1    Why does the public support or oppose agricultural nutrient runoff regulations? The effects of

2    political orientation, environmental worldview, and policy specific beliefs

3    Tian Guo [a], Victoria Campbell-Arvai[b], Bradley L. Cardinale [b]

4    a. Cooperative Institute for Great Lakes Research (CIGLR), University of Michigan, 440 Church

5    Street, Ann Arbor, Michigan 48109, USA

6    b. School for Environment and Sustainability, University of Michigan, 440 Church Street, Ann

7    Arbor, Michigan 48109, USA

8

9    **Corresponding author**: Tian Guo, tianguo@umich.edu, Cooperative Institute for Great Lakes

10   Research (CIGLR), University of Michigan, 4840 S. State Rd, Ann Arbor, Michigan 48104,

11   USA

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13   Highlights:

14   - Two models of public support for regulation to reduce agricultural runoff in Ohio
15   - Public support was moderated by regulatory-specific beliefs
16   - Autonomy beliefs decrease support for regulations on agricultural runoff
17   - Accountability beliefs increase support for regulations on agricultural runoff
18   - Environmental worldview indirectly affect support for regulations on agricultural runoff

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21 Abstract:

22 This research examines public acceptability of regulations to reduce agricultural nutrient runoff

23 and curb Harmful Algal Blooms (HABs). We tested the effects of two novel policy specific

24 beliefs including support for farmers' autonomy and support for external accountability. We also

25 simultaneously tested the direct and indirect effects of political orientation and environmental

26 worldview through a Direct Effect Model and a Mediation Model using structural equation

27 modelling. Survey data were collected from 729 Ohio residents collected in November 2018.

28 The specific regulatory policy measure we targeted is fines on excessive agricultural runoff. As

29 hypothesized, autonomy beliefs negatively affect, and accountability positively affect support for

30 fines. Both models revealed good fits. the direct effects of environmental worldviews political

31 orientation were not supported. Instead, environmental worldviews indirectly increased support

32 for fines through increased accountability beliefs and diminished autonomy beliefs. From the

33 results, we suggest that when proposing suitable regulations for specific sites, policy makers and

34 interest groups should be aware of differences in public support for farmer autonomy and

35 external accountability, and that such differences are likely rooted in environmental worldviews.

36 The study also suggests a need for coupled ecological and social studies that assess the

37 likelihood of regional agricultural producers voluntarily adopting conservation practices and

38 forecast the effectiveness of potential accountability measures.

39 Keywords: policy acceptability; Great Lakes; Environmental values

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# 1. Introduction

Facing increasing threats of nutrient pollution from agricultural runoff and the ensuing harmful algal blooms (HABs), governments in different parts of the world are using diverse methods, including regulatory policies to induce wide-spread changes in farming practices. However, people disagree on whether regulatory policies should be used in addition to existing market-based, educational, and technical assistance programs (Garnache, Swinton, Herriges, Lupi, & Stevenson, 2016; Shortle & Horan, 2013; Smith et al., 2018). In cultures that emphasize individual freedom, including the United States, regulations such as penalties, mandatory actions, and monitoring are often less acceptable than policy approaches designed to promote voluntary behavioral changes or that rely on market-based solutions (Rissman, Kohl, & Wardropper, 2017; Steg, Dreijerink, & Abrahamse, 2006; 2016; de Groot & Schuitema, 2012; Howard, Roe, Nisbet, & Martin, 2017). A better understanding of why individuals support or oppose regulations on the agricultural industry will provide insight into public support for on-farm nutrient management practices and inform related policy discussion and development.

In this study, we investigate the drivers of support for regulations to reduce nutrient pollution by testing the effects of two policy specific beliefs, political orientation, and environmental worldview with survey data from residents in Ohio, United States. We set out to advance the understanding on public support for regulations in three ways: (1) testing the effects of two novel regulation-specific beliefs, support for autonomy and support for external accountability, (2) simultaneously examining the effects of political orientation and environmental worldviews, and (3) comparing the direct and indirect effects of political orientation and environmental worldview using model selection techniques. In the next sections, we summarized relevant past studies on public acceptability of environmental regulations

64  including the effects of political orientation and environmental worldview. We proposed two

65  models that test the direct and indirect effects of political orientation and environmental

66  worldview.

67                                        2. Literature Review

68  2.1 Support for Farmers' Autonomy and External Accountability

69          We propose that two novel policy-specific beliefs, support for *autonomy* and support for

70  *external accountability*, play a critical role in determining individual support or opposition to a

71  specific regulatory policy measure. Autonomy refers to farmers' ability to make decisions that

72  they think are right for their farm, and accountability describes farmers' responsibility for their

73  farm management outcomes. Particularly, farmers' self-regulation and intention to steward

74  farmlands are the manifestation of farmers' autonomy in reducing nutrient runoff. The extent to

75  which the public supports farmer autonomy may affect their support for regulation of common

76  agricultural practices. As researchers discovered, the perception of infringements on individual

77  freedom of choice (i.e., infringement on individual autonomy) is a key source of the unpopularity

78  of many regulations (Eriksson, Garvill, & Nordlund, 2018; Steg, Dreijerink, & Abrahamse, 2006;

79  Jagers, Harring, & Matti, 2018). In other words, if the polluters are self-motivated and able to

80  change their actions on their own, it is more desirable to avoid regulation (Steg, et al., 2006).

81  Thus, support for autonomy is linked with decreased support for regulations. In comparison,

82  support for external accountability is likely to increase support for regulations. As noted by

83  Jagers et al. (2018), "examples of people voluntarily cooperating on a larger scale, involving a

84  widely dispersed and mutually anonymous multitude of people, are strikingly rare." (p. 86)

85  Environmental groups often advocate for regulations as means to ensure external accountability,

86 especially when the desired behavior change may impose economic losses on the polluter or

87 requires effort to carry out.

88     Nevertheless, beliefs about farmers' autonomy and external accountability have not been

89 explicitly tested in the policy acceptability literature. In our attempt to conceptualize these two

90 complicated concepts, we consider public support for farmers' autonomy and external

91 accountabilities as latent constructs, which consist of specific beliefs about farmers' intention

92 and behaviors. Specifically, the conceptualization of autonomy beliefs is informed by research

93 on trust. Guo, Gill, Johengen, and Cardinale (2019) found that residents who trust farmers and

94 their judgements related to water quality are less likely to support state government efforts to

95 introduce fines on excessive agricultural runoff. Others have found that low trust in business

96 actors explains why people in some countries demand more regulations (Aghion, Algan, Cahuc,

97 & Shleifer, 2010; Harring, 2018). The conceptualization of accountability beliefs is informed by

98 policy discussion around mitigating agricultural runoff to Lake Erie (Coleman, 2016; Guo et al.,

99 2019).

