The Environmental Benefits of Well-Managed Farmland

Center for Agriculture in the Environment

American Farmland Trust

DeKalb, Illinois

Center for Agriculture in the Environment Working Paper: Number 2005-01

March, 2005

Table of Contents

List Of Tables and Figures

Tables

Figures

INTRODUCTION

This report addresses the costs and benefits of different land-use patterns on the environment and how sound agricultural management practices may produce tangible environmental benefits. Various categories of land use - urban, agricultural and natural lands - affect water, soil and air quality, along with biodiversity in different and interconnected ways. While the costs of urban land use to the environment are well known, the benefits that agricultural land use may offer to the environment are less well documented. It is the contention of this report that *well-managed farmland*, using sound agricultural conservation practices, not only will neutralize many of the environmental problems caused in the past, but that positive environmental benefits - either in the form of good externalities or public goods - will be produced as a result. While the environmental costs of agriculture are easier to measure, the benefits produced by well-managed farmland are more difficult to ascertain yet not impossible to approximate. The real difficulty remains in determining how much to fairly reimburse farmers for implementing and maintaining conservation practices that produce ascertained environmental benefits.

The report addresses the costs to the environment of agricultural land use and the environmental and monetary benefits of sound agricultural management practices. These benefits include improving the quality of water, air and soil, carbon sequestration, retaining and promoting biodiversity by working landscapes practices, producing fresh fruits, grains, vegetables, oils low in saturated fats, dairy, lean meat and other highly nutritious foods, raising land values by adopting conservation measures, and farmland amenities – a public good that has become increasingly significant and valuable, both to the urban population and to farmers. For effective conservation policy analysis and implementation, we need ways to document the environmental benefits of farmland. The report addresses recent attempts to identify agri-environmental and agri-biodiversity indicators by examining a sample of U.S. and international models that have produced a number of indicators that are relevant to the environmental benefits of farmland. By promoting the use of such environmental indicators, we hope that future policy measures - programs and subsidies - will be informed by a more accurate account of the environmental benefits of well-managed farmland.

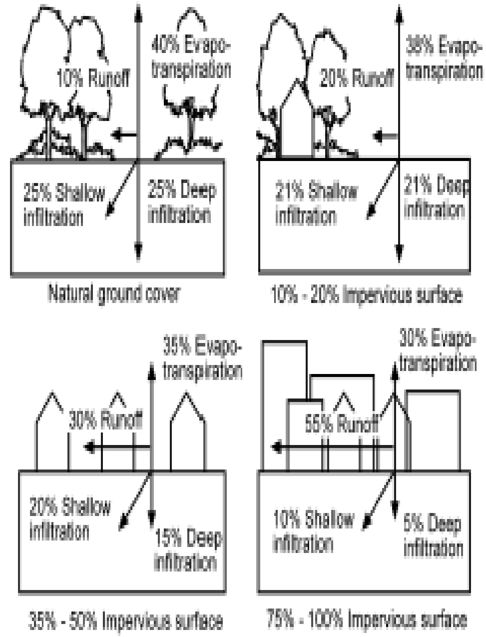
CHAPTER 1: URBAN LAND USE AND THE ENVIRONMENT

The total land area of the 48 contiguous States is approximately 1.9 billion acres and many different land uses can be identified. Although pasture and rangeland have declined since the mid 1960s, these areas still constitute the majority of land use in the United States, accounting for nearly 578 million acres or 30.5 percent in 1997. Like grassland - pasture and range, forest-use land – the second largest area of land use - has also declined from 602 million acres in 1945 to 553 million acres in 1997. As a result, total grassland pasture and range, including cropland, has declined from more than 1.1 billion acres in 1945 to approximately one billion acres in 1997. Cropland comprises the third largest area of land use in the contiguous United States (455 million acres or 24 percent in 1997) and this has not changed greatly since the 1940s. The final concrete land use category is urban land. In contrast to the other land use categories, urban land has steadily increased from 15 million acres in 1945 to 64 million acres in 1997. Other special and miscellaneous land uses include recreation and wildlife areas, public infrastructure and facilities, some forestland, marshes, open swamps and deserts.[1]

The impact of urban areas on water, soil and air quality, and biodiversity is generally negative. Numerous factors influence the quality of the surrounding environment near urban areas. Some major factors are the quantity and velocity of polluted water produced by runoff in urban areas. The development of urban areas changes the local hydrology (i.e. the way water is transported and stored). Rainfall that once infiltrated the soil is channeled into road gutters, storm sewers and paved channels. These manmade drainage patterns affect the volume and velocity of runoff from urbanized areas.

Increasing impervious surfaces (i.e. the imprint of land development on the landscape) limits rainfall from infiltrating the soil and, thus, increases the volume and velocity of runoff during precipitation and snow-melt. The combined effects of these developments result in higher peak discharges and shorter times to reach peak discharge. In addition to

[1] Versterby, M. & Krupa, K. (1997). *Major Uses of Land in the United States, 1997*.
Statistical Bulletin No. 973. Washington, DC: USDA.; Krupa, K. & Daugherty, A. (1990). *Major Land Uses:1945-1987*. Electronic Data Product #89003. Washington, DC: U.S. Department of Commerce, Bureau



potential flood damages, the increased volume and velocity cause previously stable streams to widen and erode. They become carriers of increased pollutant loadings from urban runoff. Contaminated particles from the urban-related streams settle in other streams, rivers and lakes, reducing capacities, jeopardizing water quality and threatening animal habitats.[2]

Runoff from urban areas affects water quality and biodiversity. The Environmental Protection Agency (EPA) ranks urban runoff and storm sewer discharges together as the second most prevalent source of water quality impairment in the nation's estuaries, after industrial discharges, and the fourth most prevalent source of impairment in lakes after agriculture, unspecified non-point sources and atmospheric deposition of pollutants.[3] Studies concerned with the relationship between streams and urbanization show that fish populations either disappear or are dominated by *rough* species that can tolerate a lower level of water quality.[4] A series of specific urban nonpoint-source pollutants, including sediment, nutrients, oxygen-demanding substances, toxic chemicals, chloride, bacteria and viruses, illustrate the detrimental influence of urban runoff on the environment. Each of these urban non-point source pollutants and their effect will be briefly discussed in the following paragraphs.

Sediment, consisting of tiny soil particles, can be one of the more damaging pollutants. The suspended particles are of inorganic and organic nature and, among others, originate from de-icing grit, construction activities, litter, vegetative debris and lawn clippings.

---

of the Census; Vesterby, M. (2001). *Agricultural Resources and Environmental Indicators: Land Use*. No. (AH722). Washington, DC: USDA.

[2] Schueler, T. (1997) Technical Note No. 86: Impact of Suspended and Deposited Sediment. *Watershed Protection Techniques*, 2. 443-444.; Minnesota Pollution Control Agency (2000). *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota.* St. Paul: Minnesota Pollution Control Agency; Barrios, A. (2000). *Urbanization and Water Quality*. DeKalb: Center for Agriculture and the Environment.

[3] U.S. Environmental Protection Agency. (1998). *National Water Quality Inventory: 1996 Report to Congress*, EPA841-R-97-008. Washington DC: U.S. Environmental Protection Agency.

[4] Klein, R. D. 1979. Urbanization and Stream Quality Impairment. *Water Resources Bulletin*, 15. 948-963.

These pollutants can cause a series of problems in waters, including turbidity (cloudiness), destruction of aquatic habitat, contamination of drinking water and clogging of drainage systems.[5] Increased volumes of nutrients from such sources as lawn-care products, vegetative and animal debris, automotive additives, automobile traffic and fertilizer cause harm to the environment[6]. While essential to life, an excess of nutrients like phosphorus and nitrogen is harmful. Increasing phosphorus loadings exacerbate the growth of algae and accelerate lake eutrophication. Excessive levels of un-ionized ammonia (NH_3) and ammonium (NH_2) form of nitrogen in streams, rivers, lakes and groundwater are highly toxic to aquatic organisms and they pose a risk to human health.[7]

A sudden increase or pulse of oxygen-demanding substances as a result of urban runoff can totally deplete oxygen supply in shallow, slow-moving or poorly flushed waters, adversely affect water quality and ultimately cause fish kills. Studies show that the biochemical oxygen demand (BOD) of typical urban runoff substances, such as pet wastes, street litter and organic matter, almost equals that of effluent from an efficiently run secondary wastewater treatment plant.[8] Toxic chemicals washed off from impervious urban surfaces are a major concern in relation to impaired water quality. Samples taken as part of the Nationwide Urban Runoff Program (NURP) show that trace metals like lead, zinc, copper, chromium and nickel are commonly found in urban runoff.[9] The toxicity of trace metals in runoff varies with the hardness of the receiving water. Nevertheless, as these metals bio-accumulate in plants and aquatic life, they will ultimately harm the environment.[10]

---

[5] Minnesota Pollution Control Agency (2000). *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota.* St. Paul: Minnesota Pollution Control Agency; U.S. Environmental Protection Agency (1977). *National Nonpoint Source Water Pollution Control Strategy (draft).* Washington, D.C.: U.S. Environmental Protection Agency; Oberts, G. L. (1986). Pollutants Associated with Sand and Salt Applied to Roads in Minnesota." *Water Resources Bulletin*, 22. n. pag.

[6] Shelly, P. E., & Gaboury, D. R. (1986). "Estimation of Pollution from Highway Runoff – Initial Results". In: Urbonas, B. & Roesner, L. A. (Eds.). *Urban Runoff Quality*. New York: American Society of Civil Engineers, New York, N.Y.

[7] Freshwater Foundation. (1988). Nitrate: Rerun of an Old Horror. *Health and Environment Digest*, 1.

[8] U.S. Environmental Protection Agency (1983). *Results of the Nationwide Urban Runoff Program.* Washington, DC: U.S. Environmental Protection Agency, Water Planning Division.

[9] Ibid.

Tremendous amounts of salt are used each year to melt ice from roads, parking lots and sidewalks. Sodium chloride is extremely soluble and, thus, almost all salt applied infiltrates surface and ground water.[11] As with dissolved nutrients, an excess concentration of chloride can be toxic to many freshwater organisms. In addition to chloride, high concentrations of many bacteria and viruses are found in urban runoff. The Nationwide Urban Runoff Program (NURP) study found that total coliform counts exceeded EPA water-quality criteria at almost every site in their studies and at almost every time it rained.[12] Apparently, soil can act as a source of bacteria even when it is very unlikely that the high levels are of human origin or that they indicate significant human health risk.[13] The coliform bacteria that are detected may not be a health risk in themselves, but are often associated with harmful pathogens, including sanitary sewer leaks, pets, vermin and discarded infected material.

There are various land-use patterns within urban areas, including residential, mixed and commercial developments, which translate into different urban pollutant concentrations and contribute to water deterioration. The pollutant concentrations in terms of chemical oxygen demand, suspended solids, lead, zinc, nitrogen and phosphorus from these specific urban land uses also differ in comparison to open and non-urban areas. Based on a study by NURP, Table 1 below includes the pollutant mean concentrations in milligram per liter for urban and non-urban land uses. In reviewing the data, it is important to keep in mind that, except for the open/non-urban land use category, differences in pollutant concentrations are not statistically significant. In addition, the NURP study shows that urban pollutant concentrations for most sites cannot be correlated statistically with either storm runoff volume or storm intensity.

---

[10] Meiorin, E. C. (1986). *Urban Stormwater Treatment at Coyote Hills Marsh*. Oakland: Association of Bay Area Governments; U.S. Fish and Wildlife Service. (1988). *Results of Unpublished Sampling Data from Long Meadow Lake*. St. Paul: USFWS.
[11] Pitt, R. E. (1994). *Storm Water Detention Pond Design for Water Quality Management* (Draft). Lewis Publishers.
[12] USEPA, 1983, op cit.
[13] Barrett, M. E., Malina, J.F. & Charbeneau, R. J. (1996) *Characterization ofHighway Runoff in the Austin Texas Area*. Austin: Center for Transportation Research, Univ. of Texas, Austin, Texas.

Table 1: Mean Pollutant Concentration (mg/L)

Pollutant	Land Use			
	Residential	**Mixed**	**Commercial**	**Open/Non-urban**
Chemical Oxygen Demand	83	75	61	51
Total Suspended Soils	140	101	90	216
Lead	0.18	0.19	0.13	0.054
Zinc	0.18	0.19	0.33	0.23
Total Kjeldahl Nitrogen	2.35	1.44	1.40	1.36
Nitrate Nitrogen	0.96	0.67	0.63	0.73
Total Phosphorus	0.46	0.33	0.24	0.23
Soluble Phosphorus	0.16	0.07	0.098	0.06

Source: Minnesota Pollution Control Agency, 2000.

In addition to water pollution, air pollution is also associated with urban land use. It is no secret that the concentrations of airborne pollutants in urban areas far exceed those in their rural counterparts. Originating mainly from the combustion of fossil fuels used for urban transportation, these air pollutants take a toll on human health. Despite the fact that the air quality in Los Angeles has improved dramatically, the city has one of the highest air pollution levels in the United States. Pollution reaches unhealthy levels on roughly half the days of every year, causing irritation for many and illness for some. A 1991 study found that those living in areas where pollution exceeded government standards for 42 days or more per year had a 33 percent greater risk of contracting bronchitis and a 74 percent greater risk of contracting asthma.[14] Air pollutants can also damage the environment, even when measures are taken to reduce the adverse effects of urban air pollution. Tall smokestacks built to disperse pollutants in cities like New York, Philadelphia, and Pittsburgh ultimately contributed to the acidification of lakes in the Adirondack Mountains.[15]

Ground-level ozone, which damages both human health and vegetation, is a distinctly urban problem. The complex interaction of car emissions, pollutants from various sources, and meteorological conditions unique to cities contribute to the formation of ozone. Ozone

---

[14] Lents, J. M. & Kelly, W. J. (1993). "Clearing the Air in Los Angeles". *Scientific American*, 269 (4). p. 32.
[15] Baker, J. P. et al. (1990). Biological Effects of Changes in Surface Water Acid-Base Chemistry, NAPAP Report 13. In National Acid Precipitation Assessment Program (NAPAP). *Acid Deposition: State of Science and Technology*. Washington, D.C: NAPAP.

concentrations of large North American cities can reach between 70 and 200 parts per billion and spread often over distances of several hundred kilometers. Ozone concentrations as low as 40 parts per billion can injure plant leaves, whereas exposure to concentrations of 60 to 100 parts per billion for several hours is sufficient to cause significant plant, tree, and crop damage. Once injured by ozone, plants are more susceptible to insect attack, root rot, and other diseases. In the United States, ozone is responsible for most of the crop yield losses from air pollutants and has been implicated in the declines in the numbers of ponderosa and Jeffrey pines in the San Bernardino National Forest east of Los Angeles and the white pine in the eastern United States.[16]

In addition to the adverse effects of urbanization on human health and the environment, urban environmental problems exact direct and indirect economic costs. The medical costs of treating pollution-related illnesses can be easily calculated. But many other costs prove to be far more problematic, especially when assumptions and calculations must be made concerning the value of a human life in relation to the loss of economic activity. Nevertheless, some studies illustrate the costs of urban environmental degradation on human health and the natural resource base. In Mexico City, economic damages caused by the health impacts of air pollution are estimated at $1.5 billion per year. Particulates are estimated to cause 12,500 extra deaths and 11.2 million lost workdays per year - both due to respiratory illnesses. Because of excessive exposure to lead, about 140,000 children suffer a reduction in IQ and agility, jeopardizing their future reproductive health as well.[17] As to the impact on the natural resource base, ozone damage to U.S. crops is estimated to cost several billion dollars per year.[18]

---

[16] National Research Council. (1991). Rethinking the Ozone Problem in Urban and Regional Air Pollution. Washington, DC: National Academy Press; Rose, D. J. & Gilmour, A. (1995). Acid Deposition and Related Air Pollution: Its Current Extent and Implications for Biological Conservation in Eastern and the Western Pacific. Gland: World Wide Fund for Nature International; Heck, W. W. (1989). "Assessment of Crop Losses from Air Pollution in the United States," in MacKenzie, J. J. & El-Ashry, M. T. (Eds.). Air Pollution's Toll on Forest and Crops. New Haven: Yale University Press; US Congress, Office of Technology Assessment. (1988). Urban Ozone and the Clean Act Air Act: Problems and Proposals for Change. Washington DC: Office of Technology Assessment.

[17] Bartone et al, 1994.

[18] Ibid.

CHAPTER 2: AGRICULTURAL LAND USE AND THE ENVIRONMENT

Agriculture is a major land use category and, depending on the agricultural management techniques employed, agriculture can have adverse or beneficial impacts on the environment. By the end of the 1990s, farms spent a yearly total of over $6 billion on gasoline and other fuels, over $18 billion on chemical fertilizers, crop control chemicals and other agricultural chemicals combined, and over $2.75 billion on electricity.[19] It is well documented that the continued expansion of row crop agriculture resulted in less land in resource conserving crops, a loss of biodiversity, increased water pollution, soil erosion, and other environmental damages including major pollution flows into the Gulf of Mexico. Like the environmental impacts of urban land use, the environmental challenges of agricultural land use are often interrelated. For example, soil erosion leads to the sedimentation of streams - jeopardizing water quality, exacerbating aquatic biota problems and shortening the use of reservoirs.[20]

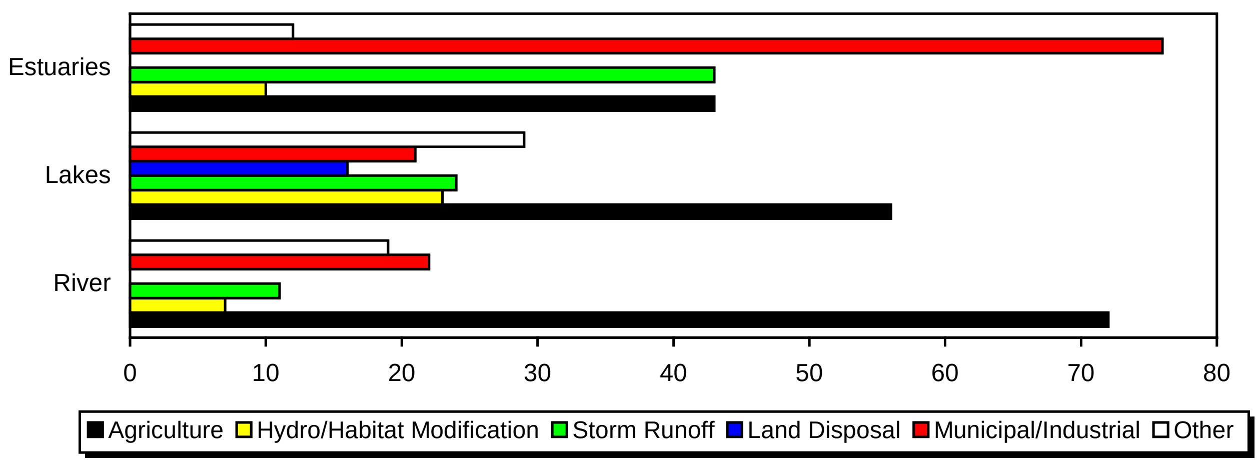
Non-Point Source Water Pollution

Due to the large quantities of fertilizers applied to field crops and manure excreted by livestock, agriculture in the United States has been a major contributor to nonpoint source water pollution.[21] Nutrient runoff occurs when nutrients are applied in excess of plant uptake. The problem is exacerbated because organic compounds found in agricultural pesticides usually take a long time to break down in water and are subsequently conveyed into water from the atmosphere or by water and soil erosion. Depending on a variety of factors, between 25 and 40 percent of soil that erodes from a field will reach a water body, where the sediments themselves can release significant amounts of pesticides and other

[19] Ruhl, J. B. (2000). "Farms, Their Environmental Harms, and Environmental Laws," *Ecology Law Quaterly*, 27. 265-349.
[20] Hewitt, T. I. & Smith, K. R. (1995). Intensive Agriculture and Environmental Quality: Examining the Newest Agricultural Myth. *Report from the Wallace Institute for Alternative Agriculture*; OECD (2001). *Environmental Indicators for Agriculture: Methods and Results*; Pretty, J. (2001). "The Real Costs of Modern Farming," *Resurgence*, 205; Kimbrell, A. (2002). "Fatal Harvest Myth 2: Industrial Food is Cheap," *Ecologist*; Kemp, L. (2001). *Stewardship Incentives: Towards Profitable Farms that Protect the Environment*. Prepared for Midwest Region Commodities and the Environment. A Collaboration Among World Wildlife Fund, American Farmland Trust and Henry A. Wallace Center for Agriculture and Environmental Policy.
[21] Runge, C. F. & Stuart, K. (1997). *The History, Trade and Environmental Consequences*

agricultural chemicals.[22] Figure 1 below illustrates that agriculture in relative terms is a major contributor to water contamination in 72 percent of U.S. river miles, 56 percent of lake acres and 43 percent of estuarine waters in 1992.[23] A 1988-90 survey of drinking water wells found nitrates in over half of the community water system wells and almost 60 percent of the rural domestic wells.[24] And low concentrations of at least one of seven major herbicides (atrazine, cyanazine, simazine, alachlor, metolachlor, prometon, and acetochlor) was found in 37 percent of the groundwater sites tested by the USGS.[25]

Figure 1. Sources of Identified Impairments to Surface-Water Quality



of Corn Production in the United States. Washington, DC: World Wildlife Fund; Conner, J. R., Dietrich, R. A. & Williams, G. W. (1999). *The U.S. Cattle and Beef Industry and the Environment.* A Report to the World Wildlife Fund.
[22] Ruhl, 2000; OECD, 2001, op cit.
[23] USDA, (1997). Agricultural Resources and Environmental Indicators, 1996-97, Washington, DC: USDA.
[24] Claasen, R., Hansen, L., Peters, M., Breneman, V., Weinberg, M., Cattaneo, A., Feather, P., Gadsby, D., Hellerstein, D., Hopkins, J., Johnson, P., Morehart, M., and Smith, M., (2001), "Agri-environmental Policy at the Crossroads: Guideposts on a Changing Landscape," USDA-ERS, Agricultural Economic Report No. 794.
[25] Ibid.

The interconnectedness of waterways, the accumulative and combined effect of increased nitrate loadings, the reduction of land in resource conserving cover vegetation and the system of corn-soybean farming with its attendant drainage, annual tillage, loss of cover, and decline in soil quality over the past twenty-five years have unwittingly contributed to oxygen depletion and the elimination of aquatic life in distant water bodies.

Hypoxia in the Dead Zone of the Gulf of Mexico is an illustration. The rush of nitrogen and other nutrients - caused by excessive fertilization or soil erosion promoting practices - that flow into the Mississippi River watershed each spring ultimately turn more than 7,000 square miles of the Gulf of Mexico into a "dead zone." Hypoxia refers to depletion of oxygen in the water or dissolved oxygen concentrations of less than 2 milligrams per liter. Hypoxia occurs when excess nutrients (like nitrogen and phosphorus) accumulate in water and stimulate algae to grow into algal blooms. Algae growth occurs both at the surface and is also deposited at the bottom of the body of water, resulting in oxygen removal caused by increased bacterial activity. The resulting lack of oxygen either kills aquatic life or forces it to relocate. The size of the zone in the gulf, which develops each spring and summer, varies and has more than doubled since it was first systematically mapped in 1985. In 1999, it was the size of the state of New Jersey. Hypoxia also affects the Chesapeake Bay and other coastal areas.

The Mississippi river drainage basin encompasses about 41 percent of the continental United States. It drains all or part of 30 states and extends from the Appalachian Mountains in the east to the Rocky Mountains in the west and from southern Canada to the Gulf of Mexico. About 70 million people live in the basin. About 58 percent of the basin is in cropland, 18 percent in woodland, 21 percent in range and barren land, 2.4 percent in water and wetlands and 0.6 percent in urban land. The majority of all agricultural chemicals used in the U.S. are applied to cropland in the basin. U.S. Agriculture contributes approximately 65 percent of the nitrogen loads entering the Gulf from the Mississippi Basin.[26] The problem is exacerbated further by the installation of drain tile in the Midwest. These measures hasten the amount of water draining from the soil and increase nitrate

[26] Ibid.

loads in streams and rivers.[27] Gyles Randall, a University of Minnesota scientist who studies the interactive impact of agricultural techniques in relation to hypoxia, believes that "the intensive corn-soybean rotation is not sustainable."[28] Yet another study believes that fertilizer runoff is responsible for about 56 percent of the nitrogen entering the Gulf and hypoxia is basically due to our propensity to "fertilize the living daylights out of the Midwest" (William Mitsch, OSU).

Studies have also estimated the monetary costs associated with water contamination, especially with respect to drinking water. The cost of measures to regulate and remove pesticides from drinking water in other countries like the United Kingdom is estimated to be around $220 million annually, with $1.6 billion in initial investment costs. To control and abate nitrate pollution of drinking water, costs were calculated at around $40 million per year between 1996 and 1997, with up to approximately $450 million in total costs of initial investment in water treatment equipment and control measures since 1989.[29] Other studies concur and suggest that millions of dollars are needed to remove pesticides, nitrate, cryptosporidium and phosphate from drinking water.[30] By extension, the accumulative indirect private and external costs due to the use of pesticides are estimated at $8.1 billion annually. A large part of this amount, $5 billion, are environmental and public health costs.[31]

The following assessment of the effect that non-point source water pollution has on U.S. coastal waters is drawn from a report on *Marine Pollution in the United States*, compiled by the Pew Oceans Commission:

---

[27] Keeney, D. & Kemp, L. (2002). *A New Agricultural Policy for the United States*, Presented in part at the Advanced Research Workshop, Krakow, Poland, November 6, 2002.
[28] Gyles cited in Keeney & Kemp, (2002), Ibid.
[29] Redman (1996). Industrial Agriculture: Counting the Costs. UK: Soil Association.
[30] Pretty, (1998), op cit.
[31] Pimentel, D., Acquay, H., Biltonen, M. Rice, P., Silva, M., Nelson, J. Lipner, V., Giordano, S., Horowitz, A. & D'Amore, M. (1993). "Assessment of Environmental and Economic Impacts of Pesticide Use," in D. Pimentel & H. Lehman (Eds.). *The Pesticide Question: Environment, Economic and Ethics*. New York: Chapman and Hall.

"The largest human-controlled addition of nitrogen to the environment is the manufacture of inorganic nitrogen fertilizer. However, other activities, including the combustion of fossil fuels and cultivation of nitrogen-fixing crops, also convert atmospheric nitrogen into reduced, oxidized, or organic forms that are more biologically available than the gaseous nitrogen that comprises most of the air we breathe. About 20 percent of the fertilizer nitrogen applied in North America leaches into waters and 65 percent is removed in crops. Most of the crops (70%) are fed to animals rather than humans; thus the amount of nitrogen reaching water bodies from animal wastes probably exceeds that from fertilizer runoff. Ammonia released into the air from animal wastes can be an important pathway though which nitrogen reaches coastal waters. Human sewage is also an important avenue for nitrogen originally contained in crops or meat to reach coastal waters.

Although global additions of nitrogen to the biosphere are continuing to increase rapidly, current trends in nitrogen loadings to U.S. coastal waters are in aggregate generally stable or growing slowly, while inputs of phosphorus are stable or declining. Although the worldwide use of chemical fertilizers is growing and projected to increase substantially to support an expanding world population and increased meat consumption, the use of chemical fertilizers in the U.S. nearly plateaued in the 1980s. However, increased inputs of both nitrogen and phosphorus have occurred in regions of the country experiencing an expansion and intensification of animal-feeding operations or human population growth. Future consumption of fertilizers and generation of animal wastes in the U.S. could increase, depending on global market forces.

Significant reductions in nutrient pollution may be achieved by approaches that (1) reduce the use of nutrients in the first place; (2) control losses to the environment at the point of release (e.g. the farm field or animal feeding operation); and (3) sequester or remove pollutants as they are transported to the sea. To be practical, the abatement of agricultural sources of nutrients must focus not only on reducing fertilizer use but also on plugging the many leaks in agricultural nutrient cycles. Efficiencies in fertilizer use in U.S. agriculture, measured by the ratio of nitrogen in harvested crops to nitrogen in fertilizer applied, have been slowly but steadily increasing since the mid-1970s. Nevertheless, about one-third of the nitrogen applied is not recovered in harvested crops. Not all of the missing nitrogen contributes to eutrophication of coastal waters. Much is denitrified in soils or aquatic systems en route to the sea or is stored in soils or groundwater.

In addition to increasing the efficiency of nitrogen uptake by crops, the return of nitrogen gas to the atmosphere can be enhanced through management practices. Various agricultural practices affect nitrogen and phosphorus runoff and losses to groundwater (which ultimately seeps into surface waters). Practices employed to reduce soil erosion, such as contour plowing, timing of cultivation, conservation tillage (little or no tilling), stream-bank protection, grazing management, and grassed waterways also reduce nutrient pollution. Other practices are more specifically targeted to the efficient use and retention of nutrients: (1) soil testing to precisely match fertilizer applications to crop nutritional needs (many farmers still overapply to ensure maximum crop yields); (2) applying fertilizer only at the time the crop needs it; (3) crop rotation; (4) planting cover crops in the fall; (5) using soil and manure amendments; and (6) specialized methods of application. Landscape practices such as maintaining buffer strips between cultivated fields and nearby streams, moderating excessive drainage by ditches and tile lines, and maintaining wooded riparian areas can further reduce the leakage of agricultural nutrients to surface waters. By combining these approaches a significant portion of the edge-of-field nitrogen losses can be reduced. Often, animal wastes are the most significant source of nutrient pollution from agriculture. Although the total production of livestock in the U.S. has not dramatically increased in recent years, the number and size of concentrated animal feeding operations have. Enclosures or trapping devices may eventually be required to stem ammonia emissions from animal wastes. Manure management also presents a risk of pollution if holding facilities fail or do not function properly. Finally, frequently too much manure is produced within a geographic area for it to be applied to near-by land without overloading soils with nutrients.

Reducing and controlling diffuse sources of land runoff must involve large-scale landscape management, including restoration of riparian zones and wetlands. The integrated assessment of hypoxia in the Gulf of Mexico estimated that 5 million acres of restored wetlands in the Mississippi River Basin would reduce nitrogen loading to the Gulf by 20 percent. Coupled with feasible controls in agriculture, this would achieve a nearly 40 percent reduction in nitrogen delivered to the Gulf. Similarly, the Chesapeake Bay Program is striving to reforest 2,000 miles of riparian zones and restore 25,000 acres of wetlands by 2010 in order to achieve nutrient-reduction goals."[32]

Additional Literature:

<u>Water Quality Management:</u>

Aillery, Marcel P., (1995), *Federal Commodity Programs and Returns To Irrigation In The West.* Natural Resources and Environment Division, Economic Research Service, U.S. Department of Agriculture, Washington DC 20005-4788. maillery@econ.ag.gov. Staff Paper AGE-9502, March 1995. (Full text not available--contact authors or NTIS)

Cohen-Vogel, Daniel R., Daniel E. Osgood, Douglas D. Parker, and David Zilberman. (1998), "The California Irrigation Management Information System (CIMIS): Intended and unanticipated impacts of public investment." *Choices*. Third Quarter 1998.

Cooperative State Research, Education, and Extension Service (CREES) and USDA, Project W-190, Western Regional Research Project, (2000), *Water Conservation,*

[32] Boesch, D., Burroughs, R., Baker, J., Mason, R., Rowe, C, Siefert, R., (2001), *Marine Pollution in the United States: Significant Accomplishments, Future Challenges*, Pew Oceans Commission, pp. 31-33. Available on CD ROM: Pew Oceans Commission, (2003), *America's Living Oceans: Charting a Course for Sea Change*, includes final report and summary report, see www.pewoceans.org

Competition, And Quality In Western Irrigated Agriculture. (Completion date: September 2004). Contact: Lansford, R. L. *Water Conservation, Competition, And Quality In Western Irrigated Agriculture.* Department of Agricultural Economics & Agribusiness, New Mexico State University, Las Cruces, New Mexico. Presentation by Daniel Osgood, "Water Conservation, Competition, and Quality in Western Irrigated Agriculture," W-190, November 2000. Phoenix, Arizona.
Project Homepage: http://lgu.umd.edu/lgu_v2/homepages/home.cfm?trackID=299
Pacific NW Pollution Prevention Resource Center:
http://www.pprc.org/pprc/rpd/fedfund/usda/csrees/watercon.html

Statement of Issues, Justification, and Progress: The rapidly changing configuration of water use in the American West in recent years has resulted in a number of economic, environmental, and institutional problems with profound impacts on irrigated agriculture. The purpose of this project is to identify, examine, and evaluate the multiple impacts of these challenges on western irrigated agriculture, help develop viable mechanisms to effectively address them, and thus contribute toward informed water policy formulation.

As new problems associated with water management emerge, the need to devise dynamic new approaches for solving them takes on added importance and urgency. Examples of such emerging areas of concern include climate change and its impact on irrigated agriculture, increasing demand for water transfer from agriculture to environmental and urban uses, impacts of animal waste management from concentrated animal feeding operations (CAFO's) on water quality, precision agriculture and the effects of site-specific management on water conservation and quality, contingent water marketing, and new approaches (e.g. game theory) to conflict resolution among competing water uses and users. The proposed revision of this regional project is a concerted effort to address these emerging concerns in innovative ways.

The consequences of water management and policy decisions are frequently difficult or impossible to predict because of the many complex interactions between technological, institutional, and economic factors. Extensive research has been done on the individual factors and their effect on economic and environmental outcomes. In addition, many models have been constructed which attempt to account for the myriad interactions that may occur that effect such outcomes. Past work by this regional project has focused on model development. Little work has been done, however, on the application of such models to evaluate and quantify the interactions, or to direct the development of sound integrated research to verify and corroborate model predictions. In addition, the difficulty in applying existing models is the lack of complete on-farm or regional data appropriate for input to them. The focus of this revision is to treat these unaddressed needs.

A comprehensive modeling framework was applied to analyze four water quality protection policies in the Southern High Plains: restrictions on per-acre nitrogen use, taxes on nitrogen use, taxes on irrigation water use, and incentives to convert

conventional to modern irrigation systems. Economic assessment was based on changes in cropping patterns, input use, farm income, and social welfare.

Important producer responses to the policies included reducing nitrogen and water use, crop substitutions, removal of land from crop production, and converting irrigated production to dryland. Adjustments were closely tied to the unique production setting (e.g., soil, climate and irrigation system) facing the producer, and illustrated the importance of representing a wide array of production adjustments and responses in water quality policy models.

The incentive to convert irrigation systems outperformed other policies from both the standpoint of society and producers. This result reflected the large amount of nitrogen lost in runoff and leaching from furrow irrigated production.

Of the regulatory and tax policies evaluated, producers preferred restrictions on per-acre nitrogen use to nitrogen use taxes or irrigation water taxes because farm income was reduced less under the restriction. From society's point of view, however, nitrogen use taxes were more desirable than nitrogen use restrictions due to the revenue generated by taxes.

Gollehon, N., and Quinb, W., (2000), *Irrigation in the American West: Area, Water and Economic Activity*, ERS Elsewhere No. 0004, June 2000.

Keplinger, Keith O., Bruce A. McCarl, Mansoor E. Chowdhury, and Ronald D. Lacewell, (1998), "Water Management Policies for Streamflow Augmentation in an Irrigation in Dry Years." *Journal of the Western Agricultural Economics Association*. Volume 23, Number 1, July 1998.

Porter, K.S., (1980), "An Evaluation of Sources of Nitrogen as Causes of Ground-Water Contamination in Nassau County, Long Island", Water Resources program, Center for Environmental Research, Cornell University, Ithaca, New York, *Ground Water,* vol. 18, no. 6, pp. 617-625.

Schuck, E.C. and Green., G.P., (2001), "Field attributes, water pricing, and irrigation technology adoption." *Journal of Soil and Water Conservation*, 2001,Vol.56, No.4.

Abstract: Water price policy can be an effective resource management tool to promote water conservation by encouraging reductions in water consumption and the adoption of less water-intensive irrigation technologies. However, a farm's ability to adopt alternative irrigation technologies depends upon the unique attributes of the farm site. In particular, interaction between field attributes like soil permeability and field slope can reduce and limit the influence of water price in promoting adoption of alternative irrigation technologies. This issue is examined using irrigation technology adoption data from California's Central Valley. Results suggest that while water prices are important to water use decisions, field-specific attributes are more important to the adoption of water conserving irrigation systems.

Schwabe, Kurt A, (2000), "Modeling State-Level Water Quality Management: The Case of the Neuse River Basin." *Resource and Energy Economics* v22, n1 (January 2000): 37-62

Abstract: This research considers how the perceived costs of achieving water quality objectives are sensitive to three issues surrounding model structure and policy design. These issues include: (i) the extent of the regulated market, (ii) the responsibility of the regulated market for background pollution, and (iii) the use of alternative policy instruments. A large-scale process model is used to evaluate and compare the costs of nutrient reduction in the Neuse River Basin in North Carolina under various instruments, including a plan currently being considered by state regulators. The results emphasize the importance of flexibility in both model structure and policy design.

Veeman, T.S. and M.M. Veeman with W.L. Adamowicz, S. Royer, B. Viney, R. Freeman and J. Baggs, (1997), *Conserving Water in Irrigated Agriculture: The Economics and Valuation of Water Rights*. 23 p. http://lipsey.re.ualberta.ca/sp-pr-95.htm

Weinberg, M., "Economic Perspectives On The Agriculture-Environment Interface: Applications In Water Policy." *Environmental Studies*, University of California, Davis: California.

Weinberg, M. and Kling, C.L., (1996), "Uncoordinated Agricultural and Environmental Policy Making: An Application to Irrigated Agriculture in the West." *American Journal of Agricultural Economics*, 78: 65-78.

Westermann, D. T. , *Reducing Erosion And Protecting Water Quality On Irrigated Land.* Agricultural Research Service, National Assoc. of Cons District, Pullman: Washington.

Whittlesey, N. K. *On-Farm Management Of Groundwater Nitrate Pollution In Pacific Northwest Irrigated Agriculture*, Department of Agricultural Economics. Washington State University, Pullman, Washington.

Wilkins-Wells, J. R.; Freeman, D. M. *Municipal And Agricultural Water Exchanges In Colorado: Opportunities & Constraints For The Future*. Department of Sociology. Colorado State University, Fort Collins: Colorado.

Willis, David B. and Norman K. Whittlesey, (1998), "The Effect of Stochastic Irrigation Demands and Surface Water Supplies on On-Farm Water Management." *Journal of the Western Agricultural Economics Association.* Volume 23, Number 1, July 1998.

Non-Point Source Water Pollution:

Anonymous, (2000), *Best Management Practices for Irrigation*. Publication Number 442-901, posted February 2000. http://www.ext.vt.edu/pubs/farmasyst/442-901a/442-901a.html

Abstract: Increased concern for the deteriorating quality of our nation's waters, such as the Chesapeake Bay, has led each state to adopt and promote nonpoint-source (NPS) pollution control measures. NPS pollution results from runoff, snow melt, or groundwater seepage from industrial, municipal, and agricultural sites. NPS pollution often goes unnoticed; however, it is extremely widespread and makes a significant contribution to our overall water pollution problem. Virginia's approach to the problem of NPS pollution is primarily through voluntary programs and education of its citizens. Agricultural producers are encouraged to adopt Best Management Practices, called BMPs. BMPs, which include management, structural, and agronomic measures, are sound, common-sense conservation practices that will result in water quality improvements. While irrigators encounter the same NPS pollution problems that all crop producers face, they can take positive measures to prevent irrigation from contributing to pollution. In addition to creating problems due to sedimentation, nutrient enrichment, and chemical poisoning, irrigation runoff and excessive leaching represent wasted water and energy.

Claassen, Roger et al, USDA, (1998), "Estimating the Effects of Relaxing Agricultural Land Use Restrictions: Wetland Delineation in the Swampbuster Program," *Review of Agricultural Economics*, v20 n2 Fall-Winter 1998, pp. 390-405.

DEFRA, (2003), Policy Instruments for the Control of Pollution of Water by Diffuse Agricultural Sources, UK Department for Environment, Food and Rural Affairs, May 2003. Available online at
http://www.defra.gov.uk/environment/water/quality/diffuse/agri/reports/pdf/dwpa08.pdf

Abstract: This document was published on the Web by the UK Department for Environment, Food and Rural Affairs (DEFRA) in May 2003. It provides information on the nature of diffuse pollution, and the policy instruments in place to help control the diffuse pollution of water by agricultural sources. This contracted consultancy paper by OXERA is UK and Common Agricultural Policy (CAP) specific but may be useful for general coverage, 35 pp.

The structure of this paper is as follows.

• Section 2 contains introductory information describing the nature of diffuse pollution, current policies, and circumstances in which government intervention may be justified. It offers signposts to further reading in research reports, government papers, and legislation.

• Section 3 introduces the main types of policy intervention available to the UK government, and some of their strengths and weaknesses.

• Section 4 outlines a process for the selection and packaging together of policy measures. The process is critical. Participants (stakeholders) in policy-making may prefer to agree on the process for policy design before sitting down to agree the design of the policy interventions themselves. To this end, the process itself must offer a level of transparency and clarity such that complex issues can be analysed and the analysis critiqued, and the process must allow the policy package to be developed stage by stage.

- Section 5 illustrates the use of the process of policy selection by applying it to broad categories of policy instruments.
- Section 6 summarises the conclusions.

Forster, D.L., (2000), "Public Policies and Private Decisions: Their Impacts on Lake Erie Water Quality and Farm Economy," *Journal of Soil and Water Conservation*, 2000, Vol.55, No.3

Abstract: Since the early 1970s, pollution abatement efforts have recognized nonpoint sources and, particularly, agriculture, as major causes of pollution in the Lake Erie region. The first objective of this research is to summarize federal and state agricultural pollution abatement programs that encouraged farmers to adopt conservation practices. Next, the economic impacts of changes in farming practices are reviewed. Statistical analyses of farm-level accounting data and a farm simulation model are used to investigate the economic effects of conservation practices in the region. Finally, simulated farm pollutant emissions in 1985 and 1995 are compared to actual pollutant loadings. This comparison offers evidence that improvements in water quality are attributable to changes in farming practices, (e.g., conservation tillage adoption)

Hoag, Dana L. and Jennie S. Hughes-Popp, (1997), "Theory and Practice of Pollution Credit Trading in Water Quality Management," *Review of Agricultural Economics*, Fall/Winter 1997 Vol. 19, No. 2.

Horan, Richard D., Roger Claassen, Joseph Cooper, (2000), *Environmental Risk and Agri-Environmental Policy Design*. American Agricultural Economics Association Annual Meeting, July 30- August 2, 2000, Tampa, Florida.horan@msu.edu, claassen@econ.ag.gov, jcooper@econ.ag.gov, 29 pages; Adobe Acrobat PDF 152K bytes.

Abstract: Agricultural nonpoint pollution is inherently stochastic (e.g., due to weather). In theory, this randomness has implications for the choice and design of policy instruments. However, very few empirical studies have modeled natural variability. This paper investigates the importance of stochastic processes for the choice and design of alternative nonpoint instruments. The findings suggest that not explicitly considering the stochastic processes in the analysis can produce significantly biased results.

Horan and Ribaudo, (1999),"Policy Objectives and Economic Incentives for Controlling Agricultural Sources of Nonpoint Pollution." *Journal of the American Water Resources Association* Vol. 35, No. 5, October 1999, pp. 1023-1035.

Kraft, S., and J. Penberthy, (2000), "Conservation Policy for the Future: What Lessons Have We Learned from Watershed Planning and Research," *Journal of Soil and Water Conservation*, 2000, Vol.55, No.3.

Abstract: In the last ten years, watershed planning has become a focal point of soil and water conservation policy in the United States (Naiman 1992; Euphrat and Warkentin 1994; Adler 1995). To proponents, the watershed and the movement of water across and through its landscape and into its streams and groundwater captures processes that results in soil loss, sedimentation of waterways, and deterioration of water quality. Consequently, conservationists argue that by changing management structures and practices across the landscape of a watershed, it is possible to advance a range of environmental goals. As a consequence of this position, there are watershed planning efforts across the country that are typically based on a partnership that is led by local citizens who rely on federal and state agency personnel for technical support. While much is currently written about such watershed based planning efforts, the development of a set of strategies for facilitating the planning process rests on lessons derived from ongoing planning efforts (U.S. Environmental Protection Agency, 1997).

Lichtenberg, Erik, "Agriculture and the Environment," in Bruce L. Gardner and Gordon C. Rausser (ed.), *Handbook of Agricultural Economics*. Amsterdam: Elsevier.

Abstract: An overview of the agricultural economics literature on nonpoint source pollution, including policy implications of heterogeneity among emitters, randomness, hidden information/adverse selection problems, and moral hazard. Impacts of agricultural policies on nonpoint source pollution problems.

Lichtenberg, Erik and Rae Zimmerman, (1999), "Farmers' Willingness to Pay for Groundwater Protection," *Water Resources Research* 35, 833-841 (March 1999).

Lichtenberg, Erik, and Lars J. Olson, (1998), "Noncooperative and Cooperative Management of an Accumulative Water Pollutant," in Richard E. Just and Sinaia Netanyahu (ed.), *Conflict and Cooperation in Transboundary Water Resources*. Boston: Kluwer Academic Publishing, 1998.

Abstract: Upstream states may force downstream states to clean up more pollution than is socially optimal. Long run equilibrium levels of a stock pollutant will also tend to be higher, especially if the pollutant degrades slowly. An empirical example using parameters relating to phosphorus pollution of the Chesapeake Bay illustrates the magnitudes of these effects.

Lichtenberg, Erik and Lisa K. Shapiro, (1997), "Agriculture and Nitrate Concentrations in Maryland Community Water System Wells," *Journal of Environmental Quality* 26, 145-153 (January-February 1997).

Abstract: Corn and poultry production are positively correlated with elevated nitrate concentrations in Maryland community water system wells.

Lovejoy, Stephen B. and Hyde, Jeffrey, (1997), "Nonpoint-source pollution defies U.S. water policy." *Forum for Applied Research and Public Policy* v. 12 (Winter '97) p. 98-101.

Abstract: Runoff from agricultural operations, including fertilizers, pesticides, sedimentation, and animal waste, represents the greatest source of water pollution in the United States. And because nonpoint-source pollution is so difficult to monitor, it will remain the biggest challenge to regulators in charge of cleaning up our waters. In response, the United States Department of Agriculture launched the 1989 Water Quality Initiative to provide the know-how for farmers to meet water-quality goals set by individual states. "These technologies include reduced tillage, integrated pest management, and nutrient and manure testing," say Stephen B. Lovejoy, a professor of agricultural and environmental policy, and Jeffrey Hyde, a graduate research assistant in the Department of Agricultural Economics at Purdue University. And though the 1996 Farm Bill authorizes more than $2.2 billion for conservation, including nonpoint-source pollution programs, the campaign for clean water still faces significant challenges. For one, those who bear the costs of cleanup--farmers--are not the ones who reap economic gains from cleaner water. "Those who benefit the most are the fishermen, swimmers, boaters, and others who are presently not using the water because of nonpoint-source pollution," the authors say.

McCann, Laura M. J., Easter, K. William, (1999), "Differences between Farmer and Agency Attitudes Regarding Policies to Reduce Phosphorus Pollution in the Minnesota River Basin." *Review of Agricultural Economics* v21, n1 (Spring-Summer 1999): 189-207.

