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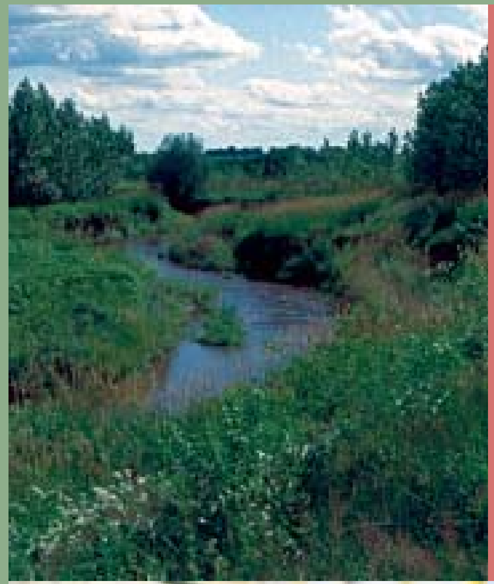


Economic Benefits WITH Environmental Protection

No-Till and Conservation Buffers in the Midwest

Conservation Technology Information Center

Syngenta Crop Protection

Introduction

No-till and conservation buffers — especially when used together — have proven to be extremely efficient and effective tools for reducing erosion, protecting the quality of surface and ground water and providing habitat for a variety of wildlife species. In addition, no-till farming has helped many growers become more efficient and cost-effective producers of key commodities. And after several years in continuous no-till, the physical characteristics of most soils improve.

Despite those benefits, the adoption of no-till has slowed in comparison to the explosive growth of the early 1990s and has not achieved its full potential in the years since. The shortfall is particularly noticeable in no-till corn, where no-till crop performance in cool, wet springs has dissuaded many growers from adopting the practice for its other advantages.

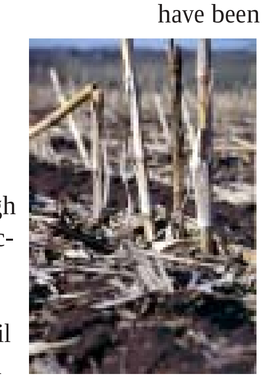
Prime Opportunities

Farmers and the environment in the nation's Great Lakes watershed and North Central region – which include Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio, Wisconsin and the western portions of New York and Pennsylvania — stand to benefit tremendously from increases in no-till and conservation buffers. Though the land is extremely productive, millions of acres in the region are highly erodible. Runoff causes significant soil loss and threatens rivers and lakes. Wildlife habitat has been dramatically reduced over the decades, but much of the region lends itself to the development of miles of outstanding cover for birds and mammals as conservation buffers are installed.

On the other hand, there is no shortage of challenges to no-till adoption in the area. Soils can be heavy and poorly drained. Cold, rainy spring weather can keep no-till fields too wet to plant in a timely fashion. And a long history of tillage is difficult to overcome, especially in areas considered to be among America's best farmland, soils that are believed to respond well to tillage. Perhaps most daunting, no-till delivers most of its soil-building benefits only after several years of continuous implementation.

Farm programs that reward yield over conservation, the demand for uniform planting conditions by large-acreage farmers, the need for more intensive management under no-till and resistance to change on the part of landlords and growers are formidable forces.

Fortunately, conservation buffers have been an easier sell — due in no small part to aggressive promotion by an array of agencies and conservation groups and to an influx of funds that make buffer contracts economically attractive to landowners.



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No-till allows buffers to function better. Buffers serve as the last line of defense for water bodies, especially during intense rain events. The synergy between buffers and no-till, coupled with lessons from successful buffer promotion, can help propel the adoption of both of these important practices to new heights.

This document will explore many of the challenges, opportunities, management tactics and successful marketing efforts that will shape the next decade of promoting conservation in the Great Lakes watershed and North Central region.

Definitions

According to the Conservation Technology Information Center (CTIC) and the National Association of Conservation Districts (NACD), no-till is a farming system in which at least 30 percent residue is left after planting and two-thirds of the row is left undisturbed from harvest through seeding. Weed control is achieved with herbicides.

Soil disturbance is limited to planters or drills that can cut through residue, though certain disturbances such as row cleaners, injection knives, row-crop cultivators, rotary hoes or harrows may also be allowed. Strip-till or zone-till also may be classified as no-till as long as less than one-third of the soil surface is disturbed.

Conservation buffers are living filters — relatively narrow strips of permanent vegetative cover strategically located to intercept runoff or wind. Size, shape and type of vegetation may vary dramatically depending on region and the task at hand.

Lake Erie Buffer Team

Status Report

Driven by the concerted efforts of growers, conservation farming advocates and the conservation compliance provisions of the 1985 and 1990 farm bills, the adoption of no-till practices in the early 1990s grew dramatically.

Conservation tillage practices are credited for saving more than 1 billion tons of soil per year nationally on cropland and Conservation Reserve Program (CRP), according to the National Resources Conservation Services (NRCS) National Resources Inventory (revised 2000). Sheet and rill erosion on the nation's cropland plummeted from an average of 4.4 tons per acre in 1982 to 3.1 tons in 1997, a 30-percent drop. Average losses to wind erosion during the same period were reduced by 31 percent (NRCS, 2000).

In the North Central region, results were just as dramatic. Missouri farmers enjoyed a remarkable decrease in erosion on cropland, cutting soil loss from 10.9 tons per acre per year in 1982 to 5.6 tons in 1997. Ohio reduced its cropland soil loss from 3.8 tons per acre per year in 1982 to 2.6 tons, while Illinois moved from 6.3 tons to 4.1 tons during the same period. Minnesota, where no-till adoption was relatively low, saw more modest reductions, moving from 2.6 tons lost in 1982 to 2.1 tons in 1997 (NRCS, 2000).

No-Till Adoption Patterns

No-till, the highest degree of conservation tillage, has exhibited an interesting adoption pattern. Between 1990 and 1992, no-till soybean acres more than doubled in the North Central region, from 3.2 million acres to 7.5 million acres. As growers found no-till to be extremely cost-effective and successful in soybeans, adoption continued on nearly the same trajectory throughout the rest of the decade, reaching a level of 17.3 million acres, or 37 percent of the soybean acreage in the region, by 2000 (CTIC, 2001).

Corn was a different story. No-till corn acres reached a high of 9 million acres in 1994 in the North Central region, then — after a couple of cool, wet springs and mixed success with no-till corn — acreage declined to 7.5 million acres in 1996 and hovered around that figure through 2000 (CTIC, 2001).

The discouraging level of no-till corn adoption in spite of expanding no-till soybean acreage reduces the total erosion control potential of no-till farming in the Midwest. This also limits the opportunity for growers to achieve the soil-building, infiltration-enhancing and equipment-reducing benefits of continuous no-till. For no-till to achieve its highest potential as a management system and profitability enhancer, further efforts must be made to increase adoption of continuous no-till — a system that employs no-till in both corn and soybeans.

NRCS

Buffers on the Land

Recognized for their role in protecting water quality and for their importance as wildlife habitat, and reinforced by financial incentives from government and private sources, conservation buffers have become a familiar component of many Midwestern landscapes. Nationwide, the National Conservation Buffer Initiative reported more than 1.2 million miles of conservation buffers, or 4.5 million acres, had been installed through April 2002 (Schnepf, personal communication). Nearly half of those miles were enrolled through continuous CRP or Conservation Reserve Enhancement Program (CREP) initiatives; another 25 percent was pre-1991 CRP land adjacent to water bodies that was credited to the buffer initiative (Schnepf, personal comm.).

Ironically, buffers seem to have become most popular where no-till has not. National Buffer Initiative data for April 2002 show just 57,625 acres of buffers in Indiana, where 60 percent of the state's soybeans and 21 percent of the corn were no-tilled. By contrast, Minnesota, where less than 2 percent of the state's corn and 4 percent of its soybeans were in no-till systems, had more than 227,000 acres of buffers enrolled through CRP and CREP.

Protecting Water Quality: The Maumee River Basin

The Nature Conservancy

The impact of conservation tillage and buffers on water quality has been demonstrated on a grand scale in Ohio's Maumee River basin, which drains into Lake Erie. The Maumee was the largest contributor of suspended sediment to Lake Erie, and the focus of a significant push for conservation tillage – in fact, between 1993 and 1998, conservation tillage practices were applied on approximately 53 percent of all crop fields (Myers et al., 2000).

At Waterville, Ohio, researchers detected an 18.1 percent decrease in the amount of total suspended solids (TSS) carried by the Maumee between 1975 and 1995 (Richards and Baker, 2002).

Data collected between 1989 and 1995 in a Maumee tributary, the Auglaize River, recorded a reduction of 49.8 percent of TSS (Myers et. al, 2000). A high conservation tillage adoption rate – 65 percent of the Auglaize watershed's cropland – may well explain the significant reduction in sediment export at that site (Baker, personal communication, 2002).

Other best management practices (BMPs) adopted widely in the Maumee River basin – notably a 37 percent drop in phosphorus application after P purchases peaked in 1979, and a jump in conservation tillage between 1990 and 1995 – are also believed to have helped lower TSS, phosphorus and nitrogen levels in the Maumee (Richards and Baker, 2002).

Adoption of reduced tillage and other agricultural BMPs was encouraged by U.S. EPA cost-share funds for the purchase of reduced-till equipment or the conversion of conventional equipment to adapt to conservation farming. The success of local farmers in managing soybeans under reduced tillage systems also sparked enthusiastic adoption (Baker, personal communication, 1999).

Linking the Two

Though there are no data linking no-till and conservation buffers, the two practices represent a natural fit. No-till lowers pressure on buffers and reduces maintenance demands. In turn, buffers serve as a backup to no-till, or a last line of defense.

The farmer who sees the water quality protection benefits of buffers could be more amenable to trying no-till. The pheasant nesting in a buffer can enjoy a more abundant food supply in an adjacent no-till field. And the NRCS conservationist or soil and water conservation district (SWCD) representative trying to promote soil and water conservation can learn volumes from the successes and challenges encountered in the drive for adoption of either practice. By supporting buffers with no-till and backing up no-till with buffers, thousands of America's farmers could enjoy the healthier farms and heftier bankbooks that conservation can deliver. ■

"Who's the Customer?"

NRCS

Anyone with a product or practice to promote will benefit from understanding who his or her customer is. The same applies to conservationists seeking to convince farmers to adopt no-till. A USDA Economic Research Service report (Christensen, 2002) helps shed some light on no-till "customers."

Based on data from 1996, Christensen determined that the no-till grower was more than twice as likely as conventional growers to have graduated from college (30 percent vs. 12 percent). No-till adopters averaged 47 years old, while conventional corn growers were an average of 52.

No-till operations tended to be larger and less diversified than their conventional counterparts. No-till farms in the study averaged 913 acres while conventional operations averaged 460 acres. No-till producers garnered 61 percent of their income from crops and just 2 percent from livestock, compared to 48 percent crops and 39 percent livestock among conventional growers. Just 6 percent of the no-till farms' cash receipts came from government payments, compared to 10 percent of the cash receipts on conventional operations.

Rotational Tillage

Deere & Co.

The acreage figures on no-till adoption in the North Central/Great Lakes region do not tell a complete story. Soil scientists and experienced no-tillers attest to a lengthy transition period between the adoption of no-till and a significant improvement in soil structure and health. It is a period that can easily last several years as the soil recovers from years of tillage — and a recovery that can be set back dramatically by a single soil disturbance event.

So although state no-till acreage data in Indiana show that 60 percent of the state's soybeans and 21 percent of its corn were no-tilled in 2000 (CTIC, 2002), less than 9 percent of the state's cropland had been continuously no-tilled during a 1994-to-1999 transect study (Hill, 2001). Those data underscore the prevalence of rotational tillage, the practice of switching between no-till and tillage on a crop-by-crop or occasional basis.

A study of soil aggregation (the formation of groups of particles stuck together by stabilizing agents such as organic matter) compared moldboard plowing with other management tactics over five years of continuous corn. The researchers found that aggregation in the top two inches of soil increased 120 percent under no-till, 35 percent in ridge-till and 31 percent when chisel plowed. Plowing the no-till plot brought the soil back to its original condition in a single season (Hill, 2000).

No Chance

Unfortunately, the large majority of no-till fields — especially in the northern Midwest — are disturbed well before the benefits in soil structure and biology are realized. In fact, the average number of years that a no-till field had been continuously no-tilled over the course of three-state, five-year transect studies was 2.4 years in Illinois, 2.3 years in Indiana and just 1.4 years in Minnesota (Hill, 2001).

