CHAPTER 3: ENVIRONMENTAL BENEFITS OF AGRICULTURAL MANAGEMENT PRACTICES

Agricultural activities may not necessarily be harmful to the environment. Depending on the agricultural management practices in use, agriculture not only is compatible with a healthy environment, agriculture can help to improve water and soil quality, protect wildlife habitat and biodiversity, and reduce the emission of greenhouse gases. In addition to these tangible environmental benefits, agriculture can improve the aesthetic appeal of landscapes if practiced using a mixture of ‘traditional’ farming practices and structures (windbreaks, barns and other farm structures) with alternative conservation practices. Because over 60% of agricultural production, by value, is produced in metropolitan counties or counties adjacent to metropolitan counties, large numbers of people have ready access to the aesthetic amenities of farmland.139

Conventional agriculture relies on practices like crop residue burning and deep soil inversion by tilling. By turning the soil and crop under with a moldboard plow, conventional tillage exposes bare soil to the erosive action of water, which in many areas is the major route of soil loss and water quality degradation. Conservation agriculture refers to several practices which permit the management of the soil for agrarian uses, altering its composition, structure and natural biodiversity as little as possible, preventing soil erosion and compaction, and improving water quality. In contrast to conventional tillage, conservation tillage does leave residue on the soil surface.140 Direct sowing (non-tillage), reduced tillage (minimum tillage), non- or surface- incorporation of crop residues and the establishment of cover crops in perennial woody crops (of spontaneous vegetation or by sowing appropriate species) or in between successive annual crops, and crop rotation are some of the specific conservation tillage techniques. These practices improve the quality of water, reduce soil erosion, protect wildlife habitat, and decrease the emission of carbon dioxide - the most abundant greenhouse gas - to the atmosphere.

Improving Water Quality

Research in the United States indicates that links between conservation practices and observed changes in water quality usually are complex and involve long time lags. Several years of data collection are necessary to distinguish long-term changes of water quality from short-term fluctuations. Nevertheless, there are indicators that conservation management practices improve groundwater - and especially surface water - quality. According to a study by Peter Hill and Jerry Mannering, conservation tillage improves surface water quality by reducing the runoff of soil particles attached to nitrate, phosphorus and herbicides. Residues protect the soil surface from the impact of raindrops and act like a dam to slow water movement. Rainfall stays in the crop field allowing the soil to absorb it. Conservation tillage in combination with the injection of fertilizer or its application in the row at planting time reduces the levels of enriched surface runoff. In addition, macropores, which are the major route for water movement through soil, remain intact, thereby enhancing water infiltration and decreasing water runoff. Table 5 shows that an increase in residue cover contributes to a decrease in surface runoff. Typically, 30 percent residue cover reduces soil erosion rates by 50 to 60 percent compared to the moldboard plow.

Table 5. Effects of Surface Residue Cover on Runoff and Soil Loss

<table>
<thead>
<tr>
<th>Residue Cover (%</th>
<th>Runoff (% of rain)</th>
<th>Runoff Velocity (feet/minute)</th>
<th>Sediment in Runoff (% of runoff)</th>
<th>Soil Loss (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>45</td>
<td>26</td>
<td>3.7</td>
<td>12.4</td>
</tr>
<tr>
<td>41</td>
<td>40</td>
<td>14</td>
<td>1.1</td>
<td>3.2</td>
</tr>
<tr>
<td>71</td>
<td>26</td>
<td>12</td>
<td>0.8</td>
<td>1.4</td>
</tr>
<tr>
<td>93</td>
<td>0.5</td>
<td>7</td>
<td>0.6</td>
<td>0.3</td>
</tr>
</tbody>
</table>


A reliance on agricultural practices to improve water quality produces concrete environmental benefits. In addition, several government programs provide farmers with

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incentives and the means to adopt water quality practices, including the Environmental Quality Incentive Program, Conservation Technical Assistance, the Wetland Reserve Program, and the Conservation Reserve Program. Although only a few studies have looked at the benefits of pollution reduction on a nationwide scale, results indicate that the annual benefits from improving water quality in the context of agricultural techniques and existing programs are significant. The water quality benefits from erosion control on cropland alone could total over $4 billion per year.\textsuperscript{143} Other studies, as indicated in Table 6, concur and point to the existing and potential benefits of water pollution control in agriculture.

