Update

SPRING 2011

Stone Environmental News on Agrochemical Fate and Exposure Issues

Inside:

Potential, Limitations, and Future Direction of the SWAT Model

Watershed hydrologic models are commonly used to assess the quality of surface and groundwater resources.

With several models being developed since the mid-1970s, the selection of an appropriate watershed hydrologic model requires an assessment of the project objectives, the watershed size, desired spatial and temporal scales, expected accuracy, and availability of resources (Borah et al., 2003).

The last several years of research have presented scientists with a multitude of watershed hydrologic models to choose from, ranging from simple models to more complex ones that offer a range of functionality. Process-based, distributed, and temporally continuous models like the Soil and Water Assessment Tool (SWAT) have been developed with the advent of computationally efficient processors, GIS, and the increasing availability of high-resolution spatial datasets. Successful application of the more complex and advanced models demands a profound understanding of the processes they simulate and their strengths and weaknesses.

SWAT is a physically-based, continuous watershed simulation model that operates on a daily time step from several months to many years (Neitsch et al., 2005). The current version of the model, SWAT2009, has undergone a continual review and expansion of capabilities since its development in the early 1990s. SWAT is a public domain model that is commonly used by government agencies, research institutions, universities, and private corporations worldwide. It is included in EPA's BASINS program and is used to support the Total Maximum Daily Load (TMDL) analyses performed for water quality impaired waters. Among the model's strengths are its capability to analyze both point and non-point source pollution dynamics at a wide range of spatial and temporal scales. For example, the model's spatial representation of a river system allows the evaluation of water quality parameters at distinct stream segments within a watershed.

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A runoff monitoring station at a paired watershed study in Minnesota. The two-foot H-flume is discharging through a "side inlet". See the full story on page 3.

Negative Exponential Curve Fit Yields Promising Results

In an analysis conducted to examine far-field drift deposition using alternative curve fits, Stone found that using a negative exponential curve fit reduced far-field drift deposition compared to other available methods.

For aerial, ground spray, and orchard airblast applications, there is currently a scarcity of deposition data for distances in excess of 120 meters downwind from a pesticide treated field. Far-field drift estimates are made using the aerial AgDisp model and empirical orchard airblast and groundspray models in AgDrift without any actual data to compare to the predictions. Without other data, this raises the question of whether the far-field deposition predictions are accurate or artifacts of the curves used by these models.

To develop the drift curves for this analysis, Stone's modelers used the results of field studies conducted in Canada to quantify spray drift from aerial and groundspray application of pesticides and a collection of orchard airblast field studies conducted in Germany to quantify airblast drift of pesticides.

Data from these field studies were empirically fit to a series of

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SWAT

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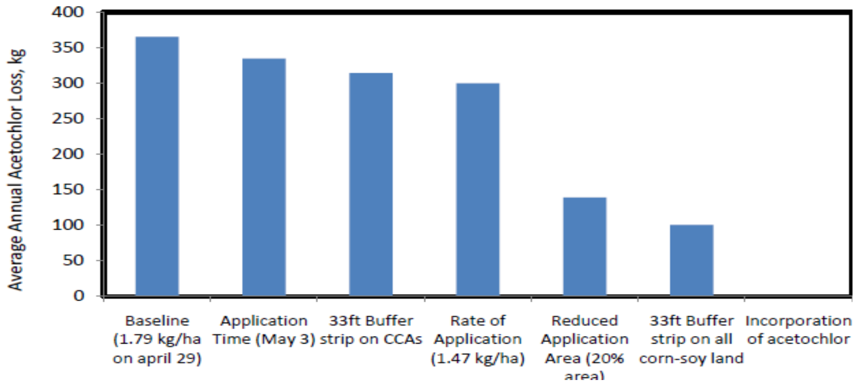

Relative importance of acetochlor management practices in the LeSueur River Watershed in Minnesota. (Folle et al., 2007). Critical contributing areas (CCA) were identified from an analysis of the compound topographic index. The full report is available at www.mda.state.mn.us (search on "Evaluation of BMPs in Impaired Watersheds Using the SWAT Model").

This representation could range from small headwater streams, to irrigation return flow ditches, to main-stem rivers. The integration of the SWAT model with GIS interfaces and large data-bases allows for efficient model setup and simulation of small to large watersheds. In addition to simulating the fate and transport of sediment, nutrients, pesti-cides, and bacteria, the model has the capability to simulate crop growth, tile drainage, wetlands, reservoirs, and carbon dynamics, broadening the model's utility and appeal. Most importantly, SWAT's high degree of flexibility and efficiency in simu-lating the effects of alternative agro-nomic management practices on water, sediment, nutrients, and pesticides make it a powerful tool for management of environmental quality.

