**CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE**
**ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL (EFA SAP)**

**MEETING AGENDA**
**May 14, 2015**
**10 am to 4 pm**
**Auditorium**
**1220 N Street**
**California Department of Food and Agriculture (CDFA)**
**Sacramento, CA 95814**
**916-654-0433**

**WEBINAR INFORMATION**
**Webinar ID - 128-713-699**
**Please register at**
**https://attendee.gotowebinar.com/register/678515588776947713**

**EFA SAP MEMBERSHIP**

Don Cameron, Member and Chair
Mark Nechodom, PhD, Member
Jocelyn Bridson, MSc, Member
Mike Tollstrup, Member
Jeff Dlott, PhD, Member
Luana Kiger, MSc, Subject Matter Expert
Doug Parker, PhD, Subject Matter Expert

| | | |
|---|---|---|
| 1. | Introductions (10 minutes) | Don Cameron |
| 2. | Welcome address – Secretary Ross | |
| 3. | Updates (10 minutes)<br>• Minutes from previous meetings<br>• State Water Efficiency and Enhancement Program (SWEEP) | CDFA |
| 4. | Soil Health | Don Cameron |
| | i. State Healthy Soils Initiative (20 minutes) | CDFA |
| | ii. Introduction to Soil Organic Matter and Soil Health (30 minutes) | Dr. Dennis Chessman, USDA NRCS |
| | iii. Strategies to increase soil organic matter in California soils (20 minutes) | Dr. Jeff Mitchell, UC Davis |
| | iv. Questions and Discussion (30 minutes) | Don Cameron |
| | v. Working lunch (panel members and speakers only) | Don Cameron |
| | vi. Panel Discussion (20 minutes each including questions)<br>- CalRecycle<br>- CVRWQCB<br>- Department of Conservation | <br>Howard Levenson<br>Adam Laputz<br>David Thesell |
| | vii. Public Comment and Discussion (2 hours)<br>• Can we set soil organic matter goals?<br>• What are good strategies to build soil organic matter?<br>• What are the scientific gaps? | Don Cameron |
| 5. | Next meeting and location | Don Cameron |

Amrith Gunasekara, PhD, CDFA Liaison to the Science Panel

All meeting facilities are accessible to persons with disabilities. If you require reasonable accommodation as defined by the American with Disabilities Act, or if you have questions regarding this public meeting, please contact Amrith Gunasekara at (916) 654-0433.
More information at: http://cdfa.ca.gov/Meetings.html and http://www.cdfa.ca.gov/EnvironmentalStewardship/Meetings_Presentations.html

**CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE (CDFA)**
**ENVIRONMENTAL FARMING ACT SCIENCE ADVISORY PANEL (EFA SAP)**

**Mendocino County Administrative Center**
**501 Low Gap Road, Conference Room C**
**Ukiah, CA 95482**

**March 4, 2015**

# MEETING MINUTES

**Panel Members**
Don Cameron, Member and Chair
Mike Tollstrup, Member
Jocelyn Bridson, MSc, Member
Jeff Dlott, PhD, Member

**Subject Matter Experts**
Luana Kiger, MSc, Subject Matter Expert

**State Agency Staff**
Amrith Gunasekara, PhD (CDFA)
Nilan Watmore, MSc (CalEPA)

## AGENDA ITEM 1 and 2

The meeting was called to order at 1:10 p.m. by the Chair, Mr. Don Cameron. Introductions were made and a quorum was established. Members present at the meeting included Mr. Cameron, Dr. Dlott (phone), Mr. Tollstrup and Ms. Bridson. Subject matter expert Ms. Kiger was also present. Introductions were made.

## PREVIOUS MEETING MINUTES

There was a delay in producing the minutes from the December 19, 2014 meeting. Dr. Gunasekara noted the minutes would be presented at the next Science Panel meeting to be held in May or June, 2015.

## STATE WATER EFFICIENCY AND ENHANCEMENT PROGRAM (SWEEP)

An update was provided on the implementation of the State Water Efficiency and Enhancement Program (SWEEP) by CDFA. Mr. Cameron noted that those projects involving the connection of pumps to utility lines (energy grid) might not be completed in time for the verification component to take place. Mr. Cameron noted that sending a letter out to the award recipients and highlighted the importance of completing the projects would be beneficial to CDFA and the growers. Dr. Gunasekara noted that CDFA will compile a letter to inform the award recipients of the importance of completing the projects by June 30, 2015 and explore other opportunities, such as contacting the utilities, to ensure interconnect issues do not delay project completion and the verification component.

## BIOCHAR

Following the December 19, 2014 meeting which was focused on Biochar, Dr. Gunasekara noted that he is in discussions with the CDFA Fertilizer Research and Education Program (FREP) about potential funding to fund research on biochar use rate recommendations through experimental field trials for different crops. The next solicitation for research will be released in September of 2015 and CDFA plans to include funding for biochar, a soil amendment, use rate research as one of several research priorities in the request for proposals.

**HEALTHY SOIL INITIATIVE**

An update on the State Healthy Soils Initiative was provided by CDFA. This initiative to incentivize and build the organic matter content of our agricultural soils for climate change resiliency and other multiple benefits from healthy soils was included in the Governor's January budget. This initiative is timely because 2015 has been memorialized by the United Nations Food and Agriculture Organization after they recognized 2015 as the Year of the Soil. CDFA has been working closely with agency leaders and the administration to evaluate existing state agency efforts on healthy soils and will develop short and long term actions. Dr. Gunasekara noted that the Healthy Soil Initiative will be a primary topic of discussion at the next EFA SAP meeting to be held in May or June, 2015.

**AGENDA ITEM 3. FARMED SMART CERTIFICATION**

The EFA SAP has been interested in learning more about a recent effort by the Pacific Northwest Direct Seed Association who is partnering with farmers to develop a new certification program called Farmed Smart. The certification would provide a "safe harbor" from regulatory agencies that support the program. CDFA had organized to have Ms. Kay Meyer, Executive Director of the program, to remotely call-in and present an overview of the program. Ms. Meyer was unavailable and therefore this agenda item will be revisited in a future EFA SAP meeting.

**AGENDA ITEM 4. GEELA**

Mr. Watmore noted that the Governor's Environmental and Education Leadership Award (GEELA) categories were in the process of being reorganized. One of the goals of the reorganization would be to ensure that agricultural applications are submitted to one category rather than multiple categories as evident from the 2014 applications. Mr. Watmore was seeking input from EFA SAP members on the most effective way to organize and frame the agricultural category for the 2015 solicitation. Mr. Watmore also was seeking feedback on how to provide greater outreach to the agricultural community on GEELA to ensure more applications. Dr. Gunasekara noted that CDFA will distribute the announcement for applications (when released in May or June, 2015) via several internal email lists, University of California Cooperative Extension, the Ag Commissioners, Resource Conservation Districts, via the CDFA blog post and the EFA SAP members.

**AGENDA ITEM 5. PUBLIC COMMENT AND OTHER ITEMS OF DISCUSSION**

Ms. Kiger noted that in the 2014 Farm Bill, farm insurance was relinked to conservation practices. She noted that some outreach by CDFA to growers would be helpful since not all California farmers might know about this change. Dr. Gunasekara noted that CDFA would assist in outreach efforts to farmers. The next EFA SAP meeting would be scheduled in May or June, 2015, with the location to be determined. The meeting was adjourned at 3:02 p.m.

Respectfully submitted by:

[signature]

Amrith Gunasekara, Ph.D.

7/17/15
Date

# Healthy Soils Initiative Proposal

**Issue Statement:**
California is the nation's leading agricultural production state in terms of both value and crop diversity. Soils are fundamental for crop growth and food production. The importance of soils has been memorialized by the United Nations Food and Agriculture Organization after they recognized 2015 as the Year of the Soil. With limited new arable land that is capable of growing food crops in California and an ongoing drought, it is critical to ensure the soil system is sustainable long into the future, resilient to potential climate change impacts such as variable temperatures and precipitation, and to be able to produce crop yields to sustain a growing local and global population. The term "healthy soils" refers to ensuring that our agricultural soils have adequate soil organic matter (SOM). Increasing the amount of SOM, from its current levels, in soils can provide multiple benefits such as:

- Source of nutrients for plants – SOM contains important nutrients that contribute to plant growth and yields (e.g., nitrogen and sulfur).
- Water retention – SOM has the ability to hold up to 20 times its weight in water.
- Contributes to the environmental fate of synthetic inputs – SOM affects persistence and biodegradability of pesticides and other soil inputs.
- Carbon sink – Stabilized carbon stored in soil serves as a carbon sink, preventing the escape of carbon dioxide and methane greenhouse gases to the atmosphere.
- Soil structure stability and reduced erosion – Soil carbon can combine with the inorganic clay mineral fraction to form structural units called aggregates. Aggregated soils have improved aeration, water infiltration and resistance to erosion, dust control, as well as numerous other benefits.
- At least a quarter of the world's biodiversity lives in the soil.

**Conceptual Proposal**
Recently, the Brown administration recognized the importance of soil health in the Governor's 2015-16 proposed budget; "as the leading agricultural state in the nation, it is important for California's soils to be sustainable and resilient to climate change. Increased carbon in soils is responsible for numerous benefits including increased water holding capacity, increased crop yields and decreased sediment erosion. In the upcoming year, the Administration will work on several new initiatives to increase carbon in soil and establish long term goals for carbon levels in all California's agricultural soils. CDFA will coordinate this initiative under its existing authority provided by the Environmental Farming Act". Consistent with this initiative, several actions have been identified to:

- Protect and restore soil organic matter (soil carbon) in soils to ensure climate change mitigation and food and economic security
- Identify sustainable and integrated financing opportunities, including market development, to facilitate increased soil organic matter
- Provide for research, education and technical support to facilitate healthy soils
- Increase governmental efficiencies to enhance soil health on public and private lands
- Ensure interagency coordination and collaboration

**Short Term Actions (within a year)**

- Establish a short- and long-term goal for building soil organic matter in California's agricultural and degraded soils by December 2015. These goals will be established through stakeholder meetings with scientific input (lead CDFA and CalRecycle).
- Establish a soil health initiative coordinator position to facilitate interagency activities including interagency communication, collaborations and to ensure resources optimization and permit streamlining to build soil carbon with carbon-based inputs (lead CDFA).
- Identify critical agronomic and economic research needed to fill knowledge gaps and build mapping tools for increasing soil organic matter throughout the state (lead CDFA).

- Identify demonstration projects and contract with University of California Cooperative Extension (UCCE) to begin the cycle of management practice adoption to implement research objectives that meet soil carbon goals (lead CDFA).
- Integrate incentives for improved soil management practices into the Sustainable Agricultural Lands Conservation Program (lead Department of Conservation).
- Encourage organic diversions from landfills to more beneficial uses, including composting facilities, by a tiered tipping fee or complementary mechanism that incentivizes the diversion of organics. (lead CalRecycle).
- Provide healthy soils guidance in the Climate Change Handbook for Agricultural Water Management Planning as well as in public and outreach and education efforts (lead DWR).
- Facilitate discussion on the benefits of compost use when managing nitrogen and include as a separate component in the nitrogen management plans required by the Irrigated Lands Regulatory Program (lead Water Boards).
- Grow CDFA's State Water Efficiency and Enhancement Program to promote soil management practices that improve water retention (lead CDFA).
- Add healthy soils as an Efficient Water Management Practice (EWMP) in the guidebook to assist Agricultural Water Suppliers to Prepare an Agricultural Water Management Plan, and as a co-benefit in water efficiency grant programs (lead DWR).
- Explore opportunities to implement healthy soil management on construction, maintenance and operation plans in DWR (lead DWR).
- Explore with other Agencies opportunities for implementation of healthy soil management on public lands.

**Long Term actions (1-5 years)**

**Identify sustainable and integrated financing opportunities, including market development, to facilitate increased soil organic matter**

Develop and fund incentive and demonstration programs with new and existing resources such as Resource Conservation Districts and UC Cooperative Extension, to promote GHG reductions, carbon sequestration, cover crops, crop rotation and organic amendments including compost to build soil carbon, increase water holding capacity and ensure crop yields for food production through on-farm management practices (lead CDFA).

**Provide for research, education and technical support to facilitate healthy soils**

Identify and secure resources to contract with the appropriate academic institution to develop a user-friendly soil management data base to incorporate research findings and practical applications.

Identify and secure short and long term funding sources to support a robust scientific research program that will fund research on topics such as carbon farming, subsidence reversal, wetland restoration, drainage issues, salt accumulation and multi-benefit farming to support and enhance healthy soils (lead CDFA).

**Increase governmental efficiencies to enhance soil health on public and private lands**

Increase the generation and use of compost in California to improve soil health, by permitting 100 new composting and anaerobic digestion facilities in California by 2020 (lead CalRecycle).

**Ensure interagency coordination and collaboration**

Include in the regular coordination between agencies the potential for broader discussions on soil health. Such as: include Healthy Soil Initiative practices to promote groundwater recharge and groundwater quality protection in DWR Sustainable Groundwater Management Program (lead DWR); with the ARB on dust mitigation as a key element in all Climate Change work across Cabinet.

# THE HEALTHY SOILS INITIATIVE

May 14, 2015

**Environmental Farming Act**
**Science Advisory Panel**

Jenny Lester Moffitt
Deputy Secretary

CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

# PRESENTATION OUTLINE

1. What is the Healthy Soils Initiative?
2. Why is this initiative important?
3. What work has been done on this initiative to date?

# GOVENORS JANUARY BUDGET PROPOSAL

"Healthy Soils

As the leading agricultural state in the nation, it is important for California's soils to be sustainable and resilient to climate change. Increased carbon in soils is responsible for numerous benefits including increased water holding capacity, increased crop yields and decreased sediment erosion. In the upcoming year, the Administration will work on several new initiatives to increase carbon in soil and establish long term goals for carbon levels in all California's agricultural soils. CDFA will coordinate this initiative under its existing authority provided by the Environmental Farming Act."

Healthy soil = adequate soil organic matter or humus

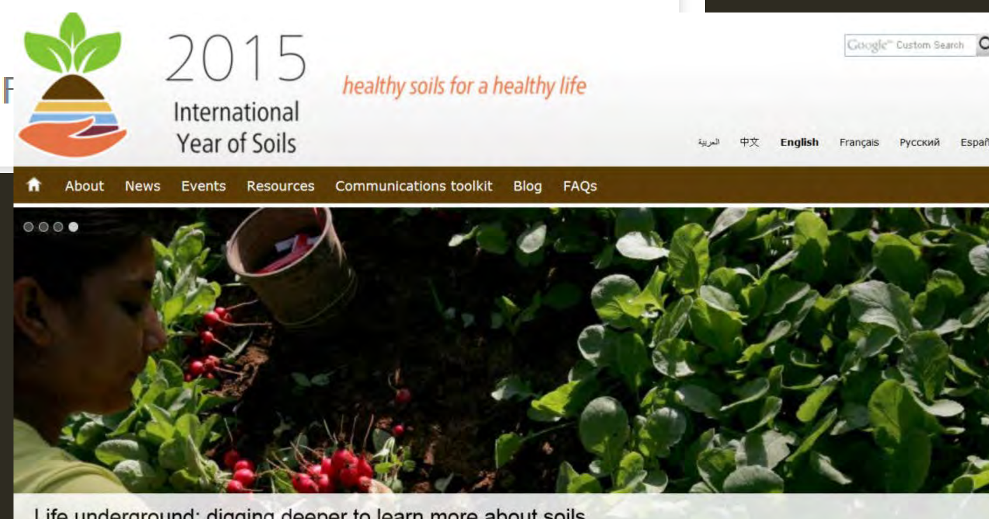
# INTERNATIONAL YEAR OF THE SOIL

## 2015

After two years of intensive work, **2015** has been declared the International Year of Soils by the 68th UN General Assembly (A/RES /68/232). The IYS aims to be a platform for raising awareness of the importance of soils for food security and essential eco-system functions.

GSP: IYS 2015

www.fao.org/global**soil**partnership/.../en...




http://www.fao.org/soils 2015/en/

# FOOD SECURITY

- California is the nation’s top agricultural state and has been for more than 50 years.
- More than 400 commodities
- California remained the No. 1 state in cash farm receipts in 2013, with $46.4 billion in revenue from 77,900 farms and ranchers.
- The state accounted for 12 percent of national receipts.
- Over 1/3 (one third) of country’s vegetables from California
- Over 2/3 (two thirds) of nation’s fruits and nuts from California.
- Some of the most fertile and diverse agricultural soils.
- Some specialty crops only produced in California
- Leads the nation in the production of more than 80 crops

## 2. Why is this Initiative Important

### Crop and Livestock Commodities in which California Leads the Nation [1/]

| | | | |
|---|---|---|---|
| **Almonds** | **Figs** | Melons, Cantaloupe | Pluots |
| Apricots | Flowers, Bulbs | Melons, Honeydew | **Pomegranates** |
| **Artichokes** | Flowers, Cut | Milk | Raspberries |
| Asparagus | Flowers, Potted Plants | Nectarines | **Rice, Sweet** |
| Avocados | Garlic | Nursery, Bedding Plants | Safflower |
| Beans, Dry Lima | **Grapes, Raisins** | Nursery Crops | Seed, Alfalfa |
| Beans, F.M. Snap | Grapes, Table | **Olives** | Seed, Bermuda Grass |
| Bedding/Garden Plants | Grapes, Wine | Onions, Dry | **Seed, Ladino Clover** |
| Broccoli | Greens, Mustard | Onions, Green | Seed, Vegetable and Flower |
| Brussels Sprouts | Hay, Alfalfa | Parsley | Spinach |
| Cabbage, Chinese | Herbs | **Peaches, Clingstone** | Squash |
| Carrots | Jojoba | Peaches, Freestone | Strawberries |
| Cauliflower | Kale | Pears, Bartlett | Tomatoes, F.M. |
| Celery | **Kiwifruit** | Peppers, Chile | Tomatoes, Processing |
| Chicory | Kumquats | Peppers, Bell | Triticale |
| Corn, Sweet | Lemons | Persimmons | Vegetables, Greenhouse |
| Cotton, American Pima | Lettuce, Head | Pigeons and Squabs | Vegetables, Oriental |
| Daikon | Lettuce, Leaf | **Pistachios** | **Walnuts** |
| **Dates** | Lettuce, Romaine | Plums | Watercress |
| Eggplant | Limes | **Plums, Dried** | Wild Rice |
| Escarole/Endive | Mandarins & Mandarin Hybrids | | |

*1/ California is the sole producer (99 percent or more) of the commodities in* **bold**.

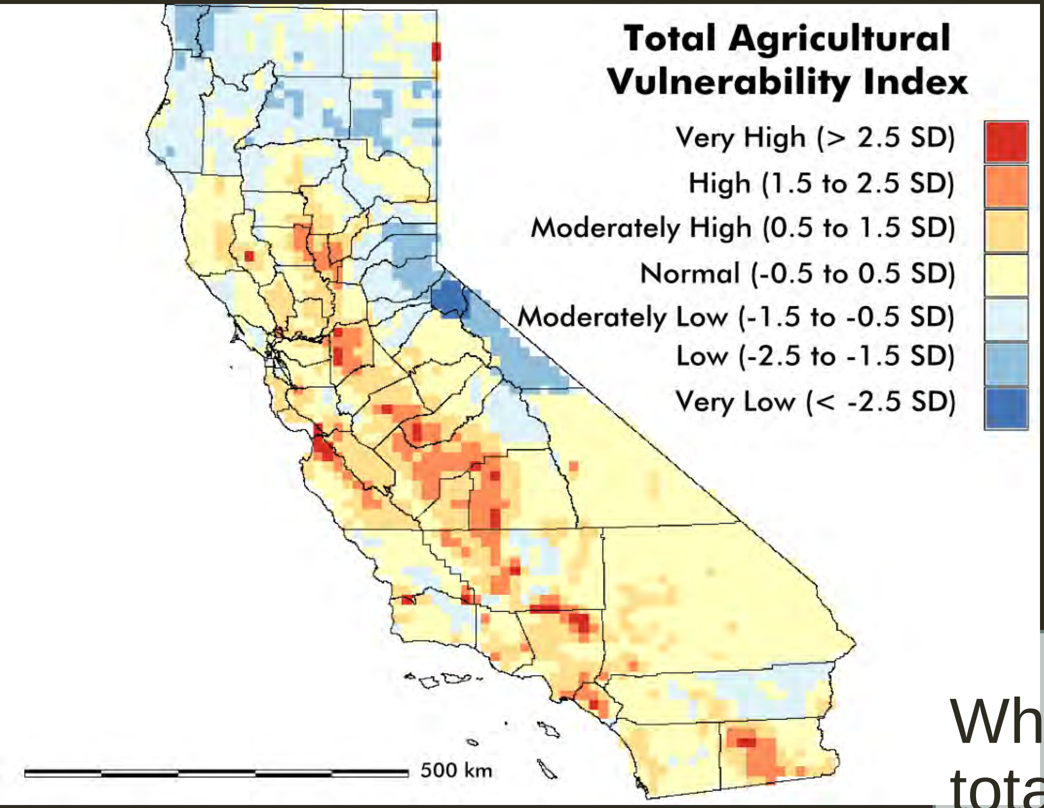
2. Why is this Initiative Important

# FOOD SECURITY

COTTON
ALFALFA
CORN
GRAPES
WINTER WHEAT
ALMONDS
PISTACHIOS

Image Source: USDA Cropscape Cropland Data Layer

# CLIMATE CHANGE RESILIENCE



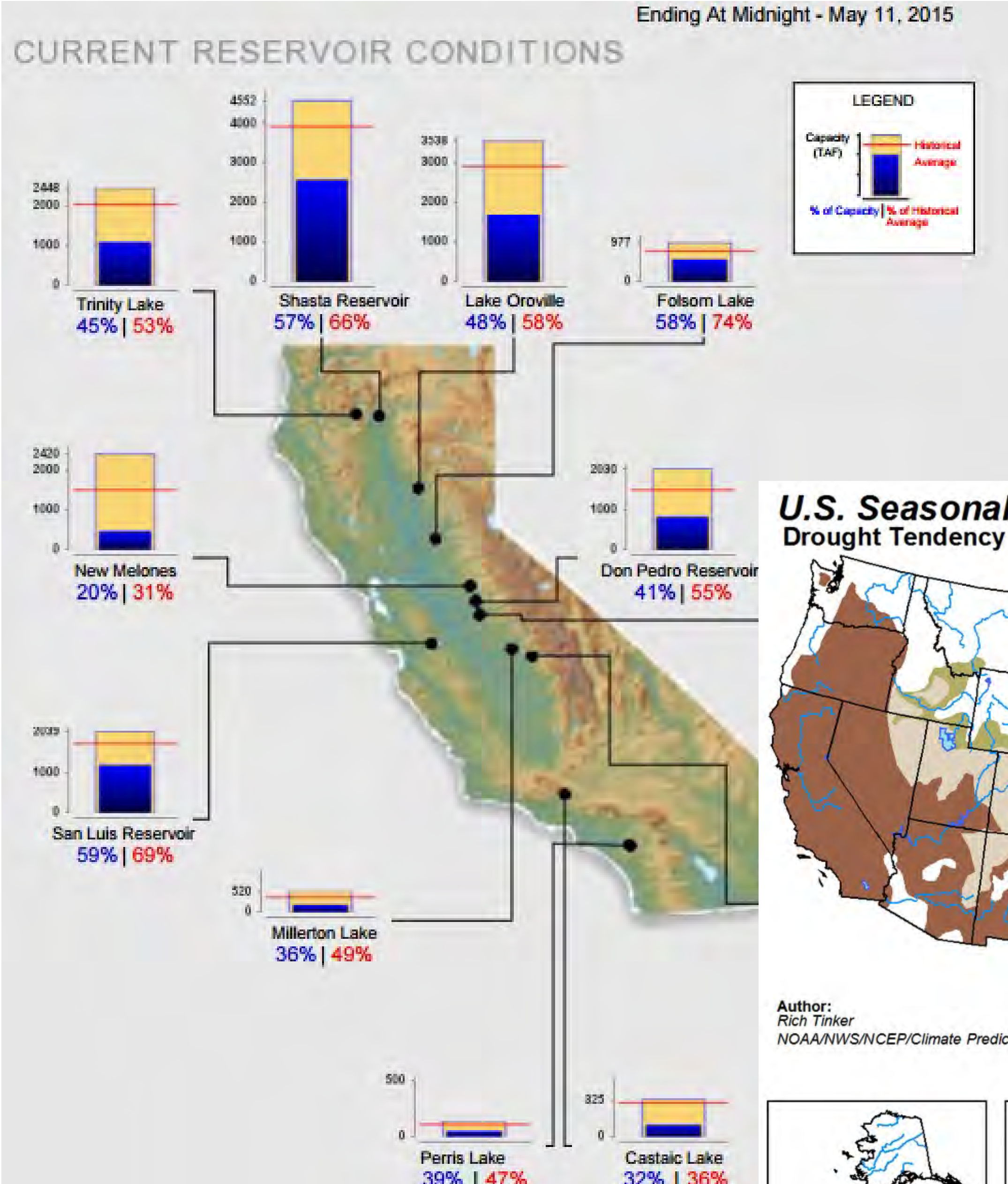

Vulnerability Index uses 4 sub indices:

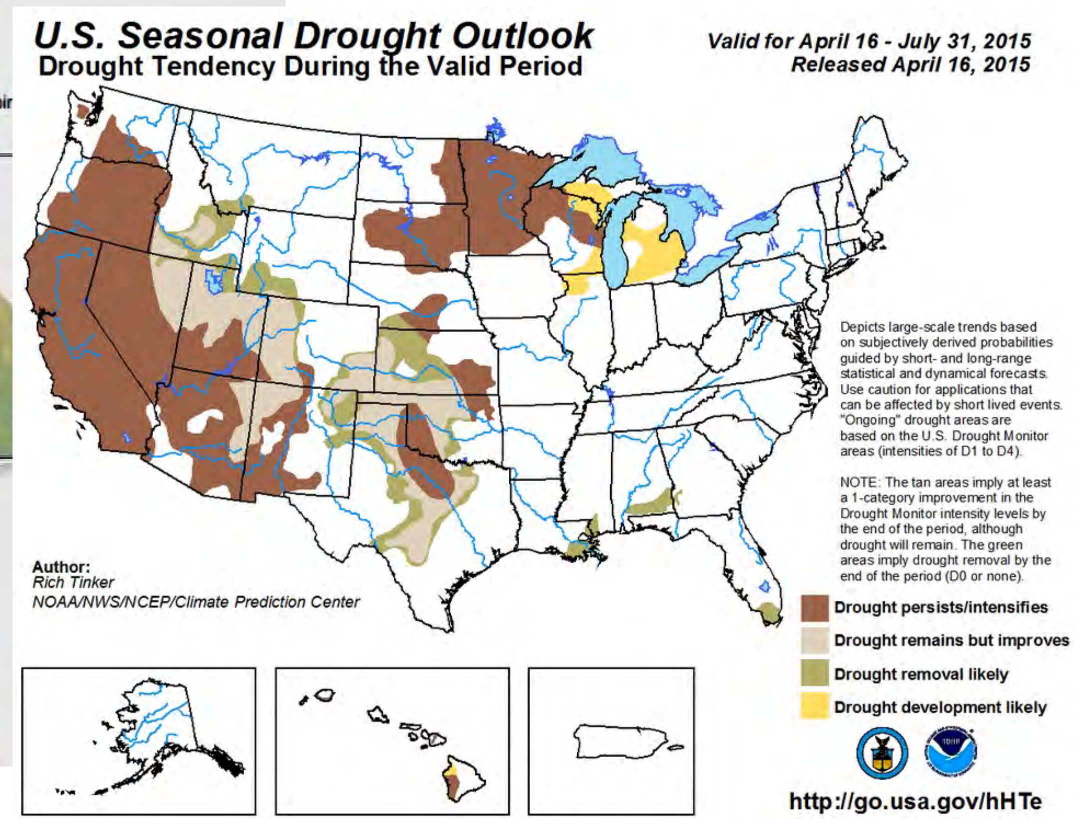
1. Climate
2. Crop
3. Land use
4. Socioeconomic

When indices are combined, total agricultural vulnerability in some areas of the state is very high

Study by Jackson et al. UC Davis with funding from CEC

# Fourth year of a historic drought in California



# BENEFITS FROM SOIL ORGANIC MATTER

• Source of nutrients for plants – SOM contains important nutrients that contribute to plant growth and yields (e.g., nitrogen and sulfur)

• Water retention – SOM has the ability to hold up to 20 times its weight in water

• Contributes to the environmental fate of synthetic inputs – SOM affects persistence and biodegradability of pesticides and other soil inputs

• Carbon sink – Stabilized carbon stored in soil serves as a carbon sink, preventing the escape of carbon dioxide and methane greenhouse gases to the atmosphere

• Soil structure stability and reduced erosion – Soil carbon can combine with the inorganic clay mineral fraction to form structural units called aggregates. Aggregated soils have improved aeration, water infiltration and resistance to erosion, as well as numerous other benefits

• At least a quarter of the world's biodiversity lives in the soil.

# ACTIVITIES TO DATE

- Meeting with Governor's Office and administration on initiative
- Interagency meetings with several other agencies and departments
    - CalEPA
        - DPR
        - CalRecycle
        - State Water Resources Control Board
        - Central Valley Regional Water Quality Control Board (ILRP)
    - Natural Resources Agency
        - Department of Conservation
- CDFA worked to develop actions document (handout today)
- Set up webpage for California Healthy Soils Initiative
- Initiate this preliminary workshop to discuss and take public comment on the Healthy Soils Initiative
- Additional meetings to gather feedback and actions related to healthy soils including co-hosting meeting with other agencies (e.g., CalRecycle)

# ACTIONS

- Protect and restore soil organic matter (soil carbon) in soils to ensure climate change mitigation and food and economic security
- Identify sustainable and integrated financing opportunities, including market development, to facilitate increased soil organic matter
- Provide for research, education and technical support to facilitate healthy soils
- Increase governmental efficiencies to enhance soil health on public and private lands
- Ensure interagency coordination and collaboration

More specific short term and long term actions (see handout)
http://www.cdfa.ca.gov/EnvironmentalStewardship/HealthySoils.html

3. What has been done on this initiative

# WEBSITE AND BLOG POST


CDFA Home > Environmental Stewardship > Healthy Soil Initiative

## HEALTHY SOIL INITIATIVE

Join the Healthy Soils Discussion on May 14th at CDFA
Next Environmental Farming Act Science Advisory Panel to discuss healthy soils
**Agenda**

To receive e-mail news updates on the Healthy Soils Initiative: subscribe here.

California is the nation's leading agricultural production state in terms of both value and crop diversity (http://www.cdfa.ca.gov/Statistics/). Soils are fundamental medium for crop growth and food production (http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/). The importance of soils has been memorialized by the United Nations Food and Agriculture Organization after they recognized 2015 as the Year of the Soil (http://www.fao.org/soils-2015/en/). The term "healthy soils" refers to ensuring that our agricultural soils have adequate soil organic matter (SOM) or soil carbon content. Increasing the amount of SOM, from its current levels, in soils can provide multiple benefits. These benefits include (among others):


← USDA announces $30 Million for food entrepreneurs and agricultural producers to develop new products

## Healthy Soils Initiative: A foundation for agricultural sustainability and climate change resilience

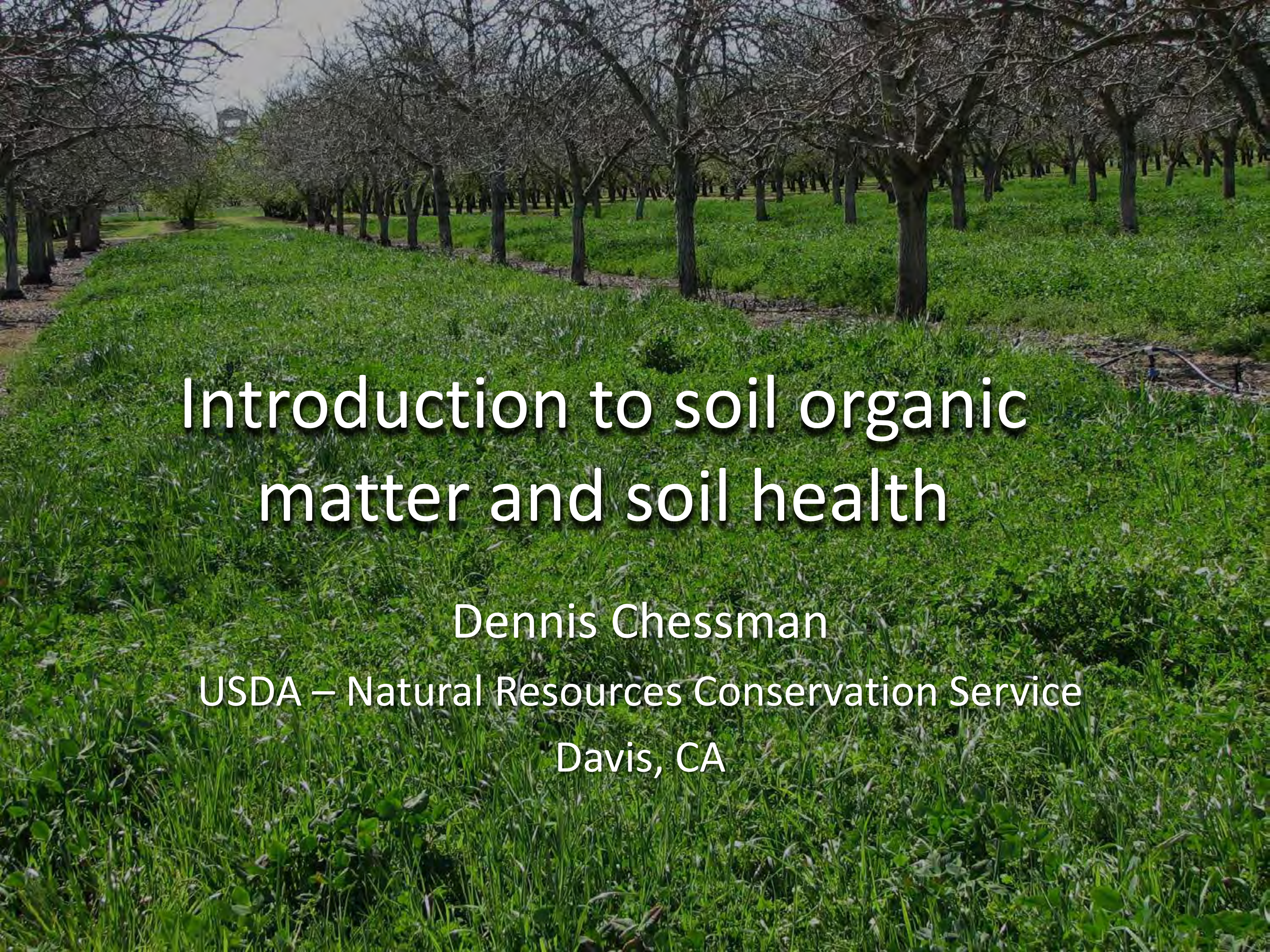
Posted on May 13, 2015 by Office of Public Affairs

Ask a shopper where their food comes from, and the answer might be "the supermarket" or "the farmers' market," or maybe even "a farm" or "a farmer." Those are all true, but of course they aren't the whole story. Ask a *farmer* the same question, and you're likely to hear "the soil." Ah, now we're getting somewhere…

In his recent budget proposal, Governor Brown included a Healthy Soils Initiative, saying: "Increased carbon in soils is responsible for numerous benefits including increased water-holding capacity, increased crop yields and decreased sediment erosion. In the upcoming year, the Administration will work on several new initiatives to increase carbon in soil and establish long term goals for carbon levels in all of California's agricultural soils. CDFA will coordinate this initiative under its existing authority provided by the Environmental Farming Act."

