SOIL QUALITY TWENTY YEARS LATER: LESSONS LEARNED AND TO BE LEARNED

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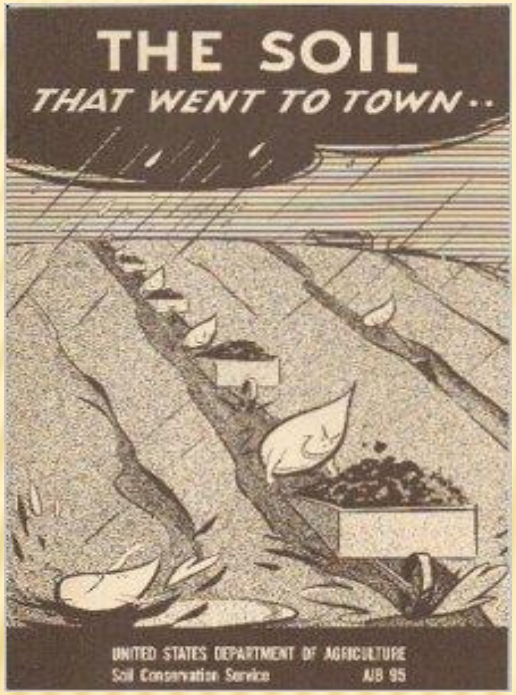
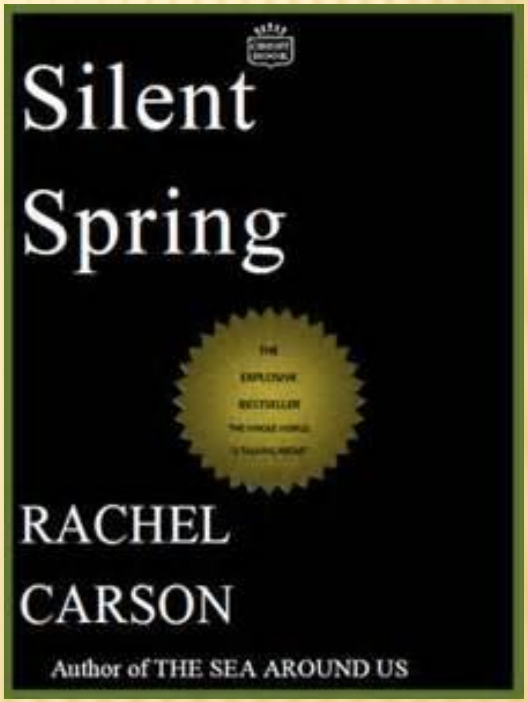
Presentation Overview

- My personal soil health timeline
- So what is soil health -- is it a new concept?
- Why should humankind be concerned?
- Lessons related to soil health assessment
- The Soil Management Assessment Framework (SMAF) and how it works
- Current and future soil health activities
- Summary and Conclusions

My Personal Soil Health History

- Recent reflections have revealed that my passion for soil health began when I was a teenager.





- As a result, "caring for the soil so that it can take care of us" became the focus for my research career.

My Soil Quality Timeline

- Pre-1970 – Yaalon, Bidwell, Hole, Jenny & many others discussed effects of humans on soil formation
- 1977 – Warkentin and Fletcher endorse Alexander's 1971 proposal to develop SQ criteria for intensification of agricultural production
- 1991 –Larson and Pierce provide an initial definition of soil quality
- 1994 – Karlen & Stott publish an assessment framework in SSSA Spec. Pub. #35; Karlen et al. use "SMAF" framework for Soil & Tillage Research articles in Volume 31 (149-167) and Volume 32 (313-327)
- 1995 – Canada published "Health of Our Soils"
- 1996/97 – SSSA publishes 'Methods of Assessing Soil Quality' and Karlen et al. SSSAJ 61:4-10
- 2004 – Andrews et al. publish SMAF framework in SSSAJ 68:1945-1962
- 2006 – 2010 –Soil quality sampling and analysis occurs within 17 ARS & NRCS Conservation Effects Assessment Project (CEAP) watersheds
- 2011 – present –SMAF used to assess sustainability of bioenergy feedstock production; Soil Health Partnership; Soil Renaissance Project

So What is Soil Quality (SQ)/Soil Health (SH)?

- It's defined as: The continued capacity of a soil to function as a vital living ecosystem that sustains plants, animals, and humans.
- It's important for guiding land use & soil management decisions so that the fragile resource protecting us from starvation is sustained for future generations.
- It's characterized as a dynamic, living entity that supports macro- and micro-organisms, nutrient cycling and physical properties needed to provide the basic necessities of life - food, shelter, and water ando perform functions required to produce food, feed, fiber and fuel.

