AP BIOLOGY · UNIT 8 · TOPIC 8.6

# Biodiversity

*Learning objective 8.6.A Describe the relationship between ecosystem diversity and its resilience to changes in the environment, and 8.6.B explain how the addition or removal of any component of an ecosystem will affect its overall short-term and long-term structure.*

Name: Date: Period:

Use the tool **The Part You Cannot Remove**. Parts 1 and 2 use **How much can it take**, Parts 3 and 4 use **Pull one out** and **Size is not the answer**, and Parts 5 and 6 use **Then and later**. A common answer for this topic is that more species make an ecosystem more resilient. When the models hold the variables apart, that is not what they show, so base each answer on the numbers in the tool.

## Part 1 · Five ecosystems, one environment getting worse

Every system below has a set of jobs that must keep being done. A shock kills every species that cannot tolerate it, and the system keeps working while every job still has somebody doing it. **Three of these systems have exactly the same number of species**. The tool opens on the How much can it take tab with one system's results showing, so write your prediction before you look at the tool: predict which system keeps working at the most severe shock, and mark it in the table. Then click each system and record where its first job is lost (the First job lost at a shock of readout).

| System | Species | Per job | Do they differ? | Your prediction: toughest? | Breaks at |
|---|---|---|---|---|---|
| Six parts, no backup | 6 | 1 | no | | |
| Twelve parts, no backup | 12 | 1 | no | | |
| Twelve parts, doubled up | 12 | 2 | no | | |
| Twelve parts, doubled and varied | 12 | 2 | yes | | |
| Thirty parts, five deep, varied | 30 | 5 | yes | | |

**1. (a) Describe the relationship between the diversity of an ecosystem and its resilience to changes in the environment.**

**(b) Identify the two separate conditions that make an ecosystem less resilient.**

**2. Three systems in the Part 1 table have 12 species each, but they do not all break at the same shock. Explain how this is possible.**

## Part 2 · Two questions, two answers

Now record the last column from the Worst capacity lost in one step readout: how much of the system's capacity is lost in the worst single step of severity. This is a different question from **when does it break**, and the two questions do not have the same answer. Look particularly at the last two rows.

| System | Species | Per job | Breaks at | Worst capacity lost in one step |
|---|---|---|---|---|
| Six parts, no backup | 6 | 1 | 0.55 | |
| Twelve parts, no backup | 12 | 1 | 0.55 | |
| Twelve parts, doubled up | 12 | 2 | 0.55 | |
| Twelve parts, doubled and varied | 12 | 2 | 0.85 | |
| Thirty parts, five deep, varied | 30 | 5 | 0.85 | |

**3. (a) Identify the condition under which having two species perform the same job protects an ecosystem.**

**(b) Using the Part 2 table, explain why having two species perform each job does not protect an ecosystem when this condition is not met.**

**4.  The last two systems in the Part 2 table both break at a shock of 0.85, but they lose 50 percent and 20 percent of their capacity in the worst step. Explain how the additional species in Thirty parts, five deep, varied affect the way that system fails.**

**5.  A farmer plants 100,000 plants of a single variety. Using the first row of the Part 1 table, explain why the field has low resilience despite the large number of plants.**

## Part 3 · Pull one species out

A twelve-species web with two rules: a consumer with nothing left to eat dies, and a competitive dominant with nothing holding it down takes the space and crowds out everything else that needs it. Click each species in the tool to remove it, and record the share of all individuals, the number of other species lost and which species are lost (the verdict names them). Work down the list in order; the tool opens with the sea star already removed.

| Removed | Its individuals | Share of all | Other species lost | Which ones |
|---|---|---|---|---|
| Phytoplankton | 20,000 | | | |
| Kelp | 5,000 | | | |
| Mussel | 3,000 | | | |
| Barnacle | 2,500 | | | |
| Limpet | 800 | | | |
| Chiton | 400 | | | |
| Anemone | 600 | | | |
| Sponge | 300 | | | |
| Whelk | 120 | | | |
| Crab | 200 | | | |
| Sea star | 40 | | | |
| Gull | 25 | | | |

