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RIVER BASINS OF KENTUCKY

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The Kentucky Geological Survey recently published a series of maps of the major river basins of Kentucky: Green/Tradewater, Kentucky, Licking, Salt, Upper Cumberland (in Kentucky), Big Sandy/Little Sandy and Tygarts Creek, and Four Rivers (Cumberland, Tennessee, Ohio, Mississippi).

The maps were designed to put each major river basin in context and help people visualize the basin for its extent, the communities it affects, and the resources associated with each basin. The maps were created for use by planners, environmentalists, fishermen, students, and anyone who lives in or has an interest in a particular basin.

The shaded topographic relief maps used as a base show streams and water bodies, source/groundwater protection areas, priority watersheds, 11-digit hydrologic unit boundaries, water withdrawal points, wastewater discharge points, boat ramps, locks, stream reaches not supporting designated uses, special-use waters, cities, roads, and county boundaries. Tables include information on boat ramps, locks and dams, and water withdrawal. Photos and diagrams illustrate features of the basin. Basin slopes and ecologic regions are illustrated with inset maps.

Map sizes range from 36 x 36 inches to 36 x 48 inches, and map scales range from 1 inch = 3 miles to 1 inch = 5 miles.

Information for the maps was taken from River Basin Coordinating Committees, the Kentucky Division of Water, the Department of Fish and Wildlife Resources, the Kentucky Infrastructure Authority, the Kentucky Department of Transportation, the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the Kentucky Division of Geographic Information.

Since the maps are print-on-demand, they can be custom-tailored to meet the needs of organizations that provide information related to their own missions.

POSTER PRESENTATION

Actual size: 36" x 36", scale, 1 inch equals 5 miles

AN INITIAL PRIORITIZATION APPROACH FOR POTENTIAL AGRICULTURAL BEST MANAGEMENT PRACTICE IMPLEMENTATION BASED ON SUBWATERSHED INDICATORS AND EXPERT KNOWLEDGE

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This poster describes a flexible approach that relies on expert knowledge and landscape conditions for making preliminary decisions on where to focus efforts to reduce agriculturally sourced nitrogen and phosphorus through voluntary use of best management practices (BMPs). Using geospatial technology and data describing landscape conditions offers an opportunity for decision-making support across an entire river basin while not relying on complete temporal and spatial water quality data. For demonstration purposes, this approach targets a subset of subwatersheds in the Licking River Basin. The 828 Hydrologic Unit Code 14 subwatersheds are used to provide the basis for a practical demonstration using only data from the Kentucky Geography Network. Subwatersheds were characterized on ten landscape indicators that have been determined to influence water quality based on literature review. A Z-score was calculated for each indicator, and the ten indicator Z-scores were weighted and then added together for each subwatershed. This results in a total Z-score for each subwatershed.

A subwatershed approach utilizing several indicators and weighting them differently can quickly generate a variety of options that can be visually evaluated by experts. For example, one weighting scheme might focus water quality BMPs towards higher densities of permitted animal feeding operations based on animal equivalent units. A second weighting scheme might focus on subwatersheds with conditions that are characterized with relatively high riparian agriculture land cover, road/stream intersection density, stream density, and steeper riparian zone slope. Very often resources are dedicated towards locations that have the worst existing conditions and are often the most expensive and/or complicated to improve. An alternative approach could be to identify subwatersheds with good riparian indicator conditions and thus likely better water quality, and further improve conditions in those subwatersheds. Such targeting might be helpful if it is determined that it is more effective to improve an area with relatively good conditions rather than completely establish riparian zone BMPs in new areas. As an additional consideration, landowners/managers in subwatersheds with intact riparian zone BMPs might be more willing to maintain and expand existing riparian zone BMPs than landowners/managers where few riparian BMPs are in existence. An advantage of this approach is that it helps decision makers combine expert knowledge of on the ground conditions and past efforts with the ability to visualize landscape conditions for the purpose of establishing or continuing landowner/manager discussion.

Acknowledgement: The poster uses data from work that was supported by the Cooperative State Research, Education and Extension Service, U.S. Department of Agriculture, under Agreement No. 2008-34628-19532. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the U. S. Department of Agriculture.

LOCATING KARST CONDUITS IN CANE RUN WATERSHED OF CENTRAL KENTUCKY USING ELECTRICAL RESISTIVITY METHODS

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The Cane Run watershed and underlying karst aquifer in central Kentucky is the recharge area of Royal Spring, the primary source of drinking-water for the city of Georgetown, Kentucky. This watershed, including the associated karst aquifer, is degraded by pathogens, nutrients, siltation, and organic enrichment and is listed by the Kentucky Division of Water as one of four focus watersheds for clean-up under the State's nonpoint-source pollution program. The pollution sources include both municipal point sources and agricultural and nonagricultural nonpoint sources. The relative contribution of different parts of the watershed to the pollution is not well understood. The geology of Cane Run watershed consists of Ordovician thin-bedded limestone with sparse interbeds of shale. The landscape is dominated by karst features such as sinkholes and springs. Cane Run only flows on the surface during times of significant rainfall, usually in the spring of the year. The remainder of the year, most water is recharged to a karst conduit system that leads from Lexington to Royal Spring.

To help locate the actual source of contamination and to track progress of remediation efforts, it is important to monitor contaminants before they reach the point of groundwater use. Kentucky Geological Survey (KGS) is attempting to drill into the conduit to establish a water quantity (discharge) and quality (temperature, pH, conductivity, dissolved oxygen, turbidity, and sampling capability) monitoring station, just a few hundred meters up gradient from where the conduit diverges from the Can Run surface watershed. However, there is no known entrance into the Royal Spring Conduit. This study is using geophysics to assist in locating the karst conduit. We have applied electrical resistivity (ER) in four scenarios: (1) 2D surveys, (2) quasi 3D surveys, (3) synthetic time-lapse simulation, and (4) time-lapse survey with calcium chloride injection. A 2D survey conducted in 2008 showed some low resistivity anomalies and subsequent field drilling and tracer tests indicated these anomalies are mud-filled voids that are not located in the main conduit system. A quasi 3D survey consisting of twelve parallel survey lines was conducted to further investigate a prominent low resistivity anomaly identified by a 2D survey conducted in summer 2009. The quasi 3D survey shows the anomaly disappears approximately 40 meters northwest from the first parallel line Figure 1). The synthetic time-lapse simulation showed that, given our hypothesis of conduit depth and size, a time-lapse survey can potentially pick up the signal disturbed by calcium chloride injection. The field time-lapse survey conducted in October 2009 showed noticeable resistivity change for a low resistivity anomaly in the southwest portion of an ER line. This anomaly will be further studied through additional time-lapse surveys and microgravity measurements. This work is being carried out in cooperation with the University of Kentucky's College of Agriculture and Department of Earth and Environmental Sciences.

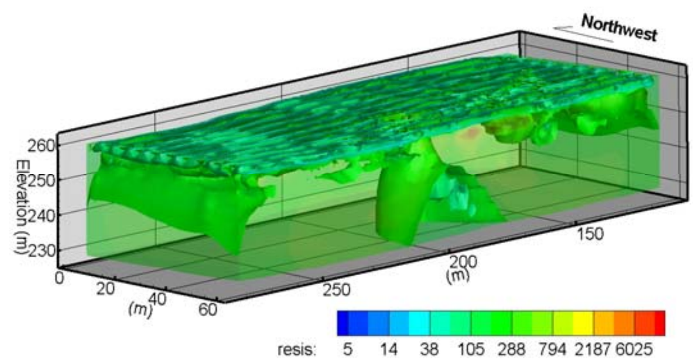

Fig 1. Inverted Electrical Resistivity for a Quasi 3D Survey

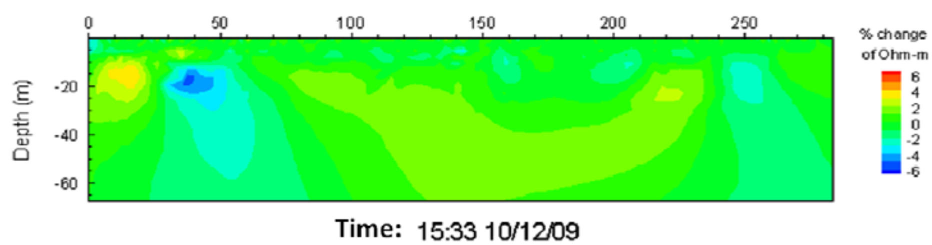

Fig.2 Resistivity Change During a Time-Lapse Survey

Reference:

R. Paylor and J. C. Currens, Royal Spring karst groundwater travel time investigation, prepared for Georgetown Municipal Water and Sewer Service, Kentucky Geological Survey, University of Kentucky, June 2004.