Abstract: Farmers and agency staff were surveyed regarding their opinions on alternative policies to reduce agricultural nonpoint source pollution in the Minnesota River. Farmers were also asked about their land and nutrient management practices. The information was used to examine determinants of policy preferences. For agency staff, farmer resistance and administrative or transaction costs were more important than farmer costs. Both agency staff and farmers indicated that their preferred policy was a requirement for conservation tillage on highly erodible land. Changes in how soil test results are reported may have potential to reduce phosphorous applications, as would improved manure management.

Minnesota River Basin Agricultural Resources and Research at the Dept. of Soil, Water, and Climate, University of Minnesota, (1996), "Internet Resources," A site listing educational resources related to water quality, bibliography's of non point source related issues, manure and waste management, wetlands, riparian buffers, and filter strips, best management practices and farm management, agricultural non point source related projects, professional, state and other agencies.
See http://www.soils.agri.umn.edu/research/mn-river/doc/links.html

Morgan, Cynthia L, Jay S. Coggins; Vernon R. Eidman, (1998), *Tradable Permits For Controlling Nitrate Pollution Of Domestic Groundwater Supplie*s, American Agricultural Economics Association Annual Meeting, August 2-5, 1998, Salt Lake City, Utah

Osei, E., P.W. Gassman, R.D. Jones, S.J. Pratt, L.M. Hauck, L.J. Beran, W.D. Rosenthal, J.R. Williams, (2000), "Economic and Environmental Impacts of Alternative Practices on Dairy Farms in an Agricultural Watershed," *Journal of Soil and Water Conservation*, 2000, Vol.55, No.3.

Abstract: Nutrient losses from agricultural nonpoint sources are a key component of surface water impairment across the United States. Nitrogen is clearly the primary pollutant problem in many agricultural areas. However, development of management practices that reduce phosphorus loadings is becoming more important in many watersheds because phosphorus is often the limiting nutrient for fresh water eutrophication. This study presents the results of computer simulations performed to assess the impacts of various management practices on phosphorus losses from dairy farms in a watershed in north central Texas. The results show that moving from nitrogen to phosphorus-based waste application rates could significantly reduce phosphorus losses at moderate cost to producers. Composting solid manure for end uses outside the impacted watersheds provides even greater phosphorus load reductions and requires less land, but results in significantly higher cost to producers. The choice for each watershed depends on such key factors as available land area and the load reduction sought.

Ribaudo, Marc O., Richard D. Horan, and Mark E. Smith, (1999), *Economics of Water Quality Protection from Nonpoint Sources: Theory and Practice*, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 782 (AER-782), 120 pp, Dec 1999. Order online at http://www.ers.usda.gov/publications/aer782/

Abstract: Water quality is a major environmental issue. Pollution from nonpoint sources is the single largest remaining source of water quality impairments in the United States. Agriculture is a major source of several nonpoint-source pollutants, including nutrients, sediment, pesticides,and salts. Agricultural nonpoint pollution reduction policies can be designed to induce producers to change their production practices in ways that improve the environmental and related economic consequences of production. The information necessary to design economically efficient pollution control policies is almost always lacking. Instead, policies can be designed to achieve specific environmental or other similarly related goals at least cost, given transaction costs and any other political, legal, or informational constraints that may exist. This report outlines the economic characteristics of five instruments that can be used to reduce agricultural nonpoint source pollution (economic incentives, standards, education, liability, and research) and discusses empirical research related to the use of these instruments. Keywords: water quality, nonpoint-source pollution, economic incentives, standards, education, liability, research.

Scottish Executive, (2002), *The 4 point Plan*: *Straightforward guidance for livestock farmers to minimize pollution and benefit your business*, November 2002. Available online at http://www.scotland.gov.uk/library5/agri/4pointplan.pdf

Abstract: Published on the Web by the Scottish Executive in November 2002, the 4 point plan provides guidance for livestock farmers on how to minimise diffuse pollution and benefit their business. The four points look at how to reduce dirty water around the farm, better nutrient use, how to carry out a risk assessment for slurry and manure, and how to manage water margins, 30 pp.

Scottish Executive, (2002), *Prevention of Environmental Pollution from Agricultural Activity*. Available online at http://www.scotland.gov.uk/library5/environment/pepf-00.asp

Abstract: Published on the Web in 2002 by the Scottish Executive, this online booklet is aimed at farmers, crofters, and all those involved in agricultural activity. It provides practical guidance on how to prevent pollution from many different agricultural activities including waste management, pesticide use, disposal of animal carcasses, and soil protection, 34 pp.

Shankar, B., E.A. DeVuyst, D.C. White, J.B. Braden, and R.H. Horn, (2000), "Nitrate Abatement Practices, Farm Profits, and Lake Water Quality: A Central Illinois Case Study," *Journal of Soil and Water Conservation*, 2000, Vol.55, No.3

Abstract: Nonpoint source pollution from agricultural sources is the largest impediment to further improvement in surface water quality. This paper investigates the environmental and economic consequences of altering nitrogen fertilizer practices for a central Illinois watershed. A model of the watershed is employed to assess the impacts of the alternative management practices. The model incorporates heterogeneity of soil types and characterizes lake water quality as a weather-driven random process affected by production practices. Results indicate that improvements in surface water quality can be obtained while increasing farm profits by reducing nitrogen fertilizer application levels. Varying the timing of fertilizer application does improve water quality, but also increases the variability of farm profits.

Shortle, James S., Richard D. Horan, Marc Ribaudo, David G. Abler, *Point/Nonpoint and Nonpoint/Nonpoint Trading Rules*, (1998), American Agricultural Economics Association Annual Meeting, August 2-5, 1998, Salt Lake City, Utah.

Stephenson, Kurt; Patricia E. Norris and Leonard A. Shabman, (1997), *Watershed-Based Effluent Trading: The Nonpoint Source Challenge.* Paper presented at the Western Economics Association Meeting, Seattle, Washington, July 1997.

Walter, M., E. S. Brooks, M.F. Walter, T.S. Steenhuis, C.A. Scott, and J.Boll, (2001), "Evaluation of Soluble Phosphorus Loading from Manure-Applied Fields under Various Spreading Strategies," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.4)

Abstract: A simple model was developed and applied to a dairy farm in the New York City (NYC) water supply watershed to evaluate the effectiveness of various manure spreading strategies for reducing non-point source, soluble phosphorus (SP) pollution. Phosphorus from manure spread fields is recognized as one of the important non-point source pollutants in the region and there is

acute interest in developing economically viable water quality management practices. The NYC watershed initiative, i.e. the Watershed Agriculture Program (WAP), mandated that water quality management practices will be scientifically justifiable based on the best information available (Walter and Walter, 1999). Thus, this project was carried-out to evaluate manure-handling strategies based on the currently available information. The model for predicting SP loading to perennial streams via surface runoff was developed by combining a mechanistic hydrological model with an empirical relationship for SP concentration in runoff. This study showed that, in the short term, because of soil P accumulation associated with a history of dairy farming, the maximum possible reduction in SP loading to perennial streams is about 50%. This is attained by exporting all manure from the NYC watersheds. Utilizing the concept of hydrologically sensitive areas (Walter et al. 2000), this study suggests possible SP loading reductions of 25% with all manure remaining on-farm. This study supports and emphasizes the finding by Walter et al. (2000) that the timing and location of manure spreading strongly influences SP transport.

Nutrient Management:

Beegle, D., (1997), "Nutrient management legislation in Pennsylvania: Who will be affected?" *Agron. Facts* 40. Pennsylvania State Univ., University Park, PA.

Bittermann, Wolfgang, Haberl, Helmut, (1998), "Landscape-Relevant Indicators for Pressures on the Environment." *Innovation* 1998, 11, 1, Mar, 87-106.

Abstract: The operationalization of sustainable development requires indicators that can serve as information tools for the appraisal of the environmental consequences of socioeconomic development. These indicators should cover three main areas: (1) pressures of the socioeconomic system on the environment; (2) the state of the environment; & (3) socioeconomic responses, ie, activities to alleviate environmental problems. The indicators are discussed in light of two approaches for the description of the interaction between socioeconomic systems & their natural environment: (A) socioeconomic metabolism, i.e., the mode in which societies organize their exchange of matter & energy with their natural environment; & (B) the colonization of nature, defined as the conundrum involving strategies employed to transform parts of the environment to render them more useful for societal needs. Four examples for indicators of sustainable development are presented for the case of Austria nutrient balances, manure management, energy consumption of crop farming, & appropriation of net primary production. These & similar indicators can be the basis for the development of spatially disaggregated sectoral ecobalances, which are necessary for an integrated economic & ecological assessment of the economic branches with the highest relevance for the sustainable development of cultural landscapes.

Caswell, Margriet, Keith Fuglie, Cassandra Ingram, Sharon Jans, and Catherine Kascak, (2001), *Adoption of Agricultural Production Practices: Lessons Learned from the U.S. Department of Agriculture Area Studies Project*, ERS Agricultural Economic Report No. 792. 116 pp, January 2001.

Abstract: The U.S. Department of Agriculture Area Studies Project was designed to characterize the extent of adoption of nutrient, pest, soil, and water management practices and to assess the factors that affect adoption for a wide range of management strategies across different natural resource regions. The project entailed the administration of a detailed field-level survey to farmers in 12 watersheds in the Nation to gather data on agricultural practices, input use, and natural resource characteristics associated with farming activities. The data were analyzed by the Economic Research Service using a consistent methodological approach with the full set of data to study the constraints associated with the adoption of micronutrients, N-testing, split nitrogen applications, green manure, biological pest controls, pest-resistant varieties, crop rotations, pheromones, scouting, conservation tillage, contour farming, strip cropping, grassed waterways, and irrigation. In addition to the combined-areas analyses, selected areas were chosen for analysis to illustrate the difference in results between aggregate and area-specific models. The unique sample design for the survey was used to explore the importance of field-level natural resource data for evaluating adoption at both the aggregate and watershed levels. Further analyses of the data illustrated how the adoption of specific management practices affects chemical use and crop yields.

Claassen, Roger, LeRoy Hansen, Mark Peters, Vince Breneman, Marca Weinberg, Andrea Cattaneo, Peter Feather, Dwight Gadsby, Daniel Hellerstein, Jeff Hopkins, Paul Johnston, Mitch Morehart, Mark Smith, (2001), *Agri-Environmental Policy at the Crossroads: Guideposts on a Changing Landscape*, ERS Agricultural Economic Report No. 794. 72 pp, January 2001.

Abstract: Agri-environmental policy is at a crossroads. Over the past 20 years, a wide range of policies addressing the environmental implications of agricultural production have been implemented at the Federal level. Those policies have played an important role in reducing soil erosion, protecting and restoring wetlands, and creating wildlife habitat. However, emerging agri-environmental issues, evolution of farm income support policies, and limits imposed by trade agreements may point toward a rethinking of agri-environmental policy. This report identifies the types of policy tools available and the design features that have improved the effectiveness of current programs. It provides an indepth analysis of one policy tool that may be an important component of a future policy package—agri-environmental payments. The analysis focuses on issues and tradeoffs that policymakers would face in designing a program of agri-environmental payments.

Comis, Don, (1999), "Protecting the Chesapeake Bay," *Agricultural Research*, Jan 99, p4, 5p, 6c.

Abstract: Focuses on the effort of the United States (US) Agricultural Research Service (ARS) to document the amount of agricultural compounds that reach the Chesapeake Bay. Information on airshed; Investigation on the effects of mixing alum residue from a drinking water treatment plant into chicken litter before applying it to cornfields; Results of a study on how a wetland can filter chemicals from farm runoff before the pollutants reach a bay tributary.

DeSena, Mary, (1999), "Water Quality: Maryland Act Pioneers Comprehensive Nutrient Management." *Water Environment & Technology*, v. 11 no5 (May 1999) p. 20-3.

Abstract: What has been described as the most comprehensive farm nutrient control legislation in the U.S. was recently enacted by the Maryland General Assembly. Under the state's 1998 Water Quality Improvement Act, just under 15,000 farms are now required to develop and implement a nitrogen and phosphorus-based nutrient management plan.

Fajardo, J.J., J.W. Bauder, and S.D. Cash, (2001), "Managing Nitrate and Bacteria in Runoff from Livestock Confinement Areas with Vegetative Filter Strips," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.3.

Abstract: A documented source of nitrate-nitrogen contamination of surface water is livestock waste and storage facilities. A vegetative filter strip (VFS) is effective in reducing some nutrients, sediment, and suspended solids in surface runoff from feedlots; however, results are variable in controlling water-soluble nutrients and bacteria in runoff. This study assessed the role of tall fescue (Festuca arundinacea Schreb.) as a VFS in reducing contaminants from stored animal wastes. The study evaluated the extent to which livestock manure stockpiles potentially contribute to nitrate-nitrogen (NO3-N) and coliform bacteria contamination of surface water resources. The experiment was conducted on Amsterdam silt loam (fine-silty, mixed, superactive Typic Haploboroll) soil. Tall fescue and bare soil (fallow) strips were established on a 4% slope. Treatments consisted of manure applications in the upland position for the strips. For comparision, vegetated and bare control (non treated) strips without manure in the upland position were also studied. Manure was applied annually (approximately 2 t fresh weight per strip). Runoff was achieved by applying water at the head of the treatments and forcing the applied water to pass through the manure stockpiles and into the VFS and fallow strips. Runoff water samples were collected and analyzed for NO3-N and coliform. Concentration of NO3-N in surface runoff from VFS with manure stockpiles in the headland was reduced up to 97% in 1997 and 99% in 1998 where a VFS was present. Coliform populations in runoff were reduced significantly by VFS in two runoff events, a 64% reduction in July 1997, and an 87% reduction in August 1998. However, the coliform counts in runoff, even from VFS treatments not receiving manure, remained substantially elevated. Dilution and residence time of water

passing through the VFS appeared to be the most significant factors affecting reductions in NO3-N and bacteria in runoff.

Lichtenberg, Erik, (1996), Department of Agricultural and Resource Economics, University of Maryland, "Conservation Practices to Reduce Bay Nutrients: How Has Agriculture Done?" *Economic Viewpoint*, 1996.

Introduction: The Chesapeake Bay Agreements of 1983, 1987, and 1992 commit the state of Maryland to restoring the Bay to its former health and productivity by (1) reducing controllable loadings of major pollutants into the Bay and each of its major tributaries to 40 percent below 1985 baseline levels by the year 2000 and (2) capping controllable loadings at 40 percent of the 1985 baseline thereafter. Agriculture plays an important role in current plans for meeting the nitrogen and phosphorous commitments. At present, agricultural sources account for about one-third of total nitrogen loadings and two- fifths of total phosphorus loadings into the Bay (for details, see the Technical Appendix for Maryland's Tributary Strategies, Maryland Department of Natural Resources, March 12, 1996). Agriculture is the biggest non-point source of both nutrients, accounting for over half of nonpoint source nitrogen loadings, and almost two- thirds of nonpoint source phosphorus loadings. In 1995, the State adopted a set of strategies for meeting its nutrient reduction commitments. Those strategies emphasize reductions in point source emissions; they call for upgrades in sewage treatment plants that will limit nitrogen emissions to a little over one-third of the 1985 baseline and phosphorus emissions to only one- tenth of the 1985 baseline. Cutting agricultural emissions is also an important part of the strategies, as Figure 1 indicates. Overall, the Tributary Strategies call for cuts in agricultural emissions of nitrogen and phosphorus of 24 percent and 21 percent relative to estimated 1992 levels. The Tributary Strategies assume that the agricultural emissions cuts can be achieved by persuading larger numbers of farmers to:

- use conservation tillage to reduce erosion and preserve soil moisture, thereby reducing nitrogen runoff;
- plant cover crops to absorb excess nitrogen after crop harvest and to prevent erosion during the winter months;
- implement nutrient management plans such as testing for soil nitrogen that will result in lower fertilizer application rates; and
- implement soil conservation and water quality plans that use a variety of site-specific practices to reduce runoff and erosion on steeply- sloped land.

Farmers will not be required to implement any of these measures. Instead, the strategies rely on voluntary compliance with State and Federal agencies providing technical and financial assistance. How has Maryland fared in reducing nutrient pollution in the Bay? Progress has been made, particularly in curbing point source emissions. By 1994, point source emissions of phosphorus had been cut by 56 percent from the 1985 baseline, while point source emissions of nitrogen had been cut by 35 percent. Some improvement has been observed in Bay water quality as well: total phosphorus in the mainstream Bay appears to have fallen 19 percent by 1990. Unfortunately, nitrogen was estimated to have increased by 2 percent over the same period; and analysis of stream quality monitoring data for the period 1978-1993 conducted by the Maryland Department of Environment suggests upward trends in nitrate and nitrite concentrations in the Susquehanna, Potomac, and Choptank Rivers. The effects of implementing nutrient emissions reduction measures in agriculture may not become evident for some time, particularly for nitrogen which, transported in shallow groundwater can take as little as a few days, or as much as several decades to travel into the Bay and its tributaries. Thus, it would be helpful to have other ways of gauging progress in implementing the measures called for in the Tributary Strategies. A set of surveys from the University of Maryland's Department of AREC allows estimation of trends in farmers' use of many of these runoff reduction practices over the past decade.

Napier, T.L., and M. Tucker, (2001), "Factors affecting nutrient application rates within three Midwestern watersheds," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.3.

Abstract: Data were collected in the winter of 1998 and spring of 1999 from 1,011 agriculturalists who were operating farms within watersheds in three Midwestern states to examine the merits of a social learning theory-farm Structure model for explaining variability in fertilizer applications rates. Study findings revealed that the theoretical perspective used to guide the investigation had limited utility for predicting nutrient application rates at the farm level. Variables commonly purported to predict fertilizer use were shown not to be useful for explaining fertilizer application rates when nutrient rates were measured as bushels of grain produced per pound of nutrient applied per acre. Study findings are discussed in the context of existing intervention programs designed to reduce fertilizer application rates at the farm level.

Sims, J.T., and A.N. Sharpley, (1999), *Nutrient Management for Environmental Protection: Challenges and Changes in the U.S.* Presented at the 1999 Annual Meeting of the Northeast Branch of the American Society of Agronomy and Soil Science Society of America, University of Guelph, Guelph, Ontario, Canada, July 12, 1999.

Abstract: Nutrient management has always been a key component of agricultural planning. Decades of research have developed and refined efficient, economic means to optimize plant nutrition and thus increase crop yields. Government advisory agencies (e.g., Cooperative Extension, USDA Natural Resources Conservation Service) and private agricultural consultants have been able to transfer much of the nutrient management research into best management practices (BMPs) that are well-accepted by farmers today. Concepts such as realistic yield goals, soil testing and plant analysis as predictive and diagnostic tools, selection of the best nutrient sources, nutrient application methods and timings for different crop rotations, and monitoring the success of a nutrient management plan are widely regarded as sensible, cost-effective practices by most farmers. Unfortunately, despite the long-term efforts in research and technology transfer to improve the efficiency of nutrient management, federal and state analyses of ground and surface water pollution consistently identify agriculture as a major nonpoint source of nutrients. These reports, in combination with a series of local or regional events, such as fish kills, nuisance algal blooms, accidental discharges of manures from lagoons into streams and rivers, high nitrate concentrations in aquifers and rivers used as drinking waters, and soil test summaries showing large and increasing percentages of soils rated as "excessive" in P, have heightened public awareness about agriculture's role in nonpoint source pollution. Questions are now arising about the effectiveness of voluntary BMPs in protecting the environment. Close upon these questions has come debate about the need for regulatory programs to ensure that the impacts of agricultural nutrients on water, air, and soil quality are reduced to environmentally acceptable levels. We summarize in this paper some recent changes in the U.S. with regard to nutrient management and the challenges agriculture faces in implementing these changes.

National Efforts to Improve Nutrient Management: Historically, nutrient management planning at the national level has had two major thrusts. First, federal support of research at land grant universities and government research agencies (USDA Agricultural Research Service, US Geological Survey) has been expected to produce the science-based solutions needed to maximize agricultural productivity while minimizing environmental impacts on air, soils, and waters. Second, advisory agencies, primarily Cooperative Extension and USDA-NRCS have been expected to review the research, extract and modify the most practical and useful options, and transfer this technology to the farm. More recently, due to reductions in the size and the changing mission of government advisory agencies, a greater reliance has been placed on private industry to provide advice on which new BMPs will be most useful to farmers. Advisory agencies continue to play a role, but are clearly moving more in the direction of broader scale nutrient management education and away from individual planning. Further, researchers are ever more reliant upon private industry for funding, which affects not only the direction of their research programs, but the duration. Consequently, it is increasingly difficult to sustain the long-term experiments that are vital to the evaluation of nutrient management BMPs, particularly those that seek to examine innovative practices that may not be practical or profitable in the short-term. Similar changes in the mission of research and advisory agencies have occurred in other countries, such as Canada, the Netherlands, and the U.K.

National legislation and policies to reduce agricultural nonpoint source pollution have also been proposed recently. Most of this legislation has been focused on animal agriculture, which is perceived to be of greatest immediate national concern for water and air pollution (Sharpley et al., 1998). However, it also has ramifications for other nutrient users and producers. Three examples of proposed legislation are: (i) the Animal Agriculture Reform Act (Senator Harkin, Iowa); (ii) the Farm Sustainability and Animal Feedlot Enforcement Act (Representative Miller, California), and (iii) the Poultry Electric Energy Power (PEEP) Act (Senator Roth, Delaware). A central theme is all this legislation has been the desire to address, at a national level, the water quality problems caused by the geographic intensification of animal production. One legislative goal has been to create a "level playing field", through national policies and regulations, that would prevent large animal operations from moving from their current location, often where environmental problems currently exist, to areas with less restrictive local environmental standards. Other goals have been to include more large animal operations, particularly poultry and swine, in permitted, regulatory programs; to assign responsibility for animal waste management to the large integrating companies, as well as to the farmer/contract grower; and to provide alternatives to land application of animal wastes, such as use for energy production (e.g., the PEEP Bill). To date, national legislation addressing nutrient management by animal agriculture, or any other major sources of nutrients (e.g., commercial fertilizers, municipal biosolids and composts) has not passed in the U.S.

National policy initiatives are also underway, again primarily addressing animal agriculture. By far the most significant is the USEPA-USDA Unified National Strategy for Animal Feeding Operations (AFOs), adopted in March of 1999 after lengthy discussion and public review. The nine "guiding principles" in this joint effort between the nation's lead regulatory agency (USEPA) and its lead technical agency for agriculture (USDA) reflect the changing national attitude towards agriculture and nonpoint source pollution.

Sims. J. T. and P. A. Moore, Jr., (1998), *Nutrient management planning: Phosphorus or nitrogen based?* P. 84-93. Proc. Natl. Poultry Waste Mgt. Symp., October 19-21, Springdale, AR. Contact: jtsims@udel.edu

Vatn, Arild, et al., (1999), "ECECMOD: An Interdisciplinary Modelling System for Analyzing Nutrient and Soil Losses from Agriculture." *Ecological Economics*, v30, n2 (August 1999): 189-205.

<u>Abstract</u>: This article discusses a set of principles for policy analysis of environmental problems. The main focus is on integrating economic and ecological analyses through a mathematical modelling framework. The paper starts by developing a general model for the study of environmental issues. Principles for operationalizing the model are discussed, and ECECMOD (a new modelling system constructed to analyze pollution from agricultural systems on the basis of these principles) is introduced. Some of the results obtained by ECECMOD are presented to facilitate a discussion about the gains to be obtained by this kind of analysis. The study shows that it is of great importance to combine economic and ecological analyses at a fairly high level of resolution when studying environmental effects of complex systems.

Weersink, Alfons et al, (1998), "Economic Instruments and Environmental Policy in Agriculture." *Canadian Public Policy* v24, n3 (September 1998): 309-27.

<u>Abstract</u>: Economic instruments can achieve environmental goals at least cost and provide incentives for further improvements. There are limited opportunities for the use of such instruments in agriculture where the pollution problems can be traced as in the case of intensive livestock operations. However, most environmental problems in agriculture involve a large number of diffuse pollution sources whose abatement practices are unobservable rendering it difficult to achieve cost-effective

> pollution control with any single instrument. Rather than relying on first-best solutions through economic instruments, the most effective way of dealing with diffuse source pollution problems in agriculture may be technological developments and business-led initiatives.

<u>Pesticides/Toxic Chemicals:</u>

Burkholder, J.M., M.A. Mallin, H.B. Glasgow, (1999), "Fish kills, bottom water hypoxia and the toxic Pfiesteria complex in the Neuse River and Estuary." *Mar. Ecol. Prog. Ser.* 179:301-310.

Burkholder, J.M., (1999), "The lurking perils of Pfiesteria," *Sci. Am*. 281(2):42-49.

Burkholder, J.M. and H.B. Glasgow Jr., (1997), "Pfiesteria piscicida and other toxic Pfiesteria-like dinoflagellates: Behaviour, impacts and environmental controls." *Limnol. Oceanogr*. 42(5):1052-1075 Part 2.

Burkholder, J.M., H.B. Glasgow Jr., and A.J. Lewitus, (1997), "Physiological ecology of Pfiesteria piscicida, with general comments on "ambush predator" dinoflagellates." In: *The physiological ecology of harmful algal blooms*, D.M. Anderson, A.D. Cembella and G.M. Hallegraeff (eds.), NATO: Paris.

Burkholder, J.M., (1997), "Implications of harmful marine microalgae and heterotrophic dinoflagellates in management of sustainable marine fisheries." Special issue, National Academy of Sciences Ocean Studies Board on Management of Sustainable Marine Fisheries. Ecol. Appl.

Burkholder, J.M. and H.B. Glasgow Jr., (1997), "Trophic controls and stage transformations of a toxic ambush-predator dinoflagellate." *J. Euk. Microbiol*. 44:200-205.

Burkholder, J.M., M.A. Mallin, H.B. Glasgow Jr., L.M. Larsen, M. Holden, C. Scalia, N. Deamer-Melia, J. Springer, D. Briley and E. Hannon, (1997), "Rupture of large swine holding lagoon in North Carolina, U.S.A.: Impacts on a coastal river and estuary." *J. Environ. Qual*. 26(6):1451-1466.

Burkholder, J.M., H.B. Glasgow Jr., and A.J. Lewitus, (1996), *Stimulation of nontoxic stages of the dinoflagellate Pfiesteria piscicida by inorganic nitrogen and phosphorus*. Abstracts of the joint meeting of the American Society of Limnology and Oceanography and the American Geophysical Union. San Diego, California..

Civelek, A.C., V.L. Villemange, R.F. Dannals, et al., (1999), "Assessment of changes in regional cerebral glucose metabolism by FDG PET in subjects exposed to Pfiesteria infected water." *J. Nucl. Med*. 40(5):112P-112P Suppl. S.

Clarke, R. A., C. D. Stanley, B. L. McNeal, and B. W. Macleod, (2002), “Impact of agricultural land use on nitrate levels in Lake Manatee, Florida,” *Journal of Soil and Water Conservation*, Mar-Apr 2002, Vol.57, No.2.

Abstract: Algal blooms in the Lake Manatee reservoir necessitate treatment of the drinking water for taste degradation, creating an economic burden. This study was conducted to assess the extent to which agricultural activities in the Lake Manatee watershed may contribute to nutrient loading of the reservoir. Water quality data for Lake Manatee were collected from eight strategically selected sites within the lake from 1983 to 1993, and were correlated with historical agricultural activity (vegetable and citrus production) in the watershed to determine if evidence for agricultural NO3-N loading was apparent. The watershed was divided into sub basins related to sampling locations in an attempt to evaluate the effects of specific agricultural activities on NO3-N levels in the lake. This allowed the separation of sampling points representing sub-basin watershed areas where 1) no agricultural activities occurred, 2) exclusively vegetable or citrus production occurred, or 3) mixed production occurred. Data were analyzed using trend analysis along with a technique to deseasonalize the data for more valid overall interpretation. Results showed that the average lake NO3-N concentration during the period was only 0.18 mg L-1 (0.18 ppm) and that seven of the eight sampling sites showed average annual NO3-N increases of 5-10% throughout the study period, depending on sampling location ($p < 0.10$). However, no strong correlation with agricultural activity in the watershed was demonstrated. This conclusion was supported by data collected in a watershed sub-basin with no agricultural activity, which showed a comparable NO3-N concentration increase during the study period.

College of Agriculture and Natural Resources, University of Maryland. Papers Available on Pfiesteria and Agriculture from the College of Agriculture and Natural Resources, University of Maryland, at http://www.agnr.umd.edu//agpros.htm , including: “Agriculture and its Relationship to Toxic Dinoflagellates in the Chesapeake Bay,” November 27, 1997; Dean Thomas A. Fretz, “Talking Points for Pfiesteria Presentation,” October 17, 1997; and "Economic Impact of Potential Avian Influenza Outbreak in the Delmarva Region" - Related Article in *Economic Viewpoints*, Vol. 1, No. 2, Fall 1996.

College of Agriculture and Natural Resources, University of Maryland, (1997), *Agriculture and Its Relationship to Toxic Dinoflagellates in the Chesapeake Bay*, November 27, 1997.

Abstract: (A group of 10 scientists, chaired by Dean Fretz, met on October 7, 1997, to review relevant issues and to develop a format for completing the assignment. Review and writing teams were established and charged with drafting this document by October 13, 1997. The Scientific Advisory Committee met twice more to review progress and discuss possible recommendations. This document forms the basis of much of Dean Fretz's verbal testimony.)

Although the evidence is circumstantial and inconclusive at this point, it has been suggested that nutrients lost from agricultural operations through runoff and leaching may be partially responsible for the recent outbreaks of Pfiesteria-like organisms in the lower Pocomoke River and several other rivers on the lower Eastern Shore. Nutrients enter water from many sources. Nutrients added to land, however, may represent a significant source of aquatic nutrients. Sewage sludge, septic tank effluent, organic manufacturing waste, and animal manures contain high concentrations of nitrogen and phosphorus. Most of this material is recycled onto land for disposal. In response to a request by Commission Chair and former Governor Harry Hughes, Thomas A. Fretz, Dean of the College of Agriculture and Natural Resources, brought together a panel of regional experts in nutrient and animal management not only to examine the most current information related to nutrient losses, but to develop a strategy for reducing those losses. While the relationship between the outbreak of Pfiesteria and nutrient loading into aquatic systems remains unclear, the agricultural community recognizes the need to take action. Thus, a primary goal of this document is to review current practices and recommend methods for controlling losses of nutrients, especially phosphorus, from agricultural land. This document contains scientific background information for the comments presented to former Governor Harry Hughes and the Blue Ribbon Commission. To the extent possible, we have attempted to discuss the level of uncertainty and the potential for recommended practices to contribute to reducing nutrient losses--especially soluble phosphorus--from land. In addition, we also discuss the length of time (immediate, short term, long term) required for implementing practices.

Everton, R.K., W.T. Harlan, J.W. Priest, and M.S. Alling, (1999), "Virginia's Pfiesteria monitoring program: water quality." *Va. J. Sci*. 50(4):311-324.

Fairy, E.R., J.S.G. Edmunds, N.J. Deamer-Melia, et al., (1999), "Reporter gene assay for fish-killing activity produced by Pfiesteria piscicida." *Env. Health Persp*. 107(9):711-714.

Faith, S.A. and C.A. Miller. (2000), "A newly emerging toxic dinoflagellate, Pfiesteria piscicida: natural ecology and toxicosis to fish and other species." *Vet. Hum. Toxicol*. 42(1):26-29.

Fernandez-Cornejo, J. and S.Jans, (1998),*A New Measure of Integrated Pest Management: The Case of Corn*, Selected Paper, 1998 AAEA meetings, Salt Lake City, Utah, August 1998.

Fernandez-Cornejo, J. and M. Smith, (1998), "Pesticide Economic Issues: A Review Article," *Review of Agricultural Economics*, 20 (2), 1998: 462-88.

Fernandez-Cornejo, J., (1998), "Environmental and Economic Consequences of Technology Adoption: Integrated Pest Management in Viticulture." *Agricultural Economics* 18, 1998: 145-55.

Fleming, L.E., J. Easom, D. Baden, et al., (1999), "Emerging harmful algal blooms and human health: Pfiesteria and related organisms." *Toxicol. Pathol*. 27(5):573-581.

Fox, J.L., (1999), "Human illness and fish kills connected to Pfiesteria outbreaks." *ASM News* 64(12):676-677.

Grattan, L.M., D. Oldach, T.M. Perl, et al., (1998), "Learning and memory difficulties after environmental exposure to waterways containing toxin-producing Pfiesteria or Pfiesteria-like dinoflagellates." *Lancet* 352(9127):532-539.

Levin, E.D., B.B. Simon, D.E. Schmechel, et al., (1999), "Pfiesteria toxin and learning performance." *Neurotoxicol. Teratol*. 21(3):215-221.

Lewitus, A.J., H.B. Glasgow, and J.M. Burkholder, (1999), "Kleptoplastidy in the toxic dinoflagellate Pfiesteria piscicida (Dinophyceae)." *J. Phycol*. 35(2):303-312.

Lewitus, A.J., B.M. Willis, K. C. Hayes, J.M. Burkholder, H.B. Glasgow, Jr., P.M. Glibert, and M. K. Burke, (1999), "Mixotrophy and nitrogen uptake by Pfiesteria piscicida (Dinophyceae)." *J. Phycol*. 35:1430-1437.

Lichtenberg, Erik and Rae Zimmerman, (1999), "Adverse Health Effects, Environmental Attitudes, and Pesticide Usage Behavior of Farm Operators," *Risk Analysis* 19, 189-211 (April 1999).

> <ins>Abstract</ins>: Corn and soybean growers in the Mid-Atlantic are willing to spend more on pesticides that won't leach into groundwater. Growers who have experienced adverse health effects from pesticides (either directly or indirectly) have heightened concern about environmental and occupational safety problems arising from pesticide use and are more likely to use certain non-chemical control practices.

Lichtenberg, Erik, (2000), "Costs of Regulating Genetically Modified Pest-Protected Plants," in National Research Council, *Genetically Modified Pest-Protected Plants: Science and Regulation*. Washington: National Academy Press, 2000.

> <ins>Abstract</ins>: The direct costs of meeting regulatory requirements for transgenic plants that express pesticidal proteins can be almost as high as the costs of breeding the transgenic genes into marketable varieties. As a result, stricter regulation may be a significant barrier to small companies and public sector research.

Lichtenberg, Erik and Rae Zimmerman, (1999), "Information and Farmers' Attitudes About Pesticides, Water Quality, and Related Environmental Effects," *Agriculture, Ecosystems, and Environment* 73, 227-236.

Lichtenberg, Erik, (1997), "The Economics of Cosmetic Pesticide Use," *American Journal of Agricultural Economics* 79, 39-46 (February 1997).

Abstract: Its not necessarily profitable for farmers to use more pesticides simply to improve appearance or other cosmetic aspects of fruit and vegetable quality. Stricter quality standards don't necessarily induce more pesticide use.

Litaker, R.W., P.A. Tester, A. Colorni, M.G. Levy and E.J. Noga, (1999), "The phylogenetic relationship of Pfiesteria piscicida, cryptoperidiniopsoid sp. Amylodium ocellatum and a Pfiesteria-like dinoflagellate to other dinoflagellates and apicomplexans." *J. Phycol.* 35:1379-1389.

Marshall, H.G., (1999), "Pfiesteria piscicida and Dinoflagellates similar to Pfiesteria." *Va J. Sci*. 50(4):281-286.

Marshall, H.G., D. Seaborn, and J. Wolny, (1999), "Monitoring results for Pfiesteria piscicida and Pfiesteria-like organisms from Virginia waters in 1998." *Va. J. Sci*. 50 (4): 287-298.

Maryland Department of Natural Resources, (1999), *Special Report of the Technical Advisory Committee on Harmful Algal Outbreaks in Maryland: Causes and Significance of Menhaden Lesions.* February 12, 1999. http://www.dnr.state.md.us/bay//98_lesion.html

Executive Summary: Members of Maryland's independent technical advisory committee on harmful algal outbreaks met together with regional experts in fish pathology and ecology to assess existing information regarding the causes of lesions found on menhaden and other fish, thought to be related to toxic outbreaks of Pfiesteria piscicida. In 1997 and 1998, lesions were found on only a small fraction of the young-of-the-year menhaden, particularly in smaller tidal rivers and creeks along the Eastern Shore and the Rappahannock and Great Wicomico Rivers in the Chesapeake Bay. The larger and deeper lesions found are ulcers developed as a result of fungal and bacterial infections and the defensive responses of the fish's cells. Fungal infections were not found on the smallest lesions and few fish collected from kills in which Pfiesteria was implicated have been examined for fungal infections. Consequently, Pfiesteria toxins, which have been demonstrated to erode the skin (epidermis) of fish in laboratory experiments, cannot be ruled in or out as initiators of fresh lesions or deep ulcers. The development of lesions is not required for Pfiesteria toxins to kill fish, consequently the uncertainty surrounding the causes of lesions does not call into question the linkages among fish kills, human health risks and toxic Pfiesteria outbreaks. This uncertainty does, however, mean that the prevalence of fish lesions alone should not be considered a reliable indicator of toxic Pfiesteria outbreaks. Development of molecular methods offers the promise of a more timely and reliable detector of Pfiesteria and its toxins for protection of public health. In addition, experimental research on the modes of fungal infection and progression of ulcer formation would help resolve the existing uncertainties regarding their relationships to Pfiesteria and improve our limited understanding of the effects of these maladies on fish populations.

McCann, Laura M.J. and K. William Easter, (1999), “Differences between Farmer and Agency Attitudes Regarding Policies to Reduce Phosphorus Pollution in the Minnesota River Basin.” *Review of Agricultural Economics*. Spring/Summer 1999 Vol. 21, No. 1.

Morris, J.G., (1999), “Harmful algal blooms: an emerging public health problem with possible links to human stress on the environment.” *Ann. Rev. Energy Env*. 24:367-390.

Morris, J.G., (1999), “Pfiesteria, "the cell from hell", and other toxic algal nightmares.” *Clin. Infect. Dis*. 28(6):1191-1196.

Musser, Wesley N. and Edward T. Mallinson, (1996), *Economic Impact of Potential Avian Influenza Outbreak in the Delmarva Region.* Department Of Agricultural And Resource Economics. Fall 1996. Vol. 1 No. 2. University Of Maryland At College Park. University Of Maryland Eastern Shore Cooperative Extension Service.

Noga, E.J., (1998), “Toxic algae, fish kills and fish disease.” *Fish Pathol*. 33(4):337-342.

Onal, Hayri; Kenneth A. Algozin; Madhu Khanna; Murat Isik, (1998), *Trade Off Between Economic Efficiency And Producers' Equity: A Case Study Of Tradeable Permits For Controlling Chemical Pollution In A Watershed.* American Agricultural Economics Association Annual Meeting, August 2-5, 1998, Salt Lake City, Utah.

O’Reilly, R.L., (1999), “The Virginia Task force on Pfiesteria.” *Virginia J. Science* 50 (4):279-280.

Pinckney, J.L., H.W. Paerl, E. Haugen, et al., (2000), “Responses of phytoplankton and Pfiesteria- like dinoflagellate zoospores to nutrient enrichment in the Neuse River estuary, North Carolina, USA.” *Mar. Ecol. Prog. Ser*. 192:65-78.

Rublee, P.A., J. Kempton, E. Schaefer, J.M. Burkholder, H.B. Glasgow and D. Oldach, (1999), “PCR and FISH detection extends the range of Pfiesteria piscicida in estuarine waters.” *Va. J. Sci.* 50(4):325-336.

Seaborn, D.W., A. M. Seaborn, W.M. Dunstan and H.G. Marshall, (1999), “Growth and feeding studies on the algal feeding stage of a Pfiesteria-like dinoflagellate.” *Va. J. Sci.* 50(4):337-344.

Stevenson, J., (1998), “Pfiesteria and learning problems.” *Jama. J. Am. Med. Assoc.* 279(3):188.

Stow, C.A., (1999), “Assessing the relationship between Pfiesteria and estuarine fish kills.” *Ecosystems* 2(3):237-241.

Traore, Namatie ; Landry, Rejean ; Amara, Nabil, (1998), “On-farm Adoption of Conservation Practices: The Role of Farm and Farmer Characteristics, Perceptions, and Health Hazards,” *Land Economics* v74, n1 (February 1998): 114-27.

Abstract: The research reported in this paper concerns (1) Quebec potato farmers and the factors that compose their concern for environmental degradation and (2) the adoption of conservation practices using a two-stage decision-making process. The surveyed farmers are concerned mainly with the problem of pest infestation. Their awareness of environmental problems is raised by the level of educational attainment, membership in producers' organizations, and participation in government sponsored farm programs. The actual adoption of conservation practices by farmers is influenced by the extent to which they perceive environmental degradation to be a problem, their educational level, the expected crop loss to pests and weeds, the perceived health effects of farm chemicals application, and the availability of adequate information on the best management practices.

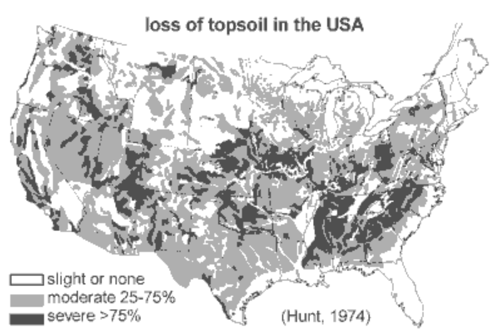
Turf, E., L. Ingsrisawang, M. Turf, J.D. Ball, M. Stutts, J. Taylor and S. Jenkins, (1999), "A cohort study to determine the epidemiology of Estuary Associated Syndrome." *Va. J. Sci.* 50(4):299-310.

Weber, E.P. and H.G. Marshall, (1999), "Water quality relationships to concentrations of Pfiesteria- like organisms in Virginia estuaries for 1998." *Va. J. Sci*. 50(4):365-380.

Wiant, C.J., (1998), "Pfiesteria to our waterways - is this the example we have been waiting for?" *J. Environ. Health*. 60(6):28-29.

Soil Quality and Erosion

Figure 2. Loss of Topsoil in the USA



In addition to water contamination, soil erosion by water and wind as a result of tillage and cultivation is another byproduct of conventional agriculture. Soil erosion is a serious environmental problem in the United States and in many parts of the world.[33] After more than sixty years of state and federal efforts to control soil erosion in the United States, it has leveled off at 1.9 billion tons per year, mostly generated in the Midwest.[34] The conversion of natural ecosystems to permanent agriculture results in a loss of soil organic matter, thus increasing the erosion potential of soils. Studies estimate that agricultural activities in this country are responsible for around 60

[33] Kaiser, J. (2004). "Wounding the Earth's Fragile Skin," *Science*, 304. 1616-1618.
[34] Uri, N. (1999). *Agriculture and the Environment*. Commack: Nova Science Publishers; USDA, (2000), *National Resources Inventory: Background and Highlights*. Washington DC: USDA, Natural Resources Conservation Service.

percent of total soil erosion. The remaining 40 percent of soil erosion results from fire, flooding, drought, forestry, construction, and off-road vehicle use.[35] Other studies estimate that of the 375 million acres of cropland in the United States, 103.5 million acres were considered highly erodible in 1997.[36] The U.S. National Research Council also acknowledges the problem of soil erosion and suggests that it is attributed to "management practices such as increased reliance on row crops grown continuously, fewer rotations involving forages and larger farms being tilled by one operator."[37]

Sediment damage caused by soil erosion is transferred to water resources and water users. Accelerated sedimentation reduces the useful lifetime of reservoirs, increases the costs of water treatment for municipal and industrial water uses, and destroys or degrades aquatic habitat - reducing diversity and damaging commercial and recreational fisheries.[38] Studies have also calculated the costs of sedimentation in general. During the 1970s and early 1980s sedimentation eliminated slightly more than 0.2 percent of the nation's reservoir capacity each year, while the annual costs to replace lost capacity were estimated at $819 million per year.[39] Annual costs to water treatment from sediment are estimated to be between $458 and $661 million in 1984.[40] Sediment damage from agricultural erosion have been estimated to be between $2 billion and $8 billion per year.[41]

Additional Literature:

Soil Health and Quality/Soil Erosion:

Cole, J.D. and B. Johnson, (2002), "Soil conservation practices on leased land: a two-state study," *Journal of Soil and Water Conservation*, Mar-Apr 2002, Vol.57, No.2

Abstract: The leasing market for cropland in the United States is

---

[35] OECD, (2001), Environmental Indicators for Agriculture: Methods and Results.
[36] Ruhl, J. B., (2000), op cit.
[37] U.S. National Research Council, (1989), *Alternative Agriculture*, Washington DC:National Academy Press, p. 115.
[38] Heimlich, R., (2003), *Agricultural Resources and Environmental Indicators,* Washington DC: USDA, Economic Research Service.
[39] Crowder, B.M., (1987), "Economic Costs of Reservoir Sedimentation: A Regional Approach to Estimating Cropland Erosion Damage," *Journal of Soil and Water Conservation*, 42. (3). 194-197.
[40] Holmes, T., (1988), "The Offsite Impact of Soil Erosion on the Water Treatment Industry," *Land Economics*, 64. (4). 356-366.
[41] Ribaudo, M.O., (1989), *Water Quality Benefits from the Conservation Reserve Program.* AER 606. Washington DC: USDA, Economic Research Service.

significant. More than 40% of U.S. farmland is leased. This study was conducted to evaluate the relationship lease arrangements have upon land use management and conservation practices. The Revised Universal Soil Loss Equation (RUSLE) was used to predict soil loss on share and cash leased tracts in Nebraska and South Dakota. Several longstanding hypotheses concerning the soil loss from leased land were tested. Evidence suggests physical location and features of the tract are primary determinants for soil loss on a particular tract. Factors such as lease type, length of lease, size of operation, business structure, and tenants' perception of retaining a leased tract did not seem to affect stewardship adversely. These results suggest that agricultural producers steward the land they operate in an environmentally conscientious manner regardless of ownership status. Tenants surveyed perceived community norms and social pressure to farm leased land as they would their own. Reputations and perceptions of individual tenants do matter. This finding coupled with their own beliefs and values concerning production agriculture and long term resource management, is reflected in their production practices, which tend to conform closely to conservation interests of owners as well as those of society in general.

Department for Environment, Food and Rural Affairs (DEFRA), *Environmental Impact Assessment* for use of uncultivated land or semi-natural areas for intensive agricultural purposes. Website at http://www.defra.gov.uk/environ/eia/default.htm.

This site provides information about the Environmental Impact Assessment (EIA) Scheme for uncultivated land and semi-natural areas. It provides access to the latest EIA guidelines and explanatory leaflet, as well as the application form for an EIA decision, news releases, and the DEFRA Codes of Good Agricultural Practice for soil, air and water. A list of frequently asked questions is also provided, along with links to related organisations.

Ervin, D., (1998), "The Role of Soil Test Information in Reducing Groundwater Pollution,"*Journal of Agr. and Resource Economics*, 23(1), 1998: 20-38, (with R. Fleming and R. Adams).

Gilley, J.E., J.W. Doran, and B. Eghball, (2001), "Tillage and fallow effects on selected soil quality characteristics of former conservation reserve program sites." *Journal of Soil and Water Conservation*, Vol.56, 2001, No.2

Abstract: Tillage and fallow have been suggested as management options for converting Conservation Reserve Program (CRP) areas to cropland. This study was conducted to measure selected soil quality characteristics of former CRP sites in Mississippi, Nebraska, and South Dakota that were tilled and then left fallow for 21 or 22 months. Soil samples from depth intervals of 0–7.6 cm and 0–30.5 cm were collected for laboratory assessment of the following soil quality indicators: bulk density, EC, pH, total C, organic C, total N, NO_3–N, NH_4–N, PO_4–P, biomass C, biomass N, anaerobic NH4–N, lab respiration 0–10 days, and lab respiration 10–20 days. When compared to undisturbed CRP, increased NO3–N values on the tillage and fallow plots suggest that under the extreme conditions employed in this study, organic residues were being mineralized. As a result, significant reductions in organic C and total N were found at the 0–7.6 cm depth on each of the fallow plots. Thus, to reduce soil quality degradation, use of minimum-till or no-till management systems may be best suited for CRP areas which are converted to cropland.

