OVERVIEW OF CURRENT AND FUTURE TECHNOLOGIES IN RANGELAND MANAGEMENT

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ABSTRACT: The U.S. Department of Agriculture and its partners have made significant progress in developing a new generation of rangeland watershed models to quantify the environmental impacts of grazing lands conservation practices at both national and regional scales. This suite of hydrologic and soil erosion prediction tools are specifically being designed for rangelands across spatial scales (hillslopes, watersheds, and river basins) to assist in quantifying the impact of current and proposed management actions. The principal grazing lands resource concerns that will be directly addressed by these tools are: a) Plant community status and dynamics, b) Water quality and availability, and c) Wildlife habitat. The initial focus is on western intermountain shrub and grass dominated rangelands, followed by efforts on deserts, eastern pastures, and the central plains. This new generation of integrated rangeland watershed models consists of the Rangeland Hydrology and Erosion Model (RHEM), to calculate hillslope runoff and erosion at the site scale, and a modified Kinematic Runoff and Erosion Model (KINEROS2) that is being updated to specifically accept RHEM inputs to address grazing land conditions at watershed scales. The Soil Water Assessment Tool (SWAT) is being modified to specifically address grazing land conditions and allow us to quantify net cumulative benefits of conservation practices applied at hillslope and watershed scales by integrating input from RHEM into KINEROS2 models for river basin scale analysis. These new rangelands risk assessment tools will begin to be available for evaluation in 2010.

Keywords: Conservation Effects Assessment Project, Soil Erosion, Conservation Practices, Hydrology, Monitoring, Assessment, Risk.

Introduction

Rangelands comprise approximately 40% of the landmass of the United States (US), including nearly 80% of the lands of the western states. Rangelands provide valuable grazing lands for livestock and wildlife and serve as a source of high quality water, clean air and open spaces for the benefit of society. While rangelands occur in every region of the US, they are the dominant land type in arid and semiarid regions. Much of the rangelands in the west are sparsely populated, and conditions on that land are not well documented or monitored over extensive areas.

The science of assessing rangelands is constantly evolving as concepts, protocols, and tools continue to be developed and evaluated. Definitions of rangeland condition and use of the concept vary among practitioners, but historically rangeland condition assessment has been based upon vegetation, either climax-based or productivity-based (Smith 1989). Both approaches depend on assessment in relation to the

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potential or capability of the ecological site and on the amount and composition of the vegetation (Smith 1988). A separate evaluation for soil and vegetation condition has been recommended since a site cannot be expected to continue to maintain desired vegetation production if it has accelerated erosion (USDI-BLM 1993 and National Research Council (NRC) 1994). The Committee on Rangeland Classification (NRC 1994, p. 4) defines rangeland health "as the degree to which the integrity of the soil and the ecological processes of rangeland ecosystems are sustained." They recommend the determination of rangeland health should be based on the evaluation of 3 criteria: degree of soil stability and watershed function, integrity of nutrient cycles and energy flows, and the presence of functioning recovery mechanisms. The Society for Range Management (SRM) (1991) proposed a site conservation rating to assess the degree of protection from erosion afforded a site. The major recommendation of the SRM (1991) was: "The effectiveness of present vegetation in protecting the site against accelerated erosion by water and for wind should be assessed independently of the actual or proposed use of the site. This assessment should be called a Site Conservation Rating. The Site Conservation Rating at which accelerated erosion begins should be called the Site Conservation Threshold. Any site rated below the Site Conservation Threshold would be considered in unsatisfactory condition and those above it, satisfactory." The difficulty in rating an area arises in identifying the thresholds that allow an area to move from one category to another (USDI-BLM 1993).

An interagency cooperative effort between the Bureau of Land Management (BLM), Natural Resources Conservation Service (NRCS), Agricultural Research Service (ARS), and USGS Forest and Rangeland Ecosystem Science Center lead to the development of a qualitative assessment tool for interpreting the health of rangelands (Pellant et al. 2005). Seventeen indicators are used to ascertain three rangeland health attributes (hydrologic function, soil surface stability, and biotic integrity). Five subjective ratings for each indicator are made using the Ecological Site Description reference sheet. The three attributes are then determined based on preponderance of evidence from the indicators. This qualitative technique has been adopted by federal agencies and has improved communication among interest groups by focusing discussion on critical ecosystem properties and processes; selecting monitoring sites; and provides an early warning of potential problems by helping land managers identify areas that are potentially at risk of degradation or where resource problems currently exist. The authors state the technique is a site based tool and should not to be used for identifying the cause(s) of resource problems, independently making grazing and other management changes, monitoring land or determining trend, or independently generate national or regional assessments of rangeland health (Pellant et al 2005).

