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Impacts to the land-water-human system of rural Iowa from high intensity continuous maize production

C. Lee Burras
Iowa State University, lburras@iastate.edu

Thanos N. Papanicolaou
University of Iowa

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Abstract

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Keywords

Agronomy, Corn-soybean cropping systems, Farming systems, Models and assessment tools

Disciplines

Agronomy and Crop Sciences | Fresh Water Studies | Statistical Models

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Abstract:
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Principal Investigator:

C. Lee Burras
Agronomy
Iowa State University

Co-investigator:
Thanos Papanicolaou
IIHR—Hydroscience & Engineering
University of Iowa
Iowa City

Budget:
$14,675 for year one
$4,706 for year two

QCan grassed waterways and buffers bring about high water quality in watersheds with continuous corn production?

AThis was answered in two steps. Step 1 modeled the effectiveness of grassed waterways in Clear Creek watershed. Step 2 examined the degree to which water quality is related to grassed buffers in typical Iowa watersheds. Results from Clear Creek show properly designed and constructed grassed waterways are highly effective in maintaining water quality in runoff regardless of cropping systems. Results from typical streams show only a weak relationship exists between water quality and buffer strips. It is unclear why the two results are inconsistent with one another. Explanations range from possible experimental flaws--e.g., grassed waterways in step 1 versus buffer strips in step 2--to geological-induced differences from one location to the next to the possibility of there being a lag time between when runoff quality improves to when stream quality improves.

E C O L O G Y

Background

Balancing freedom in farming decisions and water quality is a critical issue in Iowa where the balance point could have profound economic, social and environmental effects. Iowa scientists study water-land relationships from every perspective and scale imaginable to help determine that balance point. It is important that their analyses indicate where and when certainty and uncertainty occur.

The initial objective of this study was to develop a sound stable of management practices that meet soil and water quality goals while reaching targeted goals of corn production necessary for the production of ethanol. As the project advanced, this was found to be too open-ended and was modified into two more tightly defined objectives. The first and larger objective was to evaluate grassed waterway efficiencies using the Water Erosion Prediction Project model (WEPP) in the Clear Creek watershed west of Iowa City. This watershed was selected because 1) it is representative of the southern Iowa Drift Plain, which is Iowa's largest soil region and the region that contains some the state's best and worst soils, as well as some of Iowa's most challenging rivers; and 2) Clear Creek watershed is perhaps the best understood and monitored agricultural watershed in Iowa.

The second objective was to use publicly available water quality data to evaluate whether small Iowa watersheds exhibit a general cropping intensity-water quality threshold. This evaluation was valuable because while WEPP modeling and water quality tests of Clear Creek watershed show expected relationships (i.e., good field management such as best-placed grassed waterways results in clean runoff, while poor management results in declining water condition), it was less clear at what point

those best practices translate into improved stream quality across the range of major land regions present in Iowa.

Approach and methods

Phase 1 of the project sought to establish what general water quality-stream order relationships are in place across Iowa. Phase 2 evaluated whether water quality of small watersheds changed proportionally with the extent of buffer strip presence. Year 2 activities occurred in two phases. Each was grounded in readily available STORET data on water quality, which is part of the Iowa Storet\WQX Water Quality Database (https://programs.iowadnr.gov/iastoret/).

Deb McDonough, an ISU undergraduate student supervised by Lee Burras, completed Phase 1 during 2010-2011. McDonough used ArcGIS and Excel spreadsheets to analyze STORET data for 95 points from eleven HUC 8 watersheds distributed across Iowa. Her work examined whether water quality changed as a stream progressed from being order 1 through, in some cases, order 6. She also looked at the STORET data for several lakes. Her efforts, while considerable, failed to find any general trends in water quality, stream order and/or location.

McDonough's work did yield two critical observations. First, it appeared that higher order streams in Iowa display water quality that is generally, but not always, consistent with their lower order tributaries regardless of high or low flow or year of sampling. Second, it demonstrated the difficulty in determining land use details, let alone history, for a large set of watersheds when using STORET sites.

Results and discussion

Year 1 of the project addressed the thorny issue of water quality preservation by identifying the threshold parameters needed for grassed waterways to significantly reduce runoff and sediment from fields. A range of cropping, landscape and hydrological conditions were considered by Thanos Papanicolaou and his University of Iowa team. Year 1 demonstrated that well-designed and well-placed grass waterways reduce runoff and sediment contributions to streams across a wide range of landscape, hydrologic and cropping scenarios. It also showed that WEPP is a powerful modeling tool for evaluating the impact of continuous corn relative to watershed hydrology and stream quality. Work done in Year 1 was very successful and largely completed the original tasks set out in this grant.

