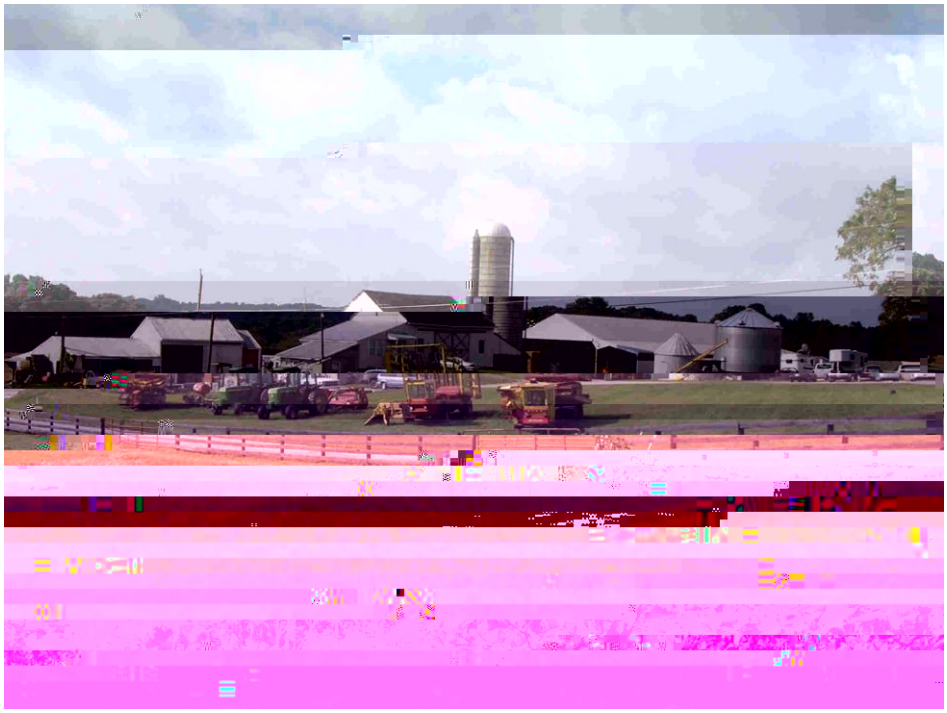
Small Farms in Maryland:

Big Challenges for a Shrinking Community



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Hope Benser
Matthew Comstock
Megan Killian

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Dr. Martin Roberge, Department of Geography and Environmental Planning

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Preface

All students who enroll in the Environmental Science and Studies Senior Sem

I. Challenges Maryland Farmers Face

Economics

Agriculture is an essential element in our economy. It provides jobs for people, helps develop communities, and supplies the food for our nation as well as other nations around the world. U.S. agricultural exports exceed $50 billion a year (U.S. Department

resources that are used in production. Resources such as fertilizer and pesticides are easier to price than other resources, and they may be valued using market prices (Hanson et al. 1988). Other resources such as soil quality and labor are not as easily given a price because they rely on opportunity costs, which consist of placing a value on a product that is not being produced (Hanson et al. 1988). For example, if a farmer produces only corn, the lost income from not producing any other type of crop is considered the opportunity cost.

Farmers must also take fixed costs into consideration (Hanson et al.1988). Fix costs are costs incurred even if there is no output being produced, and they include such components as depreciation, interest, rent and repairs, taxes and insurance (Hanson et al. 1988). For example, if a farmer paid an annual interest charge for their farm, this would be considered a fixed cost because the payment would have to be made regardless of the amount produced that year (Hanson et al.1988). Taking into consideration all possible costs is extremely important to the future success of a farm. Whether expenses pay R I I G H S H Q G V R Q W K H I D U P H U ¶ V W H F K Q L T X H V D Q G W K H H

Modern farmers attempt to maximize their profit by finding specific market niches in their local communities. Farmers in Maryland have specialized in growing a

(Maryland Highlights for 2003 2005). Other crops worth noting are hay ($23.4 millio and wheat ($16.9 million) (Maryland Highlights for 2003 2005). Potatoes, apples,

shipped out from either the Port of Baltimore or the Baltimore-Washington International Airport (University of Maryland 1999).

Modern farming bring new alternatives

Finding specific niches for recyclable material can save farmers a significant amount of money. For exampl392. -1()sar6(mndi)-3(ng)10w ei a5(nsa)1(he)4(x)-f6(oa)6mu(l)-1lc(shing)10(x)

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economy; 78,000 acres of this sector is used for large-scale farming, equine operations, dairies, beef cattle, other livestock, vegetables, horticulture, and specialty farms (Master Plan 2000). The remaining acres are in commercial forest, hobby farms, and natural lands (Master Plan 2000).

In order to protect agricultural areas within the county, the URDL must be enforced, permanent protection of productive lands must be provided, and agricultural zoning and development controls must be refined in order to allow for economic stimulation while protecting the land (Master Plan 2000). The reinforcement of property tax incentives will also encourage landowners to keep their land in agricultural use

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agricultural area include the Agricultural Preservation District, which is a five year agreement among the state, county, and owner of the land. This agreement means that the land will only be used for farming during that time period; it is also a prerequisite for the Land Preservation Easement, which makes the agreement permanent (Master Plan 2000). Land Trust, Purchased Development Rights (PDR), and Transfer of Development Rights are other options owners can explore (Master Plan 2000).

Housing developments and agriculture are not very compatible because increased traffic associated with development interferes with large agricultural equipment and the residents complain about dust, odors, and loud equipment operated in the early morning and late at night (Master Plan 2000). As Baltimore County ages, its infrastructure focus has shifted from building to maintaining and upgrading transportation networks, sewage systems, storm drain systems, solid waste treatment, and providing adequate water supply (Master Plan 2000). As farmers face economic pressure to sell their land for

to implement many of the ideas from the scientific community, but only on their own terms and of their own volition.

Since the 1960s, the position of the environment in the public mind has varied considerably. It has changed over time. Karl Marx said that ideas are voiced by elected officials and, in effect, influence policy. Differing priorities, commonly economy vs. environment, are set into the agenda of the administration and

environmental organizations such, as the Chesapeake Bay Foundation, have focused on FRQVHUYLQJ IDUPODQG DQG VXSSRUWLQJ IDUPHUV ZLWK water quality. This support suggests that farming is important to the long-term improvement of the Bay.

Recent surveys indicate that the general U.S. public has a high opinion of farmers. According to a 2004 survey from the National Corn Growers Association, the public strongly believes farmers and ranchers are concerned about the quality of their food produced and the well being of their animals and the public (CSD 2004). This survey polled over 1,000 U.S. adult consumers who were asked a number of questions relating to agriculture. The response to the poll was generally positive. Most respondents were open to the idea of genetically enhanced food with nearly half claiming that scientists should be free to use science and genetics to breed farm animals to be resistant to harmful bacteria (CSD 2004). A significant number of respondents stated that they are willing to SD\ KLJKHU SULFHV IRU IRRG FHUWLILHG DQG ODEHOHG [3] survey also showed that animal rights activist groups do not have much influence on consumer decisions to buy humanely raised products. Only 7% of people surveyed said that animal rights groups had a profound effect on their purchasing decisions, so most people are formulating opinions on their own about how farm animals should be treated (CSD 2004).

Another poll taken by the Eastern Shore Land Conservancy surveyed 1,202 registered voters about their attitudes and perceptions regarding land use on the Eastern Shore. Voters indicate that they want the government to play a bigger role in preserving farmland and habitat areas. Residents support the funding of farmland preservation and encourage that new funding programs be created (ESLC 2004). Most voters also support urban growth boundaries, citing that controlling growth, development, and sprawl is one

more harm than good, increasing paperwork and costs, while reducing crop yields for their already fragile businesses (Dewar 2000). It was feared that these new regulations would push poultry farms out of business, but so far this has not been the case, says Heather Dewar, of The Baltimore Sun (2000). Influenced by the media, the public was quick to blame agriculture for the Pfiesteriaincident; however, other factors may be at fault (Horton 2001). Other sources of pollution such as chemically treated lawns, LPSHUYLRXV VXUIDFHV DQG VHZDJH WUHDWPHQW SODQW attention (Horton 2004).

Most citizens blame agriculture as the major contributor of nitrogen pollution. 'DYH -XGD\ RI WKH +XGVRQ ,QVWLWXWH¶V &HQWHU IRU * dumping of raw sewage from urban sewage treatment plants nationwide is the number one contribution to nitrogen pollution (Juday 2003). Septic systems contribute about 4 percent of nitrogen to the Chesapeake Bay, and sewage treatment plants are an even ODUJHU FRQWULEXWRU 0DU[5HFHQWO\ D 0DU\ SDVVHG OH modest monthly fee for Maryland citizens connected to the sewer system, as well as those with septic systems. The money collected from this new tax is used for Bay restoration efforts, in the form of upgrading sewage treatment plants (Marx 2005). Before this law was passed, the Chesapeake Bay Foundation conducted an opinion poll which demonstrated a 72 percent approval rate for the sewer tax, indicating the public is willing WR SD\ D VPDOO IHH WR KHOS IXQG WKH %D\¶V UHVWRUD

While the costs associated with operating and owning farmland have risen drastically over the recent decades, the price of food has remained constant (Dewar 2000). This means that consumers are spending a smaller percentage of their income on food than prior years, even though the cost of food production has steadily increased (Dewar 2000). Another public perception regarding local farmers is that they receive

subsidies to either grow, or not grow, crops. In reality, the recipients of 72 percent of subsidies are agribusinesses (The Baltimore Sun 2005). Nearly two-thirds of Maryland farms are too small to qualify for subsidies (The Baltimore Sun 2005).

As the population in Maryland increases, there is more suburban sprawl due to the demand for additional housing (Rodricks 2005). While there has been progress made in

increased farmer confidence in the economic viability of the new practice (Badgley 2003). Farmers may offer both the support and expertise after implementing new methods with success on their farms (Gregory 2004).

Extension services play a major role in supplying farmers with the resources that are needed to ensure their farm is an economically and environmentally viable operation. Extension education is important in assisting farmers in adopting conservation practices. A variety of services are available, and research has shown that farmers rely on the technical assistance available from extension resources to develop conservation structures and practices on their farms (Gregory 2004). Maryland Cooperative Extension, which is a part of the College of Agriculture and Natural Resources at the University of Maryland, offers a large amount of information that may be helpful to farmers (MCE 2005b). They provide academic extension programs, seminars, and publications concerning agriculture (MCE 2005b). Many of the publications are free and can be downloaded online (MCE 2005b). Their website contains information about growing crops, raising livestock, and

of high quality products (USDA 2005a). They offer information about eradicating diseases in livestock and poultry and controlling insects and weeds (USDA 2005a). To ensure maximum yields for the farmer, the USDA routinely inspects seeds and fertilizers before distribution (USDA 2005a). They also study market reports and statistics so they may assist farmers in planning their farm management practices (USDA 2005a). The USDA has links connecting to information about education, outreach, laws and regulations (USDA 2005a). The Maryland Department of Agriculture website lists many links that may assist farmers such as County Agriculture and Land Use Information, Maryland Cooperative Extension, Maryland Agriculture Organizations, US Agriculture Links, and Rural Maryland Council (MDA 2005a).

The Maryland Agriculture Web Links site is maintained by the Maryland Cooperative Extension and contains a lot of agricultural links. These links provide farmers with helpful agricultural, educational and government web sites, agricultural associations and organizations, agricultural suppliers and equipment dealers, financial institutions, and publications and software (Maryland Agricultural Web Links Undated).

Information about the Small Farm Success Project may also be found online. This site is managed by a coalition of land grant universities, the USDA, and many non-profit organizations in the Mid-Atlantic region (Small Farm Success Project 2005). The FRDOLWLRQ¶V JRDO LV WR KHOS VPDOO DQG RU QHZ IDUI FaUP 6XFFHVV 3URMHFW 7KH IXQGLQJ IRU WKLV SURJ Initiative for Future Agricultural Food Systems and its intention is to help farmers use research effectively and offer them direct marketing strategies (Small Farm Success Project 2005). They also assist farmers in implementing sustainable farming practices like crop rotation (Small Farm Success Project 2005).

decide the nutrient needs of each of their fields. These soil tests are sent to analytical laboratories where the basic soil chemistry is determined and recommendations for nutrient application are made. A & L Eastern Laboratories is a local firm that provides such soil tests for Southern States and other agriculture consulting agencies. Their basic test involves analysis for organic matter, available phosphorus, exchangeable potassium,

farms has been declining, in small part due to nutrient management and runoff control techniques adopted by farmers (Chesapeake Bay Program 2005). It is vital that farmers can easily access information on sustainable agricultural practices, both for their economic success and for the protection of our natural resources. Farmer to farmer communications will likely be the most useful technique in spreading conservation practices, but these communications must be supplemented by technical support from extension services. Non-profit and governmental agencies must be willing to share information with farmers in a way that does not place valuable time and economic constraints. The web sites are wonderful but they require computers, high speed Internet access, and time. Finally, those corporations in a position to make recommendations to farmers must do so in an environmentally responsible way,

decisions are Live Near your Work, Rural Legacy Program, Priority Funding Areas Act, and Job Creation Tax Credit Program (Knapp et al. 2003). Although Maryland is one of the leading states with respect to Smart Growth policy and advocacy, these Smart Growth programs are not as effective in preserving open spaces and natural habitats including farmland as policymakers had hoped (Knapp et al. 2003). Policy for guiding urban development and the preservation of rural land (forest, farm, and open space) began in

require local governments fill the existing priority funding areas rather than expanding them or creating new zoning regulations (Knapp et al. 2003).

