

Environmental Literacy of Ohio Adults¹

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ABSTRACT. Environmental literacy is defined as an understanding of natural systems combined with how they interact with human social systems. Past surveys have measured the “pollution knowledge” of adults. This study instead examined Ohio adult’s knowledge of ecological principles as the basis of understanding. A telephone survey of 504 Ohio adults measured their knowledge of ecological principles. As a group, Ohio adults appear to understand four principles of ecology: biogeography, the earth as a biosphere, ecological energetics, and carrying capacity. Some additional attention should be paid to teaching Ohio adults about three principles of ecology: ecosystem succession, biotic interactions, and the importance of diversity. Most importantly, Ohio adults must learn more about the principle of materials cycling. Ohio adults showed poor understanding of the nitrogen, phosphorus, and hydrologic cycle and bioaccumulation.

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INTRODUCTION

Environmental literacy is the understanding of the interactions between natural systems and human social systems (Barrett and others 1997; Hausbeck and others 1992). Orr (1992) defines ecological literacy as a broad understanding of how people and societies relate to each other and natural systems, presuming an awareness of the “interrelatedness” of life and the knowledge of how the world works as a physical system. The basic principles of ecology such as energetics, cycling, growth, and competition are the common denominators in developing environmental literacy (Odum 1993).

A survey of environmental curriculum needs, completed by 169 randomly selected environmental educators, ranked 15 goal statements for students ranging from elementary school to college (Volk and others 1984). For secondary school and college students, teachers ranked gaining sufficient knowledge of ecology to permit them to make ecologically sound decisions as the highest goal.

Assessments of adult environmental literacy have, however, focused on “pollution knowledge.” The pollution knowledge questions presented by NEETF (1997), for example, ask adults to identify the major pollutants of the atmosphere or water supplies, who are major polluters, and which government agencies have jurisdiction over environmental concerns. They found in their telephone survey of 1501 adults that less than one-third of Americans know the major sources of air and water pollution. Nearly half do not know where most electricity comes from. Arcury and Johnson (1987) also measured pollution knowledge of adults in Kentucky. Their telephone survey of 680 adults found little knowledge of major sources of water and air pollution, and energy sources. Less than 10% knew the major source of surface water pollution in the state and less than half knew the

major source of groundwater pollution or how energy is generated and managed.

Understanding the principles of ecology is quite different from simply knowing pollution and energy sources. With an understanding of how natural systems interact with human social systems, people can draw from this understanding to make decisions about a wide variety of pollution issues. The basic principles of ecology can form a foundation for independent assessment of the possible impact of policies and actions.

The objective of this project was to assess Ohio adults’ knowledge of the basic principles of ecology that form the basis for environmental literacy. With this information, future environmental education programs for Ohio adults can build on their previous knowledge and understanding, and work to address lack of knowledge and understanding of important basic principles.

MATERIALS AND METHODS

A telephone survey of Ohio adults was used to collect responses to questions related to the principles of ecology. The survey met several criteria.

- Each question was unique and based on a principle of ecology.
- The line of questions was to be concise to ensure a high rate of completion.
- The survey could contain no jargon or points of argument that might confuse the participants.
- The questions were to be unbiased so as not to make the respondent uncomfortable.

Survey Development

A Delphi group process was used to develop the questionnaire. A panel of 10 environmental scientists from throughout Ohio and the nation developed and validated the survey instrument. The Delphi group process was conducted by FAX and consisted of the following 5 inquiries.

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1. Please list some of the basic principles of ecology.
2. Review and comment on the list of principles.
3. List 1 to 4 current environmental issues that illustrate each principle.
4. Please suggest 1 or 2 questions for each principle of ecology that you might ask an Ohio adult about these issues.
5. Please review the draft survey to make sure each question addresses a principle of ecology.

An environmental science faculty member who teaches the public led the panel. The panel included another environmental science faculty member specializing in public education and six who teach ecology or environmental science to college students. These seven faculty members included a first year assistant professor, four with well established teaching careers and two retired. Three practicing environmental scientists were also on the panel, one with USEPA Environmental Justice office, one consulting in environmental health and one working with an environmental group. Six of the panel members were from Ohio with the other four drawn from distant states.

The expert panel was first asked to respond to the inquiry "Please list some of the basic principles of ecology." This simple inquiry yielded more than 75 responses. Through the next inquiry a list of eight principles emerged. This set is similar to nine principles of ecology presented by Odum (1994).