# SHORT VIDEO...

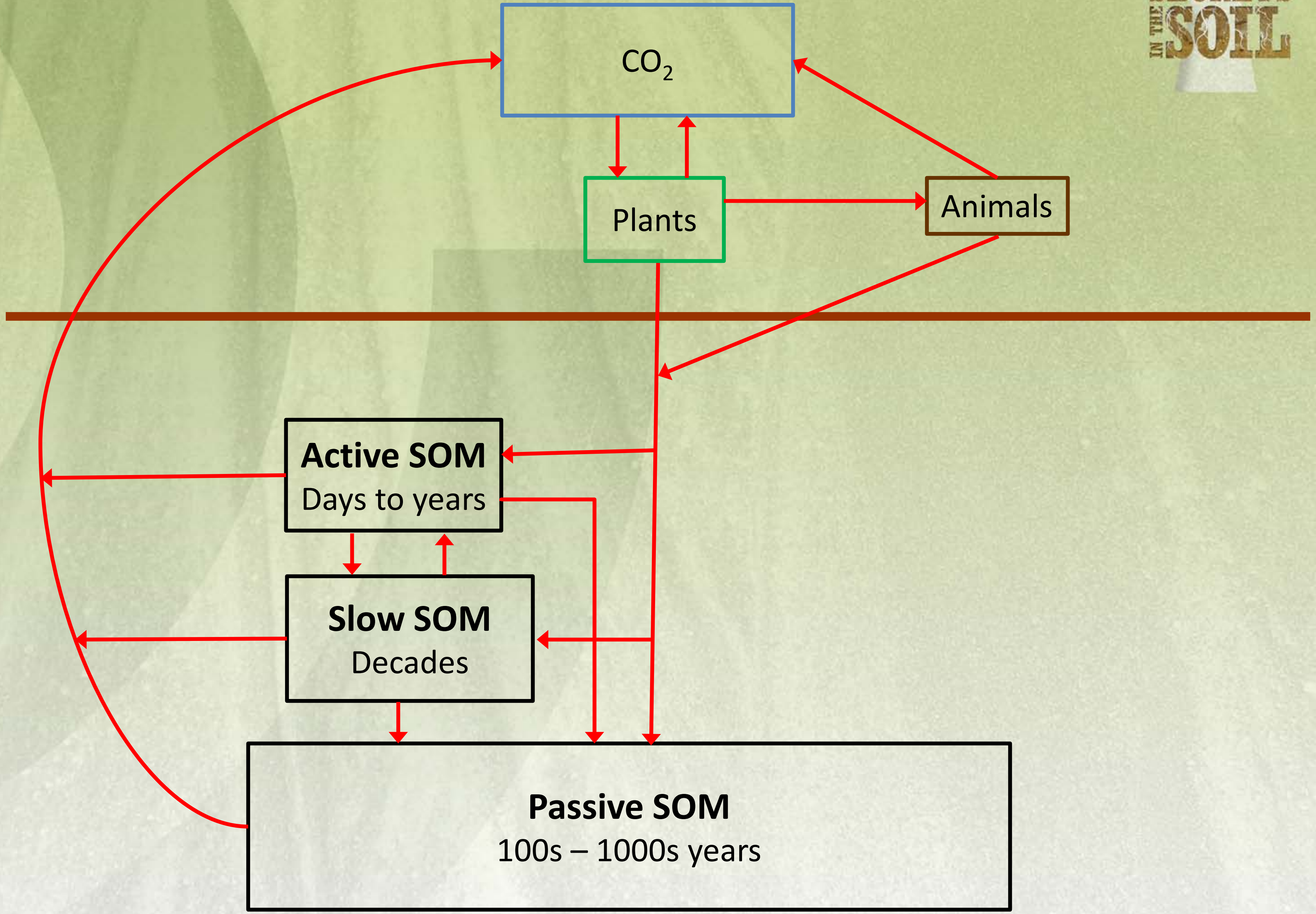
http://www.fao.org/soils-2015/blog/building-humus-watch-the-time-lapse-video-here/en/

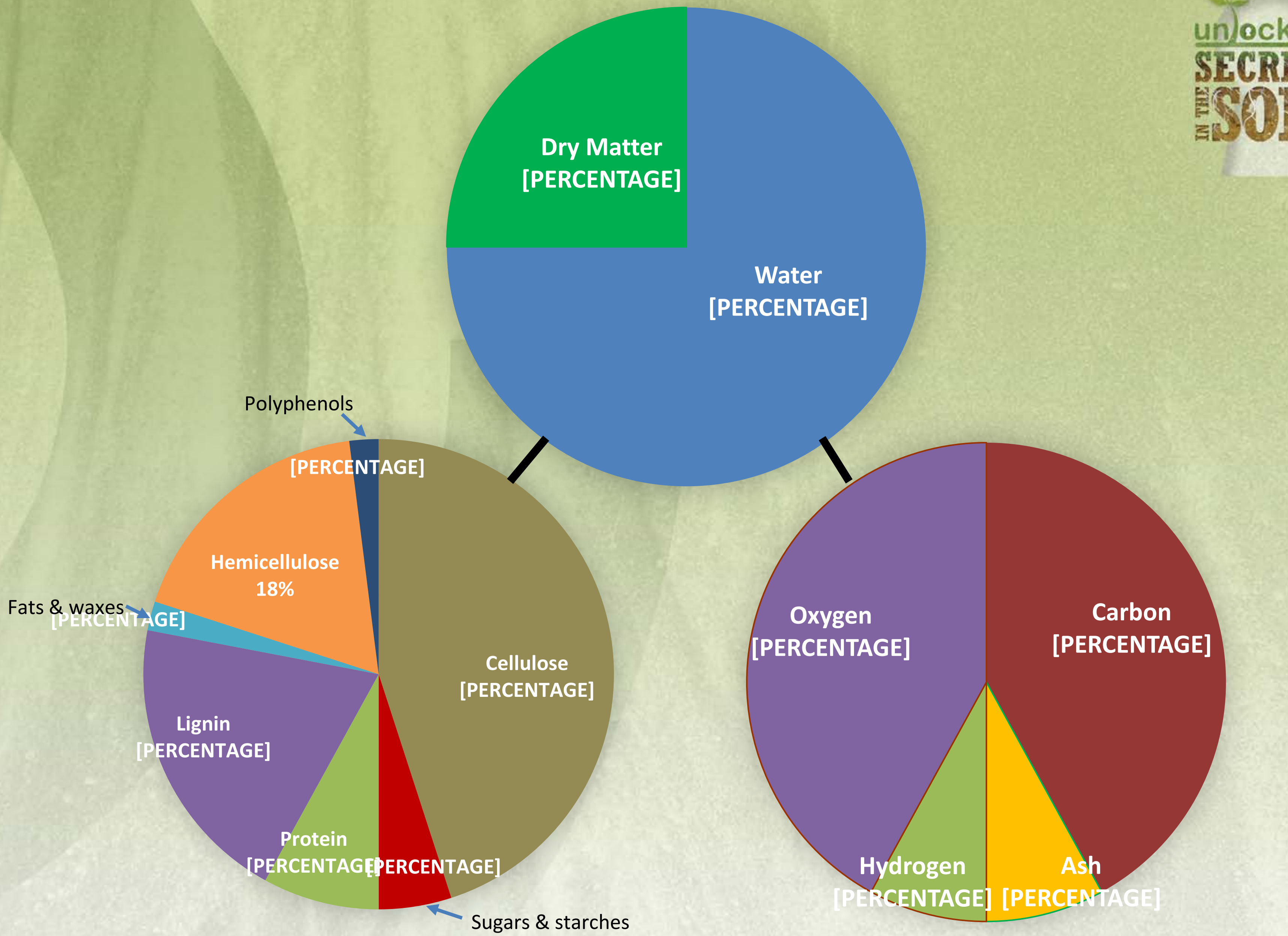


# Introduction to soil organic matter and soil health

Dennis Chessman
USDA – Natural Resources Conservation Service
Davis, CA

# Carbon and soil organic matter






Types of compounds

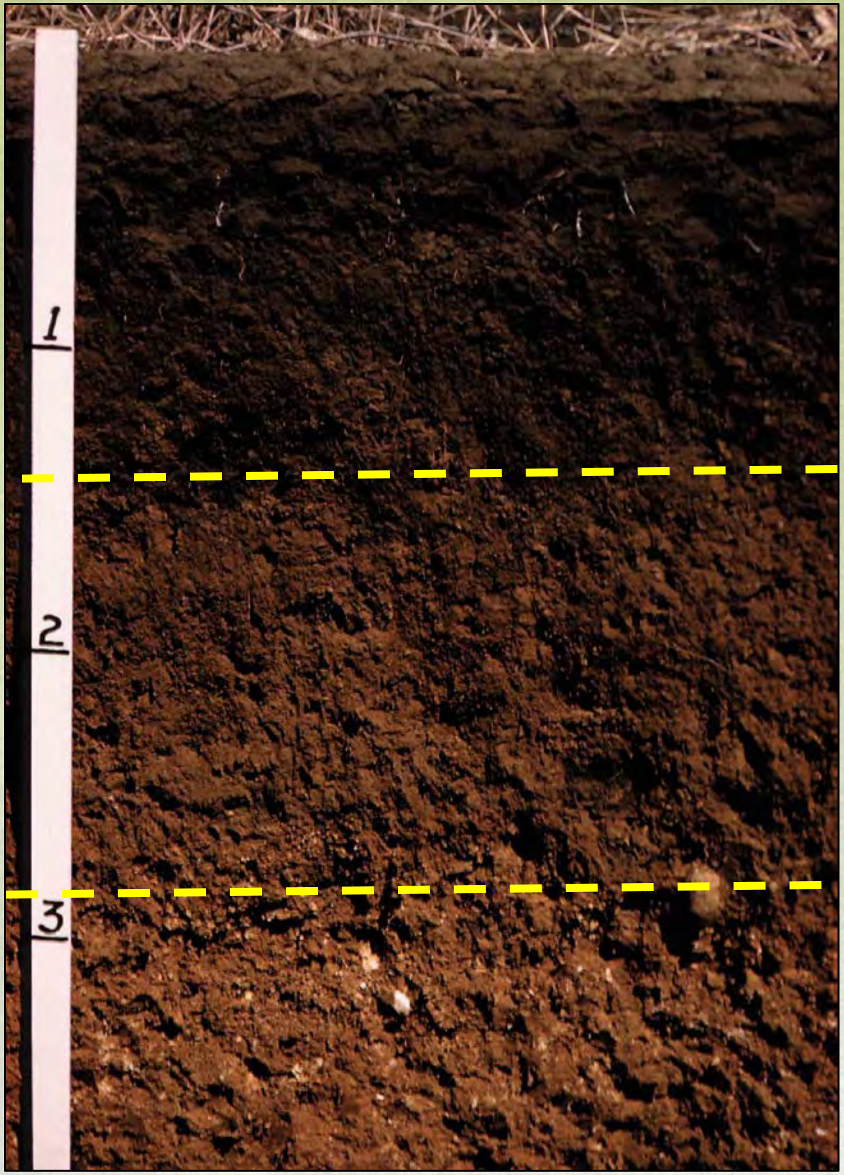
Elemental composition

Adapted from Brady & Weil, The nature and properties of soils, 14 ed.

# Factors affecting SOM levels

- Climate
- Soil texture
- Drainage
- Vegetation
- Management

# Soil Profile




A Horizon

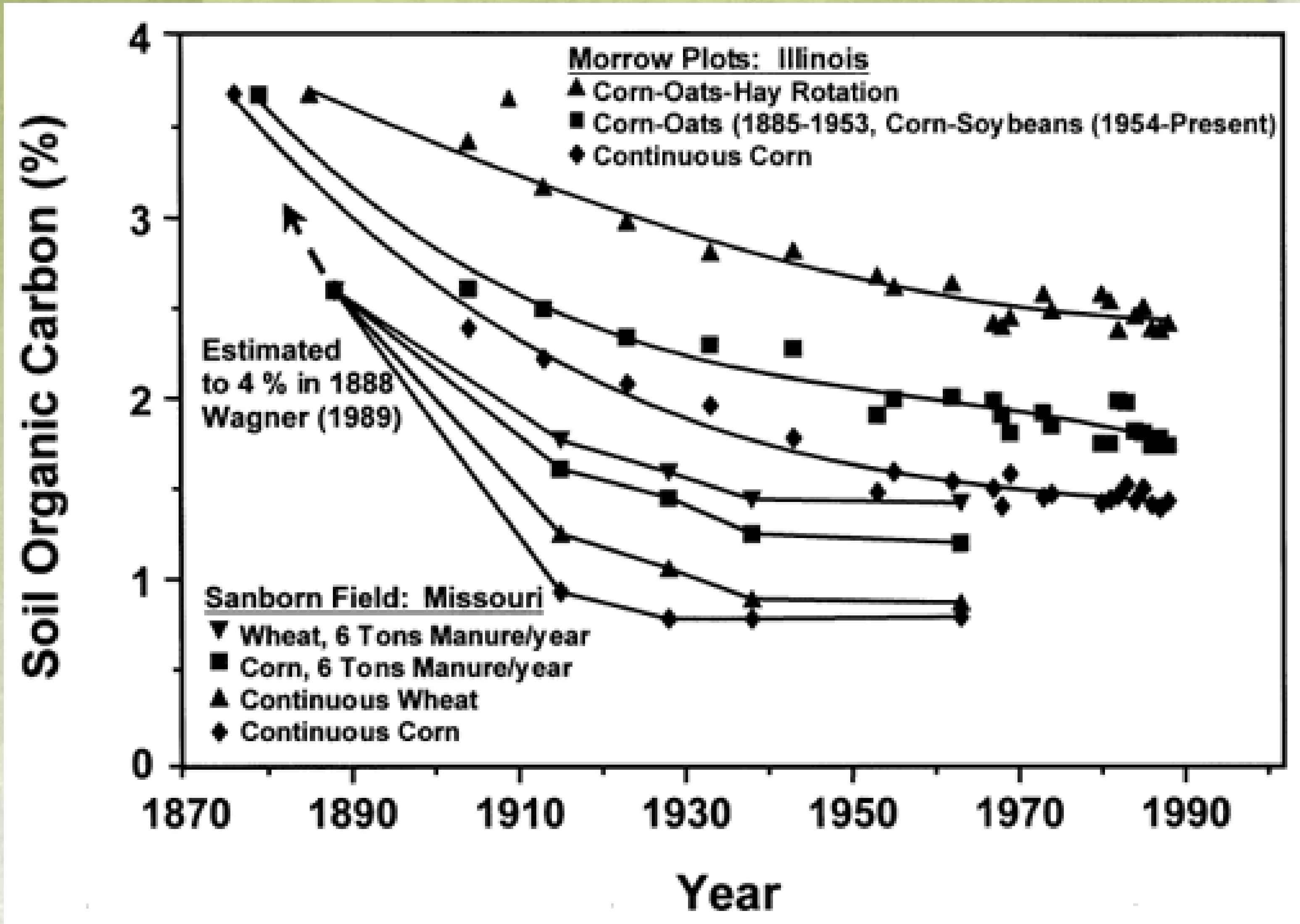
B Horizon

C Horizon

# Benefits of SOM

- Improves water infiltration, water holding capacity, and available water at field capacity
- Source of the major aggregate forming cements (ex. polysaccharides)
- Mineralization of organic nitrogen
- Accounts for 30 – 90% of CEC
- Can be a major source of plant-available P & S
- Chelates metals keeping them available
- Improves plant root environment
- Contributes to favorable habitat

# Cropping and organic matter




Al-Kaisi & Reicosky, 2002

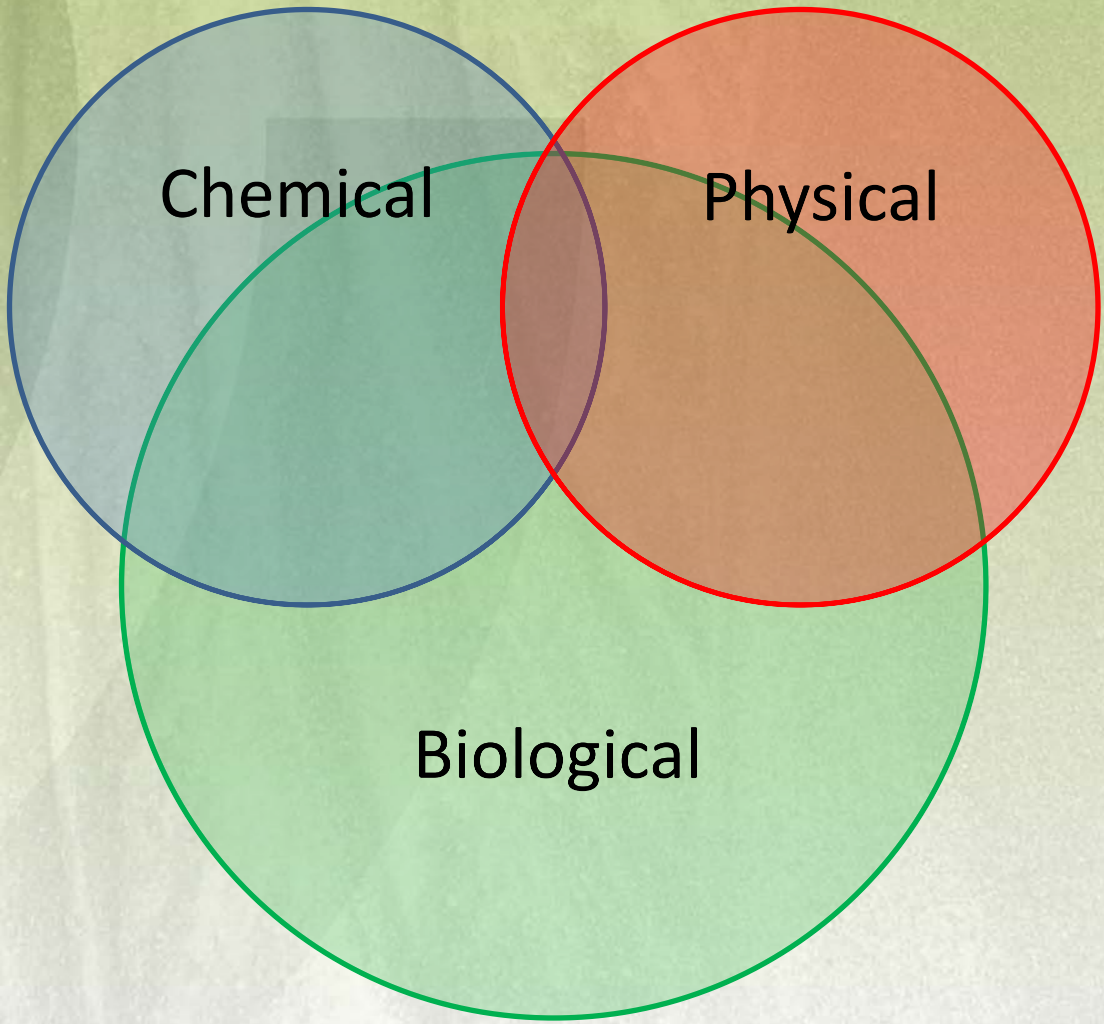
# What is Soil Health?

- …self-regulation, stability, resilience, and lack of stress symptoms in a soil as an ecosystem… the biological integrity of the soil community—the balance among organisms within a soil and between soil organisms and their environment. (Brady & Weil, 2008)
- …the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. (NRCS)

# Adjusting our thinking about soil

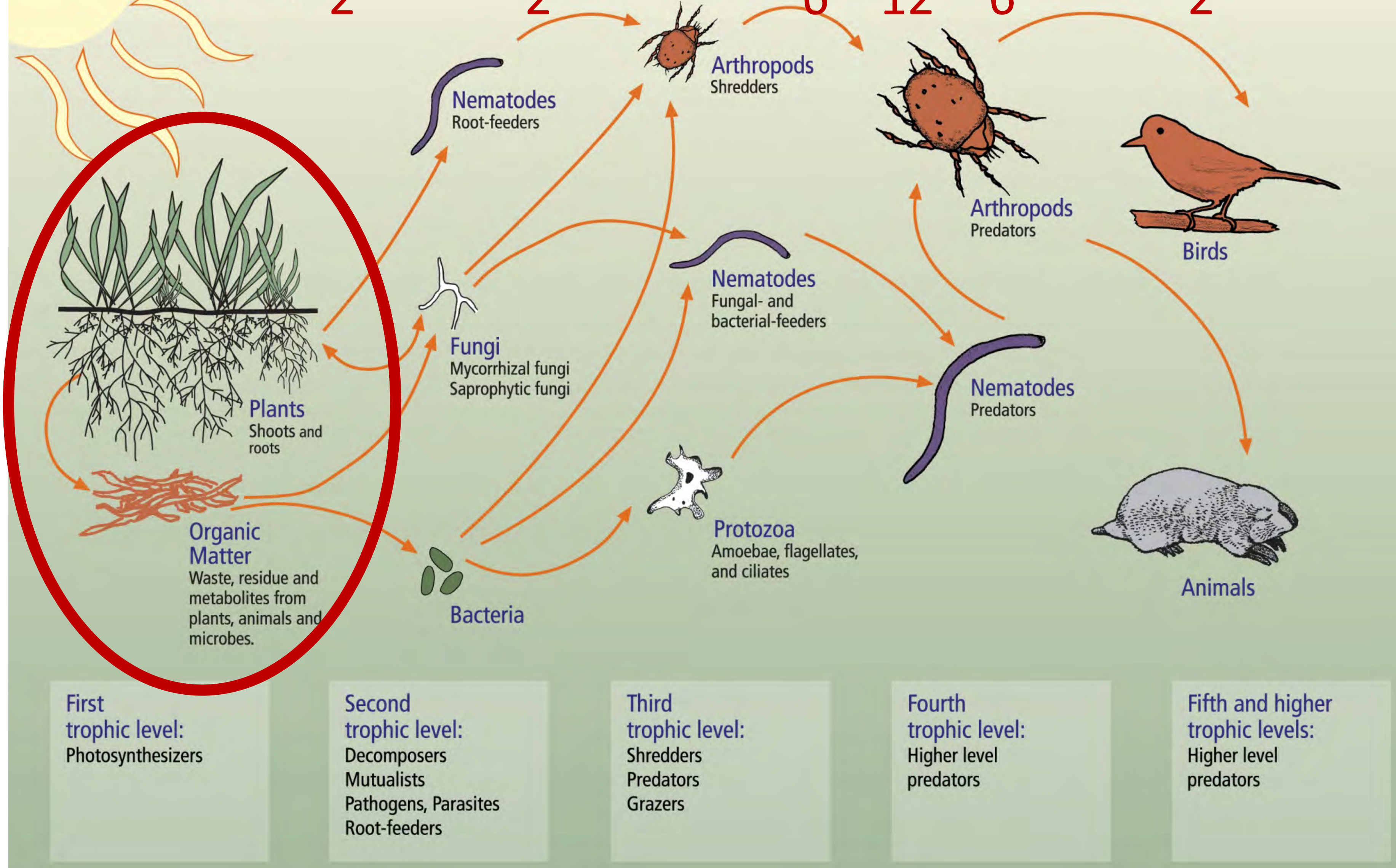
- Soil as an ecosystem
- Giving appropriate attention to the biotic component
- Ecosystems function
  - The collective intraspecific and interspecific interactions of the biota, such as primary and secondary production, mutualistic and antagonistic relationships.
- Functioning can be described

# Interrelated soil systems



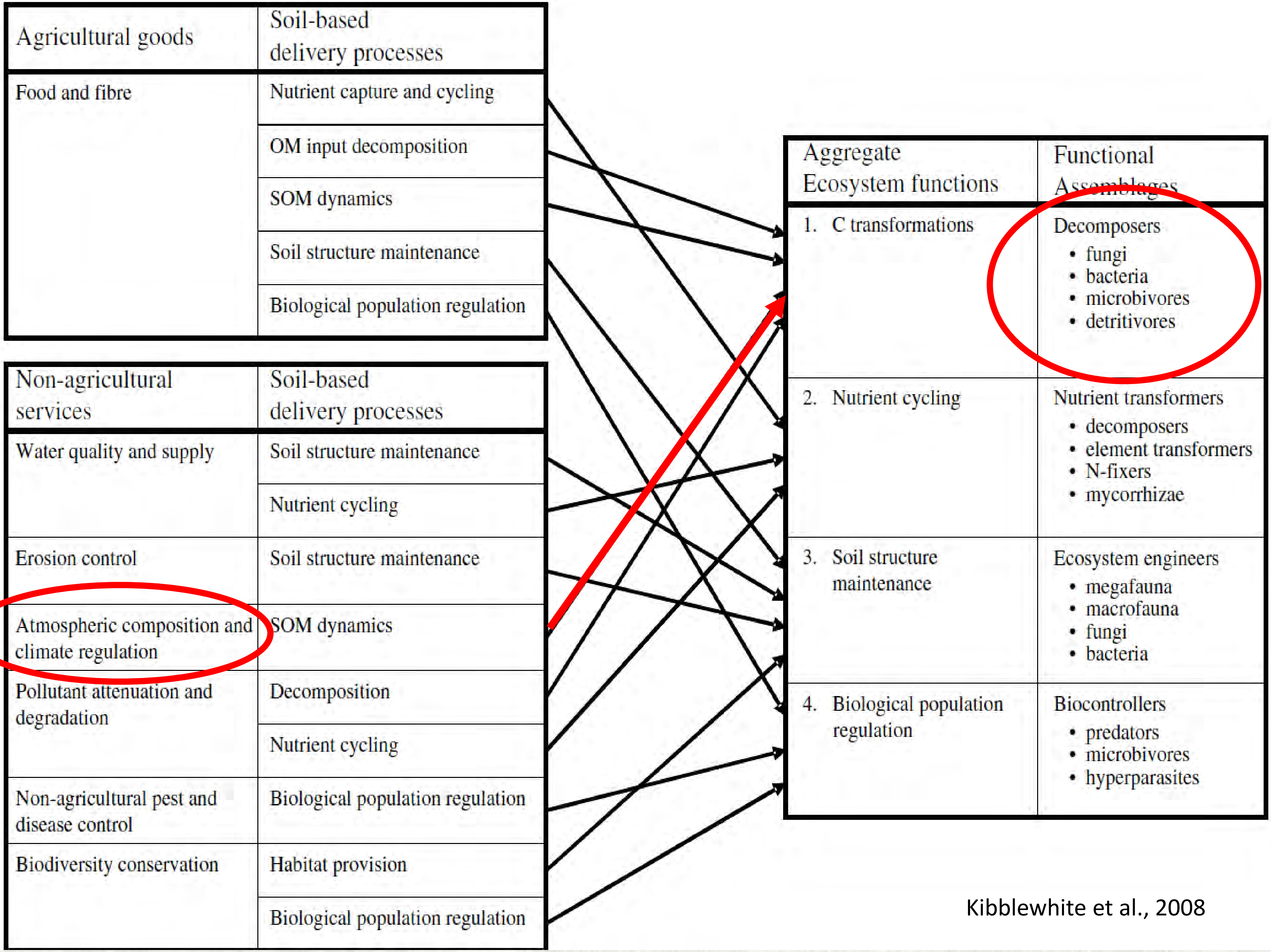
# The Soil Food Web

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$



# Why SOM is important to the soil ecosystem

- Contributes to a favorable environment for organisms
- Carbon in the labile fraction provides the energy upon which the system is built



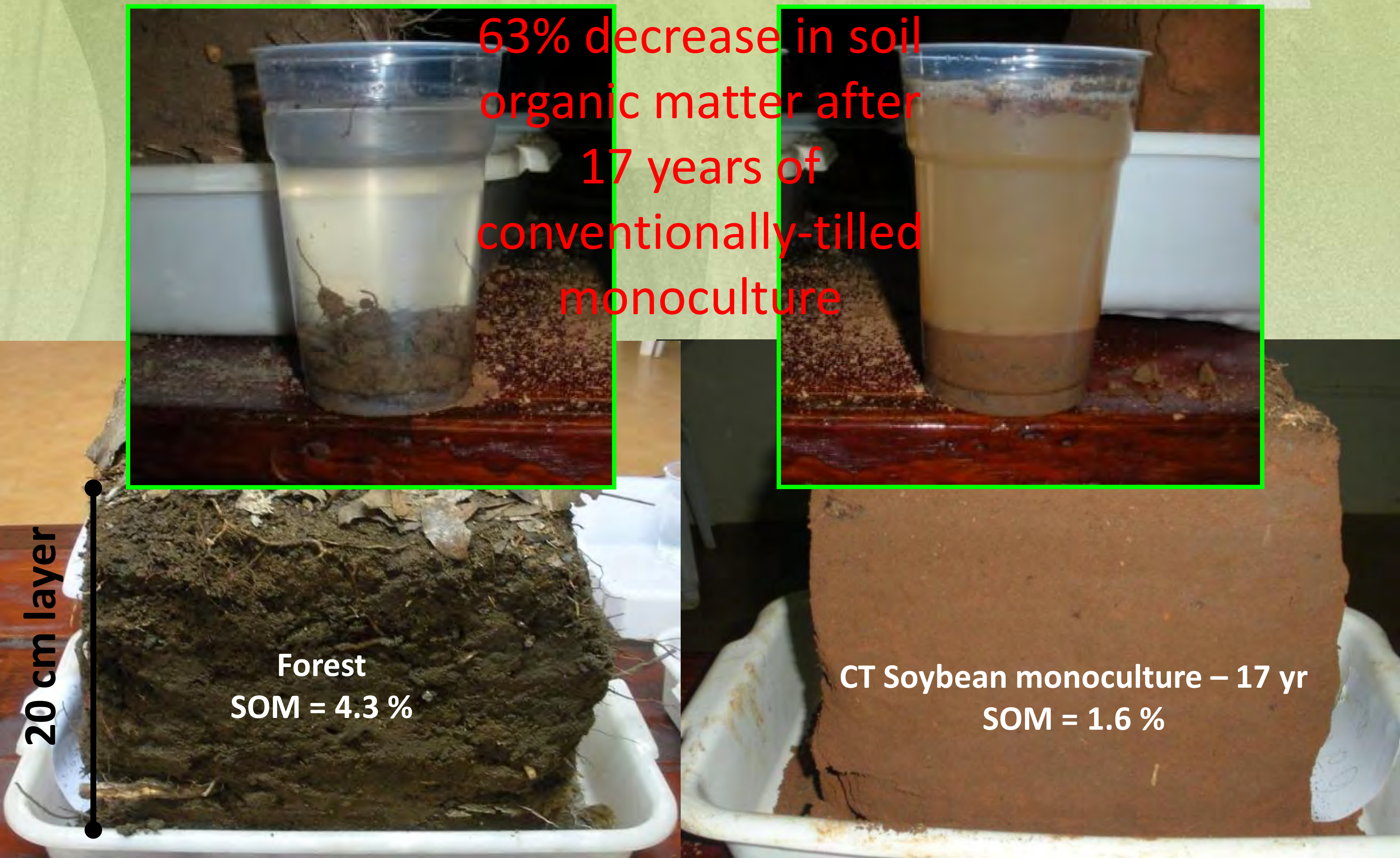

Kibblewhite et al., 2008

# How do natural systems differ from crop systems?

- Disturbance
- Diversity
- Cover
- Roots

- Water cycling
- Nutrient cycling
- Soil temperature
- C sequestered
- Plant health and susceptibility to pests
- System resistance and resilience

# Management affects soil properties & function



# Decreased SOM, structure and water

- Water that cannot enter the soil leaves the field.
- It carries soil, nutrients and pesticides.
- Water that leaves the field is not available to crops.
- Structurally poor soils hold little water for plants.

# Can management increase SOM in California?

- Sierra Foothills
  - 40 acres of orchard with some annual crops
  - Increased SOM at 0 – 12 inches from avg. of **2.2 to 5.1%** in 30 years
- Sacramento Valley
  - ~2000 acres of annual vegetables
  - Increased SOM from avg. of **2.0 to 3.8%** in 19 years

# Can management increase SOM in California?

## San Joaquin Valley, fine sandy loam after 18 y

0.9% SOM

4.0% SOM

# Help for unhealthy agricultural soil

- Reduce tillage and other disturbance
- Keep the soil surface continually covered
- Have growing plants present at all times
- Increase plant diversity
- Properly manage nutrients and pesticides

# Soil Health Field Assessment Worksheet

Location: ______________________________ Field: __________ Test: ____of____

Name: __________________________ Assessor: ____________ Date: ________

Soil Map Unit: ____________ Soil Moisture: ________ Topsoil Texture: ____________

| Indicator | Avg. Rating | Potential Practices |
|---|---|---|
| **Compaction** (3 = No evidence of compaction; 2 = Some penetration resistance; 1 = Clear evidence of a compacted layer) | | 329, 340, 345<br>Location 1____, 2____, 3____ |
| **Structure** (3 = Strong; 2 = Moderate; 1 = Weak or structure-less) | | 328, 329, 340, 345<br>Location 1____, 2____, 3____ |
| **Surface crusts** (3 = No evidence of surface crust; 2 = Surface crust in places; 1 = Surface crust throughout the field) | | 329, 340, 345, 484<br>Location 1____, 2____, 3____ |
| **Residue cover** (Plant residue cover: 3 = 75% or more; 2 = from 25 to 75%; 1 = less than 25%) | | 329, 340, 345, 484<br>Location 1____, 2____, 3____ |
| **Roots and Pores** (3 = Many roots or pores; 2 = Common roots or pores; 1 = Few to no roots or pores) | ROOTS<br>PORES | 328, 329, 340<br>Location 1____, 2____, 3____ |
| **Earthworms** (Number of worms or worm sign/cubic foot of soil: 3 = abundant (at least 10); 2 = few (1 to 9); 1 = None) | | 329, 340, 345, 484<br>Location 1____, 2____, 3____ |
| **Biological activity** (The presence of fungal hyphae, macro-invertebrates, etc.: 3 = Clearly evident; 2 = Few evident upon close examination; 1 = No biological activity visible) | | 328, 329, 340, 345, 484, 528, 590, 595<br>Location 1____, 2____, 3____ |
| **Smell** (3 = Earthy, sweet, and rich; 2 = Earthy, fresh, not unpleasant; 1 = Sour, putrid, or chemical-like) | | 328, 329, 340, 345, 484, 595<br>Location 1____, 2____, 3____ |
| **Aggregate stability** (3 = Clods remain intact; 2 = Clods exhibit moderate stability; 1 = Clods disintegrate) | | 329, 340, 345, 484<br>Location 1____, 2____, 3____ |

**(328)** Conservation Crop Rotation, **(329)** Residue and Tillage Management, No-Till, **(340)** Cover Crop, **(345)** Residue and Tillage Management, Reduced-Till, **(484)** Mulching, **(528)** Prescribed Grazing, **(590)** Nutrient Management, **(595)** Integrated Pest Management

The above indicators are related to the Resource Concerns/Planning Criteria: SOIL QUALITY DEGRADATION – Compaction and/or Organic Matter Depletion.

**Useful assessment materials:** shovel, wire flag, clear plastic cups or similar, water, small hand lens, texture by feel guide



NRCS, CA
March 2015

# Soil health is not just an annual cropland concern

# Nor are certified organic producers immune

# Summary

- Soils are ecosystems
- Soil systems are C-dependent
- Carbon cycles
- Regular C inputs are necessary to retain SOM
- Disturbance decreases SOM
- Most agricultural soils are organic matter-poor
- Management can increase SOM and achieve associated soil health benefits


dennis.chessman@ca.usda.gov

# Strategies to increase soil organic matter in California soils

**Jeff Mitchell**
Department of Plant Sciences, University of California, Davis
**Garrison Sposito and Gil Eshel**
University of California, Berkeley
**Randy Southard, Will Horwath, and Kate Scow**
Department of Land, Air and Water Resources, University of California, Davis
**Howard Ferris**
Department of Nematology, University of California, Davis
**Ron Harben**
California Association of Resource Conservation Districts
**Eric Kueneman and Judee Fisher**
Kueneman Consultancy
**Dennis Chessman and Margaret Smither-Kopperl**
United States Department of Agriculture NRCS, Fresno, CA
**John Diener**
Five Points, CA
**Anil Shrestha**
California State University, Fresno

**Environmental Farming Act**
**Science Advisory Panel**
**Public Comment Meeting**
Sacramento, CA
May 14, 2015

**My thanks to Amrith Gunasekara for the wonderful opportunity to be with you this morning.**

I thank you for this opportunity to provide information and ideas.

I very much support and applaud your consideration of the importance of goal-setting and long-term planning for cropping system improvement and sustainability.

