National Earth Science Teachers Association

**BACKGROUND INFORMATION:**

Nitrogen is an element that is found in both the living portion of our planet and the inorganic parts of the Earth system. The nitrogen cycle is one of the biogeochemical cycles and is very important for ecosystems. Nitrogen moves slowly through the cycle and is stored in reservoirs such as the atmosphere, living organisms, soils, and oceans along its way.

Most of the nitrogen on Earth is in the atmosphere. Approximately 80% of the molecules in Earth's atmosphere are made of two nitrogen atoms bonded together (N2). All plants and animals need nitrogen to make amino acids, proteins and DNA, but the nitrogen in the atmosphere is not in a form that they can use. The molecules of nitrogen in the atmosphere can become usable for living things when they are broken apart during lightning strikes or fires, by certain types of bacteria, or by bacteria associated with legume plants. Other plants get the nitrogen they need from the soils or water in which they live mostly in the form of inorganic nitrate (NO3-).

Nitrogen is a limiting factor for plant growth. Animals get the nitrogen they need by consuming plants or other animals that contain organic molecules composed partially of nitrogen. When organisms die, their bodies decompose bringing the nitrogen into soil on land or into the oceans. As dead plants and animals decompose, nitrogen is converted into inorganic forms such as ammonium salts (NH4+ ) by a process called mineralization. The ammonium salts are absorbed onto clay in the soil and then chemically altered by bacteria into nitrite (NO2- ) and then nitrate (NO3- ). Nitrate is the form commonly used by plants. It is easily dissolved in water and leached from the soil system. Dissolved nitrate can be returned to the atmosphere by certain bacteria in a process called denitrification.

Certain actions of humans are causing changes to the nitrogen cycle and the amount of nitrogen that is stored in reservoirs. The use of nitrogen-rich fertilizers can cause nutrient leading in nearby waterways as nitrates from the fertilizer wash into streams and ponds. The increased nitrate levels cause plants to grow rapidly until they use up the nitrate supply and die. The number of herbivores will increase when the plant supply increases and then the herbivores are left without a food source when the plants die. In this way, changes in nutrient supply will affect the entire food chain. Additionally, humans are altering the nitrogen cycle by burning fossil fuels and forests, which releases various solid forms of nitrogen. Farming also affects the nitrogen cycle. The waste associated with livestock farming releases a large amount of nitrogen into soil and water. In the same way, sewage waste adds nitrogen to soils and water.

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Nitrogen emissions from car exhaust and industrial sources might be increasing forest fires across the California desert by fueling the spread of invasive grasses, according to a new report by the Ecological Society of America. Agricultural nitrogen is also causing groundwater contamination in the state, the report concluded.

Most nitrogen in the atmosphere is trapped in an inert form that is unusable by most plants and animals. In nature, bacteria in the nodules of nitrogen-fixing plants, such as soybeans, must convert this bound nitrogen into a form that plants and animals use to grow.

But cars and power plants emit a form of nitrogen and oxygen called NOx, which falls to the ground when it rains or snows, said Eric Davidson, a soil ecologist and executive director at the Woods Hole Research Center in Falmouth, Mass., who led the [study [PDF]](http://www.esa.org/science_resources/issues/FileEnglish/issuesinecology15.pdf) [1]. Unlike atmospheric nitrogen, NOx emissions deposit nitrates, which are readily taken up by plants.

In California, weedy, non-native grasses are edging out native plants in desert areas such as Joshua Tree National Park, and NOx is likely to blame.

"The native plants in the desert were not adapted to have that extra nitrogen, so they don't really grow all that much better, whereas these exotic grasses have evolved to make use of that nitrogen," he said.

The grasses are highly flammable, unlike the bare rock, soil and islands of shrubs that used to predominate, Davidson said. As a result, "an ecosystem that once hardly ever had a fire in it now has fire more routinely."

NOx emissions from cars have been steadily decreasing in recent years, thanks largely to the spread of [catalytic converters](http://californiawatch.org/dailyreport/car-emissions-may-fuel-desert-forest-fires-14625) that trap most of the pollutant. Increased regulation has kept emissions in check, even as the number of cars on the road grew, he said.

By contrast, agricultural nitrogen generation, either from dairy farm manure or fertilizer, is largely unregulated.

"A quarter of the nitrogen that is in California in a particular year ends up in the groundwater," said Tom Tomich, director of the Agricultural Sustainability Institute at UC Davis, which is leading the California Nitrogen Assessment.

Farmers use nitrogen-based fertilizers on their crops and have to anticipate how much fertilizer will be needed to grow their crops in the coming year. "A relatively [cheap insurance](http://californiawatch.org/dailyreport/car-emissions-may-fuel-desert-forest-fires-14625) policy is to [apply](http://californiawatch.org/dailyreport/car-emissions-may-fuel-desert-forest-fires-14625) a little bit more than the crop is going to need," Davidson said.

The trouble is that about half of the fertilizer isn't taken up by the plants, but seeps through the soil and into groundwater or washes into streams, Tomich said. The Central and Imperial valleys have high levels of nitrates, a form of nitrogen that can cause blue baby syndrome.

No one approach could slash nitrogen groundwater contamination, Tomich said**.**

"There are a lot of practices that collectively could make a difference, but there are many small parts to add up," he said. Some techniques could include increased drip irrigation and better management of manure from dairy farms.

Still, California's groundwater issues are unlikely to go away. "Even if the nitrates going into the groundwater were to suddenly stop completely, it would be decades before we saw the effects of that in terms of our groundwater nitrate contamination." Tomich said**.**

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