Protecting and improving our water: A summary

Iowa's Nutrient Budget

What's the big deal about nutrients?

Nutrients like nitrogen and phosphorus are essential for healthy waters. A lake or river without nutrients would be a sterile place without diverse aquatic organisms such as algae, aquatic plants, insects and fish.

Nutrient enrichment causes excessive algae growth in this Iowa stream.

But high levels of nutrients can result in too much algae and too many aquatic plants. This is a condition known as nutrient enrichment, a problem both statewide and nationwide.

Potential problems from nutrient enrichment include:

- Nuisance levels of algae and aquatic plants that interfere with recreation and life cycles of aquatic life
- Cloudy water from high levels of microscopic algae suspended in the water
- Frequent blooms of potentially toxic algae, as pictured above
- Formation of cancer-causing compounds in chlorinated drinking water that can affect liver, kidney and nervous system functions
- Decay of plants can create low levels of dissolved oxygen, which can be deadly to aquatic life
- An imbalance or shift of aquatic species towards less desirable species, like carp
- Acceleration of the natural aging process of lakes

For cleaner drinking water, for improved recreational opportunities -- substantially reducing the level of nutrients is a significant and necessary challenge for Iowa.

Due to Iowa's naturally rich soils and intensive agriculture, the state has very high levels of nitrogen and phosphorus in its waters, typically two to 10 times the levels considered appropriate for Midwest streams.

Nitrogen and phosphorus are needed in much greater amounts than other nutrients by algae and aquatic plants, so strategies to control the impacts of nutrient enrichment typically focus on limiting the amount of nitrogen and phosphorus in the water. But strategies must also consider land management and hydrology.

What's a nutrient budget?

Determining the nutrient budget is an important step in a nutrient reduction strategy. Much like a financial budget, a nutrient budget accounts for nutrients -- where they come from and where they go, just as a financial budget accounts for income and where money is spent.

A nutrient budget can provide the answer to such questions as, "How much of the phosphorus in our rivers comes from agriculture versus municipal sewage treatment plants?"

How do nutrients enter a watershed?

Inputs

Commercial fertilizer
Nitrogen (N) and phosphorus (P) in commercial fertilizer for different crops, pastures, lawns, etc.

Manure
N and P in livestock waste, like beef, hogs, sheep and poultry

Atmospheric deposition
N and P dissolved in precipitation, attached to windblown particles or as aerosols

Legume fixation
Atmospheric N "fixed" by symbiotic bacteria for soybean, alfalfa and other legume crops

Human waste
N and P in human waste

Industrial waste
N and P discharged from industrial plants

How do nutrients leave a watershed?

Outputs

Harvest
N and P in crops that are consumed by grazing animals and harvested as grain

Fertilizer and manure volatilization
N that passes off in vapor (volatilizes) and is lost to the atmosphere, primarily as ammonia

Crop volatilization
N that volatilizes from growing and withering crops, mainly as ammonia

Stream loads
N and P that ends up in streams and rivers, calculated using stream N and P concentrations and flow rates for 1999 - 2001

Denitrification
N lost to the atmosphere as nitrogen gas, caused by anaerobic bacteria converting nitrate and nitrogen gas

Understanding where nutrients come from -- and where they go

Although the amount of nutrients that end up in the stream (stream loads) are the main concern, it is important to account for all the other inputs and outputs to understand the big picture and the relative significance of the various inputs and outputs.

Figure 1 shows the nutrient inputs and outputs for a watershed, the area of land that drains into a stream.

For example, application of manure and fertilizers to crops adds nutrients to a watershed. These additions are considered inputs in the budget. When crops are harvested, nutrients are removed from the watershed, and the amount of harvested nutrients becomes an output. Inputs and outputs from all the sources can then be summed on a watershed and statewide basis.