The environmental benefits of grazing lands conservation practices have not previously been quantified for reporting at the national scale. Moreover, while a limited body of literature exists on the effects of conservation practices at the hillslope scale, there is few research studies designed to measure the cumulative effects of conservation activities at watershed and river basin scales. The U.S. Department of Agriculture (USDA) recognized the need to develop a system to provide national and regional summary estimates of conservation practice benefits and developed the Conservation Effects Assessment Project to in part meet this need. The USDA's Conservation Effect Assessment Project (CEAP) was initiated in 2003 and is well advanced in terms of both the national and watershed scale work on cropland (Duriancik et al. 2008). The CEAP component aimed at assessing conservation on grazing lands was initiated in 2006. "Grazing land" is defined by the NRCS as rangeland, pastureland, grazed forestland, native and naturalized pasture, hayland, and grazed cropland. The term is applied independently of any actual use for grazing. Some of the primary conservation practices to be evaluated on rangelands include prescribed grazing, invasive species control, fire management, brush management, upland habitat management, fencing, water distribution, range seeding, and riparian management. These conservation practices are designed to reduce losses of soil, nutrients, pesticides, pathogens, and other biological and chemical materials from rangelands, and enhance and conserve natural resources, water quality, and wildlife habitat.

Through the grazing land CEAP project, USDA intends to first: synthesize what we know about the impact on the hydrologic cycle from the application of conservation practices on grazing lands and fill knowledge gaps about the impact of grazing land practices on watershed health and impacts on ecosystem services at the landscape scale. The USDA strategy for the grazing land national and regional assessments encompasses a 5 part process as described below.

1) National Assessment **-** Providing national summary estimates of conservation practice benefits and assessing the potential for USDA conservation programs and technical assistance to meet the nations environmental and conservation goals.

2)Watershed Assessment Studies **-** Basic research on conservation practices in selected watersheds nationwide to provide a framework for evaluating and improving performance of national assessment models.

3) Bibliographies – Through the USDA National Agricultural Library (NAL) dynamic bibliographies using real-time searches of publications relating to Environmental Effects of Conservation Practices on Grazing Lands are available to the public at http://www.nal.usda.gov/wqic/ceap/index.shtml.

4) Literature Reviews/Synthesis – A current literature synthesis is underway by the SRM in partnership with USDA to describe what is known about the environmental effects of grazing lands conservation practices at the field, hillslope, and watershed scale and will be published in 2010.

5) Technology transfer and outreach – Special symposia and conferences will be organized and conducted in association with professional societies to gather technical material and results from recent research that can be used to improve the scientific knowledge base for making decisions on which conservation practices are most efficient at achieving specific environmental benefits. One such conference was the Wildfires and Invasive Plants in American Deserts. Findings from this conference were published in a special issue of the journal Rangelands in June of 2009 (http://www.srmjournals.org).

The initial focus will be on intermountain dominated rangelands, followed by efforts on eastern pastures, and the central plains over the next 5 years. This report focuses on the intermountain aspects of the grazing land CEAP assessment with an emphasis on the status of hydrologic tools to assess the impact of conservation practices at the hillslope, watershed, and river basin scales.

Hillslope Erosion Component

Rangeland managers are challenged with assessing potential benefits of conservation practices and quantifying cost-effectiveness of these treatments. However, these tools do not currently exist for use by NRCS field office personnel. Hydrologic benefits of conservation practices for a site should be considered in a probabilistic framework that measures the susceptibility of a site, over a range of vegetation and surface conditions, to increased runoff and erosion from storms of different erosivity and re-occurrence probabilities, or in simple terms a risk assessment approach (Pierson et al. In Review). Accelerated erosion has been defined as "an increase in the rate of erosion that is the result of land use and/or management, and which significantly increases the rate or probability of loss of site potential from these influences" (SRM 1991, p. 13). Soil erosion is a natural process, but the quantity and rate of surface runoff and sediment yield may be altered through land use and management practices (Blackburn et al. 1982 and Weltz et al. 1998).