Why Soil Health Instead of Soil Quality?

- Only "living" things can have health.
- Viewing soil as a living ecosystem reflects a fundamental shift in perception and management
- Soil is not an inorganic growing medium, but rather a dynamic resource teaming with billions of microbes that are the foundation of an elegant, symbiotic ecosystem.
- Soil is an ecosystem that can be managed to provide multiple soil functions


Concern for Soil Resources is not a NEW concept

As Plato in 2500 BC had Critias Proclaim –

"What now remains of the formerly rich land is like the skeleton of a sick man, with all the fat and soft earth having wasted away and only the bare framework remaining. Formerly, many of the mountains were arable. The plains that were full of rich soil are now marshes. Hills that were once covered with forests and produced abundant pasture now produce only food for bees. Once the land was enriched by yearly rains, which were not lost, as they are now, by flowing from the bare land into the sea. The soil was deep, it absorbed and kept the water in the loamy soil, and the water that soaked into the hills fed springs and running streams everywhere. Now the abandoned shrines at spots where formerly there were springs attest that our description of the land is true."

Hillel (1991). *Out of the earth: Civilization and the life of the soil.*

So Why Should We Worry about Soil Health?

Soil Resources are Crucial for Sustaining Human Civilizations

Sustainability Means

Economically viable

Environmentally sound

Socially acceptable

But, Inappropriate Soil Management Still Exists










Photos from the NRCS)

Poor Choices

Row crops on steep slopes that are tilled

Excessive stover harvest plus tillage

A continued love for moldboard plowing

Massey Ferguson MF 8289 387 HP tractor

World plowing Record in 2003 – 251.5 ha (621 ac) in 24 hours

Consumed 2100 L fuel & Released ~500 tonnes CO_2

Are we really willing to change?

Adapted from D.C. Reicosky, Retired USDA-ARS Soil Scientist

Recent Government, NGO, & Private Industry Investments say – YES!

NRCS Soil Health Division

SOIL RENAISSANCE

SOIL HEALTH PARTNERSHIP

Soil Health Institute

FFAR Soil Health Advisory Team

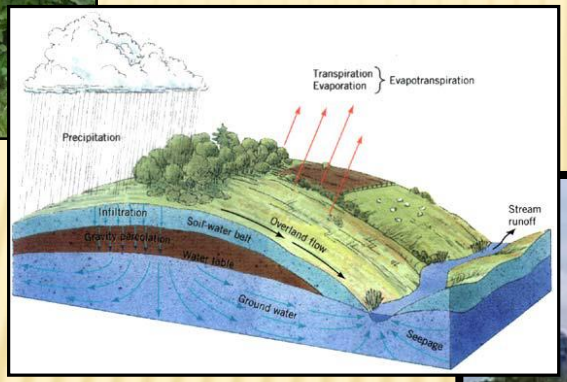
Soil Science Interagency Working Group

What We've Learned Regarding Soil Health

Soils Have Many Different Critical Functions

Sustaining Biological Productivity

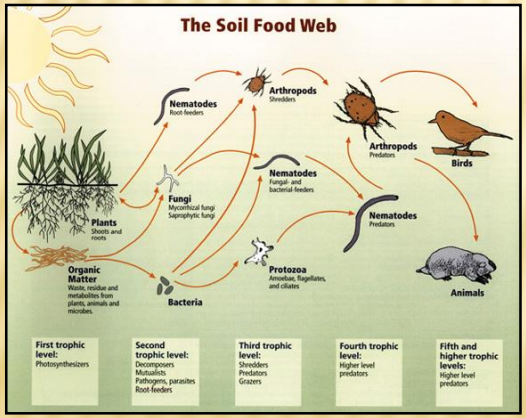
Regulating and partitioning soil water



Storing & Cycling Nutrients

Filtering and buffering

Providing Suitable Habitat for Soil Organisms



Providing an Engineering Medium

Soil Functions Are Influenced By:

- INHERENT FACTORS
  - Which reflect basic soil-forming properties: climate, topography, parent material, vegetation, & time
  - Generally reflected in the NRCS-Land Capability Classes
- DYNAMIC FACTORS
  - Which reflect the current soil status & /or condition
  - Influenced by current management decisions & past land use
- ASSESSED USING Indicators to determine the health of our soil resources

Soil Function Indicators Should:

