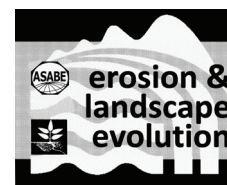


GEOSPATIAL APPLICATION OF THE WATER EROSION PREDICTION PROJECT (WEPP) MODEL

D. C. Flanagan, J. R. Frankenberger, T. A. Cochrane, C. S. Renschler, W. J. Elliot



ABSTRACT. *At the hillslope profile and/or field scale, a simple Windows graphical user interface (GUI) is available to easily specify the slope, soil, and management inputs for application of the USDA Water Erosion Prediction Project (WEPP) model. Likewise, basic small watershed configurations of a few hillslopes and channels can be created and simulated with this GUI. However, as the catchment size increases, the complexity of developing and organizing all WEPP model inputs greatly increases due to the multitude of potential variations in topography, soils, and land management practices. For these types of situations, numerical approaches and special user interfaces have been developed to allow for easier WEPP model setup, utilizing either publicly available or user-specific geospatial information, e.g., digital elevation models (DEMs), geographic information system (GIS) soil data layers, and GIS land use/land cover data layers. We utilize the Topographic Parameterization (TOPAZ) digital landscape analysis tool for channel, watershed, and subcatchment delineation and to derive slope inputs for each of the subcatchment hillslope profiles and channels. A user has the option of specifying a single soil and land management for each subcatchment or utilizing the information in soils and land use/land cover GIS data layers to automatically assign those values for each grid cell. Once WEPP model runs are completed, the output data are analyzed, results interpreted, and maps of spatial soil loss and sediment yields are generated and visualized in a GIS. These procedures have been used within a number of GIS platforms including GeoWEPP, an ArcView/ArcGIS extension that was the first geospatial interface to be developed in 2001. GeoWEPP allows experienced GIS users the ability to import and utilize their own detailed DEM, soil, and/or land use/land cover information or to access publicly available spatial datasets. A web-based GIS system that used MapServer web GIS software for handling and displaying the spatial data and model results was initially released in 2004. Most recently, Google Maps and OpenLayers technologies have been integrated into the web WEPP GIS software to provide significant enhancements. This article discusses in detail the logic and procedures for developing the WEPP model inputs, the various WEPP GIS interfaces, and provides example real-world geospatial WEPP applications. Further work is ongoing in order to expand these tools to allow users to customize their own inputs via the internet and to link the desktop GeoWEPP with the web-based GIS system.*

Keywords. *Geographic information systems, Prediction, Soil erosion, WEPP.*

WEPP is a process-based, distributed-parameter, continuous-simulation model for erosion prediction (Flanagan and Nearing, 1995). The main computer program was developed by a large team of federal government scientists, university researchers, and action agency representatives from 1985 to 1995, with an official model release ceremony in Des Moines, Iowa, in July 1995. At the time of release, the software available was a science model written in

FORTRAN and a rudimentary DOS-based interface written in the C language. In response to user responses and requests, a Windows-based stand-alone interface written in C++ was subsequently created by USDA-ARS (Flanagan et al., 1998) for hillslope profile and small watershed simulations. GIS-linked model applications were also initially created in the late 1990s, and web-based applications of the model have been developed by several agencies as well since then. This article describes the two main WEPP model geospatial interfaces, the procedures used within the software programs for creating the necessary WEPP model inputs, and how the spatial WEPP model runoff, soil erosion, and sediment loss outputs are processed and displayed.

BACKGROUND

WEPP is a complex, process-based soil erosion prediction model that incorporates the fundamentals of soil hydrologic and erosion science. The FORTRAN model (v2012.8) currently consists of 237 subroutines that simulate a myriad of processes including water infiltration into soil, surface runoff, soil water percolation, evapotranspira-

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tion, soil detachment by raindrops and by flow shear stress, sediment transport, sediment deposition, plant growth, residue management and decomposition, and irrigation.

The WEPP model can be applied to either hillslope profiles (1 to 200 m in length) or small watersheds (up to about 260 ha) that are comprised of multiple hillslopes, channels, and impoundments. For a hillslope profile model simulation, the minimum input requirements to the model are climate, slope, soil, and cropping/management input files. In watershed simulations, additional inputs needed are a watershed structure file, channel parameter files (for each channel), and impoundment parameter files (for each impoundment, if any). All inputs to WEPP are in ASCII text files, which makes it relatively easy for the creation of user interfaces by either the model developers or by outside user groups. For example, USDA-ARS has created several WEPP interfaces (Windows, GIS-linked, web-based), while the USDA Forest Service has created a number of its own targeted web-based interfaces (Elliot, 2004). Researchers at Iowa State University have created a web-based tool utilizing the WEPP model and observed radar precipitation data to provide daily estimates of runoff and soil loss across Iowa on a township basis (Cruse et al., 2006).

For application of the WEPP model to hillslope profiles, the standalone Windows interface (Flanagan et al., 1998) may be the best tool in that it allows complete control of all of the model inputs. Thus, very detailed simulation studies can be conducted in which extremely nonuniform slope, soil, and/or cropping/management inputs can be described and identified spatially on the profile by hand. Observed climate data, including precipitation information from recording rain gauges, can also be processed into WEPP input format for continuous simulations, or single-storm climate input files can be created.

Any of the several hundred WEPP model input parameters can be accessed and modified within the Windows interface. This is especially useful in a research situation where large amounts of observed data related to surface cover conditions, soil properties and soil water content, and climate have been collected, and the model is being exercised in a calibration/validation study. For other types of hillslope profile simulations, such as model application by

an action agency user, databases are available for climate, soils, and cropping/management that allow for quick model simulations of existing and alternative scenarios for land management and soil conservation planning. The simple web-based hillslope model interfaces are also an attractive alternative for these types of applications, as they only require a computer with a web browser and an internet connection or a smart phone.

When moving up in scale to a larger field or a small watershed, development of model inputs by hand becomes increasingly difficult and tedious due to the increasing number of watershed elements (hillslopes, channels, impoundments) that must be identified, correctly placed in the watershed structure, and parameterized. For these larger-scale applications, utilization of available spatial data sets, particularly topography (elevations), soils, and land use, becomes extremely helpful.

