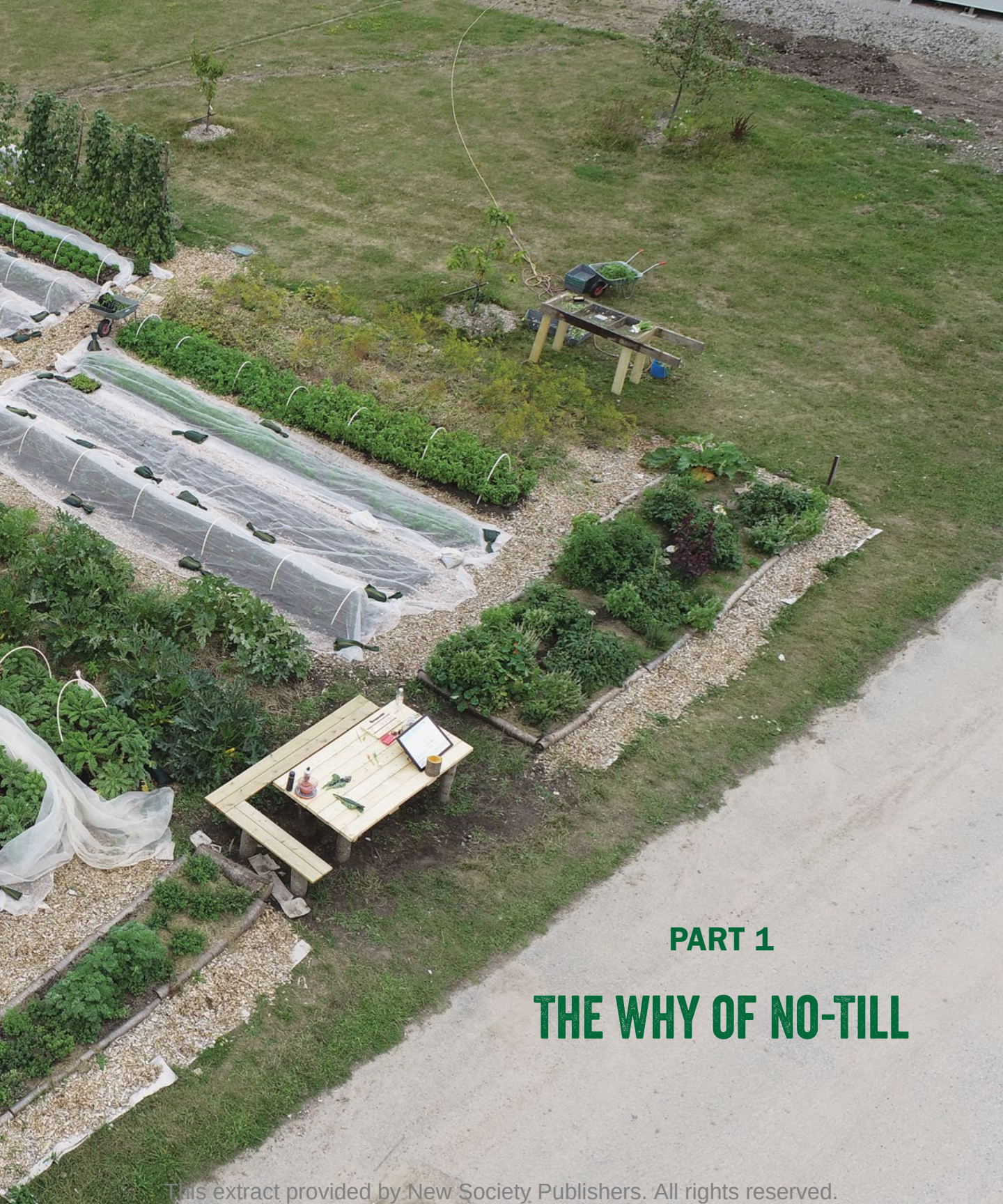

PART 1

THE WHY OF NO-TILL

Introduction

BECAUSE THIS BOOK is meant to be a quick-start guide, I hesitate to put this introduction between you and the practical stuff. However, it just doesn't seem right to put the *how* of no-till before the *why*.

