The Quality of Our Nation's Waters

Agriculture—A River Runs Through It—The Connections Between Agriculture and Water Quality

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National Water-Quality Assessment Project
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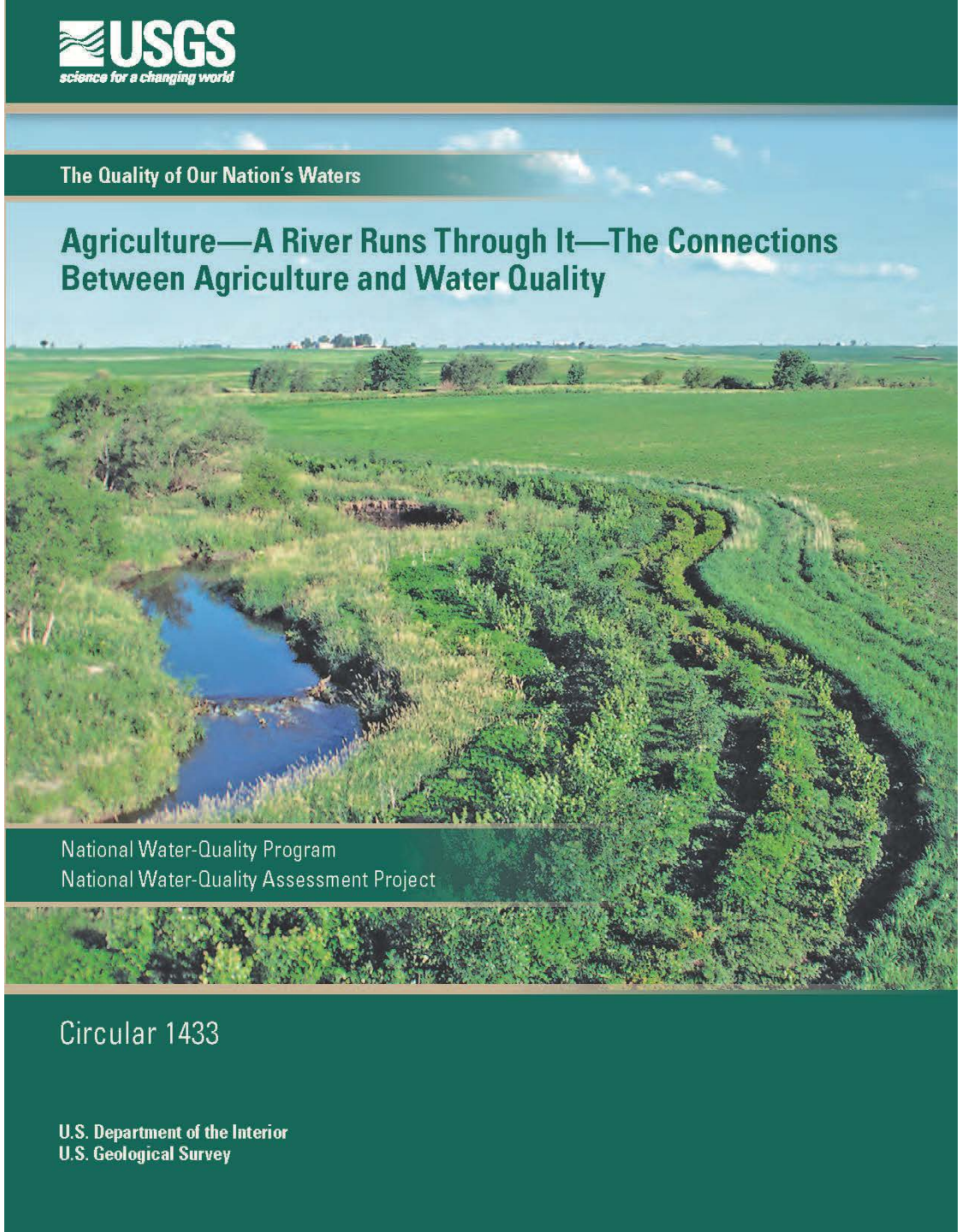
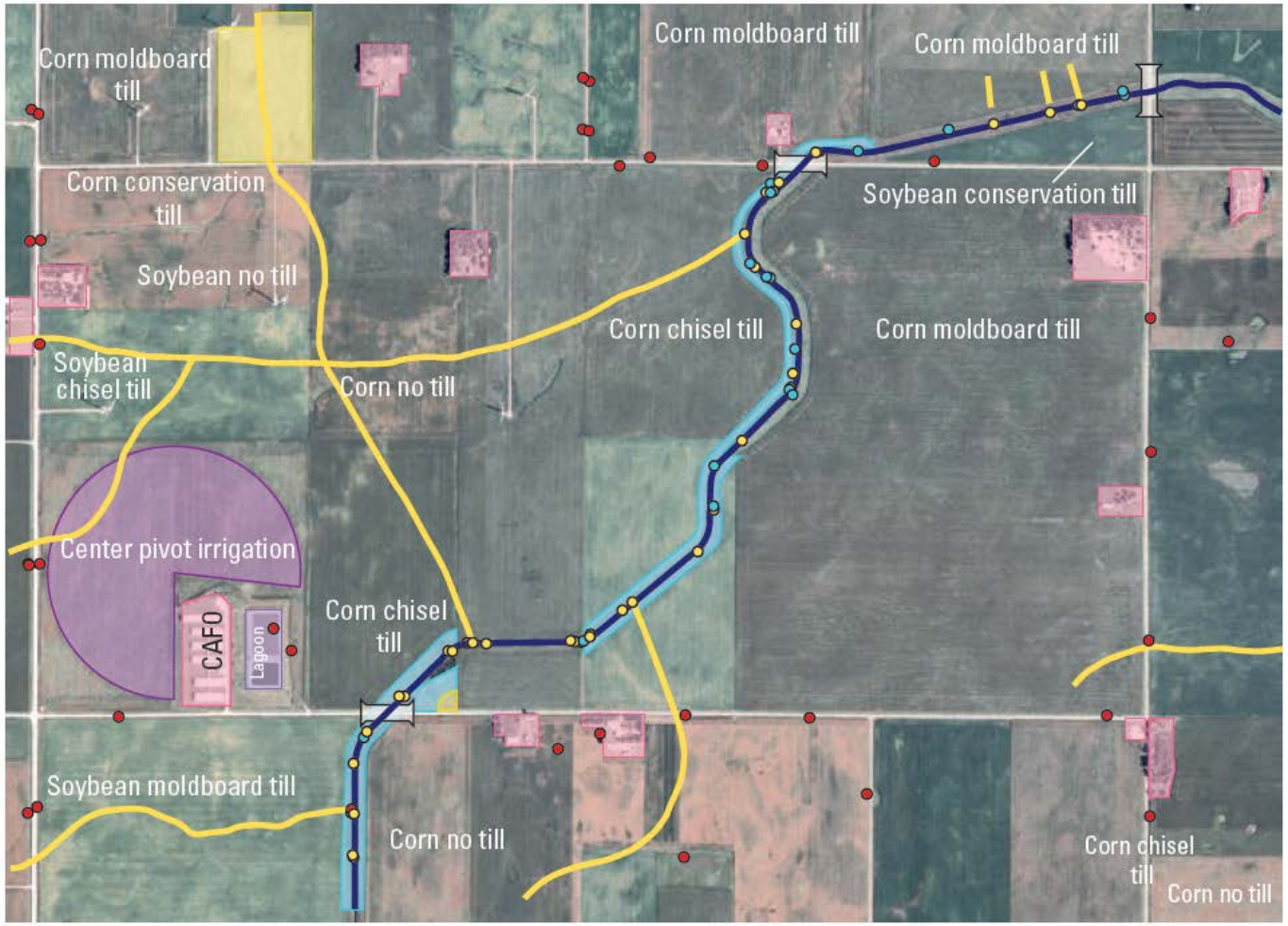
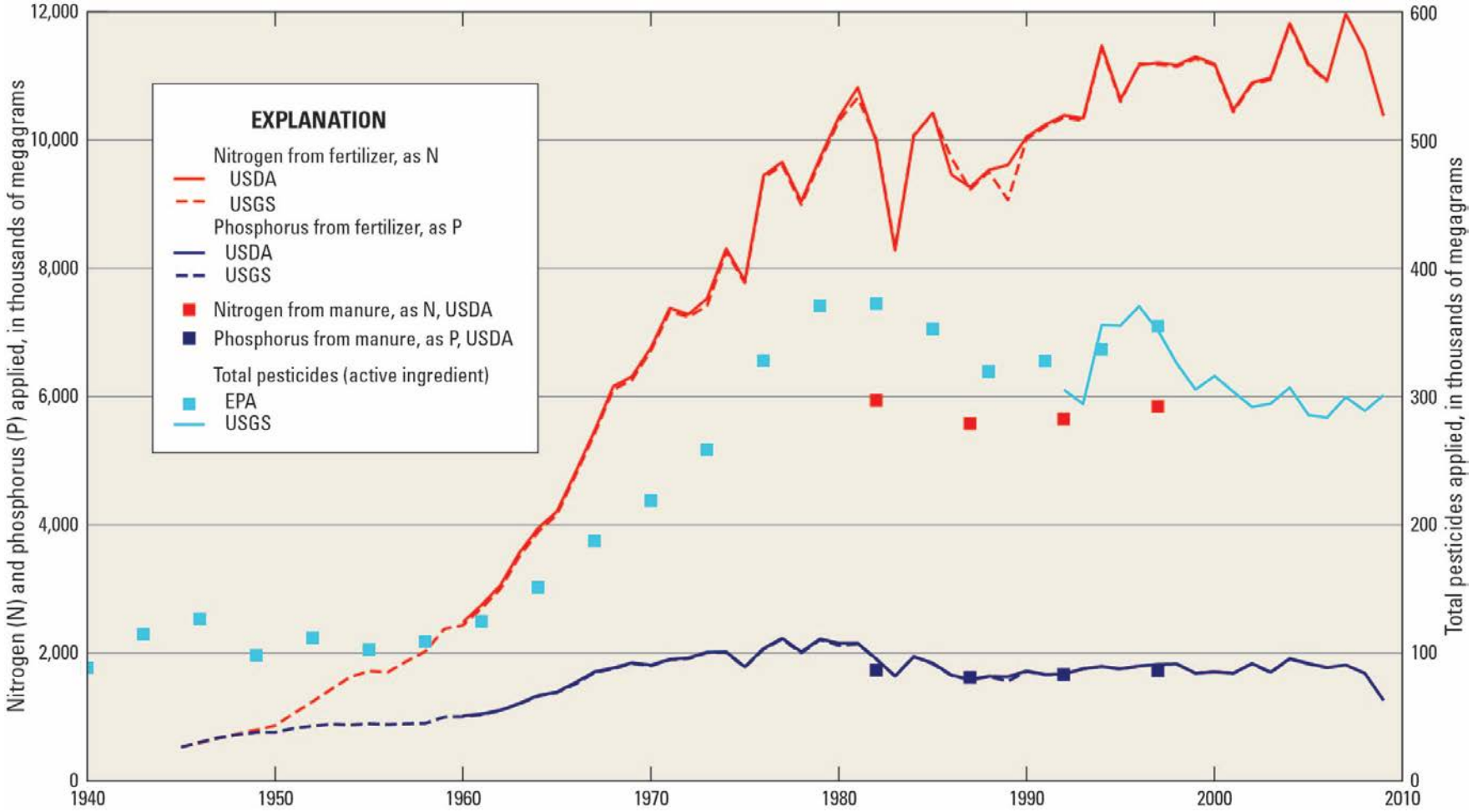


