Informing the Debate

Michigan Applied Public Policy Brief

Impact of Agriculture on Water Quality: Michigan Resident's Perceptions

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Informing the Debate

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The Urban Research Interest Group recognized the pressure on urban core leaders to make critical decisions that continue to impact people long into the future. A commitment to generating background research to add to the core of debate on possible solutions to complex, urban problems was made.

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MAPPR Policy Research Brief

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Summary

This report details a study conducted by the Center for Economic Analysis at Michigan State University and the Michigan State University Extension Winter Manure Application Issue Group, in which potential economic changes due to new restrictions for winter manure practices are considered. Winter application of fertilizers and manures to croplands can lead to nutrient runoff into freshwater systems via tile drainage which can result dangerous water use problems such as restricted access to clean drinking water or beach closures. While this issue has been researched and discussed in the agricultural and environmental arena, this is the first study to broadly consider residents' perceptions across Michigan. The motivation for this study is to better inform policy makers on the issue of winter manure applications, in particular what Michigan residents think. This study may also reflect on the effectiveness that the messaging on factors that contribute to water quality has had on the general public, in particular the International Joint Commission efforts to inform about the potential hazards related to winter manure applications. To accomplish the study objectives, we used Michigan State University's State of the State Survey as a platform to gage Michigan residents' opinion, and developed statistical and economic models to identify some residential characteristics that may influence these opinions as well as to determine residents' willingness to pay for a new, hypothetical policy intended to improve the state's water quality. The results of this study indicate that Michigan residents are concerned about water quality, and think that both urban and farm runoff contributes to water quality problems. However, about two-thirds of residents are also opposed to restricting the practice of winter manure applications on Michigan cropland. On the other hand, residents expressed an interest in a policy that would lead to improved water quality and in aggregate are willing to pay about an additional $63 million statewide annually for such a policy.

Introduction

Large quantities of nutrient runoff into surface water bodies can pose significant environmental, health and economic threats (Frame et al., 2012; Michalak et al., 2013). This has been demonstrated by multiple beach closings and fish advisories due to algal blooms. Algal blooms pose a contact and consumption hazard in water, and excessive algae lead to hypoxia, a condition where decay of algae depletes water of oxygen which, in turn, impacts fish populations. A recent report by the International Joint Commission lists agriculture as a major source of phosphorus loadings to Lake Erie, and recommends banning the spreading of manure and other biosolids on frozen or snow-covered ground (International Joint Commission, 2014).

In August 2014, Ohio lawmakers met with the Ohio Environmental Council to address legislation to ban winter manure applications by agriculture producers (OEC 2014). This meeting was one of many in direct response to the buildup of microcystic algae that made tap water to the 500,000 residents of Toledo, Ohio unsafe in the summer of 2014. When the summer 2014 Ohio water crisis occurred, most Great Lake states had some form of state-level mandates regarding winter manure applications that go beyond the directives of the EPA (MPCA 2011; OISC 2013; UIUC 2014; WDNR 2013). At the time, Ohio and Michigan were two exceptions. Due to the public pressure in the state and region, new legislation was signed by the Ohio governor in April 2015 banning winter manure application (Reese 2015). The proximity of Michigan to Ohio combined with the state and regional public pressure resulted in the Michigan Department of Environmental Quality to respond with changes to the general CAFO permit in May 2015; seeking detailed accountability of manifested manure movement from January through March (Michigan DEQ 2015). However, winter manure practices have not been banned outright in Michigan and the public is asking why this is the case.

One potential reason is that the agriculture industry is unclear and concerned, in particular about the intersection of the science—*that identifies the cause*—and policy—*the actions to address the cause* (Henry, 2015). Another potential reason winter manure practices have not been banned may be economic considerations. For example, changes to agricultural practices will have economic consequences, and understanding the public's views on such consequences is vital to informed public policy decision making. Without the appropriate intelligence, well-intended regulation may not have the intended impact. Further, these potential policies could be perceived in the public eye as a step in the wrong direction having negative economic consequences.