But, if you are absolutely itching to get your hands dirty right away, you could skip to "Part 2: The How of No-Till." If you choose to do that, I'll bet that once you get going, you will eventually find yourself wondering about the *why* that supports the *how*. If that's the case, you can come back to this section later, when it's of more use to you.

Who This Book Is For

I wrote this book primarily to help people who are interested in no-till but don't know where to start. But it's also for growers who have already started with no-till and are interested in expanding or refining their repertoire of techniques.

Over the past few years, there has been a lot of interest — and a lot written — about no-till. This is a great thing. When I started working on my first no-till farm in 2005, there was very little written information available about the subject. At the time, actually working with farmers who were doing it was almost the only way to learn about no-till.

But, happily, that situation has changed. My first book on no-till, *The Organic No-Till Farming Revolution*, came out just three years ago,

in 2019. Since then, at least five more books about no-till have been published. Many more are sure to come.

Interest in no-till is so strong that I am writing this book to fulfill the need that growers have expressed for *a quick-start guide to no-till*. Many volumes' worth of information can and will be written about the relationship between plants and the life of the soil that will add to our understanding of how no-till works, but you don't need an advanced degree to use these techniques. No-till methods are actually really easy to try. To get started, this may be the only book you'll need.

One thing that's different between now and 20 years ago, when I first got interested in no-till, is that people are much more used to the idea of a no-till farm now. Back then, there were plenty of people who were outright skeptical and laughed at the idea of growing crops without tilling. That's the reason I included a lot of grower interviews in *The Organic No-Till Farming Revolution* — so people couldn't doubt what no-till farmers were doing and could hear it from the horse's mouth. Now that people are much more used to the idea of a no-till farm, in this book, I will strip the methods down and talk as simply as possible about how to put them into practice.

As someone who wants to see the local food system grow and flourish, in this book I've focused on methods appropriate for local farmers. However, this is not a book just for already established farmers. I know more than a few farmers who got their start as gardeners, and the ideas in this book can work just as well in a garden as they do on a farm. As well, I very much hope the methods described in this book will inspire many readers to become first-time farmers. So regardless of your scale, good luck reducing or eliminating tillage with these no-till techniques!

Tilling Was Once the Only Answer

Tillage has been a standard in modern agriculture for so long, it's become a paradigm. But what we're learning from scientific research and experimentations on farms is that we don't need to stir the soil on a grand scale with our plows. If we start to think of the life in the soil as *our micro livestock* — actual living beings down there turning the soil

on a micro level for us — we can make a revolutionary change in the paradigm. We can replace the need to plow the soil with natural processes. We'll be helping ourselves if we let the little guys do their work for us. I'm pretty sure they'd rather do it than us, and the past 20 years' worth of experience with no-till systems shows they are up to the task.

Enthusiasm and Skepticism for No-Till

When I was apprenticing on farms around the United States — in Pennsylvania, California, Washington State, Virginia, New York State, and finally Maine — all of the farms I worked for tilled. Mostly by tractor but some by horse, one thing they all had in common was plowing. The only exception to that was the Virginia Tech research farm that I worked on in 2005. Even after working there, when my wife and I went on to start a farm, we tilled — just like most everyone we had worked for.

My whole farming career, I've been told that tillage was bad. However, much of the time there was no viable alternative. So on our own farm, we kept tilling. But we were searching for ways to farm without it. With the methods we had available to us at that time, we couldn't figure out how to make no-till work on a small, diverse vegetable farm. What we could've used was a guide to all the various ways of going no-till. If we had had one, we could've selected methods suited to our farm. The guide that I wish we had when we started out is what I've written here.

We know tillage has many disadvantages that we can avoid by choosing a farming system that doesn't involve tillage; the rest of this book is dedicated to helping you find the right system for your farm. The advantages and disadvantages are covered in detail below, but among the big-picture advantages of no-till is the potential to improve growers' lives and the ability to alleviate some of the ills of our time. So it's no wonder there's a growing component of the farming community that is rushing to embrace no-till.