Landscape modifications for agriculture have altered the natural flow of water and agricultural chemicals entering streams and aquifers



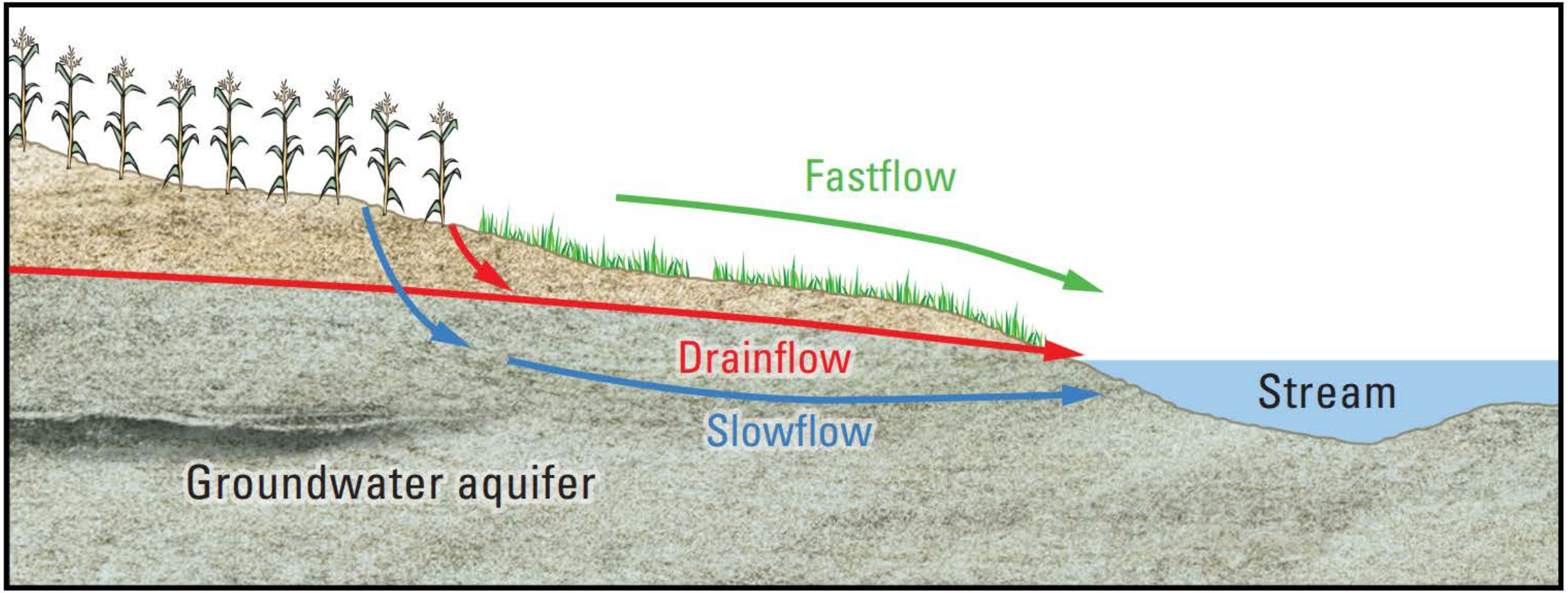
An aerial photograph of an 11-square kilometer agricultural area in northcentral Iowa with many of its agricultural modifications identified. The cumulative effects of landscape modifications have led to adverse effects on the environment, including changes in water quantity, water quality, and ecosystem health.

Chemicals are used extensively in agriculture



Considerable increases in fertilizer and pesticide use began in the 1960s. Increased levels of nutrients from fertilizers draining into streams can stimulate algal blooms and affect stream health and recreational uses of local streams, downstream reservoirs, and estuaries, and increase treatment costs for drinking water. Pesticides that are transported to streams can pose risks for aquatic life and fish-eating wildlife and drinking-water supplies.

