Compost -&- Regeneration

by *William F. Brinton*

*The science of land doctoring is being practiced with vigor,
but the art of land health is yet to be born.*
- Aldo Leopold

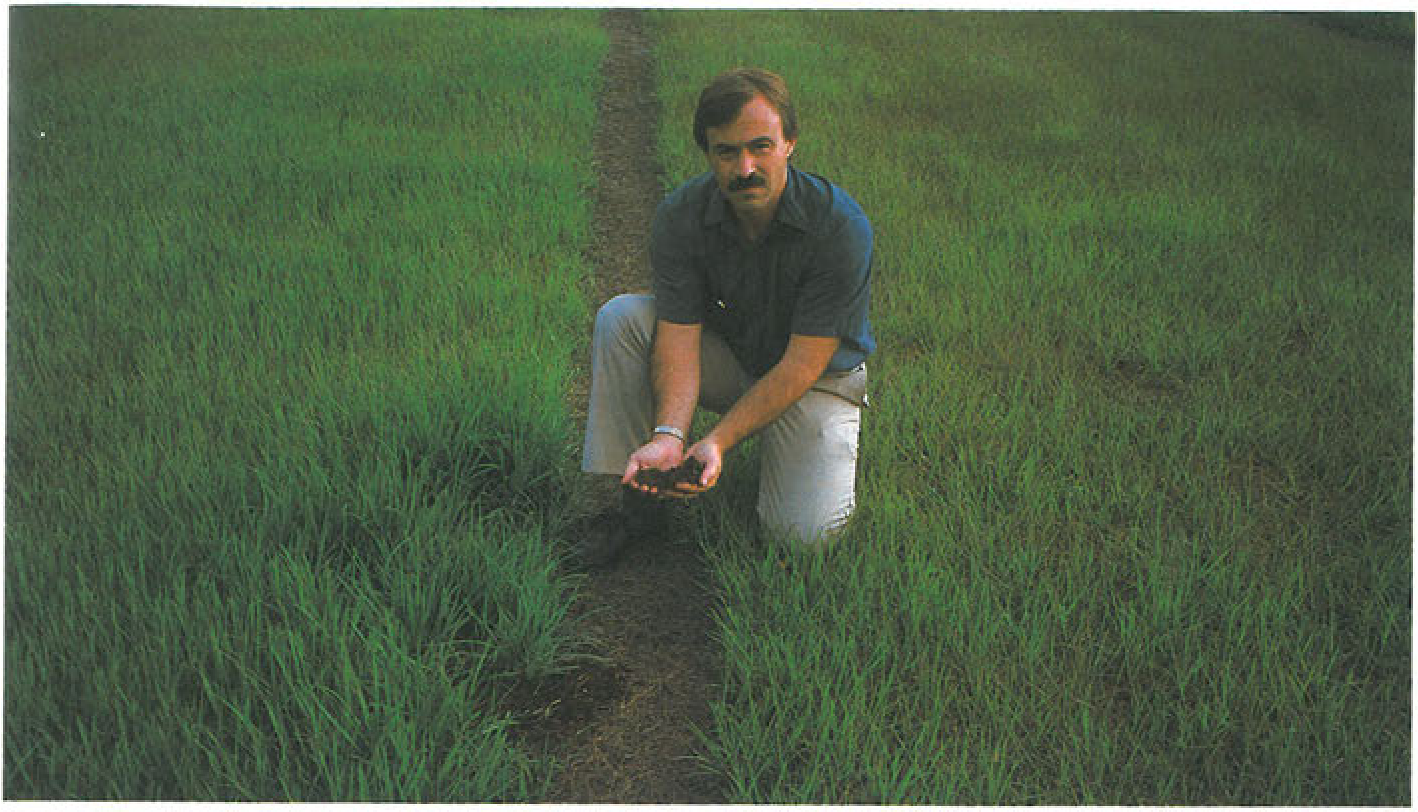
William F. Brinton is the founder and president of Woods End Research Laboratory in Mount Vernon, Maine. His business is compost. Working together with a staff that includes an engineer, an economist, biologists, microbiologists, and a horticulturist, Brinton designs and implements compost systems for farms, industries, cities, and even countries. He does not compost by the pound or the cubic yard, but by the square mile and the ton. His aim is to find organic matter that is going to waste—say, the residue from leather tanning, a lagoon of chicken sh*t, ten tons of dead dogfish, the leavings of a cranberry processor, the sawdust from a lumber mill—and combine it with other substances in open piles to undergo the process called composting. The product is fresh humus, to be returned to agricultural soils and degraded landscapes.