### Table 6. Selected Estimates of Benefits from Water Pollution Control

<table>
<thead>
<tr>
<th>Focus</th>
<th>Investigator</th>
<th>Estimates of Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water quality benefits of reduced soil erosion from conservation practices</td>
<td>Ribaudo (1986)</td>
<td>Erosion reduction from practices adopted under the 1983 soil Conservation programs were estimated to produce $340 million in offsite benefits over the lives of the practices.</td>
</tr>
<tr>
<td>Water quality benefits of reduced soil erosion from Conservation Reserve Program</td>
<td>Ribaudo (1989)</td>
<td>Conservation Reserve Program. Reducing erosion via retirement of 40-45 million acres of highly erodible cropland would generate $3.5-$4.5 billion in surface-water quality benefits over program life.</td>
</tr>
<tr>
<td>Recreational benefits of surface water pollution control</td>
<td>Carson &amp; Mitchell (1983)</td>
<td>Annual household willingness to pay for improved recreational uses of $205-$279 per household per year, or about $29 billion.</td>
</tr>
<tr>
<td>Drinking water benefits from reduced nitrates in four regions</td>
<td>Crutchfield, Cooper &amp; Hellerstein (1997)</td>
<td>Monthly household willingness to pay for drinking water meeting EPA nitrate standards of $45 - $60 per month.</td>
</tr>
<tr>
<td>Freshwater-based recreation benefits from reduced soil erosion from Conservation Reserve Program</td>
<td>Feather, Hellerstein and Hansen (1999)</td>
<td>Annual increase in consumer surplus $35.3 million from improved Quality of recreation at rivers and lakes.</td>
</tr>
</tbody>
</table>


A study by the USDA has found that environmental compliance provisions attached to certain farm program payments have had a direct impact on water quality. Farmers who wish to remain eligible for benefits from selected Federal agricultural programs - including price support loans and income support payments - must refrain from draining wetlands. Compliance incentives may deter producers from expanding crop production onto highly erodible land or wetland. Without compliance requirements, between 7 million and 14 million acres of highly erodible land or wetland that are not currently being farmed could be profitably converted to crop production, under favorable market conditions. The report also concluded that existing government payments have the potential to leverage a broader set of agricultural conservation and environmental gains. The majority of cropland with potential for nutrient runoff, for example, is located on farms receiving government program payments. Whether these payments could spur farmers to address nutrient runoff would depend upon the methods available for remediation and their cost. Compliance mechanisms will be effective only on farms where government payments exceed the cost or required conservation actions.144

**Additional Literature:**


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Improving Soil Quality

In addition to improving the quality of water, a range of management practices benefits the soil. The recent decline of soil erosion in the United States can be partly attributed to the increased use of soil conservation practices by farmers such as crop residue management, land retirement and conservation tillage. In 1995 about 35 percent of cultivated land in the United States was under conservation tillage. Depending on the region and crop, conservation tillage may be inadequate by itself to minimize erosion. For example, in the Pacific Northwest, erosion from no-till following a pea (Pisum sativum) or lentil (Lens culinaris) crop can be relatively high, especially on steeper land. Because these crops produce low amounts of residues and the residues decompose quickly, their effectiveness for controlling erosion declines rapidly.\textsuperscript{145} Despite these limitations, Noel Uri and others show that conservation tillage practices have beneficial environmental effects.\textsuperscript{146} These practices mitigate soil erosion and contribute to increased habitat complexity because the residue left on the fields is a major factor attracting birds and other animal species.\textsuperscript{147}

