Covered
- **Minimize Disturbance**
 - Tillage
 - Compaction
 - Chemicals
- Maximize Living Roots
 - Amount present
 - Amount of time present
- **Energize with Diversity**
 - Of crops, of animals, of enterprises



Core Resources



Caring for the Soil as a Living System

Mark Schonbeck
Virginia Association for Biological Farming Information Sheet



Number 2-06 05/15/06

Soil provides the basis of all plant, animal and human life on land. It consists of mineral matter (clay, silt, sand, gravel, stones), air- and water-filled pore spaces, organic matter (dead roots and other plant and animal remains, plus humus), and a great diversity of living organisms. In organic and sustainable cropping systems, the soil life is the engine of soil fertility and crop production, as well as the guardian of long term soil health.

The Soil is a Living System

A living system consists of life forms, and the food, air, water, habitat and shelter they need to thrive, grow and reproduce. In the soil *organic matter* (replenished each season) becomes food; the soil's *structure* and network of *pore space* provide habitat, air and water; and *living vegetation* and *surface residues* offer shelter. Figure 1 shows approximate proportions of mineral

Contents:

The Soil is a Living System	p.1
Living plants are a vital part of the soil life	p.2
More on the Benefits of Soil Life	p.3
The Sustainable Approach: Feed the Soil	p.3
Soil "Metabolism" and Site-Specific Soil Care	p.5
Resources	p.6
Contact Information	p.6

matter, pore space and organic components in a good topsoil.

Sustainable growers tend the soil life as they would any other valuable farm livestock. Just as farmers make sure their cattle, sheep or poultry get regular food and water, and shelter from severe weather, they can keep the soil well-fed and protect it from erosion, compaction and temperature extremes.

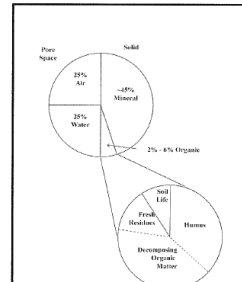


Figure 1. Approximate proportions of mineral matter, air and water-filled pore space, organic matter and living organisms in topsoil.

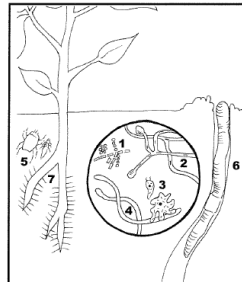
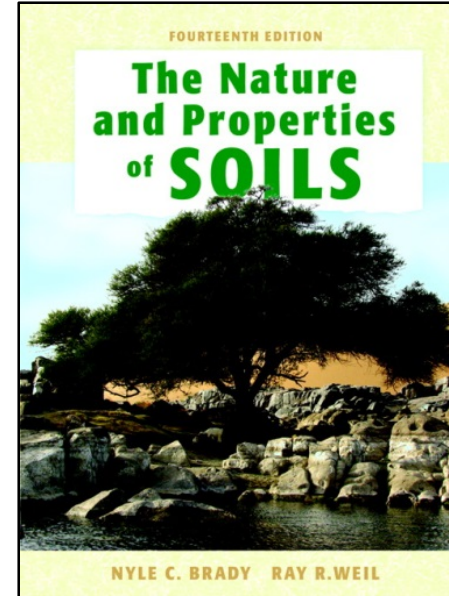


Figure 2. Main components of the soil life: (1) bacteria, (2) fungi, (3) protozoa, (4) nematodes, (5) mites, insects and other arthropods, (6) earthworms, and (7) plant roots.



***My pitch on
soil health
assessment &
measurement***



Chris' pitch on SH assessment & measurement

1. We can assess, promote, improve SH without quantitative measurement
 - Already doing it, need to continue!
2. But time is right to kick off greater emphasis on SH measurement in VA
3. The priority to focus on:
 - Being very selective/strategic about which SH indicators we measure!
4. The indicator to focus on:
 - Bioavailable or potentially mineralizable N (BAN or PMN)
5. The question to focus on:
 - How do SH-related increases in soil BAN/PMN correlate to less N fertilizer need in field?
6. Beware of under-read naysayers & the over-read obfuscators!
7. Next steps:
 - Communicate, debate, build consensus on VA SH assessment & measurement strategy
 - Fund and pursue that strategy with laser focus
 - Keep it simple and believe that we can make a difference!

Soil health:

***What
do we
assess or
measure?***



**Soil health =
capacity to
function**

**As with any
complex system
or organism with
many component
processes &
functions...**

**There is no single
test or measure
of overall health!**



Instead we assess performance of individual processes or functions.

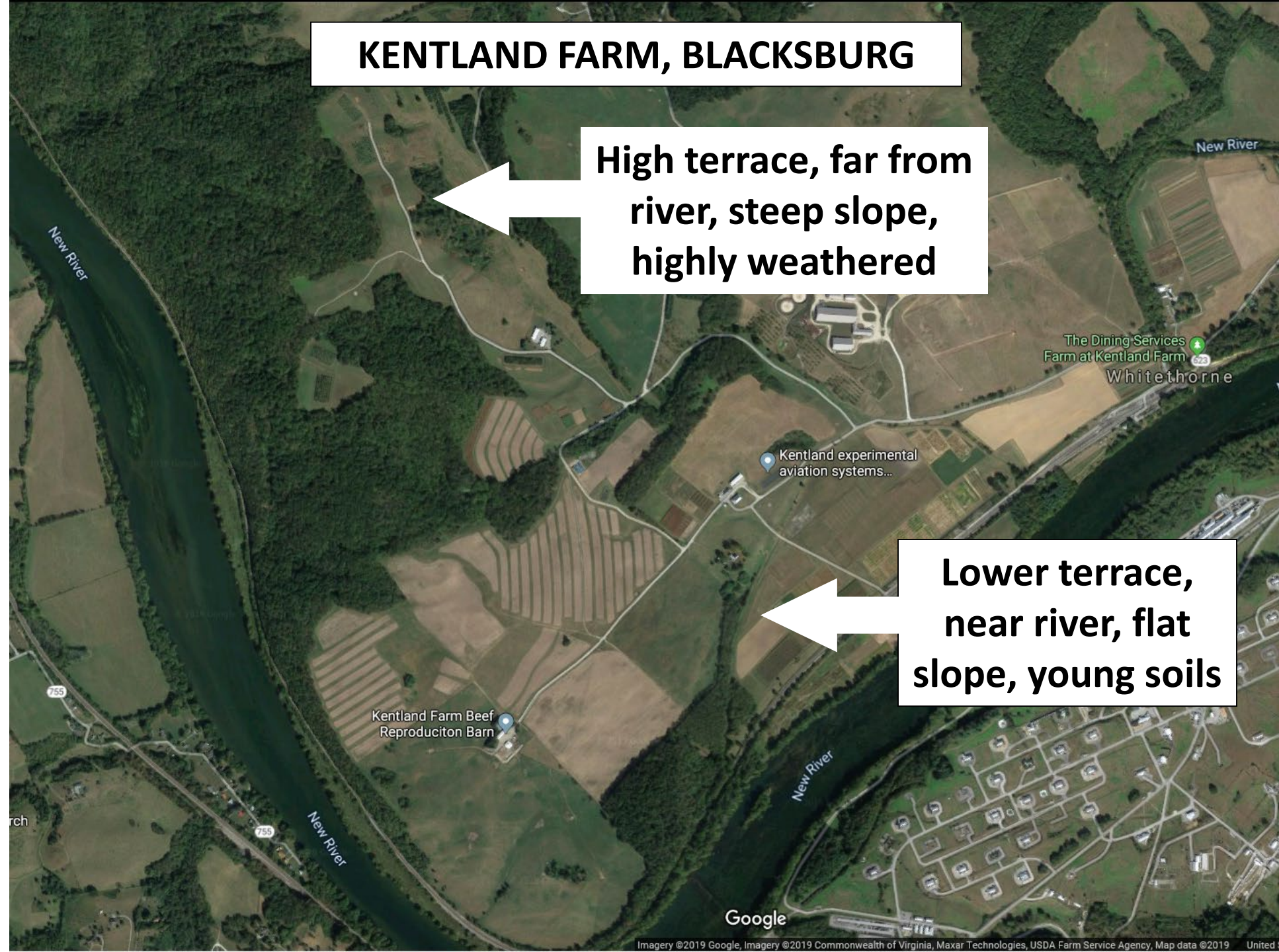
I.E. we assess INDICATORS of specific soil processes or properties.

The “sum” of assessments for multiple indicators can give us estimate of overall health of system



A soil's capacity to function is reflection of both inherent and dynamic soil properties.

Our focus is on dynamic properties that can potentially be affected by management.



KENTLAND FARM, BLACKSBURG

High terrace, far from river, steep slope, highly weathered

Lower terrace, near river, flat slope, young soils

A soil's capacity to function is reflection of both inherent and dynamic soil properties.

Our focus is on dynamic properties that can potentially be affected by management.

KENTLAND FARM, BLACKSBURG



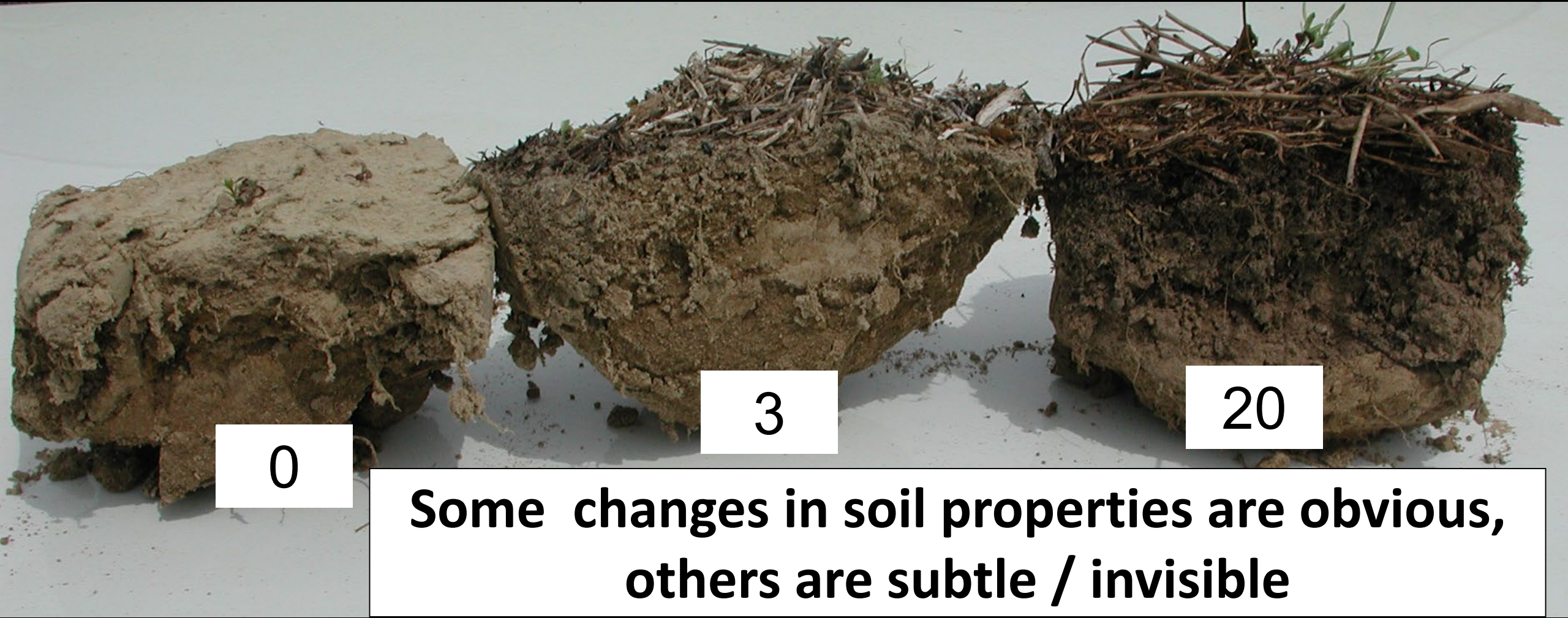
High terrace, far from river,
steep slope, highly weathered



Lower terrace, near river,
flat slope, young soils

Years in continuous no-till, Suffolk, VA

(same soil type & inherent properties)



**Some changes in soil properties are obvious,
others are subtle / invisible**

What indicators should we measure?

1994

Defining Soil Quality for a Sustainable Environment



SSSA Special Publication Number 35

1996

Methods for Assessing Soil Quality



SSSA Special Publication Number 49

Soil quality indicator properties in mid-Atlantic soils as influenced by conservation management

K.R. Islam and R.R. Weil

ABSTRACT: Soil quality or condition is best assessed by soil properties that are neither so permanent as to be insensitive to management, nor so easily changeable as to give little indication of long-term alterations. Thirteen such intermediate properties were evaluated for potential inclusion in a soil quality index by comparing soils under contrasting management systems from long-term replicated field experiments and from paired field sites. Conservation (*v.* conventional) management was defined as some combination of reduced tillage, increased crop diversity, more perennial crops, increased crop residue return, increased soil fertility and/or increased application of organic amendments. Conservation management most consistently and markedly influenced soil quality indicator properties by increasing total and active microbial biomass carbon (C_{TMB} and C_{AMB}), increasing the ratio of active microbial biomass carbon to total organic carbon (C_{AMB}/C_{ORG}), increasing aggregation and decreasing the rate of basal respiration per unit of microbial biomass carbon (qCO_2). The qCO_2 increased exponentially as C_{TMB} decreased. This may indicate reduced stress on soil microbial communities under conservation management and high microbial populations.

Key words: Aggregate stability, conservation management, ecosystem stress, enzyme activity, microbial biomass, soil organic matter, soil quality index, specific maintenance respiration, tillage-induced effects.

A widely-accepted definition of soil quality (SQ) (Karlen et al. 1997) is the capacity of a soil to function in an ecosystem to support plants and animals, resist erosion, and reduce negative impacts on associated air and water resources. As a complex functional state, SQ may not be directly measurable, but may be inferred from measurable soil properties termed SQ indicator properties (Acton and Padbury 1993). Initially, SQ evaluation focused primarily on soil chemical and physical properties because

The choice of indicator properties is likely to be related to the context in which the investigator views SQ. In making a regional or national resource inventory, investigators are likely to emphasize such inherent soil profile properties as depth to a root-restricting layer, texture of surface and subsurface horizons, steepness of slope, and soil water regime. For example, steep, shallow, loamy sands make a very different contribution to the resource base than do level, deep, silt loams. This focus on inherent profile properties

in the assessment of SQ underpins several models being developed by the National Resources Conservation Service, such as the Soil Rating for Plant Growth model (Sinclair et al. 1995) and the Soil Quality Index Determiner computer program (Norfleet et al. 1997), both of which attempt to calculate a SQ index based primarily on data available in the national soil survey data base. To use an analogy, this approach is like assessing the transportation quality of vehicles by differentiating pickup trucks, sedans, and motorcycles.

By contrast, a farmer attempting to optimize soil management on a given farm or field is likely to view SQ as the condition of an existing soil relative to the potential functional capacity of that soil. To continue the transportation analogy, this approach is like assessing the maintenance and performance levels of a particular model of pickup truck, rather than comparing it to a sedan or another truck model. This view of soil quality is essentially concerned with the health of the soil ecosystem.

Relatively immutable soil properties, such as slope and texture, are of little value in indicating the impact of management on SQ. On the other hand, such ephemeral soil properties as water content, temperature, surface soil pH, soluble nutrient levels, and field respiration rates are so easily altered by irrigation, weather, tillage, liming, and fertilization that they normally contribute little to an understanding of long-term management effects on SQ. Between these extremes of stability lie several key soil properties that are affected by management practices and may have a critical influence on how soil performs its ecosystem functions (Figure 1).

Ephemeral

**Changes within days or
routinely managed**

- water content
- field soil respiration
- pH
- mineral N
- available K
- available P
- bulk density

Intermediate

**Subject to management
over several years**

- **aggregation**
- **microbial biomass**
- **basal respiration**
- **specific respiration
quotient**
- **active C**
- **organic matter content**

Permanent

**Inherent to profile
or site**

- soil depth
- slope
- climate
- restrictive layers
- texture
- stoniness
- mineralogy

==> increasing permanence ==>

Figure 1. Classification of soil properties contributing to soil quality based on their permanence and sensitivity to management. Some soil properties are quite ephemeral and change readily from day to day as a result of routine management practices or weather. Others are permanent properties inherent to the soil profile or site and are little affected by management. A management-oriented soil quality assessment would focus on properties that are intermediate between these two extremes.

You are Here: [Home](#) / [Soil Health](#) / [Soil Health Assessment](#) / [Soil Quality Indicator Sheets](#)

- Soil Health**
- Soil Health - Home
 - Soil Biology
 - Soil Health Assessment
 - Soil Health Management
 - Resources & Publications

- Dig Deeper, Learn More**
- Soil Health Literature
 - Soil Quality Indicator Sheets
 - Soil Health for Educators
 - Soil Health Cards
 - Soil Quality Test Kit


Soil Health Literature
The Science Behind Healthy Soil


unlock the SECRETS

Soil Quality Indicator Sheets

A series of information sheets for physical, chemical, and biological soil quality indicators are available to help conservationists and soil scientists understand the relationship between soil function, factors affecting, relationship to soil function, methods for improvement, and measurement options are discussed for each topic. Review the How-to Guide to get started.

Note: Soil Quality Kit Guides that serve as soil property lesson plans for teachers and educators are available at [Soil Quality for Educators](#).

► [Soil Quality Indicator Sheets How-to Guide](#) (PDF, 416KB)

Physical Properties

- Physical Indicators – Overview (coming soon)
- [Aggregate Stability](#) (PDF, 380KB)
- [Available Water Capacity](#) (PDF, 210KB)
- [Bulk Density](#) (PDF, 340KB)
- [Infiltration](#) (PDF, 315KB)
- [Slaking](#) (PDF, 500KB)
- [Soil Crusts](#) (PDF, 250KB)
- [Soil Structure and Macropores](#) (PDF, 480KB)

Chemical Properties

- [Chemical Indicators – Overview](#) (PDF; 344KB)
- [Reactive Carbon](#) (PDF, 1.0MB)
- [Soil Electrical Conductivity](#) (PDF, 210KB)
- [Soil Nitrate](#) (PDF, 673KB)
- [Soil pH](#) (PDF, 265KB)

Biological Properties

- [Biological Indicators – Overview](#) (PDF; 375KB)
- [Earthworms](#) (PDF, 485KB)
- [Particulate Organic Matter](#) (PDF, 1.8MB)
- [Potentially Mineralizable Nitrogen](#) (PDF, 611KB)
- [Soil Enzymes](#) (PDF, 220KB)
- [Soil Respiration](#) (PDF, 329KB)
- [Total Organic Carbon](#) (PDF, 210KB)

17 Indicators - All direct observation in field or lab

Soil function – indicator matrix: when a direct relationship exists between the function and indicator, reliability and ease of use of the associated assessment method is shown with increasing stars.

Soil Quality Indicator	Soil Function				
	Sustain biological diversity, activity, and productivity "D"	Regulate and partition water and solute flow "W"	Filter, buffer, degrade, detoxify organic and inorganic materials "F"	Store and cycle nutrients and carbon "N"	Physical stability and support for plants and structures associated with human habitation "S"
Aggregate Stability ^{a,c,f}	★★	★★	—	★★	★★★
Available Water Capacity ^{a,g}	★★★	★★★	—	★★	—
Bulk Density ^{a,h}	★★★	★★★★	—	★	★★★★
Earthworms ^{b,d}	★★★★	—	★★★★	★★★★	★★★★
Infiltration ^{b,e,i}	—	★★	★	—	—
Particulate Organic Matter ^{a,c}	★★★★	★★★★	★★★★	★★★★	★★★★
Potentially Mineralizable Nitrogen ^{a,c}	★★★★	—	—	★★★★	—
Reactive Carbon ^a	★★	★	★★★★	★★	★★
Slaking ^{b,e,i,j}	★	★★★	—	—	—
Soil Crusts ^{b,d}	—	★★★	—	—	—
Soil Electrical Conductivity ^b	—	★★★★	—	—	—
Soil Enzymes ^a	★★★★	—	—	★★★★	—
Soil Nitrate ^b	★	★	—	—	—
Soil pH ^{b,d}	★★	★★★★	★★★★	★★★★	—
Soil Respiration ^{a,b,c}	★★★★	—	★	★★★★	★★
Soil Structure and Macropores ^{b,d}	★★	★★	★	★	★★
Total Organic Carbon ^a	★★★★	★★★★	★★★★	★★★★	★★★★

- ^a laboratory/office method
- ^b field method
- ^c time consuming
- ^d simple visual observation
- ^e variability requires large sample number
- ^f perhaps the most informative physical indicator
- ^g important for drought prone areas
- ^h important for weight to volume conversions, small sampling errors result in significant interpretation problems
- ⁱ effective educational method
- ^j qualitative

Published May 2019, Updated November 2019



Soil Health Technical Note No. 450-03

Recommended Soil Health Indicators and Associated Laboratory Procedures



7 Indicators - All direct observation in lab

Table 1. Recommended Indicators and Methods

Soil Process	Soil Health Indicators	Methods Considered	Notes
Organic Matter Cycling & C Sequestration	Soil organic C (SOC) content	Dry combustion	Soil Survey Sta. Involved in the SMAF.
		Wet oxidation	Recommended (2000) as presented in (2011). See appendix 4 & N-cycle. Being added to SMAF.
		Mass loss	Loss on ignition (LOI) Most commonly used but needs to be calibrated. Used by CASH.
Soil Structural Stability (Infiltration)	Aggregation	ARS wet macroaggregate stability (MAS)	Recommended Method. Rosenau (1986). Soil Nimmo and Perkins (2000). Mikha and Rice (2000). Used by SMAF.
		NRCS wet aggregation	Based on Kemper and method pre-wets the Staff 2014, pp. 213-214.
		Cornell sprinkle infiltrometer	Schindelbeck et al. (2016). Values from this method correlated with the wet aggregate stability.
General Microbial Activity	Short-term C mineralization (STCM; a.k.a. respiration)	Carbon dioxide (CO ₂) respired, 4-day incubation	Recommended Method. (2016), see appendix 4 . Incubation (CO ₂ measured conductivity, gas chromatography). Used by CASH.
		CO ₂ respired, 24-hr incubation	Like the previous method, incubation time, e.g., other 24-hr methods; variability amongst labs.
General Microbial Activity	Enzyme activity (EA)	β-Glucosidase (BG)	Recommended Method. Tabatabai (1988) as presented in Popova (2011). See appendix 4 .

Carbon Food Source

Readily available C pool	Permanganate oxidizable C (POXC)	Recommended Method. SOP from Schindelbeck et al. (2014), pp. 505-506. Being added to SMAF.
	Particulate organic matter	The fraction is determined by many methods. Being added to SMAF.
	28-day C mineralization	Too long for high-throughput labs. Being added to SMAF.
	Cold/hot water extractable organic C (WEOC)	Cold WEOC (H) WEOC (Ghani) snapshot of whole solution at time total pool.
	Soluble carbohydrates	An older method.

Technical Note No. 450-03, May 2019

Soil Process	Soil Health Indicators	Methods Considered	Notes
		Substrate-induced respiration	Research method; labor intensive.
		Microbial biomass C (fumigation-incubation) (MBC)	Research method; time and labor intensive. Used by SMAF.
Bioavailable Nitrogen	Available organic N pool	Extractable citrate soluble (ACE) protein content	Recommended Method. Schindelbeck et al. (2016). See appendix 6 . Modification, published by Hurisso et al. (2018), from Wright and Upadhyaya (1998).
		Cold water extractable organic N (WEON)	Used by the Soil Health Nutrient Tool (Haney et al. 2017). Not enough published data available currently.
		Correlation with short-term C mineralization	Picone et al. (2002). Has promise for soils of similar organic matter quality, but requires more evaluation with broader number of soils and management systems.
		7-day anaerobic potentially mineralizable N	Drinkwater et al. (1996). Too long for high-throughput labs.
		28-day aerobic PMN incubation	Used in the USDA/ARS Conservation Effects Assessment Projects (CEAP) soil health assessments (e.g., Stott et al. 2011). Too long for high-throughput labs. Used by SMAF.
		Illinois soil N test (ISNT)	Nitrogen available as amino-sugar (e.g., Sharifi et al. 2007). Measures a constant fraction of total soil N. Usually evaluated against yield rather than soil health.
		β-glucosaminidase activity (NAG)	See soil enzyme activity above.
		Protease	Must use fresh soil.
Microbial Diversity	Community structure	Phospholipid fatty acid (PLFA)	Recommended Method. PLFA (Buyer and Sasser 2012). See appendix 7 . PLFA is an older method. It is offered by some

Soil Process	Soil Health Indicators	Methods Considered	Notes
		Ester-linked fatty acid methyl ester profile (EL-FAME)	EL-FAME is a newer method and less expensive, and produces results consistent with the PLFA method. However, it is less responsive to soil properties such as SOC content.
		"Sampling for Life"	Recommended. If appropriate cryogenic storage is available, we recommend archiving samples until newer methods are available. If this method is chosen, soil should be sampled aseptically.

Cropland In-Field Soil Health Assessment Worksheet

So new it is not yet official!

