

# Causal Patterns in Ecosystems Rubrics: Understandings of Consequence Project

These rubrics are intended to help see whether students have achieved certain understandings and to diagnose the level of students' models and how they are structuring the causal concepts. The rubrics focus on causal understandings.

## Scoring Advice:

- Decide on the answer or level of response that is closest to the student's and record it on the student's summary sheet.
- If a student gives two explanations where a lower level one is elaborated by a higher level one, score for the higher one. If a student gives two competing explanations, average the score of the two unless he or she clearly weights one much more than the other.
- Be sure to include information in any student diagrams when scoring his or her response.
- When scoring for causality, don't punish your less articulate students. Score for the level of causal model that they most likely understand even if they are not articulate about it. This helps you diagnose whether they understand the causal model even if they did not write a full explanation.
- Score with the same level of rigor on the pretest as on the post-test. Otherwise it will be difficult to see whether learning has taken place.
- Use each rubric to score only the dimension that it focuses on.
- Use the examples to offer an idea of what the level is asking for but don't let it limit your analysis. Use the description at that level instead.
- When a rubric says "OR" it means that an answer only has to satisfy one part of what it says in order to qualify at that level. If the student used two or more of the "OR" statements, it still gets scored at that level.
- Responses that cannot be scored include no answer or "I don't know."

**Question 1a:** Owls, insects, skunks, mice, toads, and earthworms are all found in an area near the school. Draw and explain the food web that includes them. Include at least four other things in your web to make the very best food web that you can.

**Assessment Aim:** This question is scored twice: 1) to see if students focus on the patterns in the food web in terms of actions (“what eats what”) or in terms of energy transfer—a more passive process; 2) to assess what students include in their food webs. Do they include only the more obvious actors—the primary and secondary consumers? Or do they also include the less obvious, yet critical, producers and decomposers? Do they include distant parts of the system—the sun?

**Content Understanding Goal:** Energy Transfer

**Causal Understanding Goal:** Passive Causality

Level 1	Level 2	Level 3	Level 4
<p><i>Focuses on active causality:</i> Draws arrows from predator to prey and/or tells what eats what and/or what kills what; emphasis on domination (big things eat small things).</p> <p>Examples: Skunks → Mice “Skunks eat the mice.” GP → Sun “GP eats the sun.” Adds a human with gun or other animals such as a wolf and tells what each kills.</p>	<p><i>Mixes active and passive causality:</i> Draws arrows from sun to green plants and/or green plants to consumers, but reverses arrows between predator and prey—showing what eats what. OR Written emphasis on eating but uses lines with no arrows.</p> <p>Examples: “The sun gives energy to the green plants. The rabbits eat the green plants.”</p>	<p><i>Shifts towards passive causality:</i> Draws arrows from prey to predator but doesn’t talk about energy transfer or explains in terms of what eats what. OR Refers to food passively “Gives food to”, not energy transfer. OR Talks about animals actively and Sun to GP passively BUT shows all arrows passively. OR Draws lines without arrows and emphasizes the sun as an energy source.</p> <p>Examples: Mice → skunks “Skunks eat mice” “Owls kill mice.”</p>	<p><i>Grasps energy transfer as a form of passive causality:</i> Draws arrows from prey to predator and describes energy transfer relationships. OR No arrows on the line but describes energy transfer relationships.</p> <p>Examples: Mice → skunks “Mice provide energy for the skunks.”</p>

**Content Understanding Goal:** Role of Sun, Producers, Primary and Secondary Consumers, Decomposers

**Causal Understanding Goal:** Obvious and Non-Obvious Causes

Level 1	Level 2	Level 3	Level 4
<p><i>Includes obvious components only:</i> Includes primary and secondary consumers</p> <p>Examples: Includes skunks, mice, and toads</p>	<p><i>Includes some obvious and some non-obvious components:</i> Includes producers and primary and secondary consumers OR Includes decomposers and primary and secondary consumers</p> <p>Examples: “green plants, skunks, mice, toads” or “skunks, mice, toads, and earthworms”</p>	<p><i>Includes local obvious and non-obvious causes:</i> Includes producers, decomposers and primary and secondary consumers</p> <p>Examples: green plants, skunks, mice, toads, and earthworms”</p>	<p><i>Includes obvious, non-obvious and non-local components:</i> Includes sun, producers and primary and secondary consumers and decomposers.</p> <p>Examples: “sun, green plants, skunks, mice, toads and earthworms”</p>

**Question 1b:** Are the green plants important to the other things? If so, circle the things below that green plants are important to: Owls; Mice; Insects Earthworms; Skunks; Toads. Explain the reasons why the green plants are important to the things you circled.

