# The Nitrogen Cycle

AGRONOMY

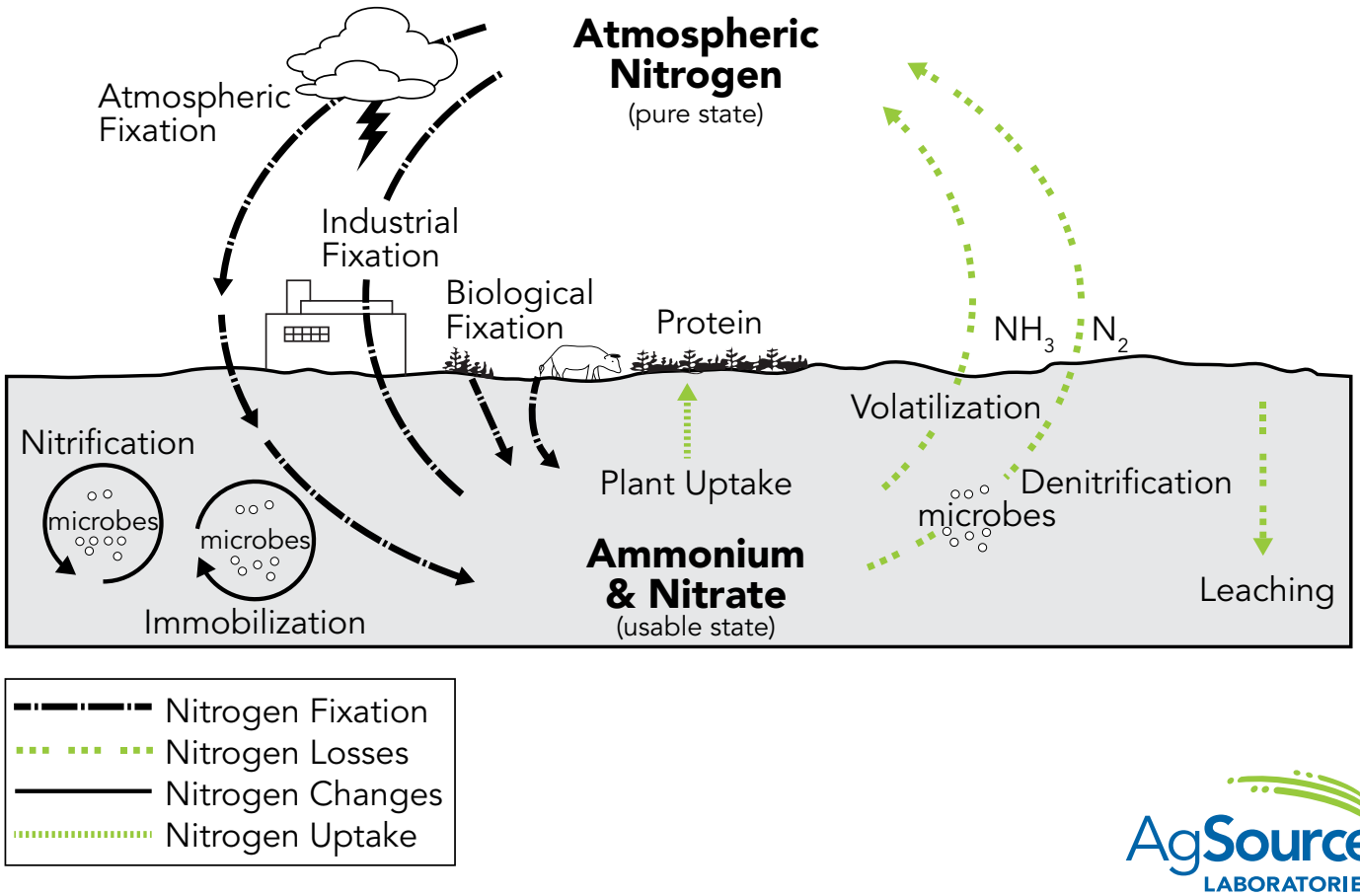
Nitrogen is one of the primary nutrients required for plant growth. Unfortunately, nitrogen cannot be used in its pure state; in order to be available to crops, nitrogen has to be combined with hydrogen or oxygen. The process of transforming nitrogen into a usable form is called nitrogen fixation. Unlike fixation for phosphorus, potassium, and micronutrients, in which these nutrients become less available to crops, nitrogen fixation is a necessary and beneficial process.