Conservation compliance provisions attached to farm program payments have also had a significant effect on soil quality. To remain eligible for Federal agricultural programs, farmers must implement soil conservation systems on highly erodible land (HEL). The USDA found that the annual rate of soil erosion on U.S. cropland declined by nearly 40% between 1982 and 1997, and that about a quarter of that decline could be directly attributed to compliance. However, a large share of cropland erosion reduction occurred on land that was not subject to compliance requirements (non-HEL cropland accounted for 38% of all cropland erosion reduction). Reduced soil erosion on land not subject to compliance, according to the USDA, suggests that other factors, such as technology, information, and markets, played an important role in triggering large-scale erosion reduction. Conversely, compliance may have acted as a catalyst for change, accelerating the adoption of farming practices—such as conservation tillage—that can conserve soil and save farmers money.\textsuperscript{148}

\begin{itemize}
\item Between 1982 and 1987, excess erosion (any erosion in excess of the maximum level
\end{itemize}

\begin{itemize}
\item Robert et al., (1986).
\item Uri, N., (1999), op cit.
\end{itemize}
consistent with maintaining soil productivity) on highly erodible cropland fell by 331 million tons annually. Nearly 90% of this reduction occurred on farms receiving government program payments, and thus can be directly attributed to conservation compliance.\textsuperscript{149}

Additional Literature:


Abstract: The rapid expansion of large swine production facilities in northeast Colorado prompted a need to evaluate the impact of swine effluent applied on irrigated corn grown on sandy soil. The objectives of this study were 1) to evaluate the use of swine effluent as a nutrient source for irrigated corn production, 2) to evaluate the response of irrigated corn grown on sandy soils to different application rates, and 3) to evaluate N movement through the soil profile under swine effluent and commercial-N fertilizer for irrigated conditions. The three year study started in 1995 on a 14.5 ha (36 ac) sprinkler-irrigated (center pivot) Valent sand field, (Mixed, mesic Ustic Torripsamments) planted to grain corn (\textit{Zea mays L.}). Both swine effluent and commercial-N fertilizer treatments were applied at four N rates labeled control, low, agronomic, and high. All treatments were replicated three times in a randomized complete block (RCB) design. Approximately 90% of the total nitrogen from the two-stage lagoon effluent was in ammoniacal form, and the total dry matter content of the effluent was only 0.1 - 0.2% by volume. Corn yields increased with the increase of both swine effluent and commercial-N fertilizer rates. In contrast to the swine effluent treatments, significant soil-N buildup was observed at the 1.5 - 3.0 m (5 - 10 ft) depths for the commercial-N fertilizer treatments. Higher total N and P plant removal for the swine effluent treatments resulted in little N accumulation below the root zone. As the swine effluent application rate increased, the plant N and P removal and recovery rate increased, even at rates of 50 kg ha\textsuperscript{-1} (45 lb ac) above the recommended agronomic rate. An increase in extractable P in the top 15 cm (6 in) of the soil was observed in the effluent-treated soils. The results indicate that managing swine effluent-N becomes very similar to managing commercial-N fertilizer under irrigated conditions.


\textsuperscript{149} Ibid.
The Environmental Benefits of Well-Managed Farmland


Abstract: Since 1985, U.S. agricultural producers have been required to practice soil conservation on highly erodible cropland and conserve wetlands as a condition of farm program eligibility. This report discusses the general characteristics of compliance incentives, evaluates their effectiveness in reducing erosion in the program’s current form, and explores the potential for expanding the compliance approach to address nutrient runoff from crop production. While soil erosion has, in fact, been reduced on land subject to Conservation Compliance, erosion is also down on land not subject to Conservation Compliance, indicating the influence of other factors. Analysis to isolate the influence of Conservation Compliance incentives from other factors suggests that about 25 percent of the decline in soil erosion between 1982 and 1997 can be attributed to Conservation Compliance. This report also finds that compliance incentives have likely deterred conversion of noncropped highly erodible land and wetland to cropland, and that a compliance approach could be used effectively to address nutrient runoff from crop production.


Carbon Sequestration
Sound agricultural methods can reduce carbon dioxide emissions. Scientists believe that rising levels of carbon dioxide and other greenhouse gases are contributing to global warming, although to what extent is difficult to determine. While limiting fossil fuel
consumption is one method of reducing emissions of carbon to the atmosphere, another is sequestering carbon sources on the land. Carbon sequestration is the use of practices, technologies, or other measures that increase the retention of carbon in soil, vegetation, geologic formations, or the oceans. Carbon sequestration offsets greenhouse emissions from other sources.\textsuperscript{150} Although most agricultural soils in the United States and Canada are nearly neutral with respect to carbon dioxide emissions, the millions of agricultural acres could serve as a carbon sink.\textsuperscript{151} Other studies estimate that agricultural soils in this country managed as a carbon sink account for net sequestration of four million metric tons (MMT) of carbon annually.\textsuperscript{152}