In a report on Indiana's transect studies, Purdue agronomists wrote, "given that most research suggests the no-till benefits to soil physical property characteristics begin to appear no earlier than the third year of continuous no-till, it appears most farmers are abandoning no-till at about the time that one would expect to reap the soil physical property benefits associated with no-till." (Evans et al., 2000)

Necessary Evil?

Certain soils and certain weather conditions arguably call for some form of tillage, especially before planting corn, which is less tolerant of the cool, wet soils that are prevalent in no-till fields.

A five-year trial in Woodstock, Ontario, between 1996 and 2000 demonstrated that adding a chisel pass before corn in a corn/no-till soybean/no-till wheat rotation added six bushels of corn per acre over no-till corn in the same rotation. Yields of soybeans and wheat were equal in both chisel and no-till systems. At $2 corn, some might question whether the cost of chiseling, (let alone the lost, intangible value of improved soil) is covered by the yield boost (Stewart, 2002).

Deere & Co.

Even so, the prospect of an additional six bushels of corn per acre — compounded by the drying action of tillage and the sense of security associated with familiar soil management practices — may well be incentive enough to draw farmers away from continuous no-till.

Fear of the severity of the transition period — during which yield impact could depend on a variety of factors ranging from short-term weather conditions to the field's history of compaction and loss of soil structure — may also lead growers to rotate back to tillage.

Hard Sell

Rotational tillage programs are not a total loss — at least they offer the greatest possible residue protection in the alternating years in which no-till is practiced. And it is likely that the tillage performed in the rotation may well conform to crop residue management practices that leave significant residue cover on the soil surface.

But rotational tillage — for benefits real or perceived — is depriving many growers of the most important soil improvements that continuous no-till has to offer. Convincing growers to adopt continuous no-till after practicing rotational tillage could be a very hard sell. After all, they are likely to have validated their fears about no-till, pulling their equipment through soils at the worst phase of the conversion process in no-till evolution. Worst, they are unlikely to have ever seen the soil return to a better state after years without tillage.

Continuous No-Till

Ralph Windmann, Mexico, Missouri

Steadily enlarging his farm since beginning to no-till in 1984, Ralph Windmann of Mexico, Mo., has waited patiently as field after field of rolling, silty clay loam soils have gutted through the transition to continuous no-till and emerged better-drained and easier to farm.

"The first year is not a problem," he says. "The second year, the soil gets a little harder, seems a little more lifeless. The third year is the worst – it's harder than a brickbat. The fourth year is more like the second, and the fifth year is like the first. Then it gets better from there."

No-till proves itself on the balance sheet, too. "I like what I see happening to the soil, I like what I see happening in the environment, but economics rule everything," Windmann notes. "It takes far less equipment, far fewer hours to no-till row crops than farming them conventionally. Machinery costs are less and herbicide costs, managed properly, have been dead even.

"The largest tractor I have in my machine shed for a 1,100-acre operation is 95 PTO horsepower," he points out. "I've also got one XT90 Allis Chalmers, which is 93 horsepower at the PTO and is old enough to vote. My wife and I farm the whole operation, and I teach vo-ag full-time. I don't see how people can say that no-till can't compete economically."

Windmann recommends that other growers experiment cautiously with no-till and give it enough time to really work before committing all their acreage.

Bruno Alesii, Monsanto's manager of technical development for conservation tillage and chairman of the Conservation Technology Information Center, adds that the past few years have taught no-till proponents that solving problems in advance eases the transition to no-till. "We now recognize that if you address soil problems such as compaction, fertility, and pH and tailor your management strategies to your soil conditions before you make the switch to no-till, you don't have to wait the four or five years it takes for Mother Nature to fix these problems," he says.

Steve Fairchild, *Today's Farmer* Magazine

Ironically, disking under a soybean stand that succumbed to cold, wet spring conditions proved to Windmann the value of continuous no-till. "One pass with a disk and the soil absolutely powdered up," he says. "When we used to till, there was no way I could have had such a great seedbed after one pass with a disk. It showed how much better the soil structure is after 15 years in no-till."

NRCS

Barriers to Adoption of No-Till

Growers in the Midwest cite an array of reasons for not adopting no-till practices — especially continuous no-till cropping, which involves no-tilling both corn and soybeans, as well as other crops. Certainly, recognizing obstacles helps explain the slowdown in the rate of increase in no-till acres. Just as important, enumerating and understanding those concerns may help growers and conservation tillage proponents to overcome them.

Among the most significant challenges in maintaining a high rate of adoption and enthusiasm for no-till and conservation buffers is that the most motivated growers have already adopted the practices. That leaves a much more skeptical audience for the next round of efforts and encouragement.

CTIC compiled a list of barriers to the adoption of no-till from numerous grower surveys.

Yields

Concerns over yield reduction topped the list. This is especially compelling in corn production, where no-till yields can be several bushels per acre less than yields from tilled fields. Yield lag is a particular concern where fields have not been in continuous no-till long enough to improve soil structure and infiltration, or if spring conditions have been cool and wet enough to slow emergence and reduce stand.

Yield reduction is of particular concern to landlords and professional farm managers, as most rental contracts are predicated upon sharing yield between landowners and farm operators. Corn yields often drop, at least slightly, in the early years of no-till corn; meanwhile, economic savings accrue to the farmer. Neither case is appealing to a landlord, and in a highly competitive rental market, many operators may be dissuaded from no-tilling because they do not want to miss the chance to rent a choice parcel.

Cold and Wet

In a related objection, many growers point out that portions of no-tilled fields can be too cold or wet at planting time. Timely planting improves yields, while planting later reduces yield potential. Just as bad, rushing to plant a crop into wet soil can create tremendous problems with soil compaction from heavy equipment — problems which can last years and could even require deep ripping to address — or challenges in placing seed and closing the seed furrow.

Equipment

Growers perceive specialized no-till equipment as a costly expense and a significant barrier to adopting no-till. Though many analyses of the economics of no-till production point out that equipment costs can be reduced by switching to no-till, many assume that the grower maintains smaller tractors and divests of tillage equipment. However, growers who hold on to their tillage equipment and invest in new planters and drills are indeed investing significant resources in no-till.

Increased Chemical Use

No-till is extremely dependent upon herbicides to replace the mechanical control of weeds on cropland. Historically, herbicide bills have been somewhat higher in no-till than in conventional systems. In recent years, the advent of Roundup Ready crops and the drop in price of many popular herbicides has narrowed the gap. In addition, agronomically sound weed control programs combining preemergence and postemergence herbicides can be much less intensive than earlier no-till weed management strategies. Many growers report that the total amount of herbicide used is often less than under conventional tillage after 4 to 5 years of no-till.

Other Reasons

In addition to the most-cited objections to no-till, other concerns often emerge. Growers worry that no-till can increase problems with certain weeds, insects and diseases — they risk yield loss, or simply do not want to take on the added management tasks necessary to combat those challenges. They chafe at the prospect that they might be limited to certain rotations. Many worry that high levels of crop residue can be too challenging for their equipment.

And thousands are convinced by high yields and a history of success with more conventional systems that they don't need to fix a system that is not broken.

Technology, management and a willingness to endure the transition period to continuous no-till — which can be a significant investment or pass by relatively unnoticed, depending on soils and weather during the critical early years — can overcome most objections. But the grower needs to commit to no-till, and that's where the marketing job lies for conservation farming advocates.

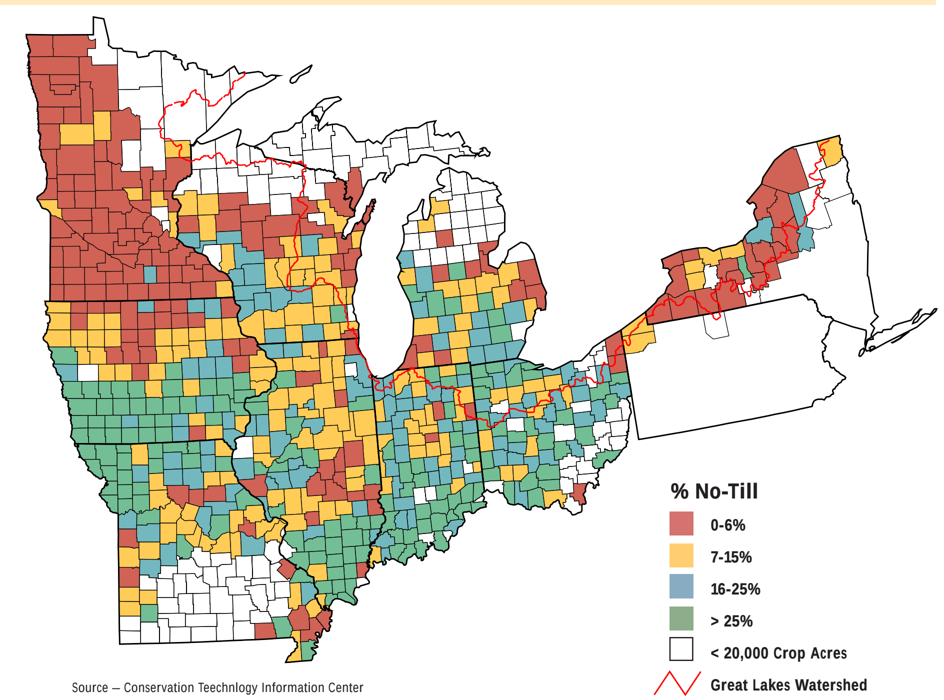
Buffers Better Accepted

Conservation buffers have been significantly easier for conservation and water quality advocates to promote to growers, largely because the buffer effort has been backed by a slew of economic incentives. Programs range from enrollment in the Conservation Reserve Program (CRP) and Conservation Reserve Enhancement Program (CREP) to incentives from the Wetlands Reserve Program (WRP), Environmental Quality Incentives Program (EQIP), the Wildlife Habitat Incentives Program (WHIP) and a host of state and private cost-share and bonus efforts.

Complaints seem to primarily surround frustration with rigid buffer construction guidelines, complicated programs and the feeling among some growers that some of the best farmland — rich bottom ground — is tied up in buffers.

But the biggest challenge facing buffer proponents appears to be the need to communicate one-on-one with growers (and prospective partner organizations) in order to get benefit and funding messages across. It is a costly and time-consuming process for many districts and local watershed groups, but it has paid off because conservation buffers offer significant benefits, up front, to both the environment and the landowner. As buffers increasingly line the landscape, promoting proper maintenance will probably grow in importance. ■

Percent No-Till Corn Acres – 2000 Crop Year



Source – Conservation Teechnlogy Information Center

The Ohio No-Till Council

A program to recognize outstanding no-tillers in the early 1990s mushroomed into an extremely successful forum for information exchange and promotion of no-till farming practices: The Ohio No-Till Council.

Informal meetings of award winners, agribusiness representatives and NRCS leaders in the state led to two key realizations, according to Norm Widman, NRCS state agronomist in Columbus, Ohio. First, all agreed that there was abundant need for information on how to make no-till work in Ohio. Second, it became clear that the award winners themselves represented a wealth of experience and knowledge.

In 1997, the core group coalesced, elected a board of directors – six farmers, two agribusiness representatives, and a representative from The Ohio State University – and approved a set of bylaws. The Ohio No-Till Council was born.

Today, the organization boasts a newsletter circulation list of nearly 400 farmers and agribusiness members, plus NRCS conservationists and Soil and Water Conservation District (SWCD) staff and extension personnel. About 200 participants attend the Council's annual conference each December, and the organization participates in the Tri-State No Tillage Conference with Pennsylvania and New York.

Membership in the organization is free – Widman, who serves as organizer and volunteer newsletter editor, points out that keeping track of dues or subscription fees was too time-consuming to be worthwhile. A core group of 12 to 14 sponsors pay $100 each to cover the organization's expenses.

Wielding that limited budget, the Council is very productive. It co-sponsors one or two field days each year. Plans are underway to include plots at the popular Ohio Farm Science Review Site, which has plots that are visited by thousands of farmers each year. Fact sheets on no-till help the group disseminate information on the latest technology; the group also plans to build a web site.

Thanks in part to the Council, no-till adoption in Ohio is the highest in the region – in 2000, 24 percent of the state's corn and 62 percent of its soybeans were no-tilled.


NRCS

Environmental Benefits of No-Till

The environmental benefits of no-till are well documented by years of research. Meanwhile, exploration continues into the mysteries of the soil ecosystem, the unseen environment.

The most compelling statistic is that no-till can reduce erosion by 90 percent (Fawcett et al., 1994; Hebblethwaite, 1995). As the physical characteristics of most soils improve under a no-till system, infiltration rates tend to improve dramatically on those soils. In no-till systems, residue reduces the overland flow velocity of water, and high infiltration rates prevent water from leaving the field (Gilley, 1995). The first benefit can be achieved in a single season of no-till; the second requires a long-term commitment to continuous no-till. The buildup of organic matter is key to the improvements in infiltration, water-holding capacity and fertility — but it requires years.