1. *Ecosystem succession* involves the impact of modifying landscapes by natural forces like flooding and human activities such as clearing woodlands, modifying waterways, and draining land.
2. *Ecological energetics* recognizes the sun as the primary energy source on earth and the finite nature of fossil fuels. It also considers how energy is expressed in natural systems through the food supply and the forces of flowing water.
3. *Carrying capacity* of an area is limited by the food and space available and the pollution potential of increasing populations.
4. *Importance of diversity* stresses the risks associated with monocultures to catastrophic disease in crops and livestock. This principle also illustrates benefits of crop rotation to maintain diversity and productivity.
5. *Biotic interactions* examines predator/prey relationships, natural selection and the impact of exotic species on native communities.
6. *Biogeography* looks at the protection of endangered species and their access to adequate habitat.
7. *Materials cycling* includes the nitrogen, phosphorus and water cycles along with an understanding of how substances accumulate through the food chain.
8. *The earth as a biosphere* includes climate change, distant air pollution impacts, and the interdependence of rural and urban communities in the production of food and the recycling of wastes.

Drawing from these principles the expert panel identified more than 150 environmental issues. These issues were used to construct 32 multiple choice or true/false questions, with four different issues related to each principle of ecology. The expert panel was asked to review the draft questions to make sure each question addressed a principle of ecology. Through this test for validity, some minor adjustments were made to the questions.

Survey testing

The reliability of the survey was tested during 3 focus group sessions with citizens in Ohio. Each focus group participant responded to the questions and commented on any confusing language. Participants also discussed their thoughts about each question to be sure they were considering the underlying principles when selecting an answer.

A group of rural residents in an agricultural area of western Ohio participated in a focus group in Maria Stein, OH. A second focus group of small town residents from an Appalachian area was conducted in Woodsfield, OH. The final group of urban residents participated in a focus group in Columbus, OH.

The questions were modified only slightly after reliability testing with the focus groups of Ohio citizens. Some jargon that caused confusion was removed along with some points that raised arguments. The complete survey is published in the project report to the Ohio Environmental Education Fund (Carr and Mancl 1998). The 32 questions related to the principles of ecology are listed in Appendix 1.

With final modifications, the survey was field tested with random phone calls and adjusted for length and ease of delivery.

Telephone survey

A random, statewide survey of 504 adults was conducted. This sample size yields 95% confidence that the sample response is within $\pm 4\%$ of the population parameter. Along with the random sampling a "within household" sampling procedure was used called the "birthday method." All adults were identified and from these adults the person who had the next birthday was interviewed. This procedure ensured that each available person within a given household had an equal chance of participating in the survey.

Following the survey, results for the four questions for each of the eight groups were checked for heterogeneity by determining Cronbach's coefficient alpha (Ary and others 1990). Cronbach's coefficient alpha is used with questions with multiple answers, like multiple choice, and a low value indicates that the items are heterogeneous meaning they measure more than one attribute or trait.

All of the Cronbach's alpha coefficients were low, indicating that each of the four questions in a group tested a different issue related to the principle. The scores ranged from 0.048 for ecosystem succession to 0.47 for diversity. The coefficients for each group of questions are listed in Appendix 1.

RESULTS

Knowledge of each ecological principle was assessed as the responses to the four different questions. Each respondent received a score for each principle ranging from 0 meaning none of the four questions were answered correctly to 4 when all questions were answered correctly. The results are displayed as means, which is the average correct answers for all respondents for each of the principles (Fig. 1). *T*-test at a significance level of $p < 0.05$ showed that all averages were significantly different.

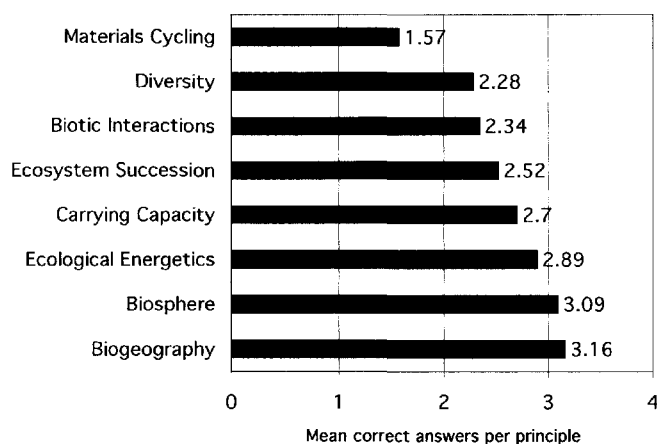


FIGURE 1. Knowledge scores (0 to 4) of principles of ecology for 504 Ohio adults.