A recent application of the model to evaluate a pesticide-impaired watershed in southern Minnesota is a good example of using SWAT to identify effective mitigation practices to reduce pesticide exposure in surface wa-ters (Folle et al., 2007). In this particular work, the effects of several alternative management scenarios in reducing the contri-bution of the pesticide acetochlor to surface water were evaluated (see figure). These study results were used to recommend the most effective practices for ace-tochlor reduction, resulting in a focusing of limited resources on mitigations that yield the best results.

Despite the strengths that have made the use of SWAT widespread, there are some simplified routines that demand further develop-ment and testing. These include the new approaches for representing land unit connectivity, the expansion of the plant parameter data-base, and enhancements to stream channel degradation and sediment deposition proc-esses. Overall, the SWAT model offers the most com-prehensive representation of environmental processes that can be used by government and pri-vate organizations to make deci-sions on the land use and man-agement alternatives that may impact water quality.

For discussion, please contact Solomon Folle at sfolle@stone-env.com.

New ArcGIS Proximity Tool Aids Salmon Ecological Risk Assessment

Ecological risk assessments often involve an analysis of the proximity of specific landscape features where an environmental stressor occurs relative to those where a sensitive receptor is present.

One example is an assessment of the risk for endangered species' exposure to pesticides in aquatic habitats. A GIS-based proximity analysis is able to identify pesticide use acreage present within a given buffer distance to aquatic habitats of interest. However, watershed-scale proximity analyses can be-come complicated and resource intensive when a critical buffer distance is uncertain or when evaluating the impacts of a range of buffer distances and aquatic habi-tats.

To address these issues, Stone, in cooperation with CropLife America, developed an approach to simultaneously evaluate a broad range of proximities from pesticide use areas to aquatic habitats at the watershed scale.

Stone applied the approach to watersheds designated as salmon evolutionary significant units (ESUs) in the Pacific Northwest. This analysis provided both total acreage and incremental acreage, and the structure of the spatial variability of agricultural land proximity to water across an en-tire ESU. This type of risk assess-ment allows regulators to gain a better understanding of the po-tential pesticide exposure of en-dangered species and the implica-tions of pesticide regulations on agriculture.

The GIS-based approach uses the latest NHDPlus hydrography data and remotely sensed land cover data from the USGS Na-tional Land Cover Dataset or the NASS Cropland Data Layer to generate cumulative distributions of pesticide use areas as a func-tion of proximity to aquatic habi-tat. The project team created an ArcGIS Proximity Tool so that the method could be applied to other geographical areas and in additional watershed-scale risk assessment contexts. The prox-imity tool includes a hydrography processing component to

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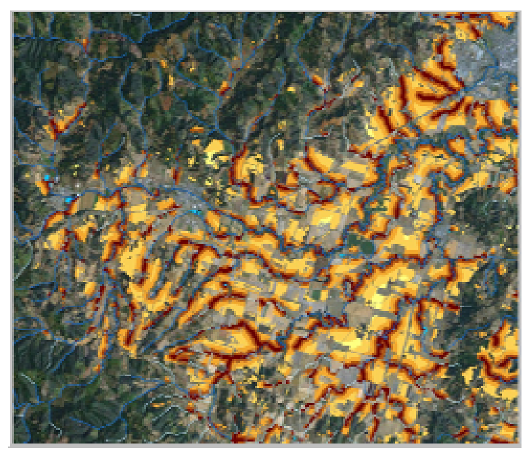
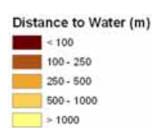
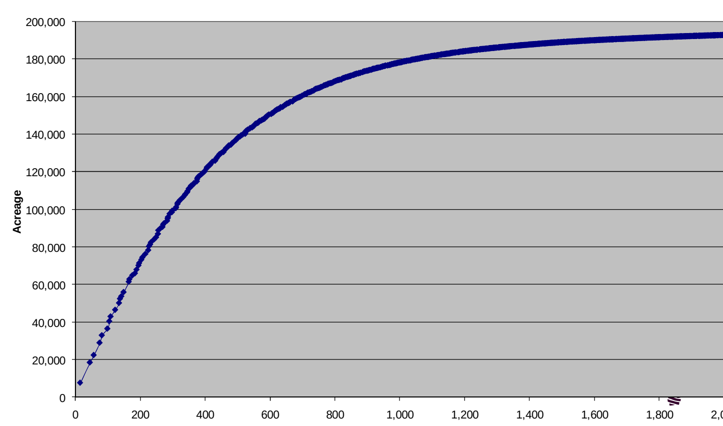


Agricultural proximity to water in "Upper Willamette Chinook ESU".