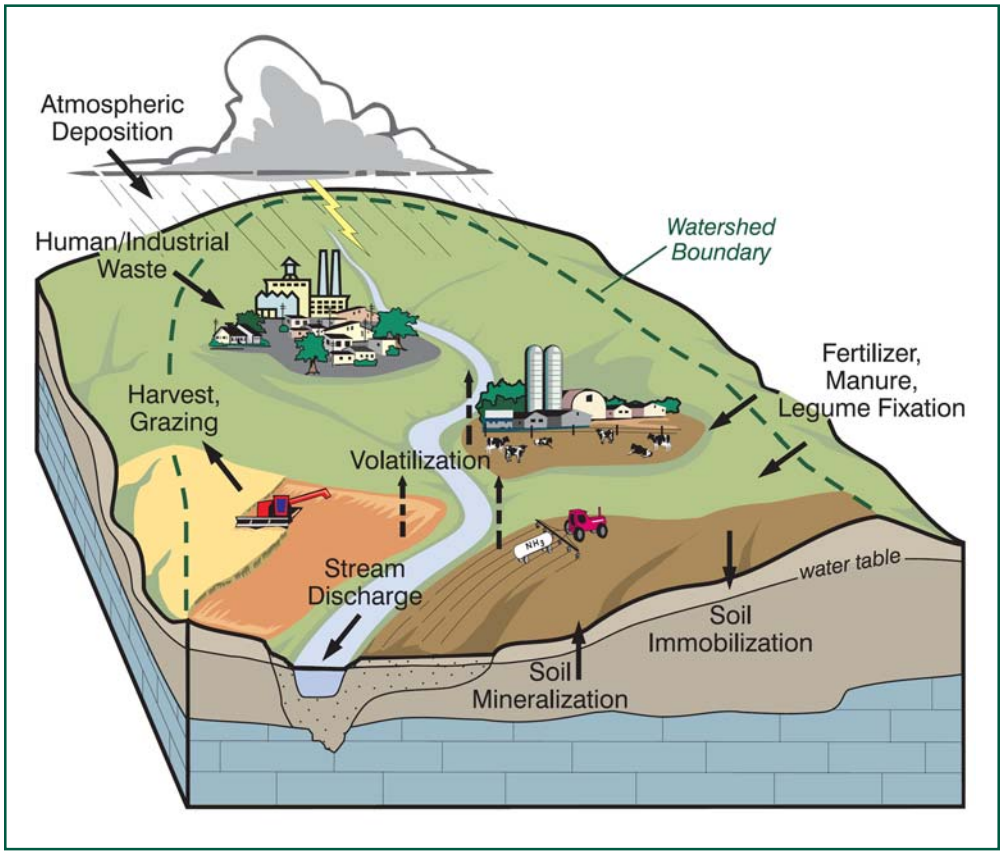


Illustration by Pat Lohmann, DNR

Figure 1: The movement of nutrients into and out of a watershed

Inputs include fertilizer and manure application, legume fixation, atmospheric deposition, human/industrial waste and soil mineralization. Outputs include crop harvest, grazing, volatilization, stream discharge and soil immobilization. Descriptions of these inputs and outputs are found in the sidebar to the left.

Developing Iowa's nutrient budget

A nutrient budget can be simple in concept, but inputs and outputs can be more complicated and difficult to estimate, as they vary significantly over time and across the state.

For example, the amount of nutrients removed in a harvested crop varies from year to year and depends on factors such as weather, soils, amount of fertilizer applied and crop genetics.

Because inputs and outputs can vary substantially from year to year, Iowa's nutrient budget was developed to reflect long-term average conditions.

Budget methods

The inputs determined for the budget include: commercial fertilizer, manure, atmospheric deposition, legume fixation, human waste and industrial waste. Outputs include: harvest, fertilizer and manure volatilization, crop volatilization, stream loads and denitrification. These inputs are described in detail on the previous page.

In addition, the budget assumed:

- Mineralization (amount of nitrogen released from the soil) was considered an input for the budget
- Immobilization (amount of nitrogen stored in the soil's organic matter) was considered an output
- Mineralization and immobilizations were assumed to be equal, as it was assumed there was no net gain or loss of soil organic matter.