Green Gareth P. and David L. Sunding, (1997), "Land Allocation, Soil Quality, and the Demand for Irrigation Technology," *Journal of Agricultural and Resource Economics*. Volume 22, Number 2, December 1997.

Jaenicke Edward C., (1998), *From the Ground Up: Exploring Soil Quality's Contribution to Environmental Health.* University of Tennessee for the Henry A. Wallace Foundation.

Kaspar, T.C., J.K. Radke, and J.M. Laflen, (2001), "Small Grain Cover Crops and Wheel Traffic Effects on Infiltration, Runoff, and Erosion," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.2.

Abstract: Oat and rye cover crops have the potential to reduce erosion when following soybean crops in Iowa. Oat and rye cover crops were overseeded into no-till soybeans in August of 1995, 1996, and 1997 on a sloping site. Infiltration, runoff, and interrill erosion were measured in April of 1996, 1997, and 1998 using an oscillating sprinkler head rainfall simulator that applied water at approximately 125 mm hr-1. Rill erosion was measured by making flow additions to the upslope end of plots. All measurements were made concurrently on tracked and untracked interrows. Cover crops had no effect on infiltration and erosion in 1996. In 1997, both oat and rye cover crops reduced interrill erosion, but in 1998 only rye increased infiltration and reduced interrill erosion and runoff. Untracked interrows had less interrill erosion and runoff, and more infiltration than tracked interrows. In 1997 and 1998, both oat and rye cover crops reduced rill erosion, but wheel traffic had no measurable effect on rill erosion.

Lichtenberg, Erik, (2001), *Adoption of Soil Conservation Practices: A Revealed Preference Approach*, Working Paper No. 01-12, Department of Agricultural and Resource Economics, University of Maryland, College Park, Maryland, August 29, 2001.

Popp, J., D. Hoag, and J. Ascough II, (2002), "Targeting soil-conservation policies for sustainability: new empirical evidence," *Journal of Soil and Water Conservation*, Mar-Apr 2002, Vol.57, No.2.

Abstract: Sustainable resource management is one of the most complex concerns today. Society has spent billions of dollars conserving soils in production, yet it is unclear whether these efforts buy sustainability, or even what sustainability is.

Further study about which soils need conservation merits consideration. We use a simulation model, regression, and optimization analysis to examine the sustainability of resource management in objective, measurable ways.
Soil quality, represented by a new index, and other nonirrigated corn production data are placed into a dynamic model to identify: 1) the conditions where soil conservation is efficient, and 2) under what definitions conservation is sustainable. Results show that decisions to use or conserve soil and the impacts of these decisions are highly dependent upon soil type and how sustainability is defined. In general, while soil conservation slowed degradation on erodible soils, it seemed to be more effective and economically efficient the better the initial quality of the soil. This calls into question whether U.S. conservation policy that focuses on marginal soils supports sustainability. Economic research was undertaken to study which soils might best be targeted for conservation, using economic and sustainability criteria. An economic model of nonirrigated corn production was created to determine—under requirements of maintaining a certain level of production or maintaining soil quality—if, when, and where it was best to apply conservation practices. Results show that decisions to use or conserve soil and the impacts of these decisions are highly dependent upon the characteristics of the soil and how sustainability is defined. In general, while soil conservation slowed degradation on erodible soils, it seemed to be more effective and economically efficient the better the initial soil quality.

Pruski, F.F. and M.A. Nearing, (2002), "Runoff and soil-loss responses to changes in precipitation: a computer simulation study," *Journal of Soil and Water Conservation*, Jan-Feb 2002, Vol.57, No.1)

Abstract: Changes in precipitation have occurred over the past century and are expected to continue over the next century. These changes will have significant implications for runoff, soil erosion, and conservation planning. This study was undertaken to investigate how runoff and soil erosion by water can be expected to be altered as a function of changes in the average number of days of precipitation per year and changes in the amount and intensity of the rain that falls on a given day. The Water Erosion Prediction Project (WEPP) model was used to simulate erosion for three locations, three soils, three slopes, and four crops. Average annual precipitation was changed ±10% and ±20% by changing either a) the number of wet days per year, b) the amount and intensity of precipitation per day, or c) a combination of the two. Results indicated that, on average, each 1% change in average annual precipitation induced a 1.28%, 2.50%, and 1.97% change in runoff and a 0.85%, 2.38%, and 1.66% change in soil loss for the three types of precipitation changes, respectively. Comparisons of the results of the soil-loss simulations to published relationships for Revised Universal Soil Loss Equation (RUSLE) R-factors in the United States suggest that the third option of changing both the number of wet days per year and the amount and intensity of precipitation per day is the most realistic scenario for representing changes in precipitation for hydrologic studies.

Sharpley, A.N., Daniel, T., Sims, T., Lemunyon, J., Stevens, R., and Parry, R., *Agricultural Phosphorous and Eutrophication (Second Edition)*, (2003), USDA-Agricultural Research Service, ARS-149, September 2003, 44pp. Available online at http://www.ars.usda.gov/is/np/Phos&Eutro2/agphoseutro2ed.pdf

Abstract: This document focuses on the importance of controlling phosphorus losses from agricultural runoff, outlining methods of P loss control. Topics covered by this document include soil phosphorus, the loss of phosphorus in agricultural runoff, and remediation. Inputs of phosphorus (P) are essential for profitable crop and livestock agriculture. However, P export in watershed runoff can accelerate the eutrophication of receiving fresh waters.
The rapid growth and intensification of crop and livestock farming in many areas has created regional imbalances in P inputs in feed and fertilizer and P output in farm produce. In many of these areas, soil P has built up to levels in excess of crop needs and now has the potential to enrich surface runoff with P. The overall goal of efforts to reduce P losses from agriculture to water should be to increase P use-efficiency, balance P inputs in feed and fertilizer into a watershed with P output in crop and animal produce, and manage the level of P in the soil. Reducing P loss in agricultural runoff may be brought about by source and transport control strategies. This includes refining feed rations, using feed additives to increase P absorption by animals, moving manure from surplus to deficit areas, finding alternative uses for manure, and targeting conservation practices, such as reduced tillage, buffer strips, and cover crops, to critical areas of P export from a watershed. In these critical areas, high P soils coincide with parts of the landscape where surface runoff and erosion potential are high.

Sharratt, B.S., M.J. Lindstrom, G.R. Benoit, R.A. Young, and A. Wilts, (2000), "Runoff and Soil Erosion during Spring Thaw in the Northern U.S. Corn Belt," *Journal of Soil and Water Conservation*, 2000, Vol.55, No.3.

Abstract: Surface water runoff and erosion can be accentuated from partially frozen soil and result in loss of soil productivity. Runoff and erosion were assessed during spring thaw on a Hattie clay (Typic Hapluderts) in 1986 and 1990 and on a Barnes loam (Calcic Hapludolls) in 1987 and 1988 in Minnesota. Simulated rain was applied at 64 mm h-1 on four dates during spring thaw to field plots subjected to autumn moldboard plow or chisel plow. Corn (Zea mays L) residue was removed or retained on plots prior to tillage in the autumn. Runoff and soil loss after an application of 96 mm of rain was similar for Hattie clay (6.0 mm m-2 of runoff and 1.43 kg m-2 of soil loss) and Barnes loam (5.8 mm m-2 of runoff and 1.90 kg m-2 of soil loss). Analysis of variance indicated that date of simulated rain and residue treatment influenced runoff while only residue treatment affected soil loss from both soil types. Regression analysis determined that runoff was accentuated by a wetter and smoother soil surface and from a soil frozen nearer the surface. In addition, nearly 60% of the variability in soil loss occurring from a 96 mm rain in the spring was explained by runoff, random roughness, soil water content, and residue cover. Rate of runoff and soil loss increased by at least 50% for

Hattie clay and 100% for Barnes loam as a result of subjecting these soils to a subsequent rain within the same day. In cold regions where autumn tillage is utilized to expedite soil warming and planting of seeds in the spring, roughening and rapidly thawing of the soil or retaining crop residue on the soil surface may be desirable for minimizing surface water runoff and soil erosion during spring thaw.

Sibbesen, E., and A. N. Sharpley, (1997), "Setting and justifying upper critical limits for phosphorus in soils," p. 151-176. In H. Tunney et al., (eds.). *Phosphorus Loss from Soil to Water*. CAB International, London.

Sims, J. T., (1998), "Phosphorus soil testing: Innovations for water quality protection." *Commun. Soil Sci. Plant Anal*. 29:1471-1489.

Truman, C.C. and R.G. Williams, (2001), "Effects of peanut cropping practices and canopy cover conditions on runoff and sediment yield," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.2).

Abstract: Runoff and sediment yields were measured from eight field plots (40 m2) over a three year period to determine the effect of peanut cropping practices and canopy cover conditions on runoff and sediment loss. Plots were located on a Tifton loamy sand, and were exposed to four 30 min simulated rainfall sequences (I = 63.5 mm h-1) four to eight times per growing season. Runoff and sediment losses were measured from four soil cover conditions: continuous fallow, bare bedded, single row peanuts (Arachis hypogea L), and twin row peanuts (2 and 4 peanut rows per 2 m wide bed). Percent Cover (PC) and leaf area index (LAI) increased to a maximum then leveled off as plants matured or were harvested. PC for single and twin row peanuts was related to days since planting (DSP) (r = 0.96 for single row peanuts and r = 0.98 for twin row peanuts). LAI values for single and twin row peanuts were related to PC (r = 0.98 for single row peanuts and r = 0.94 for twin row peanuts). Single and twin row peanut plots had as much as eight times less runoff and as much as 63 times less sediment loss than continuous fallow or bare bedded plots. Twin row peanut plots had as much as three times less runoff and sediment loss than single row peanut plots. Sequence-based erodibility values calculated from continuous fallow plots (KFC) and bare bedded plots (KBB) ranged from 4–24 (3 yr mean = 11.3, s.d. = 5.3) and 2–36 kg ha h MJ-1 ha-1 mm-1 (3 yr mean = 12.9, s.d. = 11.6), respectively. Soil loss ratios (SLR) ranged from 0.01–2.61. SLRs decreased to a low for cropstage 3 when percent canopy cover was greatest (DSP = 81–107), then increased as peanut plants matured or were harvested. Results show how management practices, such as twin row peanuts, can maximize peanut canopy development early in the growing season and minimize the time in which bare soil is vulnerable to a runoff producing rainstorm, thus reducing runoff and soil loss and conserving valuable natural resources.

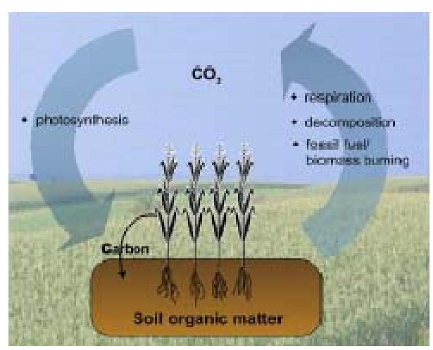
Wienhold, B.J., J.R. Hendrickson, and J.F. Karn, (2001), "Pasture Management Influences on Soil Properties in the Northern Great Plains," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.1

Abstract: The effect of management practices associated with livestock grazing on soil properties are largely unknown. Several physical, chemical, and biological soil properties were compared for soil from a native vegetation exclosure, a moderately grazed native vegetation pasture stocked at 2.6 ha (6.4 ac) steer-1, a heavily grazed native vegetation pasture stocked at 0.9 ha steer-1, and a fertilized crested wheatgrass (Agropyron cristatum L. Gaertn.) pasture stocked at 0.9 ha steer-1 near Mandan, North Dakota. The three native vegetation pastures were established in 1916 and the crested wheatgrass pasture was seeded in 1932. Soil properties varied in sensitivity to the management practices. Measures of vegetation and animal production combined with assessment of soil properties suggest that moderate grazing and fertilization of crested wheatgrass are viable management options that appear to be sustainable while providing goods and services needed by society. Range and pasture assessment should include soil assessment to more completely determine management effects on pastoral ecosystems.

Zinn, Jeffrey A., (1999), *Soil and Water Conservation Issues*. Resources, Science, and Industry Division, Congressional Research Service: Washington, D.C., February 16. (http://www.ncseonline.org/NLE/CRSreports/Agriculture/ag-18.cfm?&CFID=19337532&CFTOKEN=4634029)

Carbon Emissions

Figure 3. The Carbon Cycle



There is a relationship between land use patterns and the changing carbon cycle. Prior to the burning of fossil fuels for energy and extensive land use change for agricultural and development purposes, it is believed that the carbon cycle was in balance. The amount of carbon being released into the atmosphere from the land surface was more or less equal to the amount being pulled out of the atmosphere through photosynthesis. However, with the burning of fossil fuels and the extensive clearing of forest and grasslands for agriculture, the amount of carbon being released to the atmosphere began to outpace the amount taken out. Studies acknowledge that agriculture represents a small share in total green house emissions. Greenhouse gas emissions may contribute to global temperature increases, changes in precipitation, wind, and storm patterns, rising sea levels, habitat changes, the extermination of species, and changes in crop yields. In the United States, agricultural emission of methane and nitrous account for about 9 percent of all greenhouse emissions.[42] This occurs through the direct burning of fossil fuel by agricultural machinery, indirect fossil fuel use through agricultural inputs, the reduction of soil and organic matter, deforestation, enteric fermentation of ruminant livestock, and livestock manure.[43] In addition to animal waste and fertilizers, emissions from soil tend to contribute much more of the total agricultural emissions compared with the share of carbon dioxide emissions from fuel combustion.[44] The burning of crop residues after harvesting also intensifies greenhouse gas emissions.

Additional Literature:

Ad Hoc Committee on Air Emissions from Animal Feeding Operations, Committee on Animal Nutrition, National Research Council, Board on Agriculture and Natural Resources (BANR), Board on Environmental Studies and Toxicology (BEST), Division on Earth and Life Studies, National Research Council (NRC), (2002), *The Scientific Basis for Estimating Air Emissions from Animal Feeding Operations: Interim Report*, Washington D.C.: National Academy Press, 106pp. Available online at http://www.nap.edu/books/030908461X/html/

> Executive Summary: Concern with possible environmental and health effects of air emissions generated from animal feeding operations (AFOs) has grown with the increasing size, geographic concentration, and suburbanization of these operations in what was formerly rural, sparsely populated agricultural land. This interim report, prepared at the request of the Environmental Protection Agency (EPA), evaluates the current knowledge base and approaches for estimating air emissions from AFOs. The issues regarding emissions from AFOs are much broader than the interests of any one federal agency. In recognition of this, the U.S. Department of Agriculture (USDA) joined EPA in the request for this study.
>
> Generating reasonably accurate estimates of air emissions from AFOs is difficult. The operating environment for these farms is complex. The species of animals are varied (e.g., swine, beef and dairy cattle, poultry), and farm practices differ not only between species, but also among farms for each

[42] Lewandrowski et al., (2004), Economics of Sequestering Carbon in the U.S. Agricultural Sector. Washington DC: USDA.
[43] Babcock, B. et al, (2001), *Conservation Payments: Challenges in Design and Implementation*, Iowa State University: Center for Agricultural and Rural Development, Briefing Paper 01-BP 34.
[44] Ruhl, (2001), op cit; OECD, (2001), op cit; Boody, G. & Krinke, M., (2001), *The Multiple Benefits of Agriculture: An Economic, Environmental and Social Analysis.* While Bear Lake: Land Stewardship Project.

species. The operations vary in size (this report is concerned with AFOs as defined by EPA; see Appendix B) and differ by region across the country. The chemical composition of the emissions varies depending on animal species, feeding regimes and practices, manure management practices, and the way in which the animals are housed. Much of the air emissions come from the storage and disposal of the manure (the term here is used to mean both urine and feces, and may also include litter or bedding materials) that is part of every AFO, but some also comes from dust produced by the handling of feed and the movement of animals on manure, as well as from the animals themselves. Meteorologic conditions, of course, are an important factor. Estimates of emission rates generated in one type of AFO may not translate readily into others.

EPA has a variety of needs for accurate estimation of air emissions from AFOs. Increasing pressure has been placed on the agency to address these emissions through the Clean Air Act and other federal regulations, and EPA has indicated the need to do so in the future. Also pressing, EPA is under court order to establish new water quality rules by December 2002. The current study will focus on ways to estimate these emissions prior to December 2002 to additionally help assure that rules aimed at improving water quality do not have negative impacts on air emissions.

This interim report is intended to provide findings to date on a series of specific questions from EPA regarding the following general issues: identifying the scientific criteria needed to ensure that estimates of air emission rates are accurate, the basis for these criteria in the scientific literature, and the uncertainties associated with them. It also includes an assessment of the emission estimating approaches in a recent report *Air Emissions From Animal Feeding Operations* (EPA, 2001a). Finally, it identifies economic criteria needed to assess emission mitigation techniques and best management practices. The committee has answered the following sets of questions in the interim report within the confines of the Statement of Task (see Appendix A):

- What are the scientific criteria needed to ensure that reasonably appropriate estimates of emissions are obtained? What are the strengths, weaknesses, and gaps of published methods to measure specific emissions and develop emission factors that are published in the scientific literature? How should the variability due to regional differences, daily and seasonal changes, animal life stage, and different management approaches be characterized? How should the statistical uncertainty in emissions measurements and emissions factors be characterized in the scientific literature?

- Are the emission estimation approaches described in the EPA report *Air Emissions from Animal Feeding Operations* (EPA, 2001a) appropriate? If not, how should industry characteristics and emission mitigation techniques be characterized? Should model farms be used to represent the industry? If so, how? What substances should be characterized and how can inherent fluctuations be accounted for? What components of manure should be included in the estimation approaches (e.g., nitrogen, sulfur, volatile solids [see Appendix B])? What additional emission mitigation technologies and management practices should be considered?

- What criteria, including capital costs, operating costs, and technical feasibility, are needed to develop and assess the effectiveness of emission mitigation techniques and best management practices?

The goal of EPA (2001a) was to"develop a method for estimating emissions at the individual farm level." To accomplish this, EPA (2001a) developed a set of 23 model farms (see Appendix D) intended to represent the majority of commercial-scale AFOs. Each model farm included three variable elements: a confinement area, manure management system, and land application method. The manure management system was subdivided into solid separation and manure storage activities.

Given the specific nature of the questions answered, the committee has not yet addressed some of the broader issues related to AFOs. To the extent possible, these will be addressed in its final report, which will build on the findings of this interim report and include a more detailed response to the committee's full Statement of Task (see Appendix A). The need for further discussion of some issues in the final report is indicated in various places in this report. These issues fall in eight broad categories: (1) industry size and structure, (2) emission measurement methodology, (3) mitigation technology and best management plans, (4) short- and long-term research priorities, (5) alternative approaches for estimating emissions, (6) human health and environmental impacts, (7) economic analyses, and (8) other potential air emissions of concern.

This interim report represents the consensus views of the committee and has been formally reviewed in accordance with National Research Council (NRC) procedures. In answering these questions and addressing its Statement of Task (Appendix A), the committee has come to consensus on eight findings for the interim report. The basis of these findings is discussed more extensively in the body of the report.

Finding 1: Proposed EPA regulations aimed at improving water quality may affect rates and distributions of air emissions from animal feeding operations.

Discussion: Regulations aimed at protecting water quality would probably affect manure management at the farm level, especially since they might affect the use of lagoons and the application of manure on cropland or forests. For example, the proposed water regulations may mandate nitrogen (N) or phosphorus (P) based comprehensive nutrient management plans

(CNMPs). AFOs could be limited in the amount of manure nitrogen and phosphorus that could be applied to cropland. If there is a low risk of phosphorus runoff as determined by a site analysis, farmers will be permitted to overapply phosphorous. However, they will still be prohibited from applying more nitrogen than recommended for crop production. Many AFOs (those currently without CNMPs) likely will have more manure than they can use on their own cropland, and manure export may be cost prohibitive. Thus, AFOs will have an incentive to use crops and management practices that employ applied nitrogen inefficiently (i.e., volatilize ammonia) to decrease the nitrogen remaining after storage or increase the nitrogen requirement for crop production. These practices may increase nitrogen volatilization to the air. The committee was not informed of specific regulatory actions being considered by EPA (beyond those addressed in the *Federal Register*) to meet its December 2002 deadline for proposing regulations under the Clean Water Act.

Finding 2: In order to understand health and environmental impacts on a variety of spatial scales, estimates of air emissions from AFOs at the individual farm level, and their dependence on management practices, are needed to characterize annual emission inventories for some pollutants and transient downwind spatial distributions and concentrations for others.

Discussion: Management practices (e.g., feeding, manure management, crop management) vary widely among individual farms. Estimates of emissions based on regional or other averages are unlikely to capture significant differences among farms that will be relevant for guiding emissions management practices aimed at decreasing their effects. Information on the spatial relationships among individual farms and the dispersion of air emissions from them is needed. Furthermore, developing methods to estimate emissions at the individual farm level was the stated objective of EPA's recent study (EPA, 2001a).

Finding 3: Direct measurements of air emissions at all AFOs are not feasible. Nevertheless, measurements on a statistically representative subset of AFOs are needed and will require additional resources to conduct.

Discussion: Although it is possible in a carefully designed research project to measure concentrations and airflows (e.g., building ventilation rates) to estimate air emissions and attribute them to individual AFOs, it is not practical to conduct such projects for more than a small fraction of AFOs. Direct measurements for sample farms will be needed in research programs designed to develop estimates of air emissions applicable to various situations.

Finding 4: Characterizing feeding operations in terms of their components (e.g., model farms) may be a plausible approach for developing estimates of air emissions from individual farms or regions as long as the components or factors chosen to characterize the feeding operation are appropriate. The method may not be useful for estimating acute health effects, which normally depend on human exposure to some concentration of toxic or infectious substance for short periods of time.

Discussion: The components or factors used to characterize feeding operations are chosen for their usefulness in explaining dependent variables, such as the mass of air emissions per unit of time. The emission factor method, which is based on the average amount of an emitted substance per unit of activity per year (e.g., metric tons of ammonia per thousand head of cattle per year), can be useful in estimating annual regional emissions inventories for some pollutants, provided that sufficient data of adequate quality are available for estimating the relationships.

Finding 5: Reasonably accurate estimates of air emissions from AFOs at the individual farm level require defined relationships between air emissions and various factors. Depending on the character of the AFOs in question, these factors may include animal types, nutrient inputs, manure handling practices, output of animal products, management of feeding operations, confinement conditions, physical characteristics of the site, and climate and weather conditions.

Discussion: The choice of independent variables used to make estimates of air emissions from AFOs will depend on the ability of the variables to account for variations in the estimates and on the degree of accuracy desired, based on valid measurements at the farm level. Past research indicates that some combination of the indicated variables is likely to be important for estimates of air emissions for the kinds of operations considered in this report. The specific choices will depend on the strength of the relationships for each kind of emission and each set of independent variables.

Finding 6: The model farm construct as described by EPA (2001a) cannot be supported because of weaknesses in the data needed to implement it.

Discussion: Of the nearly 500 possible literature sources for estimating emissions factors identified for EPA (2001a), only 33 were found by the report's authors to be suitable for use in the model farm construct. The committee judged them to be insufficient for the intended use. The breadth in terms of kinds of animals, management practices, and geography in this model farm construct suggests that finding adequate information to define emission factors is unlikely to be fruitful at this time.

Finding 7: The model farm construct used by EPA (2001a) cannot be supported for estimating either the annual amounts or the temporal distributions of air emissions on an individual farm, subregional, or regional basis because the way in which it characterizes feeding operations is inadequate.

Discussion: Variations in many factors that could affect the annual amounts and temporal patterns of emissions from an individual AFO are not adequately considered by the EPA (2001a) model farm construct. The potential influences of geographic (e.g. topography and land use) and climatic differences, daily and seasonal weather cycles, animal life stages, management approaches (including manure management practices and feeding regimes), and differences in state regulations are not adequately considered. Furthermore, aggregating emissions from individual AFOs using the EPA (2001a; not a stated objective) model farm construct for subregional or regional estimates cannot be supported for similar reasons. However, with the appropriate data identified there may be viable alternatives to the currently proposed approach.

Finding 8: A process-based model farm approach that incorporates “mass balance” constraints for some of the emitted substances of concern, in conjunction with estimated emission factors for other substances, may be a useful alternative to the model farm construct defined by EPA (2001a). The committee plans to explore issues associated with these two approaches more fully in its final report.

Discussion: The mass balance approach, like EPA's model farm approach, starts with defining feeding operations in terms of major stages or activities. However, it focuses on those activities that determine the movement of nutrients and other substances into, through, and out of the system. Experimental data and mathematical modeling are used to simulate the system and the movement of reactants and products through each component of the farm enterprise. In this approach, emissions of elements (such as nitrogen) cannot exceed their flows into the system.

Board on Agriculture and Natural Resources (BANR), Board on Environmental Studies and Toxicology (BEST), Division on Earth and Life Sciences, National Research Council, (2003), .*Air Emissions from Animal Feeding Operations: Current Knowledge, Future Needs*, Washington D.C.: The National Academies Press. Available online at http://www.nap.edu/books/0309087058/html

Abstract: This book was prepared by the Committee on Animal Nutrition, which comes under the auspices of the US National Research Council. This book discusses the need "to implement a new method for estimating the amount of ammonia, nitrous oxide, methane, and other pollutants emitted from livestock and poultry farms, and for determining how these emissions are dispersed in the atmosphere." Chapter headings include: livestock agriculture and animal feeding operations; air emissions; measuring emissions; approaches for estimating emissions; government regulations and programmes; and improving knowledge and practices.

Biodiversity and Habitat Loss

A vibrant diverse natural resource base is essential in meeting the needs of present and future generations. A growing concern is the continuing decline in biodiversity. Although the interactions between agriculture and biodiversity in terms of genetic diversity, species diversity, and ecosystem diversity are complex and diverse, there is international consensus that the expansion of agricultural production and intensive use of inputs over recent decades has contributed to a loss of biodiversity and habitat.[45] While most direct habitat loss resulting from conversion of land to farming has already occurred, it has been calculated that if present trends continue, at least 25 percent of the world's wild plants and animals could be extinct or vastly reduced in number by the middle of this century.

Habitat loss continues as the amount of undisturbed grass-dominated cover and non-cropped areas on farms decreases, undisturbed grassland is dissected into small patches, hay and pasture are eliminated, farms shift to monocultures, drain wetlands, consolidate fields and eliminate fence-rows and idle areas.[46] Major causes of the loss of wild and domesticated biodiversity are current agricultural and forestry practices in the north and the expansion of agriculture and logging in the developing countries of the south. In a world of growing populations and increasingly vulnerable livelihoods, the need for food and income today threatens the resources of tomorrow. Agricultural wetland conversions averaged 31,000 acres per year in 1982-1992, and agriculture has been a factor in the decline of 380 of the 663 species federally listed as threatened or endangered in the U.S.[47]

The prevalent response to the loss of biodiversity has been to set aside areas or establish reserves that protect from exploitation. Protected areas currently cover nearly 10 percent of the Earth's land surface. But will protected areas safeguard wild biodiversity? Research shows that these reserves *alone* will not protect biodiversity. Protected areas do not contain

[45] OECD, (2001), op cit.
[46] Ruhl, (2000), op cit.
[47] Heimlich, R.E., Wiebe, K.D., Claasses, R., House, R., and Gadsby, D., (1998), "Wetlands and Agriculture: Private Interests and Public Benefits," USDA-ERS, Agricultural Economic Report No. 765, Washington D.C.; USDA-ERS, (1997), *Agricultural Resources and Environmental Indicators*, 1996-97, AH-712, Washington D.C., as cited in Claassen op cit., and Babcock, B. et al, (2001), *Conservation Payments: Challenges in Design and Implementation*, Iowa State University: Center for Agricultural and Rural Development, Briefing Paper 01-BP 34.

populations large enough to maintain species and are surrounded by landscapes degraded by pollution, invasive species, and water scarcity, and subjected to increasing development pressure.[48]

Agriculture, by reducing and isolating natural habitat, has a greater impact on wildlife than any other human activity.[49] In the United States, for example, privately owned working lands (farms, ranches, and forestlands) comprise approximately 69 percent of the acreage in the United States. Agriculture also affects aquatic resources since almost 90 percent of the rain and snow that falls on the contiguous U.S. falls first on private lands before entering streams, estuaries, and underground aquifers.[50] About half of protected species use private working lands for 80 percent or more of their habitat.

Biodiversity Facts

The following are a series of facts related to biodiversity and habitat loss from around the world. Some are related to agriculture, but all highlight the need for greater research focus to be directed towards a global problem that faces us all, and an issue in which farmers are in a position to play a leading role in helping restore habitat and species diversity.

<u>Hot Spots/Threatened Habitats:</u>

- Around the world, biodiversity, defined as the full variety of life from genes to species to ecosystems, is in trouble. Responding to the problem, conservation experts have in the past two decades shifted their focus from individual species to entire threatened habitats, whose destruction would cause the extinction of many species. Such "hot spots" in the U.S., for example, include the coastal sage of Southern California, the sandy uplands of Florida, and the dammed and polluted river systems of Alabama and other Southern states. Arguably the countries with the most hot spots in the world are Ecuador, Madagascar and the Philippines. Each has lost two-thirds or more of its biologically rich rain forest, and the remainder is under widespread assault. The logic of the experts is simple: by concentrating conservation efforts on such areas, the largest amount of biodiversity can be saved at the lowest economic cost. And if the effort is

[48] McNeely, J. and Scherr, S., (2001), *Common Ground Common Future: How ecoagriculture can help feed the world and save wild biodiversity.* IUCN and Future Harvest.

[49] L. Friesen, (1994), *A literature review on wildlife habitats in agriculture landscapes*. COESA Report No.: RES/MAN-009-94 Canada-Ontario Agriculture Green Plan.

[50] National Governors Association Center for Best Practices, (2001), *Private lands, Public Benefits: Principles for Advancing Working Lands Conservation*, Available online at http://www.nga.org/center/divisions/1,1188,C_ISSUE_BRIEF%5ED_2426,00.html

part of the political process during regional planning, the rescue of biodiversity can gain the widest possible public support.[51]

- The 25 biodiversity hotspots cover just 1.4 percent of the Earth's land surface, yet claim more than 60 percent of total terrestrial biodiversity. Under extreme threat, many hotspots have lost more than 90 percent of their original natural habitat. The major wilderness areas - Amazonia, New Guinea and the Congo Forest - are vast expanses of species-rich habitat, and the key marine areas are among the most biologically rich and productive ocean environments.[52] Hot spots are those natural environments that have the largest number of plants and animals found nowhere else and are themselves endangered. For example, Hawaii is one of the hottest spots in the world, with the highest rates of extinction as well as the greatest endangerment of plant and animal species. Other notorious hot spots include Madagascar, Ecuador's mountain forests, Brazil's Atlantic Forest, the Western Ghats of India, the forest on the southern slopes of the Himalayas, and now, increasingly, coral reefs in most parts of the world.[53]

- In hot spots around the globe, mass extinctions of local populations have been commonplace. Among them:

  - More than half the 266 species of exclusively freshwater fishes in peninsular Malaysia.

  - Fifteen of the 18 unique fishes of Lake Lanao in the Philippines, and half the 14 birds of the Philippine Island of Cebu.

  - All of the 11 native tree-snail species of Moorea in the Society Islands. Those on nearby Tahiti, as well as in the Hawaiian Islands, are rapidly disappearing.

  - More than 90 plant species growing on a single mountain ridge in Ecuador, through clear-cutting of forest between 1978 and 1986.

  These well-documented cases notwithstanding, it is notoriously difficult to estimate the overall rate of extinction. Some groups, like the larger birds and mammals, are more susceptible to extinction than most. The same is true of fishes limited to one or two freshwater streams. Most kinds of insects and small organisms are so difficult to monitor as to make exact numbers unattainable. Nevertheless, biologists using several indirect methods of analysis generally agree that on the land at least and on a worldwide basis, species are vanishing 100 times faster than before the arrival of *Homo sapiens*.[54]

---

[51] Wilson, E.O., (1995), "Only Humans Can Halt the Worst Wave of Extinction Since the Dinosaurs Died", *Time International*, October 30, 1995.
[52] Conservation International, (2001), *Press Releases*, December 9, 2001.
[53] Wilson, E.O., (2000), "Biodiversity at the Crossroads", *Environmental Science and Technology*, March 1, 2000, Vol. 34, pp. 123 A-128 A.
[54] Wilson, E.O., (1995), op cit.

- When an area of habitat is reduced by 90 percent, the amount of its biodiversity is reduced by half. Even the species that remain, however, suffer "edge effect," such as drier conditions, that heighten their vulnerability.[55]

- A review of bird distribution by the International Council for Bird Preservation, using the best data available for any group of organisms, revealed that 20% of the world's species occur within 2% of the land area. Protecting natural environments in these localities alone would help greatly to slow the rate of bird extinction. It would also shield larger numbers of other animals and plants limited to the same habitat.[56]

- Conservationists recently estimated that a current investment of U.S. $28 billion would protect, well into the future, 70 percent of the known plant and animal species in the world, and that U.S. $4 billion would be enough to secure most of the remaining tropical forest wilderness—most of which is in Congo, New Guinea, and the Amazon—to prevent it from being logged or destroyed for other uses. Another U.S. $24 billion could fund the long-term preservation of 2.4 million square kilometers of "hot spot" areas that are known to harbor a remarkably wide range of plant and animal life. 25 regions that together total only 1.4 percent of the ice-free surface of Earth contain as much as 44 percent of all major plant species and 36 percent of all the world's mammals, reptiles, and other animals.[57]

- Americans polled to rank specific environmental issues place the loss of places in nature to development (26%), loss of rain forests (25%) and toxic waste (24%) as the top three problems.[58]

<u>Extinctions:</u>

- The number of existing species is thought to be between 5 and 100 million, with a suggested conservative estimate of 12.5 million. The human-induced extinction rate is thought to be between 100 to 1000 times the non-human-induced rate. If current trends in biodiversity loss continue, the resulting extinction rates have been estimated to range between 10 percent and 50 percent of all species over the next 50-100 years.[59]

- Species declines and extinctions have always been a natural part of evolution, but the current rate - an estimated 1,000 species a year - is unprecedented. With a rough guess of four million to 40 million species still to be catalogued, many are being lost before

[55] E.O. Wilson in D.L. Parsell, (2001), "Biodiversity Expert Urges 'Buying' of Endangered Ecosystems", Address to the National Science Foundation, *National Geographic News*, May 3, 2001.
[56] E.O. Wilson, (1995), op cit.
[57] E.O. Wilson in D.L. Parsell, (2001), op cit.
[58] The Biodiversity Project (2002), *Americans and Biodiversity: New Perspectives in 2002*, Washington D.C., April 2002, pp. 9-10
[59] Tacconi, L., (2000), *Biodiversity and Ecological Economics: Participation, Values and Resource Management,* London: Earthscan Publications, p. 5.

they have been identified, before we know what their disappearance might mean for the planet's life-support system.[60]

- While the changes in the environment having to do with pollution, ozone depletion, and global warming are vitally important, they can be reversed, while on the other hand, species extinction, the loss of biodiversity, cannot be reversed. You could have climate, the atmosphere, and the world's resources all regulated for the use of a sustainable population of people, but you never will recover the loss of fauna and flora. We are, by general agreement among experts on biodiversity, heading toward extinction of as many as 20 percent of species in the next 30 years.[61]

- Each species has been evolving into its present state for some thousands to tens of millions of years. The average life span of a species before humanity came along was between half a million years in mammals and, in some groups like the insects, 10 million years. To wipe out species at the rate we are now inflicting has been to increase the extinction rate by between a hundred and a thousand times.[62]

- The outright elimination of habitat is the leading cause of extinction. But the introduction of aggressive exotic species and the diseases they carry follow close behind in destructiveness, along with overhunting or overharvesting of plants and animals. All these factors work together in a complex manner. A common sequence in tropical countries starts with the building of roads into wilderness, such as those cut across Brazil's Amazonian state of Rondonia during the 1970s and '80s. Land-seeking settlers pour in, clear the rain forest on both sides of the road, pollute the streams, introduce alien plants and animals and hunt wildlife for extra food. Many native species become rare, and some disappear entirely.[63]

- The ongoing loss in biodiversity is the greatest since the end of the Mesozoic era 65 million years ago. At that time, by current scientific consensus, the impact of one or more giant meteorites darkened the atmosphere, altered much of earth's climate and extinguished the dinosaurs. Thus began the next stage of evolution, the Cenozoic era or Age of Mammals. After the Mesozoic spasm, and after each of the four greatest previous spasms spaced over 400 million years, evolution required about 10 million years to restore the pre-disaster levels of diversity. Worse, evolution cannot perform as in previous ages if natural environments have been crowded out by artificial ones.[64] In at least one important respect, the modern episode exceeds anything in the geological past. In the earlier mass extinctions, which some scientists believe were caused by large meteorite strikes, most of the plants survived even though animal diversity was severely reduced. Now, for the first time, plant diversity is declining sharply.[65]

---

[60] Broaddus, L.E., (2001), "Protecting Nature's Diversity", *Biodiversity Initiative, DNREC Online*, Delaware Department of Natural Resources and Environmental Control.
[61] Wilson, E.O., (2000), op cit.
[62] Wilson, E.O., (2000), Ibid.
[63] Wilson, E.O., (1995), op cit.
[64] E.O. Wilson, (1995), Ibid.
[65] E.O. Wilson, (1988), "The Current State of Biological Diversity", *Biodiversity*, National Academy Press, Washington D.C.

- Almost seven in 10 Americans say that the number of plant and animal species present in the world is decreasing.[66]

Agriculture and Wildlife in the United States:

- Working landscapes include agriculture lands such as farms, ranches and orchards; forestlands and woodlots that are the sources of wood products; and estuaries, tidelands, lakes and rivers that support commercial fishing. These lands are valuable not only because of their economic impact and commodity production, but also for their benefits as undeveloped land for wildlife habitat, scenic open space, protecting water quality and acting as buffers to existing preserved land.[67]

- Almost 90 percent of the rain and snow that falls on the contiguous United States falls on private lands before making its way into streams, estuaries, and underground aquifers. More than 70 percent of the wildlife finds food and shelter on working lands. About half of the federally protected species in the United States rely on private lands for at least 80 percent of their habitat. Privately owned working lands comprise approximately 69 percent of the acreage in the United States.[68] Over 70 percent of the US population lives in counties that are at least 10 percent farmland.[69]

- Participation in bird watching increased 155 percent between 1982 and 1994 in the United States.[70]

- In 1997, agricultural lands comprised about 62 percent of all land in the contiguous 48 states. Among USDA farm resource regions, the Federal Government owns less than 9 percent of all lands in the Heartland, Northern Crescent, Prairie Gateway, Southern Seaboard, and the Mississippi Portal.[71]

- Within the contiguous 48 states, the farm sector owns most of the 92 million acres of rural non-Federal wetlands. Cropland, pasture, and range use also account for 82 percent of the 83 million acres of converted wetlands. Therefore, the farm sector is key to any national effort of protect and restore wetlands and their dependent species.[72]

- A recent boom in light geese, a population group that includes snow geese and other similar birds, is attributed to the abundance of cereal grain crops in and near Kansas, which has shortened the birds' migration and improved their diets. The establishment of sanctuaries along their migration paths, and a decline in light geese harvest rates, has also increased light geese numbers to a current population of over 5 million. The geese

---

[66] The Biodiversity Project (2002), op cit, p. 23.
[67] The Trust for Public Land, (2002), "Northwest Working Landscapes Program", Northwest, 27 February, 2002.
[68] National Governors Association Center for Best Practices, (2001), *Private Lands, Public Benefits, Principles for Advancing Working Lands Conservation*, Washington D.C., June 2001.
[69] Economic Research Service, USDA, (2000), *Agricultural Resources and Environmental Indicators*, Washington D.C., Ch.3.1, p. 7.
[70] Ibid, Ch.3.1, p. 4.
[71] Ibid, Ch.3.1, pp. 6-7.
[72] Ibid, Ch.3.3, p. 2.

summer in the far north, and their oversized population is accused of stripping clean tundra flora, which does not quickly or easily regrow. Thus, abundant habitat created by agriculture in one part of their range has created a situation where there are too many geese (in terms of available plant resources) in another part of their range.[73]

- Habitat loss associated with agricultural practices on over 400 million acres of cropland is the primary factor depressing wildlife populations in North America. Modern farming methods brought about dramatic reductions in many species, including cottontail rabbits and ring-necked pheasants.[74]

- Annual wetland loss fell from the 458,000-acre average of the mid-1950s through the mid-1970s, to a 290,000-acre average between the mid-1970s and the mid 1980s, and 32,600 acres between 1992 and 1997. Wetland losses reduce biodiversity because many organisms depend on wetlands and riparian zones for feeding, breeding, and shelter.[75]

- Agriculture is thought to affect the survival of 380 of the 663 plant and animal species listed by the Federal Government as threatened or endangered in the 48 contiguous United States.[76] Of these, 272 were listed, at least in part, due to agricultural development (extensification) and 115 due to the use of fertilizers and/or pesticides (intensification).[77]

- Recent studies by Oregon and Florida conclude that these states would need to maintain, respectively, 25 percent and 33 percent of their land area in natural or semi-natural conditions to fully support all state wildlife populations. These figures highlight the central role that privately owned lands in general, and agricultural lands in particular, will have to play if state and national efforts to protect the full diversity of wildlife resources are to be successful.[78]

---

[73] U.S. Fish and Wildlife Service (1998) in Economic Research Service, USDA, (2000), op cit, Ch. 3.1, p. 7.

[74] Risley, David L., Alfred H. Berner, and David P. Scott (1995), *How Much is Enough? A Regional Wildlife Habitat Needs Assessment for the 1995 Farm Bill*, McKenzie and Riley (eds.), Wildlife Management Institute, Washington D.C., in Economic Research Service, USDA, (2000), op cit, Ch. 3.1, p. 9.

[75] Novitski, R.P., R.D. Smith, and J.D. Fretwell (1996) "Wetland Functions, Values and Assessment" in J.D. Fretwell, J.S. Williams and P.J. Redman (eds.), National Summary on Wetland Resources. USGS Water Supply Paper 2425, pp. 79-86, Washington D.C.: U.S. Department of the Interior, U.S. Geological Survey, in Economic Research Service, USDA, (2000), Ch. 3.1, p. 9.

[76] Economic Research Service, USDA, (1997), *Agricultural Resources and Environmental Indicators*, in Economic Research Service, USDA, (2000), op cit, Ch. 3.1, p. 9.

[77] Economic Research Service, USDA, (2000), op cit, Ch. 3.1, p. 12.

[78] Noss, R.F., R.F. Peters (1998), *Oregon's Living Landscape: Strategies and Opportunities to Conserve Bio-Diversity*, Defenders of Wildlife, Washington D.C.; Cox, J., R. Kautz, M. MacLaughlin, T. Gilbert (1994), *Closing the Gaps in Florida's Wildlife Habitat Conservation System*, Florida Game & Freshwater Fish Commission, Tallahassee, Florida, in Economic Research Service, USDA, (2000), Ch. 3.3, p. 2.

- The U.S. Fish and Wildlife Service estimated the estimated benefits of a successful reintroduction of gray wolves in Yellowstone National Park at $8.3 million in existence value and $23 million in increased visitor expenditures.[79]
- Three in ten Americans have heard of the term "biological diversity", and about half of these can provide a reasonably accurate definition.[80]
- 40 percent of the American public think that the environment is getting worse; 92 percent agree that we have a personal responsibility to the Earth to protect all plant and animal life; and 89 percent agree that we have a moral responsibility to do the same.[81]
- The major reason Americans cites in support of environmental protection is "responsibility to future generations to protect the earth" (39%).[82]
- Support for protecting biodiversity is highest in the Northeast United States and lowest in the Mid-west.[83]

Species Diversity:

- Many published sources have indicated that about 1.4 million living species of all kinds of organisms have been. Approximately 750,000 are insects, 41,000 are vertebrates, and 250,000 are plants (that is, vascular plants and bryophytes). The remainder consists of a complex array of invertebrates, fungi, algae, and microorganisms. Most systematists agree that this picture is still very incomplete except in a few well-studied groups such as the vertebrates and flowering plants. If insects, the most species-rich of all major groups, are included, the absolute number is likely to exceed 5 million. Recent intensive collections made in the canopy of the Peruvian Amazon rain forest have moved the plausible upper limit much higher. Previously unknown insects proved to be so numerous in these samples that when estimates of local diversity were extrapolated to include all rain forests in the world, a figure of 30 million species was obtained. In an even earlier stage is research on the epiphytic plants, lichens, fungi, roundworms, mites, protozoans, bacteria, and other mostly small organisms that abound in the treetops. Other major habitats that remain poorly explored include the coral reefs, the floor of the deep sea, and the soil of tropical forests and savannas. Thus, we do not know the true number of species on Earth, even to the nearest order of magnitude. The absolute number may fall somewhere between 5 and 30 million.[84]
- Species diversity has been maintained at an approximately even level or at most a slowly increasing rate, although punctuated by brief periods of accelerated extinction every few tens of millions of years. The more similar the species under consideration,

[79] U.S. Department of the Interior, U.S. Fish and Wildlife Service (1994) *Final Environmental Impact Statement: The Reintroduction of Gray Wolves to Yellowstone National Park and Central Idaho*, May 1994, in Economic Research Service, USDA, (2000), op cit, Ch. 3.1, p. 4.

[80] The Biodiversity Project (2002), op cit, p. 19.
[81] Ibid, p. 28.
[82] Ibid, p. 18.
[83] Ibid, p. 26.
[84] Wilson, E.O., (1988), op cit.

the more consistent the balance. Thus within clusters of islands, the numbers of species of birds (or reptiles, or ants, or other equivalent groups) found on each island in turn increases approximately as the fourth root of the area of the island. In other words, the number of species can be predicted as a constant X (island area) 0.25, where the exponent can deviate according to circumstances, but in most cases it falls between 0.15 and 0.35. According to this theory of island biogeography, in a typical case (where the exponent is at or near 0.25) the rule of thumb is that a 10-fold increase in area results in a doubling of a number of species. This has been found to hold true not just on real islands but also on habitat islands, such as lakes in a "sea" of land, alpine meadows or mountaintops surrounded by evergreen forests, and even in clumps of trees in the midst of a grassland.[85]

- Wide-ranging species consist of multiple breeding populations that display complex patterns of geographic variation in genetic polymorphism. Thus, even if an endangered species is saved from extinction, it will probably have lost much of its internal diversity. When the populations are allowed to expand again, they will be more nearly genetically uniform than the ancestral populations. The bison herds of today are biologically not quite the same--not so interesting--as the bison herds of the early nineteenth century.[86]

- By impoverishing the planet of life forms, we also reduce the productivity and stability of natural ecosystems. For example, imagine a forest consisting of one species, which is almost the case in some of our towns that are completely planted in one of several species of ornamental tree. And then imagine, as has happened over and over again, for example, with the American chestnut, elm, and hemlock, that you have a plague of insects or fungi capable of wiping out the entire population. If there are a hundred species of trees, a dozen species could be extinguished and still a beautiful forest would be standing. So stability, for the very preservation of some of the natural habitats, depends upon diversity.[87]

- Recent experimental studies on whole ecosystems support what ecologists have long suspected: the more species living in an ecosystem, the higher its productivity and the greater its ability to withstand drought and other kinds of environmental stress. Since we depend on functioning ecosystems to cleanse our water, enrich our soil and create the very air we breathe, biodiversity is clearly not something to discard carelessly.[88]

- Over six in ten Americans (64%) ‘strongly agree’ with the statement that one of the most important things to them is living in a world with a variety of plants and animals.[89]

---

[85] MacArthur, R.H. and Wilson, E.O., (1967), *The Theory of Island Biogeography*, Princeton: Princeton University Press.

