

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**. The obvious answer to this topic is that more species means a tougher ecosystem. Run the models with the variables held apart and that is not what comes out, so work each part from what the numbers actually do before you write the sentence you already know.

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**. Predict which is toughest before you record anything.

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. State the relationship between an ecosystem's diversity and its resilience as the CED words it, and identify the two separate conditions in that sentence.

2. Three of your rows have the same number of species and they do not all break at the same shock. Explain how that is possible.

Part 2 · Two questions, two answers

Now record the last column: 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. Explain why having two species do a job protects an ecosystem only under a particular condition, and state that condition.

4. Your last two systems break at the same shock but differ enormously in the last column. Explain what the extra species bought, given that they did not move the breaking point.

5. A farmer plants a hundred thousand plants of a single variety. Using the first row of your table, explain why that field is fragile despite the number of plants in it.

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. Remove each species below and record what follows. Work down the list in order — do not skip to the one you suspect.

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. Define a keystone species.

7. Identify the keystone in this web from your table, and describe the mechanism by which it has an effect out of all proportion to its numbers.

Part 4 · Plot the damage against the size

Take your Part 3 table and plot each species: individuals along the bottom on a log scale, other species lost up the side. Then use the tool's leave-one-out table, which recomputes the correlation between the two twelve times, each time holding 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. Explain why counting individuals cannot tell you which species in an ecosystem is the keystone. Use two species from your table, one common and one rare.

9. A survey reports that abundance correlates with how much a species' loss would cost. Explain what you would want to check before believing that, and what your leave-one-out table shows here.

10. Producers are also listed in the CED as maintaining the diversity of an ecosystem. Using your table, explain why they are not therefore 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 both numbers for every removal that costs anything.

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

11. 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 minimal change. Explain what is wrong with concluding from this that the loss did not matter.

Part 6 · Adding counts too

The objective says **addition or removal**. Two additions, neither of which takes anything away. Record what each one does.

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. Explain how adding a component to an ecosystem can change its structure, giving one example from your table that helps and one that harms.

14. Both of your additions work through the same idea as Part 1. State that idea in one sentence that covers Part 1 and Part 6 together.

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 that the correlation rests on a single point can be checked rather than believed.

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.