<b>Assessment Aim:</b> This question assesses the connectedness that students see in the food web. It considers whether they detect the domino causality involved and if they see direct and indirect connections.			
<b>Content Understanding Goal:</b> Detecting Connectedness in Ecosystems			
<b>Causal Understanding Goal:</b> Domino Causality, Indirect Causality			
Level 1	Level 2	Level 3	Level 4
<p><i>No connections given:</i> Says that the green plants are important but does not elaborate on the principles behind the statement.</p> <p>Examples: “The green plants are important.”</p>	<p><i>Describes a one step linear or branching, one-way connection:</i> Producers are important only to primary consumers or sees the importance to secondary consumers as having to do with contributions other than energy transfer.</p> <p>Examples: “The green plants are important to the insects because they give the insects energy.” “The green plants matter only to the things that eat them, like the insects and the mice.” “The green plants only matter to insects for getting food but they help the rest of the things to breathe.”</p>	<p><i>Describes two step, linear connections with indirect components:</i> Producers are important to the primary consumers because they eat them and to the secondary consumers because they eat the primary consumers.</p> <p>Examples: “The insects eat the green plants and the toads eat the insects.”</p>	<p><i>Describes multi-step linear connections of three or more steps with indirect components:</i></p> <p>Examples: “The insects eat the green plants and the toads eat the insects and the skunks eat the toads.” “The green plants are important to everything because they make the energy from the sun into food and everything else uses that energy.”</p>

**Question 1c:** Are owls important to mice? Yes or no? Why or why not? Are mice important to owls? Yes or no? Why or why not?

<b>Assessment Aim:</b> This question considers whether students detect the mutual aspects of feeding relationships in the food web. Individual organisms benefit in terms of gaining energy and populations of animals are kept in balance by the activities of the predators. Because these benefits construe to the population rather than the individual, many students have difficulty recognizing them.			
<b>Content Understanding Goal:</b> Detecting Connectedness and Balance in Ecosystems			
<b>Causal Understanding Goal:</b> Mutual Causality, Population Reasoning			
Level 1	Level 2	Level 3	Level 4
<p><i>Makes a one-way connection:</i> Gives a predator-prey relationship that is described only from the perspective of the predator.</p> <p>Examples: “The mice are important to the owls because they are food for them. Owls aren’t important to mice.”</p>	<p><i>Makes a two way connection but at the level of individuals:</i> Both owls and mice are impacted but not at the level of population effects.</p> <p>Examples: “The owl gets food but the mouse dies.” “Mice help owls but owls kill mice.”</p>	<p><i>Makes a two way connection focused on the individual benefits to predators and population effects to prey OR a one way connection focused only on the population effect to the prey:</i> Mice are impacted at the population level and owls gain energy.</p> <p>Example: “If there are too many mice, there won’t be enough food for them, so the owls keep the numbers of mice to a good size.””</p>	<p><i>Makes a two way connection where predator and prey are impacted at the level of population effects:</i> Mice and owls are both impacted at the population level.</p> <p>Example: “The owls get food (or energy from the mice) and the mouse population stays a good size (or in balance).”</p>

**In scoring questions 2, 3, and 4, read across all of the students' answers in evaluating their understanding and apply the sum of their answers to each rubric item. Score for the most complex response unless the responses are competing.**

