**Modeling Assessment Rubric**

**Part A: The model**

| **1- Scoring of conceptual model and description: Components (and descriptions)** | |
|---|---|
| **Modeling Goal: Correctly identify specific components/variables of experiment and explain their importance to the research project.** | |
| **Score** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1 point:** General ideas represented only | light, plants, animals |
| **2 points:** Components are mostly general | Sun, trees, animals |
| **3 points:** Components somewhat reflect the experiment | Plant productivity, |
| **4 points:** Components accurately and specifically reflect experiment | Herbivore diversity, amount of carbon dioxide, |

| **2- Scoring of conceptual model itself and description: Use of Arrows** | |
|---|---|
| **Modeling Goal: Accurately show relationships among main variables in experiment** | |
| **Score** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1 point:** Draws arrows incorrectly. | Hare →Willow |
| **2 points:** Draws arrows correctly | Willow --→ Hare |
| **3 points:** Draws arrows to show increase and circles to show decrease correctly between prey to predator, uses arrows for abiotic factors correctly with no decrease | Willow o--→ Hare<br><br>Nitrogen → Rizobium bacteria |
| **4 points:** Draws arrows showing increase, circles to show decrease correctly between prey to predator, shows self effect loops**.** |  <br>Willow o--→ Hare |

| **3- Scoring of conceptual model and descriptions: Connections between variables** | |
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| **Modeling Goal: Show and explain the connections between variables** | |
| **Score** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1 point:** One or two linear connections, errors | Hare →Willow |
| **2 points:** Either few or many (spaghetti strings) incorrect connections, some correct, all have one or two steps (linear) | Willow → Hare |
| **3 points:** Many connections, all are purposeful and correct, some complex with at least two steps, some simple linear | Willow o→ Hare o→ Lynx |
| **4 points:** Many connections, mostly complex and multi-stepped with three or more steps, shows two-way interactions or even cyclical interactions. | Nutrients→Willow o→ Hare o→ Lynx<br>  <br>Aquatic grass o→Moose o→ Wolf |

**Part B: Rubric for Modeling Essay Questions**

| **Question 1: Explain why you chose each component depicted. Describe the relationships among all your components. What ecological process or processes does your model best depict?** | |
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| **Content Understanding Goal: Ecological diversity** | |
| **Level** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1 point:** Poorly applies diversity, very general | Interactions between biotic and abiotic factors |
| **2 points:** Minimally applies one diversity concepts | The insect diversity in the meadow is greater because of more moisture. |
| **3 points:** Adequately applies diversity concepts to research project | Meadows tend to have greater diversity of primary producers due to increased sunlight than forested site… |
| **4 points:** Shows mastery of diversity concepts, appropriately applies several concepts to research project | The presence of large woody debris may have more significantly impacted arthropod diversity than the absence of a canopy. |

| **Question 2: Develop hypothesis, (or re-write hypothesis) using components in model. Describe how hypothesis (or secondary hypothesis) will be tested.** | |
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| **Learning Goal:** Understand how to develop a testable hypothesis | |
| **Level** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1 point:** Poor | The clear cut will better handle disturbance because it has greater diversity. |
| **2:** Minimal, needs restructuring. | What is the diversity in the meadow v.s. a forest? |
| **3:** Adequately forms a testable hypothesis. | How does log decomposition effect arthropod diversity? |
| **4:** Shows mastery in forming a clear, testable hypothesis and describe method of testing hypothesis. | Species richness in fungivore arthropods will be greater in the forest opening than the forest. Measure species richness of fungivore arthropods captured in forest opening and in the forest at the same time, same experimental design. |

| **Question 3: Choose I biotic component. List or describe as many subcomponents within that. Explain if redundancy might apply or not.** | |
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| **Learning Goal: Understand Ecological hierarchy and redundancy** | |
| **Score** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1:** Poorly applies understanding of | Although the species might not be the |