Site susceptibility and vulnerability to erosion is a function of many abiotic and biotic factors (Spaeth et al. 1996). Plant and surface cover influence runoff and the basic erosion processes of soil detachment by raindrops and concentrated flow, sediment transport, and sediment deposition by altering the amount and distribution of exposed bare soil, the tortuosity and connectivity of the concentrated flow path, hydraulic roughness, and soil erosivity of the site (Weltz et al. 1998). Soil erosion is a function of total standing biomass, biomass by lifeform class (i.e., grass vs. shrub), distance between plants, canopy cover, ground cover or the components of ground cover (rock, litter, plant basal area, cryptogamic crust), bare soil, bulk density, soil texture, soil organic carbon, aggregate stability, the amount of interspace or coppice dune area, number or size of surface depressions, and rainfall intensity. The complex interaction of these and other abiotic and biotic variables determines how much, when, and where soil erosion will occur (Weltz et al. 1998).

Erosion at hillslope to watershed scales after fire is largely dependent on topography and spatial arrangement of the burn, the severity of the burn, percent bare soil, water repellent soil conditions, rainfall intensity, and storm pattern. Reed and Schaffner (2007) in reviewing runoff and erosion in southern Arizona shrub and forest dominated watersheds following fires found a several fold increase in peak flow rates, soil erosion rates, and occasional debris flows. The magnitude of change in hydrologic response was so great they developed a new risk based procedure to estimate potential flash floods for use by National Oceanic and Atmospheric Administration (NOAA). The new approach replaced the previous 5-year return period estimate for peak flow rates. The empirical equation developed was based on a multivariate runoff index that utilizes geomorphologic diversity and a multivariate runoff index that considered the hyper-effective drainage area (based on burn severity maps), average basin elevation, and an objective modified channel relief ratio.

Pierson et al. (In Review) discussed that it is important to note that susceptibility and storm erosivity both have a predictive component and these are not constant over time. That is, the susceptibility of a site to increased runoff and accelerated erosion from specified storm erosivity will change with implementation of a conservation practice and time since the practice was implemented (Figures 1 and 2). The magnitude of susceptibility at a moment in time varies with rainfall intensity, duration and storm pattern. In this framework, susceptibility for a particular storm event refers to potential hydrologic responses over a range of soil surface. Vulnerability refers to the predictability of those responses based on the probability of storm occurrence. They suggested two principal measures of assessing conservation benefits and reduced hydrologic vulnerability: 1) site susceptibility and 2) storm probability within a climate regime.

Figure 1 illustrates how runoff and erosion increase exponentially as surface protection decreases and soil water repellency increases. Overland flow velocity increases as surface cover is reduced and runoff is amplified. These effects are magnified by increasing rainfall intensity. Rain splash and sheetflow processes dominate on gentle portions of the runoff and erosion curves; concentrated flow dominates where curves steepen. The transition zone occurs when surface

