

Tillage is Like a Drug Addiction By James J. Hoorman

“Strangely enough, they have a mind to till the soil and the love of possessions is a disease within them.” Sitting Bull

Civilization and the world population started increasing when humans began growing their own food to feed themselves and their livestock rather than pursuing and hunting wild game. The first human cultivation of crops probably was no-till, requiring very little cultivation. The first crops for human consumption may have been with a stick to create a hole and a seed bed for a kernel of grain. With time, our early human ancestors used livestock to speed up the planting of crops.

Tilling the soil had many early advantages. Tillage killed the weeds (short term) and reduced the competition for water and nutrients. Tillage increased seed to soil contact and helped with seed germination. Tillage also aerated the soil and increased the mineralization and release of soil nutrients and resulted in increased crop yields. Modern farmers till the soil for many of the same reasons today. Thus, the tillage addiction began early in human civilization because of all the short-term benefits (highs) that our ancestors gained from tilling the soil.

Our early ancestors still followed the wildlife, so the soils did not become exhausted. As humans started to settle in one place and till the same soil, year after year; the native soils started to wear out and lose their natural productivity by losing their soil organic matter, eroding, or losing their nutrients. At first it was easy for our ancestors to move to another virgin patch of soil and let the abandoned soil heal itself through natural plant growth, but as time went on, our ancestors settled down and were forced to continue farming the same patch of soil every year. Early farmers learned to amend the soil with manure or compost, some used crop rotation, others rested the soil with hay or pasture, and some even started using cover crops or a combination of all these practices. All these farming practices were early remedies to revitalized worn out exhausted soils. All these remedies were based on adding or managing organic or plant-based amendments (either grown or added).

While the long-term benefits of no-till and cover crops improve soil health and soil productivity are known, very few farmers today utilize this system. Why? The answer varies but the short-term benefits or drug addiction to tillage is major hurdle to long-term soil sustainability. Tillage is like a drug, an opioid on the brain. This tillage opioid prevents most farmers and even researchers from logically acknowledging that the long-term benefits of no-till and cover crops to human civilization greatly outweigh the short-term tillage benefits. See Table 1: Short-term versus Long-term Benefits and Costs to Tillage Systems and Table 2: Input Cost and Profit Margin Comparisons to Tillage and No-till with Cover Crops.

There are many reasons why soil tillage has become so addictive. First, past generations utilized tillage with great success. The short-term benefits (the highs) to tillage are hard to ignore while the long-term benefits are often hard to see, ignored, or take time to be realized.

See Table 1. Farming is a generational industry, with lessons learned the hard way passed on from one generation to the next. Grown children who want to farm mostly follow their parent's way of farming and often need their parent's approval to farm the land they own (and control).

Second, farming traditions and past generations put great stock in having clean freshly tilled soils. Historically, farmers took great pride in seeing who could plow the straightest and bury the residue so thoroughly, that not a single stalk was seen above ground. The traditional way of farming is a hard thing to change, once the standard has been set. Most land is owned by older generations who like things done a certain way and since they own the land, if you want to farm the land, even as a tenant, you will want to keep the landowner happy and satisfied, or risk losing the right to farm that land to someone else.

Third, freshly tilled soil smells so good! Actinomycetes in the soil release a chemical called geosmin when they die. so that sweet smell is the smell of actinomycetes dying. Most farmers love this smell, but all the tillage disrupts the natural soil food web and starts the downward spiral of soil degradation. See Figure 4: Downward Spiral to Soil Degradation with Tillage.

Fourth, tillage kills weeds. Most farmers absolutely hate weeds, yet their actions are counter-productive because tillage buries the weed seed and long-term preserves the weed seed. When a farmer re-tills the soil, they are simply replanting and repopulating weeds. Weeds ecologically grow in disturbed soils, high in soil nitrates, and high in bacteria. Weeds are the first colonizers of disturbed soils and that is where they thrive. Long-term no-till with cover crops keep the weed seed on the soil surface where they are consumed by the food web, decay, or where other hardy plants can out compete them for water, nutrients, and sunshine.

