**Establishing a Baseline for Nitrogen Policy Assessment**

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## Introduction

Increasing emissions of reactive nitrogen ($N_r$) contribute to harmful changes to ecosystems, including acidification in forests, soils, and freshwater ecosystems; eutrophication and hypoxia in coastal ecosystems; biodiversity losses; regional haze; and global climate change. Agriculture uses more Nr and accounts for more environmental losses than any other economic sector (EPA, 2009). Nitrogen Use Efficiency (NUE) is the proportion of all nitrogen inputs that are removed in harvested crop biomass, contained in recycled crop residues, and incorporated into organic and inorganic soil nitrogen pools (Cassman et al., 2002). NUE can be increased by improving uptake efficiency from fertilizer applications, reducing nitrogen lost from organic or inorganic soil pools, or both. The most important management choices affecting NUE are application rates, timing (fall vs. spring), and method (surface vs. injection/incorporation) (Cassman et al., 2002; Iowa Soybean Association, 2008). Understanding how agriculture is performing in regard to these factors will help determine the design of policies for improving NUE, as well as potential tradeoffs between Nr emissions to air and water.

## Objective

We established a baseline of nitrogen and crop management practices for eight of the major U.S. field crops, against which estimates of environmental benefits and producer costs can be made. This baseline not only provides a starting point for policy, but provides valuable insights on how and where policies might be targeted.

## Methodology

We assess current nutrient management practices by using USDA's Agricultural Resource Management Survey (ARMS) data collected from producers of barley (2003), corn (2005), cotton (2003), oats (2005), peanuts (2004), sorghum (2003), soybeans (2006), and wheat (2004).

"Good" nitrogen management practices are those that make the largest contribution to a high NUE. The three criteria are:

- Applying nitrogen at a rate less than the product of the crop's nitrogen assimilative capacity per yield-unit, the grower's yield goal, and 1.5. We allow for a 50-percent overapplication to account for unavoidable environmental losses that farmers must consider when deciding how much fertilizer to apply.
- Not applying nitrogen in the fall for a crop planted in the spring.
- Injecting or incorporating nitrogen rather than broadcasting on the surface.

A farmer can fall into one of eight nitrogen management categories:

1. All of the criteria are followed.
2. The rate and timing criteria are followed.
3. The rate and application criteria are followed.
4. The timing and application criteria are followed.
5. Only the rate criterion is followed.
6. Only the timing criterion is followed.
7. Only the application criterion is followed.
8. None of the criteria are followed.

Because the crops covered were surveyed in different years, we chose one reference year, 2006, to examine the extent to which good nitrogen management practices are being followed. The percentage of total acres planted and the chemical and manure nitrogen application rates for each management category calculated using data from the ARMS survey year for each crop were applied to planted acre estimates for 2006.

## Results

Almost 242 million acres were planted to the survey crops in 2006, and 69 percent of those acres were treated with chemical and/or manure nitrogen.

*Application Rate by Crop*

- The application rate was not met on 27.6 million acres, or 16.5 percent of treated acres.
- Corn and wheat had the highest share not meeting the criterion (fig. 1).
- Almost 2.4 million tons of nitrogen (28 percent of nitrogen applied to the eight crops) were applied to crop acres not meeting the rate criterion.
- Corn accounted for more than half (fig. 2).
- The Northern Plains and Corn Belt contained the largest share of acres not meeting the rate criterion (fig. 3).
- 34 percent of nitrogen applied to crop acres not meeting the rate criterion was applied in the Corn Belt.

**Figure 1. Acres treated with chemical and/or manure nitrogen not meeting the rate, timing, or method criteria by crop, 2006**

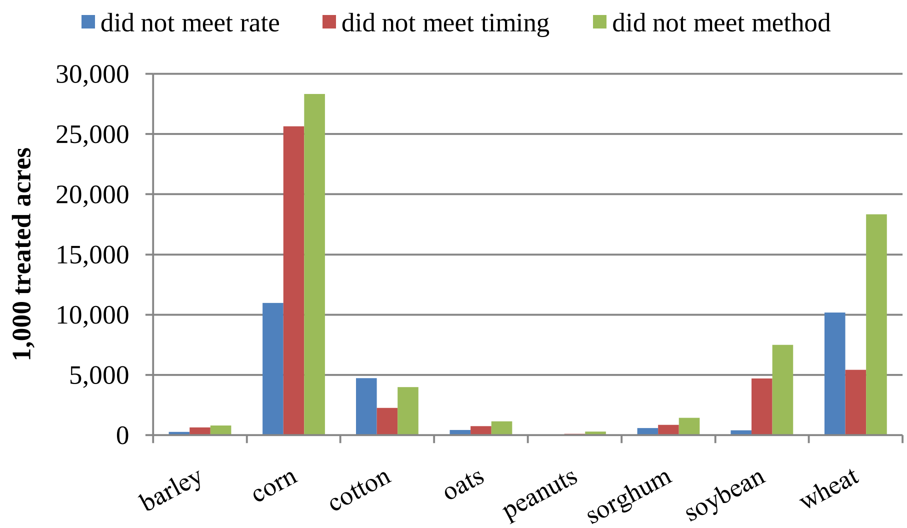


**Figure 2. Amount of chemical and/or manure nitrogen applied to cropland not meeting the rate, timing, or method criteria by crop, 2006**

