Effects on Aquatic and Human Health Due to Large Scale Bioenergy Crop Expansion

Brad J. Love [1], Matt D. Einheuser [2], A. Pouyan Nejadhashemi [1,2]

1.Department of Biosystems and Agricultural Engineering and 2. Department of Crop and Soil Science

Michigan State University

MICHIGAN STATE UNIVERSITY

Environmental Modeling Lab

Introduction

• Global energy consumption will increase by 57 percent in the next 25 years (Rooney et al., 2007).

•Increased agricultural inputs may result in pollutant loadings in water leading to negative effects on human safety and aquatic ecosystems (Carpenter *et al.*, 1998).

•Pesticides impair behavioral and physiological characteristics of aquatic organisms (Cook and Moore, 2008; Scott and Sloman, 2004).

•Some pesticides may be carcinogenic and others affect humans in other ways including risks to the nervous system and hormones, and skin irritations (Omalley, 1997).

Objectives

- Evaluate the effects of large-scale bioenergy expansion on fish and humans from pesticides
- Determine the possible stream impairment of increased pesticide use
- Identify the temporal and spatial variation of stream impairment
- Obtain information for decision making regarding landuse management

Materials and Methods

In order to effectively model the dynamic relationships of pesticides at a watershed scale, a reliable hydrodynamic model must be used (Holvoet *et al.*, 2004). Therefore, in this study SWAT model was used.

• The biological indicator chosen for this study was the LC50 for fish species ⟶ concentrations for a set period of time that are lethal to 50 percent of a test population (Helfrich, 2009).

• In this study, the Bluegill (Lepomis macrochirus) was selected as a biological indicator to represent the aquatic health and habitat needs of other aquatic life (Fargione *et al.*, 2009).

• The biological and human threshold values for different herbicides were obtained from thousands of studies available on the USEPA's ECOTOX database (USEPA, 2010).

Materials and Methods (cont)

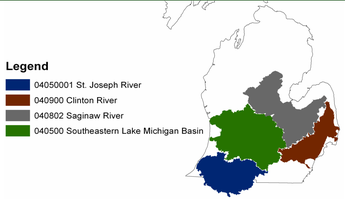

Figure 1. Basins included in study area.

•The SWAT model was calibrated for flow, sediment, and nutrients.
•Bioenergy cropping rotations were developed to provide a depiction of the practices that would be likely associated with these crops in MI.

Results and Discussion

Basin-wide Concentration Fluctuation

- Daily concentrations of pesticides in stream reaches were collected within the study area for the period (2000-2006)
- Base scenario (current landcover and practices) less than the threshold for bluegill ecotoxicity
- Switchgrass has the lowest median values indicating that this rotation is the safest of any of the rotations examined

Basin-wide Impact of Pesticides on Stream Impairment

Table 1. Kilometers of stream segments exceeding threshold toxicity levels for the bluegill and humans.

Scenario		Atrazine	Bromoxynil	Glyphosate	Metolachlor	Pendimethylin	Sethoxydim	Trifluralin	2,4-D	Total
Base	Bluegill	0	0	0	0	0	0	0	0	0
	Human	180597	0	1033	1348	0	0	0	0	181630
Continuous Canola	Bluegill	0	0	0	0	0	0	17152	0	17152
	Human	0	0	0	0	0	11	110790	0	108842
Continuous Corn	Bluegill	657	0	1063	2906	0	0	0	0	3970
	Human	532056	0	8572	34121	0	0	0	0	541152
Continuous Corn stover	Bluegill	0	0	0	0	0	0	0	0	0
	Human	399423	0	422	4377	0	0	0	0	399846
Continuous Rye	Bluegill	0	0	0	0	0	0	0	0	0
	Human	0	0	1327	0	0	0	0	137677	139004
Continuous Sorghum	Bluegill	0	0	0	6.3	0	0	0	0	6.3
	Human	339631	105	473	7770	0	0	0	0	340198
Continuous Soybean	Bluegill	0	0	0	0	0	0	0	0	0
	Human	154049	0	4727	1901	0	0	0	0	158777
Corn Soybean	Bluegill	0	0	0	0	0	0	0	0	0
	Human	173001	0	3536	2734	0	0	0	0	176537
Corn Soybean Rye	Bluegill	0	0	0	0	0	0	0	0	0
	Human	81117	0	3690	182	0	0	0	12972	97779
Corn stover Soybean	Bluegill	0	0	0	0	0	0	0	0	0
	Human	173169	0	3393	2737	0	0	0	0	176561
Miscanthus	Bluegill	0	0	0	0	0	0	0	0	0
	Human	0	0	0	0	0	0	0	0	0
Native Grass	Bluegill	0	0	0	0	0	0	0	0	0
	Human	0	0	0	0	0	0	0	0	0
Sorghum Soybean	Bluegill	0	0	0	0	0	0	0	0	0
	Human	130941	84	4083	3493	0	0	0	0	158033
Switchgrass	Bluegill	0	0	0	0	0	0	0	0	0
	Human	212	0	2590	0	0	0	0	7161	9963