IDENTIFICATION OF DNA BIOMARKERS FOR DETERMINING SOURCES OF FECAL POLLUTION IN WATER

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Fecal contamination of water sources is a serious problem worldwide. Most of Kentucky and a quarter of the world's population draw drinking water from highly porous underground karst aquifers formed in the underlying limestone. Kentucky and the Mammoth Cave region are recognized as part of the most extensive and vulnerable karst terrain on the globe. From GenBank we compiled extensive 16S rDNA sequence data of the fecal-specific bacterial group *Bacteroides* obtained from a variety of host animals. Sequences of *Bacteroides* 16S genes were trimmed to match the sequence flanked by standard PCR primers for this group and then analyzed for fragment sizes generated from a number of restriction enzymes. The fragment sizes for each enzyme were compared between animal groups using discriminant analysis methods and multiple enzymes along with the GC content were selected as assessment markers to maximize the ability to differentiate between animal groups. The results predict that different animal hosts and human activities contributing to fecal pollution can be discriminated based upon easily measured DNA sequence features including restriction sites and GC content.

NOTES

INTEGRATING PARTICIPATORY COMMUNICATION AND STRUCTURED PUBLIC INVOLVEMENT PROCESSES TO BETTER ADDRESS SUPERFUND ISSUES: THE PADUCAH GASEOUS DIFFUSION PLANT FUTURE STATE VISION PROJECT

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Through the auspices of the Kentucky Research Consortium for Energy and the Environment (KRCEE), members of the University of Kentucky Superfund Research Program Research Translation Core have joined experts in participatory rural communication appraisal and structured public involvement to develop an innovative approach for community involvement in determining the future of Superfund sites. The KRCEE team has been charged by Kentucky's Congressional delegation and the United States Department of Energy with integrating public, regulatory, and technical community visions to produce a publicly approved Future State Vision Report for the Paducah Gaseous Diffusion Plant (PGDP) National Priority List Superfund site. The three-step methodology being implemented includes personal interviews, focus groups, and large community meetings, with individuals from disparate stakeholder groups engaged at each stage. The information gathered during the interview and focus group stages will be utilized to create sample scenario visualizations that will be discussed and scored during the community meeting stage. Ultimately, the project will result in a "PGDP Future State Vision Document" that, while not decisional, will be available to inform future US Department of Energy decisions related to the disposition of the PGDP after decommissioning. In addition, CAsewise Visual Evaluation (CAVE) technology will utilize community preferences for sampled scenarios to predict preferences for additional, non-sampled model scenarios. A community consultation panel with representatives from sixteen unique stakeholder groups will advise the team throughout about potential process improvements.

NOTES

INVERTEBRATE PRODUCTION IN RESTORED AND REFERENCE STREAMS

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The restoration of stream ecosystems has recently received substantial attention. In this study, we assess invertebrate secondary production in a restored stream channel and an un-restored reference stream. Wilson Creek (restored stream) and Hart's Run (reference stream) are located in the Bernheim Research Forest (BRF) in Bullitt County, KY. Like many streams in Kentucky, Wilson Creek was historically relocated into a straight channel against its valley wall, presumably to increase arable land in the stream valley. In October 2003, a 965-meter reach of Wilson Creek was relocated into its original stream channel using natural channel design techniques. Hart's Run, which flows adjacent to Wilson Creek, lies entirely within the BRF. Approximately five years have passed since the Wilson Creek restoration was completed allowing the restored reach to recover from the channel relocation and restoration process.

Monthly benthic invertebrate samples (n=5) were collected from riffles of each reach using a Surber sampler (250 μm mesh size) for one calendar year. Invertebrate production was estimated for each taxa using one of three methods. Non-tanypodinae Chironomidae production was estimated using the instantaneous growth method. For all other taxa with sufficient abundance in the study streams, the size-frequency method corrected for the cohort production interval was used for production calculations. Production of rare taxa in each stream was estimated using an assumed P/B ratio of 5 for univoltine taxa and 10 for bivoltine taxa.

Total invertebrate abundance, biomass, and secondary production were similar between the two study streams. Total EPT production was also similar between the two study streams. However, invertebrate richness was higher in the restored stream (67 taxa) than the reference stream (62 taxa). Also, differences were observed in the production of functional feeding groups in each stream. Specifically, the restored stream had higher scraper production than the reference stream. Increased scraper production coincided with the availability of epilithic periphyton as a food resource in the restored stream. This is most likely because the canopy of the restored stream has not fully developed since the restoration project was completed, which has increased sunlight availability in the restored stream.

The results of this study indicate that, based on invertebrate production, the restored stream is very similar to the reference stream after five years of recovery from the channel relocation. Additionally, as the canopy matures on the restored reach, it is believed that the production of functional feeding groups in the reference and restored streams will also converge. Additional work in these streams will use these secondary production estimates to create quantitative energy flow food webs for the invertebrate assemblages of these two streams.

NOTES

MICROSCOPIC POPULATION DYNAMICS AND THEIR RELATIONSHIPS TO THE ACTIVATED SLUDGE PROCESS IN A 30 MGD WASTEWATER TREATMENT PLANT

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Population dynamics of protozoa and higher-life forms in the activated sludge can provide useful information in monitoring and optimizing operations, and for toxicity assessments of wastewater treatment facilities. Monitoring of protozoan abundance in mixed liquor (ML) from the Town Branch Wastewater Treatment Plant (TBWWTP), Lexington, KY was initiated by the Town Branch Lab in July 2009. The TBWWTP is classified as a single-stage conventional activated sludge system with an average design flow of 30 MGD, which can hydraulically treat a maximum flow of 64 MGD. Protozoan counts were grouped into four categories: amoebae/flagellates; free-swimming/crawling ciliates; stalked ciliates; and rotifers/nematodes. Trends in protozoan numbers (No./mg MLVSS) were compared with several parameters, including ML temperature, pH, alkalinity and TSS; F/M ratios; and sludge age. Although trend analyses were preliminary at press time, protozoan dominance was observed to be cyclical over time. As expected, dominance by amoebae/flagellates corresponded with decreases in abundance of both free-swimming/crawling ciliates and stalked ciliates, with converse results observed over time. Even though rotifers/nematodes tended to be less abundant, trends of their numbers over time were similar to those of the amoebae/flagellates. Protozoan's growth phases correlated with nutrient availability (F/M ratios), settleable solids, and sludge density indices (SDI). Along with protozoan enumerations, the Town Branch Lab is currently conducting filamentous bacteria identification. Data generated will be compared to the metrics above providing a comprehensive view of the activated sludge treatment processes. In addition, similar studies are being conducted at the West Hickman Creek WWTP (WHCWWTP), Nicholasville, KY. The WHC plant is classified as a two-stage activated sludge nitrification system with an average flow of 22.3 MGD, but can hydraulically treat 52 MGD.

NOTES

BREAKPOINT ANALYSIS AND ASSESSMENT OF NUTRIENT CONCENTRATIONS AND TURBIDITY TO DIATOM AND MACROINVERTEBRATE INTEGRITY IN THE PENNYROYAL BIOREGION OF KENTUCKY, 2007-08

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To assist the State of Kentucky in the development of numeric nutrient criteria for the Pennyroyal Bioregion, the U.S. Geological Survey and the Kentucky Division of Water collected water chemistry, turbidity, and biological-community data from 22 streams throughout the Pennyroyal Bioregion from September 2007 to May 2008. The goals of this study were to: (1) determine statistically significant and ecologically relevant relations among stressor [total nitrogen (TN) and total phosphorus (TP)] and response (biological community) variables; and (2) determine the breakpoint values of biological-community attributes and metrics in response to changes in stressor variables. Six of 11 diatom and 13 of 18 macroinvertebrate attributes and metrics were significantly and ecologically correlated (p-value < 0.10) with at least one nutrient measure. The diatom measures with the strongest correlations to nutrients were the Siltation Index, Diatom Pollution-Tolerant Index, percentage of *Cymbella* and *Achnanthidium*, and *Cymbella* group richness. The macroinvertebrate measures with the strongest correlations to nutrients were total number of individuals, *Ephemeroptera-Plecoptera-Trichoptera* richness, and average tolerance value.