Fifth, tilling the soil with high horsepower tractors and large heavy iron equipment is a status symbol to many farmers. The investment in large tractors, expensive tillage equipment, high fuel costs, high labor and time is an expensive investment. Tillage solves problems and hides many problems on the farm short-term but the long-term costs to tilling the soil are often ignored, justified or even denied. Tillage erosion seems so small (a dimes thickness of soil loss is around 10 tons per acre soil loss) that some spring tillage can easily wipe away. Justification comes in the form that everyone tills the soil and soil erosion is a natural process. Farmers feed the world, yield are good, and if the soil erodes, fertilizer can be used to fix the problem. Out-right denial comes in the form that soil erosion is manageable or nonexistent.

Once farmers start tilling a field, they seldom if ever stop tilling until the whole field is completely turned over. These are all signs of tillage addiction. Just like an alcoholic or long-term drug user, facts about long-term tillage costs can be ignored, justified, or denied. See Table 3: Symptoms of Drug and Alcohol Abuse Mirrors Tillage Addiction.

Sixth, farmers associate tillage with higher yields. Most of our modern major crops have been developed and bred for high tillage conditions, high fertilizer, and high pesticide usage. The short-term tillage benefits (drier, warm soils, good seed to soil contact, early weed termination,

good soil smell) represent the drug and the associated high that farmer get because their planted crops appear to get off to an early and fast start. However, due to excess early mineralization, poor soil structure, reduced water infiltration, poor water holding capacity, lower soil organic matter; they need to use higher soil fertilization and higher rates of pesticide usage (due to broken soil food web) to get those higher yields. Thus, their profit margins are lower along with overall farm profit. The downward spiral starts as farmers need to continue to till the soil to get the same effect (high) just like drug users become addicted to the alcohol or drug the higher use to get the same high. See Figure 4: Downward Spiral to Soil Degradation with Tillage.

Tillage addiction also mirrors alcohol and drug addiction in the recovery and rehabilitation phase once tillage stops. Alcohol and drug addicts say the withdrawal period, rehab, and recovery phase are the most painful and difficult times of their lives. When a farmer stops tilling the soil, things generally get worse before they get better. All the problems that the tillage caused like poor soil structure, reduced water infiltration, soil compaction, lack of active carbon, declines long-term soil organic matter, bacteria dominated soils, and broken soil food web need to be solved or at least improved before crop yields start to recover. The recovery phase may take three to seven years, even longer if there is a relapse. Dr. Don Reicosky, Retired ARS soil scientist from Minnesota says that the first tillage pass to a long-term-no-till field wipes out 80% of the benefits with one tillage pass. Soil recovery from long-term tillage is a slow process and that is why very few farmers are successful at making the transition. This is very similar to alcohol and drug addiction, very few people succeed because it is a long and difficult process. Farmers can tolerate a slight yield reduction for one maybe two years, but very few are willing to push through the third, fourth, or fifth year of soil recovery if yields decline are suboptimal.

Tillage is very much like an alcohol or drug addiction. Relapse is very common. Farmers who till up long-term no-till fields find that the tillage addiction start all over again. Mineralization speeds up (due to oxidation), the crops look great for a couple of years (tillage high) until the soil is depleted of soil organic matter (especially active carbon) and the soil structure starts to degrade. Soon, soil erosion, excess nutrient runoff, pest problems become a major problem and the farmer needs more fertilizer and pesticides to get the same yields resulting in lower profits. Psychologist say the best way to avoid alcohol and drug addiction is not to use them and never be tempted to go back to using those drugs. The best advice for farmers is to sell the tillage tools (sell it as scrap so no one else is tempted to use it) and go to utilize long-term crop rotations with long-term no-till and cover crops. The higher profit margins, higher yields, green fields and blooming cover crops, beautiful wildlife (butterflies, birds, etc) and the reduction in environmental issues need to become a farmer's new high. In addition, the satisfaction that future generations will be able to eat and enjoy this valuable resource, the soils that feed the world.