[86] Wilson, E.O., (1988), op cit.
[87] Wilson, E.O., (2000), op cit.
[88] E.O. Wilson, (1995), “Only Humans Can Halt the Worst Wave of Extinction Since the Dinosaurs Died,” *Time International*, October 30, 1995.
[89] The Biodiversity Project (2002), op cit, p. 33.

- The top three messages cited among Americans for maintaining biodiversity are:
    - Marshes, forest, rivers and streams clean the air and drinking water (74%)
    - New medicines are derived from plants and animals (72%); and
    - U.S. forests are important because they clean our drinking water (72%)[90]

Population:

- The world population is projected to grow from 6 billion people today to 8 billion at mid-century, while per-capita levels of water and land are dropping to "risky" levels. The situation will be further strained because of the high rates of population growth in many countries. Reducing poverty is a twin challenge to conservation because many of the world's poorest people are now heavily dependent on the natural environment to meet their basic needs.[91]
- At the present time, the ecological footprint—the amount of productive land used per capita for food production, water and waste management, habitation, transportation, and other necessities—for the United States is about 12 acres. In developing countries, it's about 1 acre. So, with 80 percent of the world's population in the developing countries and virtually *all* of the projected population growth over the next few decades occurring there, the pressures upon the earth's resources and its flora and fauna are going to be enormous because these people are understandably anxious to increase their ecological footprint.[92]

Protected Areas/Land and Marine Reserves:

- Protected Areas (PA) can only complement the other actions required to conserve biodiversity (e.g. changes in legislation, changes in ecosystem use, *ex situ* conservation) rather than substitute for them. PAs can help in conserving only a portion of all existing species. This may be illustrated by estimating the contribution of PAs to species conservation in tropical forests. In the scenario that all tropical forests were cleared with the exception of those in legally established PAs, the following percentage of species would survive: Africa 37-65 percent; Asia and Pacific 44-71 percent and Latin America 28-58 percent.[93]

- In 1996, PAs covered about 6.29 percent of the Earth's land area. The land surface covered by PAs in categories I-V and category VI will probably never exceed 10. percent and 20 percent respectively of the Earth's total land area.[94]

---

[90] Ibid, p. 44.
[91] Wilson, E.O. in Parsell, D.L., (2001), op cit.
[92] Wilson, E.O., (2000), op cit.
[93] Tacconi, L., (2000), op cit, p. 14.
[94] Reid, W.V. and Miller, K.R. (1989), *Keeping Options Alive: The Scientific Basis for Conserving Biodiversity*, World Resources Institute, Washington D.C., in Tacconi, L., (2000), p. 14.

- The success of PAs will depend upon the actual management of these areas according to their conservation objectives. Many PAs do not have management plans, and when they do, either they are not implemented or they are not respected.[95] These areas are thus protected only on paper.[96] In Indonesia, for example, the politics of forest management allows logging companies to log in PAs without being prosecuted.[97]

- It is unlikely that the development of PA systems will significantly constrain food availability at the global level. About 36 percent of the Earth's land area is dedicated to agricultural and pastoral uses.[98] The percentage of productive lands to be included in PAs is likely to be only a fraction of the agricultural-pastoral land currently used. Assuming PAs cover 10 percent of the Earth's land area, a large fraction of this area will cover land of low agronomic potential. Because of the low agricultural productivity of many tropical forest areas, agricultural output could often receive a greater boost from land redistribution policies and conservation measures applied to existing agricultural land, rather than from expansion onto forest land included in PAs. The impacts that will occur at the local level will depend on the specific management arrangements regulating each PA.[99]

- A further weakness of PAs is their susceptibility to damage caused by pollution and exotic species infestation. These problems endanger not only PAs but also agricultural production.[100]

- Nearly half of the American public believes that increasing protection for habitats and animals will result in too many government restrictions on individuals and communities.[101]

- The buying of privately owned forests and other land to protect them from development is ranked last by Americans as an effective government policy to protect biodiversity, after the tougher enforcement of anti-pollution laws and regulations that limit development that destroys habitat, tax incentives that encourage non-development of natural areas by farmers, and the use of environmental and energy saving products by consumers.[102]

- Land and marine reserves need to be as big as possible to preserve all the world's biodiversity. As you reduce the size of a reserve, or any habitat, you automatically reduce the number of species that can live sustainably on that reserve. The amount of

---

[95] Tacconi, L., (2000), Ibid, p. 15.
[96] International Union for the Conservation of Nature and Natural Resources, World Commission on Protected Areas (1997), *Protected Areas in the Twenty-first Century: from Islands to Networks*. Report of the Conference held in Albany, Western Australia, 24-29 November, in Tacconi, L., Ibid, (2000), p. 15.
[97] Barber, C.V., Johnson, N.C. and Hafild, E. (1994), *Breaking the Logjam: Obstacles to Forest Policy Reform in Indonesia and the United States*, World Resources Institute, Washington D.C., in Tacconi, L., (2000), Ibid, p. 15.
[98] World Bank (1992), *World Bank Development Report*, World Bank, Washington D.C., in Tacconi, L., (2000), Ibid, p. 15.
[99] Tacconi, L., (2000), Ibid, pp. 15-16.
[100] Ibid, p. 16.
[101] The Biodiversity Project (2002), op cit, p. 35.
[102] Ibid, p. 71.

reduction is roughly the following: A 90 percent reduction in area eventually results in a 50 percent decrease in the number of species. Although it may take a number of years, it still happens very rapidly in ecological time. This principle is illustrated in the national parks of the western United States and Canada, where the number of mammal species, which can be easily monitored, has been declining steadily and most rapidly in the smallest reserves. [103]

- All the zoos in the world today can sustain a maximum of only 2,000 species of mammals, birds, reptiles and amphibians, out of about 24,000 known to exist. The world's botanical gardens would be even more overwhelmed by the quarter-million plant species. These refuges are invaluable in helping to save a few endangered species. So is freezing embryos in liquid nitrogen. But such measures cannot come close to solving the problem as a whole. To add to the difficulty, no one has devised a plan to save the legion of insects, fungi and other ecologically vital small organisms. And once scientists are ready to return species to independence, the ecosystems in which many lived will no longer exist. Tigers and rhinos, to make the point clear, cannot survive in paddies. The conclusion of scientists and conservationists is therefore virtually unanimous: the only way to save wild species is to maintain them in their original habitats.[104]
- Ecotourism, opening the most spectacular wild lands to paying visitors, has become a major source of income in many developing countries. Reserves and the surrounding land are being reorganized to create an outer buffer zone where local peoples are helped to develop sustainable agriculture, enveloping an inviolate core zone for the maximum protection of endangered species.[105]

<u>Water Shortages and Species Diversity</u>:

- There is a looming global water shortage in the coming decades as a result of inefficient irrigation systems, population growth, and groundwater depletion. This problem affects species diversity, particularly aquatic species, as more water is diverted from rivers to sustain growing population centers. Natural resource experts agree that the major environmental constraints of the future are two in number: arable land, which has been dropping per capita for over 40 years, and available freshwater. The groundwater in most parts of the world is dropping. In a good part of the American plains it is dropping drastically. The result is that aquatic biodiversity—comprising freshwater fish, a vast array of freshwater insects, turtles, mollusks, and so on—has been the most damaged in the United States and elsewhere in the world. It has the highest extinction rate worldwide and the greatest level of endangerment.[106]

[103] Wilson, E.O., (2000), op cit.
[104] Wilson, E.O., (1995), op cit.
[105] Ibid.
[106] Wilson, E.O., (2000), op cit.

Endangered Species:

- The Baiji freshwater dolphin that once abounded along a thousand miles of the Yangtze River may now be the world's most endangered large animal. Caught in a vise of rising pollution and indiscriminate fishing during the past century, its population fell to only 400 by 1980, to 150 in 1993, and is now below 100. Zoologists doubt the species will survive in the wild for another decade. The Baiji's closest rivals for early extinction include the Sumatran rhinoceros (probably fewer than 500 individuals survive) and the giant panda of China (fewer than 1,000).[107]
- For every animal that vanishes, biologists can point to thousands of species of plants and smaller animals either recently extinct or on the brink. The rarest bird in the world is Spix's macaw, down to one or possibly two individuals in the palm and river-edge forests of central Brazil. The rarest plant is Cooke's koki'o of Hawaii, a small tree with profuse orange-red flowers that once graced the dry volcanic slopes of Molokai. Today it exists only as a few half plants--branches implanted onto the stocks of other related species. Cooke's koki'o may spend its last days in this biological limbo; despite the best efforts of horticulturists to assist the plant, no branches planted in soil have sprouted roots.[108]

Tropical Rain Forests:

- Tropical rain forests are the site of most of the known damage. Although they cover only 6 percent of the land surface, they contain more than half the species of plants and animals of the entire world. The forests are being destroyed so rapidly that they will mostly disappear within the next century, taking with them hundreds of thousands of species into extinction.[109]

- The rate of clearing and burning of rain forests averaged about 1 percent each year in the 1980s, an amount about equal to the entire country of Ireland, and the pace of destruction may now be increasing. That magnitude of habitat loss spells trouble for the planet's reservoir of biodiversity. It means that each year 0.25 percent or more of the forest species are being doomed to immediate or early extinction. In absolute numbers, as opposed to rate, if there are 10 million species in the still mostly unexplored forests, which some scientists think possible, the annual loss is in the tens of thousands. Even if there are a “mere” 1 million species, the loss is still in the thousands. These projections are based on the known relationships between the area of a given natural habitat and the number of species able to live within it. The projections may be on the low side.[110]

- Some forest tracts previously scheduled for clear-cutting are now selectively logged or cut along concentric swaths, then allowed to regenerate. Because the practices yield higher long-term profits, they are expected to be widely adopted.[111]

[107] Wilson, E.O., (1995), op cit.
[108] Ibid.
[109] Wilson, E.O. (1988), (1995), op cit.
[110] Wilson, E.O., (1995), op cit.
[111] Ibid.

- It is not unusual for a square kilometer of forest in Central or South America to contain several hundred species of birds and many thousands of species of butterflies, beetles, and other insects.[112]

- When the forest is cut and burned, the ash and decomposing vegetation release a flush of nutrients adequate to support new herbaceous and shrubby growth for two or three years. Then these materials decline to levels lower than those needed to support a healthy growth of agricultural crops without artificial supplements.[113]

- The monitoring of logged sites indicates that regeneration of a mature forest might take centuries. The forest at Angkor (to cite an anecdotal example) dates back to the abandonment of the Khmer capital in 1431, yet is still structurally different from a climax forest today, 556 years later. The process of rain forest regeneration is in fact so generally slow that few extrapolations have been possible; in some zones of greatest combined damage and sterility, restoration might never occur naturally.[114]

- Approximately 40 percent of the land that can support tropical closed forest now lacks it, primarily because of human action. By the late 1970s, according to estimates from the Food and Agricultural Organization and United Nations Environmental Programme, 7.6 million hectares or nearly 1 percent of the total cover is being permanently cleared or converted into the shifting-cultivation cycle. The absolute amount is 76,000 square kilometers (27,000 square miles) a year, greater than the area of West Virginia or the entire country of Costa Rica. In effect, most of this land is being permanently cleared, that is, reduced to a state in which natural reforestation will be difficult if not impossible to achieve.[115]

- A straight-line extrapolation from the first of these figures, with identically absolute annual increments of forest-cover removal, leads to 2135 A.D. as the year in which all the remaining rain forest will be either clear-cut or seriously disturbed, mostly the former. By coincidence, this is close to the date (2150) that the World Bank has estimated the human population will plateau at 11 billion people (The world Bank, 1984). In fact, the continuing rise in human population indicates that a straight line estimate is much too conservative. Population pressures in the Third World will certainly continue to accelerate deforestation during the coming decades.[116]

- In many local areas with high levels of endemicity, deforestation has proceeded very much faster than the overall average. Madagascar, possessor of one of the most distinctive floras and faunas in the world, has already lost 93 percent of its forest cover. The Atlantic coastal forest of Brazil is 99 percent gone. In still poorer condition--in fact, essentially lost--are the forests of many of the smaller islands of Polynesia and the Caribbean.[117]

---

[112] Wilson, E.O., (1988), op cit.
[113] Ibid.
[114] Ibid.
[115] Ibid.
[116] Ibid.
[117] Ibid.

- If present levels of forest removal continue, the stage will be set within a century for the inevitable loss of 12 percent of the 704 bird species in the Amazon basin and 15 percent of the 92,000 plant species in South and Central America. These regional losses are made worse because the Amazon and Orinoco basins contain the largest continuous rain forest tracts in the world. Less extensive habitats are far more threatened. An extreme example is the western forest of Ecuador. This habitat was largely undisturbed until after 1960, when a newly constructed road network led to the swift incursion of settlers and clear-cutting of most of the area. Now only patches remain, such as the 0.8-square-kilometer tract at the Rio Palenque Biological Station. This tiny reserve contains 1,033 plant species, perhaps one-quarter of which are known only to occur in coastal Ecuador.[118]

- At the present time, less than 5 percent of tropical forests are protected within parks and reserves, and even these are vulnerable to political and economic pressures. For example, 4 percent of the forests are protected in Africa, 2 percent in Latin America, and 6 percent in Asia. Thus in a simple system as envisioned by the basic models of island biogeography, the number of species of all kinds of organisms can be expected to be reduced by at least one-half--in other words, by hundreds of thousands or even (if the insects are as diverse as the canopy studies suggest) by millions of species. In fact, the island-biogeographic projections appear to be conservative for two reasons. First, tropical species are far more localized than those in the temperate zones. Consequently, a reduction of 90 percent of a tropical forest does not just reduce all the species lining therein to 10 percent of their original population sizes, rendering them more vulnerable to future extinction. That happens in a few cases, but in many others, entire species are eliminated because they happened to be restricted to the portion of the forest that was cut over. Second, even when a portion of the species survives, it will probably have suffered significant reduction in genetic variation among its members due to the loss of genes that existed only in the outer portions.[119]

- When a forest is reduced from, say, 100 square kilometers to 10 square kilometers by clearing, some immediate extinction is likely. However, the new equilibrium will not be reached all at once. Some species will hang on for a while in dangerously reduced populations. Elementary mathematical models of the process predict that the number of species in the 10-square-kilometer plot will decline at a steadily decelerating rate, i.e., they will decay exponentially to the lower level.[120]

- Several studies of recently created islands of both tropical and temperate-zone woodland show that when the islands range from 1 to 25 square kilometers--the size of many smaller parks and reserves--the rate of extinction of bird species during the first 100 years is 10 to 50 percent. Also the extinction rate is highest in the smaller patches, and it rises steeply when the area drops below 1 square kilometer. Three patches of subtropical forest isolated (by agricultural clearing) in Brazil for about a hundred years

[118] Ibid.
[119] Ibid.
[120] Ibid.

varied from 0.2 to 14 square kilometers, and, in reverse order, their resident bird species suffered 14 to 62 percent extinction rates.[121]

- If half the species in tropical forests are very localized in distribution, so that the rate at which species are being eliminated immediately is approximately this fraction multiplied by the rate-percentage of the forests being destroyed. Let us conservatively estimate that 5 million species of organisms are confined to the tropical rain forests, a figure well justified by the recent upward adjustment of insect diversity alone. The annual rate of reduction would then be 0.5 x 5 x 106 x 0.007 species, or 17,500 species per year. Given 10 million species in the fauna and flora of all the habitats of the world, the loss is roughly one out of every thousand species per year. How does this compare with extinction rates prior to human intervention? The estimates of extinction rates in Paleozoic and Mesozoic marine faunas ranged according to taxonomic group (e.g., echinoderms versus cephalopods) from one out of every million to one out of every 10 million per year. Let us assume that on the order of 10 million species existed then, in view of the evidence that diversity has not fluctuated through most of the Phanerozoic time by a factor of more than three. It follows that both the per-species rate and absolute loss in number of species due to the current destruction of rain forests (setting aside for the moment extinction due to the disturbance of other habitats) would be about 1,000 to 10,000 times that before human intervention.[122]

Biodiversity and Human Drugs:

- In addition to creating a habitable environment, wild species are the source of products that help sustain our lives. Not the least of these amenities are pharmaceuticals. More than 40 percent of all prescriptions dispensed by pharmacies in the U.S. are substances originally extracted from plants, animals, fungi and microorganisms. Aspirin, for example, the most widely used medicine in the world, was derived from salicylic acid, which in turn was discovered in a species of meadowsweet.[123]

- Only a minute fraction of the species or organisms--probably less than 1 percent--have been examined for natural products that might serve as medicines. There is a critical need to press the search in the case of antibiotics and antimalarial agents. The substances most commonly used today are growing less effective as the disease organisms acquire genetic resistance to the drugs. The bacterium staphylococcus, for example, has recently re-emerged as a potentially lethal pathogen, and the microorganism that causes pneumonia is growing steadily more dangerous. Medical researchers are locked in an arms race with the rapidly evolving pathogens that is certain to grow more serious. They are obliged to turn to a broader array of wild species to discover new weapons and antibiotics. Species alive today are thousands to millions of years old. Their genes, having been tested by adversity over so many generations,

[121] Ibid.
[122] Ibid.
[123] Wilson, E.O., (1995), op cit.

engineer a staggeringly complex array of biochemical devices to aid the survival and reproduction of the organisms carrying them.[124]

- More than 20 pharmaceutical companies have contracted with private and national research organizations to push "chemical prospecting" for new medicines in rain forests and other habitats.[125]

Erosion of Crop and Livestock Diversity:

- Wild species are both one of the Earth's most important resources and the least utilized. We have come to depend completely on less than 1 percent of living species for our existence, the remainder waiting untested and fallow. In the course of history people have utilized about 7,000 kinds of plants for food; predominant among these are wheat, rye, maize, and about a dozen other highly domesticated species. Yet there are at least 75,000 edible plants in existence, and many of these are superior to the crop plants in widest use. Others are potential sources of new pharmaceuticals, fibers, and petroleum substitutes. In addition, among the insects are large numbers of species that are potentially superior as crop pollinators, control agents for weeds, and parasites and predators of insect pests. Bacteria, yeasts, and other microorganisms are likely to continue yielding new medicines, food, and procedures of soil restoration.[126]

- Although people consume approximately 7,000 species of plants, only 150 species are commercially important, and about 103 species account for 90 percent of the world's food crops. Just three crops -- rice, wheat, and maize -- account for about 60 percent of the calories and 56 percent of the protein people derive from plants. Along with this trend towards uniform monocropping, the dependence on high levels of inputs such as irrigation, fertilizers, and pesticides has increased worldwide. The reduction in diversity often increases vulnerability to climate and other stresses, raises risks for individual farmers, and can undermine the stability of agriculture. In Bangladesh, for example, promotion of HYV rice monoculture has decreased diversity, including nearly 7,000 traditional rice varieties and many fish species. The production of HYV rice per acre in l986 dropped by 10 per cent from 1972, in spite of a 300 percent increase in agrochemical use per acre. In the Philippines, HYVs have displaced more than 300 traditional rice varieties that had been the principal source of food for generations. In India, by l968, the so-called "miracle" HYV seed had replaced half of the native varieties, but these seeds were not high-yielding unless cultivated on irrigated land with high rates of fertilizer, which is often unaffordable to poor farmers. Thus, the expected production increases were not realized in many areas.[127]

[124] Ibid.
[125] Ibid.
[126] Wilson, E.O., (1988), op cit.
[127] World Resources Institute, (1997), *Linking Biodiversity and Agriculture: Challenges and Opportunities for Sustainable Food Security*, Washington D.C.

Table 2. Extent of Genetic Uniformity in Selected Crops

Crop	Country	Number of Varieties
Rice	Sri Lanka	From 2,000 varieties in 1959 to less than 100 today 75% descend from a common stock
Rice	Bangladesh	62% of varieties descend from a common stock
Rice	Indonesia	74% of varieties descend from a common stock
Wheat	USA	50% of crop in 9 varieties
Potato	USA	75% of crops in 4 varieties
Soybeans	USA	50% of crops in 6 varieties
Source: World Conservation Monitoring Centre. 1992. *Global Biodiversity: Status of the Earth's Living Resources* (Brian Groombridge, ed.). London: Chapman & Hall; World Resources Institute (1997).		

- In Africa, transfer of the Green Revolution model has also reduced diversity. In Senegal, for example, a traditional cereal called fonio *(Panicum laetum)* -- which is highly nutritious as well as robust in lateritic soils -- has been threatened by extinction because of its replacement by modern crop varieties. In the Sahel, reports also confirm that traditional systems of polyculture are being replaced with monocultures that cause further food instability.[128]

- Homogenization also occurs in high-value export crops. Nearly all the coffee trees in South America, for example, descended from a single tree in a botanical garden in Holland. *Coffea arabica* was first obtained from forests of southwest Ethiopia that have virtually disappeared. Uniform varieties are also common in export crops of bananas, cacao, and cotton, replacing traditional diverse varieties. Such changes have increased productivity, but the risks of narrowing varietal selection have become clear over time. In the North, similar losses in crop diversity are occurring. Many fruit and vegetable varieties listed by the USDA in 1903 are now extinct. Of more than 7,000 apple varieties grown in the U.S. between 1804 and 1904, 86 percent are no longer cultivated, and 88 percent of 2,683 pear varieties are no longer available. Evidence from Europe shows similar trends -- thousands of varieties of flax and wheat vanished after HYVs were introduced. Similarly, varieties of oats and rye are also declining in Europe. In Spain and Portugal, various legumes that had been an important part of the local diet

[128] Ibid.

are being replaced by homogeneous crops, and in the Netherlands, four crops are grown on 80 percent of Dutch farmlands.[129]

Table 3. Reduction of Diversity in Fruits and Vegetables, 1903 to 1983

Vegetable	**Taxonomic Name**	**Number in 1903**	**Number in 1983**	**Loss (Percent)**
Asparagus	*Asparagus officinalis*	46	1	97.8
Bean	*Phaseolus vulgaris*	578	32	94.5
Beet	*Beta vulgaris*	288	17	94.1
Carrot	*Daucus carota*	287	21	92.7
Leek	*Allium ampeloprasum*	39	5	87.2
Lettuce	*Lactuca sativa*	487	36	92.8
Onion	*Allium cepa*	357	21	94.1
Parsnip	*Pastinaca sativa*	75	5	93.3
Pea	*Pisum sativum*	408	25	93.9
Radish	*Raphanus sativus*	463	27	94.2
Spinach	*Spinacia oleracea*	109	7	93.6
Squash	*Cucurbita spp.*	341	40	88.3
Turnip	*Brassica rapa*	237	24	89.9
Source: Carry Flower, and Pat Mooney. 1990. *The Threatened Gene -- Food, Politics, and the Loss of Genetic Diversity*.Cambridge: The Luthworth Press; World Resources Institute (1997).				

- Livestock is also suffering genetic erosion; the FAO estimates that somewhere in the world at least one breed of traditional livestock dies out every week. Many traditional breeds have disappeared as farmers focus on new breeds of cattle, pigs, sheep, and chickens. Of the 3,831 breeds of cattle, water buffalo, goats, pigs, sheep, horses, and donkeys believed to have existed in this century, 16 percent have become extinct, and a further 15 percent are rare. Some 474 of extant (livestock) breeds can be regarded as rare. A further 617 have become extinct since 1892. Over 80 breeds of cattle are found in Africa, and some are being replaced by exotic breeds. These losses weaken breeding programs that could improve hardiness of livestock. In sum, as these forms of

[129] Ibid.

biodiversity are eroded, food security can also be reduced and economic risks increased. Evidence indicates that such changes can decrease sustainability and productivity in farming systems. Loss of diversity also reduces the resources available for future adaptation.[130]

Increased Vulnerability to Insect Pests and Diseases:

- Homogenization of varieties increases vulnerability to insect pests and diseases, which can devastate a uniform crop, especially on large plantations. History has shown serious economic losses and suffering from relying on monocultural uniform varieties. Among renowned examples are the potato famine of Ireland during the 19th century a winegrape blight that wiped out valuable vines in both France and the United States, a virulent disease *(Sigatoka)* that damaged extensive banana plantations in Central America in recent decades and devastating mold that infested hybrid maize in Zambia.[131]

Table 4. Past Crop Failures Due to Genetic Uniformity

Date	**Location**	**Crop**	**Effects**
1846	Ireland	Potato	Potato famine
1800s	Sri Lanka	Coffee	Farms destroyed
1940s	USA	U.S. crops	Crop loss to insects doubled
1943	India	Rice	Great famine
1960s	USA	Wheat	Rust epidemic
1970	USA	Maize	$1 billion loss
1970	Philippines, Indonesia	Rice	Tungo virus epidemic
1974	Indonesia	Rice	3 million tons destroyed
1984	USA (Florida)	Citrus	18 million trees destroyed
Source: World Conservation Monitoring Centre. 1992. *Global Biodiversity: Status of the Earth's Living Resources* (Brian Groombridge, ed.). London: Chapman & Hall; World Resources Institute (1997).			

130 Ibid.
131 Ibid.

- In addition, there has been a serious decline in soil organisms and soil nutrients. Beneficial insects and fungi also suffer under agriculture that involves heavy pesticide inputs and uniform stock - making crops a more susceptible to pest problems. These losses, along with fewer types of agroecosystems, also increase risks and can reduce productivity. In addition, many insects and fungi commonly seen as enemies of food production are actually valuable. Some insects benefit farming - for pollination, contributions to biomass, natural nutrient production and cycling, and as natural enemies to insect pests and crop diseases. Mycorrhizae, the fungi that live in symbiosis with plant roots, are essential for nutrient and water uptake.[132]
- The global proliferation of modern agricultural systems has eroded the range of insects and fungi, a trend that lowers productivity. Dependence on agrochemicals, and particularly the heavy use or misuse of pesticides, is largely responsible. Agrochemicals generally kill natural enemies and beneficial insects, as well as the "target" pest. Pesticides (especially when overused) destroy a wide array of susceptible species in the ecosystem while also changing the normal structure and function of the ecosystem. This disruption in the agroecosystem balance can lead to perpetual resurgence of pests and outbreaks of new pests -- as well as provoke resistance to pesticides. This disturbing cycle often leads farmers to apply increasing amounts of pesticides or to change products -- a strategy that is not only ineffective, but that also further disrupts the ecosystem and elevates costs. This "pesticide treadmill" has occurred in countless locations. Reliance on monocultural species and the decline of natural habitat around farms also cuts beneficial insects out of the agricultural ecosystem.[133]

<u>Other Biodiversity Costs of Agricultural Expansion:</u>

- Agricultural expansion has also reduced the diversity of natural habitats, including tropical forests, grasslands, and wetland areas. Projections of food needs in the coming decades indicate probable further expansion of cropland, which could add to this degradation. Modifying natural systems is necessary to fulfill the food needs of growing populations, but many conventional forms of agricultural development, particularly large-scale conversion of forests or other natural habitats to monocultural farming systems, erode the biodiversity of flora and fauna. Intensive use of pesticides and fertilizers can also disrupt and erode biodiversity in natural habitats that surround agricultural areas, particularly when these inputs are used inappropriately.[134]
- Other direct effects of reduced diversity of crops and varieties include:
    - Decline in the variety of foods adversely affects nutrition.
    - High-protein legumes have often been replaced by less nutritious cereals.
    - Local knowledge about diversity is lost as uniform industrial agricultural technologies predominate.

---
[132] Ibid.
[133] Ibid.
[134] Ibid.

- Institutions and companies in the North have unfair advantages in exploiting the diverse biological resources from the tropics.

In sum, the loss of agro-biodiversity has immediate costs to producers, social costs to communities and nations, long-term effects on agricultural productivity, as well as jeopardizing food security.[135]

A State Perspective: Delaware:

- Forty-one percent of Delaware's forest-dependent birds are now rare or have completely stopped nesting in the state. This is due not only to the loss of total forestland, but also to the fragmentation of the remaining forests. Ecologically specialized bird species that require large tracts of forest to raise their young successfully now find it increasingly difficult to make a home there.[136]
- Among those hardest hit are the neo-tropical migratory birds that must make their way across thousands of miles of fragmentary landscapes in a search for suitable habitat. Fewer stop in Delaware and with 82 percent of our freshwater wetlands lost, there are also fewer frogs and toads. Because more is known about the nearly 10,000 bird species than any other class of animal life, they are obvious indicators of the health of an ecosystem. At least two out of every three bird species are in decline worldwide. The leading culprits are habitat alteration or loss, exotic species invasions, excessive harvesting, the extermination of “harmful” species and chemical pollution. In addition, nearly 40 percent of Delaware's native plant species are now rare or entirely missing. A disproportionate number of freshwater wetlands species are rare. Stream or wetlands-dwelling animals have been hard hit. Most were once common, but their habitat has been largely consumed by development or agriculture. Once a mainstay of Delaware's creeks and rivers, nearly 80 percent of our native species of freshwater mussel are now either rare or missing. Delaware's list of animal species headed for trouble includes six mussels, 17 fish, seven salamanders, three tree frogs, the carpenter frog, 11 snakes, two turtles, five beetles; 21 butterflies, 59 dragonflies and damselflies, and six mammals. Twenty-five species of birds, reptiles, insects and mussels have not been identified in Delaware in more than 15 years.[137]

A Regional Initiative: Skagit River Delta Conservation Initiative:

- An hour from both Seattle, Washington, and Vancouver, British Columbia, the Skagit River Delta marks the most significant undeveloped "island" of both biodiversity and working landscapes between the two hubs. With impending threats of development coming from all sides, the fertile farmland is in jeopardy. As suburbs continue

[135] Ibid.
[136] Broaddus, L.E., (2001), op cit.
[137] Ibid.

expanding, the once-remote area is now coveted by developers. With demand for space and cost of living on the rise, many farms are in financial turmoil. Also in peril are natural wildlife habitat and waterways, estuaries, and shorelines. As the only river system in the Puget Sound watershed where all five salmonids still survive and arguably the most important watershed for the recovery of Chinook and Bull Trout, this area has been identified as a protection and restoration priority for salmon.[138]

Additional Literature:

Biodiversity/Habitat Fragmentation & Loss:

Allen, A.W., B.S. Cade, and M.W. Vandever, (2001), "Effects of emergency haying on vegetative characteristics within selected conservation reserve program fields in the northern Great Plains," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.2

Abstract: Successional changes in vegetation composition within seeded grasslands may affect attainment of long term conservation objectives. Comparisons between vegetation composition within Conservation Reserve Program (CRP) fields planted to cool season, introduced grasses hayed for emergency use, and non hayed fields of the same age and species composition were completed to determine potential effects of periodic haying. Emergency haying had little long term effect on vegetation height/density, percent cover of live grass, or forb cover when compared to characteristics within non hayed fields. The presence of legumes [primarily alfalfa (Medicago sativa L)] increased in response to haying, whereas, abundance of noxious weeds [chiefly Canada thistle (Cirsium arvense (L) Scop.)] diminished. Implications for long term management CRP grasslands to achieve wildlife habitat objectives are discussed.

Bhattarai, Madhusudan and Michael D. Hammig, (1998), *Environmental Policy Analysis And Instruments For Biodiversity Conservation: A Review Of Recent Economic Literature*. Clemson University, Department of Agricultural and Applied Economics, Clemson, SC 29634-0355. Mhammig@clemson.edu

Abstract: This paper provides a synthesis of recent literature dealing with the institutional environment, policy framework, and economic instruments used in policy analysis related to the conservation and sustainable use of biodiversity resources. The paper analyzes the economic consequences of alternative policy options and summarizes the application of these economic issues in the formulation of biodiversity protection policy. The paper also concludes that the proper understanding of underlying institutions and, if needed, institutional reforming procedures are also required to provide appropriate incentive structures for conservation and sustainable use of biodiversity resources. Illustrations of these principles and examples are taken from published accounts of biodiversity policy debates and policy implications.

[138] The Trust for Public Land, (2002), op cit.

Bhattarai, Madhusudan And Michael D. Hammig, (1998), *Environmental Policy Analysis And Instruments For Biodiversity Conservation: A Review Of Recent Economic Literature*.

Broomhall, David , Extension Associate, and Waldon R. Kerns, Virginia Tech. *The Status of Wetlands Management*. Publication Number 448-106, Posted November 1997. http://www.ext.vt.edu/pubs/waterquality/448-106/448-106.html

Abstract: In recent years America's wetlands have received increasing attention. In 1988, George Bush made the protection of wetlands a campaign issue with his pledged support for a federal wetlands policy of "no net loss" of wetlands.' Increased attention to wetlands protection has caused the public to become more appreciative of the functions that wetlands provide, and has forced a reevaluation of the definition of "wetlands" and what is meant by "no net loss." The federal government has taken the lead role in developing policies to protect wetlands, but the states have quickly followed their lead, and, in many cases, developed policies which have more teeth than federal policies and which provide better protection of wetlands. The purpose of this paper is three-fold. The first part discusses the functions that wetlands perform and the causes of wetlands changes. The second portion provides an historical synopsis of the evolution of wetlands policy in the United States, including a discussion of the debate over the definition of "wetlands" and the implications for wetlands policy, followed by a discussion of the current state of wetlands policy in Virginia. The paper closes with a discussion of the ways in which economic incentives could be used to strike a balance between responsible development and preservation of wetlands.

Links include:

- Role of Wetlands
- Cause of Wetlands Changes
- Evolution of Wetland Policy
- The Definition of a Wetland
- Virginia's Wetlands Management Programs
- Some Economic Perspectives on Wetlands Management

Note: Chesapeake Bay Information from STAC: "The Scientific and Technical Advisory Committee (STAC) provides scientific and technical guidance to the Chesapeake Bay Program on measures to restore and protect the Chesapeake Bay. As an advisory committee, STAC reports quarterly to the Implementation Committee and annually to the Executive Council. STAC members come primarily from universities, research institutions, and federal agencies. Members are selected on the basis of their disciplines, perspectives, and information resource needed by the Program." http://www.chesapeake.org/home.html

Castro, M. S., K.M Eshleman, R. P. Morgan II, S. W. Seagle, R.H. Gardner, and L.F. Pitelka.Nitrogen, (1997), *Dynamics in Forested Watersheds of the Chesapeake Bay*. (STAC Publication 97-3). June 17-19, 1997.

Classen, Heimlich, House, and Wiebe, (1998), "Estimating the Effects of Relaxing Agricultural Land Use Restrictions: Wetland Delineation in the Swampbuster Program," *Review of Agricultural Economics*, Vol. 20, No. 2, Fall-Winter 1998, pp 390-405

Clemson University, Department of Agricultural and Applied Economics, Clemson, SC 29634-0355.
Mhammig@clemson.edu

Costanza, Robert ; Greer, Jack (Affiliation: U MD), (1997), *The Chesapeake Bay and Its Watershed: A Model for Sustainable Ecosystem Management*? Frontiers in ecological economics: Transdisciplinary essays by Robert Costanza. Cheltenham, U.K. and Lyme, N.H.: Elgar; distributed by American International Distribution Corporation, Williston, Vt.

Flamm, Barry R., (1997), "Sustainable Forests: It's About Time (Montana)." *Journal of Sustainable Forestry*. Volume 4 Number 3/4, 1997, page 139-147

> Abstract: Forest health should be determined by ecological criteria as opposed to the more limited tree production approach. We must recognize the vital relationships between conserving biological diversity and sustaining forest ecosystems. World-wide forest management practices have too often ignored ecological principles, thereby jeopardizing forest health in the lone-term. Much warranted attention has been given to rain forest problems. Temperate, mountain forests are also threatened, presenting unique sustainability problems. The forests of western Montana are a case in point. Sustainability is, of course, about time, and it is about time that forest management is changed to assure healthy forests for the future.

Heimlich, Ralph E., Keith D. Wiebe, et al., (1998), *Wetlands and Agriculture: Private Interests and Public Benefits*. Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 765. September 1998

Houde, E.D., M.J. Fogarty, T.J. Miller., (1998), *Prospects for Multispecies Fisheries Management in Chesapeake Bay: A Workshop*. (STAC Publication 98-002) August 1998.

Ingram, Kevin and Jan Lewandrowski, "Wildlife Conservation and Economic Development in the West," *Rural Development Perspectives*," Vol 14, issue 2, pp. 44-51

Jenkins, Dylan H. (Extension Associate, Department of Forestry, Virginia Tech; James E. Johnson, Professor, Department of Forestry, Virginia Tech), (1999), *Sustainable Forestry: A Guide For Virginia Forest Landowners*. Publication Number 420-139, posted September, 1999. http://www.ext.vt.edu/pubs/forestry/420-139/420-139.html

> Abstract: The purpose of this publication is to provide private landowners with some basic information about forest management and specifics on how timber harvesting should be conducted to ensure the sustainability of forest resources. This guide is designed to help make informed, knowledgeable decisions about managing forests. It will also help to understand the importance of management planning and how to work with professional foresters and natural resource management agencies.

The links address the following:

- What is Sustainable Forestry?
- Wildlife and Other Special Resources
- Pine or Hardwood?
- Environmental Regulations
- Forest Health
- Tax Considerations
- Planning Your Timber Harvest
- Financial Assistance
- Best Management Practices
- Management Assistance
- Economics of Reforestation
- Education Opportunities

Johnson, James E. (Associate Dean - Outreach, College of Natural Resources, Virginia Tech), Barry W. Fox (Extension Specialist - Environmental Education, Virginia State University), Gregory K. Evanylo (Extension Specialist – Soil Science, College of Agriculture and Life Sciences, Virginia Tech), Carl E. Zipper (Assistant Professor - Crop and Soil Environmental Sciences, College of Agriculture and Life Sciences, Virginia Tech.), (1999), *Natural Resources and Environmental Management A Program Focus of Virginia Cooperative Extension*. Publication Number 420-001, posted September, 1999. http://www.ext.vt.edu/pubs/forestry/420-001/420-001.html.

Abstract: The bulletin describes a few of the pressing natural resource and environmental issues common in Virginia, and how Virginia Cooperative Extension is addressing them through education.

The links address:

- Forestry and Wildlife
- Water Quality Protection and Improvement
- Waste Management and Environmental Quality
- 4-H Natural Resources and Environmental Education
- Mined Land Restoration and Development

Johnson, James E. (Associate Professor Forestry, Virginia Tech), Greg A. Scheerer (Former Extension Associate, Virginia Tech), George M. Hopper (Professor of Forestry, University of Tennessee), James A. Parkhurst (Assistant Professor of Wildlife, Virginia Tech), Mike King (Associate Professor of Wildlife, University of Tennessee), John C. Bliss (Extension Specialist, Forestry, Auburn University), Kathryn M. Flynn (Extension Specialist, Forestry, Auburn University), *Managed Forests for Healthy Ecosystems*. This publication is available on-line through the University of Tennessee, and can be accessed at http://www.utextension.utk.edu/pbfiles/pb1574.pdf

Kays, Jonathan S., Robert Tjaden, *Developing A Forest Management Plan: The Key To Forest Stewardship*. Fact Sheet 625. http://www.agnr.umd.edu/ces/pubs/html/fs625/fs625.html

Abstract: The Elements of a Successful Forest Management Plan: A forest management plan is a working guide to good forest stewardship that allows the landowner to maximize the wildlife, timber, recreation, aesthetic value, and other benefits of owning woodland. A good plan combines the natural and physiographic characteristics of the woodlot with the interests and objectives of the owner to produce a set of forest management recommendations. This plan, if followed, should transform the forest into one that is enjoyable and productive for the owner and for future generations.

A forest management plan does not need to be a long, complicated document filled with statistics and confusing jargon; the best plans are brief and to the point. Although formats vary, a sound and useful plan contains these essential elements:
1. landowner objectives for the woodlot;
2. individual maps denoting the property's location, boundaries, forest stands, and soil types;
3. forest inventory data;
4. descriptions and recommendations for each forest stand; and
5. a chronology of recommendations.
   Plans are typically written for a 10-to 15-year period but should be updated about every 5 years. We will follow a sample forest management plan for the Becker farm to illustrate the steps in developing a plan.

Lewandrowski, Jan and Kevin Ingram, (1999), "Policy Considerations for Increasing Compatibilities between Agriculture and Wildlife," *Natural Resources Journal*, Volume 39, Number 2, Spring 1999.

Lyons, J., B.M. Weigel, LK. Paine, and D.J. Undersander, (2000), "Influence of Intensive Rotational Grazing on Bank Erosion, Fish Habitat Quality, and Fish Communities in Southwestern Wisconsin Trout Streams," *Journal of Soil and Water Conservation*, 2000,Vol.55, No.3

Abstract: Riparian buffer strips can improve streams damaged by continuous livestock grazing, but they involve farmer costs that limit their application. We evaluated riparian intensive rotational grazing (IRG) as an alternative stream rehabilitation practice. We compared bank erosion, fish habitat characteristics, trout abundance, and a fish-based index of biotic integrity (IBI) among stations with either riparian continuous grazing, IRG, grassy buffers, or woody buffers along 23 trout stream reaches in southwestern Wisconsin during 1996 and 1997. After statistically factoring out watershed effects, stations with IRG or grassy buffers had the least bank erosion and fine substrate in the channel. Continuous grazing stations had significantly more erosion and, with woody buffers, more fine substrate. Station riparian land use had no significant effect on width/depth ratio, cover, percent pools, habitat quality index, trout abundance, or IBI score, but overall watershed conditions influenced these parameters. Buffers and IRG appear similarly effective for rehabilitating Wisconsin streams.

Noss, R.F., R. Peters, *Oregon's Living Landscape: Strategies and Opportunities to Conserve Bio-Diversity*, Defenders of Wildlife, Washington D.C.

Salleh, M. N., (1997), "Sustainability: The Panacea for Our Forestry Ills?" *Journal of Sustainable Forestry.* Volume 4 Number 3/4, 1997, page 33-43.

Abstract: Fewer than one tenth of tropical forests are being managed on a sustainable basis. Sustainable forest management means managing the forest in such a way as to not irreversibly reduce the potential of that forest to produce all products in subsequent harvests. The United Nations Conference on Environment and Development in Rio resulted in several decisions that are relevant to the future of forestry. The Conference also focused world attention on questions of the environment. One outcome of this increased awareness has been the growing support for eco-labelling, which may provide an opportunity for those countries able to prove their forest products are harvested sustainably. Other economic opportunities present themselves in the utilization for cellulose of tree crops such as rubberwood and oil palm trunks and fronds. Non-wood resources such as rattan also hold promise if we are able to grow them in conjunction with existing tree crops. The roles of tropical forests as carbon sinks require more in-depth study as does the question of what constitutes critical levels of biodiversity. Aesthetic values such as recreational use increasingly require that sufficient buffer zones of unique features be preserved. These challenges demand that the forestry profession becomes more proactive and support major policy changes to address the need for sustainable forest management.

Sharpley, Andrew (ed.), (1998), *Agricultural Phosphorus in the Chesapeake Bay Watershed: Current Status and Future Trends*. April 1998. (hard copies of this document are available from STAC).

Stephenson, Kurt, Waldon Kerns, and Len Shabman. *Market-based Strategies for Chesapeake Bay Policy and Management: A Literature Synthesis.* Virginia Tech Hutcheson Hall Blacksburg: Virginia.

Abstract: Each single species, each bed of Bay grasses, and each individual tributary in the Chesapeake Bay watershed are connected together as parts of a complex web of interactions that make up the Chesapeake Bay ecosystem. Likewise, human activity that makes up social and economic systems and this Bay ecosystem are intertwined. People are dependent on the water and land systems for economic activity, for recreational opportunities, for life support services, and for personal enrichment. In turn, the Bay is affected by human activity in the watershed, sometimes with adverse consequences. In the past 20 years, great strides have been made in the environmental restoration and protection of resources in the Chesapeake Bay. Despite these gains, there is still a widely recognized need for further environmental improvements. Rapid development pressure and population growth throughout the Bay region have placed new demands and more stress on Bay resources. While there is a recognizable need to make further progress in improving the environmental health of the Bay, it is also recognized that further efforts to improve environmental quality will become incrementally more costly to the public and private sectors. This growing concern with the incrementally increasing costs of environmental protection has coincided with common complaints that many existing environmental regulations are too inflexible and too insensitive to individual circumstances and choices. One of the great challenges we face is to better use strategies and mechanisms associated with everyday individual decisions to maintain the balance between the inevitable growth and development of the watershed and the health of the Bay. Improved environmental quality can be accomplished in a more cost-effective fashion by allowing for more individual discretion in making choices related to the environment, while at the same time increasing and improving environmental protection. A set of policy tools that can be used to better achieve environmental objectives has been termed "market-based" environmental policies. The increased development and use of these policies can assist in bridging the gap between the proponents of environmental protection, economic growth, and individual choice. Potentially, these policies will allow environmental goals to be reached at the least cost to society.

Walters, James T. (Former Extension Associate, Department of Forestry, College of Natural Resources, Virginia Tech) and James E. Johnson (Associate Dean of Outreach, College of Natural Resources, Virginia Tech), (2000), *Moving Toward Sustainable Forestry: Strategies for Forest Landowners*. Publication Number: 420-144, posted March 2000. http://www.ext.vt.edu/pubs/forestry/420-144/420-144.html

Invasive Species:

Council for Agricultural Science and Technology, Iowa, (2002), *Invasive Pest Species: Impacts on Agricultural Production, Natural Resources, and the Environment*, Issue Paper, Number 20, March 2002.

Sustainability in Agriculture:

Vickery, J. and Lohr, L., (1997), *Sustainability Assessment in Agriculture: Annotated Bibliography and Resource List of Methods*, Faculty Series form University of Georgia, Department of Agricultural and Applied Economics, 1997.

Abstract: Sustainability assessment is fundamental to improving the long-term viability of agricultural systems. A variety of assessment tools have been developed for the practitioner to evaluate sustainability at multiple levels, from field to farm. This report is a compilation of annotated references on assessment methods from published and unpublished sources. Each section contains a methodological description, a list of published sources, and a list of relevant programs and contacts. While not exhaustive, the report presents a range of tools and applications that are currently in use or are in testing for future use.

CHAPTER3 : ENVIRONMENTAL BENEFITS OF AGRICULTURAL MANAGEMENT PRACTICES

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

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

[139] Babcock, B., et al, (2001), op cit.
[140] Best, L. B. (1985). "Conservation vs. Conventional Tillage: Wildlife Management Considerations." In D'Itri (Ed.). *A Systems Approach to Conservation Tillage*. New York: Lewis Publishers.

Improving Water Quality

Research in the United States indicates that links between conservation practices and observed changes in water quality usually are complex and involve long time lags. Several years of data collection are necessary to distinguish long-term changes of water quality from short-term fluctuations.[141] Nevertheless, there are indicators that conservation management practices improve groundwater - and especially surface water - quality. According to a study by Peter Hill and Jerry Mannering, conservation tillage improves surface water quality by reducing the runoff of soil particles attached to nitrate, phosphorus and herbicides.[142] Residues protect the soil surface from the impact of raindrops and act like a dam to slow water movement. Rainfall stays in the crop field allowing the soil to absorb it. Conservation tillage in combination with the injection of fertilizer or its application in the row at planting time reduces the levels of enriched surface runoff. In addition, macropores, which are the major route for water movement through soil, remain intact, thereby enhancing water infiltration and decreasing water runoff. Table 5 shows that an increase in residue cover contributes to a decrease in surface runoff. Typically, 30 percent residue cover reduces soil erosion rates by 50 to 60 percent compared to the moldboard plow.