The ability of agricultural land to store or sequester carbon depends on many factors including climate, soil type, type of crop or vegetation cover and, especially, management practices. Most of the agricultural management practices that favor carbon sequestration - such as planting cover crops, converting marginal cropland to trees or grass and conservation tillage (particularly no-till) - also reduce erosion and have other environmental benefits. Afforestation and the conversion of cropland to perennial grasses have the highest potential for storing carbon. Growing trees sequesters about 1 metric ton of carbon per acre per year.\textsuperscript{153} Nevertheless, the switching from conventional tillage to conservation tillage offers substantial carbon-sink potentials. Cropland activities with lower carbon-storing potential include changing crop rotations, expanding the use of winter cover crops, eliminating periods of summer fallow, changing fertilizer management, using more organic soil amendments (i.e. manure, sludge and byproducts), improving irrigation methods, shifting land to conservation buffers and restoring wetlands.\textsuperscript{154}

To determine the economic feasibility and ability of farmland to sequester carbon, studies have generally constructed hypothetical situations. The models assume a range of

\textsuperscript{154} Lewandrowski et al., (2004), Ibid.
The Environmental Benefits of Well-Managed Farmland

incentives given to farmers to store additional carbon and often focus on a single carbon-sequestering activity. Based on a range of incentives and multiple agricultural practices, a model developed by Jan Lewandrowski suggests that agriculture can provide low cost opportunities to sequester carbon. Given a price of $10 per metric ton for permanently sequestered carbon, the adoption of agricultural land-use changes (e.g. cropland conversion) and management practices (e.g. conservation tillage) can sequester up to ten million metric tons (MMT) annually. At a price of $125 per metric ton, the annual sequestered carbon in the agricultural sector could reach up to 160 MMT. This is sufficient to offset 4 to 8 percent of the gross emission of greenhouse gases in the United States in 2001.

Additional Literature:

Climate Change/Carbon Sequestration:


Abstract: Soil organic carbon (SOC) makes up about two-thirds of the C pool in the terrestrial biosphere; annual C deposition and decomposition to release carbon dioxide (CO2) into the atmospheric constitutes about 4% of this SOC pool. Cropland is an important, highly managed component of the biosphere. Among the many managed components of cropland are the production of crop residue, use of tillage systems to control crop residue placement/disturbance, and residue decomposition. An accumulation of SOC is a C sink (a net gain from atmospheric CO2) whereas a net loss of SOC is a C source to atmospheric CO2. A simple three components model was developed to determine whether or not conservation tillage systems were changing cropland from a C source to a C sink. Grain/oil seed yields and harvest indices have indicated a steadily increasing supply of crop residue since 1940, and long term field experiments indicate SOC storage in no-tillage > non moldboard tillage > moldboard tillage systems. According to adoption surveys, moldboard tillage dominated until about 1970, but non moldboard systems are now used nationally on at least 92% of planted wheat, corn, soybean, and sorghum. Consequently, since about 1980, cropland agriculture has become a C sink. Moldboard plow systems had prevented a C sink


156 Lewandrowski (2004)
response to increases in crop residue production that had occurred between 1940 and 1970. The model has not only facilitated a qualitative conclusion about SOC but it has also been used to project production, as well as soil and water conservation benefits, when a C credit or payment to farmers is associated with the C sink in cropland agriculture.


*Abstract*: Information on the potential for carbon sequestration from the Conservation Reserve Program (CRP) and knowledge concerning the fate of accrued carbon on sod takeout and recropping to a wheat-based rotation are essential. We conducted two separate field studies in northeastern Colorado to quantify the soil organic carbon (SOC) changes after various amounts of time in the CRP program, and to assess problems associated with converting CRP grass to cropland and the potential for loss of accrued SOC with different tillage systems. For our first objective, we assessed six CRP sites, with three sites showing increased SOC content over the adjacent winter wheat/summer fallow sites, and three sites showing no differences. In the conversion study, systems with little or no tillage yielded more winter wheat (*Triticum aestivum* L.) grain than systems with tillage because of more available soil water at planting time. Furthermore, SOC loss was less with no-till and reduced-till (herbicides plus one tillage) systems than by conventional tillage with numerous sweep plow operations. Thus, NT and reduced-till systems designed to control perennial CRP grasses will enable producers to maintain some of the gains in SOC when CRP land is converted to cropland.