The high value of land in Maryland paradoxically contributes to the decline in farmland. The value of land in Maryland is among the 5th most expensive in the nation (MCE 1997). The increase in land value makes the asset value of farmland increase therefore making financing loans much less difficult, but this increase in value also makes the alternative of selling the land more enticing for the farmer (CANRP 2004). The average value of a farm in Maryland in 2000 was $501,000 compared to the U.S. average value of $429,000 (CANRP 2004). This shows that there is an increase in demand for land outside of the Priority Funding Areas which supports sprawl. Most development in Maryland has occurred in areas surrounding metropolitan areas, where the market value of housing rose 54% between 1991 and 2002 (Knapp et al. 2003). The majority of land being developed (75%) today is low-density housing (Knapp et al 2003). From 1985 to 1993 there was a 36% increase in the lot size per household and fewer people per household (in 1970 ~3.2 people per household and in 1990 ~ 2.4 people per household) (Blankenship 1995b). According to the Maryland Department of Planning, the prices of housing in Baltimore City are depressed, and both the vacancy and ownership rates of the city are declining due to the decrease in demand for homes in the city (Knappet al 2003).

Selling farms and other natural land areas have impacts on the environment, society, and the economy. For the farmer, the increase in the value of the land has made selling their farmland more attractive than their current labor of love, farming, which typically has low cash returns relative to other sources of income (CANRP 2004). The decreased number of farms and the physical separation between existing farms causes hiring labor, supplying materials, and marketing products to be more difficult and more

expensive (CANRP 2004). If the loss of farms continues it may reach a point where the agricultural industry of Maryland could collapse and become no longer commercially viable (CANRP 2004). Environmental impacts of the increase in development outside of urban areas include creating more impervious surfaces, more travel time in cars, a decrease in natural habitat, and an increase in demand for municipal services (sewers, schools, infrastructure, etc.) (Blankenship 1995b). The increase in travel time in cars increases air pollution. Cars produce one third of the nitrogen oxides emitted into the atmosphere, and they leak other harmful toxins that eventually run in storm water (Blankenship 1995a). Atmospheric nitrogen oxides are deposited onto the land and water contributing to nitrogen pollution. An increase in cars also creates a demand for more roads and other infrastructures that can alter the hydrology of surrounding habitats such as wetlands, forests and streams (Blankenship 1995a). The altered hydrology can cause flash flooding of streams (increasing sediment in streams and eroding stream banks), change in the position and quality of water tables, and overwhelm sewers and septic systems by increased storm water runoff from increased impervious surfaces (Blankenship 1995a). The growth of suburban development in districts that are not designed for such an increase in population can also overwhelm public services such as schools and wastewater treatment facilities (Boesch and Greer 2003). Many of the new developments outside of Priority Funding Areas have septic systems, which are less efficient at nutrient removal than sewers (Blankenship 1995a). The typical homebuyer of new homes in suburban developments desires open space and the more populated the suburban development becomes the further out individuals must move to acquire the desired open space (Boesch and Greer 2003). Consequently, this creates a perpetual cycle of moving further and further from metropolitan areas (Boesch and Greer 2003).

Maryland is not losing resource based land areas just because of population growth; the State is losing land because of where people are moving. People are migrating out of the metropolitan areas in what was the country (CANRP 2004). Many people work in urban areas, therefore sustaining the economy. However, as more individuals move out of these urban areas there is a decrease in the amount of money that is able to be recycled within these local urban economies (Boesch and Greer 2003). This migration makes it much harder for these urban areas to rejuvenate their public service facilities such as schools, roads, and sewage treatment plants (Boesch and Greer 2003). Many people move out of urban areas seeking better schools. With time, this produces a larger number of students within the non-urban area thereby reducing the quality of schools. This defeats the initial purpose of moving to a different district (Boesch and Greer 2003). The population growth in rural areas creates many problems for the L Q I U D V W U X F W X U H R I W K H V H F R P P X Q L W L H V D Q G I R U W K H in these areas. This makes it more difficult for businesses to acquire the basic necessities for farming (supplies, labor, community support, and marketing) (CANRP 2004).

Loss of Farms and Farmers

The number of farms and land in farms has decreased by 63% and 48 U H V S H F W L Y H O \ V L Q F H W K H ¶ V 0 & (7 K L V G H F U H D property value, the increase in the age of a typical farmer, a decrease in new farmers, and the increased cost of farming (CANRP 2004). Although the increase in property value makes farm asset values increase, it also makes the purchase of more land more difficult and the selling of current farmland more appealing to farmers (Boesch and Greer 2003). When the selling of farmland becomes the best alternative for economic ability, current farm communities become fragmented. The more fragmented the farm community

weaker and the market demands of the greater population drown out the needs of the farmer (Greer 2005a). If the number of farms and farmers continue in a downward trend, the agriculture industry may reach a point where the industry would no longer be economically sound and the industry in Maryland could collapse (CANRP 2004). This would be a terrible loss to the citizens of Maryland.

Why Farmers are Important

Agriculture is important socially, economically, and environmentally. Farming communities exemplify core family values, create a sense of community, and demonstrate a work ethic upon which many individuals base their ideals. The idea of a farmer comes with the sense of unity and passion for what they do. Farmers are stewards of the land, reducing the disconnect between society and the environment. As a result of their passion for farming, they fight to maintain their position in society. Preserving farmland is a struggle today; the nation needs a louder unified voice for its protection. The open spaces of undeveloped land are important simply for aesthetic purposes, maintaining natural places in all communities. Although farmland is not a no-impact land use, it does reduce impervious surfaces, cycles nutrients, and conserves natural landscapes and habitat. Farming is a keystone industry in rural economies; the disappearance of this industry may result in the collapse of many local Maryland

II. History of Conventional Farming

Changes in Farming Methods and Technology

Farming has seen many changes over time, but the plow has always been considered the most important tool for tillage (Beyer 2001). During the 19th century, oxen were replaced with American horses, which were used for pulling plows until tractors were invented (Culpin 1992, Beyer 2001). The moldboard plow was developed in England during the 1600's. Thomas Jefferson brought the moldboard plow back to Virginia when he returned from France at the end of the 18th century (Mountford 2004). Jefferson wanted to make improvements to the European plow that would make it lift and turn more efficiently and with the least amount of force necessary so fewer animals would be needed to pull it (Martin and Stanton 1988). His improved plow was known as the "Prospect Hill Standard Plow". The design of Jefferson's plow was simple enough

plow that cuts topsoil loose (Culpin 1992). The moldboard plow was the first plow to invert soil, which resulted in covering crop debris (Beyer 2001). Covering crop debris allows the nutrient value of the debris to become incorporated in the soil (Beyer 2001). However, critics argue that the crop residue gets buried too deep, thus preventing the decay which is required for nutrients to be re

environmentalists were at first concerned by the results, which could have led to the use of more fertilizer (Reich Undated). However, the fertilizer was now being placed in the right places at the appropriate time which helped to avoid nutrient leaching (Reich Undated). Other states and nations wanted to see the results of the soil testing program in order to establish

Tractors replaced horses because it took more time and money to produce food for horses than buy gas for tractors (Ganzel 2005). In 1915, 93 million (27%) acres of farmland was used to grow feed for horses and cows, but by 1960 only 31 million acres were being used to grow feed. This created more available land for the growth of cash crops (Ganzel 2005). There was also a downside to using a tractor; dependency on

2005). Hybridization involves the crossing of two pure lines of plants (Ganzel 2005). The hybrid plant is more vigorous and produces higher yields than its parents (Ganzel 2005). Today, 99% of corn grown in the United States is grown from hybrid seeds (Ganzel 2005).

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2005). Many other hybrids followed and new markets were developed for new soybean products (Ganzel 2005). During this time, soy oil was used in the manufacturing of plastics, soy meal was put in livestock foods, and soybeans had even become a small part of the human diet (Ganzel 2005).

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2005). As early D V W K H ¶ V V F L H Q W L V W V D Q G I D U P H U V N Q H Z essential nutrients for crop production, but they did not know how to produce the millions of tons of nitrogen, phosphorus, and potassium that was needed for crops (Ganzel 2005). Phosphorus was produced by chemical processes and/or the mining of phosphate rock *DQ]HO 7KH XVH RI ³QRUPDO VXSHUSKRVSKDWH´ IH (Ganzel 2005).

Nitrogen was one of the chief components of TNT and other explosives that were manufactured during World War II (Ganzel 2005). The United States built ten new manufacturing plants during the war to supply nitrogen for bombs (Ganzel 2005). By the end of the war, these plan0(t i)-3(n li)h. Byt ten new

(Ganzel 2005). While this change made for more efficient use of the new equipment, less crop rotation resulted in the depletion of nitrogen in the soil (Ganzel 2005). Thus, fertilizer was needed to artificially restore nitrogen in the soil (Ganzel 2005). By 1943, researchers had discovered how to inject anhydrous ammonia, which has the highest nitrogen content (82.5%) of any fertilizer, into the soil (Ganzel 2005).

&KHPLFDO SHVWLFLGHV ZHUH LQWURGXFHG LQ WKH was the first war in which fighting killed more people than disease, partially as a result of new technologies (Ganzel 2005). The insecticide DDT was first developed in 1939 by the Swiss scientist Paul Müller (Ganzel 2005). Since fleas and lice were known to carry typhus, and mosquitoes carry malaria, United States soldiers were supplied with DDT powder to put in their sleeping bags to prevent typhus and malaria (Ganzel 2005). Before the development of DDT, farmers were using arsenic compounds to combat insects on their crops. This use of arsenic resulted in fruit being sold to the consumer that contained arsenic residues (Ganzel 2005). DDT was cheap, persistent, insoluble, and effective (Ganzel 2005). Sales of DDT to the military were $10 million in 1944, but agricultural sales of DDT were $110 million in 1951 (Ganzel 2005). DDT application peaked in 1959, when 80 million pounds were used (EPA 2004). The use of DDT declined after

GXH WR WKH IDFW WKDW LQVHFWV ZHUH EHFRPLQJ UH DERXW ''7¶V LQFUHDVLQJ GHYHUVH HIIHFWV RQ WKH HQY decline in its use. Other more effective pesticides were soon developed to replace DDT (Ganzel 2005). However, the success of DDT marked the beginning of the development of other insecticides and herbicides (Ganzel 2005).

Problems with DDT were discovered as early as 1944 (Ganzel 2005). The U.S. Public Health Service warned the public that DDT could be a health hazard if absorbed through the skin and that it was killing beneficial insects and wildlife (Ganzel 2005).

the remaining on other chemicals) (Ganzel 2005). Killing weeds is a farmer (Ganzel 2005).

Aerial crop dusting using pesticides began in 1929 (Ganzel 2005). After the war, aerial crop dusting became more popular due to the fact that during the war, useful chemicals had been produced for farmers, thousands of pilots had been trained, and thousands of surplus military training aircraft were available (Ganzel 2005). Later planes were designed specifically for crop dusting (Ganzel 2005).

Pesticide regulations were first issued by the federal government with the issuance of the Federal Insecticide, Fungicide, and Rodentacide Act (FIFRA) of 1947 (Ganzel 2005). This bill required pesticide manufacturers to register all chemicals with the USDA and provide a label that states the chemical contents, directions for use, and antidotes if humans ingested it (Ganzel 2005). There were no regulations of these chemicals concerning the protection of the public (Ganzel 2005). The bill also required pesticides to be colored to prevent them from being mistakenly used for another purpose, such as baking powder (Ganzel 2005). By 1952, 10,000 separate new pesticides were registered with the USDA (Ganzel 2005).

The 1940's also saw an increase in irrigation technology (Ganzel 2005). Irrigation was important because it could control the amount of water a crop received and the time of day that a crop gets watered (Ganzel 2005). The number of acres of farmlands that were using irrigation technology during this era had increased by 143% (Ganzel 2005).