When *People Magazine* recently came to Woods End to photograph Will Brinton, the photographer asked him to dress in a chef's hat and surrounded him with labeled barrels of waste. The image is not as farfetched as it might seem. Composting is what happens when soil microbes—bacteria and fungi—plus all the other minute creatures in dirt, digest organic matter and each other. It is not just a matter of throwing any old squishy waste together, however. To arrive at a valuable end product, you must regulate the amounts of air, carbon, nitrogen, and water in the pile. The tricks of Brinton's trade have to do with the specific recipes he uses for the different materials to be composted. All combine carbon-rich materials (usually the browner wastes, like sawdust, dried leaves, etc.) with nitrogen-rich materials (manures, animal carcasses, green plant tissues, etc.), plus such ingredients as ash to control acidity or gypsum to control the loss of nitrogen to the air.

Brinton, who studied agriculture at Susan B. Anthony University in Maine and biodynamics in Germany and Sweden, usually composts in open-air windrows, where he controls air and water by mechanically turning the piles. A cross-section of a pile forms a pyramid about six to eight feet high and the same across the base. These minimum dimensions make a warm, protected environment for the microbial diners.

The right mixture of compost ingredients can be detected by smell, a critical skill in the arcana of the Woods End Laboratory. A stinking compost is a compost that is losing nitrogen and other valuable components. It may also be a compost that does not properly stabilize—that doesn't stop decomposing and so steals from the soil it is meant to help. Woods End scientists spend much of their time incubating trial samples of prospective compost mixtures, seeking the combination that yields the least noxious off-gases and stabilizes most quickly. The lab, housed in a refurbished barn, resembles an alchemist's den, full of rocking levers, flasks of bubbling liquids, and retorts hooked up to sinuous coils of tubing. The pride and joy of the Woods End's staff is the adiabatic compost simulator, a barrel-sized vessel that can simulate any conditions in a full-scale compost pile.

As Brinton argues, the result of the compost process—stabilized organic matter, a.k.a. humus—is the single most important component of a healthy soil. The notion would seem an obvious one, but for more than a century it was discredited by the leading experts in plant nutrition. The



© WOODS END RESEARCH LABORATORY

In trials for Walt Disney, Will Brinton grew a control crop (right) side by side with a crop to which compost had been added (left).

great German and English chemists Liebig, Gilbert, Lawes, and their followers theorized that plants fed on certain elements—chiefly nitrogen, potassium, and phosphorus—and that it did not matter how these elements were applied, so long as there was enough of each.

For decades, particularly following the introduction of synthetic high-nitrogen fertilizers and effective pest killers, it appeared that these scientists were right. Yields of the major crops increased manyfold, and when trials were conducted to compare the nutritive value of composts or green manures with that of synthetic fertilizers, the latter almost always won. As one researcher put it, "At that time, if you stuck to crop rotations, composting, manure, and the other things older farmers had done to improve their soils, you looked like an idiot."

Yet gradually farmers began to notice that they were adding more and more fertilizer, herbicide, fungicide, and pesticide just to maintain the same high yields. Furthermore, their soils were turning pale and hard, or sandy, so that water either ran off the surface or sluiced straight through.

The truth is that all over the world cultivated soils are dying of the chemical regimen they have received. Woods End's composting is one important effort to save and restore them. ***William Bryant Logan***

Walt Disney World is among the great public landscapes in America. To a compost scientist, it is a gold mine. The operation generates an immense amount of organic matter, thousands of tons per year of grass clippings and other yard wastes, plus food scraps from the concessions—the equivalent of the wastes produced by a city of half a million people. So I was delighted last year when the Disney horticulturists called Woods End to ask us to study the possibility of converting their entire landscaping operation to natural fertilizers. Disney's goal is to reduce and possibly even eliminate its dependence on chemical fertilizers for their two thousand acres of landscaped ground plus tens of thousands of potted plants, by composting all the organic matter and returning it to the soil.