**Question 2:** What happens to a tree in the forest when it dies? What would happen to the tree after a few years?

<b>Assessment Aim:</b> This question has multiple parts. It considers whether students understand that organisms decompose and are broken down into reusable matter as part of the matter cycle.			
Content Understanding Goal: Change Over Time and Matter Recycling			
Causal Understanding Goal: Predicted Change, Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
<p><i>Does not expect a change, or focuses on location of the tree or ability to find the tree after a few years:</i> Describes how its location might change because it had been moved by water, wind, animal, etc.</p> <p>Examples:                      “The tree is dead.”                      “An animal might move it.”                      “It would be gone; maybe water took it away.”                      “It would blow away.”</p>	<p><i>Expects changes <b>not</b> related to the decomposition of the dead tree, or focuses on near term changes such as appearance of the tree after a few years:</i> Describes how the tree would appear on a superficial level. Focuses on the tree as a habitat, that it would no longer have leaves, gets knocked over. Lists uncertain changes (“If the tree decayed”).</p> <p>Examples:                      “Animals live in the dead tree.”                      “The tree falls over.”                      “It turns brown.”                      “It looks bad.”                      “It wouldn’t have lots of branches.”</p>	<p><i>Expects changes over time that relate to the tree breaking down or falling apart, or focuses on a weakening of tree’s structure in some way that distinguishes from simple change in appearance:</i> Explains how the tree can no longer be recognized as it once was, but does not talk about recycling of matter. Focuses on the tree breaking up.</p> <p>Examples:                      “It is falling apart.”                      “It gets eaten by bugs.”                      “Bugs would live in the tree and the tree gets broken down.”                      “It shrinks until you can’t see it.”                      “It disintegrates.”                      “It will decompose” “It will rot.”</p>	<p><i>Expects changes over time and focuses on longer term changes that relate to the tree becoming part of the soil:</i> Explicitly recognizes the recycling of matter. Focuses on the tree becoming soil.</p> <p>Examples:                      “After a while, the actual tree goes away—it becomes a part of the soil.” “It gets broken down into rich soil.”</p>
Content Understanding Goal: Matter Recycling			
Causal Understanding Goal: Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
<p><i>Focuses on location of the tree or ability to find the tree after a few years:</i> Describes how its location might change because it had been moved by water, wind, animal, etc.</p> <p>Examples:                      “An animal might move it.”                      “It would be gone; maybe water took it away.”                      “It would blow away.”</p>	<p><i>Focuses on appearance of the tree after a few years:</i> Describes how the tree would appear on a superficial level.</p> <p>Examples:                      “It turns brown.”                      “It looks bad.”                      “It wouldn’t have lots of branches.”                      “It falls over”                      “Branches fall off.”</p>	<p><i>Focuses on a weakening of tree’s structure in some way that distinguishes from simple change in appearance:</i> Explains how the tree can no longer be recognized as it once was, but does not talk about recycling of matter.</p> <p>Examples:                      “It is falling apart.”                      “It disappears.”                      “It gets eaten by bugs.”                      “It shrinks until you can’t see it.”                      “It disintegrates.”                      “It will decompose” “It will rot.”</p>	<p><i>Focuses on structural change at the micro-level:</i> Explicitly recognizes the recycling of matter.</p> <p>Examples:                      “It turns into rich soil.”                      “It gets broken down into soil”</p>

**Question 3:** Think about your answer to question #2. What causes this to happen? Tell as many causes as you can think of. (Hint: Don't tell what caused the tree to die. Tell about what causes whatever happens after it dies.)

**Assessment Aim:** This question has multiple parts. It considers whether students understand that organisms decompose, that there are obvious and non-obvious causes for decomposition, and that decomposition depends upon reliable, on-going causes.

**Content Understanding Goal:** Role of Decomposers

**Causal Understanding Goal:** Existence of Causal Mechanism

Level 1	Level 2	Level 3	Level 4
<p><i>Does not expect a change:</i> Nothing would happen to the tree.</p> <p>Example: "The tree is dead."</p>	<p><i>Acknowledges that change happens, but does not attribute the changes to a causal mechanism:</i> Says that it just happens but doesn't give a cause.</p> <p>Examples: "The tree falls over." "It turns black." "It would decompose." (no explanation of why)</p>	<p><i>Acknowledges decay; attributes the changes to the lack of a cause actively keeping it together:</i> Says that things just get old and fall apart after a while, or attributes the change to the lack of a resource. <i>Uses uncertain causes:</i> Says that <i>maybe</i> something makes it happen.</p> <p>Examples: "Once the tree dies, it loses its strength and eventually, it just falls apart." "The tree breaks down if it doesn't get enough water."</p>	<p><i>Acknowledges decay; attributes the changes to a causal mechanism:</i> Something makes the changes happen.</p> <p>Examples: "It breaks down because bugs are eating it." "Lightning strikes the tree."</p>