Trophic-state is a classification system designed to “rate” rivers and streams based on the amount of biological productivity occurring in the water. To assess the trophic level of each stream, the median stressor concentrations for TP and TN were compared to Dodds’ trophic classification. Based on Dodd’s trophic-state classifications, streams in this study were most often classified as eutrophic based on the distribution of median TP concentrations (44 percent of values), and the distribution of median TN concentrations (56 percent). The biological breakpoints for the median concentrations of TP in this study were similar to the U.S. Environmental Protection Agency's proposed numeric TP criteria (0.037 mg/L), but the median concentration of TN were about 1.5 times higher than the proposed numeric TN criteria (0.69 mg/L). No sites were impacted adversely using median turbidity values for diatoms based on a 25 Formazin Nephelometric Units (FNU) biological threshold. The turbidity results for the macroinvertebrates were similar to the turbidity results for the diatoms. The breakpoints determined in this study, in addition to Dodds' trophic classifications, were used as multiple lines of evidence to show changes in diatom and macroinvertebrate community and attributes based on exposure to nutrients.

The goal of the study was not to develop numeric nutrient criteria, but to demonstrate the breakpoint analysis approach between nutrient concentrations and some aspects of diatom and macroinvertebrate attributes and metrics. Although the sample size was small, this study found meaningful relations between nutrient concentrations and changes in diatom and macroinvertebrate attributes and metrics in the Pennyroyal Bioregion. With additional biological data (such as chlorophyll *a* and fish), the biological assessment of diatom- and macroinvertebrate communities has a greater potential for success in developing and refining numeric nutrient criteria in the Pennyroyal Bioregion.

GENE EXPRESSION IN ZEBRAFISH (*DANIO RERIO*) FOLLOWING EXPOSURE TO GASEOUS DIFFUSION PLANT EFFLEUNT AND EFFLUENT RECEIVING STREAM WATER

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The expression of six genes known to serve as bioindicators of environmental stress were examined using real-time quantitative PCR in liver tissue extracted from zebrafish (*Danio rerio*) exposed to effluent and effluent containing stream water associated with the Paducah Gaseous Diffusion Plant. The PGDP, the only active uranium enrichment facility in the U.S., is located in western Kentucky and discharges treated effluents into several surrounding streams. Environmentally relevant concentrations of several heavy metals and polychlorinated biphenyls (PCBs) can be found in effluents emerging from the plant as well as in receiving streams. Fish were exposed in the laboratory to water from both effluents and downstream areas as well as to water from an upstream reference site. Expression of six genes known to be altered by metal and/or PCB exposure were quantified at both 7 and 14 day time points. Transcription of the biomarker enzyme cytochrome P4501A1 (CYP1A1) was significantly elevated in fish exposed to one plant effluent at both the 7 (16 fold) and 14 (10 fold) day time points. Sediment PCB levels from this site were the highest observed in the study, indicating PCBs may be contributing to the elevated CYP1A1

mRNA. Additionally, catalase, an enzyme responsible for hydrogen peroxide detoxification and known to be impacted by metal contamination, demonstrated significant alterations in expression in the effluent containing the highest concentrations of most metals observed in the study. Interestingly, despite the presence of metal levels consistent with the induction of metallothionein (MT) in other studies, no MT induction was observed. All other stress biomarker encoding genes were likewise unimpacted by effluent water exposure. These results strongly suggest that contaminants observed in this study altered transcription of catalase and CYP1A1 and provide an important link between pollutant levels and physiological effects.

RESTRUCTURING THE KENTUCKY GROUNDWATER DATA REPOSITORY DATABASE

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The Kentucky Groundwater Data Repository maintains groundwater information from over 15 sources, including State and federal agencies and other organizations. The principal contributor, however, continues to be the Kentucky Division of Water. Data uploads from DOW have been provided on a biannual basis since 2005. Each year, a major effort was required to input these data into the totally different framework of the Kentucky Geological Survey database. Recent improvements to the DOW database structure prompted KGS to completely redesign the Repository database to closely resemble that of DOW. This redesign will enable future data uploads to be seamlessly added to the Repository database with minimal interruption to users.

The search engine for the new database allows users to perform a geographical search for water wells and springs by county, 7.5-minute quadrangle, or by using a radius from a specified latitude and longitude. The resulting well or spring data can be viewed on a map or in tabular form, or downloaded to a text file or spreadsheet for use in GIS software. A link is also provided to run a water-quality search on the selected data set. The data vintage is currently through 2008, but an upload is being processed that will include all data for 2009.

The groundwater-quality database, part of the water-well and spring database, has also been restructured. The new water-quality data search engine includes the ability to search for any analyte in the database using a drop-down list. Previously the online search was limited to 38 parameters in five major categories: water properties, volatile organic compounds, inorganic solutes, nutrients and pesticides.

This poster uses Web screen captures to show procedures for searching, downloading, and displaying groundwater-well and spring data on the new search engine: kgs.uky.edu/kgsweb/DataSearching/Water/WaterWellSearch.asp (Fig. 1). For more information on water-well or spring data, contact the Survey at (859) 323-0524.

