

An Overview of Air, Water, and Soil in Agriculture

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Environmental health and agriculture: what is the connection? In the 1987 report *Agriculture at Risk*, the section, *Environmental Health: the Issues*, focused on the linkage between agricultural pesticides and fertilizers, groundwater pollution, and human health (National Coalition for Agricultural Safety and Health, 1989). To be sure, these are important topics that have been and continue to be addressed. However, environmental health involves more than the investigation and resolution of specific pollution problems. The purposes of this report are to provide an overview of environmental health issues, particularly water and soil issues, as related to agriculture and explore additional linkages between environmental health and agriculture.

Historically, agriculture was not considered as part of "classical" environmental health. The historical perspective segregated environmental health as being an aspect of public health concerned with surrounding conditions that may influence human health (Purdom, 1971). Air, water, food, and shelter were the listed requirements for "man's" survival. Within each of these categories, environmental conditions that fostered communicable disease transmission, toxic chemical exposure, and physical agent interaction were stressed as appropriate for study. In this mindset, the importance of agriculture in environmental health terms was relegated to specific disease outcomes associated with exposures to agricultural chemicals and to the production of an ample and proper diet.

The "official" definition of environmental health was updated in 1996 and offers a very clear and expanded connection to agriculture. In 1996, the National Environmental Health Association (NEHA), the national organization of Environmental Health practitioners, officially adopted the following definition of environmental health. Environmental health and protection refers to protection against environmental factors that may adversely impact human health or the ecological balances essential to long-term human health and environmental quality, whether in the natural or (hu)man-made environment (NEHA, 1996). This definition was a modification of an original definition developed by the NEHA Committee on the Future of Environmental Health (1993) in their report entitled *The Future of Environmental Health*. The official definition provides an important addition to the scope of environmental health, namely, ecological balances essential to long-term health and environmental quality.

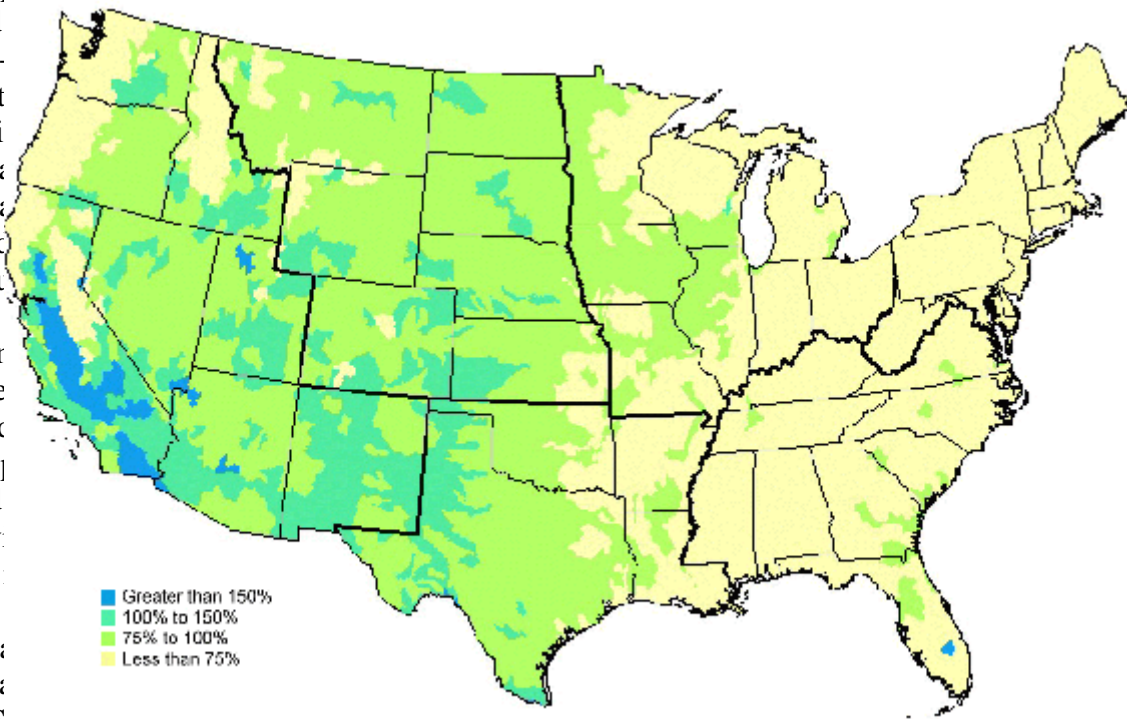
The importance of ecological balances as essential to human health and environmental quality is not a new idea. In 1959, E.P. Odum wrote what many biologists and ecologists believe is the classical text in ecology. In that text, he stated: "Ecology has many applications which contribute to the well-being of human society...ecology can also provide a valuable protective function in assembling data and principles which will prevent man from destroying his own environment (and thus himself) in his enthusiasm for the use of new-found powers" (Odum, 1959). Building on these ideas in his later years, E.P. Odum wrote a book entitled *Ecology: a Bridge between Science and Society*, in which he called ecology "the basic science of the environment" and

detailed a human life-support system in ecological terms (Odum, 1997). Odum proposed a life-sup