The application of petroleum-derived pesticides and fertilizers, and the implementation of numerous government policies on farming made the United States with the biggest farm economy in the world (Hatherill Undated). Fewer

farmers feed more people then they ever fed in the history of farm production (Hatherill Undated).

The success of and changes in farming has not been without consequences (Hatherill Undated). For instance, insects have developed resistance to some insecticides (Hatherill Undated). Broad-spectrum pesticides kill natural predators that could keep the pests in check (Hatherill Undated). The use of synthetic pesticides has increased thirty-three fold in the last half century. Today, 37% of the United States food supply is lost to

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doubled from 7% to 13% (Hatherill Undated). About 75% of the pesticides used in the United States are applied to soybeans, wheat, corn, and cotton (Hatherill Undated).

Over the last 40 years, ranchers and livestock farmers have fed their poultry, pigs, and cattle low levels of penicillin, tetracycline, and other antibiotics. This type of feeding

Input Sustainable Agriculture (LISA) research and education program (Diver 1994). The SURJUDP¶V QDPH ZDV FKDQJHG WR WKH 6XVWDLQDEOH $J (SARE) program in 1991 (Diver 1994). This program made funds available for land grant research and extension programs to focus on sustainable agriculture (Diver 1994).

Sustainable farming has become popular for a number of reasons (Humpert 2000). Many pesticides and herbicides that were commonly used by farmers are now restricted or are gradually being phased out by the Environmental Protection Agency (Humpert 2000). Sustainable farming can also save farmers money by decreasing their dependency on pesticides and herbicides (Humpert 2000). Consumers are now more health conscious, and their demand for organic food has increased by 24% each year since 1990 (Humpert 2000). Some supermarkets are now testing organic produce for pesticide UHVLGXHV + XPSHUW 7RGD\¶V Urban Cooperative Extension to understand the importance of organic matter in keeping their soil healthy (Humpert 2000). In addition, farmers are also being criticized by environmental groups for the pollution of watersheds (Humpert 2000). Urban

1997). There are many practices that help produce a healthy soil (UCSAREP 1997). The use of cover crops, crop rotation, compost, and conservation tillage may assist in the enhancement of soil productivity (Humpert 2000, Hall and Kuepper 1997).

For more information about Sustainable Farming practices, see Appendix 1.

Types of Farming

Organic Farming

The public became aware of organic farming during the period (Baker Undated). People became more environmentally aware during this period, after the publication of Silent Spring by Rachel Carson. Carson brought to light ecological problems associated with the use of agricultural chemicals, particularly the use of synthetic insecticides (Baker Undated). The consequences of modern farming practices became evident in the pollution of our watersheds, which led to pesticide regulations (Baker Undated). Consumers began demanding foods grown by farming practices that were not ecologically destructive and did not require the use of toxic chemicals for production (Baker Undated).

Organic farming is one of the methods that can be implemented to achieve sustainability. This method avoids or minimizes the use of synthetic fertilizers, pesticides, growth regulators, and livestock feed additives (Diver 1994). Organic farming also promotes and enhances biodiversity, biological cycles, and soil biological activity (Kanter 1999). Pesticides that are derived from natural sources are considered an organic source (EPA 2005b). Organic farmers employ practices such as crop rotations, crop residues, animal manures, legumes, and green manures to protect and enhance the soil. These biological practices help maintain soil productivity and control weeds, insects, and other pests (Diver 1994).

The USDA developed a national program to develop universal standards for organic farming as stipulated in the Organic Foods Production Act (Diver 1994). The intention of part of the 1990 Farm Bill was to lay out national standards, certification requirements, and food labeling for organic products (Diver 1994). Due to lack of funding, the 1990 Farm Bill never took effect (Diver 1994).

On October 22, 2002, the USDA finally issued national organic standards. Any producer or handler of organically grown food must be accredited by the USDA in order to sell, label, or market their products as organic (EPA 2005b).

Conventional Farming vs. Organic Farming

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agricultural production (Stacey 2004). However, these percentages are higher in certain regions (Stacey 2004). There are conflicting reports on crop yield differences between organic and conventional agriculture. One source states that crop yields for organic farms are 10 to 30 percent lower, and that crop losses on organic farms are significantly higher than conventional farming systems (Stacey 2004). USA organic wheat yielded 43% less than conventionally grown wheat (Stacey 2004). Other studies show that crop yields increase with organic farming, but these studies are exceptions to the norm. Long term field studies that were done over 104 seasons (26 years) demonstrated that organic farms were 75% less productive than conventional farms (Stacey 2004). Some scientists believe that organic farming has caused a serious decline in productivity (Stacey 2004). They also state that the widespread adoption of organic farming practices would worsen food security problems and increase the amount of land needed for agricultural purposes (Stacey 2004).

Another source states that results from an eight year project demonstrated that organic systems had comparable yields to conventional systems when growing tomatoes,

safflower, corn and beans. Some of the yields for these specific crops were actually greater in the organic systems (Vasilikiotis Undated). The tomato yields in the study took a few years to reach the conventional systems yields, but eventually surpassed conventional yields (Vasilikiotis Undated). The study's conventional systems had a higher variability, which resulted in lower and higher yields than conventional systems during different years (Vasilikiotis Undated).

Organic farming produces a higher organic carbon content in the soil, with larger pools of stored nutrients (Vasilikiotis Undated). Nitrogen availability is a limiting factor in organic systems. This is due to the fact that the high carbon input from cover crops and composted poultry manure, which may be used as fertilizer in an organic system, needs to associate with nitrogen in order to decay (Vasilikiotis Undated). After a few years, the organic matter starts to stabilize, which results in more available nitrogen for crops (Vasilikiotis Undated). The soil in the organic farm was shown to have larger and more active microflora, better soil structure, and more fertile topsoil due to less erosion (Reganold 1992). Higher yields in organic farming systems may be attributed to a reduction in soil erosion and the maintenance of organic matter in soil (Reganold 1992).

In one study, organic farming systems were shown to be more profitable than conventional farming systems (Vasilikiotis Undated). This was attributed to lower production costs and the outperforming of conventional farming systems in dry climates (Vasilikiotis Undated). Other studies have stated that conventional systems have appeared to be more profitable over a shorter time period (Reganold 1992). These results may be attributed to the fact that agricultural research and policy have promoted conventional agriculture over the last four decades (Reganold 1992). Subsidies for conventional farms are greater than those for organic ones (Reganold 1992). If the external costs of repairing the environmental and health damage related to conventional

farming systems was shouldered by the farmer instead of the taxpayer, the profitability of conventional farming systems would be much lower (Reganold 1992).

This study stated that both organic and conventional farms have the potential for failing when faced with unfavorable weather or marketing problems. However, alternative farms have a higher diversity of crops and more efficient practices, which leads to a greater chance of succeeding (Reganold 1992). Alternative systems were shown to have lower yields, but operating costs were lower by about the same cash

Service of Illinois was one of the first agricultural consulting firms to offer this technology to farmers (Kolling 1995). Only about three to five percent of the farmers in the United States use GPS systems (Kolling 1995) which are very costly to implement. Farmers may pick up signals from 24 satellites orbiting the earth. These satellites assist them in determining how much fertilizer needs to be applied to each section of their field (Kolling 1995).

A 20-inch antenna is installed on the top of a combine, and a monitor is placed L Q V L G H W K H F R P E L Q H (K R O O L Q J 1 9 9 5) ¶ V T h e a n t e n n a p i c k s u p s a t e l l i t e s i g n a l s , a n d t h e s e V L J Q D O V L Q I R U P W K H P R Q L W R U R I W K H F R P E L Q H ¶ V O R F D accuracy (Kolling 1995). Connected to the monitor is a sensor which relays measurements of the

$250,000, but an existing fertilizer truck may be modified for about $25,000 (Kolling 1995). These costs might not be economically feasible for small farmers (Kolling 1995).

Farmers who have commercial pesticide licenses believe that precision farming reduces most of the record keeping that is otherwise required (Kolling 1995). Farmers that do not have commercial pesticide licenses would have to employ someone to keep track of their pesticide records (Kolling 1995). These recordings would include the type of pesticide used, the amount used, the location where the pesticide was applied, and the direction in which the wind was blowing. The GPS unit records all this information automatically (Kolling 1995).

Agricultural Biotechnology

Some sources state that biotechnology may be the solution to providing an adequate diet to the 840 million hungry people in the world (Vasilikiotis Undated). Agricultural biotechnology consists of using g.ricule souryhnology m1 hnolog

chemicals and pesticides (Ganzel 2005). Proponents also state that genetically engineered crops are known to reduce tillage, improve crop yields, increase drought resistance, and reduce the amount of water that must be applied to produce a healthy crop (Ganzel 2005).

Critics argue that some of the consequences of genetically engineered crops may be the extinction of microbial, plant and animal species, and the potential contamination

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Maryland Tobacco Crop Conversion program, which was otherwise known as the

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farmers that signed the contract agreed to convert their crop production from tobacco to any crop of their choice. By joining the program, farmers also agreed to keep their property in some sort of agricultural production for the rest of their lifetime (Barnes

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crop sales in pounds during 1987 through 1999 (Barnes 2001). The settlement paid the farmer $1 per average pound for ten years (Barnes 2001). If the farmer happened to die

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2000). If the land was sold to a new owner, the new owner would not be bound by the ten-year contract (Mussendon 2000). One stipulation of the agreement was that it allowed participants to grow tobacco as long as it was not used for human consumption or smoking (Mussendon 2000). Participants may also help participants on their tobacco farms for a limited time, with permission (Mussendon 2000). If the agreement is violated, farmers could be taken to court and forced to pay the buy-out money with six percent annual interest (Mussendon 2000). The average payment to each farmer is $11,000 per year (DeGregorio 2004). The intention of the buy-out payments was to help farmers transition into growing a new crop, but the average tobacco farmer is 62 years old, which is older than the age of the average Maryland farmer (DeGregorio 2004). Most of the older farmers are not interested in learning how to raise new crops, so they are using the buy-out money as a retirement fund (DeGregorio 2004). Finding a new niche market for the tobacco farmers has also been difficult (DeGregorio 2004).

Broilers are the most important agriculture product in Maryland, with a market value in 2004 of $583 million dollars (Myers 2004). Broilers also consume more grain

production decreased by as little as four percent, 1,000 jobs and $74 million would be lost from our state (Goodman 1999).

Trendsin Farming: Statistics

Agriculture has been important to the economy in Maryland and in the entire United States. In the last half century, agriculture has experienced downwards trends in scale and in the economic viability of the industry. Today, the future of agriculture in Maryland is questionable. As well as being a vital part of the states economy, farming has also prevented land throughout the state from being lost to urbanization. In losing farms, Marylanders also lose the general understanding and the distinct culture of farming as a way of life.

Of the total 6.2 million acres of land in Maryland, the number of acres devoted to farming has decreased by 50%, or 4.2 million acres in 1945 to 2.1 million acres

agricultural production, while advances in technology allow fewer farmers to produce all WKH IRRG WKLV QDWLRQ UHTXLUHV /HVV WKDQ WZR SHU LQYROYHG LQ WKH SURGXFWLRQ RI WKH QDWLRQ¶V IRRG land used for farming causes the remaining farmland to be farmed more intensely and the former farmland to be open to further development.

The Environmental Movement

Pioneers of the United States settled in the New World with the ingrained mindset of materialism and human domination over the environment (Kline 2000). The idea that worth consisted simply of materialistic possessions was encouraged by religious beliefs and scientific reasoning originating from the Middle Ages and Enlightenment (Kline 2000). These beliefs sanctioned the idea of inferiority of nature to man (Kline 2000). Natural resources were exploited and poorly managed turning fertile land into exhausted and eroded land (Kline 2000). The majority of land throughout the United States was H [S H Q G®®ªäWL

seen in owners of encroaching factories, farmers became the success of mass production, cost efficiency, and profits (Kline 2000). This new economic perspective replaced the environmental friendly relationship that farmers once had with their land (Kline 2000).

Despite the negative environmental impacts that were caused by the industrial revolution, society continued to strive for prosperity and ignore environmental degradation. The repercussions from centuries of exhausted farm land and resources

materials in the environment decrease the impact that rain has on soil and plant roots, which creates a more stable environment for soil dwelling organisms (Primack 2002). This stability allows organisms to become more efficient in aerating the soil which also LQFUHDVHV WKH VRLO¶V DEVRUSWLRQ FDSDFLW\ 3ULPDF to maintain this process, the economic burden is certainly felt when ecosystem services are not functioning and LcWLHV DUH GHVWUR\HG DV D UHVXOW %DVH ability to prevent flooding in the Boston, Massachusetts area, its value is estimated to be $72,000 per hectare (Primack 2002). In order to improve the quality of drinking water, New York City¶V JRYHUQPHQW SDLG ELOOLRQ GROODUV WR State to preserve forests in the watershed and improve farming practices (Primack 2002). If the city would have chosen to use technology to replace ecosystem services, such as water fil

payments in exchange for enacting environmentally sound policies. They may also receive cost-share assistance which helps them set up long-term conservation practices (USDA 2004).