**6. Describe a keystone species.**

**7. (a) Using the Part 3 table, identify the keystone species in this web.**

**(b) Describe how this species has an effect out of proportion to its numbers.**

## Part 4 · Plot the damage against the size

The Size is not the answer tab plots each species from the Part 3 table: individuals along the bottom on a log scale, other species lost up the side. Record the three correlation readouts. Then read the tool's leave-one-out table, which recomputes the correlation twelve times, each time leaving one species out.

| Correlation of impact with… | Value | What it suggests |
|---|---|---|
| Abundance, all twelve species | | |
| Abundance, with phytoplankton left out | | |
| Structural role (sole supplier, or sole check) | | |

**8. Using one common species and one rare species from the Part 3 table, explain why the number of individuals of a species cannot be used to identify the keystone species.**

**9. A survey reports that the abundance of a species is correlated with the number of species lost when it is removed.**
**(a) Describe how a leave-one-out analysis tests whether such a correlation is reliable.**

**(b) Using the Part 4 table, explain what the leave-one-out analysis shows about the correlation in this web.**

**10. Producers also maintain the diversity of an ecosystem. Using the Part 3 table, explain why the producers in this web are not keystone species.**

## Part 5 · Then and later

The tool propagates consequences one round at a time: whatever depended directly on the removed species goes first, and whatever depended on **those** goes in the round after. Record each row from the table on the Then and later tab.

| Removed | Lost after one round | Lost once settled | Which ones arrive late |
|---|---|---|---|
| Sea star | | | |
| Phytoplankton | | | |
| Kelp | | | |
| Barnacle | | | |
| Mussel | | | |

**11. Using the Part 5 table, explain why the full effect of removing a species is not visible at the time it is removed.**

**12. A conservation agency surveys a forest one year after a species is lost and reports little change. The agency claims that the loss did not matter. Evaluate the agency's claim.**

## Part 6 · Adding counts too

The objective says **addition or removal**. The tool tests two additions. For the second mussel predator, the tool adds the predator and then removes the sea star; for the superior space competitor, nothing is removed. Record the species lost and the comparison for each.

| Addition | What it is | Species lost | Compared with |
|---|---|---|---|
| A second mussel predator | another species that eats and suppresses mussels | | |
| A superior space competitor | an introduced species that outcompetes even the mussel for rock | | |

**13. (a) Using the Part 6 table, describe one addition that protects the ecosystem.**

**(b) Using the Part 6 table, describe one addition that harms the ecosystem.**

**14. The second mussel predator in Part 6 protects the ecosystem in the same way that the varied systems in Part 1 do. Explain how.**

## What the model simplifies

The resilience model treats every job in the ecosystem as either being done or not done, and every species as either alive or dead at a given severity. Real tolerance is a gradient, real species are damaged before they are lost, and real ecosystems have jobs of very unequal importance. What is asserted here is the structural claim: that species count and redundancy, held apart from variety, do not move the point at which a job stops being done.

The food web is a schematic modeled on a rocky shore, not a measurement of one. Twelve species, two kinds of relationship, and abundances chosen to be realistic in their ordering rather than accurate in their values. Real webs have hundreds of species, most organisms feed at several levels, and a species rarely disappears completely when its main food does.

The competitive-dominant rule is deliberately absolute: with nothing suppressing it, the mussel takes all the space and everything needing space is excluded. In the real system Robert Paine studied on the Washington coast, removing the sea star reduced a fifteen-species assemblage to a near-monoculture of mussels over several years: severe, but not instant and not total.

Extinctions here are all-or-nothing and consequences arrive one round at a time. That regular rhythm is what makes short-term and long-term effects separable in the tool; in the field the two blur together and the delay can be years or decades.

Correlation is used here as evidence about a claim, not as decoration. The abundance-impact correlation is +0.46, which looks like a relationship until one species is held out and it falls to +0.01. The tool recomputes that leave-one-out analysis in the browser rather than displaying a stored result, so the claim can be checked rather than believed. Leaving out the sea star raises the correlation to +0.99, so single species pull it in both directions.

Simpson's Diversity Index from Topic 8.5 measures the diversity whose consequences are the subject here. The two topics are worth teaching together: 8.5 asks how you would measure diversity, and 8.6 asks what difference it makes.