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# *Using PEWI to Model and Evaluate the Tradeoffs among Crop Yield, Nitrous Oxide Emissions, and Nitrate Leaching from Land Uses and Best Management Practices*

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## Introduction

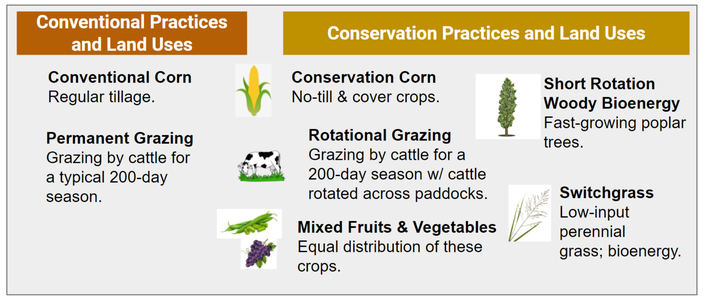
Agriculture is the largest source of nitrous oxide ($N_2O$) emissions in the U.S. $N_2O$ is a greenhouse gas about 300 times more potent than $CO_2$. Soil management practices, particularly nitrogen (N) fertilizer application, are responsible for most $N_2O$ emissions. Understanding $N_2O$ emissions and mitigation is critical for attaining climate smart agriculture while meeting increasing food demands. Since the leaching of nitrate ($NO_3^-$) is also associated with N fertilizers, it must also be considered with $N_2O$ mitigation strategies to protect water.

## Objective

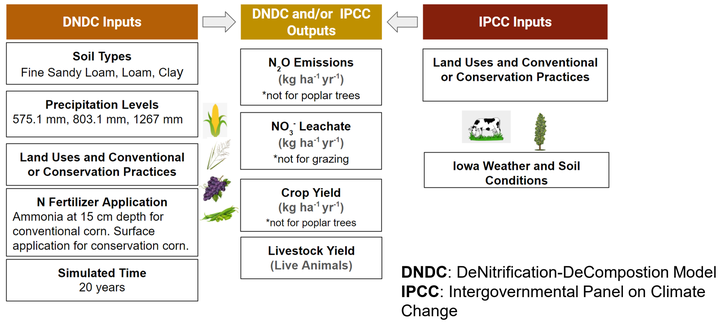
The objective of this project is to evaluate the tradeoffs among crop yield, the leaching of $NO_3^-$, and $N_2O$ emissions from land uses and best management practices. We used a combination of modeling tools to ultimately model these tradeoffs at the watershed scale using the People in Ecosystems Watershed Integration (PEWI) tool.

## Materials and Methods

**1. Land Uses and Practices:** based on the PEWI modeling tool, which assumes climate conditions, topography, and soil types in Iowa.




**2. DNDC Model, IPCC Modeling, and Empirical Data**




**DNDC**: DeNitrification-DeCompostion Model
**IPCC**: Intergovernmental Panel on Climate Change

**3. PEWI Land Use Scenarios:** to predict tradeoffs at the watershed scale with different land use scenario simulations. Land use scenarios are experimental.

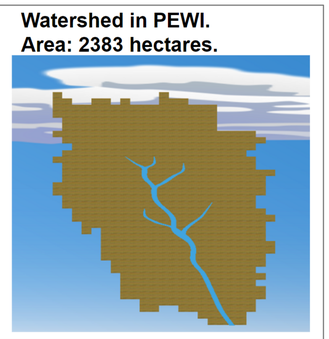
**Scenario 1**
50% conventional corn
50% permanent grazing