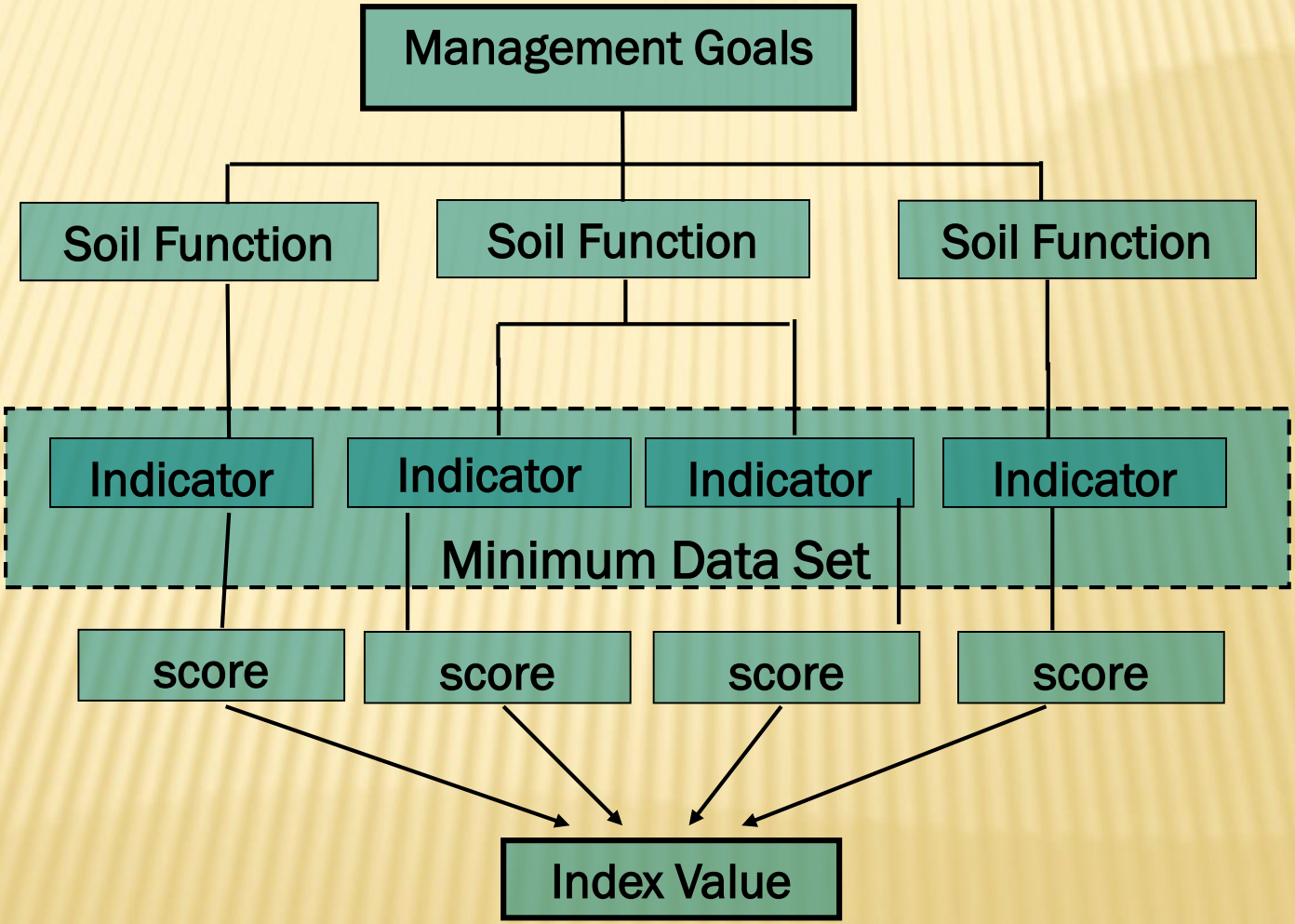
- Correlate well with ecosystem functions
- Integrate soil physical, chemical, and biological properties & processes
- Be accessible to many users
- Be sensitive to management & climate
- Be components of existing databases

