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**THE SOCIAL LIFE OF SOIL:
INFLUENCES ON ROTATION, TILLAGE, AMENDMENTS & NUTRIENTS**

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INFLUENCES ON ROTATION, TILLAGE, AMENDMENTS & NUTRIENTS

There are many interacting influences that support or detract from each of the three main soil health affecting practices of rotation, tillage, amendments and nutrients. These practices are outlined in table 1 below. These categories arise from conversations held with farmers, soil conservationists, agricultural educators and other agricultural professionals throughout the Chesapeake Bay watershed.

ROTATION	TILLAGE	AMENDMENTS & NUTRIENTS	COMMONALITY
Profits interacting with short or long-term view and policy	Systems thinking, commitment, long-term view	Shift in awareness to soil biology and systemic effects	WORLDVIEW long or short term, systemic or reductionist
Cover crops becoming the new norm	Subculture norms spread through farmers' networks & Generational shift in norms	Social norms around legacy, ease and efficiency	FARMING NORMS neighbors, peer networks, generational
Research dissemination, meetings, conferences	Formal and informal education about soil	Promotion of soil life and concern for environment	LEARNING Formal, informal, observational
Policy mandates and organic standard rules	Regulation interacting with erosion and nutrient loss	Policy influence on, and support for, nutrient management	POLICY Mandatory, voluntary
The interaction of time, climate and labor	Saving time and money interacting with labor on and off farm		LABOR Shortage, time scarcity
	Specialized equipment, cost and desire	Soil testing and novel technology interacting with application rates and cost	TECHNOLOGY Cost, power, prestige
Crop properties interacting with sequential crops and with fertilizer and herbicide use & How specific crops attract, or detract unwanted, or wanted, wildlife	Land in perennials as a management marker and challenge	Specificity of crops interacting with organic matter, fertilizer and pesticide needs	CROPS Plant properties
The soil's needs and response interacting with farmer's observations and values	Soil type, field conditions and observation & Landscape and erosion concerns		LANDSCAPE & SOIL Erosion, soil type, climate, weather
		Environmental hazards of manure and precipitation of new markets & Availability and properties of manure	MANURE Type, quantity, availability
	Specificity of the operation		SYSTEM Conventional, organic

Table 1: Influences on soil management practices

The final column in this table summarizes the general commonalities across groups of these influences. The general categories influencing soil health management practices are: worldview, farming norms, learning, policy, labor, technology, crops, landscape & soil, manure, and the farming system. They are in no way comprehensive, nor are they exclusive, but they do serve as a shorthand to help understand the many kinds of influences at play in any farmer's decision to engage, or not, in a soil management practices.

What follows here is a brief description of each of the influences outlined in the table, showing the many additional considerations that interact under each general category. It should become apparent that the general categories outlined in the table are not sufficient to capture the complexity, but again, the general categories are useful starting points to expand a discussion around these management practices. The summaries are organized by management practice and are derived from much lengthier texts that include many direct quotes from study participants.

ROTATION

FARMING NORMS | Cover crops becoming the new norm

“It’s a hot topic right now and I think it’s definitely something that’s going to be here to stay.”

Farmers recognize that the “normal monoculture of corn,” in a two or three year rotation with soy, and sometimes with wheat, does not promote soil health or ecosystem health as much as a diverse rotation with cover crops can. Throughout the Bay watershed, farmers and agricultural professionals talked about a shift occurring in the past decade to more diverse rotations, and more use of cover crops. Cover crops in particular, have become a “hot topic” in informal conversations and in meetings, and, especially in Maryland where there is a state cost-share program, many farmers have noticed more widespread use of winter cover.

LABOR | Interaction of time, climate and labor

“I need to have another person around in the fall to be able to make it all happen.”

The interaction of a particular place’s climate, its seasons, the weather in a particular year and the trained labor available, all influence the crop rotation. In particular this mix affects whether winter cover can be planted and established or not. Many farmers recognize that it would be beneficial to have this winter cover, but they cannot establish it every year because of these factors. Suggestions to overcome these influences included government-supported aerial seeding of winter cover and hiring additional, skilled, labor for the autumn.