Study Objective

In this study, we use primary data from Michigan State University's (MSU) State of the State Survey (SOSS) to gage Michigan residents' perception of agriculture practices—in particular winter manure applications—on the state's water supply. More specifically, the objectives of this study are to:

1. Identify the perception of Michigan residents' regarding the impact of agricultural practices on water quality;
2. Determine residents' willingness to pay for two hypothetical outcomes from potential changes in policy:
    a. an additional user fee for safer water consumption; or

    b. higher prices for food impacted by the policy; and
3. Identify the key demographic information, such as socio-economic factors, that may influence residents' perceptions regarding the impact of agricultural practices on water quality.

The primary goal of this project is to help inform policy makers and other stakeholders about Michigan residents' perceptions about the impact of current agricultural practices on water quality. A major benefit of using the SOSS is that it combines demographic characteristics with specific policy-relevant questions that allows for testing a wide range of potential preference models and residential characteristics. In turn, model outputs can provide policy makers with broader information regarding voter perception based on these different characteristics. These same factors may also impact the amount and method Michigan residents' are willing to pay for policy changes given two general funding paths: 1) direct costs to residents through higher costs for water usage, or 2) indirect costs to residents through higher food prices impacted by new policies.

What follows is, a brief description of the problem pertaining to nutrient runoff. Next we describe the methods and procedures used to achieve the study objectives, as well as a brief description of the data used. Then, the empirical results from the summary statistics and statistical models are presentation and discussed. We conclude with a brief summary of the study and identify potential recommendations for policy moving forward. Our primary findings indicate that while water quality is a concern for most residents, the majority (about two-thirds) do not want to restrict winter manure application practices.

THE PROBLEM: NUTRIENT RUNOFF

Nutrients from agriculture application of fertilizers and manures to cropland can move into freshwater systems through runoff and subsurface (tile) drainage, which then contribute to the growth of algae, including a class of cyanobacteria which produce microcystins (Smith et al., 2015a). In August of 2014, the city of Toledo declared its drinking water unsafe for several days because of unacceptable concentrations of microcystins. An estimated 500,000 people were affected by this drinking water emergency.

The International Joint Commission in 2014 recommended that no manure or fertilizer be applied to cropland by farmers in winter, in order to reduce the movement of phosphorus into freshwaters in early spring, which ultimately led to the summer and fall algal blooms. Various citizen groups have called upon agencies and policy makers to ban the winter application of manure and fertilizers to lessen amounts of phosphorus and other nutrients moved into freshwater systems, including Lake Erie.

Nutrient loss in runoff occurs in all seasons (Stuntebeck et al., 2011), with 63% of annual runoff taking place in the months of February, March and April. The results of several studies indicate that the relationship between winter spreading, the amount of runoff, and the amount nutrients in runoff is greatly dependent upon the timing of manure application relative to specific weather events (rapid thawing, rainfall; Komiskey, 2011). Research findings also show that bans on winter spreading are effective in reducing nutrient movement into surface waters via runoff. Lewis and Makarewicz (2009) observed a 68% decrease in nutrient concentrations in runoff over a 5-year period with the

discontinuation of winter manure spreading. The study was conducted in an environmentally-sensitive area of the Graywood Gully in New York.

Subsurface drainage also contributes to the movement of phosphorus and other nutrients into surface water (Sims et al., 1998; Gentry et al., 2007). Madison and coworkers (2014) reported that subsurface drainage can carry 17 to 41% of the total phosphorus loss from manured fields with predominantly clay-type soils. Most recently, the contribution of subsurface drainage to algal blooms has been reported by King et al. (2015) and Smith et al. (2015b).

Still however, not all states have bans on winter manure spreading, including Michigan. The state of Michigan has experienced a struggle in presenting a convincing argument that satisfies most citizens. States vary in their approaches to get farmers to manage the spreading of manure in the winter either through regulation or through voluntary programs. The variation in use of winter spreading bans reflects the abstruseness in the interpretation and application of research findings in establishing policies concerning agriculture's management of manure and fertilizer nutrients. Everyone does not agree how to avoid weather events that lead to nutrient losses in runoff and in subsurface drainage. A complete ban on winter spreading of manure is often proposed. For several states, a ban on winter spreading has been imposed, but with exceptions. Other states, including Wisconsin and Michigan, have chosen not to ban winter spreading and to let farmers make educated decisions using tools such as the Runoff Risk Advisory Forecast (RRAF; Wisconsin Manure Management Advisory System, 2015) and the Manure Application Risk Index (MARI; Gangwer, 2008).

