Assessment Report: Environmental Studies

2022

I. Assessment Cycle and Introduction

Environmental Studies has transitioned our assessment practices to StrAP 2019, approved by the Assessment Committee. According to this document, Goals 1-3 will be assessed every year, with one of the remaining goals (4-9) assessed sequentially each year. Unfortunately, due to the pandemic and unexpected loss of faculty, we have not progressed as far as we wished. This caused us to miss implementation of our graduation survey in 2020 (pandemic) and 2022 (faculty loss).
Long-term data sets (2015 onward) have been used to improve assessment of Goal 2 (knowledge of Earth Science concepts) and Goal 3 (knowledge of the relationship between human beings, society and the environment. Additional work on assessing Goal 1 (knowledge of Ecological Principles) has begun. We have also assessed Goal 4 (gaining skills in using systems thinking to assess complex natural and social systems).

II. Assessment Measures Used

1. "Pre-program" questions: To assess Goal 3, multiple choice questions specific to the goal were administered on the first day of class in ENST 100 Environment and Society in the Fall 2015 semester. This test was administered to 13 ES students and 20 non-ES students.

   To assess Goal 2, multiple choice questions specific to the goal were also administered to students in ENST 230 (previously 110) Earth Systems Science from the 2015-2016 academic year to the 2021-2022 academic year. The test was administered to 56 ES students and 111 non-ES students. This test changed beginning in the 2019-2020 academic year to address feedback from the Assessment Committee. Questions 5 & 6 (Appendix A) were removed and Question 7 rotated in to ensure even coverage of all assessment sub-goals.

   In 3 sections of ENST 230 from 2020-2021, additional questions (Appendix B) were asked in the same manner to assess Goal 4.

2. "Post-program" questions: The same multiple choice questions for both goals were administered to a majority of graduating ES majors as part of an exit survey in Spring 2019 and 2021. Questions for Goal 3 only were also administered to 13 ES students in 2016. The questions for Goal 1 (Appendix A) and Goal 4 (Appendix B) were also administered in 2021 only.

3. Indirect measures: As part of the exit survey administered to graduating ES majors, students are also asked about their perception of how well the program met all programmatic goals. These surveys have been administered annually since 2014 through 2019, and again in 2021 for a total of 64 ES majors. Questions did change in 2021 to improve wording, but this is a small amount of the total data (4 out of 64 students).

III. Results of Assessment Measures

1. Direct measures: The results of direct measures are summarized in Figures 1 & 2.

   A. Goal 2: With respect to Goal 2 (Knowledge of Earth Science concepts), the results of the direct evaluation reveal that in general, ES students come into ENST 110/230 Earth Systems Science with a knowledge of earth science that exceeds that of their peers who are not a part of ES (Figure 1). An average student was asked 5.27 questions over this time period. On average, an ES student got 3.39 questions correct (64.2%), while their non-ES peers got 2.31 questions correct (43.8%). This difference was statistically significant (t-test; $p < 0.001$).

   By graduation, ES majors answered 3.79 of 5.64 questions correctly (67.1%) on average, demonstrating a small but non-significant improvement on knowledge of earth science concepts. Considering the small sample size of exit survey questions (n=14) and the low stakes of exit survey questions, this is a positive result. Results also varied by question (Figure 1), indicating sub-categories that could be targeted more closely (e.g. sub-Goal 2.4) and those that show improvement (e.g. sub-Goal 2.1).