Many of the people I meet already have an opinion about no-till by the time we start talking about it. And, as with most things that have the potential to change paradigms and disrupt systems, a lot of

people tend to be on one extreme of the spectrum or the other. In other words, they tend to be either very enthusiastic about no-till or very skeptical. In the discussion below about the benefits and drawbacks of both no-till and tillage, we'll look at the reasons why people are excited and skeptical (sometimes at the same time) about no-till.

Becoming a No-Till Farmer

No-till is like a lot of things in life, in that if you know *what* to do, you can go from beginner to competent practitioner quickly. It's when you don't even know where to start that you can spend a lot of time spinning your wheels. As anyone who has ever bought an electronic gadget knows, the included booklet that has pages and pages of explanation is preceded by a quick-start guide. They know all you really want to do is turn it on.

The process of understanding no-till methods, choosing one or more that are appropriate to your farm, and then getting started with a no-till method is a little more complicated than turning on a new smartphone. But this book will allow you to get growing with just what you need and nothing more. Once you've gotten going, you can get into identifying the species of invertebrates in your soil, come up with cash/cover crop rotations that make the most of your season, and fine-tune the rest of your system. But in the meantime, too much information can be a distraction. Learn to ride the bike before you try to pop a wheelie.

Whether you just heard of no-till and are wondering how anybody could possibly grow anything without tillage, or whether you're staring at a grassy field wondering how you're going to grow something in it, let this be your guide to picking methods and getting started with no-till. If you want to get deeper into any of the methods, check the bibliography for further reading.

Defining No-Till: What Counts as Tillage Anyway?

We should stop here and establish a definition of tillage. At the bare minimum, and for the purposes of this book, tillage means *an action that inverts or mixes soil layers.* Textbook examples of tillage are

Though from above a power harrow may look a lot like a rototiller, the mode of action is different. Instead of tines churning through and mixing soil layers from top to bottom, a rotary harrow has tines that rotate on a vertical axis, loosening the top of the soil instead of mixing layers. When set deep, rotary harrows will still disturb a lot of soil, but when run shallowly, they can rough up the surface just enough to get some loose soil to plant into without deep soil disturbance. ***Credit: Photo by BCS America***

In this view under the hood of a power harrow, you can see how each of the five sets of tines rotates independently, with a vertical "egg beater" motion, instead of the horizontal mixing of a rototiller.
Credit: Photo by BCS America

moldboard plowing, where the soil at the bottom of the plow is flipped on top of the top layer, and rototilling, where the soil is violently mixed by the beaters on a *rototiller.* Different growers may count other things as tillage, such as the use of rotary harrows and other devices that disturb the soil surface without inverting it.

New Adaptation for Old Methods

There's nothing new under the sun — or under the soil, for that matter. I did not make up any of the methods described in this book; versions of no-till have existed under various names over the years: *lasagna gardening; no-dig; Ruth Stout's year-round mulch method;* and many others. Going back further, planting methods without tillage were used by the Incas, ancient Egyptians, and many Indigenous cultures over our 10,000-year agricultural history.

What *has* changed, is the interest in making no-till methods efficient on a farm scale. This is partially because of our increased understanding of the complex and crucial role of soil life both in feeding plants and in keeping the soil healthy for the long term. I examine some of this in the section below, "The Power of the Soil."

The Promise of No-Till

One "proof of concept" that no-till has advantages for the grower can be seen in the rapid adoption of no-till in conventional row crop farming. Experiments in the US with no-till field crops on a large scale began in the 1970s, but they really took off when genetically modified corn and soy varieties were developed in the 1990s. After that, a large percentage of the enormous acreage of those crops grown in North America quickly went no-till. "Data from the Agricultural Resources Management Survey on the production practices of corn, cotton, soybean, and wheat producers show that roughly half (51 percent) used either no-till or strip-till at least once over a 4-year period."[1] Considering that those are some of the most widely grown crops in North America, half of just corn and soy would add up to over 100 million acres in the US.

