SCHOOL OF ENVIRONMENT AND NATURAL RESOURCES

Assessing Water Quality Concepts

A Report from the Environmental and Social Sustainability Lab for the Franklin Soil and Water Conservation District

THE OHIO STATE UNIVERSITY
COLLEGE OF FOOD, AGRICULTURAL, AND ENVIRONMENTAL SCIENCES

About the Environmental and Social Sustainability Lab

The Environmental and Social Sustainability (ESS) Lab is a collaborative community of scholars working to build scientific understanding of environmental and social sustainability in an interdisciplinary context. Housed within the School of Environmental and Natural Resources within The College of Food, Agriculture, and Environmental Sciences, we are staffed by a core group of affiliated faculty members, students, and research staff representing a broad range of social science expertise. Our mission is to support a viable socio-ecological future through applied social science research, and to serve as a hub of sustainability research at Ohio State.

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Suggested Citation

Schwab, E. R., Slagle, K. M., and Wilson, R. S. 2020. *Assessing Water Quality Concepts: A Report by the Environmental and Social Sustainability Lab for the Franklin Soil and Water Conservation District.* The Ohio State University, School of Environment and Natural Resources.

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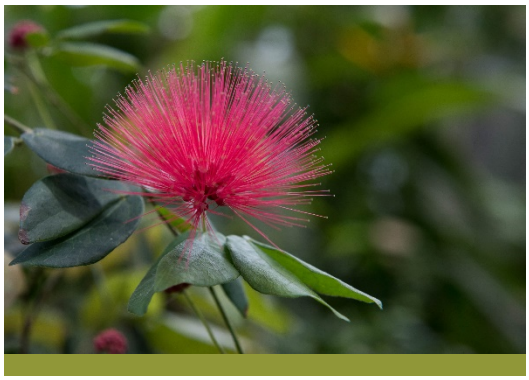

Contents

Methodology and Design 3

Section 1: Sample Characteristics 4

Section 2: Knowledge Items..... 5

Section 3: Water Quality Knowledge and Behavior..... 7

Section 4: Suggested Actions 9

Appendix A: Messaging and Survey Questions: FSWCD and OSU 11

Appendix B: Additional Data 17

References..... 27

Methodology and Design

This study was designed to assist Franklin Soil and Water Conservation District (FSWCD) in understanding how best to assess central Ohioans' water quality knowledge and engagement in behaviors that influence water quality. The questionnaire included a set of water quality knowledge questions developed by FSWCD, as well as a revised version of these questions developed by members of the Environmental and Social Sustainability (ESS) Lab at The Ohio State University (OSU).

Survey design

In order to assess the impact of FSWCD messaging about water quality on knowledge of water quality (as measured by these survey questions), participants were randomly assigned to one of four groups. Participants either received FSWCD messaging before answering the knowledge questions or did not receive messaging; and were assigned either the questions developed by FSWCD or the questions developed by OSU. A total of 42 respondents received no messaging and the FSWCD questions, 51 received no messaging and the OSU questions, 50 received messaging and the FSWCD questions, and 41 received messaging and the OSU questions.

In addition to the knowledge questions described above, we also collected information about water quality-related behaviors and norms, as well as environmental values and concern, to further understand factors that may influence the relationship between knowledge and behavior. Items were based on established scales where possible and were designed to capture relevant variables found in previous research to be important in water quality decision making (Griffin et al., 1999; Hersha et al., 2012; Kahlor et al., 2006; Slagle et al., 2015).

Survey implementation

This survey was made available to OSU students participating in the ESS subject pool in Spring 2020 (ESSREP). The ESSREP is made available to students enrolled in several School of Environment and Natural Resources courses, and via their full participation in studies, students can earn research credits that are typically applied as extra credit to their final course grades. Participants in this study were compensated with 0.5 research credits toward a course grade of their choice. A total of 187 responses were collected. See Sample Characteristics below for a brief overview of ESSREP participants.

Section 1: Sample Characteristics

Concurrent studies indicate that ESSREP participants average around 20 years old, tend to be more female than male, and report an average GPA of 3.48. Around half of participants have taken 1-2 courses on sustainability (unsurprising, given that they must be enrolled in an ENR course to be eligible for the ESSREP); however, 1 in 5 report never having taken a course on sustainability, perhaps interpreting the question or their own course enrollment differently than intended. As is typical of students at OSU, 70% of participants report having lived in Ohio for seven or more years. Around half of participants report being raised in a suburban environment, 20% in an urban environment, and 27% in a small town/village or rural enrivonment. See Table 1 for distribution of declared majors. Contact study authors for forthcoming report providing greater details and comparison with the wider OSU student body.

Table 1: Comparison of major distribution between ESSREP SP20 sample and AU19 enrollment

School/College	**Percent of Respondents**	**Enrollment AU19**
Arts and Sciences	32.2%	37.5%
Business	19.9%	15.2%
Architecture	0.3%	1.2%
Engineering	9.3%	16.9%
Agriculture	2.0%	3.3%
Education and Human Ecology	4.0%	6.6%
SENR	28.2%	1.7%
Health and Rehabilitation Sciences	0.7%	4.2%
Public Health	0.7%	0.7%
Public Affairs	1.3%	0.7%
Nursing, Dental, and Medical	0.0%	2.6%
Pharmacy	0.0%	1.0%
Social Work	0.0%	0.9%
Exploration/Undecided	1.3%	4.9%
Total *n*	301	46,818

Section 2: Knowledge Items

All survey questions and the correct answers are provided in Appendix A. This appendix also identifies individual questions for which the percent of respondents who answered the question correctly differs significantly depending upon whether the respondent received FSWCD messaging.

Percent of questions answered correctly, dependent upon messaging

The total percent of FSWCD questions answered correctly is not significantly different between those who received FSWCD-provided messaging (mean = 62.14% correct) and those who did not (mean = 61.25% correct). This indicates that the messaging did not alter the respondent's knowledge or understanding as measured by the FSWCD scale.

