

Soil Health Principles

The foundation of a healthy soil consists of five principles, which are soil armor, minimizing soil disturbance, plant diversity, continual live plant/root, and livestock integration.

The principles are intended to be applied in a system approach, maximizing the soil build impact.

1: Soil Armor

Soil armor, or cover, provides numerous benefits for cropland, rangeland, hayland, gardens, orchards, road ditches, and more.

Let's take a closer look at some of the soil armor benefits:

- **Controlling wind and water erosion:** Armor protects soil from wind and/or water as it moves across the soil surface. It holds the soil in place along with valuable soil organic matter and nutrients.
- **Evaporation rates:** Armor reduces the soil evaporation rates, keeping more moisture available for plant use.
- **Soil temperatures:** Armor helps soils maintain a more moderate range of soil temperatures, keeping soil warmer in cold weather and cooler in hot weather. Like us, the soil food web functions best when soil temperatures are moderate.
- **Compaction:** Rainfall on bare soils is one cause of soil compaction. When rainfall hits the armor instead of bare



Residual armor after corn planting was completed last spring at the Menoken Farm, located just east of Bismarck, N.D. At a minimum, the armor should last until the new crop is fully canopied. How quickly this residue decomposes depends on the carbon/nitrogen ratio of the residue. High carbon residue (eg: wheat at 80:1) decomposes much slower than low carbon residue (eg: pea at 29:1). When we supply the soil surface with a diversity of residues from one year to the next, we can achieve the benefits of soil armor and still maintain a fully functioning nutrient cycle.

The results of 20+ years of no tillage and crop diversity is a healthy, well-aggregated soil.

soil, much of the raindrop energy is dissipated.

- **Suppresses weed growth:** Limits the amount of sunlight available to weed seedlings.
- **Habitat:** Provides a protective habitat for the soil food web's surface dwellers.

2: Minimizing Soil Disturbance

Soil disturbance can generally occur in different forms:

- **Biological disturbance**, such as overgrazing, which limits the plants ability to harvest CO2 and sunlight.
- **Chemical disturbance**, such as over-application of nutrient and pesticide, can disrupt the soil food web functions.
- **Physical disturbance**, such as tillage, which will be focused on in this article.

A typical soil is approximately 45 percent mineral (sand, silt, and clay), five percent soil organic matter, 25 percent water, and 25 percent air. The water and air portions exist in the pore spaces between the soil aggregates. Over time, tillage implements reduce and remove the pore spaces from the soils, restricting infiltration and destroying the biological glues which hold the soils together.

Ultimately, tillage results in one or more of the following:

- **Water erosion:** Transporting soil, nutrient, and water to offsite locations, which negatively impacts water quality and quantity.
- **Wind erosion:** Transporting soil and nutrients to offsite locations, which negatively impacts air quality, human health, and animal health.
- **Ponding water:** Staying saturated on the surface for long periods of time, a result of reduced infiltration and increased runoff.
- **Crusting easily:** Restricting plant emergence.
- **Soil organic matter depletion.**



Can we reverse the impacts from tillage and improve soil function? Yes, we can. Minimizing soil disturbance is a good start to rebuilding soil aggregates, pore spaces, soil glue, and soil organic matter. This is an essential step for long-term soil productivity.

3: Plant Diversity

The journals of Lewis and Clark describe the northern plains landscape as having abundant plant diversity. Numerous species were observed, working together as a plant community to provide forage for large herbivore populations. Soils were built over geological time in this environment.

However, settlement of the plains brought agriculture, which resulted in the polyculture perennial landscape being replaced by a monoculture annual landscape. Where the soil food web used to receive carbon exudates (food) from a diversity of perennial plants harvesting sunlight and carbon dioxide, it now receives carbon exudates from only one annual plant at a time.

We can start to mimic the original plant community by using crop rotations, which include all four crop types. Diverse crop rotations provide more biodiversity, benefiting the soil food web. This, in turn, improves rainfall infiltration and nutrient cycling, while reducing disease and pests.

