Financial and Nutrient Reduction Tool (Finrt)

Objective: Estimate the total costs and expected nitrogen reduction of various conservation scenarios at field scales and at the HUC12 watershed-scale.

Task: Perform various scenario-oriented financial analyses such as total cost for conservation planning, comparative cost-effectiveness, and budget or N-reduction goal optimization.

# Datasets

**Cost outcomes.** Comprehensive enterprise budgets for ACPF-supported BMPs were assessed and updated (adapted from Christianson et al. (2013) and Tyndall and Bowman (2016)) for use with the Iowa Nutrient Reduction Strategy. Costs are accounted for using standard discounted cash flow techniques across designated time horizons and annualized to allow for comparative analysis with other farm-level production costs (Tyndall and Roesch 2014). All Financial data is in 2021$ value and will be updated on an annual basis.

**Direct Cost.** Partial budget, field-scale data for establishing and managing a BMP or set of BMPs over a specific period of time.

**Opportunity Cost.** Spatially explicit, long-term opportunity cost of land use for practices that remove cropland from production.

**Total Cost.** Calculated on a per acre per year unit and based on scale of application and duration of use.

# Methods

## Opportunity Costs

Calculated based on the cropland or permanent pasture land conversion to BMP (e.g., riparian buffers, contour buffer strips, nutrient removal wetlands, and farm ponds), and accounts for long-term cost of land by calculating area-weighted land rent loss as a proxy opportunity costs (Zimmerman et al. 2019).

**Cropland Conversion:**

Longterm Cost = foregone cropland rent

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MLRA = rental rate per index point averaged across MLRA

**Improved Permanent Pasture:**

Longterm Cost = foregone cropland rent

area weighted average adjusted productivity index

MLRA = Rental rate per index point averaged across MLRA

Weights:

1. State-specific crop productivity indices
   * Illinois: (currently acquiring)
   * Indiana: (currently acquiring)
   * Iowa: CSR2
   * Minnesota: (currently acquiring)
   * Nebraska: (currently acquiring)
   * Ohio:
   * Wisconsin:
2. Major Land Resource Area (MLRA) scale rent data (USDA SCS 1981). Area-weighted averages for county-data were aggregated at MLRA-levels to calculate an average MLRA-level per acre rent.
   * Iowa: Cash rental rates were gathered from Iowa State University Extension and Outreach AgDecision Maker. Typical rental rates for high, medium, and low cropland in all Iowa counties, and for pasture, hay and oat production land are reported annually by ISU Extension & Outreach (Plastina et al. 2021).
3. In situations where permanent pasture is being improved the productivity index was adjusted and multiplied by 0.35 (35%). The state average 2021 cash rental rate in Iowa for improved permanent pasture is $195 per hectare and the state average 2021 cash rental rate for corn and soybeans is $537 per hectare. The tool then calculates the area-weighted average productivity index and the per-productivity index point $ amount to get the per hectare rental rate.

## Nitrogen Reduction Estimate

Mean percent nitrate reduction efficiencies from the Iowa Nutrient Reduction Strategy allows for N load, N load reduction potential from BMPs, and cost per pound of N reduced per BMP to be estimated.

## Developing Conservation Scenarios

1. **Estimate field Nitrogen requirements.** Estimates the potential nitrogen load at the field and watershed level. Field nitrogen requirements and potential nitrogen load are generated.

Goal: Quantify the potential nitrogen load at the field and watershed level.

How: Calculates the amount of nitrogen, at the field-level, that may be lost – and thus is an opportunity for BMPs to capture and reduce.

The nitrogen requirements for each field is quantified based on 6-year land use data, and evaluates the proportion of that nitrogen that is likely to be lost from the field via leaching as N load. Quantifying the proportion of nitrogen lost due to leaching was done using input data from Maximum Return to Nitrogen (MRTN). MRTN[[1]](#footnote-1) is estimated by calculating the return to nitrogen application and finding the maximum MRTN at selected prices of nitrogen and corn directly from recent research data (Sawyer 2006).

Data is aggregated from the Iowa Nutrient Reduction Strategy (NRS) to estimate nitrate reduction from potential BMP implementation. The average and standard deviations for nitrate reduction efficiencies by BMP.