USE OF DIGITAL ELEVATION MODELS

Cochrane and Flanagan (1999, 2003) described the development of methods to integrate digital elevation models (DEMs) with the WEPP model. These procedures were named the hillslope methods and the flowpath method. The two hillslope methods (Chanleng and Calcleng) consist of discretizing the watershed into representative hillslopes and channels from a DEM (Cochrane and Flanagan, 2003). A channel network is extracted from a DEM using the critical source area (CSA) concept (Garbrecht and Martz, 1997), and then hillslopes are defined as the subcatchment areas that drain to the left, top, or right of each channel segment. The channel slope profile and length derived from the DEM is used for the WEPP watershed input, but other information, such as cross-sectional shape, needs to be supplied by the user. A “representative” hillslope profile for a WEPP model simulation in a subcatchment is then created using the flowpath information derived from the DEM (fig. 1). All of the many flowpaths (i.e., paths by which water moves downward, cell to cell, from a DEM grid cell of locally high elevation within a subcatchment until a channel grid cell is reached) can be obtained by analyzing the

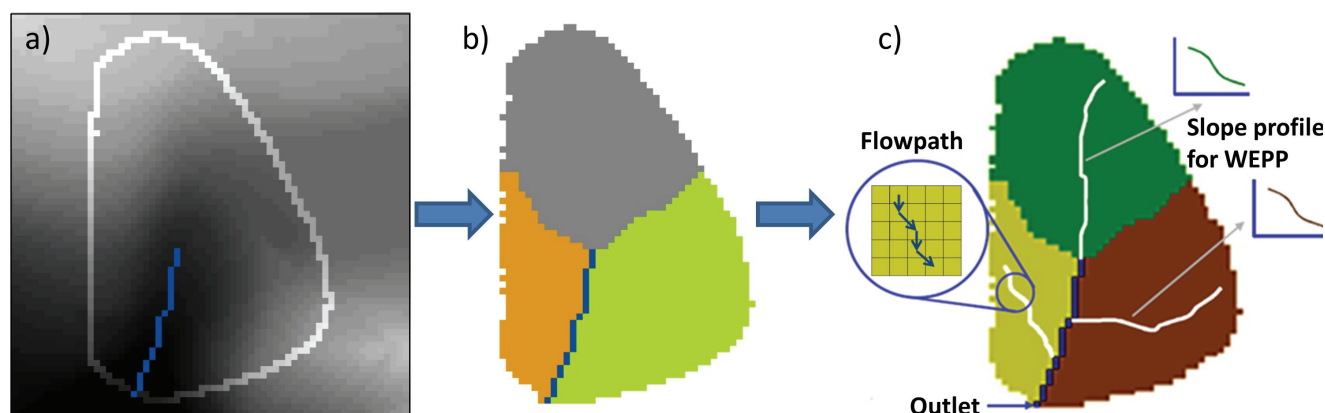


Figure 1. Example application showing steps involved in automatically creating WEPP watershed inputs from a DEM: (a) watershed and channel delineation using a selected outlet point and a critical source area, (b) discretization of subcatchments (hillslopes) based on channels, and (c) representative slope profile definition for each hillslope. The inset in (c) shows a DEM-derived flowpath used to define a representative profile (from Cochrane and Flanagan, 2003).

output from the TOPAZ program (Garbrecht and Martz, 1997). Spatial location of cells on the flowpath, distance from the terminal cell on the channel along the flowpath, and the slope gradient at each cell are calculated for each flowpath.

The representative profile is created by averaging all of the slope values on the flowpaths at distances away from a channel. The weighting utilizes the slope gradient values at the points along the flowpath, the entire contributing area of the flowpath (area of all the grid cells in that flowpath), and the entire length of the flowpath with the following equation:

$$S_i = \frac{\sum_{p=1}^n s_{pi} * k_p}{\sum_{p=1}^n k_p} \quad (1)$$

where S_i is the weighted slope value at distance i from the channel for all flowpaths in a subcatchment, s_{pi} is the slope gradient of an individual flowpath p at distance i from the channel, k_p is the weighting factor for flowpath p , and n is the number of flowpaths in the hillslope. The weighting factor is $k_p = a_p * l_p$, where a_p is the contributing area of a flowpath (sum of all contributing grid cell areas) and l_p is the entire flowpath length (Cochrane and Flanagan, 1999).

Following this, the actual representative hillslope length needs to be set. For hillslopes on the left and right side of a channel, the hillslope width is set equal to the channel segment length, and then the representative hillslope length is computed by dividing the total subcatchment area by the hillslope width (this is the Chanleng method). Since the initially computed representative profile will be as long as the longest flowpath, the actual final profile has to be truncated to the newly computed length and all points above that length deleted.

For hillslopes that flow to the top of a channel, a representative profile length is computed using an equation similar to equation 1:

$$L_R = \frac{\sum_{p=1}^n l_p * a_p}{\sum_{p=1}^n a_p} \quad (2)$$

where L_R is the representative hillslope profile length, and l_p is the flowpath length (Cochrane and Flanagan, 1999). The representative hillslope width is computed by dividing the total subcatchment area by the L_R value (this is the CalcLeng method).

The WEPP model simulation is then run using the representative hillslope profile slope input that is unique for each subcatchment, and the channel slope input files as well as the watershed structure file derived from the DEM. Soil detachment or sediment deposition is computed at each of 100 points on each profile, and runoff and sediment delivery are predicted for each hillslope. Runoff and sediment

from the hillslopes are then routed through the channels and impoundments to the watershed outlet. The runoff and sediment generated for each subcatchment are mapped back as output layers in the GIS interface being used. Since the representative profile that was simulated is rectangular and the actual subcatchments are almost always irregular in shape, it is not possible to create maps of spatial soil loss and deposition for watershed simulations using representative hillslopes.