100     We predict that increasing autonomy beliefs result in a decrease in support for regulations,

101 while increasing accountability beliefs result in an increase in support for regulations.

102     H1. Autonomy beliefs will have a direct effect on support for regulation, with increasing

103         strength of autonomy beliefs resulting in a decrease in support for regulations.

104     H2. Accountability beliefs will have a direct effect on support for regulation, with

105         increasing strength of accountability beliefs resulting in an increase in support for

106         regulations.

107     2.2 Political Orientation and Environmental Worldview

108         People's attitudes towards environmental regulation are thought to be rooted in their

109     political orientation and environmental worldviews (Dietz et al 2007; Jagers et al 2018; Van

110     Boven et al 2018). Political orientation describes a person's beliefs and opinions about

111     characteristics of the political and economic system (political ideology) and often manifests as

112     their affiliation with political parties (Cruz, 2017; Harring, Jagers, & Matti, 2017). The most

113     common scale to measure individual political ideology is along the strongly liberal to strongly

114     conservative spectrum. People who place themselves towards the 'strongly liberal' end on the

115     scale tend to support an active, non-neutral state, a more regulated market, and universal welfare

116     policies. Those who identify with the strongly conservative end of the scale tend to be prefer a

117     passive neutral state, an unregulated market, and limited social policy interventions (Harring, et

118     al., 2017). Environmental worldviews, on the other hand, reflect beliefs about a human's

119     relationship with the natural environment (Dunlap, Van Liere, Mertig, & Jones, 2000). The most

120     widely used measure for environmental worldview is the New Environmental Paradigm (NEP),

121     which measures individuals positions on belief statements such as "human activities impact the

122     balance of nature," "human beings have the right to modify and control the natural environment",

123     and "an eco-crisis is possible" (Hawcroft & Milfont, 2010). Conceptually, political orientation

124     and environmental worldview are two related components of an individual's fundamental view

125     of the world (Ziegler, 2017).

126         Overall, those who endorse a liberal political ideology, or pro-environmental worldview,

127     tend to support more stringent regulation and 'stick'-type policies (bans, penalties), those who are

128     more conservative politically and individualistic in their worldview favor market-based

129     approaches and more 'carrot'-type policies (incentives and credits) (Jagers et al 2018; Rissman et

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130 al 2017; Tosun et al 2020; Attari et al 2008; Merrill & Sintov 2016; Milman et al 2018).

131 However, few studies of policy support have examined political orientation and environmental

132 worldview simultaneously (Harring et al., 2017; Ziegler, 2017). Those studies that have been

133 conducted reveal somewhat mixed findings about the relative strengths of political orientation

134 and environmental worldviews in predicting policy support. While some have found that when

135 environmental worldview is included in the model, political orientation is no longer a significant

136 predictor of policy support (Attari et al., 2009; Harring & Jager, 2013; Shwom et al., 2010),

137 others have shown both environmental worldview and political ideology as significant

138 independent predictors (Zeigler 2017). Our hypotheses predict environmental worldview and

139 political ideology both directly affect support for regulations, yet we acknowledging that the

140 literature is inconclusive on these relationships.

141    H3. Political orientation will have a direct effect on support for regulation, with

142       conservative political orientation associated with decreased support for regulations.

143    H4. Environmental worldview will have a direct effect on support for regulations, with a

144       stronger pro-environmental worldview associated with greater support for regulations.

145    Our last sets of hypotheses expect political orientation and environmental worldview

146 affecting the autonomy beliefs and the accountability beliefs. Those who endorse a strong

147 environmental worldview may be resistant to the idea that industrial agricultural practices can

148 have positive environmental outcomes (Heise & Theuvsen 2016; Tosun et al 2020), and thus be

149 inclined to hold a low level of support for farmer autonomy but high level of support for farmer

150 accountability. Conversely, those who self-identify as politically conservative may have a high

151 level of support for farmer autonomy, consistent with their beliefs in free market, while having a

152 low level of support for farmer accountability, consistent with their reservations with

153 government intervention (Jagers et al, 2018).

154     H5.  Political orientation will have a direct effect on policy-related beliefs, with autonomy

155         beliefs increasing and accountability beliefs decreasing with increasingly conservative

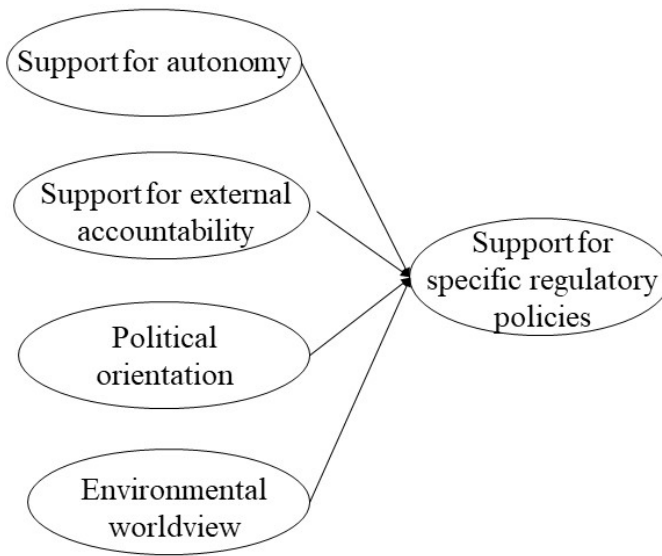156         political orientation.

157     H6.  Environmental worldview will have a direct effect on policy-related beliefs, with

158         autonomy beliefs decreasing and accountability beliefs increasing with increasingly

159         pro-environmental worldview.

160                            3. Materials and Methods

161     We tested these hypotheses through two alternative models. Our analyses are based on the

162 data collected from an online survey of Ohio residents that was conducted in November 2018.

163 The survey gauged public awareness of and preferences for solutions to harmful algal blooms in

164 Lake Erie, one of the Laurentian Great Lakes. In this section, we first introduced the models and

165 then summarized the data and analyses we used to test the models.

166 3.1 Models

167     We tested two alternative models about the effects of autonomy beliefs, accountability

168 beliefs, political orientation, and environmental worldview on support for specific regulatory

169 policies. The first model only includes the direct effects of the autonomy belief, accountability

170 belief, political orientation, and environmental worldview on regulation support (Figure 1). This

171 model emphasizes that political orientation and environmental worldview operate independently

172 and directly, and not through policy beliefs.