I encourage additional partnerships and innovations going forward.

Message | Adobe PDF

Reply | Reply to All | Forward — Respond
Delete | Move to Folder | Create Rule | Other Actions — Actions
Block Sender | Safe Lists | Not Junk — Junk E-mail
Categorize | Follow Up | Mark as Unread — Options
Find | Related | Select — Find

You replied on 5/13/2015 6:35 AM.

rom: Beck, Dwayne [Dwayne.Beck@SDSTATE.EDU]
o: Jeffrey Mitchell
c:
ubject: RE: Environmental Farming Act Science Advisory Panel

Thirty minutes to explain soil organic matter. No problem. I am not sure what you will do with the extra time.

Good luck,
Dwayne

**From:** Jeffrey Mitchell [mailto:jpmitchell@ucdavis.edu]
**Sent:** Wednesday, May 13, 2015 8:03 AM
**To:** Beck, Dwayne
**Subject:** FW: Environmental Farming Act Science Advisory Panel

LONG-TERM and TRANSFORMATIONAL thinking. There is not time for baby steps.


Five Points, CA
1982


Conservation Agriculture Systems
INNOVATION CENTER

**Don Cameron**
**Terra Nova Farms**
**Helm, CA**
**Hosting UC Davis PLS110A Class**
**October 18, 2014**

# Main points

- There are benefits to be achieved by encouraging farming practices that address the core goals and principles of soil health
- I will share science and experiences related to how intensive soil health management systems
  - lower costs
  - are more efficient in inputs, water and energy, and
  - have other benefits with respect to soil function, water conservation and competitiveness
- I acknowledge a measure of uncertainty, but also a tremendous experience base related to why these systems make sense
- That long-term planning and goal-setting are extremely important,
- Finally, I encourage your consideration of additional partnerships moving forward









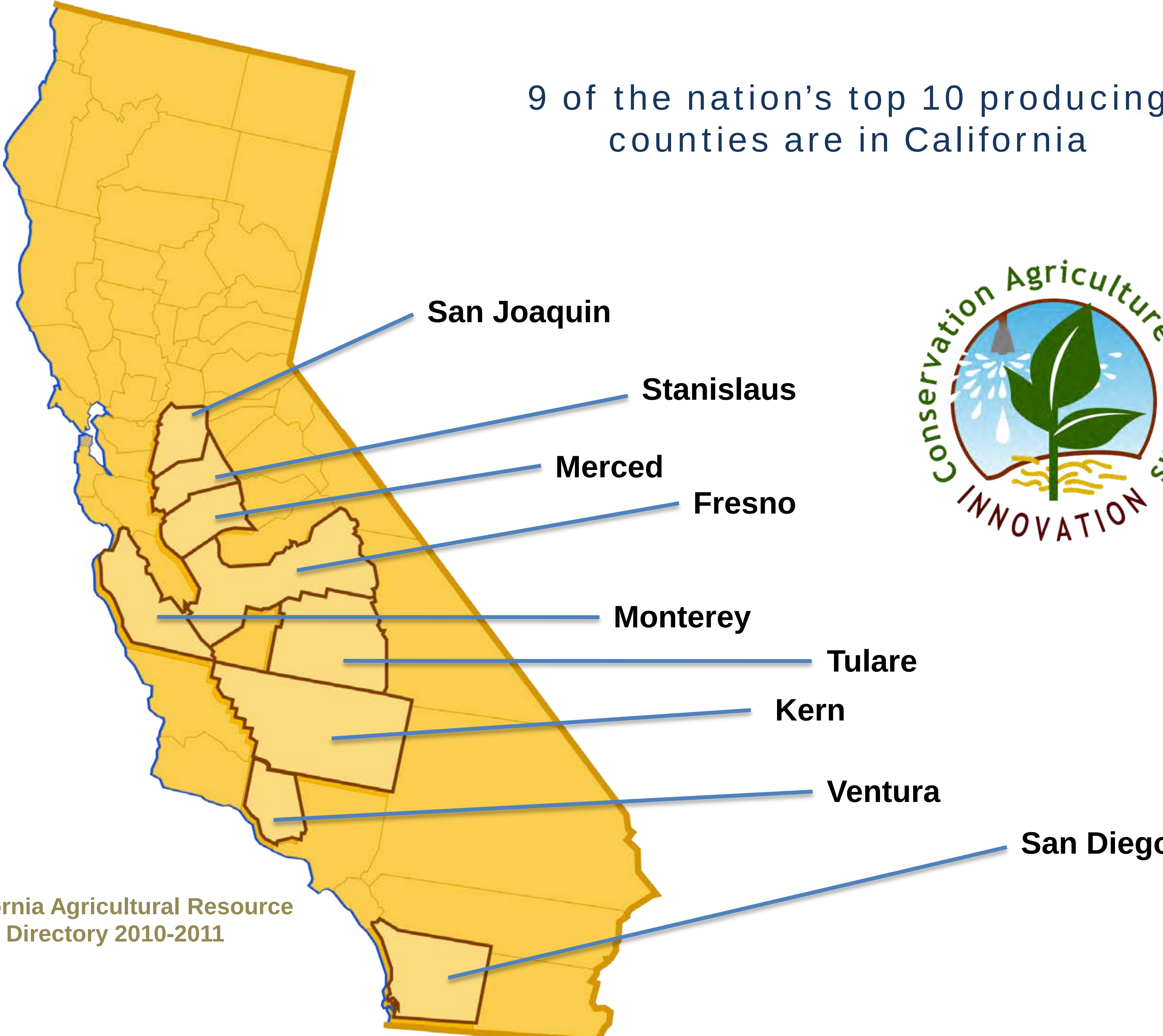

Conservation Agriculture Systems
INNOVATION CENTER

# Crop and Livestock Commodities in which California Leads the Nation

Almonds
Apricots
Artichokes
Asparagus
Avocados
Beans, Dry Lima
Bedding/Garden Plants
Broccoli
Brussels Sprouts
Cabbage, Chinese
Cabbage, F.M.
Carrots
Cauliflower
Celery
Chicory
Cotton, Am. Pima
Daikon
Dates
Eggplant
Escarole/Endive
Figs
Flowers, Bulbs
Flowers, Cut
Flowers, Potted Plants
Garlic
Grapes, Raisins
Grapes, Table
Grapes, Wine
Greens, Mustard
Hay, Alfalfa
Herbs
Kale
Kiwifruit
Kumquats
Lemons
Lettuce, Head
Lettuce, Leaf
Lettuce, Romaine
Limes
Mandarins & Mandarin Hybrids
Melons, Cantaloupe
Melons, Honeydew
Milk
Milk goats
Nectarines
Nursery, Bedding Plants
Nursery, Crops
Olives
Onions, Dry
Onions, Green
Parsley
Peaches, Clingstone
Peaches, Freestone
Pears, Barlett
Peppers, Chile
Peppers, Bell
Persimmons
Pigeons and Squabs
Pistachios
Plums
Plums, Dried
Pluots
Pomegranates
Raspberries
Rice, Sweet
Safflower
Seed, Alfalfa
Seed, Bermuda Grass
Seed, Ladino Clover
Seed, Vegetable and Flower
Spinach
Strawberries
Tomatoes, Processing
Vegetables, Oriental
Walnuts
Wild Rice

USDA, National Agricultural Statistics Service, California Field Office
California Agricultural Statistics, Crop Year 2010 (October 28, 2011)

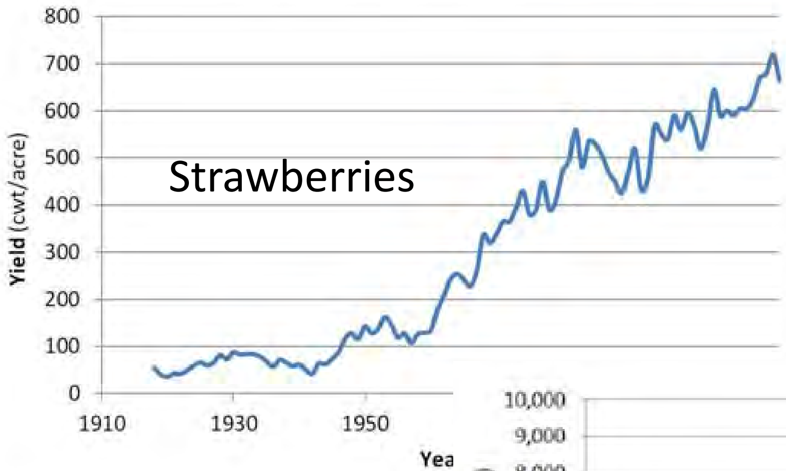
# 9 of the nation's top 10 producing counties are in California

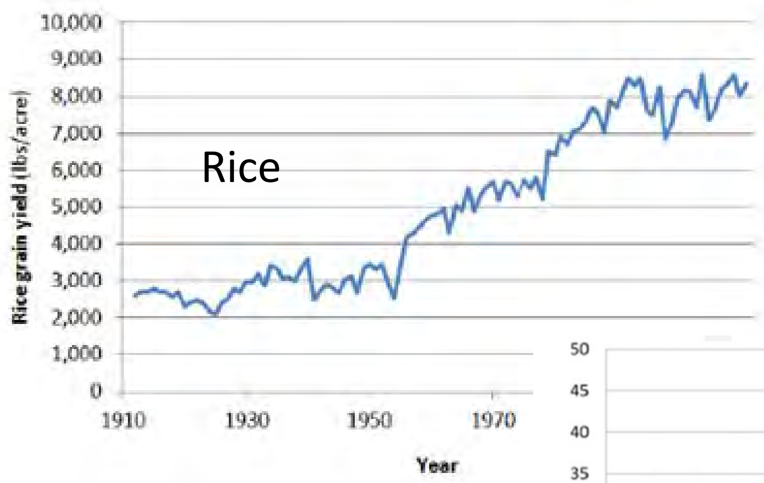


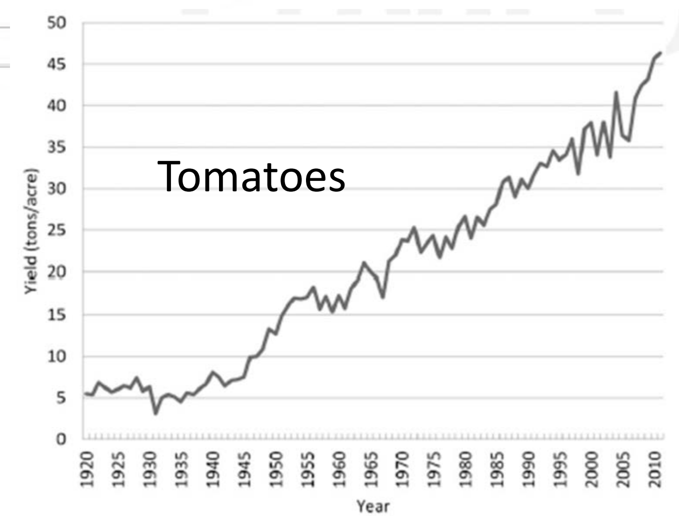

Conservation Agriculture Systems INNOVATION

California Agricultural Resource Directory 2010-2011

With historical trends of yield increases for California crop production, are there legitimate indications that soil function, soil quality, or soil health is declining?



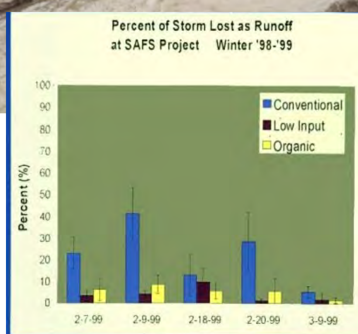



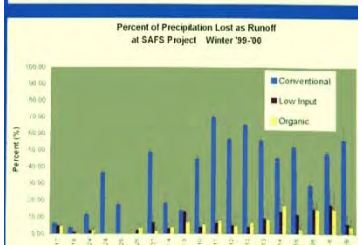

Geissler et al., 2012

# Are there indications that soil function, soil quality, or soil health is declining in California?

A legitimate, reasonable question that can be answered by testable hypotheses

Is there evidence that water intake and storage characteristics of soils might be improved?

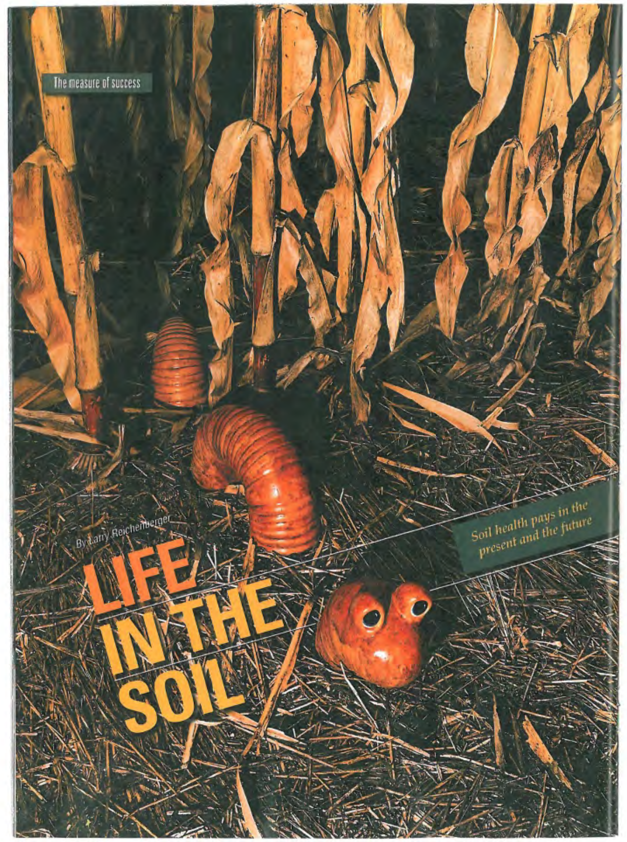



CONVENTIONAL = Winter Fallowed

ALTERNATIVE = Winter Cover Cropped

## Is there evidence that the value of soil biodiversity may not be expressed or realized to some sort of optimal extent?


Healthy soils are the ultimate measure of success for Rick Bieber. With the zeal of an evangelist, this Trail City, S.D., farmer promotes methods that enhance soil quality. He swears by the old adage, "If you take care of your soil, your soil will take care of you."

"The soil is the greatest source of wealth in the world, but most farmers squander its potential," says Bieber, who farms with his son, Ben. "The soil isn't just a tool, it's a full partner in a farming operation and deserves to be treated with respect. Learn to protect the soil and to manage it like it's really alive—because it is—and you will see an unbelievable response."

**Diversity in crops.** Bieber's recipe for a healthy soil includes long-term no-till, intensive crop rotation, and cover crops. "We started no-tilling in 1987 and soon learned we needed to diversify and intensify our crop rotation to utilize the moisture we were saving and to boost microbial activity in the soil. From wheat/fallow and wheat/corn/fallow, we changed to rotations that also include chickpeas, millet, flax, sunflowers, and alfalfa. More recently, we've added cover crops that are planted after wheat and interseeded into growing corn."

"Now, our yields are higher with fewer inputs so profitability has increased. And, the impact of drought, heat, and other stress is less. Our 10-year proven corn yields are 408% of the county average, and wheat yields are 358% of the norm," adds Bieber.

**Credit the soil.** Bieber is quick to deflect credit for this performance. "It's totally due to the soil—all I've done is provide what the soil tells me it needs to do its job," he says.

What Bieber provides is a steady supply of carbon—in the form of crop residue and living plant roots—that feeds soil microbes, moderates soil temperatures to protect the microbes, shields the soil surface from erosion, and builds soil organic matter levels.

Bieber measures performance of his system is various ways. "We used to apply 90 pounds per acre of nitrogen and produce 90-bushel corn, but now the same amount of nitrogen produces 160 bushels. That's due mainly to our soil organic matter levels, which are 4-5% in our long-term no-till."

In contrast, typical conventionally tilled fields in Bieber's area have soil organic matter levels around 2%. Soil with higher organic matter not only mineralizes more nitrogen, it also holds more water, and that's the farm's major benchmark of success.

"We judge our management skills by the amount of grain we produce per inch of rainfall, and we've seen this water-use efficiency increase as our soil health has improved. In 1998 we produced just over 4 bushels of corn per inch of rainfall. By 2001, the first year corn in our rotation grew on cover crops grown in 1998, that had increased to 5.4 bushels per inch. By 2007, that efficiency had increased to 6.23 bushels per inch of rainfall."

**Best combination.** Bieber worked with agronomist Cheryl Reese from South Dakota State University on an intensive cover crop study from 2009 through 2011. "There were 96 trials, and they showed that the best combination of cover crops and fertilizer rates resulted in 12.6 bushels of corn per inch of rainfall. Then in 2012, with a severe drought, corn on our long-term, no-till ground produced 9.54 bushels per inch of rainfall while some new ground—in its first year of no-till— produced only 4 bushels per inch. That was amazingly similar to what we saw in 1998," says Bieber.

**Hungry soil.** His water use efficiency data has convinced Bieber that his soils are hungry for live roots, even in dry years. "Living plants sequester carbon from the atmosphere and deposit it in the soil through their root system, so we want to have something growing every moment that the season allows," he says.

Cover crops allow Bieber to put this conclusion into practice. "We hire an extra man so we can plant cover crops right behind the combine during wheat harvest. And, the cover crops we interseed at the V-6 stage of our corn stay alive well after the corn matures in the fall," he says,

"We're protecting soil not just for the next generation, but for those 100 and 1,000 years from now," he adds. ■

►Left: Rick Bieber says healthy soil makes farming fun—a point emphasized by this giant earthworm he poses for frequent visitors to his farm.

►Left center: High organic matter levels have turned Bieber's soils black and fostered a teaming population of earthworms. ►Left: Cover crops, including radishes and turnips, are broadcast into corn at the V-6 stage to extend the growing season and improve winter grazing.

THE FURROW 31

**"'Soil care' is what we're doing."**

Rick Bieber
Trail City, SD
January 28, 2014

Is there evidence that soil water storage and movement are not what they might be for optimal water use efficiency and benefit?

Is there evidence that the soil management practices that are commonly used in California cropping systems as water use efficient as they might be?

REVIEW SUMMARY

SOIL SCIENCE

# Soil and human security in the 21st century

Ronald Amundson,* Asmeret Asefaw Berhe, Jan W. Hopmans, Carolyn Olson, A. Ester Sztein, Donald L. Sparks

**BACKGROUND:** Earth's soil has formed by processes that have maintained a persistent and expansive global soil mantle, one that in turn provided the stage for the evolution of the vast diversity of life on land. The underlying stability of soil systems is controlled by their inherent balance between inputs and losses of nutrients and carbon. Human exploitation of these soil resources, beginning a few thousand years ago, allowed agriculture to become an enormous success. The vastness of the planet and its soil resources allowed agriculture to expand, with growing populations, or to move, when soil resources were depleted. However, the practice of farming greatly accelerated rates of erosion relative to soil production, and soil has been and continues to be lost at rates that are orders of magnitude greater than mechanisms that replenish soil. Additionally, agricultural practices greatly altered natural soil carbon balances and feedbacks. Cultivation thus began an ongoing slow ignition of Earth's largest surficial reservoir of carbon—one that, when combined with the anthropogenic warming of many biomes, is capable of driving large positive feedbacks that will further increase the accumulation of atmospheric greenhouse gases and exacerbate associated climate change.

**ADVANCES:** The study of soil is now the domain of diverse schools of physical and biological science. Rapid advances in empirical and theoretical understanding of soil processes are occurring. These advances have brought an international, and global, perspective to the study of soil processes and focused the implications of soil stewardship for societal well being. Major advances in the past decade include our first quantitative understanding of the natural rates of soil production, derived from isotopic methods developed by collaboration of geochemists and geomorphologists. Proliferation of research by soil and ecological scientists in the northern latitudes continues to illuminate and improve estimates of the magnitude of soil carbon storage in these regions and its sensitivity and response to warming. The role of soil processes in global carbon and climate models is entering a period of growing attention and increasing maturity. These activities in turn reveal the severity of soil related issues at stake for the remainder of this century—the need to rapidly regain a balance to the physical and biological processes that drive and maintain soil properties, and the societal implications that will result if we do not.

**OUTLOOK:** Both great challenges and opportunities exist in regards to maintaining soil's role in food, climate, and human security. Erosion continues to exceed natural rates of soil renewal even in highly developed countries. The recent focus by economists and natural scientists on potential future shortages of phosphorus fertilizer offers opportunities for novel partnerships to develop efficient methods of nutrient recycling and redistribution systems in urban settings. Possibly the most challenging issues will be to better understand the magnitude of global soil carbon feedbacks to climate change and to mitigating climate change in a timely fashion. The net results of human impacts on soil resources this century will be global in scale and will have direct impacts on human security for centuries to come. ■

ON OUR WEB SITE

Read the full article at http://dx.doi.org/10.1126/science.1261071

The list of author affiliations is available in the full article online.
*Corresponding author. E-mail: earthy@berkeley.edu
Cite this article as R. Amundson et al., Science 348, 1261071 (2015). DOI:10.1126/science.1261071

CRED T: SBENTST RTON/GETTY IMAGES

**Large-scale erosion forming a gully system in the watershed of Lake Bogoria, Kenya.** Accelerated soil erosion here is due to both overgrazing and improper agricultural management, which are partially due to political-social impacts of past colonization and inadequate resources and infrastructure. The erosion additionally affects the long-term future of Lake Bogoria because of rapid sedimentation. This example illustrates the disruption of the natural balance of soil production and erosion over geological time scales by human activity and the rapidity of the consequences of this imbalance.


Aref Abdul-Baki
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Dwayne Beck
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Ron Morse
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Mike Peterson
Greeley, CO
Don Reicosky
USDA ARS
Morris, MN

# Soil health summary profiles of experienced practitioners

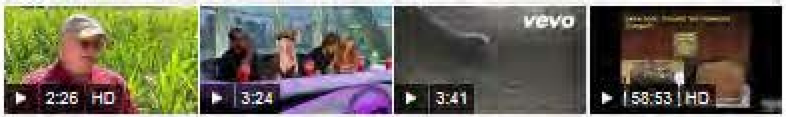
| | David Brandt<br>Ohio | Gabe Browne<br>North Dakota | Gail Fuller<br>Kansas | Leon Moses<br>North Carolina | Lawrence Sanchez<br>New Mexico |
|---|---|---|---|---|---|
| Acres farmed | 1100 | 5400 (crops+pasture) | 2000 | 492 | 300 |
| Years in soil health system | 30 | 20 | 8 | 6 | 12 |
| Primary crops | Corn, wheat, soybeans | Corn, wheat, sunflowers, alfalfa, oats, triticale, hairy vetch, red clover, peas | Corn, grain sorghum, triticale, winter barley, winter wheat, soybeans | Corn, soybeans, hay | Grass, alfalfa, corn, winter wheat, oats |
| Primary cover crops | All mixes, some 8- and 14-way blend; most used: peas, radishes, hairy vetch, crimson clover, ryegrass | Cocktail mixes with 20 to 25 different plant species | All mixes, some 8- and 14-way blend; most used: peas, radishes, hairy vetch, crimson clover, ryegrass | Ryegrass, hairy vetch, clover | Fescue, orchardgrass, clovers |
| Yields | 7- to 10- bushel/Ac increase in corn, 8% increase in soybeans | 20% higher than county average | Increased | Doubled | Increased |
| Commercial fertilizer use | $100-per-acre annual savings in nitrogen | No synthetic fertilizer used | Cut by 25% overall, up to 60% in some instances | Commercial nitrogen use cut by 100lbs/Ac | Reduced; but often uses manure in heavy does on newly rented land |
| Insecticide use | None | None used for past 10yrs. | None used for past 4yrs. | Better control with reduced use | None |
| Herbicide use | Very little | Cut by 75% | Dropped at least 1 herbicide pass in every field | Reduced; johnsongrass nearly eradicated | Reduced |
| Other benefits | Virtually no soil erosion; nutrients stay on the farm; less soil compaction; greener, healthier crops; reduced soil compaction; better water filtration; less worry about drought | Organic matter rose from 2% to more than 5%; water holding capacity and infiltration at highest levels; wildlife populations and diversity increased exponentially. | Higher-quality, more nutritious grains; no live called for in nearly 15 years; much better bottom line | Reduced soil compaction; much better water infiltration; better soil structure; 35% return on investment | Superior, more nutritios crops; less irrigation water needed; stronger soil structure; protection from wind and water erosion |

(Source: Lynn Betts, 'Put the Soil First,' Dakota Farmer, January 2013, Farm Progress (permission granted))

## [Videos of **gabe brown**]

bing.com/videos


| | | | |
|---|---|---|---|
| **Gabe Brown**: 2012 Growing | **Gabe Brown** - SARE National | 2012 Quivira Coalition | **Gabe Brown** Talks on the Va... |
| YouTube | YouTube | YouTube | YouTube |




| | | | |
|---|---|---|---|
| **Gabe Brown** - Bismarck, ND | **Gabe Brown** - Chicago Audition | Gabriel **Brown**: American Dream | **Gabe Brown**: Keys To Building |
| YouTube | Dailymotion | Yahoo Screen | YouTube |

See more videos of **gabe brown**

### Gabe Brown on Cover Crops, No-Till Farming and **Livestock**

agriculturalinsights.com/episode-035-**gabe-brown**-on-cover-crops-no...

**Gabe Brown** is using No-Till Farming, Cover Crops and **Livestock** to enhance his farming resources.

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# Clay Mitchell in NO-TILL FARMER, March 2012

## New Company Aims To Help No-Tillers Expand

Fall Line Farms will lease farm ground to top no-tillers or buy it from farmers wanting to see good soil stewardship practiced.

*We want to have long-term relationships with farmers, so leases that keep the farmer strong are important to us...*

Clay Mitchell

To contact Fall Line Farms:

www.no-tillfarmer.com

Conservation Agriculture Systems Innovation Center

University of California Agriculture and Natural Resources

*Making a Difference for California*

# Cut nitrogen by 50 lb. zero-till farmers told

Avid supporter

No CommentsPosted Jan. 24th, 2014 by Robert Arnason

9

> Wheat and durum only | Research was carried out in North Dakota and is not recommended for the Canadian Prairies

MINOT, N.D. — Dave Franzen of North Dakota State University believes in following the data.

So when North Dakota field data indicated that long-term, no-till fields require less nitrogen than conventionally tilled soils, the extension soil specialist told no tillage farmers to cut their nitrogen rates by 50 pounds per acre.


"That's the just way it worked out in the data. The data said 50 (lbs. per acre), so I used 50," Franzen said.

The recommendations apply to only wheat and durum.

"I only put out recommendations on things that I test," he said.

"I don't have any numbers to support (this) for sunflowers or anything else…. Unless I have any numbers, I'm not going to pull anything out of my back pocket. I've done the wheat and durum (research), so that's out there."

NDSU has said for the last several years that farmers growing wheat on fields with continuous no-till for more than five years require 50 lb. less nitrogen per acre than conventionally tilled fields.

Franzen is also developing nitrogen guidelines for corn grown on long-term zero-till fields.

He devised the wheat recommendation after studying North Dakota zero-tillage data

# We Will Feed the World in 2050

Lalit Verma

**Agricultural and biological engineers (ABEs) will be critically important in feeding an additional three billion people by 2050. Our profession's past contributions to safe, affordable, and abundant food are proof of that.**


Ensuring food security for the projected global population is a daunting challenge. However, a bright spot is that major contributions toward food security can be achieved without increasing production—for example, by reducing post-harvest losses. My confidence stems from my international experience as a post-harvest agricultural engineer.

In fact, because we need to produce more food with fewer inputs per unit of land, and then deliver this food to the people who need it most, production increases—by themselves—won't be enough. In addition to reducing post-harvest losses, we must also increase the efficiency of our production systems. We have started to do this by combining our engineering expertise—including precision farming, micro-irrigation, sensor networks, robotics, and other technologies—with expertise from other professionals, including agronomists, soil scientists, geneticists, entomologists, agricultural economists, and many others.

To do the most good, these collaborations need to be global, to match our combined expertise with local needs around the world. This is especially important for the developing world, as the large-scale strategies that work in developed countries must be adapted, using technologies that are appropriate for different cultures and different climates with even greater resource constraints. Fortunately, our recent successful collaborations with scientists in other fields have so far demonstrated that we can solve the complex problems of food production with constrained resources of land, water, and energy.

At the 2014 ASABE/CSBE Annual International Meeting in Montreal, we mapped out the global challenges and opportunities for ABEs as part of the Global Engagement Day activities. To further our ABE Global Initiative, we are developing a strategic position paper that identifies ABEs' importance and responsibility in sustainably feeding the world in 2050.

This paper outlines the challenges before us, highlights the specific needs of three "security" themes (food security, energy security, and water security) in the context of sustainability and climate change, and specifies how ASABE, its members, and its partners will address the grand challenges. Our strategy is expressed in the following goals:

1. Improve food productivity.
2. Reduce food losses and waste.
3. Enhance energy conservation and efficiency.
4. Develop adaptable renewable energy systems.
5. Improve water availability, conservation, and efficient use.
6. Provide clean water for multiple uses (human consumption, agriculture, recreation, ecosystem services, biodiversity, etc.).

These goals may sound familiar to you—in a way, they summarize the long-standing efforts of the ABE profession. We can be proud of what we've accomplished, so our strategy also involves showing the world who we are, what we do, and how our work has improved the quality of life for everyone. In particular, we must ensure that policy-makers are aware of the proven strengths and expertise of our profession.

Despite the challenges facing us, I believe that our future is bright, that all problems have solutions, and that our profession will be profoundly important in the global effort to feed the world in 2050.

ASABE Fellow and Past President Lalit Verma, Professor and Head, Department of Biological and Agricultural Engineering, University of Arkansas, Fayetteville, USA; lverma@uark.edu.



## A New Paradigm for Feeding the World in 2050

# The Sustainable Intensification of Crop Production

Theodor Friedrich

When the Food and Agricultural Organization (FAO) of the United Nations was founded in 1945, it was with the objective to fight hunger in the world. Since then, some progress has been made. The first of the Millennium Development Goals—to halve the proportion of hungry people in the world by 2015—appears within reach. At present, hunger along with poverty is more a problem of access to food than of availability. Therefore, hunger is being successfully addressed in many countries by political will and social programs. However, for the expected population of 9.2 billion in 2050, global food production will have to increase by about 70%, a conservative estimate considering the increased demand for animal products and bioenergy and the threats from climate change. Despite this challenge, FAO has revised its overall goal from reducing hunger to eradicating hunger. We can assume that FAO member countries, in accepting this change, are not pursuing an impossible target.

There is little hope of achieving the necessary production increase from expanding the cultivated land area. More than 80% of the necessary production increase will have to come from yield increases. Yet, the yield increases for all major food crops are declining. Therefore, this challenge will not be met by continuing with a concept of farming that caused the problem in the first place. The problem is not in the genetic potential of crops or the lack of production inputs. Instead, the problem lies in the degradation of natural resources and their yield-related functions, which do not allow closing the yield gap anymore.

Therefore, **FAO has proposed a different paradigm for agricultural production: sustainable intensification, as described in the book *Save and Grow* (www.fao.org/ag/save-and-grow). Sustainable intensification means achieving the highest possible production, applying all necessary technologies, while keeping the environmental impact below the threshold of natural recovery.**

FAO would not propose this paradigm change if it did not have "proof of application" that it actually works for farmers. Agricultural production can only be considered sustainable if the soil health and productive capacity are maintained in an optimal condition. Over the past millennia, agricultural land use globally has led to physical, chemical, biological, and hydrological degradation of the soil, and this process continues unabated on most farm lands. This is true for farms of all sizes, climatic regions, and economic development levels.

By reducing the turnover time between harvest and seeding of the subsequent crop, conservation agriculture enables farmers in climates with restricted growing periods to grow an additional crop in the same season.

The dominant global farming paradigm is based on mechanical tillage. In this paradigm, the "best practices" for crop, soil, nutrient, water, and pest management are the technical state of the art and are presumed to be suitable for obtaining high production with limited environmental damage. However, in many cases, soil degradation and environmental damage can only be controlled, not avoided, and this damage is generally accepted as an inevitable side effect of farming. This view is now being challenged, and it is increasingly considered outdated. Tillage-based farming practices cannot meet the combined objectives of production intensification with ecosystem services that are now being demanded by society. In the case of the soil, the degradation and erosion caused by tillage are always greater, by orders of magnitude, than the natural formation of soil. Hence, tillage systems cannot be sustainable. A long list of literature explores this problem, from Edward Faulkner's *Ploughman's Folly* (1943) to the more recent *Dirt: The Erosion of Civilizations* by David Montgomery (2007).

The logical response to this challenge is a farming system that does not mechanically disturb the soil and maintains the soil in a healthy state—a no-till system with biologically and ecologically active soil. Analyzing farmers' experiences with no-till around the world, FAO has come up with a definition for such a system, commonly known as conservation agriculture (CA), based on three interlinked principles for any land-based production system:

- Minimum or no mechanical soil disturbance (permanently)
- Permanent organic soil cover
- Diversification of species

When implemented correctly, CA delivers on multiple objectives: it increases yield and production in a sustainable way, closing the yield gap with reduced inputs over time, while enhancing ecosystem services. It is environmentally, economically, and socially sustainable and highly productive, and it responds to the demand for climate change adaptation and mitigation. I have seen many farmers on all continents improve their livelihoods and happiness after adopting CA on their farms. With CA, FAO had a sound basis for sustainable intensification, and hence FAO has been promoting CA around the world along with a growing number of organizations and institutions. Globally, CA is growing exponentially at 10 million ha per year, having reached 155 million ha in 2013, which represents 11% of global cropland. In some countries, CA is now the dominant farming system, and the oldest CA farms date back over 50 years.

Obviously, despite CA's many advantages, such a complex paradigm change in farming requires continued policy and institutional support for it to spread fast enough to help meet the challenge of feeding the world in 2050. This challenge is still facing us, and it is a question of political will, as is the eradication of hunger at the present time. Given that political will, there is no question that the challenge to feed the world in 2050 can be met with conservation agriculture, without the need of technological miracles that are yet to be invented.

ASABE Member Theodor Friedrich is co-founder of FAO's conservation agriculture initiative and for more than a decade has led FAO's global work on CA. He currently serves as FAO's representative in Cuba; theodor.friedrich@fao.org.

*Top photo © Matthew Collingwood | Dreamstime. Mid-page photo by the author.*

# 2015 International Year of Soils

*healthy soils for a healthy life*

## Launch of the 2015 International Year of Soils

The launch of the IYS will take place during the celebration of the first official UN World Soil Day 2014 on 5 December 2014

**INFOGRAPHIC**


International Year of Soils 2015

**WEBSITE**

FAO Soils Portal

**IN FOCUS**

Download the IYS 2015 logo

The 68th UN General Assembly declared 2015 the International Year of Soils (IYS) (A/RES/68/232).

The Food and Agriculture Organization of the United Nations has been nominated to implement the IYS 2015, within the framework of the Global Soil Partnership and in collaboration with Governments and the secretariat of the United Nations Convention to Combat Desertification.

***"The International Year of Soils will help us pave the road towards sustainable development for all and by all."***

José Graziano da Silva, FAO Director-General

**Tweets**

**Bacoban UK** @BacobanUk 1h
@BacobanUk cares by reduce disnfctnt in2 drains RT @UN #WorldSoilDay Soil hosts 1/4 of planet biodiversity j.mp/1w0U6RW #IYS2015

**Footprint to Wings** @Footprint2Wings 2h
Heads up! 2015 is the International year of Soils #IYS2015 fao.org/soils-2015/en/

**Sue Carlson** @susanmcarlson 2h
#IYS2015 A free video to view this week 5-12 Dec. symphonyofthesoil.com Beautiful, moving

Compose new Tweet...

Related Links

- Global Soil Partnership

## Soil Health Profile, David Brandt


On October 11, 2012, at the Carroll, OH farm of long-time no-till and cover crop farmer, David Brandt, USDA's Natural Resources Conservation Service (NRCS) launched *"Unlock the Secrets in the Soil,"* a major, national education and awareness campaign about soil health.

### Ohio soil health pioneer forges new frontier in farming

While David and Kendra Brandt like what they see from the soil health system they're using on their central Ohio farm, everything they do still has to pass muster through the combine's yield monitor.