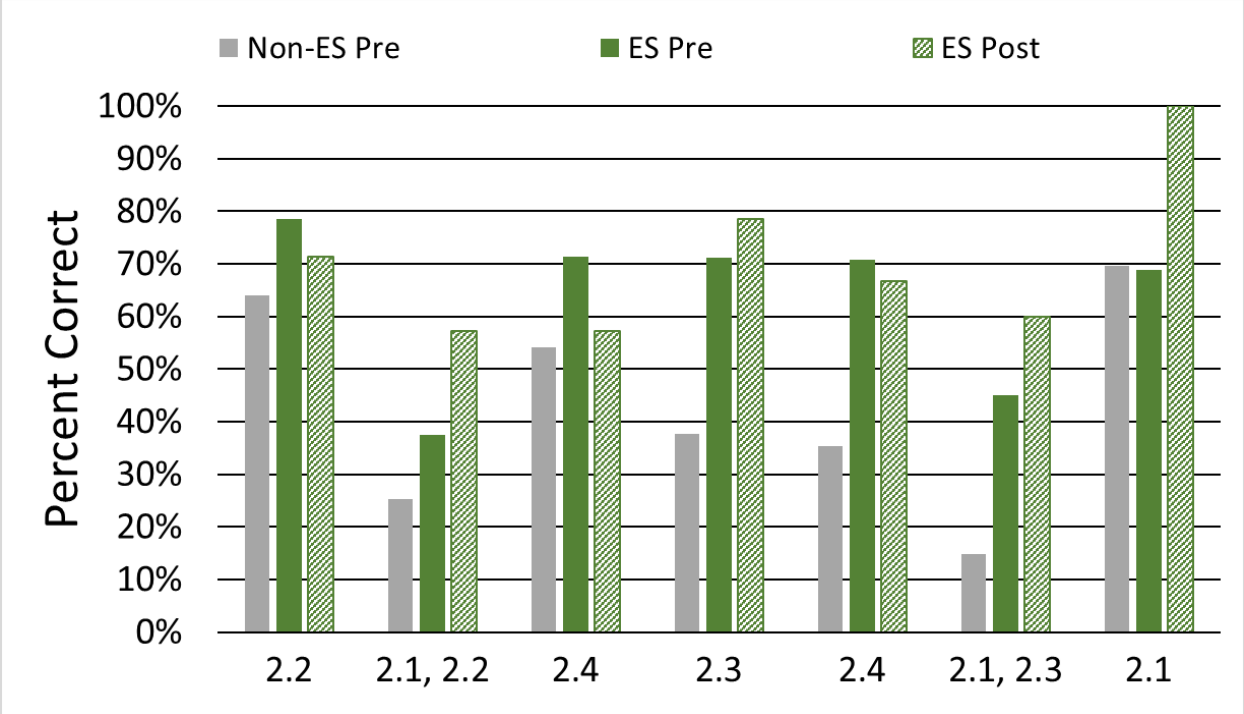

Figure 1. Percentage of correct answers on seven questions (Q1-Q7) related to Goal 2 (Foundational Knowledge in Earth Science) administered to students at the beginning of ENST 110/230 (labeled as "Pre") and as a part of a graduation exit survey (labeled as "Post"). The x-axis is labeled with the sub-goals of Goal 2 addressed by each question. Results on the pre-test have been subdivided for non-ES students who took the test, all ES students taking the pre-test and ES students who took the post-test at graduation.

   B. Goal 3: With respect to Goal 3, the results of the direct evaluation reveal that in general, ES students in 2015 began ENST 100 with a similar or lower level of

knowledge of this topic than other students in that class (Figure 2). On the pre-test, non-ES students answered 1.90 out of 5.0 questions correctly (38.0%), while ES students only answered 1.62 out of 5.0 correctly (32.2%), with no significant difference (t-test; p=0.414).

By graduation, ES majors were answering 2.54 out of 4.85 questions correctly on average (52.5%). This improvement was highly variable between questions (Figure 2), but statistically significant for aggregate scores (t-test; p = 0.013).