In the flowpath method, we apply the WEPP model to all flowpaths within a watershed and each subcatchment. The slope gradient values for each grid cell along each flowpath are used directly in the WEPP slope input files. Depending on the size of the watershed being simulated and the resolution of the DEM, there may only be a few representative hillslopes that are simulated, but several hundred (or thousand) individual flowpath model simulations. When flowpaths are simulated by WEPP, soil loss is calculated for 100 points along the slope profile, regardless of the length or resolution of the original flowpath. These results must either be averaged or interpolated so that each cell within the flowpath is assigned a single value of soil loss (detachment or deposition). Furthermore, flowpaths within the watershed often converge, especially at lower slope positions adjacent to a channel, and soil loss results from the individual WEPP flowpath simulations may vary at those specific cells of convergence. In these cases, the spatial soil loss results from multiple flowpaths that intersect in a single grid cell are weighted based on each flowpath's length and area in a similar manner as in the hillslope method. The output results for soil loss (or deposition) predicted at each grid cell are then mapped out for display within a GIS (fig. 2). Visual output in the Ge-

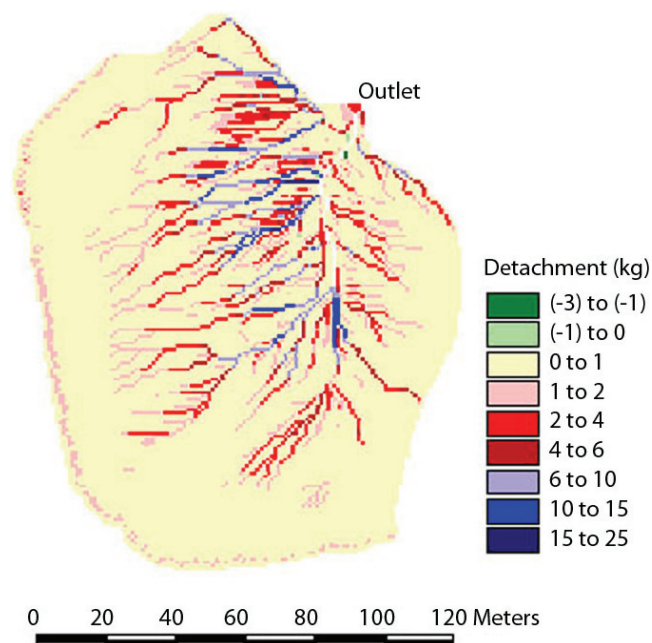


Figure 2. Weighted detachment in an example watershed in Marshall County, Mississippi (Holly Springs WC1) over seven years computed on a cell-by-cell basis using the WEPP flowpath method and a 1 m DEM. Mass (kg) of predicted detachment (+) or deposition (-) from each 1 m² grid cell is illustrated.

oWEPP program and the web-based application is restricted to displaying at most ten classes (ranges) of soil loss, which are scaled as a function of a user-selected tolerable soil loss value (T-value).

In addition to displaying the soil loss grid, the flowpath method can also be used to calculate sediment yield and runoff contributions to each cell along the channel. Simulated annual sediment yield ($t\ ha^{-1}$) and runoff (mm) contributions from each flowpath (on either side of the channel) are averaged at each channel cell. Estimates of total annual contribution to the channel are calculated by accounting for each cell in the channel. Channel routing capabilities, however, have not yet been incorporated with the flowpath method because they would exceed the current channel routing capabilities of the WEPP model.

Custom software programs were created to control the flow of information from a GIS and DEM into TOPAZ, handle the outputs from TOPAZ for watershed and sub-catchment delineation, and process the TOPAZ output into slope file inputs required by the WEPP model for hillslope and/or flowpath simulations. This software also handles WEPP model output, converting numerical information in ASCII files to graphical layers that the GIS can display (see details later in this article and also in Frankenberger et al., 2011).

GEOWEPP

GeoWEPP was the first geospatial interface to the WEPP model (Renschler et al., 2002; Renschler, 2003). It was originally an ArcView 3.2 extension, which has subse-

quently been updated to function within the ArcGIS 9 system with funding from the Interagency Joint Fire Science Program. The development of an ArcGIS 10x version is currently ongoing. The software was initially developed at the USDA-ARS National Soil Erosion Research Laboratory (NSERL) and Purdue University, and regular updates are now available from the University at Buffalo's Landscape-based Environmental System Analysis and Modeling (LESAM) laboratory at <https://lesami.geog.buffalo.edu/projects/active/geowepp/>.

The GeoWEPP ArcGIS extension is used in conjunction with the stand-alone WEPP Windows interface (Flanagan et al., 1998) and the ArcGIS software (ESRI, 2011), installed on a personal computer. GeoWEPP allows a user to access and import commonly available topographic, soils, and land use/land cover data layers to preprocess model input and conduct WEPP model scenario simulations. It utilizes the procedures described in the previous section to process data from a DEM using TOPAZ to create a channel network, delineate a watershed and subcatchments, generate flowpaths for individual WEPP model profile slope inputs, and develop the representative hillslope profile slope inputs. Digital raster graphics (DRG) from USGS can also be downloaded and used as a background layer to assist users in locating their catchment.

In a further step, GeoWEPP allows for creation of spatially and temporally variable environmental and/or management scenarios at a pixel, hillslope, or watershed scale. Figure 3 shows output from an example application of GeoWEPP for a forested region in Colorado that experienced a wildfire. It should be mentioned that the same