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| subcomponents | same, there were approximately the same number of species… |
| **2:** Minimally applies understanding of subcomponents, no mention about redundancy | The guild with the largest biomass was… predaceous arthropods. |
| **3:** Adequately applies subcomponents, some misconceptions about redundancy | Herbivore species richness was higher in the meadow, with large populations of different any species. |
| **4:** Shows mastery of understanding subcomponents and redundancy | The forested site had a g a number of predators unique to the forest, including two types of harvestmen…providing resiliency… to allow it to function as a system in a disturbance. |

| **Question 4: Discuss and illustrate feedback. Choose one component in your system and describe one change over short-term period. Describe any indirect effects you could expect. How could the patterns appear differently over longer time scales?** | |
|---|---|
| **Learning Goal:** Understanding complexity in Ecosystems, show Feedback and trace through possible indirect effects | |
| **Score** | **Examples** |
| **0:** not score-able; no response. | "I don't know." |
| **1:** Poor understanding of feedback and indirect effects, | One example of feedback is the vegetation in the meadow. |
| **2:** Shows minimal understanding of and application of feedback, minimal ability to describe indirect effects, | A change in arthropods would ricochet up the food web and the entire ecosystem. |
| **3:** Shows good understanding of and application of feedback, but less proficient describing indirect effects. Only describes one plausible pattern of change (short term) | Ecosystems function through varied array of relationships that are usually nonlinear and include many complex feedback loops… |
| **4:**Expertly understands and applies both feedback and indirect effects (4 points). Describes plausible patterns of changes over short and long time spans (4 points) | Feedback loops may have negative impacts (competition) placing limits on growth of herbivores…it may accelerate the rate of growth of plants over the short term, but due to feedback, not in the long term. |

| **Question 5:** Add specific disturbance, show how effects are propagated through system. Predict consequences of disturbance, describe experiment to test your prediction. | |
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| **Learning goal:** Ability to make accurate predictions, design a secondary experiment. | |
| **Score** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1**: Poor effects, no predictions, no experiment | The meadow could handle the effects of a drought better than the forest because the |

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| | forest would become more susceptible to disease. |
| **2**:. Minimally shows effects, poor predictions, poor experiment | Fire could change the soil respiration. You could collect data in a patch before and after a fire |
| **3:** Adequately shows how effects are propagated through system, makes modest predictions, designs ok experiment to test this. | After a hot "crown: fire, fungal and bacterial elements of soil will have been eliminated, and the forest will take a longer time to recover its intricate relationships than the meadow…post-fire experiments could quantify the loss of soil microbes… |
| **4:** Expertly shows how effects are propagated through the ecosystem, makes plausible predictions, designs plausible experiment to test this. | A fire would immediately increase light reaching the ground, and burning would release nutrients, stimulating herbaceous growth…short term, plants are not dependent upon symbiants, may no longer feed the microbes…burn a test plot and take measurements over time… |

| **Question 6: How do you think complex ecosystems function? Explain your reasoning, the better able it might be to withstand** | |
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| **Learning Goal:** Understand ecological complexity | |
| **Level** | **Examples** |
| **0:** Not score-able; no response. | "I don't know." |
| **1:** Poor response | Complex systems are interdependent and, like lasagna, you can't tell the function of one part by just observing the final product. |
| **2**: Makes some errors in discussing aspects of complexity | Complex ecosystems move in and out of balance… |
| **3:** Adequately discusses several aspects of complexity | Patch level dynamics may play a significant role in succession at local sites… what happens over time in each patch may not conform to typical successional trajectories… |
| **4:** Expertly describes the causal mechanisms of systems, i.e., feedback, direct and indirect and multiple effects, pattern over different time and space scales, subcomponents, | The greater the order of complexity, the better able it will be to withstand degradation…fungi providing nutrients to vegetation provides positive feedback loop…multiple levels of relationships might provide compensatory pathways to overcome the loss of other species over time… |