What determines the public’s support for water quality regulations to mitigate agricultural runoff?

Tian Guo⁎, Devin Gill, Thomas H. Johengen, Bradley L. Cardinale

Cooperative Institute for Great Lakes Research (CIGLR), University of Michigan, 4840 S. State Rd, Ann Arbor, MI, 48104, USA

A R T I C L E   I N F O

Keywords:
- Nutrient pollution
- Water quality management
- Environmental concern
- Great Lakes

A B S T R A C T

For many freshwater systems, mitigating agricultural runoff of nutrients is a key requirement for curbing eutrophication and reducing subsequent ecological threats. However, defining the best way to achieve reductions in agricultural runoff can be a contentious issue. A policy debate is currently unfolding in Ohio focused on whether the state government should introduce regulatory policies on agriculture to reduce nutrient loadings from watersheds in an attempt to also reduce harmful algal blooms in Lake Erie. To inform policy development, we used a survey instrument to gauge public acceptance of regulatory policies and examined the psychological determinants of Ohio residents’ support for a regulatory policy proposal that would introduce fines on excessive agricultural runoff. We designed a survey instrument with nine predictors of people’s willingness to support regulations: 1) effectiveness of voluntary programs, 2) risk perception, 3) water quality perception, 4) trust in farmers, 5) trust in state government, 6) belief about fertilizer runoff as a major cause of HABs, 7) belief that farmers alone should not bear the burden to restore water quality in Lake Erie, 8) belief that regulation is necessary to keep farmers accountable, and 9) belief that regulation harms economy and employment. We also measured variables that represented different levels of self-interests, awareness of reduction goals, political party affiliation, and demographic characteristics. We collected a sample of 1000 respondents, who were representative of Ohio residents by age, gender, race, and education level. Most predictors were significant and in the directions hypothesized, with exception of water quality perception and belief about regulation and jobs. One’s a priori belief that regulations are necessary to keep farmers accountable for their land management practices had the largest enhancing effect for accepting a regulatory policy of fines, while trust for farmers had the largest inhibiting effect. In comparison, water quality perception was not significant in predicting individual policy attitudes. This study informs the public engagement and communication efforts and suggest directions for future research on public policy support.

1. Introduction

Mitigating nutrient pollution is a challenge worldwide. Nutrients from wastewater treatment plants, soil, fertilizer, plant residues, and animal excreta accumulate in water bodies, causing severe environmental problems including harmful algal blooms (HABs), excessive growth of cyanobacteria that produces toxics to human and animals (Cheung et al., 2013; Duan et al., 2009; Hallegraeff, 1993; Taylor and Longo, 2010; Vidal et al., 2017). In regions such as the Midwestern United States (U.S.), there is a history of successful mitigation of nutrient pollution through regulatory policy initiatives. The Clean Water Act, enacted in the 1970s, provides the broad legal framework for controlling water pollution in the nation’s waterways (Garnache et al., 2016). Regulatory tools such as total maximum daily loads (TMDL) and the National Pollution Discharge Elimination System (NPDES) were implemented in the Laurentian Great Lakes region to abate nutrient pollution from point sources such as wastewater treatment plants, industrial sites, and large confined animal feeding operations. As a result of these management regulations annual phosphorus loadings from US and Canadian municipal discharges were reduced by 84% – from 15,260 tons in 1972 to 2449 tons in 1985, which resulted in restored water quality of the lakes in the 1990s (Makarewicz and Bertram, 1991). Similar successful outcomes occurred in the Chesapeake Bay area in the Eastern U.S., where EPA established a TMDL for the watershed. Under the expectation of future regulations, animal feeding operations within the watershed significantly increased their adoption of water quality related measures (Savage and Ribaudo, 2013).