The value of sticking with no-till throughout the rotation, of investing the time and resources to allow the soil to fully recover from tillage over the course of years, is the crux of the campaign for continuous no-till.

Residue Cover

The most readily apparent benefit of no-till is the protection of the soil surface by residue cover. It is residue that blunts the force of raindrops, that functions as millions of tiny dams on the field to trap water and sediment, that protects surface particles from wind, and that ultimately feeds soil flora and fauna.

Raindrops that fall unimpeded to the soil surface can dislodge small soil particles. In fact, an intense storm on an unprotected field can loosen and detach up to 100 tons of soil per acre (Shelton et al., 2000). Some of those particles can be carried off the field; others can settle between surface aggregates to seal the soil surface and reduce water infiltration.

Residue cover also traps snow and reduces evaporation of moisture from the surface of the soil. Those properties — which cause concern during a wet spring when they are characterized as slow-drying — are a boon when the weather is dry and moisture is precious.

No-till has proven to be the best system for preserving residue on the surface of row crop fields. A study on 13 Monsanto Center of Excellence farms in the Midwest showed these average surface residue levels over a four-year period:

- No-till corn/no-till beans: 69 percent
- Strip-till corn/no-till soybeans: 65 percent
- Fast start corn/conventional soybeans: 24 percent
- Conventional corn/conventional soybeans: 23 percent.

The fast start corn system uses a standard fall tillage system typical to the region, followed by spring burndown and planting into the stale seedbed, which remains untilled in the spring (Alesii and Buman, 2002).

Improved Infiltration

As soil regains its natural structure of aggregates and macropores and loses the temporary fluffy characteristics of tillage that makes many soils prone to sealing or crusting, infiltration improves. On many fields, no-till brings increased earthworms, improving infiltration further with their extensive tunnel systems. The result is a significant increase in the amount of water and water-soluble pollutants going down into the soil profile instead of running off the field's surface.

Preferential flow — the movement of water through large macropores and earthworm tunnels — in no-till is a double-edged sword. Improving infiltration can reduce flow to surface water bodies, but it might pump more chemicals and nutrients toward the ground water. The intensity of the rain event and the saturation of the soil during an individual rain event appear to be key factors.

Low-intensity rainfall can be absorbed relatively evenly across the soil surface, adsorbing certain water-soluble chemicals along the way. High-intensity rainfall appears to be more likely to saturate the soil and flow through macropores, such as earthworm tunnels, which can extend several feet into the soil (Melvin et al., 2000).

If a low-intensity rain event moves a chemical into the soil matrix, and is followed by a high-intensity rain event that causes heavy flow into macropores, the high-intensity rainfall could bypass the chemicals and minimize leaching. On the other hand, some studies suggest that if the high-intensity rain event occurs first, rainwater could wash the pollutants deep into the soil profile (Melvin et al., 2000). Other studies, including Kanwar et al. (1997), indicate that no-till fields experience less leaching under typical, natural rainfall conditions.

Fortunately, earthworm tunnels do not appear to be a perfect conduit for chemicals traveling toward the ground water. High levels of organic matter that line the tunnels appear to capture a portion of the pollutants (Melvin et al., 2000).

Keep Chemicals in Place

Minimizing the off-target movement of sediment and maximizing the infiltration of rainwater both serve to keep chemicals out of the nation's surface water. Tightly adsorbed pesticides, such as trifluralin, paraquat, glyphosate, terbufos and chlorpyrifos, cling to soil particles and can be washed into streams and lakes if soil is washed from the field. Moderately adsorbed pesticides such as atrazine, cyanizine, alachlor and metalochlor, may move with either sediment or water (Fawcett, 1995). Fawcett et al. (1994) summarized studies comparing runoff from no-till fields with runoff from fields that had received various kinds of tillage. In natural rainfall studies, no-till reduced pesticide runoff by an average of 70 percent, water runoff by 69 percent and soil erosion by 93 percent.

Organic Matter

The black gold in the soil is organic matter — the glue that binds particles into aggregates, the sponge that holds soil moisture, and the filter that can sequester pesticides. It's also a slow-release reserve of nutrients. But organic matter takes careful management — and it's among the first elements of healthy soil to disappear when tillage occurs.

Soil scientists divide organic matter into categories: the active fraction and stabilized organic matter.

The active fraction typically represents 33 to 50 percent of the total mass of soil organic matter. This is the storehouse that can release nutrients to the crop. In Minnesota, about 2 percent of the active fraction decomposes per season. At that rate, a soil with 3 percent organic matter — containing about 3,000 pounds of nitrogen per acre — could yield as much as 60 pounds of nitrogen and six pounds of phosphorous to the crop per season (Lewandowski, 2000). The active fraction can also chelate introduced nutrients, capturing them in a soluble form and keeping them available for plant uptake.

Stabilized organic matter — another 33 to 50 percent of the soil's organic matter — is the sponge and filter. Stabilized organic matter can absorb six times its weight in water, and

Does Organic Matter Matter?

Soil Texture	If OM increases from	Nutrient holding capacity may increase by	Available water holding capacity may increase by
Loamy sand (5% clay)	1.5% to 2%	14%	12%
Silt loam (20% clay)	3.5% to 4%	4%	7%

Adapted from Lewandowski, The Minnesota Soil Management Series, 2000

Minnesota studies show that a pound of stabilized organic matter has five times more cation exchange capacity (CEC) than a pound of clay (Lewandowski, 2000).

The balance of the soil's organic matter is made up of fresh organic materials and living organisms (Lewandowski, 2000).

Build-up and Burnout

Organic matter levels in the Midwest have been reduced by 50 percent or more since the prairies were broken, the result of oxidation after tillage. The University of Illinois' Morrow plots in Champaign, Ill. — the nation's oldest agronomic research fields and home of the world's longest-term continuous corn plot — offer an excellent case study. Cropped since 1876, the first organic matter measurements were taken in 1903, when levels were 40 tons per acre. By 1973, organic matter in the continuous corn plots had dropped nearly 40 percent. Studies of organic matter levels in other plots show reductions in soil carbon from 30 to 50 percent (Reicosky, 1995).

Tillage adds residue to the soil, aerates the underground environment and exposes the soil surface to solar radiation, fueling and stoking a fast-burning reaction in which microbes degrade residue and release stored carbon to the atmosphere as carbon dioxide (CO_2).

A 1976 study showed that physical disturbance of soil in a laboratory can stimulate microbial activity markedly for up to three weeks (Jenkinson and Powlson, 1976). Reicosky and Lindstrom (1995) demonstrated the phenomenon in the field. Over a 19-day period, a single pass with a moldboard plow in wheat stubble caused five times as much CO_2 loss as soil in untilled plots. During those 19 days, as much as 34 percent more organic matter was oxidized in the plowed soil than was produced all year from the decomposition of wheat straw and roots. In contrast, the no-tilled plots in the trial retained all but 27 percent of the carbon in the current crop's residue and undisturbed roots.

The decline in organic matter can be reversed through crop residue management, with no-till leading the way in soil carbon recovery. But it takes several years to encourage the shift in soil microbe populations from fast-burning, tillage-loving bacteria and bacterivorous microorganisms to a microecosystem dominated by the bacteria, fungi, fungivorous microarthropods and nematodes, and earthworms that produce organic matter.

Growers dedicated to building soil organic matter may also need to invest a portion of their applied nitrogen for use by microbes as they convert residue into soil organic matter. For every 20 to 30 carbon atoms they process, soil microbes need a nitrogen atom. If that nitrogen is not available from the residue, the microbes will take it from the soil and tie it up until they die and decompose. As a result, no-tillers may have to adjust their nutrient credit from legumes or manure by as much as 20 percent to account for nitrogen that will be tied up by microbes as they decompose carbon-rich residues (Lewandowski, 2000).

NRCS

As soil organic matter levels come to an equilibrium after a few years of no-tilling, nitrogen immobilization and mineralization processes become more balanced and may allow growers to reduce nitrogen fertilizer rates (Dinnes et al., 2001). However, even after a shift back to mineralization processes, applying starter fertilizer is extremely important in no-till, as soil nitrogen may not be released soon enough or quickly enough to supply the crop when it needs it most (Dinnes et al., 2001).

Creatures Great and Small

Healthy soils rich in organic matter are home to billions of living residents, from bacteria to insects and mammals. On the microscopic level, healthy soils contain a sustainable balance of nitrifying and denitrifying bacteria, a productive contrast to the tillage-loving bacteria that create large volumes of carbon dioxide.

Fungi also play a vital role by degrading residue, fueling a healthy food chain and stimulating crop development. Mychorrhizal fungi can act as extensions of plant roots, improving nutrient uptake and perhaps increasing access to moisture. The teeming soil around crop roots also contains beneficial organisms that release compounds that could stimulate or enhance plant growth (Lewandowski, 2000).

John Obermeyer, Purdue University

Earthworm (*L. terrestris*)

John Obermeyer, Purdue University

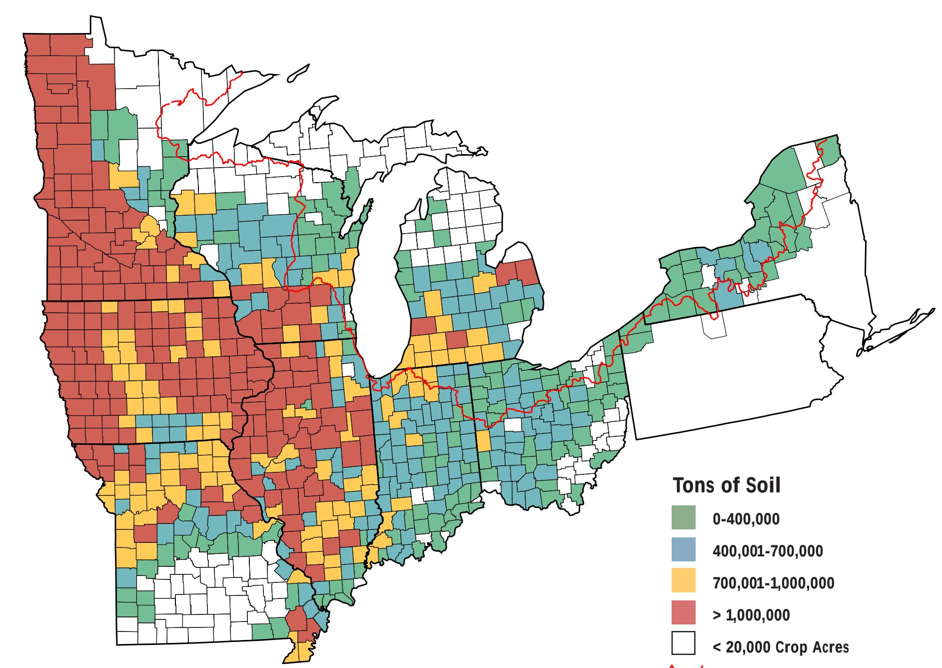
Carabid ground beetle

On a larger scale, dozens of species of carabid beetles thrive in no-till conditions — in one study, researchers found 14.4 carabid beetles per square yard in no-till soybeans and just 0.31 per square yard in plowed soybeans (House and Parmalee, 1985). Those beetles can be a significant help to growers. Insectivorous species can eat their own weight in insects daily, some thriving on a diet of corn rootworms, cutworms, armyworms and other pests (Mahr, 1996). Other species of ground beetles consume weed seeds. For example, at populations common in Midwest cropland, carabids can eat 40 weed seeds per square foot per day (Renner et al., 1998). When they are not serving as predators, ground beetles are great prey, enhancing the habitat value of no-till fields for an array of bird species.

Among the most celebrated residents of no-till fields is the earthworm. Data show anywhere from two to six times more earthworms in continuous no-till fields than in conventionally managed systems. Zaborski and Stinner (1995) note that earthworms can produce 45 to 225 tons of casts — high-organic-matter waste aggregates — per acre on the surface of well-managed pasture. In the surface layers of many soils, they note, up to half the aggregates are earthworm casts. In the process of creating those casts, earthworms distribute tremendous amounts of nutrients through the soil profile. In fact, earthworms can turn over the top six inches of soil in 10 to 20 years (Edwards, 1999).

Steve Werblow

Average Soil Loss in Tons Per County



Source – Estimated from NRCS, National Resources Inventory, 1997

Birds and Wildlife

The abundance of protective cover, insects and weed seed make no-till fields extremely valuable to wildlife, and the benefit is increased when the no-till environment is adjacent to a conservation buffer. Several studies, summarized in NRCS's Fish and Wildlife Literature Review in September 1999, have documented the increase in number and diversity of birds in no-tilled fields compared to tilled fields, as well as the use of no-till farms by migrating birds. For example, a 1986 study by Basore found that 12 species of birds nested in no-till corn and soybean fields with a density of 36 nests per 100 hectares (250 acres), while just four species, averaging four nests per 100 hectares, used conventionally tilled fields.