Confusion about winter spreading of manure is fueled by the fact that nearly, if not all of the states which have bans on winter manure application, make 'exceptions' based on selected certain conditions. The exceptions are based on factors such as the greater risk of a direct discharge from overflowing storage, the difference between 'solid' and 'liquid' manure, the slope of the field, the presence of a vegetated buffer area, and set-back from a water of the state. Criteria for exceptions vary also. For example the slope of fields deemed acceptable for winter manure spreading in Michigan differs from that slope reasoned acceptable in Wisconsin.

Adding complexity to decisions to ban winter spreading of manure is the argument heard by educators, consultants, technicians, agency staff, that the spreading of large quantities of manure in a short window of time in the spring is 'equally' or 'more' risky (Radatz et al., 2013). Runoff events can occur in any month of the year. These researchers argue that "manure spreading bans should be established based on field conditions, and not a calendar. There are times when applying manure early in the winter is optimal because lack of snow and/or frost affords the opportunity for manure to come into contact with the soil. There are also times when manure can be safely applied in late March, when the soils have thawed, snowmelt is finished and the fields are fit. Not allowing farmers to begin fieldwork based on calendar dates can greatly increase the potential for runoff because the window for manure applications is smaller and the potential for runoff from saturated soils and spring rains is greater."

Lastly, conflict arises around the issue of banning winter manure spreading possibly because many farmers cannot afford the additional manure storage capacity needed for the time that spreading manure is not allowed. Most states require that manure storage facilities be designed by an approved engineer. The amount of added manure storage

capacity will be relative to the amount of animal production. The cost of the additional storage can be related to unit of production and policy makers are concerned about this cost being inequitable. For example, it may be greater for small farms, traditional farms, older farms on a 'per cwt' of milk produced, than for a very large, intense operation. Added 'cost of production' will eventually either result in insufficient income to address the family farm's cost of living, or in an increase in price received to offset the added cost to the consumer.

In 2013, Douglas Beegle wrote, "winter manure application is probably the most sensitive nutrient management issue that farmers face. Many outside of agriculture feel that it should be completely banned. We all know that winter is not the best time to apply manure and should be our last choice. But the reality is that on many of our farms there are no other practical options." Many farmers find the cost of added storage to be beyond their means and simply not an option. They do not see how they would pay for that storage.

While the issue of winter manure application has been debated in the agricultural production, environmental and public policy arenas, it is unclear what the broader population thinks about the issue. In fact, we found no prior studies that consider the perceptions of a state's broader population on the issue of winter manure application. At the same time, state residents may have experienced some consequences from the practice, in the form of beach closures or water use restrictions.

METHODS AND PROCEDURES

To accomplish the study objectives outlined in the introduction, a survey instrument was designed to ask residents about their opinion on future water quality issues, the impact of agricultural practices on water quality, and willingness to pay for one of two hypothetical policies. The survey instrument was included as part of the winter 2015 SOSS. Based on the survey design, three different empirical models were developed to address the research questions presented in the study objective. Details regarding the survey are discussed in the Data section.

See appendix A for complete survey questions

SUMMARY AND CONCLUSION

Winter application of fertilizers and manures to croplands can lead to nutrient runoff into freshwater systems via tile drainage. This runoff then contributes to the growth of algae which can lead to potential water use restrictions, such as the events in Toledo in 2014, or beach closures. While the issue has been researched and discussed in the agricultural and environmental arena, to the best of our knowledge, this is the first study to broadly consider residents' perceptions across the state. The motivation for this study was to inform policy makers on the issue of winter manure applications, in particular what Michigan residents think. This study may also reflect, to some extent, on the effectiveness, or lack thereof, that the messaging on factors that contribute to water quality has had to the general public (e.g., the International Joint Commission efforts to inform about the about potential hazards related to winter manure applications). To accomplish this, we used MSU's SOSS as a platform to gage Michigan residents' opinion, and developed statistical and economic models to identify some residential characteristics that may influence these opinions as well as to determine residents' willingness to pay for a new, hypothetical policy intended to improve the state's water quality.

