Environmental Risk Assessment and Management System (eRAMS)

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The environmental Risk Assessment and Management System (eRAMS) is a comprehensive support system that enhances decision makers' capacity to target conservation practices for sediment, nutrient, and pesticide control. The tool can incorporate economic, environmental, and management criteria in the decision making process at the watershed scale. The eRAMS tool provides a Web-based participatory geographic information system (GIS) platform and requires no software installation by the end users. Users can access all components of the platform online at www.eramsinfo.com. The tool works across spatial scales from farmland to watersheds and daily or larger time steps (e.g., monthly, seasonal, or annual) and is fully compatible with other commonly used databases/GIS technologies and thus takes advantage of readily available data. Since these capacities are implemented and maintained on the host server, users will not be required to master the underlying database management and modeling algorithms. Ultimately, watershed stakeholders across the U.S. will be able to use this targeting tool for conservation planning and the implementation of watershed plans.

The development of eRAMS hinges on the nexus of technical and institutional barriers in the adoption of targeting strategies. Technical barriers are addressed by automating the data collections and organization, modeling, and multi-criteria decision analysis process on the Internet. While conservation practices are implemented at the field, water quality improvements are often desired at the watershed scale. In this context, the use of simulation models is ubiquitous. Complicated modeling approaches can estimate the field and watershed scale benefits but require significant computational resources that are not afforded to most stakeholders. The eRAMS technology automates spatial overlay of soil, land use, terrain, and other data layers in order to create input files for complex hydrologic and water quality models used to evaluate management practices. A cost model is included to evaluate of the cost-effectiveness of watershed plans. The technology also includes a system optimization module that fully explores the tradeoffs between conflicting socioeconomic and environmental criteria at the watershed scale, but more importantly, can unambiguously identify the range of solutions that are most consistent with stakeholders' priorities.

eRAMS takes technology transfer to a whole new level, because extension of the tool does not require installation of any specialized hardware and software by end-users. Watershed planners will benefit from vast data resources and models that are currently accessible to the research community and will be empowered to assess the costs and conservation benefits of alternative management scenarios. To foster broad participation, the Web technology is developed under the supervision of an advisory group from agencies that are likely to use the tool to assess and plan conservation systems and to make management decisions. In addition, farmers and landowners are included in this group, since decisions are implemented at a landowner and farm level. To address institutional barriers to the adoption of new technologies, the development of eRAMS is coordinated with federal and state agencies that are responsible for building capacities for conservation planning and watershed management. The eRAMS tool and its components are designed in line with the data and modeling infrastructure of these institutions.

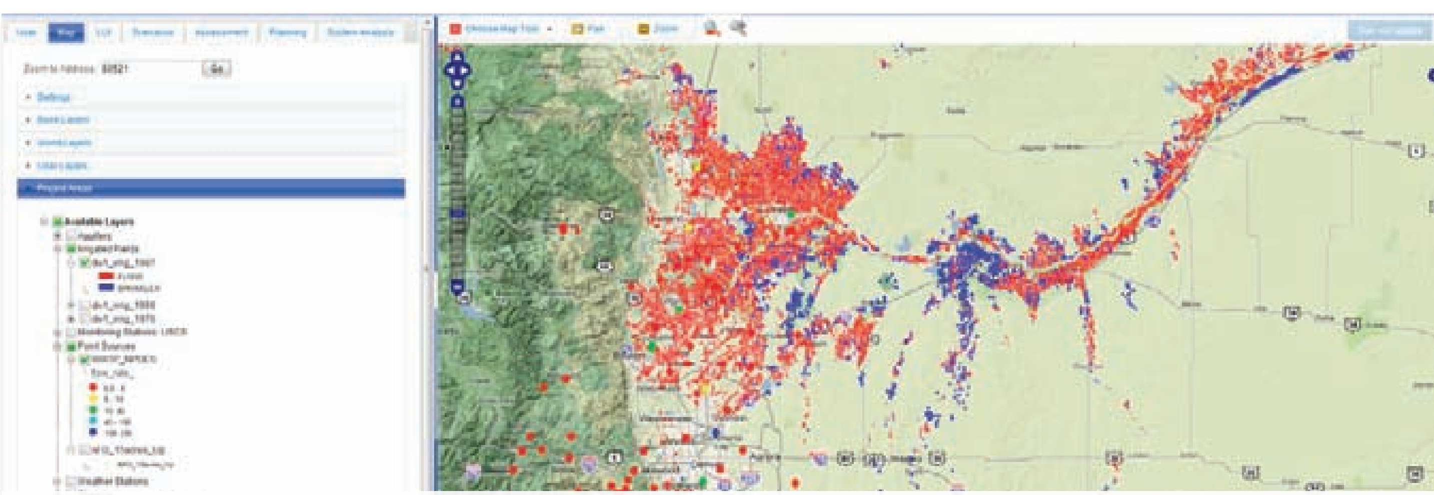

Figure 1. *An illustration of data overlay in eRAMS showing the location of irrigated fields and type of irrigation practices, along with the location and capacities of wastewater treatment plants.*

Although the initial efforts have focused on the South Platte River Basin in Colorado, the applicability of the technology will be spatially corroborated in other watersheds within the U.S. with significantly different eco-hydrologic regimes. Figure 1 illustrates the data overlay capacities of eRAMS in the South Platte River Basin, Colorado.