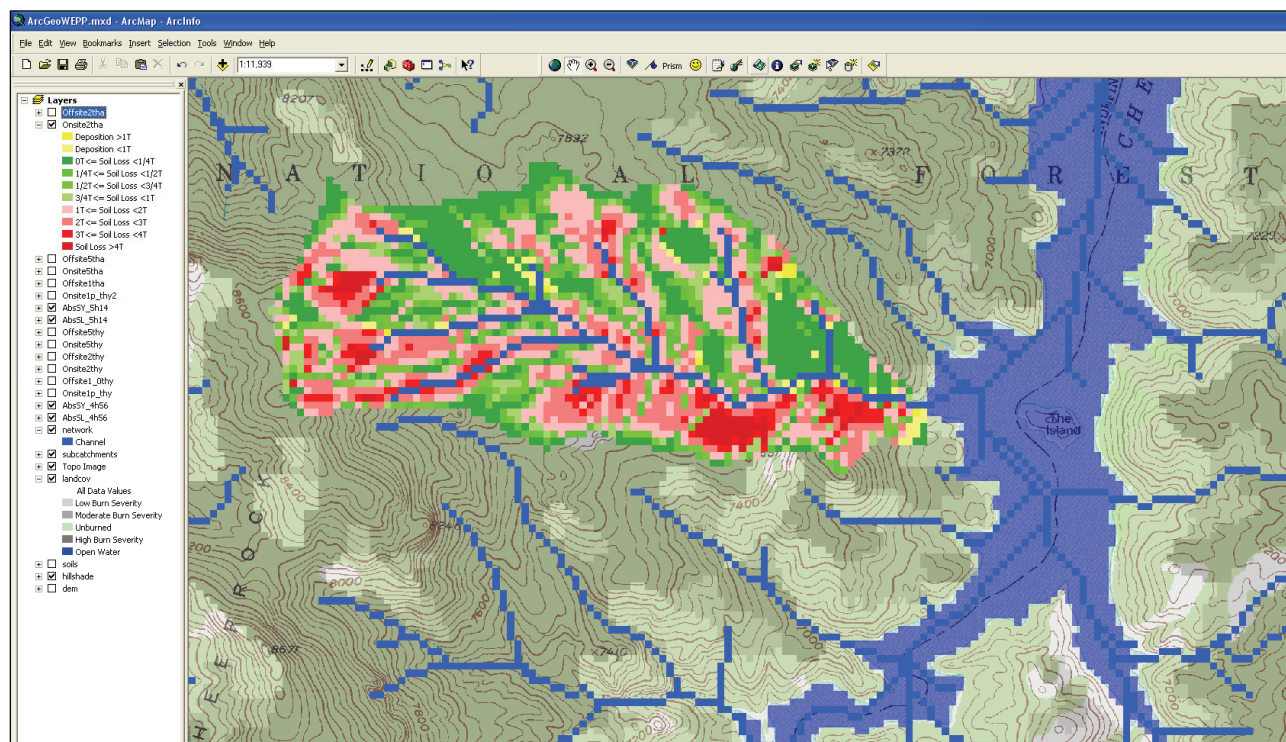


Figure 3. Application of GeoWEPP to a burned forested region in Jefferson County, Colorado, draining into the southwest portion of Cheesman Lake. Spatial soil loss results are from a 10-year model simulation. Red pixels are above the target value of $1\ t\ ha^{-1}\ year^{-1}$, and green pixels are below this target value.

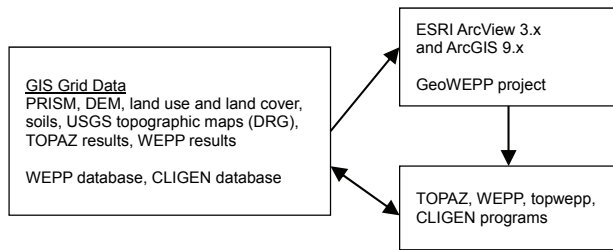


Figure 4. The ESRI ArcGIS GeoWEPP project invokes other programs to process the input data. The topwepp program performs the translation between the GIS data and WEPP simulation inputs and also creates the model output grids.

software used for evaluating post-wildfire rehabilitation strategies can also be used in a pre-wildfire setting to evaluate various fuel-reduction efforts. Figure 4 shows the flow of data between ArcGIS, the GeoWEPP extension, TOPAZ, the WEPP model, and other integrated software programs.

GeoWEPP is useful for in-depth model applications by experienced GIS users, particularly those who are able to manipulate and process unique spatial topographic, soils, or land use information. Even though GeoWEPP has been greatly improved to provide novice GIS users the ability to use commonly available data sets in WEPP simulations, its main disadvantage has been that it still requires considerable GIS knowledge to successfully import non-standardized GIS data layers and create custom datasets for complex spatial and temporal management scenarios. Various user communities have been trained through targeted workshops and online tutorials to prepare their own GeoWEPP scenarios (e.g., for wildfire effects simulations, forest fuel management, and agricultural soil and water conservation best management).

WEB-BASED GEOSPATIAL WEPP INTERFACE

Shortly after the development of GeoWEPP, efforts began at the NSERL to create web-based interfaces to WEPP for both hillslope and watershed simulations. Other efforts in natural resource modeling had successfully been implemented on the internet by Purdue University researchers (Pandey et al., 2000; Engel et al., 2003). The USDA Forest Service had also created a number of easy-to-use web-based WEPP interfaces targeted toward specific applications such as forest road design, timber harvest areas, and wildfire area remediation (Elliot, 2004). Basic web-based WEPP model applications for hillslope profiles can now be conducted at the NSERL website (<http://milford.nserl.purdue.edu/>), the Forest Service website (<http://forest.moscowfs.wsu.edu/fswcpp/>), and the USDA-ARS Southwest Watershed Research Center website (<http://typhoon.tucson.ars.ag.gov/weppcat>).

The same general procedures for processing DEM data described earlier, and implemented within the GeoWEPP ArcView and later ArcGIS extension, were utilized in creating a prototype web-based WEPP GIS interface (Flanagan et al., 2004). This initial system used the open-source MapServer environment originally developed at the Uni-

versity of Minnesota (<http://mapserver.org/>).

Through a cooperative project with the Forest Service and Washington State University, funded in part by a grant from the U.S. Army Corps of Engineers' Great Lakes Research Initiative, development of a next-generation web-based WEPP GIS interface has been underway the past three years. The current version improves upon the prototype web-based WEPP GIS from 2004 by providing a seamless map base layer using Google images and access to detailed SSURGO soil data. It also incorporates the PRISM 800 m monthly precipitation and temperature database (Daly et al., 1994). The data sources of the web-based interface are the same as the desktop GeoWEPP:

- Topography: National Elevation Dataset from USGS, 30 m raster maps for the U.S. (Gesch et al., 2002; Gesch, 2007).
- Land use: National Landcover Dataset from USGS, 30 m raster maps for the U.S. (Homer et al., 2004).
- Soils: 1:24,000 SSURGO soils data from the USDA-NRCS, accessed remotely (NRCS, 2011).
- Climate: Daily climate inputs are generated with CLIGEN (Nicks and Gander, 1994), the weather generator program for WEPP. Monthly precipitation statistics can be adjusted using the PRISM climate grid data (Daly et al., 1994). The geographic location of the user's watershed determines the closest CLIGEN station data to use.

The WEPP web main user interface is written in PHP, HTML and JavaScript. The OpenLayers software is an open-source JavaScript package that allows image layers to be displayed in geo-referenced space (OSGeo, 2010). It supports connections to GIS servers using Web Mapping Services (WMS) (OGC, 2006) as well as Google Maps and other image servers. OpenLayers is not a full-featured GIS. It primarily handles images and overlays them, providing the user with the ability to display layers. For GIS functionality, the open-source MapServer software (OSGeo, 2009) is used to convert GIS data into images and reproject data layers to be compatible with the Google image base layer. Other programs are invoked from PHP to prepare data for input to the models and add data to the MapServer configuration that can then be displayed to the user through OpenLayers.