Soil Health Resource Concerns

CPT: Compaction

SOM = Soil organic matter depletion

AGG = Aggregate instability

HAB = Soil organism habitat
degradation

Location
Field/CMU
Tract#
Client/Customer
Planner
Date
Soil Map Units
Soil Moisture
Topsoil Texture

Indicator	Meets Assessment Criteria (Y/N)
Timing: Anytime ☀️, After rain or irrigation ☔, With adequate moisture 🌱, Primarily for no-till systems 🚧, Before a tillage event 🚜, Interview 🗣️, Before growing season 🌱, During growing season 🌱	
Soil cover ☀️ SOM, HAB Meets: Surface cover from plants, residue or mulch; cover greater than 75%.	☐ Y ☐ N
Residue breakdown ☀️ 🗑️ 🗑️ SOM, HAB Meets: Natural decomposition of crop residues is as expected with crop and conditions.	☐ Y ☐ N
Surface crusts ☔ 🗑️ 🗑️ AGG Meets: Crusting on no more than 5% of the field.	☐ Y ☐ N
Ponding ☔ 🗑️ CPT, AGG Meets: No ponding within 24h following typical rainfall or surface irrigation event.	☐ Y ☐ N
Penetration resistance 🌱 🗑️ CPT Meets: • Penetrometer rating less than 150 psi within top 6" depth and < 300 in 6-18" depth; • OR Slight or no resistance with wire flag inserted to 12".	☐ Y ☐ N
Water stable aggregates ☀️ AGG, HAB Meets: • Cylinder: At least 80% remains intact after 5 minutes with little cloudy water • OR Strainer: soil remains intact with aggregates apparent • OR Soil Quality Test Kit (SQTk): meets stability class 6	☐ Y ☐ N
Soil structure ☀️ CPT, SOM, AGG, HAB Meets: Granular soil structure in A horizon and no platy structure in A or B horizons.	☐ Y ☐ N
Soil color 🌱 SOM Meets: No color difference between field and fencerow sample; OR, value is on the darker range using color chart and soil survey pedon description.	☐ Y ☐ N
Plant roots 🗑️ CPT, SOM, HAB Meets: Roots covered in a soil film (rhizosheaths) or are part of soil aggregates; OR living roots, if present, are healthy, fully branched and extend into subsoil.	☐ Y ☐ N
Biological diversity 🌱 🗑️ SOM, HAB Meets: Clearly evident; more than 3 different types of organisms observed without magnification.	☐ Y ☐ N
Biopores ☀️ 🗑️ SOM, AGG, HAB Meets: Presence of root or earthworm channels that extend vertically through the soil with some connecting to the surface.	☐ Y ☐ N

Cropland In-Field Soil Health Assessment Worksheet

Soil Health Resource Concerns

CPT: Compaction
SOM = Soil organic matter depletion
AGG = Aggregate instability
HAB = Soil organism habitat degradation

Location
Field/CMU
Tract#
Client/Customer
Planner
Date
Soil Map Units
Soil Moisture
Topsoil Texture

Indicator Timing: Anytime ☀️, After rain or irrigation 💧, W Before a tillage event 🚜, Interview 🗣️, Before g
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Biological diversity 🌱 🗣️ SOM, HAB Meets: Clearly evident; more than 3 different typ
Biopores ☀️ 🗑️ SOM, AGG, HAB Meets: Presence of root or earthworm channels the surface.

11 Indicators - Most direct observation in field...

So new it is not yet official!

Cropland In-Field Soil Health Assessment

Management History - Interview

The following questions are offered as examples to guide a consultant to thoroughly understand current conditions, the client's management history, and resource concerns. Answers to these and other similar questions will be used to assess soil health.

- What is the crop rotation?
- What are the types and frequency of ground disturbing operations?
- For how many months per year is the soil surface at least 75% covered with plants, residue or mulch?
- Are cover crops a consistent part of the cropping system?
- If yes, for how many years has the field been continually cover cropped?
- How are the cover crops terminated? If chemically, what herbicide is used?
- Does water pond or run off during or immediately after typical rainfall or irrigation events? Where in the field?
- Are there problems with crop emergence or early crop growth? Where in the field?
- Is water management a concern (i.e., field too wet or too dry at planting)?
- Other observations not captured in the assessment including plant condition, and recent weather and landscape characteristics that may affect assessment results.

But also some farmer observation / management analysis!

Comprehensive Assessment of Soil Health

The Cornell Framework

B.N. Moebius-Clune, D.J. Moebius-Clune, B.K. Gugino, O.J. Idowu, R.R. Schindelbeck, A.J. Ristow, H.M. van Es, J.E. Thies, H.A. Shayler, M.B. McBride, K.S.M. Kurtz, D.W. Wolfe, and G.S. Abawi

Third Edition



Cornell University

12 Indicators -
All direct
observation,
most in lab

PHYSICAL	<u>Available Water Capacity</u> : reflects the quantity of water that is available for plant use. It is the difference between water stored at field capacity and water stored at wilting point, measured using pressure chambers.
	<u>Surface Hardness</u> : is a measure of the maximum soil strength (psi), or compaction, determined using a field penetrometer.
	<u>Subsurface Hardness</u> : is a measure of the maximum resistance to penetration at 6 to 18 inch depths using a field penetrometer.
	<u>Aggregate Stability</u> : is a measure of how well soil aggregates resist breaking apart into smaller particles. It is measured using a standardized simulated rainfall event on a sieve containing soil aggregates between 0.25 and 2.0 mm. The fraction of soil that remains on the sieve determines the percent aggregate stability.
BIOLOGICAL	<u>Organic Matter</u> : is a measure of all carbonaceous material that is derived from living organisms. The percent OM is determined by the mass of oven dried soil lost on combustion in a 500°C furnace.
	<u>Soil Protein</u> : is a measure of the fraction of the soil organic matter which contains much of the organically bound N. Microbial activity can mineralize this N and make it available for plant uptake. This is measured by extraction with a citrate buffer under high temperature and pressure.
	<u>Soil Respiration</u> : is a measure of the metabolic activity of the soil microbial community. It is measured by re-wetting air dried soil, and capturing and quantifying carbon dioxide (CO ₂) produced.
	<u>Active Carbon</u> : is a measure of the small portion of the organic matter that can serve as an easily available food source for soil microbes, thus helping fuel and maintain a healthy soil food web. It is measured by quantifying potassium permanganate oxidation with a spectrophotometer.
	<u>Add-on Indicators:</u> <u>Root Pathogen Pressure Rating</u> : is a measure of the degree to which sensitive test-plant roots show symptoms of disease when grown in standardized conditions in assayed soil. Assessed by rating roots through visual inspection for disease symptoms.
CHEMICAL	<u>Potentially Mineralizable Nitrogen</u> : is a combined measure of soil biological activity and substrate available to mineralize nitrogen to make it available to the plant. It is measured as the change in mineralized plant-available nitrogen present after a seven day anaerobic incubation.
	<u>Soil Chemical Composition</u> : a standard soil test analysis package measures levels of pH and plant nutrients. Measured levels are interpreted in this assessment's framework of sufficiency and excess but no crop specific recommendations are provided.
	<u>Add-on Indicators:</u> <u>Salinity and Sodicity</u> : Salinity is a measure of the soluble salt concentration in soil, and is measured via electrical conductivity. Sodicity is a calculation of the sodium absorption ratio (SAR) and is measured using ICP spectrometry to determine Na ⁺ , Ca ²⁺ , Mg ²⁺ concentrations and using an equation to calculate the absorption ratio. <u>Heavy Metals</u> : is a measure of levels of metals of possible concern to human or plant health. They are measured by digesting the soil with concentrated acid at high temperature.

TABLE 2.02. Indicators of the Comprehensive Assessment of Soil Health and what they mean.

Framework that enables farmers, usually with assistance from Agricultural Service Providers, to develop a more direct interpretation of the assessment to guide farm-specific planning and implementation decisions for soil health management systems (Figure 3.02). The process is designed to alleviate field-specific constraints identified through the soil health assessment, and then maintain improved soil health.

The remainder of this section will focus on describing the framework for management planning and implementation, based on information gained from assessments of soil health. A discussion will follow with a summary of the general considerations for management options and opportunities.

A detailed case study¹ demonstrating the Soil Health Management Planning Process is available at the Cornell Soil and Crop Sciences website: scs.cornell.edu

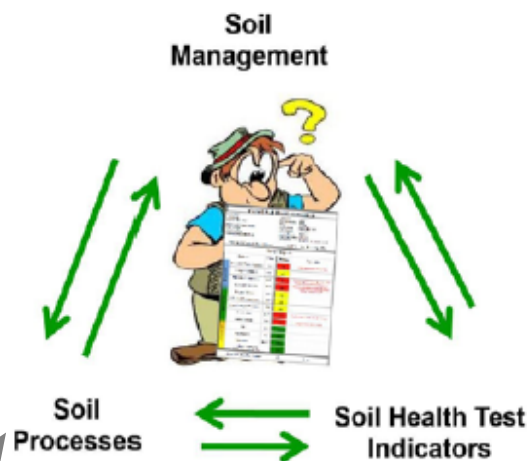


FIGURE 3.02. The soil health report, which identifies constraints and guides prioritization, is just one step in the soil health management planning process.

TABLE 3.01. The six steps of the Soil Health Management Planning Process.

SOIL HEALTH MANAGEMENT PLANNING PROCESS

- 1. Determine farm background and management history**
Compile background info: history by management unit, farm operation type, equipment, access to resources, situational opportunities or limitations.
- 2. Set goals and sample for soil health**
Determine goals and decide on the number and distribution of soil health samples, according to operation's background and objectives (pages 27 and 82).
- 3. For each management unit identify and explain constraints, prioritize**
The Soil Health Assessment Report identifies constraints and guides prioritization. Explain results based on background where feasible, and adjust priorities.
- 4. Identify feasible management options**
Identify which of the suggestions from Step 3 may be feasible for the operation. For guidance, use the management suggestions table available as part of the Soil Health Assessment Report, or online with [NIRCS practice linkages](#) (see page 84).
- 5. Create short and long term Soil Health Management Plan**
Integrate agronomic science of Steps 3 and 4 with grower realities and goals of Steps 1 and 2 to create a specific short-term schedule of management practices for each management unit and an overall long-term strategy (Appendix B).
- 6. Implement, monitor, and adapt**
Implement and document management practices. Monitor progress, repeat testing, and evaluate outcomes. Adapt the plan based on experience and data over time. Remember that soil health changes slowly.

But remember, CASH was intended to be much more than SH lab testing!

12 Indicators - All direct observation, most in lab

130-page manual lays out six-step process for comprehensive identification, assessment, explanation, and remediation of soil problems!

Also includes farmer observation / management analysis!

Root Pathogen Pressure Rating: is a measure of the degree to which sensitive test-plant roots show signs of disease when growing in standardized conditions in assayed soil. Assessed by rating

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... package measures levels of pH and plant nutrients. Measured levels are interpreted in this assessment's framework of sufficiency and excess but no crop specific recommendations are provided.

Chemical Add-on Indicators:

Salinity and Sodicty: Salinity is a measure of the soluble salt concentration in soil, and is measured via electrical conductivity. Sodicty is a calculation of the sodium absorption ratio (SAR) and is measured using ICP spectrometry to determine Na^+ , Ca^{2+} , Mg^{2+} concentrations and using an equation to calculate the absorption ratio.

Heavy Metals: is a measure of levels of metals of possible concern to human or plant health. They are measured by digesting the soil with concentrated acid at high temperature.

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Comprehensive Assessment of Soil Health

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Third Edition



Cornell University

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All direct
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TABLE 2.02. Indicators of the Comprehensive Assessment of Soil Health and what they mean.



Changing the Landscape
of Soil Health

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North American Project to Evaluate Soil Health Measurements

The Soil Health Institute announces methods for evaluating soil health indicators at a continental scale



Changing the Landscape
of Soil Health

GOALS

ACTION TEAMS

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SUPPORT SHI

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NEWS



North American Project to Evaluate

The Soil Health Institute announces m

TABLE 1. Tier 1 Soil Health Indicators and Methods to be Assessed (updated 10/8/2018)

Indicator	Method	Reference
Soil pH	1:2 soil:water, s	19 "Tier 1" Indicators...
Soil Electrical Conductivity (EC)	1:2 soil:water, s	
Cation Exchange Capacity (CEC)	Sum of Cations: For For	Knudsen, et al., 1982;
% Base Saturation (BS)	Ca For soil pH ≥ 7.2 : use ammonium acetate extractant; For soil pH < 7.2 : use Mehlich 3 extractant	Sikora and Moore, 2014
Extractable P	For soil pH ≥ 7.2 : use sodium bicarbonate extractant; For soil pH < 7.2 : use Mehlich 3 extractant	Olsen and Sommers, 1982; Sikora and Moore, 2014
Extractable K, Ca, Mg, Na	For soil pH ≥ 7.2 : use ammonium acetate extractant; For soil pH < 7.2 : use Mehlich 3 extractant	Knudsen, et al., 1982; Sikora and Moore, 2014
Extractable Fe, Zn, Cu, Mn	For soil pH ≥ 7.2 : use DTPA extractant derivatives; For soil pH < 7.2 : use Mehlich 3 extractant	Sikora and Moore, 2014; Lindsay and Norvell, 1978
Total Nitrogen	Dry combustion	Nelson and Sommers, 1996
Soil Organic Carbon (SOC)	Dry combustion, corrected for Inorganic C, if present, using pressure-calciometer	Nelson and Sommers, 1996; Sherrad, et al., 2002
Soil Texture	Except for 2 farmer observation / management analysis indicators!	
Aggregate Stability		
Available Water Holding Capacity		
Bulk Density (BD)	Core method: diameter to be determined, (most likely 2-inch or 5.08 cm)	Blake and Hartge, 1986
Erosion Rating	USDA model(s) (RUSLE2, WEPP, WEPS) appropriate for site	USDA Agricultural Research Service
Soil Penetration Resistance	Commercial soil penetrometer	Lowery and Morrison, 2002
Saturated Hydraulic Conductivity	SATURO dual head infiltrometer	Reynolds, et al., 2012
Crop Yield	Obtained from historical and current plot yield data provided by site manager	
Short-Term Carbon Mineralization	4-h incubation followed by CO ₂ -C evolution and capture at 100% RH in a sealed pore space.	Zibilske, 1994
Nitrogen Mineralization Rate	Short-term anaerobic incubation with ammonium and nitrate measured colorimetrically pre- and post-incubation	Bundy and Meisinger, 1994

plus some “Tier 3” Indicators?

12 “Tier 2” Indicators...

Changing the Landscape
of Soil Health

TABLE 2. Tier 2 Soil Health Indicators and Methods to be Assessed (updated 10/23/2018)

Indicator	Method	Reference
Sodium Adsorption Ratio (SAR)	Saturated paste extract followed by atomic absorption or inductively coupled plasma spectroscopy	M
Soil Stability Index	Combination of wet and dry sieving at multiple sieve sizes	F
Active Carbon	Permanganate oxidizable carbon (POXC). Digestion followed by colorimetric measurement	V
Soil Protein Index	Autoclaved Citrate Extractable	S
B-Glucosidase	Assay incubation followed by colorimetric measurement	T
B-Glucosaminidase	Assay incubation followed by colorimetric measurement	D
Phosphatase	Assay incubation followed by colorimetric measurement	A
Arylsulfatase	Assay incubation followed by colorimetric measurement	K
Phospholipid Fatty Acid (PLFA)	Bligh-Dyer extractant, solid phase extraction, transesterification; gas chromatography	B
Ester-Linked Fatty Acid Methyl Ester (EL-FAME)	Mild alkaline methanolysis extraction; gas chromatography	S
Genomics	16S rRNA, ITS, and shotgun metagenomics	T C
Reflectance	Diffuse reflectance spectroscopy	V

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Soil Organic Carbon (SOC)	Dry combustion, corrected for Inorganic C, if present, using pressure-calorimeter	Nelson and Sommers, 1996; Sherrill, et al., 2002
Soil Texture	Except for 2 farmer observation / management analysis indicators!	
Aggregate Stability		
Available Water Holding Capacity		
Bulk Density (BD)	Core method: diameter to be determined, (most likely 2-inch or 5.08 cm)	Blake and Hartge, 1986
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Soil Health Management
Resources & Publications

Dig Deeper, Learn More

- Soil Health Literature
- Soil Quality Indicator Sheets
- Soil Health for Educators
- Soil Health Cards
- Soil Quality Test Kit

Soil Quality Indicator Sheets

A series of information sheets for physical, chemical, and biological indicators that are available to help conservationists and soil scientists assess soil health. Factors affecting, relationship to soil function, methods for improvement, and measurement options are discussed for each topic. Review the How-to Guide to get started.

Note: Soil Quality Kit Guides that serve as soil property lesson plans for teachers and educators are available at [Soil Quality for Educators](#).

► [Soil Quality Indicator Sheets How-to Guide](#) (PDF, 416KB)

Physical Properties

- Physical Indicators - Overview (coming soon)
- Aggregate Stability (PDF, 380KB)
- Available Water Capacity (PDF, 210KB)
- Bulk Density (PDF, 340KB)
- Infiltration (PDF, 315KB)
- Slaking (PDF, 500KB)
- Soil Crusts (PDF, 250KB)
- Soil Structure and Macropores (PDF, 480KB)

Chemical Properties

- Chemical Indicators - Overview (PDF, 344KB)
- Reactive Carbon (PDF, 1.0MB)
- Soil Electrical Conductivity (PDF, 210KB)
- Soil Nitrate (PDF, 673KB)
- Soil pH (PDF, 265KB)

Biological Properties

- Biological Indicators - Overview (PDF, 375KB)
- Earthworms (PDF, 480KB)
- Particulate Organic Matter
- Potentially Mineralizable Nitrogen
- Soil Enzymes (PDF, 210KB)
- Soil Respiration (PDF, 210KB)
- Total Organic Carbon

Soil Health Literature

The Science Behind Healthy Soil

unlock the SECRETS

17 Indicators - All direct observation in field or lab

Soil function - indicator matrix: when a direct relationship exists between the function and indicator, reliability and ease of use of the associated assessment method is shown with increasing stars.

Soil Quality Indicator	Sustain biological diversity, activity, and productivity "D"	Regulate and partition water and solute flow "W"	Filter, buffer, degrade, detoxify organic and inorganic materials "F"	Store and cycle nutrients and carbon "N"	Physical stability and support for plants and structures associated with human habitation "S"
Aggregate Stability ^{a,c,f}	★★	★★	—	★★	★★★
Available Water Capacity ^{a,g}	★★★	★★★	—	★★	—
Bulk Density ^{a,h}	★★★	★★★	—	—	★★★
Earthworms ^{b,d}	★★★	—	★★★	★★★	★★★
Infiltration ^{b,e,i}	—	★★	—	—	—
Particulate Organic Matter ^{a,c}	★★★	—	—	—	—
Potentially Mineralizable Nitrogen ^{a,c}	★★★	—	—	—	—
Reactive Carbon ^a	★★	—	—	—	—
Slaking ^{b,e,i,j}	★★	—	—	—	—
Soil Crusts ^{b,d}	—	★★★	—	—	—
Soil Electrical Conductivity ^b	—	★★★	—	—	—
Soil Enzymes ^a	★★★	—	—	—	—
Soil Nitrate ^b	—	—	—	—	—
Soil pH ^{b,d}	★★	★★★	—	—	—
Soil Respiration ^{a,b,c}	★★★	—	—	—	—
Soil Structure and Macropores ^{b,d}	—	★★	—	—	—
Total Organic Carbon ^a	★★★	★★★	—	—	—

^a laboratory/office method
^b field method
^c variability requires large sample number
^d requires the most informative physical



Changing the Landscape of Soil Health

TABLE 2. Tier 2 Soil Health Indicators and Methods to be Assessed (updated 10/23/2018)

Indicator	Method
Sodium Adsorption Ratio (SAR)	Saturated paste extract followed by atomic absorption or induction

plus some "Tier 3" Indicators?

12 "Tier 2" Indicators...

USDA Natural Resources Conservation Service

Table 1. Recommended Indicators and Methods

Soil Process	Soil Health Indicators	Methods Considered
Organic Matter Cycling & C Sequestration	Soil organic C (SOC) content	Dry combustion
		Wet oxidation
		Mass loss

7 Indicators - All direct observation in lab

TABLE 1. Tier 1 Soil Health Indicators and Methods to be Assessed (updated 10/9/2018)

Indicator	Method	Reference
Soil pH	1:2 soil:water	
Soil Electrical Conductivity (EC)	1:2 soil:water	
Cation Exchange Capacity (CEC)	Sum of Cations: For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Knudsen et al., 1982;
% Base Saturation (BS)	Calculation: For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Sikora and Moore, 2014
Extractable P	For soil pH > 7.2: use sodium bicarbonate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Olsen and Sommers, 1982; Sikora and Moore, 2014
Extractable K, Ca, Mg, Na	For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Knudsen et al., 1982; Sikora and Moore, 2014
	For soil pH > 7.2: use DTPA extractant derivatives; For soil pH < 7.2: use Mehlich 3 extractant	Sikora and Moore, 2014; Lindsay and Norvell, 1978
	Calculation, corrected for inorganic C, if present, using presampler	Nelson and Sommers, 1996; Sherrod et al., 2002

19 "Tier 1" Indicators...

All direct observation in lab...

Except for 2 farmer interview / management analysis indicators!

Soil depth to be determined, (most likely 2-inch or 4-inch)	Blake and Hartge, 1986
Soil type (RUSLE2, WEPP, WEPS) appropriate for site	USDA Agricultural Research Service
Soil penetrometer	Lowery and Morrison, 2002
Soil head infiltrrometer	Reynolds et al., 2012
Soil moisture from historical and current plot yield data provided by farmer	
Soil moisture followed by CO ₂ -C evolution and capture at high temperature	Zibilske, 1994
Soil moisture incubation with ammonium and nitrate colorimetrically pre- and post-incubation	Bundy and Meisinger, 1994

12 Indicators - All direct observation, most in lab

Anyone overwhelmed yet?

- 5 lists – all published within past 4 years
- 78 SH indicators – Includes SHI Tier 2 and many repeats
- Did not attempt to count all methods for assessing those indicators

USDA Natural Resources Conservation Service

Cropland In-Field Soil Health

Soil Health Resource Concerns

CPT: Compaction
SOM = Soil organic matter depletion
AGG = Aggregate instability
HAB = Soil organism habitat degradation

Location

Field/CMU

Tract#

Client/Customer

Planner

Date

Soil Map Units

Soil Moisture

Topsoil Texture

Indicator Timing: Anytime Before a tillage

Soil cover Meets: Surface

Residue break Meets: Natural

Surface crusts Meets: Crusting

Ponding Meets: No ponding

Penetration resistance Meets: Penetrometer or OR Slight

Water stable aggregates Meets: Cylinder, OR Strainer, OR Soil Quality

Soil structure Meets: Granular

Soil color Meets: No color and soil survey

Plant roots Meets: Roots are healthy, fully branched

Biological diversity Meets: SOM, HAB

Biopores Meets: Presence of root or earthworm channels the surface

BIOL

Soil health is a measure of the degree to which sensitive test-plant roots show symptoms of disease when grown in standardized conditions in assays. Assessed by a visual inspection for disease symptoms.

Potentially Mineralizable Nitrogen is a combined measure of soil biological activity and substrate available to mineralize nitrogen to make it available to the plant. It is measured as the change in mineralized plant-available nitrogen present after a seven day anaerobic incubation.

Soil Chemical Composition is a standard soil test analysis package measures levels of pH and plant nutrients. Measured levels are interpreted in this assessment's framework of sufficiency and excess but no crop specific recommendations are provided.

Add-on Indicators:

Salinity and Sodicity Salinity is a measure of the soluble salt concentration in soil, and is measured via electrical conductivity. Sodicity is a calculation of the sodium adsorption ratio (SAR) and is measured using ICP spectrometry to determine Na⁺, Ca²⁺, Mg²⁺ concentrations and using an equation to calculate the absorption ratio.

Heavy Metals is a measure of levels of metals of possible concern to human or plant health. They are measured by digesting the soil with concentrated acid at high temperature.

TABLE 2.02. Indicators of the Comprehensive Assessment of Soil Health and what they mean.



Conclusions on “What do we measure?”

- Starting with “what should we measure?” is a trap
 - Too many options to even understand, much less implement
- Must be very selective about which SH indicators we measure
 - VA NRCS and partners are short on staff, time, expertise
 - To make an impact, must focus our efforts
 - Start with the end in mind...
- Ask “WHY are we measuring SH?”
 - Select one key assessment that clearly supports a priority need
 - Do it right - integrate into truly meaningful projects / activities

“But I thought the point of those two new NRCS Soil Health Division documents was to cut thru the confusion and give us a narrower, consistent list of SH indicators that everyone would use?”