Results and Discussion (cont)

- Base ⟶ impairment of 1.6% of streams
- Continuous corn results in 7719 km increase of impaired streams over base (glyphosate) and a total of 4.7% of all streams being impaired based on human toxicity thresholds
- Switchgrass resulted in a 171,667 km reduction in total stream length that exceeds the human threshold criteria

Basin-wide Temporal Variation of Stream Impairment

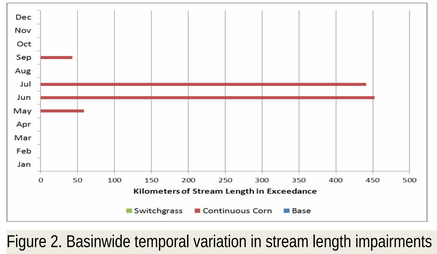

Figure 2. Basinwide temporal variation in stream length impairments of three crop rotation scenarios based on fish thresholds

- Overall, June appears to be the month that the most streams (in length) exceed the threshold limit for the Bluegill, followed by July with 452.4 and 441 kilometers, respectively.

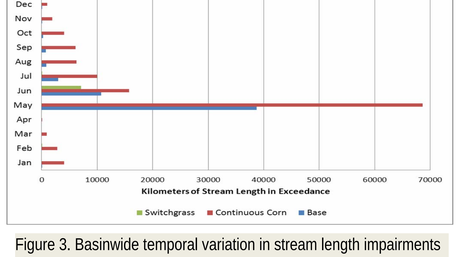

Figure 3. Basinwide temporal variation in stream length impairments of three crop rotation scenarios based on human thresholds

- May, June and July had the most stream segments exceeding the human health thresholds for atrazine, glyphosate, and metolachlor.

Results and Discussion (cont)

Basin-wide Spatial Variation of Stream Impairment

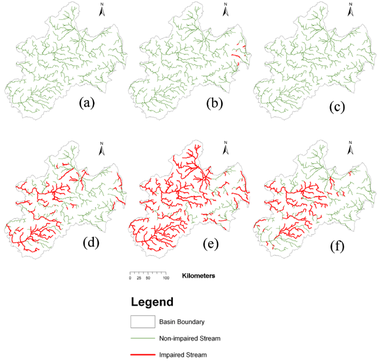

Figure 4. Streams exceeding Bluegill toxicity threshold for (a) base, (b) continuous corn, and (c) switchgrass scenarios. Streams exceeding human threshold for (d) base, (e) continuous corn, and (f) switchgrass scenarios.

- All three rotations have the potential to drastically impair surface waters for human consumption Continuous corn rotation is the only rotation to exceed bluegill ecotoxicity levels
- Percent impaired waterbodies:
  - Base (34.5%)
  - Continuous Corn (77.8%)
  - Switchgrass (38%)

Conclusions

Based on these results, large environmental cost might be associated with future large-scale bioenergy crop expansion.

• Extensive waterbody impairments, whether bluegill or human, strongly challenges the suitability of continuous corn rotations for large-scale implementation

• Variability of pesticide concentrations between different geographic landscapes suggests bioenergy crops may be suitable if pesticides application managed properly