The total percent of OSU questions answered correctly differs significantly depending upon whether the respondent received messaging (mean score = 63.97% correct) or not (mean score = 50.75% correct). This is initial indication that the OSU scale is better capturing the impact of the messaging on knowledge or understanding. However, if we weight these questions by respondents' confidence in the accuracy of their response, we find that there is no significant difference between the average scores of those who received messaging (mean score = 2.038) and those who did not (mean score = 1.615). For confidence-weighted questions, the range of possible scores is -5 to 5, where confidence in response is assessed on a score of 1 (not at all confident) to 5 (extremely confident). This confidence score is multiplied by 1 for a correct answer, or by -1 for an incorrect answer.

Use of confidence-weighting allows us to distinguish between respondents who answered questions correctly merely by chance (i.e., guessing the correct answer) and those who answered the question correctly and also felt strongly that the answer they selected was, in fact, the correct one. When we did not account for respondent confidence, we found a significant difference in OSU knowledge scores between those who received messaging and those who did not; however, we saw no significant difference between the groups when adjusting for respondent confidence. In other words, while the OSU scale seems to capture an impact of the messaging at first glance, when accounting for the respondent's confidence in the answer, the scale appeared to capture a change, but that change was not significant.

It may be that those who received messaging (who, on average, answered a higher proportion of the questions correctly than those who did not) were less confident in their

accuracy for the questions that they did answer correctly, or that they were more confident in their responses to questions that they had in fact answered incorrectly than were the participants who did not receive messaging. Using confidence-weighted questions to assess not only whether respondents correctly answer knowledge questions, but their degree of confidence in their answers, can provide a more nuanced understanding of respondent knowledge and can highlight reasons for different scores between groups.

Best-performing questions

If FSWCD is interested in keeping some of the existing questions, the following questions might more useful than others. These questions are fairly high-performing (correct answers occur more often than would be expected by chance) and are not significantly impacted by respondents' level of worry ("When you think about the possible risks posed to you from living in an area where the quality of local waterbodies is poor, how much worry do you feel?") and environmental values.

- FSWCD questions: 1, 8, 9, 11, 13
- OSU questions: 5, 7, 8, 9, 11
- OSU questions (considering the influence of confidence): 4, 5, 6, 7, 11, 12

Questions for which correct or incorrect responses are highly correlated with environmental values and worry may not be directly measuring knowledge. Rather, this may indicate that an underlying factor (i.e., worry or values) may be influencing whether respondents answer the question correctly. Thus, questions for which we do not see these strong correlations might be better measures of respondents' knowledge. Additional details follow in Section 3.

Section 3: Water Quality Knowledge and Behavior

We assessed several variables known to impact water quality-related behaviors (see Appendix B for descriptions of each of these variables and behaviors). We also assessed participant engagement in six water quality-related behaviors (e.g. local stream cleanups, proper disposal of household waste, etc.). A tally of these behaviors was correlated with knowledge scores (Figure 1) additional variables (Figure 2) to explore potential future avenues for influencing behavior.

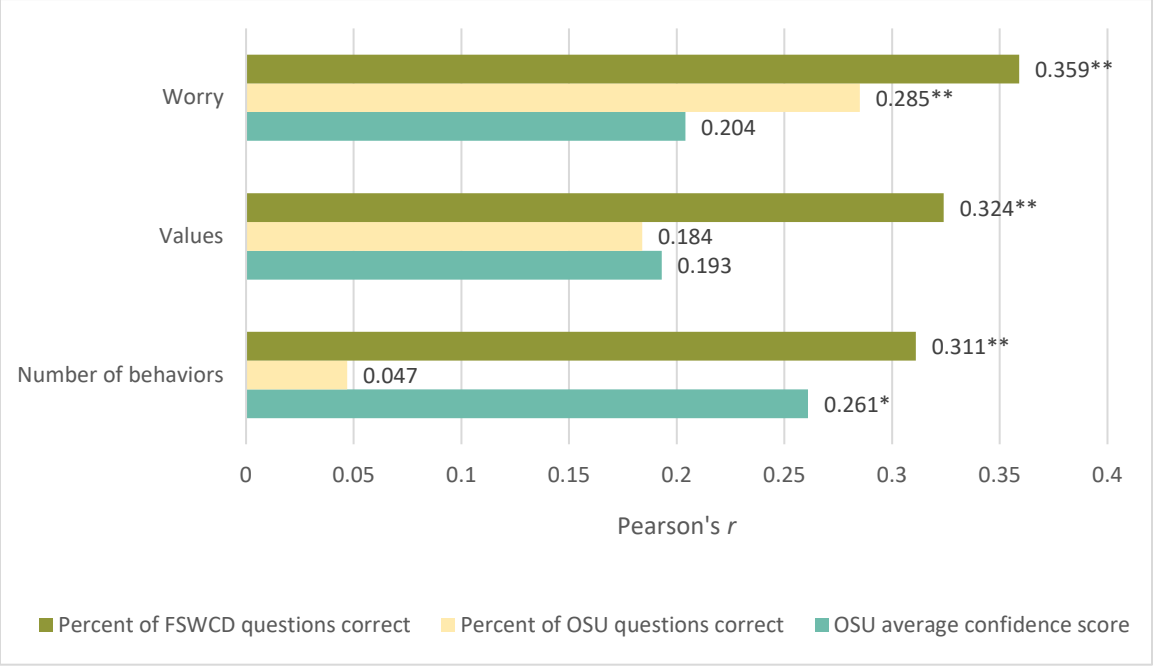

Figure 1: Correlations (Pearson's r) between knowledge scores and worry, environmental values, and number of environmental behaviors a respondent is engaged in. * denotes p < 0.05; ** denotes p < 0.01

Figure 1 suggests that answering the FSWCD questions correctly is perhaps less a function of knowledge and more a function of caring about the environment and worrying about environmental consequences, as demonstrated by strong positive correlations between FSWCD knowledge scores and worry and values. The OSU questions are less-strongly correlated with worry and values, which may make them better at capturing changes in knowledge.