United States
Department of
Agriculture

Cropland In-Field Soil Health Assessment Worksheet

Soil Health Resource Concerns

CPT: Compaction
SOM = Soil organic matter depletion
AGG = Aggregate instability
HAB = Soil organism habitat degradation

Location	
Field/CMU	
Tract#	
Client/Customer	
Planner	
Date	
Soil Map Units	
Soil Moisture	
Topsoil Texture	

Indicator	Meets Assessment Criteria (Y/N)
Timing: Anytime ☀️, After rain or irrigation ☔, With adequate moisture 🌱, Primarily for no-till systems 🌾, Before a tillage event 🌾, Interview 🗣️, Before growing season 🌱, During growing season 🌱	
Soil cover ☀️ SOM, HAB Meets: Surface cover from plants, residue or mulch; cover greater than 75%.	☐ Y ☐ N
Residue breakdown ☀️ 🌱 SOM, HAB Meets: Natural decomposition of crop residues is as expected with crop and conditions.	☐ Y ☐ N
Surface crusts ☔ 🌱 AGG Meets: Crusting on no more than 5% of the field.	☐ Y ☐ N
Ponding ☔ CPT, AGG Meets: No ponding within 24h following typical rainfall or surface irrigation event.	☐ Y ☐ N
Penetration resistance 🌱 ☔ CPT Meets: - Penetrometer rating less than 150 psi within top 6" depth and < 300 in 6-18" depth; - OR Slight or no resistance with wire flag inserted to 12".	☐ Y ☐ N
Water stable aggregates ☀️ AGG, HAB Meets: - Cylinder: At least 80% remains intact after 5 minutes with little cloudy water - OR Strainer: soil remains intact with aggregates apparent - OR Soil Quality Test Kit (SQTk): meets stability class 6	☐ Y ☐ N
Soil structure ☀️ CPT, SOM, AGG, HAB Meets: Granular soil structure in A horizon and no platy structure in A or B horizons.	☐ Y ☐ N
Soil color 🌱 SOM Meets: No color difference between field and fencerow sample; OR, value is on the darker range using color chart and soil survey pedon description.	☐ Y ☐ N
Plant roots 🌱 CPT, SOM, HAB Meets: Roots covered in a soil film (rhizosheaths) or are part of soil aggregates; OR living roots, if present, are healthy, fully branched and extend into subsoil.	☐ Y ☐ N
Biological diversity 🌱 🌱 SOM, HAB Meets: Clearly evident; more than 3 different types of organisms observed without magnification.	☐ Y ☐ N
Biopores ☀️ 🌱 SOM, AGG, HAB Meets: Presence of root or earthworm channels that extend vertically through the soil with some connecting to the surface.	☐ Y ☐ N

Natural Resources
Conservation Service


United States Department of Agriculture
Natural Resources Conservation Service

Published May 2019, Updated November 2019

Soil Health Technical Note No. 450-03

Recommended Soil Health Indicators and Associated Laboratory Procedures




“But I thought the point of those two new NRCS Soil Health Division documents was to cut thru the confusion and give us a narrower, consistent list of SH indicators that everyone would use?”

- Listed indicators and methods might be ok, but still too many.
 - We need to focus our efforts and select subset!
- Documents are new and untested in real world
 - No one should rush to judgment for or against!
- Document intros suggest their intended short-term, field-level utility is in fact more limited than one might initially assume...

Cropland In-Field Soil Health Assessment

Soil Health Resource Concerns

CPT: Compaction
 SOM = Soil organic matter depletion
 AGG = Aggregate instability
 HAB = Soil organism habitat
 degradation

Location
Field/CMU
Tract#
Client/Customer
Planner
Date
Soil Map Units
Soil Moisture
Topsoil Texture

Indi	Timi	Befo
Soil	Mea	
Resi	Mea	
Surf	Mea	
Pond	Mea	
Pene	Mea	
Wat	Mea	
Soil	Mea	
Soil	Mea	
Plan	Mea	
Blot	Mea	
Blot	Mea	

Considerations for using the assessment

The Cropland In-Field Soil Health Assessment is designed to be used as a diagnostic tool to help conservation planners determine if soil health resource concerns exist. It should not be used for comparing one field to another, or as a means of monitoring changes in a field over time, nor should it be assumed that it is a comprehensive assessment of all biological, physical, and chemical processes that are critical to soil function. Fields where multiple indicators do not meet assessment criteria will likely benefit from the implementation of a management system that utilizes as many soil health building practices as practical, to maximize biodiversity, presence of living roots and soil cover, and minimize disturbance (Factsheet: Principles for High Functioning Soils).

Normally, it will not be necessary to evaluate all eleven indicators but only those that will enable the planner to adequately assess field soil health and develop management alternatives if soil health resource concerns exist. Numerous variables will contribute to the indicators not being equally useful during any single field visit. It is anticipated that some indicators will be more interpretable and representative of soil health than others depending on the soil, landscape position, climate, weather, time of year, and cropping system. Different indicators will have different optimal sampling time or conditions and thus, sampling time and field conditions should be noted. The timing symbols associated with each indicator provide a quick reference for the recommended conditions and time for assessing that indicator.

It is recommended that Field Office staff work with State technical specialists responsible for soil health resource concerns related to conservation planning to determine which indicators are likely to provide useful resource concern assessment information for their climate, soils, and cropping systems. In addition, State and Area specialists may find it necessary to adjust the assessment criteria of the indicators that are used to insure they provide meaningful assessment information for local systems and conditions.



Published May 2019, Updated November 2019

Soil Health Technical Note No. 450-03

Limitations

This document covers a limited number of indicators and laboratory methods for assessing the functioning of soil processes that were recommended as current best available for the above goals from work by a group of over 100 scientists that collaborated to meet identified goals in USDA-led subcommittee activities and in multiorganizational workshops. Laboratory methods are not intended to be used by producers on an annual basis. Instead, these methods allow a producer to obtain baseline measurements that can inform management if combined with an available soil health assessment framework (that interprets measured values), and provide a mechanism for quantitative monitoring and evaluation that can be conducted every few years, based on regional systems and user needs. These methods and a national dataset that allows for development of their soil- and climate-based interpretation can also provide a standard starting point against which new or different methods can be compared and objectively evaluated.

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Soil Health Literature

The Science Behind Healthy Soil

17 Indicators - All direct observation in field or lab

Soil function - indicator matrix: when a direct relationship exists between the function and indicator, the reliability and ease of use of the associated assessment method is shown with increasing stars.

Soil Quality Indicator	Sustain biological diversity, activity, and productivity "D"	Regulate and partition water and solute flow "W"	Filter, buffer, degrade, detoxify organic and inorganic materials "F"	Store and cycle nutrients and carbon "N"	Physical stability and support for plants and structures associated with human habitation "S"
Aggregate Stability ^{a,c,f}	★★	★★	—	★★	★★★
Available Water Capacity ^{a,g}	★★★	★★★	—	★★	—
Bulk Density ^{a,h}	★★★	★★★	—	—	★★★
Earthworms ^{b,d}	★★★	—	★★★	★★★	★★★
Infiltration ^{b,e,i}	—	★★	—	—	—
Particulate Organic Matter ^{a,c}	★★	—	—	—	—
Potentially Mineralizable Nitrogen ^{a,c}	★★★	—	—	—	—
Reactive Carbon ^a	★★	—	—	—	—
Slaking ^{b,e,i,j}	★★	—	—	—	—
Soil Crusts ^{b,d}	—	★★★	—	—	—
Soil Electrical Conductivity ^b	—	★★★	—	—	—
Soil Enzymes ^a	★★★	—	—	—	—
Soil Nitrate ^{b,d}	—	—	—	—	—
Soil pH ^{b,d}	★★	★★★	—	—	—
Soil Respiration ^{a,b,c}	★★★	—	—	—	—
Soil Structure and Macropores ^{b,d}	★★	★★	—	—	—
Total Organic Carbon ^a	★★★	★★★	—	—	—

^a laboratory/office method
^b field method
^c time consuming
^d simple visual observation
^e variability requires large sample number
^f perhaps the most informative physical indicator
^g important for drought prone areas

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USDA Natural Resources Conservation Service

Table 1. Recommended Indicators and Methods

Soil Process	Soil Health Indicator	Methods Considered
Organic Matter Cycling & C Sequestration	Soil organic C (SOC) content	Dry combustion
	Soil organic N (SON) content	Dry combustion
	Soil organic P (SOP) content	Dry combustion
	Soil organic S (SOP) content	Dry combustion
	Soil organic N (SON) content	Dry combustion
	Soil organic P (SOP) content	Dry combustion
	Soil organic S (SOP) content	Dry combustion
	Soil organic N (SON) content	Dry combustion
	Soil organic P (SOP) content	Dry combustion
	Soil organic S (SOP) content	Dry combustion

7 Indicators - All direct observation in lab

Table 1. Tier 1 Soil Health Indicators and Methods to be Assessed (updated 10/9/2018)

Indicator	Method	Reference
Soil pH	1:2 soil:water, 25°C	Knudsen et al., 1982
Soil Electrical Conductivity (EC)	1:2 soil:water, 25°C	Knudsen et al., 1982
Cation Exchange Capacity (CEC)	Sum of Cations: For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Knudsen et al., 1982; Sikora and Moore, 2014
% Base Saturation (BS)	Calculation: For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Sikora and Moore, 2014
Extractable P	For soil pH > 7.2: use sodium bicarbonate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Olsen and Sommers, 1982; Sikora and Moore, 2014
Extractable K, Ca, Mg, Na	For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Knudsen et al., 1982; Sikora and Moore, 2014
Extractable Fe, Zn, Cu, Mn	For soil pH > 7.2: use DTPA extractant derivatives; For soil pH < 7.2: use Mehlich 3 extractant	Sikora and Moore, 2014; Lindsay and Norvell, 1978
Total Nitrogen	Dry combustion	Nelson and Sommers, 1996
Soil Organic Carbon (SOC)	Dry combustion, corrected for inorganic C, if present, using pressure-calculator	Nelson and Sommers, 1996; Sherrod, et al., 2002
Soil Texture	Pipette method	Blake and Hartge, 1986
Aggregate Stability	Wet sieving	USDA Agricultural Research Service
Available Water Holding Capacity	Core method: diameter to be determined, (most likely 2-inch or 5.08 cm)	Blake and Hartge, 1986
Bulk Density (BD)	Core method: diameter to be determined, (most likely 2-inch or 5.08 cm)	Blake and Hartge, 1986
Erosion Rating	USDA model(s) (RUSLE2, WEPP, WEPS) appropriate for site	USDA Agricultural Research Service
Soil Penetration Resistance	Commercial soil penetrometer	Lowery and Morrison, 2002
Saturated Hydraulic Conductivity	SATURO dual head infiltrometer	Reynolds, et al., 2012
Crop Yield	Obtained from historical and current plot yield data provided by site manager	
Short-Term Carbon Mineralization	4-day incubation followed by CO ₂ -C evolution and capture at 15°C in sealed pore space	Zibilske, 1994
Nitrogen Mineralization Rate	14-day incubation with ammonium and nitrate measured colorimetrically pre- and post-incubation	Bundy and Meisinger, 1994

19 "Tier 1" Indicators...

All direct observation in lab...

Except for 2 farmer interview / management analysis indicators!

SOIL HEALTH INSTITUTE

Changing the Landscape of Soil Health

Table 2. Tier 2 Soil Health Indicators and Methods to be Assessed (updated 10/23/2018)

Indicator	Method
Sodium Adsorption Ratio (SAR)	Saturated paste extract followed by atomic absorption or inductively coupled plasma spectroscopy
Soil Stability Index	Combination of wet and dry sieving at multiple sieve sizes
Active Carbon	Permanganate oxidizable carbon (POXC). Digestion followed by colorimetric measurement
Soil Protein Index	Autoclaved Citrate Extractable
B-Glucosidase	Assay incubation followed by colorimetric measurement
B-Glucosaminidase	Assay incubation followed by colorimetric measurement
Phosphatase	Assay incubation followed by colorimetric measurement
Arylsulfatase	Assay incubation followed by colorimetric measurement
Phospholipid Fatty Acid (PLFA)	Bligh-Dyer extractant, solid phase extraction, transesterification, gas chromatography
Ester-Linked Fatty Acid Methyl Ester (EL-FAME)	Mild alkaline methanolysis extraction; gas chromatography
Genomics	16S rRNA, ITS, and shotgun metagenomics
Reflectance	Diffuse reflectance spectroscopy

plus some "Tier 3" Indicators?

12 "Tier 2" Indicators...

11 Indicators - Most direct observation in field...

USDA Natural Resources Conservation Service

Cropland In-Field Soil Health Assessment Worksheet

Soil Health Resource Concerns

CPT: Compaction
SOM = Soil organic matter depletion
AGG = Aggregate instability
HAB = Soil organism habitat degradation

Location

Field/CMU

Tract#

Client/Customer

Planner

Date

Soil Map Units

Soil Moisture

Topsoil Texture

Indicator

Timing: Anytime ☀️, After rain or irrigation ☔, Before a tillage event 🌾, Interview 🗣️, Before a tillage event 🌾

Soil cover 🌿 SOM, HAB
Meets: Surface cover from plants, residue or mulch

Residue breakdown 🌿 SOM, HAB
Meets: Natural decomposition of crop residues

Surface crusts 🌿 AGG
Meets: Crusting on no more than 5% of the field

Ponding 🌧️ CPT, AGG
Meets: No ponding within 24h following typical rainfall

Penetration resistance 🌿 CPT
Meets: < 1.5 MPa

Water Meets: < 1.5 MPa

Plant Meets: < 1.5 MPa

Biopores 🌿 SOM, AGG, HAB
Meets: Presence of root or earthworm channels the surface.

Cropland In-Field Soil Health Assessment

Management History - Interview

The following questions are offered as examples to guide a conversation. The client's management history and resource concerns. Answers to these and other similar questions.

- What is the crop rotation?
- What are the types and frequency of ground disturbing operations?
- Does water pond or run off during or immediately after typical rainfall or irrigation?

But interview

12 Indicators - All direct observation, most in lab

What's my SH indicator to focus on?

Bioavailable or Potentially Mineralizable N

TABLE 2.02. Indicators of the Comprehensive Assessment of Soil Health and what they mean.

TABLE 2.02. Comprehensive Assessment of Soil Health - The Cornell Framework

measured by digesting the soil with concentrated acid at high temperature.

measured by the degree to which sensitive test-plant roots are able to grow in standardized conditions in assayed soil. Assessed by a bioassay using a sensitive test-plant root.

is a combined measure of soil biological activity and substrate availability to the plant. It is measured by the change in soil respiration after a seven day anaerobic incubation.

standard soil test analysis package measures levels of pH and plant nutrients in this assessment's framework of sufficiency and excess but are provided.

measure of the soluble salt concentration in soil, and is measured via calculation of the sodium adsorption ratio (SAR) and is measured using Na⁺, Ca²⁺, Mg²⁺ concentrations and using an equation to calculate SAR.

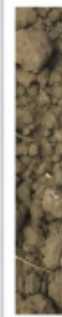
of metals of possible concern to human or plant health. They are measured by digesting the soil with concentrated acid at high temperature.



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Soil Health Technical Note

Recommended Soil Health Indicators and Associated Laboratory Procedures



Soil Process	Soil Health Indicators	Methods Considered	Notes
		Substrate-induced respiration	Research method; labor intensive.
		Microbial biomass C (fumigation-incubation, fumigation-extraction)	Research method; time and labor intensive. Used by SMAF.
	Bioavailable Nitrogen Available organic N pool	Autoclaved citrate extractable (ACE) protein content	Recommended Method. Schindelbeck et al. (2016). See appendix 6 . Modification, published by Hurisso et al. (2018), from Wright and Upadhyaya (1998).
		Cold water extractable organic N (WEON)	Used by the Soil Health Nutrient Tool (Haney et al. 2017). Not enough published data available currently.
		Correlation with short-term C mineralization	Picone et al. (2002). Has promise for soils of similar organic matter quality, but requires more evaluation with broader number of soils and management systems.
		7-day anaerobic potentially mineralizable N	Drinkwater et al. (1996). Too long for high-throughput labs.
		28-day aerobic PMN incubation	Used in the USDA/ARS Conservation Effects Assessment Projects (CEAP) soil health assessments (e.g., Stott et al. 2011). Too long for high-throughput labs. Used by

referred to as “glomalin” or “glomalin-like” substances (e.g., Balota et al. 2016, Lozano et al. 2016, Luna et al. 2016, Nogueira et al. 2016, Sandeep et al. 2016, Singh et al. 2016, Turgay et al. 2015). Although the early literature attributed the extracted proteins to the fungal taxonomic group *Glomales* (hence the name glomalin), there is clear evidence that the extracted proteins represent a wide range of organic sources, and that they reflect key soil ecosystem functions or processes likely including N supply (Rosier et al. 2006, Hurisso et al. 2018).

Correlation with CO₂ flush may be an alternative to measuring ACE proteins (Picone et al. 2002, Franzluebbers and Stuedemann 2015), but would be reflective of the microbial activity, not of the quantity and quality of the organic matter source (specifically its N-containing fraction). A combination of source and activity (ACE proteins and respiration) would conceptually lead to better information about N availability (Hurisso et al. 2018).

What's my SH question to focus on?

How do SH-related increases in soil BAN/PMN correlate to reduced N fertilizer need in field?

for a high throughput lab.

Soil health:

Why

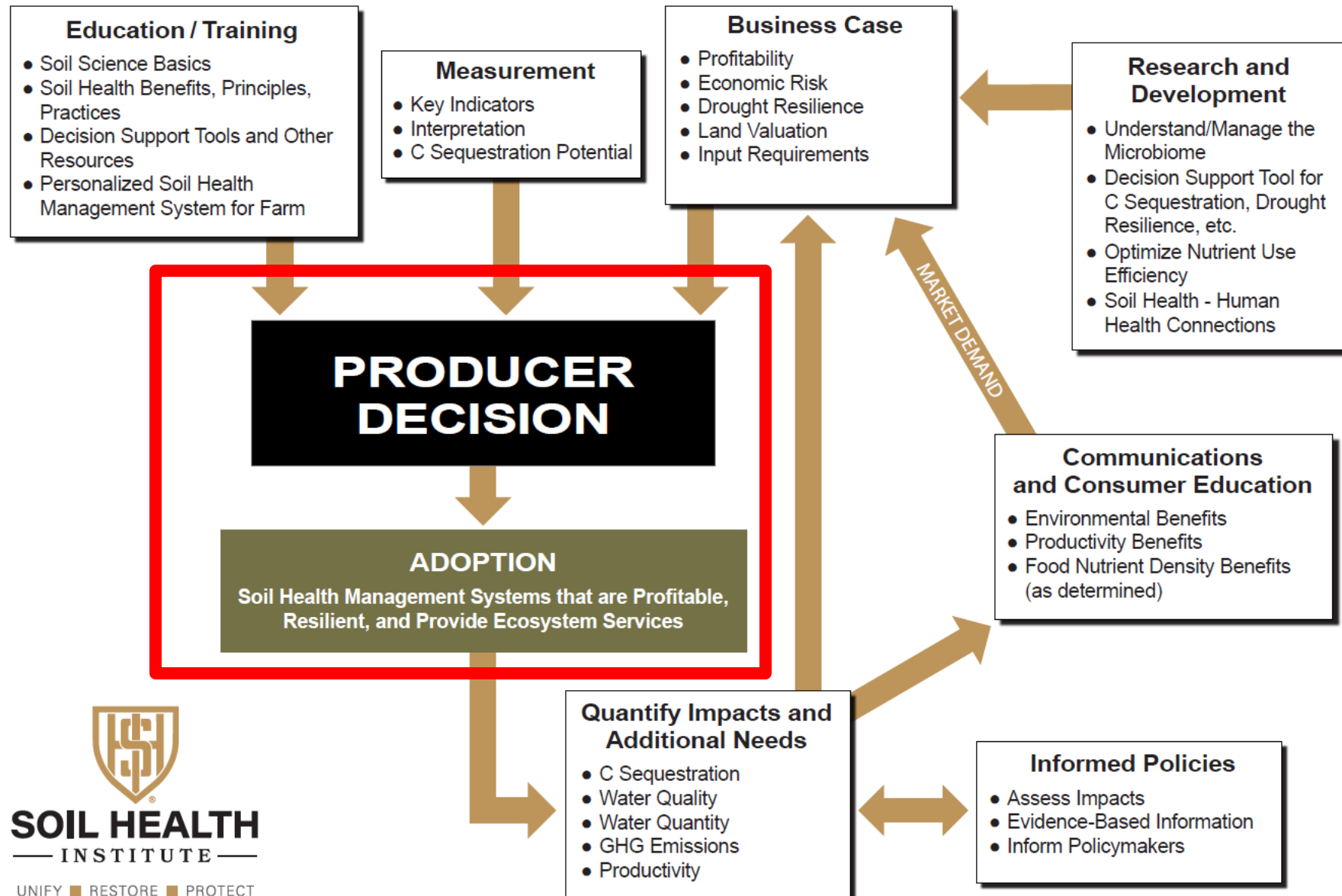
do we

assess or

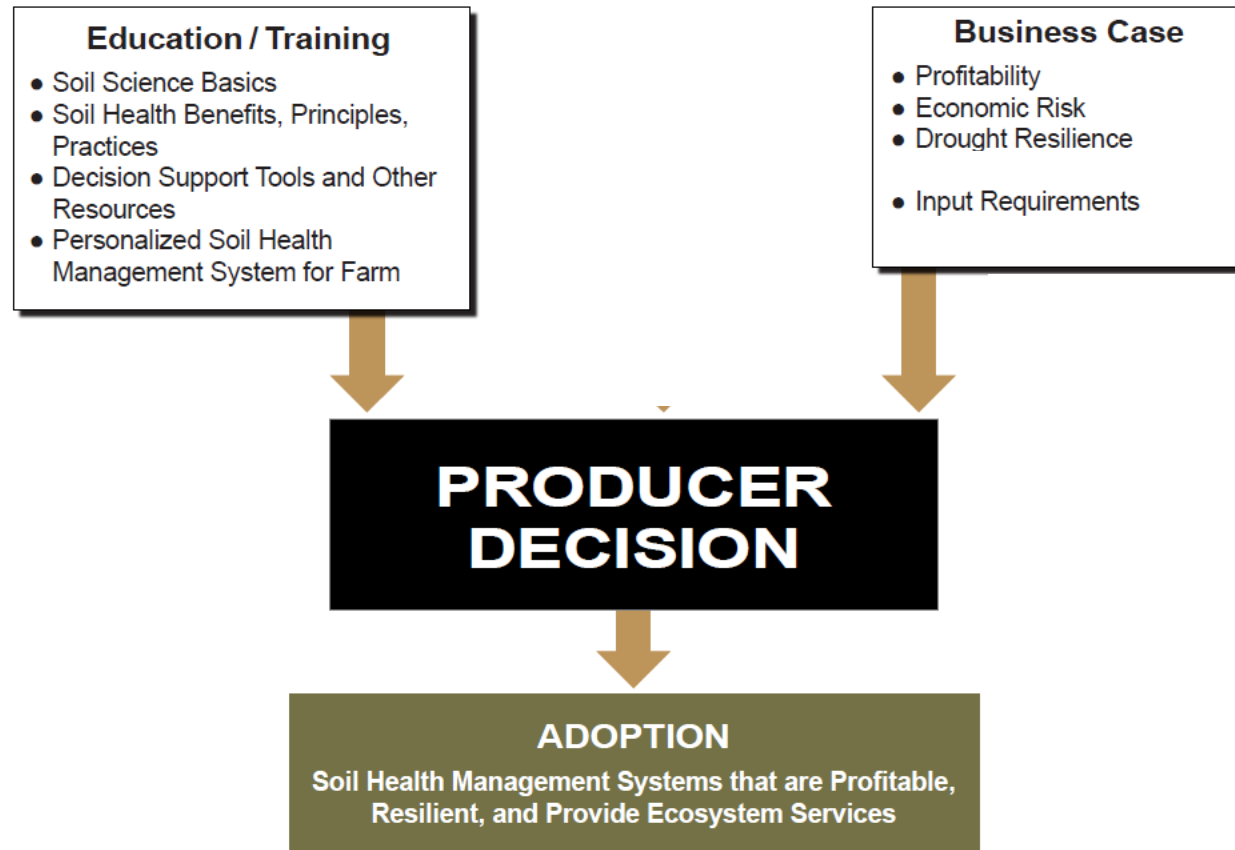
measure?