The success of Year 1 led to the Year 2 focus on determining the point at which well-established conservation practices translate into meaningful improved water quality in nine watersheds with an area of 20-100 square miles. In essence, Year 2 asked: Is today's water quality in rural Strahler order 3 streams genuinely influenced by adding more buffer strips? Lee Burras from Iowa State University led the Year 2 efforts.

Rather than grassed waterways, buffer strips were used as a proxy for all conservation practices in Year 2 because they are meant to directly protect the stream from runoff and sediment. They also have the advantage of being fairly straightforward to identify and measure from aerial photographs. The water quality data used in Year

2 came from public-accessible STORET sites maintained by the Iowa Department of Natural Resources.

The main finding of Year 2 was that water quality in Strahler order 3 streams is weakly correlated with the proportion of buffer strips used along its stream channels. This result is neither surprising nor discouraging. It shows that putting more buffer strips along streams (or grassed waterways in fields) results in better water quality, but that improvement is rarely immediate or huge. After all, there are many interactive factors affecting stream quality and only a few result in improved water within a year or two. Some might take a decade or more to be truly effective.

Conclusions

1. Grassed waterways improve runoff quality and stream quality when they are effectively sited and of appropriate size, even across a range of landscape, hydrologic and cropping conditions.
2. WEPP is an effective way to model best use of grassed waterways in continuous corn.
3. Strahler order 3 streams from across Iowa have water quality that correlates poorly with the total extent of riparian buffer strips present. That poor correlation reflects the complexity of gauging water quality, as well as a likely lag time between when conservation practices are put in place and their impact is maximized.

Perhaps the most important point to share is that conservation practices and watershed models do work, although their efficacy is variable in real world settings such as Iowa's Strahler order 3 watersheds. Studies such as this one would be enhanced by easier access across databases, including access to geo-referenced land use information available at agencies such as the Natural Resources Conservation Service. It is recognized, however, that private landowner rights would need to be carefully safeguarded.

Impact of results

The objectives were achieved in a scientifically-defined sense. The results are less clear from the broader perspectives of "how will this affect Iowa agriculture" or "how can Iowans use these results." Year 1 clearly validated the idea that grassed waterways are a crucial conservation practice. One could argue that grassed waterways are not new and a scientific improvement on threshold design isn't very important in the big picture. However, making such an argument misses a key point: Grassed waterways, such as windbreaks and other "old school" practices, are being removed as farm equipment and fields become larger. This heightens the value of newer, more rigorous scientific studies (such as that done during Year 1) that both reaffirm and improve in-field conservation practices. It is crucial that Iowans use those results to increase their use of well-designed grassed waterways.

Results from Year 2 are less scientifically robust than Year 1 and, as a result, it is more difficult to determine how they affect Iowa agriculture. Year 2 results are less robust because the watersheds examined were "uncontrolled." Their current and historical management are unknown beyond the extent of buffer strips, so there is considerably more scientific uncertainty about them. In general, Year 2 offers a

reminder that many factors such as e.g., weather, crop type, soil properties, tillage, etc., affect water quality in Iowa and improvements across stream orders will require spatially and temporally sustained efforts.

Education and outreach

Publications
Dermisis, D., O. Abaci, A.N. (Thanos) Papanicolaou and C.G. Wilson. 2010. Evaluating grassed waterway efficiency in southeastern Iowa using WEPP. *Soil Use and Management* 26:183-192.

Outreach
Papanicolaou A.N. (Thanos). 2013. Promoting Sustainable Land Management (video). Available at: http://www.iihr.uiowa.edu/tpapanicolaou/videos/ (Note: the video integrates this project with several others.)

Papanicolaou A.N. (Thanos). 2013. Coupled natural-human systems (web page). Available at http://www.iihr.uiowa.edu/tpapanicolaou/coupled-natural-human-systems/#GettingThePointAcross, reviewed February 08, 2013. (Note: the website integrates this project with several others.)

Leveraged funds

This project was extensively leveraged vis-à-vis Year 1 given the thoroughly integrated approach of the Papanicolaou Research Group. Burras leveraged year 2 of this project through the use of student class projects.

For more information, contact:
Lee Burras, ISU Agronomy, 1126 Agronomy Building, Ames, IA 50011-1010; (294) 294-0559, e-mail lburras@iastate.edu