Table 1: Short-term versus Long-term Benefits and Costs to Tillage Systems

Short-term Tillage Benefits to Soil Conditions	Transitional (3-7 years) No-till & Cover Crop Soil Conditions	Fully functioning Long-term No-till & Cover Crop Soil Conditions
Dries Soil: Tilled soils lose 0.5 to 1-inch water per acre	Wet: Poor soil structure, Poor Drainage	Moist: High soil organic matter hold water
Warms soil: Due to aeration and loss of water, takes 10X more energy to warm up cold water than air	Cold: Poor soil structure, soil compaction reduces drainage, cold water takes energy to warm up the soil.	Warm: Good soil structure, soil connectivity, and drainage
Good Seed to Soil Contact/Higher germination	Reduced seed germination, Slower germination	Requires patience, Plant when conditions are right for fast consistent germination
Early weed termination	Some weeds	Soil food web consumes weed seed
Long-term Tillage Cost to Soil Conditions	Transitional (3-7 year) No-till & Cover Crop Soil Conditions	Fully functioning Long-term No-till & Cover Crop Soil Conditions
High Soil Erosion (tons)	Declining Soil Erosion	Low rates (pounds) of soil erosion
Increase surface sealing, soil crusts due to soil drying and no soil protection	Accumulating surface residue reduces surface sealing and soil crusts	Surface residue prevents soil drying, little or no surface sealing or surface crusting
Decreasing, slow water infiltration	Improving water infiltration	Good and fast water infiltration
Poor soil structure, destroys soil aggregation, less pore space, high soil compaction	Improving soil structure, improving soil aggregation, more pore space, improving soil compaction	Good soil structure, high soil aggregation, high pore space, little to no soil compaction
Low active carbon, zero to no live roots (fallow period)	Gaining active carbon from live root exudates all year	High active carbon from live roots exudates all year
Declining long-term soil organic matter, slow turnover	Building long-term soil organic matter, intermediate carbon turnover	High long-term soil organic matter, high carbon turnover
Reduced soil water storage Less plant available water	Improving soil water storage More plant available water	High soil water storage & high plant available water
Low soil connectivity with less matrix flow and high preferential flow	Improving soil connectivity with more matrix flow and less preferential flow	High soil connectivity with high matrix flow and less preferential flow
High water and nutrient runoff (High N & P, soil erosion)	Declining water and nutrient runoff (Medium N, P, soil erosion)	Low or little water and nutrient runoff (Low N & P, soil erosion)
Bacteria dominated Fast and excess nutrient mineralization with nutrient losses to the environment.	Bacteria dominated transitioning to more fungi. Slower nutrient mineralization, less nutrient loss to the environment	Balanced bacteria & fungi Slower mineralization but nutrients are released when plants efficiently utilize them, less nutrient loss
Decreased nutrient use efficiency due to carbon loss, lower CEC	Improving nutrient use efficiency due to higher carbon, higher CEC	High nutrient use efficiency due to high carbon, higher CEC
Declining biodiversity, low functioning soil food web	Improving biodiversity, soil food web has intermediate function	High biodiversity, fully functioning soil food web
Increased weeds, buried seed	Intermediate weeds	Less weed due to soil food web
More insects, high insecticide use	Depends upon less insecticide use	Less insects, healthy plants
More disease, seed treatments	Depends upon less seed treatment	Less disease, better soil conditions

Table 2: Input Cost and Profit Margin Comparisons to Tillage and No-till with Cover Crops.