But conventional row crop no-till farming also involves technologies that many farmers are loathe to adopt: it gets around the problem of weeds with genetically modified crops that can withstand herbicide application. This has led to increasing amounts of herbicide usage even though the amount of tillage has gone down. As poor of a trade as exchanging tillage for toxic chemicals is, it is proof of concept that, even on the grandest scale, cutting out tillage can save growers time and money. But it is reliant on methodology no organic grower would want to emulate. So the challenge becomes, how to reap the benefits of not tilling without chemicals?

It's difficult to say whether the widespread adoption of conventional no-till practices is an overall win or a loss for the environment. Although many tout the environmental benefits of reduced erosion in conventional no-till farming, "globally, glyphosate [the herbicide known best as Roundup] use has risen almost 15-fold since so-called 'Roundup Ready,' genetically engineered glyphosate-tolerant crops were introduced in 1996."[2] Also, it has been found that "the concentration and the load of pesticides were greater in runoff from no-till fields than conventional fields."[3]

So, considering that conventional no-till has led to increased herbicide usage, and it also leads to increased pesticide runoff, conventional no-till is *not* a model for a healthier environment.

Obviously, organic no-till requires an approach that does not include herbicides or genetically modified crops. As will be discussed in more detail below, no-till provides many opportunities for a more organic approach. Not only does no-till have the potential to save time and money, but it also builds organic matter, sequesters carbon, increases water infiltration and water-holding capacity, and improves soil life. So it would appear to be a remedy for a lot of the ills of farming of our time, including erosion, drought, and climate change.

Whether or not you're certified organic, the methods in this book, and organic no-till in general, work because of *healthy soil*. And as much as reducing tillage is a step toward healthy soil, spraying chemicals like the herbicides that make conventional no-till possible is a

step backward because it kills soil life that may have been spared by the plow. Understanding what makes healthy soil and how it can be supported is a vast subject; what we have yet to learn about the soil alone could fill many books. So we will summarize what we know as it relates to no-till in the next section.

THE POWER OF THE SOIL

I LIKE THE QUOTE FROM ALDO LEOPOLD that appears at the beginning of this section because it describes how soil functions as both *battery* and *transmission* for the energy from the sun that is converted into storable energy by plants. For so long, Western agriculture has viewed soil as a passive thing that is just there to anchor plants, when in truth there is a lot more going on down there. The life in the soil biome has evolved many symbiotic relationships with plants; it processes nutrients in the soil in exchange for some energy from the sun.

Looking at it the other way around: plants take energy from the sun and share some of it with the life in the soil. In exchange, soil life has many ways of sharing resources in the soil with plants. This is symbiosis. Plants are the link between the extraterrestrial energy from the sun and the terrestrial resources in the soil, and it is these relationships that make life possible on Earth. That may sound like a grandiose claim, but the vast majority of all life on Earth gets its energy from the sun, directly in the case of plants, or indirectly in the case of herbivores and carnivores.

The life in the soil is both creator and destroyer. It helps plants grow and then breaks down what's left when plants die. This ability for the soil life to break down dead matter is no small thing. It has transformed life on Earth. For example, coal formation declined around 300 million years ago because that's when fungi evolved the ability to

break down lignins (the component that protects tree cells) that trees had developed 100 million years prior to protect themselves from being eaten.

Before fungi evolved the ability to break them down, trees didn't decay; they would simply drop where they died, and — eventually — some became coal. But once fungi developed the ability to break down lignins, trees started rotting, and their stored energy became available to other life forms. As growers, we can put the power of decomposers to use — if we just stop killing them with tillage, pesticides, and overfertilization.

So, the soil is the great recycler for our planet. It breaks down the organic matter from creatures fed by the sun; this is why we say when something has died that it is going back to the Earth. Once microbes and other creatures have broken dead organic matter down, the soil

Think of the Earth as an organism with its stomach on the outside. Since the Earth is filled with molten rock and is closed off from the outside world by its crust, the digesting and releasing of biological energy isn't happening on the *inside* (as with our own bodies and most creatures we are familiar with), it is happening on the *outside*. The entire surface of the planet is a stomach, breaking down, digesting, and regrowing the matter and energy on the surface of the planet.

