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Nitrogen management in agroecosystems: applying models and data in policy development

Agricultural practice dominates the flux of biologically reactive nitrogen (N) from terrestrial ecosystems. Anthropogenic forcing of the N cycle has multiple ecosystem consequences which operate at a variety of scales. Reactive forms of N are moderated by local-scale, biological activity, but are transported at regional and global scales based on abiotic drivers. Methods for scaling the impact of local land management on regional and global N dynamics are limited by the difficulty of accurately quantifying N fluxes and transport from a management unit. Nonetheless, evidence of significant freshwater and estuarine nitrate pollution, as well as increasing N2O contribution to the greenhouse gas effect, mandates policy development. Successful N management policy will require nuanced approaches to linking observational and modeling studies.

Intensively managed agricultural systems based on Haber-Bosch N fertilization loose 50% of applied N on average, suggesting the potential for alternative management to drastically reduce human impact on N cycling. We quantitatively assessed the potential for management of diversified rotations to increase agroecosystem N retention, while providing a viable livelihood for farmers. We assessed cash crop yields and N dynamics in diversified rotations with an annual cash crop using meta-analysis and the Denitrification-Decomposition (DNDC) model. We model the nitrogen budget of conventional corn-soybean rotations with alternative corn-soybean-wheat-legume rotations using Illinois silty clay loams as our model system. Model sensitivity to parameter variation is tested for a broad range of infiltration and nitrate leaching parameters. We validate model output from the conventional simulations using a 10 year record of nitrate leaching, infiltration, and crop yield. For a ten year simulation, the model predicts a 70% reduction in nitrate leaching in diversified relative to conventional systems. Meta-analysis and model results showed diversified rotations which include dependence on biological N-fixation result in viable yields and increased agroecosystem N retention.

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