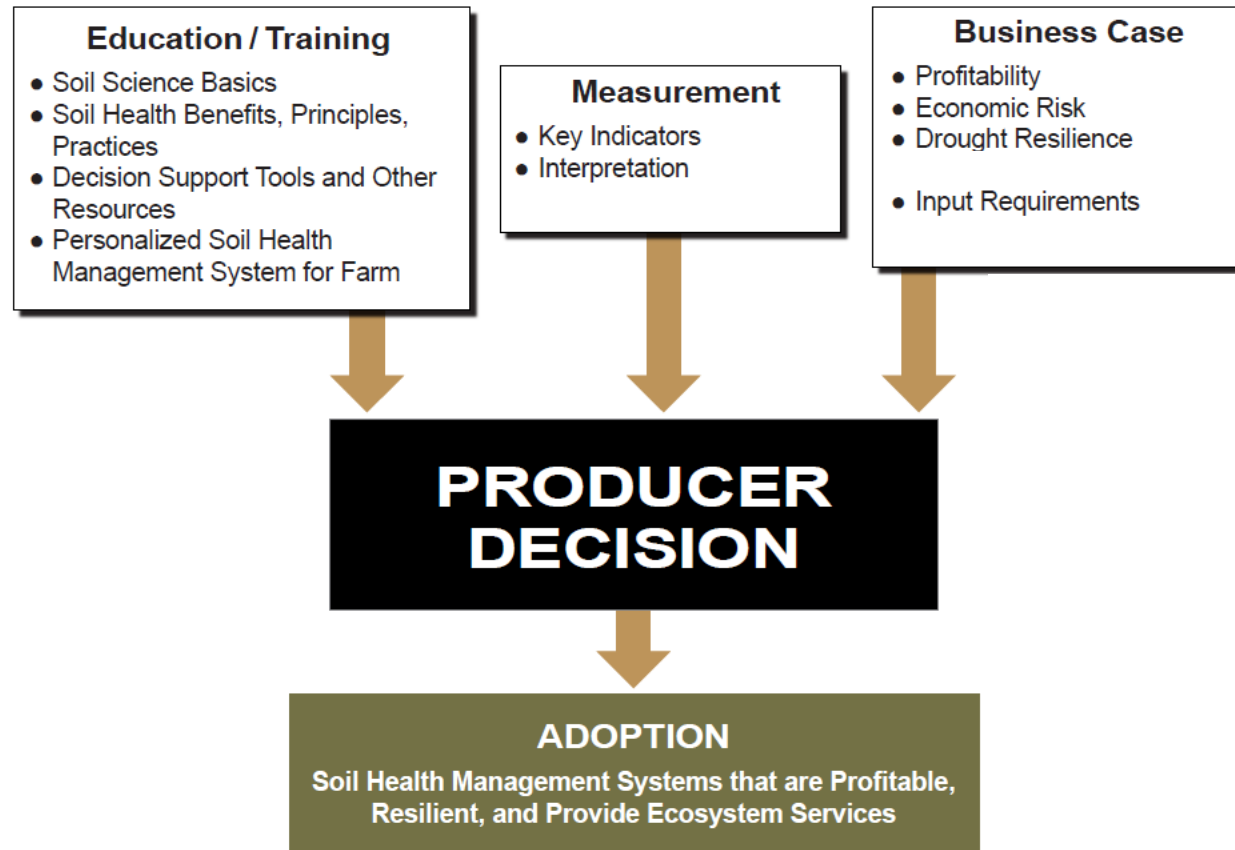
Comprehensive Strategy to Increase Adoption of Soil Health Management Systems



Comprehensive Strategy to Increase Adoption of Soil Health Management Systems



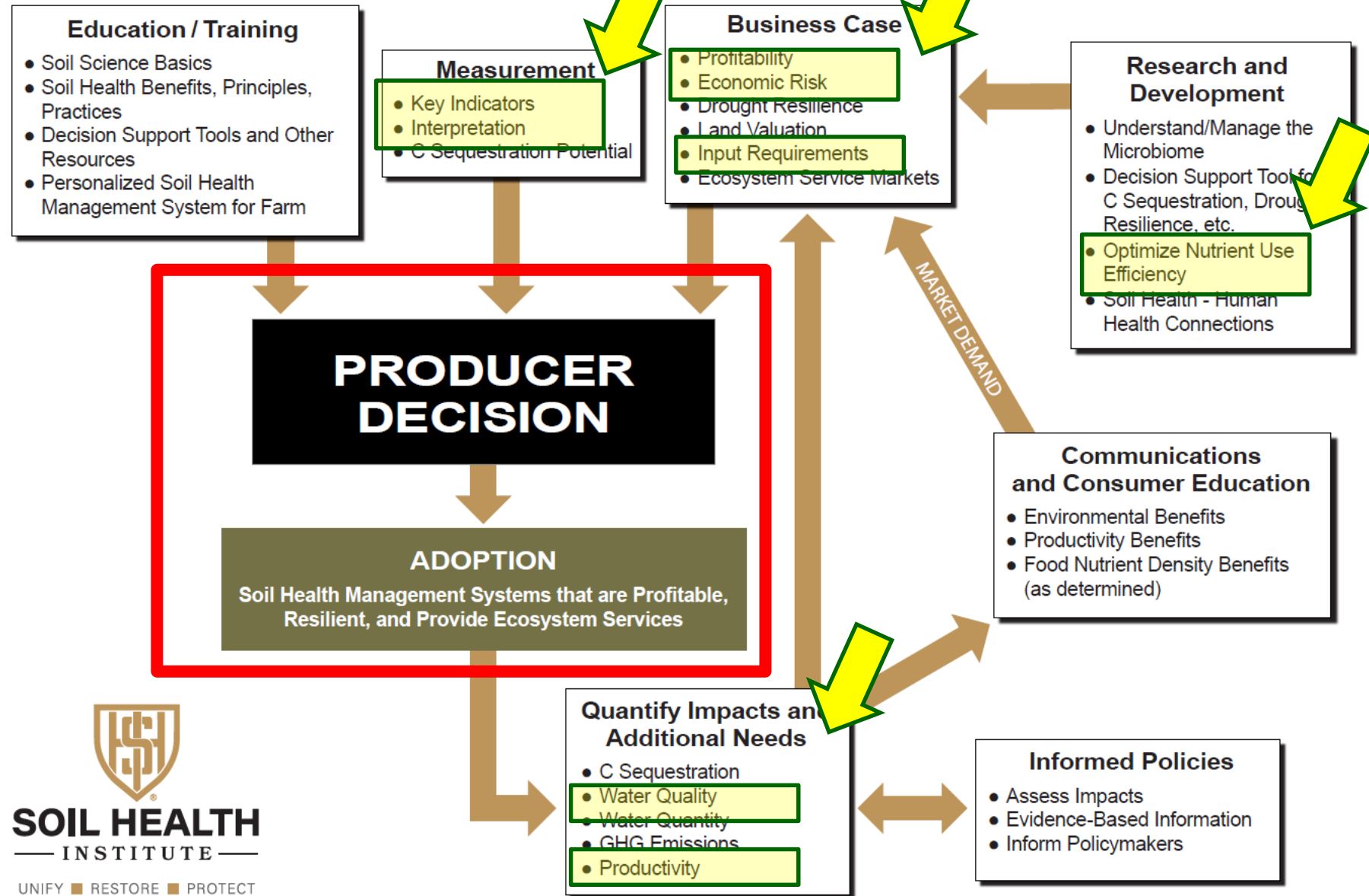
Comprehensive Strategy to Increase Adoption of Soil Health Management Systems



What's my SH
question to
focus on?

How do SH-
related
increases in
soil BAN/PMN
correlate to
reduced N
fertilizer need
in field?

Comprehensive Strategy to Increase Adoption of Soil Health Management Systems



Soil health:

How

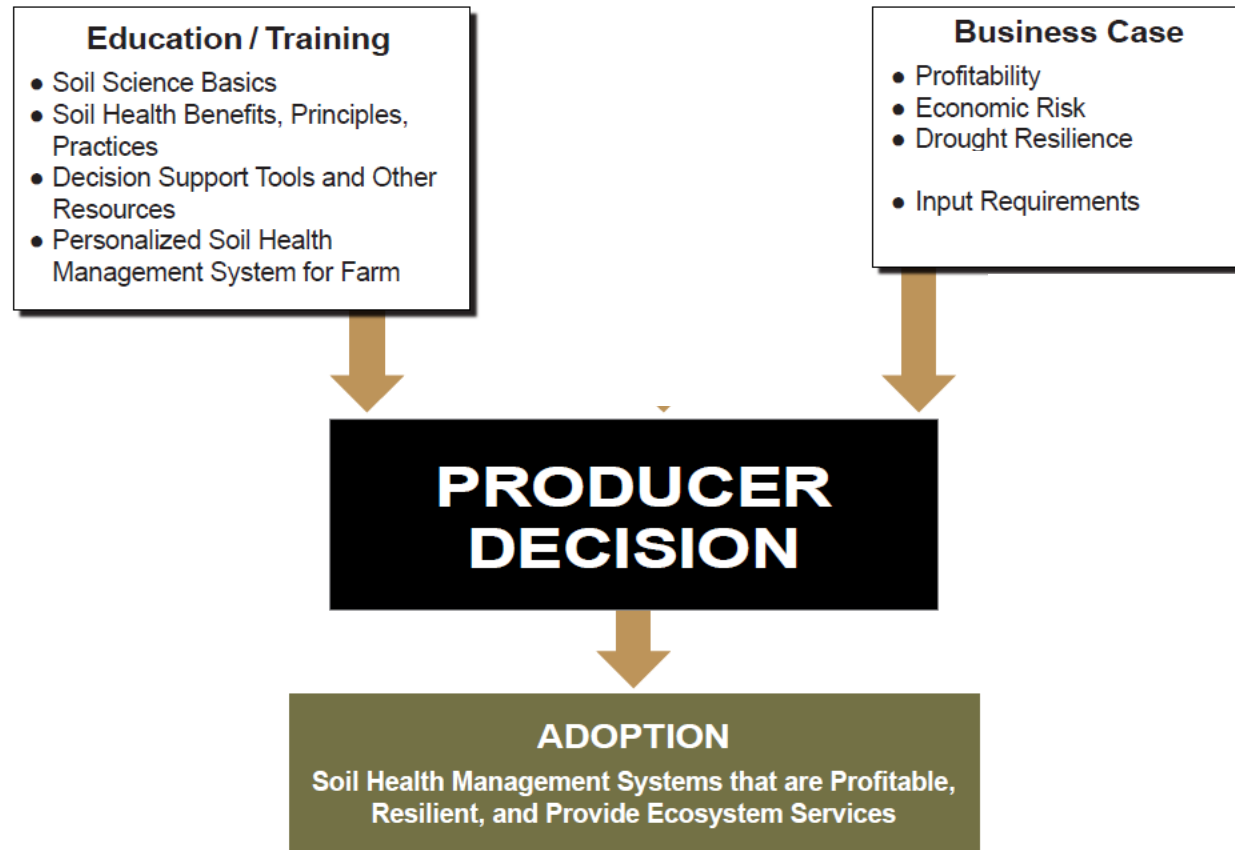
do we

assess or

measure?



Comprehensive Strategy to Increase Adoption of Soil Health Management Systems



Chris' 4 approaches to SH assessment

1. Farmer observation

- I.E.: Ask the patient – “How do things seem to be working?”
- E.G.: “I see more earthworms, less runoff, more drought tolerance.”
- Can assess both past and present performance for range of indicators

2. Management analysis

- I.E.: Ask the patient - “Tell me your daily routine, which will tell me about your health”
- E.G.: Models, from simple to highly complex
 - RUSLE2, Soil Conditioning Index (SCI), Soil Health Management System (SHMS), EPIC, etc.
 - AKA: “Decision Support Tools”
- Can assess past, present performance for range of indicators

3. Direct assessment – Qualitative / Semi-quantitative (usually field)

- I.E., Observe, touch, manipulate the patient
- E.G., Soil health field scorecard, comparative demonstrations (slaking, rain sim, etc.)
- Can only assess present condition

4. Direct assessment – Quantitative (usually lab)

- I.E., Measure patient, patient performance, or something extracted from patient
- E.G., Lab testing, rigorous field measurements (replicated & randomized), etc.
- Can only assess present condition

Chris' 4 approaches to SH assessment

1. Farmer observation

- I.E.: Ask the patient – “How do things seem to be working?”
- E.G.: “I see more earthworms, less runoff, more drought tolerance”
- Can assess both past and present performance for range of indicators

2. Management analysis

- I.E.: Ask the patient - “Tell me your daily routine, which v
- E.G.: Models, from simple to highly complex
 - RUSLE2, Soil Conditioning Index (SCI), Soil Health Management System (SHMS), EPIC, etc.
 - AKA: “Decision Support Tools”
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4. Direct assessment – Quantitative (usually lab)

- I.E., Measure patient, patient performance, or something extracted from patient
- E.G., Lab testing, rigorous field measurements (replicated & randomized), etc.
- Can only assess present condition

We are already doing these forms of SH assessment and will continue!

We can enhance our effort by adding some of this!

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The Science Behind Healthy Soil

17 Indicators - All direct observation in field or lab

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Aggregate Stability ^{a,c,f}	★★	★★	—	★★	★★★
Available Water Capacity ^{a,g}	★★★	★★★	—	★★	—
Bulk Density ^{a,h}	★★★	★★★	—	—	★★★
Earthworms ^{b,d}	★★★	—	★★★	★★★	★★★
Infiltration ^{b,e,i}	—	★★	—	—	—
Particulate Organic Matter ^{a,c}	★★	—	—	—	—
Potentially Mineralizable Nitrogen ^{a,c}	★★★	—	—	—	—
Reactive Carbon ^a	★★	—	—	—	—
Slaking ^{b,e,i,j}	—	—	—	—	—
Soil Crusts ^{b,d}	—	★★★	—	—	—
Soil Electrical Conductivity ^b	—	★★★	—	—	—
Soil Enzymes ^a	★★★	—	—	—	—
Soil Nitrate ^b	—	—	—	—	—
Soil pH ^{b,d}	★★	★★★	—	—	—
Soil Respiration ^{a,b,c}	★★★	—	—	—	—
Soil Structure and Macropores ^{b,d}	★★	★★	—	—	—
Total Organic Carbon ^a	★★★	★★★	—	—	—

^a laboratory/office method
^b field method
^c time consuming
^d simple visual observation
^e variability requires large sample number
^f perhaps the most informative physical indicator
^g important for drought prone areas

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USDA Natural Resources Conservation Service

United States Department of Agriculture

Table 1. Recommended Indicators and Methods

Soil Process	Soil Health Indicator	Methods Considered
Organic Matter Cycling & C Sequestration	Soil organic C (SOC) content	Dry combustion
		Wet oxidation
		Mass loss
		Loss on ignition (LOI)

7 Indicators - All direct observation in lab

Table 1. Tier 1 Soil Health Indicators and Methods to be Assessed (updated 10/9/2018)

Indicator	Method	Reference
Soil pH	1:2 soil:water	Knudsen et al., 1982
Soil Electrical Conductivity (EC)	1:2 soil:water	Knudsen et al., 1982
Cation Exchange Capacity (CEC)	Sum of Cations	Knudsen et al., 1982
% Base Saturation (BS)	Calculation	Sikora and Moore, 2014
Extractable P	For soil pH > 7.2: use sodium bicarbonate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Olsen and Sommers, 1982; Sikora and Moore, 2014
Extractable K, Ca, Mg, Na	For soil pH > 7.2: use ammonium acetate extractant; For soil pH < 7.2: use Mehlich 3 extractant	Knudsen et al., 1982; Sikora and Moore, 2014
Extractable Fe, Zn, Cu, Mn	For soil pH > 7.2: use DTPA extractant derivatives; For soil pH < 7.2: use Mehlich 3 extractant	Sikora and Moore, 2014; Lindsay and Norvell, 1978
Total Nitrogen	Dry combustion	Nelson and Sommers, 1996
Soil Organic Carbon (SOC)	Dry combustion, corrected for inorganic C, if present, using pressure-calimeter	Nelson and Sommers, 1996; Sherrod, et al., 2002
Soil Texture	Pipette method	Blake and Hartge, 1986
Aggregate Stability	Wet	USDA Agricultural Research Service
Available Water Holding Capacity	Core method: diameter to be determined, (most likely 2-inch or 5.08 cm)	Blake and Hartge, 1986
Bulk Density (BD)	Core method: diameter to be determined, (most likely 2-inch or 5.08 cm)	Blake and Hartge, 1986
Erosion Rating	USDA model(s) (RUSLE2, WEPP, WEPS) appropriate for site	USDA Agricultural Research Service
Soil Penetration Resistance	Commercial soil penetrometer	Lowery and Morrison, 2002
Saturated Hydraulic Conductivity	SATURO dual head infiltrometer	Reynolds, et al., 2012
Crop Yield	Obtained from historical and current plot yield data provided by site manager	USDA Agricultural Research Service
Short-Term Carbon Mineralization	4-day incubation followed by CO ₂ -C evolution and capture at filled pore space	Zibilske, 1994
Nitrogen Mineralization Rate	14-day incubation with ammonium and nitrate measured colorimetrically pre- and post-incubation	Bundy and Meisinger, 1994

19 "Tier 1" Indicators... All direct observation in lab... Except for 2 farmer interview / management analysis indicators!

USDA Natural Resources Conservation Service

United States Department of Agriculture

Cropland In-Field Soil Health Assessment Worksheet

Soil Health Resource Concerns

CPT: Compaction
SOM = Soil organic matter depletion
AGG = Aggregate instability
HAB = Soil organism habitat degradation

Location

Field/CMU

Tract#

Client/Customer

Planner

Date

Soil Map Units

Soil Moisture

Topsoil Texture

11 Indicators - Most direct observation in field...

Cropland In-Field Soil Health Assessment

Management History - Interview

The following questions are offered as examples to guide a conversation. The client's management history is unique. Answers to these and other similar questions are needed for a complete assessment.

- What is the crop rotation?
- What are the types and frequency of ground disturbing operations?
- For how many months per year is the soil surface at least 75% covered with plants, residue or mulch?
- Are cover crops a consistent part of the cropping system?
- If yes, for how many years has the field been continually cover cropped?
- How are the cover crops terminated? If chemically, what herbicide is used?
- Does water pond or run off during or immediately after typical rainfall or irrigation events? Where in the field?
- Are there problems with crop emergence or early crop growth? Where in the field?
- Is water management a concern (i.e., field too wet or too dry at planting)?
- Other observations not captured in the assessment including plant condition, and recent weather and landscape characteristics that may affect assessment results.

But interview

Table 2. Tier 2 Soil Health Indicators and Methods to be Assessed (updated 10/23/2018)

Indicator	Method
Sodium Adsorption Ratio (SAR)	Saturated paste extract followed by atomic absorption or inductively coupled plasma spectroscopy
Soil Stability Index	Combination of wet and dry sieving at multiple sieve sizes
Active Carbon	Potassium dichromate oxidizable carbon (POXC). Digestion followed by colorimetric measurement
Soil Protein Index	Autoclaved Citrate Extractable
B-Glucosidase	Assay incubation followed by colorimetric measurement
B-Glucosaminidase	Assay incubation followed by colorimetric measurement
Phosphatase	Assay incubation followed by colorimetric measurement
Arylsulfatase	Assay incubation followed by colorimetric measurement
Phospholipid Fatty Acid (PLFA)	Blight-Dyer extractant, solid phase extraction, transesterification, gas chromatography
Ester-Linked Fatty Acid Methyl Ester (EL-FAME)	Mild alkaline methanolysis extraction; gas chromatography
Genomics	16S rRNA, ITS, and shotgun metagenomics
Reflectance	Diffuse reflectance spectroscopy

Third Edition

B.N. Moebius-Clune, D.J. Moebius-Clune, B.K. Gugin, O.J. Idowu, R.R. Schindelbeck, A.J. Ristow, H.M. van Es, J.E. Thies, H.A. Shayler, M.B. McBride, K.S.M. Kurtz, D.W. Wolfe, and G.S. Abawi

Cornell University

12 Indicators - All direct observation, most in lab

Table 2.02. Indicators of the Comprehensive Assessment of Soil Health and what they mean.

Indicator	What it means
Soil cover	Meets: Surface cover from plants, residue or mulch
Residue breakdown	Meets: Natural decomposition of crop residues
Surface crusts	Meets: Crusting on no more than 5% of the field
Ponding	Meets: No ponding within 24h following typical rainfall
Penetration resistance	Meets: Penetrometer rating less than 150 psi within 10 cm of surface or no resistance with wire flag
Water stable aggregates	Meets: At least 80% remains intact after 5 minutes of shaking in water
Soil structure	Meets: Granular soil structure in A horizon and no compaction
Soil color	Meets: No color difference between field and soil survey pedon description
Plant roots	Meets: Roots covered in a soil film (rhizosphere) healthy, fully branched and extend into subsoil
Biological diversity	Meets: Clearly evident; more than 3 different types
Biopores	Meets: Presence of root or earthworm channels the surface

***A few words
on SH
measurement
interpretation***



The Soil Health Management Planning Framework – From Soil Assessment to Soil Management

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. <http://soilhealth.cals.cornell.edu>



Grower:

Bob Schindelbeck

306 Tower Rd.

Ithaca, NY 14853

Agricultural Service Provider:

Mr. Bob Consulting

rrs3@cornell.edu

Sample ID:

LL8

Field ID:

Caldwell Field- intensive management

Date Sampled:

03/11/2015

Given Soil Type:

Collamer silt loam

Crops Grown:

WHT/WHT/WHT

Tillage:

7-9 inches

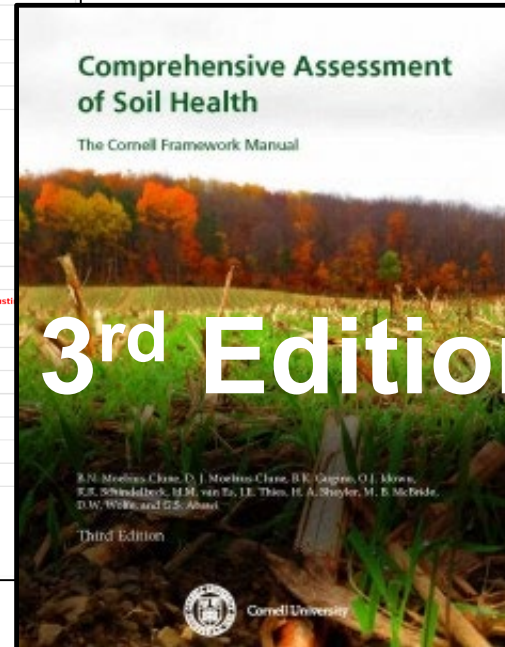
Measured Soil Textural Class: **silt loam**

Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crust Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Mg: 133.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100	

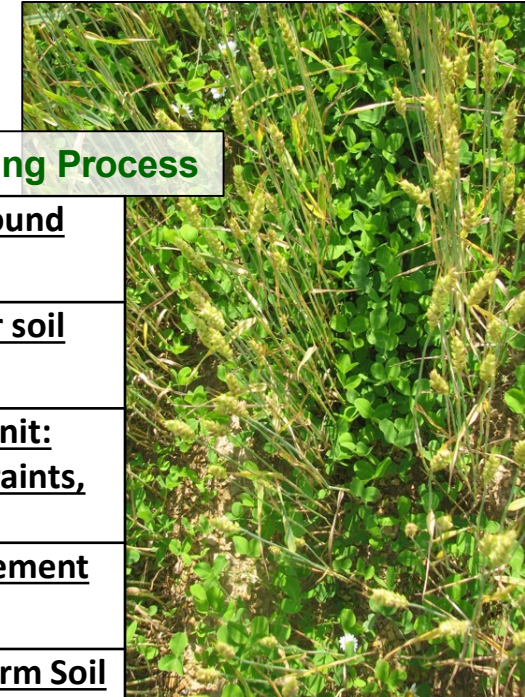
Overall Quality Score:

51 / Medium



SH Management Planning Process

1. Determine farm background and management history
2. Set goals and sample for soil health
3. For each management unit: identify and explain constraints, prioritize
4. Identify feasible management options
5. Create short and long term Soil Health Management Plan
6. Implement, monitor, and adapt



Bob Schindelbeck
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Cornell University
College of Agriculture and Life Sciences

School of Integrative Plant Science
Soil and Crop Sciences Section

Comprehensive Assessment of Soil Health

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Grower:

Bob Schindelbeck

306 Tower Rd.

Ithaca, NY 14853

Sample ID:

LL8

Field ID:

Caldwell Field- intensive management

Measured Soil Textural Class: **silt loam**

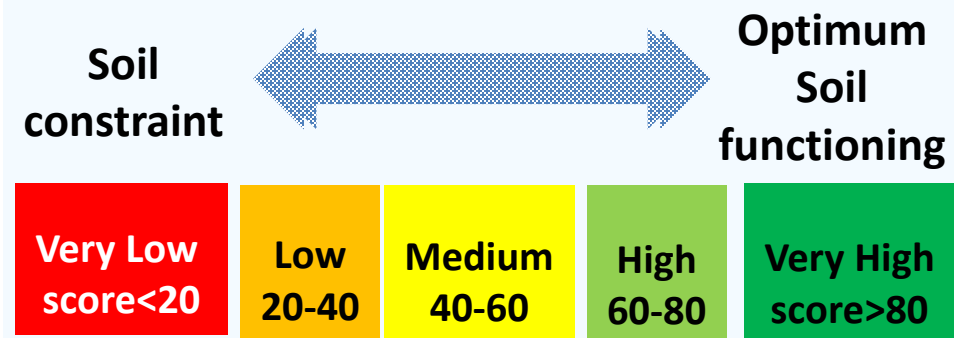
Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Mg: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100	

Overall Quality Score: **51** / Medium

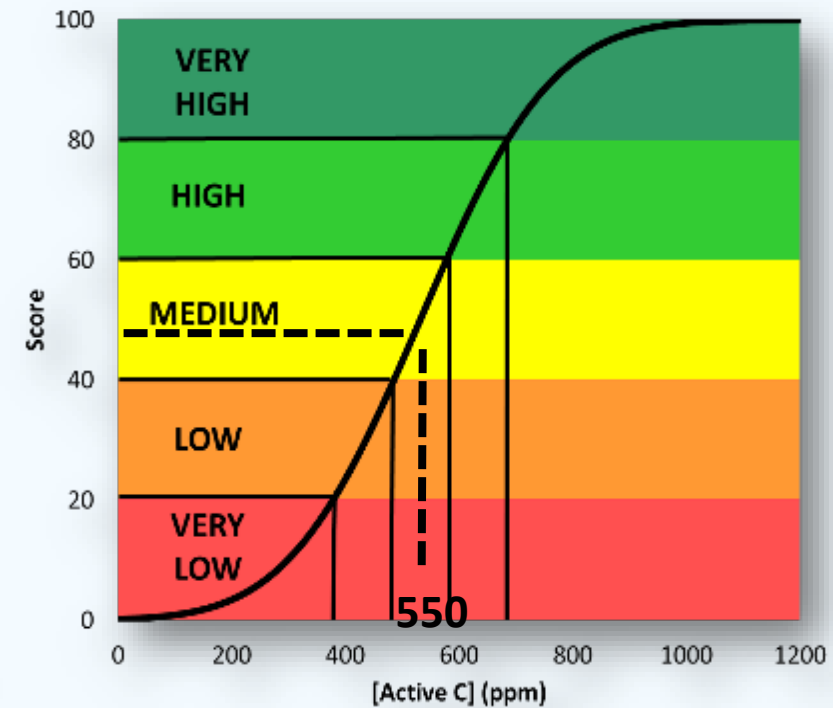
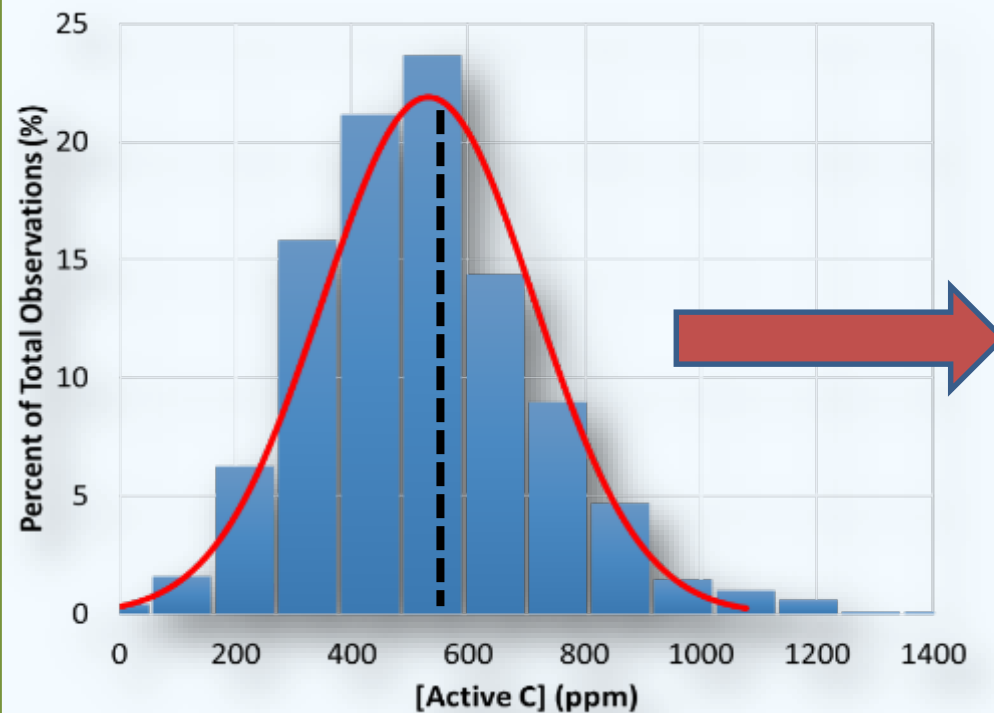
Cornell Soil Health Assessment