They've used no-till on their corn, wheat, and soybean operation since 1971, but when David saw a drop in corn yields in 1978, he added hairy vetch and winter peas to the system to get more nitrogen.

"We were using commercial nitrogen then, and I wasn't really thinking about the health of the soil," Brandt says. "We saw some improvement in water infiltration at the time, but we didn't reduce nitrogen inputs until we learned our soils were changing and we didn't really need it," he says.

#### Reducing Crop Inputs

"Cutting back on commercial inputs has been a tough one for me, because we've always been taught we need so many pounds of nitrogen, phosphorus and potash to grow a decent corn crop," Brandt says. "We're learning now with cover crops that we don't need to buy those additional nutrients because we can bring them up from deeper in the soil. They just weren't available to the crop before."

"In fact, we've learned in the last two years that we can go to using almost no purchased commercial fertilizer or herbicide and still produce a great crop of corn and beans."


LEAD21
No-till a crop of carbon
April 15, 2015

# A quantifiable assessment of the capacity of our oceans to deliver benefits and resources sustainably.

# Scores range from 0 to 100 for 10 goals for a healthy ocean.

## Globa

67

How was this score calculated?

## Ocean Region Rankings

See how overall region scores rank

## New Score Releases

Antarctica and the Southern Ocean region scored 72 while the average score of the high seas was 67 out of 100.

Antarctica Scores

High Seas Overview

2014 Key Findings


# An Index Organized by 10 Public Goals

Each goal has an optimum reference point determined by a team of experts. The target is considered attainable and is more sustainable than the current conditions. A score of 100 meets the target. The Ocean Health Index was started in 2012 and reports new scores annually. Roll over the chart to learn more about each goal.

Visit the Annual Change page to view the Index over time

Food Provision
51

Artisanal Fishing Opportunities
68

Natural Products
42

Carbon Storage
74

Coastal Protection
76

Coastal Livelihoods & Economies
82

Tourism & Recreation
44

Sense of Place
67

Clean Waters
78

Biodiversity
83

# Using the Best Available Science

Using data from the best available scientific resources, the Index calculates an annual global score for ocean health in 221 coastal regions and 15 sectors of the high seas.

The framework for the Ocean Health Index was first published in

Conservation Cropping Systems Initiative

Search ...

HOME | ABOUT | CONTACT | SOIL HEALTH EVENTS | SOIL HEALTH HUBS | SOIL HEALTH PRACTICES


## A Soil Health Approach

*Maximize profits and increase production while protecting your land*

### Indiana's Innovative Soil Health Hubs

The hubs will provide regionally centralized locations for training opportunities and will also be coordinating with local farmers and ICP staff dedicated to the project.

### On Farm Network

CCSI is a partner in Indiana's On Farm Network, a group of crop producers interested in economics, stewardship, and reducing their environmental footprint.

### Watch and Learn

Want to see conservation in action? Check out these videos for more information on how to choose and plant cover crops, how to judge soil texture by feel, how to adjust a no-till planter, and more.


## A FIVE-YEAR INITIATIVE

Over the next five years, we plan **to identify, test and measure management practices that improve soil health and benefit farmers' operations.** Right now, many farmers across the country are implementing innovative management practices that result in economic and environmental benefits. We plan to build upon the work of these farmers to **provide connections between on-farm practices and improving soil health.**

We believe the results of this farmer-led project will provide a platform for sharing information from farmers to farmers, with the support and resources to benefit farmers' bottom lines and agricultural sustainability. **We want to help provide the spark for greater understanding and more broadly implementing agricultural practices that work best.**

NATIONAL CORN GROWERS ASSOCIATION

**An NCGA Initiative**

## Managing for soil health …

- **Minimizing soil disturbance**
- **Maximizing the diversity of plants in rotation / cover crops**
- **Keeping living roots in the soil as much as possible, and**
- **Keeping the soil covered with plants and plant residues at all times**

**Unlock the Secrets in the Soil**

http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/soils/health/

**Soil Health Literature Matrix of Soil Properties** As of July 11, 2014

| Reference | Summary | Citation | Updated |
|---|---|---|---|
| Benjamin et al., 2007 | An investigation at Akron, CO, on a Weld silt loam (fine, smectitic, mesic Aridic Paleustolls) compared soil conditions in winter wheat –summer fallow (WF) plots with soil conditions in wheat–corn –fallow (WCF), wheat–corn–sunflower–fallow (WCSF), wheat–corn–millet (WCM), and a perennial grass/legume mix. Bulk density, pore size distribution, and saturated hydraulic conductivity were measured 7, 11, and 15 yr after inception. Bulk density in the grass plots decreased from 1.39 to 1.25 Mg m−3 in 15 yr. Bulk density in the annually cropped plots decreased from 1.38 to 1.30 Mg m−3 during the same time period. The pore size distribution became more uniform among the cropped treatments 15 yr after the start of the experiment. KSat increased in the grass plots from 27 mm h−1 to 98 mm h−1 in 15 yr. KSat in the annually cropped plots increased from about 14 to about 35 mm h−1 during the same period. The results from this study show that improving soil physical properties by cropping system alone may take many years. Perennial vegetation may be more effective than annually cropped systems at improving soil physical conditions because of less surface compaction from planting operations and the apparent ability of perennial root systems to create a more stable, continuous pore network. | Benjamin, J.G., M. Mikha, D.C. Nielsen, M.F. Vigil, F. Calderon, W.B. Henry. 2007. Cropping intensity effects on physical properties of a no-till silt loam. Soil Sci. Soc. Am. J. 71:1160-1165. | 6/17/2014 |
| Benjamin et al., 2008 | Comparisons of long term (15 yr) no-till treatments of non-irrigated continuous grass-legume mix vs. wheat/corn/ millet vs. wheat fallow rotation at the semi-arid ARS Central Great Plains Research Station, Akron, CO on a Weld Soil Series (deep smectitic silt loam over silty clay loam), showed significant increases in SOC in the grass and wheat/corn/millet treatments over the wheat/fallow in the surface 95 mm grading to no differences below 295 mm. K-Sat was significantly higher in the grass treatment to 370 mm but there were no differences in bulk density and water storage porosity. There were also no differences in water stable aggregates to 180 mm. | Benjamin, J.G.*; M. M. Mikha; M. F. Vigil. 2008. Organic Carbon Effects on Soil Physical and Hydraulic Properties in a Semiarid Climate. Soil Sci. Soc. Am. J. 72:1357-1362. (* USDA-ARS Central Great Plains Research Station, Akron, CO 80720). | 6/17/2014 |

Beginning in about 2006, the NRCS Soil Health Campaign began as an effort that grew from the National Soil Quality Department and grew through grassroots Soil and Water Conservation Districts and ongoing related efforts in a number of states around the country to become a national program.

# Natural systems …

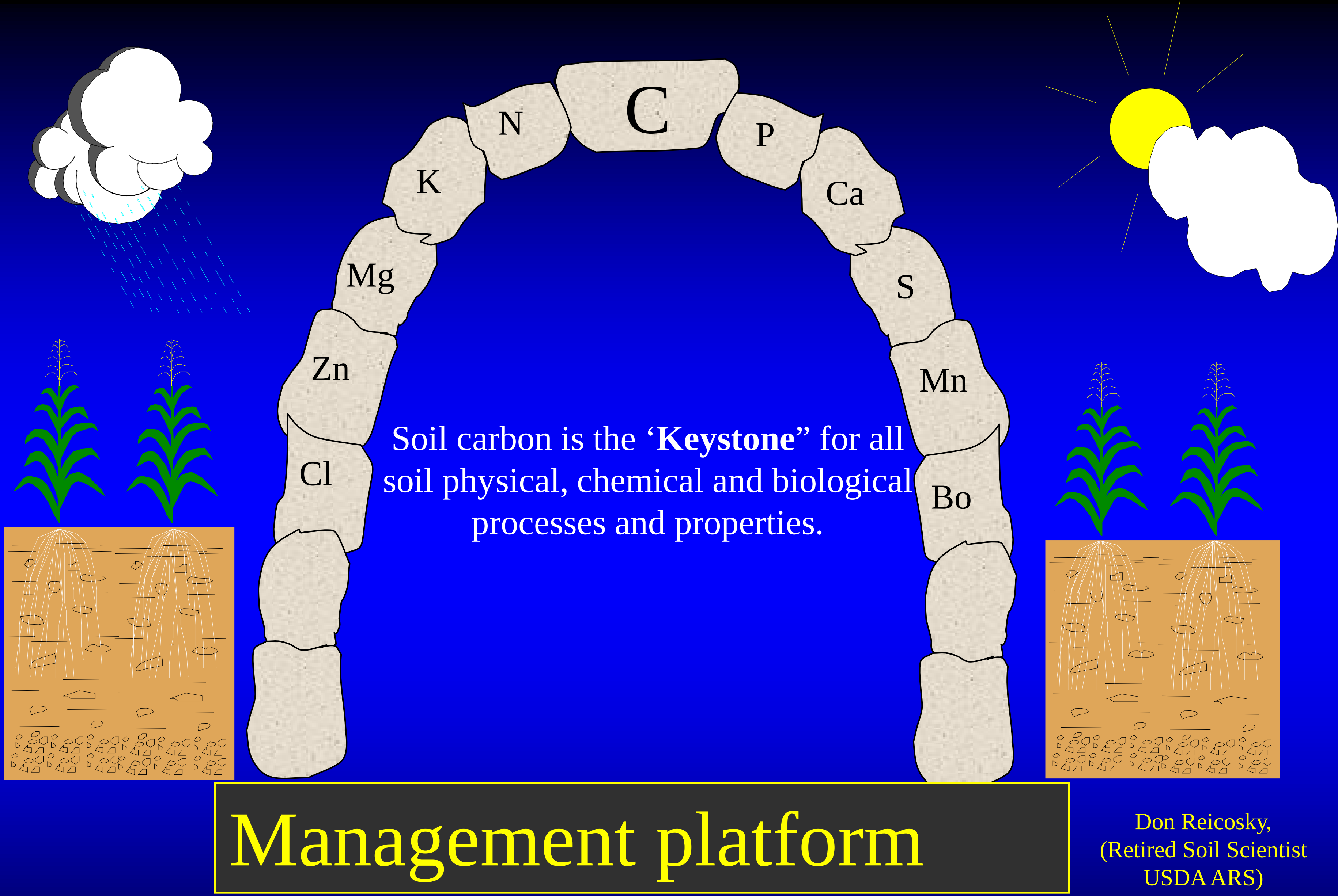
- harvest the maximum amount of sunlight
- leak very few nutrients including $CO_2$
- have diversity
- tend not to export nutrients
- make maximum use of water and nutrients by having highly developed porosity and VAM webs
- do not do tillage

Summary of comments made by Dr. Dwayne Beck, SDSU,
at 2014 Winter Conference of No-till on the Plains, Salina, KS

# Soil improving practices

1. Feed the soil (OM) (not take away everything, not mine the soil)
2. Reduced soil disturbance (physical, chemical, and biological)
3. Increase diversity (biodiversity)
4. Keep the soil covered
5. Minimize diversity-reducing inputs
6. Promote optimal soil structure
7. Reduce extremes in temperature
8. Build soil carbon
9. Use diverse cover crops
10. Rotate crops
11. Manage salinity
12. Manage nitrogen
13. Precision irrigation
14. Decrease soil-borne pests
15. Reduce compaction
16. Monitor soil conditions (lab analyses)

This list was developed in a meeting with farmers, NRCS conservationists, private sector consultants, and university researchers held at the UC West Side Research and Extension Center in Five Points, CA, April 23, 2013.




Don Reicosky,
(Retired Soil Scientist
USDA ARS)

fertility, variety, irrigation, species, cover crop, manure, rotations, tillage, soil type, erosion, timing,

**"Tillage-induced carbon dioxide loss" information and data from Reicosky used in commercial advertising**
**Tulare, CA**
**2015**

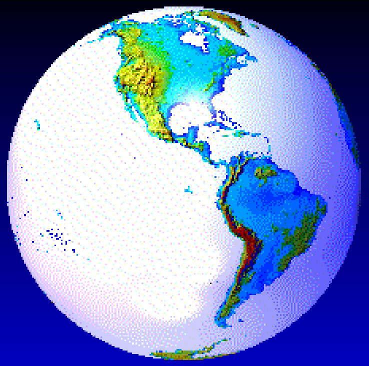
OUR HUNGRY WORLD

OUR THREATENED PLANET

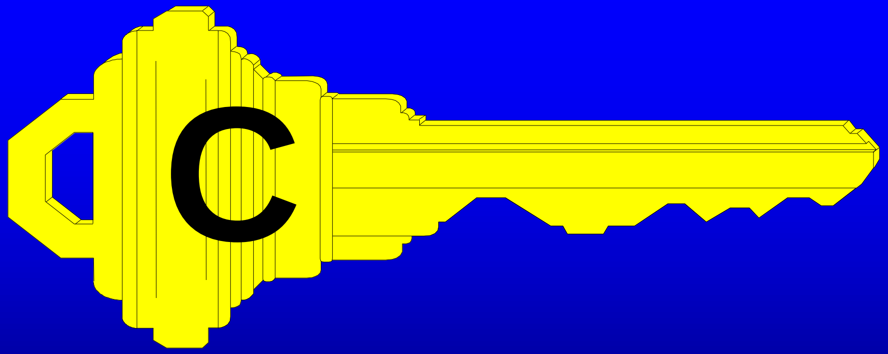
OUR CHILDREN'S FUTURE

OUR ONE CHANCE… Conservation Agriculture

All rest on "OUR LIVING SOIL" that depends on soil carbon!



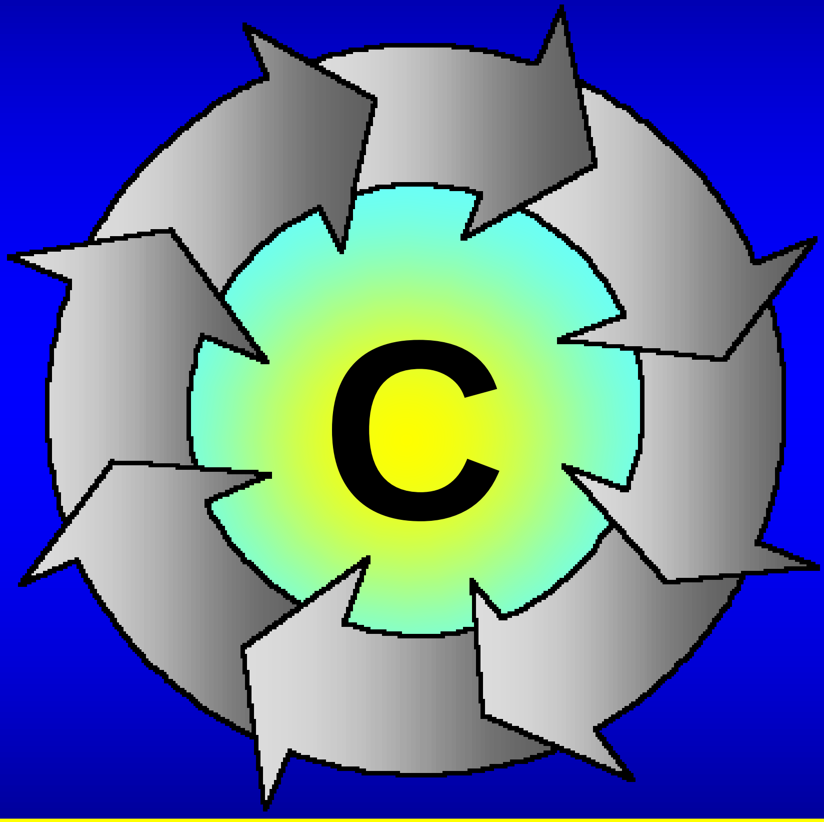
# The "key" component is:

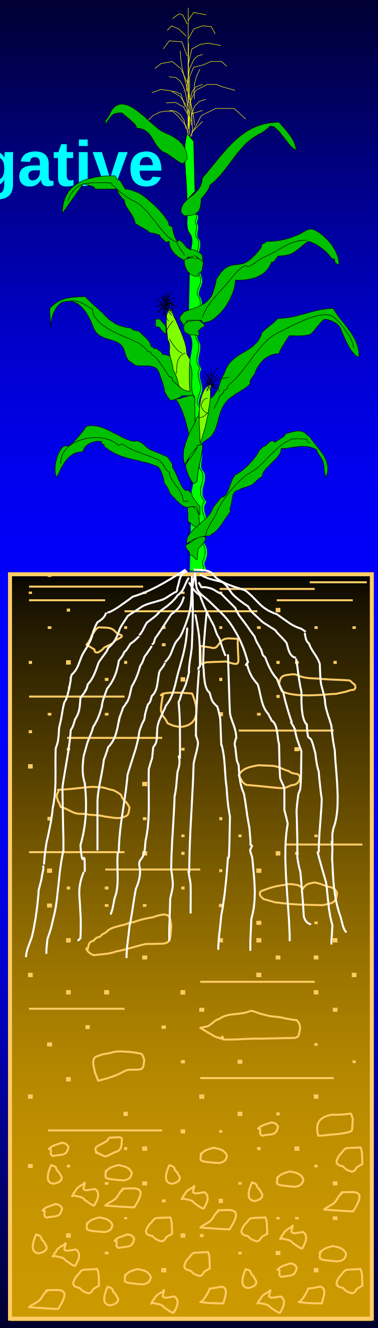



**c a r b o n !**

# Why Soil Carbon Management?

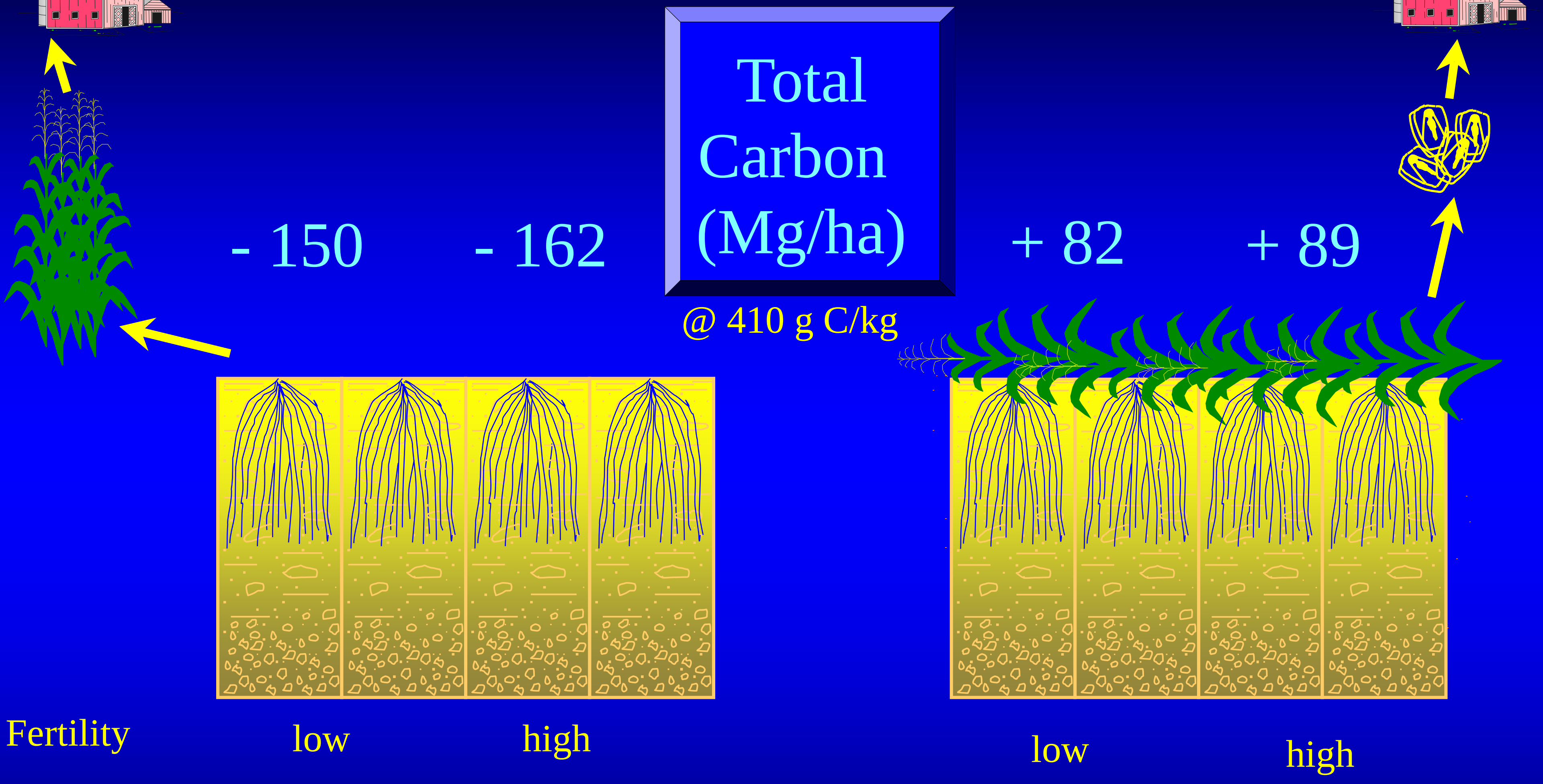
Agriculture, through better management of the "biological C" cycle, can help society offset negative environmental impacts of the "fossil C" cycle.



**Soil carbon is an important link between sustainability and productivity within our agricultural systems.**

# 30 Years Continuous Corn + Plow




Silage removed (grain and stover removed)

Grain removed (stover returned)

# 30 Years Continuous Corn + Plow

| | Silage removed (grain and stover removed) | | Total Carbon (Mg/ha) | Grain removed (stover returned) | |
|---|---|---|---|---|---|
| Total Carbon (Mg/ha) | - 150 | - 162 | | + 82 | + 89 |
| Fertility | low | high | (0-15 cm) Soil Carbon (g C/kg) | low | high |
| | 21.3 | 21.4 | | 21.3 | 21.7 |

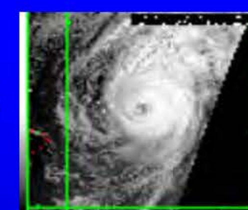
**Results suggest intensive tillage(moldboard plow) common to all treatments overshadowed stover carbon  removal or addition.**

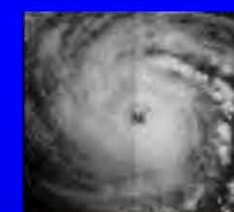
# "Turmoil of Tillage"

The soil is a natural biological system that contains a lot of life and when tilled intensively is dramatically changed. It can be considered analogous to human reaction to a combination of:

- earthquake

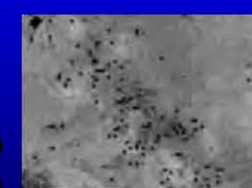
- hurricane



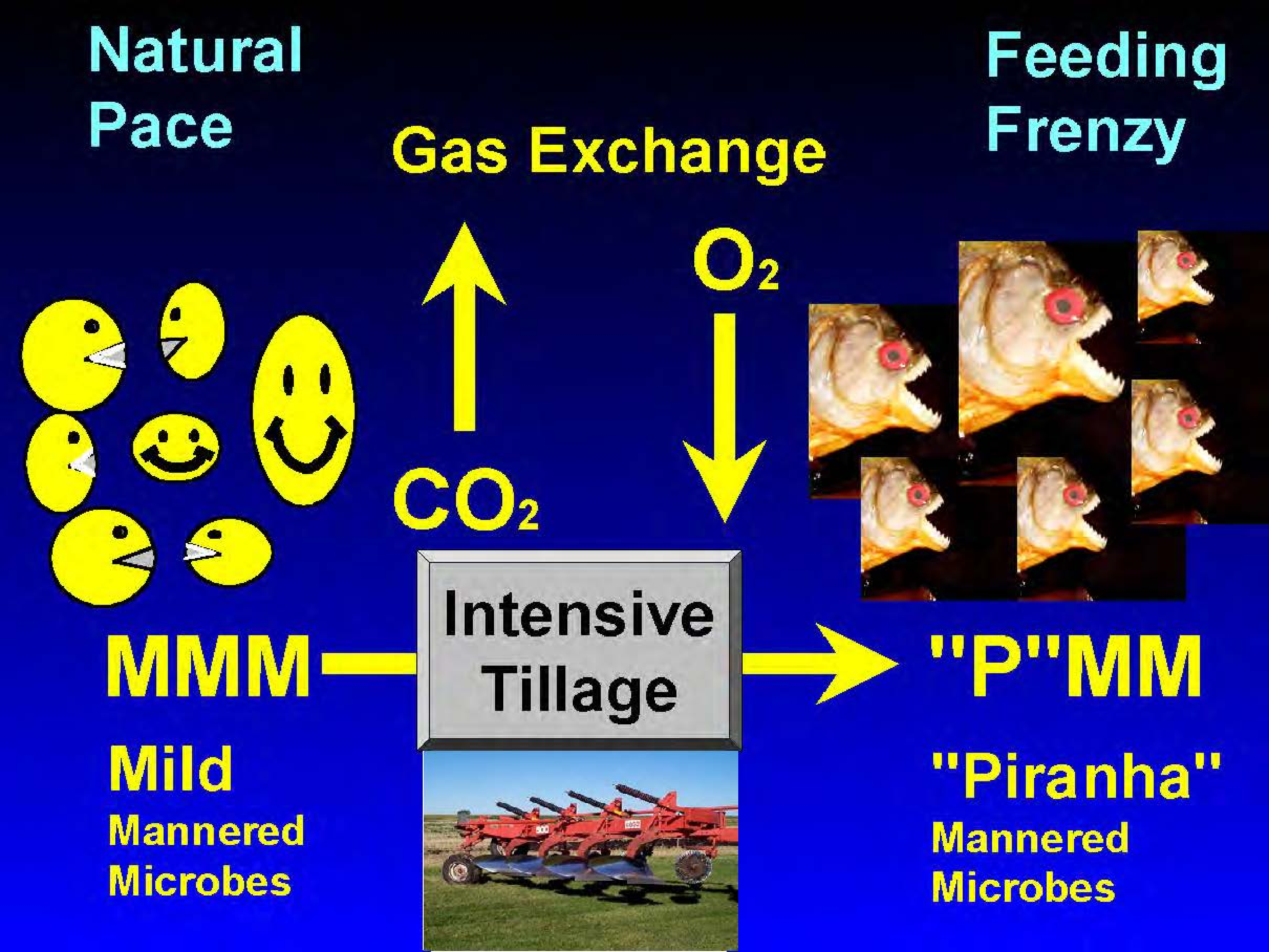


- tornado

- forest fire

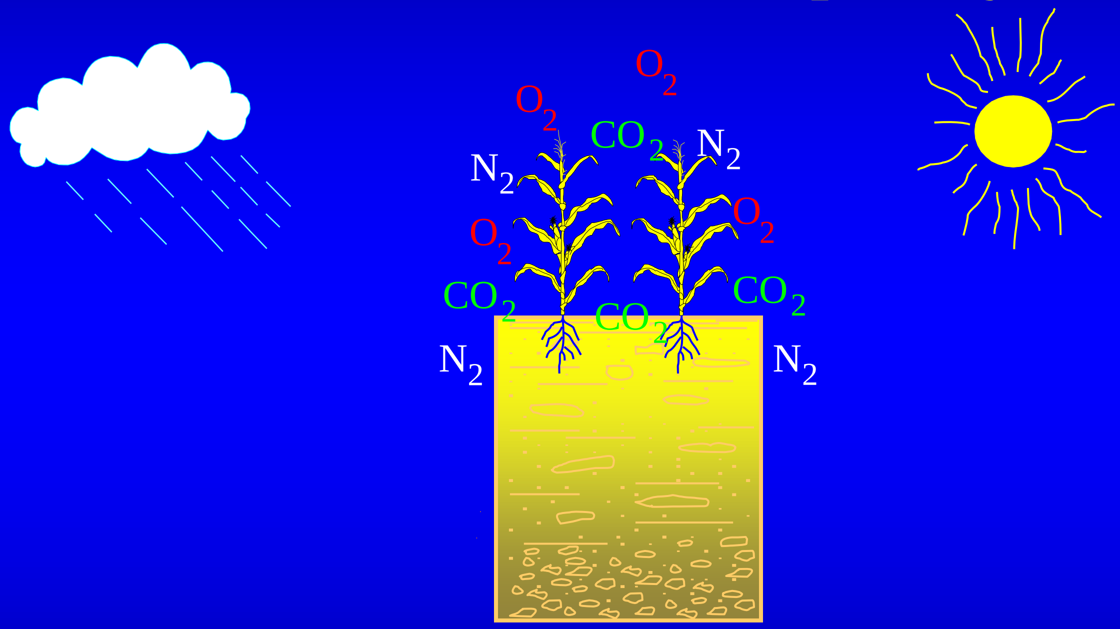



all rolled into one perturbation event.


Natural
Pace
Gas Exchange
Feeding
Frenzy
$CO_2$
$O_2$
$CO_2$
Intensive
Tillage
MMM
"P"MM
Mild
Mannered
Microbes
"Piranha"
Mannered
Microbes

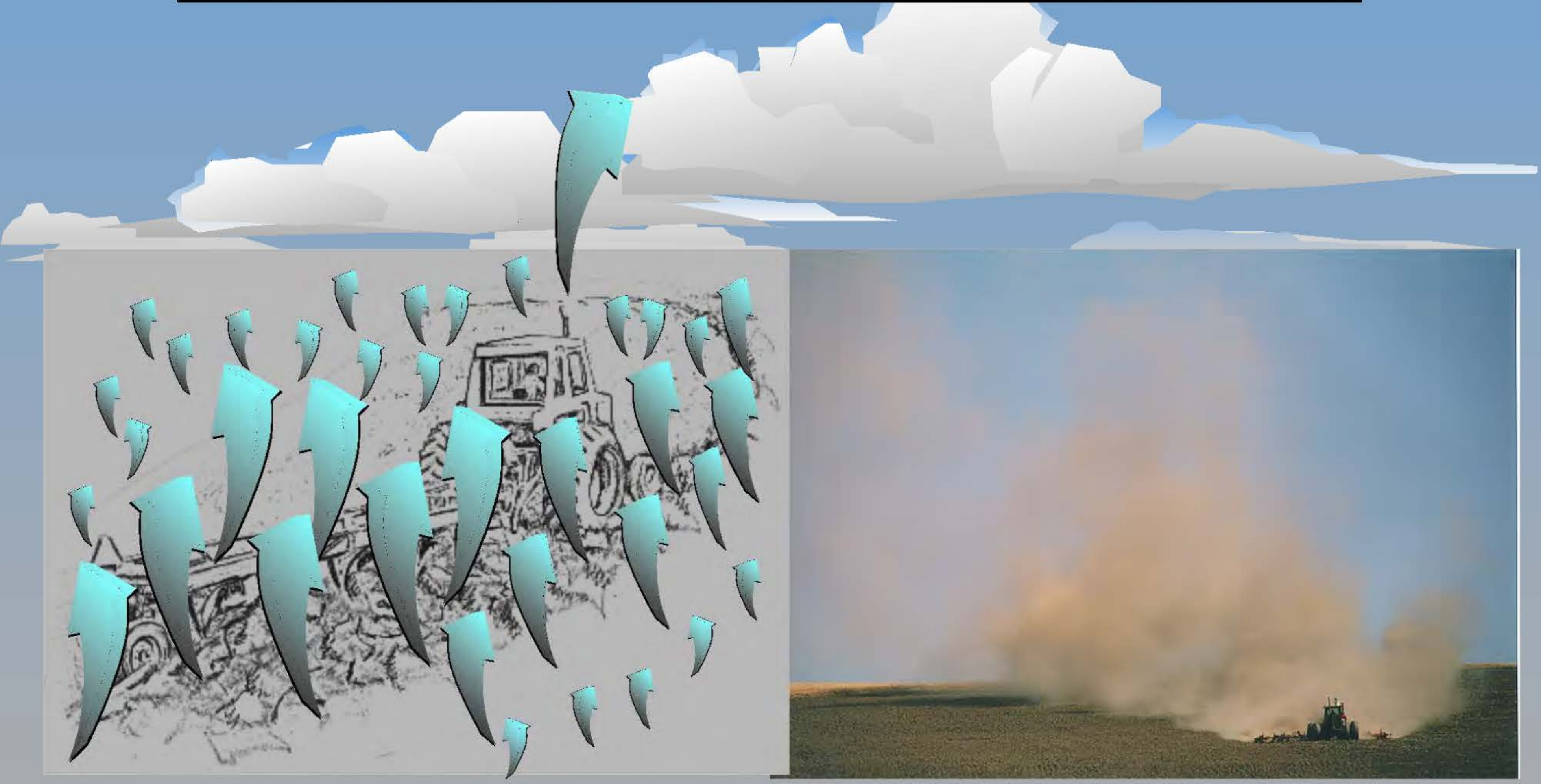
# Soil Quality is everyone's business!

## Anyone who eats should be concerned about soil quality.

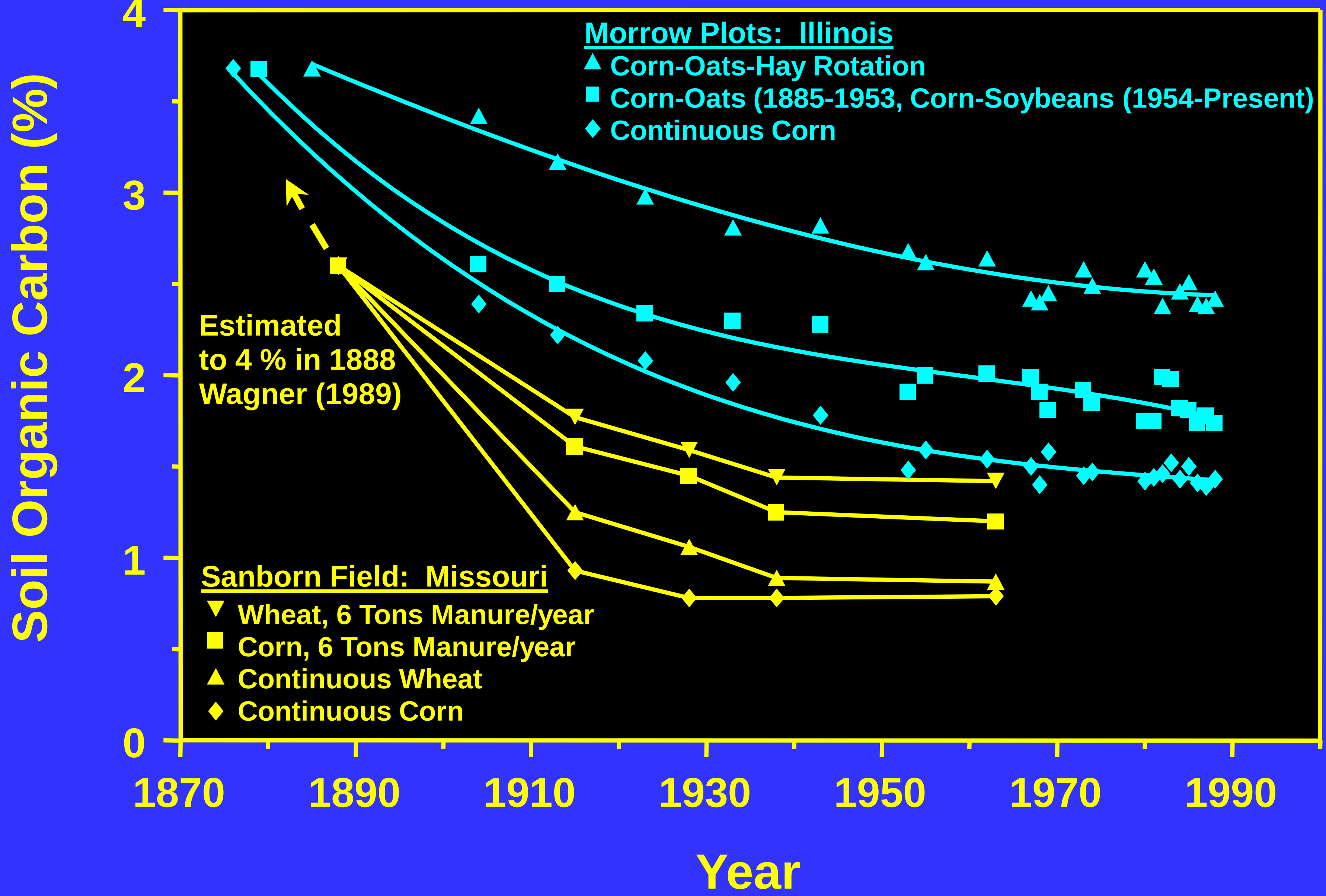



Our soils are the fundamental foundation of our life and our economy. Our soils, water, air and sun are the major resources that sustain our food production.  We are the stewards of those resources and must manage soil carbon to maintain sustainable production.