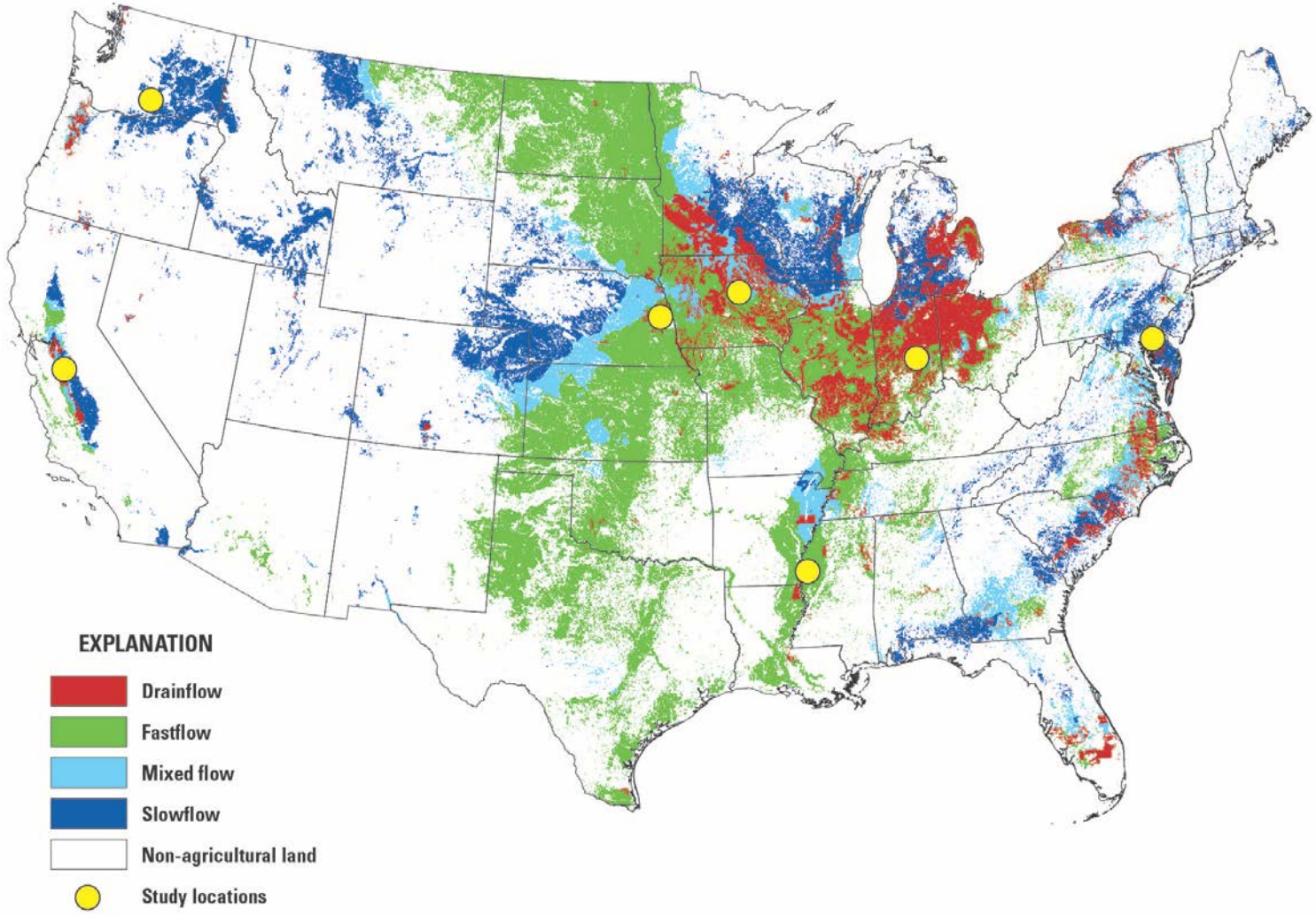
Tracking how water moves through agricultural landscapes provides insights on the movement of agricultural chemicals



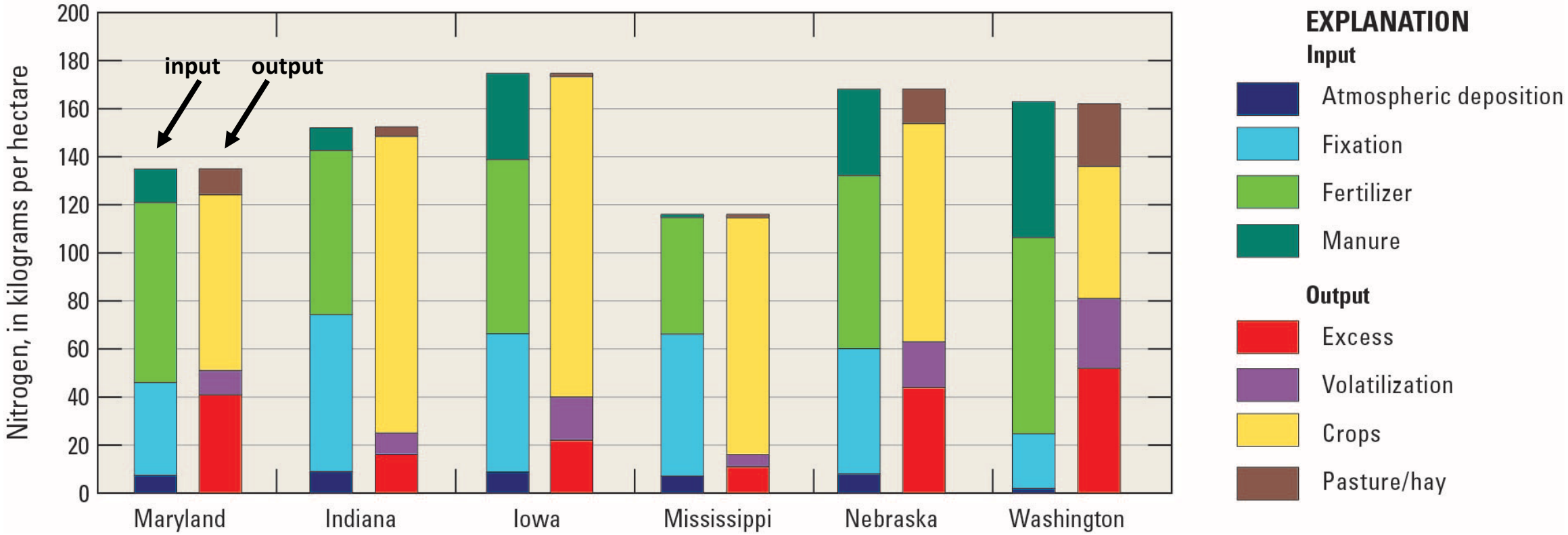
Most historical and current water-quantity and water-quality impacts from agriculture are the result of the modification of the natural water flowpaths and (or) the use of chemicals.

Water flowpaths determine how and how quickly chemicals are transported from fields to streams

Flowpaths are the ways by which water, chemicals, and sediment move through and out of the agricultural landscape. The map here shows those areas in crop agriculture that are expected to have slowflow, fastflow, and drainflow as their important flowpaths. Some areas have a mixture of flowpaths.