- Assesses soil physical, biological and chemical functioning
- Process oriented
- Measures indicators
- Uses scoring functions
- Overall score



Generalized Scoring Function

Cumulative Normal Distribution Function
separate functions by textural group for most indicators



Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. <http://soilhealth.cals.cornell.edu>



Intensive cropping



A

Measured Soil Textural Class: **silt loam**

Sand: **2%** - Silt: **83%** - Clay: **15%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.14	37	
physical	Surface Hardness	260	12	Rooting, Water Transmission
physical	Subsurface Hardness	340	35	
physical	Aggregate Stability	15.7	19	Aeration, Infiltration, Rooting, Crusting, Sealing, Erosion, Runoff
biological	Organic Matter	2.5	28	
biological	ACE Soil Protein Index	5.1	25	
biological	Soil Respiration	0.5	40	
biological	Active Carbon	288	12	Energy Source for Soil Biota
chemical	Soil pH	6.5	100	
chemical	Extractable Phosphorus	20.0	100	
chemical	Extractable Potassium	150.6	100	
chemical	Minor Elements Nq: 131.0 / Fe: 1.2 / Mn: 12.9 / Zn: 0.3		100	

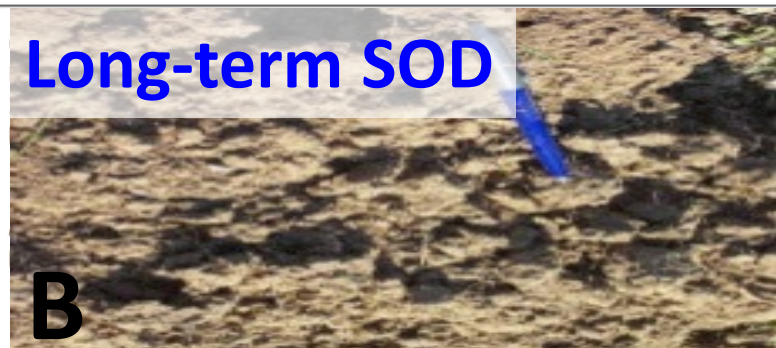
Overall Quality Score: **51 / Medium**

Comprehensive Assessment of Soil Health

From the Cornell Soil Health Laboratory, Department of Soil and Crop Sciences, School of Integrative Plant Science, Cornell University, Ithaca, NY 14853. <http://soilhealth.cals.cornell.edu>



Long-term SOD



B

Measured Soil Textural Class: **silt loam**

Sand: **1%** - Silt: **85%** - Clay: **14%**

Group	Indicator	Value	Rating	Constraints
physical	Available Water Capacity	0.31	98	
physical	Surface Hardness	95	79	
physical	Subsurface Hardness	151	91	
physical	Aggregate Stability	55.1	90	
biological	Organic Matter	5.1	99	
biological	ACE Soil Protein Index	9.7	74	
biological	Soil Respiration	1.6	99	
biological	Active Carbon	736	89	
chemical	Soil pH	6.6	100	
chemical	Extractable Phosphorus	13.7	100	
chemical	Extractable Potassium	143.9	100	
chemical	Minor Elements Mg: 161.0 / Fe: 1.6 / Mn: 20.4 / Zn: 0.5		100	

Overall Quality Score: **93 / Optimal**

Soil Health Indicators Do Not Differentiate among Agronomic Management Systems in North Carolina Soils

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Recent soil tests evaluating “soil health” on a broad scale may not properly consider the intrinsic limitations of soil properties, and have not been assessed in regionally unique soil conditions. To evaluate three soil tests in North Carolina, we used long-term agronomic management trials from three distinct physiographic regions: mountain (22 yr), piedmont (32 yr), and coastal plain (17 yr). Mountain and coastal plain trials included combinations of organic or chemical management with or without tillage; the piedmont trial included nine different tillage treatments. Soil samples were collected and submitted for analysis as recommended by the North Carolina Department of Agriculture and Consumer Services, Haney soil health test (HSHT), and Cornell comprehensive assessment of soil health (CASH). Plant nutrient concentrations varied but were still sufficient for crops. The CASH physical soil indicators, such as surface hardness and aggregate stability, were not statistically different, regardless of tillage intensity or management. Biological soil indicators (e.g., CO₂ respiration) responded differently to management, but this differentiation was inconsistent among locations and tests. Despite many years of conservation management, the CASH results described mountain soils as “low” or “very low” soil health for all but no-till organic management, which received a “medium” score. The HSHT results considered soil from all but moldboard plowing (piedmont) to be in good health. Finally, there was no correlation between soil health tests and crop yields from North Carolina soils. Soil health tests should be calibrated to better differentiate among soil management effects that vary depending on intrinsic soil limitations.

Abbreviations: AWC, available water capacity; CASH, Cornell comprehensive assessment of soil health; CEC, cation exchange capacity; CPDS, chisel plowing and disking in spring; CPE, chisel plowing in fall; CPS, chisel plowing in spring; CTC, conventional tillage chemical; CTO, conventional tillage and organic management; CTX, chisel and disk tillage with no fertilizer or pesticide inputs; DS, disking in spring; HSHT, Haney soil health test; HM, humic matter; LOI, loss on ignition; MPDF, moldboard plowing and disking in fall; MPDS, moldboard plowing and disking in spring; NCDA&CS, North Carolina Department of Agriculture and Consumer Services; NTC, no-till chemical; OM, organic matter; RYE, realistic yield expectation; WEOC, water-extractable organic C; WEON, water extractable organic N.

Soil serves as a medium for many natural processes that rely on dynamic interactions among physical, chemical, and biological soil properties to regulate important ecological and environmental functions. The state of these processes in any given soil is called “soil health,” which is defined as the capacity of soil to function as a vital living ecosystem (Doran and Zeiss, 2000; Karlen et al., 2003; USDA-NRCS, 2015). Healthy soil is believed to be highly productive, optimally functional, and naturally able to recover from disturbances (Doran and Parkin, 1994; Kibblewhite et al., 2008). The physical, chemical, and biological soil properties that comprise soil health vary in quality because of regional differences in major soil-forming factors, which include parent material, climate, biota, topography,

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Core Ideas

- Soil health metrics were not differentiated in long-term agronomic trials.
- Soil health tests produced different results and were not consistent with management.
- Soil health indicators should be tested in different agroecological regions.

Reanalysis Validates Soil Health Indicator Sensitivity and Correlation with Long-term Crop Yields

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Ames, IA 50011-3611

Soil health (SH) refers to the ability of a soil to function and provide ecosystem services. This study reanalyzes data from long-term agronomic management experiments in North Carolina and addresses previous conclusions regarding the utility of SH test metrics. Data for 15 SH indicators in the Comprehensive Assessment of Soil Health (CASH) framework from three long-term trials in North Carolina were analyzed to assess effects of tillage intensity and organic vs. conventional management. This included four soil biological indicators—organic matter (OM), active carbon (ActC), respiration (Resp), and protein (Prot); four soil physical indicators—available water capacity (AWC), water-stable aggregation (AgStab), surface and subsurface penetration resistance (SurfHard, SubHard); and seven soil chemical (fertility) indicators (P, K, Mg, Fe, Mn, Zn, pH). Corn (*Zea mays* L.) and soybean (*Glycine max* L. Merr.) yield data and SH indicator values were correlated using site-specific and multi-site datasets. Long-term management practices most commonly showed significant impacts with AgStab (up to 2.2'), ActC (2.1'), Prot (2.3'), and most chemical indicators. Tillage intensity had a greater impact than organic vs. conventional management and linear regression of multi-year mean corn and soybean yield response to tillage showed significant correlations with eight SH indicators, highest among them ActC, Protein, Resp, and Mn ($R^2 = 0.85\text{--}0.93$). Contrary to previous conclusions, CASH indicators, especially those related to labile C and N, responded well to management practices and showed utility for SH assessment in agronomic trials.

Abbreviations: ActC, active carbon, also known as permanganate oxidizable carbon; POXC; AgStab, water stable aggregation; AWC, available water capacity; CASH, Comprehensive Assessment of Soil Health; ConvTill, conventional tillage; HSHT, Haney Soil Health Test; NC, North Carolina; NCDACS, North Carolina Department of Agriculture and Consumer Services; NoTill, no tillage; OM, organic matter; Resp, respiration during a 4-d incubation; SMAF, Soil Management Assessment Framework; SurfHard, penetration resistance within the 0- to 15-cm depth range; SubHard, penetration resistance within the 15- to 45-cm depth range; SH, soil health; SOM, soil organic matter.

Healthy well-functioning soils that enhance water and air quality, support human health and habitation, and sustain plant and animal productivity are essential to ensuring a sustainable future for an ever-growing global population (Karlen et al., 2003; Karlen and Rice, 2015). Soil health refers to the ability of a soil to perform such functions based on its inherent and dynamic characteristics (Karlen et al., 1997; Andrews et al., 2004; Idowu et al., 2009). Therefore, within the context of land use and management goals, SH represents an understanding of this resource as a dynamic, complex, and living system (Doran and Zeiss, 2000). The terms “soil quality” and “soil health” are used interchangeably in the literature and can be considered equivalent (Bünemann et al., 2018), but within the past 5-yr stakeholder audiences and media sources have shown a preference for the latter term, which we use herein.

Core Ideas

- Soil health metrics were sensitive in North Carolina soils.
- Tillage intensity and fertility practices were especially differentiated by biological soil health metrics.
- Soil health metrics associated with labile organic matter correlated well with crop yields.

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***Why focus
on
bioavailable
N / PMN?***



Years in continuous no-till, Suffolk, VA

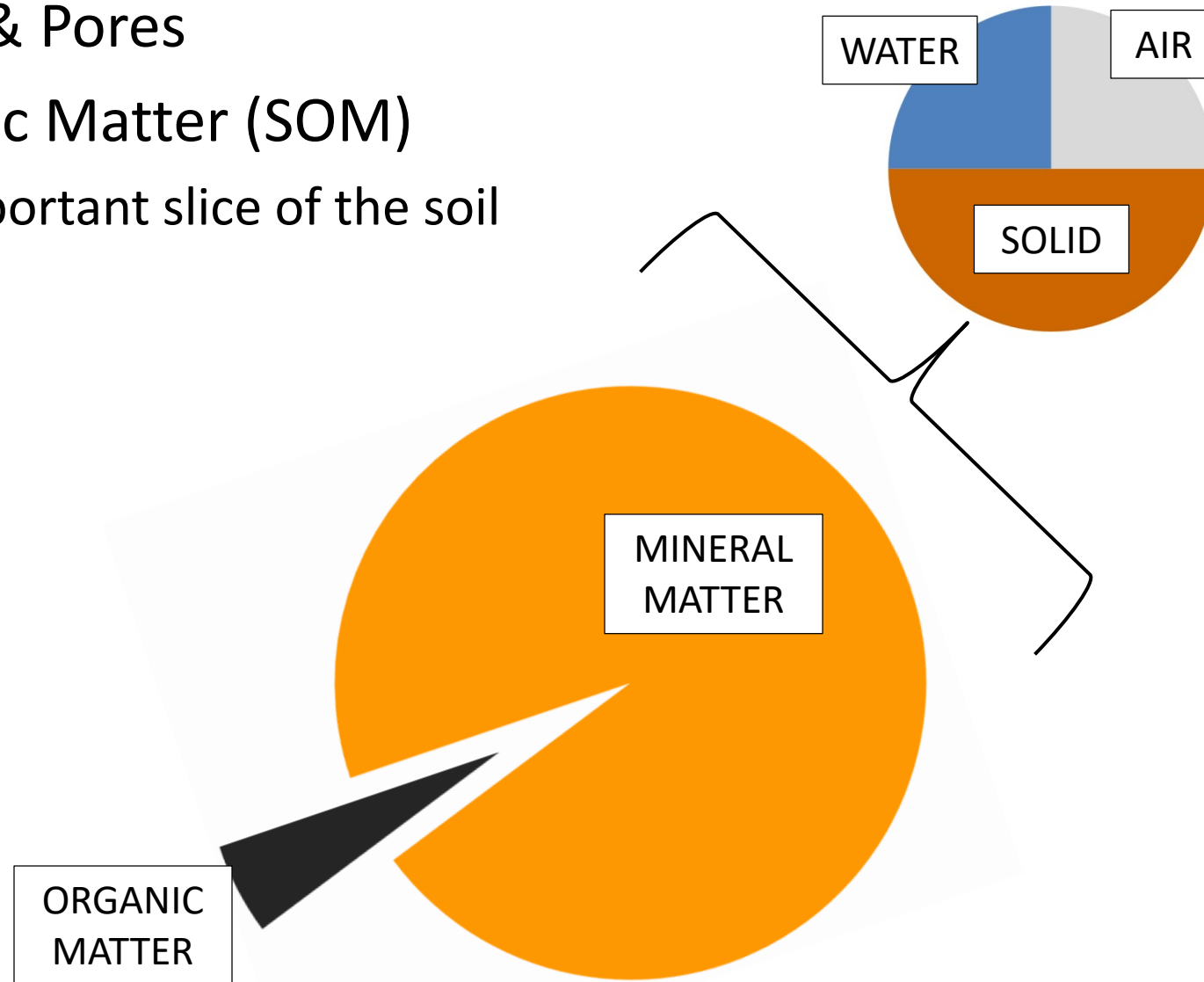
(same soil type & inherent properties)



Soil organic matter = approx. 50% C, 5% N
2% SOM increase in top 3" = 1,000 lb/ac more total soil N

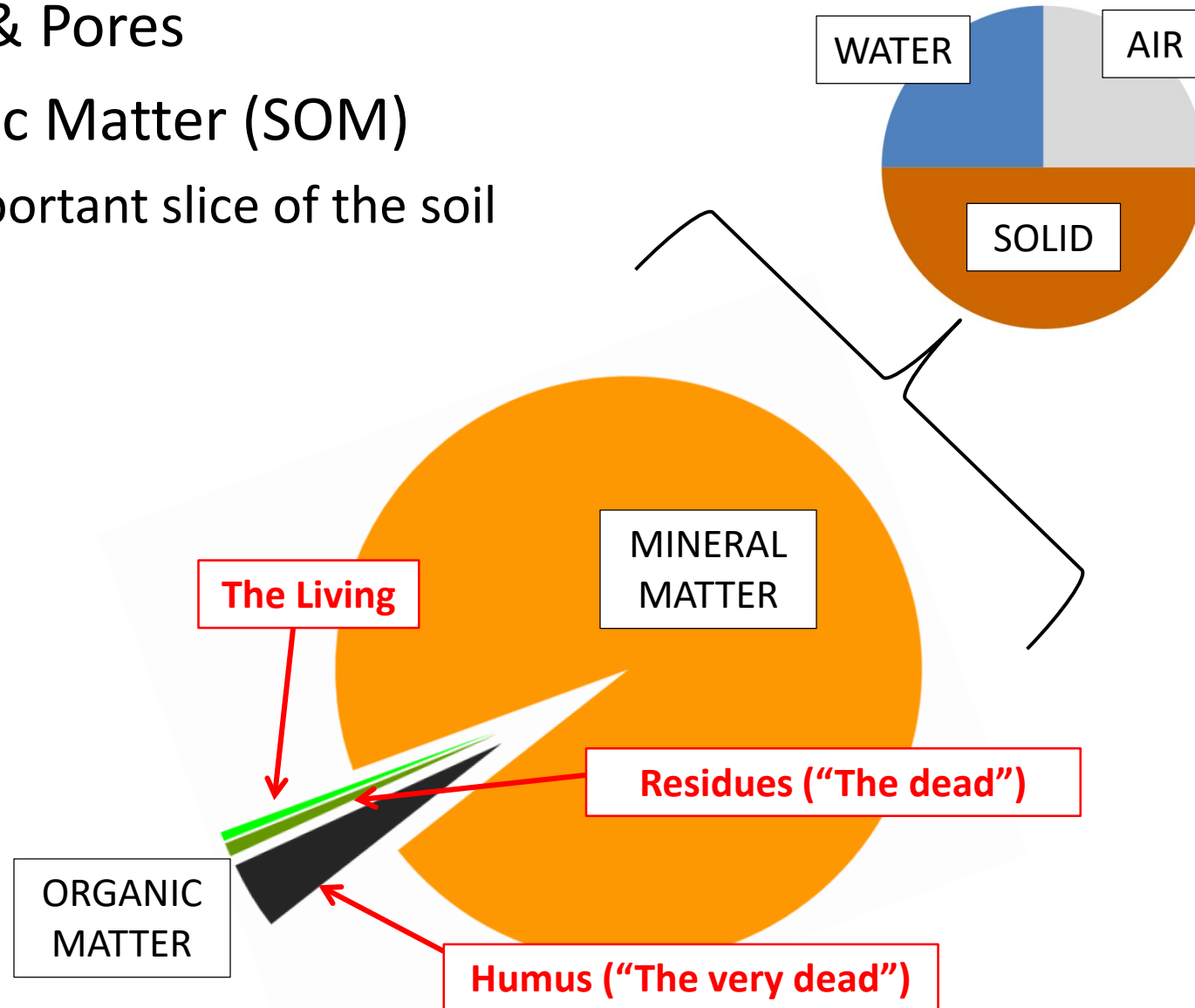
The living, dead, and very dead?

- Structure & Pores
- Soil Organic Matter (SOM)
 - Most important slice of the soil



The living, dead, and very dead?

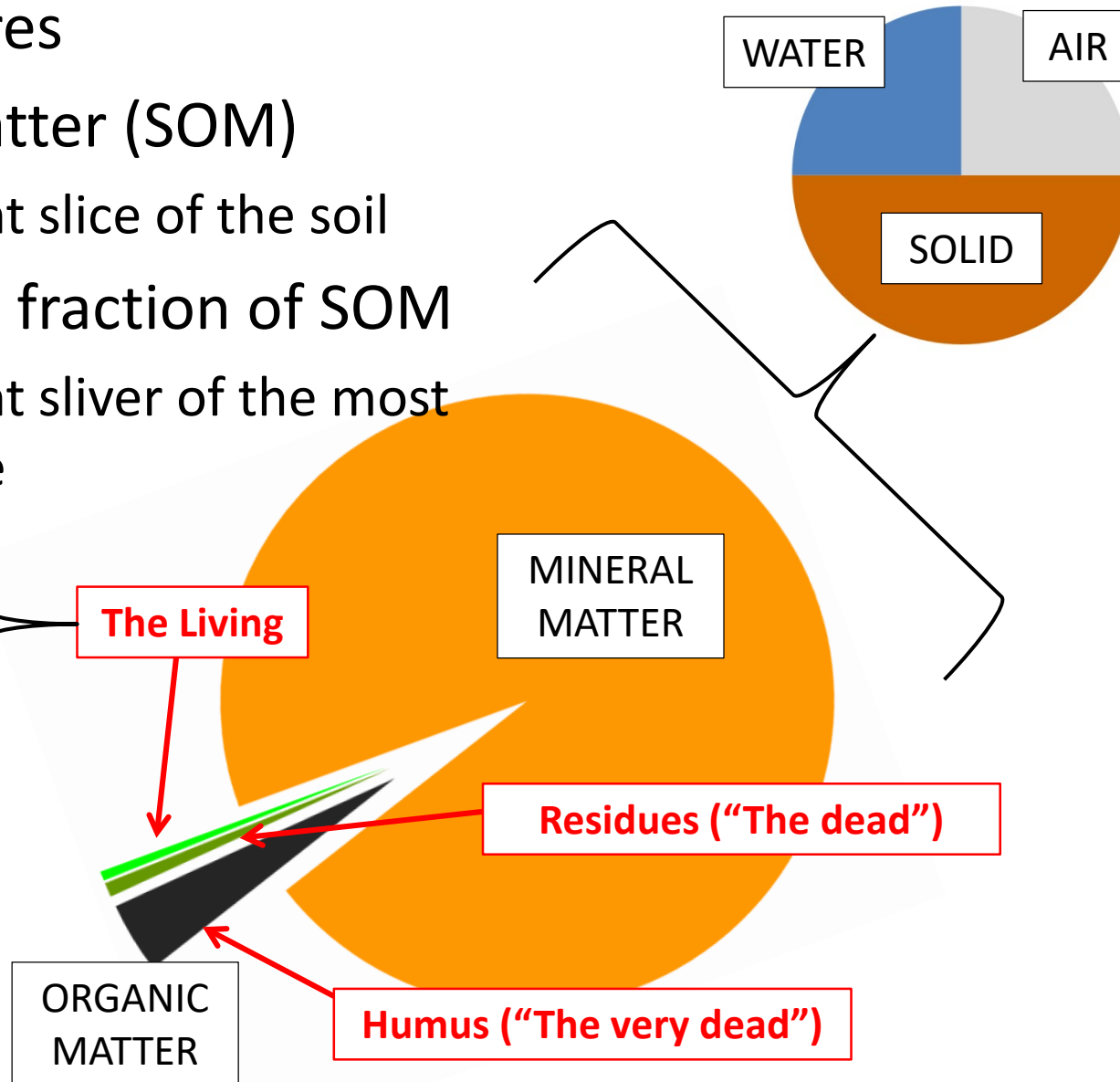
- Structure & Pores
- Soil Organic Matter (SOM)
 - Most important slice of the soil



The living, dead, and very dead?

- Structure & Pores
- Soil Organic Matter (SOM)
 - Most important slice of the soil
- Soil Life / Living fraction of SOM
 - Most important sliver of the most important slice

- Roots
- Earthworms
- Arthropods
- Nematodes
- Protozoa
- Fungi
- Bacteria



Mineralizable soil nitrogen and labile soil organic matter in diverse long-term cropping systems

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Steven B. Mirsky · Jude E. Maul ·
John J. Meisinger

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Abstract Sustainable soil fertility management depends on long-term integrated strategies that build and maintain soil organic matter and mineralizable soil N levels. These strategies increase the portion of crop N needs met by soil N and reduce dependence on external N inputs required for crop production. To better understand the impact of management on soil N dynamics, we conducted field and laboratory research on five diverse management systems at a long-term study in Maryland, the USDA–Agricultural Research Service Beltsville Farming Systems Project (FSP). The FSP is comprised of a conventional no-till corn (*Zea mays* L.)–soybean (*Glycine max* L.)–wheat (*Triticum aestivum* L.) double-crop soybean rotation (NT), a conventional chisel-till corn–soybean–wheat/soybean rotation (CT), a 2 year organic corn–soybean rotation (Org2), a 3 year organic corn–soybean–wheat rotation

(Org3), and a 6 year organic corn–alfalfa (*Medicago sativa* L.) (3 year) rotation (Org6). We found that total potentially mineralizable N was significantly greater than the conventional system (235 kg N ha⁻¹). Particulate organic N and –N also tended to be greater in the organic than conventional cropping systems, and N uptake from unamended microplots were 40 and 48%, respectively. Among the three organic systems, N availability tended to increase with frequency of manure application and N uptake (Org2 < Org3 ≤ Org6) while N release was similar between NT and CT. Our results suggest that organic soil fertility management can increase N availability by increasing labile N pools. Relatively high levels of mineralizable N should be considered when developing soil N management plans for organic systems.

Keywords Chemically-labile N (CLOM) · Organic farming · Plant available N (PAN) · Soil mineralizable N (SOM) · Soil organic matter (POM) · Soil mineralization

Introduction

Nitrogen is generally recognized as the most limiting nutrient required for the production of most crops. Nitrogen is

Measuring the amount of N released from soil organic matter pools has challenged soil scientists for decades due to the dynamic nature of soil N transformations and the chemical complexity of soil organic matter. Since total soil organic matter is primarily composed of recalcitrant humus with mean turnover times ranging from hundreds to thousands of years (Stevenson 1994), total organic C or N are of limited use for quantifying the impact of management on the quality or functionality of SOM. A number of approaches have been used to estimate soil N release from soil organic matter pools. One of the most common and direct methods is to quantify potentially mineralizable organic N using long-term aerobic incubations (Stanford and Smith 1972; Christensen and Olesen 1998; Mallory and Griffin 2007). Another

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Why no BAN / PMN in traditional soil tests?

