Keystone species

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The jaguar has a varied diet in Central and South America. It acts as a keystone predator by helping to balance the animals in the jungle ecosystem by consuming 87 different species of prey. Photo from the public domain.

A keystone species is an organism that helps define an entire ecosystem. Without its keystone species, the ecosystem would be dramatically different or cease to exist altogether.

Keystone species have low functional redundancy. This means that if the species were to disappear from the ecosystem, no other species would be able to fill its ecological niche. The ecosystem would be forced to radically change, allowing new and possibly invasive species to populate the habitat.

Any organism, from plants to fungi, may be a keystone species; they are not always the largest or most abundant species in an ecosystem. However, almost all examples of keystone species are animals that have a huge influence on food webs. The way these animals influence food webs varies from habitat to habitat.

Carnivores, Herbivores And Mutualists

Predators

A keystone species is often, but not always, a predator. Just a few predators can control the distribution and population of large numbers of prey species.

The entire concept of keystone species was founded on research surrounding the influence of a marine predator on its environment. American zoology professor Robert T. Paine's research showed that removing a single species, the Pisaster ochraceus sea star, from a tidal plain on Tatoosh Island in the U.S. state of Washington, had a huge effect on the ecosystem. Pisaster ochraceus, commonly known as purple sea stars, are a major predator of mussels and barnacles on Tatoosh Island. With the sea stars gone, mussels took over the area and crowded out other species, including benthic algae that supported communities of sea snails, limpets and bivalves. Lacking a keystone species, the tidal plain’s biodiversity was cut in half within a year.

Another example of a predator acting as a keystone species is the presence of gray wolves in the Greater Yellowstone Ecosystem. The Greater Yellowstone Ecosystem (GYE) is an enormous and diverse temperate ecosystem stretching across the boundaries of the U.S. states of Montana, Wyoming and Idaho. The GYE includes active geothermal basins, mountains, forests, meadows and freshwater habitats.

The elk, bison, rabbit and bird species in the Greater Yellowstone Ecosystem are at least partly controlled by the presence of wolves. The feeding behavior of these prey species, as well as where they choose to make their nests and burrows, are largely a reaction to wolf activity. Scavenger species, such as vultures, are also controlled by the wolf activity.

When the U.S. government designated land for Yellowstone National Park in the late 19th century, hundreds of wolves roamed the GYE, preying primarily on abundant herds of elk and bison. Fearing the wolves' impact on those herds, as well as local livestock, governments at the local, state and federal level worked to eradicate wolves from the GYE. The last remaining wolf pups in Yellowstone were killed in 1924.

This started a top-down trophic cascade in the Greater Yellowstone Ecosystem. A trophic cascade describes changes in an ecosystem due to the addition or removal a predator. A top-down trophic cascade describes changes that result from the removal of an ecosystem's top predator. (A bottom-up trophic cascade describes changes that result from the removal of a producer or primary consumer.)

Lacking an apex predator, elk populations in Yellowstone exploded. Elk herds competed for food resources, and plants such as grasses, sedges and reeds did not have time or space to grow. Overgrazing influenced the populations of other species, such as fish, beaver and songbirds. These animals rely on plants and their products — roots, flowers, wood, seeds — for survival.

The physical geography of the Greater Yellowstone Ecosystem was also impacted by the loss of wolves and subsequent elk overgrazing. Stream banks eroded as wetland plants failed to anchor valuable soil and sediments. Lake and river temperatures increased as trees and shrubs failed to provide shaded areas.

Starting in the 1990s, the U.S. government began reintroducing wolves to the Greater Yellowstone Ecosystem. The results have been noteworthy. Elk populations have shrunk, willow heights have increased and beaver and songbird populations have recovered.

Herbivores

Herbivores can also be keystone species. Their consumption of plants helps control the physical and biological aspects of an ecosystem.

In African savannas such as the Serengeti plains in Tanzania, elephants are a keystone species. Elephants eat shrubs and small trees, such as acacia, that grow on the savanna. Even if an acacia tree grows to a height of a meter or more, elephants are able to knock it over and uproot it. This feeding behavior keeps the savanna a grassland and not a forest or woodland.

With elephants to control the tree population, grasses thrive and sustain grazing animals such as antelopes, wildebeests and zebras. Smaller animals such as mice and shrews are able to burrow in the warm, dry soil of a savanna. Predators such as lions and hyenas depend on the savanna for prey.

Keystone Mutualists

Keystone mutualists are two or more species that engage in mutually beneficial interactions. A change in one species would impact the other, and change the entire ecosystem. Keystone mutualists are often pollinators, such as bees. Pollinators often maintain gene flow and dispersal throughout widespread ecosystems.