While we observed positive correlations between FSWCD and OSU confidence-weighted knowledge scores and behavior, these findings may be driven more by worry and values than by an effect of knowledge itself on behavior. Respondents may be scoring highly on these scales due to their underlying values and concern for environmental issues, and may be seeking out additional information about environmental issues or pursuing an environmentally-focused major, which may help explain the positive association with knowledge scores. The consistent correlations in Figure 2 further support this idea of interrelatedness between values, worry, and norms about information seeking.

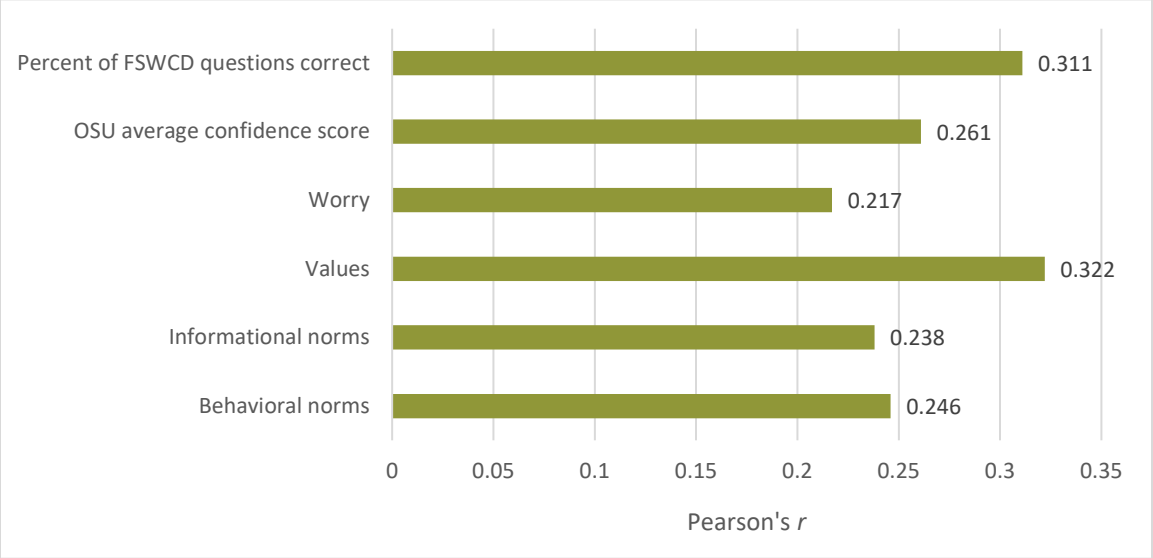

Figure 2: Correlations (Pearson's r) between variables known to impact behavior and the number of environmental behaviors engaged in by students. All correlations are significant at $p < 0.05$.

Regression models

We evaluated simple linear regression models including each of the following variables (percent of FSWCD questions correct, percent of OSU questions correct, OSU average confidence score, worry, values, informational norms, and behavioral norms; see Appendix B for descriptions of each variable) as separate predictors of the number of environmental behaviors a respondent engaged in. These simple linear regression models predicting behavior were not significant.

Further, three multiple regression models (one for each set of knowledge scores) using knowledge scores as well as worry, values, and norms as predictors of number of behaviors a respondent is engaged in were evaluated. These models were also not significant, suggesting that other factors that we are not measuring are likely better predictors of behavior than the variables we did measure, although our findings may also be a result of using a convenience sample of student volunteers.

Section 4: Suggested Actions

If FSWCD is primarily concerned with central Ohioans' knowledge of the specific ideas included in the messaging provided to respondents in this survey, then the OSU versions of the FSWCD questions appear to do a better job of assessing knowledge of these concepts. However, conversations with FSWCD have suggested that this may not be the case, and that assessing changes in water quality-related knowledge over time, as measured by changes in knowledge scores by zip code, is a higher priority. Further clarification of the goals of such a longitudinal measure would better inform any changes to the existing questions or the construction of a future survey.

Identifying a primary goal will help guide survey development

When developing this survey, it will be important to determine whether FSWCD's primary goal is to measure changes in knowledge over time or to educate respondents. If respondents are provided with feedback including the correct answers (an "education" approach), then survey design will need to be carefully considered when evaluating change over time. If respondents have completed the same survey questions multiple times, including those responses will not provide an accurate assessment of change in knowledge of the population over time. Hence, it may be easier to focus on using this survey as either an educational tool *or* as a means of assessing population knowledge over time. The primary goal should also be considered when selecting questions to include in the survey. It may be less important to select higher-performing questions when using the survey as an educational tool, but if the survey is intended to evaluate changes in knowledge over time, then a more critical approach to selecting survey questions should be considered (suggestions for best-performing questions are provided in Section 2).

Other long-term goals

One possible goal may be to influence the *behaviors* of central Ohioans that most strongly impact water quality. In Section 3 and Appendix B, we explore the relationship between several relevant variables suggested by theory to be important in predicting behavior and water quality-related behaviors. Given the moderate relationship between environmental values and behavior, outreach emphasizing water quality improvements as a reflection of environmental stewardship may tap into these values for residents who have yet to engage seriously in these behaviors. Previous research suggests that residents in this watershed believe in the importance of water quality for fish and wildlife that depend on streams in central Ohio, so framing outreach in relation to impacts on non-human species may also increase engagement (Slagle et al., 2015).

Suggestions for additional survey questions and areas of focus

Depending upon FSWCD's goals, it might be desirable to include questions that assess behaviors that respondents currently engage in, or perhaps their goals would be better served through focusing on assessing knowledge. FSWCD may also consider including questions other than those used in this pilot survey, as the knowledge questions that were included in this analysis did not perform very well overall. Recommendations for changes that can be made depending upon FSWCD's primary goals are presented below.

If the focus is on knowledge, considering the types of knowledge that FSWCD would like to assess is important, as current questions provide information about knowledge of specific facts rather than knowledge of general concepts or applications, which may be of greater interest. We cannot assume that knowledge in general is a perfect predictor of behavior. However, FSWCD might be interested in whether respondents have the knowledge that would lead them to take a desirable action in a specific situation. Including questions where respondents are provided with a scenario and asked for an appropriate response may be beneficial if this is the goal. Thinking about the types of knowledge that might be more useful or better proxies of these actions or behaviors will also be helpful.