The project is the most comprehensive compost/recycling project Woods End has yet undertaken. To add to the challenge, the soils in that part of Florida are very sandy, porous, and low in organic matter. We tested them by burying traps called lysimeters (from a Greek word meaning to dissolve or loosen) two feet deep in the soil and measuring the volume and chemical content of the water that flowed through. The results were astonishing. The moment it rained, the traps filled up. This soil was like a sieve, holding hardly any water at all. Soluble fertilizers might go straight through it.

Our first task was to prove to Disney that they could indeed grow nice green lawns using compost instead of chemicals. Compost not only functions as a storehouse of nutrients but also helps hold water, air, and nutrients in the soil, because it absorbs roughly ten times more water than soil that is largely mineral. On test plots, we showed that turf responded well to commercially purchased compost products. Now we are working to perfect a compost recipe that uses all of Disney's own wastes under the conditions of sandy soil and high rainfall.

The Death of the Soil

A Canadian study of soil degradation in the western provinces lists five categories of losses: erosion, organic matter loss, acidification, salinity, and compaction [see table]. Organic matter loss alone, however, is a contributing factor in the other four.

Consider how the lack of humus affects the following:

EROSION: Soil that loses organic matter also loses its texture. Plowing then works to compact the soil, destroying the vestiges of structure. When water is applied, it cannot penetrate and runs off, carrying with it layers of earth—and soluble fertilizers and pesticides.

ACIDIFICATION: An acid soil makes it harder for crop plants to grow. Paradoxically, the nitrogen fertilizers that we have concocted to increase and maintain crop yields are the primary cause of acidification. When chemical nitrogen fertilizers go into the ground, the ammonium compounds in them react to make nitrates, a nitrogen compound that nourishes plants. The chemical reaction, however, leaves free hydrogen ions that increase the soil's acidity. Humus substances do not create acids in this way; in fact, they help balance the soil's chemistry.

Acidification is costly to beat, particularly for farmers in the northern and western areas of the continent, far from lime-producing areas. These farmers never used lime before, because they never needed it—the soils were naturally buffered by their high organic matter. Now, millions of acres of wheatlands out there have been acidified by ammonia fertilizers and need hundreds of millions of tons of limestone.

SALINITY: Salinity is the direct result of irrigation practices, but the need for irrigation is related to the lack of humus in the soil. When a soil must be flooded frequently in order to supply water for growing plants, a part of the water evaporates, leaving natural salt residues on the surface that build and build until they make it impossible to grow crops.

More organic matter in the soil reduces the need for frequent irrigation, because it retains both water and air, making a healthy environment for roots. A typical low-humus soil, for example, might be capable of holding water equivalent to 20 percent of its dry weight; a compost, on the other hand, can hold 200 percent of its weight. Each percent of organic matter that you add to a soil increases its water-holding capacity by 6 to 10 percent.

COMPACTION: Organic matter creates a structured environment in the soil through which water and air become available to plants. The lack of organic matter leads directly to compaction, which is nothing but the lack of pores in the soil, and the consequent lack of these crucial elements.

Compaction is disastrous for a plant's roots. They can't penetrate deep into the compacted soil, so they suffer in droughts or high winds. Corn, for example, can send roots three feet deep in every direction, but in many of our agricultural soils they get no deeper than eight to ten inches. Those plants keel over in a storm and brown in droughts.

Whatever measure you use to show soil degradation, loss of organic matter is part of the problem. Our soils have become pale and lifeless slabs because we have not maintained the humus—the stable and productive organic matter—in them. WFB

COSTS OF SOIL DEGRADATION IN CANADA($ MILLIONS)*

Trait	*Western Provinces*	*Central & Eastern Provinces*
Erosion	440	89
Organic Matter Loss	325	-
Acidification	60	12
Salinity	212	-
Compaction	12	127
hline TOTAL	1049	228

* after Rennie

THE LOSS OF THE SOIL

Composting is more than an efficient way of keeping lawns green. At Woods End we are concerned with building soil. Agricultural soils in particular have suffered for forty years from practices that bleed them of organic matter and render them stiff and unproductive.