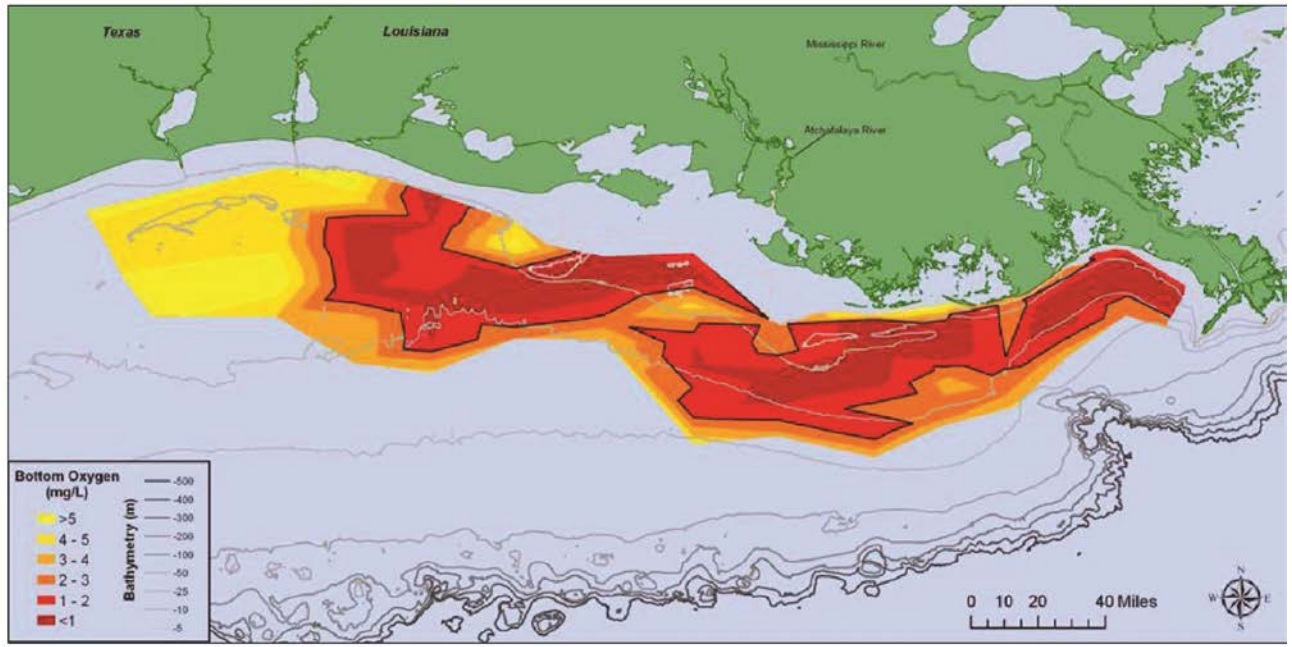
Some, but not all, of the nitrogen used in fertilizers is taken up by plants

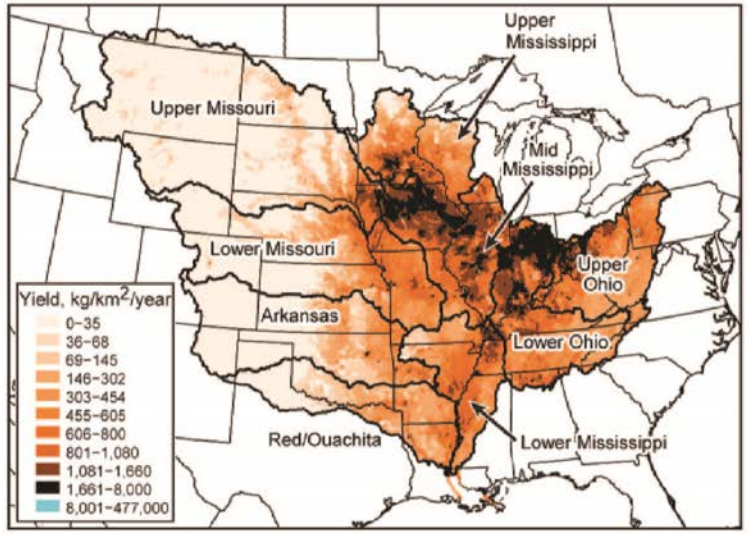


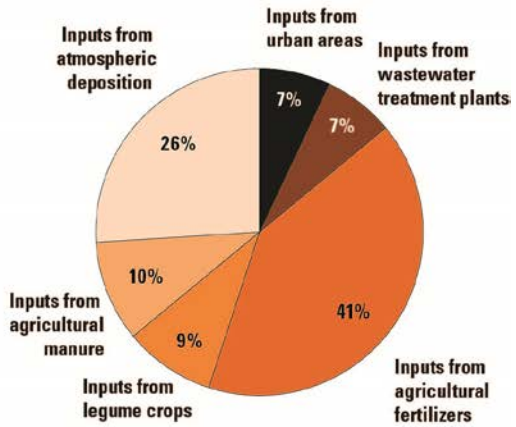
Accounting for the annual inputs and outputs of nitrogen in agricultural watersheds provides insights on the "excess" component (red), which is the amount of nitrogen that moves into the groundwater and streams and contributes to water-quality concerns.