A key program on the web server is Prepwepp, custom C++ and PHP code that implements the main translation step between the TOPAZ output files and GIS layers into WEPP simulation inputs (fig. 5). In addition, Prepwepp is responsible for translating the WEPP output files into GIS layers that can be displayed on the map. The program is also the basis for similar processing in the desktop GeoWEPP (the topwepp program in fig. 4).

From a user perspective, setting up and running a WEPP simulation is a straightforward process. Users first locate the area where the WEPP watershed model is to be applied by viewing image data from Google as well as USGS maps. These data are not kept on the local server, but are instead retrieved from other servers using the Web Mapping Services protocol. When the location of interest is identified, the custom NSERL software extracts an area of

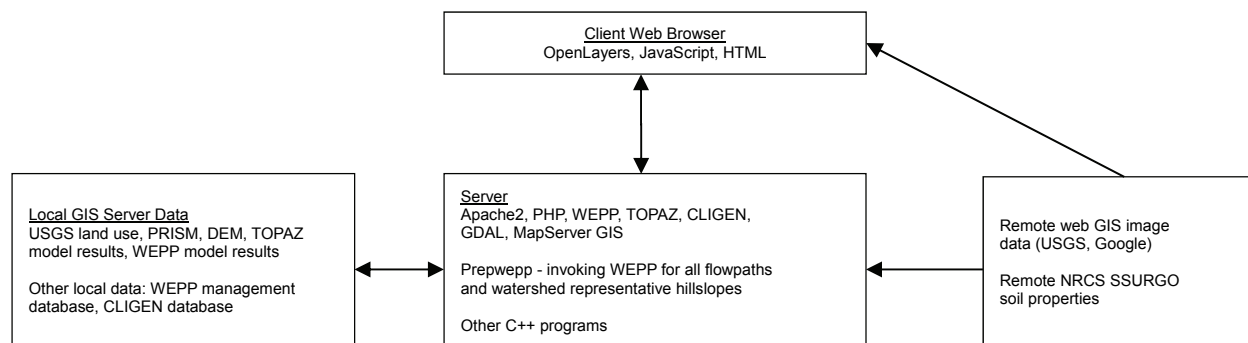


Figure 5. Major software components in the WEPP GIS web-based interface. The client web browser communicates with the server software to setup WEPP model runs and view results.

the DEM to process with TOPAZ.

The first run of TOPAZ delineates the channel network, and then from the channel network the user selects a watershed outlet point. The second run of TOPAZ defines the watershed and subcatchments from the outlet. The delineation area is limited to 0.25° latitude by 0.25° longitude, to ensure that TOPAZ can handle the extracted DEM and to allow for a reasonable response time. If the watershed delineated is acceptable, the Prepwepp program is executed again to generate WEPP inputs from the extracted DEM, land use, soils, and TOPAZ watershed structures (fig. 5). WEPP is then run on the watershed (subcatchments and channels) and/or flowpaths, and Prepwepp interprets the results and produces maps that are sent to the client using MapServer. A screen shot of this interface is shown in figure 6, with channel networks, watershed, and subcatchments delineated with the TOPAZ program. Also shown in figure 6 are the average annual spatial soil loss results predicted by the WEPP model for a 10-year simulation period.

There are some drawbacks to running the WEPP watershed simulations on the web, particularly when involving flowpath simulations in which a watershed may require thousands of WEPP model runs. To prevent excessively long model run times, the watershed area has been restricted in size, and the maximum number of simulation years is currently limited to ten for flowpath simulations. For experienced WEPP users, the inability to create new management scenarios or to use observed climate data are other drawbacks. For these types of simulations, the desktop GeoWEPP application is recommended.