Study results are relevant to the discussion regarding winter manure applications and more broadly on the discussion of water quality. First, while many states in the Great Lakes region have banned or restricted the practice, about two-thirds of Michigan residents are opposed to any restrictions on the application of manure to crop lands in the winter months. Additionally, there appears to be some regional disparity to the level of this opposition, e.g., residents in West Central Michigan, where a high proportion of the state's dairy production occurs, are much more opposed to a restriction than in Detroit. This implies that the reasons for opposition may be different. For residents in West Central Michigan, the opposition may be more strongly tied to the regional economy, whereas in Detroit the reasons may be more tied to the impact on food prices. Further, it may also be that residents do not believe that winter manure application practices necessarily lead to runoff events. However, the majority of respondents believe that runoff, in general, does contribute to water quality problems.

Second, just over half of state residents have some level of concern about the future of Michigan's water quality. Additionally, because there is also strong belief that runoff from urban areas and farms contribute to water quality problems in the state, providing information regarding the true impact of winter manure applications could impact public opinion about restricting the practice. This may also include for example, public awareness of new research that clearly links winter manure applications in Michigan to specific water quality events in the state that may influence opinion.

Third, although the majority of Michigan residents are opposed to restricting winter manure applications, most residents are in favor of paying a user fee to improve water quality through public utilities. On average, residents are willing to pay about $17 per household, which equates to about $63 million for the entire state. Further, specific groups, such as those in favor of more restrictive agricultural practices, may be willing to pay more for improved water quality. If such a policy were to be put into place, developing strategies to generate these additional revenues could provide compensation for the policy practice.

The results of this study provide direction for future research. As identified above, the most relevant is the need for more research into the impact of winter manure applications. This research may also include, more broadly, potential sources and impacts to Michigan water quality from both urban areas and farms. These research outcomes could help inform residents, agricultural producers, city leaders, and policy makers and better assist decision making on the very nest of practices for Michigan. The fact is, there is limited research on actual agricultural practices, regarding manure applications, in the state and region. Further research will not only specifically address the agricultural practice of manure spreading but also give us more information about potential economic impacts and how changes may impact residents more broadly.

Table 1. Summary Statistics (N=772)

Survey Variable	%	Survey Variable	%
Restrict Winter Practice		*Income*	
Yes	29.1%	$Less10k	4.4%
No	65.1%	$10-19k	9.1%
Undecided	5.8%	$20-29k	9.3%
Future Water Problem		$30-39k	8.5%
Very concerned	21.7%	$40-49k	12.1%
Concerned	30.9%	$50-59k	9.4%
Neither concerned nor not concerned	0.7%	$60-69k	10.8%
Not concerned	33.9%	$70-89k	11.3%
Not at all concerned	12.8%	$9k0-99k	3.3%
Water Quality Issue Farm Runoff		$100-140k	12.4%
Yes	59.9%	$150k+	9.5%
No	40.1%	*Age*	
Water Quality Issue Urban Runoff		18-24 yrs.	7.8%
Yes	77.2%	25-29 yrs.	5.0%
No	22.8%	30-39 yrs.	9.5%
Community Size		40-49 yrs.	15.9%
Small	60.9%	50-59 yrs.	24.3%
Large	39.1%	60-64 yrs.	11.6%
Region		65 yrs.+	25.9%
Upper Peninsula	5.5%	*Race*	
Northern Lower Peninsula	7.2%	*Caucasian*	83.8%
West Central	16.5%	*African American*	8.5%
East Central	8.0%	*Latino*	1.9%
Southwest	16.6%	*Native American*	1.6%
Southeast (excludes Detroit)	38.3%	*Asian*	0.8%
Detroit	7.9%	*Hawaiian or Pacific Islander*	0.1%
Education		*Other*	3.3%
Less than HS	2.3%	*Gender*	
HS graduate	22.3%	Female	45.9%
Some College	30.3%	Male	54.1%
College degree or higher	45.1%		

