CLIMATE CHANGE & AGRICULTURE

What is climate change and how does it work?

We've all heard the phrase "climate change," but what does that phrase mean? The National Oceanic and Atmospheric Administration (NOAA) defines climate change as "a long-term (decades to centuries) change in any of a number of environmental conditions for a given place and time—such as temperature, rainfall, humidity, cloudiness, wind and air circulation patterns." So any shift in weather patterns lasting for a prolonged period of time can be called climate change. Today most people who say "climate change" are referring to the steady well-documented increases in Earth's temperature that have occurred over the last 100 years.

Why focus on the last 100 years? Because people have been emitting unprecedented amounts of greenhouse gases into the atmosphere over the past century, including carbon dioxide, methane, and nitrous oxide. Industrial processes, burning of fossil fuels, reductions in forest cover, changes in agricultural practices, and other human activities have contributed to a dangerous increase in greenhouse gases.

Greenhouse gases make our planet habitable by trapping heat in the lower atmosphere, closest to Earth's surface. But there can be too much of a good thing: We have added so many greenhouse gases to our atmosphere that we are increasing the average global temperature. This has raised the temperature of both continents and oceans, which, in turn, affects all sorts of natural cycles, including ocean currents, timing and intensity of hurricanes, tornadoes and monsoons, precipitation patterns, etc. And, of course, all these changes affect agricultural productivity.

What is the relationship between climate change and agriculture?

The relationship between climate change and agriculture is a two-way street. Certain agricultural practices contribute greenhouses gases to the atmosphere, exacerbating climate change. Agriculture's contribution to climate change is small, but not negligible: Estimates for the contribution of agriculture to the amount of greenhouse gases released in the United States are all in the range of 8-10% of the total emissions. In turn, alterations in climate resulting from increased global temperature and changes to natural cycles have direct impacts on agriculture.

While some of these impacts could increase yields, there's broad consensus that climate change presents serious challenges to global food production.

Farmers and ranchers will need to adapt to climate change, but can also defend our natural environment by joining the fight to reduce greenhouse gas emissions, especially from livestock production (methane from the decomposition of animal waste and the digestive systems of ruminant livestock) and agricultural soils (carbon dioxide from poor soil management practices and nitrous oxide from poor nutrient management practices). Proper handling and management of livestock manure can reduce methane emissions, but reducing enteric methane produced during digestion by ruminants is a harder nut to crack! Fortunately, implementing best practices for improving soil health is more straightforward. Best practices can reduce agricultural releases of greenhouse gases from poorly managed soils, and in some cases may even capture greenhouse gases from the atmosphere.

There's even support at the top: USDA announced in May 2016 a new $72.3 million investment to boost carbon storage in healthy soils as part of its Building Blocks for Climate Smart Agriculture and Forestry.

What is soil health and how is it related to climate change?

Soil health is a term used to describe a high functioning soil ecosystem. Soils are combinations of mineral solids, water, air and organic matter. A healthy soil has a well-established biological community of worms, bacteria, fungi, and other organisms, working to break down the organic matter into a nutrient solution that plant roots can absorb and use as fuel for growth and seed production. For many farmers a healthy soil is like art…they might not care about the exact definition, but they sure know it when they see it!

A cross-section of a healthy soil will show plant litter on top of the soil along with growing plants. Below the surface are roots and the soil biotic community. Worms carry plant litter down below the surface where a variety of soil organisms break it—along with dead roots, worm castings, and other biologic wastes—down into the collection of soil nutrients. Movement of soil organisms such as worms and beetles, creates tunnels in the soil, as do plant roots. Water and air move through these tunnels into the soil. All of this supports healthy plants at the surface.

But there is more going on in that living, breathing soil. Soil organic carbon can be 52-58% of soil organic matter! This carbon is retained in the soil rather than circulating in the atmosphere. Improving the health of soils allows them to sequester more carbon, reducing the amount of carbon dioxide in the atmosphere. Carbon is also stored in the plant leaves and stems. Keeping vegetation on the soil stores carbon but also cools the soil and retains moisture, benefiting the soil ecosystem.

How do agricultural practices affect soil health?

Early farmers understood the importance of soil organic matter, although they probably didn't call it that. For centuries, they applied livestock manure, compost, plant residues, and even human waste to their fields. They may not have understood exactly how those materials were broken down into food for their crops, but they did understand the connection between organic matter and healthy crops with high yields.

In the mid-to-late half of the 1900s, agriculture underwent an enormous transformation. The development of inputs like fertilizers for plant nutrition and pesticides for weed and pest control, the availability of new seed varieties, and new cultivation and harvest methods involving huge machines radically changed the way farmers approached crop production. Crop yields increased, labor was reduced, and farmers prospered…for a time.

At some point, it became more and more expensive to operate the new system. Inputs, many made from petroleum, became increasingly expensive, and farmers used more and more of them as the total volume of soil organic matter available for plant nutrition dropped. Those big machines compacted the soil, and tilling fence row to fence row led to soil erosion by wind and rain. Repeated tilling destroyed the soil pores and tunnels, so that rainfall was not absorbed but ran off in sheets, carrying earth as well as any excess nutrients and pesticides into nearby streams.

And there were other, less visible results. Much of the carbon that had been stored beneath the ground or in plant tissues was released into the atmosphere. Overuse of fertilizers contributed nitrous oxide to the atmosphere as well as polluting surface and ground water supplies. Because the soil could hold less water, more irrigation was needed. While modern agriculture is justifiably proud of feeding the world, the unintended consequences of the new systems have created problems—problems that can be solved with the stewardship and determination of today's agricultural producers.

