CUMULATIVE SURFACE WATER EFFECTS

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Objectives:

A primary objective of the study is to determine the sensitivity to changes in data scale (source) of the **AG**ricultural **N**on-**P**oint **S**ource (*AGNPS*) pollution (hydrologic) model (Young *et al*., 1989). For example, this could include investigation of the change in results observed when a 1:24,000 USGS DEM is used in comparison to the results from use of a 1:250,000 DEM. This analysis of scale sensitivity will include elevation, soils, and land use data. These results will be important to researchers when future regional analyses (in the near future, only coarse scale data will be readily available) are completed to predict the effects that biomass production will have upon an area's environment. Additionally, the effect of (cell) grid size on the model's results will be considered with these various data inputs as well.

The second major research objective in the study is to model impacts upon surface water quality with the *AGNPS* model which result from a shift in current land use practices towards practices which include biomass (Switchgrass) production. The water quality characteristics (with their respective units of measure) which are provided by the model are presented in Table 1. Additionally, information about sediment movement is provided in terms of the characteristics presented in Table 2. These values are calculated for clay, silt, and sand particles as well as small and large aggregates. This multitude of factors will allow for the consideration of many view points in the final analysis

Water Quality Characteristics	Units
Volume of Surface Runoff Observed at the Watershed Outlet.	inches
Peak Rate of Surface Runoff.	$feet^3$ / second
Total Nitrogen Associated with Sediment.	pounds / acre
Total Soluble Nitrogen in Surface Runoff.	pounds / acre
Soluble Nitrogen Concentration in Runoff.	ppm
Total Phosphorous Associated with Sediment.	pounds / acre
Total Soluble Phosphorous in Surface Runoff.	pounds / acre
Soluble Phosphorus Concentration in Runoff.	ppm
Total Soluble Chemical Oxygen Demand.	pounds / acre
Soluble Chemical Oxygen Demand Concentration in Runoff.	ppm

Table - 1. Water Quality Summary Observations.

Sediment Characteristics	Units
Upland Soil Erosion	tons / acre
Channel Soil Erosion	tons / acre
Sediment Delivery Ratio	percentage
Sediment Enrichment Ratio	percentage
Mean Sediment Concentration	ppm
Weighted Sediment Yield	tons / acre
Total Sediment Yield	tons

Table - 2. Sediment Summary Observations.

Approach and Background:

These data sets are being managed with the Geographical Resources Analysis and Support System (*GRASS*) 4.1 GIS; an interface between the *AGNPS* model and the GIS (Srinivasan, 1992) was selected over the MS-DOS™ version of the model as this improved the efficiency of managing inputs. This interface extracts the data needed by the model from the GIS data sets. The program then completes the simulation, and gives the user a great deal of flexibility in viewing the results. Three watersheds (Figure 2) near West Lafayette, Indiana were selected and proportioned at both 100 and 200 m cell resolutions, as AGNPS is a raster based model. These are the Little Pine Creek Watershed (11,294 ha), the Indian Creek Watershed (6,239 ha), and the Purdue University Animal Science Farm Watershed (325 ha). The area can be described as mostly agricultural with some wooded areas. Its topography can be described as gently rolling to flat, and it is representative of much of the midwestern United States. Rainfall amounts (Hershfield) and energy intensities (Smith and Wischmeier, 1978) which are representative of 1, 2, 5, 10, 25, 50, and 100 year return period storms for the area of both 2 and 6 hour durations were also calculated (Figure 1).