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174　Figure 1.Model 1 is a direct effect model describing how political orientation, environmental

175　worldview, and policy-specific beliefs affect support for environmental policies.

176　　In comparison, the second model only includes the indirect effects of political orientation

177　and environmental worldview on regulation support (Figure 2). The model emphasizes that

178　political orientation and environmental worldview operate through the policy-related beliefs. In

179　other words, the autonomy belief and the accountability belief are hypothesized to fully mediate

180　the effects of political orientation and environmental worldview on regulation support.
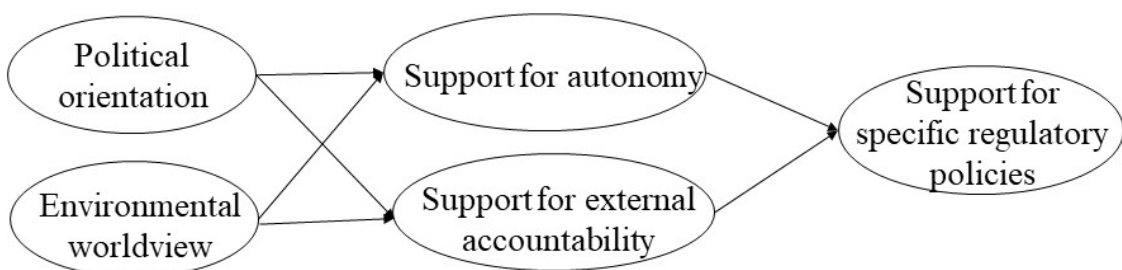


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182    Figure 2. Model 2 is a mediation model describing how political orientation, environmental

183    worldview, and policy-specific beliefs affect support for environmental policies.

184         We propose to compare the two models statistically to test whether the two policy

185    specific beliefs fully mediate the effects of political orientation and environmental worldview.

186    Traditionally, researchers directly fit a partial mediation model but test the full mediation

187    hypotheses through qualitatively assessing the significance of the direct and indirect paths. In

188    comparison, our multiple model approach will quantify which model specification best fits the

189    data, and by how much. Any detected difference in the model fit statistics results directly from

190    whether political orientation and environmental worldview are specified as directly or indirectly

191    affect regulation support. Although the multiple model approach is a standard practice in natural

192    science fields such as ecology (Johnson & Omland, 2004), it is less common in the mechanism

193    studies about public support for environmental policies. Due to insufficient prior evidence we do

194    not have a hypothesis about which model will perform better. Nevertheless, with using this

195    "novel" approach, we attempt to expand on how pathways for public policy support can be tested.

196    3.2 Study Case

197         The frequency, extent, and peak severity of toxin forming HABs in Western Lake Erie have

198    increased since the mid-1990s (Michalak et al., 2013; Stumpf et al., 2012). Annual economic

199    loss due to blooms in Western Lake Erie is estimated at \$65 to \$71 million (Bingham, Sinha, &

200    Lupi, 2015). In 2016, under the Great Lakes Water Quality Agreement, the U.S. and Canada

201    Government set a target of reducing nutrient loading in Lake Erie by 40% (Maccoux, Dove,

202    Backus, & Dolan, 2016; Scavia, DePinto, & Bertani, 2016; Stumpf, et al., 2016). Most of these

203    reductions need to occur in agricultural runoff. Regulations on agricultural runoff—including

204  fines for excessive agricultural runoff—are considered one tool that might ensure accountability

205  but face strong opposition from the farming community (Garnache et al., 2016; Shortle & Horan,

206  2013; Guo et al., 2019[a]). The center of the discussion is in the Midwestern state of Ohio, a state

207  that receives the most impacts from HABs in Lake Erie but also contributes the most agricultural

208  nutrient loading to the Lake (Maccounx, et al., 2016). In this situation, Ohio residents' support

209  for (or resistance to) regulations on agricultural nutrient runoff may motivate (or discourage)

210  politicians to introduce regulatory policies to address the HAB problem in Lake Erie.

211  3.3 Survey implementation

212      We collected public opinion data through survey firm YouGov (For YouGov's

213  recruitment and non-probability sampling methodology see Twyman, 2008). One thousand (1000)

214  Ohio residents enrolled in YouGov's online panel completed the survey. These cases matched to

215  a target sample that was drawn from a constructed sample frame using results from the American

216  Community Survey. The matching criteria were gender, age, race and education. The sample was

217  also set to represent the five Ohio EPA districts that are managed by the Central District Office,

218  Northwest District Office, Southeast District Office, Northeast District Office and the Southwest

219  District Office (https://epa.ohio.gov/Districts). Weights were calculated using propensity scores

220  and were used in all descriptive and modeling analyses.

221  3.4 Measures

222  *Support for regulation.* We selected penalties on excessive agricultural runoff as a specific

223  example of regulations because it is intuitive for respondents to understand without detailed

224  explanations. Respondents were asked "If the education, technical assistance and cost-share

225  programs reduced fertilizer runoff to Lake Erie by 5% (instead of the 40% target), how much

226 would you support state government introduction of fines for farmers who allow too much

227 agricultural runoff" using a seven-point scale with one (1) meaning strongly oppose and seven (7)

228 meaning strongly support. The question set up a scenario in which voluntary policies (i.e.,

229 education, technical assistance, and cost) were not effective in reducing agricultural runoff.

230 *Support for farmer autonomy.* We used three questions to measure individual support for farmer

231 autonomy. The first question measure respondents' self-reported trust-level, "In general, to what

232 extent do you trust Ohio farmers to manage the land well?", with one (1) meaning strongly

233 distrust and seven (7) meaning strongly trust. The other two questions are Likert Scale questions

234 asking respondents to rate their levels of agreement with two statements "Ohio farmers are

235 generally sensitive to the concerns of Lake Erie water quality," and "Most Ohio farmers have

236 been careful in applying fertilizer to their lands." For these two questions, selecting one (1)

237 meant strongly agree, and seven (7) indicated strongly disagree.

238 *Support for external accountability.* We asked respondents to rate their levels of agreement with

239 three statements" With the threat of penalty, farmers are more likely to adopt best management

240 practices to reduce fertilizer runoff," "Farmers have too much freedom to do what they want on

241 their land," and "Regulations are necessary to keep farmers accountable for their land

242 management practices." For these questions, seven (7) indicated strong agreement, and one (1)

243 indicated strong disagreement.

244 *Political orientation.* Political orientation was measured using two questions following Ziegler's

245 (2017) approach. For political ideology, respondents were asked: "In general, how would you

246 describe you own political viewpoint" on a five-point scale with one (1) meaning very liberal and

247 five (5) meaning very conservative. Respondents' party affiliation was measured on a seven-

248    point scale with one (1) meaning strong Democrat and seven (7) meaning strong Republican.