# TILLAGE-INDUCED CARBON DIOXIDE LOSS



# Long Term Effects of Crop Rotations



REVIEW

SOIL SCIENCE

# Soil and human security in the 21st century

Ronald Amundson,[1]* Asmeret Asefaw Berhe,[2] Jan W. Hopmans,[3] Carolyn Olson,[4] A. Ester Sztein,[5] Donald L. Sparks[6]

Human security has and will continue to rely on Earth's diverse soil resources. Yet we have now exploited the planet's most productive soils. Soil erosion greatly exceeds rates of production in many agricultural regions. Nitrogen produced by fossil fuel and geological reservoirs of other fertilizers are headed toward possible scarcity, increased cost, and/or geopolitical conflict. Climate change is accelerating the microbial release of greenhouse gases from soil organic matter and will likely play a large role in our near-term climate future. In this Review, we highlight challenges facing Earth's soil resources in the coming century. The direct and indirect response of soils to past and future human activities will play a major role in human prosperity and survival.

Soil is the living epidermis of the planet (1). Globally, soil is the medium through which a number of atmospheric gases are biologically cycled and through which waters are filtered and stored as they pass through the global hydrological cycle (2). Soil is a large and dynamic reservoir of carbon and the physical substrate for most of our food production. Profound changes are on the horizon for these interconnected functions particularly sparked by changes to climate and food production that will likely reverberate through society this century. Ultimately, the way in which we directly and indirectly manage our planet's soil will be interwoven within our future success as a species.

Soil is commonly thought of as the ~1-m-thick layer of biogeochemically altered rock or sediment at Earth's surface that has acquired numerous qualities during its exposure to the atmosphere that greatly distinguish it from its geological sources (3). Soil-forming chemical reactions create micrometer-sized electrically negative clay minerals that impart soil with plant nutrient retention capabilities (4). The electrical charge characteristics of soil, combined with its small particle size and high surface area, allow it to temporarily store rain and snow melt for plant use and provide sufficient residence time for a multitude of chemical reactions to occur that may remove or reduce the toxicity of contaminants. The water stored in soil termed green water (5) serves as the source for 90% of the world's agricultural production and represents ~65% of global fresh water (5). Last, the intimate intermingling of life plant, animal, and microbial within the soil matrix drives redox reactions that control many elemental cycles (6) and creates a reservoir of organic C that greatly exceeds the C in the global atmosphere and biosphere (7). The microbial communities that mediate these redox reactions are now believed to represent much of Earth's total biodiversity (8), but the nature, function, and economic potential of this soil biosphere is only beginning to be probed (6).

Soil, due to global variations in climate, geology, and biota (3), has tremendous spatial diversity. More than 20,000 soil types (or soil series) have been identified and mapped in the United States alone (9), and the number identified increases as land area investigated increases. If the soil series to land area relationship (10) is extrapolated to global ice-free land area, the results suggest that there are more than 300,000 series on the planet. The response of these soils to perturbations can be extremely varied because of their diverse chemical, physical, and biological characteristics, suggesting the importance, as a simple precautionary principle, of maintaining segments of this diversity for the stability and resilience of global biogeochemical systems in the face of anthropogenic disturbances.

### Human Imprint on Soil

Humans altered the ecosystems they encountered as they began their spread across the globe. However, the most momentous development in human landscape change occurred with the invention and adoption of agriculture (11). Most agricultural practices involve the removal of the natural flora, the simplification of biodiversity to favor monocultures, and the physical disruption of the soil. Since the Industrial Revolution, expanding populations have relied on the exploitation of more and more soil for a corresponding growth in food production. Today, ~12% of ice-free land is in cropland, and 38% is used for combined cropping and grazing (12), an area roughly equivalent to the land area covered by ice and scoured or otherwise disturbed during the last glacial maximum (Fig. 1A). In addition to the similarity in area, the agricultural impact on soil processes rivals or exceeds the effect of those ice sheets in both rapidity and magnitude.

Undisturbed soils have the characteristic, as result of a number of feedback mechanisms, of being able to retain many of their features indefinitely over time their thickness, C content, and nutrients, for example a condition that is equatable to sustainability (Fig. 2). Cultivated soils are highly modified forms of their wild predecessors and may thus be viewed as domesticated soils (9). One key characteristic is that domesticated soils seldom are able to maintain the qualities of their original conditions, and these changes greatly affect their productivity and their impact on surrounding geochemical cycles. The efforts to improve the management and conservation of these domesticated soils, and the preservation of portions of their remaining wild ancestral stock, will be among the most important challenges this century (9, 13). Analyses of the combined agricultural and urban impact on soil series in the United States, for example, revealed large areas in the agricultural heartland where more than 50% of the soil series had been domesticated. Soil diversity, like biodiversity (14), provides an array of human-valued goods and services. Among the most apparent issues is the ability of soil to provide sustained agricultural production.

The domesticated soil landscape is one of Earth's most valuable commodities. For example, nearly $3916 billion (U.S. dollars) in agricultural products were produced globally in 2012 (15). However, agriculture is competing with increasing urban and suburban soil demands. The conversion of soil to urban land is largely irreversible on human time scales. There is uncertainty both in the present and the future distribution of urban land on Earth (Fig. 1B). A recent meta-analysis suggests that between 1970 and 2000, an area greater than the size of Denmark was urbanized, and that in the next 20 years, 1.5 million $km^2$ of land (the size of Mongolia) will be urbanized (16). The conversion of farmland to urban areas must be weighed against the fact that our most productive soils have already been exploited and that demand for food production will continue to increase.

### Soil and Climate Security

A relatively stable climate has been the stage on which the great human inventions of agriculture and industrialization have evolved, and direct or indirect human impacts on soil C cycling processes will have much to do with atmospheric greenhouse gas concentrations and the associated climate implications by the end of this century.

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*Corresponding author. E-mail: earthy@berkeley.edu



Is there evidence that soil carbon levels are not what they might be in California soils?

"During the first few decades that soil is cultivated, up to 50% of the carbon pool is oxidized to $CO_2$; eventually, a quasi-steady-state soil C pool is achieved. Based on the global agricultural land area, cultivation has likely released between 50 and 70 Gt of C to the atmosphere over the course of human history, and the combined cultivation and biomass burning contributions to atmospheric $CO_2$ exceeded that of fossil fuel emissions well into the $20^{th}$ century."

REVIEW

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Human security has and will continue to rely on Earth's diverse soil resources. Yet we have now exploited the planet's most productive soils. Soil erosion greatly exceeds rates of production in many agricultural regions. Nitrogen produced by fossil fuel and geological reservoirs of other fertilizers are headed toward possible scarcity, increased cost, and/or geopolitical conflict. Climate change is accelerating the microbial release of greenhouse gases from soil organic matter and will likely play a large role in our near-term climate future. In this Review, we highlight challenges facing Earth's soil resources in the coming century. The direct and indirect response of soils to past and future human activities will play a major role in human prosperity and survival.

Soil is the living epidermis of the planet (*1*). Globally, soil is the medium through which a number of atmospheric gases are biologically cycled and through which waters are filtered and stored as they pass through the global hydrological cycle (*2*). Soil is a large and dynamic reservoir of carbon and the physical substrate for most of our food production. Profound changes are on the horizon for these interconnected functions particularly sparked by changes to climate and food production that will likely reverberate through society this century. Ultimately, the way in which we directly and indirectly manage our planet's soil will be interwoven within our future success as a species.

Soil is commonly thought of as the ~1-m-thick layer of biogeochemically altered rock or sediment at Earth's surface that has acquired numerous qualities during its exposure to the atmosphere that greatly distinguish it from its geological sources (*3*). Soil-forming chemical reactions create micrometer-sized electrically negative clay minerals that impart soil with plant nutrient retention capabilities (*4*). The electrical charge characteristics of soil, combined with its small particle size and high surface area, allow it to temporarily store rain and snow melt for plant use and provide sufficient residence time for a multitude of chemical reactions to occur that may remove or reduce the toxicity of contaminants. The water stored in soil termed green water (*5*) serves as the source for 90% of the world's agricultural production and represents ~65% of global fresh water (*5*). Last, the intimate intermingling of life plant, animal, and microbial within the soil matrix drives redox reactions that control many elemental cycles (*6*) and creates a reservoir of organic C that greatly exceeds the C in the global atmosphere and biosphere (*7*). The microbial communities that mediate these redox reactions are now believed to represent much of Earth's total biodiversity (*8*), but the nature, function, and economic potential of this soil biosphere is only beginning to be probed (*6*).

Soil, due to global variations in climate, geology, and biota (*3*), has tremendous spatial diversity. More than 20,000 soil types (or soil series) have been identified and mapped in the United States alone (*9*), and the number identified increases as land area investigated increases. If the soil series to land area relationship (*10*) is extrapolated to global ice-free land area, the results suggest that there are more than 300,000 series on the planet. The response of these soils to perturbations can be extremely varied because of their diverse chemical, physical, and biological characteristics, suggesting the importance, as a simple precautionary principle, of maintaining segments of this diversity for the stability and resilience of global biogeochemical systems in the face of anthropogenic disturbances.

## Human Imprint on Soil

Humans altered the ecosystems they encountered as they began their spread across the globe. However, the most momentous development in human landscape change occurred with the invention and adoption of agriculture (*11*). Most agricultural practices involve the removal of the natural flora, the simplification of biodiversity to favor monocultures, and the physical disruption of the soil. Since the Industrial Revolution, expanding populations have relied on the exploitation of more and more soil for a corresponding growth in food production. Today, ~12% of ice-free land is in cropland, and 38% is used for combined cropping and grazing (*12*), an area roughly equivalent to the land area covered by ice and scoured or otherwise disturbed during the last glacial maximum (Fig. 1A). In addition to the similarity in area, the agricultural impact on soil processes rivals or exceeds the effect of those ice sheets in both rapidity and magnitude.

Undisturbed soils have the characteristic, as a result of a number of feedback mechanisms, of being able to retain many of their features indefinitely over time their thickness, C content, and nutrients, for example a condition that is equatable to sustainability (Fig. 2). Cultivated soils are highly modified forms of their wild predecessors and may thus be viewed as domesticated soils (*9*). One key characteristic is that domesticated soils seldom are able to maintain the qualities of their original conditions, and these changes greatly affect their productivity and their impact on surrounding geochemical cycles. The efforts to improve the management and conservation of these domesticated soils, and the preservation of portions of their remaining wild ancestral stock, will be among the most important challenges this century (*9*, *13*). Analyses of the combined agricultural and urban impact on soil series in the United States, for example, revealed large areas in the agricultural heartland where more than 50% of the soil series had been domesticated. Soil diversity, like biodiversity (*14*), provides an array of human-valued goods and services. Among the most apparent issues is the ability of soil to provide sustained agricultural production.

The domesticated soil landscape is one of Earth's most valuable commodities. For example, nearly $3816 billion (U.S. dollars) in agricultural products were produced globally in 2012 (*15*). However, agriculture is competing with increasing urban and suburban soil demands. The conversion of soil to urban land is largely irreversible on human time scales. There is uncertainty both in the present and the future distribution of urban land on Earth (Fig. 1B). A recent meta-analysis suggests that between 1970 and 2000, an area greater than the size of Denmark was urbanized, and that in the next 20 years, 1.5 million $km^2$ of land (the size of Mongolia) will be urbanized (*16*). The conversion of farmland to urban areas must be weighed against the fact that our most productive soils have already been exploited and that demand for food production will continue to increase.

## Soil and Climate Security

A relatively stable climate has been the stage on which the great human inventions of agriculture and industrialization have evolved, and direct or indirect human impacts on soil C cycling processes will have much to do with atmospheric greenhouse gas concentrations and the associated climate implications by the end of this century.

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*Corresponding author. E-mail: earthy@berkeley.edu



"Better stewardship of domesticated soils that leads to higher organic matter contents is a valuable practice from an ecological perspective and from an agronomic point of view."

"These strategies should focus on regaining a balance in (i) organic C inputs and losses, (ii) soil erosion and production, and (iii) release and loss of nutrients."

# CONSERVATION AGRICULTURE

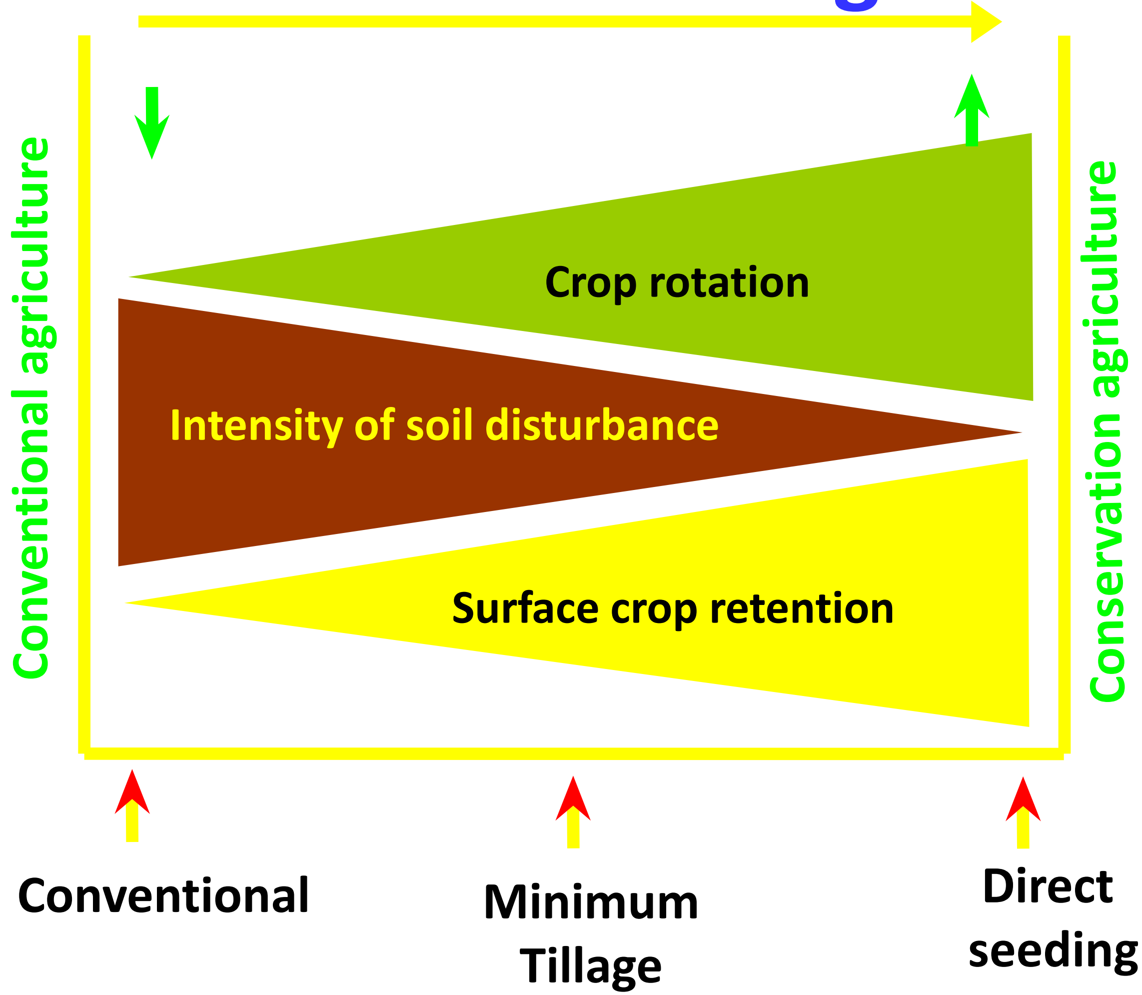
- … has developed to be a technically viable, sustainable, and economic alternative to current crop production practices,
- … is gaining acceptance in many parts of the world as an alternative to both conventional agriculture and organic agriculture
- … is the integration of ecological management with modern, scientific, agricultural production

# CONSERVATION AGRICULTURE

- … is not ‘business as usual,’ based primarily or solely on maximizing yields,
- … rather, it is based on optimizing yields and profits to achieve a balance of agricultural, economic and environmental benefits,
- …it advocates that the combined economic and social benefits gained from combining production and protecting the environment, including reduced input and labor costs, are greater than those from production alone.

Past approaches are not going to be sufficient.

# Toward conservation agriculture

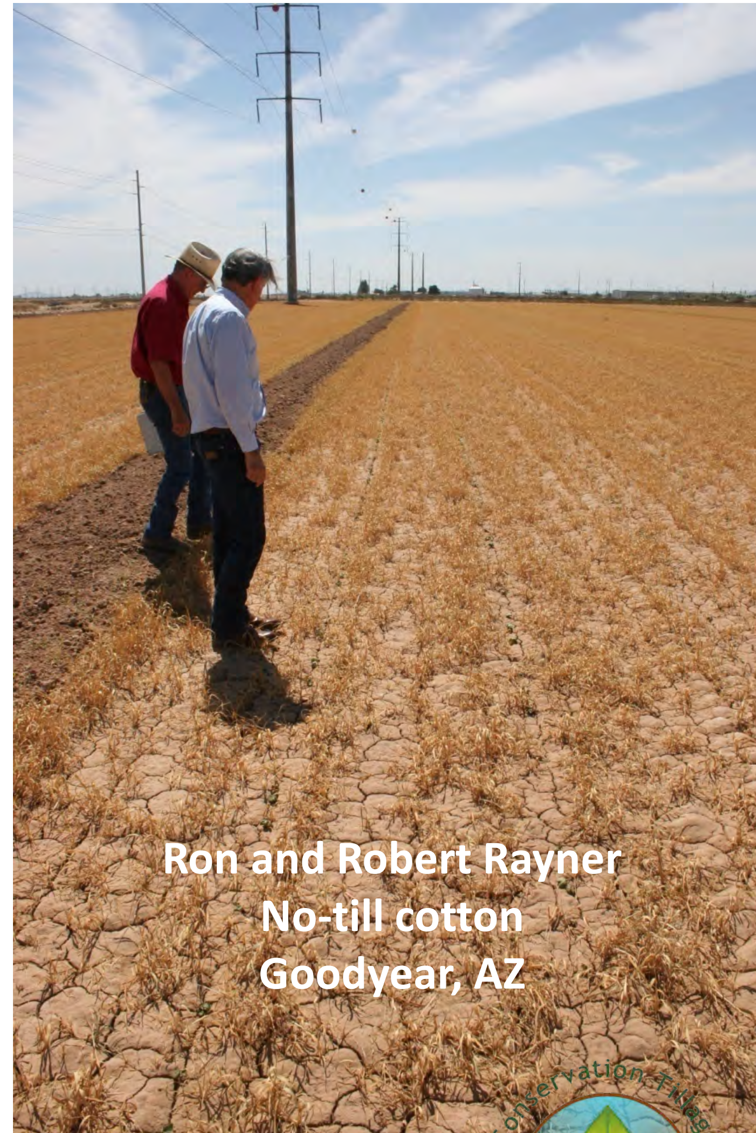


# CONSERVATION AGRICULTURE

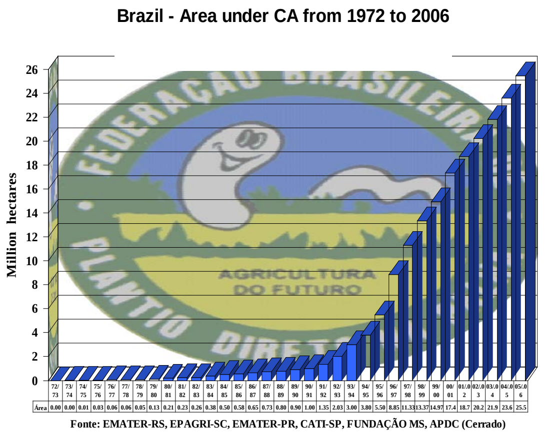
- Minimal soil disturbance
- Preservation of residues that provide permanent soil cover
- Diverse crop rotations
- Use of cover crops
- Integrated pest management
- Reliance on precision, highly efficient irrigation
- Controlled or limited mechanical traffic over agricultural soils

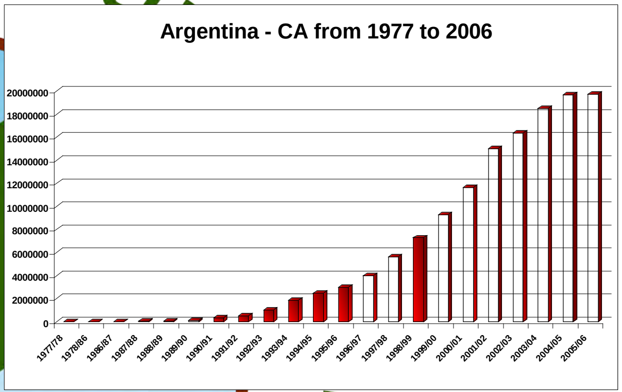

More Profit With Less Tillage
Ernest E. Behn
Iowa, 2001
Alabama, 2001
Iowa, 2001
Washington, 2007
IMPROVE SOIL & WATER
NO-PLOW ZONE
Brazil, 2007
Nebraska, 2007
Georgia, 2001
Brazil, 2004

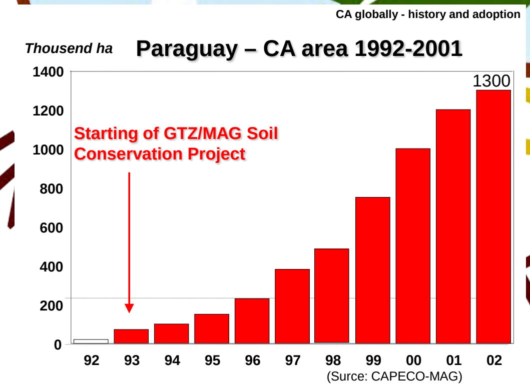

Strip-till cotton into rolled rye cover crop
Tifton, GA 2005

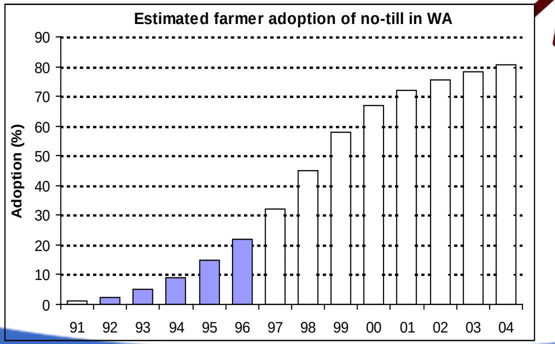

Ron and Robert Rayner
No-till cotton
Goodyear, AZ

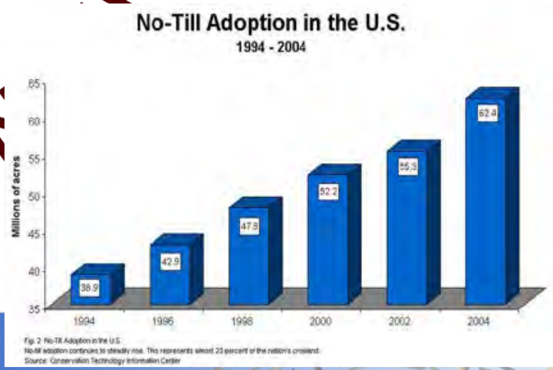

Strip-till seeded onions in wheat cover crop
Moses Lake, WA
2010



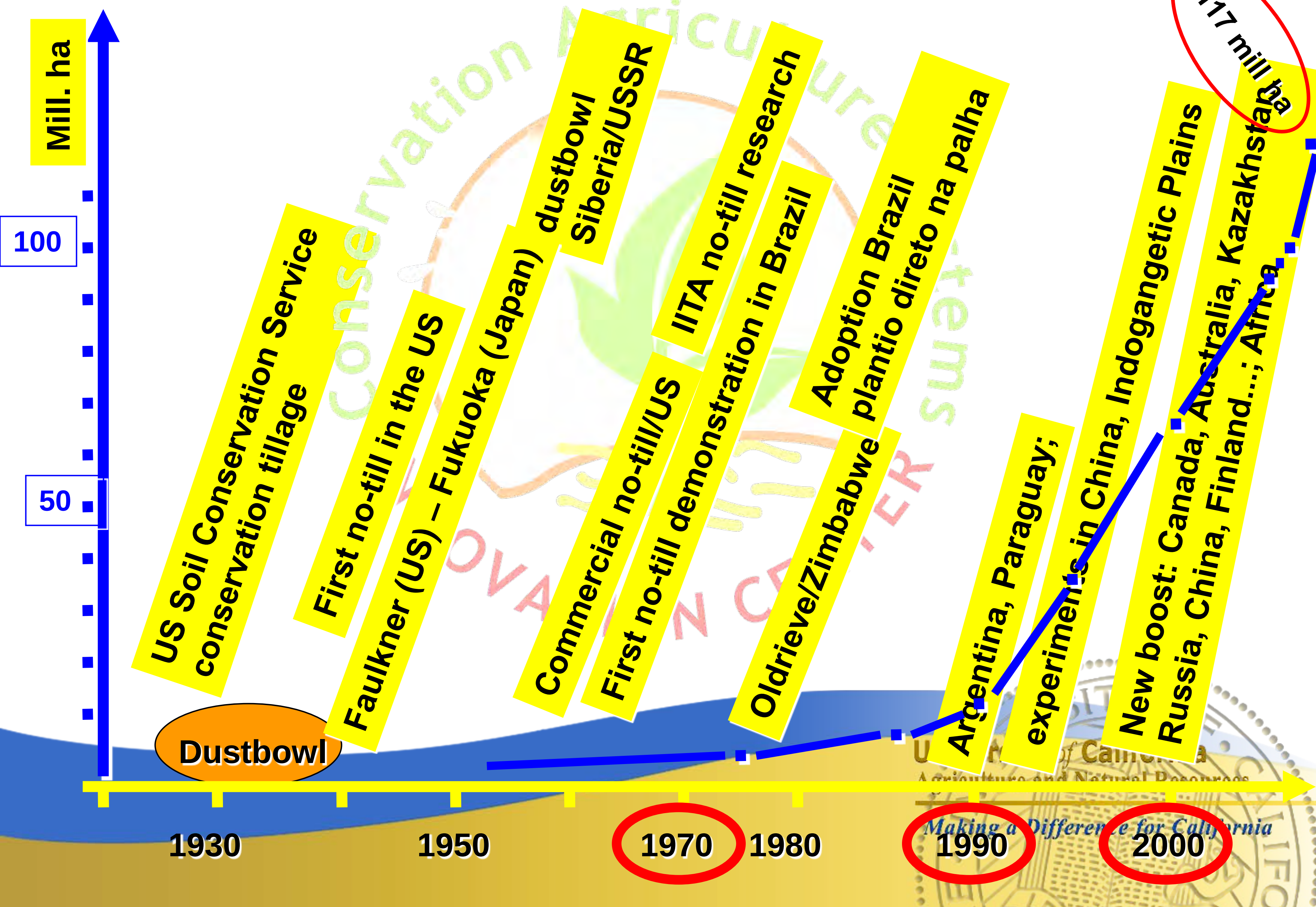



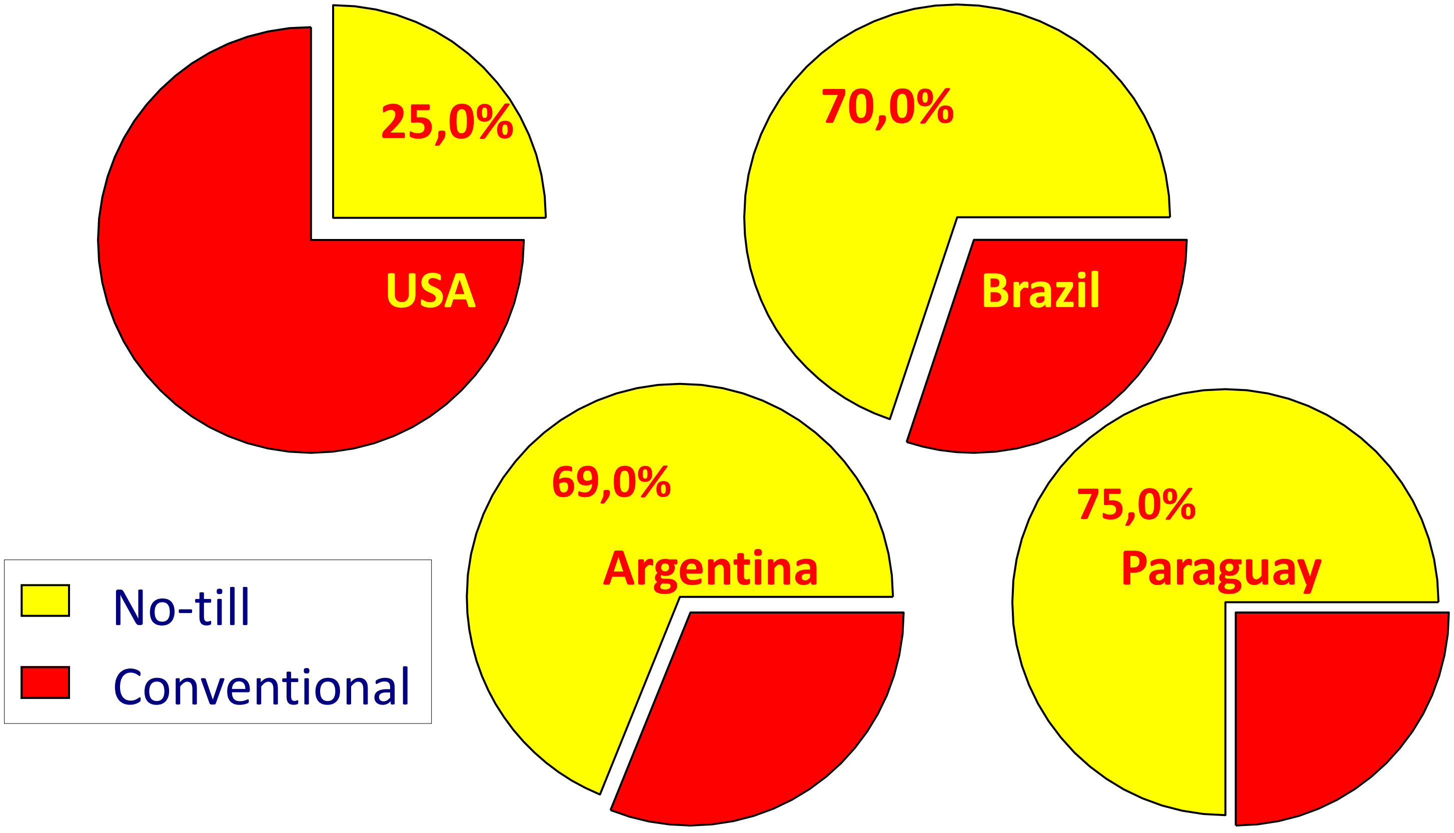

University of California
Agriculture and Natural Resources
*Making a Difference for California*

Derpsch, 2010

## History and Adoption of CA

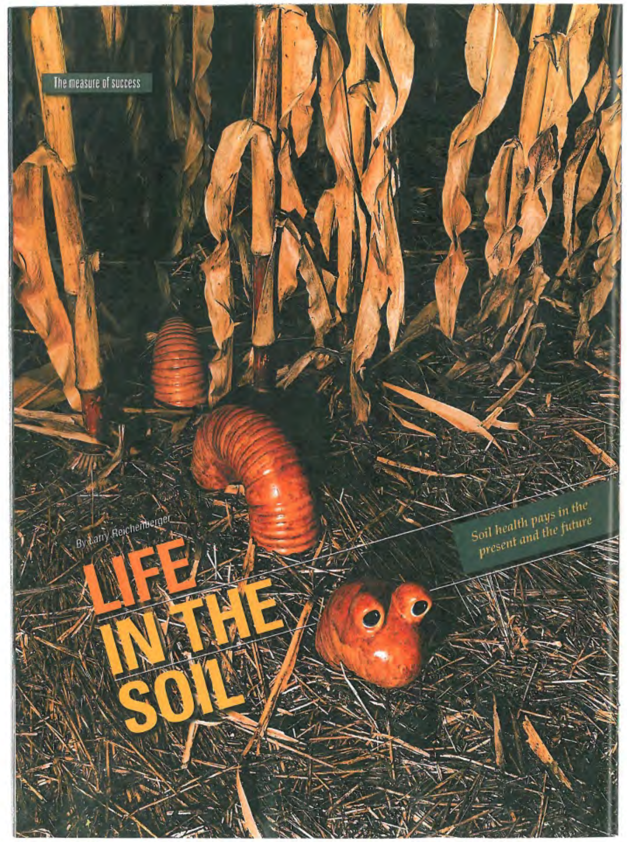


**CA Adoption relative to total cropland**




It is estimated that in less than a decade > 85% of the cultivated area will be under No-till.

**(Derpsch & Friedrich, 2008)**


Healthy soils are the ultimate measure of success for Rick Bieber. With the zeal of an evangelist, this Trail City, S.D., farmer promotes methods that enhance soil quality. He swears by the old adage, "If you take care of your soil, your soil will take care of you."

"The soil is the greatest source of wealth in the world, but most farmers squander its potential," says Bieber, who farms with his son, Ben. "The soil isn't just a tool, it's a full partner in a farming operation and deserves to be treated with respect. Learn to protect the soil and to manage it like it's really alive — because it is—and you will see an unbelievable response."

**Diversity in crops.** Bieber's recipe for a healthy soil includes long-term no-till, intensive crop rotation, and cover crops. "We started no-tilling in 1987 and soon learned we needed to diversify and intensify our crop rotation to utilize the moisture we were saving and to boost microbial activity in the soil. From wheat/fallow and wheat/corn/fallow, we changed to rotations that also include chickpeas, millet, flax, sunflowers, and alfalfa. More recently, we've added cover crops that are planted after wheat and interseeded into growing corn."

"Now, our yields are higher with fewer inputs so profitability has increased. And, the impact of drought, heat, and other stress is less. Our 10-year proven corn yields are 408% of the county average, and wheat yields are 358% of the norm," adds Bieber.

**Credit the soil.** Bieber is quick to deflect credit for this performance. "It's totally due to the soil—all I've done is provide what the soil tells me it needs to do its job," he says.

What Bieber provides is a steady supply of carbon—in the form of crop residue and living plant roots—that feeds soil microbes, moderates soil temperatures to protect the microbes, shields the soil surface from erosion, and builds soil organic matter levels.

Bieber measures performance of his system is various ways. "We used to apply 90 pounds per acre of nitrogen and produce 90-bushel corn, but now the same amount of nitrogen produces 160 bushels. That's due mainly to our soil organic matter levels, which are 4-5% in our long-term no-till."

In contrast, typical conventionally tilled fields in Bieber's area have soil organic matter levels around 2%. Soil with higher organic matter not only mineralizes more nitrogen, it also holds more water, and that's the farm's major benchmark of success.

"We judge our management skills by the amount of grain we produce per inch of rainfall, and we've seen this water-use efficiency increase as our soil health has improved. In 1998 we produced just over 4 bushels of corn per inch of rainfall. By 2001, the first year corn in our rotation grew on cover crops grown in 1998, that had increased to 5.4 bushels per inch. By 2007, that efficiency had increased to 6.23 bushels per inch of rainfall."

**Best combination.** Bieber worked with agronomist Cheryl Reese from South Dakota State University on an intensive cover crop study from 2009 through 2011. "There were 96 trials, and they showed that the best combination of cover crops and fertilizer rates resulted in 12.6 bushels of corn per inch of rainfall. Then in 2012, with a severe drought, corn on our long-term, no-till ground produced 9.54 bushels per inch of rainfall while some new ground—in its first year of no-till— produced only 4 bushels per inch. That was amazingly similar to what we saw in 1998," says Bieber.