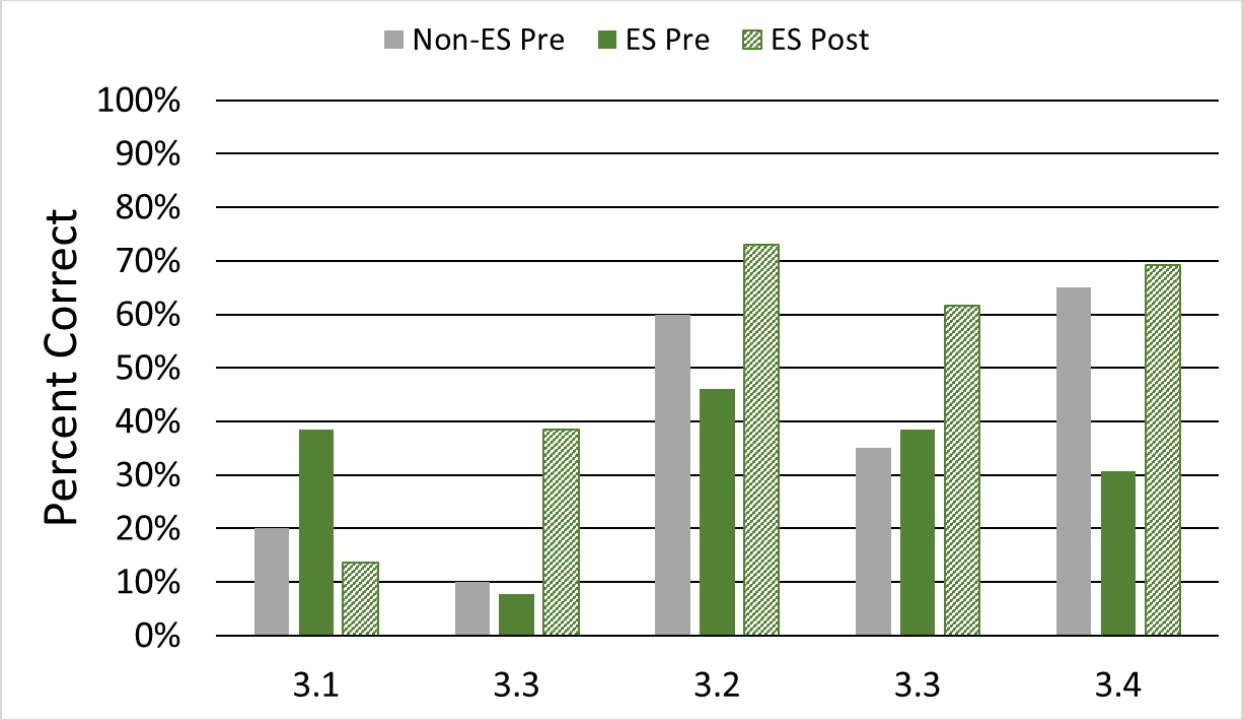

Figure 2. Percent correct answers on five questions related to Goal 3 (Foundational Knowledge in the relationship between human beings, society and the environment) administered to students at the beginning of ENST 100 (labeled as "Pre") and as part of an exit survey (labeled as "Post"). Results on the pre-test have been subdivided for students who were not in ES ("Non-ES"), and ES students taking the pre-test ("ES"). *n* = 20 for "Non-ES Pre"; *n* = 13 for "ES Pre"; *n* = 26 for "ES Post".

C. Goal 4: With respect to Goal 4, the results of the direct evaluation reveal that in general, ES students began ENST 230 with a slightly higher skill levels than other students in that class (Figure 3). On the pre-test, non-ES students answered 2.20 out of 3.13 questions correctly (70.3%), while ES students answered 2.24 out of 3.13 correctly (71.4%), with no significant difference (t-test; p=0.915).

By graduation, ES majors were answering 2.98 out of 4.0 questions correctly on average (74.5%). This improvement was highly variable between questions (Figure 3), and not statistically significant for aggregate scores (t-test; p = 0.745). Significance may increase with increasing sample size for the post-test (n = 4 out of 7 graduates).