249    These two items were used as the indicator for the latent variable political orientation in the SEM

250    models.

251    *Environmental worldview.* We measured the environmental worldview using the revised 15-item

252    NEP scale (Dunlap, et al. 2000). Respondents were asked to rate their level of agreement to

253    statements such as "The earth has plenty of natural resources if we just learn how to develop

254    them" and "If things continue on their present course, we will soon experience a major ecological

255    catastrophe." Responses were selected from a seven-point scale with one (1) meaning strongly

256    disagree and seven (7) meaning strongly agree. Eight of the items are consistent with an

257    environment-centric worldview while the other seven items were worded to represent a human-

258    centric worldview (Dunlap, et al., 2000).

259    3.5 Data Analysis

260        The hypotheses were tested with Structural Equation Modeling package LAVAAN in R

261    ver. 3.6.3. Given the variables were measured by Likert scales, we used robust Maximum

262    Likelihood Estimator (specifying "estimator=mlr" in R) to account for the impacts of

263    measurement on the multi-normality assumption (Li, 2016; Rhemtulla & Savalei, 2012). For

264    environmental worldview, we followed Dunlap's et al. (2000) scale reduction method and

265    conducted Principal Component Analysis (PCA) with anti-NEP items reverse coded. We used

266    the factor score of the first principle component as people's environmental worldview scores,

267    with higher scores indicating a stronger pro-environmental worldview[1]. To specify

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[1] There is an ongoing debate about the latent factor structure of the NEP scale. Some researchers used a single NEP scale score while others argued for three-factor, four-factor, and even five-factor structure (Hawcraft & Milfont, 2010; Amburburgey & Thoman, 2012, Xiao & Buhrmann,

268  environmental worldview as a latent variable with a single indicator (NEP score), we set the

269  variance of the latent variable as (1- $\lambda$) the variance of the single indicator, where $\lambda$ is the

270  reliability of the single item in measuring the latent variable (Petrescu, 2013). We set the $\lambda$ to be

271  a conservative value of 0.9, informed by the reliability of the NEP scale (Cronbach's $\alpha$ =0.90).

272  The value of $\lambda$ is lower than the value of 0.95 suggested by Anderson and Gerbing (1988) when

273  the estimate for the error variance of the single indicator is absent. We used five goodness of fit

274  criteria, including p-value of chi-square >0.05, CFI >0.9, TLI>0.9, RMSEA <0.06, SRMR<0.05

275  (Bentler, 1990; Hu & Bentler, 1999). Cases with missing values were deleted from the analyses.

276  We compared the Direct Effect Model and the Mediation Model using likelihood ratio test,

277  Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). The models with

278  smaller AIC and BIC indicate a better fit to the data.

279                                  4. Results

280       The survey collected 1,000 completed surveys. Some of the survey had missing answers

281  for select questions. After using listwise deletion, the resulting sample size for model testing was

282  729. In the following sections, we first describe the sample, after which we summarize the

283  modeling results.

284  4.1 Respondents profile

285       The weighted sample descriptions were as follows: 52.8% female, 82.2% white alone,

286  11.8% African American, 93.1% 25 years old and over, among whom 27.5% has bachelor's

287  degree or higher. Geospatially, 14.8% of the sample was from Northwest Ohio, 32.8% from

288  Northeast Ohio, 24.5% from Southwest Ohio, 18.1% from Central Ohio, and 9.8% from

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2017). We tested a five-factor structure and a second-order factor structure of NEP, but neither
measurement model fit the data. Instead, we followed Dunlap's suggestion (Dunlap, et al., 2000),
and used NEP score as a single indicator for the latent variable of environmental worldview

289     Southeast Ohio. In the sample, 9.7% respondents work or have previously worked in the

290     agricultural industry. It is considerably higher than the estimated number of employments per

291     1,000 jobs in Ohio for combined farming, fishing and forestry occupations (0.935, equivalent to

292     0.09%) (U.S. Bureau of Labor Statistics, 2018). Less than ten percent respondents (6.0%) work

293     or previously worked on or near Lake Erie in industries such as fishing industry, tourism,

294     recreation, and shipping. About a third of respondents (33.9%) used Lake Erie for recreational

295     purposes. On average, respondents rated their knowledge of farming in Ohio as less than

296     intermediate but more than novice (mean = 2.9, S.D.= 1.5, on a seven-point scale).

297       When voluntary programs were projected to achieve a nutrient loading reduction of 5%,

298     respondents, on average, somewhat supported the state government to introduce fines on

299     excessive agricultural runoff (Table 1).

300     Table 1. Mean and Standard deviation of items measuring fine support, autonomy beliefs,
301     accountability belief, environmental worldview, and political orientation.

| Items | N | *Mean* | *S.D.*\* |
|---|---|---|---|
| Support for fines on excessive agricultural runoff | 1000 | 4.7 | 1.7 |
| *Autonomy belief* | | | |
| Auto1: General level of trust in Ohio farmers to manage the land well | 1000 | 4.6 | 1.4 |
| Auto2: Ohio farmers are generally sensitive to the concerns of Lake Erie water quality | 884 | 4.3 | 1.4 |
| Auto3: Most Ohio farmers have been careful in applying fertilizer to their lands | 860 | 4.3 | 1.5 |
| *Accountability belief* | | | |
| Acco1: With the threat of penalty, farmers are more likely to adopt best management practices to reduce fertilizer runoff | 936 | 5.0 | 1.4 |
| Acco2: Farmers have too much freedom to do what they want on their land | 893 | 3.6 | 1.6 |
| Acco3: Regulations are necessary to keep farmers accountable for their land management practices | 947 | 5.1 | 1.5 |
| *Environmental worldview* – NEP score | 998 | 4.7 | 1.0 |
| *Political orientation* | | | |
| Ideology | 927 | 3.2 | 1.2 |
| Party ID | 973 | 3.8 | 2.2 |

302     \* S.D. Standard Deviation

15

303     Note. The beliefs items using a seven-point scale, with one indicating strongly disagree, and

304     seven indicating strongly agree.

305         The explanatory factor analysis for the six items of autonomy belief and accountability

306     belief suggested two latent factors with eigenvalues larger than one and the item-loading pattern

307     was as expected. We then calculated the mean of each scale as a proxy for the belief score. The

308     correlation between the two belief scores was significant but weak (r = - 0.21, p-value <.0001),

309     suggesting the two beliefs were distinct constructs (More details on the relationship between the

310     two beliefs are in the supplementary materials).