Considering the messaging that is provided to respondents and what FSWCD would like respondents to be able to do with that knowledge (e.g., restate facts, apply knowledge to a specific situation) may prove to be important in redesigning a survey to better meet the specific needs of FSWCD. This may also influence the messaging that FSWCD chooses to provide people with, through their website and other channels of outreach, and whether this information should include broad environmental knowledge as well as specific facts (such as those included in the messaging used in this pilot survey).

Measureable factors such as worry or concern about environmental issues may also help understand behavior, as mentioned earlier in this report. Additionally, FSWCD might consider assessing respondent beliefs (i.e., self-efficacy) that are related to water quality; for example, "which behaviors that may improve water quality do you believe that you are capable of engaging in?". Respondents' engagement in environmentally-friendly behaviors may be explained in part by understanding what actions they believe that they are capable of taking to protect against perceived environmental consequences (Floyd et al., 2000; Witte & Allen, 2000). Measuring participants' environmental values, worry, and perceived efficacy may be better predictors of behavior than variables such as knowledge.

Again, we emphasize that FSWCD define their primary goals before determining which suggestions are suitable for inclusion and how the survey should be designed.

Appendix A: Messaging and Survey Questions: FSWCD and OSU

Messaging

Farm 4R Tomorrow
Improve your bottom line by practicing the 4 Rs. Use the right source at the right rate, at the right time, with the right placement. Consult the Tri-state Fertilizer Recommendations and your 4R Certified Crop Advisor before applying nutrients.

Know Your Soil
Soil tests take the guesswork out of buying fertilizers, chemicals, and other soil amendments. Site specific management saves money, optimizes crop production, and maintains priceless soil and water quality.

Can't Beat Free At The SWCD
Do you have a concern about soil or water on your property? Come talk to your local soil and water conservation district for free tools and advice about how to get back on track.

Cover Your Assets
Simply planting cover crops on inactive fields can have enormous benefits to your bottom line, field soil health, and water quality. By reducing erosion, weeds, and adding organic material to the topsoil; cover crops can have a positive impact on your yields.

Protect The Edge
Whether its grasses, native wildflowers, or trees, buffer strips will help shield streams, ponds, and lakes from receiving excess nutrients. Buffer strips absorb some surface runoff and act as a natural filter of fertilizers, chemicals, and sediment before they enter into the waterway.

Only Rain Down the Drain and Ditches
The storm drain in your street carries rain water and snow melt as well as trash, grass clippings, fertilizer, oil and other wastes directly to our streams. Pick up or soak up all spills from vehicles or household activities off of your sidewalk and driveway. Fertilizer pellets and grass clippings should be swept back on to your lawn. Do not wash or dump

any yardwaste or spills out into the roadway and down into our storm drains. Keeping storm drains free of trash and debris also prevents flooding.

Leaf It On Your Lawn
You can save time and provide nutrients for your lawn by mulching leaves in the fall. Shredded leaf material blocks weeds and breaks down fast into free fertilizer! This means less time and money you have to spend on your lawn. Do your part by keeping leaves and grass out of your street where they can clog storm drains and feed algae.

Pick Up Poop
Animal waste can pollute our water supply! Storm sewers drain directly into rivers and carry disease-causing pathogens and extra nutrients from dog waste.

Don't Drip and Drive
Concerned that your car might be leaking? Did you know that even a single drop on your driveway can mean a shorter lifespan for your car? It's also having a huge impact on the health of our local waters. Fix that leak! A single drop of motor oil can contaminate a million drops of water. Keeping your vehicle maintained saves you money, improves fuel efficiency, and ensures our waters are safe for people, pets, and wildlife.

Pump It Out
Septic tanks and aeration tanks fill up. To keep your home sewage treatment system and your family healthy, your tank should be pumped every three to five years. Find out how much water you use and ideas for conserving by visiting www.home-water-works/calculator.

Rain Is Your Resource: Soak It In
Heavy rain events are increasing along with flooding and drainage concerns. Do your part and use rain barrels, rain gardens, native plants and healthy lawns to soak in the rain on your property.

A Barrel Of Savings
Harvest roof water by installing a rain barrel. Use the water collected to water your flower pots. Your plants love soft, mineral-free rainwater that you'll capture and store for when you need it.

Plant Native Plants
Add a pop of color to your yard! Going native can save money and time over non-native plants while also providing needed nutrients for butterflies and insects to feed baby birds. Even better deep roots of native plants break clay soil to soak up more rain and protect streams by preventing erosion.

Garden For Clean Water

Install a rain garden to collect and absorb runoff from rooftops and driveways. Rain gardens typically absorb 30 percent more water than the same size lawn and you are beautifying your yard at the same time. Rain gardens are the perfect spot for native plants.

Donate A Kidney to Nature

Filtering water is a major role of wetlands, as such they act as nature's kidneys. They trap pollutants, break down organic material, and turn dissolved nitrogen into nitrogen gas. Wetlands also provide vital habitat for many birds, fish, amphibians, and invertebrates.

Survey Questions

Correct answers are italicized.

[i] Individual item for which percent answered correctly changes significantly in response to messaging
[iii] Items recommended as better options for inclusion in future assessments, among those tested
[ii] Individual item for which confidence-weighted score (correct x confidence) changes significantly in response to messaging
[iv] Items recommended as better options for inclusion in future assessments, among those tested (confidence-weighted responses)

FSWCD

1. All the following practices promote cleaner water except:[iii]
    a. Installing a grassed waterway where a gully has formed (1)
    b. Using cover crops on a bare field (2)
    c. Cultivating a rain garden (3)
    d. Applying manure right before a rain event (4)
2. What agency can assist landowners with a drainage problem?
    a. Ohio Division of Wildlife (1)
    b. Attorney General's Office (2)
    c. Soil and Water Conservation Districts (3)
    d. Ohio Environmental Protection Agency (4)
3. In general, how long does it take nature to replace 1 inch of topsoil in Ohio?
    a. 1 years (1)
    b. 10 years (2)
    c. 100 years (3)
    d. 500 years (4)
4. What are the 4 R's of fertilizer application?
    a. Right place, right time, right rate, right tools (1)
    b. Right place, right time, right rate, right crop (2)
    c. Right place, right time, right rate, right wind (3)
    d. Right place, right time, right rate, right source (4)
5. Who has the biggest impact on water quality in the U.S.?[i]
    a. The federal government (1)
    b. Private landowners (2)
    c. Large industry (3)
    d. Aquafina (4)
6. What should go down the storm sewer?
    a. Venti Starbucks double mocha latte with whipped cream and extra espresso (1)
    b. Dog/pet waste (2)
    c. Yard waste is okay (3)
    d. None of the above (4)