Data used

A wide variety of data sources was used for the nutrient budget, including:

- Population data
- Land use
- Soil properties
- Rainfall
- Crop acreage and yields
- Fertilizer sales data
- Various research and technology publications

Most data were derived from readily available sources, such as the National Agricultural Statistics Survey and U.S. Census data.

Putting it all together

Teams consisting of DNR staff, Iowa State University faculty and National Soil Tilth Laboratory researchers provided expert advice and consensus on assumptions and data (e.g., the nitrogen and phosphorus content of manure) used in preparing the budget.

Resources

Inputs and outputs for 68 major watersheds and for the entire state were calculated based on various DNR GIS (Geographic Information System) data layers.

DNR photo

Nutrients cause a large algae bloom in this Iowa creek.

Common terms used in this brochure

Nutrients
A variety of elements that are needed by living organisms, including nitrogen, phosphorus, calcium, magnesium, sodium, potassium, iron, copper, manganese, boron and zinc. Of the many nutrients needed, nitrogen and phosphorus are considered macronutrients as they are needed in greater amounts than the other nutrients.

Watershed
All of the land that drains into a stream or river.

Inputs
The sources of the nitrogen and phosphorus that enter the watershed of a stream or river.

Outputs
How nutrients leave a watershed; most nutrients are not lost to streams.

Stream loads
The amount of nitrogen or phosphorus carried downstream by a stream or river over a period of time.

Point source
A direct and identifiable source of a nutrient or pollution into a waterway.

Nonpoint source
Nonpoint sources of nutrients and pollution come from different sources in a landscape and can be difficult to pinpoint. For example, runoff from farm fields draining nutrients into streams.

What does the nutrient budget tell us?

Human and industrial inputs are relatively small, accounting for one percent or less of the total inputs for both nitrogen and phosphorus.

One of the most important findings of the nutrient budget is the relative amounts of various inputs and outputs, which are summarized below.

Manure and commercial fertilizer account for about one-third of nitrogen inputs and 99 percent of phosphorus inputs in Iowa.

The amount of nitrogen and phosphorus ending up in our streams and rivers is a relatively small part of the outputs, about five percent for nitrogen and four percent for phosphorus.

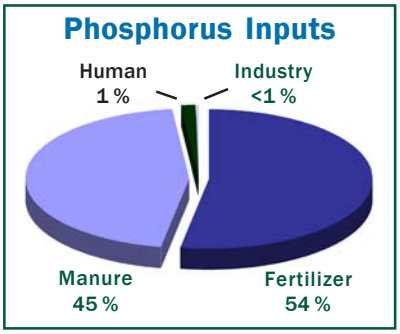
However, these small amounts are still enough to result in high nutrient levels in streams.

The amount of nutrients in Iowa waters is a relatively small amount of the big picture-- about five percent of total outputs for nitrogen and four percent of total outputs for phosphorus.

But these levels still range between 2 to 10 times the level considered appropriate for healthy waters.

How nutrients get in our water

Nutrients, as well as other substances or pollutants found in water, come from either point or nonpoint sources.



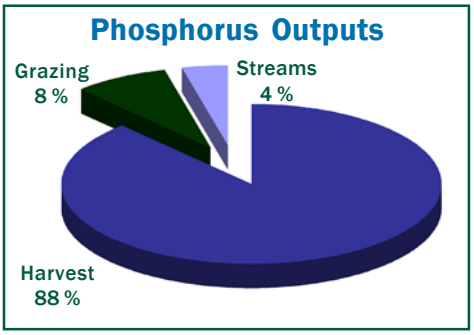
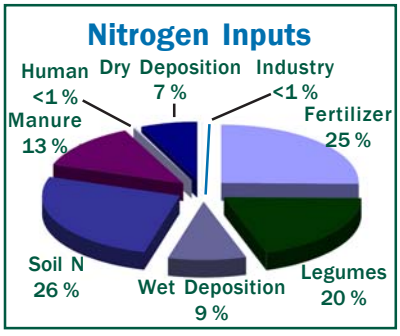


Figure 2: Phosphorus inputs and outputs
Nearly all phosphorus inputs come from manure and commercial fertilizer; most phosphorus leaves a watershed through harvest, not streams.



