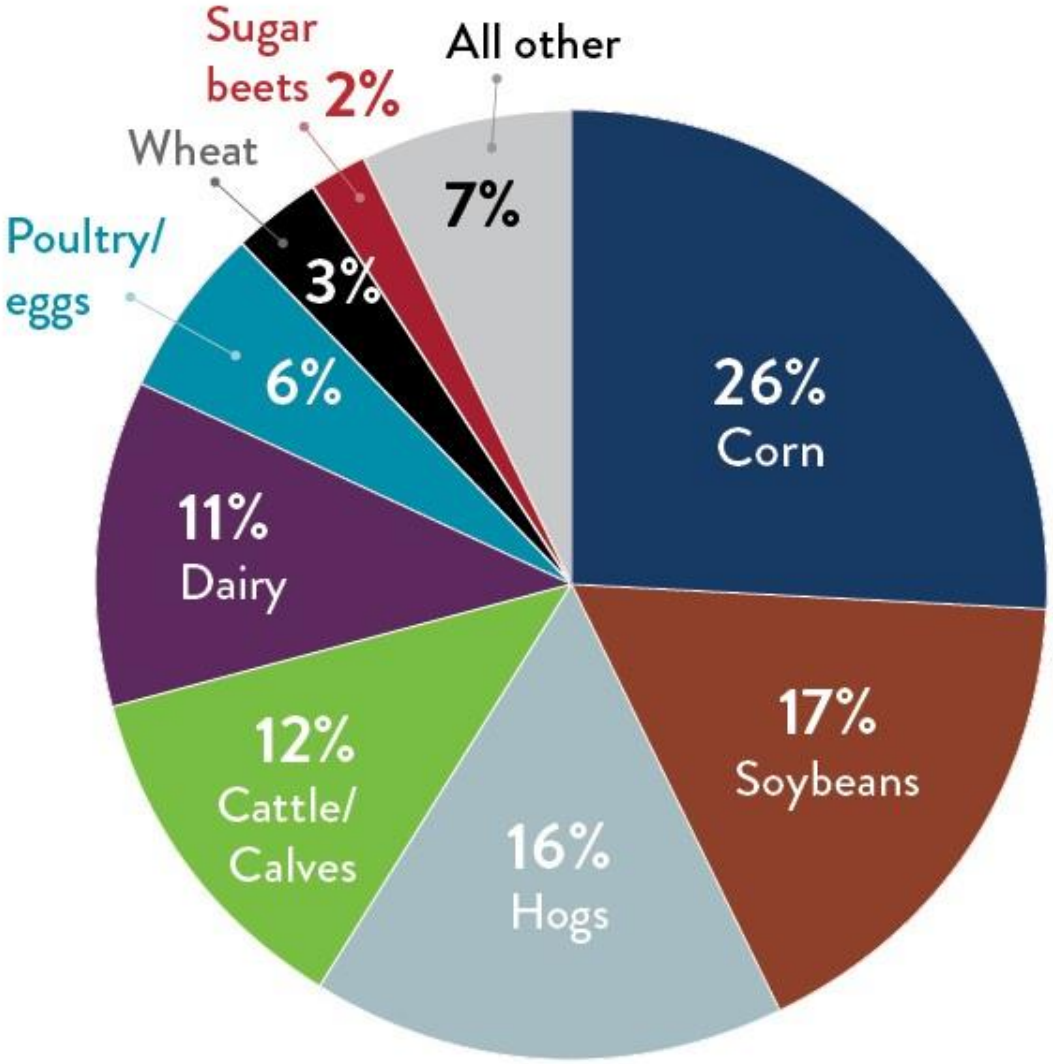
Agriculture and the Upper Mississippi Basin

