

Supplemental Information

GWAVA-S Model Parameterization

To focus our output to nitrogen fertilizer applied to corn only, we excluded the following layers from the original GWAVA-S calculation: Confined Manure, Population Density, Orchards and Vineyards, and Crop/Pasture/Fallow. We excluded the confined manure layer for three reasons: (1) it assumes an equal manure application rate across cropland in a county given the total application amount within the county. In our experience, this is extremely unlikely; (2) the CERES Maize model does not incorporate manure application directly; (3) it complicates comparing groundwater quality between counties with wildly disparate manure application rates. Orchards and vineyards made up less than 0.1% of cropland in our study area in 2012. The crop/pasture/fallow layer added a level of complexity in land use that detracted from our intended focus on potential yield and nitrate pollution produced per-hectare of corn planted and kilogram of N applied. Because GWAVA-S is a linear combination of five non-linear models, with each model corresponding to each N input (confined manure, population, etc.) multiplied by the transportation and attenuation subsections (Eq. 1, main paper), these manipulations are valid for capturing relative nitrate pollution dynamics due to synthetic nitrogen input.

Groundwater Nitrate

GWAVA-S input data was compiled in Arc GIS 10.0 (ESRI) and outputs calculated in *R* (The *R* Development Core Team). Input layers relating to “Transportation” or “Attenuation” were pre-compiled by Nolan & Hitt, (2006) and downloaded from the US Geological Survey’s database (‘USGS GWAVA-S Data Sets - Index to all GIS Data Layers’). From these, a 'transportation-attenuation' layer was created (Fig. S2) per the equations of Nolan and Hitt (2006). We calculated a “farm fertilizer” layer assuming the entire area of each grid was fertilized and also based on the proportion of land in each grid devoted to corn (see below). GWAVA-S output representing potential yield and nitrate pollution per hectare of corn was then calculated using parameter values that Nolan & Hitt (2006) present.

CERES-Maize Model Parameterization

The varieties chosen were the two preset variety responses with DSSAT called 2500-2600 GDD Maize and Medium Season Maize. We acknowledge that these varieties were not optimal for modeling because they represent longer developing varieties than would normally be grown in northeast Iowa, but were chosen because of data availability limitations. Our assumed planting data was May 1, 1990 with a population density of 9 plants m⁻² and a row spacing of 72 cm. It was assumed that the initial soil conditions were 100% soil moisture and 25 kg ha⁻¹ of available N from the previous crop, rainfall and other sources. See Table S1.

Estimating Total Yield and Water Quality

To estimate total yield and water quality at the county and study area levels, we calculated percent corn was calculated from the 2012 crop data layer (CDL) (USGS NASS). The 2012 CLD was reclassified as either corn or other and filtered with a majority (nearest 8 cells) three times to remove noise. This layer was then generalized to a 1 km * 1 km grid with values equating to the percentage of corn land in a particular block. Using this percent corn layer, total yield and nitrate were calculated using:

$$O = C \cdot P \quad [S1]$$

Where *C* is percent corn in a grid cell, *P* is the potential yield or nitrate pollution a cell can produce, and *O* is the total yield or nitrate pollution a cell can produce.

Table S1 Yield response to nitrogen curves by soil type calculated from DSSAT CERES-Maize output. In the yield response equations, y is yield and x is nitrogen application rate. All equations were significant at $P < 0.05$ level.

Soil Surface Textures in STATSGO[†]	Associated DSSAT Soil Surface Texture	Yield Response Equations	Nitrogen Range (kg ha⁻¹)
silty loam clay loam loam silty clay loam	silty loam	$y = 2086.24 + 47.77x - 0.082x^2$	0-350
sandy loam loamy fine sand	sandy loam	$y = 1203.98 + 38.95x - 0.048x^2$	0-350
clay silty clay	sandy clay	$y = 3542.18 + 85.60x - 0.36x^2$	0-125
clay silty clay	sandy clay	$y = 8798.82 + 0.31x$	125-350

[†] Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. U.S. General Soil Map (STATSGO2). Available online at <http://soildatamart.nrcs.usda.gov>. Accessed 04/18/2013.