My wife Ann, who is a geologist, told me she likes studying rocks because they're the Earth's bones; by that analogy, soil is the planet's exterior stomach, held in by the Earth's skin, its vegetation. What you're doing when you put a tarp on the Earth is inviting the soil life, which drives the digestion, up to the surface of the soil to eat what is there. In the dark, the plants die of starvation, and in turn, the microfauna digest the dead plants. That's why as a soil farmer, the soil life is your *micro livestock*.

We used to think in agriculture that chemistry drove biology; what we're realizing is that it's the biology that drives the chemistry, at least when it comes to the availability of nutrients for plants.

becomes a *battery*, storing energy and nutrition from the previous forms of all that organic matter.

We are learning more all the time about how, in addition to being fed by breaking down the organic matter from dead organisms (and keeping the Earth from filling up with dead things), the soil biome is also fed by exudates from plant roots. Thus, energy is passed from the sun through plants and then to the organisms of the soil which, in turn, give some of that energy back to the plants. It is a symbiotic trade that we have only glimpsed the tantalizing potential of.

These all-important relationships were misunderstood by chemical agriculture, which viewed the soil as simply a substrate to give plant roots something to hold. Until recently, from the conventional agricultural perspective, the real work was thought to be done by chemical companies making fertilizers and the farmers adding them to the soil. It turns out that all along the soil could do the work for us.

Misunderstanding and underestimating the power of the soil is as understandable as it is unfortunate. To mid-20th century chemical company scientists, it was easier and more profitable to study plants' responses to different manufactured fertilizers than it was to study the soil life that was naturally cycling nutrients in the soil.

The "green revolution" technologies that are widely praised for increasing short-term agricultural productivity are also responsible for the long-term degradation of the very farmland they are credited with increasing the productivity of — through erosion and soil biocide caused by tillage and chemicals. Reducing or eliminating tillage is one of the biggest ways growers can stop chasing their tails, trying to augment organic matter by adding it in various forms only to burn it up with tillage and send its carbon back into the atmosphere. This subject is discussed in more detail in the section on "Disadvantages of Tillage."

Putting a Face on the Soil

It is easy to think of soil as a pile of inert brown dust. On the contrary, it is *full of* life. Not only that, but it has "the greatest concentration of

biomass anywhere on the planet! Microbes, which make up only one half of one percent of the total soil mass, are the yeasts, algae, protozoa, bacteria, nematodes, and fungi that process organic matter into rich, dark, stable humus in the soil."[4]

Soil is so full of life that it's hard to fully comprehend facts like this: "Much more than a prop to hold up your plants, healthy soil is a jungle of voracious creatures eating and pooping and reproducing their way

It's easy to think of soil as homogenous brown dust; however, when we look closely, there's an amazing amount of diversity within. Dicyrtomina ornata, *a type of springtail, is just one of the many thousands of species living in the soil and crop residue.*
Credit: Andy Murray

We're in a golden age of learning about soil. Not only have we taken it for granted in the past and not considered it worth studying, but it's been very hard to study because all the action in the soil takes place in the dark, conducted by organisms who, in most cases, are invisible to the naked eye.

toward glorious soil fertility. A single teaspoon (1 gram) of rich garden soil can hold up to one billion bacteria, several yards of fungal filaments, several thousand protozoa, and scores of nematodes...Most of these creatures are exceedingly small; earthworms and millipedes are giants, in comparison. Each has a role in the secret life of soil."[5]

Even though the soil is teeming with life, much of it is invisible to the naked eye. Also, it's dark down there. So it's been only since the advent of modern imaging that we have been able to actually see what's going on in the soil. Happily, though, we're living in a golden age of soil science. Every day, modern microscopy and photography are getting us better acquainted with the critters who do the work. The combination of improving equipment to study the soil and a better understanding of the importance of soil and soil life has yielded a great deal of informational fruit recently. Now, I know we're trying to keep this book short, but since biology is the engine of no-till practices, we must touch on biology as the power behind no-till before we move on to how to grow no-till.