- - Doran and Parkin, 1996

Developed the SMAF to Interpret Indicators

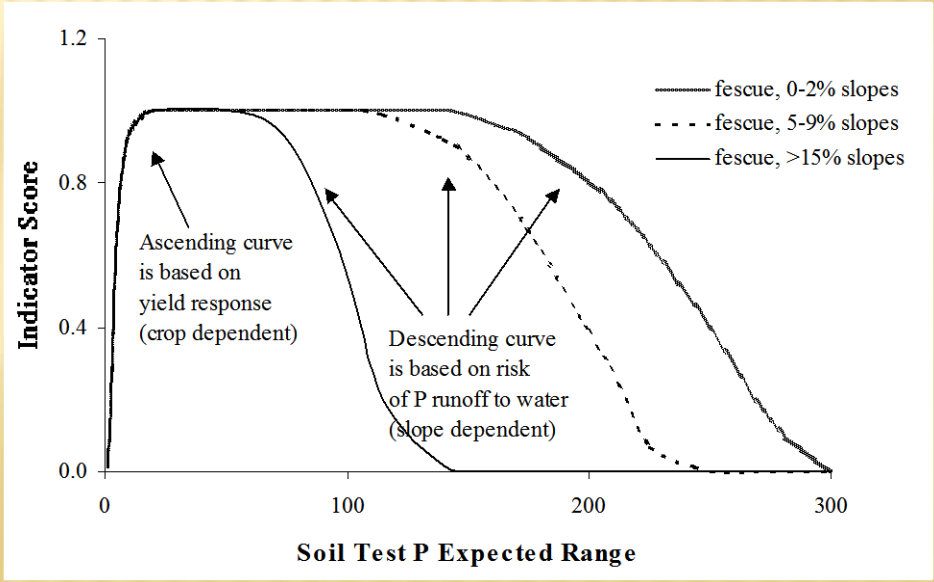
- SMAF is an acronym that stands for the Soil Management Assessment Framework
- SMAF is not a model – It is a framework, intentionally developed to be highly adaptable
- SMAF requires measured or expert opinion data that is interpreted using scoring curves
- The data and scoring curves should reflect performance of one of more critical soil functions