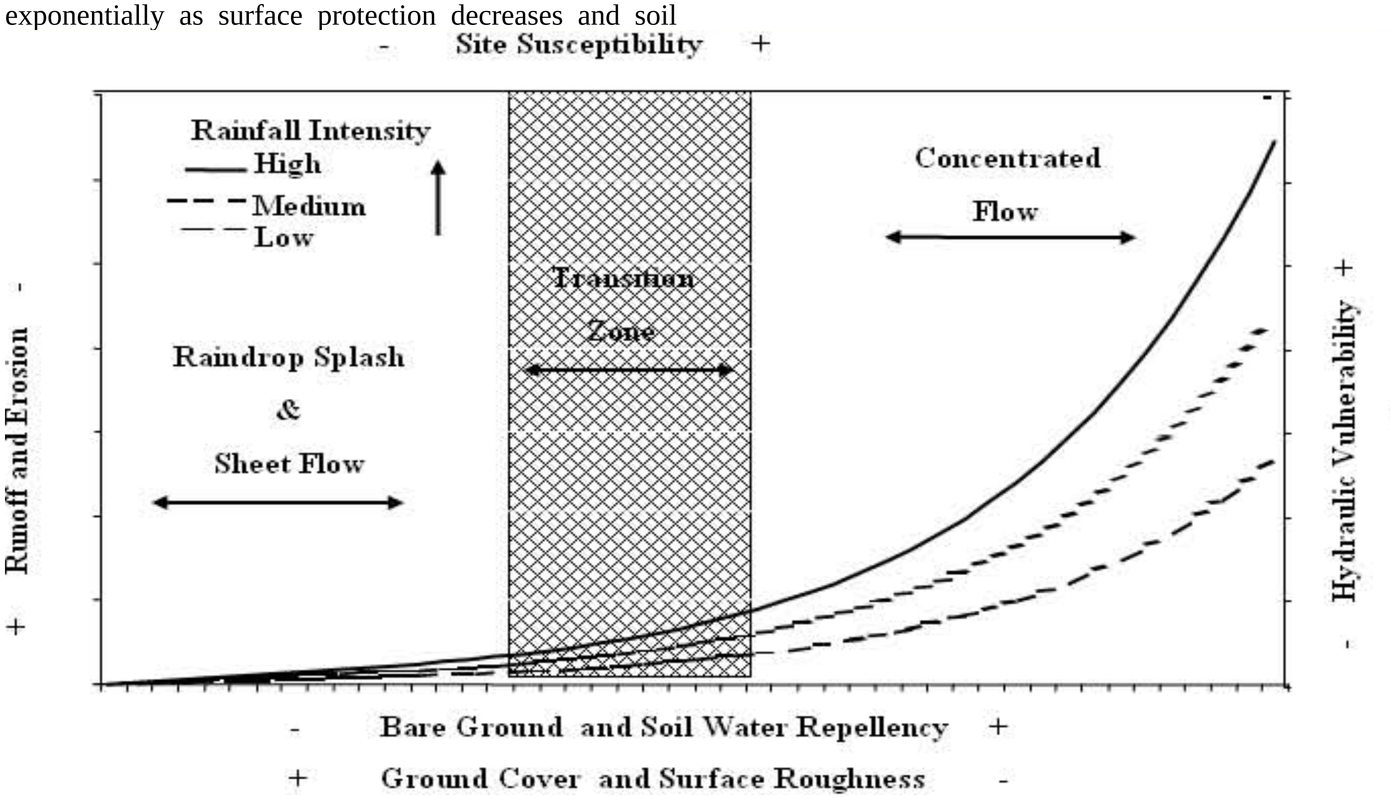

Figure 1. Conceptual hillslope runoff and erosion responses to varying driving (rainfall) and resisting (surface cover) forces. Figured based on concepts discussed in Pierson et al. (In Review). Symbols illustrate direction increase (+) or decrease (-) in respective variable.