A North Carolina study of bobwhite quail found that quail chicks met their daily nutritional needs in less than six hours of foraging in no-till soybeans drilled into wheat, compared to more than 20 hours of foraging in tilled soybean fields (Palmer and Lane, 1999). Quail chicks also gained more weight in no-till soybeans than conventional soybeans.

Because fewer field operations take place on no-till fields, they may also allow better nesting success by birds that raise single broods or that renest infrequently if disturbed (Best, 1995).

Economic Benefits of No-Till

Syngenta Crop Protection

The long-term payoff of continuous no-till comes in the form of healthier, more productive soils. But growers fighting for the razor-thin margins in today's commodity markets need shorter-term payoffs, too. Savings on labor, fuel, equipment costs and other inputs become necessary considerations when growers contemplate which crops, if any, they will no-till.

The math is not simple and must include owner-supplied labor, equipment depreciation and interest — the sorts of line items that can be hardest for growers to get excited about when cash flow is a primary concern.

For instance, Doster et al. (1996) found that no-till returns over direct costs were within a few dollars of conventional operations in an Indiana corn/soybean rotation. However, profits (which factored in rent and equipment depreciation) were as much as $10 to $13 per acre higher in no-till than conventional tillage.

Labor Savings

One of the most significant benefits of no-till is the labor savings that can be enjoyed because of the reduced amount of time spent preparing the soil with tillage. Instead of fall and spring tillage, no-tillers begin their season on the planter. Even alternative approaches to no-till systems such as strip-tilling and rotary harrowing only add a pass to the season — a net gain that could amount to a savings of several trips across the field.

A USDA survey of the time input for corn and soybean crops showed a range of 0.4 hours to 0.6 hours per acre invested in conventional tillage systems and just 0.1 to 0.3 hours per acre in no-till (Bull and Sandretto, 1995).

In a University of Missouri study, Raymond Massey (1997) calculated that labor costs were reduced by $2.09 per acre in no-till corn vs. conventionally tilled corn. However, Massey is careful to point out that the savings are only realized if the labor represents the salary of a hired, hourly hand who is either working fewer hours or doing something else that generates income as a result of the switch to no-till. Owner-supplied labor would have to be channeled into farming more land, scouting crops, purchasing inputs or marketing crops. The savings are a result of using the time for some other profitable activity.

Equipment Costs

Because strictly defined no-till fields do not require the high horsepower necessary to pull heavy tillage equipment, many no-tillers can operate with smaller, less expensive tractors than their conventionally tilling neighbors. Fewer hours spent on the tractor also result in lower costs for equipment because of a smaller line of machinery, lower repair bills, lower equipment interest and lower depreciation because no-tillers log fewer hours per year on the equipment (Massey, 1997; Casady and Massey, 2000).

Syngenta Crop Protection

However, many new no-tillers hold onto conventional equipment until they are comfortable with no-till (Doster, et al., 1996). Producers who must rip hardpans or run strip-till toolbars still need larger tractors. Many growers practice rotational tillage, so they keep several tillage implements for use before corn. Keeping heavy equipment in the shed keeps it on the farmer's books, so the potential equipment savings advantage is often not realized unless or until a grower commits to continuous no-till and sells his tillage equipment.

Cost Increases

Traditionally, herbicide costs in no-till have been higher than in conventional management systems, though one can argue that the cost of tillage or cultivation for weed control — when labor, equipment costs and fuel are accounted for — outweigh or at least equal the extra herbicide. In fact, analysis at Monsanto's Center of Excellence plots indicate that nearly 90 percent of the production cost differences between no-till and tillage crops is the cost of tillage (Alesii and Buman, 2002).

Net Benefits

Casady and Massey compared the profitability of six tillage systems on a 750-acre corn-soybean operation. Their study included three types of Indiana soils – poorly drained Brookston silty clay loam on a 0 to 2 percent slope; light, somewhat poorly drained Crosby silt loam on a 0 to 4 percent slope; and light, eroded, well-drained Miami soil on slopes greater than 6 percent.

Compared to fall plowing, no-till showed a profit advantage of $8 per acre on Brookston soils, $15 per acre on Crosby and $35 per acre for Miami. (Casady and Massey, 2000).

To fully capture the economic benefits of no-till, value must be assigned not just to cash expenses and depreciation tables, but to soil, the environment and management. As Massey noted in his 1997 paper, "if some value was placed on saving soil (and undoubtedly there should be), no-tillage production would become more economical. If decreased time performing fieldwork led to increased time for management so that savings or income were enhanced on the farm, no-tillage would have additional economic benefits not accounted for in the budgets presented here."

Monsanto Centers of Excellence

A five-year research project covering 42 sites around the country – including 13 sites across the Midwest – Monsanto's Centers of Excellence put no-till to the test in the field. More than 10,000 visitors viewed Center of Excellence plots around the country each year to see the results.

"The idea was to demonstrate solutions to local agronomic issues seen as barriers to conservation tillage – to see what the issues were in those locations and bring some solutions to them," says Bruno Alesii, Monsanto's manager of technical development for conservation tillage. "We are focusing the research and demonstrations on the farmers' profitability and viability, trying to reduce the cost of production, increase profitability from the farmers' viewpoint and reduce risk year-in and year-out."

Center of Excellence growers in the Midwest compared various tillage options in strict corn-soybean rotations on plots that averaged 4.5 acres in size. Plot designs and data collection were managed by an independent researcher. A data summary for the program's first four years provided insight on the numbers behind the residue, and indicate that no-till – and strip-till – offer distinct profitability advantages.

Break-Even and Profitability 1998-2001

	Profit by crop per year (per acre) – Corn	Profit by crop per year (per acre) – Narrow-row Soybeans	4-Year Average Break-Even (per bushel) – Corn	4-Year Average Break-Even (per bushel) – Narrow-row Soybeans
No-Till	$101.00	$110.42	$1.34	$2.75
Strip-Till	$102.00		$1.35	
Conventional Till	$93.00	$96.27	$1.42	$3.09

Assume: $2 corn and $5 soybeans

Four-Year Profits per Acre 1998-2001

Strip-Till Corn/No-Till Narrow-Row Soybeans	$426.00
No-Till Corn/No-Till Narrow Row Soybeans	$423.00
Conventional Corn/Conventional Soybeans	$379.00

Assume: $2 corn and $5 soybeans

Source – Monsanto Centers of Excellence

Syngenta Crop Protection

Getting Started

The switch from tillage to no-till farming requires many adjustments on the farmer's part: adjustments in equipment and adjustments in thinking. Certain crops — soybeans in particular — lend themselves well to no-till, while corn can present much more of a challenge.

A grower's early success with no-till has proven to be extremely important in increasing the chance that a grower will consider continuous no-till, which delivers the maximum benefits to the environment, soils and the bottom line. Experimenting with no-till where it is most likely to work can lead to strongly committed no-tillers.

Preparing for the Switch

Smart growers considering the switch to no-till can take advantage of a few seasons of working the soil before they commit to putting tillage equipment aside. Ripping hardpans, plow pans or even more subtle layers of differing soil density can help minimize drainage problems. Laying tile, a long-term investment in no-till success in many areas, can have similar results.

Leading up to no-till by building up soil nutrient levels and distributing them well in the top several inches of the soil profile — and incorporating lime if necessary — can reduce problems with stratification and pH later.

Growers should try to address key weed problems, especially perennials and winter annuals, while tilling and cultivating are still options. The years leading up to a switch to no-till also offer a chance to learn the current state of a field's soils and to study varieties that do well in no-till conditions in the area.

Many districts or conservation organizations have no-till equipment available for rent or lease, offering an outstanding opportunity for growers to get acquainted with the machinery without having to invest in a purchase.

Equipment Demands

Spreading chaff properly is a fundamental component of successful no-till. Clumps of residue can trap excessive levels of moisture, plug planting equipment and inhibit growth of the subsequent crop through allelopathy, the release of growth-suppressing chemicals. Farmer and equipment dealer Gregg Sauder of Tremont, Ill., says the mat of soybean residue left behind a conventionally equipped combine can reduce the subsequent corn stand by 2,000 to 3,000 plants per acre (Sauder, personal communication). Therefore, straw and chaff spreaders on combines are key components of successful no-till.

An array of sweeps, coulters, spoked wheels and special planter shoes help growers manage residue with their no-till planters. It is essential to cut through residue; form a furrow at a consistent, appropriate depth; place seeds precisely; and close the furrow without smearing. Members of a fairly tight-knit community of no-till producers often share "discoveries" on equipment, fostering innovation and creating trends. For instance, retrofitting planters of all makes with grooved Case IH gauge wheels has been a boon to Ohio growers anxious to prevent sidewall compaction (Widman, personal communication). Learning how to apply adequate, but not excessive, down-pressure has also been extremely important in minimizing compaction (Sauder, personal communication).

Controlled Traffic Lanes

Starting a no-till regimen by establishing controlled traffic lanes can significantly reduce compaction problems across most of the field — a benefit that lasts years. Controlled traffic patterns sacrifice narrow bands of soil by having each piece of equipment follow in the tire tracks of the pass that came before. Compaction is intense in the lanes, but most of the field is spared from traffic. In addition, spray boom overlap is nearly eliminated, and compacted lanes offer better traction if it is necessary to work in wet soil conditions (Reeder and Smith, 2000).

Controlled traffic requires some forethought — wheel spacing must be uniform for all tractors and sprayers. Growers committed to avoid ripping or deep tillage, or in regions where freeze-thaw patterns are inadequate to disrupt compaction layers, establishing a controlled traffic pattern is time and effort well spent.

Nutrients and Chemicals

Because growers in continuous no-till systems do not distribute nutrients and lime through the soil profile with tillage, subsurface placement of relatively immobile nutrients such as phosphorous and potassium is very important in no-till.

Nitrogen must also be managed carefully to reduce the potential for loss to leaching or denitrification. In fact, high populations of denitrifying bacteria in no-till conditions can cause a loss of as much as one-third of the nitrogen applied to the surface of no-tilled fields (Rehm and Howard, 2000). Subsurface injection is extremely helpful; even then, fall-applied nitrogen in particular should be applied with a denitrification inhibitor.

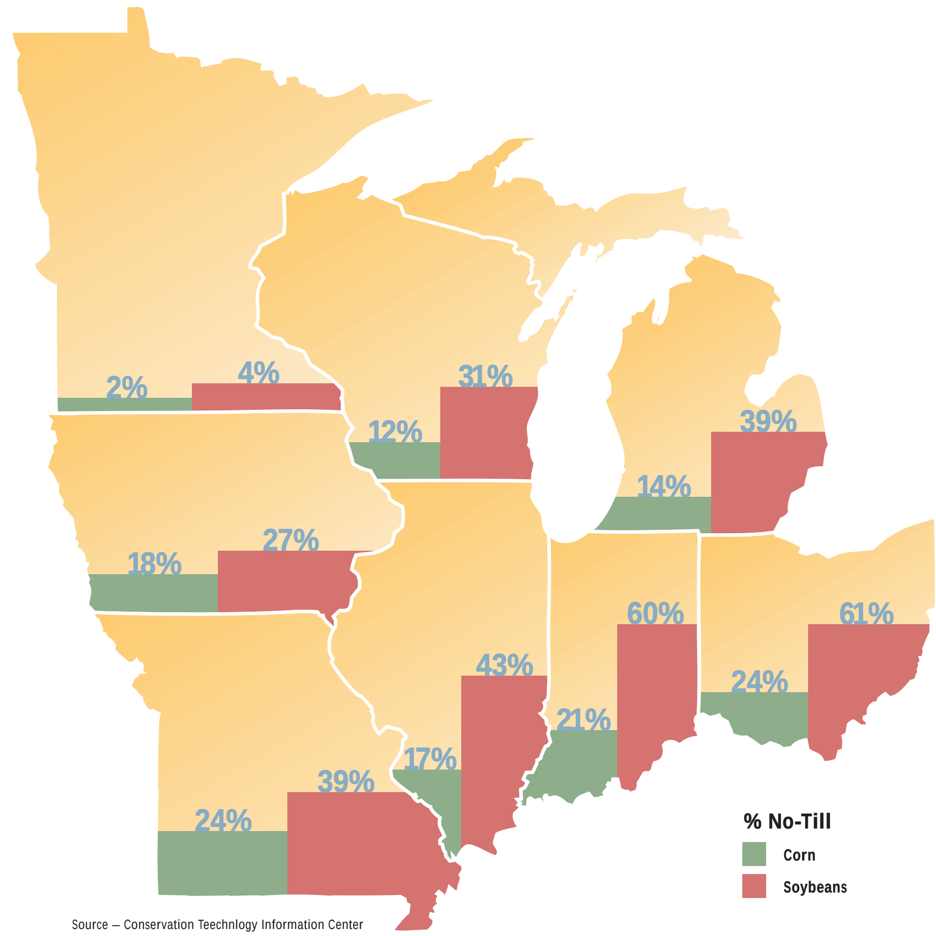
Growers should also consider the solubility, adsorption potential and persistence of the herbicides and insecticides they apply so they can choose the most appropriate best management practices to contain them. Weakly or moderately adsorbed chemicals are more likely to travel off the field with runoff water or leachate, while keeping highly adsorbed products on the field is more a matter of trapping sediment. Consulting the NRCS Pesticide Properties Database (http://www.wcc.nrcs.usda.gov/water/quality/common/pestmgt/ppd/ppd.htm) provides important perspective on solubility, persistence and adsorption of an array of pesticides, allowing producers to select the best management practices for the chemicals in use (Melvin et al., 2000).