311         Both political ideology and Party ID significantly correlated with individual support for

312     fines on excessive agricultural runoff. Residents who held more conservative ideology (r = - 0.31,

313     p-value <.0001) or identified with the Republican Party more strongly (r = - 0.20, p-value <.0001)

314     were less likely to support fines, even under the scenario that voluntary nutrient reduction

315     programs were deemed ineffective. Similarly, respondents who held stronger pro-environmental

316     worldview showed stronger support for fines on excessive agricultural runoff when voluntary

317     programs were deemed ineffective (r=.46, p-value<.0001).

318     4.2 Modeling Results

319         The initial measurement model consisted of political worldview, environmental

320     worldview, autonomy beliefs, and accountability beliefs revealed acceptable values of CFI

321     (0.960), TLI (0.941), RMSEA (0.070), and SRMR (0.056), but the chi-square was significant

322     (chi-square = 130.013, $df$=45, p-value <.001), indicating poor model fit to the data. Therefore,

323     we used the Modification Index (MI) to improve model fit. MI calculated by the LAVAAN

324     package in R suggested five changes, including adding correlated errors between three pairs of

325     items, and adding two items to additional latent variables (For details of measurement model re-

16

326    specification see Supplementary materials). The re-specified model was a significant fit to the

327    data (Chi-square = 21.62, *df*=17, p-value = 0.2).

328         Using the re-specified measurement model, Model 1 (the Direct Effect Model) fit the data

329    well (Robust Chi-square = 28.837, df = 22, p-value =.153, Robust CFI=.996, Robust TLI=.991,

330    Robust RMSEA=.028, SRMR=.030, Table 2). It explained 44.9% of the variance in support for

331    fines. Model 2 (the Mediation Model) also fit the data (Robust Chi-square = 29.31, df = 23, p-

332    value =.17, Robust CFI=.996, Robust TLI=.992, Robust RMSEA=.027, SRMR=.029). It

333    explained 44.5% of the variance in support for fines.

334    Table 2. Model Fit Results

| Model | Chi-square | df | p-value | Robust CFI | Robust TLI | Robust RMSEA | SRMR | AIC | BIC |
|---|---|---|---|---|---|---|---|---|---|
| Model 1: Direct Effect | 28.837 | 22 | .150 | .996 | .991 | .028 | .030 | 23387 | 23538 |
| Model 2: Mediation | 30.086 | 25 | .221 | .997 | .994 | .023 | .030 | 23386 | 23523 |

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336    In Model 1, autonomy belief (Standardized β = -.20, p-value= .001) and accountability beliefs

337    (Standardized β = .62, p-value <.001) significantly predicted individual support for fines,

338    supporting H1 and H2 (Figure 3). Conversely, political orientation (Standardized β =-.05, p-

339    value =.377) and environmental worldview (Standardized β = -.08, p-value=.384) did not

340    directly predict support for fines, rejecting H3 and H4.
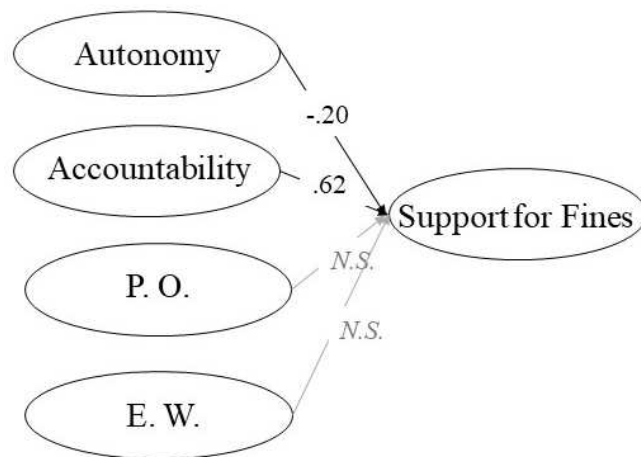
(Direct Effect Model)

Figure 3. Model 1: standardized coefficients of the significant paths in the direct effect model

In Model 2, autonomy beliefs (Standardized $\beta$ = -.17, p-value= .002) and accountability beliefs (Standardized $\beta$ = .59, p-value <.001) remained significant predictors of individual support for fines, supporting H1 and H2 (Figure 4). Environmental worldviews significantly predicted the autonomy beliefs (Standardized $\beta$ = -.42, p-value <.001) and the accountability beliefs (Standardized $\beta$ = .68, p-value <.001). As we hypothesized, individuals who hold stronger pro-environmental worldview were more likely to support external accountability, while less likely to trust the autonomy of farmers in reducing nutrient runoff (supporting H6). However, different from our expectation, political orientation did not significantly predict autonomy belief (Standardized $\beta$ = .07, p-value= .342) or accountability belief (Standardized $\beta$ = -.06, p-value= .439) (rejecting H5).

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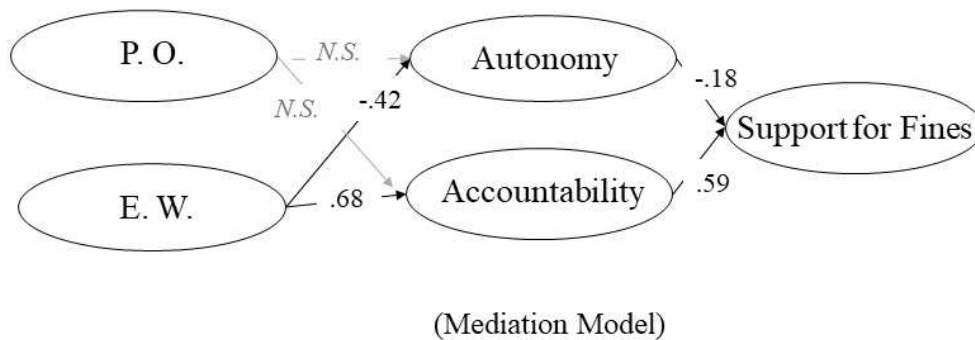
(Mediation Model)

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354  Figure 4. Model 2: standardized coefficients of the significant paths in the mediation model

355       When comparing the two models, the likelihood ratio test suggested no significant

356  difference between the two models (Chi-square difference = 1.817, Degree of Freedom

357  difference =3, p-value = .6113). The AIC and BIC of the models were also similar, suggesting

358  neither the Direct Effect model nor the Mediation Model fit the data better (For extended

359  modelling efforts, including the test on a partially mediated model, please see Supplementary

360  Materials).

361                                    5. Discussion

362       In this paper, we used survey data from Ohio residents to analyze how autonomy beliefs,

363  accountability beliefs, political orientation and environmental worldview influence individual

364  support for specific regulatory policies to reduce agricultural nutrient runoff. We fitted a direct

365  effect model (Model 1) and a mediation model (Model 2), with the two beliefs fully mediating

366  the effects of political orientation and environmental worldview on support for regulations. The

367  results supported the direct effects of autonomy beliefs and accountability beliefs on support for

368  fines but did not support the direct effect of political orientation or environmental worldview.