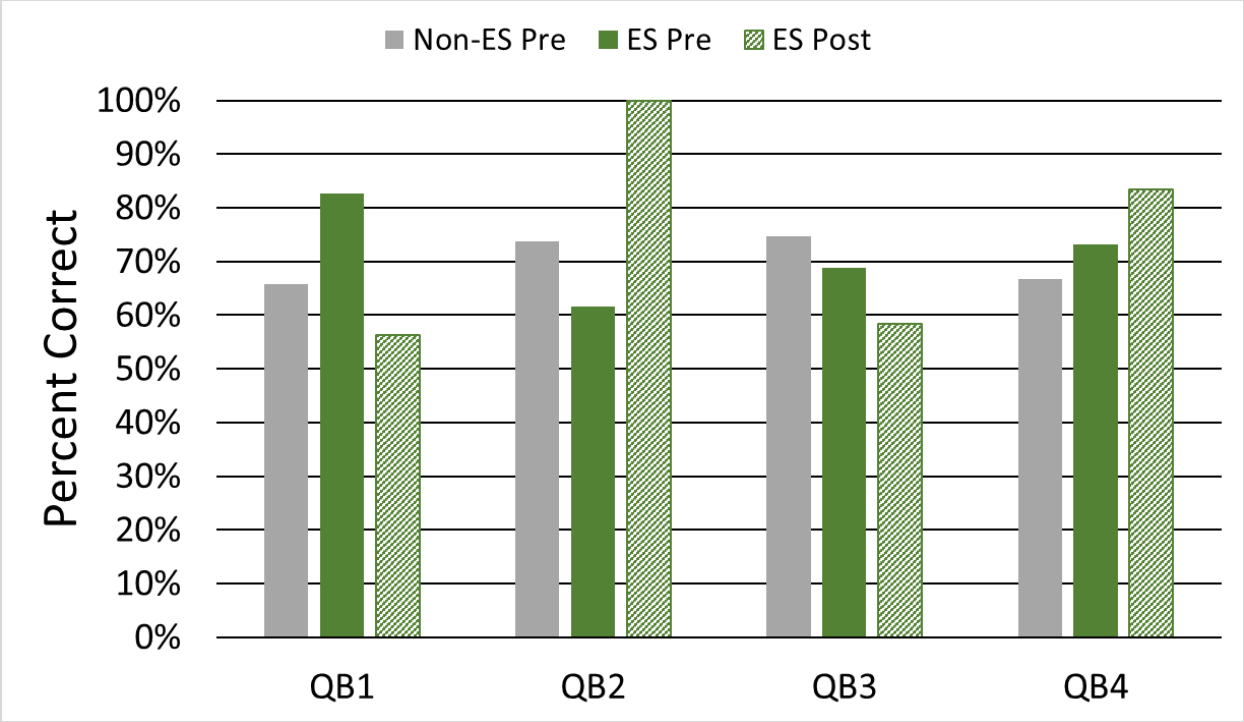

Figure 3. Percent correct answers on five questions related to Goal 4 (Gaining skills in using systems thinking to assess complex natural and social systems) administered to students at the beginning of ENST 230 (labeled as "Pre") and as part of an exit survey (labeled as "Post"). Results on the pre-test have been subdivided for students who were not in ES ("Non-ES"), and ES students taking the pre-test ("ES"). *n* = 32 for "Non-ES Pre"; *n* = 23 for "ES Pre"; *n* = 4 for "ES Post".

2. Indirect measures: The results of the indirect measures are summarized in Figures 4.

   A. Goal 2: The majority of graduating seniors reported that they felt that they acquired Foundational Knowledge in Earth Science concepts either "very well" or "well" on average (Figure 4).

   B. Goal 3: The majority of graduating seniors reported that they felt that they acquired Foundational Knowledge in environment and society concepts "very well" average (Figure 4).

   C. Goal 4: The majority of graduating seniors reported that they felt that they acquired Skills in Systems Thinking either "very well" or "well" on average (Figure 4).

   D. Goal 1: The majority of graduating seniors reported that they felt that they acquired Foundational Knowledge in ecological concepts either "very well" or "well" on average (Figure 4).

