The NAPRA Program[1]

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1.0 Overview

The *National Agricultural Pesticide Risk Analysis* (NAPRA) tool was developed to simulate the effects of agricultural crop production and crop management on surface and sub-surface losses of water, sediment, nutrients, and pesticides at the field scale. It is a continuous simulation tool and utilizes a water quality simulation model [(*Groundwater Loading Effects of Agricultural Management Systems* (GLEAMS, Leonard et al., 1987)] combined with statistical analysis to give average annual, long-term, and risk-based losses of various agricultural pollutants. NAPRA can be used to evaluate potential hydrologic/water quality benefits of various agricultural management alternatives. Multiple databases, including climate and soils data, are provided to help users parameterize the model for any agricultural field located in conterminous USA.

A web-interface developed for NAPRA (NAPRA-web) enables users to easily alter input parameters that describe their field scenarios and evaluate various 'what-if' scenarios. NAPRA-web can be used to make field management decisions for agricultural production with the goal of reducing negative, unintended hydrologic/water quality consequences. A brief overview of NAPRA is provided below. NAPRA technical documentation, and user's manual are available online at: https://engineering.purdue.edu/napra.

1.1 NAPRA Evolution

NAPRA was developed to estimate the complex environmental risks of pesticide use. A web-based NAPRA (NAPRA-web) was developed to estimate the effects of land use and management on water quality for specific sites, with pesticides being the main concern. NAPRA-web was extended to include a nutrient component of GLEAMS to simulate nutrient loading and to perform simulations at the county or watershed level. NAPRA-web provides an easy-to-use web interface and spatial and relational databases to simplify the process of developing model input files. NAPRA-web is easily accessible via the

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Internet.

NAPRA uses GLEAMS to simulate surface and sub-surface hydrologic/water quality response of agricultural production and management. GLEAMS model was developed from the CREAMS (Chemicals, Runoff, and Erosion from Agricultural Management Systems) model (Knisel, 1980). The GLEAMS model was developed to evaluate the effects of agricultural management systems on the movement of agricultural chemicals within and through the plant root zone (Leonard et al., 1987).

1.2 GLEAMS Components

The components of the GLEAMS model include: hydrology, erosion, pesticide, and nutrient (Figure 1). The hydrology component simulates runoff due to daily rainfall using a NRCS curve number method. Hydrologic computations for evapotranspiration, percolation, infiltration, and runoff are determined at a daily time step. Two options are provided in the hydrology component to estimate potential evapotranspiration:

(1) Priestly-Taylor method (Priestly and Taylor, 1972) using daily temperature and radiation data computed from mean monthly data; and
(2) Penman-Monteith method (Monteith, 1965) that requires additional data such as wind speed and dew point temperature.

Water routing through the soil profile is based on the storage routing concept which allows the downward movement of water, in excess of field capacity water content, from one layer to the other. Soil profile description and crop data are used to estimate effective rooting depth.

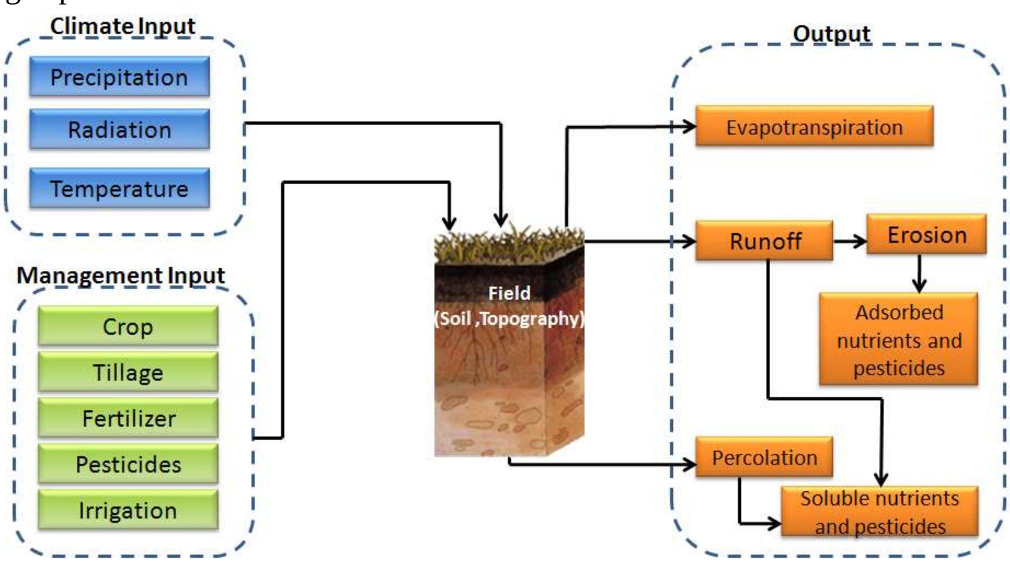

Figure 1. GLEAMS model schema (modified from Thomas, 2009)

The erosion component in GLEAMS is similar to the one developed for the CREAMS model (Knisel, 1980). This component considers multiple flow paths: overland, channel, impoundment, or any combination of these pathways. The model uses the Universal Soil Loss Equation (USLE) and the continuity of mass to predict erosion and sediment transport under different topographic and cultural conditions.