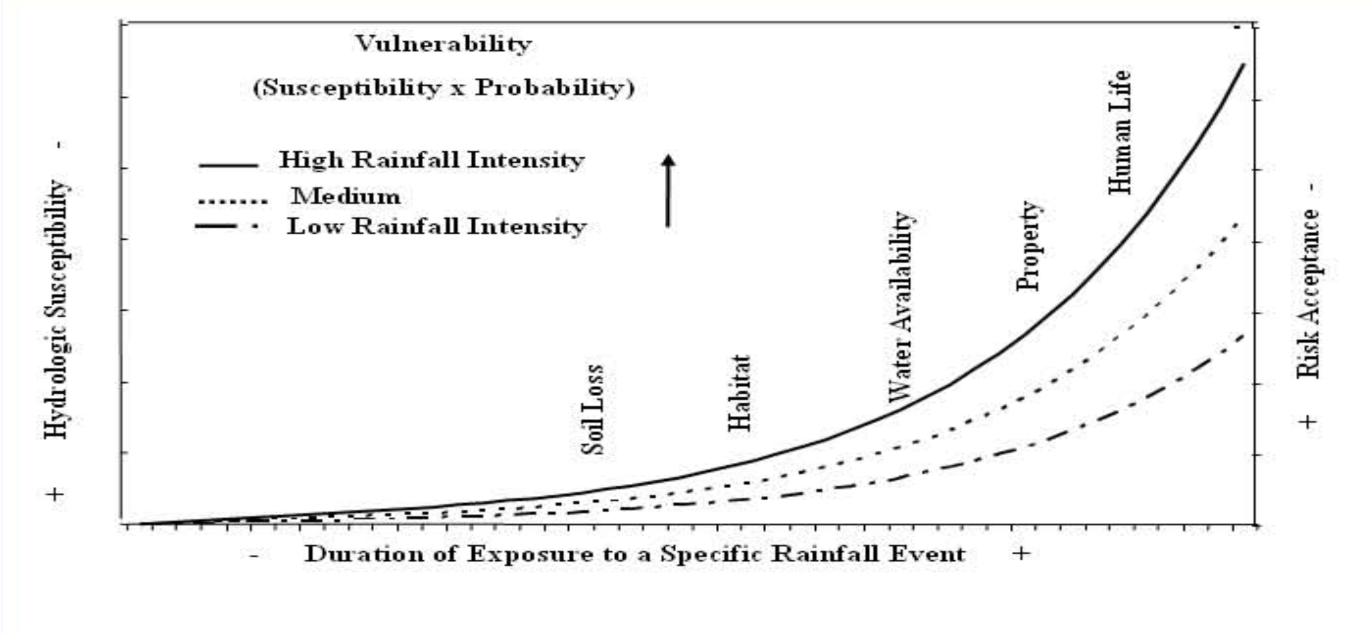

Figure 2. Conceptual model of risk (soil loss, habitat, water availability, property, and human life) based on assumed and arbitrary assignment of values in terms of hydrologic vulnerability and risk acceptance. Figured based on concepts discussed in Pierson et al. (In Review). Symbols illustrate direction increase (+) or decrease (-) in respective variable

protection decreases or increased surface runoff facilitate concentrated flow initiation. Hillslope gradient is assumed constant in the diagram. Steeper slopes generally amplify runoff and erosion with increasing bare ground. Susceptibility refers to the potential hydrologic responses of a range of surface conditions to a particular storm or intensity. Susceptibility increases with site degradation (i.e., decreased cover) and is greater for higher rainfall intensities. Vulnerability represents the liklihood of responses based on susceptibility and storm probability and therefore increases with susceptibility and rainfall intensity (Pierson et al. In Review).

Figure 2 illustrates how vulnerability is expressed as a function of the interaction between susceptibility and the probability of storm occurrence with a specific intensity (e.g., storm return period). Conservation goals will vary (i.e., protecting against soil loss is more important then protecting habitat) with individuals and therefore, ranking of categories to protect and assigning risk is arbitrary on graph. However, Figure 2 does illustrate how value-based decisions must accompany risk assessments and decisions on how to mitigate risk through implementation of a conservation practice.

Site susceptibility and storm probability within a climate regime encompass the resistive and driving forces that dictate hydrologic response (Figure 1). The conceptual model (Figure 2) places risk assessment in the probability framework from which cost-benefits ratios of respective hydrologic responses and conservation practices can be derived. Susceptibility of the site is a function of the duration of time the site is exposed to possible climatic events that if they occurred would result in negative consequences (i.e., accelerated soil erosion). Vulnerability of the site is a function of capacity of the site to resist negative hydrologic consequence should it occur. A site with 70% bare soil may be highly vulnerable to increased surface runoff and accelerated soil erosion prior to application of a conservation practice. After the conservation practice has been applied, bare soil reduced to 20%, the site will have a significantly reduced risk of surface runoff and accelerated soil erosion. We have not altered the susceptibility of the site receiving an extreme precipitation event; however, we have altered its vulnerability to accelerated runoff and soil loss by altering the exposure of the soil surface. The risk of the site to a negative hydrologic occurrence can be estimated as a function of the susceptibility-vulnerability interactions that prevails during a storm event. Risk is amplified as a function of rainfall intensity and duration (storm return period) (Figure 2). The acceptability of the respective risk and whether it requires application of a conservation practice requires a value-based definition of benefits to determine a cost-benefit ratio.

Hydrologic susceptibility must be placed in context of the prevailing climatic regime and storm probabilities. For example, snow-dominated rangelands with infrequent summer thunderstorms will generate different seasonal runoff and erosion than monsoonal rainfall dominated sites with the same canopy and ground cover and surface soil conditions (Branson et al. 1981). Potential responses to more infrequent, intense precipitation events should be evaluated based on the probability of storm occurrence over varying degrees of susceptibility based on canopy and ground cover characteristics.

Watters (et al. 1996) developed an approach to identify a Site Conservation Threshold, the point at which accelerated erosion occurs. The authors discussed that the amplitude in standing and litter biomass over a growing season, due to climate and land management practices, would result in significant changes in estimated sediment yield depending on when sampling occurred. This caused the predicted Site Stability Rating for the site to alternate above and below the Site Conservation Threshold based on sampling date. Sampling at only one date was not recommended in the southwest US because of the large amplitude in above-ground net primary production. They suggested a conservative approach would be to sample when the least amount of vegetation is expected prior to the time of highest probability (risk) of intense thunderstorm activity (e.g., June prior to onset of the Monsoon season in Arizona and New Mexico).