Tillage	Transitional (3-7 years) No-till & Cover Crop	Fully functioning Long-term No-till & Cover Crop Soils
Higher Horsepower Tractor/More Tractors	Smaller Horsepower Tractors/ Fewer Tractors	Smaller Horsepower Tractors/ Fewer Tractors
Large Tillage Equipment	Higher usage of planters, drills, or cover crop seeders	Higher usage of planters, drills, or cover crop seeders
Higher Fuel Cost/Acre (2-3X)	Lower Fuel Cost/Acre	Low Fuel Cost/Acre
High Labor/Time Cost (2X)	Lower Labor/Time Cost	Lower Labor/Time Cost
Low Management Less Pest Scouting	Higher Management High Pest Scouting	High Management Some Pest Scouting
Fertilizer: Higher N due to lower NUE, Soil N is in the nitrate (NO ₃ ⁻) form: High leaching, denitrification, volatilization losses, 1% mineralization	Initially higher N may be needed (legumes, manure, or fertilizer) to stabilize soil organic matter additions. Each 1% SOM needs 1000#N. Nutrient losses decreasing as mineralization increasing (2%)	Due to High Mineralization (2-3%) and High NUE, soil N additions may decrease 50% or more over time. Soil N is more in the ammonium (NH ₄ ⁺), amino acid or protein form. Nutrient losses are low
Higher P fertilizer needed due to lower NUE. P lost by surface runoff or preferential flow. P tied up inorganically	Lower P fertilizer may be needed due to higher AMF and NUE. Less surface runoff, higher matrix flow, lower preferential flow, more organic P	Lower P fertilizer needed due to higher AMF and NUE. Less surface runoff, higher matrix flow, lower preferential flow, high organic P
Higher Micronutrients needed due to lower SOM chelation	Lower Micronutrients may be needed due to higher SOM chelation	Lower Micronutrients needed due to higher SOM chelation
Higher Herbicides due to weed seed preservation and broken soil food web	Lower Herbicides due to less weed seed preservation & soil food web recovering (33% reduction)	Lower Herbicides due to less weed seeds and fully functioning soil food web (50%+ reduction)
High insecticide usage and higher seed treatment due to broken soil food web	Lower insecticide usage and lower seed treatment due to recovering soil food web	No or little insecticide usage and no or little seed treatment due to fully functioning soil food web
High Fungicide Usage, Low functioning soil food web	Low or Zero Fungicide Usage, disrupts AMF & soil food web	No Fungicide Usage, disrupts AMF & soil food web
Higher treatment for disease due to broken soil food web	Lower treatment for disease due to improving soil food web	Low treatment for disease due to healthy soil food web
Lower Profit Margins, Average Yields, Lowest Total Profit	Higher Profit Margins, Slightly Lower Yields, Medium Total Profit	Highest Profit Margins, Higher Yields, Highest Total Profit

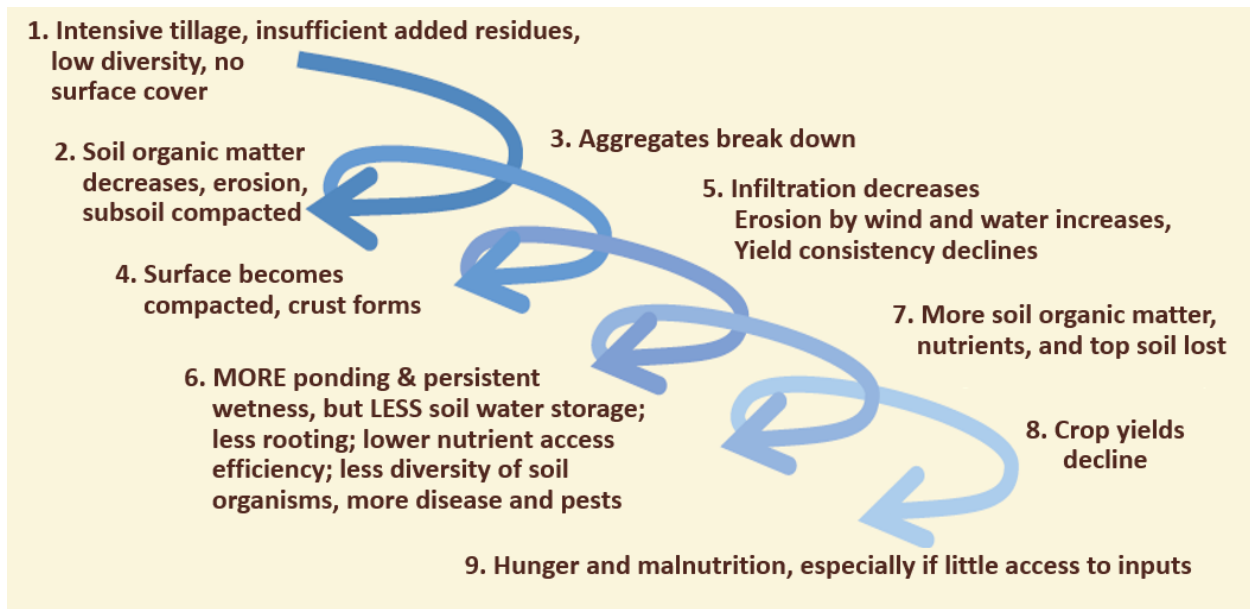
- N = Nitrogen, P=Phosphorus, SOM = Soil organic matter, NUE = Nutrient use efficiency, AMF= Arbuscular Mycorrhizae Fungus

Table 3: Symptoms of Drug and Alcohol Abuse Mirrors Tillage Addiction.