**Content Understanding Goal:** Role of Decomposers and Matter Recycling

**Causal Understanding Goal:** Obvious and Non-Obvious Causes

Level 1	Level 2	Level 3	Level 4
<p><i>Does not describe any causes:</i> Thinks nothing will happen or does not account for changes.</p> <p>Examples: "It gets brown and mushy." "Nothing happens." "It would decompose." (no explanation of why)</p>	<p><i>Describes only obvious causes:</i> Attributes changes to causes that one can see (e.g., bugs, people cutting the tree) or processes (e.g., weather, weakening), or uses the word "decomposers" without elaboration. <i>Incorrect or vague responses (e.g., chemicals in the tree).</i></p> <p>Examples: "Earthworms break down the dead matter." "Rain makes the tree weak and it falls apart."</p>	<p><i>Describes only non-obvious causes:</i> Attributes changes to microbes as the primary decomposers.</p> <p>Example: "Bacteria break down dead matter by digesting it."</p>	<p><i>Describes obvious and non-obvious causes.</i> Attributes changes to both observable and non-observable causes. Include "little organisms" (but they have to say "little" or equivalent).</p> <p>Examples: "Bugs and fungi break down the tree." "Storms, pollution, decomposers."</p>

**Content Understanding Goal:** The Nature of Decomposers

**Causal Understanding Goal:** Characterization of the Causal Mechanism

Level 1	Level 2	Level 3	Level 4
<p><i>Does not describe any causes:</i> Thinks nothing will happen, or does not account for changes. Doesn't mention a cause at all.</p> <p>Examples: "It turns brown." "Nothing happens."</p>	<p><i>Describes unreliable causes:</i> Attributes changes to things that may or may not happen.</p> <p>Examples: "Animals happen to sit on it." "A thunderstorm could do it." "People take it away."</p>	<p><i>Describes processes or conditions as the cause:</i> Attributes changes to background conditions (heat, wetness, aging, rain) that may or may not affect rate of decay</p> <p>Example: "The sun or wind dries it out."</p>	<p>Describes on-going, reliable micro causes: Talks about the role of micro- (molds, bacteria) or macro- (worms, sow bugs) decomposers</p> <p>Examples: "Bacteria feed on and break down dead matter." "Worms digest it and it is broken up into the soil."</p>

**Questions 4a and 4b:** Is what happens to the tree after it dies important to the plants in the forest? Yes or No? Would it matter if nothing happened to the tree after it died? Why or why not? (Hint: Think about your answer to question #2. what if the thing that you wrote about did not happen.)

**Assessment Aim:** This question is scored twice. It considers whether students see decomposition as part of the larger phenomenon of matter recycling. It also assesses whether students grasp the cyclic nature of the process and the conservation of matter that it entails.

**Content Understanding Goal:** Matter Recycling

**Causal Understanding Goal:** Cyclic Causality

Level 1	Level 2	Level 3	Level 4
<p><i>Does not view it as important.</i></p> <p>Examples:                      “No, it doesn’t matter.”                      “No the tree is dead, it doesn’t matter anymore.”</p>	<p><i>Views it as important for life or as a “next step”</i></p> <p>Examples:                      “It’s important because it is part of life.”                      “It’s what happens next after the tree dies.”</p>	<p><i>Mentions cycles or circles without explanation: Says it’s like a cycle but does not connect it to matter recycling. Or, implies a cycle but doesn’t connect it to matter recycling.</i></p> <p>Examples:                      “It’s like a cycle.”                      “It’s like the circle of life.”                      “The tree dies and a new tree grows there.”                      “It’s like a cycle.”</p>	<p><i>Mentions decay as part of recycling: Says that decay turns dead matter <u>back</u> into soil or stuff in the soil. AND/OR discusses it as a circle or recycling: Says that dead matter turns back into soil <u>and</u> this is like a circle or recycling.</i></p> <p>Example:                      “It turns back into dirt.”                      “The tree grows using the soil and then becomes soil again.”                      “It turns back into soil. This is part of a big cycle that creates rich soil which helps the plants to grow and then they die and create more soil.”</p>