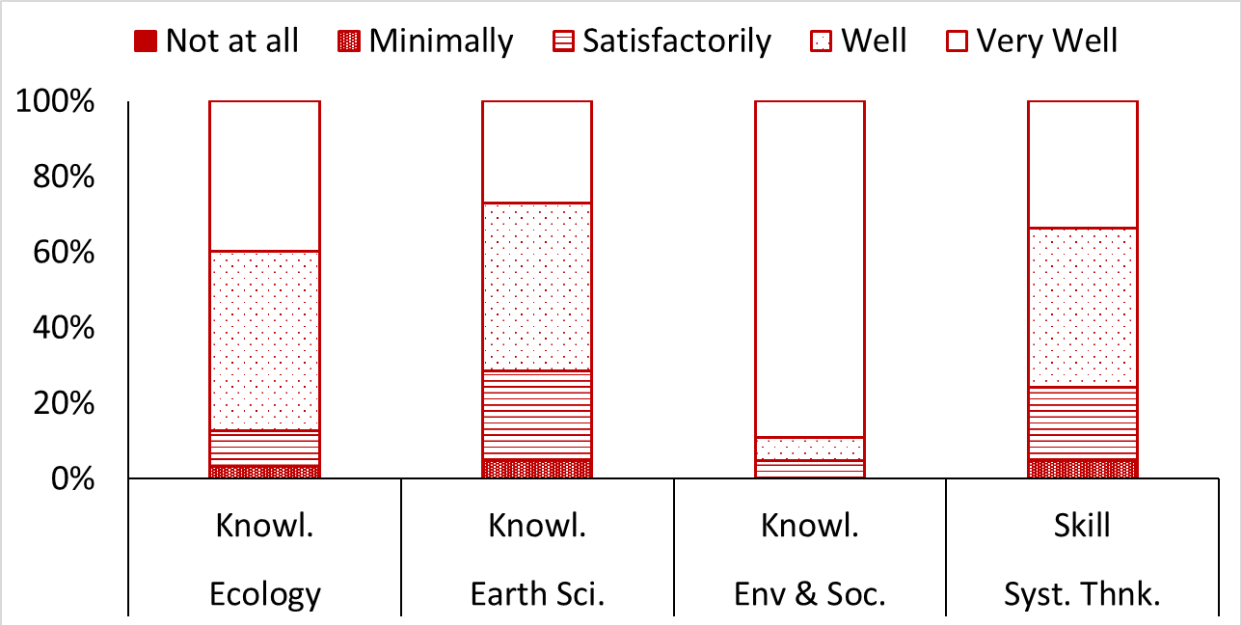

Figure 4. The percentage of students providing each answer on a graduation exit survey in response to the question questions asking them to rate their acquisition of either knowledge or skills in each area. The y-axis shows year of the survey and the number of respondents. n = 64 in all cases.

IV. Data Evaluation Process

The data were evaluated by the Assessment Coordinator, Aaron Wilson.

V. Implications of Data

It should be noted that for all goals, results varied between questions. Post-tests and indirect measures drew responses from a small number of students, ranging from 4-13 with an average of 9. This is due to the size of graduating classes in ES. This limited the power of the statistical tests that could be conducted, making it more likely that differences would not be significant.

1. Goal 2: Graduating ES majors felt confident about their knowledge of earth science concepts for the most part, and they are able to answer questions about these concepts significantly better than their peers. There is a small increase from pre- to post-test, probably owing to the lower number of post-test respondents and the low stakes of an exit survey. It also could be due to entering class with prior earth science knowledge, as these concepts are regularly taught in high school.

2. Goal 3: Graduating ES majors felt extremely confident about their knowledge of environment and society concepts. They enter the program at a similar level to their peers, but show a significant improvement by the time they take the post-test. This shows their improvement on concepts that are not typically taught at the high school level.

3. Goal 4: Graduating ES majors felt confident about their skills at systems thinking for the most part, and they are able to answer complex questions using systems thinking at about the same rate at their peers. By graduation, their rate has improved, but not significantly. This is likely owed entirely to a low sample size, although it could be because we did no assess systems thinking outside of earth science systems.

4. Goal 1: Graduating ES majors felt confident about their knowledge of earth science concepts for the most part. We will work in the future to ensure that we are administering pre- and post-tests.

VI. Academic Unit Responses to Data

Foundational knowledge pre- and post-tests for goals 1 through 3 will be administered every year, in order to provide longitudinal data about these critical goals. Due to the uneven results of testing based on individual questions, a question bank will be developed for each sub-category that will allow rotation of questions in a given year, while teaching the same concepts. This will aid in identifying questions that should be adjusted to give quality assessment. Greater coordination in question formulation will also take place, since the current batch of questions was developed by multiple faculty members.

ES also plans to begin administering some pre-test questions in all knowledge areas at the beginning of ENST 100 Environment and Society (a fall semester course), in order to better understand the knowledge level of students as they initially enter the ES program. Taking these steps will improve data quality for future analysis.

ES has already begun changing the wording of questions on the exit survey. This work will continue in order to ensure that quality feedback can be garnered from students. The post-test questions may be administered at the end of ENST 480 Senior Seminar, in order to raise the stakes of the assessment and therefore better represent the abilities of the seniors.