The SMAF Framework

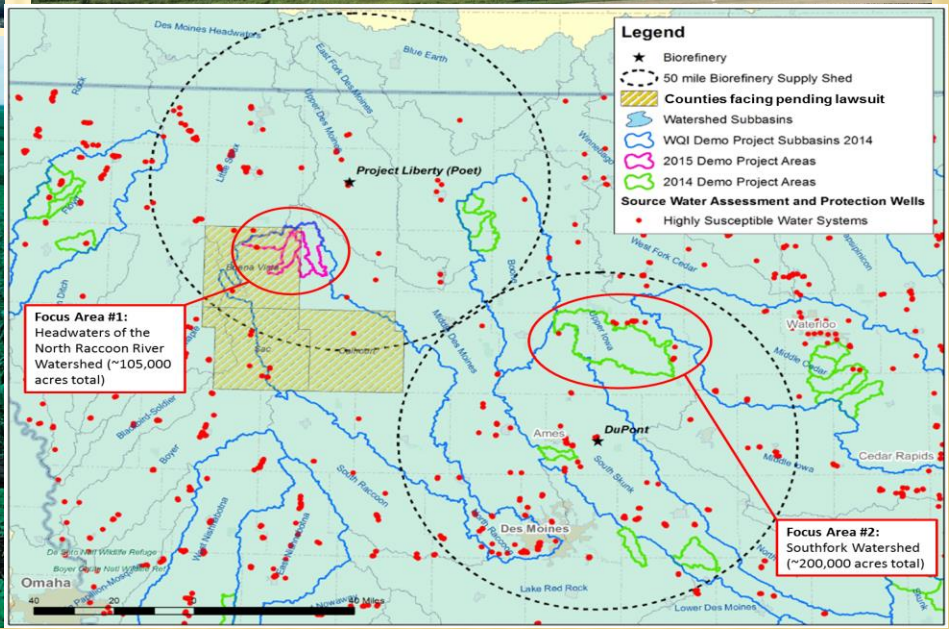


SMAF Began to Evolve in 1989

The Initial SMAF Evaluation was for Bioenergy Feedstock



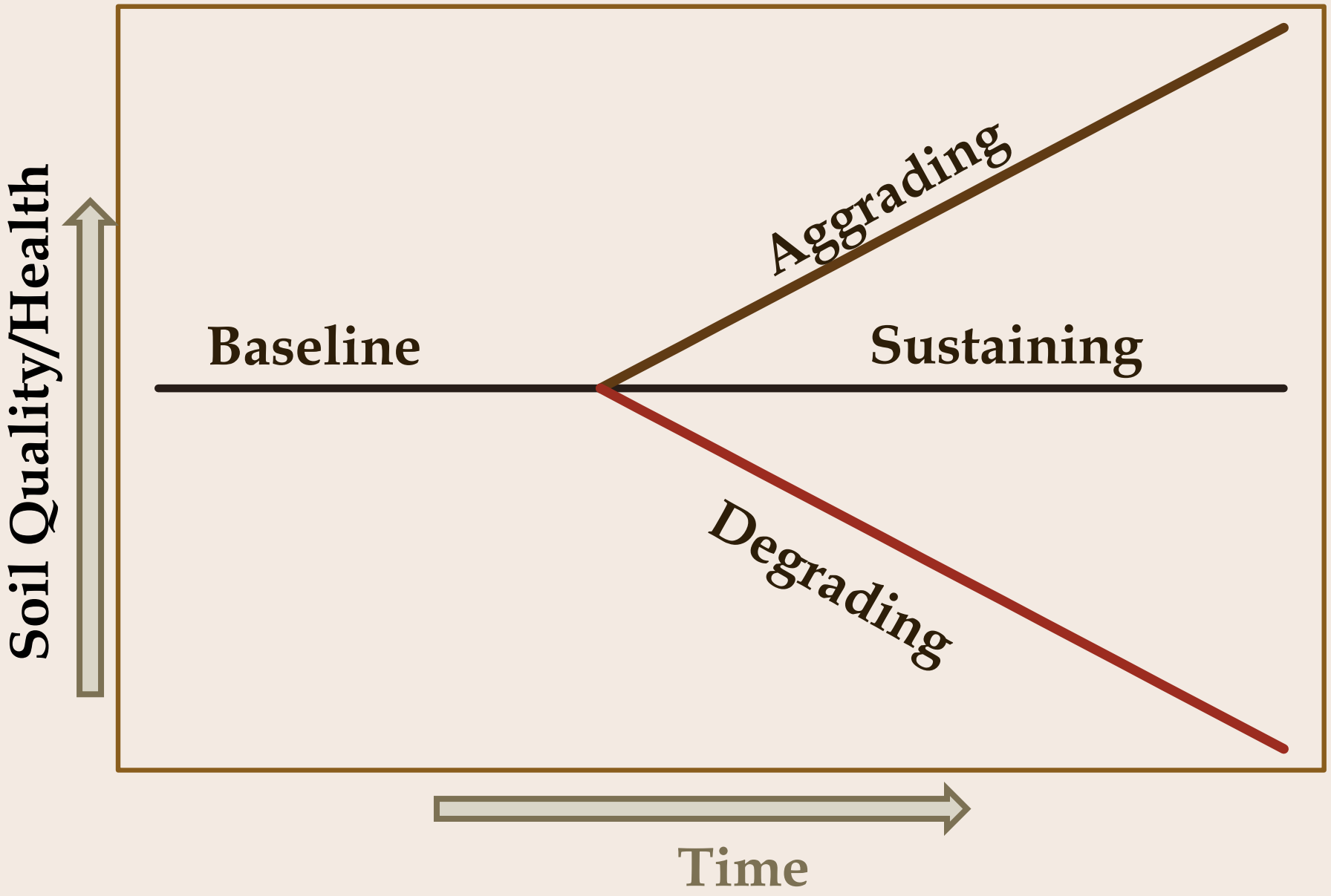
SMAF has been Used for Landscape Studies