WORLDVIEW | Profits interacting with short or long-term view and policy

“From an economic standpoint, these cover crops get pretty expensive, but in the long run, it makes sense to me. So, it’s a decision we’re making to hopefully to build better soil.”

Tensions exist between farmers needing to make a profit on the short-term, and investing in the long term viability of their soil, and their farm. This tension resulted in farmers talking about long and short-term views, where those that take the long-term view felt economically justified in the cost necessary to plant cover crops and work in a diverse rotation. Those that were more closely tied to short-term economic cycles and larger, sometimes international markets, felt that they had little choice but to maximize yields and reduce costs. State cost sharing for cover crops was both heralded and denigrated; while it helped farmers plant cover crops in Maryland, it disallowed their harvesting those crops. In New York, farmers were unsure how new cost-sharing would help, considering the main obstacle to cover there is a very short growing season. In Pennsylvania, where there is no cost-share currently offered, the feeling that cover cropping was important enough to do, even without a cost-share, was widespread among participants, although the labor required to implement cover was often an insurmountable hurdle.

CROPS | Crop properties interacting with subsequent crops and with fertilizer and herbicide use

“You’re going to be making money with the reduction of fertilizer”

The specific proprieties of crops affect soil physical, chemical and biological properties differently. In some cases, these affects influence farmers’ decisions when it comes to arranging their crop rotation and using cover crops. Crops and rotations that will reduce weed pressure can help reduce herbicide use; crops and rotations that balance nutrient removal or those that fix or catch nutrients, can reduce fertilizer inputs; and crops that build organic matter or break up compaction will aid overall soil health and may benefit yields. Precise quantification of the beneficial affects on a specific farm, for instance in terms of herbicide or fertilizer reduction, are not easily grasped. Nonetheless, farmers learn about these effects from direct experience, from other farmers and from research dissemination. The general understanding that these benefits accrue, does influence some farmers to diversify their rotations.

CROPS | How specific crops attract or detract unwanted, or wanted, wildlife

“The rest of my fields right now are all hay fields. We’re not producing any corn or oats, because the animals, the wildlife, love it.”

Animals, both wild and domestic influence crop rotations. In the case of wildlife, the presence of deer and woodchucks influence some farmers to not plant certain crops, such as soybeans, alfalfa, corn or oats. Rats deter some from growing and storing feed crops for their livestock. On the other hand, livestock have a strong influence on what crops must be planted to provide their feed, bedding or pasture in sufficient quantity. The influence of animals on crop rotation interacts with the ability to deter or attract them, by hunting, fencing, or human presence in working fields.

LEARNING | Meetings, conferences, research dissemination

“They’re saying, have a living, growing crop on your land as many months out of the year as you can.”

While many farmers are learning about cover crops and diversifying rotations by going to conferences and meeting where research is disseminated, some are also skeptical of traditional research and extension apparatus. This skepticism results from research findings not being applicable to the particularities of any one farming enterprise, or to research findings being outdated by the time they are presented, or to the perception that research is supported by large agribusiness companies that do not operate in the interest of many farmers. Some farmers seek out one-on-one meetings with researchers to best understand specific rotations and cover crops in the context of how they farm. Many other farmers do attend meetings and field days, and while there is a belief that some of this information is not directly applicable to their farm, the general appeal to diversify and apply cover crops is widely understood and accepted.

POLICY | Policy mandates and organic standards

“They don’t let me plant the cover crops that I like.”

Many farmers elect to opt-in to voluntary mandates from policy bodies, whether through statewide programs to promote cover-crop use, or national programs to ensure quality standards, these mandates influence the crop rotation. Among the Bay watershed states, Maryland has the largest policy influence on the use of cover crops. The state offers a popular cost-sharing program in a socio-political context where Chesapeake Bay pollution is a common topic of conversation among all those involved in agriculture and environmental issues. Farmers in active soil conservation districts have benefitted from grants that cover most, or all, of the cost of planting cover crops, which has influenced their doing so in many cases. In other parts of the watershed, other standards, such as the National Organic Program standards, mandate the use of cover crops or specific rotations. Farmers who are certified organic must comply with these standards to satisfy their certifying agencies.