Best management practices for improving soil health and reducing climate change impacts of agriculture

What to do? It turns out that improving soil health is not only good for the producer's bottom line but also a good way to reduce agriculture's contribution to climate change. Like everything in agriculture, shifting your focus to soil health takes time and attention—but it's worth it. Publications like Building soils for better crops offer great in-depth resources for farmers, and below is a snapshot of options for improving the health of your soil, while reducing some of your costs! Your local soil and water conservation district can put you in touch with information as well as possible sources of funding.

Inputs

Misuse of chemical inputs can reduce the effectiveness of the soil ecosystem, sometimes even destroy it. Not to mention that many agrochemicals are made from petrochemicals, a sort of double whammy—greenhouse gases released as the soil ecosystem falters and greenhouse gases released through the production of the materials themselves!

Always apply fertilizers with the 4Rs of nutrient stewardship in mind: right source, right rate, right time and right place. Soil tests tell you what nutrients your crop needs—consider whether you can get those nutrients from a natural, rather than synthetic, source. Repeated use of inorganic fertilizers can overstimulate bacteria in the soil ecosystem, which not only breaks down the nitrogen in the fertilizer also break down soil organic matter more rapidly, releasing both nitrous oxide and carbon into the atmosphere. Once the organic matter in the soil is depleted, the bacteria may weaken and even die. With no soil bacteria to decompose organic matter, plants must depend entirely on inputs of synthetic fertilizers. Applying more inorganic fertilizers than the crop can use also leaves excess nutrients in the soil, and those nutrients can be leached into surface and groundwater by rain or even irrigation.

All crop-producing soils need inputs of organic matter, but you can still use too much. Over-applying compost, manure, and other organic materials can lead to the many of the same negative impacts as overuse of synthetic fertilizers.

Keep your pesticide use to a minimum. Pesticides can kill the insects, worms, bacteria and other biologic components of the soil ecosystem as well as pollinator and predator species. Implement integrated pest management (IPM): avoid bringing pests onto your farm, monitor to identify pest infestations, set economic thresholds for the crop, and incorporate biological, cultural and physical tools for minimizing pest risk. When you do use pesticides, preference low toxicity, pest-specific pesticides, and use them only as directed on the label.

Cover cropping

Planting cover crops between production cycles for annual crops, or even intercropping a perennial cover crop between the rows of the main crop can improve soil health. Picking the right cover crop depends on your goals. In addition to improving soil health, the right cover crop can reduce erosion and interrupt disease and pest cycles. Publication such as Cover crops and soil health can help guide decision-making, as can Oregon State University's Organic Fertilizer and Cover Crop Calculator and other OSU publications.

Crop rotation

Growing the same thing in the same place year after year is a no-win proposition. In addition to reducing pest and disease pressures, crop rotations often result in higher yields, reduced erosion, and less leaching of soil nutrients. When you use a perennial forage crop in your rotation, you let the soil ecosystem rebuild itself and begin to sequester carbon.

Crop choice

Soil health and carbon sequestration are best achieved by undisturbed perennial plant communities. Think of the extensive grasslands that once covered the Great Plains in the US. Some livestock producers can mimic that environment by managing their pastures for perennial forages, or a combination of perennial and annual plantings. It's much harder for a crop producer, particularly someone who grows annual crops like corn, green beans or wheat. Where feasible, consider switching to a perennial crop, such as blueberries or hops. Using perennials in rotation with annual crops also helps.

Tillage options

Wherever possible, reduce or eliminate tillage to minimize disturbance of the soil community. Some crops can be grown with no-till methods, but be careful—in some cases you end up using more herbicides. That can be hard on the soil ecosystem and hard on your check book! Other crops can be grown with zone, strip or ridge tillage, practices that till only the planting bed, leaving plant residues between the rows.

Livestock management

Soil health in pastures can be improved with good grazing management. Proper pasture rotation gives the plants enough time to regrow on top the soil and also allows them to increase their root systems, protecting the soil ecosystem. Well-distributed manure can provide organic matter and nutrients, and rotating livestock species (cattle, sheep, goats, chickens, etc.) can break disease and pest cycles without the use of chemicals.

Composting animal waste and incorporating it into the soil adds organic matter, but still releases methane. Some producers choose to use a biodigester to handle stored manure, capturing the methane for energy production. As ruminants digest grass and other forage, they burp up methane. Selecting forage for digestibility, grazing on younger more tender plants, and including legumes in the forage mix can all help to reduce enteric methane.

Thinking Ahead

Building healthy soils reduces greenhouse gas emissions associated with agricultural production and increases productivity while lowering costs. It also helps farmers prepare for the many fluctuations and changes we expect to result from rising average global temperatures.

Increased pest and disease pressures, changes to the timing and amount of rainfall in a given location, increased temperatures, more extreme weather events, and changes to the length of the growing season are all likely outcomes as Earth's climate changes. The report of the National Climate Assessment has an entire chapter devoted to exploring the possible impacts of climate change on US agriculture. One of their key findings is

Current loss and degradation of critical agricultural soil and water assets due to increasing extremes in precipitation will continue to challenge both rain fed and irrigated agriculture unless innovative conservation methods are implemented. (Key Message 3: Extreme Precipitation and Soil Erosion)

Farmers may have to change production practices, shift to a different crop rotation, even abandon some currently profitable crops, but healthy soils with sufficient vegetation cover have a better chance of remaining productive even in the face of these challenges.

Photo by Andrea Bremis

Photo by Dan Thall

Additional Resources

Building Soils for Better Crops, 3rd Edition
Comprehensive Assessment of Soil Health
Cornell Climate Change: Agriculture Resources
Implementing the 4Rs/4R Nutrient Stewardship
Soil Health Glossary
The Potential Impact of Climate Change on Soil Properties and Processes and Corresponding Influence on Food Security
Building Blocks for Climate Smart Agriculture and Forestry

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