Despite the tightened regulatory control on point source nutrients,
HABs returned to Lake Erie and have increased in frequency and severity in the last decade. The spatial extent of the bloom area was 170 km² in 2002, but reached a record high of 2968 km² in 2011 (Stumpf et al., 2012). Although the extent of HABs fluctuates from year to year, the new norm of more severe annual HABs outbreak threatens public health and adversely affect the multi-million dollar fishery and tourism industry in the region (Gill et al., 2018; Scavia et al., 2014; Wolf et al., 2017). Researchers have identified agricultural nutrient runoff as the major contributor to HABs in Lake Erie (Kalcevic et al., 2016; Maccoux et al., 2016; Scavia et al., 2016; Stumpf et al., 2016). In comparison to point sources, non-point source agricultural runoff is rarely regulated (Garnache et al., 2016; Shorle et al., 2012). It remains largely unanswered whether the regulatory approach used to successfully abate point-source nutrients entering Lake Erie can also be effectively applied to agricultural non-point source nutrients in the region. Policy makers in the Lake Erie region hotly debate this question in the pursuit of management solutions (Guo et al., 2019).

Public policy preferences play a major role in signaling policy change or directly affecting policy makers’ decisions about whether to consider a specific policy option or not, among other social-economic factors such as the cost-benefit comparison of the policy proposal, politics, and interest groups (de Groot and Schuitema, 2012d; Davis and Wurth, 2003; Klüber, and Sagarruzz, 2016; Newig, 2004; Wlezien, 1995). Ideally, policy effectiveness should determine public policy support. However, there is not always sufficient information about the projected effectiveness of a proposed regulatory policy. Moreover, psychological factors such as values, beliefs, attitudes, and risk perceptions affect individual policy attitudes (Clayton et al., 2015; de Groot and Schuitema, 2012d; Eriksson et al., 2008; Lubell et al., 2006; Steg et al., 2006; Stoumborough et al., 2013). A stronger understanding of the human dimensions of HABs will facilitate public discussion and engagement by fostering dialogue and identifying common ground (e.g., Bauer et al., 2010). Such clarification of individual thinking processes related to nutrient pollution is also informative to other regions with a political climate marked by polarization.

In the conservation social science literature, few studies have examined public attitudes toward regulatory policies to mitigate agriculture run-off. The studies that have been conducted inconsistently used psychological and demographic factors to explain policy preferences. For example, Guo et al. (2019) found political ideology affected individual support for regulatory policies to mitigate agriculture runoff through the mediation of news exposure and risk perception. Rissman et al. (2017) found individual cultural views (communitarian, egalitarian), runoff concern, and age explained support for regulatory and incentive-based policies to reduce non-point source pollution, but perceived water quality or whether the respondent living in rural communities did not. Howard et al. (2017) found program costs, program effectiveness, and program details (e.g., regulatory or voluntary measures) affected individual willingness to pay for nutrient reduction policies. The Binational Poll commissioned by the International Joint Commission (IJC) found 55.3% of residents living within the Great Lakes Basin felt there were too few policies and regulations in place to protect the Great Lakes, while 5.3% of the residents felt there were too many policies and regulations (Great Lakes Water Quality Board Public Engagement Work Group, 2018). However, this review did not include and conclusions on why such preference existed. The present study aimed to advance the research on public support for regulatory policies to mitigate agriculture run-off through testing a social-psychological model that included policy effectiveness and individual attitudes and beliefs.

Specifically, we reported the results of a survey study of public support for or against regulations on agricultural nutrient runoff, addressing two research questions: 1) How does policy effectiveness affect support for regulatory policies? 2) Which psychological factors determine support for regulatory policies? We expected that the effectiveness of voluntary programs would predict support for regulatory policies (de Groot and Schuitema, 2012d; Howard et al., 2017). In U.S., voluntary programs are often implemented as a first step before regulatory approaches are considered (Garnache et al., 2016; McDowell et al., 2016; Shortle et al., 2012; Vollmer-Sanders et al., 2011). If voluntary programs are subsequently deemed ineffective, a rational response is to develop alternative policies, including regulatory policies. However, people’s decisions of supporting or opposing a regulatory policy proposal are not always rational, and can be heavily influenced by individual perceptions, trust, beliefs, self-interests, and background.