The 2002 Farm Act allows FSA to help farmers with programs such as marketing loans and direct payments (USDA 2004). Some farmers and ranchers are temporarily unable to establish private, commercial credit; therefore FSA provides credit counseling and supervision to them. Farmers can apply for Farm Storage Facility loans which grant them money to build or renovate storage structures, or install grain handling and drying

and local government recognized the negative effects of land development on habitat and aquatic resources (Critical Area 2005).

These federal and state programs, along with local ones, work together to establish regulations and policies that suit a specific area and address specific issues. Nutrient management is a key issue in the agricultural business nationwide. Plans for nutrient management are developed for different areas based on policy requirements from the Natural Resources Conservation Service (NRCS). Nutrient planning is based on soil tests developed in accordance with the Land Grant University (USDA 2003). These tests analyze nutrients in the soil to get specific information that will help create a nutrient plan. The tests are conducted by state certified programs, the North American Proficiency Testing Program, or any laboratory whose tests are accepted by the Land Grant University in the state in which the tests are to be used (USDA 2003). Plans are then developed that specify the source, amount, timing, and application method of nutrients on each field to achieve realistic production goals while minimizing nitrogen and phosphorus movement to surface and groundwater (USDA 2003).

Nutrient management is extremely important to the State of Maryland because of

for the purpose of protecting land from development in the future. Private owners still own the land, but they give up the right to subdivide or develop it. This is fairer than other policies because the price is mutually agreed upon between buyers and sellers, so the price accurately reflects the value of the land. This internalizes the positive social values of the land that may not usually show in the price of the land. State and local governments have spent over $1.5 billion to purchase development rights to private lands and by doing so nearly two million acres of farmland had been protected through 1995 (Miller 1995). Through the purchase of easements, Baltimore County has preserved 27, 438 acres of farmland with the private sector preserving 500 acres per year (Helfin 2000). Baltimore County has the highest number of privately donated easements in the State of Maryland (Bartenfielder et al. 2000). These private donated easements represent the

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difficult for a farmer to decide which land should be preserved since different types of land are more or less valuable to different people.

Land trust programs are nonprofit conservation organizations that aim to protect natural, scenic, recreational, agricultural, historic, or cultural property. The United States currently has alm

for administering site plan reviews (Weaver 2002). Baltimore County has the Development of Prime and Productive Land Ordinance, which directs a landowner to maintain farm use on a specific property (Bartenfielder et al. 2000).

III. Environmental Issues Related to Farming

Nutrients

The use of fertilizer in agriculture is thousands of years old, though its use has changed significantly over the last few hundred years. Some early forms of fertilizers used by ancient civilizations are plant residues, manure, wood ashes, animal bones, and human wastes (Eckert 2000). Around 400 years ago, scientists began studying plants in order to enhance the productivity of crops for farmers and the growing population. After considerable experimentation it was found that there are certain minerals in the soil that plants need, including nitrogen, phosphorus, and potassium. Early agricultural chemists soon learned that when fields were let to be fallow (left vacant of crops for a season) these essential nutrients were replenished assuring successful crop when it was finally used. Early research also revealed that yit(, e5e)4(ssrn(v)-t7(ble)-r)-6(c)4(d)3(ter)5 0 0 1 90.024 705.1 ls

method of application is good in places with till to minimize the loss of urea to volatilization (Eckert 2000).

Ammonium nitrate contains 34 % nitrogen and is used as a solid fertilizer. It is also found in many types of dry and liquid fertilizers. This type of fertilizer contains both usable forms of nitrogen in NO_3^- and NH^{4+} (Eckert 2000). Ammonium sulfate is another type of fertilizer, but it is not used very often. It is used in special situations because of its sulfur content (Eckert 2000). It contains 20 % nitrogen and 24 % sulfur. Soils with sulfur deficiencies would benefit from ammonium sulfate.

Recommended nitrogen fertilizer rates are different from place to place and need to be followed closely so that there is no harm done to the environment, and farmers do not incur unnecessary cost. The recommended rates depend on a number of factors that include the crop being grown, yield goal, and quantity of nitrogen that might be provided by the soil (Eckert 2000). The decisions needed to determine rates are usually acquired by the farmer through soil practices, local recommendations and experience (Eckert 2000).

Alternative Fertilizer Use

There are other forms of nitrogen available as fertilizer for crops. Organic compost, manure, and plant waste all contain nitrogen. Organic materials do not have as much bioavailable nitrogen as commercial fertilizers do. When contemplating using organic materials, the carbon-nitrogen ratio needs to be considered (Barbarick 2005). A

2005). Sawdust, which is a plentiful source of organic material, has a C:N ratio of 400:1, which means that if used it, would not supply crops with adequate nitrogen (Barbarick 2005). Some commercial fertilizer would need to be added to adjust the ratio. When this type of organic compost is available, the cost of buying fertilizer and the amount of applied nitrogen, which has the potential to be leached into groundwater, can both be log10(rol 0 d)] pe/Pagiwhich

2001). This can become a problem when phosphorus finally does leach into waterways, it will enter the water in large doses. Manure runoff is also a major source of non-point pollution (Carpenter et al. 1998). The issues that are associated with manure are similar to the issues of human waste (Carpenter et al. 1998). Human waste disposal is regulated and processed and is therefore point source pollution; however, excess manure is very common on farms and can be used to fertilize crops, therefore making it a possible cause of non point source pollution (Carpenter et al. 1998).

Just as crops require nutrients for growth, aquatic vegetation, such as algae, requires nutrients as well. In the natural environment, aquatic vegetation will continue to grow until there is not enough of one essential nutrient cl contt9(. nb)-3ee.0242k.586 3al nut

dissolved oxygen makes it very difficult for fish to survi

attached to particles and in the soil/water solution (Donahue et al. 1977), are absorbed by plant roots across a concentration gradient from the soil to the plant (Hull 2005). The availability of soluble soil nutrients is largely affected by pH (Donahue et al. 1977).

The pH of soils may determine the equilibrium state of certain nutrients, thus affecting the concentration of soluble nutrients available for plant uptake. The cation exchange capacity depends upon the chemistry of pH variation (Hausenbuiller 1985). As the soil pH increases, so does the cation exchange capacity, and as pH decreases, so does the ability of plants to absorb ions (Hausenbuiller 1985). Acidic soils can make nutrients unavailable to plants, and could also cause the leaching of nutrients into ground water and streams (Donahue et al. 1977). Acid soils tend to accumulate organic or inorganic acids that may affect the ability of microorganisms, especially bacteria that break down organic materials (Donahue et al. 1977). Highly acidic soils also tend to release toxic amounts of minerals detrimental to plant growth, such as aluminum (SERC 2005). Under basic conditions, micronutrients are less soluble and phosphate may become locked up (Donahue et al. 1977). The ideal soil pH for optimal plant growth is between 6.0 and 7.0 (CET-SUMES 2004). This provides the optimal environment for the nutrient requirements of most plants.

Other factors involved in soil productivity are aeration and porosity within soils. Air and water are located in the pore spaces between organic materials and sand, silt, and FOD\ SDUWLFOHV 7KH VXSSO\ RI R[\JHQ LQ WKH VRLOV¶ water conditions within the soil (Hausenbuiller 1985). Oxygen is necessary for the expansion of roots, and plant respiration (Hausenbuiller 1985). Waterlogged soils tend to be less productive for most agricultural purposes (Hausenbuiller 1985), and lack of

gaseous oxygen also inhibits microbial breakdown of organic matter (Hausenbuiller 1985). Porosity is important for gaseous exchange because larger pores drain quickly after rain events (Hausenbuiller 1985). Clayey soils tend to have small but numerous pore spaces and hold a lot of water. For this reason, loamy soils containing sand, silt, and clays are the best suited for agriculture. Loams hold enough water for plant requirements, and they provide enough aeration that plants require as well (Donahue et al. 1977).

Water is an important catalyst for soil formation and is an essential factor in the production of plants. It is also responsible to some extent for fluctuations in soil temperature (Hausenbuiller 1985). Water is the medium by which nutrients in the form of soluble ions reach plants, so plants require a regular supply of water for growth and maintenance (Donahue et al. 1977). Soil erosion occurs when water from heavy rain

(Deacon 2005). Because it is unusable by plants, it needs to be converted or fixed into

Phosphorus is essential for photosynthesis and is a major constituent of the nuclear parts of cells, however it only constitutes a small part of the atmosphere (Smith and Smith 2001). Phosphorus is only available to plants when it is in its fixed form, which is known as phosphate (Smith and Smith 2001). When phosphorus is lacking in the soil, the plant is probably suffering from a nutrient deficiency (Hopkins 2003). When phosphorus is present in the soil in excess, the plant is probably suffering from nutrient toxicity (Shober et al. 2003). Phosphorus reacts with clay, iron, and aluminum

decreasing the amount of nitrogen entering aquatic ecosystems (Carpenter et al. 1998). Over the years there has been a decrease in the number of wetlands in Maryland, so it is very important that wetland restoration become a priority (Gresens 2005). Also, vegetation along waterways forms a riparian buffer, which traps nutrients before they enter the water (Carpenter et al. 1998). Riparian buffers can be replaced wherever they have been removed or enlarged as necessary. Cover crops will also help to decrease nutrient pollution (Carpenter et al. 1998).

Another important way to regulate nutrient pollution is to monitor livestock waste (Carpenter et al. 1998). In order to control livestock waste it is necessary to monitor it and create regulations similar to those set for human waste (Carpenter et al. 1998). By doing this, livestock waste would change from non-point source pollution to point source pollution, which is much easier to regulate and control (Carpenter et al. 1998). This transformation would make it easier to lower the amount of pollution released into our waterways.

Erosion

Soil erosion is the movement of soil particles by wind or water (Smith and Smith 2001). Erosion is a natural process, accelerated by farming activity that removes topsoil, reduces levels of soil organic matter, and contributes to the breakdown of soil structure (Crosson and Stout. 1983). The reduction of levels in organic matter and the breakdown of soil structure in turn affect soil fertility, the movement of water into and from the soil surface, and crop yields (Foster et al. 1985). The problem may become so severe that the land can no longer be cultivated (Brown and Wolf 1984). A study at Iowa State University on forty soil samples reported that the impact of soil erosion on soil

productivity was largely determined by subsoil properties because they effect root

humus, which is nutrient rich and contains organic matter (CBF 2004). This results in soils that are less ideal for plant growth (CBF 2004). Wind erosion causes the most extensive damage where the climate is dry and large expanses of fields are unprotected and fallow (IECA 2005). Water erosion is most common on a sloped landscape (Smith and Smith 2001); the severity of the slope is proportionate to the severity of erosion (Smith and Smith 2001). Water erosion risk is greatest on land under extensive cultivation (Vanderwel and Abday 2001). Fine-textured, erodible soils are especially vulnerable to erosion by rainfall and runoff (IECA 2005). Tillage erosion is mostly caused by the way a farmer tills the land (Baker and Lafnen 1983). The kind of equipment a farmer uses, how often the farmer tills the fields, and how the farmer manages the fields during the winter months affect how much soil may be lost (Foster et al. 1985). Heavy machinery, frequent tilling, and lack of cover crop during winter months contribute to soil erosion (Conservation Tillage Information Center 2002). Types of erosion include: sheet, rill, and gully (Smith and Smith 2001). Sheet erosion occurs over open fields (Smith and Smith 2001). Rill erosion occurs when water that is traveling down hill in small streamlets causes the streamlets to become larger and produce small channels (Smith and Smith 2001). Gully erosion occurs in larger channels than rill erosion and is more destructive (Smith and Smith 2001).

Soil erosion has short-term damage as well as long-term economic effects (Dickey et al. 1984). Short-term damage and increased costs can result from: loss of seeds, seedlings, fertilizer and pesticides, the need to repeat field operations, soil being washed from plant roots, young plants being hit by wind erosion, extra cultivation to level out eroded surfaces, increased fuel consumption and man hours (Baker 1985).

Good management practices can reduce erosion; methods are: leaving crop residue, strip-cropping, grassed waterways, contour tillage, no till methods, and planting winter crops (EPA 2005d, USDA 1996). Modifying tillage practices to keep crop residue on the surface can greatly reduce erosion (Vanderwel and Abday 2001). Crop residue left on the soil surface can slow the flow of runoff that can displace and carry away soil particles (National Academy of Sciences 1986). Conservation tillage leaves at least thirty percent of residue left behind such as stems, stalks and leaves on the soil surface from harvest time to the next planting (Conservation Tillage Information Center 2002). Conservation tillage methods include no-till, where no tillage is done at all and seeds are SODFHG GLUHFWO\ LQWR D FURS FRYHU-till, in which the previous crop residue is only a narrow, five to seven inch strip is created down each row; ridge till; and mulch till

conservation planning, rehabilitation of degraded soil, and rural water quality (EPA 2005d).