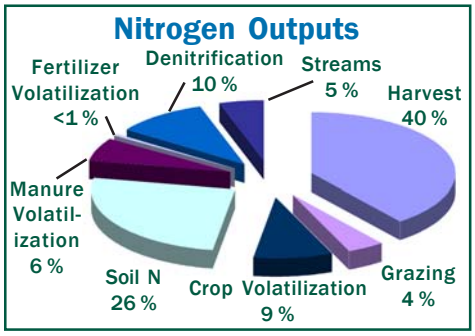


Figure 3: Nitrogen inputs and outputs
Nearly all nitrogen inputs come from nonpoint sources, like fertilizer and manure. Most nitrogen leaves the watershed through harvest, while only five percent leaves in streams.

Municipal and industrial wastewater plants are point sources because the pollutants enter the water at a specific "point," such as the end of a pipe.

On the other hand, agriculture and some other land uses are considered nonpoint sources, as they come from numerous sources that are difficult to pinpoint.[1]

The nutrient budget findings show that approximately eight percent of nitrogen and 20 percent of phosphorus found in Iowa waters comes from municipal and industrial discharges. The remaining 92 percent of nitrogen and 80 percent of phosphorus comes from nonpoint sources.

To substantially reduce nutrient levels of our waters, the amount of nutrients coming from nonpoint sources like agriculture must be reduced significantly.

1 The EPA considers some large confined animal feeding operations (CAFOs) point sources, but for the budget figures presented, CAFOs were considered nonpoint sources.

Comparing inputs and outputs

The nutrient budget data show that watersheds that have high levels of nitrogen inputs generally have high levels of nitrogen stream outputs. This suggests that the amount of nitrogen in streams is related to with the amount of nitrogen applied as fertilizer and manure.

However, watersheds with high levels of phosphorus inputs are not necessarily those with high levels of stream outputs. Other factors, such as soil erodibility, impact the delivery of phosphorus in streams.

The total inputs and stream outputs for 68 major Iowa watersheds were divided by the number of acres in the watershed, creating information on a pounds per acre basis. This allows watershed-to-watershed comparisons of inputs and outputs.

Maps outlining inputs and stream outputs in 68 major Iowa watersheds are available at www.iowadnr.com/water/nutrients/

Important budget results

The findings below are an important first step in working towards reducing the amount of nutrients in Iowa's streams, rivers, lakes and groundwater. amount of the nitrogen and phosphorus found in Iowa streams and rivers. Solutions to reduce the nutrient levels in our waters will have to involve agriculture, but nutrient reductions in municipal and industrial wastewater discharge will also be needed.

Nutrient inputs and outputs vary significantly

Across the state, inputs and outputs of nitrogen and phosphorus vary widely with a variety of factors such as land use, soil, hydrology and topography accounting for the differences.

Manure and commercial fertilizer

Manure and commercial fertilizer applied to crops provides a significant portion of the nitrogen and almost all of the phosphorus inputs.

Agriculture contributes a significant amount

Agricultural practices add a significant

Reduce the amount of manure and commercial fertilizer

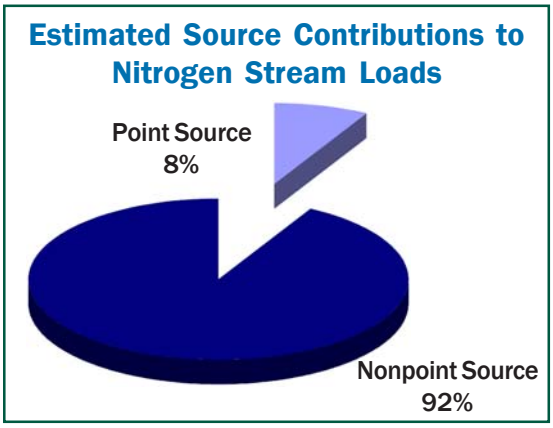
Reducing the amount of manure and fertilizer applied to crops will help reduce the nitrogen levels in our streams and rivers but will not, by itself, significantly reduce phosphorus levels.