Thus, we proposed eight psychological factors that are associated with public support for regulatory policies in addition to defining hypothetical effectiveness of voluntary programs including, 1) risk perception 2) water quality perception, 3) trust in farmers, 4) trust in state government, 5) belief about the contribution of fertilizer runoff on HABs (fertilizer runoff and HABs), 6) belief that farmers alone should not bear the burden to restore water quality in Lake Erie (restoration burden), 7) belief that regulation is necessary to keep farmers accountable (regulation and accountability), and 8) belief that regulation harms economy and employment (regulation and employment). These factors are commonly reflected in the policy discussions taking place throughout media outlets. In the literature on public support for environmental policies, risk perception, water quality perception, and contributions beliefs were frequently studied (e.g., Hornsey et al., 2016; Lubell et al., 2006; Rissman et al., 2017). Some studies supported the association between trust in government and policy support (e.g., Harring and Jagers, 2013), but trust in the targets of regulations were rarely examined. If farmers can manage lands well on their own, it is reasonable to assume that people may feel there is no needs to infringe on their autonomy. Beliefs about restoration cost are often related to the concept of fairness, and have been commonly studied in the traffic control literature (Eriksson et al., 2008). The two beliefs focused on, regulation related to the effectiveness and costs of policies, were associated with levels of policy support (e.g., Feldman et al., 2017).

2. Methods

2.1. Case study area

The present study area is located in the Midwestern United States (Fig. 1). Lake Erie is one of the Great Lakes within this region, bordered by both the U.S. and Canada. It is the shallowest and warmest Laurentian Great Lake and the twelfth largest lake in the world (Markewicz and Bertram, 1991). The lake provides drinking water to 11 million people and supports fishery and tourism industries that are economically important for the region (Gill, et al., 2018). The state of Ohio forms a long coastline along the southern shore of Lake Erie containing over 14,000 acres of farmland producing significant values of crops and livestock (Turner and Morris, 2018). Some challenges associated with the vital agricultural industry in the state are how to manage soil erosion and nutrient runoff given large amounts of spring precipitation. The Maumee River watershed has been identified as the key contributor to the nutrient (phosphorus) that cause HABs in Lake Erie (e.g., Maccoux et al., 2016).

2.2. Survey sampling

The final survey sample included one thousand Ohio residents, age 18 years or older. YouGov administered the survey by sending out 16,062 invitations among its on-line opt-in panel. One thousand five hundred and fifty five (1555) individuals completed the survey. One thousand cases from among the completed interviews were extracted to create a target sample that would match the whole population based on gender, age, race and education. The target sample was randomly drawn from a sampling frame construed using the American Community Survey estimates. The matching method is commonly used for on-line panel surveys with the expectation that when matched by
gender age race and education level, the extracted samples show similar representativeness of a randomly drawn sample (Twyman, 2008).

The weighted sample descriptions were as follows: 52.8% female, 82.2% white alone, 11.8% African American, 93.1% 25 years old and over, among whom 27.5% has bachelor’s degree or higher. The median household income was between $10,000 to $49,999. Thirty-four point two percent (34.2%) of respondents affiliated with the Democratic Party, 28.0% affiliated with the Republican Party, and 35.8% of the weighted sample had no party affiliation. Geospatially, 14.8% of the sample was from Northwest Ohio, 32.8% from Northeast Ohio, 24.5% from Southwest Ohio, 18.1% from Central Ohio, and 9.8% from Southeast Ohio1.