Drug or Alcohol Symptoms	Tillage Addiction
Addiction Denial: Alcohol or Drug I can stop at any time, I only do it occasionally	Tillage Denial: I only do conservation tillage, I only do rotational tillage (tillage every other year), I only do shallow tillage.
High Drug or Alcohol Addiction: Need to take more drugs or alcohol to get same high	High tillage addiction: Till soil 3-4 times, plow, work it down, level it, want firm seed bed
Alcohol or Drugs: Feel strange without drug or alcohol, shaky, depressed, jittery	Tillage: Cannot stand to see “unclean untilled fields”. Get shaky, depressed, jittery if cannot till.
Paranormal Feeling: People are judging me	Paranormal Feelings: What will the neighbor or landowner say if I do not till?
Borrow or Steal to get Drugs or Alcohol	Go deep in debt to buy new high horsepower tractor or tillage equipment
Drug or Alcohol gives you a “High”	Love the smell of fresh tilled soil. Feeling of satisfaction when I get a field tilled. “Tillage High”
Cannot stop yourself from using drugs or alcohol	Once you start tilling field, never stop until it is completely tilled. Must till every farm field even if wet in fall and spring.
Spend lots of time thinking about drug or alcohol	Go to Tractor and Tillage Equipment shows to buy bigger and better equipment to till faster
Lose interest in other things	Always want more land, spend all your time on tractor tilling soil, even on Sundays.
Hide drug or alcohol use from others	Hide new tractor and tillage equipment that you bought from spouse.
Sleep too little or not enough	Spend late nights or early morning tilling soil and “Cat Nap” on tractor while tilling
Gain weight or lose weight, bloodshot eyes	Always eating junk food in tractor or too nervous or too busy tilling soil to eat right, bloodshot eyes
Have more than one drug prescription Beer, wine, whiskey, anything with alcohol	Have a whole fleet of large horsepower tractors and tillage tools hooked up in shed.
Have only friends that share your addiction	Hang out at the local coffee shop where everyone does full-blown tillage and shares your beliefs and makes fun of No-tillers.
Look in other people’s medicine cabinet for drugs or refrigerator for alcohol	Visit other farmers (may be when they are not home) and look at their tillage equipment, perhaps borrow it to try it out on your farm
Drug or Alcohol Justification: It’s my genes, my whole family takes drugs or alcohol	Tillage Justification: My whole family farms, we have to feed the world, everyone does it.

- Adapted from www.webmd.com from drug addiction

Figure 4: Downward Spiral To Soil Degradation with Tillage



Adapted from *Building Better Soils For Better Crops*

Summary

Soil tillage has become an addiction on our landscape. The short-term farmer highs (drier soils, warm soil, good seed-to-soil contact, fast mineralization, sweet smell) are offset by the long-term tillage costs. Long-term tillage costs include higher soil erosion, high nutrient runoff, poor soil structure, soil compaction, reduced water infiltration, reduced water storage capacity, low nutrient use efficiency, excess fertilizer usage, declining soil food web, increased pests, higher pesticide usage, lower profit margins, and ultimately, lower crop yields. Farmers (like alcohol and drug addicts) either justify, ignore, or deny that tillage is an addiction or even cause problems. Like alcohol and drug addicts, the tillage withdrawal period, the rehab, and the recovery period are difficult to management. Finding solutions to tillage may depend on farmers understanding some of the following quotes:

***“Love is an addiction, most farmers love to till the soil and that becomes their addiction, even though that addiction is destructive to the soil, the environment, and to future generations.”
Soil Health Specialist***

“When we see the land as a commodity to which we belong, we begin to use it with love and respect.” Aldo Leopold