Municipal and industrial discharges account for only 8 percent of nitrogen and 20 percent of phosphorus in Iowa waters.

The remainder of nutrients come from nonpoint sources like agriculture.

Most nutrients don't leave Iowa watersheds in streams

The nitrogen and phosphorus leaving Iowa in streams and rivers is actually a relatively small proportion of the total nutrient inputs and outputs.



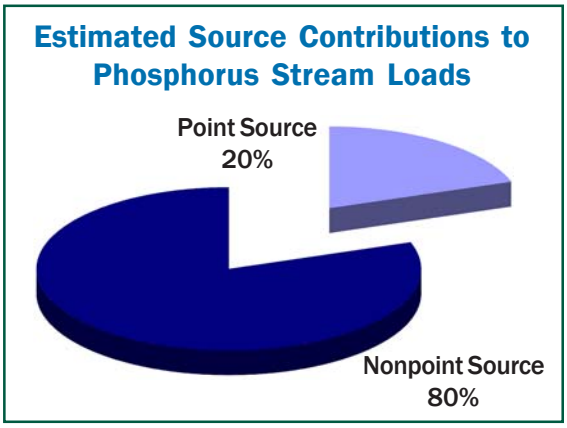


Figure 4: Nonpoint sources of pollution, such as runoff from a cropped field, are the source of much of the nitrogen (left) and phosphorus (right) found in Iowa's streams and rivers.

Limitations of the nutrient budget data

The nutrient budget used the best available information and is believed to accurately portray the "big picture" of nutrient use and cycles in Iowa.

Further refinement of data and new research may change some numbers slightly, but is unlikely to change the overall picture. Nonetheless, there are some issues that should be considered when interpreting the data:

- A better understanding of the sources and transport of sediment-related phosphorus is needed, along with refined characterization of stream phosphorus concentrations and loads. Sediment and related phosphorus measured in streams may originate from a variety of sources, such as cropland erosion, streambank erosion or scouring from stream beds. Both natural phosphorus and phosphorus from fertilizer or manure applications are associated with this sediment.

- Better documentation is needed for nutrient concentrations in wastewater effluent, particularly for consideration of point versus nonpoint phosphorus sources within specific watersheds.

- The understanding of the transport and fate of atmospheric nitrogen, and the role of soil nitrogen cycling — mineralization and immobilization — needs refinement.

More detailed information on these limitations and a more detailed look at the nutrient budget as a whole is available in the technical report "Nitrogen and Phosphorus Budgets for Iowa and Iowa Watersheds," IDNR/IGS Technical Information Series 47. The report includes the various assumptions and calculations used to develop the inputs and outputs.

To obtain a copy of the technical report, contact Bob Libra at (319) 335-1585 or blibra@igsb.uiowa.edu; or visit www.iowadnr.com/water/nutrients/

What's next?

The nutrient budget is just the first step in an overall state nutrient strategy that includes:

- An assessment of the impact high levels of nutrients are having on Iowa waters
- An evaluation of the effectiveness of nutrient control strategies
- The development and adoption of nutrient water quality standards
- The development of an implementation plan identifying the methods and costs of meeting adopted nutrient standards

The DNR has already begun work on these other important steps and will be establishing technical advisory committees and stakeholder groups to provide input and advice to DNR staff prior to proposing nutrient standards for the Environmental Protection Commission's consideration.

Managing nutrient levels will help keep Iowa's water clean.

For more information:

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The full technical report, along with detailed maps and other information, is available at:
www.iowadnr.com/water/nutrients/