2.3. Measures

To keep the measure of policy support specific, we selected fines on excessive agricultural runoff as the tested regulatory policy proposal, because the concept of a fine is easily understood by the public. We used hypothetical scenarios to measure respondent support for fines on excessive agricultural runoff (i.e., dependent variable). In these hypothetical scenarios, the state government was considering whether to introduce fines for farmers as a means of reducing nutrient inputs into Lake Erie, and participants were asked what their level of support would be on a scale of 1–7 (1 indicating strong opposition and 7 indicating strong support) for the implementation of fines (Fig. 2).

Survey respondents were presented with three scenarios containing different voluntary program effectiveness outcomes to assess whether their reported level of support for fines changed. The first hypothetical scenario stated that voluntary efforts (including education, technical assistance, and cost share programs) had only reduced fertilizer runoff to Lake Erie by 5%. In the other two scenarios, fertilizer runoff was reduced by 20% and 35% through voluntary efforts. The percentages were selected because as part of the 2012 Great Lakes Water Quality Agreement (GLWQA), the U.S. and Canadian governments agreed to reduce total nutrient loading (i.e., phosphorus loading) to Lake Erie by 40% using the loading levels in 2008 as a baseline.

The measures of other independent variables are listed in Table 1. All psychological predictors were measured on a seven-point scale indicating respondent support for the given statement, except for risk perception that was measured on an eleven-point scale, and water quality perception and belief about fertilizer and HABs that were measured on a five-point scale. To pilot test the questionnaire, two focus-group workshops were conducted with participants that included natural scientists familiar with the science behind Lake Erie nutrient reduction goals and members of a politically diverse community service group. Information from the pilot workshops were used to improve question order, amount, and wording.

2.4. Data analysis

We fitted mixed effects linear regression models with sampling weights to predict respondents’ level of support for fines on farmers using SAS PROC GLMMIX procedure. We included a random effect of respondent. The equation is as followed:

\[
y_{ij} = \beta_0 + \beta_1 EVP_{j1} + \beta_2 EVP_{j2} + \beta_3 WQP_{j1} + \beta_4 RP_{j1} + \beta_5 TF_{j1} + \beta_6 TSG_{j1} + \beta_7 Belief_{j1} + \beta_8 Belief_{j2} + \beta_9 Belief_{j3} + \beta_{10} Age_{j1} + \beta_{11} Gender_{j1} + \beta_{12} RaceBL_{j1} + \beta_{13} EduHI_{j1} + \beta_{14} EduAD_{j1} + \beta_{15} EduBD_{j1} + \beta_{16} ParRep_{j1} + \beta_{17} PAOth_{j1} + \mu_j + \epsilon_{ij}
\]

\(Y_{ij}\) is respondent j’s rating of their support for fines on excessive agricultural runoff under the \(i_{th}\) scenario of the effectiveness of voluntary programs \((i = 1, 2, 3; j = 1, 2, 3, 4,5,...n)\). \(EVP_{ij}\) is the indicator for the 5% projected reduction of voluntary programs in the first scenario. \(EVP_{ij}\) is the indicator for the 20% projected reduction of voluntary

---

1 We used Ohio EPA’s district office jurisdiction to define regions.
programs in the second scenario, $\mu_j$ is the random intercept by respondent and $e_j$ is the random error. The remaining predictors are listed in Table 1. $\beta_{j1}$ through $\beta_{j3}$ are the coefficients for controlling variables including agricultural occupation, lake recreation, log distance, awareness of reduction goals, age, gender, race, education level, and party affiliation (See appendix for details).

3. Results

3.1. Descriptive results

Our descriptive analysis revealed that people preferred voluntary measures rather than regulatory measures to increase best farm management practices. About two thirds of the respondents selected a tax system that rewards farmers who protect the environment (39.8%) as the best way to increase adoption of best farming management practices, while 21.6% of respondents selected more education, technical assistance, or cost share programs, and 20.2% of respondents selected the implementation of regulatory fines for farmers.