Ohio adults show greatest understanding of biogeography, the earth as a biosphere, ecological energetics, and carrying capacity. Lower levels of understanding were observed in ecological succession, biotic interaction, and the importance of diversity. The lowest understanding was noted with materials cycling.

DISCUSSION

On average, Ohioans are fairly well educated on the principles of ecology. They tend to score higher on some ecological principles than others. This is in contrast to the findings of the NEETF (1997) and Arcury and Johnson (1987) who measured pollution knowledge. The NEETF/Roper National Report Card (NEETF 1997) gave two out of three American adults failing grades on pollution knowledge. Based on environmental, energy and water pollution knowledge, Arcury and Johnson (1987) gave Kentucky residents a poor rating.

An understanding of the basic principles of ecology may be a more important knowledge base for adults. While the facts of pollution and energy sources may change, the basic principles of ecology act as a basis for decision making when developing policies and taking actions about pollution and energy sources.

As a group, Ohio adults appear to understand four principles of ecology. Educational efforts can build on this basic understanding to expand their capability to discuss issues, adopt policies, and take actions. Because of this understanding of the principles, Ohio adults are

prepared to expand their vocabulary, learn more about model programs, and participate in activities that enhance the natural environment applying the four basic principles of; biogeography, the earth as a biosphere, ecological energetics and carrying capacity.

Some additional attention should be paid to teaching Ohio adults about three principles of ecology. By first increasing the understanding of these basic principles of; ecosystem succession, biotic interactions, and the importance of diversity, Ohio adults will be better able to consider and discuss changes in personal action and public policy.

Most importantly, Ohio adults must learn more about the principle of materials cycling. Ohio adults showed poor understanding of the nitrogen, phosphorus, and hydrologic cycles and bioaccumulation. Without a clear understanding of how nitrogen changes form and moves through the environment, how phosphorus cycles through plant and animal systems, and how water is constantly moving and being reused, Ohio adults will be unable to discuss and support important resource management issues. Without an understanding of how toxic substances accumulate through the food chain, Ohio adults will be confused by discussions about toxic chemicals. It appears premature to invest in action oriented educational programs on the importance of nutrient management, water conservation, and toxic chemical disposal until the underlying principle is understood.

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APPENDIX 1

Questions to measure the knowledge of ecological principles of Ohio adults (Cronbach's coefficient alpha).

1. Ecosystem succession (0.048)

- Flooding on a river renews and replenishes the river environment. True or False.
- People around Ohio cities are moving into wooded areas to build homes, clearing away all the trees to plant a lawn. What type of care will be needed to maintain these lawns? a) no special care b) regular mowing to keep trees from growing in the lawn c) a lawn will not do well no matter what care you give it.
- Landowners sometimes build dams on streams to create ponds. What is the impact of a dam on a stream? a) no major impact b) changes the stream in the pond area c) changes the entire stream.
- Wetland areas have been drained in Ohio for decades. New efforts are in place to restore wetlands to their natural state. Filling those drained areas again with water: a) restores a wetland to its natural state right away b) begins a restoration process that will take years c) will not be effective, because once destroyed a wetland cannot be restored.

2. Ecological energetics (0.156)

- At the present rate of use the world's supply of coal, oil and natural gas will: a) last forever b) be used up eventually c) renew itself.
- The primary source of energy on earth is the sun. True or False.
- For a person to get the most food energy out of 100 pounds of vegetables and grain the person should: a) eat the vegetables and grain b) feed the vegetables and grain to an animal and eat the meat c) feed the vegetables and grain to a cow to produce milk, feed the milk to an animal and eat the meat.
- To protect an area from flooding, walls are constructed along the river banks. As a result, downstream flooding will: Increase, Decrease, or Stay the Same.

3. Carrying capacity (0.123)

- The total space being used to produce food to feed Ohioans is adequate even if the population of Ohio increases. True or False.
- There is a limit to how many people the world can support. True or False.
- As the population in an area increases, the potential for pollution: Increases, Decreases, or Stays the Same.
- Rangers observe deer eating all the small plants in a park. To maintain a healthy deer population in the

park, the rangers should: a) decrease the number of deer in the park b) bring in extra food for the deer c) no action is necessary.