Inputs: Field boundaries, land use table, fertilizer rates in pounds for cropping systems (default)[[2]](#footnote-2)

* + Corn after Soybean Fertilizer Rate: 131
  + Corn after Corn Fertilizer Rate: 165
  + Soybean Fertilizer Rate: 0
  + Sugarbeet Fertilizer Rate: 83
  + Wheat Fertilizer Rate: 110
  + Small Grain Fertilizer Rate: 70
  + Legume Fertilizer Rate: 60
  + Pasture Fertilizer Rate: 0

Output:

|  |  |
| --- | --- |
| **Attributes** | **Description** |
| FBndID | Unique field boundary polygon identifier |
| Acres | Area in acres |
| isAG | 0 = NonAg, 1 = Agricultural, 2 = pasture/grass/alfalfa |
| Shape\_Length | Field size (m) |
| Shape\_Area | Field size (m2) |
| GenLU | Rule-based general land use assignment. Crop rotation for agricultural fields |
| CropRotatn | Crop rotation string representing the last 6-yr of the major land use in the field |
| CropSumry | String showing counts of distinct crop cover in CropRotatn |
| CCCount | Count of occurrences of continuous corn in the crop rotation string (out of 6 yr) |
| CornYrs | Number of years of corn |
| CCpairs | Number of paired corn years |
| N\_6Yrs | Cumulative N requirements in lbs for field, based on 6-year crop rotation |
| N\_Annual | Average N requirement in lbs per field per year (average of N\_6-years) |
| N\_Rate | N rate in lbs for fertilized crops for field |
| Nconc | N concentration in mg/L for field |
| NloadAc | Leachable N load per acre in mg/L |
| wsNload | Potential contribution of N load in lbs from field |
| NLoadReduced | Potential reduction of N load in lbs from field when BMP is installed |

1. **Analyze Conservation Scenario N load.** Quantifies the expected nitrogen load reduction and financial costs associated with the user-selected sitings generated while using the ACPF GIS toolset.

Goal: Generate scenarios based on user-selected BMP sitings.

How: Each BMP layer generated from the ACPF has its own designated field. All BMP layers are optional; only BMP layers being considered for a certain scenario should be included in the tool.

Calculate N load and Reduction: Each BMP has a watershed associated with it, from which the water that is treating flows and is intercepted by the BMP. Once the BMP areas are identified it creates a feature class named <BMP>\_WSSumrybyField.

Fields in the individual practice watersheds are examined to extract N load characteristics as calculated above by the Field N Requirements tool.

* The N-load-per-acre value is applied to row-crop acres, in the portion of the field in the practice watershed in order to estimate by-field N load for the affected acres.
* The aggregate of these N load parameters across the individual practice watersheds is created to generate the <BMP>\_WSnutrientSummary feature class.

Calculate the costs associated with BMPs, estimated direct costs, as annualized direct establishment and management costs, are used for each BMP feature in the BMP feature class. Opportunity costs for area of land removed from production for relevant practices in the BMP feature class are estimated using state-specific, soils-based crop productivity indices.

Input: Field boundary class, land use, nutrient table, gSSURGO soils raster, flow direction aster, flow accumulation raster, optional BMP input layers

Output: Practice summary layer (<BMP> practiceSummary), watershed nutrient summary layer (<BMP> WSnutrientSummary), summary by field layer (<BMP> WSSumrybyField), scenario summary table (scenarioSummary).

# Appendix A: Definitions

Annualized

Corn Suitability Rating (CSR2) – an index of the inherent soil productivity of each soil series relative to corn production in Iowa and is scale from 5 to 100 for the least to most productive soils (Burras & Miller 2015). The data is used to measure soils’ capacity to grow corn and estimate relative average yields

Direct Costs

Discounted Cash Flow

Discount Rate

Enterprise Budgets

National Commodity Crop Productivity Index (NCCPI)

Opportunity Costs

Partial Budget

Total Cost

# Appendix B: Read List

* Iowa Nutrient Reduction Strategy
* Ellen Audia
* Emma Bravard
* Tyndall & Bowman 2016
* Tyndall & Roesch 2014
* Christianson et al. 2013
* Zimmerman et al. 2019
* Iowa State University Extension and Outreach AgDecision Maker
* Sawyer 2006

# Appendix C: Enterprise Budgets

2% discount rate

1. Maximum Return to Nitrogen (MRTN) was developed to assist producers in identifying the nitrogen application rate where the economic net return to nitrogen application is greatest. <http://cnrc.agron.iastate.edu/> [↑](#footnote-ref-1)
2. Default data come from the MRTN but may be changed by the user to align with field- or watershed-specific nutrient management [↑](#footnote-ref-2)