369  Environmental worldview had an indirect effect on support for fines for excessive agricultural

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370     runoff through autonomy and accountability beliefs. There were no significant indirect effects of

371     political orientation.

372           As hypothesized, autonomy beliefs and accountability beliefs appear to play a significant

373     role in determining individual support for specific regulations. Our measurement of autonomy

374     beliefs reflects trust in the agriculture industry (Guo et al, 2019), and results are consistent with

375     other studies showing that trust in the targets of regulation (in this case, agricultural producers)

376     decreases individual support for environmental regulations (Aghion et al, 2010; Harring, 2018).

377     The modelling results also suggest accountability beliefs play a larger role in determining

378     support for regulations than the effects of autonomy belief. In other words, a key driver for

379     public support of environmental regulations may be a desire for external accountability. This

380     finding follows similar conclusions from Tosun et al (2020), who documented growing public

381     awareness of aquatic pollution, an ascription of responsibility to agriculture and industry actors,

382     and increased support for strong top-down regulation of these sectors.

383           When comparing the effects of political orientation and environmental worldview,

384     neither directly predicted individual support fines on excessive agricultural runoff. However,

385     environmental worldview showed indirect effects on support for fines through autonomy beliefs

386     and accountability beliefs.  As predicted, people who held a strong pro-environmental worldview

387     showed high levels of support for external accountability but low levels of support for farmer

388     autonomy. These results are consistent with biased information processing and motivated

389     reasoning (Hart, Nisbet, & Myers et al., 2015). Environmental worldview may affect how people

390     view the intentions and willingness of agricultural producers to solve the HABs problem. The

391     different views on farmers then played a critical role in individual attitude formation toward

392     stringent regulatory policy.

393        We found that there were no direct or indirect effects of political orientation on support

394    for fines. Our results add to the mixed findings from other studies that have simultaneously

395    tested the effects of environmental worldview and political orientation (Attari, et al., 2009;

396    Harring & Jager, 2013; Ziegler 2017). The results from our study suggest that environmental

397    worldview may be a more salient factor in the formation of autonomy beliefs, accountability

398    beliefs, and support for fines, as compared to political orientation. One speculation for this

399    difference was that the HABs issue in Lake Erie was not as politically polarized as other

400    environmental issues like climate change. People's policy preference for HABs may instead be

401    more in tune with their views on human's relationship with the natural environment, and their

402    observations of the potential vulnerability of Lake Erie to human stressors. Another possibility is

403    that political orientation and environmental worldview measured by NEP are highly correlated,

404    and thus political orientation did not make a significant independent contribution to the

405    explanatory power of the model. In addition, conservative political orientation might decrease

406    support for regulations through other mediators such as decreasing news exposure and risk

407    perceptions (Guo, et al, 2019). Political orientation may moderate the effects of environmental

408    worldview on autonomy beliefs and accountability beliefs. These alternative explanations of the

409    lack of effects of political orientation are worth investigating in future research.

410        Lastly, although autonomy and accountability beliefs fully mediated the effects of

411    environmental worldview on support for regulations, the model-comparison methods were

412    inconclusive. Overall, the strengths of this study include a representative sample with 729 cases

413    and a rigorous modelling approach. We were able to achieve our first and second contributions,

414    but left questions for future studies to discern the specific nature of the effects of political

415    ideology and environmental worldview on environmental policy.

## 5.1 Limitation and Future Research

416

417    The study has limitations that are worth acknowledging. First, we used cross-sectional

418    data and Structural Equation Modeling to infer the causal effects of political orientation,

419    environmental worldviews, autonomy beliefs, and accountability beliefs, on support for fines.

420    Although our results revealed strong signals for some of the effects, confirming causality

421    requires longitudinal studies or controlled experiments with interventions (Dunning 2008).

422    Second, there may be additional variables which play a role in mediating the effects of political

423    orientation on support for fines, and which were not included in this study, such as perceived

424    efficacy of the fine and risk perceptions (Hart, et al., 2011). Third, as with other studies that used

425    the NEP scale to measure environmental worldviews, we encountered difficulty in discerning the

426    factor structure of the scale. In this study, environmental worldview was aggregated into a single

427    measure and thus it was not possible to parse out which specific aspects of environmental

428    worldview might determine a person's views on autonomy, accountability, and support for fines.

429    Lastly, our measurements for autonomy beliefs and accountability beliefs have not been

430    tested in previous studies. The validity and reliability of the measurement requires further tests.

431    We acknowledge that the latent construct approach may appear less intuitive than a single item

432    approach (e.g., "Farmers should be able to make the decisions they think are right for their

433    farm"), but we believe it adds useful details about public beliefs related to farmer autonomy

434    which can inform more effective policy-related messaging. In spite of these limitations, the study

435    provides insight into the role of autonomy beliefs, accountability beliefs, political orientation,

436    and environmental worldview in support or opposition for specific environmental regulations.

437    Looking to future research, we believe it would be beneficial to continue this line of work

438    on environmental regulations through comparing the Direct Effect Model and Mediation Model

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439 with additional fundamental beliefs and goals such as environmental values (de Groot & Steg,

440 2006) and cultural worldviews (Rissman, et al., 2017). This would allow for integration of

441 research on different dispositional factors (e.g., environmental values, cultural worldviews,

442 religious beliefs) and how they affect the tending to and processing information and formation of

443 environmental attitudes. In a separate line of economic research, studies have shown that the

444 costs, benefits, and perceived efficacy of a policy affect individual policy preferences (Howard,

445 et al., 2017). One can argue the autonomy beliefs and accountability beliefs are closely

446 correlated with the effectiveness of regulatory policies, or even tapping into the same construct.

447 Comparing the relative strengths of different policy specific beliefs and specifying the conditions

448 under which individual policy specific beliefs may play a larger or smaller role can shed more

449 light on the dynamic and nuanced process of policy attitudes formation.

