Tools for Prioritizing Ground Water Protection in Colorado

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Introduction

Nonpoint source pollutants (NPS) are a significant threat to water resources in Colorado, especially ground water. The challenge for decision makers is to decide where outreach, demonstration, cost share, and monitoring resources will have the largest impact on mitigating existing and preventing future NPS from agricultural chemicals and nutrients. Prevention strategies require limited public resources and decision makers need tools to prioritize where to use these resources.

Objective

Develop statewide ground water vulnerability/sensitivity maps to pesticide and nitrate contamination that will aid decisions makers in prioritizing limited protection resources in areas with the greatest potential for contamination.

Methodology

- Various spatial data sets were utilized that influence contaminant transport to ground water. (Figure 2.)
- Geographic Information Systems (GIS) were used to integrate spatial layers using mechanistic, index, or statistical models depending upon the project and data available.
- Vulnerability/sensitivity maps were validated with ground water quality monitoring data collected through-out the state (Figure 1).
- Partners included Colorado State University, Colorado Departments of Agriculture and Public Health and Environment, U.S. Geological Survey, and Colorado School of Mines.
- Completed outreach includes fact sheets, technical bulletins, oral presentations, and USGS reports.

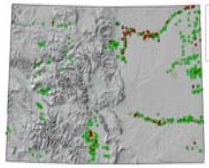
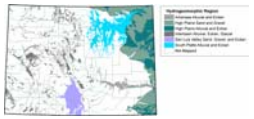
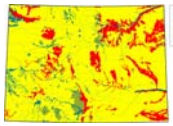


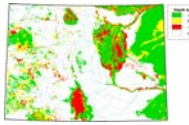
Fig
calibration/validation of nitrate vulnerability/probability maps. Data sources (nitrate and atrazine) included the Colo. Ag. Chemicals and Groundwater Protection Program and USGS NAWQA (n= 574).



Hydrogeomorphic region used by Rupert, 2003



Various STATSGO soil characteristics were used by Rupert, Ceplecha, and Hall



Aquifer location and depth used by Ceplecha, and Hall

Reclassified USGS National Land Cover Database (NLCD) used by Ceplecha and Rupert

Figure 2. Examples of selected data layer inputs for vulnerability models.

Selected Map Products

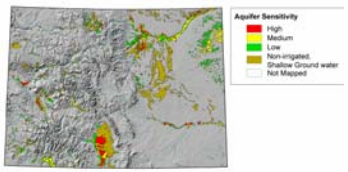


Figure 3. Relative sensitivity of ground water to pesticide impact as mapped by Hall, 1998a. Vulnerability map is in 1000 meter resolution. Map equation produced using a DRASTIC approach:

Sensitivity =

(aquifer presence) x (recharge by irrigation) x { (2 x depth to water) + soil infiltration }

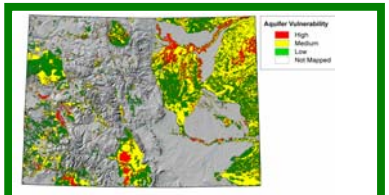


Figure 4. Vulnerability of Colorado ground water to nitrate contamination as mapped by Ceplecha, 2001. Map equation produced by utilizing a hybrid approach using the NLEAP model (Shaffer *et al.*, 1991) . Vulnerability map is in 1000 meter resolution.

Aquifer Vulnerability Value = (soil drainage + (land use + irrigation) + depth to aquifer) x presence of aquifer

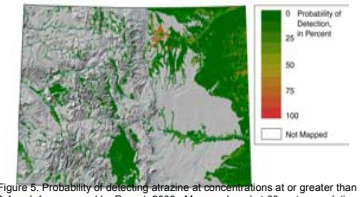


Figure 5. Probability of detecting atrazine at concentrations at or greater than 0.1 ug L^{-1} as mapped by Rupert, 2003. Map produced at 60 meter resolution. Map equation produced using a statistical approach with a logistic regression model:

$$\text{Probability}^* = \frac{e^{a + b1(B) + c2(C) + d3(D) + e4(E)}}{1 + e^{a + b1(B) + c2(C) + d3(D) + e4(E)}}$$

*Small cap letters are coefficients and large cap letters are input data layers values.

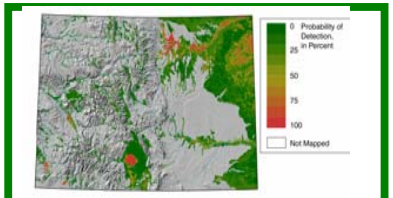


Figure 6. Probability of detecting nitrate-nitrogen at concentrations at or greater than 5.0 mg L^{-1} as mapped by Rupert, 2003. Map produced at 60 meter resolution. Map equation produced by using a statistical approach with a logistic regression model:

$$\text{Probability}^* = \frac{e^{a + b1(B) + c2(C) + d3(D) + e4(E)}}{1 + e^{a + b1(B) + c2(C) + d3(D) + e4(E)}}$$

*Small cap letters are coefficients and large cap letters are input data layer values.

Example Validation Results

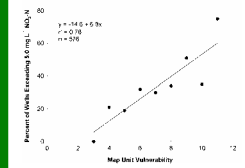


Figure 7a. Regression results of Figure 4 at 5.0 mg L^{-1} using ground water NO_3-N values. Figure 6 has r^2 of 0.97 when regressed in similar manner.

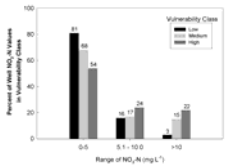


Figure 7b. Percent of wells with NO_3-N levels from 0-5, 5.1-10, and >10 mg L-1 in each map vulnerability class from Figure 4.

Lessons Learned

While developing tools for evaluating Colorado ground water contamination potential at varying scales and complexities we learned:

- Quality GIS inputs for statewide scale work are limited; improved depth to ground water and soils data (SSURGO) would improve maps.
- Availability of ground water quality data allows for more options for model development and validation; lack of widespread pesticide detections in Colorado limited validity of data driven models in some regions.
- Model complexity increases time and cost, but may improve accuracy and defensibility.
- Simpler models allow for easier integration of improved data layer inputs as they become available.

Future Plans

- Update maps with improved irrigation coverage (Figure 8).
- Increase availability of ground water tools for users through written publications and the Internet.
- Allow users to access and utilize sensitivity/vulnerability maps, supporting ground water quality data, and input layers on the we

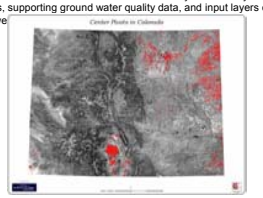


Figure 8. Center pivot irrigation in Colorado digitized using satellite imagery.

Summary

In an attempt to better understand the vulnerability of Colorado ground water to contamination, several statewide maps were produced to evaluate pesticide sensitivity, nitrate vulnerability, and atrazine and nitrate contamination probability. The outcome of this work provides a better understanding of the potential for ground water contamination. Our ultimate goal is to make the outputs more accessible to farmers, consultants, and agency personnel.

References

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Shaffer, M.J., Halvorson, A.D. and Pierce, F.J.: 1991, 'Nitrate Leaching and Economic Analysis Package (NLEAP): Model description and application. Managing Nitrogen for Ground water Quality and Farm Profitability', *Soil Science Society of America*. 285--322.