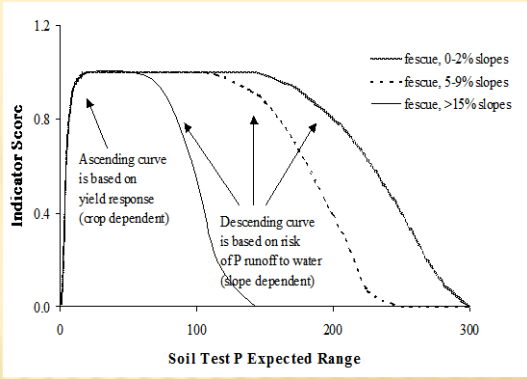
Understanding How the SMAF Works

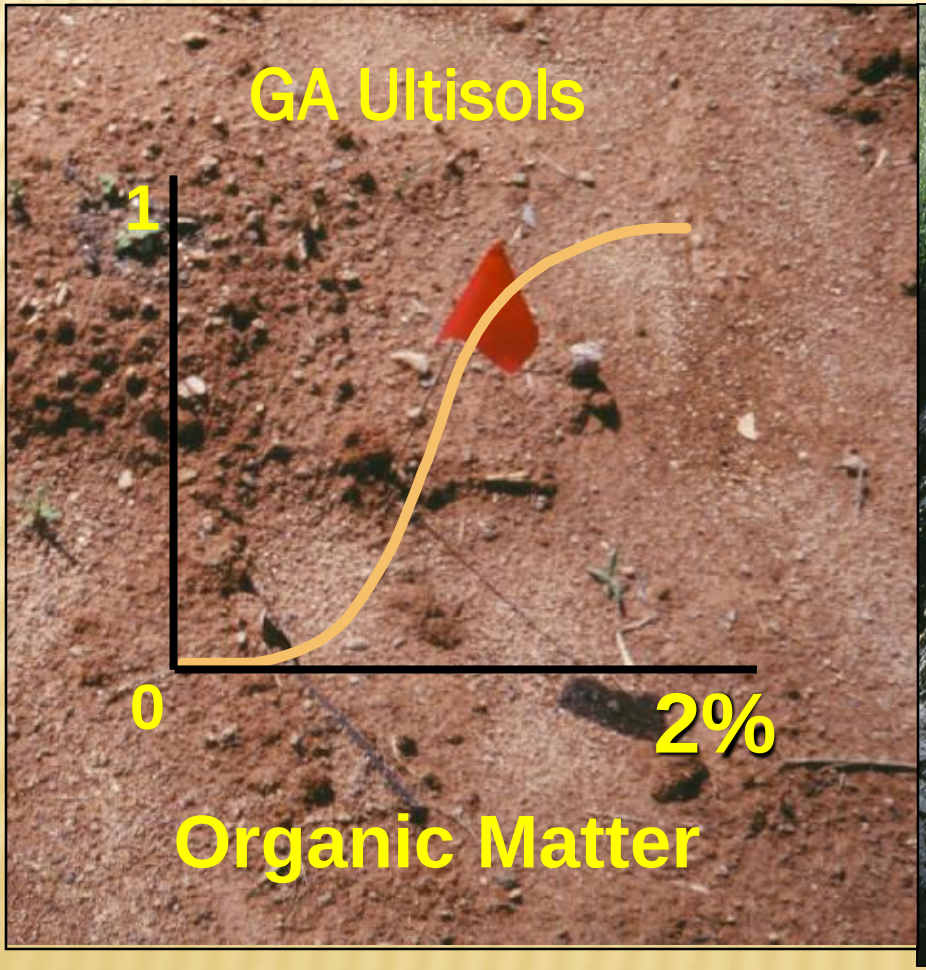
- The SMAF was created and currently exists as an Excel spreadsheet
- It is available from me or Dr. Diane Stott (NRCS Soil Health Division)
- Currently scoring curves have been developed for 14 potential indicators, but using 5 to 10 is sufficient for a meaningful assessment
- The key is to represent physical, chemical, and biological attributes of critical soil functions

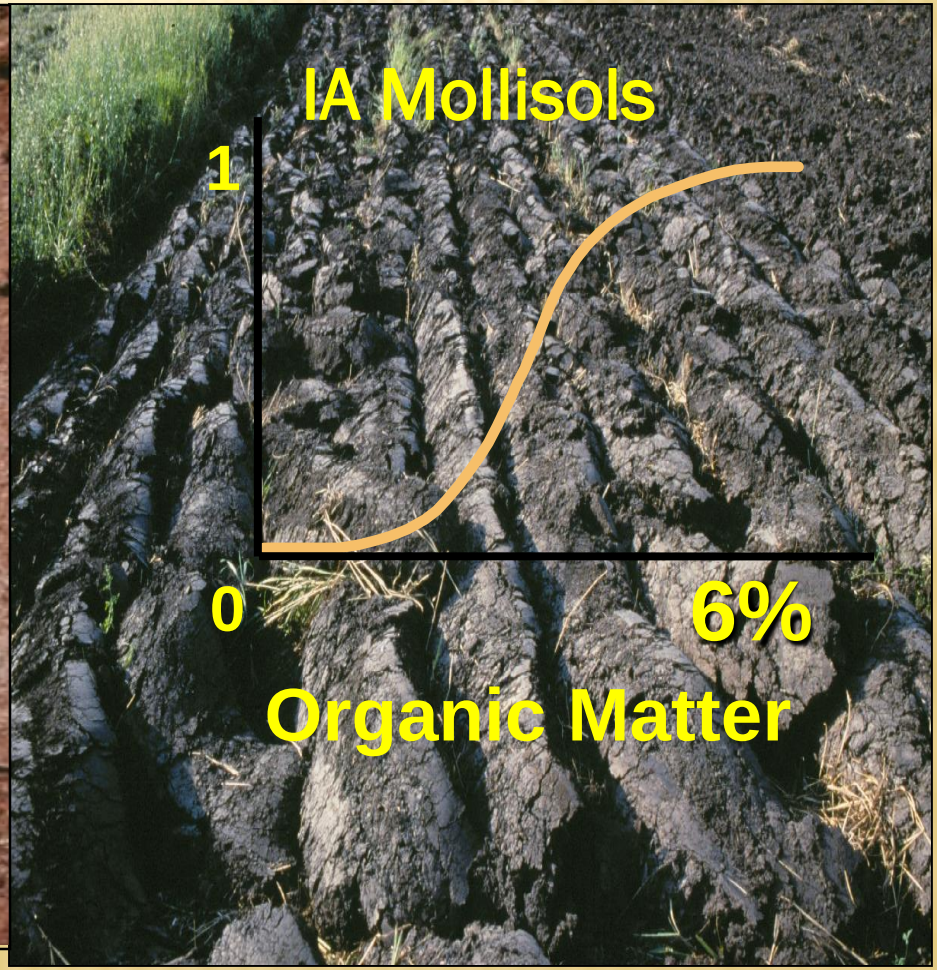
What Does the SMAF Provide?