*The Climate Change and Food Security report offers a synthesis of ERS research on the potential impacts of global warming on developing countries in the Tropics and discusses how future climate change research could contribute to food security policies in the region.*
Abstract: Land use changes to sequester carbon also provide “co-benefits,” some of which (for example, water quality) have attracted at least as much attention as carbon storage. The non-separability of these co-benefits presents a challenge for policy design. If carbon markets are employed, then social efficiency will depend on how we take into account co-benefits, that is, externalities, in such markets. If carbon sequestration is incorporated into conservation programs, then the weight given to carbon sequestration relative to its co-benefits will partly shape these programs. Using the Conservation Reserve Program (CRP) as an example, we show that CRP has been sequestering carbon, which was not an intended objective of the program. We also demonstrate that more carbon would have been sequestered had CRP targeted this objective, although the “co-benefits” would have increased or decreased.


Johnson, W. C.; Boettcher, S. E., Sequestering Carbon In Soil & Vegetation Through The Management of N. Great Plains Agroecosystems. Department of Horticulture, Forestry Landscape And Parks. South Dakota State University, Brookings, South Dakota 57007


Abstract: The erosive power of rainfall can be expected to change as climate changes. Such erosive changes are likely to have significant impacts on local and national soil conservation strategies. This study uses results of climate change scenarios from two coupled Atmosphere-Ocean Global Climate Models to investigate the possible levels and patterns of change that might be expected over the 21st century. Results of this study suggest the potential for changes in rainfall erosivity across much of the continental United States during the coming century. The magnitude of change (positive or negative) across the country over an 80 year period averaged between 16–58%, depending upon the method used to make the predictions. Some areas of the country showed increases and others showed decreases in erosivity. Spatial distributions of calculated erosivity changes indicated areas of both consistency and inconsistency between the two climate models.

Abstract: Greenhouse gases and global warming have become major topics. Much of the greenhouse gas discussion has dealt with carbon dioxide (CO2) and methods to sequester or store atmospheric carbon in soils and forests. The entire carbon cycle needs to be studied to better understand the overall process. The major carbon transformations are loss of CO2 to the atmosphere or the storage of carbon in sinks such as soil. Although it is a minor pathway, carbon leached through the soil and into groundwater needs to be quantified. Numerous carbon studies have been performed, but concentrations and losses of total organic carbon (TOC) moving through a soil profile have received little attention. Therefore, this study was to assess TOC levels in subsurface flow under two management practices. TOC was determined monthly in the percolate from large soil blocks, called lysimeters, (2.4 m [8 ft] deep) with undisturbed soils under row crops. Most of the TOC concentrations in the percolate ranged from 0.5 to 6.0 mg/L with the corn/soybean-rye rotation. Developed springs in two rotational grazing systems were sampled for 10 years. TOC concentrations in the groundwater from the springflow developments had less variability than in the lysimeter percolate. Most TOC values from these pasture systems were in a concentration range of 1 to 3 mg/L. Annual averages of TOC transport were similar for the lysimeter percolate and groundwater springs, ranging from 3.7 to 6.0 kg/ha (3.3 to 5.4 lb/ac).

**Animal Waste:**


Abstract: Modern poultry production systems face a number of complex environmental challenges. Most poultry operations are agricultural in nature, combining animal and crop production. Unfortunately, the inputs of feed and fertilizer required by concentrated animal operations are greater than the outputs in animal products and harvested crops. This often results in large excesses of nutrients on individual farms and in regions where poultry-based agriculture predominates. Many studies have shown that this can result in losses of nitrogen to groundwaters and phosphorus to surface waters, negatively affecting water quality. Other environmental concerns include the fate of trace elements, hormones, antibiotics, and pesticides added to poultry feed. This paper summarizes recent information on the environmental impact of poultry wastes in the U. S., with a particular emphasis on water quality. It also addresses some recent advances in
poultry waste management and existing or proposed measures designed to minimize the environmental impacts of poultry based agriculture.