Agricultural activities can affect water quality at a large scale

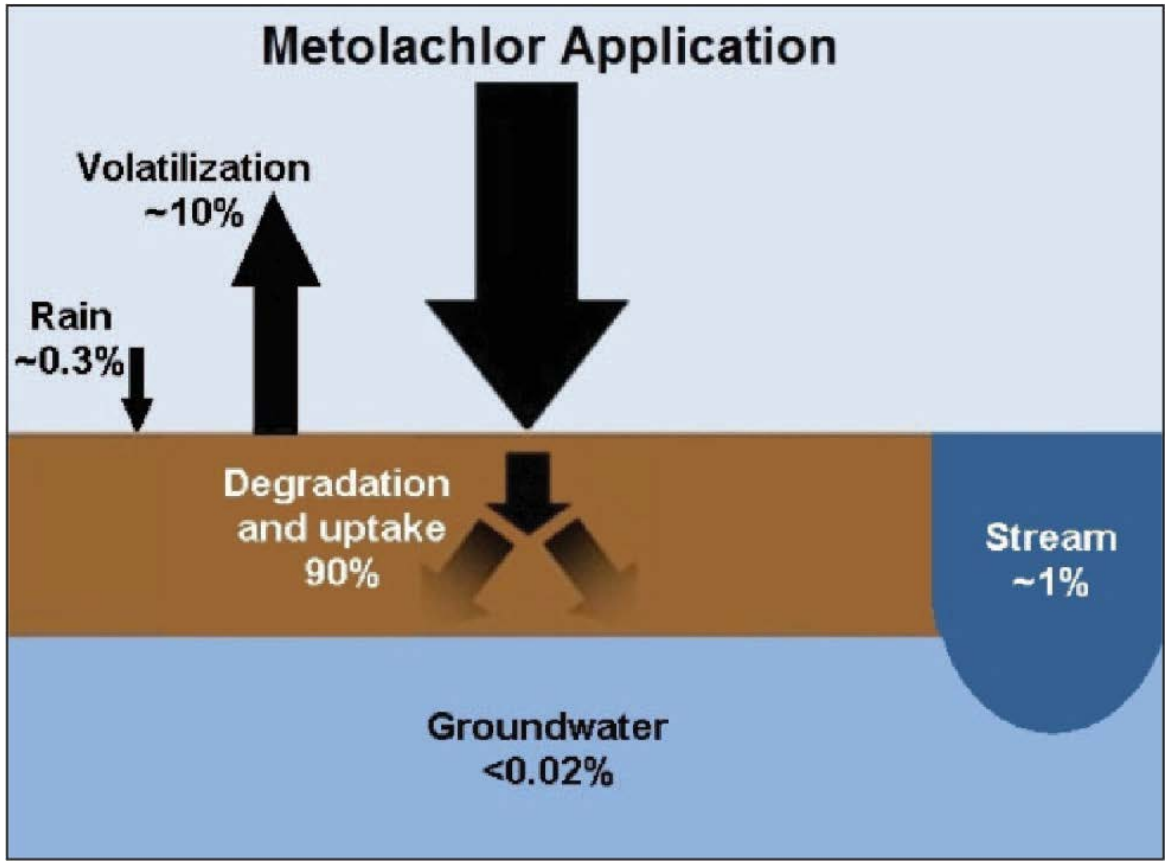
Nutrients originating across a large part of the United States flow down the Mississippi River to the Gulf of Mexico. The nutrients cause algal blooms and die-offs that deplete dissolved oxygen in the water, creating a large hypoxic (low oxygen) area in the Gulf each summer (top). When oxygen levels are less than 2 milligrams per liter, less mobile or immobile animals, such as mussels, cannot move out of the hypoxic areas and often die. The corn and soybean growing region from Kansas to Ohio (dark area, bottom left) contributes the largest amounts of nitrogen to the Gulf of Mexico. Overall, agricultural activities contribute about 60 percent of the total nitrogen flowing into the Gulf (bottom right).