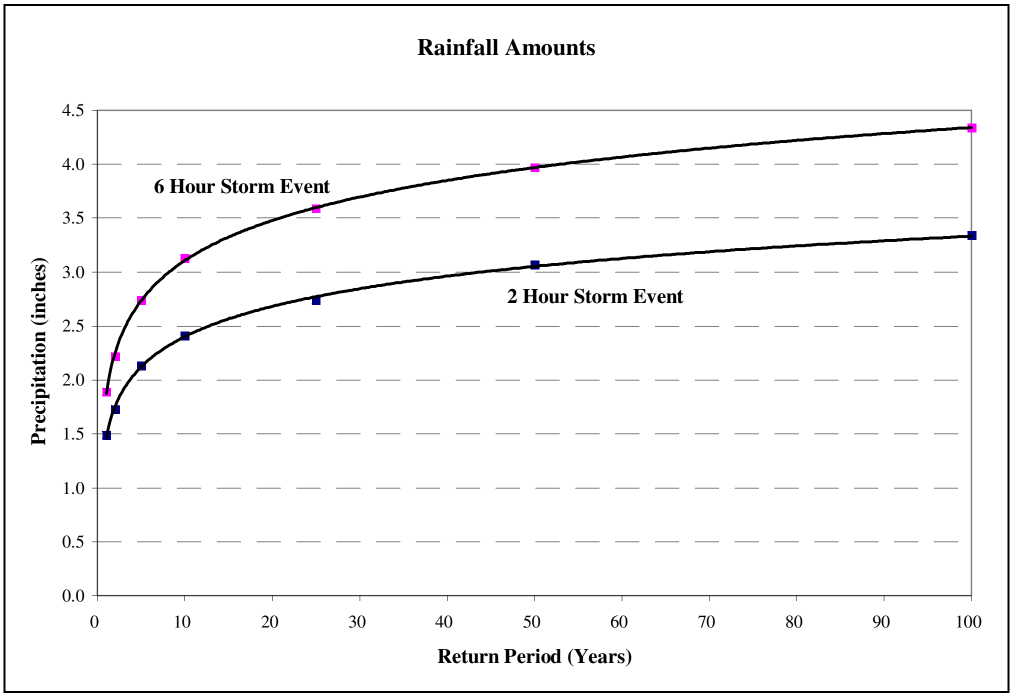

Figure 1. - Rainfall Amounts for Selected Storm Events.

The preparation of data sets for use with *AGNPS* has included gathering information on land use, soils, and elevations. More specifically, these include field survey land use (only for the smallest watershed), TM land use imagery, 1:250,000 USGS LUDA land use data (Figure 3), 1:15,840 soil series (Figure 4), 1:250,000 STATSGO soil associations (Figure 5), 1:24,000 USGS DEM (Figure 6), and 1:250,000 USGS DEM (Figure 7).

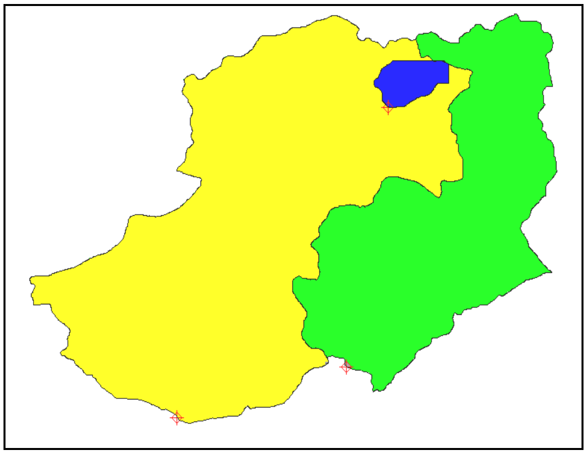

Figure 2. - Watersheds in the Study Area.

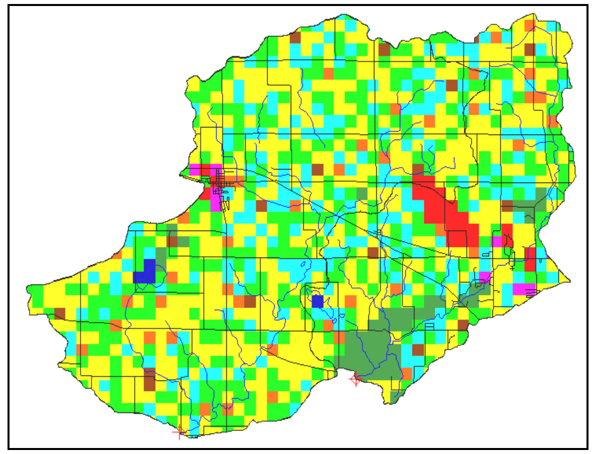

Figure 3. - USGS 1:250,000 LUDA Land Uses.

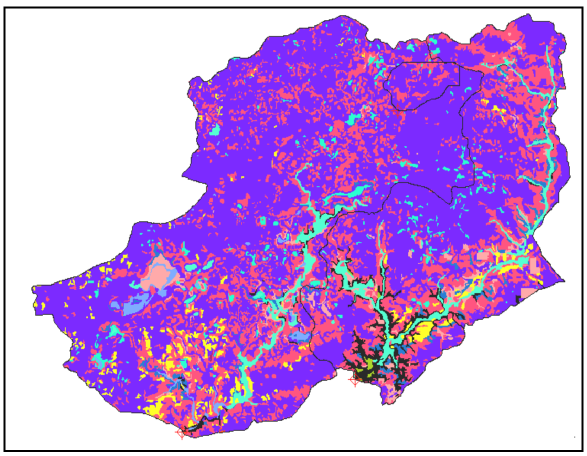

Figure 4. - SCS Soil Series Land Capability Classes.