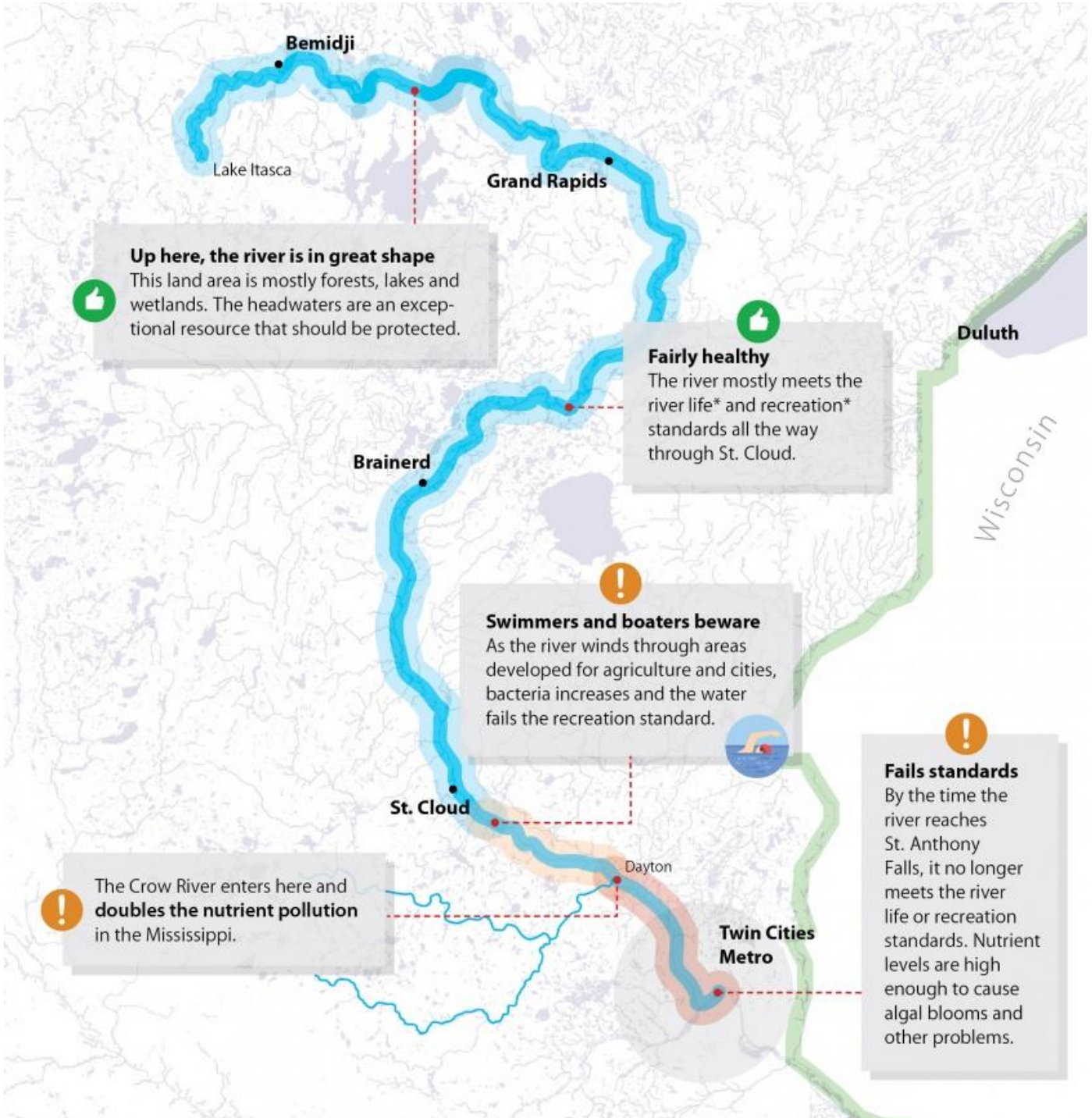
The state of Upper Mississippi agriculture

- We're 5th in the nation for agricultural output, producing $16.7 billion per year in agricultural production (2020).
- 25.4 million acres of our 55.7 million are used for agriculture.
  - 8.4m acres of corn
  - 7.7m acres of soybeans
  - 427k acres of sugarbeets



Agriculture and the Upper Mississippi

- The Mississippi headwaters are in good quality for recreation and river life, but as the river winds through St. Cloud and agricultural areas in southern MN, it picks up excess nutrients and bacteria.