LANDSCAPE & SOIL | Soil’s needs and response interacting with farmer’s observations and values

“I’ve never made a decision on my farm that the soil wasn’t the first decision that I made with the cropping.”

Some farmers, both conventional and organic, talked about supporting the system of soil life by making management decisions that enhance soil biology rather than those that detract from it. Cover crops were mentioned in this light as being beneficial to soil health because they provide the soil biota with nutrition throughout the year, this soil biota then helps with disease suppression and promotes healthier crops needing fewer inputs. Farmers who make practice decisions in this holistic mindset believe that cover crops and other soil-health promoting practices are helping to build the soil, which in turn enables their crops to thrive.

TILLAGE

WORLDVIEW | Systems thinking, commitment, long-term view

“Each one enhances the other, and I guess you would say that the sum is greater than the parts...”

No-till can be thought of as simply not tilling the soil, as its name implies. But some farmers and soil conservationists note that it is a system—not tilling is one part of a management system that includes the use of amendments, such as manure and crop residue, along with cover crops in a purposefully diverse rotation. Some also suggest that the system below the crop surface—the soil system—is the management goal, so that the system of no-till aims to support soil health first. This systems view of no-till promoting soil health requires a long-term commitment from the farmer.

SOIL & LANDSCAPE | Landscape and erosion concerns

“On the hills, you can’t do nothing. You’d have nothing left come in a few years time.”

The landscape itself influences the kinds of tillage a farmer is likely to employ. Erosion control and the landscape have influenced many farmers to adopt conservation tillage or no-till to ensure soil stays in place. The recognition of erosion as a problem, and conservation tillage as the main solution, is generated both from direct observation of eroding land after plowing and from policy and promotion of the link for more than a half century now.

POLICY | Regulation interacting with erosion and nutrient control

“We are able to meet our requirements with the conservation plans with no-till.”

For this region, the necessitation of conservation plans for federally designated highly erodible land has promoted the use of no-till. At the same time, no-till is reducing the width of contour strips on some of this same land, a practice that some farmers hail for its increased efficiency and others lament for the increase in erosion it might cause. In addition, regulations such as those aimed at nutrient management in Maryland, can have a negative affect on a farmer’s ability to employ no-till as a longstanding system because they require incorporation of manure.

LANDSCAPE & SOIL | Soil type, field conditions and observation

“We had some clay fields that’s the only way you could farm it.”

Just as the landscape and weather related forces of erosion influence tillage regimes, soil type and field conditions are also mentioned by farmers as influential in determining what kind of tillage is most appropriate. Soil type interacts with field conditions, so that a very wet clay field influences tillage differently than a loamy dry field. No-till was not observed to affect all soils and fields uniformly. Farmers observed differences among their fields when treated with the same tillage practices. Observation of no-till not working on certain soils is a salient influence for many farmers. The type of soil, often its physical properties, and field conditions at a given time influence farmers to use tillage or not use tillage. While soil health serves as an observational proving ground for management practices for some farmers, others have found that regardless of their interventions, soil seems to have an inherent homeostasis that management cannot affect.

CROPS | Land in perennials as a management marker and challenge

“First thing you do is go to an old hedgerow, dig in that soil and that will tell you what your soil should look like.”

The influence of the soil health in relation to previous cultivation impels some dedicated farmers to continue no-till, by using herbicides to remove unwanted plants, even if it is more difficult to bring the land under cultivation that way. However, for many farmers, when a field needs to be converted to a very different crop, whether because it has not been cultivated or it is standing in an unwanted perennial, tillage is the tool of choice to convert the field, even if it will be followed by a no-till regime.

SYSTEM | Specificity of the operation

“I think the chemicals are more healthy than tillage.”

Organic farmers did not talk about tillage as problematic or damaging, while conventional farmers do. While no-till organic is being researched, the practice is rarely mentioned by farmers. Most farmers associate no-till with herbicide use, and for organic farmers, this association rules the practice out. At the same time, many conventional farmers believe that tillage in organic systems is worse for soil health than the chemicals in a no-till system. Clearly, the system has an influence on the tillage used; norms, values and rules in each system dictate what is appropriate for that system and farmers who adhere to one or the other generally agree, and even strenuously agree, at time.