When I talk to groups of people about the soil, I show my audience two pictures and ask for their comments. I don't tell them what to look for. The first is a shot of a bare, pale potato field. The landscape actually looks quite serene, but people say things like "It looks like a desert, it's so light in color." Intuitively, they can tell that a loss or a deprivation is taking place on that land. Something is missing.

The next shot I show them is a dark heap of compost. It is a remarkable contrast to the wasted soil of the potato field. In fact, in this steaming pile is everything the pale field lacks. And people sense this fact without being told.

Yet the pale, degraded soil of that potato field is not unusual. Wherever intensive monocrop agriculture has been practiced, a damaged soil is not the exception but the rule. Increasing doses of high-nitrogen fertilizers, plus herbicides, pesticides, and fungicides, can mask the symptoms, but not forever. A 1989 USDA study shows that soil erosion alone costs Americans $10 billion each year in off-farm damage. A Canadian study estimates that the cumulative costs of soil degradation in that nation will reach $45 billion between 1990 and the first quarter of the next century.

The same study estimates that in Canada's western

Too often farmers are not given the choice of acting to manage their land sustainably. In practice they find themselves caught between the positivist scientist's supreme faith in technology and the environmentalist's puritan zeal.

provinces alone, more than $1 billion of value annually is drained from the fields. The losses are broken down into five categories: erosion, organic matter loss, acidification, salinity, and compaction.

These might seem to be five separate problems of varying gravity, but in fact all of them are related [see sidebar]. The loss of organic matter contributes to the other four problems.

For all five of these quantified losses, then, the cure is to replace the humus that years of intensive farming have removed from the soil. There are two important ways to do this: by managing crop rotations to include soil-building crops, and by applying stabilized compost.

THE ORGANIC ARCHITECTURE OF SOILS

The conventional understanding of a fertile soil puts emphasis on the quantities of plant "nutrients" it contains. In theory, if I apply sufficient fertilizer to meet these needs—chiefly compounds containing nitrogen, phosphorus, and potassium—then the soil will be fertile and plants will thrive. What this idea fails to note is that the soil is not a factory but a habitat. Good soil is not only a question of inputs and outputs, but structure and biology. The soil's health depends in large measure on how well water, air, and nutrients are able to circulate through it, nourishing the diverse populations of soil flora and fauna.

Structure is a magic word in understanding soil. A healthy soil is an assembly of what are known as stable aggregates. Basically, an aggregate represents hundreds of little particles held together dynamically in one macro-particle. In this form, the particles will hold five times as much water and air as they would separately, because each one not only holds its own envelope of liquid and gas, but creates enclosed channels and vessels, protected habitats where more air and water can be stored.

Humus is the architect of this structure. Classically, the Germans have thought of humus as being of two kinds: *Dauerhumus*, from the German word to last, is the stable organic matter that promotes long-term structure in the soil. Some humus of this type has been dated at almost two thousand years old. This stable humus physically bridges the mineral grains, making room for air and water to penetrate. It is a kind of architecture from inside. *Nahrhumus*, from the word to nourish, is nutritive humus on which the megabillions of soil microbes feed. When this readily decomposing organic matter is digested by the microbes, most of it returns to the air as carbon dioxide, but in the process it contributes to the growth of the microbes and to their secretion of long-chain organic molecules like polysaccharides, which bind particles together like rubberbands around a sheaf of papers.

Picture the result: the stable humus turns a tight, stiff structure into a labyrinth of winding paths and hidden chambers, and the polysaccharides and other "glues" secreted by the microbes bind these structures into relatively permanent features, able to withstand the continued action of air, water, and nutrients.

Stable aggregates are so important to soils that we can tell the health of a soil simply by testing for aggregate stability. The experiment is simple: Place a given mass of the soil sample in a wire basket whose mesh is small enough to pass the smaller soil particles. Dip the basket in water twenty or thirty times. Dry what remains in the basket and weigh it. The comparison between original and final weight gives you a reliable measure of how well your soil would hold its structure through a winter's rains. Some aggregates survive the test virtually unchanged, but many don't. I've had people watch this test and call out, "Hey look! This soil's falling to pieces!"

The soils coming from even a single farm can differ like night and day, depending on whether they were intensively cropped or held in a cover crop. We often test the soils and flabbergast the farmer by telling him which was which. He may think it is speculation on our part, but it is just the aggregate test. Sometimes, the difference in amounts of organic matter between one field and another are not that significant—maybe only the difference between 1 and 1.3 percent. But that first soil might have an aggregate stability of only 10 percent, while the second would have one of 40. The quality of the humus would make the difference.