Computation begins at the upper end of the overland slope and proceeds downslope. The overland flow may be selected from several possible overland flow paths based on the slope. The processes of detachment and deposition are both considered and each condition occurs based on the relationship between transport capacity of runoff water and sediment load.

The nutrient component of the GLEAMS model incorporates both nitrogen and phosphorus cycles (Shirmohammadi, 1998). The nitrogen component includes: mineralization, immobilization, denitrification, ammonia volatilization, nitrogen fixation by legumes, crop N uptake, and losses of N in runoff, sediment, and percolation below the root zone. It also incorporates fertilizer and animal waste applications.

The phosphorus component includes: mineralization, immobilization, crop uptake, losses to surface runoff, sediment and leaching, as well as fertilizer and animal waste application. Tillage algorithms are included in the model to account for the incorporation of crop residue, fertilizer and animal waste. Soil temperature and soil moisture algorithms are included that provide adjustments for ammonification, nitrification, denitrification, volatilization, and mineralization rates.

Nitrogen concentration in precipitation is an input to the model and may vary depending upon the study region. Initial soil total N and total P are sensitive parameters in the model. Additional details are provided in Knisel (1993) and Leonard et al. (1987).

2.0 Decision Support System

NAPRA-web offers capability to populate model parameters using on-line databases, such as STATSGO soil data. Several capabilities are added to the tool, including

1. An option to using soil information from STATSGO, SSURGO (currently available for Indiana) and NASIS.
2. An option to evaluate impact of certain conservation practices, including buffer strips, and contour tillage.
3. An option to analyze impacts of various bioenergy crop production scenarios on losses of runoff, sediment, nutrients, and pesticides through surface and sub-surface pathways.

NAPRA-web contains three main components (Figures 2):

- Input Interface to the model using maps and tabular input
- Analysis and the databases that are stored on the server
- Output in tabular and graphical form to show the level of impact of pesticides and nutrients.

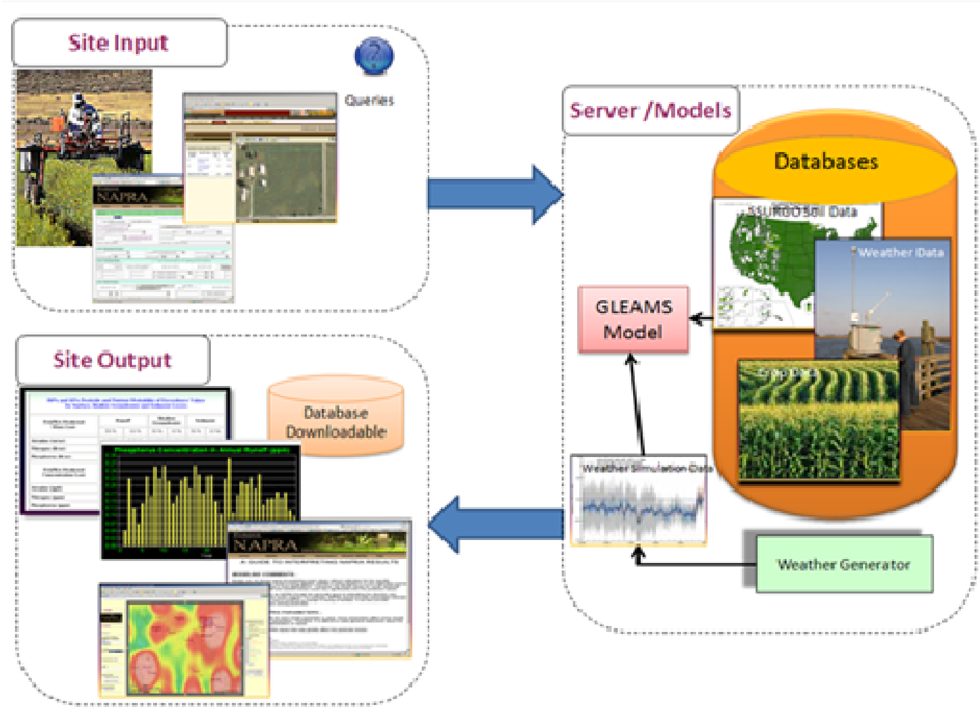

Figure 2. Conceptual schema of NAPRA-web

2.1 NAPRA-web Input

NAPRA inputs required from the user are:

- Management practice
- Pesticide applied
- Nutrient applied
- Crop
  - Type
  - Root zone depth
  - Planting date
  - Maturity date
  - Harvest date
- Land use practice
- Hydrologic condition
- Foliage
- Soil fractions of pesticide application
- Soil loss factor for each stage in the cropping cycle
- Nutrient application
  - Date
  - Type
  - Amount
  - Method used

NAPRA-web simulates the effects of different agricultural management practices on hydrology, erosion, pesticides and nutrients. Figure 3 shows the NAPRA-web input screen.

