CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1. Summary of objectives

Research was conducted with the objectives of developing, describing, and evaluating methods of integrating WEPP and GIS. To fulfill these objectives two Hillslope methods (Chanleng and Calcleng) and the Flowpath method were developed for watershed modeling and discretization using grid-based DEMs. The TOPAZ program was used to help in the discretization of watersheds for the Chanleng and Calcleng methods and the extraction of flowpaths for use in all methods. The Arc View™ GIS was used as the platform for the WEPP - GIS interface. Programming was conducted in FORTRAN and Arc View™'s object oriented programming language Avenue. This interface between GIS and WEPP was instrumental in fulfilling the objectives of the study. A summary of the three main objectives is presented next.

6.1.1. Objective 1. Development of methods

The Hillslope methods (named Chanleng and Calcleng) consisted of the discretization of the watershed into hillslopes and channels from a DEM. A channel network was extracted from the DEM using the concept of a critical source area (CSA). Hillslopes were then defined as the areas that drained to the right, left, or top of each of the channels. Each hillslope was represented by a single soil, crop, and management type in the form of WEPP input files. A representative slope profile was also created for each hillslope from the DEM. The actual slope profile created by the Chanleng and Calcleng methods is derived in the same way, however they differ in how the hillslope length is calculated. In the Calcleng method a representative hillslope length is calculated by a method of weighting flowpath lengths and flowpath drainage areas. This same weighting procedure is used for hillslopes draining to the top of channels in the Chanleng methods, however the lengths of hillslopes are calculated differently for hillslopes draining to the sides of channels. In the Chanleng method, for hillslopes adjacent to a channel, the hillslope width is set to equal the channel length and the hillslope length is calculated by dividing the total area of the hillslope by its set width. WEPP is then applied to the hillslopes and channel structure.

The Flowpath method consisted of applying WEPP to all possible flowpaths in the watershed. Flowpaths were defined in terms of DEM grid cells starting at a point where no other cell in the grid flows into it, then following through a path defined by individual grid flow vectors, and ending when it reaches a channel. Interactions with other flowpaths were frequent and results from the application of WEPP to each flowpath were weighted with the interactions of other flowpaths. However, since there are many flowpaths draining at distinct points along the channels, the WEPP channel routines could not be used. Development of an adequate channel routing mechanism or modifications of the original WEPP code to enable distributed lateral inflow to channels is necessary to apply the Flowpath method to watersheds. The current WEPP channel routines are limited in the number of channel segments simulated and also limited conceptually in the way sediment yield and runoff inflow from hillslopes are distributed along the channel. Consequently, WEPP simulation results for this method can only show sediment loss and runoff from each hillslope or spatially distributed in the watershed over a selected period of time.

6.1.2. Objective 2. Application to research watersheds

The second objective was to describe these methods and their application to research watersheds where simulation results could be compared to measured values. Six research watersheds, three in Holly Springs, Mississippi, two in Watkinsville, Georgia, and one in Treynor, Iowa were used for this purpose. Analyses were conducted in Chapter 4 to study runoff and sediment yield from the watersheds and hillslopes using the Hillslope (later referred to Chanleng) and Flowpath methods with the best available data. Each simulation was compared against manual applications of WEPP by expert users and measured runoff and sediment yield events. The expert users, as described in Chapter 3 and 4, were the scientists that originally applied WEPP to these watersheds (Liu et al., 1997 and Kramer 1993). Results from the study showed that all automatic methods perform as well as the manual application of WEPP by an expert user for runoff, sediment yield from the watershed, and sediment yield from hillslopes. Simulations were also comparable to measured sediment yield events from the watersheds.