Stick with It

After investing the time and effort to make no-till work in their conditions, growers should consider investing enough years in continuous no-till to allow it to overcome the tight soils and possible yield dips of the early-year challenges. Most growers say the transition to healthy soil structure takes about five years, and the data seem to reinforce that. For instance, no-till plots at Coshocton, Ohio, required five to six years to build up enough earthworms to significantly increase large pore space and infiltration (Best, 1995).

Planning and careful attention to detail at the start should help ease most operators through the transition phase to more economical, environmentally sound farming practices. ■

Percentage of No-Till Corn and Soybeans in the Midwest – 2000 Crop Year



Source – Conservation Teechnlogy Information Center

Worth the Wait

Bill Richards, Circleville, Ohio

Bill Richards has brought his commitment to no-till farming from his southern Ohio farm to the halls of Washington, D.C., and back again. Starting his tillage-cutting efforts fresh out of college in the early '50s, Richards' equipment shed has housed dozens of no-till tools and attachments, and his farm has served as a living experiment on conservation farming. As chief of the USDA Soil Conservation Service (now the Natural Resources Conservation Service) four decades later, he helped foster history's largest increase in no-till adoption as he oversaw the implementation of the conservation compliance provisions of the 1985 and 1990 farm bills.

No-till showed Richards its true colors in the late '70s, when he quit incorporating herbicides and broke from conventional wisdom by not breaking up the ground every few years. "The first years, we were just out to save money," he notes. "Up until 1978, we were really just going for saving trips over the field, saving labor and horsepower. Then we went to 20-inch rows and controlled traffic lanes. Years later, we found out that with continuous no-till it was getting easier and easier to plant."

NRCS

A recent NRCS infiltration study on Richards' farm highlighted the soil-building benefits of continuous no-till. On a terrace soil underlain with gravel, an inch of water took 24 minutes to infiltrate into a neighbor's mulch-tilled field. Nearby, on a field Richards has no-tilled for two decades, an inch of water infiltrated in 2.5 minutes. He says he saw the same degree of difference – a 10-fold increase in infiltration rate – in no-tilled finer, more poorly drained Miami-Crosby soils, too.

Richards says the first few years of continuous no-till tended to show a yield boost followed by about three years of lower performance before the soil really improved, but it's been worth the wait.

Now that his three sons are farming the family's 3,000-acre operation, Richards has time to speak on conservation policy issues and contemplate future improvements in no-till technology, ranging from rotations to cover crops.

DMI

Management Strategies & Alternatives

No-till is especially challenging in poorly drained soils, in areas where springtime is cold and wet and in regions where corn is king. Data from a Minnesota study indicate that more than 20 percent residue cover in the row in no-till corn is likely to lower yield potential (Hill, 2000). Growers complain that no-till can delay planting for days, even weeks, in poorly drained soils during wet springs.

The challenges of classic no-till production have yielded some ingenious and effective management alternatives that provide most of the benefits of no-till and few of the drawbacks. Many of these alternatives could make no-till viable in areas that have historically resisted the practice — or failed with it.

Strip-Till

Perhaps the most promising modification to classic no-till farming is strip-till or zone-till, in which a narrow band of soil is disturbed to promote faster drying and a warmer, mellower seedbed. Though the width and depth of the tillage zone can vary, most strip-till rigs include a large coulter, a mole knife that breaks the soil and deposits fertilizer about eight inches deep and a set of unsharpened disks that mounds the worked soil over the row.

The strip-till process, typically performed in the fall before a corn crop, reduces compaction below the seed, allows better seed-to-soil contact at planting and promotes faster soil warming in the spring. Researchers have measured increases in springtime soil temperature of 5 to 10 degrees F in strip-tilled rows compared to no-tilled rows.

Strip-till does not differ philosophically from no-till, say its proponents, in that most no-till planters are already outfitted with attachments that move residue aside, work up a narrow slice of soil and band starter fertilizer under the seed. The shift in strip-till operations is that growers perform those functions in the fall, allowing them a chance to jump more quickly into planting when springtime weather permits.

Experience with strip-till has taught growers and agricultural engineers some important lessons. The first is that it is important to design the strip-till rig to leave a berm over the row a few inches tall. That berm will mellow over the winter but remains 2 to 3 inches high at planting time. Without that berm in place, the worked strip of soil can mellow into an erosion-prone furrow. No-till researcher and farmer Jim Kinsella, who has strip-tilled his farm near Lexington, Ill., since the mid-1980s, says 3-to-4-inch-high berms on 30-inch centers can drain rainwater effectively into row middles on fields up to 10 to 12 percent in slope (Kinsella, personal communication). When planting, Kinsella sets planter gauge wheels to apply firm but not excessive pressure to the mound — packing the soil too tightly can create a channel for erosive runoff.

Another key lesson, says Purdue University agricultural engineer Tony Vyn, is to make sure that berming disks are dull and do not cut deeply into the soil. Furrows from sharp disks can create channels that can erode into gullies (Vyn, personal communication).

In-Line Ripping

Hardpans, plow pans and less dramatic subsoil shifts in soil density can inhibit drainage and root growth beneath many Midwestern fields. Many soil scientists and dedicated proponents of continuous no-till say that many of those fields would loosen up after five or more years of continuous no-till. However, there is a significant proportion of growers and advisors who believe that a periodic pass with a deep shank to fracture soil in the root zone is worthwhile.

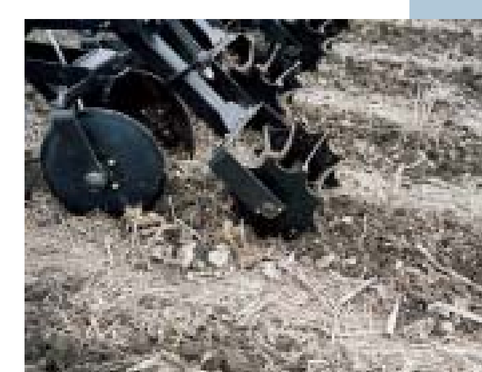
Ripping, or subsoiling, can also counteract compaction. Ag engineer Randall Reeder, from The Ohio State University, says subsoiling silty clay loam soils 12 to 18 inches deep can boost yields 4 to 5 percent — with results climbing as high as 10 to 15 percent in some fields — by fracturing compaction zones (Pollock, 2002).

Good engineering and proper use have created the opportunity for growers to perform a ripping operation while minimizing soil disturbance and residue loss. The downside of deep soil work is that it demands heavy, high-powered equipment, which eliminates some of the benefits of no-till systems: horsepower demands are not reduced, and compaction from passes with large equipment can be a problem.

Rotary Harrows

Rotary harrows have caused a stir on the no-till scene. These ground-driven systems of rolled steel links or spiral blades run quickly over the ground, fluffing up crop residue and lightly scratching the surface of the soil. The goal is to speed warming and drying in

DMI Model 5310 Nutri-till'r (pictured above and below)



DMI

The Fall Nitrogen Conundrum

Environmental protection comes to loggerheads in the fall, when no-till farmers are faced with conflicting goals. To protect soils from erosion, reduce soil compaction and spread out their workload, many are eager to fall-apply nitrogen so they can shift immediately into the planting mode when soils warm up and dry out in the spring. On the other hand, there is plenty of evidence to suggest that high levels of nitrate in warm soil can pose environmental and economic risks, being subject to losses of 60 percent or more from leaching, denitrification, volatilization or immobilization (Dinnes et al., 2001).

One important solution could be stabilizing fall-applied nitrogen with a denitrification inhibitor, especially when the realities of scheduling operations in the fall dictate application when the risk of nitrogen loss is high. "If you wait until soils get under 50 degrees [in the fall], I'd say your odds of strip-tilling a significant acreage drops to 50:50," says Illinois farmer and no-till researcher Jim Kinsella. "We as farmers could not stay in business if we had to depend on spring nitrogen. If you have a wet spring, you could end up applying nitrogen when your soil is too wet, which is not good. If you plant your corn and it stays wet and you can't get in with your nitrogen, it's a disaster. And if everybody waited until spring, with 79 million acres of corn, there's no way they could get enough nitrogen pumped up here for a three-week application season. I've also experienced severe erosion in no-till after sidedressing."

Regulation of fall fertilizer application could result in unintended effects on no-till, Kinsella notes. He points out that anything that can be accomplished in the fall to help relieve the severe time crunch most no-tillers experience at planting time is beneficial. And fear that regulators could restrict fall nitrogen application in the near future could inhibit investment in production capacity for new and better stabilizers, he adds. "What we need is research and fast-track approval for a longer-lasting inhibitor," says Kinsella.

Spring application can significantly reduce the loss of nitrogen and increase fertilizer use efficiency (Dinnes et al., 2001). Application of nitrogen in a readily available form as starter fertilizer at planting, followed by in-season sidedressing, tends to be most efficient (Dinnes et al., 2001). Applying a significant amount of the crop's nitrogen as starter fertilizer with the planter also keeps the spring workload more streamlined.

Precision Metal Fabricating, Ltd.

Phoenix Harrow

the spring by running the units weeks or even just a couple of days before planting. Rotary harrows can also level fields in the spring to erase ridges left by rippers or anhydrous knives in the fall.

Though the warming effects are not as dramatic as those of strip-till, proponents of rotary harrows report soil temperature differences of 6 degrees F over no-till and planting dates three to four days before no-till fields are ready for planting (Sauder, personal communication). Vyn points out that his experiments with rotary harrows showed no yield benefit over corn planted no-till the same day, though the harrows can allow earlier planting — which in itself could allow higher yield potential and a less harried workload (Vyn, personal communication).

Central Illinois crop consultant Ken Ferrie, who has studied several rotary harrows, likens the operation to screeding the surface of newly poured concrete. Different makes and models offer different degrees of leveling and aggressiveness. Ferrie says the flexible links comprising Phoenix and Phillips reel harrows can level out knife or ripper ridges up to three inches in height. McFarlane and To The Max harrows — called chopper harrows — have rigid spiral blades, tines in back and leveling boards, which make them more aggressive. Ferrie notes that the aggressive action of the chopper harrow blades can leave divots in tight, no-tilled soils, which can interfere with smooth planting. As a result, he recommends them for mellow conditions or areas that were worked the previous fall.

Shattertines

Another approach to loosening dense soils in no-till conditions employs a series of spoked wheels that aerates the soil and fractures the surface layers of the soil while maintaining most of the field's residue cover.

Rather than pulling a shank or sweep through the soil, AerWay's twisted "shattertines" pierce the soil surface and shift the soil sideways, shattering compaction in the top 6 to 8 inches of soil, according to the manufacturer. Aeration is improved in the root zone, water-holding capacity is increased and roots are freer to grow.

To The Max Harrow

Precision Planting, Inc.

Many growers swear by the results. Purdue's Vyn says he has not seen any yield improvements in experiments with AerWay units, but he has noted infiltration improvements after the application of hog manure (Vyn, personal communication). Agriculture and Agri-Food Canada researchers found that an AerWay manure applicator applied manure more uniformly and with less ammonia loss than a conventional splash plate applicator, indicating that the system could have benefits for manure application in grassland and minimum-or no-till systems (van Vliet et al., 2001).

Is It No-Till?

As new approaches emerge to managing tough-to-no-till soils, questions abound over whether they fall under the definition of no-till. A spray of soil rooster tailing behind a fast-turning rotary hoe does not fit the conventional notion of what no-till looks like. But as the implement passes, the residue remains on the soil surface and the soil in the root zone is spared the disruption of a chisel or disk, so most of the benefits of no-till remain. In fact, those benefits may be enhanced: the tossing action of rotary harrows can actually increase surface residue on fields where anhydrous knives have buried some stubble, notes Ferrie (personal communication).