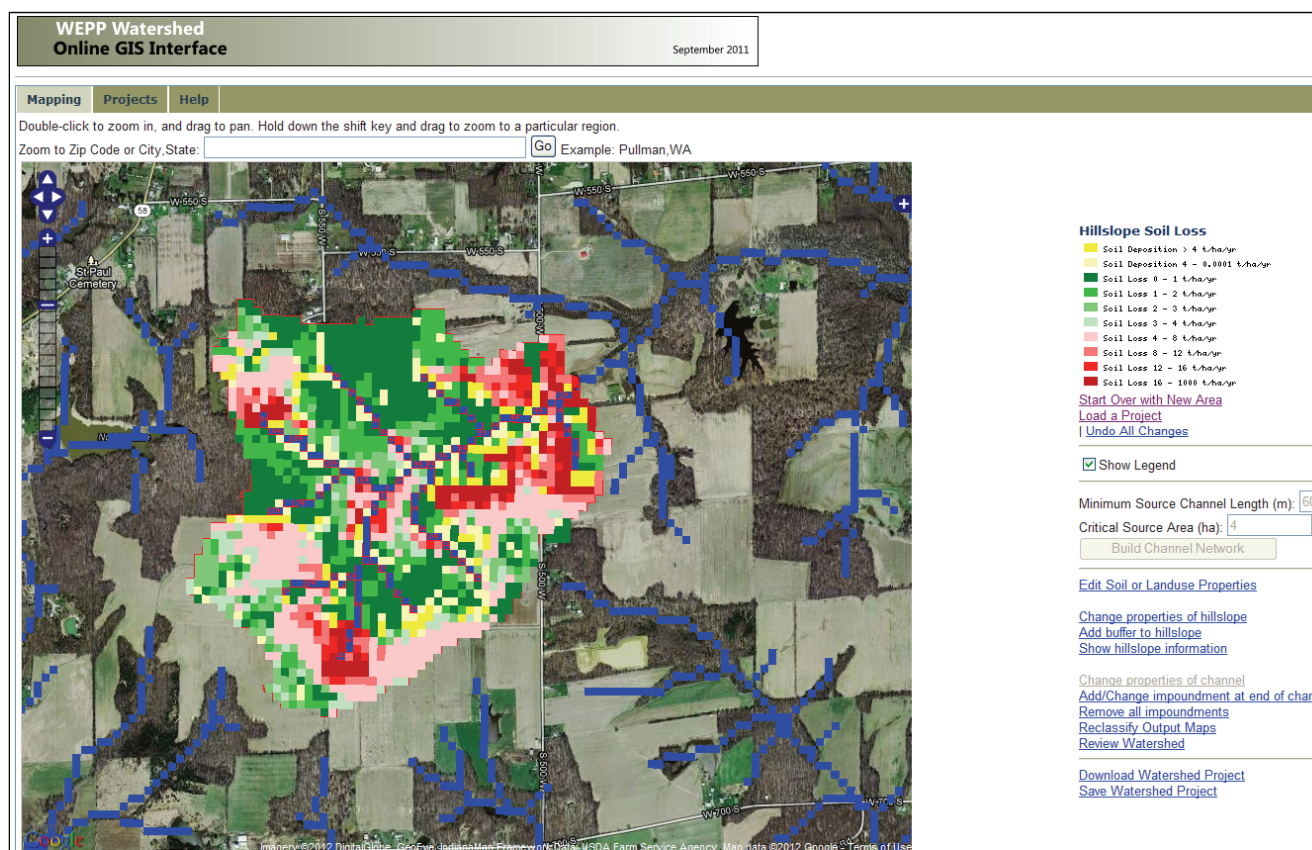


Figure 6. Current WEPP web-based watershed interface using OpenLayers and Google Maps, showing the spatial soil loss results of a 10-year model simulation in Bartholomew County, Indiana.

GEOSPATIAL WEPP APPLICATIONS

Forests are one of the land use areas that are particularly suited to spatial analysis. One of the main needs for estimating the distribution of erosion potential in forests is to assess the effectiveness and benefits of post-fire mitigation treatments. The original ArcView version of GeoWEPP was used to evaluate the areas of greatest erosion risk in the 50 km² School Fire in the Umatilla National Forest in southeast Washington State in 2005 (Elliot et al., 2006). Specialists from the Rocky Mountain Research Station assisted the Forest Service Burned Area Emergency Response (BAER) team to evaluate areas of greatest erosion risk based on burn severity and topography. Details of the analysis are described by Elliot et al. (2006). The outputs from this first version of GeoWEPP provided the spatial distribution of erosion risk from the flowpath simulations, assisting the BAER team in targeting treatments (fig. 7). With the aid of a scripting tool, topographic information was abstracted from the slope files built by GeoWEPP for use in running the online Erosion Risk Management Tool (ERMiT) to evaluate the effectiveness of potential hillslope mitigation treatments (Robichaud et al., 2007). In addition to the immediate assistance provided to the BAER team, areas for improving the technology were identified. Subsequent versions of geospatial WEPP applications have included return-period analyses within the interface, incorporation of the PRISM database, and the web-based version has an output window with the topographic information of all of the hillslope polygons and channel segments in the watershed.

In order to perform the School Fire analysis, it was necessary for the modeling team to manually enter the burn severity of every hillslope polygon in the watershed (Elliot et al., 2006). After every large wildfire, the Forest Service develops a burned area reflectance category (BARC) map from satellite imagery and, after field investigation, modifies the map as needed to produce a burned severity map (Collins et al., in review). For the School Fire, the BARC map was used to estimate the burn severity of each hillslope in consultation with local specialists. To automate the tedious job of manually changing hillslope polygons, a customized version of GeoWEPP (GeoWEPP BAER) was developed to automatically incorporate the burn severity map as a GIS layer and to use the information to specify soil and vegetation files for each hillslope polygon. Although not widely applied, this tool has since assisted in the erosion analysis for a number of fires, including three fires in 2008, two in 2009, and one in 2010. GeoWEPP BAER was also used to support an analysis of the role of spatial variability in forest management (Collins et al., in review).

In addition to analyzing erosion risk associated with wildfire, forest managers need predictive tools to evaluate the watershed impacts of forest management. One example of this was the Big Bear Lake watershed in San Bernardino County, California. Much of this watershed is managed by the Forest Service, with lakeside properties in private ownership. In this watershed, there were growing concerns of water quality degradation in Big Bear Lake due to phosphorus. To estimate the phosphorus delivery from the for-