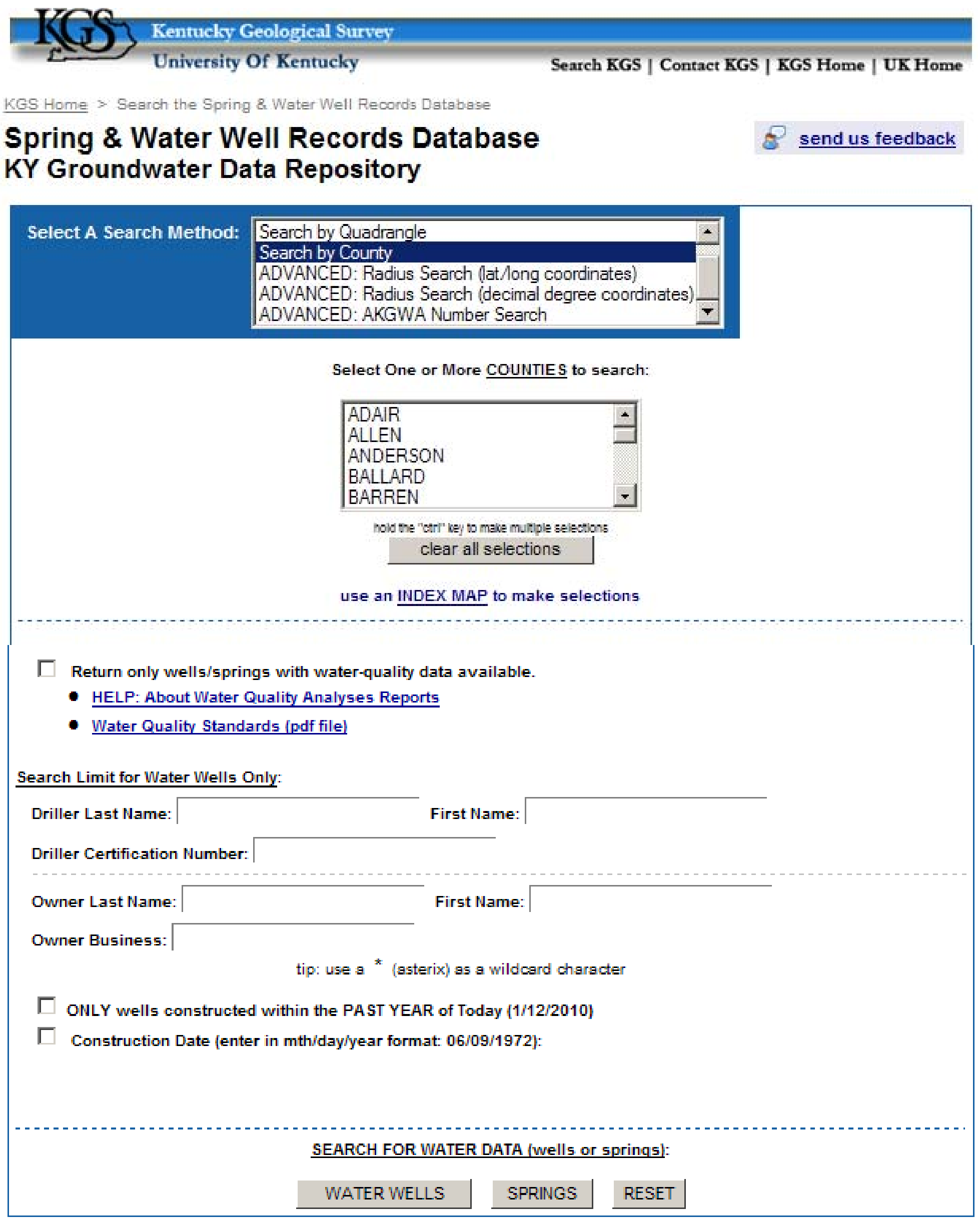

Figure 1. Layout of new water-well and spring search page.

FEASIBILITY OF USING ^{15}N-ENRICHED *E. COLI* AS A BACTERIAL TRACER IN THE CANE RUN/ROYAL SPRING BASIN

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Karst aquifers are an important source of groundwater in Kentucky, supplying water in both rural and urban areas and supplementing surface water in streams. The nature of karst aquifers and the ease with which unfiltered contaminants can enter them make them particularly vulnerable to contamination. A novel tracer method has used ^{15}N to label *Escherichia coli* and closely track the transport of bacteria, a common contaminant, through karst aquifers (J.W. Ward, 2008, PhD dissertation, University of Kentucky). Information on the fate of the ^{15}N label over the lifespan of the bacteria can extend the applicability of the tracing method.

A wild strain of *E. coli* was isolated from the Cane Run basin in the Inner Bluegrass region of Kentucky. Serotyping and virulence testing were performed to identify if the isolated strain had any of the characteristics of commonly pathogenic *E. coli*. Five karst microcosms were filled with sterilized water collected from Royal Spring in Georgetown and incubated at 14° C for 130 days. The wild-type *E. coli* was enriched in ^{15}N and used to inoculate each of the microcosms on day 0. The microcosms were sampled for *E. coli* concentration at days 0, 1, 3, 8, 15, 28, 60, and 130 and the δ^{15}N value of *E. coli* cells on days 1, 28, 60, and 130.

The wild-type *E. coli* was serotyped O^-:H^- and was negative for all of the tested virulence factors, indicating that the strain is likely commensal to either humans or animals. The *E. coli* survived for 130 days in sterilized Royal Spring water under simulated karst conditions. The concentration at day 0 was within the standard error of the concentration at day 130 and vice versa. The *E. coli* had a mean starting concentration of 5.62×10^{10} (standard error 4.12×10^{9}) and a mean ending concentration of 5.88×10^{10} (standard error 7.53×10^{9}). Statistical modeling showed no significant difference in δ^{15}N values from day 1 and day 130. The mean δ^{15}N value from day 1 was 834.6 ‰ with a standard error of 17.9 ‰ and the mean δ^{15}N value from day 130 was 1023.9 ‰ with a standard error of 55.5 ‰. This strain is therefore recommended for traces in the Cane Run watershed and Royal Spring groundwater basin. Use of this method could provide valuable insight into the movement of bacterial contaminants in the already-contaminated system, which would help improve remediation methods and strategies.

NOTES

THE USE OF STABLE ISOTOPE ANALYSIS TO IDENTIFY SOURCES OF SEDIMENT TRANSPORTED FROM FOUR APPALACHIAN WATERSHEDS IN SOUTHEASTERN KENTUCKY

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Stable isotope analysis was used to identify sources of soil particulate organic matter (SPOM) spatially in four watersheds with high gradients in the Appalachian region of southeastern Kentucky over a two-month sampling period. The four watersheds varied in the time since coal mining occurred with one watershed having reclamation about 20 years ago, one having reclamation about 5 years ago, one having active coal mining in progress, and one with old growth forest (no mining activities). Sediment sources were characterized and sampled in the four watersheds as the upland surface soils, the streambanks, and the streambed. Weekly samples of transported sediments were collected from the four watershed using *in situ* sediment trap samplers from April 2009 to May 2009 at outlet of each watershed. Streambank, streambed, and surface soil samples were also collected during this period. Bulk sediment-water samples collected from the traps and end-members were prepared in the laboratory to isolate the fine fraction of sediment with particle diameter less than 53 µm and then further prepared and analyzed for their carbon and nitrogen isotopic signatures on the stable isotope ratio mass spectrometer. The stable carbon and nitrogen isotope signatures of the surface soils and

streambanks bracketed the signatures of the streambed and transported sediments, which suggests that the streambed and transported sediments are a mixture of the uplands surface soils and the streambanks. It has been hypothesized that the streambed signature does not solely consist of a mixture upland surface soils and streambank samples, but also includes an enrichment of the signatures due to the benthic growth occurring in-stream. Research is ongoing to quantify the instream benthic processes associate with fine sediment deposition. The methods under further investigation are placing trap samplers to quantify the amount of enrichment over time and gathering bed samples at different points in the deposition's profile. A mass balance un-mixing model was used to calculate the contributions from each source to the transported sediments from each of the four watersheds.

REAL TIME SEDIMENT DISCHARGE ESTIMATES USING A TURBIDITY AND VELOCITY BEND SENSOR NETWORK

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Sediment is one of the major causes of impaired streams in the United States and threatens the ecology of watersheds. Total suspended solids have been difficult to quantify and sensor networks that provide real time data at a frequency high enough to measure sediment discharge have not been practical to implement. New technologies and monitoring techniques need to be developed that are easy to implement and operate. The objective of this study is to develop a sensor network so that a real time monitoring system for velocity and sediment discharge of any watershed can be implemented quickly and in remote locations.

New, real time inexpensive turbidity and velocity bend sensors will be applied. Turbidity sensors measure turbidity and a relationship between turbidity and concentration of total suspended solids (TSS) will be derived for the stream. Turbidity curves must be calibrated for each watershed as different sediment types will yield a different TSS turbidity curve. Velocity bend sensors measure velocity with a variable resistance strip;

the water causes the strip to bend and the resistance to electrical conductivity varies as the strip bends, and a relationship between velocity and resistance is found.

Salamanders are sensor networks designed by Prof. Harnett that are used to perform the research. Each Salamander is made up of a turbidity and velocity bend sensor placed on opposite sides of a pole but at the same height. This paired sensor configuration exists at three height locations on the pole with a pressure transducer at the base to measure depth of flow. This will allow the researcher to obtain vertical velocity and sediment profiles. To accurately represent a cross section's sediment and velocity profiles, many salamanders need to be placed in the cross section. Five Salamanders will be placed in a cross section perpendicular to the flow. One will be in the thalweg and two others will be placed closer to the banks. These three will be used to monitor base flow and also the center of larger events. Two additional salamanders will be placed (one on either bank) to ensure that large flows are adequately measured. The cross section location of salamanders may vary depending on the stream (in the stream which these are to be placed, the width varies significantly with discharge).

The sensor network operates so that each Salamander in the cross section transmits its data via radio signal to a device which will simultaneously log the data for back up and also relay the information to a cell phone located nearby. The cell phone receives data and sends this data to another phone which is linked to a computer in the office. The computer converts the data from binary into velocity, concentration, and depth using the relationships developed for the stream. This information is passed into a program that will use the known channel geometry in conjunction with the height, velocity, and concentrations given by the Salamanders to calculate the sediment discharge. The computer will store the intermediate and end results as well as provide the interface in which the real time data can be viewed.