A farmer might try to tell me that he could get just as effective a level of organic matter by plowing back crop residues into the soil as he would by composting, but I would have to disabuse him of the notion. After the microorganisms have digested what he ploughs under, the amount that remains behind is so small, it can't even be measured. Most of it has returned to the atmosphere as carbon dioxide. To get the organic matter he needs to give him a healthy soil, he must return a good deal more than just the dried stalks of his corn or the chaff of his wheat. One thing he can do effectively and cheaply is to compost.

THE FARMER IN THE MIDDLE

When I work with farmers and we begin to compost on their farms, they take one look at the compost heap and know, without seeing my data, that this is what they want. "I don't want to sell this, or give it away," they conclude. "I want to use it to build my own soil."

Farmers are practical participants in nature—they go out into their fields to get a sense of the day's weather, they

© WOODS END RESEARCH LABORATORY

A worker mixes woolen mill waste and sludge with horse manure to make compost windrows.

© WOODS END RESEARCH LABORATORY

© WOODS END RESEARCH LABORATORY

Above: A spreader mixes paper waste and manure into a compost pile.
Above right: This compost recipe combines culled potatoes with paper, sludge, and sawdust.

© WOODS END RESEARCH LABORATORY

A Polish farmer seeds compost-fertilized fields using a horsedrawn wagon.

rub and squeeze the soil to see if it is fit to plow. They have an experiential knowledge that is qualitatively different from knowledge learned in laboratories or offices. Yet too often farmers are not given the choice of acting to manage their land sustainably. In practice they find themselves caught between the positivist scientist's supreme faith in technology and the environmentalist's puritan zeal. Neither one has the farmer's practical knowledge of nature, but both presume to tell the farmer what to do.

The mounting impasse between scientific and environmental forces results from a profound likeness in the thinking on both sides. On the one side this technological thinking gives rise to environmental abuse; on the other side it produces controls, punitive standards, and regulatory "cleanup mechanisms." It is like a tug of war, with the farm as the battleground. On the one end, the agricultural scientists, from their industrial framework, are saying, "Yes, yes, more, more!" On the other end, the environmentalists, from their regulatory framework, are saying, "No, no, less, less!" And the farmer, pulled more and more, less and less able to make his own decisions, feels frayed and ready to break.

The technologies some scientists are creating present a bizarre paradox. Instead of working in an area where we do have a serious problem—with soils, crop rotations, water—these scientists go to the molecular level and begin to manipulate genes, potentially creating new problems where previously we had none. Instead of helping the soils, for instance, they say, "Let's make plants that grow bigger faster."

I once worked in a major research lab where the geneticists were obsessed with the fact that a plant uses only a tiny proportion of incident sunlight for photosynthesis (less than two percent)—that nature had built such apparent inefficiency into her systems. If only they could double her efficiency, they reasoned, just think of what it would mean for agriculture.

I did think about it. A corn plant twelve feet tall already exists, and it is pretty staggering, but imagine this new, sun-efficient corn plant. It might stand twenty feet high. It would certainly fall over in a wind, because the soil couldn't hold it. And the ears would be bigger too. How would they be kept on the plant? Finally, the nutrient demand these superplants would place on the soil would require a far greater volume of fertilizer than we use already. In short, the heroic scientist would face problems engendered by his solutions. Yet who would take the blame?

The farmer, most likely.

And who would do the blaming?

The heroic environmentalist, whose response to all problems is to say no. A farmer's blood boils when he sees a headline like the recent one in the *New York Times*: "EPA Says It's Ready to Battle Drainage from Farms." To the EPA, chemical fertilizers, manure, and municipal sludge—whichever—are all now classified as "alternate pollutants" when they are applied to agricultural fields. Such rulings focus entirely on the negative and do not discriminate. Soon, legumes are likely to be classed as "alternate pollutants," too, because potentially they can fix too much nitrogen. The environmentalists correctly identify the problems, but they don't know how to solve them.