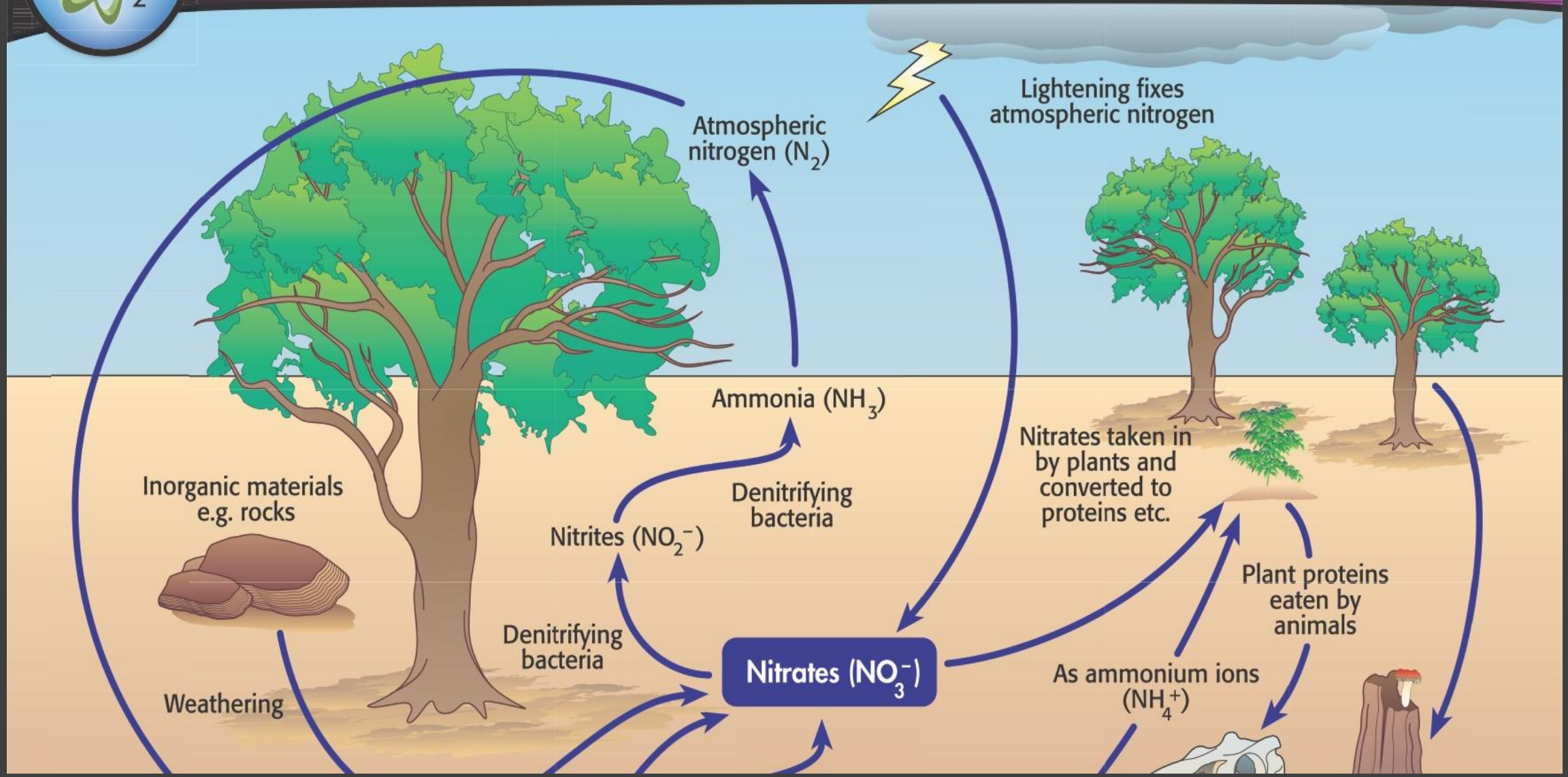
Fertilization

- Corn is extremely sensitive to nutrient-poor soil and needs high amounts of fertilizer. To maximize crop yields, farmers err on the side of caution and overfertilize crops.
- In addition to manmade fertilizers, intensive industrial livestock farming produces more manure than can be used by crop farmers.
- Both of these issues lead to huge amounts of excess fertilizer and chemicals draining out of farms and into watersheds.

Fertilization chemistry

- Plants cannot break down the molecular nitrogen in the air into a usable form. Instead, bacteria and decomposers in the soil change the fertilizer into ammonium, nitrites, and nitrates.
- Ammonium and nitrates are assimilated by the plant, turned into ammonia, and used as building blocks for amino acids and other essential compounds.
- Nitrites and nitrates, which are anions (negatively charged), do not react with the soil, but are extremely soluble in water. Rainwater and irrigation systems flush nitrates out of the soil, through drainage systems and groundwater, and into rivers, streams, and lakes.