Data Inventory: eRAMS is equipped with a digitization module that facilitates drawing point, line, and/or polygon features on Google Maps or Bing Maps to specify field boundaries or conservation practices and enter their attributes (Figure 2). The digitized features are automatically overlaid with data sources such as soils, land use, and elevation for conservation assessment and planning. Specifically, major soil types, land use, and slopes of polygons are extracted and stored. Additionally, eRAMS enables the stakeholders to identify their water quality goals for the assessment/planning process. Goals might include reducing pollutant loads from a field or at the outlet of the watershed. The stakeholders then select the conservation practices that will be included in the analysis and the costs that are included in the analysis. The economic analysis may be a maximum total budget, or the goal may be to reduce costs to achieve a certain water quality target.

Watershed Modeling: The field-scale water quality benefits of conservation practices are evaluated using the Agricultural Policy/Environmental eXtender (APEX) model, while the watershed scale benefits are estimated using the Soil and Water Assessment Tool (SWAT). Both of the models have been extensively examined for conservation planning and watershed assessment. The U.S. Geologic Survey's MODFLOW (three-dimensional finite-difference ground water model) and SPARROW (surface water quality model) are among other capacities that will be integrated with eRAMS.

System Analysis: eRAMS is equipped with sensitivity analysis, uncertainty analysis, and automatic calibration engines that facilitate parameterization of the SWAT, APEX, and other models for the area of interest on a parallel computing platform. eRAMS benefits from distributed/parallel computing capacities that will expedite the convergence of the computational procedure.

Conservation Practices (Best Management Practices or BMP) [1]: The BMP module simulates the impact(s) of conservation practices on fate and transport of pollutants. Various processes that are considered when representing a practice include: infiltration, surface runoff (peak and volume), upland erosion (sheet and rill erosion), gully and channel erosion, nutrient and pesticide loadings from upland areas, and within-channel processes. The list of management practices incorporated in eRAMS includes: wetlands, irrigation practices, buffer strips, tillage and residue management, detention ponds, grassed waterways, and other agricultural and urban stormwater management practices.

Scenario Analysis: With this module, the user can compare various scenarios and evaluate the tradeoffs between costs and conservation benefits of different management decisions. For example, they will be able to compare the performance of buffer strips with varying widths or evaluate the impacts of different fertilizer application rates, timing, and methods.

Optimization [2]: The system optimization component of eRAMS enables users to identify desired cost-effective conservation plans that achieve their water quality targets. This tool explores the tradeoffs between environmental, economic, and sustainability criteria. In several case studies, we demonstrated that conservation plans derived from this optimization approach could achieve the same conservation benefits in term of reduction of pollutant