Summary

Our unit continues to develop longitudinal data on how well we impart foundational knowledge in 3 areas. It is clear that our students perform better than their peers in Earth Science, and show vast improvement in their knowledge of Environment and Society over the course of their IWU career. They leave IWU confident in their knowledge in all three foundational areas. Small improvements in Systems Thinking were recorded, but hindered by a small sample size owing in part to extreme disruptions caused by a pandemic and faculty turnover within the program.

APPENDIX A – DIRECT ASSESSMENT QUESTIONS FOR FOUNDATIONAL KNOWLEDGE (Q1-Q12)

1. Imagine ice cubes placed in a glass of water. Which of the following is the *most correct and complete* description of the resulting phenomenon?
   A. The ice cubes displace heat energy from the glass into the surrounding air, condensing water on the outside of the glass
   B. Anti-heat in the ice cubes negates heat in the surrounding water
   C. The ice cubes absorb heat energy from the water, which causes them to melt and the water to cool
   D. The ice cubes transfer their lower temperature to the surrounding water
   E. The melting ice cubes release a lower temperature into the glass, lowering its overall temperature

2. The greenhouse effect refers to the process through which:
   A. Certain gases reflect light back towards the surface, warming the Earth's surface
   B. Certain gases absorb incoming light from the sun, warming the atmosphere
   C. Certain gases emitted by humans cause the atmosphere to warm
   D. Certain gases transmit more light from the sun, warming the Earth's surface
   E. Certain gases absorb outgoing thermal energy, warming the atmosphere

3. Without a tilted axis, the Earth:
   A. Would not have different climates at different latitudes
   B. Would not have a Coriolis effect
   C. Would not experience uneven heating from the Sun
   D. Would not experience a diurnal cycle
   E. Would not experience distinct seasons at most latitudes

4. Which of the following represents a *short-term* stock in geologic terms?
   A. Phosphorus stored in sedimentary rocks
   B. Carbon stored in deep-sea sediments
   C. Energy stored in the chemical bonds of fossil fuels
   D. Water stored in an aquifer underground
   E. Nitrogen stored in the tissues of plants

5. Because the Earth rotates:
   A. The troposphere experiences a greenhouse effect
   B. A greater percentage of radiation is reflected near the poles
   C. The Earth's different latitudes are heated unevenly
   D. The Earth experiences diurnal cycles
   E. The Earth experiences distinct seasons at most latitudes

6. An example of a *flow* or *flux* of matter into a stock *not* offset by rapid, significant flows out would be:
   A. Carbon accumulated by plants through photosynthesis
   B. Phosphorus in chemical fertilizers buried in ocean sediments
   C. Energy stored in the chemical bonds of molecules making up tree trunks
   D. Water taken up by crop roots
   E. Nitrogen fixation by soil microorganisms

7. What flow of matter is a part of photosynthesis?
   A. Carbon from atmosphere into land plants
   B. Water from soil to land plants
   C. Energy from land plants to consumers
   D. Nitrogen from land plants to soil
   E. Phosphorus from soil to land plants

8. Which of the following is ***false***?
   The concept of **wilderness** in Western society…
   A. signifies a pristine environment, devoid of humans.
   B. was adopted from Native American views of nature.
   C. has historically led environmentalists to prioritize conservation over pollution prevention.
   D. is socially constructed.

10. The **precautionary principle** states that with regard to environmental problems, we…
   A. must take all precautions to assure that conclusive scientific evidence is available before acting to prohibit production or use of a substance.
   B. must act before conclusive scientific evidence is available to prohibit production or use of a substance if potential environmental costs may be very high.
   C. must take all precautions to assure that legislation adopted to protect the environment does not pose prohibitive costs to business.
   D. must have faith that everything will be O.K.

12. Which of the following is ***true***?
   A. The Earth's carrying capacity grows as the population grows.
   B. The ecological footprint of a country's population is the environmental impact of the population's consumption of the country's natural resources.
   C. Over the long term, the ecological footprint of a country's population cannot exceed the carrying capacity of the country's ecosystem if that country is to support its population indefinitely.
   D. Over the long term, the ecological footprint of the global population cannot exceed the Earth's carrying capacity if the Earth is to support the human population indefinitely.

9. Garrett Hardin's theory of **Tragedy of the Commons** is significant for all of the following reasons ***except:***
   A. It helps explain the collapse of deep sea fisheries due to over-fishing.
   B. It helps explain why a scarce resource with a private property regime will always be destroyed.
   C. It has been widely accepted by policy makes as true and provides the justification for government intervention in environmental issues.
   D. It has been widely accepted by economists as true and provides the justification for privatizing natural resources.

