Biofuels and Nutrient Cycling

(R.E. Knighton, USDA)

The issue of reactive nitrogen and it's interaction in the environment is becoming more and more important to aquatic and terrestrial systems. The US Environmental Protection Agency over the last two years has created a science advisory board to look at reactive nitrogen issues. Since agriculture is responsible for the generation of much of the reactive nitrogen as fertilizer, it is not surprising that the EPA's advisory board is recommending that agriculture be a principal player in mitigating problems that arise from reactive nitrogen concentrating in the atmosphere and in ground and surface waters. All of these issues will impact the production and processing of biofuel feedstocks.

Agriculture is leaky and inefficient in utilizing soil-applied nutrients. For example, less than 40% of applied nitrogen as inorganic fertilizer is removed by corn grown for grain. When this grain is fed to cattle only about 15% of the nitrogen is removed by the animal, leaving 85% to move to the soil, water, or air. The production of biofuels suffers from these same limitations. Much of the science surrounding biofuels has been centered on sequestering and extracting carbon for fuel rather than examining the life-cycle of nutrients such as nitrogen and phosphorus. Carbon is inextricably linked to nitrogen. The carbon to nitrogen ratio (C:N) of biological materials could be used as a good indicator of a biofuel's suitability and it's environmental impact from co-products.

The environmental impacts of applying nitrogen and phosphorus in agricultural ecosystems have been well-documented. Less well documented are the pathways of these nutrients and their losses to the environment once the agricultural product has been removed and processed. Biofuels present an interesting problem in that the nitrogen and phosphorus are typically co-products of biofuel production. In the case of nitrogen, the sequestering of nitrogen as protein is the focus of many agricultural products but for biofuels it is largely a waste stream. Nitrogen is highly reactive in the forms used by biological processes such as biofuel production and remains highly reactive after being processed. For example the nitrogen content in distiller's grains, a co-product of ethanol production from corn, is significantly higher than the concentration in the original grain. Recent research has shown that ammonia emissions from cattle are directly proportional to the crude protein content in the feed. Cattle fed higher rates of distiller grains in their diet emit more ammonia. Similarly, other biofuels such as algae have much higher nitrogen content in the waste stream than in the feed stock.

Why is reactive nitrogen or the cycling of nutrients important to the discussion of deployment? Whether nitrogen is directly emitted from processing plants that are adjacent to urban centers or it resides in co-products from the generation of fuel, nitrogen will need to be dealt with as a source of environmental pollution at production facilities. If the nitrogen is contained in useful co-products such as feed or fertilizer, there need to be local or regional markets that utilize these materials. Even if markets do exist, there may still be environmental consequences of utilizing these co-products from an air quality or water quality standpoint.

We have seen the pollution scenarios come full circle in many respects with fossil fuel feedstocks such as coal. Legislation was drafted in the seventies to reduce sulfur and NOx emissions because of the impact of acid rain. These actions were successful for sulfur. The wet deposition of sulfate has been reduced dramatically all across the country as evidenced by concentrations of sulfate in precipitation measured by the National Atmospheric Deposition Program (NADP) over the last 30 years (Fig. 1). Ammonium concentrations in those same samples have not decreased (Fig. 2). In fact, in most parts of the country wet deposition of ammonium has increased over the same time frame. The source of much of this reduced nitrogen is from ammonia from agriculture. Energy production will be an easier target with which to regulate agriculture than food production.

As we embark down this road of biofuel production, let's think about not only the carbon footprint but how other nutrients in co-products will be used and react in the environment.

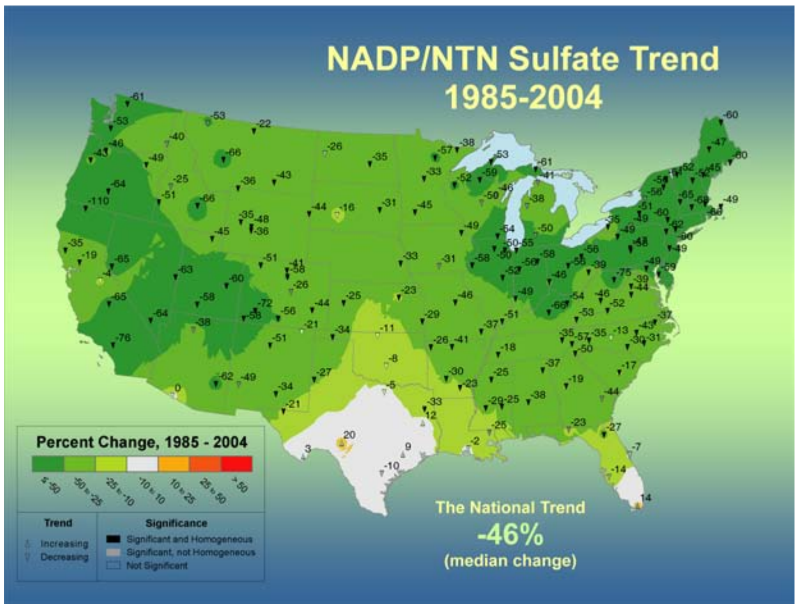

Figure 1. NADP/NTN sulfate trends from 1985 through 2004.

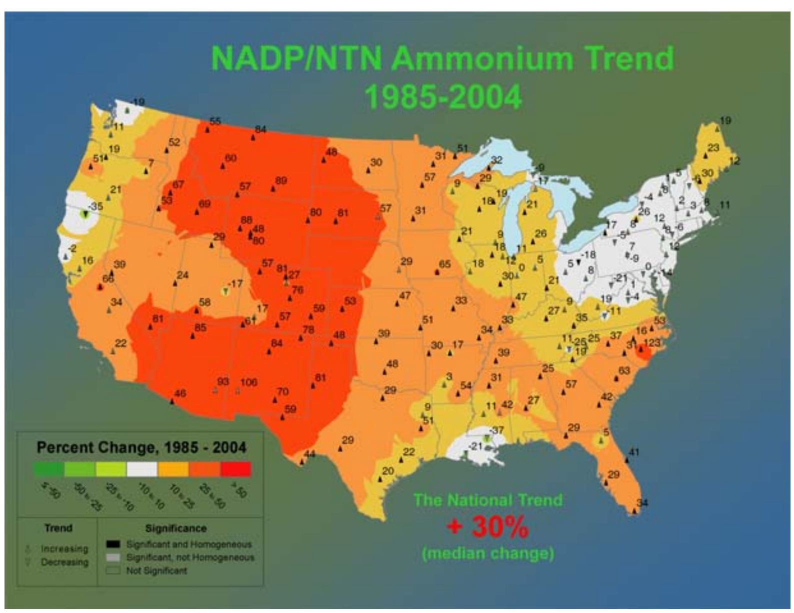

Figure 2. NADP/NTN ammonium trends from 1985 through 2004.