7. Dog waste left on a lawn or sidewalk can get washed into our rivers when it rains. Which pollutants does dog waste contain?
    a. Nitrogen that feeds algae (1)
    b. Harmful bacteria (2)
    c. Parasites (3)
    d. All of the above (4)
8. Which of the following can prevent weeds in a garden or farm field?[iii]
    a. Planting cover crops (1)
    b. Watering less (2)
    c. Building a drainage swale (3)
    d. Certain fertilizers (4)
9. What's the most important thing you can do to maintain your septic system?[iii]
    a. Flush scented soaps into it every several months to eliminate bad smells (1)
    b. Pump it out every three to five years (2)
    c. Plant trees in your leach field to help soak up pollutants (3)
    d. Inject the system with bacteria every year to break down solids (4)
10. What is the benefit of having a rain garden?
    a. It collects and absorb stormwater runoff from hard surfaces (1)
    b. It creates rain (2)
    c. It provides good habitat for fish. (3)
    d. It grows larger vegetables than a typical garden bed. (4)
11. The most important action you can take to help save pollinators is to:[iii]
    a. Install a honeybee hive (1)
    b. Build lots of native bee houses (2)
    c. Plant native trees, shrubs and perennials (3)
    d. Cut down on driving so they don't get smashed on your windshield (4)
12. What do general soil tests test for?
    a. Acidity (pH) (1)
    b. Cation exchange capacity (2)
    c. Phosphorous and Potassium levels (P and K) (3)
    d. All of the above (4)
13. Which of the following statements about rain barrels is false?[iii]
    a. You can drink water from rain barrels. (1)
    b. They can save you money (2)
    c. The water in rain barrels is mineral-free and better for plants than tap water. (3)
    d. They reduce the amount of runoff that enters our rivers and streams. (4)
14. Motor Oil is dripping from your car! If a single drop of oil makes it to a storm drain how many water drops can it contaminate?
    a. 1 (1)
    b. 100 (2)
    c. 1,000 (3)
    d. 1,000,000 (4)

OSU

1. The 4 R's of fertilizer application are right place, right time, right rate, right crop. *(False)*
2. Soil testing saves money, optimizes crop production, and maintains soil and water quality.[i] *(True)*
3. The best place to get help for soil and water issues on your property is the Ohio Environmental Protection Agency.[i, ii] *(False)*
4. Planting cover crops in a farm field or garden does not prevent weeds.[i, iv] *(False)*
5. Lots of vegetation (for example, trees, bushes and grass) on the streambank is good for stream health.[iii, iv] *(True)*
6. Storm sewers drain directly into local streams.[iv] *(True)*
7. Mulching leaves into your lawn in the fall keeps nutrients on your lawn and out of streams.[i, ii, iii, iv] *(True)*
8. Leaving dog waste to wash away in the rain has no impact on local water quality.[ii, iii] *(False)*
9. A single drop of motor oil can contaminate a million drops of water.[iii] *(True)*
10. Collecting water in rain barrels can reduce flooding and be a source of water for gardens and flower pots. *(True)*
11. Planting native plants will help pollinators, but does not impact water quality.[iii, iv] *(False)*
12. Rain gardens and wetlands contribute to the healthy function of watersheds by filtering contaminants.[iv] *(True)*
13. Septic tanks need pumped out every 10 years.[i, ii] *(False)*

Appendix B: Additional Data

The following section contains additional tables, figures, and information to support the findings reported above. These additional materials include a breakdown of knowledge scores by question for FSWCD and OSU question sets, summaries of overall scores on each question set and questions for which respondent performance changes significantly depending on whether they received messaging, and an analysis of question performance followed by suggestions for the questions that may be most suitable for inclusion in future surveys.

Abbreviations used throughout the report

Number of behaviors: Number of environmental behaviors the respondent is already engaged in (1: "I would volunteer for local stream cleanups", 2: "I would switch to non-toxic household cleaners and products", 3: "I would participate in local watershed groups", 4: "I would ensure hazardous household waste is not dumped in the stream, street gutter or yard", 5: "I would sign a petition in support of city efforts to improve local water quality", 6: "I would contact my local representative in support of city efforts to improve local water quality").

Scale of 0 (engaged in no behaviors) to 6 (engaged in all behaviors)

Percent of _____ questions correct: percent of (FSWCD or OSU, depending on question set) questions answered correctly

Scale of 0 to 100

OSU average confidence score: average score on all OSU questions (confidence-weighted)

Scale of -5 (all questions incorrect with extreme confidence in correctness of response) to 5 (all questions correct with extreme confidence in correctness of response)

Worry: "When you think about the possible risks posed to you from living in an area where the quality of local waterbodies is poor, how much worry do you feel?"