450

451 5.2 Implications for Policymakers and Practitioners

452      Overall, this study demonstrates the importance of autonomy and accountability beliefs in

453 the public support for regulatory policies. For the study site of Lake Erie, our results revealed

454 moderate support for fines on excessive agricultural runoff to curb HABs. We suspect such

455 moderate level of support will not be sufficient to motivate policy makers to push a proposal for

456 fines given the political costs and existing oppositions. Other regulatory policies, such as

457 mandated nutrient management planning and soil testing, should be assessed in terms of its

458 public acceptability. When such suitable regulations are identified, our results have implications

459 for how to improve the acceptability of specific measures. Policy makers and interest groups

460 should take into account public trust in the agricultural industry, meaning perceptions of how

461 likely farmers will adopt conservation practices without external requirements. Further, policy

462     makers and interest groups should partner with natural and social scientists and provide best

463     available information on agriculture industry's self-regulation measures and historical adoption

464     rates for conservation practices. Projections about adoption rates with or without the proposed

465     regulation can also help the public caliber their trust or distrust in the agricultural industry.

466     Coupled ecological and social studies are needed to assess the likelihood of the agricultural

467     industry voluntarily adopting conservation practices and forecasting the effectiveness of potential

468     accountability measures in reducing nutrient runoff, such as mandated nutrient management plan

469     and soil testing.

470          It is worth recognizing that presented with similar information, individuals may form

471     different autonomy and accountability beliefs because of differences in environmental worldview.

472     During policy development and implementation stages, policy makers should give greater

473     consideration to biased information processing and motivated reasoning among the public.

474     Individuals with stronger pro-environmental worldview are most predisposed to support

475     environmental regulations, and thus may be more attentive and receptive to evidence that

476     reinforces these policy preferences. Identifying such differences in Ohio residents is important,

477     policy agencies need to craft tailored outreach messages that will resonate individuals with

478     different environmental worldviews (Hart, et al., 2011). These suggestions may apply to other

479     regions that have problem with agricultural nutrient runoff and see increasing public polarization

480     along political ideology and environmental worldview.

481     5.3 Conclusion

482          The goal of the study was to examine drivers of support for regulations in the context of

483     agricultural nutrient runoff in Ohio and HABs in Lake Erie. We found belief about farmer

484     autonomy and belief about external accountability significantly predicted individual support for

485    regulations on agricultural runoff. Both beliefs were rooted in individual environmental

486    worldview but not in their political ideology. When tested simultaneously, environmental

487    worldview showed stronger effects on support for regulations than political orientation. We

488    believe that improvements in Lake Erie water quality (including reductions in the frequency and

489    intensity of HABs) can be achieved—in part—by building  support for regulatory policies across

490    a broad spectrum of the Ohio public and by tailoring related communication and outreach to the

491    diversity of policy-specific beliefs and environmental worldviews that underlie this support.

References

Attari, S. Z., Schoen, M., Davidson, C. I., DeKay, M. L., Bruine de Bruin, W., Dawes, R., &

Small, M. J. (2009). Preferences for change: Do individuals prefer voluntary actions, soft

regulations, or hard regulations to decrease fossil fuel consumption? *Ecological Economics*,

*68*(6), 1701–1710.

Barnett, M. D., Archuleta, W. P., & Cantu, C. (2019). Politics, concern for future generations,

and the environment: Generativity mediates political conservatism and environmental

attitudes. *Journal of Applied Social Psychology*, *49*(10), 647–654.

Bentler, P. M. (1990). Comparative fit indices in structural models. *Psychological Bulletin*, 107,

238–246.

Bingham, M., Sinha, S. K., & Lupi, F. (2015). *Economic benefits of reducing harmful algal*

*blooms in Lake Erie*. Retrieved from

http://ijc.org/files/tinymce/uploaded/Publications/Economic-Benefits-Due-to-Reduction-in-

HABs-October-2015.pdf

Birch, S. (2019). Political polarization and environmental attitudes: a cross-national analysis.

*Environmental Politics*, *4016*.

Coleman, L. (2016). Message in a water bottle: The call for a tri-state TMDL for Western Lake

Erie. *William and Mary Environmental Law and Policy Review*, *40*, 565–590.

Cruz, S. M. (2017). The relationships of political ideology and party affiliation with

environmental concern: A meta-analysis. *Journal of Environmental Psychology*, *53*, 81–91.

Eriksson, L., Garvill, J., & Nordlund, A. M. (2008). Acceptability of single and combined transport policy measures: The importance of environmental and policy specific beliefs. *Transportation Research Part A: Policy and Practice*, *42*(8), 1117–1128.

Dunlap, R. E., McCright, A. M., & Yarosh, J. H. (2016). The political divide on Climate Change: Partisan polarization widens in the U.S. *Environment: Science and Policy for Sustainable Development*, *58*(5), 4–23.

Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). New trends in measuring environmental attitudes: Measuring endorsement of the New Ecological Paradigm: A Revised NEP Scale. *Journal of Social Issues*, *56*(3), 425–442.

Dunning, T. (2008). Improving Causal Inference: Strengths and Limitations of Natural Experiments. *Political Research Quarterly*, 61(2), 282–293.

Feinholdt, A., Schuck, A. R. T., Lecheler, S. K., & De Vreese, C. H. (2017). Shifting frames: Conditional indirect effects of contested issues on perceived effectiveness through multiple emotions. *Journal of Media Psychology*, *29*(2), 81–91.

Fischer, A., & Glenk, K. (2011). One model fits all? - On the moderating role of emotional engagement and confusion in the elicitation of preferences for climate change adaptation policies. *Ecological Economics*, *70*(6), 1178–1188.

Garnache, C., Swinton, S. M., Herriges, J. A., Lupi, F., & Stevenson, R. J. (2016). Solving the phosphorus pollution puzzle: Synthesis and directions for future research. *American Journal of Agricultural Economics*, *98*(5), 1334–1359.

Guo, T., Nisbet, E. C., & Martin, J. F. (2019)[a]. Identifying mechanisms of environmental decision-making: How ideology and geographic proximity influence public support for managing agricultural runoff to curb harmful algal blooms. *Journal of Environmental Management*, *241*(April), 264–272.

Guo, T., Gill, D., Johengen, T. H., & Cardinale, B. L. (2019)[b]. What determines the public's support for water quality regulations to mitigate agricultural runoff? *Environmental Science & Policy*, *101*(September), 323–330.

Harring, N., & Jagers, S. C. (2013). Should we trust in values? Explaining public support for pro-environmental taxes. *Sustainability (Switzerland)*, *5*(1), 210–227.

Hart, P. S., Nisbet, E. C., & Myers, T. A. (2015). Public attention to science and political news and support for climate change mitigation. *Nature Climate Change*, *5*(6), 541–545.