Scoring curves provide the mechanism for combining indicators





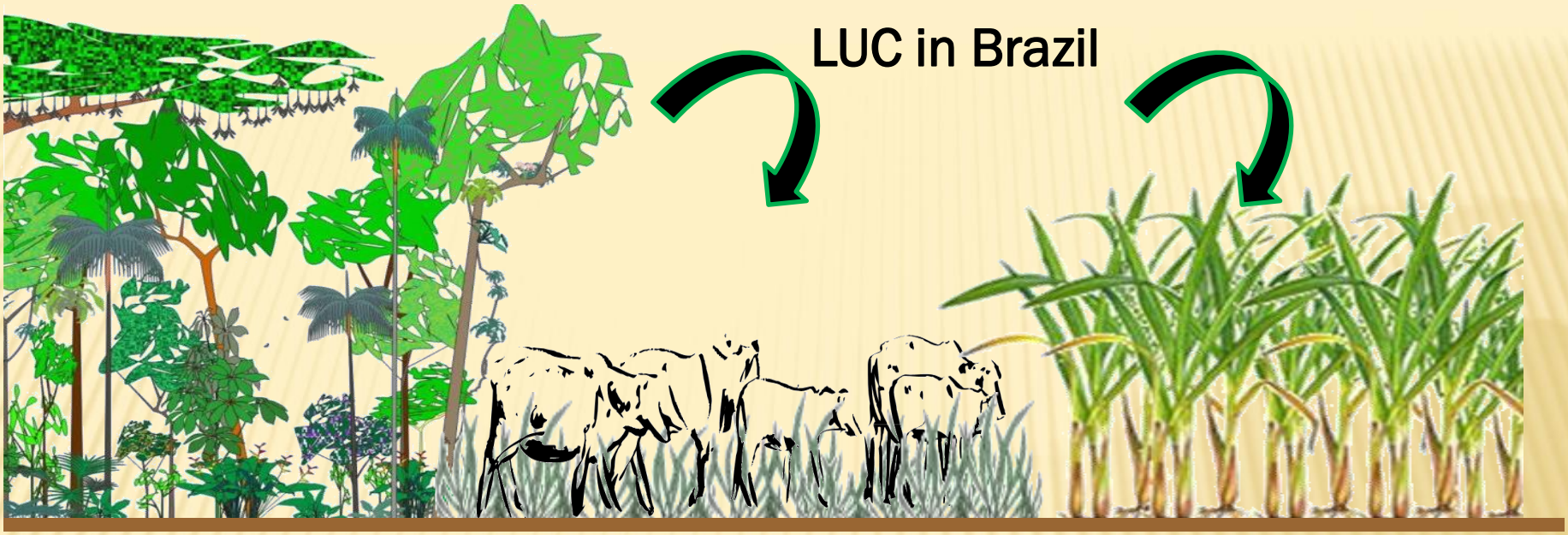


What's Needed for a SMAF Assessment?

- Recent soil and crop management information
- Basic soil-test data – pH, P, and K, plus:
  - Total organic C, Total N, EC, Bulk density;
- Other recommended laboratory analyses:
  - Aggregate stability; Microbial biomass carbon; soil enzymes; POM-C; Secondary and micronutrients; soil enzymes; PMN; NO_3-N
- Supplemental information such as compaction, crusting, infiltration, leaching, runoff, water holding capacity and soil strength (the latter two can be calculated)

Current SMAF Applications

- Numerous studies around the globe including Land Use Change (LUC) & Agro-Enviromental Monitoring System (SIMAA) studies in Brazil
- Baseline assessments for 14 ARS Cropland Conservation Effects Assessment Project (CEAP) & three NRCS Special Emphasis watersheds
- Quantifying corn stover harvest impacts through multi-location research projects
- Quantifying cover crop effects for Soil Health Partnership studies within the U.S. Corn Belt