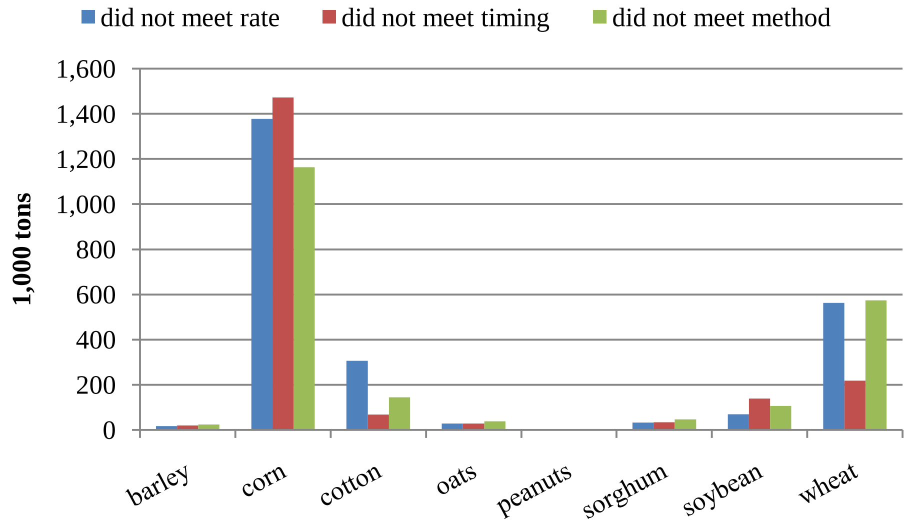
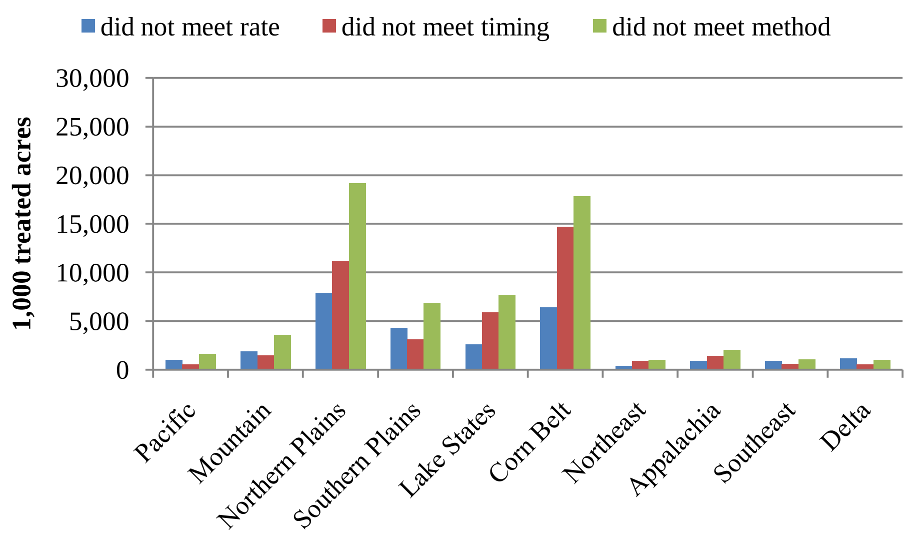



**Figure 3. Acres treated with chemical and/or manure nitrogen not meeting the rate, timing, or method criteria by region, 2006**



*Timing*

- The timing criterion was not met on almost 40.4 million acres of cropland, or 24.1 percent of treated acres.
- Almost 34 percent of treated corn acres received fertilizer in the fall, accounting for over 63 percent of the surveyed acres not meeting the timing criterion.
- Almost 23 percent of nitrogen was applied well before plants needed it, with corn accounting for over 74 percent of the total.
- The Corn Belt accounted for 36 percent of total crop acres not meeting the timing criterion.
- The Corn Belt accounted for 43 percent of the total nitrogen applied to crop acres not meeting the timing criterion.

*Method*

- Nitrogen was not incorporated into the soil on almost 61.8 million of the surveyed crop acres, or 37 percent of the treated acres.
- 24 percent of the nitrogen applied (2.1 million tons) was not incorporated or injected.
- Corn accounted for almost 46 percent of the treated acres not meeting the method criterion and for over 55 percent of the nitrogen applied without incorporation.
- The Northern Plains accounted for 31 percent of the treated acres not meeting the method criterion.
- The Corn Belt accounted for 34 percent of unincorporated nitrogen.