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

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

Source: Hill & Mannering, (1995).

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

[141] Smith, R.A., Alexander, R. B. and Lanfear, K. J. (1993), "Stream Water Quality in the Conterminous United States-Status and Trends of Selected Indicators during the 1980's," National Water Summary 1990-91. Water Supply Paper 2400. Washington DC: US Department of the Interior, Geological Survey. 111-140.

[142] Hill, P. R. & Mannering, J. V. (1995). "Conservation Tillage and Water Quality," *Water Quality*, 20.

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

Table 6. Selected Estimates of Benefits from Water Pollution Control

Focus	Investigator	Estimates of Benefits
Water quality benefits of reduced soil erosion from conservation practices	Ribaudo (1986)	Erosion reduction from practices adopted under the 1983 soil Conservation programs were estimated to produce $340 million in offsite benefits over the lives of the practices.
Water quality benefits of reduced soil erosion from Conservation Reserve Program	Ribaudo (1989)	Conservation Reserve Program. Reducing erosion via retirement of 40-45 million acres of highly erodible cropland would generate $3.5-$4.5 billion in surface-water quality benefits over program life.
Recreational fishing benefits from controlling water pollutants	Ruseell & Vaughan (1982)	Total benefits of $300-$966 million, depending on the quality of fishery achieved.
Recreational benefits of surface water pollution control	Carson & Mitchell (1983)	Annual household willingness to pay for improved recreational uses of $205-$279 per household per year, or about $29 billion.
Recreational benefits of soil erosion reduction	Feather & Hellerstein (1997)	Total of $611 million in benefits from erosion reductions on Agricultural lands since 1982, based on recreation survey data.
Drinking water benefits from reduced nitrates in four regions	Crutchfield, Cooper & Hellerstein (1997)	Monthly household willingness to pay for drinking water meeting EPA nitrate standards of $45 - $60 per month.
Freshwater-based recreation benefits from reduced soil erosion from Conservation Reserve Program	Feather, Hellerstein and Hansen (1999)	Annual increase in consumer surplus $35.3 million from improved Quality of recreation at rivers and lakes.

Source: Heimlich, (2003).

[143] Hrubovcak, J., M. LeBlanc,& B.K. Eakin. (1995). *Accounting for the Environment in Agriculture.* TB-1847. U.S. Department of Agriculture, Economic Research Service.

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

Additional Literature:

Dahl, T.E., (1990), *Wetland Losses in the United States*, 1780's to 1980's, Washington D.C.: Department of the Interior, U.S. Fish and Wildlife Service.

Dahl, T.E., and Johnson, C.E., (1991), *Status and Trends of Wetlands in the Conterminous United States*, Mid-1970's to Mid 1980's, U.S. Department of the Interior, Fish and Wildlife Service. Washington DC.

Dosskey, M., (2001), *Toward Quantifying Water Pollution Abatement in Response to Installing Buffers on Cropland.* Environmental Management, 28(5): 577-598.

Gburek, W.J., Sharpley, L., Heatherwaite, L., and Folmar, G.J., (2000), "Phosphorus Management at the Watershed Scale: A Modification of the Phosphorous Index," *Journal of Environmental Quality*, 29: 130-144.

---

[144] Claassen, R., Breneman, V., Bucholtz, S., Cattaneo, A., Johansson, R., and Morehart, M., (2004), *Environmental Compliance in U.S. Agricultural Policy: Past Performance and Future Potential*, Agricultural Economic Report No. 832, June 2004, Washington D.C.: USDA-ERS.

Heatherwaite, L., Sharpley, A.N., and Gburek, W.J., (2000), "A conceptual approach for integrating phosphorous and nitrogen management at watershed scales," *Journal of Environmental Quality*, 29:158-166.

Heimlich, R., Wiebe, R., Claassen, R., House, R., and Gadsby, D., (1998), *Wetlands and Agriculture: Private Interests and Public Benefits*, USDA-ERS, Agricultural Economic Report No. 765, September.

Heimlich, R.E., and Claassen, R., (1998), "Paying for Wetlands: Benefits, Bribes, and Taxes," *National Wetlands Newsletter*, 20: 1-15, Nov-Dec.

Huang, W-y., Uri, N., and Hansen, L., (1994), *Timing Nitrogen Fertilizer Applications to Improve Water Quality*, USDA-ERS, Technical Bulletin No. 9407. February.

Johansson, R., (2002), *Watershed Nutrient Trading under Asymmetric Information*, Agricultural Resource Economics Review.

Kramer, R., and Shabman, L., (1993), "The Effects of Agricultural and Tax Policy Reform on the Economic Return to Wetland Drainage in the Mississippi Delta Region," *Land Economics*, 69(3): 249-62.

Ribaudo, M., (1989), *Water Quality Benefits from the Conservation Reserve Program*, USDA-ERS, Agricultural Economic Report No. 606. February.

Ryan, J., Barnard, R., Collender, and Erikson, K., (2001), *Government Payments to Farmers Contribute to Rising Land Values*, Agricultural Outlook, USDA-ERS, June-July, pp. 22-26.

Sharpley, A., Chapra, S., Wedepohl, R., Sims, J., Daniel, T., and Reddy, K., (1994), "Managing Agricultural Phosphorous for Protection of Surface Waters: Issues and Options," *Journal of Environmental Quality, 23: 437-451.*

Tolman, J., (1997), *How we Achieve No Net Loss*, National Wetlands Newsletter, 19(4): 1-22.

OECD, (2004), OECD Expert Meeting on Agricultural Water Quality and Water Use Indicators, 7-13 October 2003, Gyeongju, Korea. Available online at http://webdomino1.oecd.org/comnet/agr/water.nsf/viewHtml/index/$FILE/Publication.htm Includes PUBLISHED PROCEEDINGS DOCUMENT, RECOMMENDATIONS AND SUMMARY, INDIVIDUAL DISCUSSION PAPERS For hard copy version of the published Proceedings document and copies of individual papers contact Kevin.Parris@oecd.org

Improving Soil Quality

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

Conservation compliance provisions attached to farm program payments have also had a significant effect on soil quality. To remain eligible for Federal agricultural programs, farmers must implement soil conservation systems on highly erodible land (HEL). The USDA found that the annual rate of soil erosion on U.S. cropland declined by nearly 40% between 1982 and 1997, and that about a quarter of that decline could be directly attributed to compliance. However, a large share of cropland erosion reduction occurred on land that was not subject to compliance requirements (non-HEL cropland accounted for 38% of all cropland erosion reduction). Reduced soil erosion on land not subject to compliance, according to the USDA, suggests that other factors, such as technology, information, and markets, played an important role in triggering large-scale erosion reduction. Conversely, compliance may have acted as a catalyst for change, accelerating the adoption of farming practices-such as conservation tillage-that can conserve soil and save farmers money.[148] Between 1982 and 1987, excess erosion (any erosion in excess of the maximum level

[145] Robert et al., (1986).
[146] Uri, N., (1999), op cit.

consistent with maintaining soil productivity) on highly erodible cropland fell by 331 million tons annually. Nearly 90% of this reduction occurred on farms receiving government program payments, and thus can be directly attributed to conservation compliance.[149]

Additional Literature:

Al-Kaisi, M.M. and R.M. Waskom, "Utilizing swine effluent for sprinkler-irrigated corn production," *Journal of Soil and Water Conservation*, Mar-Apr 2002, Vol.57, No.2

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

Claassen, R., Breneman, V., Bucholtz, S., Cattaneo, A., Johansson, R., and Morehart, M., (2004), *Environmental Compliance in U.S. Agricultural Policy: Past Performance and*

---

[147] OECD, 2001; Best, 1985; Warburton, D. B. & Klimstra, W.D., (1984), "Wildlife Use of No-Till and Conventionally Tilled Corn Fields," *Journal of Soil and Water Conservation*, 39. 327-330.

[148] Claassen, R., et al, (2004), op cit.

[149] Ibid.

Future Potential, Agricultural Economic Report No. 832, June 2004, Washington D.C.: USDA-ERS.

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

Claassen, R., Johnston, P., and Peters, M., (2000), *Compliance Provisions for Soil and Wetland Conservation.* Agricultural Resource and Environmental Indicators, USDA-ERS.

Cook, K., (1982), "Soil Loss: A Question of Values. Journal of Soil and Water Conservation," 37(Mar-Apr): 89-92.

Heimlich, R.E., (1986), "Agricultural Programs and Cropland Conversion," 1975-81. *Land Economics*, 62(May): 174-181.

Hyberg, B., (1997), *Conservation Compliance,* Agricultural Resources and Environmental Indicators, 1996-97, USDA-ERS, Agriculture Handbook No. 712.

OECD, (2004), *Agricultural Impacts on Soil Erosion and Soil Biodiversity: Developing Indicators for Policy Analysis*. Proceedings from an OECD Expert Meeting Rome, Italy, March 2003. Available online at http://webdomino1.oecd.org/comnet/agr/soil_ero_bio.nsf

Pierce, F., Larson, W., Dowdy, R., and Graham, W., (1983), "Productivity of Soils: Assessing Long-Term Changes Due to Erosion," *Journal of Soil and Water Conservation*, 38(Jan-Feb): 39-44.

Carbon Sequestration

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

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

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

[150] Al-Kaisi, M. (2001). *Impact of Tillage and Crop Rotation Systems on Soil Carbon Sequestration*, (PM 1871). Iowa State University: University Extension.
[151] Bruce, J., Frome, M., Haites, E., Janzen, H., Lal, R. & Paustian, K., (1998). "Carbon Sequestration in Soils," Paper from Soil and Water Conservation Society, Carbon Sequestration in Soils Workshop, Calgary Alberta, May 1998.
[152] USEPA, 2003 cited in Lewandrowski et al., (2004), op cit.
[153] Babcock, B., et al, (2001), op cit.
[154] Lewandrowski et al., (2004), Ibid.

incentives given to farmers to store additional carbon and often focus on a single carbon-sequestering activity.[155] Based on a range of incentives and multiple agricultural practices, a model developed by Jan Lewandrowski suggests that agriculture can provide low cost opportunities to sequester carbon.[156] Given a price of $10 per metric ton for permanently sequestered carbon, the adoption of agricultural land-use changes (e.g. cropland conversion) and management practices (e.g. conservation tillage) can sequester up to ten million metric tons (MMT) annually. At a price of $125 per metric ton, the annual sequestered carbon in the agricultural sector could reach up to 160 MMT. This is sufficient to offset 4 to 8 percent of the gross emission of greenhouse gases in the United States in 2001.

Additional Literature:

Climate Change/Carbon Sequestration:

Allmaras, R.R., H.H. Schomberg, C.L. Douglas Jr., and T.H. Dao, "Soil Organic Carbon Sequestration Potential of Adopting Conservation Tillage in U.S. Croplands," *Journal of Soil and Water Conservation*, 2000, Vol.55, No.3

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

[155] Stavins, R. N. (1999). "The Costs of Carbon Sequestration: A Revealed-Preference Approach," *American Economic Review*, 89. (4). 994-1009; Pautsch, G. R.; Kurkalova, L.A.; Babcock, B.A. & Kling, C.L. (2001). The Efficiency of Sequestering Carbon in Agricultural Soils, *Contemporary Economic Policy*, 19. (2). 123-134; McCarl, B. A. & Schneider, U. A. (2001), "Greenhouse Gas Mitigation in U.S. Agriculture and Forestry," *Science*, 294. (5551). 2481-2482.
[156] Lewandrowski (2004)

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

Bowman, R. A., and R. L. Anderson, "Conservation Reserve Program: Effects on soil organic carbon and preservation when converting back to cropland in northeastern Colorado," *Journal of Soil and Water Conservation*, Mar-Apr 2002, Vol.57, No.2

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

Darwin, R.F., and D. Kennedy. 2000. "Economic Effects of CO2 Fertilization of Crops: Transforming Changes in Yield into Changes in Supply," *Environmental Modeling and Assessment* 5(3):157-168.

Darwin, R.F. 1999. "The Impact of Global Warning on Agriculture: A Ricardian Analysis: Comment," *The American Economic Review* 89(4):1049-1052.

Darwin, R.F. 1999. "A Farmer's View of the Ricardian Approach to Measuring Effect of Climatic Change on Agriculture," *Climatic Change* 41(3/4):371-411.

Darwin, R.F., *Climate Change and Food Security*, ERS Agriculture Information Bulletin No. 765-8. 2 pp, June 2001,

The Climate Change and Food Security report offers a synthesis of ERS research on the potential impacts of global warming on developing countries in the Tropics and discusses how future climate change research could contribute to food security policies in the region.

Hongli Feng, Catherine L. Kling, Philip W. Gassman, (2004), *Carbon Sequestration, Co-Benefits, and Conservation Programs,* Center for Agricultural and Rural Development, Iowa State University, November 2004 (04-WP 379).

Abstract: Land use changes to sequester carbon also provide "co-benefits," some of which (for example, water quality) have attracted at least as much attention as carbon storage. The non-separability of these co-benefits presents a challenge for policy design. If carbon markets are employed, then social efficiency will depend on how we take into account co-benefits, that is, externalities, in such markets. If carbon sequestration is incorporated into conservation programs, then the weight given to carbon sequestration relative to its co-benefits will partly shape these programs. Using the Conservation Reserve Program (CRP) as an example, we show that CRP has been sequestering carbon, which was not an intended objective of the program. We also demonstrate that more carbon would have been sequestered had CRP targeted this objective, although the "co-benefits" would have increased or decreased.

Houghton, R.A. *Emissions of carbon from land-use change.* In: The Carbon Cycle (T.M.L. Wigley and D.S. Schimel, editors), Cambridge University Press, Stanford, California.

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

Kinsella, J. 1999. *Agriculture's Potential for Reducing Greenhouse Gases: A Carbon Storage Policy Workshop*. Agricultural Technology Center, Lexington, IL 61753

Lewandrowski, J.K., and D.E. Schimmelpfenning. 1999. "Economic Implications of Climate Change for U.S. Agriculture: Assessing Recent Evidence." *Land Economics* 75(1):39-57.

Nearing, M.A., "Potential changes in rainfall erosivity in the U.S. with climate change during the21st century," *Journal of Soil and Water Conservation*, Vol.56, 2001, No.3

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

Owens, L.B., G.C. Starr, and D.L. Lightell, "Total organic carbon losses in subsurface flow under two management practices." *Journal of Soil and Water Conservation*, Mar-Apr 2002, Vol.57, No.2

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

Animal Waste:

Boland, Preckel and Foster. "Reducing Manure Phosphorus from Large-Scale Hog Farms." *Choices*. First Quarter 1999.

Fleming, Babcock, and Wang. "Swine Manure Management." *Choices*. Third Quarter 1998.

Gollehon, "Confined Animal Production Poses Manure Management Problems," *Agricultural Outlook*, AO-274, September 2000.

Kellogg, Robert L. and Charles H. Lander. *Trends in the Potential for Nutrient Loading from Confined Livestock Operations*. NRCS/USDA. Poster Presentation for "The State of North America's Private Land," a Conference Held January 19-21, 1999, Chicago, Illinois. http://www.nhq.nrcs.usda.gov/land/pubs/ntrend.html

Lander, Charles H., David Moffitt, and Klaus Alt (retired). *Nutrients Available from Livestock Manure Relative to Crop Growth Requirements.* U.S. Department of Agriculture, Natural Resources Conservation Service. Resource Assessment and Strategic

Planning Working Paper 98-1. February 1998. http://www.nhq.nrcs.usda.gov/land/pubs/nlweb.html

Letson, David, Noel Gollehon, Vincent Breneman, Catherine Kascak and Carlyle Mose. “Confined Animal Production and Groundwater Protection.” *Review of Agricultural Economics* Fall/Winter 1998 Vol. 20, No.2.

Martin, Laura L. and Kelly D. Zering., “Overview of Environmental Issues Related to the Industrialization of Animal Agriculture.” In *Industrialized Animal Agriculture, Environmental Quality and Strategies for Collaborative Problem Solving and Conflict Resolution*. Proceedings of the Southern Regional Information Ex change Group's Annual Meeting, Atlanta, Georgia, May 22-23, 1997. SRDC Number 208, SRIEG-10 No. 34. Knoxville, TN: SRIEG-10, December 1997. (Also issued as MSU Agricultural Economics Staff Paper 97-44).

Moore, Jr., P. A. 1998. “Best management practices for poultry manure utilization that enhance agricultural productivity and reduce pollution.” pp. 89-124. In J. Hatfield and B. A. Stewart (eds.) *Animal waste utilization: Effective use of manure as a soil resource*. Ann Arbor Press, Chelsea, MI.

Noel Gollehon, Margriet Caswell, Marc Ribaudo, Robert Kellogg, Charles Lander, and David Letson, *Confined Animal Production and Manure Nutrients*, ERS Agriculture Information Bulletin No. 771. 40 pp, June 2001.

Sharpley, A. N., J. J. Meisinger, A. Breeuswma, J. T. Sims, T. C. Daniel, and J. S. Schepers. 1998. “Impacts of animal manure management on ground and surface water quality.” P.173-242. In J. Hatfield and B. A. Stewart (eds.) *Animal waste utilization: Effective use of manure as a soil resource*. Ann Arbor Press, Chelsea, MI.

Sims, J.T. 1997. “Agricultural and environmental issues in the management of poultry wastes: Recent innovations and long-term challenges.” p. 72-90. In J. Rechcigl and H.C. MacKinnon (eds.) *Uses of By-products and Wastes in Agriculture*. Am. Chem. Soc., Washington, D.C.

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

poultry waste management and existing or proposed measures designed to minimize the environmental impacts of poultry based agriculture.

Stout, W.L., Fales, S.A., Muller, L.D., Schnabel, R.R., Priddy, W.E. And Elwinger, G.F. 1997. "Nitrate leaching from cattle urine and feces in Northeast USA. Soil." *Sci. Soc. Am. J*. 61:1787-1794.

Sullivan, "Environmental Regulation and Location of Hog Production." *Agricultural Outlook*, AO-274, September 2000.

CHAPTER 4: BIODIVERSITY AND AGRICULTURE

Working Landscapes and Biodiversity

There is growing awareness, especially in the U.S. and Europe, that working landscapes - private and public productive lands, both forest and farm - *can and should play a critical role in maintaining biodiversity*. Yet policies, programs, and resources, both human and financial, often take the most productive working lands out of production or support environmental degradation, rather than enhancing biodiversity and improving the livelihoods of those dependent on the resources.

New opportunities for improving management and supporting wise stewardship of resources are emerging. Global trends of democratization, decentralization and economic liberalization create new, more open and diverse markets. These trends and new markets have led to or can give stakeholders a stronger voice in the management of local and national resources. Local communities have more opportunities to benefit from natural resources and more incentives to better manage and protect the resources.

In the United States, farm bills that occur every five to seven years have traditionally had a major impact through their incentive structures on how farmers manage agricultural lands. A new farm bill passed in the spring of 2002 provides new opportunities for conservation on working lands by substantially increasing funds available for conservation, along with challenges from creation of programs that can encourage overproduction. These new laws and policy changes provide a mix of measures for attracting the attention of farmers and landowners and for influencing decisions on managing working lands for multiple objectives, including enhancing biodiversity. Despite the apparent availability of dollars at the federal level, *lasting change* requires new institutional partnerships and relationships among government, NGOs, local communities, foundations, and agricultural interests, as well as improved coordination, accountability and progress on meeting clear performance objectives, and application and integration of new tools for managing resources at various spatial scales.[157]

What is needed is the development and implementation of policies and practices that will enable productive farming and forestry lands to also provide ecological services essential to conservation. For this to occur, new approaches must be used that will go beyond a sectoral focus and reflect the multiple uses and values of an area. There is growing acceptance of utilizing a *landscape approach* in conservation management (see definitions below) that identifies linkages within and across the landscape and creates the framework for evaluating current activities and identifying future options and their opportunities. New technologies and approaches, such as geographic information systems (GIS) integrated agronomic and biophysical computer models and low-cost in-site and remote data collection systems, now provide the tools for assessment, planning, and monitoring that enable the implementation of the landscape approach.

Involving communities that live on or are dependent upon the resources in key decisions integrates local benefits, values, and knowledge in the choice of options and timelines and engages those most immediately affected by resource use in the success of outcomes. Multiple objectives at a variety of geographic scales and generational timeframes require pluralistic management arrangements (including participation from local to national and in some instances international stakeholders) that can accommodate multiple interests in land use planning.

The challenge is to develop and support *working landscapes* that capture new opportunities and reflect emerging circumstances and technologies. A coherent strategy builds on these opportunities: linking policy with on-the-ground experience and enabling private landowners to take the lead in landscape-scale management for agricultural and environmental services.

[157] J.B. Ruhl. "Keeping the Agriculture in Sustainable Agriculture: The Challenge of Environmental Policy Reform for Agriculture in the American Midwest," Paper prepared for World Wildlife Fund, American Farmland Trust, Henry A. Wallace Center for Agricultural & Environmental Policy at Winrock International. 2001.

Biodiversity: The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and their ecological complexes of which they are part; this includes diversity within species, between species and of ecosystem. Convention on Biological Diversity, Article 2, 1990.

Working Landscape approach: Utilizing working landscapes as the focus in developing and supporting multiple functions - multiple objective land use that will result in improved rural livelihoods and conservation of natural resources. Ideally, the working landscape approach identifies what functions are to be encouraged/supported in the landscape, the most effective ways to promote these functions, addresses the issue of land tenure and resource access, builds on positive trends and farmer experimentation, involves key stakeholders, collects real data and rethinks assumptions.[158]

Landscape approach: Dynamic approach that focuses on the process of how and why landscape patterns vary over time. It is interdisciplinary and links natural science with social sciences; biophysical elements (including biodiversity and climate change) with the social elements (livelihoods, policies, capacities, etc.). A potentially powerful concept because it accepts mosaics and overlays of diverse use, value and ownership and recognizes scale - values and uses contextualized at one level being weighted differently at other levels.[159]

Agriculture: Wide variety of ways that natural ecosystems are modified to provide goods and services for people through the nurturing of domesticated species of plants and animals, including farming, ranching aquaculture, fishing and forestry. [160]

---

[158] This definition draws heavily on concepts presented by D. Kaimowitz, Beyond Traditional Projects: A Broad Approach to Landscape Restoration, at the *International Expert Meeting on Forest Landscape Restoration (27Februay -2 March 2002), Costa Rica.*

[159] Shepherd, G., "Redefining forestry in a landscape context," Paper presented at the *International Expert meeting on Forest Landscape Restoration*, (27 February -2 March 2002), Costa Rica.

7 McNeely, J. and Scherr, S., (2001), *Common Ground Common Future: How ecoagriculture can help feed the world and save wild biodiversity*. IUCN and Future Harvest.

Farming Practices that Promote Biodiversity

Increasing biodiversity on farms is *highly site specific* and will likely depend on the particular combination of *land*, *available biodiversity* and *commercial enterprise present*. Each of these three factors must be taken into account in the restoration process (*The Farm As Natural Habitat*, 2002). Based on 36 case studies around the world, McNeely and Scherr (2001) recommend a four prong approach to promoting biodiversity including 1) Increase agricultural production on currently farmed land; 2) Enhance wildlife habitat on farms; 3) Establish protected areas near farming areas; and 4) Mimic natural habitats within farming systems. Here in the United States, numerous practices to promote biodiversity have been identified. Most are site specific and many were expressly developed for the Upper Midwest (see Jackson, D. and Jackson, L., (2002), *The Farm as Natural Habitat*; Imhoff, (2002), *Farming with the Wild*)

- Plant several different kinds of grasses and legumes in pasture mixes
- Plant fields in strips of several crops
- Intercrop one species with another (such as field peas with small grains)
- Use cover crops between plantings of major crops
- Add cover crops and farmscape planting to attract pollinators and other beneficial insects (e.g. hedgerow and pollination corridors)
- Maintain hedgerows and windbreaks
- Predator-friendly livestock raising
- Plant a diversity of crops
- Decrease the amount of tillage
- Encourage rotational pastures and mixed-species forestry
- Use Integrated Pest Management
- Establish more habitat niches in wood lots, along roadsides, on orchard and pasture edges and along streams and ponds
- Leave areas in pastures ungrazed during the nesting season for grassland birds
- Remove low areas in fields from cultivation to restore wetlands
- Repair gully erosion including annually clipped grass filter strips along field borders as well as diversions, waterways and grade stabilization structures to better manage flow from field runoff
- Return to crop rotations with sod-forming crops in two or three of every five years (e.g. small grains rotated with legume-grass hay mixtures)
- Add significant perennial cover through prairie, pastures for rotational grazing, 300 foot buffer strips along streams (Upper Mississippi)

In addition to these specific practices, the American Farmland Trust Farms Division recommends:

- Intensive rotational grazing systems- Grass-based livestock management systems are particularly good at promoting BD, especially when combined with set aside paddocks that are left ungrazed for one growing season or part of an annual grazing rotation.
- Streambank fencing, improved low-water crossings, and riparian buffers- Effective barriers between livestock and riparian zones are critical for protecting the biotic diversity of aquatic systems. Animals have very little impact on a stream when they are allowed to water and cross at designated areas that have been improved for this purpose. A minimum 8-10 foot riparian buffer should be maintained between pastures and streambanks. This can be accomplished with permanent or movable fencing.
- Field buffers strips and hedgerows- Hedgerows with trees and shrubs along the edge of a crop field or pasture provide significant habitat for many, many species. A grass strip planted along the edge of a fencerow creates the edge habitat critical for a number of desirable species and opens travel lane for wildlife so they can move more easily between dedicated habitat areas.
- Tailwater ponds and wetlands- On irrigated acres, the collection of tailwaters into a small pond or wetland can create a true oasis for many species of plants and wildlife. In areas with natural wetlands, it is more economically feasible to leave remaining wetlands in place for biodiversity than to drain them for agricultural purposes.
- Residue management- Under intensive row crop conditions, biodiversity (both micro and macro) can be significantly increased simply by leaving more crop residue on the soil surface.
- Reduced tillage- Reduced tillage and zero till keep the biotic diversity of plants and animals in the soil much higher than on fields with heavy annual tillage.
- Controlled burns- On farms that do not have livestock, burning can often be used to control invasive plants and promote the succession of native species (does not include the burning of crop residues).
- Brush piles and nest trees- While most farmers burn brush piles, strategically placed piles of brush around a farm provide shelter for many birds and animals. Also, nest trees with holes suitable for cavity nesting birds should be maintained whenever possible.
- Nest boxes, nesting platforms and hunting perches- Everything from bluebirds to barn owls can benefit from well-placed nest boxes at strategic locations around a farm. Waterfowl have a much better chance of successful nesting when floating nest platforms are places in the open water of ponds and wetlands. Raptors of all sizes will use hunting perches placed in fields, and they will have a big impact of controlling rodents and other small pests.

To protect and restore natural areas (margins, edges, fragments), practices include:

- Restore marginal lands

- Protect remaining habitat remnants on farms (e.g. tall grass prairies with conservation easements)
- Restore roadsides and other publicly owned lands (e.g. seed with native prairie species)
- Enhance remaining pasture and hay lands with native plants (in former prairie states)
- Slow the spread of exotic species

Additional Literature

Centre for Ecology and Hydrology (CEH), Natural Environment Research Council, (2003), *A Review of Research into the Environmental and Socio-Economic Impacts of Contemporary and Alternative Arable Cropping Systems*, CEH PROJECT No: C02067, Huntingdon, Cambs. UK. Available online at http://www.defra.gov.uk/environment/gm/research/pdf/epg_1-5-99.pdf

> Executive Summary: Arable cropping systems have developed and continue to change in response to economic and social pressures. Concern for the state of wildlife and the quality of soil and water has led to further pressures on the way that crops are farmed. There is therefore an ongoing debate about the future of arable farming. This review summarizes current information about the impacts of arable cropping systems, including contemporary agriculture, which is compared with alternative cropping systems in the UK and elsewhere. Studies are reviewed to identify differences between contemporary and five alternative arable cropping systems in relation to their environmental and socioeconomic impacts. They are also assessed in terms of their profitability and levels of input usage. General insights from the literature on farming systems are presented to ensure that this review builds on existing knowledge. For three of the alternative arable cropping systems (low-input systems, integrated arable farming systems and organic farming), a significant body of UK and European research is available for review. For these areas, the information available is not comprehensive, but an indicative picture emerges about them. A number of key information gaps are also identified. For two of the alternative systems (reduced tillage systems and precision farming systems), much less UK and European research has been carried out. Research from countries outside Europe is cited to complement the local results, but for both these systems, the potential for confident conclusions for the UK is lower. Evidence is presented to show the direct and indirect effects of agricultural practices (chemical and physical) on organisms for a range of taxonomic groups. For example: birds, arthropods and earthworms are all detrimentally affected by pesticides; plant and earthworm abundance are affected by nitrogen input; and reduced tillage causes increases in weeds and invertebrates, and reduces earthworm mortality. Therefore, in most cases a reduction of chemical inputs and a reduction in severe soil disturbance will

have ecological benefits. Different arable cropping systems affect the landscape in different ways. This is especially important for birds, mammals and insects that move around in the countryside. Ecological benefits are shown to accrue from mitigation measures such as arable margins, beetle banks, conservation headlands and wild bird cover. These mitigation measures are normally carried out with the assistance of agri-environment scheme payments. Large scale uptake of planned agri-environment schemes is likely to have widespread positive effects on fauna and flora but these effects might not necessarily be large on a per field scale. According to one key report, organic farming of crops is relatively profitable. Although it has lower yields than conventional systems, these are compensated by higher prices. We have some concerns about whether the economic analysis has fully captured the costs of switching to different rotations in organic farming (e.g. including costly years of manure crops to maintain soil fertility) since the study was based on small samples in single years. Low input systems and integrated arable systems were both variable in their economic performance. Their economic returns compared well with conventional systems in some situations but not in others. There is scope for additional economic modelling to broaden the knowledge base about the performance of these systems in different circumstances. Reduced tillage currently has limited economic potential in the UK. Farmers have been reluctant to adopt it. Large capital investment is required at the beginning so it is unsuitable for small farms. Precision farming has been evaluated positively in the one major UK study, but a more sophisticated economic analysis from Australia raises suggests that the UK study may have overstated the likely benefits. Implications for farm labour were identified, the most important of which are a likely increase in labour demand in low input systems and a requirement for more skilled labour in some systems.
Table 1 of the report summarises the review of each of the five alternative cropping systems compared against conventional cropping.

Center for Integrated Agricultural Systems (UW-Madison), (2005), *The Social Implications of Management Intensive Rotational Grazing: An Annotated Bibliography*, Available online at http://www.cias.wisc.edu/bibliog2.php

Numerous studies have documented the economic benefits to farms and farm families using managed grazing systems. However, the social impacts of the use of managed grazing have not been fully researched and documented. This Center for Integrated Agricultural Systems of the University of Wisconsin-Madison has compiled this annotated bibliography with the goal of assisting in a better understanding of the social issues of management intensive rotational grazing. The bibliography presents a comprehensive literature review of social issues of managed grazing, including a summary and analysis of future research needs; over 100 abstracts covering economic, social, and general reports on grazing with links to full web documents provided; more than 30 abstracts covering the

agronomic, environmental, human nutrition, and grazing “how-to” literature; additional internet information sources are also identified.

CIP-UPWARD in collaboration with GTZ, IDRC, IPGRI and SEARICE, (2003), *Conservation and Sustainable Use of Agricultural Biodiversity: A Sourcebook*, Available online at http://www.eseap.cipotato.org/upward/Abstract/Agrobio-sourcebook.htm

Abstract: The appreciation for agricultural biodiversity has grown and matured, resulting in an increasing awareness that its valuation and use could contribute to long-term conservation and use. This sourcebook encourages action aimed at managing agricultural biodiversity resources within existing landscapes and ecosystems, in support of the livelihoods of farmers, fishers and livestock keepers. The publication is a compilation of field-based experiences by scientists, development specialists, academics, policy-makers and donors around the world; it consists of three volumes: 1) understanding agricultural biodiversity, 2) strengthening local management of agricultural biodiversity, and 3) ensuring an enabling environment for agricultural biodiversity. It is designed for use by rural development practitioners and local administrators, as well as trainers and educationalists.

Defenders of Wildlife, (2003), *Integrating Land Use Planning and Biodiversity*, Washington D.C., Available online at http://www.biodiversitypartners.org/pubs/landuse/Landuse_report.pdf

Executive Summary: Sprawl now has such a large and permanent impact on every aspect of the landscape that to achieve their goals for wildlife and ecosystem protection, conservationists must become involved in land use planning. Development is encroaching on parks and protected areas. For every new acre protected, many more are lost to poorly planned development. The Natural Resources Inventory estimates that in the United States, 2.2 million acres are now being converted to development each year. Roads have an ecological impact on an estimated 20 percent of the U.S. landscape. Of the 6,700 species in the U.S. considered at risk of extinction, 85 percent suffer primarily from habitat loss. Although federal wildlife agencies list only approximately 1,300 of these species under the Endangered Species Act, implementing the act remains controversial. If such ecological problems are to be solved, conservationists and land use planners must work together. Yet how can the planning community make use of the vast quantity of available conservation information and the tools of their trade to improve the prospects for the preservation of biodiversity? Land use planning occurs at many different scales across the country. At its best, it is progressive, democratic, timely and responsive to change. When it works, communities thrive and enjoy a high quality of life. When land use planning fails, communities struggle for years with the consequences. Many planners understand the importance of the natural environment to their communities' quality of life, and realize that their decisions can affect human society and wildlife habitats far into the future. Despite this

understanding and land use planning's influence on the landscape, conservationists have traditionally made little use of the local planning process in working toward biodiversity protection. With funding from the Doris Duke Charitable Foundation, Defenders of Wildlife brought together land use planners and conservationists from around the country at a workshop held in the spring of 2002. The workshop's goal was to begin a national dialogue about the integration of biodiversity and land use planning. This report attempts to summarize that discussion and draw attention to the numerous fledgling efforts at conservation planning currently underway in communities throughout the country. The workshop emphasized large-scale conservation planning: the networks of conservation lands that are being planned at state and regional levels across the country. Ideally, this approach will help preserve the country's rich biodiversity by protecting its most viable habitats and species populations. This strategy represents current theories on the application of conservation biology principles to wildlife preservation, and is conservation biologists' recommendation for curtailing loss of habitat and biodiversity. Workshop organizers felt it was crucial to understand how local land use planners view such plans. Among the messages repeated at the workshop was that existing land use planning tools can be used to protect biodiversity. The conservation plans presented at the workshop showed how a variety of incentive-based programs and regulations can be applied locally to protect biodiversity. These presentations also indicated that planners can and do make efforts to assemble networks of conservation lands but that land acquisition — by conservation organizations and/or federal agencies — is not the only solution to protecting lands of conservation value. The lack of political will among community leaders can, however, hamper planners' efforts to use conservation information or make creative use of planning tools. Developing political support for biodiversity protection may be one of the more significant hurdles for large-scale conservation planning efforts to overcome. Planners are not the only people with whom conservationists need to communicate effectively. Members of local planning boards and commissions are tremendously influential, and must be educated and kept informed about conservation issues. Planners at the workshop were quick to point out that conservation planning exercises cannot take place in isolation. Property owners, government agencies and special interest groups will all want to be involved in making decisions that affect land use. For years, the conservation community has discussed the need to include partnerships and multiple stakeholders in their projects. This is especially true in the local land use planning process, particularly in urban areas with large, diverse populations. A conservation plan can only succeed when a community understands and accepts the plan's methodology, goals and results. Large-scale conservation plans work best when used as guidelines and should not be confused with specific, prescriptive land use plans. Large-scale conservation plans can be used to steer development away from ecologically significant areas, but this also requires many more detailed site-specific decisions than such large-scale plans provide. To ensure that they satisfy local needs for open space, large-scale conservation plans may have to be modified. Land use planning can determine how — or even if — the country's urban areas expand, how they affect the surrounding landscape, and health of our environment. The workshop discussion indicates that biodiversity conservation and large-scale conservation plans can be effectively incorporated into the land use planning process.

How to Promote Biodiversity Policies

The following are examples of how agricultural stakeholders can co-ordinate their efforts with the aim of promoting biodiversity and formulating policy measures.

A. Provide Community-based oversight and coordination

Example: Wisconsin Farming And Conservation Together (FACT) formed to address U.S. Fish and Wildlife plan for Lower Baraboo River area: developed framework for private landowners, conservation organizations and governmental agencies to work together to pursue synergistic relationships between conservation and agriculture - fundamental premise is to keep land in private ownership. Have hired a coordinator and are seeking "Special Project" eligibility for the WRP and "Conservation Priority Area" status for CRP. Also seeking additional support from U.S. Fish and Wildlife Service's private land program and Waterfowl Production Area programs (Jackson, D.L. and Jackson, L.L., 2002, *The Farm as Natural Habitat*, www.westgov.org/wga/initiatives/hppbroch.htm).

B. Establish Regional Cooperation

Example: High Plains Partnership (includes 10 states, formed by local Soil and Water Conservation Districts, supported by Western Governors' Association and National Fish and Wildlife Foundation to coordinate programs and projects that benefit at-risk species in short-grass and mixed-grass prairies of the High Plains (Jackson, D.L. and Jackson, L.L., 2002, *The Farm as Natural Habitat*, www.westgov.org/wga/initiatives/hppbroch.htm).

C. Undertake Whole Farm Planning

Whole farm planning can help producers develop, enhance or expand areas where biodiversity can thrive. Producers must: 1). Set goals. 2). Inventory resources (e.g. complete an environmental assessment of the farm). 3). Write the plan and 4). Monitor the results

Environmental Assessment tools include:

- Farm-A-Syst. USDA Extension in Wisconsin. Step-by-step fact sheets and worksheets to identify and address environmental risk. http://www.uwex.edu/farmasyst
- Ontario Environmental Farm Plan (OFEC) - developed in Canada. Highlights a farm's environmental strengths and set goals for improvements. http://www.gov.on.ca/OMAFRA/english/environment/efp/efp.htm
- Kansas "River Friendly Farm Program
- Livestock and Poultry Environmental Stewardship curriculum (developed by 30 land grants, NRCS and ARS). www.LPES.org
- American Soybean Assoc. Best Management Practices Handbook/Workbook. How to select the appropriate BMPs and develop comprehensive action plan. www.soygrowers.com/?v2_group=0&p=498>
- America's Clean Water Foundation On Farm Assessment and Environmental Review. Reviews water quality, odor and pest risk factors for livestock producers www.acef.org/projects/projects.htm
- NRCS Conservation Planning Procedures Handbook. Conservation plans for individuals, area-wide conservation plans or assessments for groups. http://policy.nrcs.usda.gov/scripts/lpsiis.dll/H/H_180_600_1/HTM
- Stream and Riparian Area Management: A Home Study Course for Managers. For livestock producers. www.homepage.montana.edu/~stream>
- Minnesota Land Stewardship Project Monitoring Tool Box (includes quality of life, farm sustainability with financial data, birds, frogs, soils, streams, pasture vegetation. www.landstewardshipproject.org/mtb/lsp_toolbox_html
- Allan Savory Center for Holistic Resource Management. http://www.holisticmanagement.org/
  (*Agricultural Environmental Management Systems*, University of Wisconsin)

D. Draft Farm Stewardship or Resource Conservation Agreements

Example: Florida Stewardship Foundation's voluntary agreement between private landowner and government or nonprofit lasts at least 20 years and covers the implementation of a plan to protect "landscapes that harbor endangered species, wetlands or other natural ecosystems." In return, farmer receives tax breaks or other conservation funding as well as assurances that the economic use of land can continue. This type of agreement is also being explored in Oregon and California and could be expanded as an income payment program (Jackson, D.L. and Jackson, L.L., 2002, *The Farm as Natural Habitat*).

Example: Safe Harbor agreements (California Wilderness Coalition, 2002, *Wild Harvest: Farming for Wildlife and Profitability*).

E. Establish Farmer Support Networks

Traditional model of spawning "innovations" is using on-farm demonstrations hosted by respected farmers. Studies have found that farmers who are part of some sort of producers' organization or informal network are more likely to be successful economically and ecologically because they have access to more information and helpful advice (Jerry DeWitt, in Jackson, D.L. and Jackson, L.L., 2002, *The Farm as Natural Habitat*).

Example: Management intensive rotation grazing networks - usually meet once a month.

F. Communicate Appropriately (why many conservation groups fail)

Conservationists and farmers tend to have different learning styles. While conservationists tend to start from the abstract, think of long-term consequences and use logic and scientific facts to learn and solve problems, farmers tend to start from their own observations and experiences, think in a year-to-year time frame, and rely on storytelling and anecdotes to learn and solve problems. A demonstration that a farmer can explore, contribute to, discover for him or herself is more likely to bring about change in thinking than a string of facts and figures and a logical argument why the new method is better than the old. (Judith Soule, in Jackson, D.L. and Jackson, L.L., 2002, *The Farm as Natural Habitat*).

Recommended Policy Fixes:

(California Wilderness Coalition, 2002, *Wild Harvest: Farming for Wildlife and Profitability*; Jackson, D.L. and Jackson, L.L., 2002, *The Farm as Natural Habitat*).

- Finance a centralized database that enables one-stop shopping for conservation incentives funding (*Wild Harvest*)
- Create a consolidated application for landowners to request incentive funding (*Wild Harvest*)
- Create a commission to help local communities coordinate conservation partnerships between private landowners and state and federal agencies (*Wild Harvest*)
- Encourage self-evaluation tools (see above; *Wild Harvest*)
- Support local partnerships that preserve working agricultural lands, native ecosystems and habitat connectivity (*Wild Harvest*)
- Expand the capacity of local conservation providers that offer technical assistance and in-kind support (*Wild Harvest*)
- Encourage the development of Safe Harbor Agreements (*Wild Harvest*)

- Finance innovative permit coordination programs that simplify the process of regulatory compliance (*Wild Harvest*)
- Create a compliance information program to educate landowners about regulatory processes related to habitat stewardship (*Wild Harvest*)
- Increase funding and staffing for incentive-based stewardship programs within regulatory agencies to increase landowner/agency collaboration (*Wild Harvest*)
- Promote and implement the Conservation Security Program. Expand the Conservation Reserve Enhancement Program (*Wild Harvest*).
- Find a way to offset extreme agricultural losses that result from the recovery of threatened and endangered wildlife populations (*Wild Harvest*)
- Create tax incentives that provide financial compensation to landowners for the restoration of threatened and endangered species habitat (*Wild Harvest*. Also incorporated into Resource Conservation Agreements)
- Create a state or federal tax credit that reimburses the cost of local property taxes to landowners who conserve habitat for threatened and endangered species (*Wild Harvest*)
- Use a Farm Results Index (Land Stewardship Project) that awards points (and dollars) to farms according to environmental and social results they achieve as defined by national and regional goals (would include biodiversity, wetlands protection, ground and surface water protection, and social factors and recalculated every year). Start has been made with Conservation Security Act (*The Farm as Natural Habitat*, George Boody).

More Immediate Policy Fixes:

- Promote targeted risk management options such as American Farmland Trust's ACIC nutrient management policy (to be marketed in pilot program by USDA RMA started in March 2003 in Minnesota, Wisconsin, Iowa and Pennsylvania). Widespread use of policy by corn producers could reduce nitrogen applications by 25 percent, phosphorus applications by 40 percent.
- Address seven key elements in implementation of conservation programs:
  1. fairness and flexibility.
  2. improved priority setting.
  3. a balance between land treatment and retirement.
  4. simplification.
  5. regulatory assurance (using USDA conservation programs will help farmers achieve a measure of compliance with current or pending regulations).
  6. objectives framed so they are appropriate to site and scale.
  7. monitoring and evaluation.
- Articulate national vision.
- Address weaknesses in U.S. conservation technical services infrastructure.
- Strengthen conservation compliance.
- Address invasive species.
- Strengthen the buffer strip initiative (see CRP recommendations that follow).
- Specific recommendations for Conservation Reserve Program from SWCS):

1. Allow limited, managed haying and grazing of conservation buffers in the continuous CRP for maintenance and other purposes (SWCS buffer recommendations). Essential to keep buffers filtering out sediment, nutrients, chemicals and pathogens. Change in statutory language necessary.
2. Increase the CRP acreage cap to accommodate the continuing enrollment of conservation buffers (SWCS buffer recommendations). Also codify into statutory language.
3. Allow wetland restoration as an eligible practice on marginal pastureland (continuous CRP sign-up now accommodates only the enrollment of riparian buffers): fish and wildlife habitat enhancement. (SWVS buffer recommendations). Change in statutory language.
4. Permit contracts longer than 15 years under continuous CRP sign-up: add additional contract options in statutory language).
5. Make all agricultural land eligible for filter strips/riparian buffers (extends continuous CRP sign-up to all cropland and grazing land). Requires rule change (SWCS buffer recommendations).
6. Streamline enrollment in continuous CRP (interactive computer systems, third-party technical assistance). Requires rule change (SWCS buffer recommendations).
7. Provide a restrictive covenant or permanent easement option for participants in the continuous CRP sign-up with rental payments up front. Requires rule change (SWCS buffer recommendations).
8. Change the riparian buffer standard to permit more grass and fewer trees and shrubs. Give USDA personnel at state and local levels greater flexibility to adjust the mix of grass, trees and shrubs, include native vegetation and harmonize buffer installations with local ecological conditions. Requires administrative change (SWCS buffer recommendations).
9. Provide a new incentive for initial buffer demonstrations in any particular county or watershed. Requires administrative change (SWCS buffer recommendations).
10. Allow local USDA officials, via local work groups, greater flexibility in implementing the continuous CRP sign-up (e.g. kind, number and seeding rats of plant materials used; width of buffers; planning of integrated buffer systems; protection of remnant prairies areas; etc.). Requires administrative change (SWCS buffer recommendations).
11. Offer financial bonus or incentive to those farmers and ranchers who collectively use the continuous CRP sign-up to install buffers along a particular watercourse, around a water body, or within a particular landscape (e.g. the Oregon CRP). Requires administrative change (SWCS buffer recommendations).
12. Extend all financial incentives in the continuous CRP sign-up to all eligible buffer practices (currently apply to only five of the 10 practices). Requires administrative change (SWCS buffer recommendations).

13. FSA and NRCS administrators need to promote the continuous CRP sign-up and become more proactive in the field. Requires administrative change (SWCS buffer recommendations).
14. Allow naturally occurring re-vegetation, managed for weeds, as a cover practice option. Requires administrative change (SWCS ACPP recommendations).
15. Allow more flexibility in planting mixtures for CP4D (establishment of permanent wildlife habitat cover on non-easement land). (SWCS ACPP recommendations).
16. Eliminate incentive to break out land as means of gaining eligibility to enroll in CRP Requires administrative change (SWCS ACPP recommendations).

- Work with self-help environmental assessment programs to incorporate practices that promote biodiversity.

Perennialize the Agricultural Landscape: (Laura Jackson, *The Farm as Natural Habitat*). Laura describes the Wes Jackson idea as *natural system agriculture*. She points out that new perennial crops will require decades of plant breeding and agronomic research; that we have little experience selecting for high yields (although the yields of various domesticated woody perennials are encouraging), that there are many problems to work out (how plant species composition will change over time; how weeds and insects will be managed; how nutrient exported at harvest would be replaced; how these new species would be incorporated into human and livestock diets). She concludes that perennializing grain crops may be a long term goal but that we could begin now to "perennialize" the landscape by returning to diverse crop rotations that involve small grains and legume-grass hay mixtures (sod-forming crops).