The Impacts of Other Land Uses

other sources of nonpoint pollution. Another factor is that remaining farmers are dutifully adopting nutrient management and runoff control techniques. But perhaps most importantly, a large cause of this shifting focus is that the land uses that are replacing farming are creating more of an environmental impact than agriculture ever did.

The Natural Resource Conservation Service ranks Maryland fifth in the country for its percentage of land that is developed for urban uses (roads, housing, industry, commercial) (CANRP 2004). The percentage of urban land uses has increased from 12.3% in 1973 to 18.4% in 1997 (CANRP 2004). If current trends continue, urban development in the Chesapeake Bay watershed may expand by more than 60% over the coming 30 years (Boesch and Greer 2003). Among the major land use categories, urban and suburban lands contribute, per acre, the largest amount of nutrients to the Bay when septic and wastewater treatment plant discharges are factored in (Chesapeake Bay Program 2001). Waste management, the proliferation of impervious surfaces, and residential land use are the three primary pathways by which urban and suburban land

had not had their systems cleaned in the last three years (Swann 1999). When questioned about their awareness of the connection between septic system maintenance and water quality, one-third of all septic owners either disagreed that septic system maintenance was necessary to protect water quality or responded that they did not know (Swann 1999). This stresses the importance of septic system owner awareness, to reduce the impact of these systems on Bay quality as they become more widespread.

Also, as land is developed, storm water runoff from urban and suburban areas increases as groundwater infiltration and soil retention of rainwater decreases, preventing the removal of pollutants before they reach surface waters (Chesapeake Bay Program 2001). Wastewater treatment has also been a major (point) source of nutrient pollution in the Bay watershed; however, government regulation and new technologies have reduced the input of nitrogen and phosphorus in many surface waters within the watershed

the high peak flows associated with rainfall in urban environments increase the erosive power of the stream and cause channel degradation, and increase sedimentation

watershed is receiving twice the nutrient load necessary for healthy turfgrass management.

It has been found that Americans apply fertilizers to their lawns at rates similar to or exceeding those of cropland systems (CWP 2002). A comparison of fertilizer application between land uses has shown that fertilizers are applied to cropland at rates comparable to residential land use and golf courses (See Table III-1). It is apparent that fertilizer application to other land uses is causing worrisome impacts that must be addressed as well.

Table III-1: Comparative Nitrogen Application Rates for Various Land Uses

Location	Year	kgN/ha/yr	Reference
Ontario	2003	65.7	

et al. 1990). Surface runoff losses of total N and P for tobacco were 2.34 and 0.48 kg per hectare per month, respectively. Losses of N and P from the turf averaged only 0.012 and 0.002 kg per hectare per month, respectively (Gross et al. 1990). This is due to increased productivity of the lawn area through an increased number of shoots (Beard and Green 1994). Thus, although residential fertilizer rates are high, uptake of nutrients is also high and the nutrients are less likely to leach into groundwater or runoff into streams, when careful turfgrass management is applied. Poor turfgrass management can have the same detrimental environmental impacts as poor agricultural practices.

Agriculture remains a source of non-point pollution to the Chesapeake Bay watershed. However, as a primary source, it is decreasing. The land utilized for agriculture has been decreasing for decades and land uses replacing agriculture are proving to cause more environmental degradation than was previously occurring. Urban and suburban sprawl are emerging as the largest changes to the water quality of the Chesapeake Bay watershed, and sprawl is projected to increase over coming decades. Protection of our ground and surface water resources will require growth policies that mitigate environmental disturbances, and the retention of agricultural and forested lands for the conservation of wildlife habitat and natural resources.

The Bay

The Chesapeake Bay is among the largest estuaries in the world and is the biggest in North America. An estuary is a body of water that is open to an ocean so that saltwater from the ocean can mix with freshwater running off from the surrounding land (Chesapeake Bay Program 2005). This surrounding land is a watershed, an area of land containing smaller waterways such as creeks, streams, and rivers which collect all

rainwaterfalling onto the land and then flow or drain into a larger body of water (Chesapeake Bay Program 2005). The Chesapeake Bay watershed is comprised of hundreds of thousands of small waterways, spanning over 64,000 square miles across parts of six states: Maryland, Virginia, Delaware, West Virginia, Pennsylvania, and New York (Chesapeake Bay Program 2005). The Bay has long provided an environment in which many different living organisms have functioned and thrived and interacted with one another and nonliving components of the Bay habitat. Currently, the Bay is home to more than 3,600 species of plants and animals and more than 16 million people (Chesapeake Bay Program 2005). The increasing human population within the watershed with its associated land use practices has resulted in greater levels of pollutants entering the Chesapeake Bay. These stresses have impacted the Bay in a way never before experienced.

The Chesapeake Bay Foundation estimated in their health, the State of the Bay Report, that the Chesapeake Bay watershed was its healthiest in the 1600s, having a perfect rating of 100 (CBF 2005). A recent report indicates that the Chesapeake Bay received a rating of 27 out of 100, putting it on the Environmental Protection Agency´s (EPA) list of ³dirtiest waters´ (CBF). The most significant

water in the world, therefore nutrients have a greater chance to enter and impact the Bay (Pegg 2004). As the population grows, and as urban sprawl increases as a result, the amount of runoff from impervious surfaces will carry greater amounts of nutrients, heavy metals, and other contaminants into the Bay. There are numerous sources from which nutrients are exposed to the Bay, but much scrutiny has been on agriculture.

Agriculture is prominent in the Chesapeake Bay watershed and provides crops/food for the human population but growing crops requires cultivating the land and providing it with essential nutrients such as nitrogen and phosphorus. Farming practices such as manure applications are employed to help fertilize the soil and enhance the growth of crops, thus keeping the land fertile enough to continue crop production. Animal manure is the largest source of agricultural pollution, since it contains significantly high levels of nitrogen and phosphorus (Pegg 2004). There are three manure hotspots in the Chesapeake watershed, the Delmarva Peninsula, Rockingham Co., VA in the Shenandoah Valley, and in Lancaster Co., PA in the lower Susquehanna River basin (Horton 2003). The farmers in these agricultural areas produce far more animal manure than local farmers can use as fertilizer, anrgrrenhntamingces cab5(e)4( )] TJ ET BT 1 0 0

concentrations of the nutrients within each manure type. Also, different areas of the Chesapeake Bay watershed can rely on different types of animal production, such as chickens or livestock. There are 185 million livestock animals in the watershed, more than 11 times the human population (Horton 2003). Chickens outnumber people DSSURLPDWHO\ WR RQ 0DU\ODQG¶V (DVWHUQ 6KRU (44 million tons) of manure a year (Horton 2003). In either case, they influence the amountof nutrients that are transferred into the environment. No matter what the manure or waste type, there is presently an increase in the number of animals and decrease in available farmland, causing many farms to produce more manure than what the land can uVH 2¶%ULHQ $GGLWLRQDOO\ VRLO WHVWV LQ FHU QRW QHHG H[WUD SKRVSKRUXV WKHUHE\ UHGXFLQJ WKH 2003). So the excess nutrients that are not applied to field crops or absorbe

phytoplankton living in the Chesapeake Bay and its tributaries including diatoms, dinoflagellates, and green algae (DNR 2005). Excessive levels of nitrogen and phosphorus cause algae to grow prolifically and build up on the surface of the water (Chesapeake Bay Program 2005). These collections or blooms of algae cloud the water DQG DIIHFW WKH KHDOWK RI WKH %D\¶V VHDJUDVV EHGV. The algae block the OLYLQJ R sunlight that is needed by underwater grasses or submerged aquatic vegetation (SAV) in the shallow parts of the Bay (Chesapeake Bay Program 2005). This vegetation is extremely important in the functioning of the Bay ecosystem, for it act as a food source for some types of birds and as a habitat for shellfish and other fishes (Chesapeake Bay Program 2005). This vegetation also acts as a buffer trapping the enormous amount of sediment that enters the bay. Sediment is trapped by water grasses keeping the bay clean and would decrease the amount of dredging needed each year. Harming this vegetation affects the other organisms that depend on the vegetation and the loss of SAVs can have a devastating effect on the ecosystem. Further, when algae die, they GHFRPSRVH DQG WKH GHFRPSRVHUV µIHHGLQJ¶ RQ WKH O oxygen in the water producing areas of the Bay with very low levels of oxygen (Chesapeake Bay Program 2005). These areas are then referred to as GHDG]RQHV ´ IRU levels of dissolved oxygen are often too low to sustain life, resulting in the death of DTXDWLF RUJDQLVPV 3DUNHU DQG :ULJKW 7KH ZRU said to have covered 40 percent of the central portion of the Bay, stretching 150 miles (Pegg 2004). Nutrient pollution affects fisheries in the Bay, by contaminating spawning grounds and destroying habitats, thus leading to fishing restrictions (Chesapeake Bay Program 2005).

Nutrient pollution can lead to fish kills and it can also lead to a decrease in the populations of keystone species. Keystone species are organisms that are critical to the overall health of an environment or what is happening within the environment. Within the Chesapeake Bay, two notable keystone species are oysters and blue crabs. With

from farms (BRCPAC 1997). Particularly, phosphorus from large chicken farms on the Eastern Shore was identified as a potential cause for the Pfiesteria outbreaks (BRCPAC 1997). As a result, on April 10, 1998, Governor Glendening and Maryland legislative leaders agreed to the nations most comprehensive, mandatory limits on the use of farm fertilizers (Simpson 1998). Farmers, who had long opposed such a regulation, finally agreed to accept the bill in exchange for a delay in its introduction and milder penalties for those who do not comply with the law. The Water Quality Improvement Act of 1998 states that farmers using chemical fertilizers are to test their soil and draft plans limiting their nitrogen and phosphorus use by 2001, and the plans must be implemented by 2002 (Simpson 1998). Farmers using manure or sludge have till 2004 to have the plans drafted and 2005 to be implemented (Simpson 1998). Those who fail to comply with the new restrictions face fines up to $2000 a year (Simpson 1998). Government funding pays farmers subsidies of $3 an acre, roughly 50% of the total cost, to offset the cost of the management plans.

Farmers feel that this type of treatment by the state is unjust, because other sources of pollution, such as residential lawns, golf courses, and marinas, are not as closely regulated nor are they put under the pressure of a time line for mitigation (MDE 2005). Farmers have been regulated not only for their pollution contributions to the bay, but also because they are an easy target. Not all farms pollute the same, yet all crop farmers must pay to incorporate nutrient management plans to avoid being fined. The identified cause of the toxic Pfiesteria blooms was from large scale poultry farms in the form of manure runoff (BRCPAC 1997). It might make more sense for large poultry companies, who employ Maryland farmers, to foot the bill for nutrient management and

manure transport off of the farms, than to have the farmers pay the bill. The WQIA of 1998 was aimed at crop farmers and placed no liability on the major pollutor, the poultry industry. Farmers are much easier to target for changing their farming practices than poultry industry. If too much restriction is placed on the poultry industry politicians risk destroying a billion dollar industry by having businesses relocate to states without regulations. For reasons such as this, farmers feel that they are unfairly targeted by environmental organizations and the government, which is why they think the government should foot the bill for nutrient management plans (MDFB 2005).

In June of 2003 Maryland's then newly elected Governor, Robert Ehrlich, announced that he would abandon efforts by the previous administration to force Maryland agriculture to reduce nutrient runoff though mandatory efforts. By 2004, Ehrlich and the General Assembly passed legislative amendments, based on input from the many stakeholders involved, to the WQIA of 1998 making it easier for farmers to comply with nutrient management laws (MDA 2004). Many of the changes are in effort to make the application and reporting process easier for farmers by simplifying the paperwork and providing educational outreach about nutrient management plans (MDA 2004). Both consulting groups and interested farmers can receive training to be certified to develop these plans (MDA 2004).

Manure Transport Program contributing to a total of $581,200 to remove manure from areas of high concentration.

IV. The Reynolds Farm

A local farmer in Baltimore County, Tom Reynolds, graciously allowed us to use his farm for our studies of agriculture and its affect on the environment. This is just one small farm and cannot represent all small farmers in Maryland, but it allowed us to get a feeling for farming and farmers. In addition to learning about farming practices, we took samples of soil and stream and ground water during our project. Our attempts to carefully assess the soil and water were sincere but we are not professionals; therefore, the data that is reported here should be reviewed with that in mind. It would not be fair to GUDZ DQ\ GHILQLWH FRQFOXVLRQV UHODWLQJ WR WKH IDUP results although we believe that the overall pattern we observed is probably accurate. The description of the farm and farming practices that follows comes from discussions with the Reynolds and our observations of their farm.