NITROGEN CYCLE

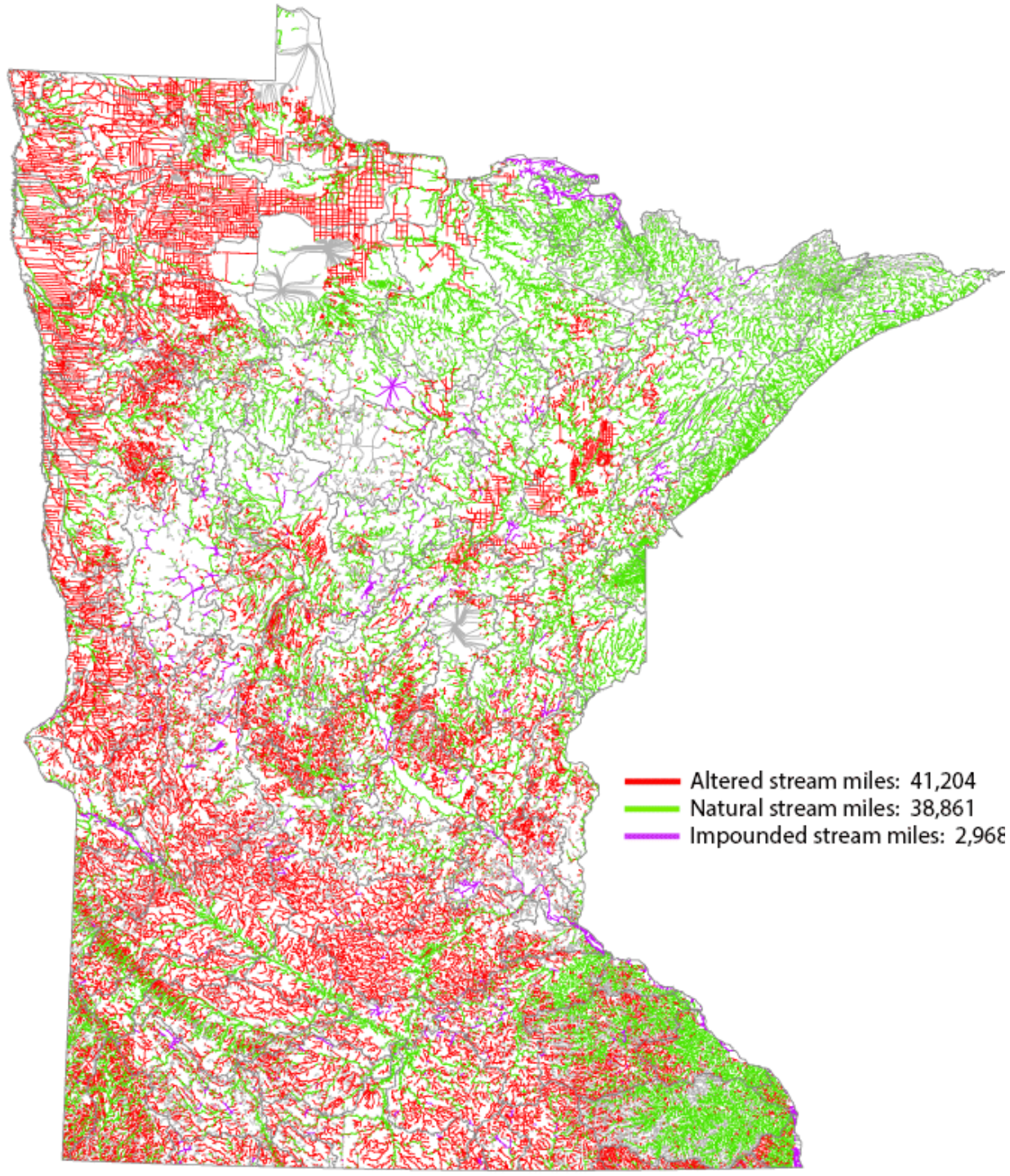


Some more fertilization chemistry

- The most common fertilizers are urea and ammonium nitrate. Other fertilizers, such as other nitrate salts, are used, but have comparatively lower concentrations of nitrogen.
- Slow-release fertilizers, consisting of granules of urea and ammonium nitrate coated in an insoluble material, reduce runoff without affecting crop yield, but are too expensive for large agricultural operations to accept.
- Many modern fertilizers are highly inefficient. More than half of the nitrogen used turns into runoff and is lost, and efficiency has decreased by 22% since 1961, despite the rate of fertilizer usage more than tripling.