Additional Literature:

Biodiversity and Sustainable Agriculture (General and by Region)

General Literature:

Alitieri, Miguel, (1999), *Multifunctional Dimensions of Ecologically-based Agriculture in Latin America*, Paper for the FAO/Netherlands Conference on the Multifunctional Character of Agriculture.

Anonymous, (2002), "Trends in Biodiversity," *Science*, Vol. 297, 30 August 2002.

Barrios, A., *Agriculture and Water Quality*, CAE Working Paper Series, WP00-2, June 2000, American Farmland Trust, DeKalb IL.

Batie, S. and D. Ervin, (2001), "Biotechnology and the Environment: Issues and Linkages," *Environment and Development Economics*, 6, 2001: 435-457.

Batie, S. and D. Ervin, (1999), "Flexible Incentives for Environmental Management in Agriculture: A Typology," in *Flexible Incentives for the Adoption of Environmental Technologies in Agriculture*, F. Casey, S. Swinton, A. Schmitz, and D. Zilberman, ed's. Kluwer.

Becker, G. and Womach, J., (2002), *The 2002 Farm Bill: Overview and Status*, CRS Issue Brief for Congress, April 2002, Congressional Research Service, Library of Congress.

Biodiversity Partners *Incentives for Conservation*, (http://www.biodiversitypartners.org/incentives/index.shtml),

The Biodiversity Project, (2002), *Americans and Biodiversity: New Perspectives in 2002, A Cluster Analysis of Findings from a National Survey*, Conducted by Belden Russonello & Stewart, Washington D.C.

The Biodiversity Project, (2002), *Biodiversity Notes*, The Biodiversity Project, Fourth Quarter 2002, Volume VIII, Number 4.

Björklund, Johanna, Karin E. Limburg and Torbjörn Rydberg, (1999), "Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: an example from Sweden," *Ecological Economics* 29 (2) 1999, pp. 269-291.

> Abstract: This paper identifies a number of essential ecosystem services, and estimates their generation by the Swedish agricultural landscape under different production intensities. This is exemplified with data from a low-intensity period (1950s) and a high-intensity one (1990s). The services are described in qualitative and, to the extent possible, quantitative terms, and the ecological functions that support these services are identified. About 20% of Swedish agricultural land has been removed from production during the past 40 years. Production has been strongly intensified with respect to external inputs, and specialized regionally. Local landscape mosaics have been substantially altered, which resulted in a decreased ability of agricultural landscapes to support natural ecosystem components and processes. The authors argue that all of these changes affect the ability of the landscape to generate ecosystem services. Local, ecological `goods and services' have largely been replaced by fossil fuel driven technology and the regulation of the system is now driven much more by external factors. However, there is no notable change in the system's ability to assimilate solar energy, measured by net primary production (NPP) and corrected for the cost of production (external inputs considered as foregone NPP). Most of the measures the authors derive indicate a loss of ecosystem services from the Swedish agricultural landscape. This is tantamount to losing an important form of `local ecological insurance', and could lead to serious problems in a future with lower access to external resources, or with an altered energy policy.

Bugg, R.L. and C.H. Pickett, (1998), "Habitat management to enhance biological control: a concept and its applications," Pp. 1-23 in: Pickett, C. H. and R. L. Bugg [Eds.], *Enhancing biological control: habitat management to promote natural enemies of agricultural pests.* University of California Press, Berkeley, CA.

California Wilderness Coalition, (2002), *Wild Harvest: Farming for Wildlife and Profitability: A Report on Private Land Stewardship*, California: Davis.

Christensen, L. A., (2002), *Soil, Nutrient, and Water Management Systems Used in U.S. Corn Production*, Economic Research Service, USDA, Agriculture Information Bulletin No. 774.

Christman, C. and Sponenberg, D. Phillip, *A Conservation Breeding Handbook,* American Livestock Breeds Conservancy.

Cincotta, Richard P. and Engelman, Robert, (2000), *Nature's place: Human Population and the Future of Biological Diversity*, Population Action International, Washington D.C.

Cincotta, R.P., and Engelman, R., (2000), "Real Numbers- Biodiversity and Population Growth," *Issues in Science and Technology*, spring 2000.

Clark, J. Alan and May, R. M., (2002), "Taxonomic Bias in Conservation Research," *Compass, Science*, Vol 297, 12 July 2002, (http://www.sciencemag.org/)

Conservation International, (2001), "Can We Defy Nature's End?" *Science Magazine*, September 21, 2001, Summary proceedings from Defying Nature's End conference, Conservation International: Washington D.C.

Conservation Technology Information Center, (2001), *Better Soil: More Carbon, Greater Benefits*: *Success Story: Arizona Producer Profits with Conservation*, Partners, Conservation Technology Information Center, March/April 2001, Vol. 19 No. 1.

Council for Agricultural Science and Technology, (2002), *Animal Diet Modification to Decrease the Potential for Nitrogen and Phosphorous Pollutio*", Issue Paper Number 21, July 2002, Council for Agricultural Science and Technology.

Daily, Gretchen C., Susan Alexander, Paul R. Ehrlich, Larry Goulder, Jane Lubchenco, Pamela A. Matson, Harold A. Mooney, Sandra Postel, Stephen H. Schneider, David Tilman, George M. Woodwell, (1997),"Ecosystem Services: Benefits Supplied to Human Societies by Natural Ecosystem", *Issues in Ecology,* 2, 1997.

Defenders of Wildlife, (2002), *Conservation in America: State Government Incentives for Habitat Conservation,* 2002, Defenders of Wildlife.

Defenders of Wildlife *Saving Biodiversity: A Status Report on State Laws, Policies and Programs*, The Biodiversity Center, Defenders of Wildlife, (www.defenders.org/bio-stfl.html) (State profiles on environmental law, programs and policy).

Engelman, R., Cincotta, R.P., Dye, B., Gardner-Outlaw, T., and Wisnewski, J., (2000), *People in the Balance: Population and Natural Resources at the Turn of the Millennium*, Population Action International, Washington D.C.

Environmental Law Institute, *Status of the States: Innovative Strategies for Biodiversity Conservation*, ELI 2001 Research Report, Washington D.C., (http://www.eli.org/store(1)/rr01statesbiodiversity.html)

Environmental Law Institute, *Smart Links: Turning Conservation Dollars into Smart Growth Opportunities*, ELI 2002 Research Report, Washington D.C., (http://www.eli.org/store/rr02smartlinks.html)

EPA, (2002), *Nonpoint Source*, News-Notes, January 2002, #67, Special Focus: Land use and Water Resources, (http://www.epa.gov/OWOW/info/NewsNotes/index.html)

ERS, USDA, (2000), *Agricultural Resources and Environmental Indicators (Biodiversity)*, Washington D.C.

Ervin, D. and F. Casey. "Private Environmental Management in Agriculture." *Choices*, American Agricultural Economics Association.

Ervin, D., J. Kahn, and M. Livingston, Elgar. *Does Environmental Policy Work: The Theory and Policy of Outcomes Assessment*.

Ervin, D. and F. Casey. "The New Economics of Agriculture and the Environment: Voluntary Business Approaches" in *Challenging the Agricultural Economics Paradigm*, Luther Tweeten, editor. Iowa State University Press.

Ervin, D., S. Batie, R.Welsh, C. L. Carpentier, J. Fern, N. Richman, and M. Schulz. *Transgenic Crops: An Environmental Assessment*, Policy Studies Report, Wallace Center for Agricultural and Environmental Policy, Winrock International, November, 2000.
Ervin, D., "A New Era of Environmental Management in Agriculture?" *American Journal of Agricultural Economics*, 78 (December, 1996): 1198-1206, (with A. Schmitz).

Ervin, D., "Agriculture and Environment: a new strategic vision". *Environment*, 1998.

ESA, *Ecological Principles for Managing Land Use*, Committee on Land Use, Ecological Society of America, Washington D.C.

ESA, (2000), "Ecological Principles and Guidelines for Managing Land Use", Ecological Society of America , *Ecological Applications*, Volume 10, 3, June 2000, (http://esa.sdsc.edu/esalanduse.htm)

ESA, (1999), *Biodiversity and Ecosystem Functioning: Maintaining Natural Life Support Processes*, Issues in Ecology, Number 4, Fall 1999, Ecological Society of America.

ESA, (1997), *Biodiversity*, Ecological Society of America, Fall 1997, Washington D.C., (www.esa.org)

ESA, (2000), *Ecological Principles for Managing Land Use*, The Ecological Society of America's Committee on Land Use, ESA, April 2000, (http://esa.sdsc.edu/esalanduse.htm)

FAO, *Biological Diversity in Food and Agriculture*, Food and Agriculture Organization of the United Nations, (http://www.fao.org/biodiversity).

Farm-A-Syst, *Agricultural Environment Management Systems*, Farm-A-Syst, Madison: Wisconsin.

Friesen, L., (1994), *A Literature Review on Wildlife habitats in Agricultural Landscapes*, COESA Report No.: RES/MAN-009/94, Canada-Ontario Environmental Sustainability Accord.

Future Harvest, (2002), *Agriculture and Biodiversity Can Survive and Thrive Together*, Future Harvest, September 2002, Washington D.C., (www.futureharvest.org).

Gottfried, Robert, David Wear, and Robert Lee, (1996), "Institutional solutions to market failure on the landscape scale." *Ecological Economics* 18:133-140.

> Abstract: This paper offers an ecologically-based view of land and land value, building upon the multiproduct nature of ecosystems and upon landscape-ecology. The paper questions the ability of markets to create optimal Landscapes, even when traditional methods of internalizing externalities are applied. and concludes that attempting a complete valuation of ecosystems is quixotic. Achieving sustainable landscapes requires both sufficient ecological knowledge and institutions capable of overcoming landscape-scale market failure. Accordingly, the paper examines factors of public-and private ownership in the United States to assess how well particular institutional conditions might facilitate ecological adaptation there.

Greene, R. P., Stager, J., (2001), "Rangeland to Cropland Conversions as replacement for Prime Farmland Lost to Urban Development," *The Social Science Journal*, 38, 2001, pp. 543-555.

de Groot, Rudolf S., Matthew A. Wilson, and Roelof M. J. Boumans, (2002), "A typology for the classification, description and valuation of ecosystem functions, goods and services," *Ecological Economics*, Volume 41, Issue 3 June 2002, pp. 393-408.

> Abstract: An increasing amount of information is being collected on the ecological and socio-economic value of goods and services provided by natural and semi-natural ecosystems. However, much of this information appears scattered throughout a disciplinary academic literature, unpublished

government agency reports, and across the World Wide Web. In addition, data on ecosystem goods and services often appears at incompatible scales of analysis and is classified differently by different authors. In order to make comparative ecological economic analysis possible, a standardized framework for the comprehensive assessment of ecosystem functions, goods and services is needed. In response to this challenge, this paper presents a conceptual framework and typology for describing, classifying and valuing ecosystem functions, goods and services in a clear and consistent manner. A classification is given for the fullest possible range of 23 ecosystem functions that provide a much larger number of goods and services. In the second part of the paper, a checklist and matrix is provided, linking these ecosystem functions to the main ecological, socio–cultural and economic valuation methods.

Heinz Center, (2002), *The State of the Nation's Ecosystems*, 2002, The H. John Heinz III Center for Science, Economics and the Environment, Washington D.C. (www.us-ecosystems.org), also available in print from Cambridge University Press.

Hodge, Ian, (2001), "Beyond agri-environmental policy: towards an alternative model of rural environmental governance," *Land Use Policy*, Volume 18, Issue 2 April 2001, pp. 99-111.

Abstract: Following the Second World War there were clear priorities for the domestic production of food. Agriculture was viewed as playing a central role in the protection of the rural environment and the support of the rural economy. These assumptions have now been largely rejected and a new framework for the conservation of the countryside is needed. The development of agri-environmental policy signals a start, but there are a number of limitations to this approach. A wider framework is required that includes a variety of alternative linkage mechanisms between the demand for countryside goods and the control of land. These include a range of alternative institutional arrangements among individuals and organisations, with significant roles for government, market and non-profit organisations. No single model can deliver the variety of environmental characteristics that is sought. The development of this new framework presents a challenge for the governance of the countryside.

Jackson, D.L. and Jackson, L.L., (2002), *The Farm as Natural Habitat: Reconnecting Food Systems with Ecosystems*, Washington DC: Island Press.

Jetz, W. and Rahbek, C., (2002),"Geographic Range Size and Determinants of Avian Species Richness," *Science*, Vol. 297, 30 August 2002.

Krieger, D. J., (2001), *Economic Value of Forest Ecosystem Services: A Review*, The Wilderness Society, Washington D.C.

Land Stewardship Project, (2001), *The Multiple Benefits of Agriculture Project, An Economic, Environmental & Social Analysis*, 2001, Land Stewardship Project, (http://www.landstewardshipproject.org/).

Land Stewardship Project, (2001), *Whole Farm Participatory Research, Recommendations from the Monitoring Project Team*, Biological, Financial and Social Monitoring Project, July 2001, Land Stewardship Project.

Land Stewardship Project, *Multiple Benefits of Agriculture*, Programs, Land Stewardship Project, (www.landstewardshipproject.org/programs).

McNeely, J.A. and Scheri, S.J., (2001), *Common Ground Common Future: How Ecoagriculture Can Help Feed The World And Save Wild Biodiversity*, IUCN-The World Conservation Union, Future Harvest.

McNeely, J.A., Scherr, S.J., Rice, R.E., and Backiel., A., (2001), *Beyond Sustainable Agriculture: Increasing Food Production and Sustainable Ecological Diversity*, Environmental Change and Security Project, Woodrow Wilson International Center For Scholars, Washington D.C.

National Association of State Universities and Land-Grant Colleges, *Century III Challenges: A Major Role for Agricultural Research/Extension/Education*, Washington D.C., (wysiwig://11/http://www.nasulgc.org/publications/centuryiii.htm).

National Governors Association Center for Best Practices, (2001), *Private Lands, Public Benefits: Principles for Advancing Working Lands Conservation*, Washington D.C.

The Nature Conservancy, *State Resources, National Biological Information Infrastructure*, USGS, The Nature Conservancy, (www.nbii.gov/geographic/us/state.html).

The National Academies, (2000), "National Strategy needed to Protect Coastal Areas from dangerous Levels of Nitrogen and Phosphorous", *News*, The National Academies, April 4, 2000.

NRCS, USDA, *National Conservation Practice Standards-National Handbook of Conservation Practices*, NRCS, USDA, (National conservation practices in alphabetical order by practice name), (www.ftw.nrcs.usda.gov/nhcp_2.html).

Parliamentary Commissioner for the Environment, (2001), *Weaving Resilience into our Working Lands: Future Roles for Native Plants on Private Land*, Wellington: New Zealand.

Pew Center on Global Climate Change, *Innovative Policy Solutions to Global Climate Change: Agriculture's Role in Addressing Climate Change*, *In Brief*, Number 2, Pew Center on Global Climate Change, Arlington, Virginia. (http://www.pewclimate.org/).

Population Action International, (2000), *Why population matters to Natural Resources*, Factsheet Number 13, 2000, Population Action International: Washington D.C.

Pretty, J. N., C. Brett, D. Gee, R. E. Hine, C. F. Mason, J. I. L. Morison, H. Raven, M. D. Rayment and G. van der Bijl, (2000), "An assessment of the total external costs of UK agriculture," *Agricultural Systems*, Volume 65, Issue 2 August 2000, pp. 113-136.

> Abstract: This trans-disciplinary study assesses total external environmental and health costs of modern agriculture in the UK. A wide range of datasets have been analysed to assess cost distribution across sectors. The authors calculate the annual total external costs of UK agriculture in 1996 to be £2343 m (range for 1990–1996: £1149–3907 m), equivalent to £208/ha of arable and permanent pasture. Significant costs arise from contamination of drinking water with pesticides (£120 m/year), nitrate (£16 m), *Cryptosporidium* (£23 m) and phosphate and soil (£55 m), from damage to wildlife, habitats, hedgerows and drystone walls (£125 m), from emissions of gases (£1113 m), from soil erosion and organic carbon losses (£106 m), from food poisoning (£169 m), and from bovine spongiform encephalopathy (BSE) (£607 m). This study has only estimated those externalities that give rise to financial costs, and so is likely to underestimate the total negative impacts of modern agriculture. These data help to identify policy priorities, particularly over the most efficient way to internalise these external costs into prices. This would imply a redirection of public subsidies towards encouraging those positive externalities under-provided in the market place, combined with a mix of advisory and institutional mechanisms, regulatory and legal measures, and economic instruments to correct negative externalities. Further work examining the marginal costs and benefits of UK agriculture would help to inform future policy development.

Research and Development Group, The Bio-Dynamic Farming and Gardening Association in New Zealand, *A Review of New Zealand and International Organic Land Management Research*, 2002.

> Abstract: Until the mid-1980s organic agriculture struggled to gain scientific credibility in New Zealand and elsewhere in the world. Internationally, the situation has changed dramatically since then. The International Federation of Organic Agriculture Movements (IFOAM) has developed into a highly credible organisation and one that has been instrumental in setting minimum standards for organic practices and products. There are now many research institutes dedicated to organic research, particularly in Western Europe, that are funded by individual governments or the European Union and work collaboratively with traditional research agencies. The biennial IFOAM conferences increasingly highlight the multidisciplinary character of organic research, encompassing areas as diverse as soil ecology, economics and sustainable development. Many New Zealand farmers and orchardists are attracted to organic methods but seek the backing of scientific research. It is becoming evident that organic agriculture requires comprehensive research.This research

review report and catalogue were compiled to provide scientists, policy makers, funding agencies and farmers with information on the current state of organic farming systems research and research methodology, focused around organic soil management. The report provides lists of research institutions and websites that specialize in organic systems research, as well as references to relevant books and research articles. Much of the material is drawn from overseas sources. Where relevant, findings from New Zealand research are provided. This serves to highlight some important points in relation to organic systems research:

- over the last decade a strong scientific basis has been developed, building on the work of the pioneers of organic agriculture in the early part of the 20th century;
- multi-disciplinary and whole-system research approaches that take account of regional, local and on-farm characteristics are required, over long time periods;
- New Zealand organic farmers have mainly relied on knowledge gained from their own experience and trials;
- involvement of organic producers is essential to ensure practical questions are addressed and to conduct credible organic systems research (particularly for participatory and observational approaches that are increasingly being used);
- there are significant opportunities for advancement of knowledge and collaborative research in New Zealand, based on overseas experience;
- increased knowledge of organic farming systems will not benefit the organic sector alone, but will also be of wider benefit to sustainable land management in New Zealand.

Given the significant developments in organic research taking place overseas, it is becoming evident that similar capabilities are required in New Zealand. Some overseas research is applicable in New Zealand, but because organic farming systems often reflect the unique character of the producers and their farm environments, local and regional research is essential to increasing the New Zealand knowledge base. However, the adoption of new research methodologies (as in use by the organic research centres discussed) can contribute significantly to closing the knowledge and experience gap. Early organic research was often focused on comparative trials, using conventional experimental plot design and statistical techniques. Unfortunately, such approaches often required the exclusion of multiple variables that actually determine the viability and vitality of organic farming systems. Quantitative science has an important place, but equally important to research on organic farming systems are more qualitative approaches. This stems from an understanding that organic agriculture is both a technology and a process.

Ruhl, J.B., (2000), “Farms, Their Environmental Harms, and Environmental Law,” *Ecology Law Quarterly*, Bol. 27:263

Scherr, S.J. and McNeely, J.A., (2002), *Reconciling Agriculture and Biodiversity: Policy and Research Challenges of 'Ecoagriculture'*, World Summit on Sustainable Development, The Equator initiative, UNDP.

Shand, Hope, (1997), *Human Nature: Agricultural Biodiversity and Farm-Based Food Security*, RAFI.

Soil and Water Conservation Society, (2000), *Seeking Common Ground for Conservation*, An Agricultural Conservation Policy Project by the Soil and Water Conservation Society, Iowa.

Soil and Water Conservation Society, (2001), *Realizing the Promise of Conservation Buffer Technology: A Report Based on the National Conservation Buffer Workshop, June 12-13, 2001*, Soil and Water Conservation Society, Iowa.

Soil and Water Conservation Society, *Growing Carbon: A New Crop that Helps Agricultural Producers and the Climate Too*, NRCS, USDA, Environmental defense, Soil and Water Conservation Society (www.swcs.org).

Squillace, P., Scott, J., Moran, M., Nolan, T., and Kolpin, D., VOCs, (2002), "Pesticides, Nitrate, and their Mixtures in Groundwater Used for Drinking Water in the United States," *Environmental Science and Technology*, 2002, 36, pp.1923-1930.

Stinner, D. H., Stinner, B.R., and Martsolf, E., (1997),"Biodiversity as an organizing principle in agroecoystem management: Case studies of holistic resource management practitioners in the USA," *Agriculture, Ecosystems and Environment*, 62, 1997, 199-213

United Nations, (2000), *Ecological and Socio-Economic Foundations for Defining Best Practices for Sustainable Agriculture and Rural Development (SARD)*, Agriculture Dialogue Paper 3, 2000, United Nations Commission on Sustainable Development (CSD).

Vickerman, Sara, (1998), *National Stewardship Incentives: Conservation Strategies for U.S. Landowners*, 1998, Defenders of Wildlife.

Villa, Ferdinando, Matthew A. Wilson, Rudolf de Groot, Steven Farber, Robert Costanza and Roelof M. J. Boumans et al, (2002), "Designing an integrated knowledge base to support ecosystem services valuation," *Ecological Economics*, Volume 41, Issue 3 June 2002, pp. 445-456.

> Abstract: Quantifying the value of ecosystem services is important for the social recognition and acceptance of ecosystem management across multiple geographic scales. Yet, the data required to perform such quantifications and the dynamic models that allow the projection of policy changes into the future are currently scattered, incomplete, and difficult to use. The authors describe the design of the Ecosystem Services Database (ESD), an integrated, web-accessible knowledge base that links a relational database for temporally and spatially explicit data to dynamic simulation models. The ESD architecture supports unit standardization, scale translation in space

and time, and statistical analysis. Process-based dynamic models and valuation methods can be run by end users either through a web-based simulation engine or on their own computers by means of open-source software. The knowledge base will serve as: (1) a communication tool for use by researchers in several fields; (2) an analytical tool for meta-analysis, synthesis, and prediction; (3) an educational tool to disseminate knowledge on ecosystem services and their valuation; (4) a collaborative tool for institutions involved in different aspects of ecosystem service valuation; and (5) a prototype for linking databases and dynamic models.

Wildlife Habitat Management Institute, (1999), *Conservation Tillage and Terrestrial Wildlife*, Fish and Wildlife Literature Review, September 1999, Number 1, Wildlife Habitat Management Institute, NRCS, USDA.

Zinn, J.A., (2002), *Soil and Water Conservation Issues*, CRS Issue Brief for Congress, March 2002, Congressional Research Service, Library of Congress.

Regional Literature:

High Plains, Great Plains and Rangelands:

Anonymous, (2001), "Rangelands for the future," *Rangelands* 23(3): 3-4 .

Child, R. Dennis, (2002), *Indicators for maintenance of productive capacity on rangelands*, Bartlett, E.T. and J.E. Mitchell (eds.), Sustainable Rangeland Management: Status of a Roundtable to Determine Criteria and Indicators, Kansas City, MO. pp. 47-49.

Committee on Rangeland Classification, Board on Agriculture, National Research Council. 1994. *Rangeland Health*, National Academy Press, Washington, DC.

Flather, C.H., and S.H. Sieg, (2000), "Applicability of Montreal Process Criterion 1 conservation of biological diversity to rangeland sustainability", *International Journal of Sustainable Development and World Ecology*, 7: 81-96.

Joyce, L.A., Mitchell, J.E., and Loftin, S.R., (2000), "Applicability of Montreal process criterion 3- maintenance of ecosystem health- to rangelands," *International Journal of Sustainable Development and World Ecology*, 7: 107-127.

Joyce, L. and Heitschmidt, R., *Indicators for Ecological Health and Diversity on Rangelands*, (The authors are Research Project Leader, Rocky Mountain Research Station, Fort Collins, CO, and Research Leader and Superintendent, Fort Keogh Livestock & Range Research Laboratory, USDA-ARS, Miles City, MT).

Abstract : This paper is a progress report outlining efforts of the Sustainable Rangeland Roundtable to develop standardized Ecological Health and Diversity indicators for monitoring the sustainability of rangeland ecosystems. To date, 16 indicators have been developed to capture aspects of ecological health and diversity that range from a broad-based assessment of the location and amount of rangeland in the United States to detailed assessments of rangeland ecological processes. The current developmental status of these indicators will be reviewed.

Karl, M.G., Pyke, D.A., Tueller, P.T., Stednick, S.J., Borchard, S.J., and Haglan, W., (2002), "Indicators for Soil and Water Conservation on Rangelands," Bartlett, E.T. and Mitchell, J.E. (eds), *Sustainable Rangeland Management: Status of a Roundtable to Determine Criteria and Indicators*, Kansas City, MO. pp. 41-46.

LaFrance, J.T. and Watts, M.J., (1995), "Public Grazing in the West and Rangeland Reform'94," *American Journal of Agricultural Economics*, Vol. 77, No.3: pp 454-461

Northern Plains Sustainable Agriculture Society, *New Directions for Ag Research* (A Position Paper of the Northern Plains Sustainable Agriculture Society), Northern Plains Sustainable Agriculture Society, (http://www.npsas.org/Research.html).

Society for Range Management, (2000),"Great Plains Grasslands at the Millennium", Symposium at the 1999 Society for Range Management Meeting, Omaha, NE, 24-25 February 1999, *Proceedings in Great Plains Research*, 9 (2) Spring 2000.

West, N.E., (1993), "Biodiversity of Rangelands." *Journal of Range Management*, 46: 2-13.

Midwest:

Cornelia Butler Flora, March 2001, *Midwestern Beef and The Environment The Ecosystem Strengths of Better Integrated Value Chains*, North Central Regional Center for Rural Development, Iowa State University

Crabtree, John, (2001), *A New Vision for Midwest Agriculture*, Commission on the Future of Agriculture, March 2001.

Foster, R. and B. Flood. *Vegetable Insect Management With Emphasis on the Midwest*, 1995. Meister Publishing Company, Willoughby, Ohio, 206 pp.

Harmon, J., Glanville, T., Richard, T., *Swine Carcass Composting as Part of an Environmentally Friendly Production System*, Iowa State University, Armstrong Research and Demonstration Farm.

Kemp, Loni, (2001), *Stewardship Incentives: Toward Profitable Farms that Protect the Environment*, The Minnesota Project Co-Chair, National Campaign for Sustainable Agriculture, January 2001.

Kosobud, R.F., (1998), *Urban Deconcentration and Biodiversity Valuation in the Chicago Region, A Study of Some Benefits and Costs of Natural Area Recovery*, Prepared for the Chicago Wilderness Project Coalition, Chicago, IL.

Ruhl, J. B., (2001), *Keeping the Agriculture in Sustainable Agriculture: The Challenge of Environmental Policy Reform for Agriculture in The American Midwest*, Florida State University College of Law, January 2001.

Swinton, Scott M., (2001), *Policy Alternatives to Achieve a Dramatic Reduction in Environmental Impacts from Midwestern Agriculture*, Michigan State University, March 2001.

Teaching Research Extension, Iowa State University, *Conserving Resources-Impacts for Iowans*, (www.ag.iastate.edu/news/harmony01.html).

Wiedermann, R., (2002), *Exotic Invasive Species in Illinois*, The Illinois Steward, Volume 11, No. 1, Spring 2002.

Wildlife Habitat Management Institute, *Buffer Management Options for Nontraditional Wildlife Species in the Midwest*, WHMI's Carryover Projects FY01, FY02, Wildlife Habitat Management Institute, NRCS, USDA, (http://www.ms.nrcs.usda.gov/whmi/projects.htm)

World Wildlife Fund, American Farmland Trust, and the Henry A. Wallace Center for Agriculture & Environmental Policy, *Midwest Region Commodities and the Environment Conference*, Chicago IL (April 30-May 1, 2001), Executive Summary, Proceedings, Links to Partners, Working Papers, (http://www.farmlandinfo.org/MRCE_Workshop/)

California:

Altieri, M. A., (2000), *Agroecology: principles and strategies for designing sustainable farming systems*, Agroecology in Action, University of California, Berkeley: California.

California Wilderness Coalition, (2002), *Wild Harvest: Farming for Wildlife and Profitability- A Report on Private Land Stewardship*, Davis: California, (http://www.calwild.org/).

California Wilderness Coalition, (2002), *California's 10 Most Threatened Wild Places*, Davis: California.

California Agriculture, Division of Agriculture and Natural Resources, University of California, (2002), *New Realities for Irrigated Agriculture*, May/June 2002, (http://danr.ucop.edu/calag/0204JA/editover.html)

Caswell, M. and D. Zilberman, (1985), "The Choices of Irrigation Technologies in California", *American Journal of Agricultural Economics*, 67(2): pp. 224-234.

Charbonneau, R. and Kondolf, G.M., "Land Use Change in California, USA: Nonpoint Source water Quality Impacts," *Environmental Management* Vol. 17, No. 4, pp. 453-460.

Community Alliance with Family Farmers, *Living Soil Symposium*, (www.caff.org).

Diamond Organics, *California Certified Organic Farmers Organic Farming Basics*, (http://www.diamondorganics.com/organicfarming.html).

Ehler, L.E. (2000). *Farmscape Ecology of Stink bugs in Northern California*, Entomological Society of America. 59 pp.

> Stink bugs feast on crops in tropical and temperate regions throughout the world. This ESA memoir summarizes a 3-year study on stink bugs that was conducted at a northern California farmscape. The author studied a complex of stink bugs whose eggs were exploited by predators such as the common pillbug and by several species of parasitic wasps. His analysis suggests that an understanding of the farmscape ecology of mobile pests and their natural enemies will improve our ability to devise ecologically based management systems for these pests. 59 pp.

Sustainable Agriculture, Sustainable Agriculture Research and Education Program, University of California, (1997), *What is Sustainable Agriculture?* (www.sarep.ucdavis.edu/concept.htm).

Sustainable Agriculture, Sustainable Agriculture Research and Education Program, (1995), University of California *Farming Practices Survey*, Fall 1995.

Pacific Northwest:

Beers, E.H., J.F. Brunner, M.J. Willett and G.M. Warner (eds), (1993), *Orchard Pest Management: A Resource Book for the Pacific Northwest.* Good Fruit Grower. Yakima: Washington, 276pp.

> Abstract: Contains findings on integrated pest management tactics, not only in the Pacific Northwest, but throughout the United States. It explains in detail the philosophy of IPM, and the tools and tactics needed to implement this management approach.

Noss, R.F., R. Peters, *Oregon's Living Landscape: Strategies and Opportunities to Conserve Bio-Diversity*, Defenders of Wildlife, Washington D.C.

Vickerman, Sara, *Stewardship Incentives: Conservation Strategies for Oregon's Working Landscape*, Defenders of Wildlife.

Florida:

Cox, J., Kautz, R., Maclaughlin, M., and Gilbert, T., (1994), *Closing the Gaps in Florida's Wildlife Habitat Conservation System*, Florida Game & Freshwater Fish Commission, Tallahassee: Florida.

Wyckoff-Baird, B., (2000), *Institutional arrangements for Ecosystem Management: The Case of South Florida, United States - A Case Study for Shifting the Power: Decentralization and Biodiversity Conservation*, Biodiversity Support Program: Washington D.C. (www.BSPonline.org).

Louisiana:

ECONorthwest, (2001), *Sustainable Louisiana, An Introduction to Sustainable Development in Louisiana*, Eugene: Oregon.

Mississippi:

ESA, *Hypoxia*, Ecological Society of America: Washington D.C., (www.esa.org).

Mississippi State University Extension Service, *Environmental Quality: Sustainable Agriculture*, (http://msucares.com/environmental/sustainable/bmp.html).

Ohio State University, "Potential Solutions for Gulf of Mexico's 'Dead Zone' Explored", *Research News*, (www.acs.ohio-state.edu/units/research/archive/hypoxia.htm).

USGS, (2000), "Nitrogen in the Mississippi Basin-Estimating Sources and Predicting Flux to the Gulf of Mexico", *Fact Sheet*, 135-00, December 2000.

North Carolina:

Department of Environment and Natural Resources, State of North Carolina, (1999), *Efforts to improve erosion and sedimentation control in North Carolina continue to evolve.* State of North Carolina, Department of Environment and Natural Resources, Vol 6 No 1, January - March 1999 Land Quality Section Division of Land Resources.

Environmental Defense, (2001), *Challenge-Saving Rare Species and Other Wildlife*, 12/10/2001, (http://www.environmental defense.org/).

Environmental Defense, (2001), *How Farmers, Ranchers, and Forest landowners Can Protect Wildlife Habitat on their Land*, 12/10/2001, (www.environmental defense.org).

Environmental Defense, (2002), *North Carolina Helps Level the Field, Measure Removes Tax Penalties for Landowners Choosing to Preserve Land*, 09/10/2002, (http://www.environmental defense.org/).

Walker, Joseph C., Gregory D. Jennings, and Jon A. Arnold, *Erosion and Sedimentation Control in North Carolina*, North Carolina Cooperative Extension Service, Publication Number: AG 473-20.

Abstract: When the land is disturbed at construction sites the soil erosion rate accelerates dramatically. The major problem associated with erosion at a construction site is the movement of soil from the site and the impact of the soil on water quality in streams and rivers and wildlife habitat. This fact sheet describes the North Carolina regulations and practices that address sediment control for construction activities.

CHAPTER 5: AGRICULTURAL CONSERVATION, LAND VALUES AND PRODUCERS

Conservation and Land Values

In addition to the environmental benefits - public goods or positive externalities - that the adoption of agricultural conservation management practices bring to the table, there is much evidence to show that land values increase as farmers adopt these various techniques. The following is a sample of research on how farmers stand to benefit directly through an economically tangible indicator - their land values.

A. Conservation Practices of Farmers

- Corporation for the Northern Rockies. 2004. *Sustainable Land Stewardship* http://www.northrock.org/sustainable_stewardship.shtml.
  This article highlights how both financial and quality of life benefits can be obtained from sustainable land stewardship. The article does not specifically state that land conservation will increase land value, but indirectly touches upon the issue through a descriptive piece outlining numerous benefits and techniques farmers or ranchers can use in land conservation. The techniques include physical practices, such as fencing to keep cattle away from sensitive areas, and upland water developments.

- Scottish Executive Publications Online. 2004. *Nature Conservation Designations and Land Values*. http://www.scotland.gov.uk/cru/kd01/orange/nedlv-07.asp. (see under "The Effects of Environmental Policies on Land Values): Has a policy focus and cites literature indicating, "in areas where CRP entries are concentrated…land prices tend to drift upwards".

- A comprehensive discussion of farmer decision alternatives between soil degrading practices and conserving practices and the calculations of present, short- or long-run gains in net farmland value (and from one parcel of land to the next) can be read at ERS' *Linking Land Quality, Agricultural Productivity, and Food Security*. By Keith Wiebe, Resource Economics Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 823. http://www.ers.usda.gov/publications/aer823/aer823.pdf

B. Conservation Reserve

- The 1996 Farm Bill's elimination of most acreage planting restrictions led to the upward pressure on land values, as some farm operators sought additional land on which to plant crops. See "Farm Real Estate Values Continue to Increase"

[*Agricultural Outlook*, ERS-USDA, December 1996]
http://www.ers.usda.gov/publications/agoutlook/dec1996/ao236d2.pdf

C. Conservation Easements

Where easements are concerned, a few examples of land value impact:

- The Land Trust Alliance (undated) notes that easements may raise the value of neighboring lands http://landtrustalliance.bc.ca/public/tax%20consequences.pdf

- *Carolinian.org* (undated) says, "Conservation easements also have value for the surrounding area. A conservation easement may increase the value of nearby properties. An easement may also redirect or avoid development that would be very costly for a municipality and other agencies to service (with roads, sewers, school buses, etc.)." http://www.carolinian.org/ConservationPrograms_Easements.htm

- "Top Ten Reasons to Be Skeptical About Voluntary Conservation Easements" by John D. Echeverria, Georgetown Environmental Law & Policy Institute, October 28-31, 2004, "Owners are paid to restrict their land but the restrictions may have little or no adverse effect on the value of the land; indeed, easements restrictions can sometimes increase land values.
  http://www.law.georgetown.edu/gelpi/papers/topten.pdf

- Short-term Effects of Land Conservation on Property Tax Bills - A general discussion of questions that can be raised once the net revenue loss due to conservation has been calculated, whether such an investment is worthwhile.
  http://www.tpl.org/tier3_cdl.cfm?content_item_id=1136&folder_id=827

- The New Roxbury Land Trust, Inc. July 23, 2004. *Tax Benefits of Land Conservation* – "Don't let another year pass without conserving your land".
  http://www.nrlt.org/tax_benefits_of_land_conservatio.htm.
  The concept of land value increasing through conservation tax breaks is described. Income Taxes, Estate Taxes, and Conservation Easements are summarized.

D. Conservation, General

- In a recent University of California study, property values were positively correlated with the distance to the nearest stand of native oak trees.[161] A decrease of 10 percent in the distance to the nearest oak stands and to the edge of the permanent open space land resulted in an increase of $4 million in the total home value, and an increase of $16 million in total land value in the community. This study clearly

[161] Standiford, R.B. and Scott, T.A., (2001), "Value of oak woodlands and open space on private property values in Southern California." Special Issue-Investigacion Agraria: Sistemas Y Recursos Forestales-Towards The New Forestlands Commercial and Environmental Benefits Accounting. Theories and Applications (P. Campos Palacin, ed.). 1: 137-152.

> showed that oaks on a parcel, the presence of oaks in a neighborhood, and the presence of hardwood rangeland open space adjacent to a property, all positively affect land and home values. Large blocks of open space may therefore contribute to not only the value of the specific property, but may increase the overall value of an entire community. http://nature.berkeley.edu/forestry/OakWoodlandWP.pdf

Farmland Amenities

Not all of the benefits of working farmland may be classified and measured in tangible terms by the economic value of goods produced, or even by the indirect beneficial affects that agricultural conservation practices may have upon the environment. Much evidence shows that the public is also attracted to the aesthetically pleasing features of working farms, particularly those that have adopted conservation practices. These attributes of working farm include farmland amenities, which range from scenic beauty to the cultural value of farming as a way of life, and non-farm amenities like open space, wildlife habitats, and absence of development. It is difficult to accurately measure the value of farmland amenities, partly because they are subjective and partly because they are considered a public good, i.e.- one person's use or enjoyment of this type of product does not exclude another's. In some cases, they do indeed carry a market value where, for example, a farmer may control hunting access to his land or where the public may be charged a cost to pick their own apples. But because most farmland amenities are not of this type, they could be under-provided as they are not reflected in the farmland's market price. This justifies the need for government programs to subsidize their provision and non-government organizations to promote them. Placing a value on their provision, however, requires an assessment of the public's 'willingness to pay' for them, which may be difficult to measure unless a distinction can be made between rural amenities and farmland-specific amenities. Various studies suggest that farmland-specific amenity values are positive and are in addition to the 'rural amenity' value of farmland.[162]

According to Irwin et al, the relative value of farmland amenities varies from region to region and depends on several factors, including - the total amount of farmland (preserved

[162] Irwin, E., Nickerson, C., and Libby, L., (2003), "What are Farmland Amenities Worth?", *Choices*, Third Quarter 2003, pp. 21-23.

and unpreserved) which determines the relative scarcity of farmland amenities in a region, the population within a region and the characteristics of people living in a region, the geographic pattern of the farmland, and the geographic distribution of the population visa-vie the farmland.[163] The variations in farmland amenity values across locations will have important implications for how preservation programs are best implemented - nationally or locally. Further complications arise as farmland amenity values vary over time, changes in other rural land uses occur, and competing effects from working farmland make preservation of large blocks of farmland attractive for promoting rural amenities - which in turn would reduce public access to farmland amenities.[164] Protecting farmland and rural amenities has become an important point of discussion in international trade negotiations, yet placing values on such amenities remains elusive.

Additional Literature:

Bergstrom, J., Dillman, B., and Stroll, J., (1985), "Public environmental amenity benefits of private land: The case of prime agricultural land," *Southern Journal of Agricultural Economics*, 17(1), pp. 139-149.

Irwin, E.G., (2002), "The effects of open space on residential property values," *Land Economics*, 78(4), pp. 465-481.

Johnston, R.J., Opaluch, J.J., Grigalunas, T.A., and Mazzotta, M.J., (2001), "Estimating amenity benefits of coastal farmland," *Growth and Change*, 32, pp. 305-325.

Kline, J. and Wichelns, D., (1996), "Public preferences regarding the goals of farmland preservation programs," *Land Economics*, 72, pp. 538-549.

Kline, J. and Wichelns, D., (1994), "Using referendum data to characterize public support for purchasing development rights to farmland," *Land Economics*, 70(2), pp. 223-233.

Kreiger, D., (1999), *Saving open spaces: Public support for farmland protection*, Working paper series wp99-1, DeKalb: Center for Agriculture in the Environment, American Farmland Trust.

Nickerson, C.J. and Hellerstein, D., (2003), "Protecting rural amenities through farmland preservation programs." *Agricultural and Resource Economics Review*, 32(1), pp. 129-144.

[163] Ibid.
[164] Ibid.

Producers and the Environment - Survey Research

During 2001, American Farmland Trust sponsored two coordinated surveys to measure (among other things) the extent to which owners of urban-edge agricultural land were willing to provide environmental benefits that urban and suburban voters valued.[165] If many owners currently did use their land in ways the voters preferred or would do so in the future in response to incentives that the surveys specified, there could be justification for substantial public expenditures to achieve the valued benefits. Alternatively, so few owners might be willing to cooperate that too little could be accomplished. The risk would be high that too many farms or ranches causing environmental problems or having the potential to provide positive amenities (e.g., scenic vistas, wildlife habitat) would not be enrolled for technical assistance or cost- sharing because the owners did not care to participate.

Fortunately, for three important environmental objectives, the AFT surveys found considerable agreement between what voters wanted from agriculture and what owners of farms and ranches on the urban edge said that they were either doing currently or would undertake in response to financial incentives: managing their crop or livestock operations so as to avoid pollution of surface and groundwater, protecting or improving habitat for wildlife, and preserving the land for agricultural use rather than selling it for development purposes.

Conducted in June and July 2001, AFT's telephone survey of registered voters interviewed 2,216 randomly chosen adults spread over all 50 states.[166] A total of 1,511 reported that they lived in urban or suburban areas. The companion survey reached from 316 to 329 owners of urban-edge farm or ranch land in each of five important agricultural states: *California, Michigan, New York, Texas, and Wisconsin***.** Either interviewed by telephone or surveyed by a mailed-back questionnaire during the period, late August 2001 to February 2002, these owners were asked about the current conservation activities on their

[165] The major findings, survey design, details and conclusions may be found in Esseks, J.D. and Kraft, S.E., "Are Owners of Urban-Edge Agricultural Land Willing to Provide Environmental Benefits that Urban and Suburban Residents Value? Findings from Two Coordinated Surveys: A National Survey of Registered Voters and A Survey of Owners of Agricultural Land in Urban-Edge Counties of Five States: California, Michigan, New York, Texas, and Wisconsin," American Farmland Trust, Survey Memo # 9, April 2002.

land and their likely responses to federal incentive payments designed to stimulate new stewardship effort.

These states were chosen for their agricultural and political importance. California's agricultural output has the highest dollar value among all 50 states. Texas ranks second.[167] Wisconsin and New York are major dairy states. Michigan's farm economy has important dairy, greenhouse/nursery, and grain sectors. California, New York, and Texas have the three largest Congressional delegations, while--as demonstrated in the 2000 election--Wisconsin and Michigan can be key states when choosing presidents.

The five-state survey focused on urban-edge because farms and ranches there have the potential to provide environmental services of high value to large numbers of urban and suburban residents such as:

- open-space that can be enjoyed for its scenic vistas and--with the owner's agreement--for hunting, hiking, and camping;
- habitats for many species of wildlife;
- surface and groundwater for human consumption that is free of agricultural pollutants, and
- fresh fruits and vegetables sold locally through farm stands, farmers' market, or grocery stores.

To achieve and sustain these environmental benefits, many farms and ranches need financial assistance. If the five-state survey found a good match between the environmental benefits voters wanted from agriculture and what many owners of farm and ranch land close to the majority of voters (i.e., residents of cities and suburbs) were willing to provide, there would be a strong argument for appropriately targeted and adequately funded governmental assistance.

The surveyed owners were asked a series of questions designed to determine the variety of conservation practices being applied to their land in the current year. The researchers were interested in seven types:

---

[166] These respondents were reached through random digit dialing.
[167] USDA, Economic Research Service, 1999 data for "Final agricultural sector output" by state. www.ers.usda.gov/StateFacts/ [October 27, 2001].

- "This year does any of the agricultural land you own have applied to it one or more methods that aim to minimize soil erosion?
- . . . that aim to minimize the flow of chemical fertilizers or pesticides into surface or groundwater?
- . . . that aim to minimize the flow of livestock waste into surface or groundwater?
- . . . that aim to protect or improve wildlife habitats?
- . . . that aim to protect or improve wetlands?
- . . . that aim to minimize overgrazing or other damage to pasture or range land?
- . . . irrigation methods applied to it that aim to minimize the quantity of water used or minimize the rate of water evaporation?"

Urban and suburban residents should be personally interested in most, if not all, seven kinds of practices. Eroded soil (from tilled fields or overgrazed pastures), pesticides, fertilizers, and livestock waste can dangerously pollute drinking-water supplies for cities and suburbs, as well as contaminate lakes, rivers, and other bodies of water used for recreation. AFT's national public opinion poll found that urban and suburban respondents showed considerable concern that "agricultural pesticides or livestock manure may contaminate drinking water in your community." Forty percent said they were "very concerned" and another 25 percent were "somewhat concerned," for a combined 65 percent (Table 7). Since the question dealt with contamination "in your community," the conservation activity or lack of it by urban-edge farmers was particularly relevant.

Table 7. Extent that urban and suburban respondents were "concerned that agricultural pesticides or livestock manure may contaminate drinking water in your community"

Response Choices	% Respondents per Choice
Very concerned	**40**
Somewhat concerned	**25**
Not too concerned	17
Not concerned at all	17
Don't know or won't say	1
Total percent	100
Total respondents	1,511

The wildlife habitat provided by urban-edge farms and ranches should also be important to urban and suburban residents. Such habitat's closeness to these residents was probably one of the reasons that so many of the national poll's respondents from urban and suburban locations--56 percent--"highly valued" "farms or ranches as habitats for wildlife like pheasants, wild ducks, and other animals" (Table 8). Twenty-seven percent "moderately valued" them for that reason, for a combined 83 percent. Many, if not most, Americans are wildlife watchers. Among the 1,000 randomly selected adults polled in a recent national survey sponsored by Ducks Unlimited:

- "76% said they have a medium to high interest in wildlife.
- 44% said they participated in bird watching in the past year.
- 55% said they have viewed wildlife away from home."[168]

Table 8. Extent that urban and suburban respondents valued farms or ranches as habitats for wildlife like pheasants, wild ducks, and other animals

Response Choices	% Respondents per Choice
Value highly	56
Value moderately	27
Value slightly	10
Value not at all	6
Don't know or won't say	1
Total percent	100
Total respondents	1,511

Wetlands can provide recreational opportunities (bird watching, hunting), as well as help to prevent down-stream flooding, to filter out impurities from water, and to achieve other significant benefits to urban and suburban areas. Irrigation practices that conserve water should also be valued since in dry parts of the country the water that agriculture saves is freed up for use by cities and suburbs.