**Hungry soil.** His water use efficiency data has convinced Bieber that his soils are hungry for live roots, even in dry years. "Living plants sequester carbon from the atmosphere and deposit it in the soil through their root system, so we want to have something growing every moment that the season allows," he says.

Cover crops allow Bieber to put this conclusion into practice. "We hire an extra man so we can plant cover crops right behind the combine during wheat harvest. And, the cover crops we interseed at the V-6 stage of our corn stay alive well after the corn matures in the fall," he says.

"We're protecting soil not just for the next generation, but for those 100 and 1,000 years from now," he adds. ■

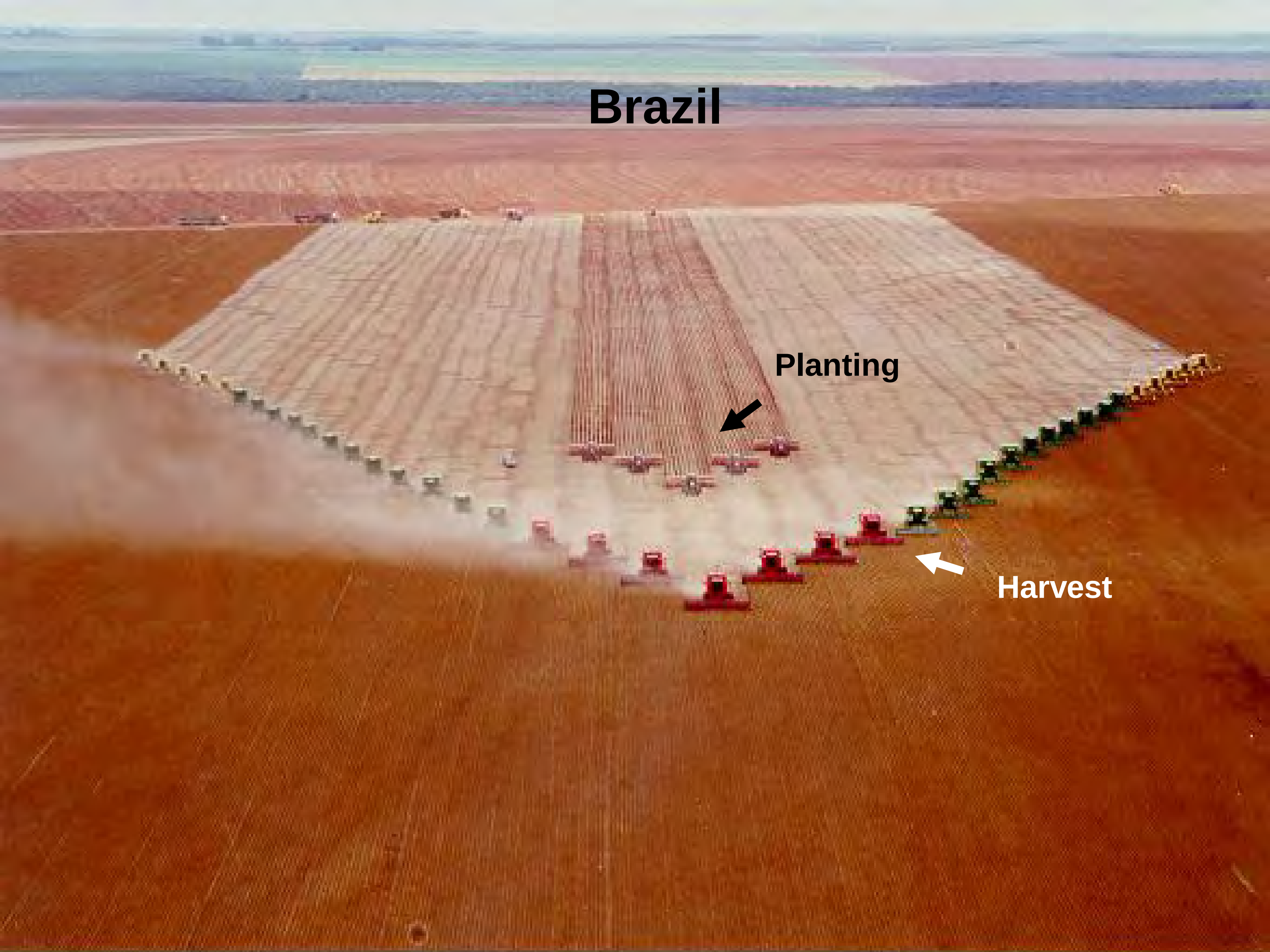
►**Left:** Rick Bieber says healthy soil makes farming fun—a point emphasized by this giant earthworm he poses for frequent visitors to his farm.

►**Left center:** High organic matter levels have turned Bieber's soils black and fostered a teaming population of earthworms. ►**Left:** Cover crops, including radishes and turnips, are broadcast into corn at the V-6 stage to extend the growing season and improve winter grazing.

THE FURROW 31

**"'Soil care' is what we're doing."**

Rick Bieber
Trail City, SD
January 28, 2014


Brazil
Planting
Harvest


ASSOCIAÇÃO DE PLANTIO DIRETO NO CERRADO
APDC
Affiliated to FEBRAPDP

ASSOCIAÇÃO DE PLANTIO DIRETO NO CERRADO
APDC
Affiliated to FEBRAPDP

# Zero Tillage
## The key to safe renovation of hill pastures

How might we begin to imagine more water- and nutrient-use-efficient tillage, residue and irrigation management systems becoming of value and adapted and becoming more widely adopted in California?

# CONSERVATION AGRICULTURE

## Row Crop System Development • 1993 – 2015

**Cover Crop Residues**

Species selection 1991 - ongoing

Water Use 1991 - ongoing

Water Balance / Runoff 1997 - ongoing

Pollution Reduction 2001 - ongoing

**Single Crop CT Development**

Tomatoes 1996 - ongoing

Melons 1998 - 99

Cotton 2000 - ongoing

Corn and Wheat 2000 - ongoing

**Integrated Irrigated Systems Development**

Tomato - Cotton 1999 - ongoing

Wheat - Tomato 1999 - ongoing

Corn - Tomato 2000 - ongoing

Dairy Forage 2000 - ongoing

**CONSERVATION AGRICULTURE Cropping Systems**

Conservation Agriculture Systems Innovation Center

University of California Agriculture & Natural Resources

Conservation Tillage Workgroup

soil

disease control

harvest efficiency

return on investment

emissions

labor

profitability

regulations

insect control

# RETHINK THE SYSTEM

soil life

residues

weed control

equipment

environmental impacts

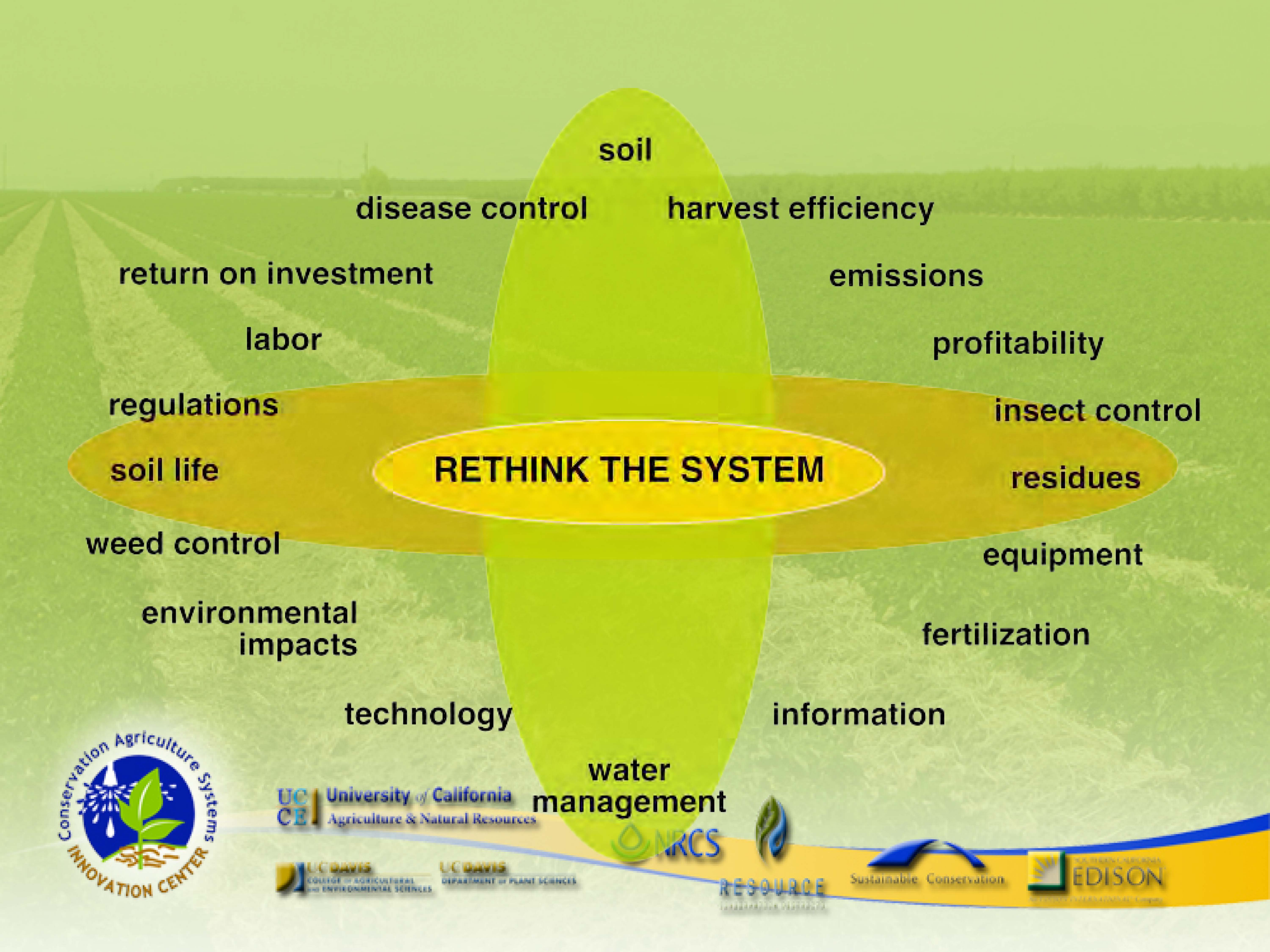
fertilization

technology

information

water management


soil
disease control
harvest efficiency
return on investment
emissions
labor
profitability
regulations
insect control
RETHINK THE SYSTEM
soil life
residues
weed control
equipment
environmental impacts
fertilization
technology
information
water management
Conservation Agriculture Systems Innovation Center
UC CE University of California Agriculture & Natural Resources
UC Davis
NRCS
Resource
Sustainable Conservation
Edison


soil
disease control
harvest efficiency
return on investment
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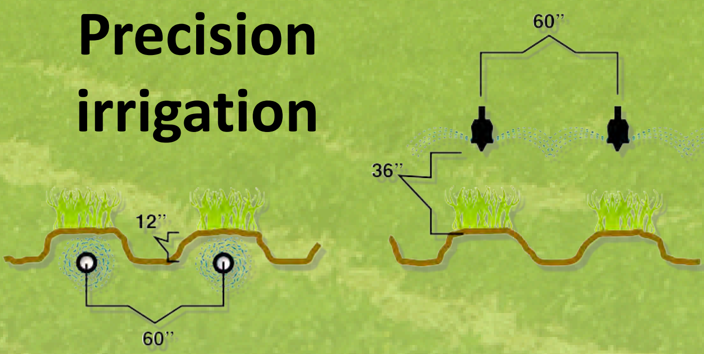
insect control
soil life
RETHINK THE SYSTEM
residues
weed control
equipment
environmental impacts
fertilization
technology
information
water management
Conservation Agriculture Systems Innovation Center
UC CE University of California Agriculture & Natural Resources
NRCS
UC DAVIS
UC DAVIS Department of Plant Sciences
Sustainable Conservation
EDISON

# Merging practices and technologies to achieve advanced conservation agriculture systems

*"No-till is a tool for what we're trying to achieve."*

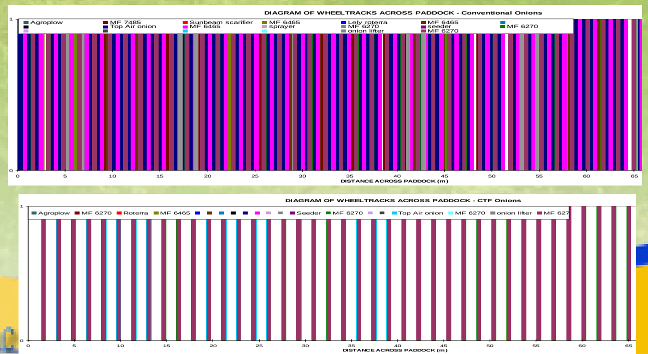
## Microbial diversity

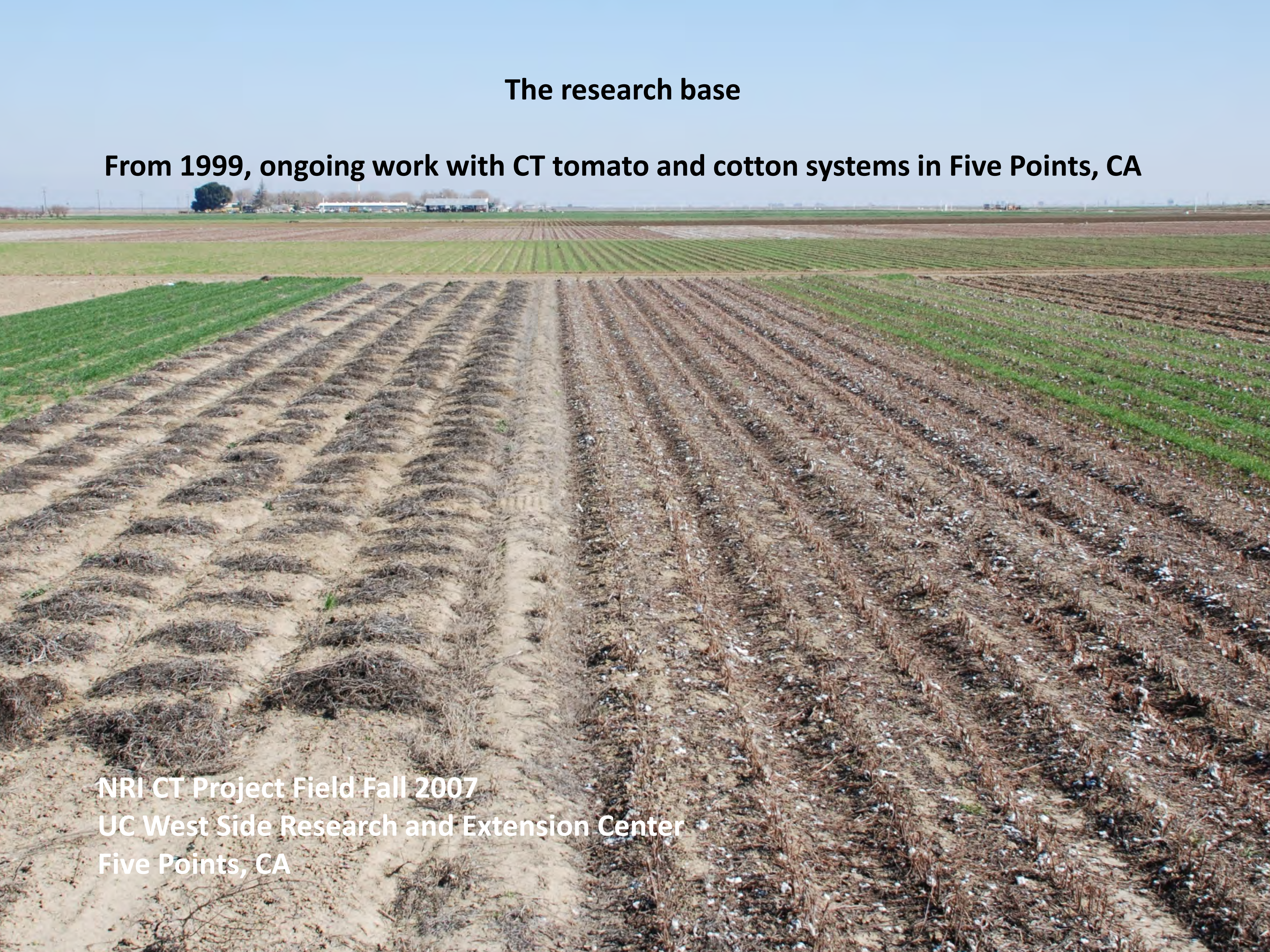
## Precision irrigation




## Generating and preserving surface residues


## Controlled traffic farming




The research base
From 1999, ongoing work with CT tomato and cotton systems in Five Points, CA
NRI CT Project Field Fall 2007
UC West Side Research and Extension Center
Five Points, CA


SUNFLOWER
Rainfed winter cover crop being seeded into cotton and tomato residue Five Points, CA 2007

Winter, rainfed triticale, rye and pea cover crop no-till seeded into cotton and tomato residues
Five Points, CA 2008

No-till tomato transplanting into cotton and cover crop residue
Five Points, CA
2007


No-Till
No-till cotton 2011 yields
3.2 bales/ac

# Tillage and cover crop system erosion estimates, soil condition index sub-factors, soil tillage intensity rating and estimates of diesel fuel use.

| Cropping System* | Erosion Estimates‡ RUSLE2 (Mg ha-1) | Soil Conditioning index | STIR Average Annual | Diesel fuel use | Fuel cost for entire simulation ($) |
|---|---|---|---|---|---|
| STNO | 0.2 | -0.71 | 261 | 32 | 128.6 |
| STCC | 0.07 | -0.96 | 390 | 40 | 160.6 |
| CTNO | 0.04 | 0.43 | 30.6 | 9.3 | 36.8 |
| CTCC | 0.03 | 0.52 | 37.1 | 11 | 43.27 |

* STNO = Standard tillage no cover crop, STCC = Standard tillage with cover crop, CTNO = Conservation tillage no cover crop CTCC = Conservation tillage with cover crop.

USDA NRCS Natural Resources Conservation Service

# Soil carbon mass for tillage and cover crop treatments* at two soil depths At the start of the study in the fall of 1999 and in the fall of 2007.

| 1999 | | | 2007 | | |
|---|---|---|---|---|---|
| Depth (cm) | Treatment | Mean[§] (t ha$^{-1}$) | Depth (cm) | Treatment | Mean[§] (t ha$^{-1}$) |
| **0 – 15** | **NTCC** | **9.33** (0.18, A) | **0 - 15** | **NTCC** | **16.20** (0.53, A) |
| | **STCC** | **9.25** (0.40, A) | | **STCC** | **12.69** (0.29, AB) |
| | **NTNO** | **9.27** (0.41, A) | | **NTNO** | **13.13** (0.46, AB) |
| | **STNO** | **8.87** (0.31, A) | | **STNO** | **10.84** (0.19, B) |
| **15 - 30** | **NTCC** | **10.39** (0.30, A) | **15 - 30** | **NTCC** | **12.91** (0.62, AB) |
| | **STCC** | **10.66** (0.99, A) | | **STCC** | **13.67** (0.65, A) |
| | **NTNO** | **11.40** (1.11, A) | | **NTNO** | **10.96** (0.51, B) |
| | **STNO** | **9.69** (0.52, A) | | **STNO** | **11.81** (0.31, AB) |
| **Total** | **NTCC** | **19.71** (0.45, A) | **Total** | **NTCC** | **29.11** (0.94, A) |
| | **STCC** | **19.91** (1.20, A) | | **STCC** | **26.36** (0.78, AB) |
| | **NTNO** | **20.67** (1.03, A) | | **NTNO** | **24.09** (0.81, BC) |
| | **STNO** | **18.57** (0.75, A) | | **STNO** | **22.65** (0.26, C) |

**ST**= conventional tillage; **NT**= no-tillage; **NO**= no cover crop; **CC**= winter cover crop

Mitchell et al., 2015
Agron. J. 107(2):588-596

Values in parentheses are standard error of the means (n= 8).
Within a column, means followed by the same letters are not significantly different using a one-way ANOVA analysis with Tukey HSD means comparison.

Published February 12, 2015



# Tillage and Cover Cropping Affect Crop Yields and Soil Carbon in the San Joaquin Valley, California

Jeffrey P. Mitchell,* Anil Shrestha, William R. Horwath, Randal J. Southard, Nicholaus Madden, Jessica Veenstra, and Daniel S. Munk

**ABSTRACT**

Rising costs and air quality regulations have created interest in California's San Joaquin Valley (SJV) in production systems that reduce tillage operations and soil disturbance. From 1999 to 2009, we evaluated conventional (CT) and reduced tillage (RT) systems for a cotton (*Gossypium hirsutum* L.)/tomato (*Solanum lycopersicon* Mill.) rotation with (CC) and without (NO) cover crops in a Panoche clay loam soil (fine-loamy, mixed, superactive, thermic Typic Haplocambid) in Five Points, CA, in terms of yield, soil C, and the NRCS soil conditioning index (SCI). The RT reduced tractor operations by 50% for tomato and 40% for cotton. Cover cropping produced 38.7 t $ha^{-1}$ of biomass. Tomato yields were 9.5% higher in RT vs. CT systems and 5.7% higher in NO vs. CC systems. The CT cotton yields were 10.0% higher than RT yields and 4.8% higher in NO systems, but yield patterns were not consistent from 2005 to 2009. Soil C content was uniform (0–30-cm depth) in 1999 (19.72 t $ha^{-1}$) and increased in all systems in 2007 (t $ha^{-1}$): RTCC 29.11, CTCC 26.36, RTNO, 24.09, and CTNO 22.65. Soil C content of RT and CT systems did not differ, but was greater in CC than in NO systems. In the 0- to 15-cm depth, RT increased soil C, indicating stratification, and also increased C in the occluded light and mineral fractions. The SCI was positive for RT treatments, predicting a soil C increase, and negative for CT systems, predicting a soil C decline, but measured soil C content increased in all systems. Results show that RT maintains or increases yields relative to CT, and CC stores more soil C than NO.

Conservation tillage practices such as no-tillage, strip-tillage, and mulch-tillage are currently used on <2% of annual crop hectarage in the Mediterranean climate of California's SJV (Mitchell et al., 2007). Traditional tillage systems in this region, that consistently includes six of the nation's top 10 agricultural production counties (USDA NASS, 2011), have been used since the introduction of irrigation beginning in the late 1930s. These systems enable the predictable production of rotations of crops such as cotton, wheat (*Triticum aestivum* L.), safflower (*Carthamus tinctorius* L.), and sugar beet (*Beta vulgaris* L.), as well as vegetables, such as tomato, melon (*Cucumis melo* L.), onion (*Allium* spp.), lettuce (*Lactuca sativa* L.), and garlic (*A. sativum* L.). Cropland in the SJV generally has little or no slope and thus concerns about soil erosion have not been a major driver for RT practices as in other regions. In recent years, however, increased diesel fuel prices and interest in reducing labor needs and dust emissions in SJV crop production systems have provided incentives for RT options.

A variety of "minimum-tillage" approaches that consolidate tillage functions and reduce the total number of tillage passes across a field are now being used (Mitchell et al., 2009). These minimum-pass systems rely on combining tillage passes and do not necessarily reduce the overall volume of soil that is disturbed (Reicosky and Allmaras, 2003; Mitchell et al., 2004). Sustained RT practices such as no-tillage (Derpsch et al., 2010) or zone tillage systems (Luna et al., 2012; Sohi et al., 2001) and their abilities to increase soil C sequestration over time have been reported (Franzluebbers and Follett, 2005; Martens et al., 2005). However, there has been no system developed in the SJV to evaluate the capability of the more classic forms of RT management to reduce production costs or to increase soil C sequestration. Although successful RT systems have been implemented elsewhere for a number of the crops commonly produced in the SJV (Wiatrak et al., 2006; Siri-Prieto et al., 2007; Sainju et al., 2005), these RT systems have been employed in rainfed production regions. The arid SJV receives about 180 mm of rainfall annually and contemporary cropping systems are completely dependent on irrigation. Management of these systems can be complicated by surface plant residues that tend to accumulate in RT fields to higher levels than in CT fields.

In 1999, we began research in Five Points, CA, to evaluate RT tomato and cotton systems with and without winter cover crops

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**Abbreviations:** CC, winter cover crop; CDFA, California Department of Food and Agriculture; CT, conventional tillage; NO, no winter cover crop; NRCS, Natural Resource Conservation Service; PBW, pink bollworm; RT, reduced tillage; SCI, soil conditioning index; SJV, San Joaquin Valley; SOM, soil organic matter; STIR, soil tillage intensity rating.

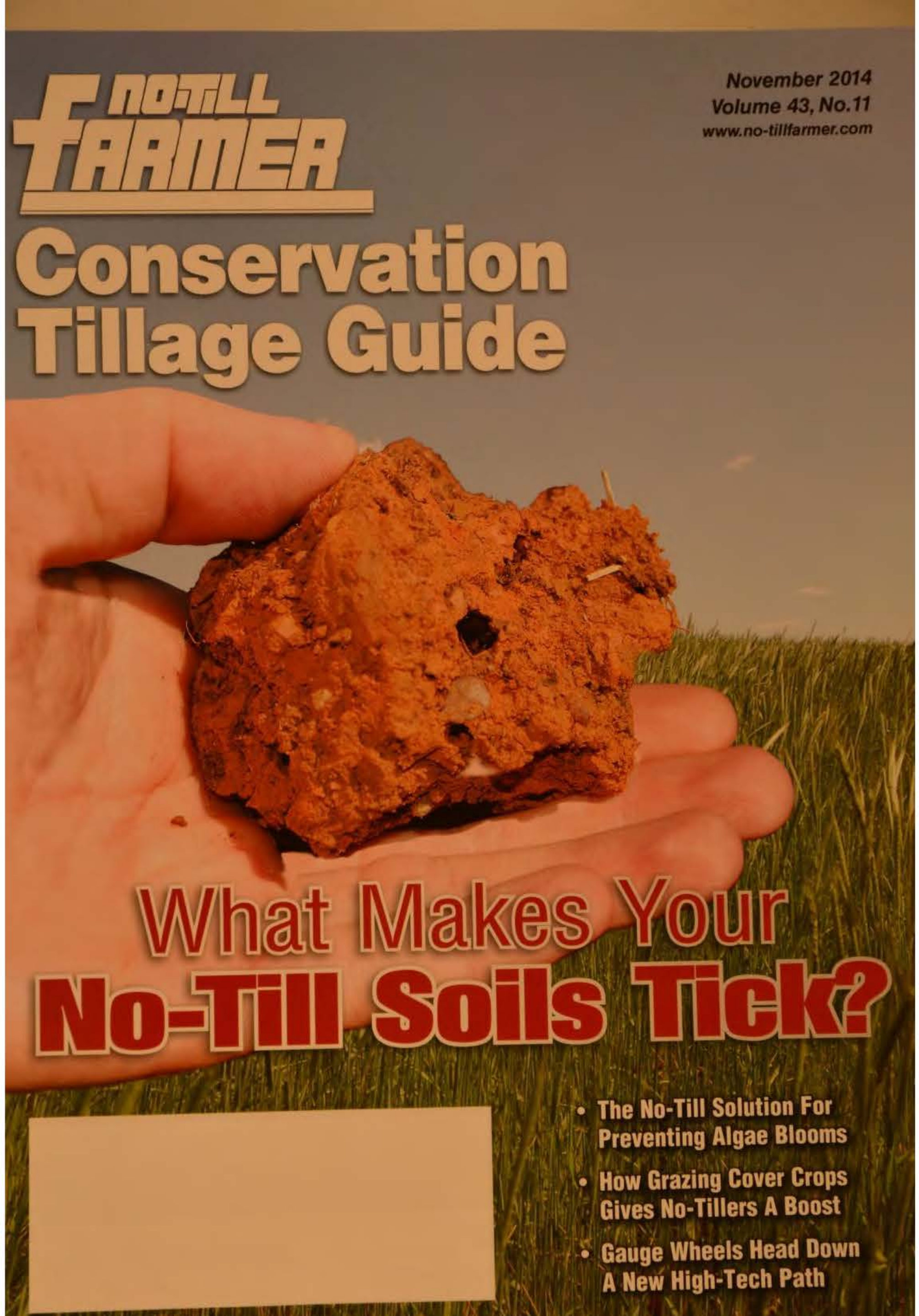


# Trade-offs between winter cover crop production and soil water depletion in the San Joaquin Valley, California

**Abstract:**

Cover crops are currently not widely used in annual crop production systems in California's semi-arid Central Valley due to concerns about lost opportunity costs and uncertainties about water use. From 1999 through 2014, we quantified cover crop biomass production for a variety of mixtures under winter precipitation and limited supplemental irrigation. In a separate study, we also determined changes in soil water storage under three cover crop mixtures compared to fallowed plots during two (2013 and 2014) winter periods to investigate tradeoffs associated with water use by cover crops in this region. Over the 15 years of the project that were characterized by recurring drought, a total of 56 t $ha^{-1}$ of aboveground cover crop biomass was produced with a total precipitation of 209 cm and 20 cm of supplemental irrigation applied in 1999, 2012, and 2014. Cover crop biomass varied from 39 kg $ha^{-1}$ in the low precipitation period (winter 2006 – 2007) to 9,346 kg $ha^{-1}$ (winter 2000 – 2001). Soil water storage in the sampled depth (0 – 90 cm) for the fallow and each of the cover crop mixtures was compared each year from January to March, the primary growing period for cover crops in this region. Net soil water storage increased during this period by 4.8 and 4.3 cm in 2013 and 2014, respectively for the fallow system but in the cover crop mixture plots, there was no additional water storage. Instead, water use by the cover crop mixes resulted in a negative water balance over the cover crop growth period on an average of 0.47 cm and 0.26 cm in 2013 and 2014, respectively. Thus, compared to the fallow system, cover crops depleted 5.3 cm and 0.67 cm more water in from the 0 – 90 cm

Journal of Soil and Water Conservation
In press, 2015



NO-TILL FARMER

November 2014
Volume 43, No.11
www.no-tillfarmer.com

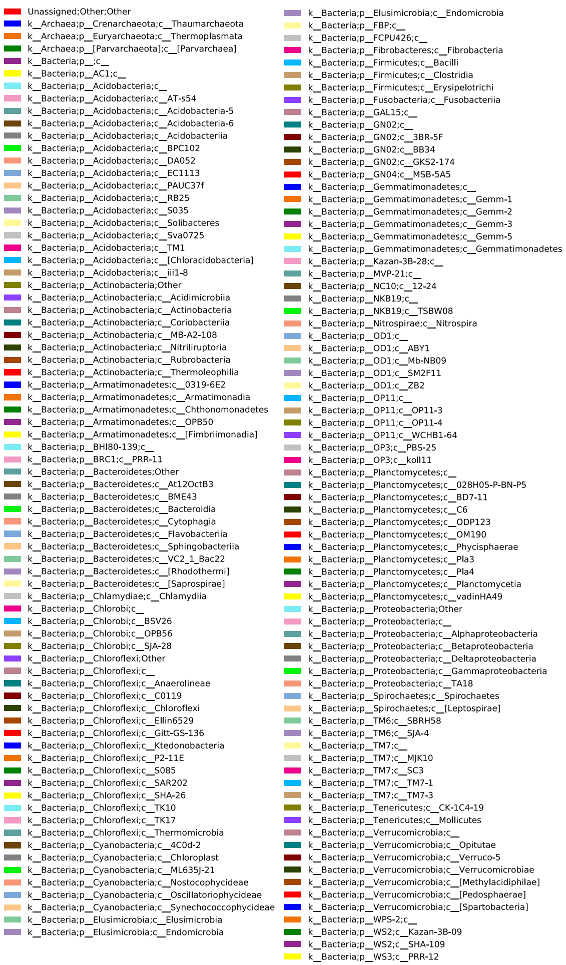
# Conservation Tillage Guide

## What Makes Your No-Till Soils Tick?

- The No-Till Solution For Preventing Algae Blooms
- How Grazing Cover Crops Gives No-Tillers A Boost
- Gauge Wheels Head Down A New High-Tech Path

# Community Taxonomic Composition

- NOST at all depths and NOCT 0-5 cm show much higher proportion of Firmicutes (mainly Bacillus and other Bacillaceae) (28.1±5.5%) than all other soils (8.3±3.5%).
- Higher Fimicute numbers are offset primarily by lower Proteobacteria in the high Firmicute soils in comparison to other soils (19.9±3.5% vs 27.4±3.9% respectively).
- Some information on Archaea is available, though the primers used may not provide a highly accurate representation of the Archaeaal community.



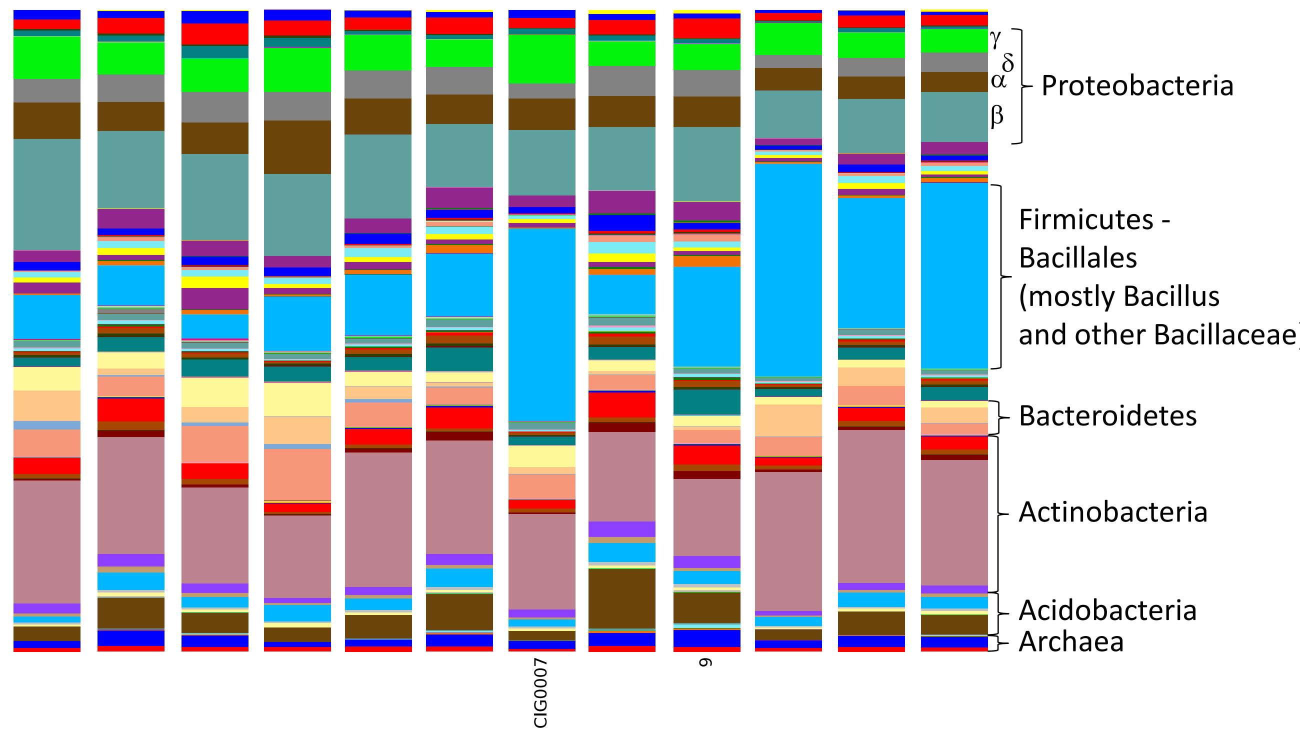




**Figure 1.** Taxonomic composition of CCCT, CCST, NOCT and NOST treatments at three depths 0-5, 5-15, 15-30 cm. November 2013 sampling. Some of the most important groups are shown next to their respective color bands to the right of the graph.