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pastureland, or rangeland. Of that 50 percent, more than 55 percent is categorized as cropland and pastureland. Privately owned cropland is concentrated in the central section of the US, the Ohio Valley, and the Central Valley of California. Privately owned pastureland and rangeland is primarily concentrated in Montana, the Dakotas, Western Nebraska, Eastern Wyoming, Colorado and New Mexico, and Kansas, Oklahoma, Texas. During the five years between the 1992 and 1997 National Resources Inventories, an estimated, additional 2.2 million acres per year of land has been lost to development (USDA-NRCS, 2001). On the average, approximately 645,000 acres of prime farmland is estimated as lost to development per year from 1992-1997 (USDA-NRCS, 2001).

Loss of land for agricultural use is not the only impact of urbanization. With increasing development and the requisite water supply issues that follow, water availability for agricultural use is or will be a significant national water issue in this century. Certain areas of the United States, notably the Southwest, have insufficient precipitation to meet water demand. Within these areas, water is either imported from other watersheds or ground water is mined to meet industrial, urban, and agricultural demand. Where water demand exceeds 75 percent of precipitation, water supply conflicts are emerging (USDA-NRCS, 1997). Large areas of the US where average annual demand from 1985 through 1990 exceeded 75 percent of annual precipitation are seen primarily in states west of the Mississippi River (Figure 1). Caution in drawing conclusions from this information is warranted because not all available water is supplied solely through precipitation falling in the watershed where it is used (USDA-NRCS, 2000).

An important function of the life-support environment is the production of clean water. Because

soil buffers the flow of water and movement of nutrients off-land and largely determines water's chemical and biological characteristics, soil quality and watershed health are intertwined. To assess the state of the soil and water quality associated with agricultural landscapes, relevant information was found using the National Resources Inventory and a series of reports from the National Resources Conservation Service (NRCS) and the US Environmental Protection Agency (USEPA). Key problems of agricultural lands that interfere with the production of clean water include soil erosion, nutrient losses, and pesticide runoff.