When the voluntary programs were projected to fail at reducing agricultural runoff (5% reduction) in scenario one, the mean support for state government introducing fines for farmers was 4.28 (on a seven point scale) with a S.D. of 1.71. In the second scenario where voluntary programs were projected to reduce agricultural runoff by 20%, the mean for fines support slightly decreased to 4.19, with reduced variability (S.D. = 1.59). When voluntary programs were proposed to be more successful (i.e., projected to reduce agricultural runoff by 35%), the mean support for state government introducing fines for farmers was 4.28 (on a seven point scale) with a S.D. of 1.71.

The majority of people somewhat to strongly agreed that Ohio farmers alone should not bear the burden of restoring Lake Erie’s water quality (73.3%, Mean = 5.39, on a seven-point scale, S.D. = 1.43), but that regulations were necessary to keep farmers accountable for their land management practices (67.6%, Mean = 5.09, on a seven-point scale, S.D. = 1.49). Survey respondents expressed some level of distrust for the state government (Mean = 3.57, on a seven-point scale, S.D. = 1.47) and a slightly greater trust for Ohio farmers (Mean = 4.39, on a seven-point scale, S.D. = 1.21). On average, most people rated the overall water quality of Lake Erie as neither bad nor good (Mean = 4.39, on a seven-point scale, S.D. = 1.49). They reported that HABs posed some threat to public health, economy, and personal wellbeing in Ohio (Mean = 6.52, on a eleven-point scale, S.D. = 2.27). Lastly, beliefs about environmental regulation and jobs were variable. Nearly forty-five percent (44.7%) of respondents somewhat to strongly disagreed that environmental regulations decrease job opportunities and harm the economy, while 35.9% somewhat to strongly agreed with...
the statement, and 19.4% remained neutral. All the correlations among the psychological predictors were below 0.5, suggesting no large pairwise collinearities (Table 2; additional model fitting results are presented in the supplemental materials).

3.2. Modeling results

The multivariate regression model explained 49.82% of the variance of support for fines on excessive agricultural runoff (Table 3). Most predictors were significantly associated with the support for fines as expected, except for water quality perception (Stand. \( B = 0.37 \), p-value = 0.87) and beliefs about regulation and jobs (Stand. \( B = -4.67 \), p-value = 0.09).

For the first research question (how does policy effectiveness affect support for regulatory policies), we found that respondents changed their support for fines based on the levels of projected effectiveness of voluntary programs. As expected, the more effective voluntary programs were at reducing agricultural runoff, the less likely people were to support fines, suggesting policy attitudes toward using fines in reducing agricultural runoff were adaptive.

For the second research question (which psychological factors determine support for regulatory policies), among the significant psychological predictors, the belief that regulations were necessary to keep farmers accountable had the largest enhancing effect (Stand. \( B = 28.49 \)). Trust in farmers had the largest inhibiting effect (Stand. \( B = -4.39 \)), we found that respondents changed their support for regulatory policies when the levels of projected effectiveness of voluntary programs. (i.e., education, technical assistance and cost share program). Moreover, the belief that regulation is necessary to keep farmers accountable was the strongest predictor of public support for introducing fines on excessive agricultural runoff. Trust in farmers was the second strongest predictor and in the opposite direction. Strong trust in farmers reduced public support for introducing fines on excessive agricultural runoff. Trust in farmers alone should not bear the burden to restore water quality in Lake Erie (Stand. \( B = -9.10 \)) were less likely to support fines.

Not surprisingly, those who worked in agriculture were less likely to support fines (Stand. \( B = -4.6 \), although the effect compared to psychological factors was marginal. The other two indicators for self-interest (i.e., distance from western Lake Erie and using the lake for recreational purpose) were not significant. Whether residents were aware, or not, of the nutrient reduction goal by U.S. and Canadian governments was not a significant predictor of their policy support. Political party affiliation was not significant in the multivariate regression model.