Until a particular process is officially brought under the no-till umbrella, as defined by federal agencies, employing them could present some economic uncertainties. Though effective — perhaps the difference between success and failure on some soils — a practice that is not recognized as no-till could impact eligibility for certain farm programs, incentive payments, participation in carbon sequestration contracts and other opportunities designed to encourage no-till.

Dave Schertz, national agronomist for the NRCS, points out that further study is needed on these new tools. Full-width disturbance of the soil, even at a very shallow depth, could have significant negative effects on carbon sequestration. USDA-ARS researcher Don Reicosky notes that incorporating residue at any depth can increase carbon loss, though if a grower can use an implement to scratch the soil surface without increasing residue-soil contact, he says, carbon loss can be minimized. Working the soil surface when soils are dry and/or cold also helps reduce carbon loss (Reicosky, personal communication).

Looking deeper into the soil, Reicosky points out that the mass of carbon lost shortly after a soil disturbance shows a linear relationship with the volume of soil disturbed. However, he notes that a one-way pass with an in-line ripper may disturb the soil to the depth of the shank only in a zone immediately around the shank; between shanks, disturbance may be shallower. It is a complicated relationship, and specifics on the volume of disturbed soil are unknown for many pieces of equipment (Reicosky, personal communication).

Despite concerns about carbon release, Schertz is quick to point out that a tool that allows a grower to curb erosion by leaving more residue on the soil surface is an important step in the right direction — a step worth encouraging even if all of the benefits of no-till, such as maximizing the buildup of organic matter by capturing atmospheric carbon, may not be achieved. The most important thing is to help the producer meet his or her conservation objectives, he notes (Schertz, personal communication).

Alternative management technologies, from periodic ripping to fluffing and aerating passes, are sure to be a significant factor in the future of no-till adoption, especially in northern latitudes where no-till has limited acceptance. Used appropriately, these tactics may be essential in helping many growers succeed at maintaining high levels of residue and nursing soils back to health, weathering the transition to a productive continuous no-till system. ■

Precision Planting, Inc.

Soil Density: Hidden Thief

Density changes are becoming more widely recognized as a significant barrier to top yields, and many growers are using rotary harrows to prepare shallow seedbeds and warm the soil surface without creating density changes between tillage layers and the soil below.

In a five-year, 500-acre *Farm Journal* study, Illinois agronomist Ken Ferrie recorded an average yield benefit of 12.7 bushels of corn per acre in plots that had been in-line ripped in the fall and run in the spring with a rotary harrow, compared to plots that had been field cultivated in the spring. He attributes that yield boost to the use of in-line rippers (which he calls "vertical tillage") and chopper harrows to create uniform soil density in the rotary harrowed plots. Ferrie notes that the effect was most noticeable in silty clay loam soils, where yields jumped as much as 25 bushels per acre. Soybean yields did not respond to the fall ripping/spring rotary harrow treatment even though their roots were affected by soil density layers, probably because soybeans are adept at compensating for stress.

Because corn roots grow to suit the soil in which they live – thick roots forming in loose soil and thin ones in tighter soils – a shift in soil density can have a significant impact on root development. A gradual shift in density allows the plant to taper its roots to suit the new soil conditions, but a more sudden shift could force thick roots to grow sideways or cause the plant to stall as it produces new, smaller roots to penetrate the denser soil, notes Ferrie. Tilled soil can also get waterlogged when the denser soil below does not drain as quickly as the loose soil takes in water.

Because the issue revolves around relative density, not absolute values, density shifts can impact even relatively productive soils and healthy crops. The impact is so large because the first and second sets of corn roots – which have a profound impact on yield potential – are least able of all the root systems to adapt to density changes (Ferrie, personal communication).

Environmental Benefits of Buffers

Lake Erie Buffer Team

Conservation buffers have been extremely popular across the Midwest, enjoying high rates of adoption driven by a combination of attractive economic incentives and readily perceivable environmental benefits.

Understanding how buffers function, and the types of environmental benefits they can deliver, can help conservation advocates promote and develop the most appropriate buffers to meet the demands of site, pollutant removal, runoff control, habitat value and economic considerations.

Pollutant Removal

Buffers remove pollutants such as sediment, nutrients and pesticides in three principal ways: deposition, infiltration and dilution (Dosskey, 2001). Deposition takes place primarily within the first few yards of travel from the field's edge into the buffer; additional cleansing occurs through infiltration and dilution (Dosskey, 2001).

Deposition occurs when vegetation in the buffer retards the velocity of flow of the runoff water, decreasing its capacity to keep sediments in suspension. The sediments drop into the buffer as the water weaves its way through the rest of the vegetation (Dosskey, 2001). Many studies have shown that buffers are extremely efficient at deposition — stiff grasses such as switchgrass can capture sediment, especially large particles, in distances of less than three feet (Dosskey, 2001).

Infiltration is a product of the healthier soil structure, vigorous root growth and thriving microbial community that build up under buffer vegetation. A 1997 study in Iowa showed an infiltration rate 5 times greater in a multi-species riparian buffer than in adjacent row-cropped fields or heavily grazed pasture (USDA, 2000). Infiltration allows buffers to capture smaller soil particles and dissolved pollutants (Dosskey, 2001). Because it relies on the movement of water into the soil, infiltration — and thus, herbicide trapping — is least effective when the soil is saturated from prior rain events (USDA, 2000).

Dilution can reduce pollutant concentration by mixing runoff water with captured rainwater in the buffer zone (Dosskey, 2001). Infiltration augments the effectiveness of dilution by reducing the amount of polluted runoff water that must be blended with rainwater (Dosskey, 2001).

In addition to the physical processes of deposition, infiltration and dilution, buffers transform pollutants through the biological and chemical processes of adsorption to soil particles, degradation and assimilation (National Research Council, 2002).

Varying Results

Data on pesticide and nutrient removal by buffers range widely. Highly adsorbed, or sediment-attached, pesticides, such as chlorpyrifos, lindane and trifluralin, have been captured by buffers at rates from 62 to 100 percent (USDA, 2000). Capture rates vary so widely because highly adsorbed pollutants can be challenging to trap (even by very effective sediment-trapping vegetation), as the chemicals often adhere to small soil clay particles that are most likely to remain in suspension and pass through buffers (Dosskey, 2001).

There is some debate over the effectiveness of buffers at removing moderately adsorbed pesticides, such as alachlor, cyanazine, atrazine and 2,4-D — studies show removal rates that range from 8 percent to 100 percent (USDA, 2000). An extensive general review of literature suggests that dissolved pollutants, such as nitrate, dissolved phosphorus and atrazine, are removed at similar percentages as water volume removal (Dosskey, 2001).

High-Performance Design

Not surprisingly, buffer design can have a significant impact on performance. Perhaps most critical is encouraging sheet flow of water to utilize the entire breadth of the buffer, rather than allowing concentrated flow that permits much of the runoff to bypass the cleansing effects of the vegetation and soils. Velocity-slowing vegetative barriers and riparian filter strips can be paired with upland buffer strips. The strips serve as a first line of defense by capturing runoff and sediments from smaller sections of sloping fields, and grassed waterways, which slow the flow of water and deliver it to a stable outlet in a non-erosive manner. Riparian buffers are recognized as vital strips of habitat that perform a great number of biological and physical functions per unit of area to safeguard water quality and wetland health (National Research Council, 2002).

The selection of appropriate vegetation is also important. Many buffer programs default to switchgrass, whose stiff stalks, extensive root system, dense growth habit and native origins make it a strong performer for trapping sediment, standing up to heavy flows of runoff and attracting wildlife. However, other native grasses and forbs may also be employed in buffers on relatively flat fields (Agroecology Issue Team, 2002). Woody vegetation creates long-lasting buffers, develops deep root systems that can remove nitrate from ground water flowing beyond the reach of grass roots, enhances habitat for many terrestrial wildlife species and shades riparian areas for the benefit of aquatic wildlife.

Channels and Ground Water

Streambank erosion is another significant contributor to sediment and phosphorus load in many Midwestern streams, and riparian buffers could play a role in reducing it. In many streams, the erosive force of the stream exceeds the capacity of vegetation to stabilize the banks or channel. However, along relatively stable streams, roots and vegetation can reduce bank erosion, and debris can blunt the erosive force of the water (Dosskey, 2001).

Nitrate and soluble chemicals can also travel to surface water supplies through ground water flow. Riparian buffers, especially those that combine grasses with woody vegetation, have been demonstrated to reduce nitrate concentration in ground water flowing through the root zone, though two studies showed very high nitrate levels in outflows from buffers (Dosskey, 2001).

Soil organic matter carbon levels increased 8.5 percent under a poplar/switchgrass buffer in Iowa after 6 years and increased by 8.6 percent under switchgrass in the same period (Marquez et al., 1999). Soil respiration rates under buffers planted to poplar, switchgrass or cool-season grasses were up to twice as high as respiration rates under row-cropped fields (Tufekcioglu et al., 1999). The combination of high soil organic matter levels, a high rate of respiration and dense root growth are believed to make the soil under buffers relatively effective at cleansing shallow ground water.

Scott Bauer, USDA-ARS

The problem is that areas with ground water in the root zone — where it can be cleansed by buffers — is not likely to be productive agricultural land and does not represent a significant amount of land that would be changed from row cropping to buffers (Dosskey, 2001).

Drainage systems — tile or ditches — often bypass buffers and deliver pollutants directly to streams (National

Buffers + No-Till = Synergy

A book by the National Academy of Sciences' Water Science and Technology Board defines agricultural riparian buffer zones as "a secondary practice" that assists in-field and upland conservation practices (National Research Council, 2002). Though Dosskey (2001) points out that very few studies have explored the interaction between tillage practices and buffer management and their impact on water quality, there is a fair amount of intuitive evidence to support no-till as a highly compatible field management system that can help buffers perform optimally.

First, no-till fields – especially continuous no-till fields – have demonstrated better infiltration and lower runoff rates (Gilley, 1995), leaving less water for buffers to process. Runoff from no-till fields also contains less suspended sediment (Fawcett et al., 1994; Hebblethwaite, 1995), which can seal the soil surface within buffers and reduce their ability to trap herbicides. In a 1994 Iowa study, buffers removed more than 80 percent of the atrazine, cyanazine and metalachlor in sediment-free runoff water and allowed 83 percent of the total water volume to infiltrate into the soil. When sediment was suspended in the runoff water, infiltration was reduced to 30 percent and herbicide trapping fell to about 50 percent (USDA, 2000).

Dosskey (2001) notes that filter strips are more effective where sediments in runoff are coarse-textured or well aggregated. After several years of continuous no-till, aggregation is substantially enhanced in most soils.

From a habitat perspective, no-till fields provide cover from standing residue, as well as insects that complement the enhanced ground nesting opportunities afforded by buffers. Pheasants, quail and field mice see the synergies between no-till and conservation buffers – and so do many growers and conservationists.

Ohio Lake Erie Buffer Team

More than 20 federal, state, local and private entities that comprise the Ohio Lake Erie Buffer Team have leveraged existing incentive programs to maximize the economic value of buffers for Ohio growers. Combining the resources of incentives such as the Conservation Reserve Enhancement Program (CREP), Conservation Reserve Program (CRP), Environmental Quality Incentives Program (EQIP), Wildlife Habitat Incentives Program (WHIP), Wetlands Reserve Program (WRP) and the Northwest Ohio Windbreak Program, the packages have raised eyebrows throughout the Lake Erie Watershed. The effort lined up more than 30,000 acres of buffers in the team's first three years of operation.

Lake Erie Buffer Team

For instance, a 30-year commitment for a riparian buffer and tree planting within 300 feet of a river on alluvial soils can ring up a payment of 175 percent of the base CRP rate for 15 years, a 50-percent cost-share on expenses and a $500-per-acre bonus from the state, explains Steve Davis, NRCS resource conservationist in Lima, Ohio. At a typical soil rental rate of $100 per acre, total contract payments including federal and state bonuses would total $3,340; the average annual equivalent over the 30-year term of the contract would equal $171 per year (Davis, personal communication).

The financial incentives are very compelling. So is the Team's outreach program. In addition to promoting buffers aggressively through literature and door-to-door contacts, the Team also trains growers and crop consultants in buffer design and management, Davis notes.

Research Council, 2002). However, the buffer design process can include managing drainage systems to raise the groundwater level underneath buffers into the root zone to facilitate nitrate removal, notes Dosskey (2001). Tile outlets can also be directed into created wetlands or buffers to allow pollutant removal and enhance habitat (Clark, personal communication).