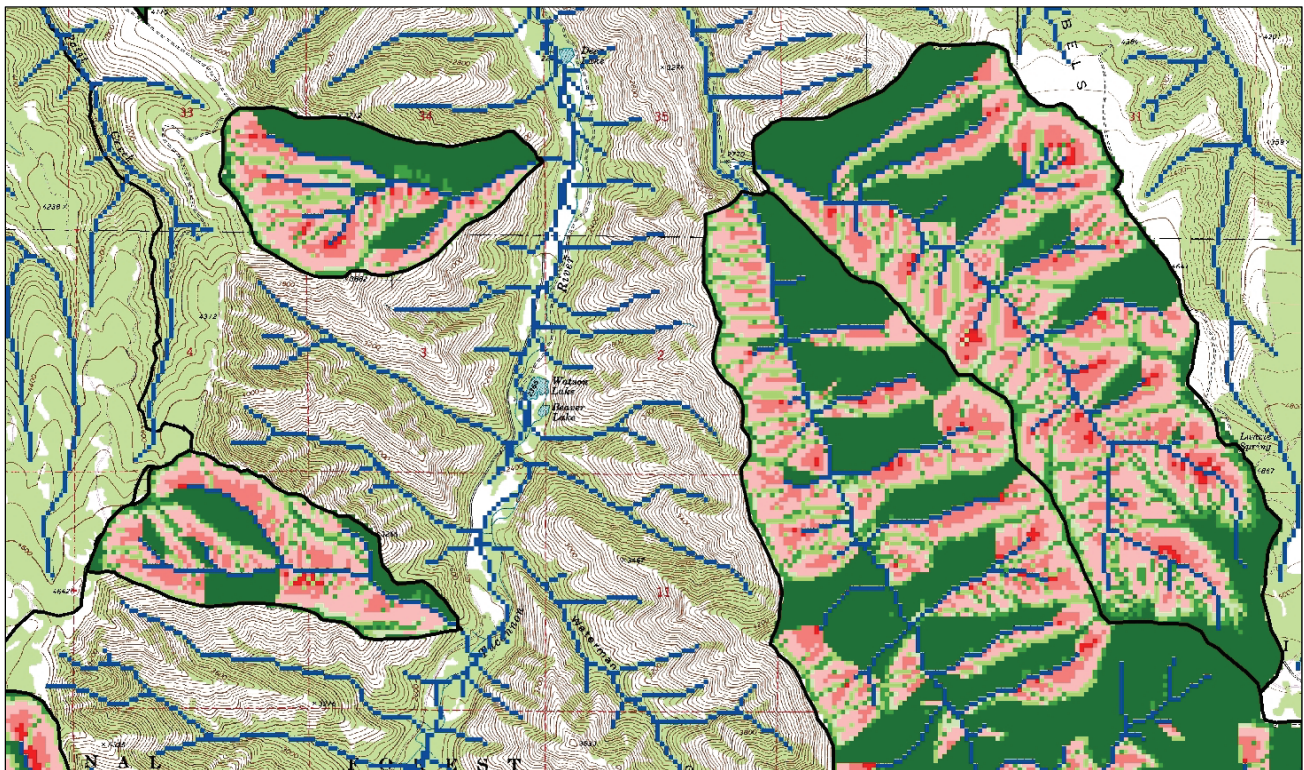


Figure 7. A portion of the School Fire in southeast Washington State, analyzed with GeoWEPP in flowpath analysis mode. The redder the pixel, the greater the erosion rate predicted during a year with a 10-year return-period runoff event (Elliot et al., 2006). The darker the green pixels, the lower the predicted fraction of a user-specified soil loss target rate.

ests, the ArcGIS version of GeoWEPP was run for about 60% of the forested watersheds around Big Bear Lake in “watershed” mode to estimate the sediment yields contributed from each hillslope polygon feeding into any of the delineated channels. Figure 8 shows a portion of this analysis.

One of the features of this version of GeoWEPP was the incorporation of the PRISM 4 km resolution monthly precipitation database, which was particularly useful in this study, as the average annual precipitation varied from less than 685 mm on the eastern end of the lake to more than 935 mm on the western end over a distance of less than 12 km. Three different climate input files were used for the north side of the lake and two more for a portion of the south side that was analyzed. The study concluded that there was little sediment, and hence little phosphorus coming from forested watersheds, with more sediment likely coming from forest roads in these watersheds. To maintain minimum sediment generation, a recommendation was made that a fuel management program be initiated to remove excess vegetation to reduce the likelihood of a high-severity wildfire. Before this could be accomplished, there was a wildfire (Butler Fire in 2009) in the vicinity of the

portion of the analysis shown in figure 8, and the GeoWEPP BAER tool had its first application for identifying hillslopes with the greatest risk of erosion.

A study similar to the Big Bear Lake analysis was carried out for forested and rangeland watersheds for the entire western U.S., an area of about 650,000 km² (Miller et al., 2011), with a grant from the U.S. Environmental Protection Agency. The purpose of this study was to estimate the potential for post-fire erosion as a function of current vegetation conditions. In this analysis, the GeoWEPP GIS extension was run in a batch mode, allowing the analysis of numerous watersheds. Miller et al. (2011) found that erosion rates were generally low, with unexpectedly high values in northern California forests. Fire severity was estimated from current vegetation conditions, as described by the Landfire GIS layers (Rollins, 2009).

The web-based version of the WEPP Geospatial interface was released in May 2011. Initial work has focused on assessing the performance of this new tool (Dun et al., 2011). The interface also proved to be useful in assisting with a major analysis of the Upper Santa Fe River watershed in New Mexico (fig. 9). This watershed is a critical source of water for the city of Santa Fe. An analysis similar

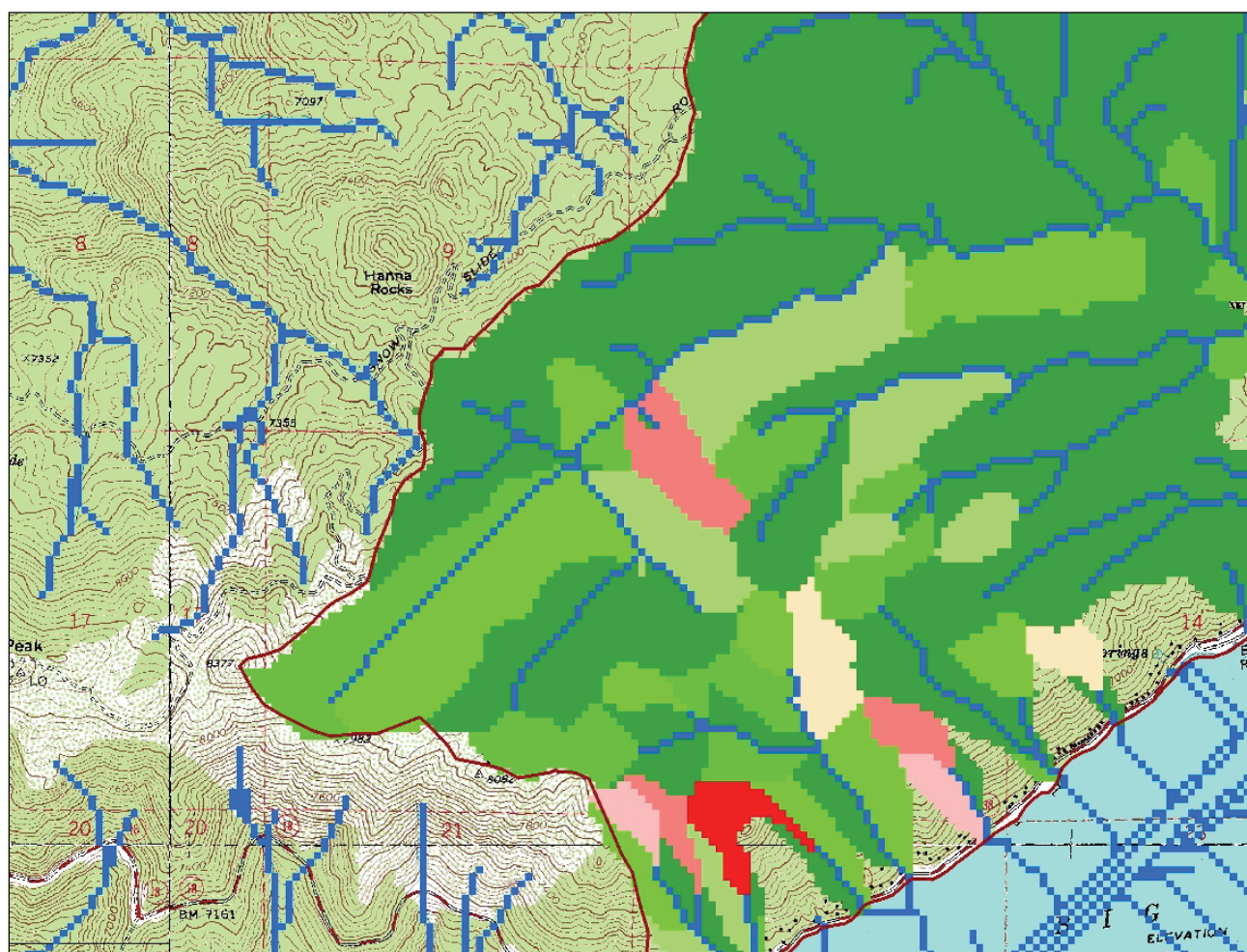


Figure 8. Sediment yields simulated for contributing hillslope areas into channel segments on the northeast corner of Big Bear Lake, San Bernardino County, California. Note that the map illustrates which hillslope polygons generate potentially the greatest amount of sediment (reddish subcatchments) in the event of a high-intensity burn wildfire.