TAKING ACTION

I show a farmer the EPA study that blames sixty-five percent of surface water pollution on agriculture, but unlike the environmentalist, I don't just stay, "Stop it." I say, "What are we going to do now?" We don't need more studies. We need to take a positive, active approach to the soil problems we now recognize. If we start thinking with our hands, as the farmer does when he practices his craft, people will see the results, and something may begin to change.

At Wood's End we put the return of organic matter to the soil at center stage, because that is one of the important links in soil building that has been broken by modern agriculture. When we created an intensive, specialized agriculture, we separated the components by great distances—the cows may be in one state, the grain fields in another, and the processing plant in a third, hundreds of miles apart. Because of this separation, the manures and straws and other residues that once would have found a use have come to be regarded as noxious wastes.

What other people see as troublesome remains we see as opportunities. Say industry A is over here and industry B over there. Between them is farmland. All the raw ingredients for their products came from farms, but none of the residues are going back to farms. After all, you can seldom apply chicken-processing wastes or leather wastes in a raw state to the soil. Both are high in nitrogen, but also very volatile. People would say, this is recycling? It smells awful. Even if you could get the neighbors to put up with the stench of the raw waste, many of the nutrients would be lost to the air. But by bringing these residues back where they came from and composting them, we can do something sensible and practical. We can transform these unpalatable wastes into stable humus.

Composting takes divers materials that are not useful or desirable in themselves and converts them into a new product, one that is superior to any one of its source materials in stability, smell, and plant nutrients. We have documented that by using composts, growers can reduce their need for chemical fertilizers by twenty to seventy-five percent, depending on the conditions and the crops. That is by no means optimal—we would prefer to see no chemicals used at all, but we haven't the leisure to wait for perfection.

Our first effort at Wood's End to put compost into action was with the seafood industry in Maine and Florida. Fish wastes—the guts and dead discards of crabs, dogfish, salmon, etc.—are very high in nitrogen and very obnoxious to the nose. Nobody wants to see them on the land. But we combined them with sawdust—a waste of the forest-products industry—to make a compost that has been very effective in growing everything from tomatoes to corn.

In British Columbia, we did a variation on the theme. We took the wastes from the local aquaculture industry—chiefly dead salmon—and mixed it into the manure lagoons on dairy farms. Then we added straw and composted the mixture. The finished compost was sweet-smelling, and most of it went back to the farm's fields.

Another source of tremendous waste is chicken-processing plants. Our introduction to the problem was through a mass grave. A large farmer in Maine had lost one hundred thousand chickens, all suffocated in a fire. He buried them right away, in an aquifer zone back of the poultry houses. When the Maine Department of Environmental Protection found out, they naturally had a fit. The farmer had to hire a big crane and dig them all up again. It was a ghoulish sight, all those sloppy, gooey, half-rotted animals. That is when the farmer called us in.

Of course, they could have dried and incinerated the carcasses, but what an expense that would have been. Instead, we mixed them up with sawdust and chicken manure into windrow compost piles. A month later, it was all humus. Even the bones had been transformed. And within another week, the farmer had spread all of that sweet-smelling compost back on the land to grow more chicken feed. Everybody was happy, even the DEP.

We can even deal with wastes that are diseased, because composting generates sustained heat that kills the pathogens, making the finished compost safe to return to the soil. Intensive, monocrop farming and centralized processing are very susceptible to the spread of disease. In Maine, for example, we started having a crisis with potato wastes, especially with the decline of the starch industry. And the potato culls were found to be full of diseases—*Fusarium, Rhizoctonia, Phytophthora, Erwinia, Corynebacterium.* We proposed composting.

We did the trials on the farm of one of Maine's largest potato producers, composting the potato culls with wood shavings and cattle manure and tracing the pathogens through the entire process. At the end they were all gone, except for *Rhizoctonia*, which is pervasive in nature anyway. The sustained 150-degree heat of a properly cooking compost pile had killed them. As a final test, we took this potato compost and grew a new crop of potatoes, mixing the compost into the farmland in different dosages. There was no disease transmission, even at the highest doses of compost.

