



## ***Some Animals Are More Equal than Others: Trophic Cascades and Keystone***

### OVERVIEW

The short film [\*Some Animals Are More Equal than Others: Trophic Cascades and Keystone Species\*](#) opens by asking two fundamental questions in ecology: “What determines how many species live in a given place? Or how large can each population grow?” The film then describes the pioneering experiments by Robert Paine and James Estes, in the 1960s and 1970s, which started to address them. Paine’s experiments on the coast of Washington state showed that the starfish is a keystone species, having a disproportionately large impact on its ecosystem relative to its abundance. Estes and colleague John Palmisano discovered that the kelp forests of the North Pacific are indirectly regulated by sea otters, which feed on sea urchins that consume kelp. The presence or absence of sea otters causes a cascade of direct and indirect effects down the food chain, which in turn affect the structure of the ecosystem. These early experiments inspired countless others on keystone species and trophic cascades in ecosystems throughout the world.

### KEY CONCEPTS

- Keystone species have direct and indirect effects on the abundance and number of species in an ecosystem that are disproportionately large relative to their own abundance in the ecosystem.
- Not all species in an ecosystem have strong interactions. The removal of some species has little or no effect on others.
- Many keystone species are apex predators: predators at the top of a food web that are not preyed on by others.
- Removal or addition of an apex predator that is a keystone species causes changes in the type and number of species, and their population sizes, at multiple trophic levels.
- Keystone species are critical to maintaining the diversity and stability of an ecosystem.
- Identifying the interactions among species in an ecosystem and determining how species numbers and population sizes are regulated requires experiments conducted over long time periods.

### CURRICULUM CONNECTIONS

Standards	Curriculum Connections
NGSS (2013)	LS2.A, LS2.B, LS2.C, LS4.C
AP Biology (2015)	4.A.5, 4.A.6, 4.B.3, 4.C.4
AP Environmental Science (2013)	II.A, II.B
IB Biology (2016)	4.1, 4.2, C.1, C.2, C.3, C.4, C.5
IB Environmental Systems and Societies (2017)	2.2, 2.3, 2.4, 3.3
Common Core (2010)	ELA.RST.9-12.2, WHST.9-12.4
Vision and Change (2009)	CC4, CC5

### KEY REFERENCE

Paine, R. T. (1966). Food web complexity and species diversity. *The American Naturalist* 100:65-75.