So far, results of this new technology include relationships developed for new, inexpensive velocity and turbidity sensors. Full implementation of the project is ongoing at this time and includes collaboration between Civil Engineers at UK and Electrical Engineers at U of L. Results are expected to provide accurate data of suspended sediment load derived from the watershed that can be used to calibrate hydrologic and suspended sediment transport models. The sediment monitoring network will be set up at a location where sediment fingerprinting is occurring which will help provide insight into the source of the sediment. By the end of the research period, new techniques will have been developed so that instrumentation can be quickly set up in any watershed to capture the hydrologic and sediment fluxes in real time.

ESTIMATES OF PARTICULATE ORGANIC CARBON FLUX IN VARIOUS LEVELS OF THE WATERSHED SYSTEM

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Substantial levels of carbon are deposited and stored in oceanic sediments through means of organic carbon flux. Particulate organic carbon (POC) is the carbon associated with fine sediments and is differentiated from dissolved organic carbon by the size of the carbon particles. The fate and transport of POC in river systems is an important component of the carbon cycle because on the order of half of the POC transported is buried or mineralized in-stream. POC fate in streams and rivers has proven difficult to quantify at varying watershed scales. Source contributions of organic carbon vary from watershed to watershed. In streams, POC can accumulate from numerous sources such as runoff from fields and forest floors, gully erosion and growth of algae in the river bed. Smaller basins with steep slopes have little to no storage and are heavily impacted by events such as landslides; whereas large watersheds have relatively low slopes in which storage plays a substantial role. The objective of this study was to tie in existing POC flux estimates, obtained from the literature, to new estimates of POC flux from a small watershed in the lowland region of central Kentucky. In addition, a geospatial analysis of the United States was conducted in order to provide approximations for the country's POC flux.

A table summarizing POC flux from different watersheds was developed through review of existing literature. Flux was given for some studies however others needed to be calculated, with values being reported in t km^{-2} yr^{-1}. We found that values typically ranged from 0.5 to 3 t km^{-2} yr^{-1}, in agriculture/forested watersheds with mild gradients. Steep gradient, mountainous areas had significantly larger fluxes with values reaching 222 t km^{-2} yr^{-1}. POC flux from the lowland region in central Kentucky was modeled using inputs of TOC content found through analysis of *in situ* sediment trap samples, and an in house sediment transport model. The annual POC flux from the watershed was found to be 0.825 t km^{-2} yr^{-1}, which was comparable to the watersheds with mild gradients found in the literature. Though flux values from lowland regions are significantly lower than reaches with steep gradients, it is essential to determine their contribution to the carbon cycle because the areas are more abundant. Calculations can be integrated over large areas which in turn determine the POC flux contribution of basins with mild gradients. POC flux was found to vary primarily due to the hydrologic forcing, rather than seasonally, which agrees with research performed in agricultural areas in the Midwest. The sediments are derived from a number of sources including banks, surface erosion, and in-stream storage deposits. An initial estimate of POC generated in storage zones showed that 29% of the carbon is newly generated—showing the importance of benthic processes to the POC load.

Geospatial approximations were conducted using ArcGIS software to estimate POC flux throughout the United States. A sediment concentration map provided by the USGS, and STATSGO soils data provided by the NRCS were used to approximate POC flux. Source to sink values were approximated by the following equation; $POCFlux = (\%SOC) * (ER) * (Sed.Flux)$, where ER is the enrichment ratio, sed flux is the sediment flux for each catchment, and % SOC is the percent of soil organic carbon for the area. This study assumes that soil organic carbon is an adequate representation of eroded material in stream but accounts for SOC derived from different sources, namely, variability is considered should sediment be derived from subsurface or surface erosion. Enrichment ratios were also varied between 1 and 1.3 to account for benthic processes that occur in the streambeds. Results show high variability in POC flux results based on inclusion, or lack thereof, of source and fate processes.

Although the preceding results show high variability when quantifying POC flux from watersheds of different magnitudes, it is important to push this research forward to create a framework that can allow us to estimate POC flux and its contributions from different levels of the watershed system, i.e., from a small sub basin in central Kentucky, to the Mississippi River Basin. Looking forward, the longterm goal is to develop uniformity with respect to calculations of POC flux that incorporate source and fate processes.

STUDY OF PERFORMANCE OF VELOCITY BEND SENSORS IN FLOW OVER GRAVEL BED FLUMES AND RIVERS

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In past research, velocity sensor technology has gained importance for measuring and understanding the mean and turbulent characteristics of river flows. Inexpensive sensors which are reliable and accurate and which can be left in the field to monitor watersheds and understand the spatial variability of flow with time are needed.

The objective of this study was to test the inexpensive Velocity Bend Sensor (VBS) for performance under both field and lab conditions. In order to meet this objective, we determined the following specific goals: (a) Mean velocity was compared for different sensors and different velocity conditions. Comparison was performed between VBS measurements and “modeled” velocity measurements. (b) Turbulence quantities were compared for the lab conditions. Comparison was performed between VBS measurements and acoustic Doppler velocimeter (ADV) measurements at a point in the flow for the same conditions. (c) Mean and turbulence quantities were measured at the same time in the field with VBS, ADV and a propellometer to test the sensors in the field.

Statistical analysis, correlations, spectrum and moving average values of data obtained from both VBS and ADV were compared to identify the ability and accuracy of the VBS in collecting mean and turbulent characteristics of flow. Basic statistical analysis was helpful in identifying the range of error exhibited by the VBS in collecting the data while correlations were useful to compare the time scales and length scales of turbulence as calculated from both VBS and ADV. While the VBS measures only 10% of the turbulence intensity, it was able to capture macroturbulence length scales fairly reliably. Spectrum was useful to identify different amplitudes of velocity, i.e., small scale versus large scale turbulence, present in turbulence flow structure. The values found from both ADV and VBS compared well. The macroturbulent time-scale found from the measurements collected from both the ADV and VBS were calculated and compared using moving average technique. This study showed that the sensors were able to measure the mean and turbulent characteristics of flow reliably. This study thus helps to understand the performance and variability of the VBS to identify and measure mean and turbulent characteristics of flow.

SPATIAL PATTERNS OF NUTRIENT LEACHING IN A CENTRAL KENTUCKY PASTURE UNDERGOING FORAGE RENOVATION

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Endophyte-infected tall fescue (*Festuca arundinaceae*) is a dominant forage grass in the southeastern United States. Efforts are being made to find replacement forages for animal production, but knowledge about such renovation effects on soil structure, associated soil hydraulic characteristics, chemical transport, and pollution potential are limited. This study focused on the potential effect of forage renovation on nutrient leaching. Two tall fescue cultivars differing in endophyte infection status (KY 31 and novel endophyte-free KYFA9301) were planted in 3 m x 160 m-long strips spanning a sinkhole, which represents a typical topographic feature in central Kentucky pastures. A similar strip of the original undisturbed native pasture (a mixture of tall fescue, bluegrass [*Poa pratensis*], and mixed forbs) was also utilized. We analyzed and compared nutrient leaching patterns under each forage type by means of anion and cation exchange resins buried in each strip. Ion exchange resin lysimeters were installed at 50 cm depth along each 160 m transect with a 5 m lag distance between lysimeters to capture nutrient leaching. The resin lysimeters were installed on July 1, 2009 and recovered five months later. The net nutrient fluxes were analyzed in terms of forage variety, spatial structure, and spatial auto correlation. Spatial cross correlations between nutrient fluxes and related soil hydraulic properties such as pore size distribution, saturated hydraulic conductivity, bulk density and mean weighted diameters of soil aggregate were also evaluated.