4. Importance of diversity (0.477)

- A farmer plants corn one year, soybeans the next year and follows with wheat. This is called crop rotation. The need for pesticides on a farm using crop rotation will: Increase, Decrease, or Stay the Same.
- Mary plants tomato plants in the same garden spot every year. Bob also plants tomatoes, but plants them in a different part of the yard each year. With everything else being the same, who will harvest the most tomatoes? a) Mary, who plants in the same spot b) Bob, who plants in different spots c) they harvest the same amount of tomatoes.
- Today chickens in the US are raised in large buildings containing thousands of birds. Under those conditions, in the mid-1980s poultry flu killed millions of chickens in the US, eliminating entire flocks. Today's farming practices will prevent this from happening again. True or False.
- People living in a rural area grow only potatoes year after year with great success. To join in their success, each year more people in the area start growing only potatoes. As more potatoes are planted in the area, the risk of a disease or an insect damaging the potato crop will: Increase, Decrease, or Stay the Same.

5. Biotic interactions (0.065)

- Each summer your neighborhood is sprayed with the same bug killer to control mosquitoes. After a few years of spraying the same product what do you think will happen? The mosquitoes will likely: a) disappear b) become resistant to the spray c) remain the same year after year.
- When colonizing a new area, plants, animals and even people compete for resources to live, grow and reproduce. What usually happens when an area gets crowded? a) they compete against each other b) they cooperate with each other c) they usually die out.
- Tremendous numbers of flies are bothering people who live near some of Ohio's large chicken farms. Special fly-eating beetles were imported to Ohio and placed in the chicken houses to solve the problem. While the beetles do a good job controlling the flies in the chicken house, once the beetles get out they become so numerous that they get into nearby homes and become a pest. Why are the beetles a pest? a) they are a pest everywhere in the world b) they are only a pest in a new area with no natural controls on their growth c) they are not as big a pest as people think.
- As Ohio and other Midwestern states were settled, people encountered wolves that hunted deer and other wild animals, but the wolves threatened their families and livestock. As the wolves were eliminated to protect people, did the number of deer: Increase, Decrease, or Stay the Same.

APPENDIX 1 (CON'T.)

6. Biogeography (0.165)

- Saving an endangered plant species is just as important as saving an endangered animal species. True or False.
- The most effective way to save an endangered animal is to: a) stop hunting or eating the animal b) provide it with an adequate food supply c) establish a large enough reserve area for it to live and reproduce.
- The land area needed to protect an endangered animal should be: a) large enough to support one family of animals b) large enough to support several animal families c) the same size reserve for all endangered animals.
- Some tropical birds that live in Central and South America migrate to and live in Ohio for part of the year. Which of the following is the greatest threat to these birds? Loss of habitat in: a) Central & South America b) Ohio c) both places.

7. Materials cycling (0.143)

- PCBs, a toxic chemical, can be found in very low levels in Great Lakes water. The PCBs are taken up by small shellfish that live in the water. Which will have the highest level of PCBs: a) the shellfish b) fish that eat the shellfish c) birds that eat the fish.
- Phosphorus fertilizer is applied to lawns, gardens and crop fields to encourage plant growth. What happens when phosphorus washes into a lake? a) the phos-

phorus kills the fish b) phosphorus will increase the growth of algae c) not much will happen.

- Nitrogen fertilizer is applied to gardens and crop fields to increase food production. The nitrogen is taken up into the food. When a person eats food for energy and growth they produce sewage wastes. The human sewage contains some of the nitrogen that was first applied as fertilizer. True or False.

- The amount of water on earth is: Increasing, Decreasing, or Staying the Same.

8. The earth as a biosphere (0.215)

- The warming of the Pacific Ocean influences the weather a) just in California b) just in the US c) throughout North & South America

- Burning fuel in Ohio to heat homes, operate cars, and produce electricity contributes to air pollution: a) only in the city where it's burned b) throughout Ohio and neighboring states c) burning fuel does not contribute to air pollution

- A major volcanic eruption in the Philippines creates dust and reduces sunlight only near the volcano during the eruption. True or False.

- Fruit, vegetables, milk and meat produced in rural Ohio are sold and trucked to grocery stores to feed people in many large cities. The people who live in these cities produce sewage sludge. Spreading sewage sludge from big cities on Ohio farm land: a) pollutes the soil b) is a form of recycling c) gets rid of the sludge.