Model inputs include climate data (30-50 years of weather data, based on the location selected by the user), soils data (STATSGO, SSURGO, NASIS), crop data and pesticide data. The National Soil Information System soil properties for Indiana are available in the NAPRA database. STATSGO soil data are currently available for all conterminous states in USA for NAPRA. Users can select an area of interest from pull down menus in the input interface. The soil parameters required by NAPRA are obtained from the soil database. Relevant soil parameters such as porosity, field capacity, wilting point, organic matter content, and soil erodibility are extracted from a relational database to build the NAPRA-web input files.

Web-based NAPRA uses simulated climate data from a climate generator (observed Indiana weather data are available within a NAPRA database providing an option to use observed data within Indiana).

To enable easy entry of information, search capabilities are incorporated to retrieve the required pesticide by selecting either the trade name or common name. The query is submitted to the database and the NAPRA-web queries obtain the pesticide attributes of water solubility, organic carbon partitioning coefficient (Koc), half-life, and washoff fraction.

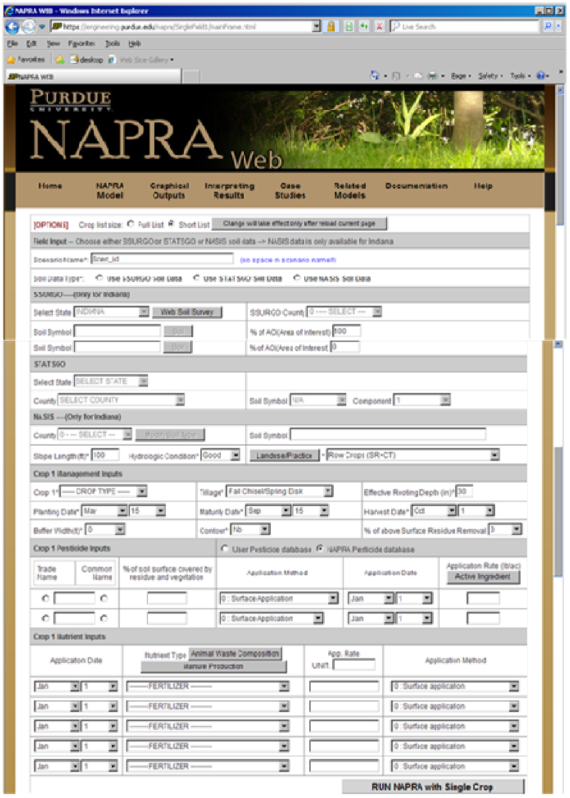

Figure 3. NAPRA-web Input Form

2.2 Databases

The databases in the server are soil data, weather data, pesticide data and crop data. These data along with user inputs are given as input to the GLEAMS model. The input data from the database are retrieved by querying the databases and by running the weather generator model. The weather generator creates the weather data for the time when the data are not available. The different input parameters are soil properties, crop management information for the area of interest, long-term daily temperature and precipitation data, tillage practice data, pesticide properties and nutrient properties. The model conducts the analysis to estimate the pesticide and nutrient loss.

2.3 NAPRA-web Output

NAPRA-web generates output in the form of tables and graphs. NAPRA-web aggregates and converts GLEAMS output into time series data. Results are probability based. The outputs are the hydrology, pesticide, and nutrient loss probability of exceedance and annual values (Figures 4 and 5). The probability of exceedance values are calculated from simulated sorted values. The annual values are arranged from largest to smallest and plotted as the percentage of time this value is exceeded based on the model (order in list/total number of values * 100). The exceedance value shows the probability that a certain of the output will be met or exceeded. For example, the 50% probability of exceedance is the annual median and the 10% probability of exceedance value represents that the value of the output will be either met or exceeded 10% of the time.