The Farm

The Reynolds farm, which has been in the Reynolds family for at least 40 years, is located in Reisterstown, MD (see Fig. IV-1). The Reynolds have purchased a neighboring 17 acre parcel but this land is mostly stream buffer; of the original 50 acre farm approximately 45 acres are currently cultivated. At one point the farm was an orchard, but it is now being used for vegetable crop production. We were told that in the past some of the soil had been abused; it had been heavily farmed without much concern about soil being replenished. Now the Reynolds pay considerable attention to conserving and restoring the quality of the soil. When the farm was a peach orchard, the peaches were fruit was sold at a farm stand on a nearby major road. Today, most of the crops on the

LW LV WKHQ XVHG IRU EHGGLQJ +rdcesseHQ FaRmC HFWV WK
manure they contain into mulch. The finished wood mulch mixture is sold to the public and used on the farm. The mulch is used on the farm for fertilizer and is also placed between the crop rows to prevent soil erosion. The compost mulch helps heat up the soil, allowing crop seeds to germinate faster. It also helps replenish organic matter in the soil.

The soils on Reynolds Farm are loamy soils containing roughly equal parts of sand, silt and clay. The particular types of soil being farmed are from the Glenelg and Manor series (see Fig. 12, Glenelg soils are labeled with a G and Manor series with an M), and formed from the underlying bedrock, which is a type of schist common to the central portion of Baltimore County (Reybold and Matthews 1976). Both soils are acidic which allows for better nutrient uptake by crops (Reybold and Matthews 1976). For the most part these soils are well drained with moderate moisture capacities and are relatively easy to work compared to other types of soils in the county (Reybold and Matthews 1976). The Glenelg and Manor soils are suited for cultivation according to the Baltimore County Soil Survey, yet may be moderately to severely eroded, so care must be taken to prevent further erosion if possible (Reybold and Matthews 1976). Manor loams are considered to be among the soils more susceptible to erosion in Baltimore County (Reybold and Matthews 1976). The erosive potential by water is largely based on the slope of the land and the consistency of the soil. The Glenelg and Manor soils on the west and eastern sides of the farm are located on slopes with 2-5 percent rise, and the Glenelg soil on the central portion of the farm is located on a 3-8 percent rise.

Fig. IV-2. A soil map of the Reynolds farm. The two major soil types on the farm are Glenelg and Manor.

Farming for Mr. Reynolds is a bit of a juggling act; he works hard to replenish his soils and minimize the negative impact of his farming practices for the environment while producing a yield that is sufficient to pay the bills and of a quality to keep his

Fig. IV-4. The placement of grassy strips between rows of vegetables is apparent in this view of the Reynolds farm.

Fig. IV-5. Newly prepared strawberry beds with black plastic. The plastic increases soil temperature, holds moisture and reduces weeds.

For the other crops (pumpkins and sweet corn) he applies fertilizer directly. He is aware that nitrogen remains in the soil after harvest and plants rye to take up that extra nitrogen.

+H ILQGV WKDW LI KH XVHV OHVV QLWURJHQ KLV FURS L market. TheH [WUD 1 IROORZHG E\ D FRYHU FURS LV KLV FRPSU pesticides, herbicides, and fungicides but will apply them to crops in the smallest amount possible in order to produce the needed crop.

7KH FURSV SURGXFHG RQ WKH IDUP DUH VROG WKURXJK ZKROHVDOH DQG UHWDLO markets. There is also a small produce stand close to the farm where strawberries, WRPDWRHV DQG FRUQ DUH YHU\ SRSXODU ,Q WKH IDOO

Soil Sampling

Since the pollution problems associated with farming are related to nutrient runoff, we thought it important for us to investigate nutrient levels in the farm soils. While farming, in general, might be responsible for delivery of nitrogen to the waterways, we wanted to know more about the levels of soil nutrients present that S D U W L F X O D U F U R S V D Q G V S H F L I L F I D U P L Q J S U D F W L F H V going to be able to move into the water. The sampling and analytical techniques we used were new to us. Therefore, we have learned a great deal about soil nutrient analysis, but again, we request that readers use caution accepting our data as a totally accurate reflection of the soils tested.

Materials and Methods

On September 25 and November 6, 2005, soil samples were taken at different locations around the Reynolds farm to assess levels of soil nitrogen. We analyzed our samples for levels of total extractable nitrogen (using a Carbon/Nitrogen (CN) analyzer), nitrite (NO_2^-) and nitrate (NO_3^-) (using an ion chromatograph). All of the fields that were sampled had received fertilizer. We also sampled a pasture located directly behind the composting operation, the compost piles themselves, and a grassy strip down hill from a fertilized section of a field.

We selected sampling sites that reflected different crops, slopes, planting dates and, in the case of the pasture, places that seemed at risk for high nitrogen. Within each selected field, sampling was random. Sampling was done using a garden trowel and soil corer and the samples were placed into clean and dry 120 mL cups or clean and dry plastic bags. Surface (the top one inch) and below surface (from soil four inches below

the surface) samples were taken in the following fields (See Fig. IV-6). Soil corer samples consisted of one sample from the surface down to about 7 inches.

- A pumpkin field at the top of a slope
- A pumpkin field in the middle of a slope
- Harvested corn field, between the pumpkin fields
- Unharvested corn field
- Harvested cucumber/squash patch, within the 5 acre vegetable field
- Tomato patch in the 5 acre vegetable fields
- A grassy strip below the sampled tomato patch

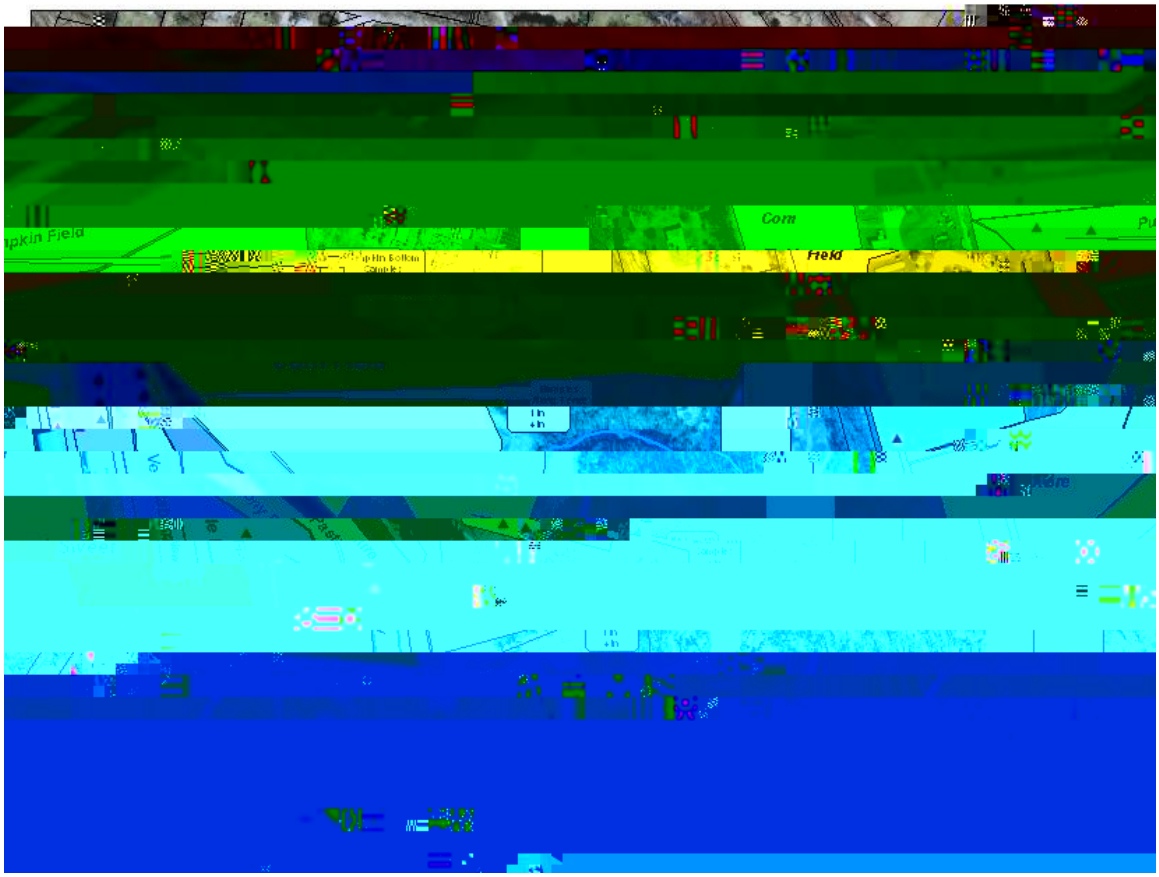

Figure IV-6. Soil sampling sites on the farm are indicated by red triangles.

Each one inch sample consisted of three separate random samples of the top soil that were combined and mixed from each field sampled. The four inch samples were obtained by using the garden shovel to obtain soil from a four inch depth. Each four inch

sample consisted of three separate random samples of four inch soil directly below the top inch sample that were combined and mixed from each field sampled. Core samples were taken using the soil corer at the following sites:

- The pasture field located directly behind the compost piles
- The bottom of the pasture field behind the compost piles
- The unharvested corn field also sampled above.

One duplicate core sample was taken from the unharvested corn field on the first sampling date, and a second duplicate sample taken from the 4 inch chopped pumpkin field on the second sampling date. Not all sites listed were sampled on the second date.

Small cups (approx 100 cc) of samples of compost, in duplicate, were taken from compost piles with distinctly different colors – light, medium and dark brown. The lightest color pile of compost is the most recently mixed compost. The darker compost is the oldest and has had more time for microorganisms to act on the substrate.

Total extractable nitrogen

To determine how much nitrogen was in the soil, we analyzed for Total Extractable Nitrogen. This test determines how much total soil nitrogen is readily extractable in water. The forms of nitrogen that make up the total extractable nitrogen are nitrite, nitrate, ammonia, and organic nitrogen. We also measured nitrite and nitrate levels specifically (see ion chromatography). The total extractable nitrogen analysis does not isolate specific forms of nitrogen; rather it reflects the water soluble and plant accessible nitrogen. Nitrate is the form of nitrogen that is most leachable into waterways. To measure the levels of the most readily leachable nitrogen in the soil (nitrate and nitrite), we used an ion chromatograph. For further information on CN analysis see Appendix 2.

Table IV-2: The levels of total extractable nitrogen and nitrate nitrogen found in compost piles at different stages of development. The darker piles were composted while the lighter piles were new. Nitrate and phosphate levels were determined by ion chromatography.

Sept 25 Compost Samples	**Total Extractable Nitrogen (mgN/kg)**	**mg NO_3^- N per K**	**mg PO_4^{-3} P per K**
Compost Light 1	2425.0	10.3	1002.8
Compost Light 2	2957.7		
Compost Med.1	2580.5	12.1	
Compost Med. 2	3856.3	14.1	1605.8
Compost Dark 1	952.7	309.1	92
Compost Dark 2	10529	282.8	96

Much of the nitrogen in the soil is found in the form of nitrate. Ammonium ions not immobilized or taken up quickly by plants are usually converted rapidly to nitrate ions by a process called nitrification. This is a two step process, during which bacteria called Nitrosomonas convert NH_4^+ to nitrite (NO_2^-), and then another type of bacteria, Nitrobacter, converts the NO_2^- to NO_3^-. This process requires a well aerated soil, and occurs rapidly enough that one usually finds mostly nitrate rather than NH_4^+ in soils during the growing season. The ease with which nitrogen changes form in the soil (from a form available to plants, then taken up by plants and converted to tissues, then decomposed and returned to the soil as organic nitrogen, etc.) makes it a very difficult nutrient to manage (and it is notorious that soil testing services are very critical to farm soils).

The measurements obtained for total extractable nitrogen for the compost piles were large due to organic nitrogen in manure and the amount of microbial growth that

W-1. W-2 and W-3 (see fig. IV-7). W-1 was the furthest upstream and located behind Franklin elementary school on Cockeys Mill lane. Our second sample site W-2, was located upstream from Reynolds Farm and below the culvert that crosses beneath interstate 795. Sample site W-3 was located adjacent to Reynolds Farm and was furthest downstream. On 09/25/2005 and 10/08/2005, each of the three sites was sampled and the following chemical parameters were assessed: pH, conductivity, dissolved oxygen, ammonia, chlorine, alkalinity, and hardness.