The surveyed urban-edge agricultural landowners in California, Texas, Wisconsin, Michigan, and New York indicated the following levels of conservation activity on their land (Table 9):

Table 9. Extent of conservation activity on surveyed owners' land: Percent of respondents reporting that practices were currently being applied to agricultural land they owned (by type of conservation practice and by state)

[168] Ducks Unlimited website. "New DU Study Examines Americans' Attitudes and Knowledge of the Environment": www.ducks.org/news/du_study_environment.asp [January 23, 2002].

Type of Conservation Practice by Purpose	Percent of Total Respondents Who Reported At Least One Practice of The Indicated Type				
	California	**Texas**	**Wisconsin**	**Michigan**	**New York**
1. To minimize soil erosion	45	44	60	53	58
2. To minimize flow of chemical fertilizers or pesticides into surface or groundwater	31	21	36	36	34
3. To protect or improve wildlife habitats	34	35	40	36	28
4. To protect or improve wetlands	17	9	24	23	21
5. To minimize flow of livestock waste into surface or ground water[1]	25	14	37	35	41
6. To minimize overgrazing or other damage to pasture or range land[1]	55	61	22	23	29
7. Irrigation methods to minimize the quantity of water used or the rate of water evaporation[2]	52	8			
Applied one or more practices from at least *one* of the above seven types of practices.	81	70	77	71	76
Applied one or more practices from at least *two* of the above seven types.	59	49	54	52	54
Total Respondents	323	322	316	327	329

[1]Question asked only of owners with livestock raised on their land during the current year (2001).
[2]Asked only of owners in California and Texas.

The survey process had three design features to increase the chances of obtaining honest reports about conservation activity. It invited owners to reply "unsure" rather than providing only "yes" and "no" response options when asked about a particular conservation purpose. Secondly, "yes" answers triggered a follow-up question, "What was the main method you used to minimize . . . ?" That is, a false "yes" response would require another, perhaps more painful-to-give, falsehood. Thirdly, the interview questions made it clear that a "no" answer was socially acceptable. Owners who said "no," a certain type of conservation practice was not being applied to their land, were asked a follow-up question about their interest in applying such practices in the future in order to become eligible for federal incentive payments. Moreover, the researchers reviewed the practices given as the "main methods" and did not count any that looked inappropriate.[169] With relatively few exceptions the reported methods clearly fit the given categories:

- no-till, contour farming, and grass waterways were among the frequently reported practices to reduce soil erosion;
- filter-strips, organic farming, and soil tests, among the listed methods to minimize the flow of agricultural chemicals into surface or groundwater;

[169] When the given "practice" was implausible; or the response was simply, "I don't know," we treated the respondent as not having that type of conservation method being currently applied to his/her land.

- providing supplementary food, planting trees, setting aside fields or woodlands for wildlife, and limiting hunting, were among the "main methods" to enhance wildlife habitat;
- avoiding draining and digging ponds to protect or improve wetlands;
- rotational grazing to prevent overuse of pasture land;
- constructing ponds or lagoons that hold animal wastes, fencing livestock out of creeks and other bodies of water, and incorporating manure into the soil rather than leaving it on field surfaces, were among the listed practices to prevent water pollution from livestock waste; and
- drip irrigation, sprinkler systems, and recycling of water, among the methods for economizing on irrigation water.

For three of the seven kinds of practices, some impressive levels of conservation activity were reported. However, the findings for some samples, especially regarding the other four kinds of practices, suggest that there is room for significant conservation gains. Notably, across the samples for all five states, no more than 36 percent of the surveyed owners reported using practices with the objective of minimizing the flow of chemical fertilizers or pesticides into surface or groundwater. Among these non-users, 74 percent said they had field crops, that is, farm enterprise that might well use agricultural chemicals. The percentage of owners with practices to protect wildlife did not exceed 40 percent in any state and was as small as 28 percent in the New York sample. Virtually all farmland can have wildlife-protection measures.

Many of the surveyed owners with such conservation gaps stated in the survey that they were willing to use their own time or money to apply relevant practices if, by doing so, they became eligible for federal incentive payments. For the 2002 Farm Bill both Senator Harkin and Senator Lugar advocated these kinds of payments. Senator Lugar's draft Farm Bill provided for bonus payments of up to $25,000 annually for "producers who implement new [to them] conservation systems."[170] Senator Harkin's concept of three tiers of conservation effort and commensurately higher payments was written into the Farm Bill voted out of the Conference Committee on April 30, 2002. Included in the bill's

[170] NACD (National Association of Conservation Districts), "Comparative Analysis of Conservation Provisions of Combest/Stenholm's H.R. 2646, the Farm Security Act of 2001, Senator Lugar's Farm and Ranch Equity Act of 2001 & Existing Law": www.nacdnet.org/govtaff/FB/Combest-Lugar [October 29, 2001].

"Conservation Security Program," it provides annual payments of up to $45,000 "for maintaining or adopting practices on private agricultural land."[171]

Table 10. Likely effectiveness of conservation incentive payments in leveraging new stewardship effort: Percent of surveyed owners who were willing to contribute time or money to apply to their land conservation practices if, by so doing, they became eligible for federal conservation payments (by type of practice and by state)					
Question wording: "In order to be eligible for federal conservation payments, would you contribute time or money to apply to your land methods that…?"	**Among owners of land to which the indicated type of conservation practice was NOT applied "this year," the percent willing to implement a practice of that type in order to be eligible for a federal incentive payment**				
Type of Conservation Practice by Purpose	**California**	**Texas**	**Wisconsin**	**Michigan**	**New York**
	%	%	**%**	**%**	**%**
Minimize soil erosion[1]	39	44	42	54	45
Minimize flow of chemical fertilizers or pesticides into surface or groundwater[1]	35	45	50	49	44
Protect or improve wildlife habitats[1]	31	33	38	38	37
Protect or improve wetlands[1]	17	22	35	38	34
Minimize flow of livestock waste into ground or surface water[2]	34	42	44	49	53
Minimize overgrazing or other damage to pasture or range land[2]	28	40	33	34	40
Minimize irrigation water used or rate of evaporation[3]	23	27			
Willing to apply at least *one* of the above six or seven types of practices to their land for the first time or after a hiatus[4]	53	63	61	63	67
Willing to apply at least *two* of the above six or seven types of practices to their land for the first time or after a hiatus[4]	30	45	36	38	41
Number of Total Respondents	323	322	316	327	329

[1]Percentages are based on the number of respondents who reported the indicated type of conservation practice was not being applied to their land in 2001.
[2]Question asked only of owners with livestock raised on their land during 2001 and whose land did not have the indicated type of practice applied to it in that year.
[3]Question asked only of owners in California and Texas.
[4]Prcentages based on all respondents.

As Table 10 shows, significant proportions of sampled owners in five states said they would respond positively to incentives to adopt practices. In summary, an incentives approach like that offered by Harkin's Conservation Security Program may be able to leverage considerable new or resumed conservation activity among owners of urban-edge

[171] The United States Senate Committee on Agriculture, Nutrition & Forestry. "Conference Report Documents: Conference Bill Text," p. 103; and "Conference Statement of Managers," p. 58: www.senate.gov/~agriculture/Briefs/2001FarmBill/2001farmbill.html [May 1, 2002].

agricultural land in these five states. Positive interest was found among more than half of the total respondents per state.

Data from the AFT survey suggests that incentive payments may be able to motivate significant numbers of non-operator owners to help apply conservation practices who previously were largely passive about conservation. Across the five samples, from 24 percent of the surveyed owners in California to 37 percent in Wisconsin were non-operators.[172] These respondents were asked if any of their written leases required "the application of conservation practices such as for soil, water, wildlife, or wetlands conservation." A companion question asked if, "independent of written leases," the owner requested any of his/her operators to apply practices. From 22 percent of the non-operator owners in the Texas sample to 39 percent of their counterparts in California reported requiring/requesting practices either through leases or orally. However, among the other non-operators--the 61 percent to 78 percent who apparently did not ask for conservation effort--many to most would respond positively to incentive payments to apply new practices to their land. From 48 percent of this subgroup of non-operators in California to 62 percent in the New York sample said that they would contribute time or money to apply at least one kind of practice that currently was not being used on land they owned. It is of course possible that owners who do not require conservation effort from their operators invest in practices on their own or that their passivity is justified by the operators' good performance record. However, it looks as though incentive payments like those in the Conservation Security Program can activate numerous owners who have been passive about conservation.

The combination of current and contingent conservation effort is promising of significant environmental benefits. Table 11 adds together (a) the surveyed owners who reported having a type of practice currently applied to the land and (b) the respondents not presently having such a practice but willing to contribute time or money to apply one in exchange for incentive payments.

[172] They said "no" to the question, "Are you an operator of any of the agricultural land you own, that is, by yourself or with others, do you make decisions about the day-to-day operations of the farm or ranch, such as what to plant or raise, when to harvest, and when to market the crops or animals?"

Table 11. Combined current and contingent conservation effort: Combined percent of total surveyed owners who either (a) reported that a type of conservation practice was currently being applied to their land or (b) stated they were willing to contribute time or money to apply that kind of practice to their land if, by so doing, they became eligible for federal conservation payments (by type of practice and by state)

Type of Conservation Practice by Purpose	California	Texas	Wisconsin	Michigan	New York
	%	%	%	%	%
1. Minimize soil erosion	66	68	77	77	77
2. Minimize flow of chemical fertilizers or pesticides into surface or groundwater	55	56	68	66	63
3. Protect or improve wildlife habitats	54	56	63	60	55
4. Protect or improve wetlands	27	27	47	47	44
5. Minimize flow of livestock waste into ground or surface water[1]	50	49	64	67	72
6. Minimize overgrazing or other damage to pasture or range land[1]	67	76	48	49	57
7. Minimize irrigation water used or rate of evaporation[2]	63	33			
8. Number of Total Respondents	323	322	316	327	329

[1]Question asked only of owners with livestock raised on their land during 2001, who comprised 162 in the California sample, 259 in Texas, 181 in Wisconsin, 133 in Michigan, and 182 in New York.
[2]Asked only of owners in California and Texas.

The combined percentages were impressive, particularly for minimizing soil erosion, avoiding water pollution from agricultural chemicals, protecting/improving wildlife habitat, and preventing livestock-derived water pollution. For the first three of these four types, the percentages of owners with current applications and future effort contingent on incentives combine to more than 50 percent of each of the five samples. For the fourth, the low end of the range is 49 percent of the owners with livestock on their land. However, these present or future conservationists might collectively own such small proportions of the land that little progress could be made in solving environmental problems. Fortunately, when the researchers added together all the farm or ranch land acres they owned and compared those sums to the total agricultural land reported by the full sample, the percentages were high (Table 12).

Table 12. The significance of the surveyed owners who currently apply or, contingent on incentives payments, say they will apply at least one conservation practice of the indicated type: Their share of the total land owned by all members of the sample of owners of urban-edge agricultural land (by type of practice and state) (Number of owners per group in parentheses)

Type of Conservation Practice by Purpose	California	Texas	Wisconsin	Michigan	New York
	%	%	%	%	%
1. Minimize soil erosion	**72** (209)	**68** (216)	**85** (241)	**91** (253)	**89** (253)
2. Minimize flow of chemical fertilizers or pesticides into surface or groundwater	**56** (179)	**66** (179)	**77** (215)	**81** (217)	**78** (208)
3. Protect or improve wildlife habitats	**67** (172)	**67** (177)	**67** (198)	**65** (195)	**51** (181)
4. Protect or improve wetlands	**46** (88)	**17** (88)	**55** (149)	**48** (154)	**45** (145)
5. Minimize flow of livestock waste into ground or surface water[1]	**54** (79)	**55** (126)	**64** (116)	**77** (89)	**82** (131)
6. Minimize overgrazing or other damage to pasture or range land[1]	**74** (107)	**94** (194)	**40** (86)	**45** (65)	**51** (104)
7. Minimize irrigation water used or rate of evaporation	**71** (200)	**16** (105)			
Total acres owned by all surveyed owners and total owners reporting acres	383,226 (319)	466,016 (317)	84,470 (314)	106,178 (323)	122,084 (329)

[1]The base for this percentage is the total acres owned by all respondents who reported livestock being raised on their land. The total acres owned by respondents with livestock on their land were 301,044 in the California sample; 447,623 for the Texas cases; 56,912 acres in the Wisconsin sample; 41,504 in Michigan; and 78,431 in the New York cases.

One cannot assume that all the current and contingent conservationists identified in the AFT survey will continue or begin to apply appropriate practices. But, for at least the four conservation outcomes discussed in the previous paragraph, the groups of actual or potential practitioners seem large, both in their numbers and the amount of land they own. From among them should come enough conservation effort to make real progress, particularly if they are encouraged, such as through technical assistance and cost sharing. And the encouragement seems justified, not just by the numbers of clients, but also by the finding in another AFT survey that urban and suburban voters value the same kinds of environmental outcomes.

AFT's survey of owners of urban-edge agricultural land in California, Texas, Wisconsin, Michigan, and New York found substantial willingness among owners to provide environmental benefits that urban and suburban voters value: drinking water for their communities that is free of agricultural pollution, wildlife habitat on farms and ranches, and protection of farmland from conversion to nonagricultural uses. That willingness was manifested in current application of relevant conservation measures to the owners' land or in their willingness to respond to federal financial incentives to adopt practices, as well as in their interest in programs to purchase development rights.

In another AFT study conducted in 2001-2002, surveyed owners of urban-edge agricultural land in five states were asked to evaluate 15 types of government assistance.[173] They found two related stewardship objectives to be as important or nearly as valuable to them as was income support assistance. That is, (1) help to minimize use of chemical pesticides or fertilizers and (2) aid in preventing water pollution from crop production were rated about as high as either (3) government payments to offset low market prices for crops or (4) subsidized insurance against crop damage from severe weather. Though related in the sense that reduced chemical use should help to avoid water pollution, the first objective may be pursued exclusively to economize on inputs, while the second may be achieved through means other than decreased application of chemicals (e.g., through buffer strips along water courses).

Whatever the actual relationships, the surveyed owners tended to evaluate both these stewardship purposes as more important than nine of 11 other kinds of assistance that they were asked to assess. Since aid to reduce chemical use and help with avoiding water pollution competed so well in the minds of agricultural land owners, policy makers who allocate public funds should give careful consideration to these two stewardship goals when deciding how best to serve the needs of the sizable urban-edge components of the five states' agricultural sectors.

This AFT study focused on the question of how government can best assist urban-edge agriculture in five important states: California, Michigan, New York, Texas, and Wisconsin. In each state from 316 to 329 randomly selected owners of farm or ranch land were interviewed by telephone or surveyed by mailed questionnaire about:

- their objectives in owning agricultural land,
- the types of conservation practices currently being applied to their land, and
- their assessments of the importance to them of 15 kinds of governmental assistance, including income-support payments, technical assistance and cost-sharing to achieve environmental objectives, and help in diversifying crops or livestock outputs and in marketing products.

[173] The major findings, survey design, details and conclusions may be found in Esseks, J.D. and Kraft, S.E., “What Types of Government Assistance Are Important to Owners of Urban-Edge Agricultural Land? Findings from Surveys Conducted August 2001 to February 2002 in California, Michigan, New York, Texas, and Wisconsin,” American Farmland Trust, Survey Memo # 8, May 2002.

Among the 15 forms of aid that the owners evaluated were five with the potential for environmental benefits:

1. "technical assistance and cost-sharing to minimize the amount of chemical pesticides or fertilizers used on your agricultural land,"

2. "technical assistance and cost-sharing to minimize water pollution from crop production,"

3. "technical assistance and cost-sharing to protect or improve wildlife habitat,"

4. "technical assistance and cost-sharing to minimize water and odor pollution from livestock," and

5. "technical assistance and loans to produce organically grown food."

Technical assistance and cost-sharing grants to help minimize use of chemical pesticides or fertilizers were evaluated as "very" or "moderately important" by 51 percent of the total California respondents, 55 percent in Texas, 59 percent of the Wisconsin sample, 67 percent in Michigan, and 60 percent in New York (data line 1a of Table 13). Such assistance can presently be obtained from, among other sources, USDA's Environmental Quality Incentives Program, which provides grants and technical aid for nutrient and pest management plans.[174]

Table 13. How surveyed owners of urban-edge agricultural land evaluated seven kinds of governmental assistance: Five with potential for environmental benefits and two designed mainly to support owners' income from agriculture: Percentages of (1) all surveyed owners and (2) operator owners with crops or livestock on their land who evaluated a type as either *"very important"* or *"moderately important"* (by type of assistance and by state)

[174] "The Environmental Quality Incentives Program provides technical, educational, and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. . . . The purposes of the program are achieved through the implementation of a conservation plan which includes structural, vegetative, and land management practices on eligible land. Five- to ten-year contracts are made with eligible producers. . . . Incentive payments can be made to implement one or more land management practices, such as nutrient management, pest management, and grazing land management." USDA, Natural Resources Conservation Service, *USDA Conservation Programs:* www.nrcs.usda.gov/NRCSProg.html [December 16, 2001].

Type of Assistance		California	Texas	Wisconsin	Michigan	New York
With Potential for Environmental Benefits		%	%	%	%	%
1. "Technical assistance and cost-sharing to **minimize amount of chemical pesticides or fertilizers** used on your agric. land"	**a. All owners**	**51**	**55**	**59**	**67**	**60**
	b. Operators with crops*	53	60	59	70	62
2. "Technical assistance and cost-sharing to **minimize water pollution from crop production**"	**a. All owners**	**43**	**46**	**64**	**68**	**60**
	b. Operators with crops*	44	49	63	72	63
3. "Technical assistance and cost-sharing to **protect or improve wildlife habitat"**	**a. All owners**	**41**	**54**	**58**	**58**	**47**
	b. Operators with crops*	37	60	53	57	42
4. "Technical assistance and loans to **produce organically grown food**."	**a. All owners**	**33**	**27**	**37**	**33**	**26**
	b. Operators with crops*	35	28	42	34	26
*5. "*Technical assistance and cost-sharing to **minimize water and odor pollution from livestock**"	**All owners w/ livestock****	**40**	**42**	**59**	**65**	**61**
	Operators w/ livestock***	45	45	59	66	59
Income-Support Assistance						
6. "Government . . . payments to you to **offset low market prices for crops**."	**a. All owners**	**40**	**51**	**64**	**70**	**57**
	b. Operators with crops*	45	55	73	74	65
7. "Help with the cost of insurance policies that **insure against damage to crops from [severe weather**]"	**a. All owners**	**52**	**54**	**58**	**65**	**51**
	b. Operators with crops*	62	56	66	67	56
Total Respondents		323	322	316	327	329

*The surveyed operators with crops were 191 in California, 168 in the Texas sample, 191 in Wisconsin, 204 in Michigan, and 226 in New York.
**The owners with livestock numbered 162 in the California sample, 259 in Texas, 181 in Wisconsin, 133 in Michigan, and 182 in New York.
***The surveyed operator owners with livestock were 128 in California, 189 in the Texas sample, 156 in Wisconsin, 114 in Michigan, and 161 in New York.

Reductions in chemical inputs may of course yield more than environmental benefits. Chemicals cost money, so that decreases in their use may achieve higher dollar savings than whatever losses in yield result from lower levels of pesticide or fertilizer applications.[175] For farmers on the urban edge, another practical benefit of reducing chemical use may be avoidance of nuisance complaints from non-farm residents who live

[175] Iowa State University evaluated a two-year program (1993-1995) of promoting Integrated Crop Management statewide. Among the recorded results were cost savings along with higher yields or no change

downwind or downstream from farm operations. Less use may translate into fewer occasions when such residents experience, or believe they are encountering, farm chemicals in the air or water.

One criterion is how such ratings compare to the evaluations given by the same landowners to the country's most expensive form of government assistance to agriculture: crop subsidies. In each of the five states, payments related to past or present crop production (e.g., from Production Flexibility Contracts, Loan Deficiency Payments, Market Loss Assistance) comprised the principal form of federal aid.[176] The surveyed owners were asked, "How important is it or would it be, for the government to give payments to you to offset low market prices for crops?" From 40 percent of the total respondents in the California sample to 70 percent in Michigan rated this form of aid as either "very" or "moderately important" to them. Across the five samples, from 42 percent to 68 percent of the respondents who rated this kind of aid as at least moderately important had *not* received them the previous year.

On the urban edge of the five states, assistance to reduce use of chemicals was regarded about as important as were crop subsidies. Yet among this subset of surveyed owners in Wisconsin, Michigan, and New York, the higher percentages of "very important" evaluations for crop subsidies are significantly different from the corresponding values for assistance to reduce use of chemical pesticides or fertilizers. Surveyed owners also rated help to reduce chemical usage approximately as high as another form of income support: government subsidies of "insurance policies . . . against damage to crops from drought, flood, hail, or other severe weather."

---

in yields. George Cummins, "Iowa: ICM Practices Adopted by Iowa Farmers" (Iowa State University Cooperative Extension): www.ipm.iastate.edu/ipm/ncr/599/iowa.html [March 23, 2002].

[176] The Environmental Working Group breaks federal agricultural assistance payments into three broad categories: "Farming Subsidies," "Conservation Programs," and "Disaster Payments." In its "EWG Farm Subsidy Database, 1996-2001," five crop-related subcategories of "Farming subsidies”---"Production Flexibility Contracts," "Market Loss Assistance - Commodity Crops," "Loan Deficiency Payments," "Market Loan Gains,” and “Oilseeds Program”--account for 64 percent of total USDA payments to New York farms in that six -year period, 68 percent of the Texas payments, 76 percent in Wisconsin, 81 percent in California, and 85 percent in Michigan. www.ewg.org/farm [April 25, 2002].

Table 14. How surveyed owners evaluated two forms of governmental assistance with potential for environmental benefits compared to how they assessed two forms designed mainly to support owners' income from agriculture: Percentages of (1) all surveyed owners and (2) operator owners with crops on their land who evaluated a type as *"very important"* (by type of assistance and by state)

Types of Assistance		California	Texas	Wisconsin	Michigan	New York
With Potential for Environmental Benefits		%	%	%	%	%
1. "Technical assistance and cost-sharing to **minimize amount of chemical pesticides or fertilizers** used on your agric. land"	**a. All owners**	**21**	**33**	**29**	**35**	**30**
	b. Operators with crops*	24	34	31	33	30
2. "Technical assistance and cost-sharing to **minimize water pollution from crop production**"	**a. All owners**	**21**	**25**	**30**	**38**	**32**
	b. Operators with crops*	19	27	31	39	34
Income-Support Assistance						
3. "Government . . . payments to you to **offset low market prices for crops**."	**a. All owners**	**22**	**33**	**37**	**46**	**35**
	b. Operators with crops*	27	36	48	51	42
4. Help with the cost of insurance policies that **insure against damage to crops from [severe weather]**"	**a. All owners**	**27**	**33**	**27**	**38**	**29**
	b. Operators with crops*	32	33	32	39	32
Total Respondents		323	322	316	327	329

*The surveyed operators with crops were 191 in California, 168 in the Texas sample, 191 in Wisconsin, 204 in Michigan, and 226 in New York.

Another form of environmentally oriented governmental assistance that competed well with crop subsidies was "technical assistance and cost-sharing to minimize water pollution from crop production." Though likely to include advice for reducing use of chemical pesticides or fertilizers, assistance to avoid water pollution may focus also (or alternatively) on diverting run-off away from bodies of water. From 43 percent (in California) to 68 percent (Michigan) of the full samples rated help to prevent water pollution from crop production as either "very" or "moderately important" to them. In three of the five samples (California, Wisconsin, and New York) these evaluations were as high or higher than the combined ratings for payments to offset low crop prices, while in the remaining two samples the differences were trivial. Perhaps this type of environmentally oriented government assistance does not compete quite as well as does help to reduce use of chemicals because it lacks the latter's clear potential for improving profitability.

Another form of stewardship-oriented assistance--"technical assistance and cost-sharing grants to protect or improve wildlife habitat"--received many "very" or "moderately important" ratings, but tended to do less well than crop subsidies. Assistance for habitat may be obtained through USDA's Wildlife Habitat Incentives Program (WHIP), [177] among other sources.

The surveyed owners evaluated two other kinds of government aid with environmental objectives: assistance to produce organically grown food and help to minimize water and odor pollution from livestock operations. Only respondents with livestock on their land assessed the second of these two types of aid. The question about organic production was asked of all owners. Across the five samples from 26 percent of the New York sample to 37 percent in Wisconsin evaluated this form of aid as at least "moderately important" to them. These ratings were the lowest for any of the four kinds of environmentally oriented government assistance that the full samples evaluated. Organic production is probably the most risky objective among the four. The process of becoming certified to sell organic food usually takes three years and may require the farmer to master new nutrient and pest management skills, as well as new techniques of marketing.[178] For the five survey states, the estimated proportion of total agricultural land in certified organic production in 1997 ranged from 0.02 percent in Texas to 0.37 in California. Given these small values, the findings do not seem so modest. With 26 percent to 37 percent of surveyed owners per state rating aid to become organic farmers as at least moderately important, there may be the potential among urban-edge producers to increase organic acreage significantly.

The survey indicated that help with reducing use of chemicals and assistance to avoid water pollution from crop production are important to large numbers of owners of agricultural

[177] WHIP provides financial incentives to develop habitat for fish and wildlife on private land. "Participants who own or control private land agree to prepare and implement a wildlife habitat development plan. . . . , [and USDA] offers participants technical and financial assistance for the establishment of wildlife habitat development practices" (USDA, Natural Resources Conservation Service website: www.nhq.nrcs.usda.gov/CCS/FB96OPA/WhipFact.html. [November 20, 2001]).

[178] Catherine R. Greene, 2001. *U.S. Organic Farming Emerges in the 1990s: Adoption of Certified Systems* (Washington, DC: US Department of Agriculture, Economic Research Service, Resource Economics

land on the urban edge. In each of the five state samples, the owners rated one or the other of these two forms of assistance with likely environmental benefits as high or nearly as high as crop subsidies. These two highly rated kinds of stewardship assistance are particularly relevant to the non-farmer populations that live amidst or not too far from the agricultural land of the owners making the evaluations. Reduced use of chemical pesticides and fertilizers may lower air pollution for residents of nearby homes, as well as decrease contamination of fresh fruits and vegetables sold through farm stands or in farmers' markets. Government assistance explicitly designed to avoid water pollution may result in safer drinking water and healthier recreational experiences for urban and suburban residents who use the many bodies of water subject to storm water runoff from agricultural land.

A further related piece of AFT research is an examination into what factors promote agricultural landowners to adopt appropriate conservation measures.[179] The 2002 Farm Security and Rural Investment Act (farm bill) passed by the United States Congress significantly increases conservation assistance to farmers. However, research is still lacking concerning what causes farmers to adopt conservation practices. To make conservation policy as effective as possible, it is necessary to understand why farmers adopt conservation practices. Answers to this question provide information on the ability to change behavior and the tools that are most effective to increase agricultural land stewardship and, in turn, this information helps us more to accurately develop stewardship legislation.

This research analyzes several hypotheses believed to explain whether landowners will adopt conservation techniques. Multiple hypotheses are tested, since adopting a conservation measure is not a single, discreet action, many factors influence adoption. Two methods of inquiry are used to explore this question: a 1,617 respondent survey of agricultural landowners in five states (using data gathered in the above two research projects), and focused interviews of a subset of these landowners. Logistic regression is

---

Division, Agricultural Information Bulletin No. 770), 28 pp. www.ers.usda.gov/publications/aib770. March 24, 2002.

used to analyze the survey data to find factors that are associated with the likelihood of adopting various types of conservation practices. The open-ended interviews are then used to explore issues difficult to address in survey questions.

Results from the logistic regression models disprove some of the literature-based hypotheses, support others, and offer some unexpected findings. The focused interviews show that landowners have multiple motivations for adopting conservation practices, but they are constrained by their operations and external factors. The researcher finds that providing farm subsidies for "environmental improvement" only as the most cost effective method to improve environmental quality would be complicated by a lack of an environmental baseline and the lack of compensation for those already providing environmental amenities. Conversely, providing payments for good practices may promote adoption of practices on land for which they are impractical and may not prevent production from expanding on to productive land. While performance based payments necessitate higher cost planning and enforcement, payments for good practices may have low planning and enforcement costs.

[179] Long, L., (2003), *Conservation Practices Adoption by Agricultural Landowners*, Unpublished Doctoral Dissertation, Department of Political Science, DeKalb, Illinois: Northern Illinois University.

CHAPTER 6: ENVIRONMENTAL BENEFITS OF FARMLAND: PERFORMANCE MEASURES

Agriculture and the environment are inextricably linked. Each depends upon the other for its preservation. The practice of agriculture requires making use of the natural landscape and, in return, the integrity of that land is maintained as open space. This symbiotic relationship has existed for hundreds of years. However, inappropriate use of land can create significant environmental problems. Overgrazing, for example, can lead to severely degraded soil, and the unnecessary use of fertilizers and pesticides may result in polluted soil and groundwater. Agricultural productivity is inevitably lowered, often leading to lower revenue. The U.S. government has chosen farm subsidies as an economic remedy to this cycle. Yet data from several sources has suggested that the employment of subsidies that are not attached to conservation practices has only exacerbated the situation.

The employment of sound agricultural management practices carries the greatest potential to produce environmental benefits. Examples include the conservation of rural landscapes, the propagation of plant and animal biodiversity, and the maintenance of vital ecosystems. Therefore, a change in the US government's subsidization program seems necessary to reallocate public subsidies based on farmland production of food, or lack thereof, to the environmental benefits of farmland on the agricultural landscape. A system of quantifiable measurements will be needed in order to assess such benefits. These measurements will indicate whether the employment of sound conservation practices benefit the environment, and agriculture. The following synopsis identifies the existing models that are used to determine this issue.

Heinz Model

The Heinz Center has defined farmland as including not only fields, orchards, pastures, and vineyards, but also hedgerows, streams, ponds, wetlands, prairies, and woodlots ("Indicators of the Condition and Use of Farmlands," available online at www.heinzctr.org/ecosystems/farm/index.shtml). Within this framework, the Center has delineated eighteen (18) separate indicators, categorized into four (4) groups, to describe the environmental condition and use of farmlands in the US. Each indicator is phrased in the form of a question, and followed parenthetically with information dealing with the indicator).

The first category, SYSTEM DIMENSIONS, looks at the size, extent, and scope of the farming operation itself. These indicators include: 1) How much land is used directly for production of crops and livestock? (cropland acreage has declined since the 1950s, but because official estimates vary, it is difficult to determine exactly how much farmland has been converted to other uses); 2) How much of the farmland landscape is forest, grassland or shrubland, wetlands, or developed land? (some non-cropland areas provide wildlife habitat or serve as streamside buffers or windbreaks, and all add to the visual character of the farmland landscape); 3) How intermingled are croplands and urban and suburban development? (increased development in farming areas can interfere with traditional farming practices and may make farming economically unviable); and 4) How much of the "natural" area in farmlands is in patches of different shapes? (the size and shape of these "natural" patches help determine the ecological services they provide).

The second category, CHEMICAL AND PHYSICAL CONDITION, examines the conditions of farmland surface and groundwater, and the state of the soil. These indicators include: 1) How much nitrate is there in farmland streams and groundwater? (high levels of nitrate in drinking water, especially untreated well water, are a human health concern); 2) How much phosphorous is there in farmland streams? (about three-fourths of farmland stream sites had phosphorous concentrations that exceeded the level recommended by the EPA); 3) How many pesticides are found in farmland streams and groundwater, and how often do they exceed federal standards and guidelines? (83% of monitored streams in farmland areas had at least one pesticide whose concentration exceeded aquatic life guidelines); 4) How much organic matter is there in cropland soils? (organic matter improves the ability of soils to hold water, provides nutrients for crops, reduces erosion, and can help to support soil microorganisms); 5) How much cropland is subject to erosion by wind or water?; 6) How much cropland soil has salt levels? (high-salinity soils, which typically result from irrigation in arid climates, can reduce the ability of soils to support plant growth).

The third category, BIOLOGICAL COMPONENTS, looks at the biological condition of farmlands. These indicators include: 1) What is the condition of the microscopic animal communities in cropland soils? (the condition of nematodes (roundworms) in the soil is a good indicator of overall soil condition); 2) What is the condition of wildlife in areas that are heavily dominated by farmlands?; 3) In areas that are heavily dominated by croplands, is most of the remaining non-cropland vegetation native or non-native? (non-native vegetation often provides less suitable wildlife habitat); 4) What is the quality of the habitat in streams in farmland regions? (stream habitat quality often reflects the effects of activities, including farming practices, in the watershed).

And the final category, HUMAN USE, analyzes aspects of production and other human uses of farmland. These indicators include: 1) How has the per-acre yield of major crops changed over time?; 2) How have farm output and the inputs (pesticides, fertilizers, labor, land, etc.) needed to produce that output changed over time?; 3) What is the value of the nation's production of crops and livestock?; 4) How much recreation takes place on farmland? (a considerable amount of recreation takes place on farmlands (hunting and fishing, for example) and some farmers depend on income from such activities).

ATTRA Model

Another model with which researchers might examine the environmental benefits of farming is presented by the ATTRA Group ("Protecting Riparian Areas: Farmland Management Strategies" Barbara C. Bellows, NCAT Ag Specialist, available online at www.attra.ncat.org/attra-pub/PDF/riparian.pdf). It is the contention of this organization that one of the best ways to determine the extent to which a plot of farmland benefits the environment is by examining the health of its water - and stream - systems. In conducting such an examination, a close scrutiny of the riparian areas provides the best evidence of a stream's health. The model divides its twenty-five (25) indicators into four (4) categories. The parenthetical information following the indicators represents the qualities that would ideally appear in a riparian area (specifically for that indicator).

The first category, VEGETATION INDICATORS, looks to the variety, coverage, diversity, and health of plants in farmland riparian areas. These indicators include: 1) Environmental function of plants (effective water infiltration, effective capture of sediments, structural support of streambanks, reduces stream velocity during floods, shade for reducing water loss and moderating temperatures, habitat for wildlife, birds, and aquatic species); 2) Plant species diversity (predominately native, water-loving riparian vegetation, combination of sedges, rushes, grasses, herbaceous plants, shrubs, and trees); 3) Diversity of plant ages (both young and mature trees and shrubs are present); 4) Plant vigor and reproduction (healthy plant growth and reproduction, plant growth exceeds 80% of potential production); 5) Palatable vegetation (diversity of plant species and plant ages provides palatable vegetation throughout the growing season, trees have an open or park-like appearance); 6) Plant and litter cover (full vegetation coverage throughout the year, litter layer present particularly during winter and spring, provides woody debris that serves as shelter for fish and habitat for aquatic insects); 7) Plant litter movement and plant lodging (uniform distribution of litter, plants remain standing following heavy rainfalls or snowmelts); 8) Width of riparian area (riparian vegetation at least two channel widths on each side of stream).

The second category, SOIL INDICATORS, examines the extent of organic matter, quality of topsoil, and vegetation cover. These indicators include: 1) Organic matter (soil covered by growing plants and plant residues throughout the year, organic matter has accumulated in the soil profile, high soil biological activity, topsoils are deep, soils are well aggregated); 2) Diverse microbial community structure (organic matter decomposes rapidly, effective loss of nitrogen through dentrification, good soil aggregation by microbial slimes); 3) Minimal compaction (soil is soft with high organic matter content, good water infiltration, good soil aggregation, healthy plant growth); 4) Good infiltration (vegetation coverage over the soil surface, good soil aggregation, relatively thick topsoil); 5) Limited runoff (good water infiltration, deep topsoil with good water holding capacity, high amount of organic matter in soil and good soil aggregation); 6) Limited erosion (complete vegetation cover over the soil surface, no indication of soil movement, stream is not muddied by runoff water).

The third category, STREAMBANK AND CHANNEL INDICATORS, looks at water tables, channelization, and streambank elevation. These indicators include: 1) Streambank stability (banks are at elevation of active flood plain, little or no streambank erosion, many strong, fine roots hold streambank in place); 2) Stream channel shape (channel is relatively narrow, banks are relatively straight with deep undercut that provides shade for aquatic species, stream has pools and meanders); 3) Frequency of riffles (relatively frequent occurrence of riffles, distance between riffles is no more than 7 times the measurement of the width of the stream); 4) Riparian water table (water table remains high and stable throughout the year, water loving vegetation predominates, riparian area provides an interface between wet and dry environments); 5) Channel alteration (stream has not been subject to channelization, stream alteration, or dredging).

The final category, INDICATORS OF AQUATIC AND RIPARIAN WILDLIFE, analyzes sedimentation, bird species, and water characteristics. These indicators include: 1) Water quality and quantity (adequate water supply and quantity throughout the year, presence of macroinvertebrate indicators of good water quality such as caddis flies and mayflies, water contains few contaminants such as pesticides, heavy metals, or excess nutrients); 2) Water temperature (streamside vegetation cools streams, undercut streambanks provide shade, presence of aquatic species used for fish food); 3) Stream pools (numerous both deep and shallow stream pools, woody debris present to form pools, complex channel structures); 4) Sediment load (low amount of sediments in streams, water is clear of tea colored); 5) Nutrient and pathogen concentration (natural concentrations of nutrients and pathogens from wildlife in area, little or no evidence of livestock access to streams); 6) Waterfowl habitat (native plant communities are dominant vegetation, land use delayed until chicks have left the nest, land is rested for several years to allow for homing, larger clutches, and earlier nesting, sufficient blocks of land are protected to provide corridors of movement and foraging).

NRCS Model

The Natural Resources Conservation Service (NRCS) has a number of working models to measure the environmental benefits of farmland to the natural landscape. Their "Action Plan on Providing Ecosystem-Based Assistance to the Management of Natural Resources" provides the best means for gauging the environmental aspects of farmland (available online at www.nrcs.gov/technical/ECS/agecol/eireport.pdf). It is a model broken into four (4) categories that implicate eleven (11) broad ranging indicators. The indicators are presented in the form of a question, followed by helpful information related to the indicator itself.

The first category, SYSTEM PROCESSES, examines the system-sustaining, ecological processes of farmland. These indicators include: 1) Are precipitation and ground water resources captured, stored, used, and released in a safe and stable manner? (hydrologic cycle, soil stability, soil infiltration rates, and vegetation cover); 2) Are kinds and flows of chemicals (minerals, nutrients, other) and energy in balance and optimized for plant and animal communities and biomass production requirements? (nutrient cycling, crop/biomass production/decomposition rates, atmospheric transport, energy flow, trophic accumulation); 3) Are annual cash flows, technical assistance and conservation incentives timely and adequate for desired community and landuser incomes? (financial viability, government/industry programs).

The second category, RECOVERY PROCESSES, considers ecosystem structure and the functioning of ecological and human community processes that determine system resistance and resilience to disturbance or stress. These indicators include: 1) Are soil, water, air, plant and animal resources, and biophysical processes in place and in a condition to allow timely and full recovery from stresses and disturbances, and to meet management objectives? (trophic diversity, niche diversity, soil potential/resiliency, disturbance regime, competition, gene pool quality/quantity, contaminant buffering, predator-prey relationships); 2) Are social and economic systems available to allow land-users, and communities and the resources they manage, to recover from environmental and socioeconomic stresses? (social safety nets); 3) Are there human and animal resource health concerns associated with the management of present or planned enterprises? (health problems and treatment).

The third category, LANDSCAPE AND COMMUNITY STRUCTURE, examines plant and animal species composition and human, cultural, social, and economic diversity. These indicators include: 1) Do landscape features and patterns facilitate use, protection, and optimization of ecosystem processes? (diversity, connectivity, land cover, community dynamics, patterns); 2) Do commodity markets, investment capital, and public programs encourage landuses, enterprises, and resource management that are compatible with ecosystem processes? (economic diversity); 3) Are decision-making processes available to communities and individuals to resolve conflicts regarding current and desired uses, management and protection of natural resources? (institutional incentives/constraints, ownership); 4) Does the social infrastructure (health care, education, multi-culture recognition, etc.) support and promote the desired quality of life for the communities and individuals? (infrastructure, cultural diversity, demographics).

Finally, the fourth category, ABIOTIC FEATURES, looks to the abiotic or physical characteristics of the farmland ecosystem. The sole indicator examines: 1) Are current and planned landuses and desired future conditions suited to the abiotic conditions (e.g. stream temperature, flow velocities, riffle/pool ratios, riparian shading, climate, topography, soils, and geology? (topography, soil types/potentials, geology, land uses, water quality/quantity, physical habitat, channel morphology).

Schenck & Vickerman Model

Rita Schenck (Institute for Environmental Research and Education) and Sara Vickerman (Defenders of Wildlife) have proposed a twelve (12) point list of biodiversity indicators that should be identified when considering the environmental benefits of farmland. The indicators are followed again with information pertinent to the indicators themselves.

The indicators are as follows: 1) Protection of priority habitats/species (the acreage of habitat that is physically protected (i.e. through fencing or other methods)); 2) Soil characteristics and soil health (the concentration of organic carbon in the soil); 3) Proximity to and protection of high priority vegetative communities (acreage of habitat set aside (not farmed) that is identified as "high priority."); 4) Interface between water and terrestrial habitats/buffer zones (total linear space of aquatic habitat (i.e. river, lakeshore, etc.) protected via physical means vs. total area managed); 5) Assimilative capacity of water and land and hydrologic function (depletion of water resources - annual use versus recharge rate); 6) Percent coverage of invasive species within protected area (for physically protected areas, density of non-native vegetation - area percentage); 7) Road density (miles of road per square mile); 8) Percent native-dominated vegetation (acreage in native species dominated areas/total area managed); 9) Restoration of native vegetation (acreage newly returned - in last 12 months - to native habitat); 10) Adoption of BMP's linked to biodiversity objectives (number of BMP's adopted); 11) Distribution (patchiness, evenness, etc.) - (size of native-managed acres vs. total acres managed, and size of native-managed acres vs. average field size); 12) Connectivity of native habitat (on managed acres - percent of native-managed land units that has at least one adjacency to other native-managed land).

USDA Model I

Of further interest is the "Pasture Condition Score List" produced by the USDA , which involves the visual evaluation of ten (10) indicators to rate pasture condition (available online: ftp://ftp-fc.sc.egov.usda.gov/GLTI/technical/publications/pasture-score-guide.pdf). The USDA has discovered through use of this model that poor plant growth, weedy species invasion, poor animal performance, visible soil loss, increased runoff, and impaired water quality are causes of concern to the environment. Thus, it has estimated that the higher the indicator scores (in ranking how a farm does with that indicator), the better off the overall environment will be.

These indicators include: 1) Percentage of desirable plants (determines if the pasture has the kind of plants that the livestock on it will graze readily); 2) Plant cover (percentage of soil surface covered by plants is important for pasture production, and soil and water protection); 3) Plant diversity (number of different forage plants that are well represented in a pasture); 4) Plant residue (plants in various states of decay provides additional surface cover and organic matter to the soil); 5) Plant vigor (if plant growth conditions suffer, bare soil will begin to appear); 6) Soil fertility; 7) Severity of use (close, frequent grazing (mown lawn appearance) often causes loss of vigor reducing yields and ground cover); 8) Site adaptation of desired species; 9) Climate stresses (extremely wet, hot, dry, or cold weather may threaten plant vigor even when climatically adapted forage species are present); 10) Soil pH levels, and insect and disease pressure (the former influences plant vigor primarily through its effect on nutrient availability and the latter damages the leaves, stems, and roots of farmland plants).

USDA Model II

The USDA has also produced "Interpreting Indicators of Rangeland Health," (available online:ftp://ftp-fc.sc.egov.usda.gov/GLTI/technical/publications/range-health-indicate.pdf), a collaboration between the BLM, NRCS, ARS, and USGS that provides a model to evaluate the soil/site stability, hydrologic functioning, and the integrity of the biotic community on rangelands. This model presents seventeen (17) indicators used to assess the environmental impact farmland has on the natural landscape.

These indicators include: 1) Rills (rills are small erosional rivulets that result from the interaction between raindrops, overland flow, and the characteristics of the soil surface; 2) Water flow patterns (these patterns are the path that water takes - i.e. accumulates - as it moves across the soil surface during overland flow); 3) Pedestals and/or Terracettes (these are important indicators of the movement of soil by water and/or by wind); 4) Bare ground (bare ground is exposed to mineral or organic soil that is susceptible to raindrop splash erosion, the initial form of most water-related erosion); 5) Gullies (a channel that has been cut into the soil by moving water); 6) Wind-scoured, blowouts, and/or deposition areas (accelerated wind erosion on an otherwise stable soil increases as the surface crust is worn by disturbance or abrasion); 7) Litter movement (the degree and amount of litter - i.e. dead plant material that is in contact with the soil surface. Movement, or redistribution, is an indicator of the degree of wind and/or water erosion); 8) Soil surface resistance to erosion (assesses the resistance of the surface of the soil to erosion); 9) Soil surface loss or degradation (loss or degradation of part or all of the soil surface layer, or horizon, is an indicator of a loss in site potential); 10) Plant community composition and distribution relative to infiltration and runoff (vegetation growth form is an important determinant of infiltration rate and interrill erosion); 11) Compaction layer (a near surface layer of dense soil caused by the repeated impact on or disturbance of the soil surface); 12) Functional/Structural groups (this indicator addresses the various roles that different species fulfill in energy flow and nutrient cycles); 13) Plant mortality/Decadence (the proportion of dead or decadent - moribund or dying - to young or mature plants in the community relative to that expected for the site, under normal disturbance regimes, is an indicator of the population dynamics of the stand); 14) Litter amount (litter in any dead plant material that is in contact with the soil surface); 15) Annual production (above-ground biomass - annual production - is an indicator of the energy captured by plants and its availability for secondary consumers in an ecosystem given current weather conditions); 16) Invasive plants (this indicator deals with plants that are invasive to the area of interest); 17) Reproductive capability of perennial plants.