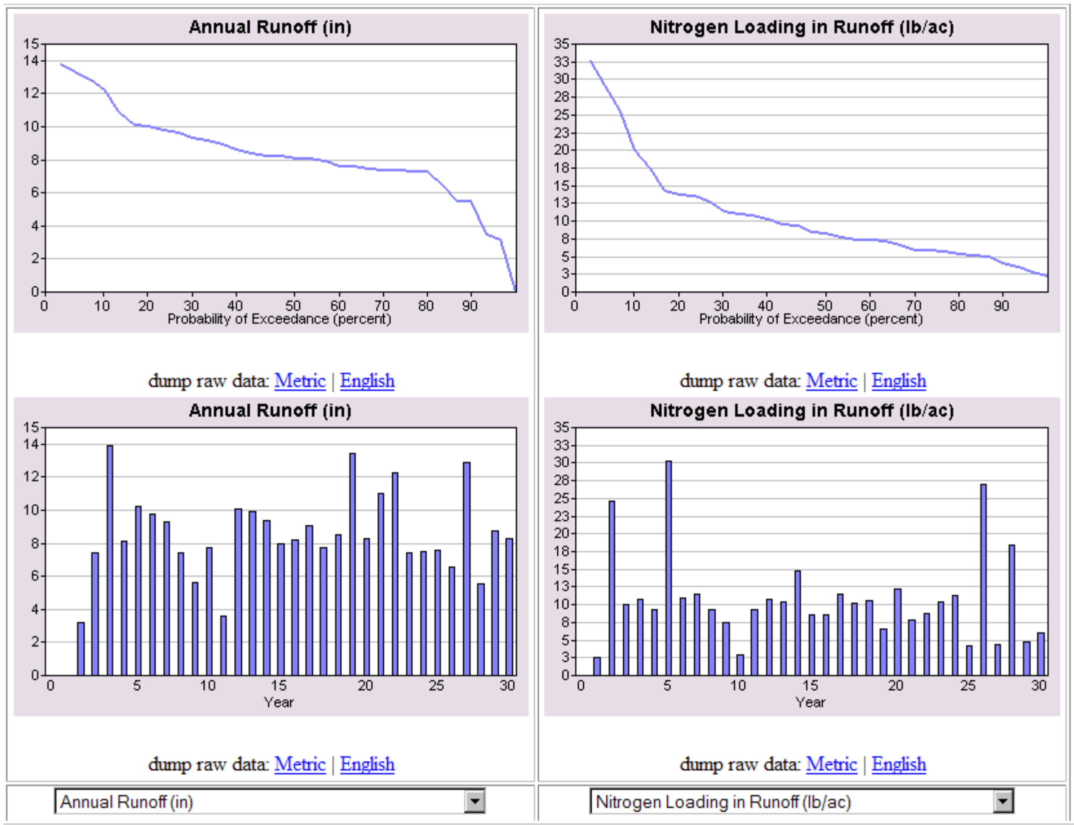

Figure 4. NAPRA Graphical outputs

The output interface also provides users access to all GLEAMS input and output files generated during model runs.

50% and 10% Pesticide and Nutrient Probability of Exceedence Values for Surface, Shallow Groundwater and Sediment Losses						
NAPRA Predicted Mass Lost	Runoff		Shallow Groundwater		Sediment	
	50 %	10 %	50 %	10 %	50 %	10 %
Atrazine (oz/ac)	0.0519	0.1944	0.0004	0.0059	0.0000	0.0002
Nitrogen (lb/ac)	3.3980	6.1157	0.1531	0.5650	0.0006	0.0105
Phosphorus (lb/ac)	0.0169	0.1773	0.0001	0.0002	0.0883	0.2023
NAPRA Predicted Concentration Lost	Runoff		Shallow Groundwater		Sediment	
	50 %	10 %	50 %	10 %	50 %	10 %
Atrazine (ppb)	1.5407	7.1426	0.0142	0.1485	---	---
Nitrogen (ppm)	2.0057	2.2242	0.1009	0.3454	---	---
Phosphorus (ppm)	0.0098	0.0748	0.0001	0.0001	---	---

Figure 5. Pesticide and nutrient loss at the edge of the field and bottom of the root

3.0 Summary

Once the input data has been entered, the user clicks on the "Run NAPRA" icon and the program runs the calculations accessing the necessary databases and generates output. Outputs include: sediment, pesticide and nutrient loss probability tables and yearly probability graphs. NAPRA-web also provides access to the GLEAMS input and output files generated during the model runs which users can download to use for further analysis.

4.0 References

Kinsel, Walter G.(ed.). 1980 CREAMS: A Field Scale Model for Chemicals, Runoff, and Erosion From Agricultural ManagementSystems. U.S. Department of Agriculture, Conservation Report No. 26, 640 pp.

Leonard, R. A., W. G. Knisel, and D. A. Still. 1987. GLEAMS: Groundwater loading effects of agricultural management systems. *Trans. ASAE* 30(5): 1403-1417.

Knisel, W. G. 1993. GLEAMS version 2.1 user manual. UGA-CPES-BAED Pub. No. 5. Washington, D.C.: USDA.

Shirmohammadi, A., B. Ulen., L. F. Bergstrom, and W. G. Knisel.1998. Simulation of nitrogen and phosphorus leaching in a structured soil using GLEAMS and a new submodel PARTLE. *Trans. ASAE* 41(2): 353-360.

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