Industrial wastes are also candidates for composting. We worked with a wool plant and a farmer, neighbors in western Maine, who have cooperated to solve a waste problem and help build soil through the use of compost. The recipe we concocted used the fleece fibers and feces, dirt, and other residues from the factory, mixed with horse

The new governments of Eastern Europe have an unprecedented opportunity. Many small farms have biologically sustainable natural systems already in place, because, ironically, their farmers have never been able to afford herbicides, fungicides, pesticides, or chemical fertilizers.

manure from a local raceway. Both the woolens people and the track people were in trouble with the EPA—the wool processor told me that a single day's fine for dumping excess waste into a stream was equal to more than two years of Woods End's fees—so they gave their wastes to the farmer in return for his composting them on land leased to him for free by the woolens company. The compost he produces goes directly onto his corn acreage, where it reduces his need for chemical fertilizers by more than fifty percent. Whatever he can't use on his own lands he sells for landscaping.

As we gain experience, we begin to look around an area for the wastes that need composting. Sometimes the combinations are surprising. In Massachusetts, we took on a project that combines seven thousand tons of guinea pig manure, ten thousand tons of cranberry waste, six thousand tons of paper sludge, and ten thousand tons of chicken manure. Everywhere, the point is to regenerate landscapes by means of their own wastes.

THE FUTURE IN THE PAST

In some corners of the world, soil building never went out of fashion. On the old agricultural estates of turn-of-the-century Poland, for instance, the farmers polished their plowshares in the field before returning to the barn. They didn't want even a crumb of soil to be lost. And farmers composted all their manure. Each year, they'd take it from the barns out into the fields, where they would mix in straw and leave it to cure in windrows for the winter. Those estates are gone, but in the villages of Eastern Europe these land-wise traditions are still being carried on. When I visited last spring, the Polish farmers were caringly, sparingly spreading the composted manure around their fields.

The new governments of Eastern Europe have an unprecedented opportunity. Many small farms have biologically sustainable natural systems already in place, because, ironically, their farmers have never been able to afford herbicides, fungicides, pesticides, or chemical fertilizers. And their farmers have always been careful with their resources. Furthermore, Poland does not subsidize its agriculture at all, and the country is completely self-sufficient in food. Now, with freedom and private ownership, these countries have the ingredients for a remarkable system.

Last year Woods End was called to Poland to study ways of improving the large farms. The Ministry of Agriculture believes Poland will never be able to afford the level of chemical fertilizers and pest controls we in the West use, so they are deeply interested in natural methods. Fortunately, the Poles were not as efficient as the Soviets at converting small holdings into state farms. Only fifteen percent of Polish farms went that route, and to the Poles, two thousand acres is an enormous farm. (Many private farms in America are that size or larger.) The state farms that I visited were sick and disorganized places. They were terribly run down, because there was no pride in the work there. The farmers were just state workers, and their whole demeanor made me think of a prison farm in the United States.

As Eastern Europe opens, we in the West have a choice. We can either lead these countries down the same road that has done so much damage to our own soils, or we can help legitimize the methods of their best small farms, which can be models of farming useful to us all. In Poland, for instance, we can show the Ministry of Agriculture how these small farms can work as biologically and economically sustainable systems, and help augment their practices and apply them to the rest of the nation's farms. Now that the former state farms are being privatized, our task, for instance, is to bring together the waste material on and around these farms—materials that up to now have simply been dumped in landfills and lagoons—and compost it, so that these farmers can treat the soil as carefully as their smaller neighbors do.

Woods End is certainly not the only Western firm now consulting in Eastern Europe. Farmers there are under great pressure to convert to intensive, chemical-driven farming. I can hear the salesmen saying, "So you're already self-sufficient, but think of the export market you could have! I could make this field of yours ten times more productive!" This would, among other things, give farmers the hard currency to purchase Western agricultural chemicals.

Events may well take this course. But the people would pay for it, as we are paying for it, with billions of dollars' worth of lost and degraded soil each year. Eastern Europe has the chance today to avoid the mistakes that we in the West started making a long time ago. We went the chemical route, because our science sanctioned it; we did not see the consequences. Now we know better, but we are enmeshed in a virtual tradition of chemical farming. Our situation is difficult because we are going to have to dismantle whole blocks of policies, educational structures, and incentives in order to get into our future. The Poles can build a new agriculture on the basis of a sound existing tradition. Perhaps they are going to be the ones to show the way to a sustainable future, through a revaluation of their surviving past. ●

William F. Brinton is founder and director of Woods End Research Laboratory.