FARMING NORMS | Subculture norms spread through farmers' networks

“Some of the most innovative soil health driven farmers are right here in Pennsylvania.”

While most farmers in the Chesapeake Bay watershed employ some form of conservation tillage, there is also an avid, and perhaps unique in this region, subculture of ‘never-till’ farmers in Pennsylvania. They are buoyed by a farmer-organized network called the Pennsylvania No-Till Alliance, which in turn is fortified by the annual National No-Till Conference. This network is an important influence on tillage decision-making for its members and others in Pennsylvania. The Pennsylvania No-Till Alliance is influencing tillage practices at both its members and members’ neighboring farms throughout the state. Their focus on soil health and the systems view of no-till is beneficial for soil health outcomes on farms in this region. Their considerable influence and the strong social support network they have built also allows for active members to gain what they believe may be a slight advantage in farming on the ‘leading edge.’

LEARNING | Formal and informal education about soil

“Life is too short to learn it all, so I learn a lot from other people.”

There are farmers throughout the Chesapeake Bay watershed who seek out educational and networking opportunities about no-till beyond the Pennsylvania No-Till Alliance. These kinds of formal and informal education influence tillage regimes on many farms. Many farmers are aware of no-till and related soil health issues by going to meetings and talking to other farmers who had gone to meetings. Learning about the effects of tillage on soil is a motivator for many farmers to discontinue tillage and to begin approaching no-till as a system, rather than a singular practice. No-till has been spreading via networks that conventional farmers and educators create around the region. The recent emphasis on soil health as a reason for no-till is percolating through learning avenues geared towards conventional farmers, influencing the tillage regimes some conventional farmers employ and enabling an understanding of the systemic effects of tillage that were not at the forefront until previously. Organic farmers do not often mention the availability of these kinds of educational opportunities regarding tillage in organic systems.

LABOR | Saving time and money interacting with labor on and off farm

“We’re farming but we’re also doing other things and there just isn’t enough time, it’s a financial thing.”

Farmers cite the issue of efficiency as a reason to begin no-till or to become more committed to never tilling as a system. In particular, farmers talked about the time and cost savings that no-till engenders. However farmers define efficiency for their operations, the promise of cost and time savings supports less tillage in many cases, often for the benefit of soil health. However, in cases where no-till allows widening of contour strips, the outcome is perceived by some to be a detriment to larger conservation measures.

TECHNOLOGY | Specialized equipment, cost and desire

“For a small operation like me it’s hard to go out and invest \$20,000 in a nice no-till grain drill.”

The availability, accessibility and appropriateness of specialized equipment plays a part in enabling different types of tillage regimes; desire, cost, necessity, training, and even neighborliness, all influence what types of equipment are used on each farm. The impression that expensive equipment signals a better farmer indirectly influences the kind of tillage employed, as many farmers aspire to using the latest no-till technology but do not have the financial means to obtain it resulting in continued use of the system they do have equipment for. In this way, the link between expensive machinery and the system of no-till is detrimental, in that it is possible to find less expensive means of employing no-till (making or sharing equipment) but these means are not widely recognized because of the strong link with novel technology, private ownership, and the system of no-till.

FARMING NORMS | Generational shift in norms

“There’s a tillage gene in the farmer that you cannot kill.”

There is an influential and widespread norm that farming involves plowing; this was evident in conversations with farmers across the Chesapeake Bay Watershed. However, it mostly came up in the context of how previous generations worked the land and, while there is clearly a thread between generations, there is a strong counter current that the norm is now shifting to no-till. The norms for conventional farmers in this region do appear to be shifting away from tillage towards no-till, especially with the next generation of farmers and those who are active in farmer networks and interested in soil health issues. However, at the same time, there remains a norm to use tillage, especially among conventional farmers who are not part of the active networks supporting no-till.

AMENDMENTS AND NUTRIENTS

MANURE | Availability and properties of manure

“The problem is we all don’t have livestock anymore.”