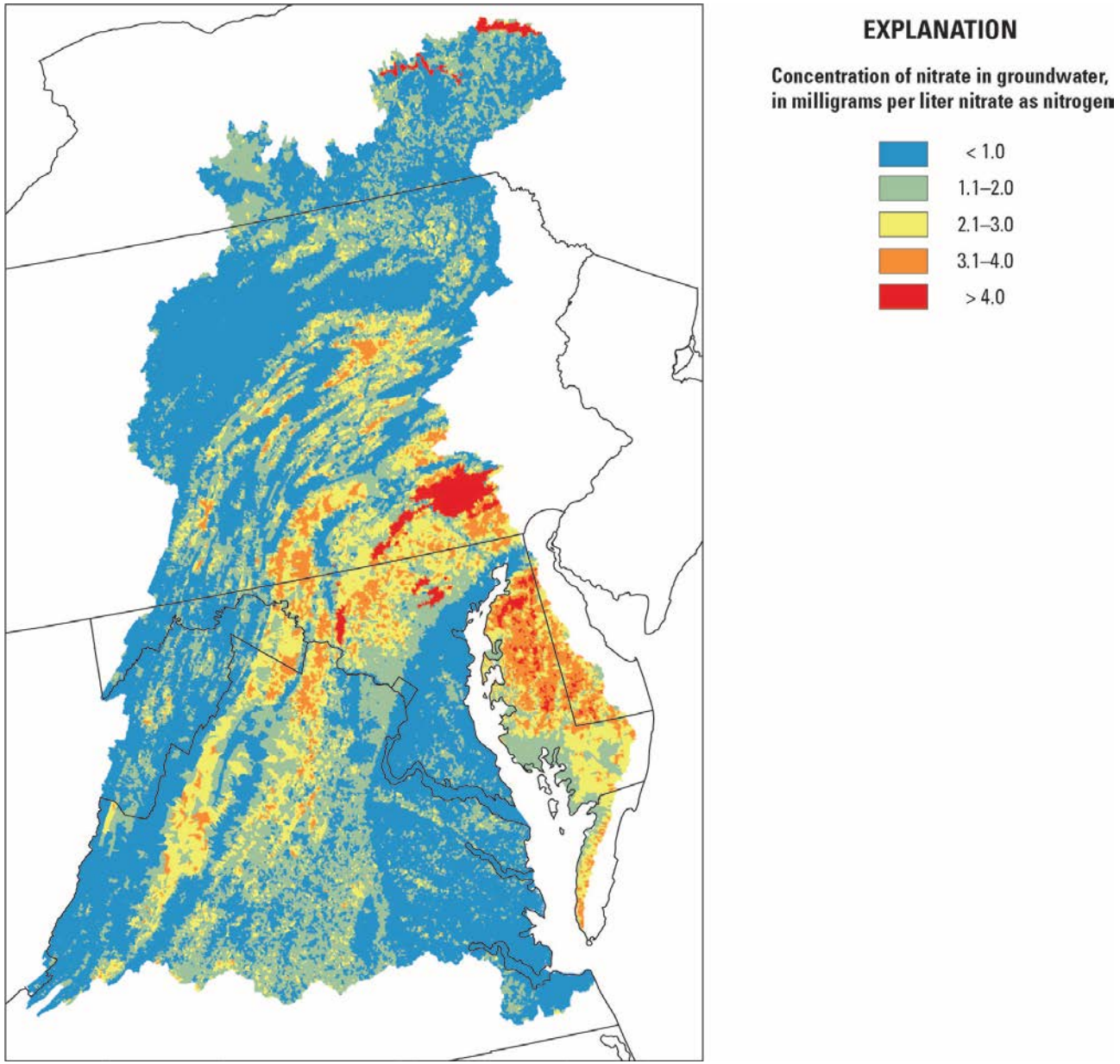


Pesticides and their transformation products are detected throughout the environment



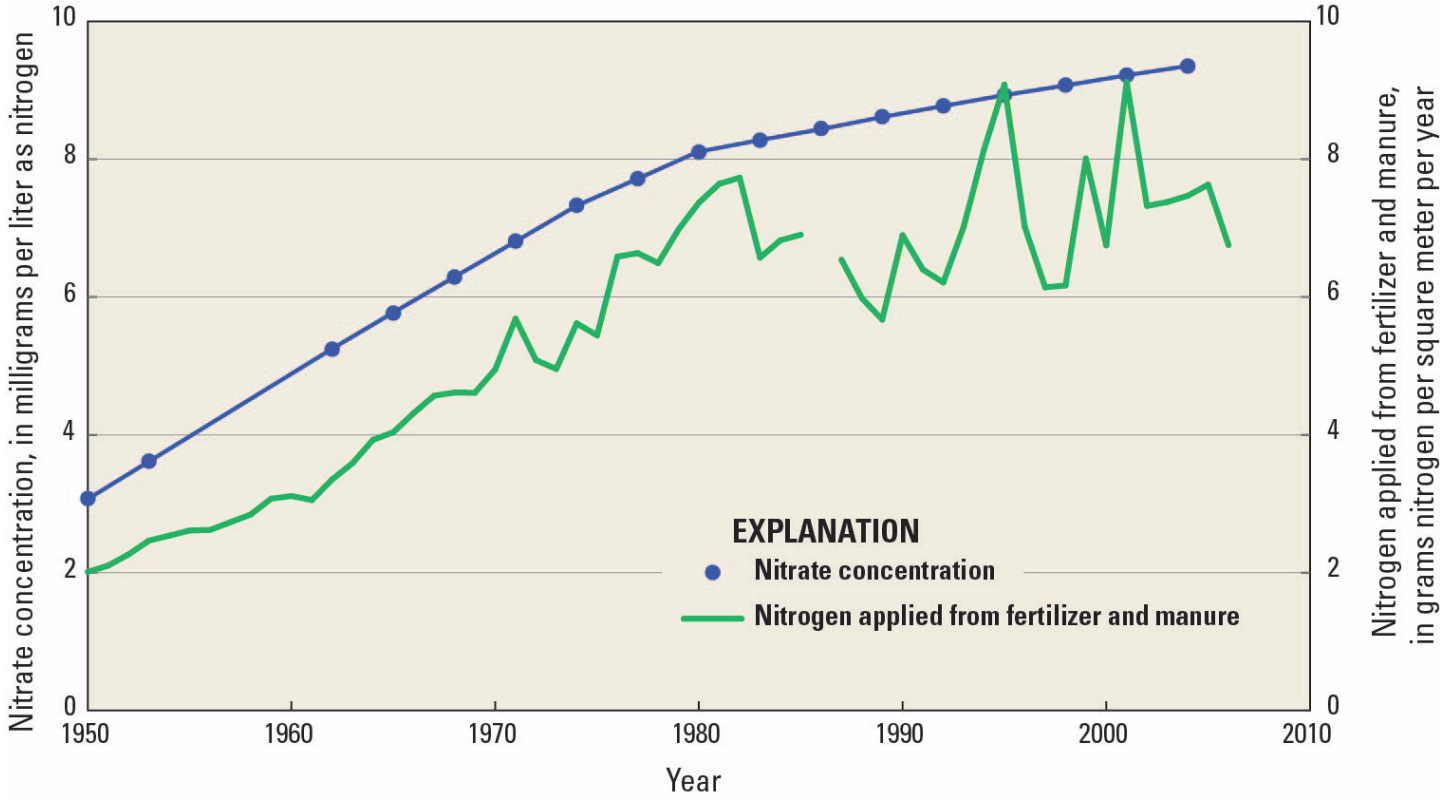
Typically, about 1 percent of the herbicide metolachlor that is applied annually moves off the field into streams and groundwater, and 10% is released into the air. Some metolachlor is transformed into other chemicals. Some of these transformation products are detected in water, but information about their occurrence is insufficient to do the type of mass budget shown here for the parent chemical, metolachlor.

Some parts of the landscape disproportionately affect water quality



The concentration of nitrate in groundwater is not evenly distributed across the Chesapeake Bay watershed because of differences in land use, differences in use of nitrogen fertilizers, and the type of underlying aquifer.