OECD Model

In 2001, the OECD convened a meeting of international experts to develop indicators of agri-biodiversity as part of a wider project to develop agri-environmental indicators. (The proceedings of this meeting are available in OECD, (2003), *Agriculture and Biodiversity: Developing Indicators for Policy Analysis*, Proceedings From an OECD Expert Meeting, Zurich, Switzerland, November 2001, 278 pp, esp. p. 38. Available online at http://www1.oecd.org/agr/biodiversity/index.htm; The complete list of OECD Agri-environmental indicators is available in OECD, (2001), *Environmental Indicators for Agriculture Volume 3: Methods and Results*, Paris, France, 416 pp). Both sets of indicators are relevant when considering the environmental benefits of farmland. Though general, the OECD's agri-environmental indicators are very useful for assessing the holistic approach that is reflected in some of the more specific models above. Agri-environmental indicators are classified into 4 major categories and several sub-categories of each as follows:

I. AGRICULTURE IN THE BROADER ECONOMIC SOCIAL AND ENVIRONMENTAL CONTEXT:

1. Contextual Information and Indicators.
    - Agricultural GDP
    - Agricultural output
    - Farm employment
    - Farmer age/gender distribution
    - Farmer education
    - Number of farms
    - Agricultural supports
    - Land use
        - Stock of agricultural land
        - Change in agricultural land
        - Agricultural land use

6. Farm Financial Resources.
    - Farm income
    - Agri-environmental expenditure
        - Public and private agri-environmental expenditure
        - Expenditure on agri-environmental

II. FARM MANAGEMENT AND THE ENVIRONMENT:

1. Farm Management
    - Whole farm management
        - Environmental whole farm management plans
        - Organic farming
    - Nutrient management
        - Nutrient management plans
        - Soil tests
    - Pest management
        - Use of non-chemical pest control
        - Use of integrated pest management
    - Soil and land management
        - Soil cover
        - Land management practices
    - Irrigation and water management
        - Irrigation technology

III. USE OF FARM INPUTS AND NATURAL RESOURCES:

1. Nutrient Use
    - Nitrogen use
    - Nitrogen efficiency
2. Pesticide Use and Risks
    - Pesticide use
    - Pesticide risk

3. Water Use
    - Water use intensity
    - Water use efficiency
        - Water use technical efficiency
        - Water use economic efficiency
    - Water stress

IV. ENVIRONMENTAL IMPACTS OF AGRICULTURE:

1. Soil Quality
    - Risk of soil erosion by water
    - Risk of soil erosion by wind
2. Water Quality
    - Water quality risk indicator
    - Water quality state indicator
3. Land Conservation
    - Water retaining capacity
    - Off-farm sediment flow (soil retaining capacity)
4. Greenhouse Gases
    - Gross agricultural greenhouse gas
5. Biodiversity
    - Genetic diversity
    - Species diversity
        - Wild species
        - Non-native species
    - Eco-system diversity
6. Wildlife Habitats
    - Intensively-farmed agricultural habitats
    - Semi-natural agricultural habitats
    - Uncultivated natural habitats
    - Habitat matrix
7. Landscape
    - Structure of landscapes
        - Environmental features and land use patterns
        - Man-made objects (cultural features)
    - Landscape management
    - Landscape costs and benefits

The indicators of agri-biodiversity are more specific, yet remain flexible, common and transparent. They form part of an integrated Agri-Biodiversity Indicator Framework (ABF) that the OECD recommends could be adopted by both member and non-member countries. There are 4 main groups of indicators within the ABF: (1) Agricultural Genetic Resources; (2) Habitat Quantity; (3) Habitat Quality; and (4) Habitat Quantity and Quality, and the overall loss (gain) of biodiversity. These categories contain their own indicators as follows:

(1) *Indicators of Agricultural Crop and Livestock Genetic Resources*

(i) Total number of crop varieties/livestock breeds for the main crop/livestock categories (e.g. wheat, rice, cattle, pigs) that have been registered and certified for marketing, including native and non-native species and landraces.

(ii) Share of crop varieties in total production of individual crops (e.g. wheat, rice)

(iii) Share of livestock breeds in total livestock numbers for respective categories of livestock ((e.g. cattle, pigs, poultry, sheep).

(iv) Number and share of national crop varieties/livestock breeds used in agricultural production that are endangered.

(v) Number of available species and accessions (samples) conserved *in situ* and *ex situ* in national programs.

(2) *Indicators of Habitat Quantity*

(i) The current area and share (stock) of different habitat types across all agricultural land, including intensively or extensively farmed land (e.g., arable crops, rangeland, rice paddies), semi-natural areas (e.g. certain grasslands, heather moorland) and uncultivated land (e.g, fallow, areas of remnant native vegetation, ponds).

(ii) Changes in the area and shares of habitats (flows) both within agriculture (e.g. less arable land, more pasture) and between different land uses (e.g. from agricultural use to forestry or change from wetlands to agricultural use).

(3) *Indicators of Habitat Quality*

(i) Habitat Structure Indicator (Trends in the quality and quantity of habitat features and their spatial composition across agricultural land), e.g. extent of alpine meadows, area of field margins, area and fragmentation of remnant native vegetation patches on agricultural land, patch size and patch mosaic, fragmentation of habitats, linear features and networks. More detail is needed to refine indicators for:

- ***patch size*** **–** size of habitat patches, may be important for some species;
- ***fragmentation*** **–** extent to which a given habitat type is divided into several patches;
- ***linear features and networks*** **–** e.g. the length, age quality, and connectivity of hedges;
- ***vertical structures*** **–** habitat structures in terms of vertical layers (e.g, bushes and trees) which are especially important to bird and invertebrate communities;
- ***mosaic*** of different habitats in an agro-ecosystem, e.g. habitat diversity, location, juxtaposition and heterogeneity of land cover, and linkages to indicators of agricultural landscapes in countries where this is important.

(ii) Habitat Management Indicator (Trends in farm management practices and systems which affect biodiversity), e.g. timing of grass cutting, nutrient and pesticide management, stocking densities, integrated land management systems, area of organic farming.

(iii) Wild Species Indicator (Tends in the abundance (i.e. the number), richness (i.e. the diversity) and ecologically indicative value (i.e. species associated with specific habitats such as prairie grazing land) of wild species using agricultural habitats or affected by farming activities. This indicator is based on:

- a minimum set of wild species collectively representing a wide range of habitat types across agricultural land;
- a range of wild species that require different types of agricultural land and from various species groups (e.g. birds, mammals, arthropods, plants, etc.);
- rare, endangered, or widespread species;
- selecting wild species relevant to policy issues at different scales from the local to global level.

(4) *Indicators Linking Habitat Quantity to Quality*

(i) Habitat Species Matrix: Changes in the area and management of all agricultural habitat types and the identification, explicitly (i.e. direct observations) or implicitly (i.e. indirect information such as expert knowledge), of the impact of these changes on wild species (flora and fauna).

(ii) Natural Capital Index: The product of the *quantity* of agricultural habitat types and their *quality* in terms of wild species abundance, richness, habitat structure and management, measured between the current state of the agro-ecosystem and a baseline state.

These last two indicators, Habitat Species Matrix and Natural Capital Index, allow the effects and changes in agriculture on biodiversity to be summarized more succinctly, and provide the possibility to project the implications for wild species related to future changes in agricultural land use and cover.

The types of modeling described above helps in understanding the environmental benefits that farmland can potentially provide to its surroundings. In the case of water quality, properly managed farm and rangeland can reduce soil erosion and runoff, which in turn results in lower levels of nutrients, sediments, and pesticides entering water bodies. This changes the biological conditions of the water and directly affects what users of the water body value. For example, fishermen could benefit from larger fish populations, and boaters, swimmers, and non-contact recreationists benefit from clearer, more aesthetically appealing water. The relationship is similar in the case of wildlife - establishing grassland or forest cover creates suitable habitat for birds, small game, and large game. Along with improvements in water quality, this increases wildlife populations, and hunters and wildlife viewers alike will then benefit from these results. In the end, the key question is how well practical measures implemented by farmers match the environmental goals set by society. These decisions are influenced by the latest information on protective measures, and by the economics of these measures with respect to the farmers' individual holdings. Therefore, any model through which we might gain insight into the reasons for, or indications of, environmentally sound farmland will ultimately benefit us all.

Additional Literature

DEFRA, (2002), Using Economic Instruments to Address the Environmental Impacts on Agriculture. Available online at
http://www.defra.gov.uk/farm/sustain/newstrategy/econ/section2.pdf

Executive summary:

1. The publication of the Strategy for Sustainable Food and Farming provides an opportunity to take stock and discuss the best way to approach addressing the

environmental impacts of agriculture. 2. Many environmental issues arise because their costs or benefits are incurred by society as a whole rather than by the person creating them. For example, when pollution costs are not taken into account by those causing the pollution, because the costs are borne by others, then the market does not function efficiently. And the same is true when private business activity creates public benefits (e.g. through stewardship of the countryside) which are not fully rewarded in the market place. There may then be a case for Government intervention to improve the working of the market, and raise the efficiency of the economy and to deliver better environmental outcomes. There may also be a need to intervene to improve environmental outcomes in order to meet international obligations, for example under EC Directives and international agreements. 3. The effects of agriculture on the environment are significant and complex, with both positive and negative impacts operating at local, regional, national and global levels. Positive environmental impacts include: providing a 'carbon sink'; supporting and maintaining diverse and attractive landscapes with historic features; and providing a complex range of habitats and food sources for farmland wildlife. Major negative impacts include: greenhouse gas emissions (carbon dioxide, methane and nitrous oxide); soil erosion; water pollution; and adverse impacts on biodiversity. Estimates of the economic value of these impacts are necessarily broad brush and imprecise and studies to assess these impacts have used different methodologies. Three recent studies conclude that there are very large negative impacts (estimated in the range £1 billion to £11⁄2 billion for the UK). Research studies also show very large environmental and landscape benefits (estimated in the range £0.6 billion to £0.9 billion for the UK). Of course, other types of land use will also generate environmental impacts (both positive and negative). 4. In the case of agriculture, production subsidies have had a strong influence on agricultural practices and hence on environmental outcomes. Removal of these subsidies will help considerably, overall, to reduce pollution (although with some risks of reducing stewardship benefits in some locations). This document does not deal in any detail with reform of production subsidies, but focuses on policy instruments that can be used for specific environmental purposes. 5. The best mechanism for informing a decision on whether or not to take action – and the type and extent of any action – should be to assess costs and benefits wherever it is practicable. The 'best' instrument or package of instruments will have the highest environmental benefits for the lowest cost of implementation and compliance, although it will also be necessary to take into account possible wider economic impacts (e.g. on competitiveness) and social impacts, including the distributional effects upon farm incomes and other stakeholders. 6. The forms of intervention available include: facilitating change by providing information (e.g. offering free advice, running awareness-raising campaigns); encouraging voluntary action (e.g. supporting industry-led environmental initiatives); incentivising change using economic instruments (e.g. taxes, subsidies, tradable permits, tendering systems); and requiring change using regulatory instruments (e.g. limits on emissions, technology standards). 7. The most appropriate form of intervention depends upon a number of factors, but will be determined in part by the type of market failure. Where an adverse environmental impact results from the effects of production subsidies, then policy reform which removes (or “de-couples”) these subsidies represents the most obvious means of addressing the problem. Where there is an information failure, then providing advice, education or training services or running awareness-raising campaigns can help to reduce negative environmental impacts and increase provision of positive environmental impacts. Where there are negative environmental impacts, voluntary instruments (such as farm assurance schemes), regulation, taxes, charges, tradable permit schemes, or some combination of these, might be appropriate, according to the particular situation. 8. Subsidies (including agri-environment payments, grants for capital investment, tax breaks) can be used to address negative environmental impacts. The Polluter Pays Principle creates a presumption against using subsidies in this way, but there may be cases in which they offer the best solution to a problem particularly when the distributional effects upon farm incomes, and other stakeholders are taken into consideration. Subsidy is more appropriate where positive environmental impacts are being provided (the “Provider Gets” principle). They may be paid direct to farmers or via someone else (e.g. a conservation organisation). However, there are limits to what is affordable; and on what is permissible under EC State Aid rules. There may be other ways in which the market could be encouraged to deliver, such as through labelling, farm assurance or other voluntary schemes. 9. Economic instruments will generally be more advantageous for farmers than regulations. Regulations generally impose the same standards on all producers, regardless of how expensive it is for individual producers to change their environmental performance. Economic instruments allow those with high clean up costs to make smaller changes in their behaviour and incentivise those with low clean up costs to make relatively major changes. This means that economic instruments can sometimes achieve the same environmental benefits as regulation but at a lower cost to the economy and to the industry concerned. 10. No instrument is likely to perform better than alternative options in all respects and there will be trade-offs between the use of different instruments, reflecting their relative strengths and weaknesses. Frequently a single instrument does not operate in isolation. Combinations of different types of instrument work alongside each other to achieve a desired environmental outcome. This may be because, for example, there is more than one type of market failure; there is a need to take distributional consequences into account; or because it is necessary to encourage a transition from the current position to the optimum outcome, recognising that this will involve transition costs for those involved. A combination of regulatory and economic incentives, comprising both payments and taxes, may therefore provide an effective means of addressing the mix of positive and negative environmental impacts which arise from agriculture. 11. A review of policies in other OECD countries shows that only environmental subsidies or payments have been widely adopted. While all OECD countries have introduced some form of environmental payments, only a handful have introduced charges and none has chosen to apply tradable permits on any significant scale. 12. There is a need to look across a broader range of policy instruments – information, voluntary, economic and regulatory – and seek cost-effective options or packages of measures. In particular, it would be useful to assess the scope for using economic instruments to address the environmental impacts of agriculture, as these can allow more flexibility for farmers, resulting in lower compliance costs.

Economics for the Environment Consultancy (eftec) and Institute for European Environmental Policy (IEEP), (2004), *Framework for Environmental Accounts for Agriculture*, Final Report, July 2004.

Abstract: This study *'A Framework for Environmental Accounts for Agriculture'* examines the potential application of monetised environmental accounting to the UK agricultural sector. Undertaken for Defra, DARDNI, Scottish Executive and the Welsh Assembly, the research responds to terms of reference that call for "a study to identify data sources for the environmental impacts of agriculture and to develop methodologies that would enable us to produce an account to give an adjustment to the aggregate agricultural accounts showing this impact". The main driver for creating environmental accounts is the recognition that the current national accounting system does not reflect the full costs and benefits to society of economic activities, and, therefore, is an inadequate indicator of well being or true economic progress. Given the primary importance of traditional accounting indicators such as Gross Domestic Product (GDP) and Net Domestic Product (NDP) in public policy making, adjustments of these measures for environmental outcomes of economic activities are a step towards a better understanding of the sustainability (or otherwise) of economic development. The work undertaken for this study draws from the large body of literature on green accounting which is grounded in the concept of sustainability, and which has sought to identify greener measures of national wealth and income. Practical attempts to operationalise these concepts include those undertaken by the United Nations' Statistical Office (UNSTAT) and its System of Environmental and Economic Accounts (SEEA), as well as the World Bank's annual cross-country estimates of genuine (or adjusted net) saving and its components. While many countries have satellite environmental accounts that record environmental inputs and outputs, as with the Environmental Chapter of the UK Agricultural Accounts, none have yet attempted to integrate these within the final accounts, although the potential benefits are well recognised. Once fully developed, a monetised environmental account for agriculture would be capable of providing: an economic measure of the sustainability of agriculture and a truer measure of the quality of life; an indication of the extent to which agriculture is a net contributor to the nation's wellbeing as well as how it affects the welfare generated by other sectors; information that can be used for priority setting within agricultural policy; and inputs to cost benefit analysis for agricultural and related environmental policies. As this report shows, current limitations on data and incomplete understanding of the linkages between agricultural practices and inputs, and environmental and economic outcomes mean that these remain goals, rather than reality, for the moment. Past attempts at monetary Environmental Accounts of *UK agriculture* and recent attempts to place monetary values on the environmental impacts of UK agriculture provide a useful starting point for this exercise. However, the study expands on previous research in a number of respects: (i) by focusing on positive as well as negative impacts of agriculture; (ii) by taking a systematic approach to identifying the accounting framework and how this would

apply to a particular sector; (iii) by undertaking a wide review of the economic valuation literature and (iv) by presenting recommendations for future research.

CONCLUSION

This report considered different land-use patterns and their effects on water, soil and air quality, and biodiversity. The impact of urban areas on these environmental aspects is generally negative. Urban areas modify the local hydrology resulting in the erosion of streams and the contamination of streams, rivers and lakes from urban runoff. The contaminated particles from urban runoff reduce capacity, decrease water quality, and threaten animal habitats in these water bodies. Conventional agriculture also tends to harm the environment and, as is the case with the environmental impacts of urban land use, the effects of conventional practices in agriculture on water quality, soil and biodiversity are often interrelated and complex.

Yet agricultural land-use may not necessarily be harmful to the environment. A range of agricultural practices associated with conservation management can minimize its harmful effects and even benefit the environment. Non-tillage, minimum tillage, non - or surface - incorporation of crop residues, the establishment of cover crops and crop rotation contribute to improved water quality and reduce both soil erosion and the emission of carbon dioxide. A range of alternative practices associated with conservation management and working landscapes promote carbon sequestration and gains in biodiversity. Sound conservation management agricultural practices can indeed increase the value of farmland, attract well-directed subsidies to encourage such action, and promoting farmland amenities may provide farmers with additional financial support.

Globally, it has become increasingly important to develop meaningful indicators of the environmental benefits of well-managed farmland in order to accurately account for such benefits - both nationally, and in the agricultural sector[180] - and to achieve effective policy measures for addressing immediate and looming environmental concerns. Absorbing the values attached to the various positive externalities and public goods associated with well-managed farmland will benefit all parties interested in preserving and improving the

[180] Economics for the Environment Consultancy (eftec) and Institute for European Environmental Policy (IEEP), (2004), *Framework for Environmental Accounts for Agriculture*, Final Report, July 2004.

environment. If such benefits may be accurately accounted and absorbed into the policy making process, then not only will farmers who adopt conservation management practices assume a win-win position, environmental groups and governments can promote the neutralization of the environmental costs traditionally associated with conventional agriculture while they witness the tangible environmental benefits tied to well-managed farmland.

FURTHER ADDITIONAL LITERATURE

Albrecht, D., G. Bultena, E. Hoiberg, and P. Nowak, (1982), "Measuring environmental concern: the new environmental paradigm scale." *Journal of Environmental Education*, 13:39-43.

Albrecht, D., G. Bultena, E. Hoiberg, and P. Nowak, (1982), "Land use planning: farm and city perspectives." *Journal of Soil and Water Conservation*, 37:341-344.

Appropriate Technology Transfer for Rural Areas (ATTRA), (2002), *Farmscaping to Enhance Biological Control: Pest Management Guide*, Fayetteville, AR.

Bachmann, Janet, et al., (1995), *Habitat enhancement for beneficial insects in vegetable and fruit farming systems*. SARE/ACE Annual Report AS92-2. Southern Region. p. 87.

Bugg, Robert L., (1990, *Biological control of insect pests in sustainable agriculture*. Components. UC Sustainable Agriculture Research and Education Program. Vol. 1, No. 3. p. 5–9.

Bugg, Robert L., (1990), "Farmscaping with insectary plants." *The Permaculture Activist*. Summer. p. 1, 6–9.

Bugg, Robert, (1992), "Using cover crops to manage arthropods on truck farms," *HortScience*. Vol. 27, No. 7. p. 741–745.

Bugg, Robert, (1994), "Using cover crops to manage arthropods of orchards: A review," *Agriculture, Ecosystems and Environment*. Vol. 50, No. 1. p. 11–28.

Bultena, G., P. Nowak, E. Hoiberg, and D. Albrecht, (1981), "Farmers' attitudes toward land-use planning." *Journal of Soil and Water Conservation*, 36:37-41.

Bultena, G., E. Hoiberg and P. Nowak, (1984), *Sources of conservation information and participation in conservation programs: an interregional analysis.* Sociological Studies of Environmental Issues, Sociology Report 156. Ames, IA: Iowa State University.

Carroll, K. and P. Nowak, (1989), *Characteristics, Practices and Problems of Wisconsin Farmers Using Sustainable Agriculture Techniques*. 69 pages. A Final report to the Wisconsin Department of Agriculture, Trade and Consumer Protection's Board on Sustainable Agriculture.

Des Jardins, Michael, (1994), "Making a home for fly-by-night friends." *Farmer to Farmer*. October. p. 12.

Dietrick, E.J., J.M. Phillips and J. Grossman, (1995), *Biological Control of Insect Pests Using Pest Break Strips*. Nature Farming Research and Development Foundation. Lompoc, CA. (booklet)

Gilkeson, Jill, and Joel Grossman, (1991), "The Organic Gardening guide to important beneficial insects and mites of North America," *Organic Gardening*. May-June. p. 46–56.

Flaherty, M., (1998), “Old Challenges, New Tools. Farm friendly ‘carrots’ thrive in rural Wisconsin as soil conservation improves and planning expands.” *On Common Ground*, June 1998.

Hoiberg, E., P. Nowak, G. Bultena, J. Bohlen, and D. Albrecht, (1980), *Land use planning in Iowa: a study of farmers' attitudes towards planning issues.* Sociological Studies of Environmental Issues, Sociology Report 148. Ames, IA: Iowa State University.

King, Shawn, and William Olkowski, (1991), “Farmscaping and IPM,” *The IPM Practitioner*. October. p. 1–12.

Kite, Patricia, (1990), “Attract these insects,” *Organic Gardening*. April. p. 71–72.

Korsching, P., and P. Nowak, (1983), “Soil erosion awareness and use of conservation tillage,” *Water Resources Bulletin*, 19(3):459-462.

Korsching, P., C. Stofferahn, P. Nowak, and D. Wagener, (1983), “Adopter characteristics and adoption patterns of minimum tillage: implications for soil conservation programs,” *Journal of Soil and Water Conservation*, 38:428-431.

Korsching, P., and P. Nowak, (1982), “Farmer acceptance of alternative conservation policies.” *Agriculture and the Environment*, 7:1-14.

Korsching, P., and P. Nowak, (1983), “Flexibility in conservation policy.” Pp. 149-159 in D. Brewster, W. Rasmussen, and G. Youngberg (eds.) *Farms in Transition: Interdisciplinary Perspectives on Farm Structure*. Ames, IA.: Iowa State University Press.

Korsching, P. and P. Nowak, (1983), “Water resources research: potential contributions by sociologists.” Pp. 203-222 in T. Napier, D. Scott, W. Easter and R. Supalla (eds.) *Water Resources Research: Problems and Potentials for Agriculture and Rural Communities.* Ankeny, IA.: Soil Conservation Society of America.

McCallister, R., and P. Nowak, (1999), “Whole-soil knowledge and management: A foundation of soil quality,” pp. 173-194 in R. Lal (ed.) *Soil Quality and Soil Erosion*. CRC Press, Boca Raton: Florida.

Nowak, P. (Task Force Member), (1981), *Preserving Agricultural Land: Issues and Policy Alternatives.* Report No. 90, July. Ames, IA: Council for Agricultural Science and Technology.

Nowak, P., (1981), *The sociology of conservation tillage,* Pp. 34-39 in Proceeding of Research-Extension Conference on Conservation Tillage. ISU Information Service. Ames, IA: Agriculture and Home Economics Experiment Station.

Nowak, P., (1982), “Attitudes and behaviors of farm operators to soil conservation: research and policy implications.” Pp 193-197 in H. Halcrow, E. Heady, and M. Cotner (eds.) *Soil Conservation Policies: Institutions and Incentives*, Ankeny, IA.: Soil Conservation Society of America.

Nowak, P., (1982), O*bstacles to soil conservation.* Pp. 12-16 in Farm Agricultural Resources Management: Conservation Tillage. Cooperative Extension Report 1755. Ames, IA: Iowa State University CES.

Nowak, P., and D. Wagener, (1982), “Risk and social position in explaining the adoption of conservation practices.” Pp. 19-37 in *Perceptions, Attitudes, and Risk: Overlooked Variables in Formulating Public Policy on Soil Conservation and Water Quality.* Washington, DC: Economic Research Service Report No. A6ES820129.

Nowak, P., (1983), “Adoption and diffusion of soil and water conservation practices.” *The Rural Sociologist*. 3(2):83-91.

Nowak, P., (1983), “Strategies for increasing the adoption of conservation practices.” *The Rural Sociologist* (4):243-246.

Nowak, P., (1983), “Obstacles to the adoption of conservation tillage.” *Journal of Soil and Water Conservation*, 38:162-165.

Nowak P., and P. Korsching, (1983), “Social and institutional factors affecting the adoption and maintenance of agricultural BMPs.” Pp. 349-373 in F. Schaller and G. Bailey (eds.) *Agricultural Management and Water Quality*. Ames. IA.: Iowa State University Press.

Nowak, P., (1984), “If conservation tillage is so great, why don't more farmers use it?” *Agri Finance* Vol 26:1 (January): 34-35, 38-40.

Nowak, P., (1984), “A critical look at conservation education.” *Journal of Soil and Water Conservation* 39: 220-221.

Nowak, P., (1984), “Adoption and diffusion of soil and water conservation practices.” Pp. 214-237 in B. English, J. Maetzold, B. Holding, and E. Heady (eds.) *Future Agricultural Technology and Resource Conservation.* Ames, IA.: ISU Press.

Nowak, P., (1985), “Farmers' attitudes and behaviors in implementing conservation tillage decisions.” Pp. 327-340 in Frank D'Itri (ed.). *A Systems Approach to Conservation Tillage.* Chelsea, MI: Lewis Publications, Inc.

Nowak, P., (1985), “Farmers' reaction to agricultural land retention.” Pp. 25-31 in J. Skees (ed.) *Farmland Retention in the Southeast*. Southern Rural Development Center, SRDC 78.

Nowak, P., (1986), “New challenges for conservation partners.” *Journal of Soil and Water Conservation*, 41:5, 278-284.

Nowak, P., (1987), "Implementation of soil and water conservation policy." Pp. 47-68 in D. Halbach, C. Ford Runge, and W. Larson (eds.) *Making Soil and Water Conservation Work*. Soil and Water Conservation Society of America. Ankeny, IA.

Nowak, P. and J. Griswold, (1987), "Conservation systems: The farmers perspective." Pp. 10-17 in *Optimal Erosion Control at Least Cost*. American Society of Agricultural Engineers, St. Joseph: Michigan.

Nowak, P. and Max Schnepf, (1987), "Implementation of the conservation provisions in the 1985 farm bill: A survey of county-level U.S. Department of Agriculture agency personnel." *Journal of Soil and Water Conservation*, 42:4 285-290.

Nowak, P., (1988), "Agrichemicals and Groundwater: Assumptions about Farmer Information Processes." Pp. 31-36 in *Agrichemicals and Groundwater Protection: Resources and Strategies for State and Local Management*. Freshwater Foundation, Navarre, MN.

Nowak, P. and Max Schnepf, (1989), "Implementing the conservation provisions in the 1985 farm bill: A follow-up survey of county-level U.S. Department of Agriculture agency personnel." *Journal of Soil and Water Conservation*, 44:5 535-541.

Nowak, P., (1991), "Why farmers adopt production technology." Pp.31-33 in *Crop Residue Management for Conservation*. Soil and Water Conservation Society. Ankeny, IA.

Nowak, P., M. Schnepf and R. Barnes, (1991), *When Conservation Reserve Program Contracts Expire: A National Survey of Farm Owners and Operators Who Have Enrolled Land in the Conservation Reserve.* 80 pages. Soil and Water Conservation Society. Ankeny, IA.

Nowak, P., (1992), "Why farmers adopt production technology." *Journal of Soil and Water Conservation* 47:1 14-16.

Nowak, P. and K. Hakenson, (1992), *An Evaluation of the Sustainable Agriculture Demonstration Program:* Wisconsin Department of Agriculture, Trade and Consumer Protection. 138 pages.

Nowak, P., Lockeretz, W., et al, (1993), *Understanding the human element in agricultural resource conservation*, Soil and Water Conservation Society, Socioeconomic Research Agenda Project Task Force, Soil and Water Conservation Society. Ankeny: Iowa.

> Abstract: A 10 page report summarizing the findings of a task force examining the behavior of farmers and their response to various efforts to adopt resource-conserving production techniques. Addressing social science research methods and approaches, the findings suggest institutional arrangements in the study of research conservation behavior. Among the suggestions for individual research projects, the task force recommend broadening the range of variables used to explain farmers'

behavior and the aggregation of qualitative data for co-operative, regionally oriented research, in preference to individually oriented efforts.

Nowak, P., (1997), "A sociological analysis of site-specific management." Pp. 397-422 in F.J. Pierce and E.J. Sadler (eds.) *The State of Site-Specific Management for Agriculture*. ASA Misc. Publ., ASA, CSSA, and SSSA, Madison, WI.

Nowak, P. F. Madison and R. Shepard, (1998), "Farmers and manure management: A critical analysis." Pp. 1-32 in J. Hatfield and B. Stewart (Eds.), *Animal Waste Utilization: Effective Use of Manure as a Soil Resource*, Ann Arbor Press, Chelesa, MI.

Nowak, P. and P. Korsching, (1998), "The human dimension of soil and water conservation: A historical and methodological perspective." Pp. 159-184 in F.J. Pierce and W.W. Frye (Eds.) *Advances in Soil and Water Conservation*. Ann Arbor Press, Chelesa, MI.

Phatak, Sharad, (1992), "An integrated sustainable vegetable production system," *HortScience*. Vol. 27, No. 7. p. 738–741.

Pickett, C.H. and R.L. Bugg (eds.), (1998), *Enhancing Biological Control: Habitat Management to Promote Natural Enemies of Agricultural Pests*. University of California Press, Berkeley, CA. 422 p.

Abstract: This book provides detailed technical insights into habitat manipulation for biological control. Each chapter is written by an expert about a particular aspect of habitat management (i.e., The Role of Spiders and Their Conservation in the Agroecosystem, or, Within-field and Border Refugia for the Enhancement of Natural Enemies). Good resource for farmers and land managers, though a fair amount of the information is specific to the Lower Sacramento Valley. Contains much useful information about establishing habitat for wildlife—from hedgerows and native perennial grass stands to riparian enhancement and tailwater ponds. Also includes information on how to attract beneficial insects, birds and bats, planting techniques and weed control, and cost share programs (Federal, State (CA) and local) for habitat enhancement.

Pierce, F.J. and P. Nowak, (1999), "Aspects of precision agriculture." *Advances in Agronomy,* Vol. 67 Pp. 1-84. Academic Press, NY.

Platt, J.O., et al., (1999), "Effect of buckwheat as a flowering border on populations of cucumber beetles and their natural enemies in cucumber and squash." *Crop Protection*. Vol. 18. No. 5. June. p. 305–313.

Poncavage, Joanna, (1991), "Beneficial borders." *Organic Gardening*. May-June. p. 42–45.

Pottinger, Lori, (1994), "Improve your pest-control batting average." *Farmer to Farmer*. December. p. 5.

Pottinger, Lori, (1994), "Take a walk on the wild side." *Farmer to Farmer*. October. pp. 6–7.

Prokopy, Ronald J., (1994), "Integration in orchard pest and habitat management: A review." *Agriculture, Ecosystems and Environment*. August. p. 1–10.

Rickson S. R. Rickson and P. Nowak, (1993), "Farmer responses to land degradation and conservation policy: Sociological dilemmas of sustaining tropical agriculture." In E. Baum, P. Wolff and M. Zobisch (eds.) *Topics in Applied Resource Management in the Tropics, Vol. III: Acceptance of Soil and Water Conservation Strategies and Technologies.* Witzenhausen: Deutsches Institut Fur Tropische Und Subtropische Landwirtscaft.

Rickson R., P. Nowak and S. Rickson, (1993), "Social bases of policy implementation in soil conservation: American and Australian comparisons." In S. Chamala and K. Keith (eds.) *Participative Approaches to Land Care: Prospective, Politics and Programs*. Sidney, Academic Press.

Sustainable Agriculture Network, (2000), *A Whole-Farm Approach to Managing Pests.*

> Abstract: This bulletin from the Sustainable Agriculture Network (SAN) outlines how to use ecological principles to control pests on farms. Contains successful strategies and a resource listing.

Wolf, S. and P. Nowak, 1999, "Institutional failure in agro-environmental management." *Research in Social Problems and Public Policy,* Volume 7: Pp. 293-310. JAI Press, Stamford, CT.

Yolo County Resource Conservation District, (1999), *Bring Farm Edges Back to Life! How to Enhance Your Agriculture and Farm Landscape with Proven Conservation Practices for Increasing the Wildlife Cover on Your Farm*, 1999. 4th Edition. Woodland: California, 105 pp.

REFERENCES

Al-Kaisi, M., (2001), *Impact of Tillage and Crop Rotation Systems on Soil Carbon Sequestration.* (PM 1871). Iowa State University: University Extension.

Babcock, B., Beghin, J., Duffy, M., Feng, H., Hueth, B., Kling, C., Kurkalova, L., Schneider, U., Secchi, S., Weninger, Q., Zhao, J., (2001), *Conservation Payments: Challenges in Design and Implementation*, Iowa State University: Center for Agricultural and Rural Development, Briefing Paper 01-BP 34.

Baker, J. P. et al., (1990), *Biological Effects of Changes in Surface Water Acid-Base Chemistry*, NAPAP Report 13. In National Acid Precipitation Assessment Program (NAPAP). *Acid Deposition: State of Science and Technology*. Washington, D.C: NAPAP.

Barber, C.V., Johnson, N.C. and Hafild, E., (1994), *Breaking the Logjam: Obstacles to Forest Policy Reform in Indonesia and the United States*, World Resources Institute, Washington D.C.

Barrett, M. E., Malina, J.F. & Charbeneau, R. J., (1996), *Characterization of Highway Runoff in the Austin Texas Area.* Austin: Center for Transportation Research, Univ. of Texas, Austin, Texas.

Barrios, A., (2000), *Urbanization and Water Quality*. DeKalb: Center for Agriculture and the Environment.

Bartone, C. et al., (1994)., *Toward Environmental Strategies for Cities: Policy Considerations for Urban Environmental Management in Developing Countries*, Urban Management Programme Policy Paper No. 18, Washington DC: The World Bank.

Best, L. B., (1985), *Conservation vs. Conventional Tillage: Wildlife Management Considerations*, in D'Itri (Ed.), A Systems Approach to Conservation Tillage. New York: Lewis Publishers.

The Biodiversity Project, (2002), *Americans and Biodiversity: New Perspectives in 2002*, Washington D.C., April 2002.

Boesch, D., Burroughs, R., Baker, J., Mason, R., Rowe, C, Siefert, R., (2001), *Marine Pollution in the United States: Significant Accomplishments, Future Challenges*, Pew Oceans Commission, Arlington, Virginia. Available on CD ROM from Pew Oceans Commission, (2003), America's Living Oceans: Charting a Course for Sea Change, Pew Oceans Commission, Arlington, Virginia, (http://www.pewoceans.org/).

Boody, G. & Krinke, M., (2001), *The Multiple Benefits of Agriculture: An Economic,* *Environmental and Social Analysis.* While Bear Lake: Land Stewardship Project.

Broaddus, L.E., (2001), *Protecting Nature's Diversity*, Biodiversity Initiative, DNREC Online, Delaware Department of Natural Resources and Environmental Control.

Bruce, J., Frome, M., Haites, E., Janzen, H., Lal, R. & Paustian, K., (1998), C*arbon Sequestration in Soils*. Paper from Soil and Water Conservation Society, Carbon Sequestration in Soils Workshop, Calgary Alberta, May 1998.

California Wilderness Coalition, (2002), *Wild Harvest: Farming for Wildlife and Profitability: A Report on Private Land Stewardship*, California: Davis.

Claassen, R., Breneman, V., Bucholtz, S., Cattaneo, A., Johansson, R., and Morehart, M., (2004), *Environmental Compliance in U.S. Agricultural Policy: Past Performance and Future Potential*, Agricultural Economic Report No. 832, June 2004, Washington D.C.: USDA-ERS.

Conner, J. R., Dietrich, R. A. & Williams, G. W., (1999), *The U.S. Cattle and Beef Industry and the Environment*. A Report to the World Wildlife Fund.

Conservation International, (2001), *Press Releases*, December 9, 2001.

Cox, J., R. Kautz, M. MacLaughlin, T. Gilbert, (1994), *Closing the Gaps in Florida's Wildlife Habitat Conservation System*, Florida Game & Freshwater Fish Commission, Tallahassee, Florida.

Crowder, B.M., (1987), "Economic Costs of Reservoir Sedimentation: A Regional Approach to Estimating Cropland Erosion Damage," *Journal of Soil and Water Conservation*, 42. (3). 194-197.

Economic Research Service, USDA, (1997), *Agricultural Resources and Environmental Indicators*, Washington D.C.

Economic Research Service, USDA, (2000), *Agricultural Resources and Environmental Indicators*, Washington D.C.

Economics for the Environment Consultancy (eftec) and Institute for European Environmental Policy (IEEP), (2004), *Framework for Environmental Accounts for Agriculture*, Final Report, July 2004.

Esseks, J.D. and Kraft, S.E., (2002), "What Types of Government Assistance Are Important to Owners of Urban-Edge Agricultural Land? Findings from Surveys Conducted August 2001 to February 2002 in California, Michigan, New York, Texas, and Wisconsin," American Farmland Trust, Survey Memo # 8, May 2002.

Esseks, J.D. and Kraft, S.E., (2002), "Are Owners of Urban-Edge Agricultural Land Willing to Provide Environmental Benefits that Urban and Suburban Residents Value? Findings from Two Coordinated Surveys: A National Survey of Registered Voters and A Survey of Owners of Agricultural Land in Urban-Edge Counties of Five States: California, Michigan, New York, Texas, and Wisconsin," American Farmland Trust, Survey Memo # 9, April 2002.

Freshwater Foundation, (1988), "Nitrate: Rerun of an Old Horror." *Health and Environment Digest*, 1.

Heck, W. W., (1989), "Assessment of Crop Losses from Air Pollution in the United States" In MacKenzie, J. J. & El-Ashry, M. T. (Eds.). *Air Pollution's Toll on Forest and Crops*. New Haven: Yale University Press.

Heimlich, R., (2003), *Agricultural Resources and Environmental Indicators, 2003.* Washington DC: USDA, Economic Research Service.

Hewitt, T. I. & Smith, K. R., (1995), *Intensive Agriculture and Environmental Quality: Examining the Newest Agricultural Myth.* Report from the Wallace Institute for Alternative Agriculture.

Hill, P. R. & Mannering, J. V., (1995), "Conservation Tillage and Water Quality," *Water Quality*, 20.

Holmes, T., (1988), "The Offsite Impact of Soil Erosion on the Water Treatment Industry," *Land Economics*, 64 , 4: 356-366.

Hrubovcak, J., M. LeBlanc,& B.K. Eakin., (1995), *Accounting for the Environment in Agriculture*. TB-1847. U.S. Department of Agriculture, Economic Research Service.

Imhoff, D., (2003), *Farming with the Wild: Enhancing Biodiversity on Farms and Ranches*, Sierra Club Books.

International Union for the Conservation of Nature and Natural Resources, World Commission on Protected Areas, (1997), *Protected Areas in the Twenty-first Century: from Islands to Networks*. Report of the Conference held in Albany, Western Australia, 24-29 November.

Irwin, E., Nickerson, C., and Libby, L., (2003), "What are Farmland Amenities Worth?" *Choices*, American Agricultural Economics Association, Third Quarter 2003, pp. 21-23.

Jackson, D. and Jackson, L., (2002), *The Farm as Natural Habitat*: *Reconnecting Food Systems with Ecosystems*, Washington D.C.: Island Press.

Kaiser, J., (2004), "Wounding the Earth's Fragile Skin," *Science*, 304: 1616-1618.

Keeney, D. & Kemp, L., (2002), *A New Agricultural Policy for the United States.* Presented in part at the Advanced Research Workshop, Krakow, Poland, November 6, 2002.

Kemp, L., (2001), *Stewardship Incentives: Towards Profitable Farms that Protect the Environment.* Prepared for Midwest Region conference of Commodities and the Environment. A Collaboration Among World Wildlife Fund, American Farmland Trust and Henry A. Wallace Center for Agriculture and Environmental Policy.

Kimbrell, A., (2002), "Fatal Harvest Myth 2: Industrial Food is Cheap," *Ecologist*.

Klein, R. D., (1979), "Urbanization and Stream Quality Impairment," *Water Resources Bulletin*, 15: 948-963.

Krupa, K. & Daugherty, A., (1990), *Major Land Uses:1945-1987.* Electronic Data Product #89003. Washington, DC: U.S. Department of Commerce, Bureau of the Census.

Lents, J. M. & Kelly, W. J., (1993), "Clearing the Air in Los Angeles," *Scientific American*, 269 , 4: 32.

Lewandrowski et al., (2004), *Economics of Sequestering Carbon in the U.S. Agricultural Sector.* Washington DC: USDA.

Long, L., (2003), *Conservation Practices Adoption by Agricultural Landowners*, Unpublished Doctoral Dissertation, Department of Political Science, DeKalb, Illinois: Northern Illinois University.

MacArthur, R.H. and E.O. Wilson, (1967), *The Theory of Island Biogeography*, Princeton, N.J.: Princeton University Press.

McCarl, B. A. & Schneider, U. A., (2001), "Greenhouse Gas Mitigation in U.S. Agriculture and Forestry," *S*cience, 294. (5551). 2481-2482.

Meiorin, E. C., (1986), *Urban Stormwater Treatment at Coyote Hills Marsh*. Oakland: Association of Bay Area Governments.

Minnesota Pollution Control Agency, (2000), *Protecting Water Quality in Urban Areas: Best Management Practices for Dealing with Storm Water Runoff from Urban, Suburban and Developing Areas of Minnesota.* St. Paul: Minnesota Pollution Control Agency.

National Governors Association Center for Best Practices, (2001), *Private Lands, Public*

Benefits: Principles for Advancing Working Lands Conservation, Washington D.C., June 2001. Available online at http://www.nga.org/center/divisions/1,1188,C_ISSUE_BRIEF%5ED_2426,00.html

National Research Council, (1991), *Rethinking the Ozone Problem in Urban and Regional Air Pollution.* Washington, DC: National Academy Press.

Noss, R.F., R.F. Peters, (1998), *Oregon's Living Landscape: Strategies and Opportunities to Conserve Bio-Diversity*, Defenders of Wildlife, Washington D.C.

Novitski, R.P., R.D. Smith, and J.D. Fretwell, (1996), "Wetland Functions, Values and Assessment," in J.D. Fretwell, J.S. Williams and P.J. Redman (eds.), *National Summary on Wetland Resources*. USGS Water Supply Paper 2425, pp. 79-86, Washington D.C.: U.S. Department of the Interior, U.S. Geological Survey.

Oberts, G. L., (1986), "Pollutants Associated with Sand and Salt Applied to Roads in Minnesota." *Water Resources Bulletin,* 22.

OECD, (2003), *Agriculture and Biodiversity: Developing Indicators for Policy Analysis*, Proceedings From an OECD Expert Meeting, Zurich, Switzerland, November 2001, Paris: OECD Publications, 278 pp. Available online at http://www1.oecd.org/agr/biodiversity/index.htm

OECD, (2001), *Environmental Indicators for Agriculture Volume 3: Methods and Results*, Paris: OECD Publications, 416 pp.

Pautsch, G. R.; Kurkalova, L.A.; Babcock, B.A. & Kling, C.L., (2001), "The Efficiency of Sequestering Carbon in Agricultural Soils," *Contemporary Economic Policy*, 19 , 2: 123-134.

Pimentel, D., Acquay, H., Biltonen, M. Rice, P., Silva, M., Nelson, J. Lipner, V., Giordano, S., Horowitz, A. & D'Amore, M., (1993), "Assessment of Environmental and Economic Impacts of Pesticide Use." In D. Pimentel & H. Lehman (Eds.). *The Pesticide Question: Environment, Economic and Ethics.* New York: Chapman and Hall.

Pitt, R. E., (1994), *Storm Water Detention Pond Design for Water Quality Management* (Draft). Lewis Publishers.

Pretty, J., (2001), "The Real Costs of Modern Farming," *Resurgence*, 205.

Redman, (1996), *Industrial Agriculture: Counting the Costs.* UK: Soil Association.

Reid, W.V. and Miller, K.R., (1989), *Keeping Options Alive: The Scientific Basis for Conserving Biodiversity*, Washington D.C.: World Resources Institute.

Ribaudo, M.O., (1989), *Water Quality Benefits from the Conservation Reserve Program*. AER 606. Washington DC: USDA, Economic Research Service.

Risley, David L., Alfred H. Berner, and David P. Scott, (1995), *How Much is Enough? A Regional Wildlife Habitat Needs Assessment for the 1995 Farm Bill*, McKenzie and Riley (eds.), Washington D.C.: Wildlife Management Institute.

Rose, D. J. & Gilmour, A., (1995), *Acid Deposition and Related Air Pollution: Its Current Extent and Implications for Biological Conservation in Eastern and the Western Pacific.* Gland: World Wide Fund for Nature International.

Ruhl, J. B., (2000), "Farms, Their Environmental Harms, and Environmental Laws," *Ecology Law Quarterly*, 27 : 265-349.

Runge, C. F. & Stuart, K., (1997), *The History, Trade and Environmental Consequences of Corn Production in the United States.* Washington, DC: World Wildlife Fund.

Schueler, T., (1997), *Technical Note No. 86: Impact of Suspended and Deposited Sediment,* Watershed Protection Techniques, 2 : 443-444.

Shelly, P. E., & Gaboury, D. R., (1986), "Estimation of Pollution from Highway Runoff - Initial Results." In: Urbonas, B. & Roesner, L. A. (Eds.), *Urban Runoff Quality.* New York: American Society of Civil Engineers, New York: New York.

Smith, R.A., Alexander, R. B. & Lanfear, K. J., (1993), *Stream Water Quality in the Conterminous United States-Status and Trends of Selected Indicators during the 1980's,* National Water Summary 1990-91. Water Supply Paper 2400. Washington DC: US Department of the Interior, Geological Survey: 111-140.

Stavins, R. N., (1999), "The Costs of Carbon Sequestration: A Revealed-Preference Approach," *American Economic Review*, 89 , 4 : 994-1009.

Tacconi, L., (2000), *Biodiversity and Ecological Economics, Participation, Values and Resource Management,* London: Earthscan Publications.

The Trust for Public Land, (2002), *Northwest Working Landscapes Program,* Northwest, 27 February, 2002.

Uri, N., (1999), *Agriculture and the Environment*. Commack: Nova Science Publishers.

US Congress, Office of Technology Assessment, (1988), *Urban Ozone and the Clean Act Air Act: Problems and Proposals for Change.* Washington DC: Office of Technology Assessment.

USDA, (2000), *National Resources Inventory: Background and Highlights.* Washington DC: USDA, Natural Resources Conservation Service.

_____, (1997), *Agricultural Resources and Environmental Indicators, 1996-97.* Washington, DC: USDA.

U.S. Department of the Interior, U.S. Fish and Wildlife Service, (1994), *Final Environmental Impact Statement: The Reintroduction of Gray Wolves to Yellowstone National Park and Central Idaho*, May 1994.

U.S. Environmental Protection Agency, (1998), *National Water Quality Inventory: 1996 Report to Congress*, EPA841-R-97-008. Washington DC: U.S. Environmental Protection Agency.

_____, (1983), *Results of the Nationwide Urban Runoff Program.* Washington, DC: U.S. Environmental Protection Agency, Water Planning Division.

_____, (1977), *National Nonpoint Source Water Pollution Control Strategy (draft).* Washington, D.C.: U.S. Environmental Protection Agency.

USEPA — See U.S. Environmental Protection Agency

U.S. Fish and Wildlife Service, (1988), *Results of Unpublished Sampling Data from Long Meadow Lake.* St. Paul: USFWS.

U.S. Fish and Wildlife Service, (1998), *Snow Goose FAQs*, Jan 1998.

USFWS, (1988), — See U.S. Fish and Wildlife Service

U.S. National Research Council, 1989, *Alternative Agriculture*. Washington DC: National Academy Press.

Vesterby, M., (2001), *Agricultural Resources and Environmental Indicators: Land Use.* No. (AH722). Washington, DC: USDA.

Versterby, M. & Krupa, K., (1997), *Major Uses of Land in the United States, 1997.* Statistical Bulletin No. 973. Washington, DC: USDA.

Warburton, D. B. & Klimstra, W.D., (1984), "Wildlife Use of No-Till and Conventionally Tilled Corn Fields," *Journal of Soil and Water Conservation*, 39 : 327-330.

Wilson, E.O., (1995), "Only Humans Can Halt the Worst Wave of Extinction Since the Dinosaurs Died," *Time International*, October 30, 1995.

Wilson, E.O., (1988), *The Current State of Biological Diversity*, Biodiversity, National Academy Press, Washington D.C.

Wilson, E.O., (2000), "Biodiversity at the Crossroads," *Environmental Science and*

Technology, March 1, 2000, Vol. 34, pp. 123 A-128 A.

Wilson, E.O. in D.L. Parsell, (2001), *Biodiversity Expert Urges 'Buying' of Endangered Ecosystems,"* Address to the National Science Foundation, National Geographic News, May 3, 2001.

World Bank, (1992), *World Bank Development Report*, Washington D.C.

World Resources Institute, (1997), *Linking Biodiversity and Agriculture: Challenges and Opportunities for Sustainable Food Security*, Washington D.C.