Cumulative distribution function of agriculture proximity to water in the "Snake River Chinook Spring/Summer ESU".

Paired Watershed Studies Ideal for BMP Evaluations

In evaluating agricultural best management practices (BMPs), a paired watershed study design is an ideal choice for a scientifically sound, statistically valid evaluation of the effectiveness of a treatment.

The premise of this approach is that there is a quantifiable relationship between the water quality data gathered from adjacent or nearly adjacent watersheds of similar conditions (e.g., weather, size, soils, etc.) and that this relationship is valid until a major change occurs between the watersheds. This change (or treatment) could be anything you wish to study, from changes in tillage practices to incorporation of applied pesticides to the planting of vegetative buffers.

Paired watershed design requires two phases: calibration and treatment. During the calibration phase, water quality data are collected from the watersheds until an acceptable statistical relationship between them is obtained. During the treatment phase, a change is made to one of the watersheds (the other watershed remains in the original condition as a control) while all other conditions are kept essentially the same. The collection of water quality data is continued into the future and the differences between the pre-treatment conditions and the post-treatment conditions are measured as the effect of the change. (A full explanation of the study design and statistics involved can be found in EPA guidance document 841-F-93-003, available on Stone's web site at stone-env.com/agchem/agres).

Stone is currently conducting a three-year, paired watershed study near Mankato, Minnesota to evaluate the effectiveness of buffers planted around culverts known as "side inlets". A side inlet is a colloquial term in Minnesota for culverts installed through ditch berms created by the deepening and straightening of waterways. These culverts are ubiquitous in southeastern Minnesota and can become direct routes of input for pesticides into the state's waterways when cropland runoff occurs. Thirty-foot, semi-circular grass buffers around critical drainage areas from agricultural fields are a BMP being promoted by the Minnesota Department of Agriculture to improve water quality in the state.

Stone began the study in 2009 on behalf of the Acetochlor Registration Partnership, and in collaboration with the Minnesota Department of Agriculture, to evaluate the effectiveness of the grass buffer BMP in reducing acetochlor, sediment, and nutrients in runoff from agricultural fields. After a disappointing 2009 field season with no runoff events and therefore no chance at

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NEWS BRIEFS

Solomon Folle, Ph.D.
SWAT Modeling, Hydrology

Julie Moore, P.E.
Water Resources Management, Agricultural Stewardship

Michael Winchell
Hydrology, Spatial Analysis

Tammara Estes
Modeling, Statistical Analysis, Regulatory Support

Kim Watson, RQAP-GLP
Quality Assurance, Health & Safety

John Hanzas
Geology, Hydrology

Staff Additions

Solomon Folle, Ph.D., an expert in water quality modeling, joined Stone as a senior environmental modeler/hydrologist. Dr. Folle was responsible for development of the SWAT model at the University of Minnesota, St. Paul. He received his Ph.D. in soil science, with a minor in water resources science, from the University of Minnesota. His dissertation work focused on using SWAT to model pesticides, sediment, and nutrients in the Le Sueur river watershed of south-central Minnesota.

Julie Moore, P.E. joined Stone as a senior engineer and leader of the Water Resources Management group. Ms. Moore has led a variety of projects related to stormwater management, agricultural stewardship, wetland restoration, and riparian corridor protection. She previously worked for the Vermont Agency of Natural Resources where she was the director of the Clean & Clear Program. Here she managed the state's efforts to implement the TMDL (total maximum daily load) for phosphorus pollution in Lake Champlain. Ms. Moore is a registered professional engineer in Vermont. She received her master's degree in environmental engineering from Johns Hopkins University in Baltimore, MD and an undergraduate degree in civil engineering from the State University of New York at Buffalo.

New Projects

Stone was awarded a project for the non-profit Lake Champlain Basin Program that seeks to identify critical source areas of non-point source phosphorus pollution in the Missisquoi Bay Basin of Lake Champlain. A natural freshwater lake, Lake Champlain is located mainly between the US states of Vermont and New York but is also partially in the Canadian province of Quebec. With the goal of reducing phosphorus loading into Missisquoi Bay, the project will utilize a variable source area hydrology adaptation of the Soil and Water Assessment Tool (SWAT-VSA) to identify and delineate areas of the basin that contribute disproportionately large amounts of phosphorus pollution to the bay. The project is scheduled for completion in August 2011. Read about the results in our next newsletter.