*All Three Measures*

- About 39 percent of the acres treated with nitrogen met all three criteria (fig. 4).
- Only 1.7 percent of the treated acres did not meet any of the criteria.
- 39 percent of the nitrogen applied was done so in a manner that maximizes NUE.
- Corn had the smallest share of treated acres meeting all three criteria.
- Mountain and Northern Plains regions had the highest share of acres meeting all three criteria (fig. 5).
- Appalachia and Corn Belt regions had the smallest.

**Figure 4. Share of treated crop acres by nitrogen management category by crop, 2006**

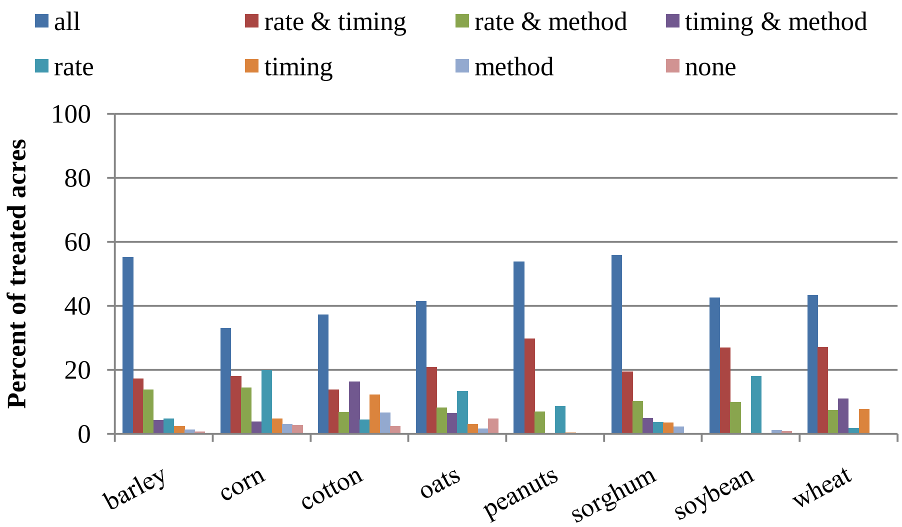
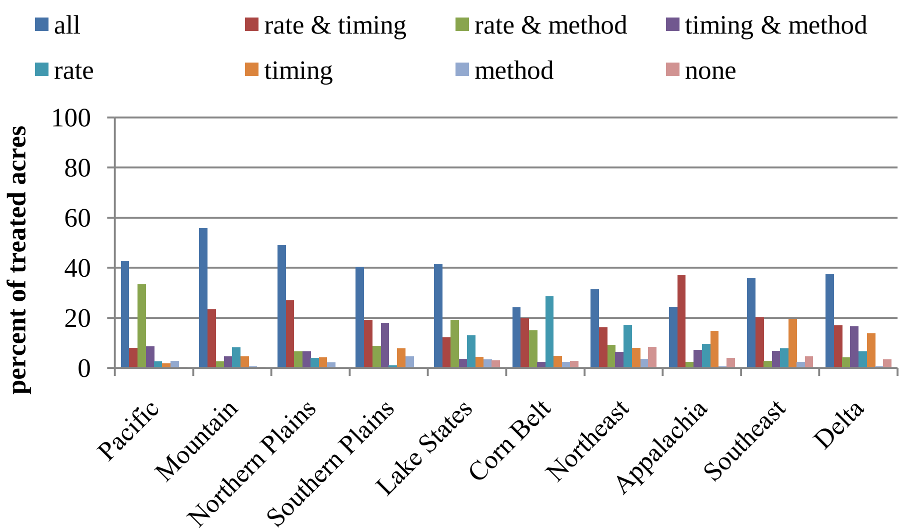



**Figure 5. Share of treated crop acres by nitrogen management category by production region, 2006**



## Implications

The survey data indicate that a high percentage of crop acres are meeting at least some of the nitrogen management criteria. One crop, however, meets the criteria less often—corn. Corn is the most intensive user of nitrogen and the most widely planted crop. Over 65 percent of nitrogen applied to all major field crops is applied to corn. Corn grown in the Mississippi Basin is a major source of nutrients contributing to Gulf hypoxia. Recent demand pressures due to the biofuels mandate as well as the need to feed a growing world population suggest that corn acreage and the intensity of corn production are likely to increase. Together, these factors could increase Nr emissions to the environment unless nitrogen use efficiency is improved.

## References

Cassman, K.G., A. Dobermann, and D.T. Walters. 2002. "Agroecosystems, Nitrogen-use Efficiency, and Nitrogen Management," *Ambio* 31(2):132-40.

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