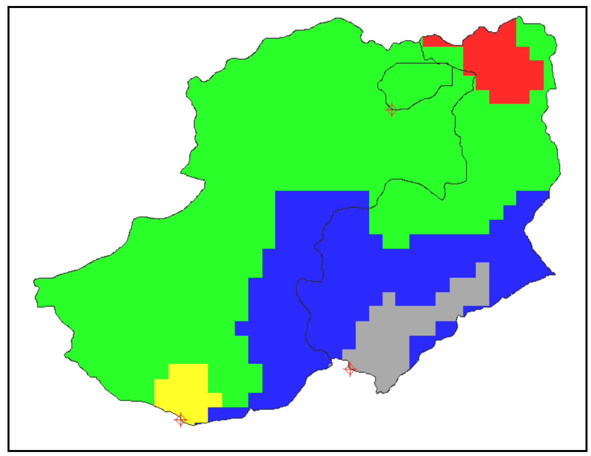

Figure 5. - STATSGO 1:250,000 Soil Associations.

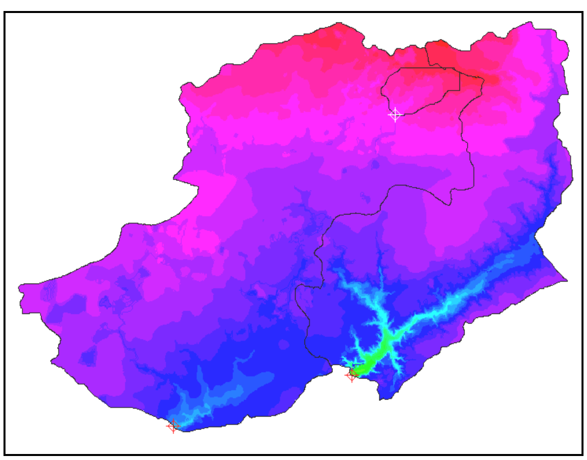

Figure 6. - USGS 1:24,000 DEM.

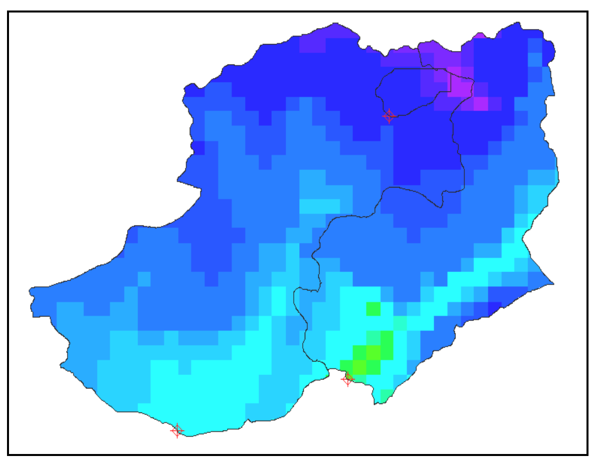

Figure 7. - USGS 1:250,000 DEM.

All possible permutations of these data inputs were defined for three variations on the land use data. These included Phase I: Current Conditions, Phase II: Economic Biomass (biomass was placed more frequently on soils which it is most productive), and Phase III: Water Quality Biomass (distributing biomass in the watershed as buffers around bodies of surface water and on steeply sloped areas). This resulted in the establishment of 2,352 model simulations to be completed. This was later reduced to 2,016, as a result of the model's inability to process the largest watershed at the finer resolution. The criteria for placement of the biomass crop considers the Natural Resource Conservation Service (NRCS) land capability class of the soil and the crop which is being displaced (Table 3). This conversion is achieved by using a random assignment routine in the GIS.

Original Crop	**Probability of Converting to Biomass (Switchgrass)**	
	Land Capability Class = 2W[1]	**Land Capability Class ≠ 2W**
Corn	25.0 %	45.0 %
Soybeans	25.0 %	45.0 %
Wheat	60.0 %	60.0 %
Alfalfa Hay	60.0 %	60.0 %
Pasture	0.0 %	0.0 %

Table 3. - Land Use Conversion Between Phase I and Phase II (provided by ORNL).