4. Discussion

This study examined psychological factors associated with public acceptability of regulatory environmental policies to reduce agricultural nutrient runoff and HABs in Lake Erie. With a sample of one thousand Ohio residents, we confirmed that public support for fines on excessive agricultural runoff depended on the stated effectiveness of voluntary programs. (i.e., education, technical assistance and cost share program). Moreover, the belief that regulation is necessary to keep farmers accountable was the strongest predictor of public support for introducing fines on excessive agricultural runoff. Trust in farmers was the second strongest predictor and in the opposite direction. Strong trust in farmers reduced public support for introducing fines on excessive agricultural runoff. Other psychological variables including risk perception, trust in state government, belief about fertilizer runoff and HABs, and belief about restoration burden played smaller roles in predicting policy support.

Although our results agreed with a number of a priori predictions,
several findings did not, and require further consideration. Surprisingly, perception of water quality was not a significant predictor of Ohio residents’ support for fines on excessive agricultural runoff. This finding contradicts the general assumption that water quality perception affects policy attitudes (Rissman et al., 2017). To explain the contradiction, we fit a model only using data from respondents who lived in the coastal counties of Lake Erie and supposedly had more accurate water quality perception. However, water quality perception remained insignificant. We then tested whether water quality perception moderated the effects of trust in farmers, risk perception, and belief about fertilizer runoff and HABs. We found statistically significant interaction terms for fertilizer belief (Stand. B = −22.62) and the risk perception (Stand. B = 20.55, Fig. 3) on individual support for fines. In the contexts of agricultural nutrient runoff and HABs in Lake Erie, water quality perception may not directly affect policy attitudes, but it moderates the effects of other psychological predictors.

The model explained 49.82% of the variance of the public support for fines on excessive agricultural runoff. Although this percentage is satisfactory, we experimented with adding other psychological measures that were included in the survey but not in the model to increase the explanatory power of the model. Additional parameters included: 1) environmental worldviews measured by Dunlap et al.’s (2000) New Ecological Paradigm scale, 2) environmental concern measured as worries about HABs, 3) self-reported exposure to HABs related news, 4) self-reported knowledge level about farming practices, 5) awareness of voluntary programs to reduce agricultural runoff, 6) expected reduction percentage threshold for voluntary programs to be effective, 7) types of community the respondent grew up at, 8) Lake Erie related occupation, 9) frequency visiting Lake Erie for recreation purposes, and 10) political ideology.

With this large model, the significance (or insignificance for water quality perception and belief about regulation and jobs) and direction of the original nine predictors remained the same. Furthermore, the $R^2$ of the entire model only increased to 52.37%, suggesting adding more psychological and individual characteristic variables in the expense of model parsimony can only marginally increase the explanatory power of the model. We then added polynomial terms of the original eight psychological predictors, obtaining a similar $R^2$ of 52.32%. Finally, we evaluated the effect of adding interaction terms. Given the number of potential interactions, we only added interactions between party affiliation and all other predictors (no interactions with polynomial terms). Again, the $R^2$ only slightly increased to 52.50%.

In contrast to our study, Hansla et al. (2017) were able to explain 84% of the variance of the actual voting behaviors for a road-pricing scheme, which is a rare case in policy attitude research. Their model included some predictive factors that conceptually overlapped with our model tested, such as public perception of fairness, trust in state government, and effectiveness of the policy. However, Hansla’s et al. used more specific variables for each concept. For example, for trust in state government, they included measurements of perceived political responsiveness and procedural legitimacy. Moreover, Hansla et al. predicted actual voting behavior while we predicted individual policy attitudes. Attitudes may inherently have more random variability than behaviors that have already happened. In other words, an explanation worth further investigation is that Ohioan attitudes toward fines on excessive agricultural runoff have not been fully formed, allowing for more variability.