Rangeland Hydrologic and Erosion Model

A new process based model has recently been developed by ARS and NRCS for assessing soil erosion rates on rangelands that will allow us to assess the risk of soil erosion. The Rangeland Hydrology and Erosion Model (RHEM) was developed based exclusively on data collected from a large number of geographically distributed rangeland erosion experiments (Wei et al. 2009). The unit scale for splash and sheet erosion is the rangeland rainfall simulator plot (> 12 m^2). This was done in order to incorporate scale of rangeland heterogeneity and complexity associated with complex vegetation patterns on most rangeland sites. Source terms for RHEM are based on rangeland data, which models splash and sheet flow effects as the dominant process on undisturbed natural grasslands. RHEM models concentrated flow erosion, which is active on degraded woodland and shrublands and disturbed lands (e.g., those sites having been exposed to over-grazing, wildfire, drought, encroachment by invasive weeds, etc.). An important aspect of the model relative to rangeland application by rangeland managers is that RHEM is parameterized based on plant growth form classification using the data that is typically collected for rangeland management purposes (e.g., rangeland health assessments). Research has shown that infiltration, runoff, and erosion dynamics are correlated with presence/absence and composition of specific plant taxas and life/growth form attributes (Spaeth et al. 1996). Model inputs are surface soil texture, slope length, steepness and shape, canopy cover, ground cover, plant community type, and precipitation (Figure 3). Precipitation can be estimated by the model by selecting the nearest weather station by using the model interface. The user may also use data from the NOAA Atlas 14 to find the precipitation inputs for particular return period storms (http://hdsc.nws.noaa.gov/hdsc/pfds/index.html).

Figure 3. Rangeland Hydrology Erosion Model user interface.

RHEM is designed to look at risk of soil loss not long term annual soil loss like the Revised Universal Soil Loss Equation (RUSLE) model. This concept is a sharp departure for USDA traditional evaluation of soil loss which has used average annual soil loss. This new approach will allow us to classify lands as being at risk to soil loss as a function of topography, plant community, precipitation intensity, and duration of the storm. This will allow us to develop a risk index which can describe when the site is most vulnerable (time of year) to soil loss. It will also provide a means of evaluating alternative conservation practices to determine which practices are most effective at lowering the risk of accelerated soil loss (Figure 4).

RHEM will be used to calculate runoff and erosion at the site scale. Efforts are currently underway to apply RHEM to NRCS National Resource Inventory (NRI) sampling sites. Once the protocol for using the NRI data is established, and current erosion rates are estimated on as many sites as possible, the intention is to use remotely sensed information to spatially expand the site-scale information to produce regional and national estimates of the condition of private rangelands. A beta version of the RHEM has been implemented as an interactive, web-based tool (http://dss.tucson.ars.ag.gov/rhem/). RHEM is currently undergoing extensive validation and is scheduled for release in 2010.

Watershed Erosion Component

The RHEM tool will be incorporated into both the Kinematic Runoff and Erosion Model (KINEROS2) watershed scale model and the Soil Water Assessment Tool (SWAT) basin scale model in order to conduct 8-digit HUC level analyses across the west, similar to the assessments that have been done on croplands. This will provide 3 scales of evaluation of conservation practices: 1) hillslope with RHEM; 2) small Watershed scale with the KINEROS2 model (Smith et al. 1995); and 3) river basin scale with the Soil Water Assessment Tool (SWAT) for river basin scale. The KINEROS2 model is a physically based model describing the processes of interception, infiltration, surface runoff and soil erosion from small agricultural and urban watersheds. The watershed is represented by a cascade of overland flow planes and trapezoidal channels; the partial differential equations describing overland flow, channel flow, sediment transport are solved by finite difference techniques. The spatial variation of rainfall, runoff, and erosion parameters can be accommodated. KINEROS2 may be used to determine the effects of various artificial features such as buffer strips, urban developments, small detention reservoirs, or lined channels on flood hydrographs and sediment yield. Full model documentation, publications, and software are available at: http://www.tucson.ars.ag.gov/kineros/.