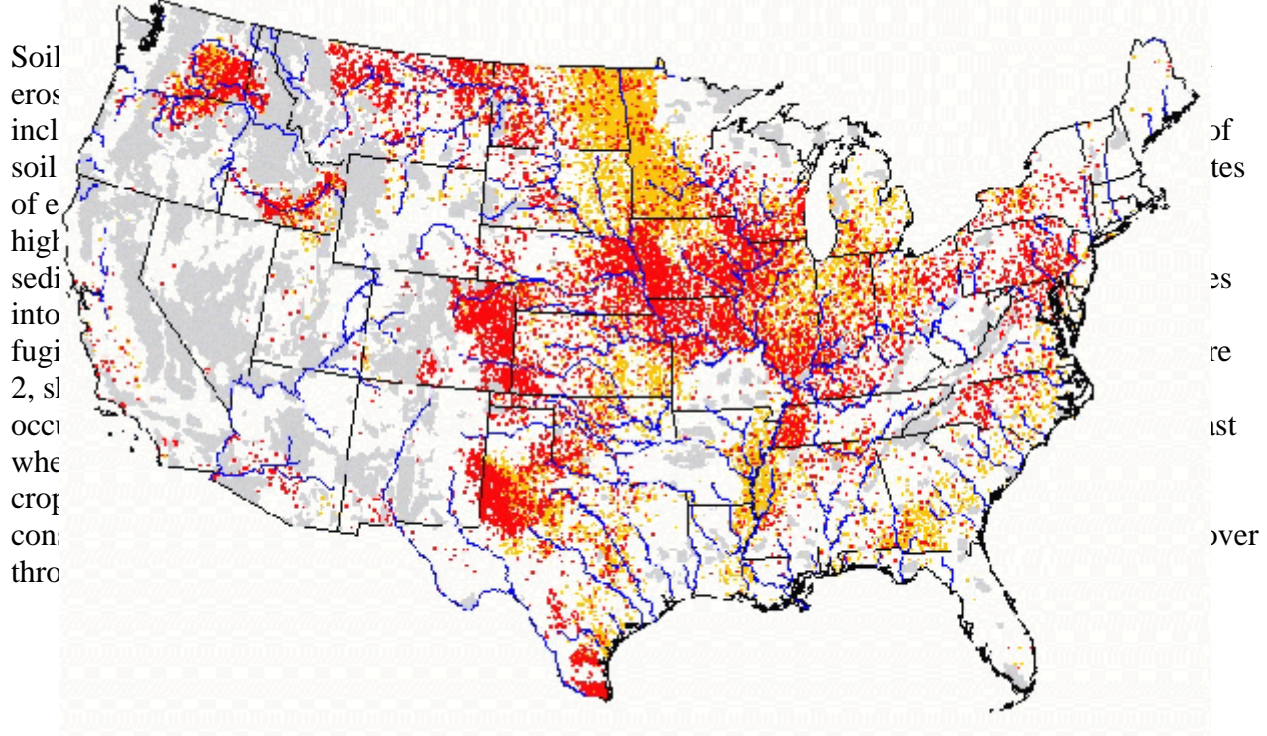


Figure 2. Excessive Erosion on Cropland, 1997. Each red dot represents 5000 acres of highly erodible land and each yellow dot represents 5000 acres of non-highly erodible

Agricultural lands are a recognized nonpoint source of water contaminants. Currently, complete and consistent data of surface water and ground water quality is lacking at a national level. Several inventories have been done that cover different watersheds and different time periods. Perhaps the most current, albeit incomplete, data are supplied by the National Water Quality Inventory, which is completed every two years as required by Section 305(b) of the Clean Water Act (USEPA, 2000). For this inventory, states, territories, tribes, and interstate commissions assessed the health of their waters in relation to designated water use and accompanying water quality standards. A subset of US rivers and streams, lakes, Great Lakes shoreline, estuaries, and ocean shoreline were evaluated. States and tribes assessed 23% of the total river and stream miles; 42% of the lake, reservoir, and pond acres; 90% of the Great Lakes shoreline miles; 32% of the estuary square miles; and 5% of ocean shoreline miles.

Ninety-seven percent of assessed river and stream miles, 89 percent of assessed lake, reservoir, and pond acres, and 100 percent of Great Lakes shoreline miles in the United States fully supported use by agriculture. Waters supporting agricultural use are those that can be used for irrigating fields and watering livestock without treatment (USEPA, 2000). Other designated uses of waters include aquatic life support, fish consumption, primary contact, secondary contact, and drinking water supply. Considering all uses combined, 65 percent of assessed river and stream miles, 55 percent of lake, reservoir, and pond acres, and only four percent of Great Lakes' shoreline miles supported all uses. Agricultural activities contributing silt (a size class of sediment particles from eroded soils) and nutrients were reported as the most widespread source of pollution in assessed rivers and streams, lakes, reservoirs, and ponds. An estimated 60 percent of total riverborne sediment came from irrigated and nonirrigated agricultural fields.

Caution must be applied when interpreting the above information. At this point, these data cannot be used to characterize water quality nationwide. Unlike the Natural Resources Inventory, the evaluated areas were not chosen based on a statistically derived random sample. Many states and tribes directed their limited resources to problem areas and monitored those waters. In addition, the information about pollutants and sources of these pollutants is incomplete because many reporting agencies do not identify these parameters for impaired waters (USEPA, 2000).

In 1991, the US Geological Survey (USGS) began the National Water Quality Assessment Program (NAWQA) in which the water quality in more than 50 major river basins and aquifer systems was assessed using a consistent approach and standardized methods (USGS, 1997). One of the primary objectives of the USGS program was to provide information to understand how human activities and natural factors affect water quality nationwide. To accomplish this objective, results from sampled watersheds were synthesized with climate, soils, agricultural practices, and geographic, geologic, and hydrologic information to identify common characteristics and to explain water quality differences. Due to national concern, nutrients and pesticides were two of the water quality issues evaluated and synthesized by the NAWQA Program.

Results of the national synthesis were based on water quality data collection between 1992 and 1996. Within this time frame, analyses for 76 pesticides and seven degradation products in approximately 8200 water samples in 20 of the nation's major hydrologic basins were completed. These data are the most extensive collected to date. Fifty-eight different pesticides were detected

at least once in both groundwater and surface water. Pesticides were present more frequently and at higher concentrations in surface water. Greater than 95 percent of all surface water samples but less than 50 percent of groundwater samples contained one or more pesticides. The same herbicides (atrazine, metolachlor, prometon, and simazine) were most commonly found in streams and groundwater in all study areas. For the most part, concentrations of pesticides found in groundwater samples and the annual average concentration for streams were less than the current USEPA drinking water standards and guidelines. However, more than 50 percent of agricultural and urban streams had concentrations of at least one pesticide that exceeded a guideline for aquatic life protection. Concentrations of the most heavily used herbicides in agriculture (atrazine, metolachlor, alachlor, cyanazine) were frequently detected in streams and shallow groundwater in agricultural areas (USGS, 1997).