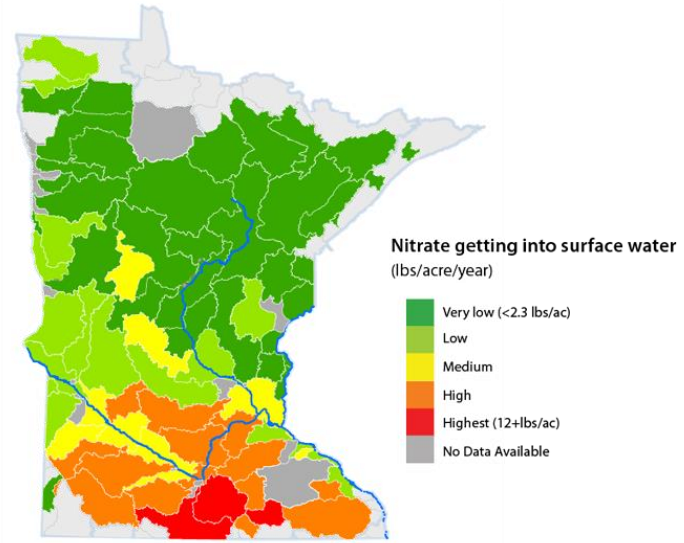
Agricultural drainage

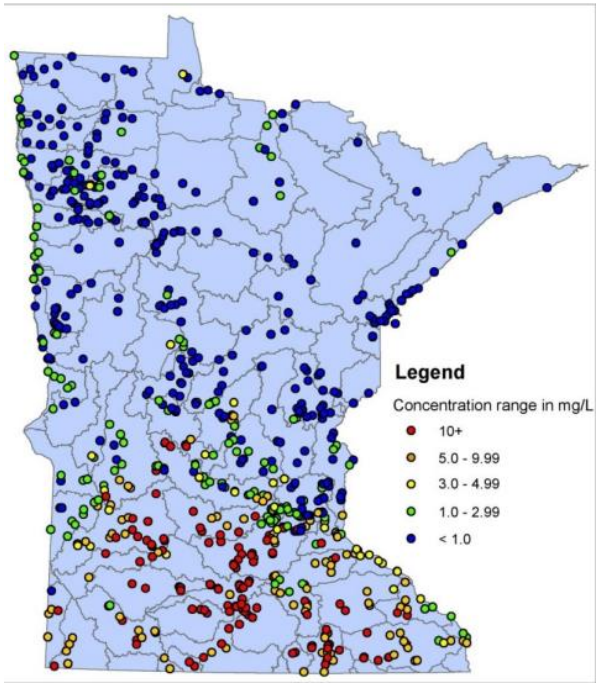
- Our soils are highly productive, but poorly drained. Farmers remedy this by employing a combination of surface ditches and underground pipe, or "tile", to an outlet such as a stream.
- These drainage systems are a boon to crops, but surface ditches cause high runoff rates of sediment, and tile drainage contains large amounts of soluble nutrients such as nitrates.
- Artificial drainage systems have also drastically reduced the extent of Minnesota's wetlands.

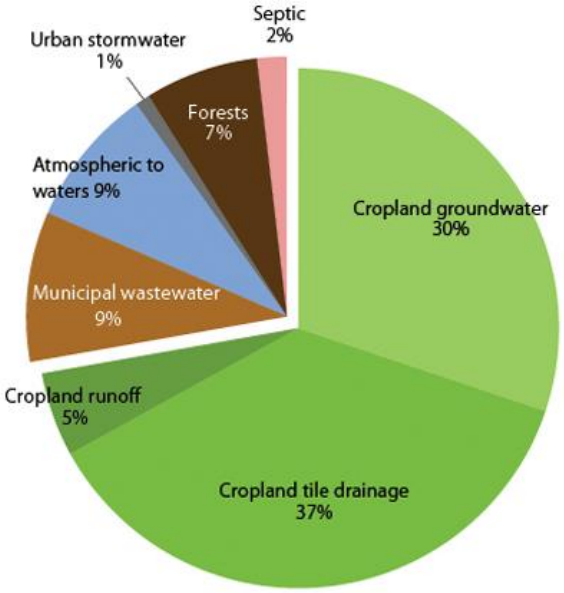


The effects of nitrates

- Elevated nitrate levels are harmful to aquatic life.
- High levels of nitrates—more than 10 ppm (mg/l)—pose human health risks.
- Nitrates in the upper Mississippi contribute to a growing "dead zone" in the Gulf of Mexico.
  - The nutrient-filled waters encourage the rapid growth of algae.
  - Algal blooms inhibit photosynthesis and use up oxygen in the water, leading to asphyxiation.
  - Algal blooms are harmful to humans and pets as well—and they're an eyesore!
- Excess nitrogen can also form nitrous oxide, a greenhouse gas.







Nitrates in Minnesota

- Cropland is the source of three-quarters of the total nitrogen load in the Mississippi River.
- 27% of locations in various rivers and streams surveyed by the MPCA contained levels of nitrogen above the accepted safe standard.
- Almost three-quarters of nitrates in the Mississippi are from cropland runoff and drainage.

Nitrates in the Metro and drinking water

- Nitrate concentrations in the river have increased by 44% since 1976.
- In the Metro, the median nitrate concentrations in the river remain around 2.5 ppm, although the influence of the Minnesota River increases this to around 3.5 ppm.
- Some private wells in southern Minnesota have nitrate concentrations above 10 ppm.
- If you are on a public water system, the EPA requires the system to publish a CCR (Consumer Confidence Report) that you can read to verify that the nitrate levels in the system are healthy.