Upcoming Conferences

Society for Quality Assurance Annual Meeting
San Antonio, Texas
27 March to 1 April 2011

Kim Watson, RQAP-GLP, will present a poster on the Good Laboratory Practices Specialty Section.

American Chemical Society National Meeting & Exposition
Denver, Colorado
28 August to 1 September 2011

John Hanzas, Tammara Estes, Michael Winchell, and Solomon Folle will attend and will make presentations.

STONE ENVIRONMENTAL INC

535 Stone Cutters Way
Montpelier, Vermont
05602

Tel: 802.229.4541
E-mail: sei@stone-env.com
Web Site: www.stone-env.com

Officers
Christopher Stone, President
David Healy, Vice President
Seth Pitkin, Vice President
Bruce Douglas, Vice President

Editors
John Hanzas
Lesley Allen
update@stone-env.com

Printed on recycled paper

535 Stone Cutters Way
Montpelier, Vermont 05602
USA

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Paired Watershed Study

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calibration between the study watersheds, the 2010 field season was one of the wettest in recent years. With seven runoff events occuring between the application of acetochlor in April and the beginning of September, significant regression relationships were achieved between the study watersheds. An analysis of regression error suggests that with enough post-treatment runoff events, even a relatively small change in the water quality data would be statistically attributable to the vegetative buffers. Having achieved an acceptable level of calibration by September 2010, grass buffers were planted around the side inlets. The buffers were sown from a mixture of grass species recommended by the National Resources Conservation Service. The grasses germinated well and established good root systems before the cold weather set in.

During the calibration phase, water quality data were collected from each watershed using tipping bucket rain gages to measure rainfall; 2-foot H flumes and ISCO 4230 bubbler flow meters for the quantification of runoff flow; ISCO 6712 autosamplers with a 24-bottle carousel for the collection of runoff samples; and ISCO 2105-C interface modules to log the data, trigger the autosampler to collect samples based on flow, and communicate all the data to a web site.

With two years of data collection in the treatment phase ahead of us, we are confident that we will collect enough data from runoff events to make definitive conclusions as to the usefulness of this BMP in reducing acetochlor, sediment, and nutrients. Look for more articles in the future as results for this study come in.

Proximity Tool

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select the water body feature types of interest for use in the analysis.

The tool is flexible enough to allow the incorporation of hydrography datasets that represent more specific water bodies of interest, such as streams classified according to species habitat suitability. The proximity analysis component allows the user to select any raster-based dataset that can be used to classify potential pesticide use sites for each run of the tool.

The Proximity Tool is freely available for download through the GeoSTAC website (http://geostac.tamu.edu/).

Drift Curves

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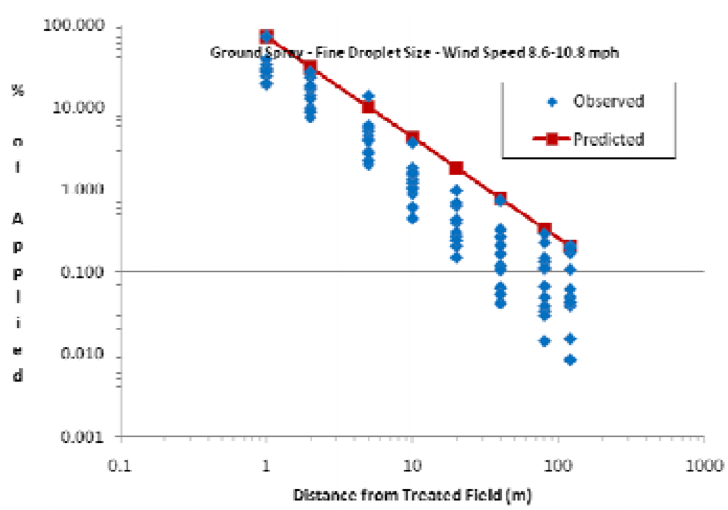
negative exponential distributions.

Stone then tested the distributions for goodness-of-fit and selected conservative distributions, particularly in the far-field distance tails. Predictions from the selected distributions were compared against data from independent aerial pesticide drift deposition studies conducted by the Spray Drift Task Force in the United States in 1992.

These comparisons were made to evaluate model performance of this study's empirically-derived drift curves using an independent dataset. Initial comparisons showed that the negative exponential distribution is slightly overestimating task force data for groundspray and orchard airblast applications and underestimating data for aerial.

Tammy Estes presented these findings at SETAC in November 2010. Three posters illustrating her work and results are posted on Stone's web site (stone-env.com/agchem/agres).



Observed versus predicted results for fine droplet size, consolidated to an average.