Crop rotations can also be designed to include crops



Harvesting a cool season grass (spring wheat) at the Menoken Farm. Previous crops grown on this field include warm season grass (corn), cool season broadleaf (pea), warm season broadleaf (soybean), and cover crops. All supplying the soil resource with the benefits of plant diversity.

- **Cool Season Grass:** Wheat, oat, barley, and rye.
- **Cool Season Broadleaf:** Flax, pea, and lentil.

Diverse crop rotations mimic the original diverse plant landscapes. They are important to the long-term sustainability of soil resource and food security.

4: Continual Live Plant/ Root

Perennial grasslands consist of cool-season grasses, warm-season grasses, and flowering forbs. Consequently, adaptable plants are able to grow during the cool spring and fall weather, as well as the summer heat. This allows for a continual live plant feeding carbon exudates to the soil food web during the entire growing season.

Cropland systems typically grow cool- or warm-season annual cash crops, which have a dormant period before planting and/or after harvest. Cover crops are able to fill in the dormant period and provide the missing live root exudate, which is the primary food source for the soil food web.

Cover crops may be incorporated into a cropping system as annuals, biennials, or perennials. Starting on a small acre scale will allow farmers and ranchers to find the best fit for their operation.

Cover crops can address a number of resource concerns:

which are high water users, low water users, tap root, fibrous root, high carbon crops, low carbon crops, legumes, and non-legumes to name a few.

Four crop types with common crop examples are:

- **Warm Season Grass:** Corn, sudan, and millet.
- **Warm Season Broadleaf:** Sunflower and soybean.



An eight-way cover crop combination was seeded after spring wheat harvest at the Menoken Farm, benefiting numerous resource concerns. The cover was seeded immediately after harvest.

Yearlings and dry ewes grazing rotational perennials, grass plants, legumes, and forbs at the Menoken Farm.

- **Harvest CO₂ and sunlight:** Provides the carbon exudates to the soil food web.
- **Building soil aggregates and pore spaces:** Improves soil infiltration.
- **Cover the soil:** Controls wind and water erosion, soil temperature, and rainfall compaction.
- **Catch and release of inorganic nutrients:** Improves water quality.
- **Salinity management.**
- **Pollinator food and habitat.**
- **Weed suppression.**
- **Wildlife food, habitat, and space.**
- **Livestock integration.**
- **Adding crop diversity.**
- **Adjusting the cover crop combination's carbon/nitrogen ratio:** To either accelerate or slow decomposition.

5: Livestock Integration

Animals, plants, and soils have played a synergistic role together over geological time. In recent years, animals are playing a reduced role due to being placed in confinement and fewer farms now including livestock as part of their overall operation.

Why do we want to return livestock to the landscape?

- **Balance the carbon/nitrogen ratio:** Fall or winter grazing to convert high-carbon annual crop residue to low-carbon organic material balances the carbon/nitrogen ratio and manages our crop rotation residue for no-till seeding.
- **Harvest additional sunlight and CO₂:** Spring or summer grazing annual and/or perennial plants with short exposure periods followed by long recovery periods allows the plants to regrow and harvest additional sunlight and CO₂.
- **Reduce nutrient export:** In lieu of transporting feed to a feedlot, we can reverse the roles and have



the livestock graze the material in place, reducing nutrient export from cropland and hayland fields. This recycles the majority of nutrients, minerals, vitamins, and carbon.

- **Manage weed pressure:** Grazing in lieu of a herbicide helps manage weed pressure.
- **Higher nutritional diet:** Grazing cover crops and/or crop residues allow us to take the livestock off the perennial grasslands earlier in the fall, extending the grass recovery period and providing a higher livestock nutritional diet.
- **Reduce livestock waste:** Grazing reduces livestock waste associated with confinement, helping manage water quality and nutrient management concerns.

How do we return livestock to the landscape?

- Winter and fall grazing cover crops and annual crop residues.
- Summer grazing a full season cover crop, allowing adequate plant recovery, followed by a second grazing during the fall or winter.
- Winter feeding on hayland fields by rolling out bales or bale grazing.
- Seed rotational perennials, graze, and manage as part of the crop rotation.