What can be/is being done?

The Minnesota Pollution Control Agency, or MPCA, identifies 3 categories of solutions:

- Managing nutrient use
- Managing drainage systems
- Diversifying vegetation and landscapes

Voluntary conservation practices can reduce nitrogen in streams and rivers by over 34 percent.

Fertilizer efficiency

- The MPCA hopes to have reduced nitrates in the Mississippi by 45% by 2040 (from their 1976 levels), and apply more efficient fertilization practices on 11.9m acres of land.
- Applying fertilizer during the spring instead of the fall slows nitrification and increases crop yield.
- https://www.mda.state.mn.us/protecting/cleanwaterfund/toolstechnology/runoffrisk is an applet that can be used to determine the risk precipitation and runoff poses to fertilizer usage at the current time.
- There is no "one size fits all" approach—the diversity of Minnesota's ecology and soil makes it farmers' responsibility to determine best management practices.

RIGHT SOURCE

Matches fertilizer type to crop needs.

RIGHT RATE

Matches amount of fertilizer to crop needs.

RIGHT TIME

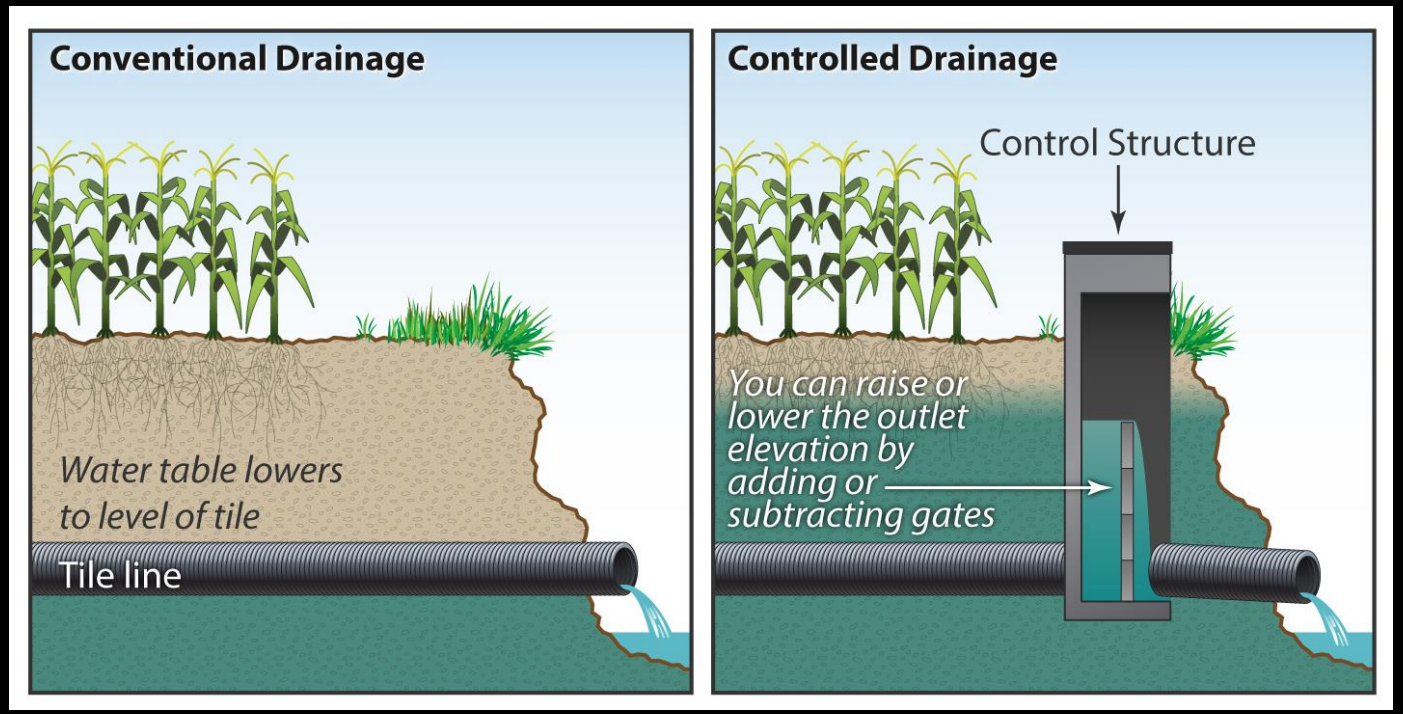
Makes nutrients available when crops need them.