- Most lab methods take too long, too expensive
- Typical degraded soils very low in BAN / PMN
- N dynamics complex, weather-dependent = hard to predict how soil N release in lab correlates to N release in field.
- Therefore:
 - Just not worth testing for BAN / PMN
 - Our starting point for N recommendations:
 - Make general assumption about soil N-supplying capacity, apply to all soils
 - Make sure you apply enough
 - Maximize efficiency with timing, placement, etc.
 - Have agronomists use judgment & site specifics to adjust for BAN / PMN

Strengths and Limitations of Nitrogen Rate Recommendations for Corn and Opportunities for Improvement

Thomas F. Morris,*
John Grove, Quirino
John J. Meisinger, Jeff
John E. Sawyer, Pete

ABSTRACT

Nitrogen fixation by the Ha doubled the amount of fixed encing the global N cycle. M fertilizer that is used to prod Too much of the N fertilizer p from agroecosystems throu leaching, and runoff. Most of States is applied to corn (Zea environmental footprint of co fertilizer applications. Accur needed by corn, however, has of the effects of rainfall, temp properties on the N cycle. Fo mentsations is critical for pr reducing N losses to the en paper were to review curren of corn by: (i) reviewing fund about how N recommendat performance, strengths, and used for making N fertilizer how adaptive management pr recommendations; and (iv) p ing N fertilizer rate recomm

and E factors in Eq. [10]. A number of interacting factors likely cause BBC including: better temperature and moisture conditions for organic N mineralization (increased Q); less leaching and denitrification losses due to less extreme soil moisture conditions (increased Q); larger root systems with greater mass flow to enhance N uptake (increased E); and greater portioning of dry matter to shoots than roots thus increasing yield with the same N (decreased n). The effect of BBC on N fertilizer requirements has been shown to decrease the expected amount of N fertilizer needed by the crop (Fox and Piekielek, 1995; Schlegel et al., 1996; Vanotti and Bundy, 1994a), and the effect is discussed in detail by Meisinger et al. (2008).

This review of the ideas and the equations describing those ideas supporting N recommendations by the yield goal method show that creating accurate N recommendations for individual fields is a difficult task. Much greater knowledge about fundamental mechanisms of the N cycle in soils and how to apply that knowledge to individual fields are needed to improve N recommendations. Improvement of N fertilizer recommendations should be a national priority due to the effect of the recommendations on U.S. and world food production and economies, the tremendous increase in grain yield per unit of land from N applications, and the need to protect and improve

ground and surface water quality. As a first step to improving N recommendations, we provide a review of current methods for making recommendations and the tools used to enhance the recommendations. We then propose a method of adaptive management to enable farmers to learn over time what is a reasonable estimate of a rate for individual fields or parts of fields, and lastly, we provide a framework for improving N fertilizer rate recommendations.

SYSTEMS AND TOOLS USED TO MAKE NITROGEN RECOMMENDATIONS

Yield-Based Nitrogen Recommendations for Corn

Stanford's equation of expected grain yield or yield goal and N_f as described in Eq. [7] underpinned all N recommendations at Land Grant Universities until development of the maximum return to nitrogen (MRTN) system of N recommendations (Sawyer et al., 2006). Currently, Land Grant Universities in 34 states (Fig. 5) make N recommendations based on a derivation of Stanford's equation, representing 41% of the planted corn land area and 35% of the grain harvested in the United States (National Corn Growers Association, 2017). Kentucky does not use either yield goal or MRTN approaches, but rather groups results of numerous corn N response studies, and makes

Core Ideas

- Nitrogen recommendations for accurate than desired.
- Nitrogen recommendations need environmental reasons.
- A review of fundamental concepts about N recommendations.
- Examination of N recommendations to improve recommendations.

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Soil Health Management and Assessment

How did we get here?

...one scientist's perspective



United States Department of Agriculture

Agricultural Research Service

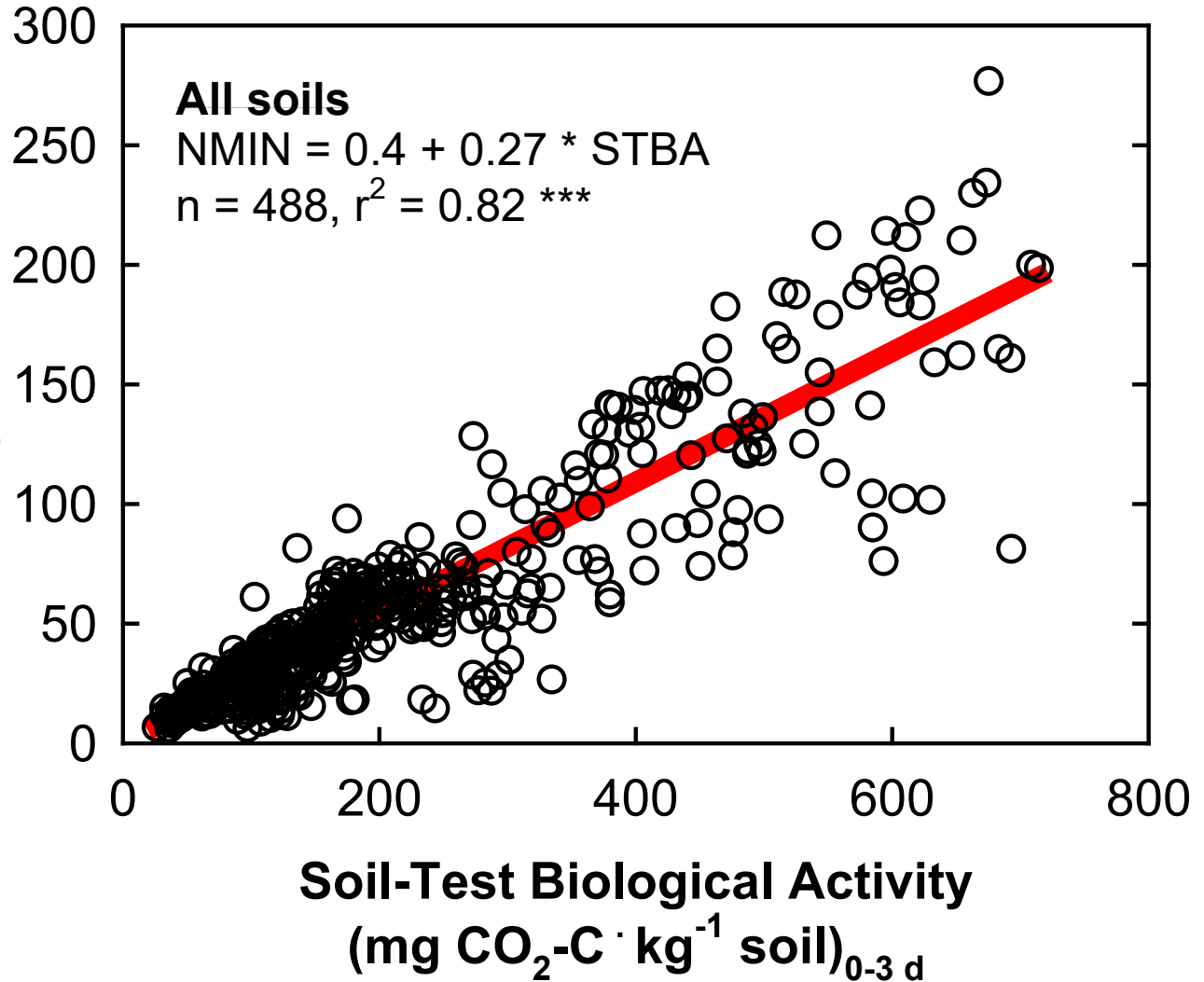
**NC STATE
UNIVERSITY**

**Crop & Soil
Sciences**

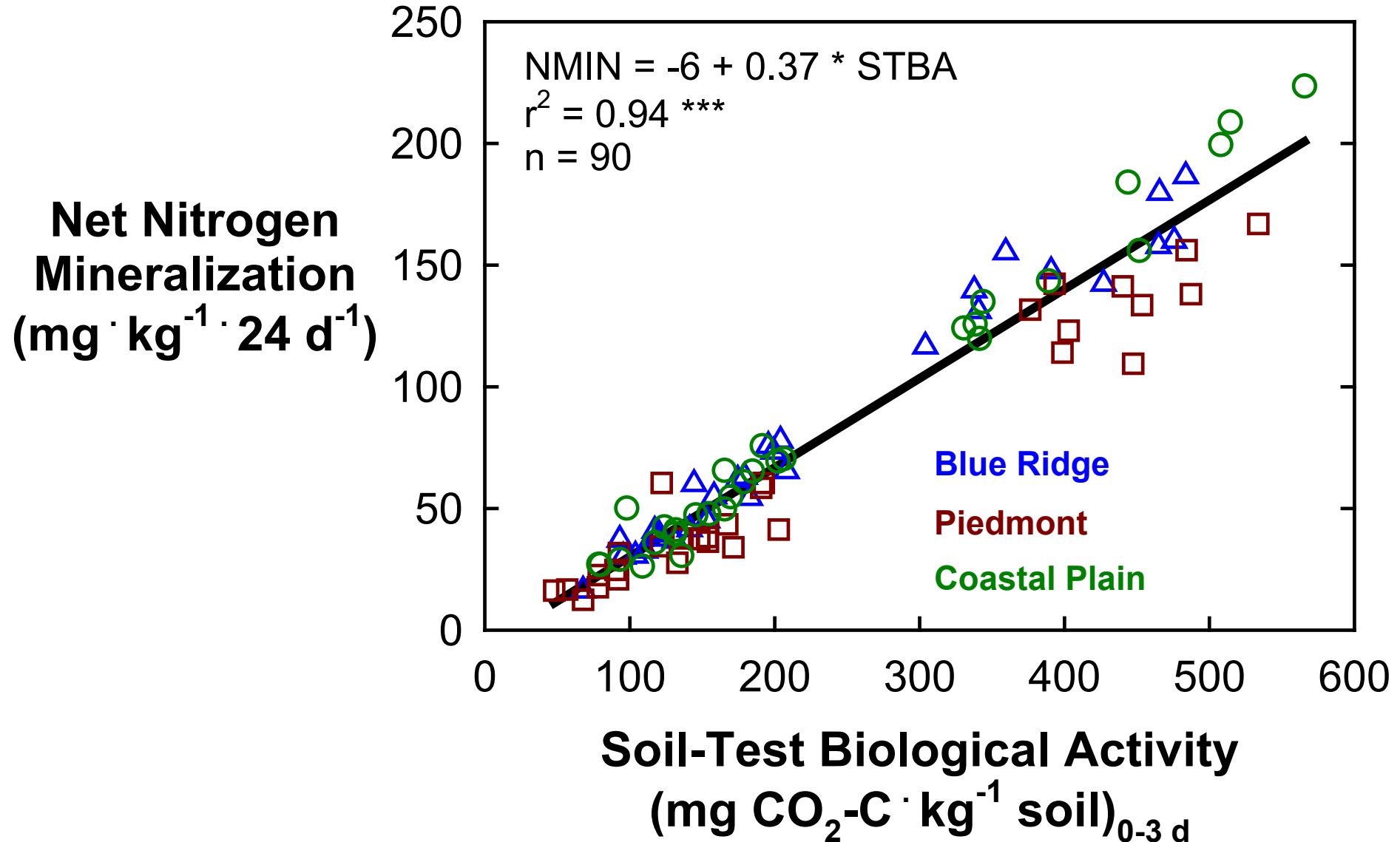
alan.franzluebbers@usda.gov

Association with N mineralization across all soils

**Net Nitrogen
Mineralization**
(mg N · kg⁻¹ soil · 24 d⁻¹)



STBA and NMIN association is independent of soil type



A photograph of a cornfield showing rows of corn plants. The leaves are mostly green but show significant yellowing and browning, indicating stress or disease. A pile of harvested yellow corn cobs lies on the ground in the center-left area.

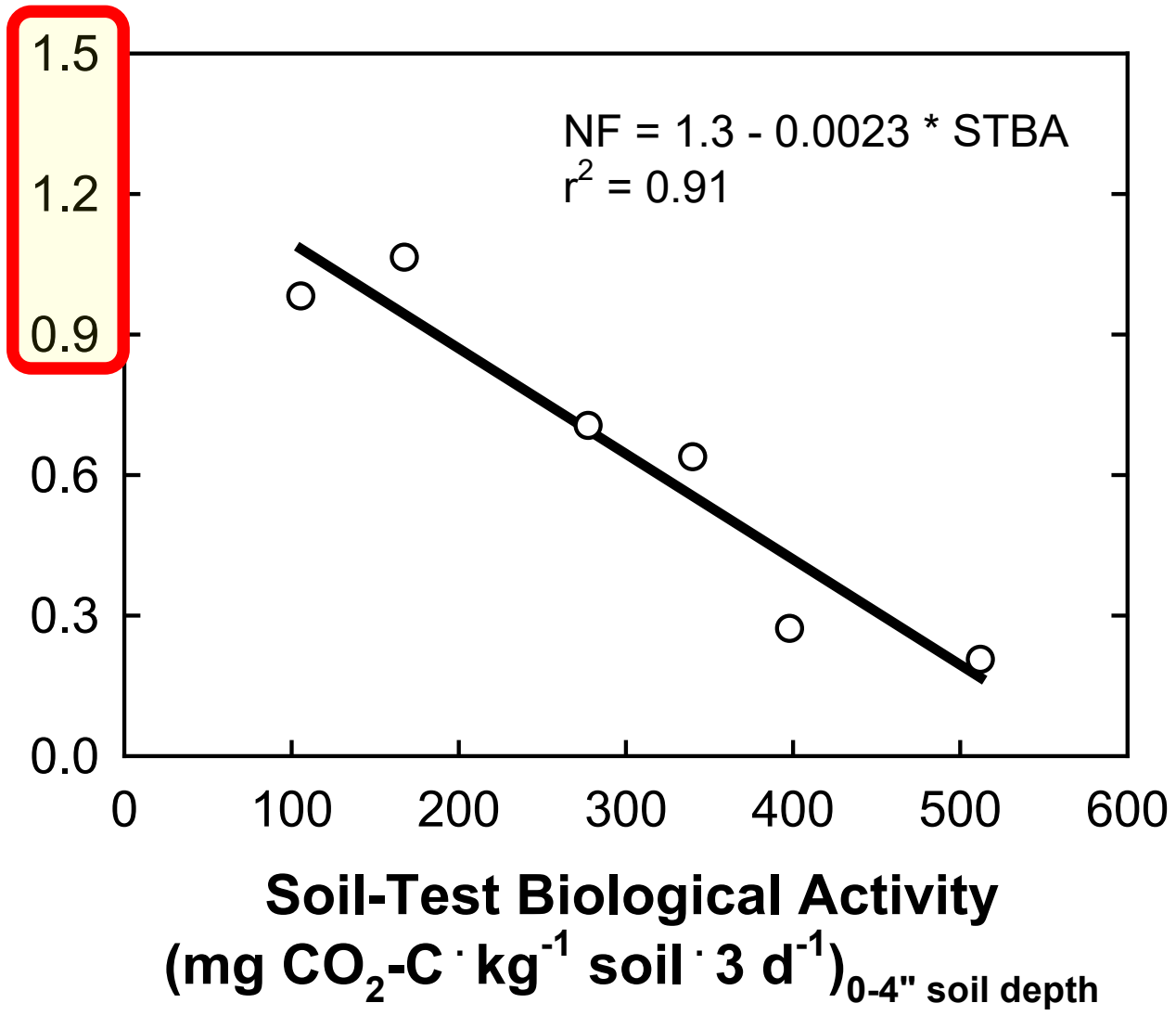
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**Blue Ridge
Great Valley
Piedmont
Coastal Plain**

Soil-test biological activity modifies the need for supplemental N fertilizer

**Nitrogen Factor
for Economically
Optimum Production
(lb N · bu⁻¹ grain)**

36 field sites in NC, VA
from 2014-2016
(values are means of 6
consecutive sites)



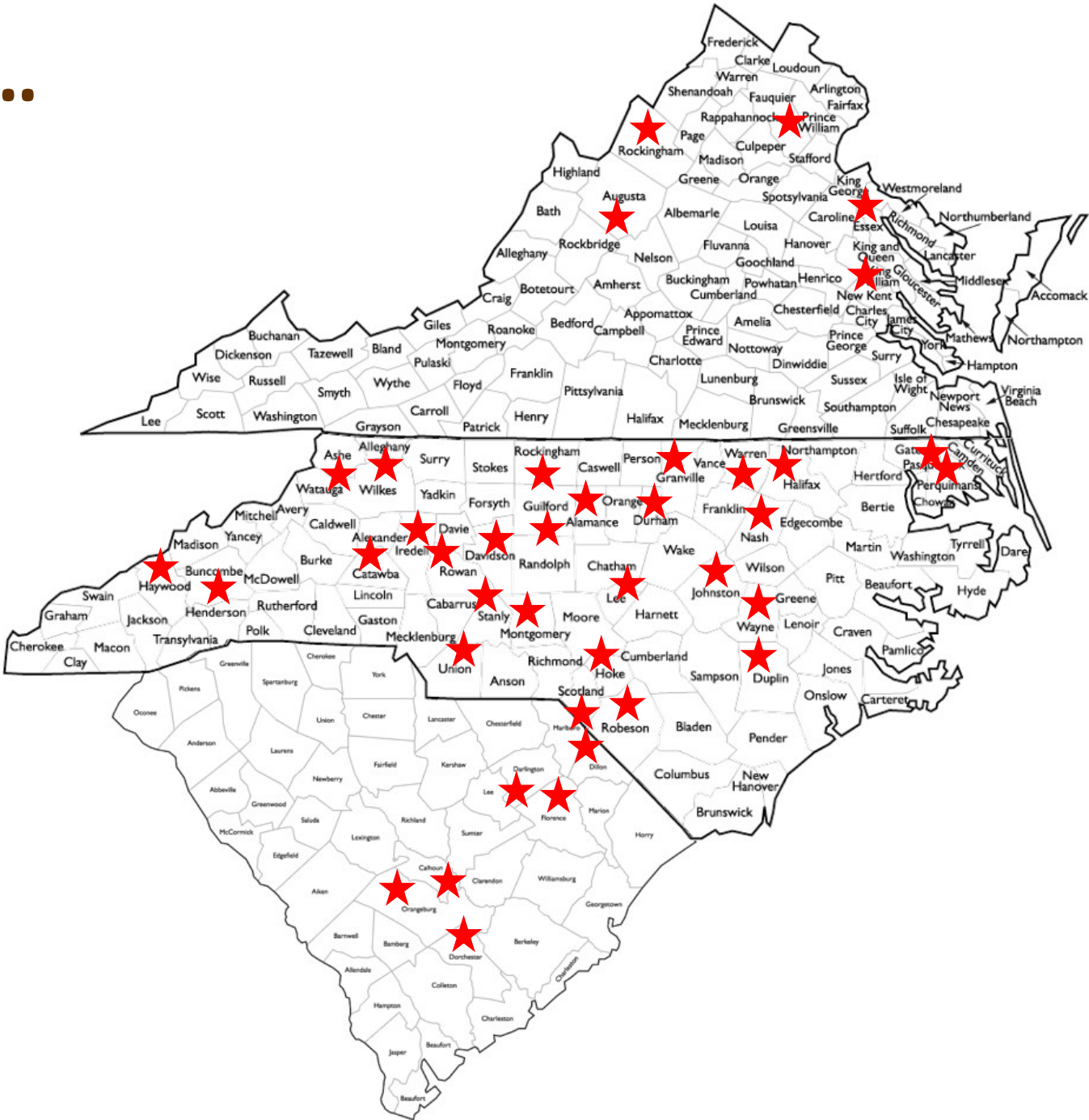
Let's try this again...

2017-2018

Number of trials

111

39 counties



Corn Nitrogen Trial Collaborators (2014-2019)



Kevin Craun
Rockingham Co VA



Matt Rohrer
Rockingham Co VA



Ray Showalter
Rockingham Co VA



Dwight Wenger
Rockingham Co VA



Everette Gardner
Augusta Co VA



Sid Rogers
Fauquier Co VA



Kraig Smith
Fauquier Co VA



Paul Davis
New Kent Co VA



Anthony Beery
Rockingham Co VA



Jimmy Crosby
Augusta Co VA



Dale Reeves
Augusta Co VA



Beauregard Farm
Culpeper Co VA



NCDA - Cherry Research Farm
Wayne Co NC



Zeb Winslow
Halifax Co NC



Al Wood
Camden Co NC



Billie and Sam Reid
Pasquotank Co NC



Wesley Moore
Pasquotank Co NC



Kenny Haines
Hertford Co NC



Brian Chatham
Ashe and Wilkes Co NC



Mark Styer
Rockingham Co NC



Reid Smith
Davidson Co NC



Russell Hedrick
Catawba and Iredell Co NC



William Wollett
Nash Co NC



Brian Ragan
Lee Co NC



Jeff Bender
Warren Co NC



Louis and Quinn Howard
Duplin Co NC



Franklin Lee
Stanly Co NC



Keith Sink
Davidson Co NC



Jason Davis
Buncombe Co NC



NCDAs
Upper Mountain Res. Sta.
Mountain Res. Sta.
Oxford Tobacco Res. Sta.
Tidewater Res. Sta.
Central Crops Res. Sta.



Matthew Knowles
Duplin Co NC



Adrian Locklear
Robeson Co NC



Kay McGirt
Robeson Co NC



Adam Grady
Duplin Co NC



NCDAs
Piedmont Res. Sta.
Rowan Co NC



Phillip Cartner
Davie Co NC



Brian Moore
Rowan Co NC



Andy Corriher
Rowan Co NC



Cody Waller
Rowan Co NC



Joseph Johnson
Alamance Co NC



USDA Soil and Water Lab
Florence Co SC



Carl Coleman
Dillon Co SC



Sonny Price
Dillon Co SC



Pat Shooter
Robeson Co NC



Sam Smith
Brunswick Co NC



Curtis Furr
Stanly Co NC



Nathan Lowder
Stanly and Montgomery Co NC



Don York
Guilford Co



Allan Baucom
Union and Anson Co NC



James Cooley
Scotland Co NC



Stever Herlocker
Scotland Co NC



Gary Hendrix
Hoke Co NC



Josh Johnson
Calhoun Co SC



Jeff Lucas
Orangeburg Co SC

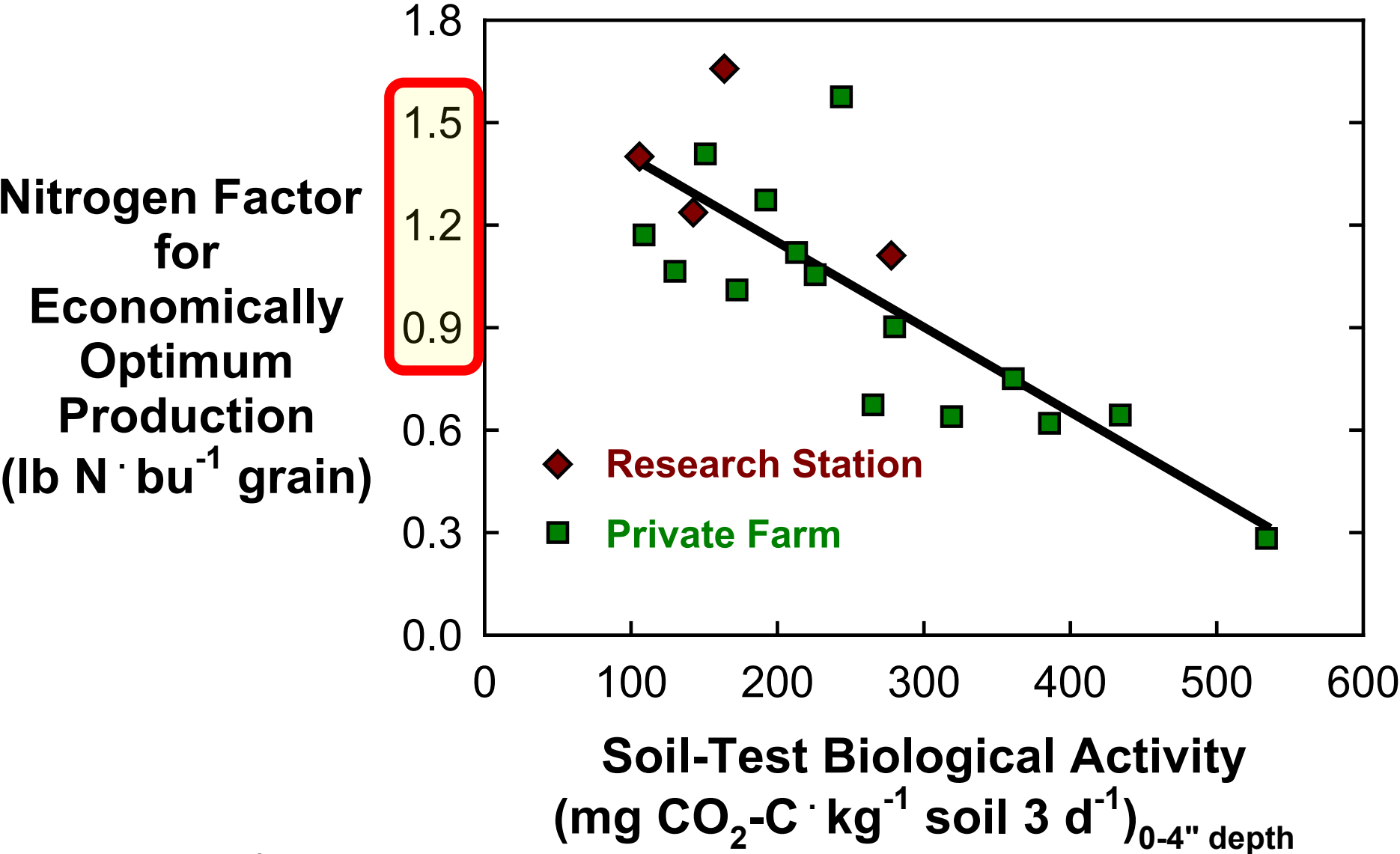


Jeff Westbury
Dorchester Co SC



Trent Pendarvis
Dorchester Co SC

Similar results obtained!