Scale of 0 (none of this feeling) to 10 (a lot of this feeling)

Values: Mean score on three environmental values questions (How important are each of these as a guiding principle in your life? 1: "Protecting the environment, preserving nature", 2: "Unity with nature, fitting into nature", 3: "Respecting the earth, harmony with other species")

Scale of 0 (not important) to 6 (supremely important)

Informational norms: Mean score on three information-related norms questions ("People who are important to me would expect me to stay on top of information about actions to improve water quality"; "People who are important to me would expect me to know about actions to improve water quality"; "People I spend time with are likely to seek information about local water quality")

Scale of 1 (strongly disagree) to 7 (strongly agree)

Behavioral norms: Mean score on three behavioral norms questions ("People would expect me to take action to improve local water quality" [2 variations]; "People would expect me to take action to make sure my actions don't worsen local water quality")

Scale of 1 (strongly disagree) to 7 (strongly agree)

Knowledge scores by question: FSWCD

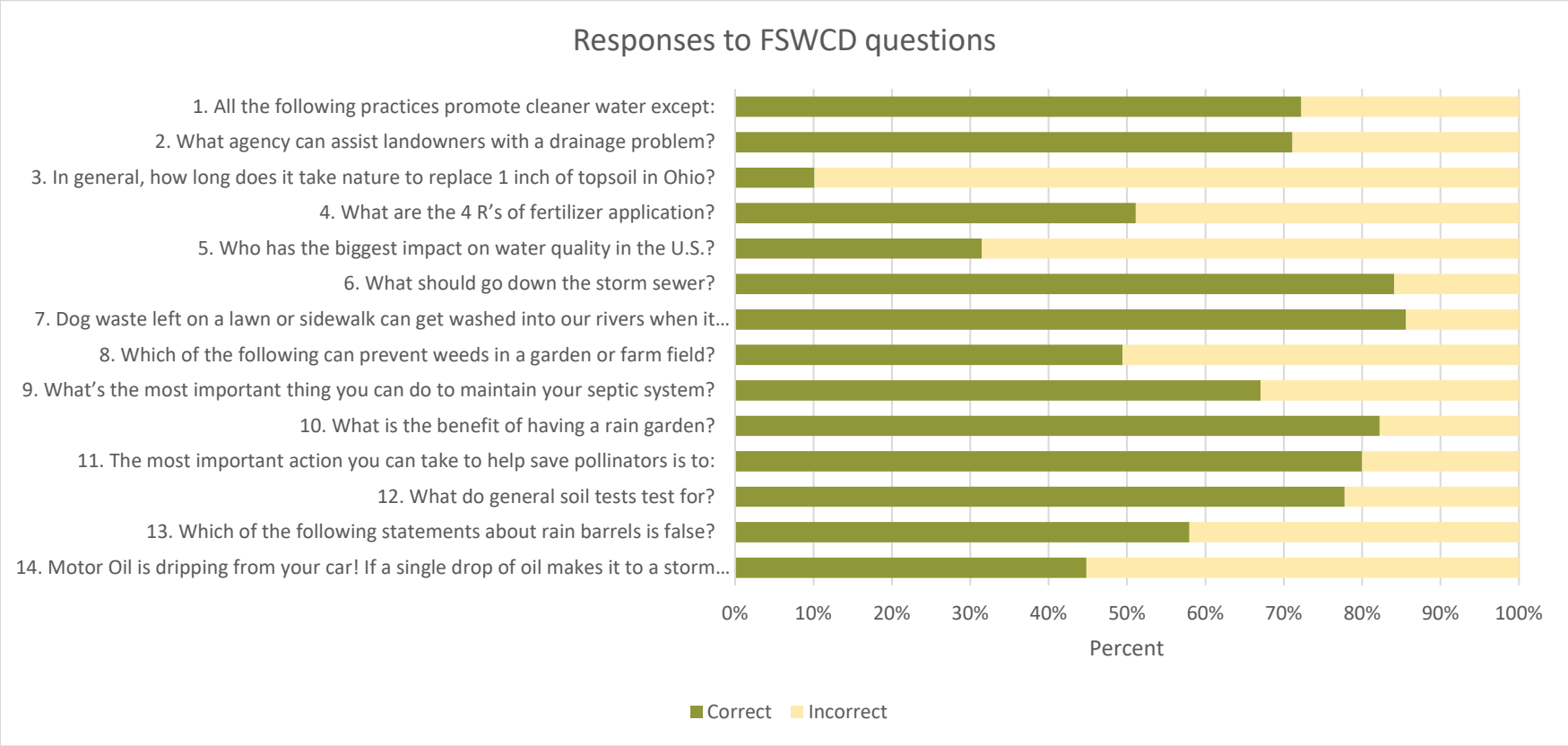

Figure A.1: Bar chart illustrating correct and incorrect responses to FSWCD questions