Soil: Where the Microbe Magic Happens

Almost any discussion of no-till methods will get around to talking about soil life at some point. And that's because no-till tries to let the soil biology cycle nutrients to our plants, instead of needing to spoon-feed them fertilizer. Everybody understands the connection between a cow pooping and that poop being used as plant food. If it's helpful, think of the critters in the soil as little tiny cows.

Life in the soil is doing the same things as life on the surface; soil critters are eating each other, and what they poop out is plant food. This is important because, regardless of what your soil test says is in the soil, it's not all available to your plants. One of the major ways nutrients go from being locked up to plant-available forms is by being cycled through soil microorganisms.

Think about it: natural systems don't depend on someone rototilling every few months to keep things productive. Mother Nature does fine on her own, digesting and recycling the nutrients in any given

environment. But since we want to harvest high yields of densely planted, heavy-feeding vegetables and flowers, we must do a little extra for our plants to get them to reach the potential we expect as commercial growers.

It's true that we need a higher level of production than might be supplied by just letting nature take its course on our farms, but we can still tilt things in our plants' favor by eliminating competition and preventing weeds. On the fertility side of things, the less we disturb the soil and the more we encourage the right kinds of organisms in it, the more we can rely on them to feed our plants.

Now of course this is all a gross oversimplification; to really talk about the soil food web would take many, many books. See the Bibliography for resources that will help you better understand how energy is cycling from the sun through our plants and back to us.

Taking Care of Our Livestock

As no-till farmers, it is appropriate to think of soil life as *micro livestock*. And our job is the care and feeding of that micro livestock — because, as already discussed, they make nutrients available to plants.

As you will see, there are many ways of caring. For example, let's say you have a dense cover crop that needs to be incorporated into the soil. You could plow it into the soil, and wait two weeks or more for the soil to start digesting the biomass before planting the next crop. But, with a little more time, you could let the soil life do the incorporation for you. For faster breakdown, you could *flail mow* the cover crop (chop it into bits), and then tarp it and let the worms and other soil microorganisms break down the crop residue — so you don't need to plow.

Soil Life Drives the Success of No-Till Systems

Once we understand soil as more than just something to hold plants and fertilizer, we can talk about why *healthy* soils do what they do. To me, it's like magic — in part because we still know so little about it all. It's thought that we've only identified 10% of all the species that live in the soil.

Modern microscopy makes it easier to understand what is going on in the soil by showing us the creatures that live there.

Credit left: *By José Roberto Peruca, used under Creative Commons Attribution 2.0*
Credit below: *By Pr.zs.i, used under Creative Commons Attribution-Share Alike 4.0 International*

What we do know is that microbes cycle dead plants and other formerly living matter and rocks into usable plant nutrients. Soils that have been tilled and/or heavily sprayed with chemicals have less microbial life. This is one of the reasons many growers trying no-till systems report that they work better over time — most agricultural soils have been degraded through farming, and tilling them less is one of the many steps we can take toward healing them. "Very few people understand that the soil is an ecosystem, so it is our duty to educate as many people as we can that the soil is alive," said Gabe Clark in his book *Dirt to Soil.*

Simply the physical action of tillage kills many of the things that live in the soil. Imagine if you lived in the soil when a rototiller came through; it's harder to imagine surviving going through a rototiller than not. Tillage tends to affect the larger creatures more severely, which makes sense when you think about the long, fragile hyphae of fungi or the chances of an earthworm going unscathed between rototiller tines.

This is also why tilled soil tends to become dominated by bacteria instead of fungi. The smaller organisms like bacteria are more likely to survive, so the surviving bacteria eat the dead and dying after tillage. Imagine a village that is destroyed, and the rats move in to eat whatever

Another interesting critter that we may find in the soil and crop residue is Neanura muscorum. *They are a type of springtail that eats small plants and fungi.*
Credit: Andy Murray

is left of the bigger critters. Destroying the village over and over again favors the rats.