Chemical monitoring is a useful aid in detecting stream pollution, however the data will only reveal what is in the stream at the exact moment the sample was taken. Biological stream monitoring is a method of studying the level of pollution present in a stream by looking at its impact on organisms within the system. Monitoring methods, such as an invertebrate analysis, allow us to assess the impact to the stream over longer periods of time. Organisms are sensitive to different types of stress and disturbance; their presence, absence, or abundance, can shed light on stresses and disturbances that have occurred over time. A benthic macroinvertebrate analysis was applied to Norris Run because we felt it might give us a better idea of what pollutants, if any, were impacting the stream. Our macroinvertebrate samples were taken at sample-sites W D Q G ¶ R Q 10/30/2005.

Another type of biological assessment we used to analyze the potential for pollution from the farm was a toxicity bioassay. A runoff sample was collected at the base of a gully running through the farm, and directly into Norris Run, between sites W ¶ D Q G ¶ on October 8, during a heavy rain event that ended a dry spell. The runoff sample was then used in a toxicity test to determine if toxic chemicals were being transported from the farm to Norris Run.

Methods

Chemical Analysis – Series One: For our first series of chemical analysis, two stream sites were selected upstream, and one site was selected downstream from the Reynolds farm. Prior to taking each sample, a 300ml sample jar was rinsed two times with the stream water from that site. The sample jar was then filled with stream water and sealed tightly. Stream samples were then immediately placed into a cooler filled

with ice until they reached the laboratory refrigerator, where they were stored for no more then 48 hours, at approximately Û & 2 W K H U V D P S O H V W D N H Q I R U Q L phosphors were also put on ice and taken to the lab and stored (see

Run (see Fig. IV-8). However, the overland flow of water encountered grass strips and vegetation on its way through the farms watershed, which would have lessened nutrient loading, and some of the nutrients would have entered the soil. We just wanted to know what possible nutrient levels there might be in runoff.

Biological Assessments: For the toxicity test a water sample was collected on 10/08/05, during a large rain event, at the point where a gully, running across the fields and through the farm, meets Norris Run. This sample was then placed on ice until it got to the lab, where it was stored for less then 24 hours at approximately 4°C. The sample was then divided into six aliquots and each aliquot diluted with specifically designed

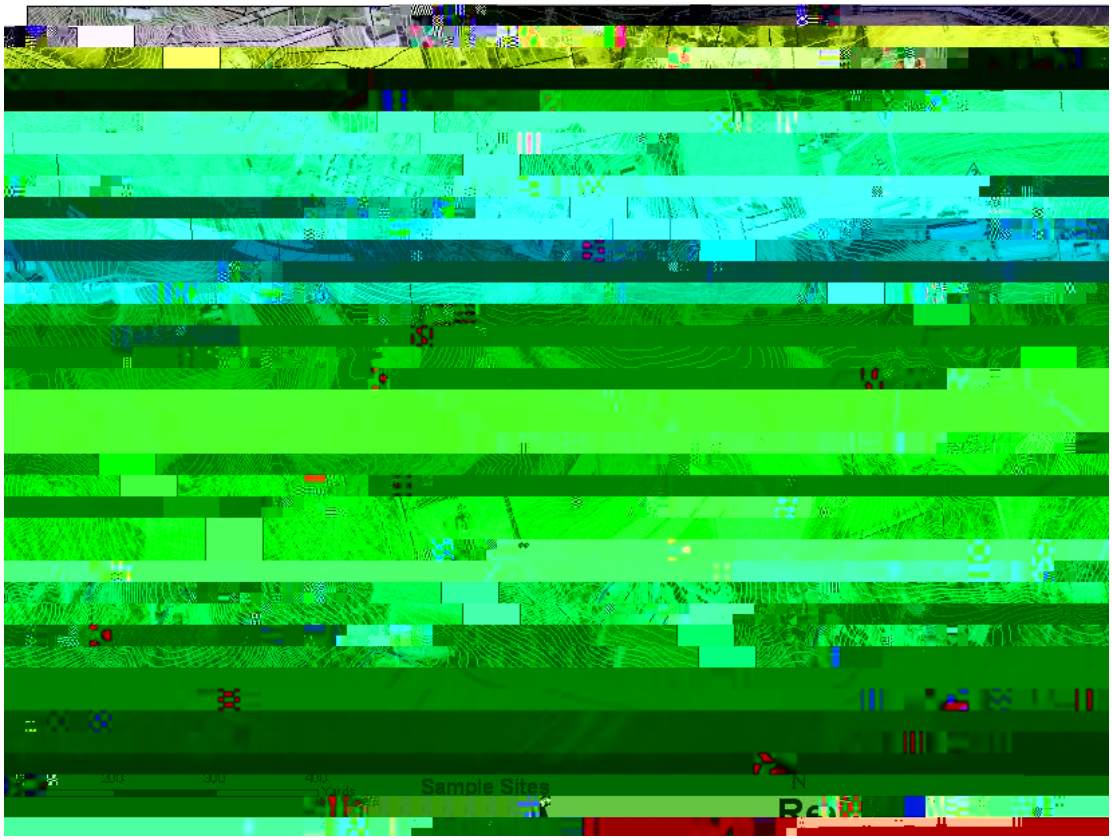

Figure IV-8. Sites where runoff samples were collected during a heavy rain event are indicated.

laboratory water to make different concentrations of runoff water. The concentrations of runoff water used for the test were 0%, 20%, 40%, 60%, 80%, and 100%. Eight Ceriodaphnia dubia, a small aquatic invertebrate which is also a standard test organism for fresh water toxicity testing, were placed into individual vials at each concentration.

can be found in Appendix 4). We found that conductivity tended to be lower at the sites below the farm, W-3 and W-4, than at the sites above the farm (see Figure IV-9).

Data on nitrate load is presented in Figure IV-10 and ion chromatograph data for nitrite and nitrate can be found in Appendix 7. According to the LaMott kit, total nitrate loads are higher at site W-1 than at the other three sites. Nitrate levels at W-1 between 28 October and 2 November, whereas there is a decrease at W-4. This suggests that the high nitrate levels are specific events, i.e., rain storms and that with time, nitrate input decreased. The complete results from the second round of our chemical analyses are presented in Appendix 5.

In our toxicity test, we observed a death rate of 12.5% among our test organisms in the 80% and 100% runoff water concentrations. One of the eight test organisms died at each of these concentrations. There was 100% survivorship at each of the other runoff water concentrations.

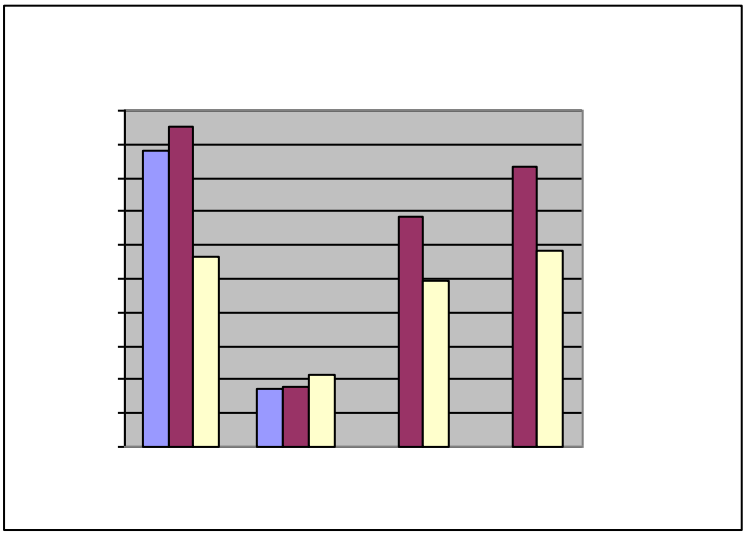

Figure IV-9. The conductivity of Norris Run on four different days at three sampling sites, near the beginning of the stream (W-1), after it passes under interstate 795 (W-2) and as it flows by the farm (W-3). The weather had been extraordinarily dry in September but the drought broke on October 8.

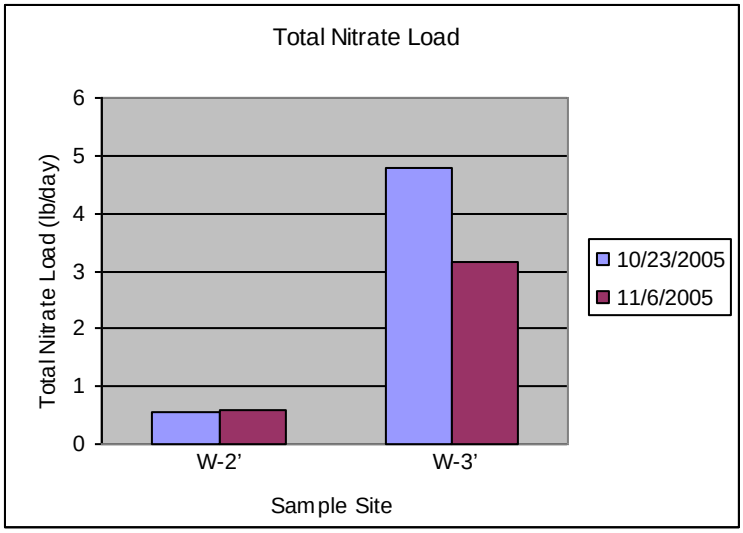

Figure IV-10. The total nitrate load into Norris Run on two different days. The first site is just downstream from interstate 795 (W-2) and the second site is slightly downstream from the farm (W-3).

In our second method of biological assessment, our macroinvertebrate sampling, we notice several differences between our two sample sites. In figure IV-11, it is apparent that sample site W-3 has a larger abundance of organisms than W-2 (from Fig. IV-12). We can also see that the diversity, or taxa richness is greater at site W-3 than at W-2.

From our invertebrate data we were able to calculate a Family Biotic Index (FBI) for each sample site. The FBI, based on a scale of 0 to 10, indicates the tolerance to pollutants, indicates that the two sites are not very different from each other (as assessed by the invertebrates in the water). From Fig. IV-13, we can see that our FBI values for each site are similar, with a difference of only 0.4 units on a scale of 10. We were also able to calculate EPT (Ephemeroptera, Plecoptera and Trichoptera) values, which is a value that corresponds to the number of specific pollution sensitive organism at each site. In our EPT calculations we found that 80% of the organisms from sample site W-2 were

those specific, sensitive organisms, while only 47.8% of the organisms found at site W ¶ were composed of those organisms. The complete data set is presented in Appendix 6.

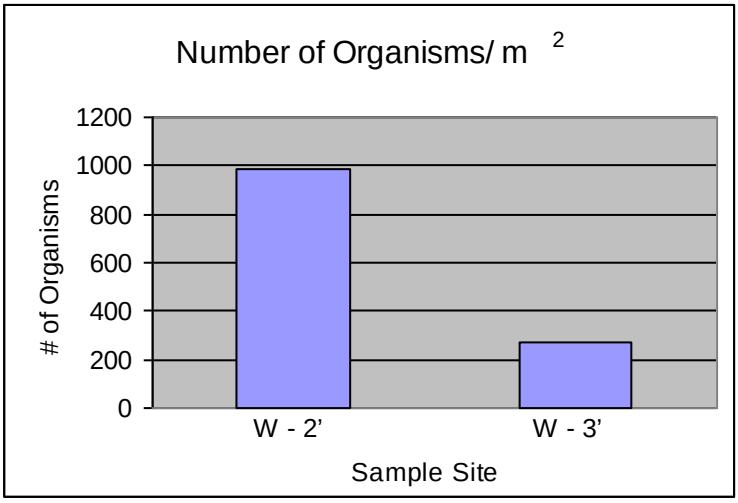

Figure IV

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There were two sets of nutrient measurements taken. The procedures we used were learned through the course of the semester, and for the most part we only got one chance to analyze our measurements due to time constraints. Therefore, our data may not be as accurate as what a professional watershed resource manager would produce. One set of data was taken using the LaMott field kit, which generally is thought to measure nitrate and phosphate less accurately than laboratory procedures, however it is easier to get quick results. The nitrate levels as measured by the LaMott kit were lower than those analyzed using the ion chromatograph. For site W1 the nitrate levels were 0.0 mg/L for both dates. For site W2 the nitrate levels were 0.0 and 3.0 mg/L. These values fall in the low to moderate range for nitrate as reported from a set of stream quality criteria from the Maryland Stream Symposium in October of 2005 (Carroll Community College 2005).

The measurements from the ion chromatograph (IC) showed nutrient levels that were much higher than the LaMott measurements. There is a definite difference between the way the first measurements on 9/25/05 and 10/8/05 were handled, compared to the rest of the IC measurements at later dates. The first two dates were refrigerated, rather than frozen, for a considerable length of time. As a result, the nutrients in the samples could have changed during storage. These measurements, which were taken during drought conditions and after the first rain event, were low, only between 0.24 and 0.56 mg/L for

measurements from this set can be seen in Appendix 7. The stream measurements show nutrients upstream at site-W¶ W R around 5.0 mg/L, and the downstream site W- ¶ W R have nutrient values at 8.41 and 11.01 mg/L. Any nitrate concentrations above the 5 mg/L threshold are considered to be high (Carroll County Community College 2005). It is evident that there are differences in our nutrient data that reflect the learning process involved in obtaining these measurements. It would have been better to have used only one method consistently, had replicated our samples and taken the samples over a longer period of time, but time constraints and technical difficulties prevented us from doing so. Care should be taken in concluding how the farm is impacting Norris Run when looking at this data.