Hart, P. S., Nisbet, E. C., & Shanahan, J. E. (2011). Environmental Values and the Social Amplification of Risk: An Examination of How Environmental Values and Media Use Influence Predispositions for Public Engagement in Wildlife Management Decision Making. *Society and Natural Resources*, *24*(3), 276–291.

Heise, H., & Theuvsen, L. (2016). What do consumers think about farm animal welfare in modern agriculture? Attitudes and shopping behaviour. *International Food and Agribusiness Management Review, 20*(3), 379-399.

Hornsey, M. J., E. A. Harris, and K. S. Fielding. 2018. Relationships among conspiratorial beliefs, conservatism and climate scepticism across nations. Nature Climate Change **8**:614-620.

Hu, S., Jia, X., Zhang, X., Zheng, X., & Zhu, J. (2017). How political ideology affects climate perception: Moderation effects of time orientation and knowledge. *Resources, Conservation and Recycling*, *127*, 124–131.

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55.

Jagers, S. C., Harring, N., & Matti, S. (2018). Environmental management from left to right–on ideology, policy-specific beliefs and pro-environmental policy support. *Journal of Environmental Planning and Management*, *61*(1), 86–104.

Jakobsson, C., Fujii, S., & Gärling, T. (2000). Determinants of car owners' acceptance of road pricing. *Transport Policy*, *7*(2), 153–158.

Johnson, J.B. & Omland, K.S. (2004) Model selection in ecology and evolution. *Trends in Ecology and Evolution, 19(2) 101-108.*

Kunda, Z. (1990). The case for motivated reasoning. *Psychological Bulletin*, *108*, 480-498.

Leiserowitz, A. (2006). Climate change risk perception and policy preferences: The role of affect, imagery, and values. *Climatic Change*, *77*(1–2), 45–72.

Liu, X., Vedlitz, A., & Shi, L. (2014). Examining the determinants of public environmental concern: Evidence from national public surveys. *Environmental Science and Policy*, *39*, 77–94.

Lubell, M., Vedlitz, A., Zahran, S., & Alston, L. T. (2006). Collective action, environmental activism, and air quality policy. *Political Research Quarterly*, *59*(1), 149–160.

Michalak, A. M., Anderson, E. J., Beletsky, D., Boland, S., Bosch, N. S., Bridgeman, T. B., … Zagorski, M. A. (2013). Record-setting algal bloom in Lake Erie caused by agricultural and meteorological trends consistent with expected future conditions. *Proceedings of the National Academy of Sciences of the United States of America*, *110*(16), 6448–6452.

Milman, A., Warner, B., Chapman, D. and Short Gianotti, A. (2018), Identifying and quantifying landowner perspectives on integrated flood risk management. J Flood Risk Management, 11: 34-47.

Merrill, R., and N. Sintov. 2016. An Affinity-to-Commons Model of Public Support For Environmental Energy Policy. Energy Policy **99**:88-99.

Mueller, J. T., & Mullenbach, L. E. (2018). Looking for a White Male Effect in Generation Z: Race, Gender, and Political Effects on Environmental Concern and Ambivalence. *Society and Natural Resources*, *31*(8), 925–941.

Pliskin, R., Bar-Tal, D., Sheppes, G., & Halperin, E. (2014). Are Leftists More Emotion-Driven

    Than Rightists? The Interactive Influence of Ideology and Emotions on Support for Policies.

    *Personality and Social Psychology Bulletin*, *40*(12), 1681–1697.

Rissman, A. R., Kohl, P. A., & Wardropper, C. B. (2017). Public support for carrot, stick, and

    no-government water quality policies. *Environmental Science and Policy*, *76*(November

    2016), 82–89.

Shortle, J.S., & Horan, R. D. (2013). Policy instruments for water quality protection. *Annual
    Review of Resource Economics*, *5*(1), 111–138.

Shortle, J. S., Ribaudo, M., Horan, R. D., & Blandford, D. (2012). Reforming agricultural

    nonpoint pollution policy in an increasingly budget-constrained environment.

    *Environmental Science and Technology*, *46*(3), 1316–1325.

Shwom, R., Bidwell, D., Dan, A., & Dietz, T. (2010). Understanding U.S. public support for

    domestic climate change policies. *Global Environmental Change*, *20*(3), 472–482.

Smith, N., & Leiserowitz, A. (2014). The role of emotion in global warming policy support and

    opposition. *Risk Analysis*, *34*(5), 937–948.

Smith, D. R., Wilson, R. S., King, K. W., Zwonitzer, M., McGrath, J. M., Harmel, R. D., …

    Johnson, L. T. (2018). Lake Erie, phosphorus, and microcystin: Is it really the farmer's fault?

    *Journal of Soil and Water Conservation*, *73*(1), 48–57.

Stern, P. C. (2000). Toward a coherent theory of environmentally significant behavior. *Journal of Social Issues*, *56*(3), 407–424.

Stern, P. C., Dietz, T., Abel, T., Guagnano, G. a., & Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. *Human Ecology Review*, *6*(2), 81–97.

Stoutenborough, J. W., Sturgess, S. G., & Vedlitz, A. (2013). Knowledge, risk, and policy support: Public perceptions of nuclear power. *Energy Policy*, *62*, 176–184.

Stumpf, R. P., Wynne, T. T., Baker, D. B., & Fahnenstiel, G. L. (2012). Interannual variability of cyanobacterial blooms in Lake Erie. *PLoS ONE*, *7*(8).

Tam, J., & McDaniels, T. L. (2013). Understanding individual risk perceptions and preferences for climate change adaptations in biological conservation. *Environmental Science and Policy*, *27*, 114–123.

Tosun, J., Schaub, S., & Fleig, A. (2020). What determines regulatory preferences? Insights from micropollutants in surface waters. *Environmental Science and Policy*, *106*(February), 136–144.

U.S. Bureau of Labor Statistics (2018) May 2018 State Occupational Employment and Wage Estimates Ohio. Retrieved from U.S. Bureau of Labor Statistics website: https://www.bls.gov/oes/2018/may/oes_oh.htm#45-0000

Van Boven, L., Ehret, P. J., & Sherman, D. K. (2018). Psychological barriers to bipartisan public support for climate policy. *Perspectives on Psychological Science*, *13*(4), 492–507.

Wang, S., Leviston, Z., Hurlstone, M., Lawrence, C., & Walker, I. (2018). Emotions predict

    policy support: Why it matters how people feel about climate change. *Global*

    *Environmental Change*, *50*(August 2017), 25–40.

Ziegler, A. (2017). Political orientation, environmental values, and climate change beliefs and

    attitudes: An empirical cross-country analysis. *Energy Economics*, *63*, 144–153.