Once nitrogen fixation has occurred, the unusable nitrogen becomes nitrate or ammonium, both of which can be used by plants. However, nitrate and ammonium do not remain in this usable state and can be changed back to pure nitrogen in a variety of ways. Thus, the nitrogen cycle is a continual process of recycling nitrogen from a pure state to a usable state back to a pure state again, as illustrated in Figure 1 below.

## Nitrogen Fixation – Making Nitrogen Available To Plants

Fixation makes nitrogen available to plants by converting pure nitrogen to various nitrogen compounds. There are three forms of fixation: atmospheric, biological and industrial.

Figure 1.

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**Atmospheric Fixation:** Ammonia and nitrogen are found naturally in the air. During a storm, lightning creates a reaction that converts the nitrogen gas collected in rain clouds into usable nitrogen. Rain or snow then carry these usable nitrogen compounds to the soil.

**Biological Fixation:** Certain microorganisms in the soil create nodules on plant roots that convert unusable nitrogen into usable nitrogen for the host plant. Other microbes break down the complex proteins in plant and animal waste to yield simpler amino acids. This is called aminization. Then, those amino acids are converted into ammonia and usable ammonium. This is called ammonification.

**Industrial Fixation:** Industrial fixation is the technical term for how manufacturers chemically convert nitrogen into fertilizer. Each year, the fertilizer industry fixes several million tons of nitrogen into such common forms as anhydrous ammonia, ammonium nitrate, or urea. Usable nitrogen takes two forms: nitrate and ammonium. Nitrate and ammonium will either be taken up by plants, be lost into the subsoil or atmosphere, or be changed within the soil.

## Plant Uptake – Making Use of Available Nitrogen

Plant uptake is the goal growers have for their soil's usable nitrogen. When plants take up sufficient nitrate and ammonium, plants grow strong and healthy, and crop yields are positively affected.

## Losing Available Nitrogen: Leaching, Denitrification & Volatilization

While growers hope soil nitrate and ammonium are being absorbed by plant roots, available nitrogen could be disappearing from the soil by leaching, denitrification and volatilization.

**Leaching:** When water passes through the soil, nitrate is moved below the root zone where it cannot be utilized by crops. This leaching often means a financial loss for the grower and raises environmental concerns.

**Denitrification:** The same microbes that break down animal and plant waste in biological fixation to make usable nitrogen also need oxygen to live. This is normally not a problem, but when the soil is very wet, there is less air in the soil. In order to breathe, these microbes strip the oxygen from nitrate ($NO_3$) or nitrite ($NO_2$) in the soil, breathing the oxygen and releasing gaseous nitrogen ($N_2$) to the air in its pure, unusable form.

**Volatilization:** When you use a household cleaner, the ammonia you smell is the ammonium in the cleaner being released to the air as ammonia gas. Soil ammonium can escape from the soil surface in the form of ammonia gas in the same way: the soil breathes the ammonium ($NH_4$) and breathes out ammonia gas ($NH_3$). The net effect is that usable ammonium is lost to the atmosphere.

## Changing Available Nitrogen – Immobilization & Nitrification

Microbe activity in the soil causes other changes to the available nitrogen. However, this activity doesn't completely remove the nitrate and ammonium from the soil.

**Immobilization:** Microbes don't only need to breathe, they also need to eat. Unfortunately, microbes feed on the same available nitrogen that feeds crops. Therefore, plants and microbes are in a battle for the nitrate and ammonium in the soil. All too often, the microbes win. However, when these micro-organisms decompose, the nitrogen they consumed once again becomes available to plants.

**Nitrification:** Certain microbes get energy from converting ammonium to nitrate. Although this change does not remove available nitrogen from the soil, nitrate is in high demand as a food source by microbes as well as plants. If you think of nitrate as the ice cream and ammonium as the broccoli, you'll understand why the nitrate disappears more quickly. Even though nitrate is in higher demand, soil ammonium levels tend to be lower than nitrate levels because the microbes are very efficient at nitrification.

**Summary:** Pure nitrogen cannot be used by plants. When pure nitrogen is converted into usable nitrate and ammonium, this process is called fixation. Once the usable nitrate and ammonium are in the soil, they can be removed or changed-either by being used by plants (through plant uptake), by being lost to the root-level soil (through leaching, denitrification, and volatilization), or by being changed into different forms of usable nitrogen (through immobilization and nitrification).