**Content Understanding Goal:** Matter Recycling

**Causal Understanding Goal:** Conservation of Matter, Cyclic Causality

Level 1	Level 2	Level 3	Level 4
<p><i>Does not think what happens is important or does not view decay as important or does not address decay: Does not recognize that decay is essential.</i></p> <p>Examples:                      “No it doesn’t matter if nothing happened.”                      “It’s what happens, but if it didn’t, it wouldn’t be such a big deal.”                      “Dead things might smell, but that’s all.”</p>	<p><i>Does not recognize the finite nature of matter, but considers decay essential, otherwise dead matter would accumulate.</i></p> <p>Examples:                      “There’d be tons of dead matter everywhere until there would be no room for anything else.”</p>	<p><i>Does not mention the finite nature of matter, but believes that decay is essential for having good soil.</i></p> <p>Example:                      “The tree creates good rich dirt to grow plants in.”                      “The nutrients from the dead tree go into the soil.”</p>	<p><i>Recognizes that matter is finite and is recycled: Recognizes that if dead matter was not recycled, that the building blocks for new life would not exist. Discussion of conservation of matter.</i></p> <p>Examples:                      “The particles go back into the soil to become a part of new things.”                      “The matter in the tree will become the matter in something else someday.”</p>

**Question 5a and 5b:** What is balance in an ecosystem? How does an ecosystem get balanced or unbalanced?

<b>Assessment Aim:</b> This question considers whether students have a concept of balance at the population level, whether they view balance as playing a role in ecosystem stability, and if they have a sense of factors that lead to balance.			
<b>Content Understanding Goal:</b> Understanding Balance in Ecosystems			
<b>Causal Understanding Goal:</b> Mutual Causality, Population Reasoning, Cyclic Causality			
Level 1	Level 2	Level 3	Level 4
<p><i>Has a concept of balance, but not as it pertains to the abstract concepts in an ecosystem:</i> Describes balance in terms of a seesaw, a balance scale, not tipping over, etc.</p> <p>Example: “If something is in balance, like a seesaw, then the two sides even out.”</p>	<p><i>Views balance in terms of individual organisms and mutual causality:</i> Animals have to eat certain amounts or they will deplete their diet sources.</p> <p>Example: “If a snake eats too many mice, then it will run out of mice to eat.”</p>	<p><i>Views balance as a population effect:</i> In order for an ecosystem to be in balance, the sizes of the populations of organisms has to be just right for the populations of the things that they need to eat.</p> <p>Example: “The numbers of each animal has to be in the right balance with the numbers of the animals that it feeds upon for there to be balance.”</p>	<p><i>Views balance as what creates stability at the level of populations, Might understand factors that give rise to it:</i> When things are in balance, organisms have what they need to survive. Might describe measures of redundancy (multiple acceptable food sources or habitats) and adaptability (switch food sources or habitats) that provide balance .</p> <p>Example: “Balance means that all the animals have what they need and the ecosystem stays pretty much the same. If it is out of balance, things will die out and things can crash quickly.”</p>

**Question 5c and 5d.** A student said, “It is good for ecosystems to always be in balance.” Do you agree or disagree? Explain why you agree or disagree.”

Level 1	Level 2	Level 3
<p><i>Focuses on the negative aspects of flux or the essential nature of balance:</i> States that it is bad for an ecosystem to be in flux because it is unstable.</p> <p>Examples: “If an ecosystem is not in balance things could overpopulate or die out.” “A balanced ecosystem keeps everything running smoothly.” [Score answers recognizing that flux is inevitable but stating that balance is desirable as a 1.5]</p>	<p><i>Focuses on the limiting aspects of balance of the essential nature of flux:</i> States that it is bad for ecosystems to always be in balance or necessary for them to be in flux.</p> <p>Example: “If ecosystems are always in balance, how would new species become established?”</p>	<p><i>Sees the value of balance and flux:</i> Considers balance and flux to both play important roles in ecosystems.</p> <p>Example: “Balance and flux both have roles in ecosystems. More mice than predators can keep in check might result in an unbalanced population until an event like a dry spell causes large numbers of mice to die off.” “Flux is a part of balance.”</p>