The use of manure as a nutrient amendment is influenced, in part, by the qualities of the manure itself, its physical proximity, availability and the feasibility of alternative nutrient sources for the type of operation. Manure is a critical nutrient source and soil amendment for organic farmers across the Bay watershed, and many continue to work in an integrated crop-livestock system or pasture system to ensure that feed and manure can be produced on their land with limited imported inputs. For both organic and conventional farmers, the value of particular nutrient properties of different kinds of animal manure is becoming more widely understood, especially in terms of phosphorus overload issues that are widely discussed in the Bay watershed context. Some farmers intentionally purchase chicken manure, while others intentionally seek out cattle manure, and still others are wary of importing any manure due to the potentially unknown contaminants that it might introduce to their soils. For those that produce manure in excess of the land’s capacity to recycle it, knowing and promoting the nutrient and amendment values of that manure is key to enabling the sale of it regionally.

MANURE | Environmental hazards of manure and precipitation of new markets

“Chicken litter’s become a nemesis... I’m saying, for soil health, that’s the best thing I’ve got, and they want to burn it all.”

Manure is both a boon for soil health and, especially in the case of chicken litter, a bane for water quality in the Chesapeake Bay watershed. The environmental risk of manure leaching into waterways has meant that states are focusing on regulating its use more closely than in the past, especially in Maryland. At the same time, farmers without livestock are seeking out manure as a nutrient amendment and helping to create markets that shift the excess nutrients away from saturated soils and environmentally sensitive landscapes. Putting a nutrient and monetary value on manure leads some to suggest that it will not be over applied as readily as it has been in the past. These new markets are turning what was a liability for some concentrated livestock operations into an asset. However, the lack of coordination of watershed wide manure sales has some concerned that there is little affect on the nutrient balance or the outcomes for the phosphorus load in the Bay.

LANDSCAPE & SOIL | Promotion of soil life and concern for environment

“We try to get just a light coating of manure, not so much for the nutrient value but the inoculant value.”

Amendments, like manure or compost or incorporation of residue, are seen by some farmers and agricultural professionals to go beyond simply providing nutrients, to promoting soil life or biological activity and resulting in optimal soil health that makes for the best growing conditions over the long-term. This view of amendments as soil-life promoters influences amendment choices and nutrient availability. Farmers talked about the inoculant values of manure as well as the deleterious effects on soil biology caused by anhydrous ammonia, residual nitrogen, and herbicides. This concern for soil life alters which amendments are chosen, so that one farmer suggests that even though potassium sulfate is more expensive than potassium chloride, he will choose the latter because the former works against soil health. While many farmers across the watershed want to promote soil life, the complexity of interactions and the constraints of crops and farming systems mean that this concern plays out in very different ways, in that some farmers purposefully take the time to understand these complex interactions by seeking out knowledge and observing their particular soils, while others feel the complexity is such that it is impractical to try to grasp it.

CROPS | Specificity of crops interacting with organic matter, fertilizer and pesticide needs

“The problem is the stalks grow so big and so green, that they’re hard to break down.”

Crop varieties and the system in which they are intended to be grown (organic or conventional) influence the kinds of amendments that a particular field will receive. The topic of crop varieties and plant breeding is complex, as the interactions among science, technology, power, industry and economics all shape seed markets. While few farmers talked about this complexity, many did talk about the specificity of crops as an influence on their nutrient and amendment regime. The topic of certain varieties of genetically modified (GM) corn residue not breaking down emerged in several conversations across the watershed. This plant trait interacts with the soil and other amendments, so that a farmer who is managing to promote soil biology has found that his GM corn breaks down at about the same rate as his non GM corn, while a farmer who is not managing for soil health has found that his heavy use of fungicides with the GM corn disables residue breakdown, leading to the use of specialized shredding equipment. The conventional system is also responsible for the heavy use of insecticides in many cases, which many farmers suggested was probably detrimental to soil biology. Some conventional farmers felt constrained by this system, not seeing a viable alternative, while others mentioned that promoting soil health is the viable alternative that will allow for less pesticide and fertilizer application in the future. Organic farmers mentioned how leguminous crops provide nitrogen; buckwheat suppresses weeds; and the long root system of rye aids organic matter buildup and halts erosion.