Knowledge scores by question: OSU

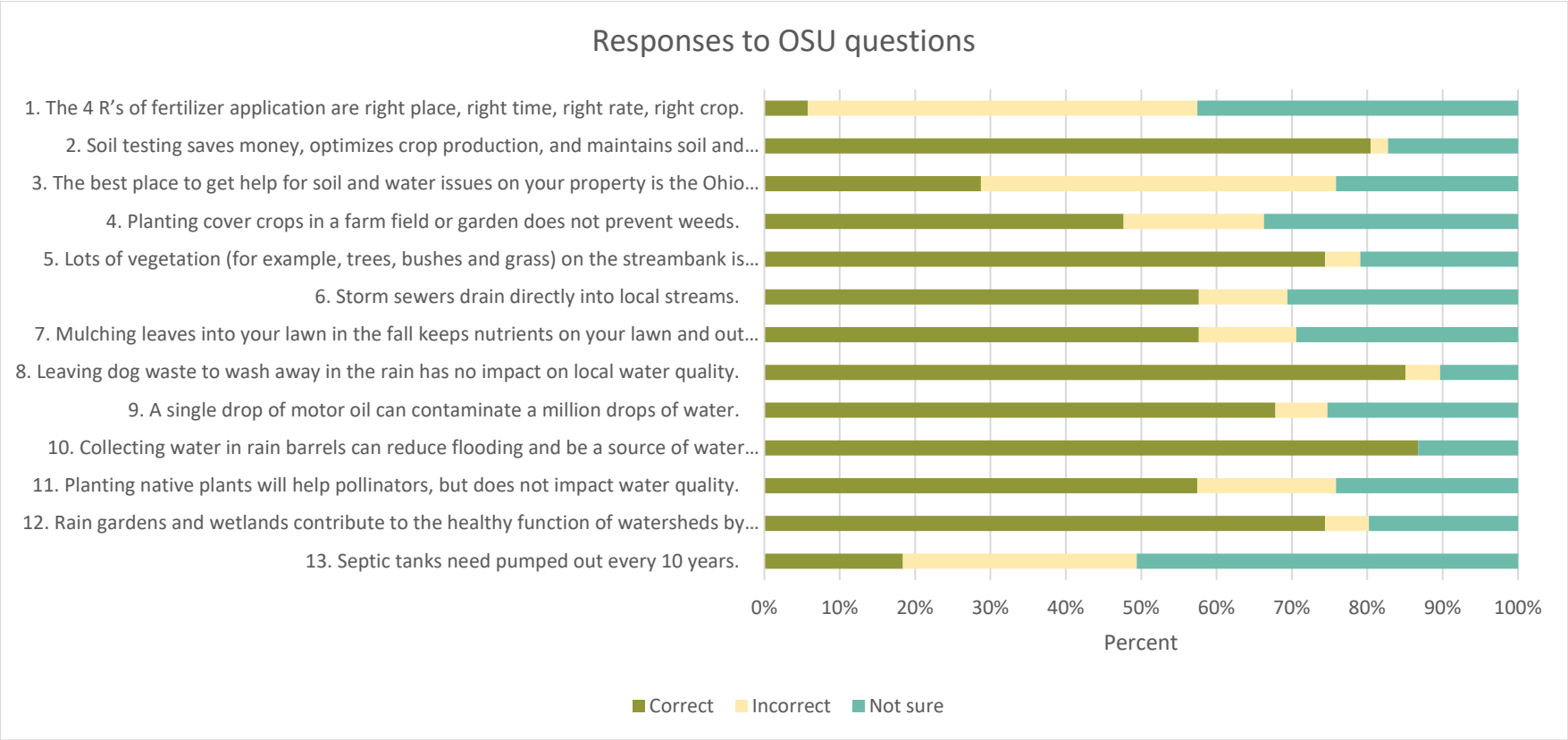

Figure A.2: Bar chart illustrating correct, incorrect, and "not sure" responses to OSU questions

Knowledge scores: FSWCD

Table B.1: *t*-tests comparing percent of respondents who correctly answered each FSWCD question, grouped by whether respondents received messaging

Question	% correct (no messaging)	% correct (messaging)	*t*	df	*p*
FQ1	76	69	0.655	86.91	0.514
FQ2	68	74	-0.665	81.03	0.508
FQ3	13	08	0.723	72.13	0.472
FQ4	48	54	-0.607	83.55	0.545
FQ5	20	41	-2.178	87.00	0.032
FQ6	80	88	-0.935	75.61	0.353
FQ7	88	84	0.556	87.68	0.580
FQ8	48	51	-0.327	83.43	0.745
FQ9	64	69	-0.516	80.01	0.607
FQ10	85	80	0.716	87.77	0.476
FQ11	80	80	0.105	85.65	0.917
FQ12	78	78	0.056	85.40	0.955
FQ13	56	59	-0.259	81.21	0.797
FQ14	41	48	-0.638	81.81	0.525

Table B.2: Overall percent of FSWCD questions answered correctly, separated by whether respondent received messaging

	n	Range	Mean	Std. dev
No messaging	41	7.14 – 100	61.25	20.16
Messaging	50	7.14 – 100	62.14	23.38

The percent of FSWCD questions answered correctly does not significantly differ between those who received messaging (mean = 62.14) and those who did not (mean = 61.25) ($t(88.76) = -0.192$; $p = 0.846$).

Knowledge scores: OSU

Table B.3: *t*-tests comparing percent of respondents who correctly answered each OSU question, grouped by whether respondents received messaging

Question	% correct (no messaging)	% correct (messaging)	*t*	df	*p*
OSUQ1	6	5	0.223	83.80	0.824
OSUQ2	73	90	-2.067	82.78	0.042
OSUQ3	17	44	-2.773	70.00	0.007
OSUQ4	36	62	-2.392	80.65	0.019
OSUQ5	72	77	-0.482	82.57	0.631
OSUQ6	57	59	-0.226	80.89	0.822
OSUQ7	43	76	-3.343	82.63	0.001
OSUQ8	88	82	0.692	75.37	0.491
OSUQ9	60	77	-1.671	84.66	0.098
OSUQ10	83	82	0.155	80.30	0.877
OSUQ11	52	64	-1.127	82.55	0.263
OSUQ12	67	84	-1.923	83.98	0.263
OSUQ13	8	31	-2.638	59.21	0.011

Table B.4: Overall percent of OSU questions answered correctly, separated by whether respondent received messaging

	n	Range	Mean	Std. dev
No messaging	48	0 – 92.31	50.75	20.31
Messaging	39	0 – 100	63.97	22.51

The percent of OSU questions answered correctly differs significantly depending upon whether the respondent received messaging or not ($t(77.49) = -2.845$; $p = 0.006$). Those who received messaging scored significantly higher on the knowledge questions (mean score = 63.97) than those who did not (mean score = 50.75).

Knowledge scores: OSU (confidence-weighted)

Table B.5: *t*-tests comparing mean confidence-weighted scores for each OSU question, grouped by whether respondents received messaging.

Question	Mean (no messaging)	Range (no messaging)	Mean (messaging)	Range (messaging)	*t*	df	*p*
OSUQ1	-1.64	-5 – 4	-2.18	-5 – 5	0.906	44.04	0.370
OSUQ2	2.76	-4 – 5	3.06	1 – 5	-0.929	61.88	0.356
OSUQ3	-1.42	-4 – 3	0.16	-5 – 5	-2.186	56.90	0.033
OSUQ4	1.00	-4 – 4	1.75	-4 – 5	-0.990	53.15	0.326
OSUQ5	2.75	-5 – 5	3.23	-3 – 5	-1.016	64.52	0.314
OSUQ6	2.25	-3 – 5	1.73	-3 – 5	0.866	50.46	0.391
OSUQ7	1.10	-4 – 4	3.16	-3 – 5	-3.437	50.49	0.001
OSUQ8	2.70	-4 – 5	3.85	-2 – 5	-3.085	67.81	0.003
OSUQ9	2.33	-4 – 5	3.16	-3 – 5	-1.628	60.36	0.109
OSUQ10	3.14	-4 – 5	3.15	-3 – 5	-0.010	64.80	0.992
OSUQ11	1.20	-4 – 5	1.97	-5 – 5	-1.183	60.45	0.241
OSUQ12	3.21	-1 – 5	2.67	-5 – 5	1.218	57.26	0.228
OSUQ13	-1.20	-4 – 3	1.00	-5 – 5	-2.359	37.80	0.024

For each question, if the respondent selected the correct answer, their score is 1 x their confidence. If the respondent selected the incorrect answer, their score is -1 x their confidence.