Table 2. Summary Statistics of Key Variables by Region(N=772)

Survey variable	Region						
	Upper Peninsula	Lower Peninsula	West Central	East Central	Southwest	Southeast[a]	Detroit
Restrict Winter Practice							
Yes	30%	22%	22%	37%	25%	31%	40%
No	65%	74%	73%	56%	67%	64%	53%
Undecided	5%	4%	5%	7%	8%	5%	7%
Future Water Problem							
Very likely	20%	21%	17%	20%	19%	26%	19%
Likely	25%	36%	29%	32%	33%	30%	36%
Neither likely nor unlikely	0%	0%	0%	2%	1%	1%	0%
Unlikely	40%	34%	40%	39%	33%	32%	26%
Very unlikely	15%	9%	15%	7%	15%	11%	19%

[a] Excludes Detroit

Table 3. Summary Statistics of Key Variables by Community Size and Education (N=772)

Survey variable	Community Size		Education			
	Small	Large	< HS	HS grad.	Some College	College deg. +
Restrict Winter Practice						
Yes	28%	30%	47%	29%	30%	28%
No	67%	62%	47%	69%	64%	65%
Undecided	5%	8%	6%	2%	6%	7%
Future Water Problem						
Very likely	24%	18%	29%	21%	20%	23%
Likely	31%	31%	24%	32%	34%	28%
Neither likely nor unlikely	1%	1%	0%	61%	1%	0%
Unlikely	32%	37%	29%	34%	32%	35%
Very unlikely	13%	13%	18%	12%	13%	13%

Table 4. Future water issues (N=772)

Parameter	Estimate	Std. Err.	p-Value
Restrict	0.6405	0.1553	0.0001
Small community	0.1992	0.1447	0.1686
Female	0.3723	0.1376	0.0068
African American	0.0184	0.2535	0.9421
Latino	0.3475	0.5099	0.4955
Native American	0.5661	0.5046	0.2620
Asian American[a]	-1.6943	0.8088	0.0362
Hawaiian/Pac. Isl.	-0.8431	1.8624	0.6508
Other	-0.4467	0.3866	0.2480
Millennials	-0.0277	0.2064	0.8932
Low income	0.0684	0.2089	0.7434
High income	-0.1805	0.1770	0.3077
College plus	0.0056	0.1469	0.9697
Urban Runoff	1.3571	0.1689	0.0001
Intercept 1	0.6661	0.2092	0.0014
Intercept 2	2.0065	0.1184	0.0001
Intercept 3	2.0374	0.1190	0.0001
Intercept 4	3.5642	0.1444	0.0001
Pseudo R-squared			
Aldrich-Nelson	0.1326		
Veall-Zimmermann	0.3650		

[a.] All race variables are relative to white/Caucasian

"How would you rate your opinion about Michigan experiencing water quality problems in the future (1: Very Concerned, 5, Not Concerned)?"

Table 5. Restrict application (N=772)

Parameter	Estimate	Std. Err.	p-Value
Low Concern	-0.4519	0.2076	0.0295
High Concern	0.5254	0.2104	0.0125
Small Community	-0.0461	0.1834	0.8016
Female	0.2001	0.1721	0.2451
African American[b]	0.7521	0.2885	0.0091
Latino	1.5299	0.5740	0.0077
Native American	-0.6543	0.7229	0.3654
Asian American	0.6227	0.8952	0.4867
Other[a]	-0.1851	0.5250	0.7244
Millennials	-0.2367	0.2675	0.3763
Low income	0.1165	0.2540	0.6463
High income	0.1183	0.2250	0.5991
College plus	-0.2039	0.1863	0.2738
Urban Runoff	0.5415	0.2208	0.0142
Intercept	-1.4492	0.2812	0.0001

[a.] Includes Hawaiian or Pacifica Islander

[b.] All race variables are relative to white/Caucasian

"Dou you think that Michigan farms should be restricted from applying manure in the winter?"