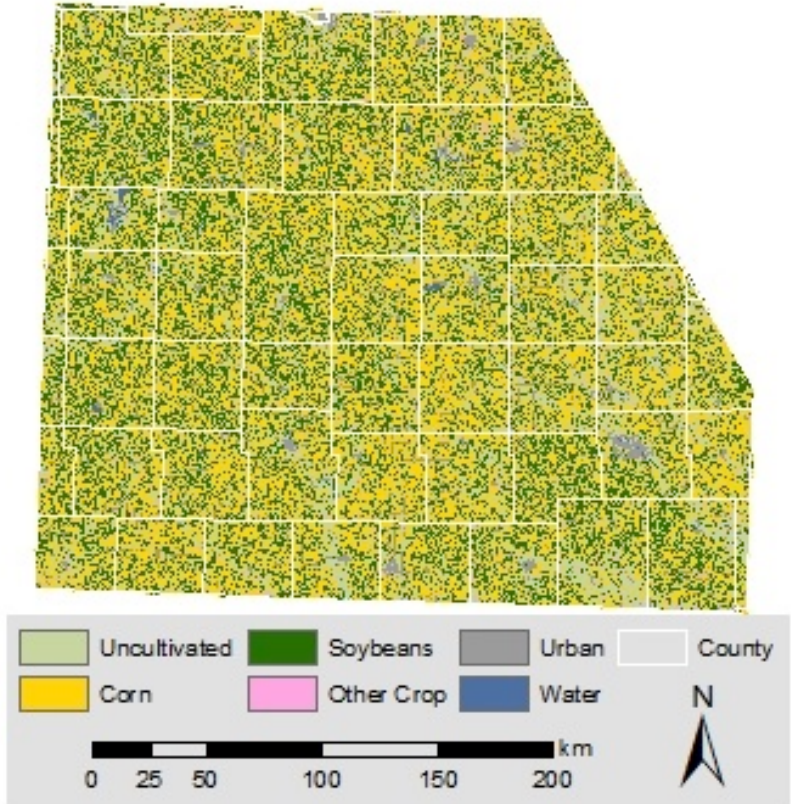


Fig. S1 Generalized Crop Data Layer from 2012 (USDA-NASS).

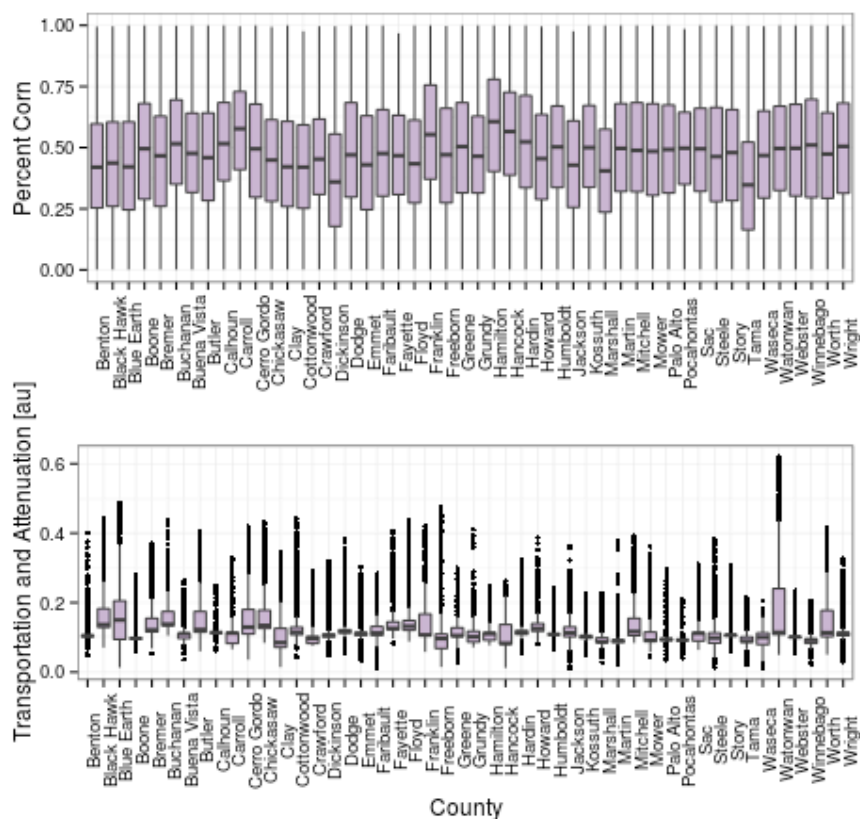


Fig. S2 Soil and management characteristics of each county. The top plot shows the dominance of corn across the study area. The data behind this plot is used to calculate total yield for each county as a function of cropped corn area. The bottom plot shows transportation and attenuation by county. All counties are greater than 10,000 km².