**Scenario 2**
50% conservation corn
50% rotational grazing

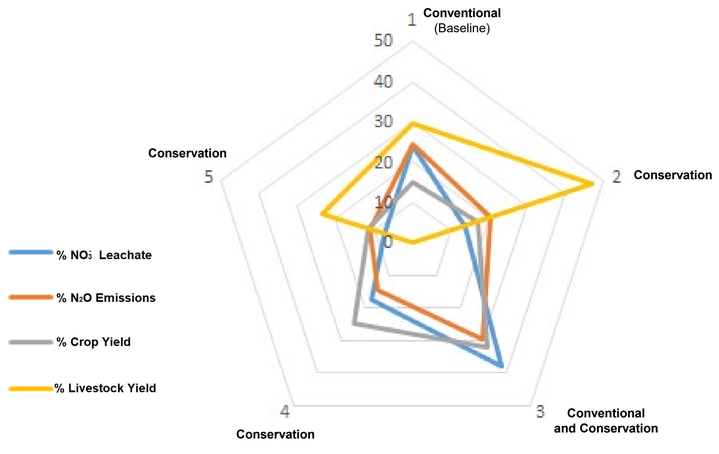
**Scenario 3**
50% conventional corn
50% conservation corn

**Scenario 4**
50% conservation corn
25% switchgrass
25% green beans and grapes

**Scenario 5**
25% conservation corn
25% switchgrass
25% short woody rotation (poplar trees)
25% rotational grazing




## Results




**Scenario 2 compared to Scenario 1**
Replace conventional corn/grazing with conservation corn/grazing.

- **$N_2O$ emissions:** 4% lower.
- **$NO_3^-$ leachate:** 10% lower.
- **Yield**: 17% higher for livestock and only 2% higher for corn.

**Scenario 3 compared to Scenario 1**
Replace permanent livestock with conservation corn.

- **$N_2O$ emissions:** 5% higher. Highest of all scenarios.
- **$NO_3^-$ leachate:** 14% higher. Highest of all scenarios.
- **Yield**: 17% higher for corn. Highest crop yield of all scenarios.

**Scenario 4 compared to Scenario 1**
Replace conventional corn/livestock with conservation corn, switchgrass, and mixed green beans and grapes.

- **$N_2O$ emissions:** 10% lower.
- **$NO_3^-$ leachate:** 7% lower.
- **Yield**: 10% higher. Highest of all scenarios with only conservation practices.

**Scenario 5 compared to Scenario 1**
Replace conventional corn/livestock with conservation corn, rotational grazing, switchgrass, poplar trees and (short woody rotation bioenergy).

- **$N_2O$ emissions:** 14% lower.
- **$NO_3^-$ leachate:** 17% lower.
- **Yield**: 4% lower for corn and 6% lower for livestock.
- Lowest for all measures out of all scenarios.

## Conclusion and Implications

The modeled results indicate the following:

- Land use decisions have a direct impact on $N_2O$ emissions, the leaching of $NO_3^-$ , and crop yield.
- Tradeoffs between $N_2O$ emissions and leaching of $NO_3^-$ depend on land use and management practices.
- Corn production results in the highest $N_2O$ emissions and leaching of $NO_3^-$ , even when grown with conservation practices.
- Conservation practices and land uses result in the lowest $N_2O$ emissions and leaching of $NO_3^-$, including crops for bioenergy.
- The environmental impact of food production can be achieved by diversifying and implement additional mitigation strategies for both $N_2O$ and $NO_3^-$ ; those were not modeled in this study.

## Future Work

Once sensitivity analysis validates these modeling results:

- PEWI simulations can show the tradeoffs among $N_2O$ emissions, $NO_3^-$ leaching and yield from land use and management decisions.
- PEWI simulation data can assist multiple stakeholders in making decisions that serve to attain sustainable agriculture.

## References

1. People in Ecosystems Watershed Integration, Iowa State University, https://www.nrem.iastate.edu/pewi/
2. The DNDC Model; University of New Hampshire, https://www.dndc.sr.unh.edu/
3. The Intergovernmental Panel on Climate Change, https://www.ipcc.ch/

The RET for Teachers is funded by the USDA-NIFA Award No. 2020-68012-31824, Consortium for Cultivating Human and Naturally Regenerative Enterprises.