Years in continuous no-till, Suffolk, VA

(same soil type & inherent properties)

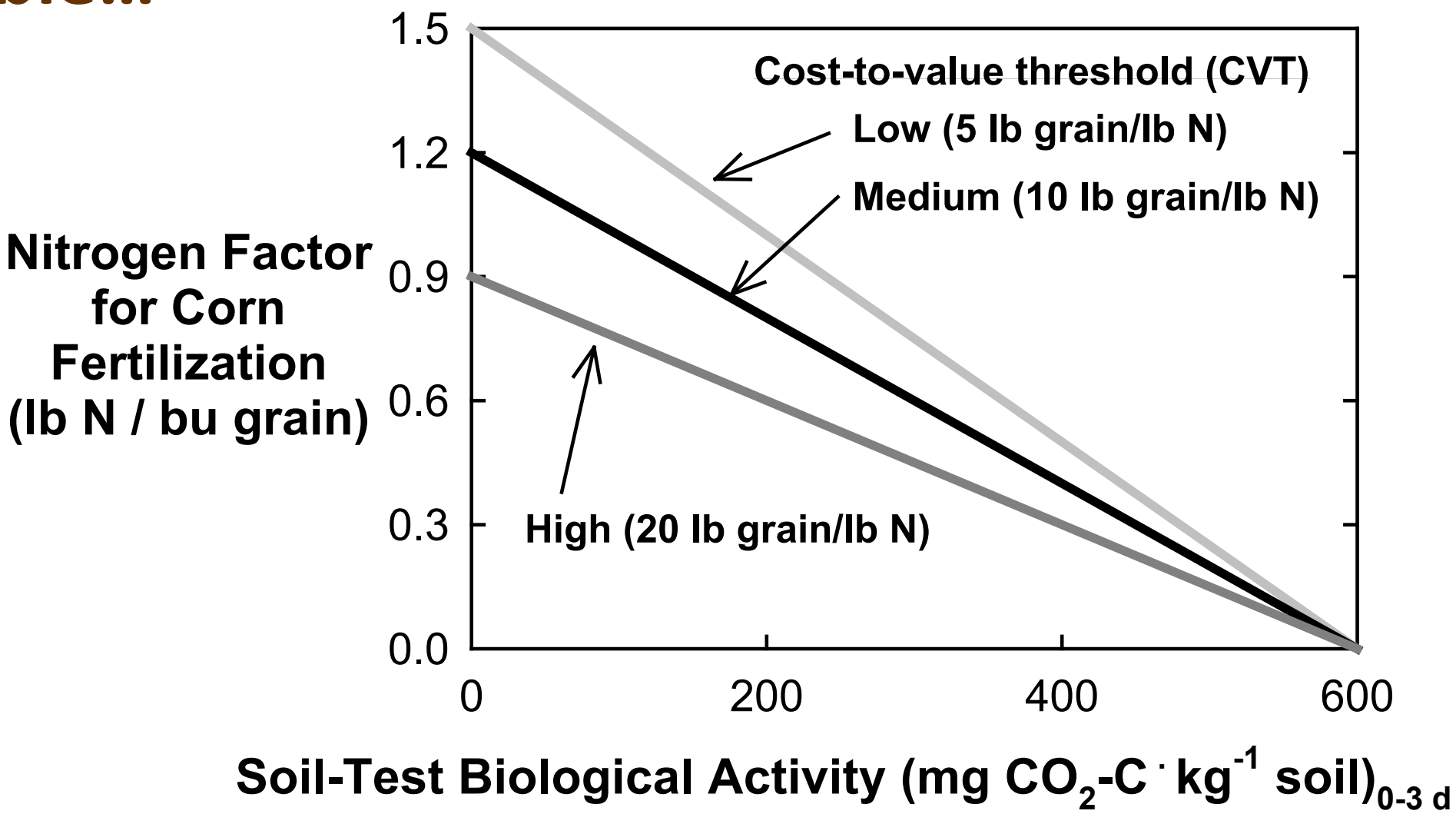


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3

20

An alternative N recommendation system now available...



Strengths and Limitations of for Corn and Opp

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ABSTRACT

Nitrogen fixation by the Haber–Bosch process has more than doubled the amount of fixed N on Earth, significantly influencing the global N cycle. Much of this fixed N is made into fertilizer that is used to produce nearly half of the world's food. Too much of the N fertilizer pollutes air and water when it is lost from agroecosystems through volatilization, denitrification, leaching, and runoff. Most of the N fertilizer used in the United States is applied to corn (*Zea mays* L.), and the profitability and environmental footprint of corn production is directly tied to fertilizer applications. Accurately predicting the amount of N needed by corn, however, has proven to be challenging because of the effects of rainfall, temperature, and interactions with soil properties on the N cycle. For this reason, improving N recommendations is critical for profitable corn production and for reducing N losses to the environment. The objectives of this paper were to review current methods for estimating N need of corn by: (i) reviewing fundamental background information about how N recommendations are created; (ii) evaluating the performance, strengths, and limitations of systems and tools used for making N fertilizer recommendations; (iii) discussing how adaptive management principles and methods can improve recommendations; and (iv) providing a framework for improving N fertilizer rate recommendations.

Core Ideas

- Nitrogen recommendations for individual corn fields are less accurate than desired.
- Nitrogen recommendations need improvement for economic and environmental reasons.
- A review of fundamental concepts will improve understanding about N recommendations.
- Examination of N recommendation systems, tests, and models will improve recommendations.

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underlying complexity in Eq. [10].

Careful analysis of the cost of adding better estimates for parameters in the N recommendation equation compared with the benefits in terms of improved estimates of N need should always be part of the process. Improvements in recommendations will be incremental, and we cannot wait until every parameter in an N recommendation equation is well described before we make use of modest improvements in recommendations through better parameter estimates. Farmers, the agricultural community, environmentalists, and citizens interested in our food system must be realistic about the uncertainty inherent in N recommendations; in humid environments rainfall will always create large uncertainties in the amount of N fertilizer needed by corn.

Several current methodologies discussed in this paper

***My pitch on
soil health
assessment &
measurement***



Chris' pitch on SH assessment & measurement

1. We can assess, promote, improve SH without quantitative measurement
 - Already doing it, need to continue!
2. But time is right to kick off greater emphasis on SH measurement in VA
3. The priority to focus on:
 - Being very selective/strategic about which SH indicators we measure!
4. The indicator to focus on:
 - Bioavailable or potentially mineralizable N (BAN or PMN)
5. The question to focus on:
 - How do SH-related increases in soil BAN/PMN correlate to less N fertilizer need in field?
6. Beware of under-read naysayers & the over-read obfuscators!
7. Next steps:
 - Communicate, debate, build consensus on VA SH assessment & measurement strategy
 - Fund and pursue that strategy with laser focus
 - Keep it simple and believe that we can make a difference!

Cropland Irrigation Management as a Best Management Practice: Findings from a Scientific Review

USDA-NRCS Virginia State Technical Committee

NRCS Virginia State Office – Richmond, Virginia

November 14, 2019



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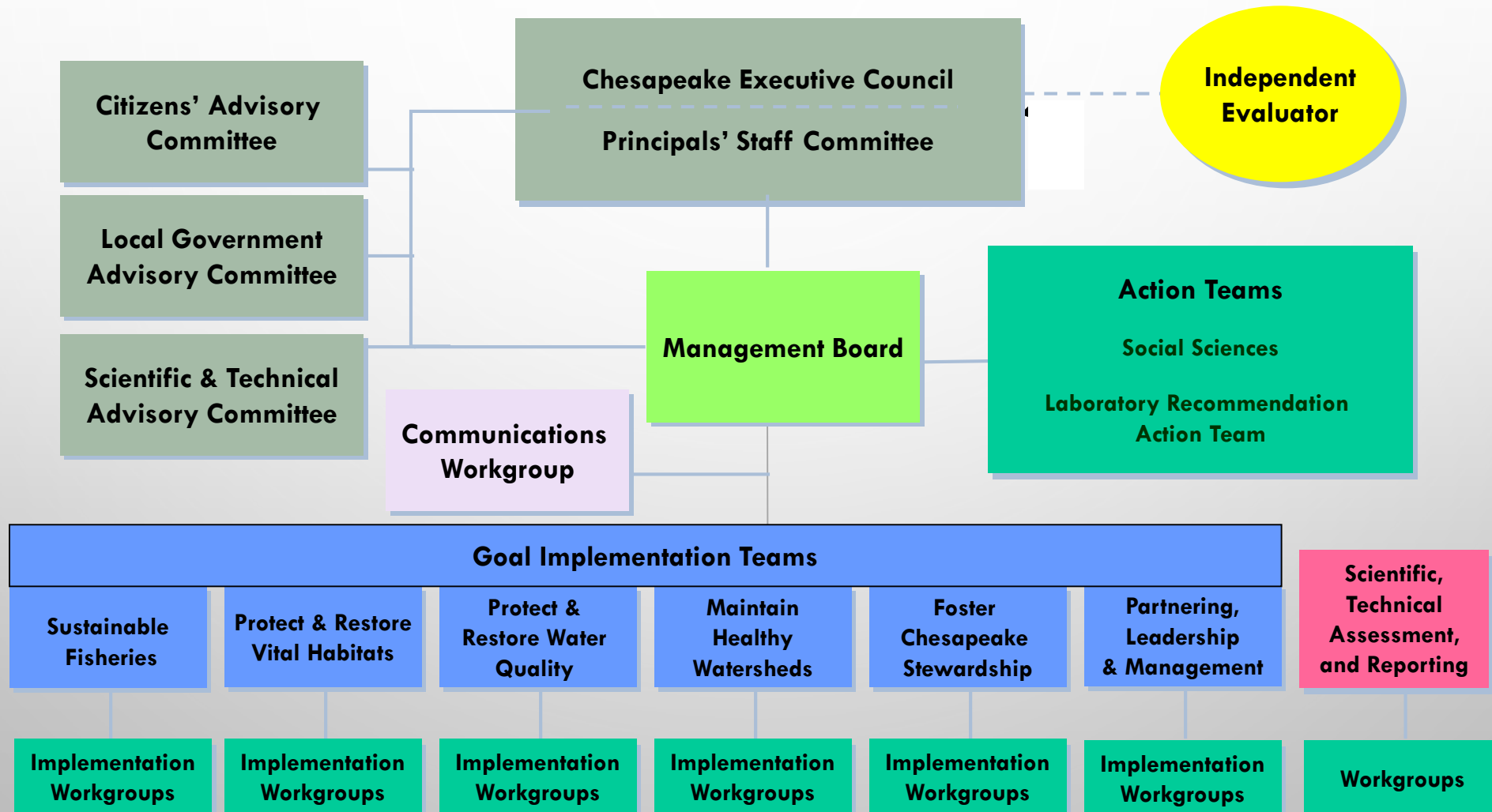
Cropland Irrigation Management as a Best Management Practice

Presentation Agenda:

- ❖ **Chesapeake Bay Program Partnership**
- ❖ **Cropland Irrigation in the Mid-Atlantic Region**
- ❖ **Cropland Irrigation Expert Panel Formation**
- ❖ **Expert Panel Conclusions**
- ❖ **Expert Panel Recommendations**
- ❖ **Expert Panel Recommendation Report Review**



CHESAPEAKE BAY PROGRAM MANAGEMENT STRUCTURE



GOAL IMPLEMENTATION TEAMS' WORKGROUP STRUCTURE



The background image shows a center pivot irrigation system with multiple metal wheels and support structures stretching across a vast field of mature, golden-brown corn. The perspective is from a low angle, looking down the length of the system towards the horizon. The sky is a pale, clear blue. The overall scene conveys a sense of large-scale agricultural management.

Cropland Irrigation Management as a Best Management Practice

Cropland Irrigation in the Mid-Atlantic Region

Cropland Irrigation Management as a BMP

Cropland Irrigation in the Mid-Atlantic Region:

- Irrigation is the addition of water to lands via artificial means. While irrigation is essential to agricultural systems in arid regions, it is also practiced in humid and sub-humid climates – such as the Mid-Atlantic – to protect crops against periods of drought and to maximize production and the farmer's profit by applying water when needed by the crop.
- Water used for irrigation can be from either groundwater or surface water sources. Some irrigation systems use reclaimed wastewater from treatment facilities, but those systems are not considered for the purposes of the Expert Panel report.

Cropland Irrigation Management as a BMP

Cropland Irrigation in the Mid-Atlantic Region:

- There are multiple methods for irrigation, and many more types of irrigation systems, summarized below. However, only a subset of irrigation systems are currently applicable to the Chesapeake Bay region and the Delmarva Peninsula.
- The basic methods of applying irrigation water include
 - (1) surface (or flood) irrigation by gravity,
 - (2) sprinkler,
 - (3) trickle (micro-irrigation),
 - (4) subsurface.
- Those four methods include multiple types of irrigation systems.

Cropland Irrigation Management as a BMP

- **Surface (or flood) Irrigation:**

An irrigation method that encompasses furrow, basin, border, contour-levee or contour ditch types of irrigation systems. Also commonly referred to as irrigation by gravity. Irrigation by gravity is uncommon in the Chesapeake Bay watershed.

- **Sprinkler or Pressure-based Irrigation:**

There are many types of sprinkler irrigation systems, but the most common ones are: self-propelled lateral move or center-pivot systems and traveling gun or other traveling single- or multi-sprinkler systems portable by hand or tractor. This method is the most common in the Chesapeake Bay Watershed for cropland irrigation systems.

- **Micro-irrigation or Trickle Irrigation:**

Includes a variety of irrigation systems that generally apply water through frequent, low volume and low-pressure systems of porous tubing with uniformly spaced emitter points. These systems are typically associated with orchards, vineyards, or other cropping systems.

- **Subsurface Irrigation:**

methods involve systems that manage the water table by providing subsurface and controlled drainage, irrigating via buried laterals; these systems are not applicable to the crop types and Chesapeake Bay watershed.

Cropland Irrigation Management as a BMP

Cropland Irrigation in the Mid-Atlantic Region:

- Irrigation Fact:

Nationally, irrigation represents one-third of all water use; the majority of water used for irrigation occurs in 17 western states, with those states accounting for 83 percent of total irrigation water withdrawals and 74 percent of irrigated acres based on 2010 data (Maupin et al., 2014).

Cropland Irrigation Management as a BMP

Cropland Irrigation in the Mid-Atlantic Region:

- **Irrigation Fact:**

Altogether the six Bay states account for only about three-tenths of one percent of the total water withdrawals and nine-tenths of one percent of the total irrigated land nationwide.

- These estimates are state-wide values and are not adjusted to the portion of the states within the Chesapeake Bay Watershed. Furthermore, they include all irrigation uses, not just agriculture. However, they still illustrate the relative importance of irrigation in the comparatively smaller states of Delaware and Maryland, whose estimated water withdrawals for irrigation are larger than that of the other states and account for over half of the total water use (194,800 acre-feet out of 373,000 acre-feet in 2010).

Cropland Irrigation Management as a BMP

Cropland Irrigation in the Mid-Atlantic Region:

- Irrigation Fact:

The 2012 Census of Agriculture reinforces the relative importance of irrigation in Delaware and Maryland. Proportionally speaking, approximately 1-in-5 Delaware farms and 1-in-10 Maryland farms have irrigation.

- Irrigation Fact:

Consistent with Maupin et al. (2014), Delaware and Maryland account for over half the total irrigated land in the Chesapeake Bay Region on a statewide basis, despite their relatively small size. Large portions of these two states are located within the Chesapeake Bay watershed (CBW), whereas irrigated land in New York State is mostly outside the CBW.

Cropland Irrigation Management as a BMP

Cropland Irrigation in the Mid-Atlantic Region:

- Irrigation Fact:

Virginia implements irrigation on approximately 63,400 acres statewide, the majority on agricultural harvested cropland amounting to some 62,300 acres every year.

- Irrigation Fact:

Virginia agriculture implements irrigation on multiple types of production statewide, including approximately 14,800 acres on berry production, 13,600 acres on grain corn, and 4,100 acres on silage corn production in the Shenandoah Valley annually.

Cropland Irrigation Management as a

- Best Management Practice

Cropland Irrigation Expert Panel Formation

Cropland Irrigation Management as a BMP

Expert Panel Formation:

- In the Phase 5.3.2 Chesapeake Bay Watershed Model, cropland irrigation was first recognized as an interim best management practice (BMP) for planning purposes.
- Interim BMPs can be used for planning scenarios but are not credited in annual progress scenarios as part of net management actions or BMP implementation until the BMP has been reviewed and approved by the Chesapeake Bay Program (CBP) partnership.
 - The process to review and approve BMPs for this purpose is described in the Water Quality Goal Implementation Team's (WQGIT) Protocol for the Development, Review, and Approval of Loading and Effectiveness Estimates for Nutrient and Sediment Controls in the Chesapeake Bay Watershed Model, aka the "BMP Review Protocol" or "BMP Protocol."²

Cropland Irrigation Management as a BMP

Expert Panel Formation:

- In 2015 the Agriculture Workgroup (AgWG) identified cropland irrigation as a BMP that should be considered by a BMP Expert Panel (EP) under the BMP Protocol.
- The AgWG formed an ad hoc group – or Expert Panel Establishment Group (EPEG) – to formulate the scope of work and suggested expertise for the subsequent panel.
- The EPEG's recommendations were approved by the AgWG in April 2015 and when staff resources were available a group of experts were identified for partnership consideration in May 2016.
- The panel convened following AgWG approval of the membership in July 2016. The panel met eight times from August 2016 to December 2018.

Cropland Irrigation Management as a BMP

Expert Panel Formation:

- **Cropland Irrigation Management Expert Panel:**
 - Tim Sexton, Panel Chair, Virginia Department of Conservation and Recreation
 - James Adkins, University of Delaware
 - Judy Denver, US Geological Survey (retired)
 - Greg McCarty, PhD, US Department of Agriculture – Agriculture Research Service
 - Cory Whaley, PhD, University of Delaware
- **Panel Support:**
 - Jeremy Hanson, Virginia Tech
 - Loretta Collins, University of Maryland
 - Mark Dubin, University of Maryland
 - Brian Benham, PhD, Virginia Tech
 - Jerry Lewis, US Department of Agriculture -- Natural Resource Conservation Service

Cropland Irrigation Management as a BMP

Expert Panel Charge:

- Determine water quality benefits of irrigation on cropland
 - Address benefits of nitrogen, phosphorus, and sediment, if exist, based upon research
- Determine main crops irrigated in Chesapeake Bay Watershed (CBW)
- Refine current interim Best Management Practice (BMP) definition of cropland irrigation.
- Cropland Irrigation – Identify decreased variation in annual yields for irrigated cropland versus non-irrigated cropland and the possible influences on water quality.
- Cropland Water Management – Determine if soil moisture management and water conservation practices have identified water quality benefits.

Cropland Irrigation Management as a BMP

Expert Panel Charge:

- **Fertigation – Determine the effect of the utilization of irrigation systems for the application of water as well as organic inorganic nutrient sources has on water quality.**
- **Consider a baseline condition that addresses irrigation system operation and management.**
- **Identify any regional variations in irrigation practices and BMP effectiveness values.**

Cropland Irrigation Management as a

- Best Management Practice

Cropland Irrigation Expert Panel Conclusions

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- **Literature Review:**
 - 120 peer-reviewed research papers (most outside CBW)
 - Very limited research addressing WQ issues on irrigated land
 - Some research not applicable due to different climatic conditions
 - Limited research on irrigation systems other than center pivot.
 - Limited research on crops other than corn
- **USGS water quality irrigation research project completed and report published. Conclusions did not identify water quality benefits associated with irrigation.**
- **Some local research locally on-going (UD), but not published. Inconclusive due to abnormally wet weather conditions.**

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- **Variable Factors Effecting Outcomes:**
 - Rainfall is unpredictable in the Chesapeake Bay Watershed, and becoming more so over time.
 - In the Chesapeake Bay Watershed only 0.3% of total water withdrawals are for irrigation. Concentrated on Delmarva.
 - Soils vary from loamy sands with low water holding capabilities to clays with high runoff potential.
 - Primary intention of irrigation is to maximize crop yields and economic profits.

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- All Chesapeake Bay states have separate Land Grant University recommendations for crop nitrogen applications on irrigated versus non-irrigated lands. Differences in application rates are accounted for as part of Nutrient Management.
- Current research available nationally or regionally does not sufficiently show a water quality benefit associated with cropland irrigation. In some instances there may be increased nitrogen losses to the environment.
- All aspects of irrigation influence the amount of nitrogen loss, including system designs, calibration and management.
- Majority of the Available Research:
 - Comes from mid-western states or more arid area
 - Addresses engineering efficiencies of different types of systems instead of water quality benefits.

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- Nitrogen Efficiency:
 - The Expert Panel agreed that there is not sufficient science-based research available to indicate a reduction in N losses due to irrigation of corn, therefore an N efficiency value cannot be established at this time.
 - This does not preclude the possibility of revisiting cropland irrigation as a BMP for a future expert panel, should a more robust catalogue of scientific research literature addressing cropland irrigation management and its water quality impacts emerge.
 - The panel strongly encourages further research on the impacts of cropland irrigation on nutrient and sediment loss and encourage the readers to review the *Ancillary Benefits and Unintended Consequences and Future Research and Management Needs Section* of the recommendations report. (p. ii)

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- **Phosphorus Efficiency (TP):**
 - The Expert Panel likewise determined that there is little to no science-based research available to indicate a reduction in TP losses due to irrigation of corn, therefore a TP efficiency value was not considered.
- **Sediment Efficiency (TSS):**
 - Similar to Phosphorus, the Expert Panel also determined that there is little to no science-based research available to indicate a reduction in TSS losses due to irrigation of corn, therefore a TSS efficiency value was not considered.

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- Taking into account the limited research data currently available and the variable nature of the conclusions to be drawn from that data, the EP has determined that an N efficiency value for cropland irrigation cannot be assigned at this time. Among the research available for review, there is reasonable indication that irrigating cropland can result in increased N leaching past the root zone relative to non-irrigated cropland. Increased N leaching would warrant a negative N efficiency in the context of water quality.

Cropland Irrigation Management as a BMP

Expert Panel Conclusions:

- The efficiency values associated with past CBP BMP Expert Panels (e.g., cover crops, conservation tillage) were determined not by nutrient uptake or removal, but by how a practice could reduce nutrient runoff or leakage of nutrients past the root zone. This panel chooses not to deviate from this approach. This recommendation does not prevent the possibility of an N efficiency for cropland irrigation as a CBP BMP at a future date if new research addresses gaps and uncertainties highlighted in this report. At this time, however, the panel's best professional judgment could not be used to fill the gaps, conflicting evidence and uncertainties in the existing available research, especially for nitrate leaching and NUE.

Cropland Irrigation Management as a

- Best Management Practice

Cropland Irrigation Expert Panel Recommendations

Cropland Irrigation Management as a BMP

Expert Panel Recommendations:

- The conclusion of this EP is that there is not currently enough evidence to definitively state that irrigation on corn will decrease N loss and thus prevent water quality degradation. On the contrary, there is some research indicating that irrigation may result in increased nitrate concentrations and loads in groundwater. That said, there is agreement among panel members that more research on cropland irrigation impacts to water quality is needed in the CBW and more specifically on the Delmarva Peninsula, where center-pivot irrigation systems are now a mainstay in corn cultivation. For this reason, the EP has several recommendations for further research that could better inform our understanding of cropland irrigation and its interception with nutrient reduction into the future.

Cropland Irrigation Management as a BMP

Future Research Opportunities:

- Understanding P behavior under irrigated versus dryland cropping conditions.
- Crop response and Nitrogen use efficiency –
 - Data collection on crop response to irrigation rate on the coastal plain
 - Field tests OF NUE assumptions regarding non-irrigated vs. Irrigated plots under Delaware field conditions (sims et al. 2012) and the impact of those assumptions on nitrogen loss.
 - Chesapeake Bay Watershed field research on supplemental irrigation.
 - Inconclusive data limits the assertion that increased crude protein in corn is an indication of less nutrients subject to leaching.
- Nutrient Source –

Explore the impact of litter and manure applications under irrigated conditions.
- Nutrient Management –
 - Research on most efficient N rates for irrigated corn and other crops to ensure that nutrient application recommendations are based off the latest scientific data.

Cropland Irrigation Management as a BMP

Future Research Opportunities:

- **Water Quality Research:**
 - Sensitivity analyses of studies looking at N leaching associated with irrigation to account for potential noise in the observed data.
 - Development of model scenarios to address impacts of various environmental conditions on potential for nutrient leaching and transport.
 - Identification of modeling data that does exist that can inform evaluation of irrigation under different environmental conditions.
 - Monitoring water and land management practices in a strategic manner to collect the data most critical to informing modeling scenarios.
 - A long-term (5-8 year) study with broad participation is needed to get a better sense of average conditions.
 - Research and data informing the conditions under which a water quality benefit could be expected from cropland irrigation
 - (i.e. weather, water management, nutrient management, healthy soil practices, soil organic matter content).