Status / Accomplishments:

Preparation of data inputs was the focus of research activities in 1994. In addition to previously mentioned data sets, inputs for other parameters required by the *AGNPS-GRASS* interface were developed. These include flow routing networks, soil textures and other soil properties, management practices, nutrient inputs, USLE 'C' factors, and tillage passes.

In 1995, modeling efforts for Phase I have been completed. Phase II and III simulations are currently in progress and should be completed by the end of calendar year 1995. Results analysis is partially completed, and results are still preliminary. However, an example of the scale affect between "all coarse" (1:250,000 DEM, LUDA land use data, and STATSGO soil data) and "all fine" (1:24,000 DEM, 1:15,840 soil series data, and TM land use data) data inputs is shown in Figure 8; these values indicate that the scale affect appears to be minimal. When analyzing these values, the detailed data can be fitted with Equation 1 which results in $r^2 = 0.9639$ and Equation 2 is fitted to the coarse data with a resulting $r^2 = 0.9632$. These results were from simulations completed on the Little Pine Creek Watershed at a resolution of 200 m.

$$y = 632.47 \ln(x) + 138.50 \quad [1]$$

$$y = 620.76 \ln(x) + 124.13 \quad [2]$$

Future work includes completion of simulations, results analysis, and the publication of an M.S. thesis based upon this research by May, 1996.

[1] - Class 2W are "nearly level to gently sloping soils that have moderate limitations caused by excess water." (USDA, 1959) This is the predominant land capability class in the study area.

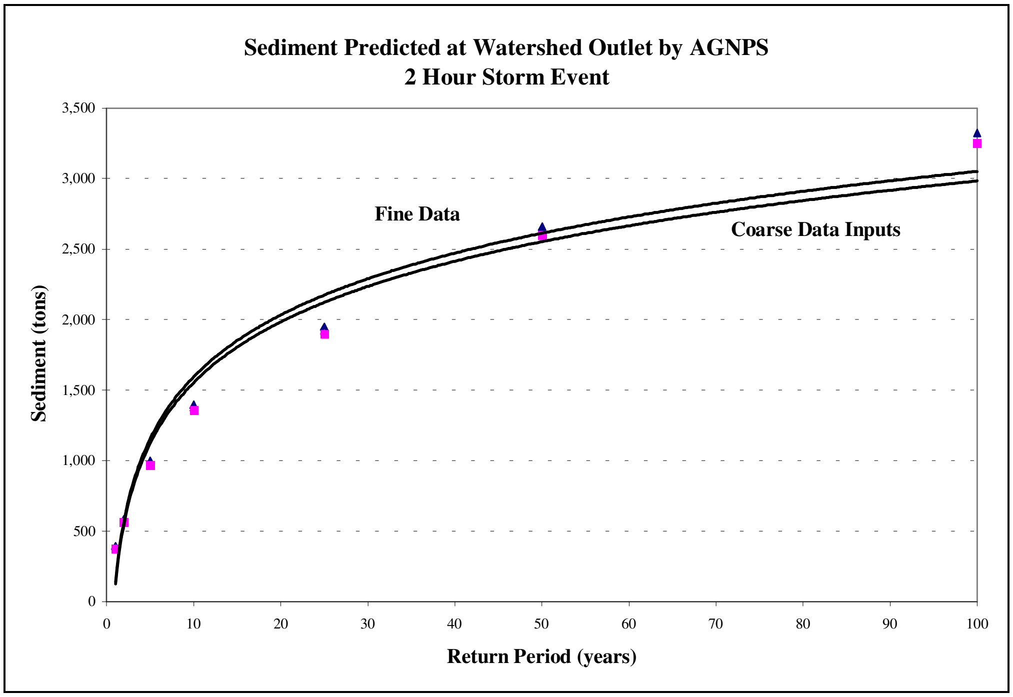

Figure 8. - Simulated Erosion Using Detailed and Coarse Inputs for the Little Pine Watershed.

References:

Hershfield, David M, 1963. *Technical Paper Number 40, Rainfall Frequency Atlas for the United States for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years*, Washington, D.C.: United States Department of Commerce.

Smith, Dwight and Walter H. Wischmeier, 1978. *Predicting Rainfall Erosion Losses - A Guide to Conservation Planning. Agriculture Handbook Number 537*, Washington, D.C.: United States Department of Agriculture, Science and Education Administration.

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United States Department of Agriculture, Soil Conservation Service, 1959, *Soil Survey for Tippecanoe County, Indiana*, Washington, D.C.: U.S. Government Printing Office, pp. 89.

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