TECHNOLOGY | Soil testing and novel technology interacting with cost and social norms

“It really is a tool to measure your soil health. These other soil tests just measure your nutrients.”

Technologies like soil testing, soil health testing and precision agriculture influence the kinds of nutrients and amendments applied at a given farm in interaction with social norm around these technologies. On the one hand, there are farmers who shun soil chemical testing and apply nutrients just as their forbearers did, while on the other hand there are farmers who are learning about and using new soil health testing because it is being promoted at meetings and picked up by colleagues. For some farmers, there is a preference to use in-field metrics, such as yield or disease or even the kinds of weeds present, to gauge amendment and nutrient needs. Regarding the suite of technologies under the precision agriculture label, some farmers do seek out these out for their promise of fertilizer reductions and time efficiency. However, there is still a widespread recognition that this kind of high-tech equipment is also a signal of power or prestige, something to aspire too and a mark of a successful, conventional, farmer.

FARMING NORMS | Social norms around legacy, ease and efficiency

“It worked then and it still workin’ so...”

Legacy, ease and efficiency play a role in decisions regarding amendments and nutrient application for most farmers. These three influences emerged as widespread social norms, especially among conventional farmers. Following in the previous farmer’s (often family member’s) footsteps is common. While legacy issues are complex and family specific, at least a part of the influence here is due to the ease this imparts on decision-making. The ease of doing what has always been done can trump novelty or innovation. On the other hand, doing things the way they have always been done also plays a role in influencing how some of the most innovative, soil-health driven, farmers operate, because they are carrying on a legacy of conservation specific to their farms. Organic farmers who grew up in conventional farming families have clearly made a shift away from how things were done in the past, but ease and efficiency are still important influences on these farms. In many cases the influence of ease and efficiency is the result of an increase in acres under cultivation without an increase in labor. These legacy and ease issues influence some farmers to spray fertilizer, when dry blends would be better for promoting soil health; or they influence other farmers to purchase additional fertilizer rather than simply turn under corn stalks for the same nutrient boost. For livestock farmers it means that some continue to spread regularly throughout the winter rather than pile it up to make a huge spring chore.

POLICY | Policy influence on, and support for, nutrient management

“The nutrient management plan brought about us paying more attention.”

Most farmers have some regulatory mandate or are involved in a voluntary conservation program. The most commonly discussed regulatory topic regarding nutrients and amendments was nutrient (or manure) management plans, which are required for all farms in Maryland and some in Pennsylvania and New York. In general, farmers say they understand the purpose of a nutrient management plan, but the plans themselves are not that useful for their operations because they are not specific enough. In Maryland, rules disallow winter manure spreading and require manure incorporation, which, while unpopular, have been a boon to water quality there. In Pennsylvania, the regulations on CAFOs provoked a farmer to pay more attention to nutrient use reduction in novel ways. Across the Chesapeake Bay watershed, farmers felt that agriculture is, unfairly, the focus of nutrient regulations, often suggesting that culpable urban and suburban are not receiving the same regulatory attention. However, some farmers do recognize that regulation has slowed the rate of erosion and decreased the toxicity of agricultural chemicals over time. Some farmers welcomed aid, especially with tailored nutrient management, but others felt that participating in programs meant ceding control of land to the government. Other forms of voluntary regulation influence nutrients and amendments, most notably organic certification standards.

WORLDVIEW | Shift in awareness to soil biology and systemic effects

“I guess you would say that the sum is greater than the parts”

There is a shift occurring among some farmers in the Chesapeake Bay watershed from a view of soil as a substrate for inputs with discrete effects, to a more systemic understanding of the soil as a living system, and fertilizer and amendments having systemic effects. This shift is supported by farmers seeking out a greater understanding of soil biology from texts, from other farmers, and from direct observation when possible. This trend may perhaps reflect the increasing scientific and popular attention being paid to soil health. Among no-till farmers, soil health has become a much talked about topic and is becoming a widely acknowledged management goal. In this case, manure as a nutrient and amendment is an important part of the system of no-till. For organic pasture-based livestock farmers, the author and grazing advocate Allen Savory was mentioned several times in different regions, along with his whole-farm holistic management school of thought.