This is important because crops prefer a certain ratio of fungi to bacteria in the soil. Most vegetable and flower crops prefer soil that is balanced between fungal and bacterial populations. Many trees, on the other hand, prefer a soil environment that is fungally dominated, like an undisturbed forest floor. When we use no-till methods, we allow important symbiotic relationships to thrive because the soil life is left to function as it has evolved to function. These symbiotic relationships between the plants and the life in the soil can do a lot to help keep our plants healthy — if we let them.

Soil Testing

New approaches to soil testing are showing us that we may not need as much fertility in the soil as traditional soil tests have indicated. Industry standards in testing have all been based on a chemical approach. Testing told us which nutrients were *present* in the soil, but not how available they were to plants. Nutrients can be "locked up" in non-available forms. This means that plants can't get at them to power photosynthesis and growth. When we have active soil life to cycle the nutrients and make them available to our plants, we don't need as much fertilizer as traditional soil tests have been telling us we need.

Currently, a minority of the soil tests done, like the *Solvita Soil Health Suite,* take into account the *biological activity* in soil, which indicates how much of a nutrient might actually be available to plants. Such tests should be helpful for growers to get an idea of how well they're feeding the life in the soil, and they will likely end up giving growers the confidence to use less fertilizer and let the soil feed the plants as the community of soil microorganisms thrives.

The point is, the less we till, the less we will need to till. We avoid compaction from tillage implements and wheels, and we retain the soil's structure, which allows for water infiltration, among many other benefits, which are covered in more detail later. This is a paradigm shift from us being very involved — with tilling, cultivating,

and fertilizing — to being able to let the life in the soil keep the soil aerated and the plants fed. And we get a break from a lot of future weeds by simply not churning their seeds up in the first place.

Healthy Soil Can Lead to Healthier Farmers

It's a big mind shift to trust that the soil life can do so much and that we don't need to be intervening with tillage all the time. Even if no-till doesn't end up with you working less (there's always something else to do on a farm), it may mean you can focus more on remunerative activities, cutting out the *muda* (lean-farm terminology for work that doesn't add value), and making your farm more efficient and profitable. Read *The Lean Farm* by Ben Hartman for more on eliminating muda, and many other ideas for simplifying your farm and making it more efficient.

It doesn't matter how straight of a furrow you can plow, or how cleanly you can cultivate; customers don't buy plowing or clean cultivation. You might say those activities are essential to producing something you can sell, but on the other hand, if you could skip plowing and cultivation and have the same amount of salable product, wouldn't you? Even if you never get to the point where your fields are so weed-free that you spend zero time weeding, no-till offers a plan where you can skip those activities and still be profitable; if you choose to work the same amount, a higher percentage of your work can be on directly profitable activities like planting and harvesting.

Left: *A* Monobella grassei *springtail that lives in the soil and leaf litter. Credit: By AJ Cann, used under Creative Commons Attribution-Share Alike 2.0*

Below: *The soil at Pleasant River Produce on New Zealand's South Island hasn't been turned in over three years. Grower John McCafferty used truckloads of brought-in compost and wood chips to make the transition to no-till. He reports decreased weed pressure and increased water infiltration and retention. Crimped cover crops are visible in the foreground. Credit: John McCafferty*

This picture from my farm shows a bed of sweet potatoes in a hoophouse that was otherwise being tarped with landscape fabric. After removing the previous crop, we simply applied fertilizer and compost, broadforked, and poked the sweet potato slips into holes we had poked for transplanting and firmed the soil back around them. Credit: Andrew Mefferd

And if you do find that no-till saves you some time, after managing your no-till systems for a few years (because like any other business — but especially with farming — it can take time for systems to become established and smoothly functioning), it's your choice whether to invest any time saved back into the farm, or to use it for family or personal time — which is so important to avoid burnout.

Now that we know these no-till methods work, it is a matter of finding the method that works for your farm. Or, maybe it's a matter of starting a farm from the beginning. In any case, we'll look at the best ways to transition an existing farm to no-till, as well as how to start a farm from scratch without tilling.