# Beta Diversity

- Beta diversity is the variation in species composition among distinct samples (e.g. treatment, depth).
- Unweighted Pair Group Method with Arithmetic mean (UPGMA) is a hierarchical clustering method using average linkage used to interpret beta diversity distance matrices.
- Clustering of NOST treatments at all depths with NOCT 0-5 cm (Figure 3) is consistent with similarities observed n taxonomic composition analysis.

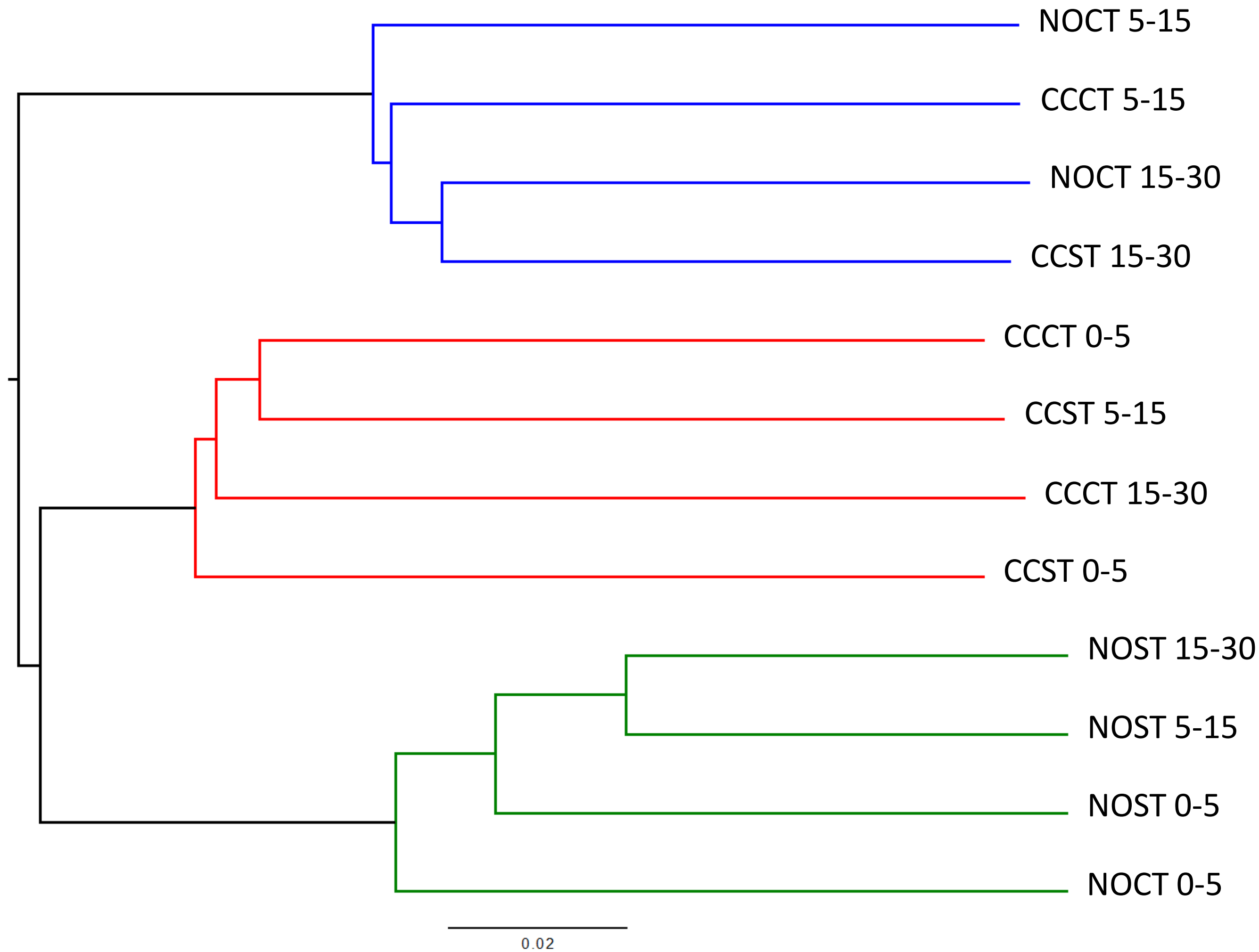



**Figure 3.** UPGMA consensus tree for beta diversity of CCCT, CCST, NOCT and NOST treatments at three depths 0-5, 5-15, 15-30 cm. November 2013 sampling.

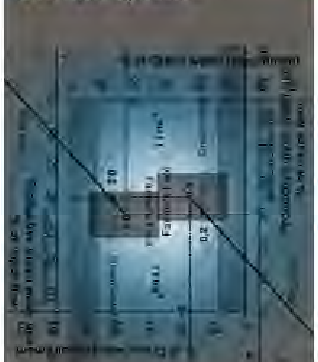
# Conclusions (preliminary)

- Some of the cover crop treatment soils show highest species richness, while some of the no cover crop soils show least richness.
- NOST treatments and NOCT at 0-5 cm show similar trends in community composition and also cluster together in beta diversity analysis.
- While we have not yet been able to assign soil functions to differences in firmicute and proteobacteria percentages, the trend for higher percentage of proteobacteria in conservation tilled plots has been observed in at least one other study (no-till rice paddy fields; Aslam, Z, Yasir, M, Yoon, HS, Jeon, CO and Chung, YR (2013). "Diversity of the bacterial community in the rice rhizosphere managed under conventional and no-tillage practices." Journal of Microbiology 51(6): 747-756)
- The sequencing results are consistent with other data from Five Points and show that:
  - cover crops exert a strong influence on microbial community composition as well as soil properties.
  - the NOST treatment is distinct from the other three treatments.
- There is more diversity in the cover crop soils.
- This might have relevance in terms of resilience.

Special Section: VZJ Anniversary Issue

# Green Water and Global Food Security

Garrison Sposito*



It is widely understood that crop production must increase at least twice as fast as human population growth during the coming 40 yr to meet global food demand. Tested strategies for achieving this goal have not yet emerged, but some stipulations to guide in the search for them can be made. Adverse ecological impacts of land conversion to agricultural use and freshwater withdrawals for irrigation will strongly limit the viability of these two traditional approaches to increasing crop production, whereas abundant opportunity exists for optimizing soil water availability to and consumption by rainfed crops to increase their yields by twofold or more. This optimization, however, will require major campaigns in multidisciplinary basic research on positive plant–soil feedbacks that increase crop biomass by influencing the rhizosphere, through which 40% of the global freshwater flow passes annually.

To ensure global food security, crop production must outpace human population growth significantly during the next 40 yr. This review makes the case that this challenge can largely be met by optimizing the management of "green water" (soil water directly available to plant roots), an often overlooked resource whose annual global flow in fact matches that of all the rivers in the world flowing to the sea.

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Vadose Zone J.
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Received 7 Feb. 2013.
Open Access



*But if the soil breathes steaming vapors out,*
*Drinks moisture in, and when it wants to, breathes*
*The moisture out again, and if it's always*
*Green with the greenness of its grasses and*
*Never corrodes the blade of the plow with rust,*
*Then that's the place to drape your flourishing vines*
*Upon your elms, the place that will produce*
*Rich olive oil, the place (as the tilling will show)*
*That makes the plowing easy for the beasts*
*Because the soil is easy for the plow.*

—Publius Vergilius Maro (Virgil), Georgics, Book II (Ferry, 2005)

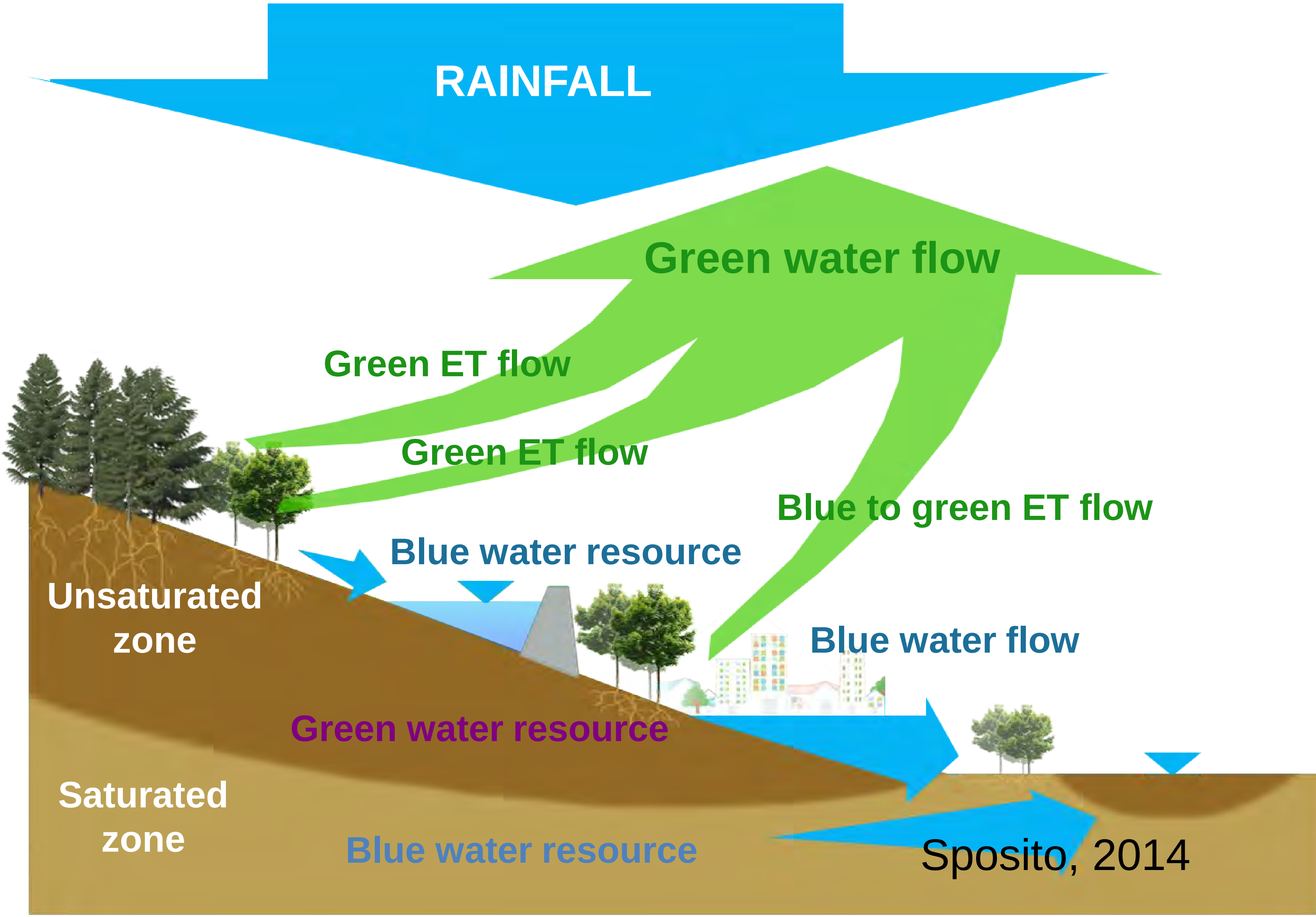
**Despite a decline in growth rate by almost half** during the past 40 yr, estimates of the global human population place it at 8 billion in 2024, with more than 9 billion expected by 2050 (Roberts, 2011; Tilman et al., 2011). This latter figure represents an increase of the current world population by about 30%, but the corresponding percentage change in food crop production to meet projected world demand will be much larger because it is driven by not only population growth but also personal income growth (Kearney, 2010; Tilman et al., 2011). Current analyses indicate that, to accommodate both of these upward socioeconomic trends, food crop production has to increase by 50 to 100% during the next 40 yr. That is, it must at least double the percentage change in population (de Fraiture et al., 2009; Hanjra and Qureshi, 2010; Gregory and George, 2011; Tilman et al., 2011). Moreover, as will emerge from arguments to be made in the next section, this large relative increase in food crop production will have to come mainly from increasing crop yield per hectare planted—crop intensification—not from converting more land to agricultural use. The challenge posed becomes even more daunting when considered in light of the evident stagnation or even decline in food crop yield increases over the past decade along with the dramatically increasing competition for resources from nonfood crops, particularly biofuels (Hanjra and Qureshi, 2010; Foley et al., 2011; Gregory and George, 2011).

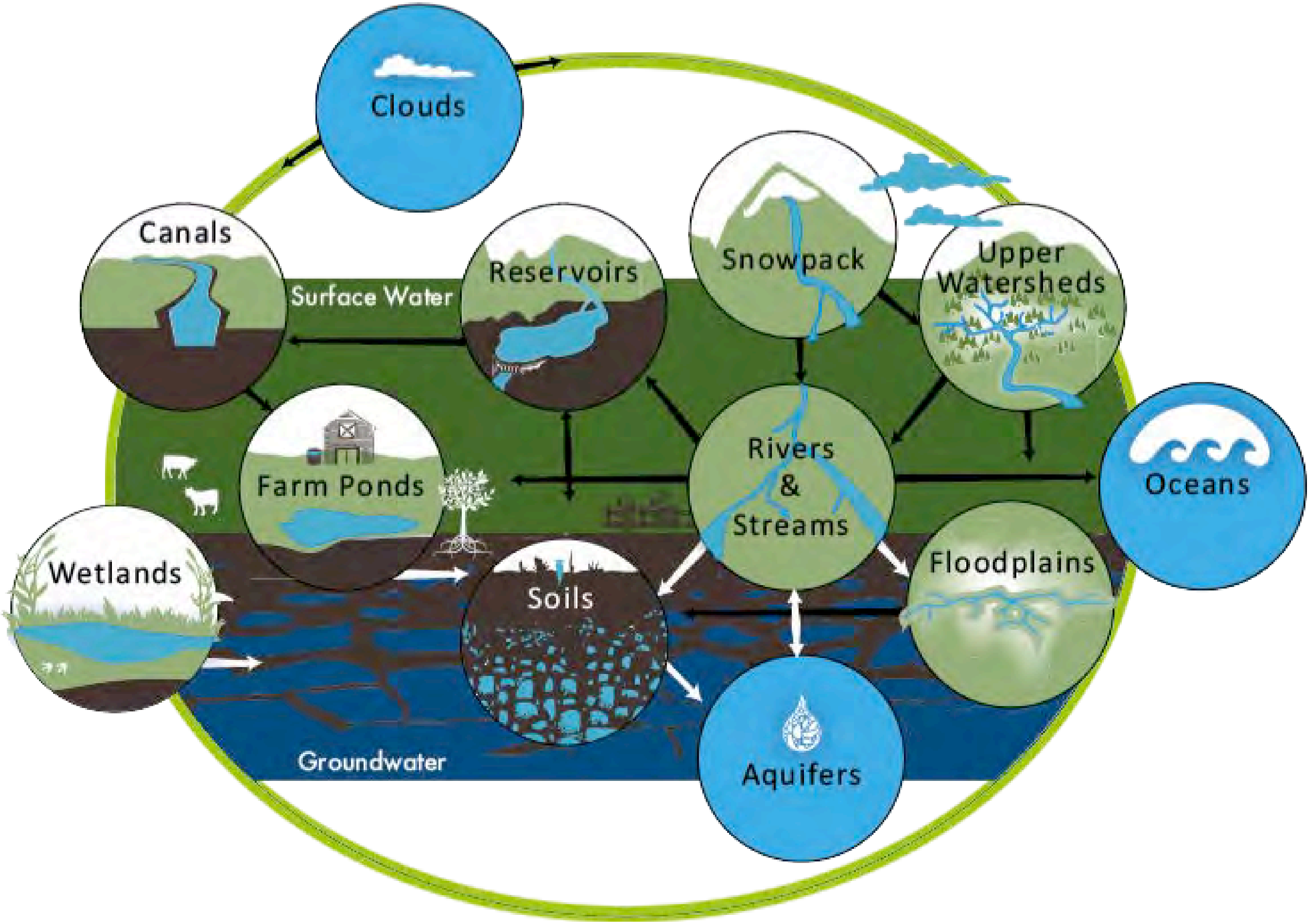
## Framing the Challenge: Constraints

One useful way to approach a challenging problem is to establish the conditions under which any viable solution of it must operate. For the problem of determining ways to increase food crop production sufficiently to meet global demand, the results of recent detailed studies of land and water use worldwide, along with their ecological impacts, lead to three constraints that, in all likelihood, will narrow the range of possible alternatives. One of these constraints limits land conversion, as noted above; another limits agricultural water withdrawals, while the third one reveals a key facet of the consumptive use of water by croplands.

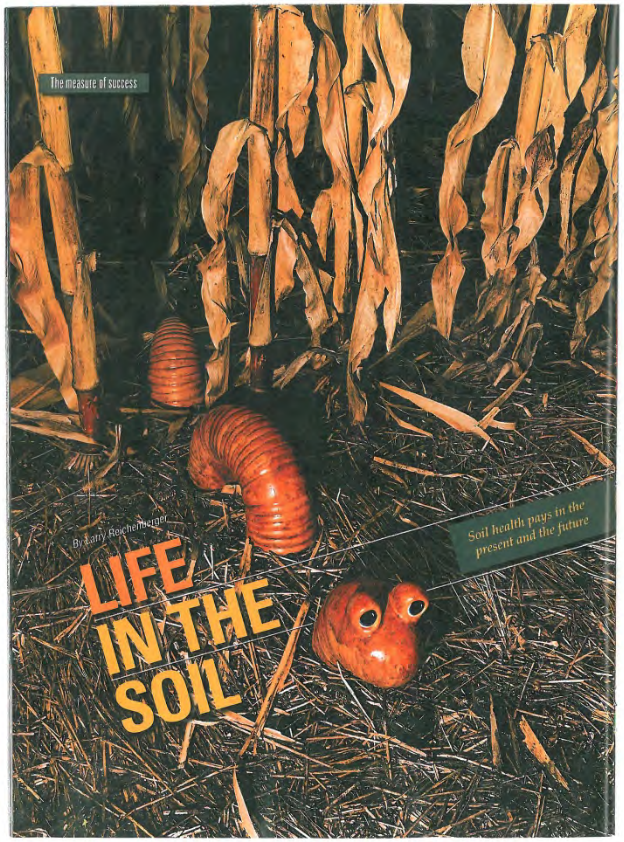


G. Sposito
Vadose Zone J.
2013


RAINFALL
Green water flow
Green ET flow
Green ET flow
Blue to green ET flow
Blue water resource
Unsaturated zone
Blue water flow
Green water resource
Saturated zone
Blue water resource
Sposito, 2014




**From Storage to Retention: Expanding California's Options for Meeting its Water Needs**
**California Roundtable on Water and Food Supply**
November 2012


Healthy soils are the ultimate measure of success for Rick Bieber. With the zeal of an evangelist, this Trail City, S.D., farmer promotes methods that enhance soil quality. He swears by the old adage, "If you take care of your soil, your soil will take care of you."

"The soil is the greatest source of wealth in the world, but most farmers squander its potential," says Bieber, who farms with his son, Ben. "The soil isn't just a tool, it's a full partner in a farming operation and deserves to be treated with respect. Learn to protect the soil and to manage it like it's really alive — because it is—and you will see an unbelievable response."

**Diversity in crops.** Bieber's recipe for a healthy soil includes long-term no-till, intensive crop rotation, and cover crops. "We started no-tilling in 1987 and soon learned we needed to diversify and intensify our crop rotation to utilize the moisture we were saving and to boost microbial activity in the soil. From wheat/fallow and wheat/corn/fallow, we changed to rotations that also include chickpeas, millet, flax, sunflowers, and alfalfa. More recently, we've added cover crops that are planted after wheat and interseeded into growing corn."

"Now, our yields are higher with fewer inputs so profitability has increased. And, the impact of drought, heat, and other stress is less. Our 10-year proven corn yields are 408% of the county average, and wheat yields are 358% of the norm," adds Bieber.

**Credit the soil.** Bieber is quick to deflect credit for this performance. "It's totally due to the soil—all I've done is provide what the soil tells me it needs to do its job," he says.

What Bieber provides is a steady supply of carbon—in the form of crop residue and living plant roots—that feeds soil microbes, moderates soil temperatures to protect the microbes, shields the soil surface from erosion, and builds soil organic matter levels.

Bieber measures performance of his system is various ways. "We used to apply 90 pounds per acre of nitrogen and produce 90-bushel corn, but now the same amount of nitrogen produces 160 bushels. That's due mainly to our soil organic matter levels, which are 4-5% in our long-term no-till."

In contrast, typical conventionally tilled fields in Bieber's area have soil organic matter levels around 2%. Soil with higher organic matter not only mineralizes more nitrogen, it also holds more water, and that's the farm's major benchmark of success.

"We judge our management skills by the amount of grain we produce per inch of rainfall, and we've seen this water-use efficiency increase as our soil health has improved. In 1998 we produced just over 4 bushels of corn per inch of rainfall. By 2001, the first year corn in our rotation grew on cover crops grown in 1998, that had increased to 5.4 bushels per inch. By 2007, that efficiency had increased to 6.23 bushels per inch of rainfall."

**Best combination.** Bieber worked with agronomist Cheryl Reese from South Dakota State University on an intensive cover crop study from 2009 through 2011. "There were 96 trials, and they showed that the best combination of cover crops and fertilizer rates resulted in 12.6 bushels of corn per inch of rainfall. Then in 2012, with a severe drought, corn on our long-term, no-till ground produced 9.54 bushels per inch of rainfall while some new ground—in its first year of no-till— produced only 4 bushels per inch. That was amazingly similar to what we saw in 1998," says Bieber.

**Hungry soil.** His water use efficiency data has convinced Bieber that his soils are hungry for live roots, even in dry years. "Living plants sequester carbon from the atmosphere and deposit it in the soil through their root system, so we want to have something growing every moment that the season allows," he says.

Cover crops allow Bieber to put this conclusion into practice. "We hire an extra man so we can plant cover crops right behind the combine during wheat harvest. And, the cover crops we interseed at the V-6 stage of our corn stay alive well after the corn matures in the fall," he says,

"We're protecting soil not just for the next generation, but for those 100 and 1,000 years from now," he adds. ■

►**Left:** Rick Bieber says healthy soil makes farming fun—a point emphasized by this giant earthworm he poses for frequent visitors to his farm.

►**Left center:** High organic matter levels have turned Bieber's soils black and fostered a teaming population of earthworms. ►**Left:** Cover crops, including radishes and turnips, are broadcast into corn at the V-6 stage to extend the growing season and improve winter grazing.



**"'Soil care' is what we're doing."**

Rick Bieber
Trail City, SD
January 28, 2014

"…No-till systems have changed cropping practices in the Central Great Plains because of beneficial impacts on water relations and soil health.  Some scientists have suggested that no-till systems have initiated a spiral of soil regeneration in this region, where interactions among more favorable water relations, residue production, and crop yield are continually improving soil health and, consequently, future crop performance."

Randy Anderson
USDA ARS, Brookings, SD
Advances in Agronomy
Volume 80

# NEW PRODUCTS

### R4023 SELF-PROPELLED SPRAYER FROM JOHN DEERE

- 4.5-liter, 173-horsepower Tier 4 Final engine
- 600-gallon poly tank
- 80-foot booms that can fold to 60 feet for tight conditions
- Ideal for small, odd-shaped fields

Additional product information can be requested via "e-inquiry" at www.no-tillfarmer.com/rs. Click on Reader Service No. 101

### LOOK AT POTASSIUM BASE SATURATION ON SOIL TESTS

In addition to pounds per acre, Lance Tarochione recommends no-tillers look closely at the base saturation percentage of potassium (K) levels on soil tests for soybeans.

Base saturation is an indication of how much plant-available K is being held in the cation exchange sites. If base saturation of K falls below 3%, the crop may struggle to get the K it needs, the technical agronomist for Monsanto says.

If the base saturation level is below 3%, Tarochione suggests no-tillers apply more K, which will flood the exchange sites and correct the problem. A K base saturation of 3-4% is an ideal range, he says. *(Find more soybean fertility tips on pages 14-15.)*

### BENEFICIAL INSECTS MAY REDUCE COVER CROPS

No-tillers broadcasting small-seeded cover crops may want to consider increasing their seeding rate if they have a lot of beneficial insect activity in their fields.

Granivores — insects that eat seeds — each week consume about 1-10% of seeds that lie on the soil surface, says Jonathan Lundgren, research entomologist with the USDA North Central Agricultural Research Laboratory in Brookings, S.D.

Larger seeds are not at risk for consumption, but some smaller-seeded covers can see a significant reduction in seed, he says.

# NO-TILL TIP OF THE MONTH

## WHEN TO USE A SEED TREATMENT ON SOYBEANS

While no-tillers looking to trim costs in 2015 may consider forgoing a fungicide seed treatment on their soybeans, a fungicide seed treatment serves as an insurance policy to protect the seed and young seedlings until plants have emerged.

Here are some reasons no-tillers should consider using a fungicide seed treatment:

- **Farm has a history of replanting.** One replant will pay for more than 10 years of a seed treatment.
- **Farm drainage has not been updated or the field is slow to drain after heavy rains.** All soil-borne pathogens that can infect soybeans require high moisture. If a tile system is poor, old or not functioning well, the field will be saturated longer, increasing the odds of the seeds/seedlings becoming infected.
- **Seeding rate has been reduced.** With many no-tillers reducing soybean seeding rates to trim expenses, every seed becomes important and seed treatments can have a larger contribution to maintaining early plant populations and final stands.
- **Fields with numerous pathotypes of *Phytophthora sojae*.** A number of studies show that seed treatments are needed to protect plants if a no-tiller is completely dependent on the partial resistance portion of a resistance package.
- **Early planting and cool temperatures.** The cooler the spring, the longer the seed or seedling will sit belowground, giving soil-borne pathogens more time to feed.

***— Anne Dorrance, Ohio State University***

### IT PAYS TO CONTROL RESISTANT RYEGRASS

Researchers at Mississippi State University (MSU) recently assessed the benefit-to-cost ratio for treating glyphosate-resistant Italian ryegrass before planting corn.

By calculating the weed's impact on corn growth rate and yield, weed scientist Jason Bond says that for every dollar spent on controlling the ryegrass prior to planting corn, they received $13 back in corn yield. Uncontrolled ryegrass took a little over a bushel of corn each day.

### NO-TILL INCREASES YIELD DURING DRY CONDITIONS

South Dakota State University found that reduced-tillage practices that conserve moisture, plants that use water more efficiently and soil with more organic matter have produced significantly higher yields in dry conditions.

Soil scientist David Clay compared corn, soybean and wheat yields during droughts in 1974 and 2012. Despite 2012 being a worse drought, corn yields were up more than 200%, soybeans by 50% and wheat by almost 150% over 1974 yields.

Clay estimates that the increased water availability through a reduction in tillage had a net impact of $1.1 billion on South Dakota agriculture in 2012.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"Take the 'E' out of 'ET' and the 'T' out of 'can't."
Dwayne Beck
South Dakota State University
(South Dakota Hall of Fame 2008)


First recorded example of no-till,
high residue planting with two
irrigations avoided because of residues
Five Points, CA
July 3, 2003


"Take the 'E' out of 'ET.'"
Dwayne Beck
South Dakota State University
We estimated 0.89 and 0.97 inches (2.3 and 2.5 cm)
more water retained in the surface foot of soil under
no-till than in tilled soil following intercrop tillage between
wheat silage and corn.
In press
California Agriculture
April 2012


VALLEY
Soil evaporation study under residue mulch and bare conditions
Five Points, CA
September 2009
Assuming a seasonal crop evapotranspiration demand of 30 inches, coupling no-tillage with high residue preserving practices could reduce summer season soil evaporative losses by about 4 inches (10.2 cm) or 13%.
In press
California Agriculture
Apirl 2012


NOVATION CENTE

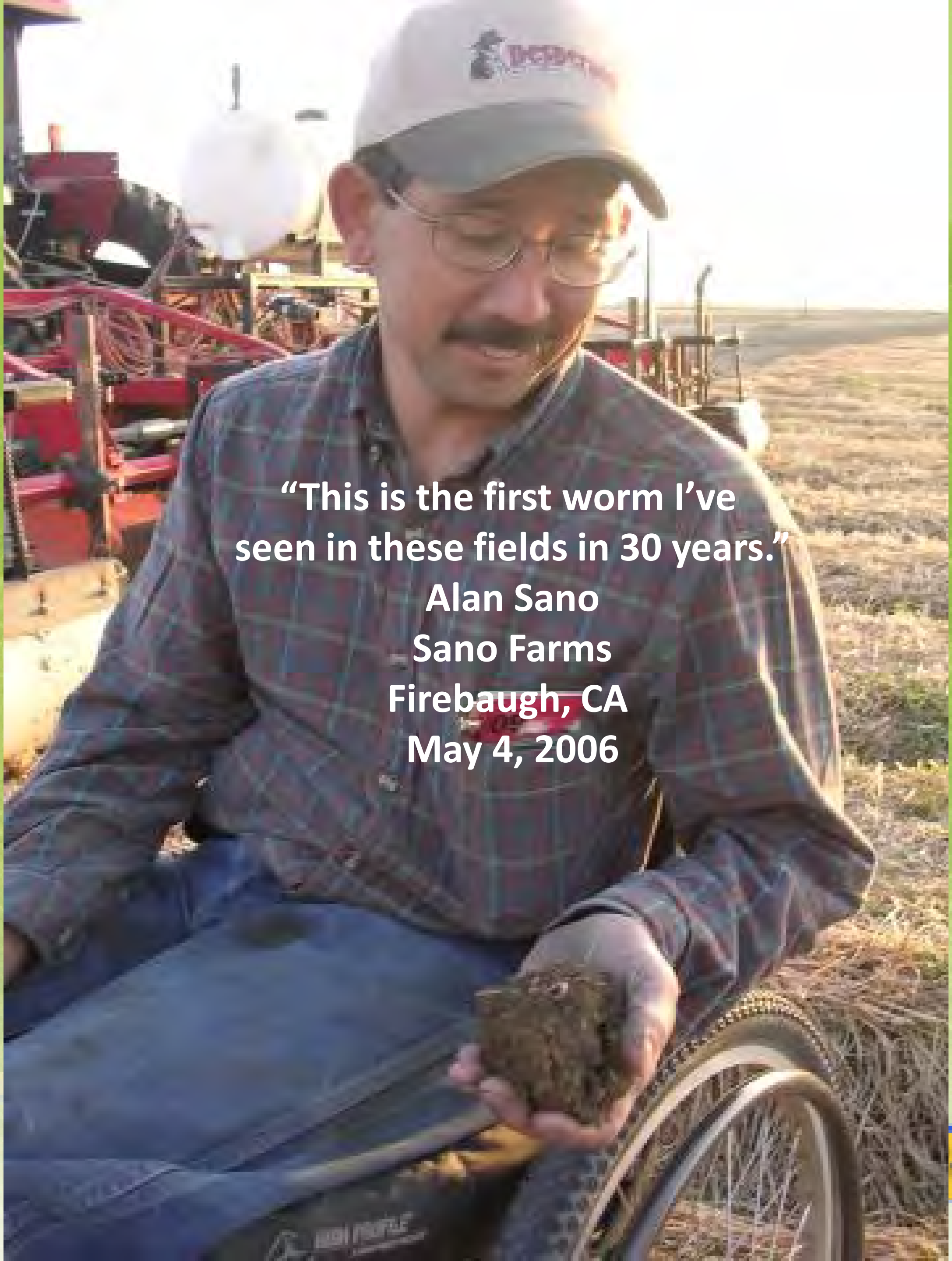
UC DAVIS COLLEGE of AGRICULTURAL and ENVIRONMENTAL SCIENCES

UC DAVIS DEPARTMENT of PLANT SCIENCES

RESOURCE

Sustainable Conservation

EDISON



"This is the first worm I've seen in these fields in 30 years."

Alan Sano

Sano Farms

Firebaugh, CA

May 4, 2006

Eight-row 60" strip-tilled cover crop tomato transplanting
The Morning Star Company
Hollister, CA
2010


First-ever strip-tilled cotton
into wheat residue
Firebaugh, CA
2013


Richie and Shannon Iest
and NRCS Conservationist
Iest Dairy
Chowchilla, CA
Attention to soil health
2009

*No Farms No Food*

American Farmland Trust

**Stewardship Profiles in California Agriculture**

## Land Conservation and Air Quality

## GIACOMAZZI DAIRY

Dino Giacomazzi is a fourth-generation dairy farmer whose 900-acre farm has been in operation, southeast of Hanford, since 1893. He and his family live on the dairy property and oversee all aspects of its operations. Mr. Giacomazzi has been on the forefront of land conservation; his use of conservation tillage that has reduced air pollution, combined with his outreach efforts through field days on the farm, an informative blog, and social media websites earned him the 2012 Leopold Conservation Award.

### LEADING THE WAY ON SUSTAINABILITY

Although conservation tillage (CT) has gained traction in much of the country, farmers in California's high value crops have been slower to make the transition. Mr. Giacomazzi first used CT in the spring of 2005 as part of an Environmental Quality Incentives Program contract received through the USDA Natural Resources Conservation Service. The following year Mr. Giacomazzi was using CT for all of his corn production and was actively experimenting with different implements, corn varieties, and planting configurations to maximize yield and minimize pollution. Since 2005, Mr. Giacomazzi's implementation of the land ethic has gone beyond CT and now includes water, nutrient, and pest management, along with twin row cropping, in a holistic management practice termed "biological farming."

## ACHIEVEMENTS

- Recipient of the 2012 Leopold Conservation Award for actively living a land ethic
- Reduced pollution from decreased use of diesel tractors and reduction of airborne dust particulate matter from soil tillage
- Creation of a public outreach and education campaign to encourage conservation tillage farming
- Development of a handbook titled: A Systems Approach to Conservation Tillage of Forage Crops

PHOTOS COURTESY OF V6 RANCH

**"[Biological farming is] to work with the systems of nature to develop a farm which is environmentally sound, and which leaves the land, water, plants and animals in a healthy, productive state for all future generations."**

**- Dino Giacomazzi Dairy Farmer**

"What we're doing is designing completely new production paradigms for the San Joaquin Valley."

Dino Giacomazzi
Hanford, CA
2012

Michael and Adam Crowell

IT TAKES NO TILLAGE

# Conventional farmers drop their plows in favor of conservation

By **Nathanael Johnson** on 15 Apr 2014 44 comments



The Michael and Adam Crowell duo works this way: Michael handles the crops, and Adam handles the dairy cows; Michael is the colorful wisecracker, and Adam is the straight man; Michael casts about for a word when his tongue outpaces his memory, and Adam fills it in; Michael is the father, and Adam is the son.

I visited their dairy farm near Turlock, in California's Central Valley, to get a look at the growing trend of conventional farmers adopting ecologically friendly techniques. In the Midwest, where farmers grow a small number of grain crops,


As of 2014, commercial strip-till and corn planting support is now available to help interested farmers learn about these silage production system alternatives.


This program has been hugely successful
in providing learning opportunities
to farmers who are interested in
these approaches.

**OKLAHOMA ASSOCIATION**
of Conservation Districts

**WESTERN FARMERS**
Electric Cooperative

**OKLAHOMA**
Conservation Commission

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## Buy An ECOpass

One Acre - $5.00 USD

Buy Now

# How It Works

Where does your dollar go? When you purchase an ECOpass, be it a $5 pass or a $200 pass, that money goes directly back to farmers and ranchers in Oklahoma who are making a difference for our environment and positively impacting conservation in our state. For each $5 pass, $3.50 goes right back to producers. The remaining $1.50 goes to local conservation districts and the Oklahoma Conservation Commission to verify the practices that have been put under contract. This ensures that everyone is getting their money's worth and when we say you have an acre, we can tell you where that acre is and what that landowner is doing on that acre. For more information or if you have any questions, email sarahblaney@okconservation.org.