Wildlife Habitat

As of 2000, the 33 million acres of wildlife habitat that exists under the Conservation Reserve Program (CRP) exceeds the acreage in the National Wildlife Refuge system and state departments of natural resources lands in the 48 contiguous states (Clark, 2002). Conservation buffers are one part of the CRP that provides habitat for birds, mammals and insects in a region where row crop farming has eliminated most habitat.

Though the optimal habitat would comprise broad expanses of prairie and trees, an adequate network of riparian buffers can allow populations of game birds and other highly desirable wildlife to spread out across the landscape to reduce the effects of predation (Clark, personal communication). Pheasants are especially attracted to buffers because many feature areas of tall grass that extend into more open ground, enabling roosters to find corners from which to attract hens to a variety of nesting locations in the landscape (Clark, personal communication).

At the bottom of the food chain, crickets and other seed-eating insects are significantly more plentiful in diverse buffer vegetation than in cropland. Renner et al. (1998) trapped 208 seed predators in a soybean field, 1,105 in an adjacent legume/grass strip and 1,824 in a contiguous switchgrass strip. Those insects are important prey for a variety of wildlife species, including pheasants and quail. If no-till or weedy fields adjoin the buffers, chicks enjoy outstanding foraging opportunities.

Small mammals such as voles and mice also thrive in buffers. Owls and hawks benefit from small mammal populations in buffers. Of course, that may not be entirely beneficial to ground-nesting birds. There is considerable debate over whether small mammals serve as a buffer for nest predation of game birds or an invitation to predators such as fox, skunks and coyotes that subsequently lower bird populations (Clark, 2002).

Designing for Habitat

Clark (personal communication) strongly advocates the establishment of the widest, most botanically diverse buffers landowners will allow. Diverse vegetation offers the best habitat for wildlife, especially young birds that depend on insects. Buffer maintenance is extremely important to maintaining high habitat value in any CRP planting, including buffers, by ensuring adequate diversity — weed incursion — and preventing the formation of impenetrable clumps of dense grass (Clark, personal communication).

Wide buffers may also help reduce the chance of having buffers choked with snow, stressing year-round residents such as pheasants and forcing them to seek shelter in often-scarce stands of trees, tall grass or cattail marsh. Creating a living snow fence of tall, dense vegetation on the upwind side of the buffer could make a nice combination with a wide grass buffer, according to Clark.

Buffer Maintenance

Buffer maintenance covers two broad categories: maintaining an appropriate flow over the buffer and maintaining the plants that comprise the vegetative filter.

Trapped sediment builds up over time within and alongside buffers. Berms of soil can form along the buffer's edge, channeling water along the buffer instead of over it, and creating an opportunity for gullies to form. Careful field cultivation along the buffer can drag sediment back into the field and eliminate the barrier (Agroecology Issues Team, 2002).

Vegetation within the buffer must be maintained so it is healthy and actively growing, preserving its value as habitat and a storehouse for captured nutrients. The 2002 Farm Bill removed a restriction on harvesting biomass from riparian forest buffers, buffer strips and filter strips, opening up new opportunities for better buffer management.

In Illinois, NRCS conservationists recommend burning native plantings every three years, treating one-third of the buffers at a time. To protect resident wildlife such as pheasant, burns should be conducted in the spring prior to nesting; fall or winter burning maintains forbs in the buffer, which is good for butterflies and young birds (NRCS-Illinois, 2001).

Because buffers are not a bottomless sink for nutrients, biomass must also be removed through burning, haying, grazing or harvest of trees to allow the buffer to continue sequestering nutrients (Agroecology Issue Team, 2002). In fact, the Iowa State University team recommends harvesting or burning buffer grasses every year or two after the first 5 years of buffer growth. Trees may be harvested every 8 to 12 years.

Without proper maintenance, buffer strips can actually become a source of phosphorus pollution as captured P cycles back into an available, mobile form over time (Dosskey, 2001).

Properly designed and appropriately maintained — and, ideally, augmented by continuous no-till on cropped acreage — conservation buffers offer long-lasting benefits to growers, water quality and wildlife.

Pheasants Forever

NRCS

"With the Continuous CRP program, we think there's a dramatic opportunity to make big improvements for wildlife," says Pheasants Forever (PF) national spokesman Joe Duggan in Minneapolis, Minn. "It's an excellent program economically for landowners, and easy to put on the land. But buffers just weren't coming as fast as they should have."

To help communicate the benefits of buffers to Iowa landowners, Pheasants Forever chapters and a wide range of partners began to underwrite the salaries of technicians in soil and water conservation district (SWCD) offices. The technicians examined aerial maps to determine where buffers could offer the greatest potential and contacted the landowners of the promising parcels to walk them through the options and benefits.

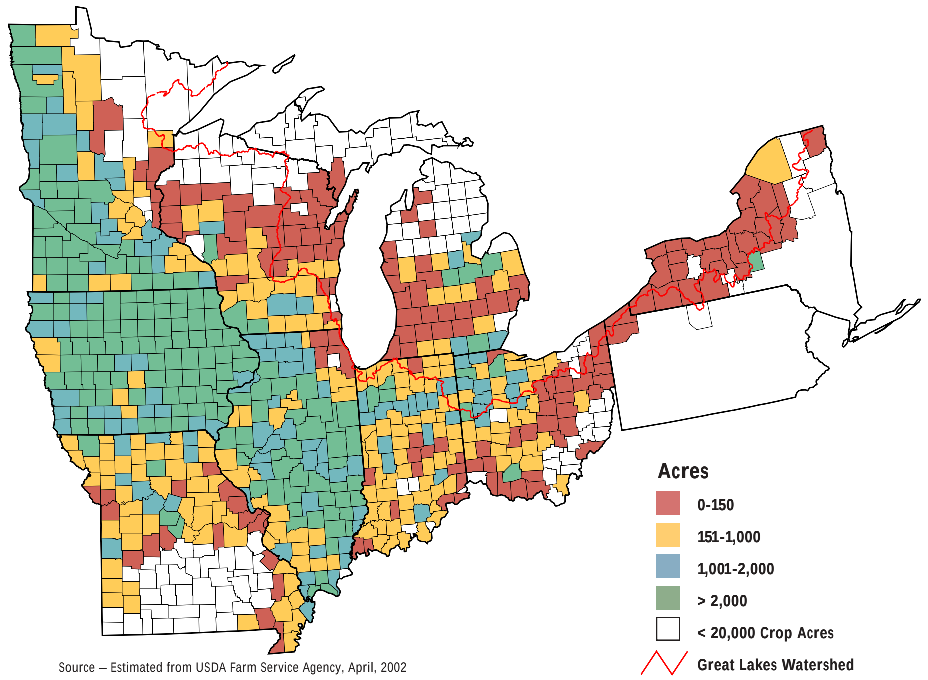
In the first four years of the collaborative effort, the Iowa Department of Agriculture and Land Stewardship, the Department of Natural Resources, NRCS, the U.S. Environmental Protection Agency, the National Fish and Wildlife Foundation, SWCDs and local Pheasants Forever chapters provided more than $1.7 million plus in-kind contributions.

Pheasants Forever also wrote grant applications and helped coordinate buffer promotion. PF field biologist Jim Wooley of Chariton, Iowa, describes the effort as "a great partnership of agencies and groups that care about water quality and wildlife, and have made this program a collective success."

Pheasants Forever chapters, which controls their own locally raised funds, have been jumping at the chance to create buffer promotion programs in other states, too, Duggan adds. Efforts in Illinois, Michigan, Minnesota, Nebraska, and Wisconsin have helped put miles of buffers on the landscape. In one Minnesota county alone, eager advocates and willing landowners kicked off a campaign with 1,500 acres of buffers enrolled in a matter of months, he says.

Wooley calculates a program cost of $9 to $10 per enrolled acre in the Iowa partnership. That cost is well worthwhile, says Duggan. Healthy wildlife populations are important to more than just avid bird hunters. "There is a quality of life benefit when people see critters out there," Duggan points out, "whether it's a deer along a creek or a pheasant along the road on your way to work. It's an indicator that positive things are happening on the landscape, and in our streams and lakes."

Acres of Buffer Enrolled in CRP through April 2002



Source – Estimated from USDA Farm Service Agency, April, 2002

NRCS

The Future of No-Till and Buffer Adoption

The next 10 years promise opportunities and challenges for the adoption of no-till farming systems and conservation buffers. Not surprisingly, economics drive the issue.

2002 Farm Bill

On the heels of several years of soft commodity prices, the 2002 Farm Bill strengthened yield-based, commodity title programs. Placing a strong emphasis on rewarding yield, commodity payments could mitigate against no-till, a system that increases risk and can decrease corn yields, especially as soils transition back to their natural structure.

On the other hand, the 2002 Farm Bill included $17.1 billion for conservation spending, significantly enlarging the CRP, WRP, WHIP and other programs. The bill introduced a $2 billion Conservation Security Program that could lend tremendous support to the no-till and buffer efforts and opens up conservation incentives on producing land, not just retired acreage.

Reviewing Buffer Management

The 2002 Farm Bill also allows greater flexibility in the management plans for conservation buffers enrolled in CRP. Harvesting and managed grazing, long seen as important management tools in grassland and timber management, may now be more viable tactics in buffer management plans, too.

The management of buffer vegetation — aspects ranging from plant height to species composition to the timing of haying, grazing or burning — will demand research in the coming years. As buffers and no-till cover more of the Midwest and Great Lakes watershed over longer periods of time, the art and science of maintaining buffers will be a vital component of the region's conservation effort.

Conservation partners will need to understand how buffers function as they age, and how various management practices can ensure their longevity. Though many miles of buffers are designed with wildlife in mind, it is very important to assess the water-protecting qualities of grass-and-forb mixtures. And the links between conservation buffers and no-till farming — and these conservation practices and water quality on a watershed level — will need to be explored in depth, quantitatively and qualitatively.

Understanding buffer function and maintenance will be invaluable in promoting buffers and no-till and in ensuring more effective conservation on each of those acres.

Land Ownership Remains a Challenge

More than 40 percent of the cropland in the U.S. is leased, which puts landlords in a significant position of power.

While cash rent arrangements might lend themselves well to no-till because they disconnect the grower's management decisions from the landlord's, most renters are not eager to spend time and money protecting someone else's soil. Crop-share arrangements can also present a challenge. In a typical crop-share arrangement, landowners share the cost of seed, fertilizer and chemicals — which can increase under no-till, especially in the early years of implementing the system – and accept a share of the potential yield reduction that can occur in no-till systems, especially in corn. At the same time, they do not benefit directly from the labor or equipment savings offered by no-till.

In addition, year-to-year lease arrangements can hinder investment in converting a farm to no-till and in long-term improvements that help no-till work, such as installing drainage tile. Renters do not want to spend the money to improve land that they may only farm for a year or two, and many landlords are seeking higher returns without substantial investment.

Carbon Sequestration Contracts

Carbon sequestration contracts — through which companies pay farmers to capture enough atmospheric carbon with their no-till crops to offset carbon that the companies release into the air — could represent a promising source of private industry incentives for no-till farming. Studies by Reicosky and others have demonstrated that no-till farming converts atmospheric carbon into soil organic matter, which remains relatively stable without tillage (Reicosky, 1995).

A groundbreaking agreement between Entergy Corporation and the Pacific Northwest Direct Seed Association (PNDSA) provides a glimpse into the emerging business of carbon credits. In 2002, PNDSA leased 30,000 tons of carbon emission credits to Entergy. Members contract with PNDSA to capture 0.15 tons of carbon per acre per year for a 10-year period. During that time, the enrolled acreage must be cropped in a direct-seeded (no-till) system and crop residue must not be burned.

The carbon sequestration concept has been a hot topic among politicians and many in the non-farming public. Though plenty of growers wonder out loud about the validity of climate change theories, many would be happy to see a new incentive for continuous no-till.

"It's something the public is interested in," says Richards in Ohio. "The money could improve soil and water quality. It would be a good investment, whether there is a climate change or not."

Jim Kinsella of Lexington, Ill., a grower and no-till researcher, outlined to Congress a carbon sequestration program for America's farms. "The public would benefit by paying farmers $100 a ton to sequester in our soil some of the carbon they are expelling into the atmosphere," he says. Kinsella points out that growers run the risk of losing money on carbon sequestration contracts if the value of carbon is set too low or if brokers and other middlemen eat up the margins. The increased risk of no-till and the cost of extra nitrogen to balance soil carbon-nitrogen ratios could also quickly weigh down farmers' bottom lines, he warns.