River Basin Component

The SWAT model (Gassman et al. 2007) will be used to evaluate the impact of conservation practices at the river basin scale. SWAT is a river basin scale model that operates on a daily time step and is designed to predict the impact of management on water, sediment, and agricultural chemical yields in ungauged watersheds. In SWAT the watershed is divided into multiple subwatersheds, which are then further subdivided into hydrologic response units (HRUs) that consist of homogeneous land use, management, and soil characteristics. The HRUs represent percentages of the subwatershed area and are not geospatially referenced within a SWAT simulation. Alternatively, a watershed can be subdivided into only subwatersheds that are characterized by dominant land use, soil type, and management. Full model documentation, relevant peer reviewed publications, and the software is available at: http://www.brc.tamus.edu/swat/soft_model.html

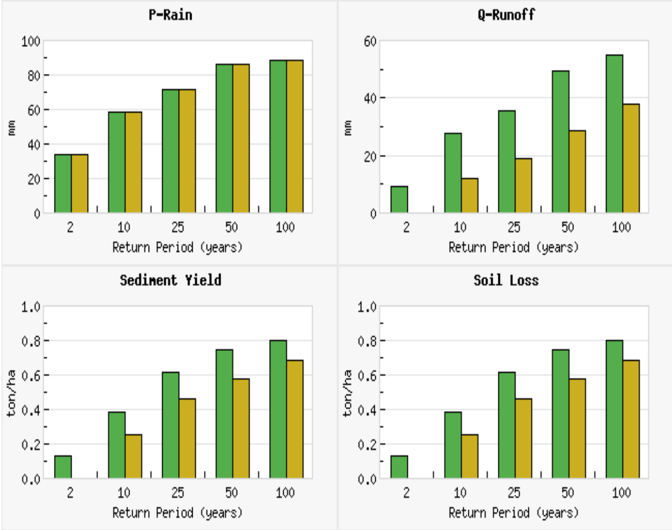

Figure 4. Rangeland Hydrology Erosion Model output showing theoretical affect of a conservation practice (prescribed grazing ▭ vs. continuous grazing ▭) on a sagebrush steppe plant community that increased canopy and ground cover and its impact on runoff and soil loss as a function as rainfall storm intensity (return period).

To reduce the time and effort to develop parameters for the SWAT and KINEROS2, models, execute them, and visualize the model output the Automated Geospatial Watershed Assessment (AGWA) tool has been developed (Miller et al., 2007). Using commonly available digital data in combination with the automated functionality of AGWA greatly reduces the time required to use these two watershed models. Through this robust and intuitive interface, the user can select a watershed outlet from which AGWA delineates and discretizes the watershed using Digital Elevation Model (DEM) information. Watershed elements are then intersected with soil, land-use/cover, and precipitation (uniform or distributed) data layers to derive the requisite model input parameters. The model is then run, and the results are imported back into AGWA for visual or tabular display. Model outputs that can be displayed in AGWA are shown in Table 1 and Figure 5.

Table 1. Hydrologic variables that can be spatially displayed in Automated Geospatial Watershed Assessment (AGWA) tool by model component: RHEM for hillslope; KINEROS2 for Watershed; and SWAT for river basin.

RHEM	KINEROS	SWAT
Precipitation	Precipitation	Precipitation (mm)
Infiltration	Infiltration	Infiltration (mm)
Runoff	Runoff	Runoff (mm)
Peak flow	Peak	Peak flow (m^3s^{-1})
Sediment yield	Sediment yield	Sediment yield (kg/ha)
Sediment discharge	Sediment discharge	Sediment discharge (kg/s)
	Channel scour	Channel scour (mm/m^2)
		Evapotranspiration (mm)
		Transmission loss (mm)
		Ground water (mm)
		Base flow (mm)

The user may select an "Area of Interest" and AGWA will interactively locate the impacted watershed outlets and then uses the stream network and boundary polygons to cover the area with the fewest and smallest number of watersheds necessary to parameterize and simulate the area as one unit (i.e., pasture or grazing allotment). This option allows the user to determine if soil erosion is initiated above the area of interest and is being routed through the area or if the soil erosion is occurring within the area of interest (Figure 6).

If soil erosion is being initiated within the area of interest then the user can evaluate if and where conservation practices should be placed to have optimal impact for the least cost. An example of this would be to evaluate the effectiveness of installing a stream side buffer. A second example would be to evaluate the impact of brush control and revegetation practices and its impact on surface hydrologic processes and associated soil erosion processes. This technique can also be used to estimate the potential for floods and catastrophic soil loss following wildfires and help guide placement of structures and soil stabilization treatments to minimize loss of life and property by using burn severity maps to guide changes in key model parameters.