NOTES

THE EFFECTS OF INVASIVE AMUR HONEYSUCKLE LEAF CONSUMPTION ON GREEN FROG TADPOLES

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Amur Honeysuckle (*Lonicera maackii*) is an invasive Asian shrub that thrives along the edges of aquatic ecosystems in Eastern North America. This shrub is one of the first to leaf out in the spring and one of the last to drop its leaves in the fall. Our previous investigations suggest that allochthonous litter of *L. maackii* decompose faster than native riparian leaf litter, changing the water chemistry and having negative external effects on frog tadpole growth and digestion, survival to metamorphosis, and froglet fitness (Fig 1 and Fig. 2). This raises the question of digestive effects in tadpoles when *L. maackii* leaves are a food source. This study investigates the impact on green frog (*Lithobates clamitans*) tadpole digestion of an algae diet mixed with different concentrations of *L. maackii* leaves or native riparian leaves throughout the experiment. The results of each replicate are compared to set of control tadpole replicates that were fed only algae. Feeding experiments were carried out over four weeks, and dried food and fecal output material were used in nutritional analyses. Fig. 3 suggests that energetically, tadpoles consumed significantly more food when it did not contain leaf material and food containing honeysuckle was consumed the least. Assimilation efficiencies were calculated from a variety of laboratory based tests including: caloric content, percent

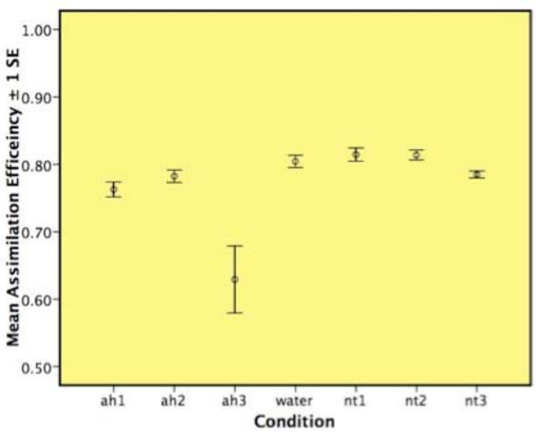

Fig. 1. Energy assimilation by tadpoles raised in Amur honeysuckle (AH) or native (NT) tea under various concentrations (1 – 3 [strongest]).

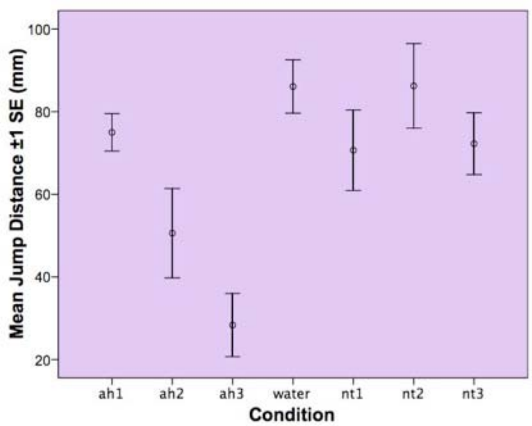

Fig. 2. Fitness (jumping performance) of frog metamorphs raised in Amur honeysuckle (AH) or native (NT) tea under various concentrations (1 – 3 [strongest]).

nitrogen (crude protein) analyses, organic content from ash-free dry mass, and spectroscopic analyses of mineral (Ca^{+2}, Mg^{+2}, Na^{+1}, etc.) depletion. Fig. 4 indicates that the tadpoles extracted the greatest amount of energy from the control diet, and that more of the honeysuckle diet was assimilated than that from native plant leaves. Total and lignated fiber analyses were carried out with the Van Soest method.

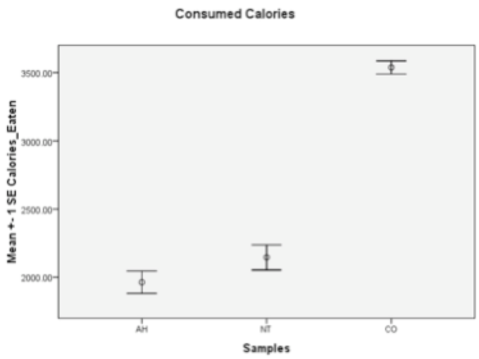

Fig. 3. Caloric content of algae food containing either leaf matter of Amur honeysuckle (AH) or native (NT by tadpoles) plants or lacking leaf matter (control) consumed by tadpoles.

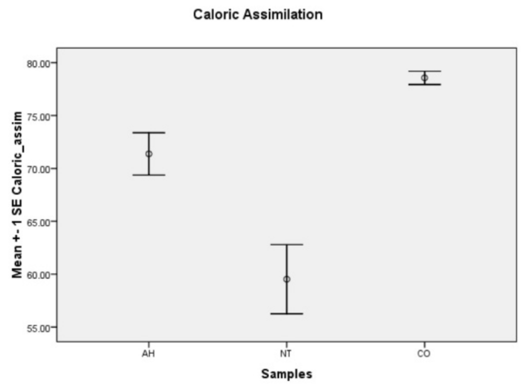

Fig. 4. Calories assimilated by tadpoles that consumed either algae food containing leaf matter of Amur honeysuckle (AH), of native (NT) plants or lacking leaf matter (control).

IMPACT OF THE INVASIVE AMUR HONEYSUCKLE (*LONICERA MAACKII*) ON STAND TRANSPIRATION IN A WETLAND FOREST

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The effect of Amur honeysuckle (*Lonicera maackii*) on water use by a wetland forest near the Ohio River was determined during the summer of 2009. An old-growth stand was compared with a second-growth stand on the St. Anne Wetlands Research and Educational Center in Melbourne, KY. While the old-growth stand had a very sparse shrub canopy, the second-growth stand had a dense cover of Amur honeysuckle. Shrub basal area was more than 5 times greater on the second-growth stand, and >85% was honeysuckle (Table 1).

Basal Area (m^2 ha^{-1})	**Old-Growth**	**Second-Growth**
Trees	20.3	38.7
Shrubs	0.45	2.05
L. maackii (% shrub total)	0.34 (75.5%)	1.76 (85.9%)

Table 1. Tree, shrub and Amur honeysuckle basal area at the old-growth and second growth stands.

Sapflow rates in trees and large shrubs were measured with Granier sapflow probes, while rates in small shrubs were determined with heat balance sensors. Sapwood areas were then used to calculate transpiration rates. Transpiration rates from trees were similar in the two stands (Fig. 1). Shrub transpiration from the old-growth stand was only 1.4% of the tree transpiration (0.9% from honeysuckle), but 6.7% (5.5% from honeysuckle) from the second-growth stand (Fig. 1-2). Shrub transpiration was dominated by *L. maackii* in the second-growth stand (Fig. 2-3). Because of its extended leaf-out period, *L. maackii* continued to transpire late in the fall, when tree and native shrub transpiration has ceased (Fig. 3). Amur honeysuckle transpired the equivalent of ~7 mm of rainfall in the second-growth site over the monitored period, whereas it transpired the equivalent of ~ 1.3 mm in the old-growth site, a greater than 5-fold increase. The additional transpiration caused by *L. maackii* may shorten the lives of ephemeral ponds and streams in wetlands, with adverse impacts on organisms, such as amphibian larvae, that require them.

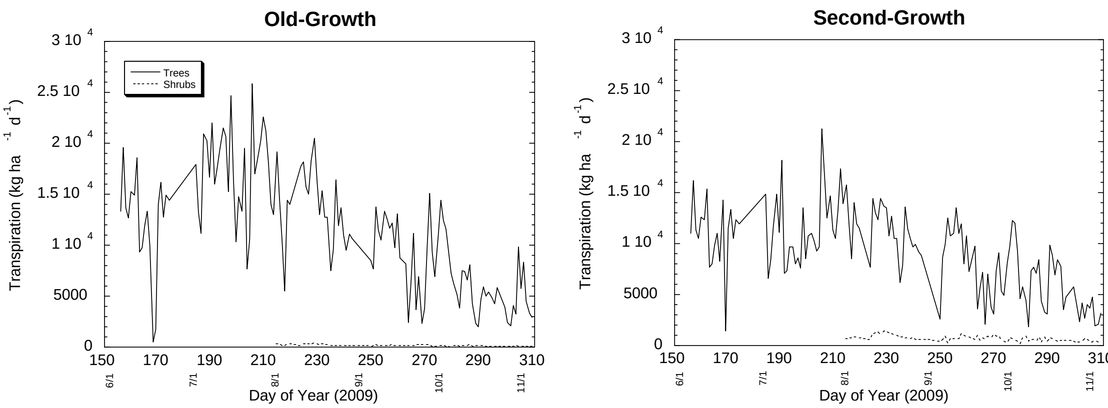

Fig. 1. Transpiration rates for trees and shrubs in each of the two stands. Both day of year and date are shown on the x-axes.