Elevated levels of the nutrients, nitrogen and phosphorus, occurred in streams and groundwater in agricultural and urban areas. Relative levels of contamination were linked to land use. Some of the highest concentrations of nitrogen were detected in samples from streams and shallow groundwater in agricultural areas. Nitrate concentrations in excess of the USEPA drinking water standard of 10 mg/L were found in 15 percent of samples collected in shallow groundwater beneath agricultural and urban land. Conversely, some of the highest concentrations of phosphorus were detected in samples collected from urban streams. Nitrate nitrogen is a very mobile ion with a high potential to leach into groundwater, volatilize into the atmosphere, or be carried overland to nearby surface waters. Phosphate is not as mobile as nitrate and tends to be carried on soil particles that move off the field because of erosion. Concentrated animal production sites also provide the potential for nutrient inputs into aquatic systems as well as bacterial contamination. Parts of the Southeast and West have animal manure problems that are a product of soil and climatic factors and the lack of adequate cropland for proper application (USDA-NRCS, 1997). Results from the USGS national synthesis support the general agricultural impacts as reported in the National Water Quality Inventory.

As exemplified by the familiar agriculture and environmental health problems of water quality degradation due to soil erosion and fertilizer and pesticide runoff, agricultural lands in general are not serving as a supporting host for developed landscapes as envisioned by E.P. Odum. Rather, they can be viewed as an additional burden on the remaining natural landscapes. According to Odum (1997), the key to removing these agricultural lands as an additional burden is to view them as the functional parts of larger regional systems that provide life-support. A NRCS publication entitled *America's Private Land: A Geography of Hope*, is an effort to promote this approach among private landowners. A fundamental purpose of the publication is to share a vision, to educate farmers, ranchers, and other landowners to think about the soil, water, and air as a part of a larger landscape, and to focus on conservation and environmental quality as essential for life-support (USDA-NRCS, 1997). This vision is exemplified in the following excerpt: ...farmers and ranchers produce much more than food and fiber. Through their care and stewardship of the land, farmers and ranchers produce safe drinking water, clear-flowing streams, lakes full of fish, skies full of ducks and geese, and scenic landscapes. The challenge that is before all is to capture this vision and translate it into local action.

Realizing that this life-support vision for agriculture is fundamental to providing the ecological balances essential to long-term human health, environmental health professionals are clearly

called to an expanded involvement in agriculture issues. At this time, the United States does not have an environmental health and protection system but rather a web of organizations doing "environmental health activities" at the federal, state, and local levels. According to Burke, Tran, and Shalauta (1995) in their report profiling state environmental health and protection services, the trend toward decreasing the environmental responsibilities of state health agencies continues. At that time, public health departments remained as the lead agency for environmental health services in eight states including Colorado, Hawaii, Idaho, Kansas, Montana, North Carolina, North Dakota, and South Carolina. The majority of states give responsibility for environmental protection to regulatory agencies that are organized predominantly in the media specific USEPA model. Federal statute implementation requirements have heavily influenced this organization and promoted a focus toward the regulatory aspects of environmental protection and away from the broader public health aspects. The narrow, regulatory focus does not encourage an improved understanding of the important, life-supporting relationship between the environment and human health.

Additional findings of Burke, Tran, and Shalauta (1995) included that very few environmental and agricultural agencies implement traditional environmental health programs that include epidemiology, risk assessment, and environmental sanitation. These programs are essential in providing an improved understanding of the relationship between agriculture and health issues as exemplified by a recent paper in Environmental Research (Xiang, Nuckols, and Stallones, 2000). In addition, funding priorities for environmental health and protection do not support expanded non-regulatory involvement (Burke, Tran, and Shalauta, 1995). In 1995, greater than 5.5 billion dollars were allocated by the states for environmental health and protection services. Of this amount, about 1 billion dollars were devoted to environmental health activities (epidemiology, surveillance, education) while 4.7 billion dollars were devoted to regulatory activities (permitting, monitoring, remediation).

In conclusion, the connection between agriculture and environmental health is a fundamental one of the provision and maintenance of a life-supporting environment for humans. This paper presented an update on soil and water quality impacts due to agricultural activities and briefly described the NRCS vision that promotes conservation on agricultural lands using a landscape approach to improve the environmental quality essential for life-support. Based on recent reports, environmental health and protection activities take place in a variety of state agencies that are primarily regulatory rather than public health in nature. Therefore, the lack of a consistent focus on health outcomes in environmental protection activities is identified as a gap in linking the expanded role of the environment as a life-support system to human health.

Figure 1. Freshwater Consumption as a Percentage of Local Average Annual Precipitation.

Legend: Percentage of Local Average Annual Precipitation

Source: USDA-NRCS, 2001

Figure 2. Excessive Erosion on Cropland, 1997

Legend: Each red dot represents 5000 acres of highly erodible land and each yellow dot represents 5000 acres of non-highly erodible land with excess erosion above the tolerable soil erosion rate.

Source: USDA-NRCS, 2001

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