Yes = 1

Table 6. Choice questions (N=772)

Parameter	Policy 1 (higher food prices)			Policy 2 (water user fee)		
	Estimate	Std. Err.	p-Value	Estimate	Std. Err.	p-Value
Intercept	-0.5739	0.2681	0.0323	0.6421	0.2236	0.0041
Restrict practice	1.6681	0.2501	0.0001	0.8575	0.2254	0.0001
Small communities	-0.2901	0.2254	0.1982	-0.3702	0.1865	0.0471
Low income	-1.1780	0.3708	0.0015	-0.6045	0.2573	0.0188
Millennials	1.0305	0.3447	0.0028	0.7863	0.3001	0.0088
65 years or older	-0.3378	0.2613	0.1962	-0.0590	0.2018	0.7701
College deg. or higher	0.5842	0.2260	0.0097	0.1252	0.1873	0.5039
High water concern	1.0611	0.2739	0.0001	0.7311	0.2446	0.0028
Price	-0.0387	0.0061	0.0001	-0.0387	0.0061	0.0001
Pseudo R-squared						
Aldrich-Nelson	0.2109					
Veall-Zimmermann	0.3069					

Table 7. Willingness to pay 95% confidence intervals by residential group (N=772)

Group	Policy 1 (higher food prices)		Policy 2 (water user fee)	
	Lower	Upper	Lower	Upper
Overall	$0.00	$0.00	$6.06	$27.13
Restrict practice	$16.48	$40.06	$28.13	$49.37
Small communities	$0.00	$0.00	$0.00	$0.00
Low income	$0.00	$0.00	$0.00	$0.00
Millennials	$0.00	$0.00	$22.77	$51.05
65 years or older	$0.00	$0.00	$5.56	$24.57
College deg. or higher	$0.00	$0.00	$11.00	$28.65
High water concern	$0.00	$0.00	$23.96	$47.01

Appendix A

SOSS Survey

There have been reports of water quality problems in the past few years that have resulted in actions such as beach closures and tap water advisories. Some have attributed these problems to different sources such as farms, urban water runoff and waste, and natural forces.

1. On a scale from 1 to 5, where 1 is **"I am very concerned"** and 5 is **"I am not at all concerned"**, how would you rate your opinion about Michigan experiencing water quality problems in the future?

I am very Concerned	I am somewhat concerned	I am neutral	I am not very concerned	I am not at all Concerned
1	2	3	4	5

2. Do you think the following contribute to water quality problems in Michigan?
   A. Farm runoff? Yes No
   B. Urban runoff? Yes No

A practice used by some farms is applying manure on fields in the winter. Some people are concerned that if the ground is frozen, nutrients are not all absorbed and heavy rain or snow melting could lead to runoff into water sources.

3. Do you think that Michigan farms should be restricted from applying manure in the winter?
   A. Yes
   B. No
   C. Undecided

The following is a hypothetical scenario. Suppose policymakers decide that there are two approaches to increasing the quality of Michigan's municipal water supply. The first is to restrict agricultural practices that will increase the cost consumers pay for food. The second is to require water suppliers to install special filters that filter pathogens from the tap water that will increase household water bills. Alternatively policy makers can decide to do nothing and hope the water supply remains safe.

4(a). Would you rather:
   A. policymakers enact new farm restrictions that will increase your food expenditures by **$25.00** a month
   B. policymakers enact new water safety legislation that will increase your water bill by **$5.00** a month
   C. policymakers do nothing and hope the water supply remains safe?

4(b). There are three choices, would you rather:
   A. policymakers enact new farm restrictions that will increase your food expenditures by **$5.00** a month
   B. policymakers enact new water safety legislation that will increase your water bill by **$25.00** a month

C. policymakers do nothing and hope the water supply remains safe?

4(c). There are three choices, would you rather:

A. policymakers enact new farm restrictions that will increase your food expenditures by **$25.00** a month
B. policymakers enact new water safety legislation that will increase your water bill by **$25.00** a month
C. policymakers do nothing and hope the water supply remains safe?

4(d). There are three choices, would you rather:

A. policymakers enact new farm restrictions that will increase your food expenditures by **$5.00** a month
B. policymakers enact new water safety legislation that will increase your water bill by **$5.00** a month
C. policymakers do nothing and hope the water supply remains safe?

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