Cropland Irrigation Management as a BMP

Future Research Opportunities:

- **Irrigation Management:**
 - Chesapeake Bay Watershed research on variable rate irrigation to address irrigation on fields encompassing wetlands or uneven soil moisture conditions.
 - Research on the interaction of irrigation management with other measurable variables
 - (i.e. yields, biomass, soil moisture).
 - Increased management data available on private systems from use of pump monitors, onsite weather monitoring stations, soil moisture monitors, nutrient application and crop yield mapping, etc.

Cropland Irrigation Management as a • Best Management Practice

Cropland Irrigation Expert Panel Report Review

Timeline And Next Steps

Date	Action
January 16, 2019	Recommendations Report released for review
February 26, 2019	Webinar and Public Meeting: Recommendations of the Cropland Irrigation Expert Panel
March 12, 2019	Final day for partnership feedback (no feedback received)
March 21, 2019 (AgWG meeting)	Panel Chair requests approval from AgWG; decision postponed pending DE feedback
April 15, 2019	DE feedback submitted to AgWG leadership and Expert Panel
April 18, 2019	Panel Chair acknowledges receipt of DE feedback and anticipated panel review in time for decision for approval at May AgWG meeting.
April 18 – May 7, 2019	Draft responses compiled and shared with panel; panel convenes to discuss feedback and responses; consensus from the panel on the responses and acceptable revisions to the report
May 9, 2019	Revised report and responses from panel distributed for AgWG
May 16, 2019 (AgWG meeting)	Panel Chair requests approval from AgWG, with DE feedback considered. (motion not approved – transferred to the WQGIT for approval)
June 10, 2019	Panel Chair requests approval from Water Quality GIT, with DE feedback considered (motion not approved – transferred to the Management Board)

Cropland Irrigation Management as a BMP

CBP Partnership Review and Decisions:

- CBP Management Board Quarterly Meeting – November 21, 2019 (Tentative)
 - The CBP Management Board is asked to approve the recommendation report of the cropland irrigation expert panel.
 - The CBP Management Board is asked to make a determination for continuance or removal of the interim BMP efficiency for cropland irrigation
- Copy of Panel Recommendation Report -
https://www.chesapeakebay.net/channel_files/30678/cropland_irr_ep_report_final_09may2019-revised-for-cbp.pdf

Cropland Irrigation Management as a

- Best Management Practice

Audience Questions

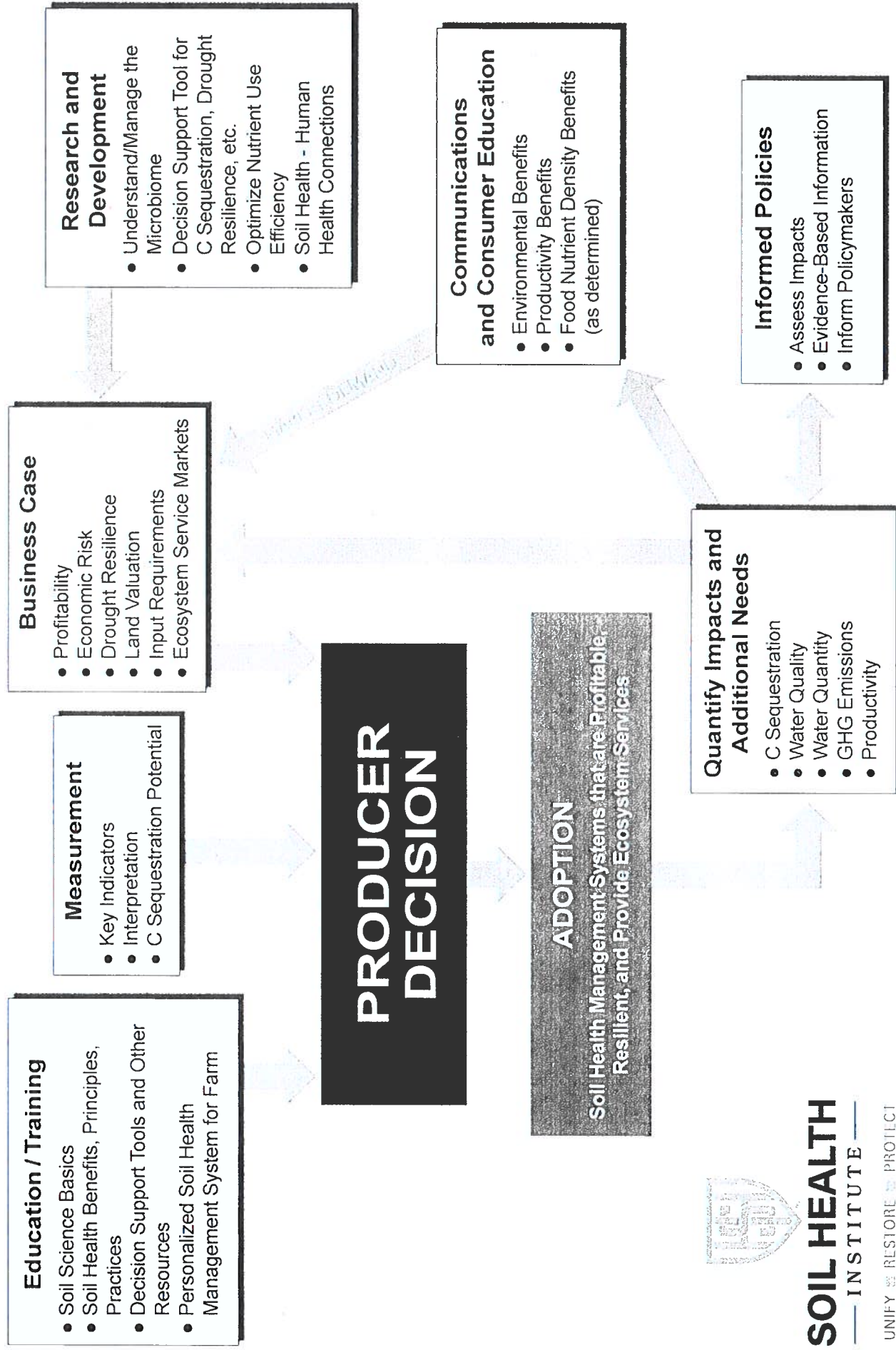
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2. But time is right to kick off greater emphasis on SH measurement in VA
3. The priority to focus on:
 - Being very selective/strategic about which SH indicators we measure!
4. The indicator to focus on:
 - Bioavailable or potentially mineralizable N (BAN or PMN)
5. The question to focus on:
 - How do SH-related increases in soil BAN/PMN correlate to less N fertilizer need in field?
6. Beware of under-read naysayers & the over-read obfuscators!
7. Next steps:
 - Communicate, debate, build consensus on VA SH assessment & measurement strategy
 - Fund and pursue that strategy with laser focus
 - Keep it simple and believe that we can make a difference!

Chris' 4 approaches to SH assessment

1. Farmer observation
 - I.E.: Ask the patient – “How do things seem to be working?”
 - E.G.: “I see more earthworms, less runoff, more drought tolerance.”
 - Can assess both past and present performance for range of indicators
2. Management analysis
 - I.E.: Ask the patient - “Tell me your daily routine, which will tell me about your health”
 - E.G.: Models, from simple to highly complex
 - RUSLE2, Soil Conditioning Index (SCI), Soil Health Management System (SHMS), EPIC, etc.
 - AKA: “Decision Support Tools”
 - Can assess past, present performance for range of indicators
3. Direct assessment – Qualitative / Semi-quantitative (usually field)
 - I.E., Observe, touch, manipulate the patient
 - E.G., Soil health field scorecard, comparative demonstrations (slaking, rain sim, etc.)
 - Can only assess present condition
4. Direct assessment – Quantitative (usually lab)
 - I.E., Measure patient, patient performance, or something extracted from patient
 - E.G., Lab testing, rigorous field measurements (replicated & randomized), etc.
 - Can only assess present condition

Comprehensive Strategy to Increase Adoption of Soil Health Management Systems



SOIL HEALTH
— INSTITUTE —

UNIFY • RESTORE • PROTECT



On-Farm Research

2019-202

Nitrogen Fertilizer

Recommendation System using Soil-Test Biological Activity

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Basis

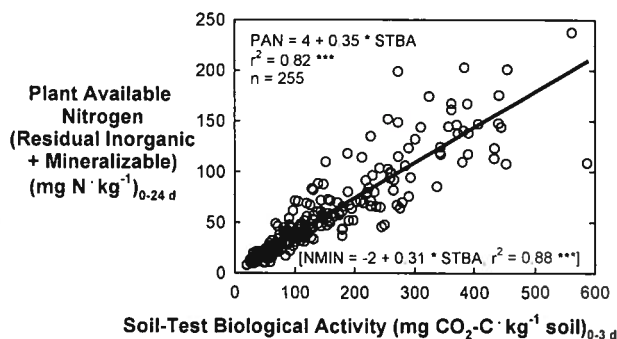
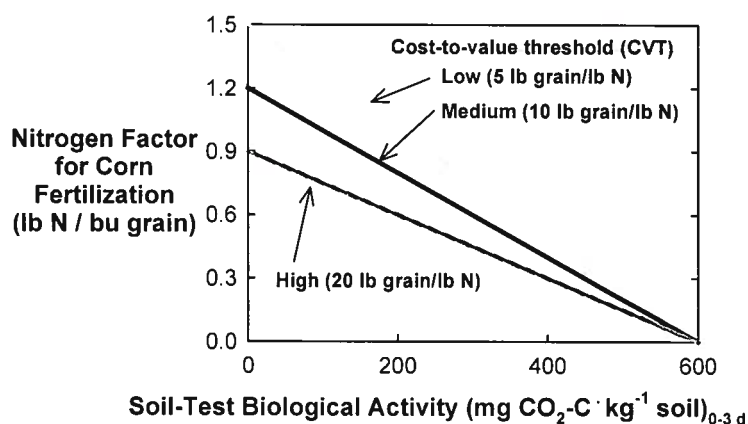
Research on corn yield response to sidedress application of nitrogen (N) was conducted on 158 farm fields in North Carolina, South Carolina, and Virginia from 2014-2018. Trials on 47 fields conducted in 2014-2016 were published in *Soil Science Society of America Journal* (2018) Volume 82, Pages 708-721. A manuscript describing 111 field trials conducted in 2017-2018 is under review in *Agronomy Journal*. The upper figure to the right synthesizes the results of these trials into a N fertilizer recommendation system based on soil health condition. In this case, soil-test biological activity (STBA) is the most revealing attribute of soil health condition for nutrient cycling. Soil-test biological activity is highly associated with soil N mineralization potential (note lower figure at right). Therefore, the larger the value of STBA, the greater the likelihood of significant N mineralization from soil.

Refer to OFR-2018-01 for information on sampling guidelines.

Recommendation

Cost-to-value threshold needs to be considered when fertilizing corn. Nitrogen fertilizer has a marginal cost per unit of application that needs to be recovered with a minimum value of grain produced. The table to lower left describes some scenarios. The table at right describes how the N factor can be adjusted based on soil-test biological activity and knowing the cost-to-value threshold that matches your current conditions.

Value of Grain (\$/bu)	Cost of N Fertilizer (\$/lb)		
	0.50	0.75	1.00
	--- Cost-to-Value Threshold ---		
3.00	9.3	14.0	18.7
4.00	7.0	10.5	14.0
5.00	5.6	8.4	11.2



Soil-Test Biological Activity (mg/kg/3 d)	Cost-to-Value Threshold (lb grain/lb N)		
	Low (5)	Medium (10)	High (20)
	--- Nitrogen Factor (lb N / bu grain) ---		
50	1.38	1.10	0.83
100	1.25	1.00	0.75
150	1.13	0.90	0.68
200	1.00	0.80	0.60
250	0.88	0.70	0.53
300	0.75	0.60	0.45
350	0.63	0.50	0.38
400	0.50	0.40	0.30
450	0.38	0.30	0.23
500	0.25	0.20	0.15



Easements: FY-2019 Summary on Land Conservation Easements

Agricultural Conservation Easement Program (ACEP)

Components: Agricultural Land Easement (ALE) & Wetland Reserve Easement (WRE)

FY-19 Highlights

- **New applications:** 6 ALE (5 funded), 3 WRE (0 funded), requests total ~\$3,300,000.
Obligated ALE Agreements for \$1,648,500 (including \$200,000 RCPP ALE).
Returned WRE \$249,314 due to two ineligible and one canceled.
- **In progress at years-end:** Acquisitions: 7 ALE, 1 WRE, and 5 WRE restorations.
- **Closed** one ALE 154-acre farm.
- **Restoration** completed on one WRE wetland.
- **Stewardship:** Monitored 100% of NRCS-funded easements.
- **WRE compensation:** the FY-19 valuation utilizes a Geographic Area Rate Cap (GARC) percentage of 95%, applied to individual property appraisals (as in recent years).
- **WRE special area compensation** was approved for 20 counties. These higher value areas have high development pressure and networks of tributaries flowing through the Chesapeake Bay Watershed.

Perpetual Easements Acquired with NRCS Funds (1993 – 2019, life of program)

141 perpetual easements, totaling 16,555 acres

78 # Agricultural (Farmland) Easements (ALE, FRPP, GRP)

63 # Wetland Easements (WRE, WRP, EWPP)

141 # Total easements funded (both Ag & Wetland)

16,555 acres Total acres funded (both Ag & Wetland)

Diane.Dunaway@usda.gov . Easement Program Manager . 804.287.1634

USDA Natural Resources Conservation Service . [VA NRCS Easement Website](#)

EQIP Budget Allocation - 9/30/19

Fund Code	Account Name	Allocated	Contracts	Contract Approval	Funds Remaining
76F 51	Virginia	\$26,146,252.57	608	\$25,816,922.22	\$329,330.35
76F 51 BC	Beginning Farmer - Cropland	\$268,541.00	6	\$268,541.00	\$0.00
76F 51 BF	Beginning Farmer - Livestock	\$391,891.01	6	\$391,891.01	\$0.00
76F 51 CA	CAPS-Conservation Activity Plans	\$81,195.10	25	\$81,195.10	\$0.00
76F 51 CC	Cropland - Christiansburg	\$58,799.00	2	\$58,798.79	\$0.21
76F 51 CF	Cropland - Farmville	\$57,258.00	3	\$57,258.00	\$0.00
76F 51 CH	Cropland - Harrisonburg	\$433,300.00	11	\$433,300.00	\$0.00
76F 51 CS	Cropland - Smithfield	\$792,345.00	21	\$792,345.00	\$0.00
76F 51 FS	Forestry - Longleaf/ Shortleaf Pine & Hardwood Mgm	\$96,669.24	11	\$96,669.24	\$0.00
76F 51 CP	Forestry - SDA Initiative CAPs	\$11,272.00	7	\$11,272.00	\$0.00
76F 51 SB	Forestry SDA Initiative	\$125,493.24	12	\$125,493.24	\$0.00
76F 51 2	FY19 Organic Certified	\$82,494.00	2	\$82,494.00	\$0.00
76F 51 3	FY19 Organic Transition	\$39,752.00	5	\$39,752.00	\$0.00
76F 51 GW	Golden Winged-Warbler	\$222,222.00	7	\$200,312.00	\$21,910.00
	Golden Winged-Warbler - Prior Year Funds FY18	\$703,706.00	6	\$688,024.00	\$15,682.00
76F 51 HT	High Tunnel Systems	\$364,366.80	39	\$364,366.80	\$0.00
76F 51 JC	Joint Chiefs - Lower Cowpasture Restoration Projec	\$150,000.00	6	\$149,906.00	\$94.00
76F 51 AC	Livestock - Christiansburg	\$2,058,881.00	9	\$2,058,881.00	\$0.00
76F 51 LF	Livestock - Farmville	\$2,168,608.06	27	\$2,168,608.06	\$0.00
76F 51 LH	Livestock - Harrisonburg	\$2,536,214.60	24	\$2,536,214.00	\$0.60
	Livestock - Harrisonburg - Prior Year FY15	\$1,170,004.00	3	\$1,153,625.00	\$16,379.00
76F 51 LS	Livestock - Smithfield	\$1,959,695.00	11	\$1,959,695.00	\$0.00
76F 51 GS	Livestock Grazing Systems Pilot	\$103,613.00	7	\$103,613.00	\$0.00
76F 51 LP	Long Leaf Pine Initiative	\$36,727.00	2	\$36,725.91	\$1.09
76F 51 FM	NWQI - Smith Creek - Gap Creek	\$29,269.00	2	\$29,269.00	\$0.00
76F 51 MR	NWQI - Smith Creek - Mountain Run	\$147,077.00	2	\$147,077.00	\$0.00
76F 51 WB	NWQI - Smith Creek - War Branch	\$36,225.00	2	\$36,225.00	\$0.00
76F 51 SC	Socially Disadvantaged - Cropland	\$110,252.13	12	\$110,252.13	\$0.00
76F 51 SD	Socially Disadvantaged - Livestock	\$385,139.36	9	\$385,139.36	\$0.00
76F 51 SP	StrikeForce - CAPS	\$114,163.07	43	\$114,162.62	\$0.45
76F 51 FC	StrikeForce - Cropland	\$2,277,859.65	72	\$2,277,859.65	\$0.00
76F 51 SS	StrikeForce - High Tunnel Systems	\$423,232.00	43	\$423,232.00	\$0.00
	StrikeForce - High Tunnel Systems - Prior Year FY18	\$307,000.00	31	\$295,598.40	\$11,401.60
	StrikeForce - High Tunnel Systems - Prior Year FY15	\$29,996.00	3	\$29,996.00	\$0.00
76F 51 SF	StrikeForce - Livestock	\$6,677,941.64	69	\$6,677,941.64	\$0.00
76F 51 WA	Wildlife - Aquatic Habitat	\$1,917.00	1	\$1,917.00	\$0.00
76F 51 WT	Wildlife - Terrestrial Habitat	\$778,780.00	44	\$778,780.00	\$0.00
76F 51 PS	WLFW 2.0 - Northern Bobwhite in Pine Savannahs	\$233,867.32	6	\$233,867.32	\$0.00
76F 51 AB	WLWF 2.0 - American Black Duck	\$38,360.00	2	\$38,360.00	\$0.00
76F 51 BQ	WLWF 2.0 - Northern Bobwhite in Working Grasslands	\$166,632.61	15	\$166,632.61	\$0.00
76F 51 18737	FY19 CIG State Component	\$133,650.00	0	\$133,650.00	\$0.00
76F 51 18922	FY19 EQIP Reserve	\$168,925.54		\$77,982.34	\$90,943.20
	Balance Available	\$172,918.20			\$172,918.20
	Total	\$26,146,252.57	608	\$25,816,922.22	\$329,330.35

Conservation Stewardship Program Budget Allocation (CSP-Classic) - 9/30/19

Fund Code	Account Name	Allocated	Contracts	Contract Approval
95F 51 85	Ag Land SDA	\$58,295.00	2	\$58,295.00
95F 51 86	Ag Land BF	\$740,511.87	20	\$740,511.87
95F 51 87	Ag Land General	\$2,723,839.52	41	\$2,723,839.52
95F 51 93	NIPF General	\$781,590.45	16	\$781,590.45
95F 51 97	NIPF SDA	\$11,400.00	1	\$11,400.00
95F 51 98	NIPF BF	\$607,225.43	20	\$607,225.43
	Total	\$4,922,862.27	100	\$4,922,862.27

CSP - Grassland Conservation Initiative - 9/30/19

82F 51 01	CSP-GCI	\$357,965.20	127	\$357,965.20
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RCPP Budget Allocation - September 30, 2019

Fund Code	Account Name	Allocated	Contracts / Approved	Contract Approval	Funds Remaining
RCPP-TNC	Upper Clinch-Powell Watershed Partnership	\$2,114,999.03	48	\$2,108,313.95	\$6,685.08
RCPP-VRMC	Oyster Bottom Restoration through Aquaculture	\$776,284.00	31	\$590,450.18	\$185,833.82
RCPP-NM	Chesapeake Bay Farm Stewardship and Preservation	\$1,363,240.00	11	\$1,354,659.00	\$8,581.00
RCPP-FCD	Franklin County Dairy Ag and Water Protection	\$637,500.00	1	\$164,699.00	\$472,801.00
RCPP-Small AFO's	Engaging Small AFOs in the NM Planning Process	\$651,000.00	2	\$553,113.00	\$97,887.00
	Totals	\$5,543,023.03	93	\$4,771,235.13	\$771,787.90



Agricultural Marketing Service

U.S. Domestic Hemp Production Program

To produce hemp, you first need to be licensed or authorized under a state, tribal, or USDA Hemp Program. The program plan you are licensed under depends on the location of your hemp growing facility.

Contact your local state department of agriculture or tribal government to see if they have a production plan that has been submitted to or approved by USDA.

If your state or tribal government has an approved plan or is in the process of developing a plan, you must apply to and be licensed or authorized under its hemp program. If your state or tribal government does not have a pending or approved hemp production plan, you may apply for a USDA hemp production license.

Applications to obtain a license to produce hemp under the USDA production plan are available on the USDA Hemp Program webpage.

You cannot receive a hemp production license from a state, tribal government or USDA if you have been convicted of a felony related to a controlled substance in the last 10 years.

STEPS TO BECOMING A HEMP PRODUCER:

Under a State or Tribal Government Plan:

1. Apply to the state or tribal government and receive authorization to grow hemp.
2. After you have planted, visit your local USDA Farm Service Agency (FSA) office:
 - ♦ Provide your state or tribal license or authorization identifier
 - ♦ Provide the geospatial location(s) where you are growing hemp
 - ♦ Receive a lot number or numbers from FSA



3. When it is time to sample the lot for the THC content:

- ♦ Request an authorized agent to sample each lot
- ♦ Follow proper sampling and testing procedures for measuring hemp THC content

4. Submit all required information to your state or tribal government.

Under the USDA Plan:

1. Verify:

- ♦ Your state or tribal government does not prohibit the production of hemp
- ♦ Your state or tribal government does not administer a hemp production program

2. Submit to the USDA Hemp Program:

- ♦ USDA License Application
- ♦ FBI Criminal History Report

3. After you have planted, visit your local FSA office:

- ♦ Provide USDA License Number
- ♦ Report the geospatial location(s) where you are growing hemp
- ♦ Receive a lot number or numbers from FSA

4. Submit all required information to the USDA Hemp Program.

CONTACT INFORMATION

For more information, please visit:

www.ams.usda.gov/rules-regulations/hemp

If you have any questions, please contact us at (202) 720-2491 or email Farmbill.Hemp@usda.gov.

Hemp and Farm Bill Programs



Hemp producers growing in accordance with USDA guidelines are eligible for certain USDA programs in 2020. USDA's Farm Agency (FSA), Natural Resources Conservation Service (NRCS), and Risk Management Agency (RMA) are updating guidelines on several programs to support growers of hemp, which was reclassified by the 2018 Farm Bill.

Once production plans are approved and licenses are issued, hemp producers may be eligible for many USDA programs for the 2020 crop year.

What could hemp producers be eligible for?

Whole-Farm Revenue Protection

The Whole-Farm Revenue Protection (WFRP) will be available for hemp grown for fiber, flower, or seeds. WFRP allows coverage of all revenue for commodities produced on a farm up to a total insured revenue of \$8.5 million.

Producers can purchase WFRP coverage if they have a contract for the purchase of the insured industrial hemp and meet all applicable state, tribal, and federal regulations.

Hemp that has tetrahydrocannabinol (THC) above the 0.3 compliance level will not be covered by crop insurance. Additionally, hemp will not qualify for replant payments under WFRP.

Noninsured Crop Disaster Assistance Program

The Noninsured Crop Disaster Assistance Program (NAP) will be available for eligible hemp producers to provide insurance-type coverage due to adverse weather conditions.

NRCS Conservation Programs

Multiple USDA conservation programs will be offered for eligible producers, including the Environmental Quality Incentives Program, Conservation Stewardship Program, Regional Conservation Partnership Program, and Agricultural Conservation Easement Program.

Farm Loans

Hemp producers may be eligible for FSA farm loans, such as operating, ownership, beginning farmer, and farm storage facility loans.

How do hemp producers report acres to USDA?

Acreage Reports

Hemp producers are required to file an acreage report with FSA. This is a requirement for growing under USDA-approved hemp plans as well as prerequisite for many USDA programs.

To file an acreage report, producers should:

- Obtain a hemp production license or authorization number issued by USDA, state, or tribe.
- File an acreage report with FSA, identifying each field or subfield on which hemp is planted, including the license or authorization number. The field or subfield could be referred to as a “lot” and does include greenhouses.
- Identify the intended use of the hemp being reported:
 - Fiber – used for cloth, pressed plastics, ropes, animal bedding, paper, biofuel, packaging, concrete additives, spill cleanup.
 - Processing – grown for extraction of plant resin, which includes cannabidiol (CBD) and other phytocannabinoids to be extracted from the flower. Resin is used in oils, lotions, cleansers, bath or other pharmaceutical or topical products.
 - Grain – used for hemp hearts, crushed seed oil (not CBD), protein supplements (human or animal consumption).
 - Seed – used for propagation stock, hybrids (non-human consumption).

Next Steps

USDA is working to make available program options for hemp producers. As information is available, USDA will post on farmers.gov/hemp. If you have additional questions, contact your local USDA service center, which you can find at farmers.gov/service-locator.