4.1. Limitation and future research

There were a few limitations of the study worth noting. First, we used weights to mitigate the potential bias associated with using a non-probability based sampling. However, with weights certain demographic groups were still under represented in the sample including Asians, Hispanics, and those aged from 18 to 24 years. Second, we measured public support for fines using hypothetical scenarios. To keep the survey reasonably short and avoid mental fatigue, as described by Galesic and Bosnjak (2009) and Dillman et al. (2014), we did not ask probing questions about how respondents interpreted each scenario. Finally, our study was based on a cross-sectional study, and was not sufficient to support casual inferences (e.g., trust in farmers causes opposition to regulations).

We tested a social-psychological model to explain Ohio residents’ attitudes toward fines on excessive agricultural runoff. It would be valuable to test the model for other types of policies and in different regions (e.g., Michigan, Indiana, or other regions with similar needs to mitigate agricultural runoff). Potential differences and similarities in model results across more diverse communities and ecosystems could help improve understanding of the public’s response to policy proposals. To establish causal effects, future experimental studies should consider use-messages to highlight or alter certain beliefs, perceptions, and trust levels and discern the effects of these treatments. It would also be interesting to examine the effects of water quality perception on policy support using multiple public opinion data sets.

4.2. Practical implications

In the context of curbing HABs and restoring Great Lakes water quality, although the public expresses general support of increased regulations (Great Lakes Water Quality Board Public Engagement Work Group, 2018), our study revealed individual attitudes toward specific regulatory policy proposals depend on a wide range of factors. In particular, Ohioans cared the most about accountability (i.e., who is responsible for nutrient loading) and the risks of HABs. Agricultural communities concerned about the potential impacts of more stringent regulations should consider developing self-regulatory mechanisms to keep individual farmers accountable for their land management practices. Meanwhile, people concerned that farmers are unfairly targeted in environmental issues may find some consolation in our finding that the public recognizes the costs associated with reducing agricultural
runoff, and such perceptions affect their policy support. As the public adjusts their policy attitudes based on the effectiveness of voluntary programs, we suggest public are receptive to innovative HABs policies and market-based interventions. It also highlights the importance of monitoring the effectiveness of voluntary programs in reducing agricultural runoff to Lake Erie. Lastly, our study demonstrates the decision to introduce stringent regulatory policies invokes different social values such as environmental protection, fairness, effectiveness, avoiding unexpected consequences, accountability, and collaboration. Understanding the nuances between these values is the key to promoting constructive dialogs in policy debates.

Appendix A

See Table A1

Table A1 Measurement for controlling variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural occupation</td>
<td>Do you work, or have you previously worked in the agricultural industry (e.g., farming, dairy, etc)?</td>
</tr>
<tr>
<td>Lake recreation</td>
<td>Do you or any of your family members use Lake Erie for leisure or recreational purposes?</td>
</tr>
<tr>
<td>Logdistance</td>
<td>Log distance from the centroid of census tract to the shoreline of western Lake Erie</td>
</tr>
<tr>
<td>Awareness of reduction goal</td>
<td>Have you heard of the goal established by U.S. federal and state governments surrounding Lake Erie to reduce nutrients entering Lake Erie by 40% by 2025?</td>
</tr>
<tr>
<td>Party affiliation</td>
<td>Three categories, democrats, republicans, and other</td>
</tr>
<tr>
<td>Age</td>
<td>In years</td>
</tr>
<tr>
<td>Gender</td>
<td>Two categories male, female</td>
</tr>
<tr>
<td>Race</td>
<td>Three categories, Caucasian or White, African American or Black, and other</td>
</tr>
<tr>
<td>Education level</td>
<td>Four categories, including one high school or less, graduated high school, some college or associated degree, and four-year college degree or higher</td>
</tr>
</tbody>
</table>

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2019.09.008.

References


de Groot, J.I.M., Schuitema, G., 2012d. How to make the unpopular popular? Policy standing the nuances between these values is the key to promoting constructive dialogs in policy debates.