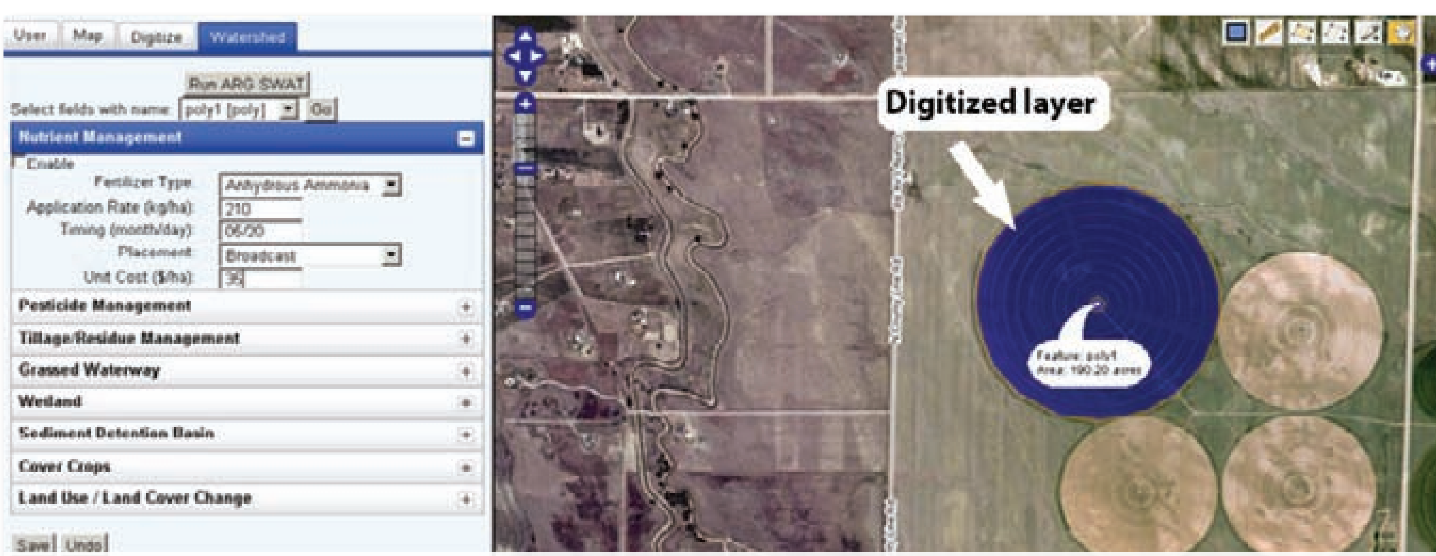

Figure 2. *An illustration of mapping a field boundary and specifying attributes of conservation practices.*

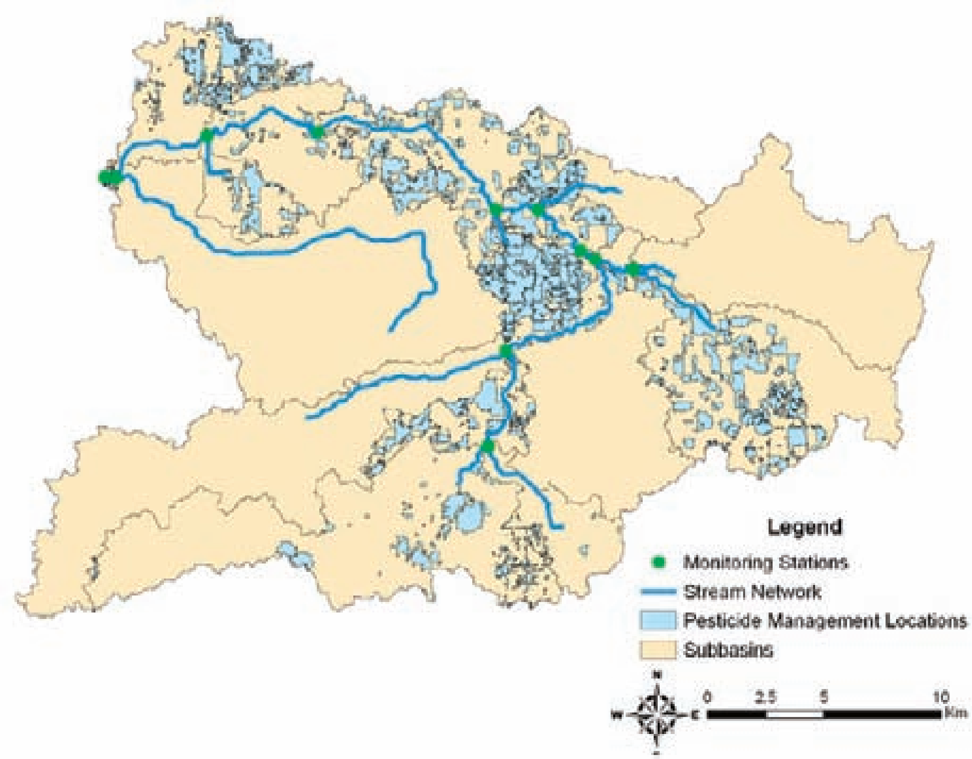

Figure 3. *An example of outputs of eRAMS identifying the landscape position of most effective management practices for pesticide control at the watershed scale.*

loads at significantly lower costs when compared to existing watershed plans. Figure 3 depicts an example of maps created from optimization and planning module of eRAMS.

Map Production: eRAMS provides the ability to quickly define map collections for the production of map sheets that can facilitate the conservation planning and watershed assessment process.

Other Modules: eRAMS is also equipped with modules for location-based information on management, recreation, renewable energy assessment, solar energy park development, and urban drainage, to name a few.

References

[1] Arabi, M., J.R. Frankenberger, B. Engel, and J.G. Arnold (2008). "Representation of agricultural management practices with SWAT." *Hydrological Processes*, vol. 22, 3042-3055.

[2] Arabi, M., R.S. Govindaraju, and M.M. Hantush (2006). "Cost-effective allocation of watershed management practices using a genetic algorithm." *Water Resources Research*, 42, W10429.

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