NATIVE VEGETATION PASTURE SUGARCANE

Examples of CEAP Sites

Ft. Cobb, OK

Little River, GA

UNH Organic Site

CEAP Sampling Sites Continued

Jobos Bay, Puerto Rico

ChopTank, MD

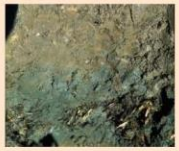
St. Joseph's River, IN

SMAF Results for Selected Watersheds

Watershed	Types of comparisons	Minimum	Maximum
South Fork, IA	Soil series, landscape position & manure history evaluations in for glacial till derived soils.	64	94
Riesel, TX	Native prairie, Coastal Bermuda grass (BG), BG + turkey litter, row crop (RC1) – wheat-corn/sorghum-cotton-pasture (4 yr), RC2 – W – C/S - Cot/fallow	61	83
Little River, GA	Rotations, continuous cotton; forest & riparian zones	51	86
Choptank, MD	Tillage/no-tillage; Landscape position; corn/wheat/soybean rotation;	61	87
Beasley Lake, MS	Row crop, buffer, CRP, ditch areas having various soil types and slope conditions	58	87
UNH Organic Transition Farm	Fields with slopes of 0 to 3%, 3 to 8%, and 8 to 15% in various stages of transition from conventional to organic production	58	87

What's Needed for Further Development?

- A rigorous review of current SMAF scoring curves and development of new ones for other potential soil health indicators
- Development of SMAF scoring curves for sub-surface soil health assessments
- More streamlined SMAF data entry and set-up
- Incorporation of other soil erosion assessments and/or techniques such as the Visual Evaluation of Soil Structure (VESS) protocol into the SMAF

Structure quality	Size and appearance of aggregates	Visible porosity and Roots	Appearance after break-up: various soils	Appearance after break-up: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter
Sq1 Friable Aggregates readily crumble with fingers	Mostly < 6 mm after crumbling	Highly porous Roots throughout the soil			 Fine aggregates	 The action of breaking the block is enough to reveal them. Large aggregates are composed of smaller ones, held by roots.
Sq2 Intact Aggregates easy to break with one hand	A mixture of porous, rounded aggregates from 2mm - 7 cm. No clods present	Most aggregates are porous Roots throughout the soil			 High aggregate porosity	 Aggregates when obtained are rounded, very fragile, crumble very easily and are highly porous.
Sq3 Firm Most aggregates break with one hand	A mixture of porous aggregates from 2mm -10 cm; less than 30% are <1 cm. Some angular, non-porous aggregates (clods) may be present	Macropores and cracks present. Porosity and roots both within aggregates.			 Low aggregate porosity	 Aggregate fragments are fairly easy to obtain. They have few visible pores and are rounded. Roots usually grow through the aggregates.
Sq4 Compact Requires considerable effort to break aggregates with one hand	Mostly large > 10 cm and sub-angular non-porous; horizontal/platy also possible; less than 30% are <7 cm	Few macropores and cracks All roots are clustered in macropores and around aggregates			 Distinct macropores	 Aggregate fragments are easy to obtain when soil is wet, in cube shapes which are very sharp-edged and show cracks internally.
Sq5 Very compact Difficult to break up	Mostly large > 10 cm, very few < 7 cm, angular and non-porous	Very low porosity. Macropores may be present. May contain anaerobic zones. Few roots, if any, and restricted to cracks			 Grey-blue colour	 Aggregate fragments are easy to obtain when soil is wet, although considerable force may be needed. No pores or cracks are visible usually.

Soil Health Lessons to be Learned

- Soil Health Institute
  - Newly established NGO with a Mission to: "*safeguard and enhance the vitality and productivity of the soil through science-based research and advancement*"
- NRCS Soil Health Division
  - Preparing a two-volume book documenting "What we Know about Soil Health" and "Methods For Soil Health Indicator Assessment"
- Foundation for Food & Agriculture Research
  - Developing a "Healthy Soils, Thriving Farms Initiative" to build knowledge, fuel innovation, and enable adoption of innovative soil health practices

Summary, Next Steps, & Recommendations

- Developing and implementing a soil health assessment framework is crucial for global soil security and improved soil management decisions
- The NRCS Soil Health Division, Soil Renaissance project, Soil Health Partnership, Soil Health Institute, Foundation for Food and Agriculture Research, and numerous state soil health endeavors are rapidly advancing the science of Soil Health Assessment
- Soil Health Assessment – should be viewed as a value added opportunity for private sector businesses such as soil testing laboratories and crop consulting services

Healthy Soils → Healthy Landscapes → Vibrant Economies

Any Questions?