Acknowledgements

The study was supported by funding awarded to the Cooperative Institute for Great Lakes Research (CIGLR) through the U.S. National Oceanic and Atmospheric Administration (NOAA) Cooperative Agreement with the University of Michigan (NA17OAR4320152). The CIGLR contribution number is 1150. Our sincere gratitude goes to the citizens who participated in the survey and supported social science research.

See Table A1

Table A1 Measurement for controlling variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural occupation</td>
<td>Do you work, or have you previously worked in the agricultural industry (e.g., farming, dairy, etc)?</td>
</tr>
<tr>
<td>Lake recreation</td>
<td>Do you or any of your family members use Lake Erie for leisure or recreational purposes?</td>
</tr>
<tr>
<td>Logdistance</td>
<td>Log distance from the centroid of census tract to the shoreline of western Lake Erie</td>
</tr>
<tr>
<td>Awareness of reduction goal</td>
<td>Have you heard of the goal established by U.S. federal and state governments surrounding Lake Erie to reduce nutrients entering Lake Erie by 40% by 2025?</td>
</tr>
<tr>
<td>Party affiliation</td>
<td>Three categories, democrats, republicans, and other</td>
</tr>
<tr>
<td>Age</td>
<td>In years</td>
</tr>
<tr>
<td>Gender</td>
<td>Two categories male, female</td>
</tr>
<tr>
<td>Race</td>
<td>Three categories, Caucasian or White, African American or Black, and other</td>
</tr>
<tr>
<td>Education level</td>
<td>Four categories, including one high school or less, graduated high school, some college or associated degree, and four-year college degree or higher</td>
</tr>
</tbody>
</table>

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2019.09.008.

References


de Groot, J.I.M., Schuitema, G., 2012d. How to make the unpopular popular? Policy standing the nuances between these values is the key to promoting constructive dialogs in policy debates.

Acknowledgements

The study was supported by funding awarded to the Cooperative Institute for Great Lakes Research (CIGLR) through the U.S. National Oceanic and Atmospheric Administration (NOAA) Cooperative Agreement with the University of Michigan (NA17OAR4320152). The CIGLR contribution number is 1150. Our sincere gratitude goes to the citizens who participated in the survey and supported social science research.

See Table A1

Table A1 Measurement for controlling variables.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural occupation</td>
<td>Do you work, or have you previously worked in the agricultural industry (e.g., farming, dairy, etc)?</td>
</tr>
<tr>
<td>Lake recreation</td>
<td>Do you or any of your family members use Lake Erie for leisure or recreational purposes?</td>
</tr>
<tr>
<td>Logdistance</td>
<td>Log distance from the centroid of census tract to the shoreline of western Lake Erie</td>
</tr>
<tr>
<td>Awareness of reduction goal</td>
<td>Have you heard of the goal established by U.S. federal and state governments surrounding Lake Erie to reduce nutrients entering Lake Erie by 40% by 2025?</td>
</tr>
<tr>
<td>Party affiliation</td>
<td>Three categories, democrats, republicans, and other</td>
</tr>
<tr>
<td>Age</td>
<td>In years</td>
</tr>
<tr>
<td>Gender</td>
<td>Two categories male, female</td>
</tr>
<tr>
<td>Race</td>
<td>Three categories, Caucasian or White, African American or Black, and other</td>
</tr>
<tr>
<td>Education level</td>
<td>Four categories, including one high school or less, graduated high school, some college or associated degree, and four-year college degree or higher</td>
</tr>
</tbody>
</table>

Appendix B. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.envsci.2019.09.008.

References


de Groot, J.I.M., Schuitema, G., 2012d. How to make the unpopular popular? Policy standing the nuances between these values is the key to promoting constructive dialogs in policy debates.
review of the policies and implementation of practices to decrease water quality impairment by phosphorus in New Zealand, the UK, and the US. Nutr. Cycl. Agroecosyst. 104 (3), 289–305.