RIGHT PLACE

Keeps nutrients where crops can use them.

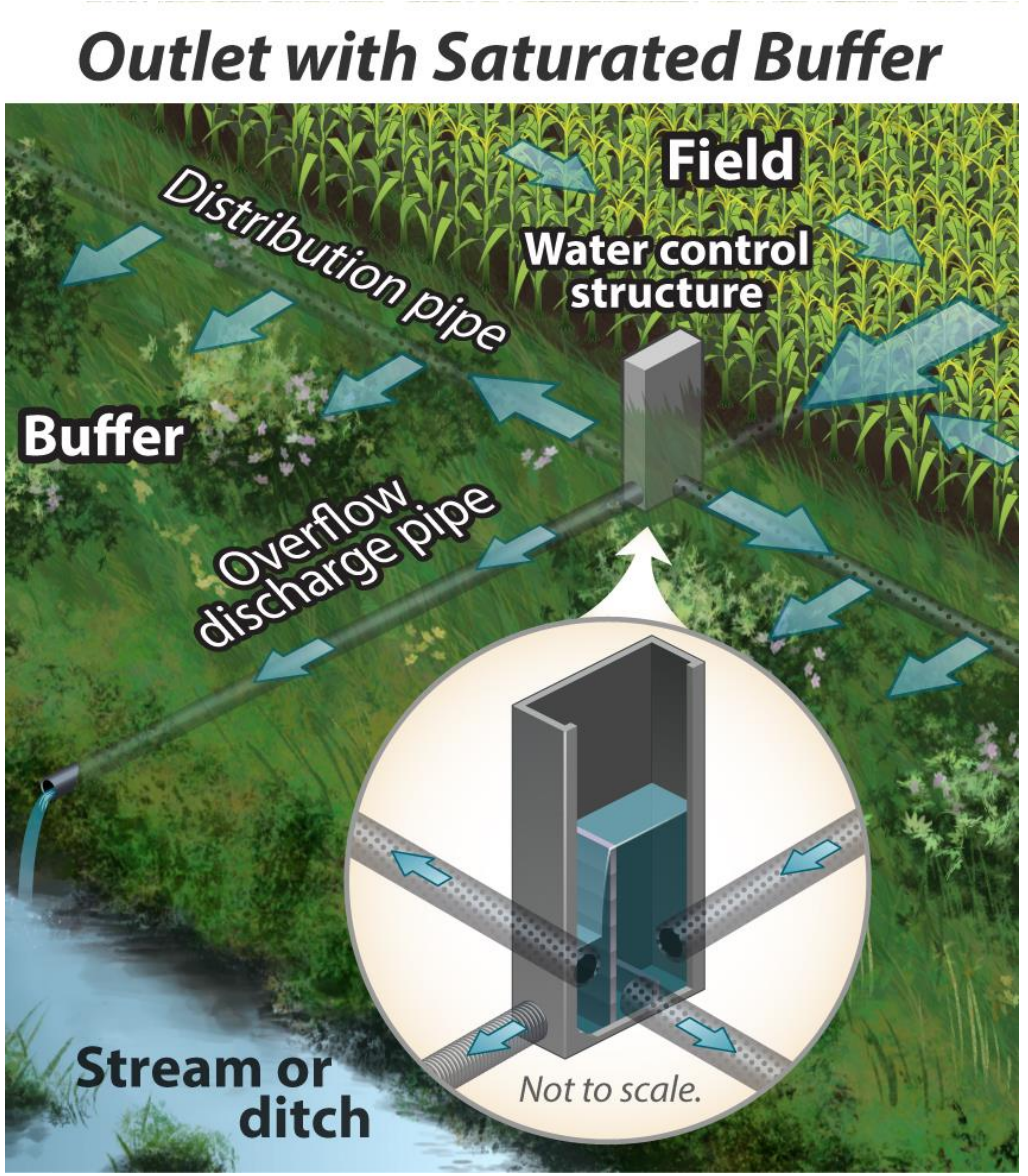
Controlled drainage

- The MPCA hopes to provide promotions and incentives for drainage management on more than one million acres of cropland.
- Implementing control structures such as displayed in the diagram can reduce the amount and rate of drainage, especially in low-slope croplands such as the plains of southern Minnesota.
- Implementing shallower drainage systems is another way to keep water and nutrients in the soil rather than out to the edge of fields.