11. All of the following are true of **Cap and Trade** systems ***except:***
   A. They assure a fair distribution of exposure to pollutants between localities.
   B. They provide for the most economically efficient way to reduce emissions.
   C. They privatize rights to common property resources.
   D. They are presently used in the U.S. for reducing sulfur dioxide (SO_2) emissions, which cause acid rain.

APPENDIX B – DIRECT ASSESSMENT QUESTIONS TO DEMONSTRATE SKILLS IN SYSTEMS THINKING (QB1-QB4)

B1. *Inga vera* is a tropical plant from the dry forests of Costa Rica. It uses extra-floral nectaries to attract wasps and ants that in turn eat caterpillars that try to feed on *Inga vera* leaves. Which of the following is/are (an) *element(s)* of the system?

A. Caterpillars
B. Wasps
C. Tropical dry forest
D. A & B
E. A & C
F. B & C

B2. *Inga vera* is a tropical plant from the dry forests of Costa Rica. It uses extra-floral nectaries to attract wasps and ants that in turn eat caterpillars that try to feed on *Inga vera* leaves. Which of the following is *not* a *relationship* within the system?

A. Wasps prey on caterpillars
B. Caterpillars compete with ants for resources
C. *Inga vera* provide food for ants and wasps
D. Caterpillars damage *Inga vera* leaves
E. Ants collect nectar and caterpillars for food

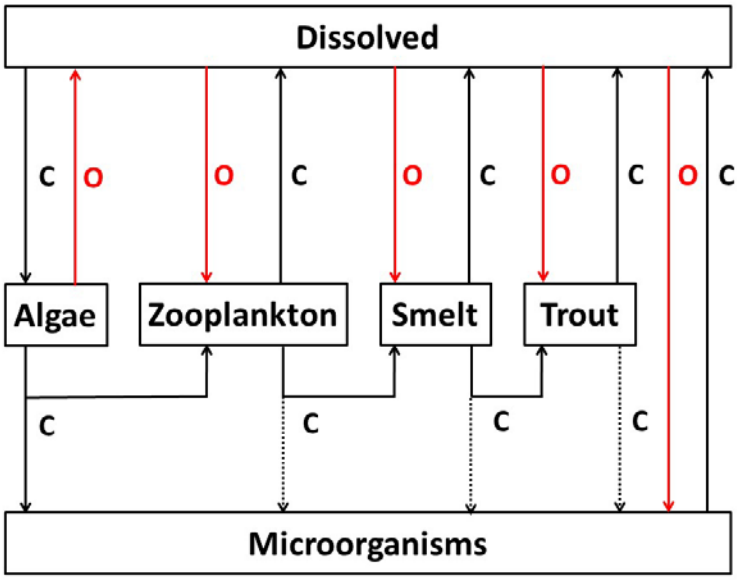

Figure. A simplified aquatic ecosystem drawn as a stock and flow diagram, showing flows of carbon (C, in black) and oxygen (O, in red) between different biotic and abiotic stocks. Dotted lines indicate flows that are of small importance compared to the others.

B3. If nutrients are added to this system and algae growth increases, which of the following is likely to happen immediately? Select all that apply.

A. Dissolved oxygen will increase due to increased photosynthesis
B. Dissolved oxygen will decrease due to increased decomposition
C. Trout population growth will increase due to increased food
D. Trout populations will decrease due to depleted oxygen
E. Dissolved carbon dioxide concentrations will decrease due to increased photosynthesis
F. Dissolved carbon dioxide concentrations will increase due to increased respiration

B4. If nutrients are added to this system and algae growth increases, which of the following is likely to happen once dissolved nutrients have been used up? Select all that apply.

A. Dissolved oxygen will increase due to increased photosynthesis
B. Dissolved oxygen will decrease due to increased decomposition
C. Trout population growth will increase due to increased food
D. Trout populations will decrease due to depleted oxygen
E. Dissolved carbon dioxide concentrations will decrease due to increased photosynthesis
F. Dissolved carbon dioxide concentrations will increase due to increased respiration