Table B.6: Overall average knowledge x confidence scores (OSU questions), separated by whether respondent received messaging

	n	Range	Mean	Std. dev
No messaging	46	-1.43 – 3.44	1.615	0.977
Messaging	38	-0.30 – 4.67	2.038	1.290

There is no significant difference in overall OSU knowledge x confidence scores between those who received messaging and those who did not ($t(67.84) = -1.667$, $p = 0.100$).

Knowledge score changes in response to messaging

Summary of questions for which percent answered correctly (or mean score, in the case of OSU confidence-weighted scores) changes significantly in response to messaging:

- FSWCD: question 5
- OSU: questions 2, 3, 4, 7, 13
- OSU confidence-weighted: questions 3, 7, 8, 13

Questions that did not perform well; questions that may be influenced by worry and values

FSWCD

- Very low performance
  - Q3 (13% of those who did not receive messaging and 8% of those who did receive messaging answered correctly)
  - Q5 (20% of those who did not receive messaging and 41% of those who did receive messaging answered correctly)
- Performance around 50% correct
  - Q4 (48% of those who did not receive messaging and 54% of those who did receive messaging answered correctly)
  - Q8 (48% of those who did not receive messaging and 51% of those who did receive messaging answered correctly)
  - Q14 (41% of those who did not receive messaging and 48% of those who did receive messaging answered correctly)
- Influenced by worry (* denotes $p < 0.05$; ** denotes $p < 0.01$)
  - Q2 — $r = 0.238$*
  - Q4 — $r = 0.227$*
  - Q6 — $r = 0.319$**
  - Q7 — $r = 0.259$*
  - Q10 — $r = 0.307$**

- Influenced by values (* denotes $p < 0.05$; ** denotes $p < 0.01$)
    - Q6 — $r = 0.462$**
    - Q7 — $r = 0.389$**
    - Q10 — $r = 0.247$*
    - Q12 — $r = 0.242$*
    - Q14 — $r = 0.246$*

Based on the criteria of performance and influence of worry/values, the following questions might be the most suitable: 1, 8, 9, 11, 13.

OSU

- Very low performance
    - Q1 (6% of those who did not receive messaging and 5% of those who did receive messaging answered correctly)
    - Q3 (17% of those who did not receive messaging and 44% of those who did receive messaging answered correctly)
    - Q13 (8% of those who did not receive messaging and 31% of those who did receive messaging answered correctly)
- Performance around 50% correct
    - Q4 (36% of those who did not receive messaging and 62% of those who did receive messaging answered correctly)
    - Q6 (52% of those who did not receive messaging and 64% of those who did receive messaging answered correctly)
    - Q11 (36% of those who did not receive messaging and 62% of those who did receive messaging answered correctly)
- Influenced by worry (* denotes $p < 0.05$; ** denotes $p < 0.01$)
    - Q4 — $r = 0.243$*
    - Q6 — $r = 0.290$**
    - Q10 — $r = 0.240$*
- Influenced by values (* denotes $p < 0.05$; ** denotes $p < 0.01$)
    - Q2 — $r = 0.223$
    - Q12 — $r = 0.289$**

Based on the criteria of performance and influence of worry/values, the following questions might be the most suitable: 5, 7, 8, 9, 11.

OSU, confidence-weighted

- Very low performance (mean scores < 0)
    - Q1 (mean score for those who did not receive messaging = -1.64; mean score of those who did receive messaging = -2.18)
    - Q3 (mean score for those who did not receive messaging = -1.42; mean score of those who did receive messaging = 0.16)

    - Q13 (mean score for those who did not receive messaging = -1.20; mean score of those who did receive messaging = 1.00)
- Influenced by worry (* denotes $p < 0.05$; ** denotes $p < 0.01$)
    - Q2 — $r = 0.298$*
    - Q9 — $r = 0.289$*
    - Q10 — $r = 0.316$**
- Influenced by values (* denotes $p < 0.05$; ** denotes $p < 0.01$)
    - Q2 — $r = 0.282$*
    - Q8 — $r = 0.233$*
    - Q9 — $r = 0.301$*
    - Q10 — $r = 0.353$**

Based on the criteria of performance and influence of worry/values, the following questions might be the most suitable: 4, 5, 6, 7, 11, 12.

References

Floyd, D.L., Prentice-Dunn, S., & Rogers, R.W. (2000). A meta-analysis of research on protection motivation theory. *Journal of Applied Social Psychology, 30*(2), 407–429. https://doi.org/10.1111/j.1559-1816.2000.tb02323.x

Griffin, R. J., Dunwoody, S., & Neuwirth, K. (1999). Proposed model of the relationship of risk information seeking and processing to the development of preventative behaviors. *Environmental Research, 80*, 230–245.

Hersha, D. K., Wilson, R. S., & Baird, A. M. (2012). A conceptual model of the citizen stream stewardship decision process in an urbanising Midwestern United States watershed. *Journal of Environmental Planning and Management, 55*(2), 253–270.

Kahlor, L., Dunwoody, S., Griffin, R. J., & Neuwirth, K. (2006). Seeking and processing information about impersonal risk. *Science Communication, 28*(2), 163–194. https://doi.org/10.1177/1075547006293916

Slagle, K. M., Wilson, R. S., & Heeren, A. (2015). Seeking, thinking, acting: Understanding suburban resident perceptions and behaviors related to stream quality. *Journal of the American Water Resources Association, 51*(3), 821–832. https://doi.org/10.1111/jawr.12277

Witte, K. & Allen, M. (2000). A meta-analysis of fear appeals: Implications for effective public health campaigns. *Health Education & Behavior, 27*(5), 591–615. https://doi.org/10.1177/109019810002700506

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