Wetlands and buffers

- Introducing plant sources that use up excess nitrogen faster than the crops can use it is a realistic nutrient reduction practice.
- Buffer strips, zones of high organic material soil along riverbanks, can be saturated by runoff that would normally be wasted.
  - Minnesota requires buffer strips, with or without control systems, along streams and rivers.
  - http://arcgis.dnr.state.mn.us/gis/buffersviewer/
- Constructed and restored wetlands can also increase nitrogen uptake, although they are much larger than other nitrogen uptake strategies.

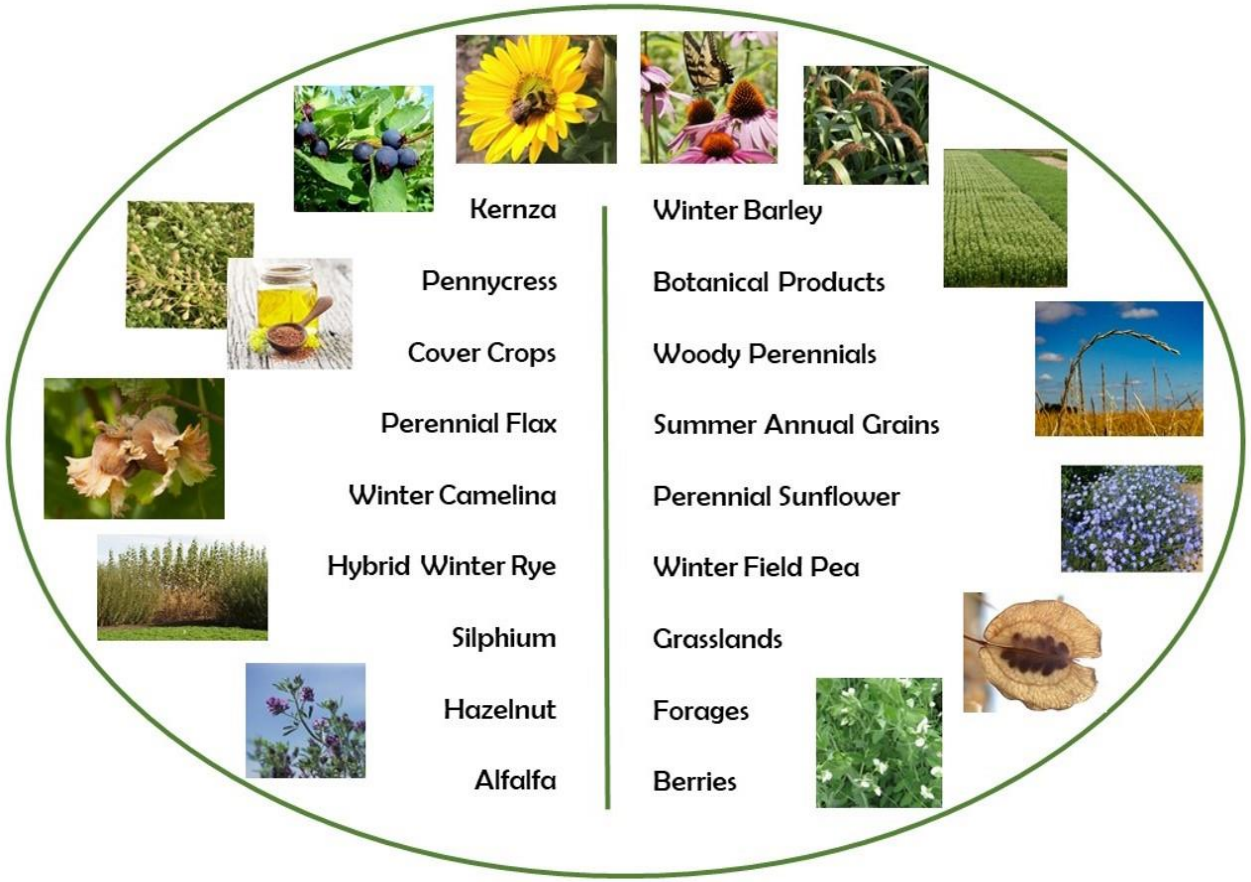


Winter and Perennial crops

- Winter cover crops and perennial, year-round crops round out the growing season, increasing plant uptake and reducing drainage flow.
- In order to make incentive for farmers, we must develop markets for those additional crops.
- Economic and policy decisions have driven Minnesotan agriculture towards homogenous corn-soy rotations.
- Biocultural diversity in agriculture improves soil and crop quality, decreases soil erosion and runoff, and reduces economic risk to farmers.

Forever Green

- Forever Green Initiative at the U of MN is developing rapid improvements and high efficiency systems for 16 winter and perennial crops.
- Markets for Forever Green crops are already being developed: https://fmr.org/legislative-updates/where-buy-food-drinks-made-clean-water-crops



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