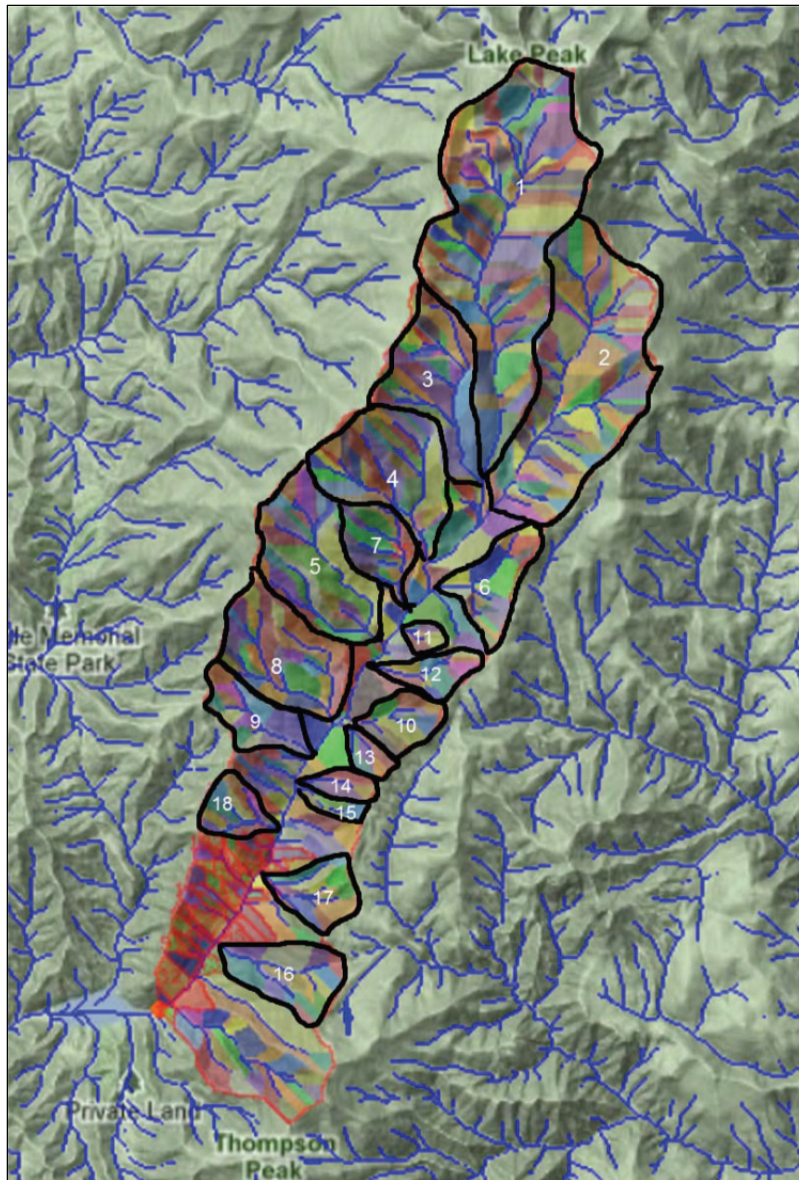


Figure 9. Subwatersheds of the Upper Santa Fe watershed, Santa Fe County, New Mexico, analyzed with the online WEPP Geospatial Tool (Lewis, 2011).

to that done for Big Bear Lake was carried out to determine the current levels of sediment generation and the likely amount of sediment that would be generated in the event of wildfire. This analysis, like the School Fire analysis, used topographic information generated for hillslope polygons from the web interface to run the online ERMiT post-fire erosion model to evaluate the probability of large sediment generation if there were a wildfire. Like the Big Bear analysis, the study determined that reducing the fuel load with prescribed fire should be considered to minimize the erosion risk after a wildfire (Lewis, 2011).

SUMMARY AND CONCLUSIONS

WEPP is a process-based soil erosion prediction model that has been developed over the past 25 years by the USDA. In addition to the core model that simulates funda-

mental physical processes (including infiltration, runoff, and soil detachment), a number of interface programs and databases have also been created to allow the program to be more easily applied by field engineers, foresters, and soil conservation personnel. The Windows interface for the model is typically used for hillslope and simple watershed applications but is too cumbersome to apply model scenarios for larger watersheds.

GIS-based interfaces, such as the GeoWEPP approach, allow much easier model setup for larger and more complex watershed simulations, since digital elevation data and other land use/land cover and soil GIS data layers can be automatically processed to create the watershed structure and slope inputs, and other geospatial data can provide soil and land use information. The community of international users of geospatial WEPP applications is continuously increasing because GeoWEPP enables them to use their own data formats and standards that are different from the U.S.

Web-based geospatial interfaces are powerful tools that can allow even a novice WEPP model user to quickly and easily create and complete watershed evaluations for land management impacts on runoff, soil erosion, and sediment loss. The newest web-based WEPP GIS interface that has been developed provides additional features and functionality, which should be of great value to action agency personnel conducting watershed assessments in the U.S.

Although the customized interfaces for GeoWEPP and the web-based WEPP GIS simulations are easy to setup and run for particular types of users (e.g., foresters, ranchers, and farmers in the U.S. and abroad), further work is needed to be able to customize the applications for users with more specific scenario building capabilities. Linking the desktop GeoWEPP and the web-based WEPP GIS could allow users to more easily prepare data inputs on a server, download the input datasets locally, and then use GeoWEPP to further customize the scenario input data to run the core WEPP model on a desktop.

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