6.1.3. Objective 3. Evaluation of performance of methods

The third objective was to evaluate the performance of the methods. To fulfill this objective, a statistical analysis was conducted which compared simulated results to measured values and compared all interactions between methods, resolution, and event sizes. This was done in Chapter 5 using the three methods, four different sized resolutions, and four event size ranges. The following three main hypothesis were studied:

> Hypothesis 1: The resolution of the DEM used for a WEPP watershed simulation has a significant effect on the prediction of runoff and sediment yield from the watershed outlet, runoff an sediment yield from the hillslopes, and sediment loss along the hillslopes. Finer DEM resolutions should result in better simulations for all three levels of simulation.
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> Hypothesis 2: Smaller runoff or sediment yield events are predicted less accurately than larger events. Variability between measured and predicted events for smaller sized evnts using coarse DEM resolutions is larger than for larger events using fine DEM resolutions.
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> Hypothesis 3: When defining the length of a hillslope profile, there is a significant difference between setting the length of hillslope by using the length of the adjacent channel or calculating an independent length of hillslope profile.

Hypothesis 1 was not true for either sediment yield or runoff results from the watershed outlet and from the hillslopes draining to the channels. Using finer resolution DEM did not significantly improve sediment yield and runoff results when compared to measured values. Hypothesis 2 was correct for sediment yield but was not true for runoff. Larger sediment yield events were predicted better than smaller events. Simulations with larger event sizes and finer resolutions performed better than simulations with small event sizes and coarse resolutions for sediment yield results. Hypothesis 3 was incorrect for both runoff and sediment yield. Both the Chanleng and Calcleng methods produced model simulation results not significantly different from each other for runoff and sediment yield from the watershed outlet, from hillslopes, and soil loss along the hillslope profiles.

6.2. Overall conclusions

The studies and research on WEPP and GIS using the six research watersheds presented in this thesis resulted in the following conclusions and contributions to society and science:

* A unique interface was created between WEPP and GIS using DEMs to discretize a watershed into WEPP channels, hillslopes, and representative profiles. This interface can successfully be used to help create and run WEPP simulations. The Hillslope methods, developed for the WEPP-GIS interface, work as well as the manual application of WEPP by an expert user when predicting erosion and runoff from hillslopes or watersheds. The applications of Hillslope methods (Chanleng and Calcleng) were also not significantly different than actual sediment yield measurements from the watershed outlet. There were also no significant differences in runoff, soil loss, or sediment yield results in comparisons between the Chanleng and Calcleng methods. This has favorable implications for GIS modeling because hillslope lengths can simply be calculated by matching the hillslope width to the length of the adjacent channel. The interface using the Hillslope methods thus facilitates the application of WEPP to watersheds when GIS data is available to users. It can help both users that are not very familiar with WEPP by automatically defining

the required components and it can also help expert WEPP users in rapidly simulating different conservation scenarios.

* Studying the effects of using different DEM resolutions for simulations made a unique contribution to the practical application of erosion modeling using DEMs and GIS. The results of this study showed that simulations with the Hillslope methods using fine resolution DEMs are not significantly better than simulations using coarser resolutions for both runoff and sediment yield from hillslopes or the watershed outlet. The finding that a wide range of DEM resolutions can be used for runoff and sediment yield simulations from the watershed outlet and hillslopes is of significant importance because it implies that it is not necessary to produce costly DEMs of fine resolutions for the application of erosion models. A basic rule of thumb for selecting the appropriate DEM resolution for erosion modeling can therefore be established as follows. If the user is only interested in sediment yield from hillslopes or watershed outlet, coarse resolutions will work as well as finer ones. However, if the watershed channel network or boundary is compromised, then the resolution is too coarse. On the other hand, if the user is interested in results of soil loss within the hillslope profile, then finer resolutions are better as long as the fine resolutions accurately represent the hillslope or watershed topography.

* The study of DEM resolution and the Flowpath method made a unique contribution to the understanding of spatially distributed erosion within hillslopes. As the DEM resolution used for simulations using the Flowpath method became coarser, sediment yield from the hillslopes increased. The main reason for this was that the flowpath distribution changed and the average length of flowpaths increased with the change in resolution, which in turn increased simulation results of erosion. Therefore the development and study of the Flowpath method was scientifically important because it challenges the notion that a hillslope can be represented by a single slope profile, which may be over-estimating soil loss.