Strategic, long-term water-quality monitoring and modeling provide a basis for sound management decisions



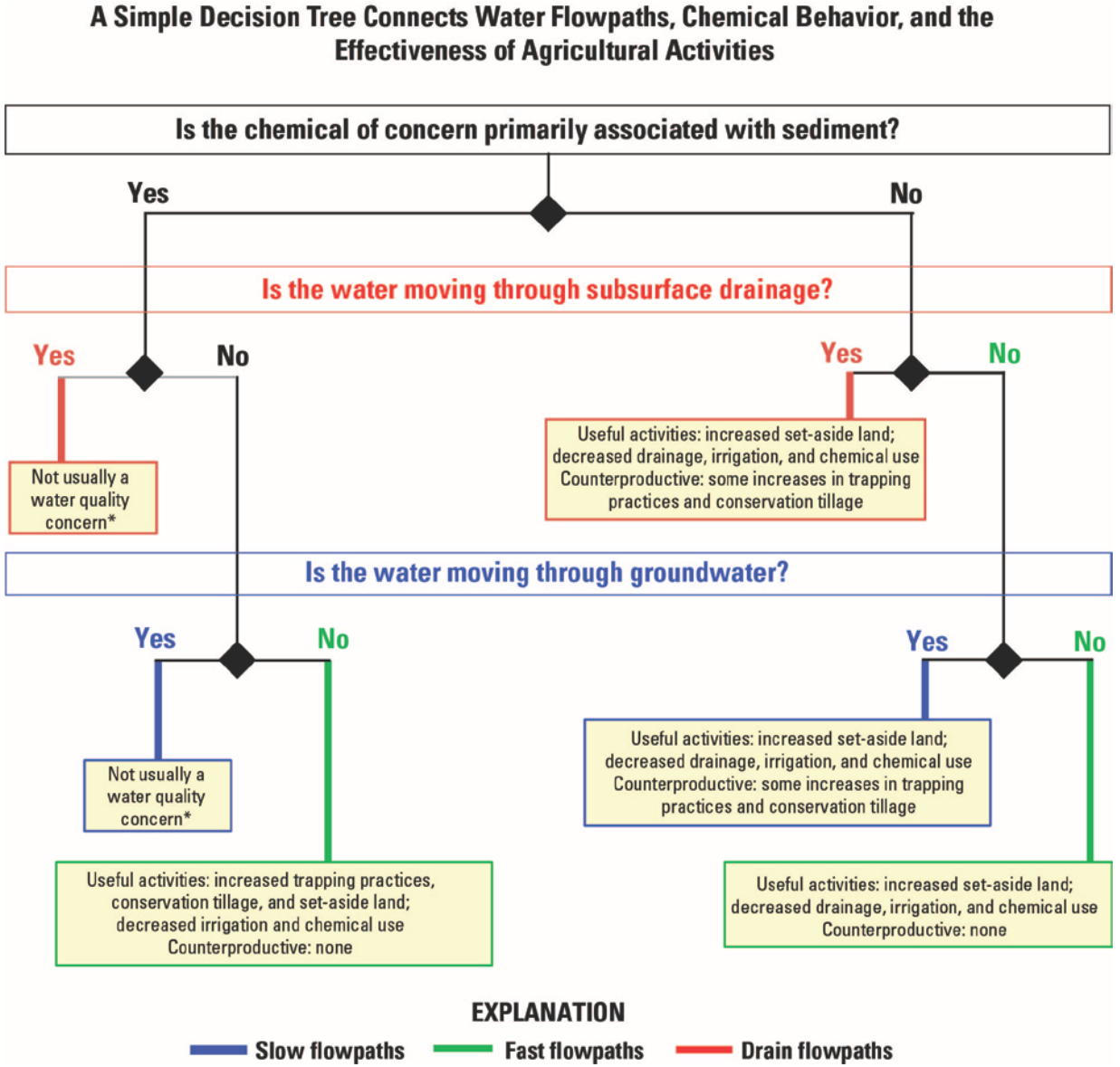
Long-term trends, such as those measured at the Maumee River, provide insights into the relations between human activities and nitrate concentrations. The trend in nitrate concentration in the Maumee River, which flows through the intensely row-cropped area of northwestern Ohio into Lake Erie, show a rapid increase between 1950 and 1980 as nitrogen inputs from fertilizer and livestock increased. This nearly 6-decade record of nitrate river concentrations and fertilizer use provides a perspective that short-term monitoring efforts may miss.

Understanding the connections among hydrologic settings and chemical behaviors can help set realistic expectations for water-quality improvements

A Simple Decision Tree Connects Water Flowpaths, Chemical Behavior, and the Effectiveness of Agricultural Activities

The decision tree can assist with identifying which agricultural activity(s) might be effective in protecting or improving stream-water quality and which agricultural activity(s) could be counterproductive.

An asterisk (*) indicates that these chemicals are not usually a concern in water moving along subsurface flowpaths, but they can be a concern in the water moving along flowpaths on the land surface.



The Challenging Connections Between Agriculture and Water Quality

We are entering a time of unprecedented demands upon the Earth and its resources. Some 7 billion humans inhabit this single planet, all of whom need food to eat, fiber for clothing, shelter for protection from the elements, and clean water to drink. The challenges for agriculture are great and the stakes are high. Can agriculture on a global basis produce enough food, fiber, and fuel to satisfy the needs of humanity, and do it in such a way that it is ecologically sustainable, so as not to degrade the quality of our air, water, soil, and other natural ecosystems? This, then, is the challenge. Meeting the goal of providing for the material needs of humanity will require a cooperative effort among producers, scientists, consumers, and policy makers to think seriously, plan carefully, and develop a sound strategy to wisely use the Earth's resources.