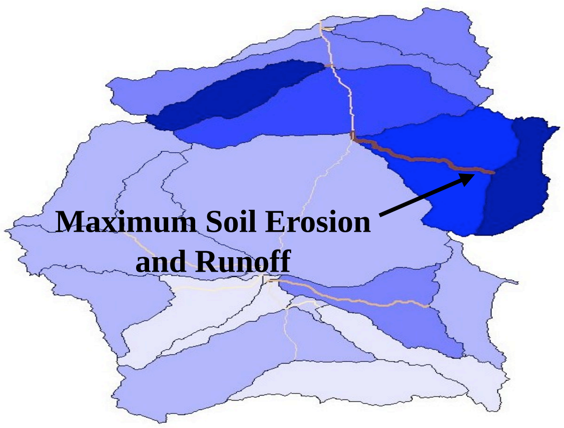

Figure 5. Illustration of how the Automated Geospatial Watershed Assessment (AGWA) tool uses color-ramped output to indicate areas with maximum runoff and soil loss for rapid determination of where conservation practices should be deployed to optimize costs and benefits.

This aspect of the AGWA model package allows managers to rapidly identify problem areas for further monitoring and management activities. Additional functionality can generate alternative future land-use/ cover scenarios and display differences between simulation outputs (potential change) designed to provide decision support when combined with planning efforts. AGWA is designed to provide qualitative estimates of runoff and erosion relative to landscape change as a function of either climate or management actions in ungauged river basins. If calibration data is not available it can provide useful information on relative difference between alternative management actions for estimating the potential impact on hydrologic and soil erosion processes. This information can then be used to guide the selection of appropriate conservation practices to deploy and where they should be deployed to optimize the cost-benefit ratios of large scale restoration projects. The AGWA model package can provide reliable quantitative estimates of runoff and erosion if appropriate calibration datasets are available. Full model documentation, relevant peer reviewed publications, and the software is available at: http://www.tucson.ars.ag.gov/agwa.

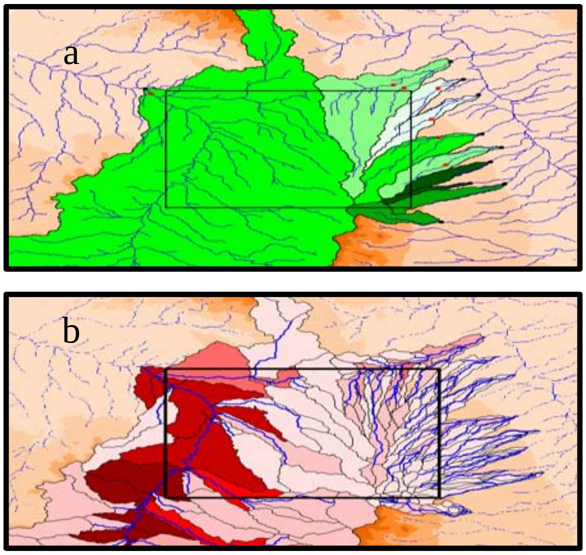

Figure 6. Users selects an Area of Interest (i.e., "a" an allotment) and then the Automated Geospatial Watershed Assessment (AGWA) tool interactively locates watershed outlets (b) by using the stream network and boundary polygons to cover the area with the fewest, and smallest, watersheds necessary. The newly discretized watersheds form a watershed group that is parameterized and simulated as one unit providing the user a simple means of determining how management impacts both the allotment and the surrounding watersheds.

Conclusions

CEAP will develop approaches, methodologies, and databases to produce scientifically credible estimates of environmental benefits/impacts of conservation. Project findings and results will be used to report progress on the environmental effects of these programs, aid discussions on conservation policy development, guide conservation program implementation, and ultimately, help farmers and ranchers make informed conservation choices based on sound science. Anticipated products and impact of the of the rangeland CEAP work include: 1) the development of new site-specific risk assessment tools specifically designed and validated for use on rangelands (e.g., RHEM) and will be available beginning in 2010 and can migrate into an agency planning environment; 2) comprehensive literature review and synthesis document for use by rangeland managers is expected to be published in 2010; 3) determination of the status and extent of private western rangelands; 4) development of a database for national, regional, and local assessments; and 5) better understanding of the on-site and off-site benefits and impacts of practices. Information on the CEAP effort may be found at http://www.nrcs.usda.gov/TECHNICAL/NRI/ceap.

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