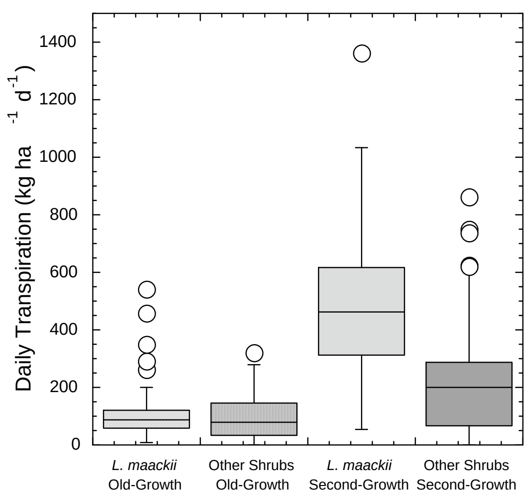

Fig. 2. Boxplots, showing medians and ranges, of daily transpiration rates for *L. maackii* and other shrubs in each of the two stands.

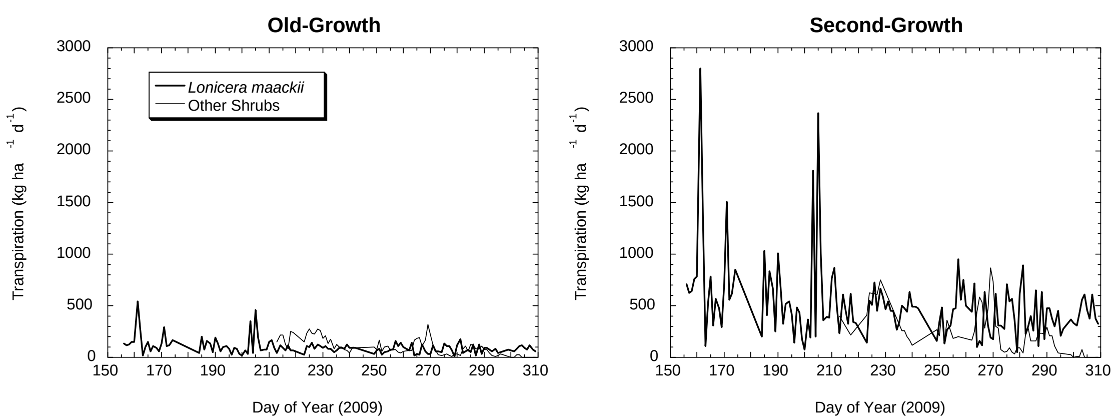

Fig. 3. Transpiration rates for *L. maackii* and other shrubs in each of the two stands.

RELATIONSHIP BETWEEN FECAL COLIFORM AND E COLI VALUES WITHIN THE KENTUCKY RIVER BASIN

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Fecal coliform criteria for primary and secondary contact recreation were first proposed by the federal government by the National Technical Advisory Committee in 1968. Potential deficiencies of using fecal coliform as a pathogen indicator organism were later identified by a National Academy of Science Report in 1972. Despite, these deficiencies, EPA standardized the adoption of fecal coliform for use as an indicator organism in 1976. Finally, in 1986, EPA published recommendations for a shift from using fecal coliform to a more specific coliform species (i.e. E coli) in 1986. In subsequent years, various states have begun the process of transitioning from using fecal coliform to E coli. Kentucky is one of those states. Currently, water quality criteria for primary and secondary recreation include both species. However, a significant amount of the legacy bacteriological data collected in the state have been fecal coliforms. Indeed, in some cases, fecal coliforms continued to be used. Given that fact, it would be beneficial to have some way to relate fecal counts to “equivalent” E coli counts. Several states, including Ohio, Virginia, and Oregon have attempted to develop such relationships. One thing that has come out of these efforts is the realization that such relationships tend to be regionally or even locally dependent. This poster will summarize efforts to develop such a relationship for the Kentucky River Basin using water quality samples collected over the last ten years by Kentucky River Watershed Watch. The resulting relationship may be used to estimate possible equivalent values for the purposes of extending existing fecal coliform data sets, or extrapolating backward to obtain extended series of E coli values.

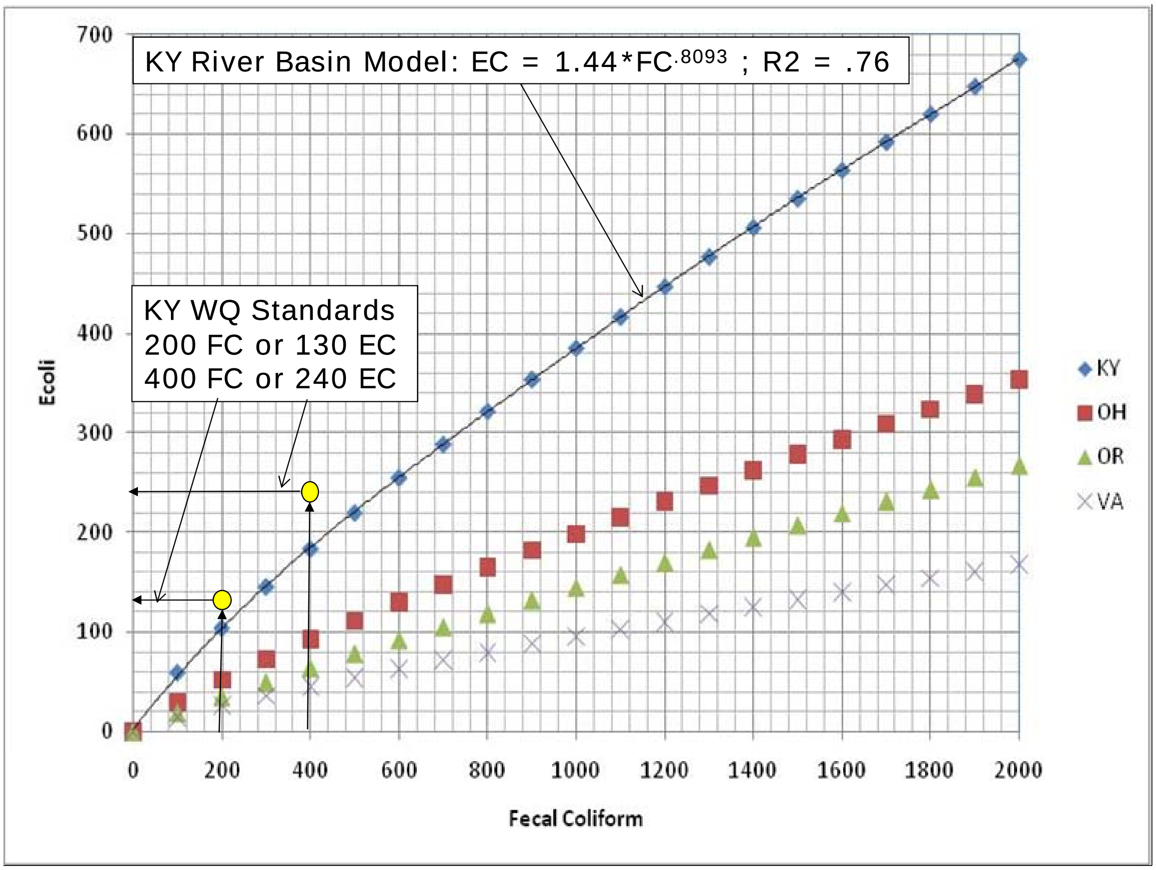

Figure 1. Relationship Between Fecal Coliform and E coli in the Kentucky River Basin

TEN MILE CREEK WATERSHED BASED PLAN

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This project addresses illegal point source issues (i.e. straight pipes and failing septic systems) within the Ten Mile Creek subwatershed of Eagle Creek, the majority of which is located within Grant County. Ten Mile Creek is a fifth order stream that joins with Eagle Creek near the town of Folsom. Arnolds Creek is a major tributary of Ten Mile Creek that enters near the stream mouth. Independent sampling results from the TMDL development process and from Kentucky River Watershed Watch volunteer sampling suggest that these tributaries are contributing to the overall pathogen contamination of Eagle Creek.