More Acreage Yields More Barriers

Though one of the key benefits of no-till is that it reduces the labor and equipment requirements of farming — allowing growers to farm more ground — there appears to be a threshold beyond which no-till corn becomes a liability for large operations. Slow drying no-till fields can require growers to delay corn planting for a day or more. Though that is inconvenient to a grower with 1,000 acres or less, it is generally a condition he can work around, notes Illinois crop consultant Ken Ferrie. A 5,000-acre farm is more likely to have a stricter schedule to optimize the use of equipment and labor, so operators cannot wait for an individual field to dry, Ferrie points out. By contrast, a quick pass with a field cultivator can often create more optimal, uniform planting conditions and keep large operators on the go.

Large farms rely on hired tractor drivers, many of whom are not well trained in deciding whether a particular field is truly ready to plant, adds Kinsella. Mistakes in no-till planting

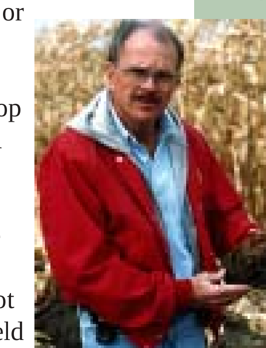
Rebuilding the Soil

Jim Kinsella, Lexington, Illinois

Jim Kinsella brought his master's degree in soil science home to his 840-acre family farm in Illinois in 1974 and put it to work rebuilding the soil organic matter on his piece of the central Illinois prairie. At the time, the farm's average organic matter level was 1.9 percent; today, Kinsella's commitment to strip-till corn and no-till soybeans has allowed it to return almost to its native level of 4 percent.

Three decades of rebuilding his soils has made Kinsella a huge fan of no-till and an outspoken advocate of carbon sequestration contracts for no-till farmers. Kinsella figures he has taken 0.4 tons of carbon per acre each year from the air and sequestered it in the soil as he built up his organic matter reserve – a total of 11 tons of carbon per acre between 1974 and 2001. He believes that is a benefit that Americans should be willing to pay for.

"Last year, we received substantial government payments on our small farm with no strings attached," Kinsella told members of the U.S. Senate Agriculture Committee in 2001. "We could have plowed 20 inches deep and worked the soil 10 times, putting thousands of tons of CO_2 in the air and thousands of tons of sediment with attached nutrients in the streams, lakes and rivers. Agriculture needs some subsidies to get through these tough economic times. Why not give something back to the taxpayer for their generosity, in this case better air and cleaner water, and improving the soil on which we produce their food?"



Kinsella Farms, Inc.

Kinsella figures a $100-per-ton carbon payment for continuous no-till farmers would benefit farmers and society. Government administration of the program would ensure compliance and keep the incentive at the farm gate, where it needs to be in order to cause a change in soil management, he says. Farmers and landowners would have a strong incentive to adopt no-till and stick with it, enjoying the economic and agronomic benefits besides. And the program could keep America focused on a long-term solution.

"It could take 20 to 30 years to rebuild the soil organic matter," he says. "An effective carbon sequestration program would buy us time to improve fuel efficiencies and develop alternative energy sources."

decisions could lead to poor emergence or long-term compaction problems. By contrast, fields managed with tillage can much more easily be trusted to unskilled labor, Kinsella notes.

Perhaps the biggest obstacle for large operations considering no-till is that owners or managers are not able to maintain the regular contact with each field that no-till demands. “You need to be able to see the field out the tractor window to manage properly,” says Kinsella. “You can teach someone to run a field cultivator in an hour, but it takes years to truly understand no-till farming.”

No-till has helped many farmers enlarge their operations to a scale that is economically sustainable. However, as consolidation continues and farms grow larger, conservation proponents may have to address new demands, such as developing large-scale no-till management schemes, hiring no-till consultants (a common practice in South America, according to Kinsella) and training hired laborers to make appropriate decisions in no-till conditions.

Manure Application

Many areas of the Midwest that can benefit from no-till are also home to millions of head of livestock or poultry. Dairy farms, hog farms and poultry operations continue to grow in size. Meanwhile, USEPA-required nutrient management plans for those animal-feeding operations include manure application guidelines. Clearly, manure application is an important issue in those areas, but traditionally, manure and no-till have not been very compatible because of the need to incorporate manure into the soil in order to minimize runoff, volatilization loss and odor.

Manure injection may provide an avenue for no-tillers to utilize manure. Not surprisingly, surface residue loss varies among competing injector designs. In a *Successful Farming* field trial in Grundy County, Iowa (Freese, 2000), a Yetter Avenger injector fitted with a coulter and a rubber closing wheel actually saw a residue coverage gain of 4 percent after application in corn stubble through more even

USDA

distribution of the residue; in soybeans, there was just a 10-percent loss (Everts, personal communication). A Kongskilde injector from Holland, where manure application is strictly regulated, buried 24 percent of the soybean stubble in its plot, leaving 67 percent cover. And a knife injector — models are available from Houle and Balzer — buried 33 percent of soybean stubble and 25 percent of corn residue. Residue coverage figures were high because the trial was conducted soon after harvest in late October (Everts, personal communication).

By contrast, broadcasting manure and incorporating it with a tandem disk buried 65 percent of the soybean stubble in its plot, leaving just 25 percent cover (Freese, 2000).

At $20,000 to $40,000 plus a high horsepower requirement, manure injectors are not a small investment. But they may prove to be an important tool to help growers adopt no-till while adhering to nutrient management plans in livestock-intensive areas.

Improving Genetics

Herbicide-tolerant soybeans and corn have vastly simplified weed management in no-till since their introduction in the mid-1990s, and Bt genes have protected millions of acres of no-till corn from corn borer. Still, one of the biggest barriers to the adoption of no-till corn, and continuous no-till, is that many corn hybrids do not offer strong performance in cool, wet no-till soil conditions.

Though uniform planting with plot-scale seeding equipment is a challenge in no-till plots, seed breeders have been screening parent material and new hybrids for cool-condition emergence, seedling vigor and resistance to diseases common in no-till, such as grey leaf spot. Over the past decade, the general level of performance of corn hybrids in no-till conditions has improved as a result of that screening effort, according to Dale Sorensen, corn technical manager for Monsanto.

DeKalb and Asgrow have introduced a Residue Proven designation that identifies the corn, soybean and milo varieties best suited to no-till conditions, Sorensen says. Pioneer Hi-Bred International does not currently label its top no-till varieties with a special call-out, but outlines the attributes of each hybrid or variety so growers can select the most appropriate product for their no-till fields, according to Joe Keaschall, corn research director for Pioneer.

Challenges remain. Corn is inherently prone to slow germination and growth in cool soil conditions. Though seed treatments provide outstanding control of seedling diseases, those pathogens can still pose a challenge. And Keaschall notes that the strong stalks that growers demand for standability and resistance to boring insects decompose slowly, leading to longer-lasting residue that can harbor overwintering insects and plug planting equipment in the spring.

The good news is that modern genetic research techniques offer outstanding opportunities to help breeders understand the genetic components of cold tolerance, germination and vigor, says Sorensen. As that understanding grows, so will the options for growers seeking no-till-compatible genetics.

Syngenta Crop Protection

Going Forward

In all, there is an abundance of data that supports the importance of no-till and conservation buffers in protecting our nation's soil and water, and in promoting the sustainability of farms across the country. There are also challenges, ranging from agronomic hurdles to the fact that many growers who have not adopted no-till are not inclined to change their traditional approach to farming.

But with some of the proposed incentives provided by the 2002 Farm Bill and the private sector, along with the energy of committed conservationists throughout the area, the North Central region and Great Lakes watershed could enjoy another significant jump in the number of acres under no-till and conservation buffers.

The Nature Conservancy

Private Incentives

In addition to an array of federal and state programs that provide rental payments and cost-share funds to encourage the adoption of no-till farming and the installation of conservation buffers, many private sources have sweetened the pot with additional funds to make adoption even more attractive. Those private incentives have met with mixed success.

In the conservation buffer realm, they have been extremely effective. One-to-one contact between paid buffer advocates and local landowners in Iowa's Raccoon River watershed helped sign up 80 farmers in a single year. So did augmenting CRP rental payments with a war chest including a $100-per-acre signing bonus from the Lake Panorama Association, plus cost-share funds for grass seed and tree planting from the Association, Pheasants Forever and Trees Forever. Then there was cost-sharing by the Farm Services Agency, technical assistance from the NRCS and the Lake Panorama Association's buffers consultant, information from the local conservation district, and a low-cost rental on a seed drill and operator from the Carroll County Conservation Board.

In Indiana's Upper St. Joseph River/Fish Creek watershed, more than 20 miles of buffers protect indigenous freshwater mussels (including three endangered species) from siltation and nutrient runoff, and no-till adoption beats state averages handily. Again, door-to-door contact with landowners along creeks and streams paid off. So did a $218-per-acre signing bonus from The Nature Conservancy, and a 30-percent cost-share up to $3,000 for conservation tillage equipment. Again, Pheasants Forever chapters contributed funds, as did Turkeys Forever.

In 2001, 30 percent of the watershed's corn crop was in no-till, more than double the area's 1990 acreage and nearly 10 percent higher than the state average for no-till corn. No-till soybeans accounted for 67 percent of the watershed's bean crop in 2001, 7 percent higher than the state average.

Ironically, a progressive Risk Reduction Program offered to conventional-till growers in the watershed by The Nature Conservancy generated nearly no interest. Under the plan, growers would be covered for any losses incurred as a result of switching up to 150 acres to conservation tillage practices. Recordkeeping with the MAX™ program, recommendations from a certified crop consultant provided by the program and side-by-side conventional tillage on the rest of their fields provided a benchmark for comparison. If the conservation tillage system provided higher profit than the conventional program, the grower would pay The Nature Conservancy 20 cents for every dollar of additional profit up to $3 per acre to help defray the cost of the crop consultant.

The Risk Reduction Program promised to take the uncertainty out of the switch to conservation tillage, addressing one of the most often-stated objections to trying no-till. Still, just six landowners in the 105,000-acre watershed enrolled in 2002. Why? Perhaps the program was too complicated. Or maybe The Nature Conservancy and the watershed advocates had gotten down to the die-hard conventional till believers who will not switch for any reason. In either case, the surprising lack of participation in the Risk Reduction Program underscores that it takes more than money more to win over farmers who are skeptical of no-till.

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Foreword

Bruce Knight
Chief
USDA Natural Resources
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"In the 2002 Farm Bill, Congress authorized an 80-percent increase in funding for conservation. I am interpreting that as a vote from society and a vote from Congress about a need for investment in conservation and the environment, and a vote of faith in voluntary incentive measures for conservation and environmental issues.

What is perhaps most significant coming out of this Farm Bill is that society is now embracing a working lands approach as opposed to an idling lands approach.

We will be called upon to use that working lands approach to create a balanced approach to natural resources, addressing the challenges of improving water quality and air quality without sacrificing the good work that's been done on reducing soil erosion and improving range management.

With the vote of confidence that has been embodied in the Farm Bill, we have society saying, 'we are going to give you the tools.' Now it's up to us to find the priorities and the way to respond by applying cost-effective conservation solutions.

On millions of acres of cropland (including my farm in South Dakota) no-till and conservation buffers will continue to be an important part of that response — a response that helps growers achieve balanced, effective and profitable conservation systems on America's working lands."

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Prepared by the Conservation Technology Information Center. July 2002

Cover photos (counterclockwise from top left): NRCS; NRCS; Susan Davis

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Agricultural Research Service (USDA)
http://www.ars.usda.gov/

Agroecology Issue Team
http://www.buffer.forestry.iastate.edu/HTML/issueteam.html

Areas of Concern in the Great Lakes
http://www.great-lakes.net/envt/pollution/aoc.html#mich

Buffer Notes
http://nacdnet.org/buffers/

Conservation Technology Information Center
www.CTIC.purdue.edu

Illinois NRCS
http://www.il.nrcs.usda.gov

Illinois SOILS Project
http://www.soilsproject.org/

Missouri No-Till Planting Systems
http://muextension.missouri.edu/xplor/manuals/m00164.htm

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http://books.nap.edu/books/0309082951/html/index.html

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http://www.unl.edu/nac/conservation/

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http://www.nacdnet.org/

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Natural Resources Conservation Service Home Page
www.nrcs.usda.gov

NRCS Wildlife Habitat Management Institute
http://www.ms.nrcs.usda.gov/whmi/sitenew.htm

Ohio BMPs
http://newfarm.osu.edu/management/water.html#Buffers

Pheasants Forever
www.pheasantsforever.org

Riparian Forest Buffers
http://www.ext.vt.edu/pubs/forestry/420-151/420-151.html

Soil and Water Conservation Society
http://www.swcs.org

Trees Forever
http://www.treesforever.org

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