Our two sites, W ¶ DQG ¶ : Z H U H V L P L O D U F K H P L F D O O \ Z L W K V nitrate and conductivity) which would lead us to expect similar populations of macroinvertebrates. From the data that we gathered in our invertebrate sampling we seyn(C4h2(0

organic and nutrient pollution sensitivity for each macroinvertebrate family; a low number corresponds to a low pollution tolerant species, whereas a higher number indicates a more pollution tolerant species. The FBI is an average pollution sensitivity score for the macroinvertebrate community at each site. So, FBI values that are low correspond to a community that is less impacted and a FBI value that is higher corresponds to a community that is more impacted. Site-¶WUHFHLYHG D VFRUH RI while site W- ¶ UHFHLYHG D BVth scores indicate that the water quality is ³YHU\ JRRG´ IRU ERWK UHDFKHV DFFRUGLQJ WR WKH)%, a slight effect from organic pollution. Site-W¶ GRZQVWUHDP IURP WKH IDUP score that is 0.41 higher then our site upstream. This suggests that the downstream site contains species that are slightly more pollution tolerant than those upstream and that there could be more of an organic pollutant downstream (fig. IV-13). But, this is to be expected in a farm setting. What matters is that the FBI value at site-¶WLQGLFDWHV D good water quality for this reach and there were a variety of pollution sensitive organisms present. It appears that the nutrient runoff from the farm does not negatively affect benthic macroinvertebrate community.

In summary our invertebrate data suggests that quantity does not necessarily equal quality. Our sample site downstream from the Reynolds farm should reflect any stream pollution from the farm when compared to our site upstream from the farm. In comparison we can see that according to our FBI and EPT values, the stream appears to EH ³KHDOWK\´ ZLWK SROOXWLRQ VHQVLWLYH RUJDQLVPV there is a noticeable difference in abundance. Since the proportion of pollution sensitive organisms did not decrease at our downstream site from the number at our upstream site,

considerable amount of vegetation in the pasture fields, which helps in reducing runoff and increases nutrient uptake. It is possible that a flush of grass growth after the rain could change the value of nitrate in the soil. The Reynolds currently practice sustainable agriculture by using grass buffers, cover crops, and contour farming which deters nutrient runoff and leaching. This practice would alter the amount of nutrients in the fields and could lead to incorrect inferences of where nutrients might have come from and how they got there. There are many factors and variables in the nitrogen cycle, which makes it difficult to monitor. With best management practices being utilized on the farm, the fact that there are leachable nutrients is not a red flag or cause for alarm.

Our water sampling suggest that runoff from I 795 is impacting the stream, Norris Run. Chloride increased after the rain suggesting that road salt residues are still coming off the road. Levels of dissolved oxygen were higher downstream than upstream. High levels of dissolved oxygen are critical for stream biota. Nitrate levels were higher near the farm but still in the acceptable range.

Invertebrate samples indicate a higher diversity and more total organisms upstream. Our EPT index, an index reflecting abundance of pollution sensitive invertebrates, was higher at the downstream site. A second index, the FBI, which measures stream health based on the known sensitivity of organisms to pollutants was also assessed. The two sites were very similar in their FBI index with the upstream site having a score that was lower than the downstream by only 0.41units.

V. Suggestions for Improving and Ensuring the Future of Farming in Maryland

& R Q V X P H U V H [S H F W 0 D U \ O D Q G ¶ V - q u D W L R Q L V D U P H U V W R free product at a competitive price. The farmers are expected to do this using minimal amounts of fertilizers and pesticides, and to adopt conservation practices that can often be prohibitively expensive. Farmers are unable to meet both of these contrasting expectations, and thus are unable to please everyone. This, along with other frustrations and difficulties of farming, has caused the agricultural community to shrink considerably, and has simultaneously allowed development to occur over vast expanses of farmland in Maryland.

It has become apparent that the proliferation of development poses a great threat to the Chesapeake Bay watershed. Finally, the importance of farms in Maryland is being recognized. However, this revelation also comes with the sad realization that farming in Maryland is unsustainable; our agricultural community cannot survive without major changes. In any given year, farmers are lucky to break even. The work is back-breaking and the hours are long. One local farmer remarked that he once went seven years without a day off. In this industry, vacations are few and far between. Instilling conservation practices into agriculture is becoming increasingly important, and most farmers adopt as

indeed caused improvements in the agricultural community, they could be modified to accomplish even more, and with greater efficiency. For example, certain programs created by the Farm Service Agency (FSA), an important division of the U.S. Department of Agriculture, offer farmers subsidies for planting certain crops or building storage units to hold grain. These activities, while worthwhile in some respects, are a potential source of frustration for farmers who may feel as if they are being offered welfare. As an alternative, the FSA could provide subsidies to farmers for installing conservation structures, such as wind breaks, cover crops, or grass buffers, which could give a farmer the sense that he or she is earning the money by providing a service, rather than simply accepting charity.

State and federal programs which reward farmers for conservation efforts are available to farmers, but the design of such programs may cause them to be inefficient. The Water Quality Cost Share Program (MACS), compensate farmers for installing conservation or best management practices on their farms. However, full funding is hard to get, the requirements for the conservation practices are exceptionally stringent, and a large volume of paperwork that farmers must fill out to receive funding or determine eligibility, make programs such as these less attractive to farmers. A better program would be one that compensated farmers for their conservation practices based upon their degree of compliance. For example, if the ideal riparian buffer is at least 50 feet wide and 10 acres long, then farmers could receive 100% of the offered compensation for installing such a buffer, but could still receive 75% of the compensation if installing a buffer that was 45 feet wide and 7 acres long. More flexibility would increase compliance considerably. Also, since

I D U P H U V K D Y H Y H U \ I X O O V F K H G X O H V S U R J U D P V Q H H G W

Agency officials could visit farms, rather than forcing farmers to come see them, and paperwork could be simplified as much as possible. Finally, training courses for continuing education programs, such as nutrient management, could be completed online.

Farmer support agencies, such as cooperative extension services, help farmers deal with challenges and solve problems. Yet as the agricultural community shrinks, such programs seem to shrink as well. For example, for decades, the University of Maryland Cooperative Extension provided soil testing for the agricultural community as well as the general public. This program has been discontinued in recent years, and the shrinking agricultural community has certainly been a factor. Funding must be available for such agencies to continue to serve their purpose of assisting farmers, especially now,

The general public also has a responsibility to reduce pollution related to agriculture, and making it possible for farmers to become sustainable. It is extremely important for consumers to purchase food that has been grown locally (within approximately 50 - 100 miles of their homes). The transportation of food over long distances causes excessive pollution. Also, purchasing food in season is critical to reducing pollution, and for supporting local farmers. For example, buying citrus in December requires the fruit to be shipped over great distances. Consumers also must be aware that by consistently demanding blemish-free fruit, they force farmers to use pesticides, about which consumers then complain. If consumers truly want farmers to reduce pesticide use, they must be willing to buy imperfect produce, and must understand that a spot or a small blemish does not take away from the quality of the product they are purchasing. To increase public awareness and appreciation of farming, more people must try farming for themselves. Compared to produce grown in another state and picked several days ago, locally grown produce is richer in nutrients and taste. Getting people to realize that is it fun and rewarding growing a few tomato plants on their porch, or a small garden plot in the backyard, will help reduce pollution. If growing your own food is not possible, eating seasonally and regionally may be made easier by shopping at your local farmer's market. To locate local growers or sustainable farms in your area, a useful information source for the Buy Local movement, provides a searchable database by region (LocalHarvest.org). As more people learn these things, the ideas will spread and help to further educate the public.

Agricultural education is necessary for farming to become sustainable in Maryland, and the responsibility must be shared by all parties involved. Farmers are

uniquely able to give the public a first-hand experience of the farming lifestyle. To gain the public's support and to educate consumers to open their operations to the public. Seeing the conservation efforts being made by farmers will help people understand the importance of supporting these efforts, by doing things such as buying fruits and vegetables that have not been exposed to pesticides. Agricultural education can also occur in a classroom setting, both for children and adults. Children and adolescents can learn through schooling at all levels about the value of the environment and how it relates to agriculture and contemporary issues surrounding the industry. Adults can participate in workshops and community-supported agriculture events to gain an appreciation of farming. Farmers are very well aware of the issues society has with agriculture, so it is only fair to ask society to understand the issues farmers have with the general public.

The survival of small farms in Maryland is threatened by a lack of sustainability that has slowly evolved as land becomes more economically valuable for development, as food prices are driven down by large, commercial farms, and as the environmental degradation of our water resources continues. Yet Maryland's small farms are an important state with environmental, social, and economic benefits that are undeniably important and cannot be replaced. To ensure that farming in Maryland has a future, society must work at all levels to improve the farmer's situation and to help farms with the challenges they face. Through sustainable farming, not only in the environmental sense, but also in the social and economic sense, and supported by the government, private support agencies, scientists, homeowners, educators, and the general public, the future of farming in Maryland will be successful and bright.

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Appendix 2: Technical Methods

Total Extractable Nitrogen Analysis (C/N analyzer);

Total extractable nitrogen (TN) was determined for soils using a Shimadzu TOC V equipped with a TN analyzer. Wet soil samples were extracted with 30 mol high purity water overnight on an orbital shaker table. Samples were centrifuged and the supernatant was retained for analysis of TN (including organic N, ammonia, nitrite and nitrate). Wet soil weights were normalized for water content and all results are reported in terms of dry weight (mg N per kg dry soil).

Determination of Nitrate, Nitrite and Phosphate Concentrations using Ion Chromatography

The same soil extracts, along with surface and groundwater samples, were also analyzed for nitrite and nitrate concentrations using a Dionex DX-320 ion chromatograph. All samples were filtered through 0.45 µm PÂTÉ syringe filters prior to analysis. Calibration was based on commercially prepared standard solutions. For soil extracts, NO_2-N and NO_3-N are reported in terms of dry weight (mg N per kg dry soil).

Appendix 3: Soil Sample Analyses

Appendix 3 (continued):

Appendix 4: Stream Water Quality Data Set 1.

The results from our first round of chemical monitoring for three sites. The first site was upstream from interstate 795 (W-1), the second site was just downstream from interstate 795, but upstream from the farm (W-2), and the third site was slightly downstream from the farm (W-3).

Date sampled (analyzed)	9/25/2005

Appendix 5: Stream Water Quality Data Set 2.

The results from our second series of chemical monitoring for two sites. The first sample site is just past interstate 795, and upstream from the farm ¶W DQG WKH VHFRQG VL was slightly downstream from the farm {W¶ Nitrate and Phosphate levels measured with LaMott test kits.

Date sampled (analyzed)	10/23/2005 (10/24/2005)	11/6/2005 (11/8/2005)
	W - 2'	W - 2'
Temp. Sampled		

Appendix 6: Benthic Macroinvertebrate Data.

The benthic macroinvertebrate data for Norris Run was collected at two sample sites. The first sample site is just past interstate 795 and upstream from the farm (W-2) and the second sample site was slightly downstream from the farm (W-3).

Families	W-2' (# of orgs.)	W-3 (# of orgs.) '	Pollution score
Tipulidae	25	0	3
Veliidae	1	0	NA
Hydropsychidae	34	15	4
Corydalidae	4	0	0
Nemouridae	1	1	2
Philpotamidae	5	0	3
Elmidae	5	2	4
Chironomidae	13	3	6
Perlidae	4	1	1
Heptageniidae	0	3	4
# organisms/m^2	989.92	269	
# of organisms	92	25	
# of Families	9	6	
Family Biotic Index	3.63	4.04	
E.P.T.	0.478	0.8	

Appendix 7: Water Nutrient Analysis

An ion chromatograph (IC) (see Appendix 2 for technical information on the IC) was used to analyze water samples. Stream samples are W-1, W-2, W-2 ¶ -3, and W- ¶ Ground water samples (from a shallow well used for irrigation) are labelled GW. RO samples were obtained from different sites on the farm during a heavy rain event (see page 116 for details). As a result of being moved over the summer, the IC did not initially function. Therefore, samples from 9/25 and 10/8 were refrigerated for several weeks prior to analysis. The remaining samples were put on ice in the field and then frozen until being thawed and promptly analyzed.

Date	Site	Nitrite (mg/L)