This poster will provide an overview of water quality sampling, watershed plan development, and best management practice (BMP) development and implementation associated with 319 funded activities in the watershed from 2004-2009. Specific activities conducted in the watershed have included: a grant incentive program to upgrade problem onsite wastewater systems (including straight pipes); public education encouraging agricultural and construction of BMPs; water quality education efforts in communities and local schools; and community efforts to increase the appreciation of the recreational and aesthetic value of the Eagle Creek Basin. Onsite wastewater system upgrades were begun in May 2006 and concluded in August 2008, with 85% of the work being done by the end of 2007.

A split sample statistical analysis of pre and post sampling (2004-2006 versus 2007-2009) reveals improvement of water quality conditions at all monitored stations, with the majority of stations showing a statistical level of confidence in excess of 90%.

Table 1. Water Quality Regarding Fecal Coliform Bacteria.

Sampling station	Total number of samples (2004-2006)	Number of samples with fecal coliform counts > 400 cfu/100 ml (2004-2006)	Percent violations (2004 - 2006)	Total number of samples (2007-2009)	Number of samples with fecal coliform counts > 400 cfu/100 ml (2007-2009)	Percent violations (2007 - 2009)
K318	34	7	21%	35	3	9%
K319	35	8	23%	36	5	14%
K321	34	8	24%	36	7	19%
K327	35	8	23%	36	6	17%
K328	32	8	25%	36	5	14%

Table 2. Probability of Improvement Fecal Coliform Values for Sampling Stations.

Sampling station	Mean of ln transformed data		t test results at a 95% Confidence Level	Actual Confidence Level
	(2004-2006)	(2007-2009)		
K318	4.717	4.034	Barely Fails 95% (t<1.67)	94.1%
K319	4.930	4.658	Fails 95% (t<1.67)	71.3%
K321	4.968	4.434	Fails 95% (t<1.67)	86.5%
K327	5.102	4.231	Meets 97.5% (t>2.00)	97.5%
K328	5.121	4.330	Meets 95% (t>1.67)	95.8%

Figure 1. Location of Sampling Sites

PATHOGEN TMDL FOR SOUTH ELKHORN WATERSHED

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This poster summarizes activities associated with the development of a fecal coliform Total Maximum Daily Load (TMDL) for South Elkhorn Creek. The South Elkhorn Creek watershed is contained within Fayette, Franklin, Jessamine, Scott, and Woodford Counties, in central Kentucky. The watershed receives drainage from the Town Branch subwatershed, the Wolf Run subwatershed, and the Steeles Run subwatershed, all of which drain highly urbanized areas of Lexington, Kentucky, in Fayette County. The watershed also contains the city of Midway in the Lee Branch subwatershed located in the northeast corner of Woodford County.

The Kentucky Division of Water's 2008 303(d) list of waters for Kentucky indicates that the South Elkhorn Creek watershed does not support Primary Contact Recreation use due to fecal coliforms. The streams include South Elkhorn Creek (river mile (RM) 16.6 to 34.5), Town Branch (RM 0.0 to 9.2, and RM 9.2 to 10.6), and Wolf Run (RM 0.0 to 4.1). Additional sampling as part of the development of this TMDL has documented impairment with additional stream miles within the larger South Elkhorn watershed (see Figure 1).

In order to assess the sources and associated fecal coliform loadings in the South Elkhorn Creek watershed, an HSPF computer model of the watershed was developed subdividing the watershed into 45 catchments. The US EPA Bacterial Indicator Tool (BIT) was used to determine the initial loading conditions in the watershed. Loads were allocated between both permitted and non-permitted sources. Permitted sources included KPDES point sources (e.g. wastewater treatment plants) and municipal separate storm sewer system (MS4) nonpoint sources (e.g. stormwater runoff). Non-permitted sources included non-MS4 nonpoint sources and illegal point sources (e.g. straight pipes, sanitary sewer overflows, and failing onsite wastewater treatment systems). Once the initial loads were developed and the model calibrated, HSPF was used to simulate the effect of incremental load reductions on water quality until all water quality criteria were satisfied.

Loads were divided between a wasteload allocation, a load allocation, and a margin of safety. The wasteload allocation included KPDES point sources and MS4 sources from developed lands. The load allocation included MS4 sources from non-developed lands, and non-MS4 sources (including both developed and non-developed sources). All illegal sources were assumed to be eliminated. A margin of safety was enforced through the adoption of conservative modeling assumptions. The difference between the allowable load and the initial conditions is the reduction required. Wastewater Treatment Plants receive no percent reduction in this TMDL report, as their permit limits are already set at the water quality criterion.

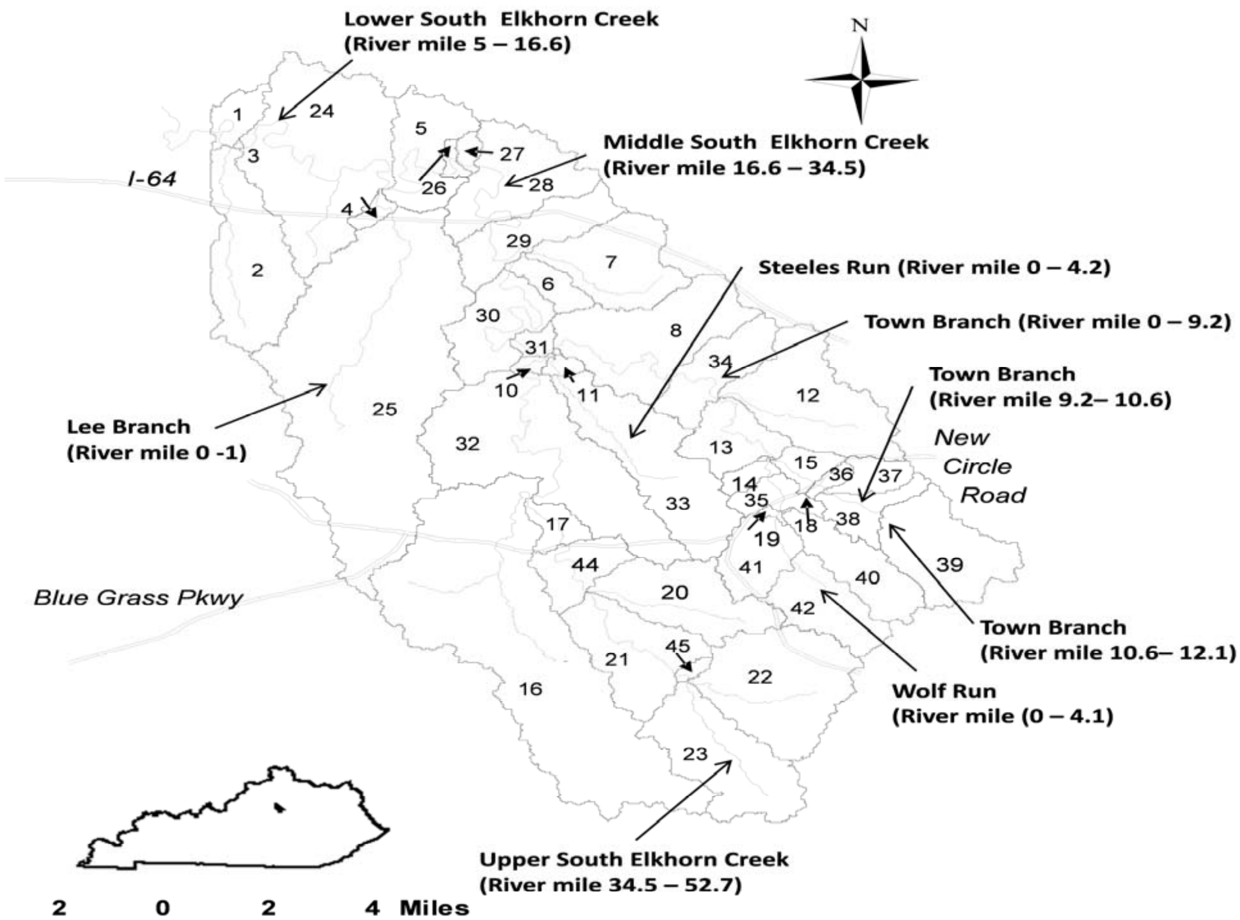

Figure 1. Map of South Elkhorn Watershed with Subbasins and Impaired Stream Segments