Below are more details about how each practice positively impacts Oklahoma:

## No-till Crop Systems

No-tillage or zero tillage is a farming system in which the seeds are directly deposited into untilled soil that has retained the previous crop residues. It is also referred to as no-till. Special no-till seeding equipment with discs (low disturbance) or narrow tine coulters (higher disturbance) open a narrow slot into the residue-covered soil that is only wide enough to put the seeds into the ground and cover them with soil. The aim is to move as little soil as possible in order not to bring weed seeds to the surface and not stimulating them to germinate. No other soil tillage operation is done. The residues from the previous crops will remain largely undisturbed at the soil surface as mulch. If the soil is disturbed even only superficially then the system cannot be termed no-tillage and is defined as mulch tillage (CTIC, 2011). In Oklahoma, we are behind the curve when it comes to adoption of no-till. This is something the

Reply | Reply to All | Forward | Delete | Move to Folder | Create Rule | Other Actions | Block Sender | Safe Lists | Not Junk | Categorize | Follow Up | Mark as Unread | Find | Related | Select | Send to OneNote
Respond | Actions | Junk E-mail | Options | Find | OneNote

From: Don Reicosky [don.reicosky@gmail.com]
To: Jeffrey Mitchell
Cc:
Subject: Fwd: ECO - pass
Sent: Wed 4/29/2015 2:4

I ran across an article in the Minneapolis Star Tribune Parade magazine which had an article on 50 eco-friendly things the various states are doing celebrating Earth Day in the US. The brief article from Oklahoma stated **"under a program from the Oklahoma Conservation Commission, state residents can buy ECO passes ($5-$200) with the money going directly to farmers and ranchers in the state would adopt no-till crop systems to stem erosion."** Even with all of the conservation programs in the US, wind and water erosion still is a major problem. The eco-pass concept that was presented struck a positive chord as a way of providing incentives for decreasing soil erosion and degradation.

In searching the Internet, I visited the three websites below looking for information on your version of the eco-pass concept. If there are other websites that I should visit, please let me know.

http://www.ok.gov/conservation/

http://ecopassok.com/

http://newsok.com/oklahoma-ecopass-program-connects-city-country-for-conservation/article/3668472/?page=2

There are many aspects of the ECO-pass program that appealed to me.

-it's a voluntary program, to put more conservation on the landscape,

-this type of a program would help develop sustainable programs and food security for future generations

-may provide an opportunity to support conservation without taxes and regulation and supplement some of the government programs

-people in the metro areas want to help the environment in some way

-urban and rural folks can come together to improve soil, water, and air quality

-reward and incentivise producers with money going directly to the farmers for good stewardship

-the voluntary approach helps ourselves while helping protect the earth.

-A voluntary way of protecting the water quality in our rivers streams and lakes

-would provide an opportunity to offset your individual carbon footprint or impact on the environment

-customer choice allows consumer preferences for sustainable food production to be reflected in market transactions.

-Lessening our dependence on fossil fuels is critical to the health of all living things, and conservation practices can do just that

-Using CA, Soil erosion is reduced, reducing soil runoff into streams and rivers.

-Consumer oriented/approved conservation practices

I'm sure there are other aspects that can be added to this list.

BUSINESS NEWS: LOCAL BUSINESS: LOCAL BUSINESS: ENERGY

# Oklahoma ECOpass program connects city, country for conservation

0 comments

by Paul Monies *Published: April 22, 2012*

With ECOpass, the Oklahoma Association of Conservation Districts signs up farmers to a three-year contract, said Clay Pope, executive director. Once the contracts are in place, they are verified by officials with the Conservation Commission.

by Paul Monies
ENERGY REPORTER

Paul Monies is an energy reporter for The Oklahoman. He has worked at newspapers in Texas and Missouri and most recently was a data journalist for USA Today in the Washington D.C. area. Monies also spent nine years as a business reporter and...

+ show more

RELATED MULTIMEDIA

***Video:*** *(Apr 20)*
*ECOpass supporting local farmers and environment*

# Carbon Sequestration Certification Program

## Projects

The carbon program is growing by leaps and bounds! Check out the projects we are partnering on:

### North Canadian River Watershed Carbon Pilot Program

The Pilot Program was initiated to support development of the new Oklahoma carbon sequestration certification program. However, interest in the program has been so great, and project opportunities so bountiful, the pilot is now running tandem with all pro
carbon pilot program is being conducted in conjunction with the North Canadian River Water Quality Project, whose goal is to improve the water quality of the river between Canton Dam and Lake Overholser by reducing polluted runoff from land. The pilot p
incentives from carbon offset payments and water quality program cost share monies to encourage producer participation. As part of the pilot program, soil carbon samples are being taken from select participating fields by Oklahoma State University. Goals
on the willingness of Oklahoma agriculture producers to sign carbon contracts; use contracted acres to develop and test field verification protocols; encourage improved land management practices that store carbon dioxide and improve water quality; encou
Oklahoma to determine carbon sequestration rates in Oklahoma. **Partners:** Western Farmers Electric Cooperative (WFEC), Oklahoma Association of Conservation Districts, OK-NRCS, Oklahoma State University, Central North Canadian River Conservatio
Conservation District, Dewey County Conservation District. Partnership Designation: Lead. Funding Source: WFEC. Start Date: 2008. Duration: Five years (rolled into Expansion Project).

### *Expansion Project: Developing high quality carbon offset verification protocols and quantifying water quality improvements of best management practices to ensure the environmental benefits of agricul*

This project completes carbon sequestration verification protocols under development in Oklahoma, pairs them with soil sampling, and demonstrates how verified carbon offsets and related water quality improvements can be bundled for ecosystem market
be compiled into a verification handbook. The purpose of this project is to develop, test, and implement carbon sequestration verification protocols for agricultural and silvicultural practices that are recognized to have carbon market value to ensure environm
market transactions. **Partners:** Western Farmers Electric Cooperative, Oklahoma Association of Conservation Districts, OK-NRCS, Oklahoma State University, Central North Canadian River Conservation District, Blaine County Conservation District, Dewe
District. Partnership Designation: Grantee. Funding Source: NRCS FY2010 CIG. Start Date: 2010. Duration: Three years.

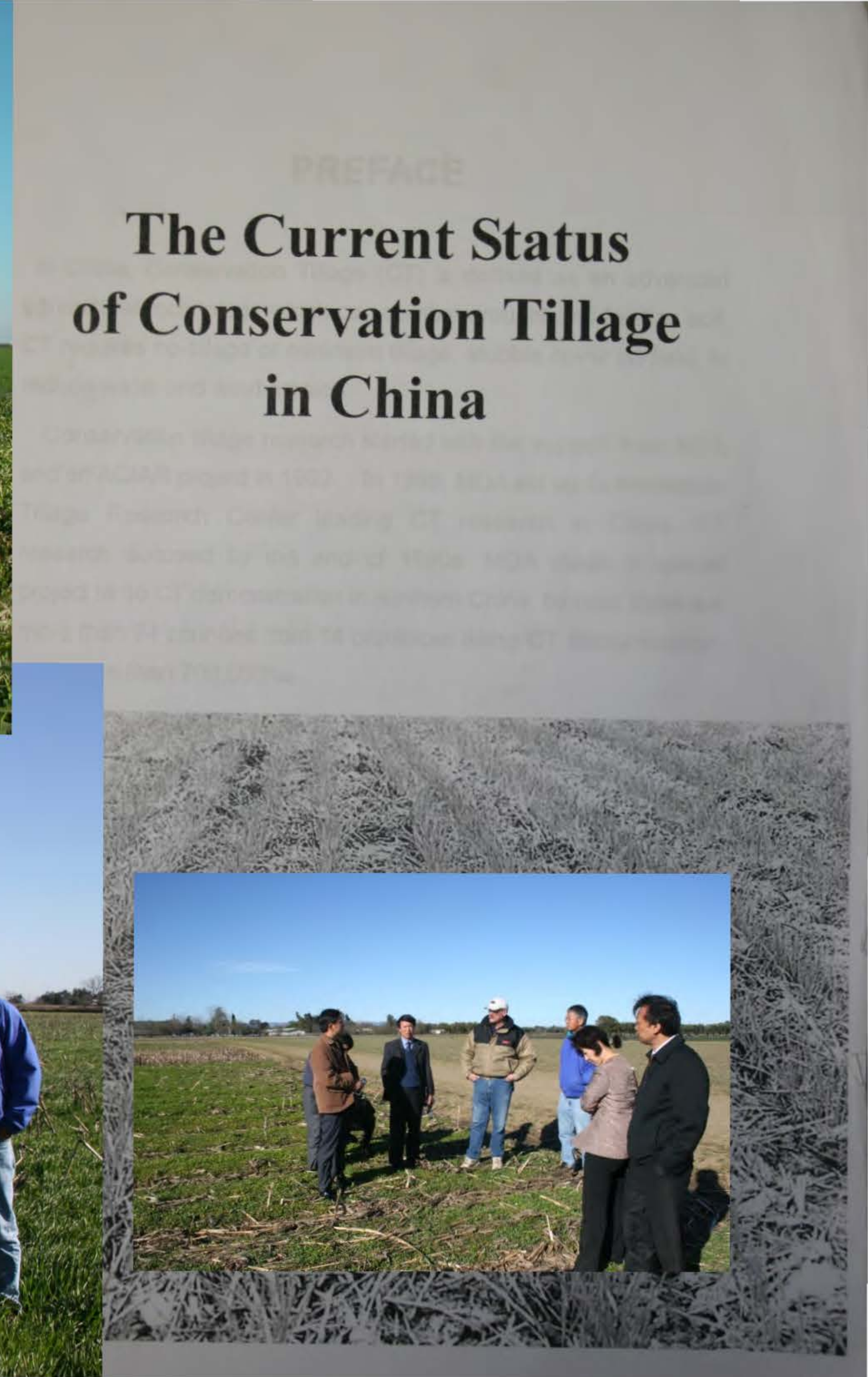
### Soil Carbon Sampling

Soil carbon sampling is an integral part of most Oklahoma Carbon Program projects because the Conservation Commission and partners are committed to expanding soil carbon research in Oklahoma. The overall goal of soil carbon research in Oklahoma
rates of these practices in specific soils in as much of Oklahoma as possible. we have partnered with Oklahoma State University (OSU) to assess carbon sequestration rates in Oklahoma. OSU is evaluating the impact of spatial variations on the accuracy a
measurements for use in carbon sequestration verification. Assessments of both small scale (meters) and large scale (kilometers) variations are conducted so that future sampling protocols can be developed that minimize sample requirements and insure a
measurements for the aggregated acres by carbon offset verifiers. See the soil sampling page for more details. **Partners**:Oklahoma State University (OSU), Western Farmers Electric Cooperative (WFEC), USDA-Natural Resources Conservation Service (N
Association of Conservation Districts. Partnership Designation: Lead. Funding Source: NRCS FY2010 CIG, WFEC, OSU. Start Date: 2008. Duration: Five years.

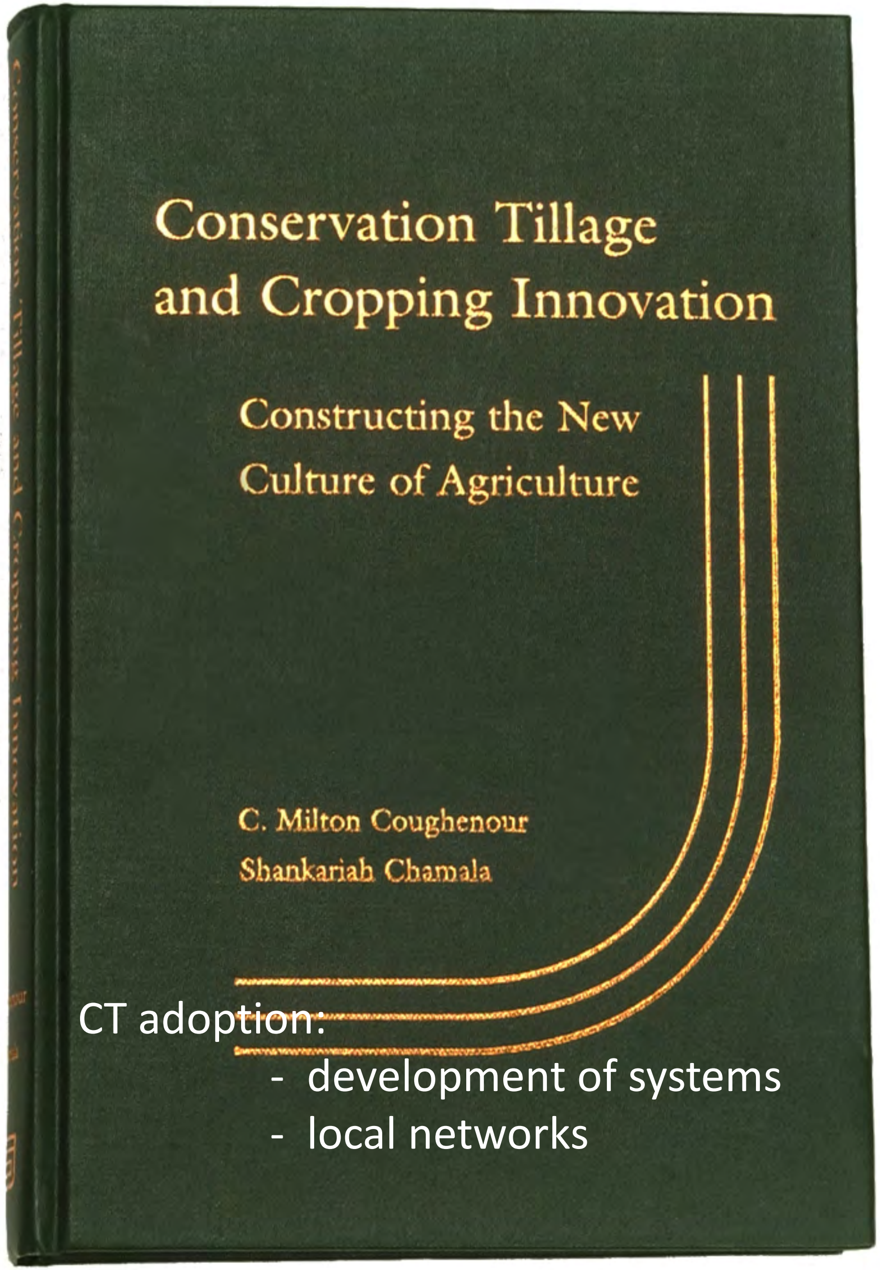
### *Ecosystem Services Project*

The purpose of this project is to continue and expand implementation efforts in the North Canadian River watershed to address nonpoint source (NPS) pollution-related impairments to streams, the river, and the recipient drinking water reservoirs. The proje
approach to conservation management to reap the co-benefits of multiple conservation strategies working synergistically in a defined area to demonstrate to producers that it is feasible to continue implementation of best management practices (BMP) beyo
improving water quality and optimizing farm yields. The ultimate goal is load reductions of bacteria, sediment, and nitrogen to streams, with the co-benefits of carbon sequestration and avoided nitrogen emissions. This will be done by providing technical ass
rationales to producers to encourage BMP longevity including managing no-till fields, pastures, and riparian areas, nutrient management, wildlife habitat, and carbon sequestration beyond their contract life. **Partners:** USEPA, Oklahoma State University, Ok
Wildlife Conservation, Central North Canadian River Conservation District, Blaine County Conservation District, Dewey County Conservation District. Partnership Designation: Grantee. Funding Source: USEPA. Start Date: 2011. Duration: Two years.

### *Bringing Greenhouse Gas Benefits to Market: Nutrient Management for Nitrous Oxide Reductions*



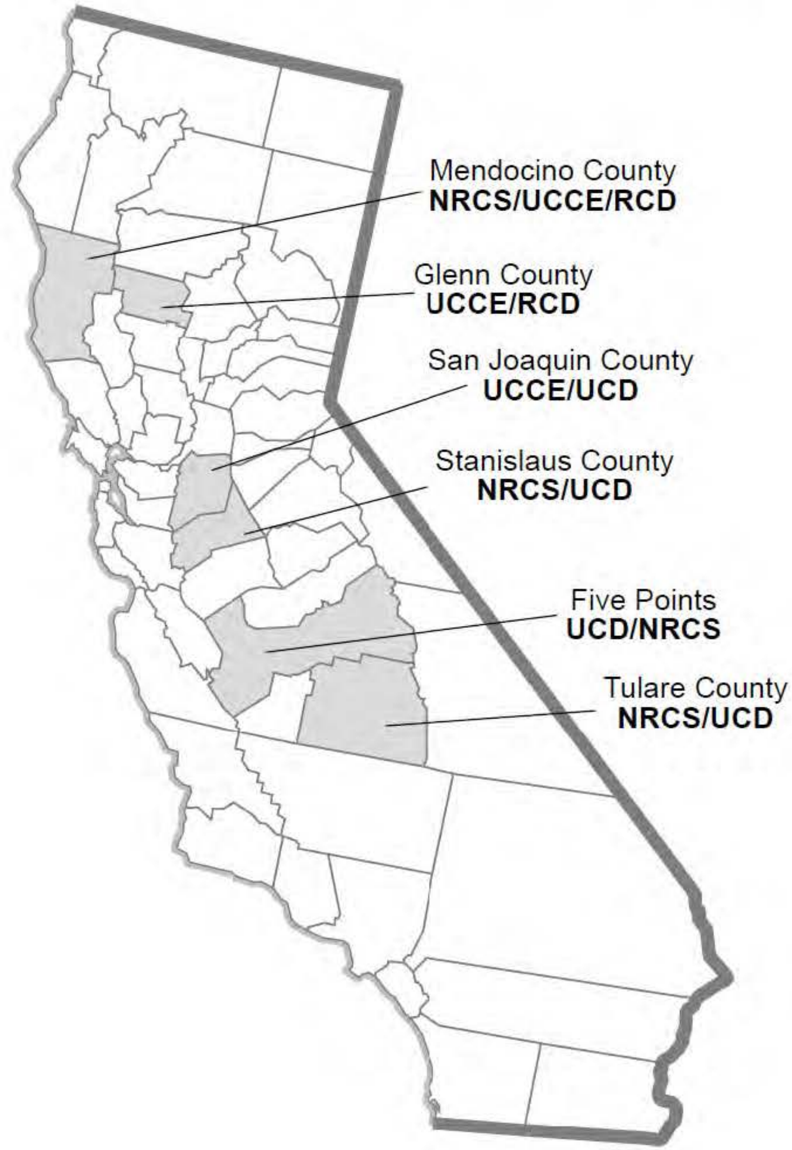
# The Current Status of Conservation Tillage in China




CT adoption:

- development of systems
- local networks

# California Soil Health
# Farm Demonstration Evaluation Sites - 2015




**Coming in 2015!**

**A video series about soil health in California featuring local leaders and contexts**

UNIVERSITY OF CALIFORNIA
AGRICULTURE AND NATURAL RESOURCES

COOPERATIVE EXTENSION

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO • SANTA BARBARA • SANTA CRUZ

KEARNEY AGRICULTURAL CENTER
9240 South Riverbend Avenue
Parlier, California 93648
(209) 646-6500
(209) 646-6593

October 26, 1998

To: Kevin Collins (209) 866-5666

# REMINDER

## OPPORTUNITIES FOR CONSERVATION TILLAGE IN THE WEST SIDE OF THE SJV

***(Discussion of possible on-farm demonstration and research project)***

**Friday**
**October 30, 1998**
**10:00 am - noon**
**University of California**
**West Side Research and Extension Center**
**Corner of Oakland and Lassen Avenues**
**Five Points, CA (209) 884-2411**

Conservation Tillage WORKGROUP

Conservation Tillage and Cropping Systems WORKGROUP

California OVERHEAD IRRIGATION ALLIANCE
Conservation Tillage WORKGROUP

California Conservation Cropping Systems and Irrigation INSTITUTE

CONSERVATION AGRICULTURE SYSTEMS INSTITUTE

Conservation Agriculture Systems INNOVATION CENTER

# Our goals have been to

- Develop information
- Bring people together
- Partner with innovative farmers
- Emphasize the whole system
- Create a strategy for better educational impact and wider adoption of conservation agriculture and efficient irrigation systems

# Sharing and showing equipment has been a big part of our information work.





Aref Abdul-Baki
USDA ARS
Beltsville, MD
Dwayne Beck
SDSU
Pierre, SD
Andy McGuire
Moses Lake, WA
Ron Morse
Virginia Tech
Blacksburg, VA
Dick and Sharon Thompson
Boone, IA
Suat Irmak
Lincoln, NE
Karl Kupers
Rearden, WA
Steve Groff
Lancaster County
Pennsylvania
John Landers
Cerrado Region
Brazil
John Luna
Oregon State
University
Corvallis, OR
Horizons for
California
Mike Peterson
Greeley, CO
Don Reicosky
USDA ARS
Morris, MN


CASE IH
2007
California
CONSERVATION TILLAGE
FARMER TOUR
UCDAVIS
USDA
ars
Agricultural Research Service
SPRINKLER IRRIGATION RESEARCH
LATERAL-MOVE SPRINKLERS
IRRIGATION METHODS
CROPPING SYSTEMS
BLOOM BUILDINGS
OSKALOOSA, IOWA
ECONOMICS
NEBRASKA
... the good life
Home of Arbor Day
National Soil Tilth Laboratory
Making Conservation Tillage Conventional:
Building a Future on 25 Years of Research
Proceedings of the 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture
Auburn, AL, USA 24-26 June 2002
IMPROVE SOIL & WATER
NO-PLOW ZONE

2005
Bob Prys
Lemoore, CA

2006
Tom Barcellos
Tipton

2007
Jim Couto
Kerman

2007
Tony Turkovich
Winters

2008
Dino Giacomazzi
Hanford

2009
Jesse Sanchez
Firebaugh

2009
Alan Sano
Firebaugh

2010
John Diener
Five Points

2011
Fred Leavitt
Firebaugh

2011
Michael Crowell
Turlock

2012
Gary Martin
Firebaugh

2013
Danny Ramos
Los Banos

2013
Ralph Ceseña, Sr.
Stockton

Conservation Agriculture Systems Innovation Center

# Conservation Tillage
## CT Farmer Innovator Awardees

UC CE University of California Agriculture & Natural Resources

UC DAVIS College of Agricultural and Environmental Sciences

UC DAVIS Department of Plant Sciences

NRCS

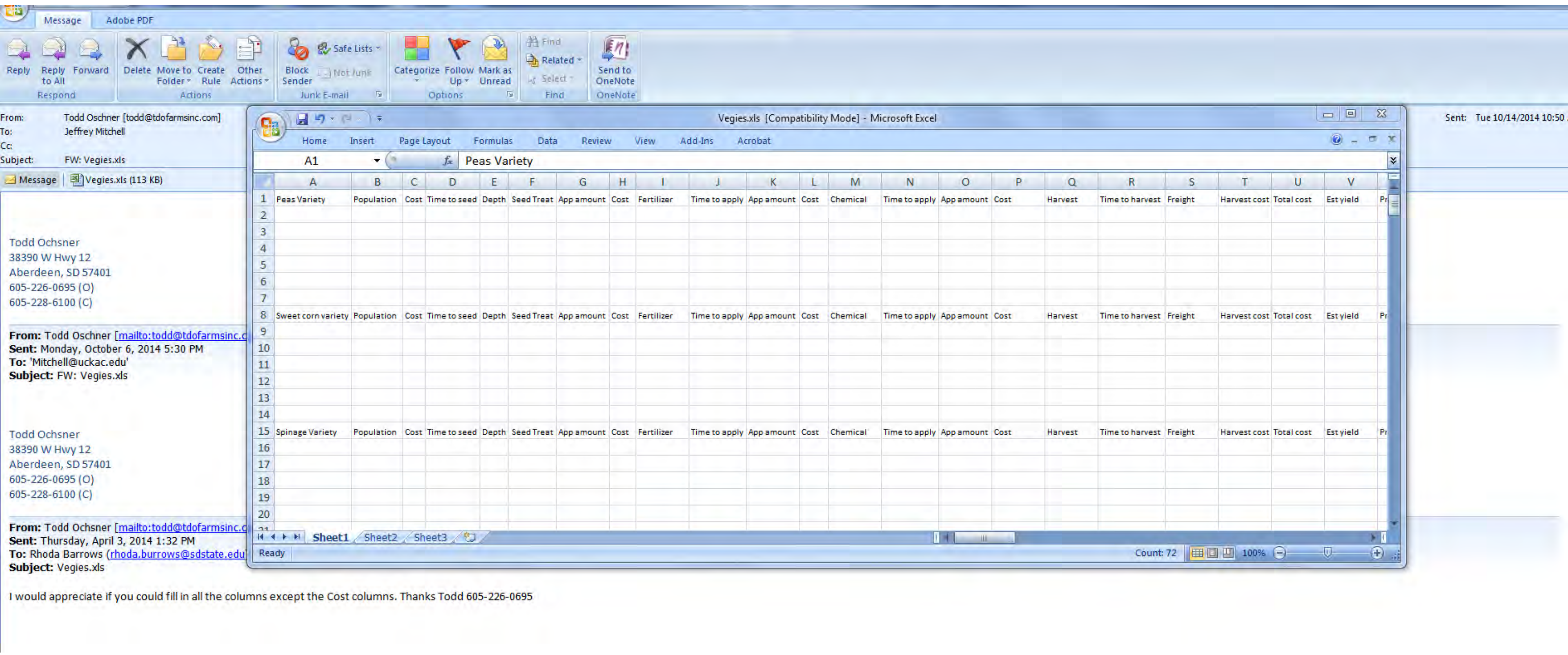
Resource

Sustainable Conservation

Edison

# I would like to encourage and propose a

formal partnership between CDFA and our CASI Center and its diverse partners in moving forward with an expanded implementation of your Environmental Farming Act.




South Dakota no-till vegetable farmer inquiry about production details

# USDA
# Agricultural Research Service

National Program 216

Agricultural Systems Competitiveness and Sustainability


‘The agronomic and ecological equivalent
of the moon race of the 1960’s’
Dwayne Beck, 2012

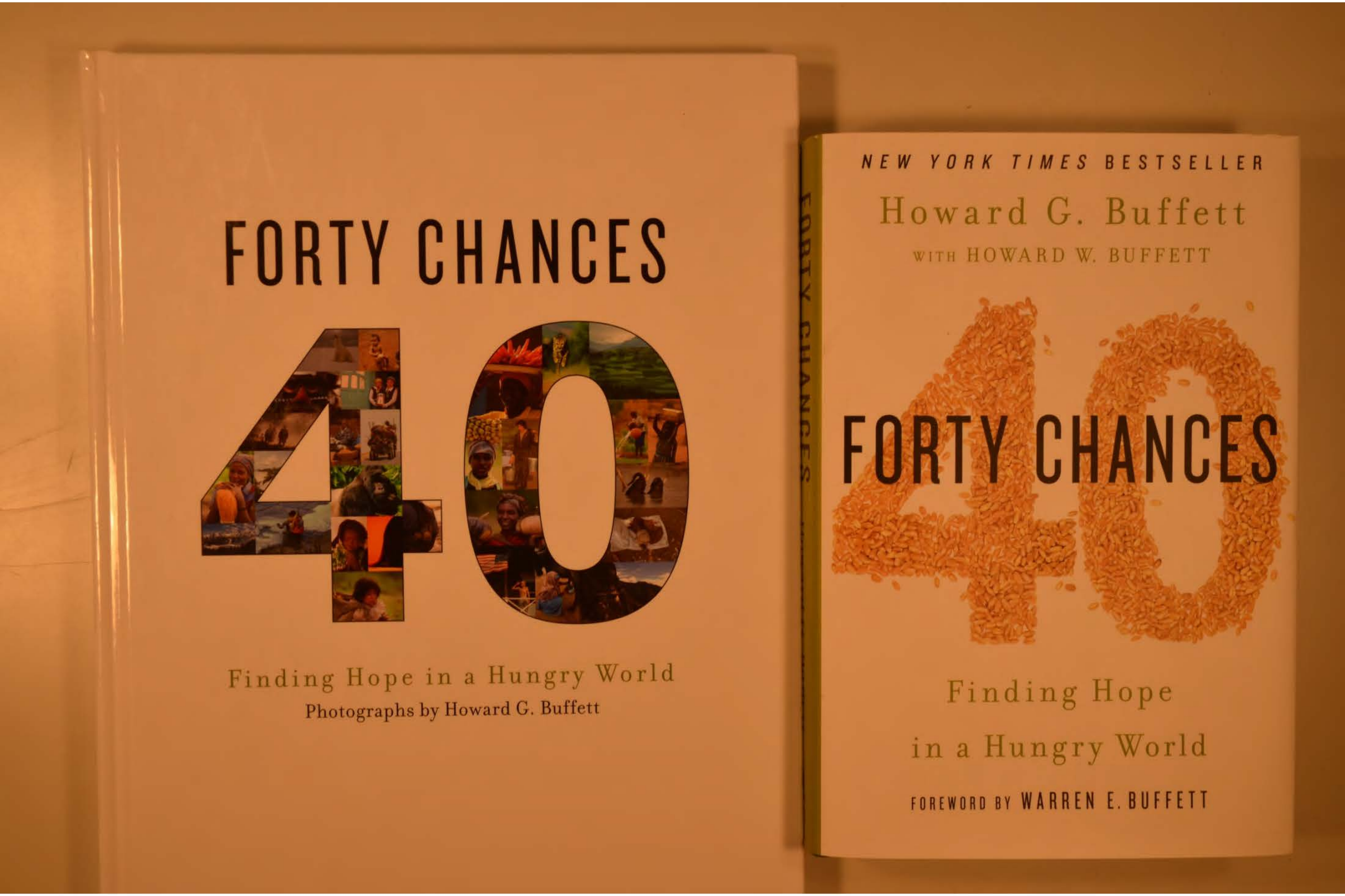

‘They did not achieve a successful landing
by testing small incremental improvements
in rocket design. They did it by having a
specific goal and teams focused on developing
the techniques required to achieve that goal.’

# 2014 Winter
# Conference of No-till on the Plains

## Salina, KS
## January 27 – 28, 2014

‘Take the hardest crop you have and show that it will work.’

Rick Bieber
Trail City, SD


FORTY CHANCES
40
Finding Hope in a Hungry World
Photographs by Howard G. Buffett
FORTY CHANCES
NEW YORK TIMES BESTSELLER
Howard G. Buffett
WITH HOWARD W. BUFFETT
40
FORTY CHANCES
Finding Hope
in a Hungry World
FOREWORD BY WARREN E. BUFFETT

# ‘Overcome the mindset that it can’t be done.’

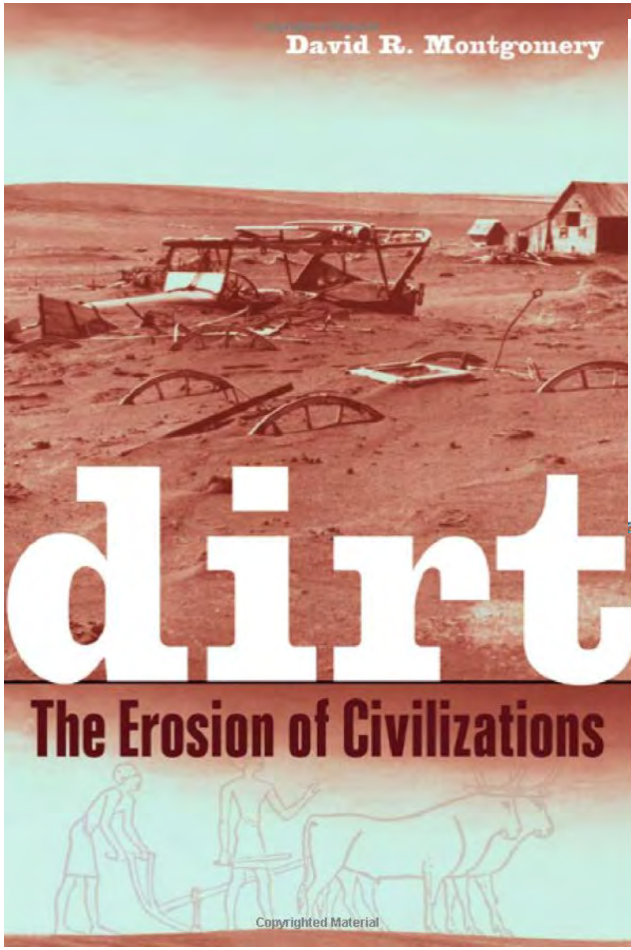
Dwayne Beck

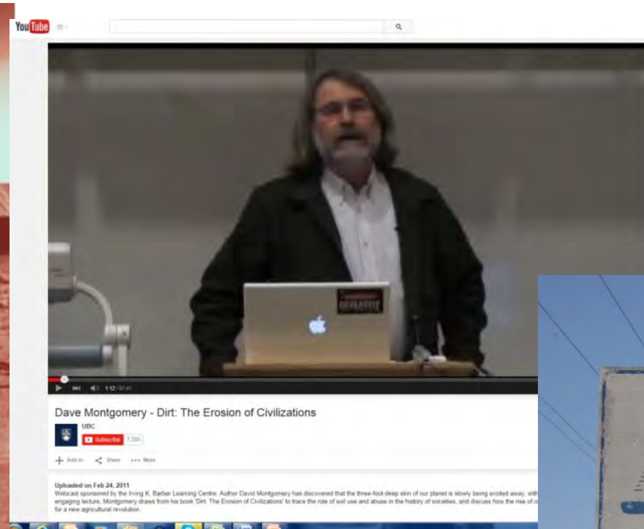
2014

# “Take the ‘E’ out of ‘ET’ and the ‘T’ out of ‘can’t.”

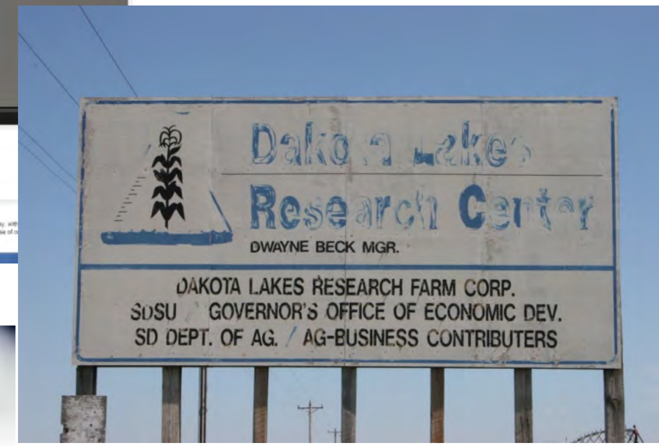
Dwayne Beck

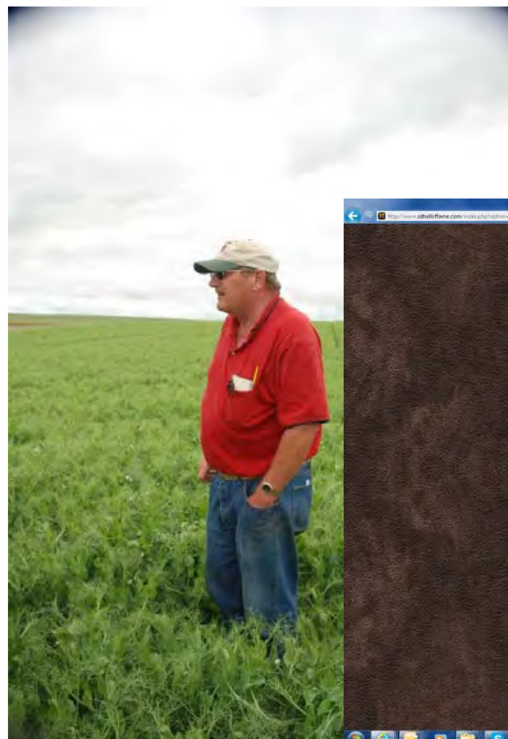
2014




**David Montgomery**
**Professor of Geology**
**University of Washington**




**Dwayne Beck**
**Ag Engineer**
**Dakota Lakes Research Farm**
**South Dakota Hall of Fame**

David Montgomery was here last week.  After seeing all the no-till in the area he asked “Did you every dream there would be this much adoption in two decades?”.

My response was that I was surprised that it took so long and could not understand why other areas were had not transformed also.

Dwayne Beck
May 9, 2015

# “Do everything we can.”

David Pimentel

Cornell University

2005

Conservation Agriculture Systems
INNOVATION CENTER

RESOURCE
CONSERVATION DISTRICTS

SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL Company

SOIL AND WATER CONSERVATION SOCIETY

Sustainable Conservation

# *Thank you.*

NRCS

UC CE

UC DAVIS
COLLEGE of AGRICULTURAL AND ENVIRONMENTAL SCIENCES

UC DAVIS
DEPARTMENT of PLANT SCIENCES

University of California
Agriculture and Natural Resources

*Making a Difference for California*