In the woody grasslands of Patagonia (at the southern tip of South America) a species of hummingbird and indigenous plants act together as keystone mutualists. Local trees, shrubs and flowering plants have evolved to only be pollinated by Sephanoides sephanoides, a hummingbird known as the green-backed firecrown. Green-backed firecrowns pollinate 20 percent of local plant species. In turn, these plants provide the sugary nectar that makes up most of the hummingbird's diet.

Pockets of the existing Patagonian habitat would collapse without green-backed firecrowns, because their functional redundancy is nearly zero — no other pollinator has adapted to pollinate these plants.

Other Organisms Crucial To Ecosystems

In addition to keystone species, there are other categories of organisms crucial to their ecosystems' survival.

Umbrella Species

Umbrella species are often conflated with keystone species. Both terms describe a single species on which many other species depend. The key distinction between umbrella species and keystone species is that the value of an umbrella species is tied to its geographic species range.

Umbrella species have large habitat needs, and the requirements of that habitat impact many other species living there. Most umbrella species are migratory, and their range may include different habitat types.

The identification of an umbrella species can be an important aspect for conservation. The minimum species range of an umbrella species is often the basis for establishing the size of a protected area.

The Siberian tiger, an endangered species, is an umbrella species with a range of more than 1,000 kilometers (620 miles) in Russia's far east, with territory stretching into China and North Korea. The species range includes heavily forested ecosystems in both temperate and boreal (subarctic) biomes. Populations of deer, boar and moose are under the snowy "umbrella" of the Siberian tiger range.

Foundation Species

Foundation species play a major role in creating or maintaining a habitat.

Corals are a key example of a foundation species across many islands in the South Pacific Ocean. These tiny animals grow as a colony of thousands and even millions of individual polyps. The rocky exoskeletons of these polyps create enormous structures around islands: coral reefs.

Coral reefs are one of the most vibrant and biologically diverse ecosystems on the planet. Microscopic plankton, as well as crustaceans, mollusks, sponges, fish and marine reptiles and mammals are all part of healthy coral reef ecosystems.

Coral reef ecosystems also contribute to the human geography of a region. Pummeled by waves and ocean currents, coral exoskeletons can experience bioerosion. These eroded fragments of coral (along with bony fragments of organisms such as foraminifera, mollusks and crustaceans) create a soft sand known as coral sand. Coral sand beaches are among the most popular tourist destinations in the world.

Ecosystem Engineers

Like foundation species, ecosystem engineers contribute to the physical geography of their habitat. Ecosystem engineers modify, create and maintain habitats.

Ecosystem engineers modify their habitats through their own biology or by physically changing biotic and abiotic factors in the environment.

Autogenic engineers modify their environment by modifying their own biology. Corals and trees are autogenic engineers. As they grow, they are a living part of the environment, providing food and shelter to other organisms. (The hard exoskeletons left as corals die continue to define and modify the ecosystem.)

Allogenic engineers physically change their environment from one state to another. Beavers are a classic example of allogenic engineers. Beavers help maintain woodland ecosystems by thinning out older trees and allowing young saplings to grow. Converting these trees into timber for dams radically alters woodland meadows and streams, changing them into wetland habitats.

Invasive species are often ecosystem engineers. Lacking natural predators or abiotic factors to constrain them, these introduced species modify the existing environment in ways that inhibit the growth of the indigenous ecosystem.

Kudzu, the so-called “vine that ate the South,” is an invasive species of plant that modified the environment of the southeastern United States. Kudzu regularly outcompetes native species for space and nutrients. As it crowds out native species, kudzu limits the pollinators, insects and bird species that inhabit an area.

Indicator Species

An indicator species describes an organism that is very sensitive to environmental changes in its ecosystem. Indicator species are almost immediately affected by changes to the ecosystem and can give early warning that a habitat is suffering.

Changes associated with external influences such as water pollution, air pollution or climate change first appear in indicator species. For this reason, indicator species are sometimes known as “sentinel species.”

In the “nation’s estuary” of the Chesapeake Bay, oysters are an indicator species. Oysters and other bivalves are filter feeders, meaning they filter water as they strain it for food particles. Oysters filter nutrients, sediments and pollutants that enter the bay through natural or anthropogenic sources. Oyster beds help protect fisheries, coastal habitats and even benthic

ecosystems. The health of oyster populations in the Chesapeake, therefore, is used to indicate the health of the entire ecosystem.

Flagship Species

A flagship species acts as a symbol for an environmental habitat, movement, campaign or issue. They can be mascots for entire ecosystems.

The identification of a flagship species relies heavily on the social, cultural and economic value of a species. They are often “charismatic megafauna,” — large animals with popular appeal due to their appearance or cultural significance. Flagship species may or may not be keystone or indicator species.

Flagship species can sometimes be symbols of general ideas about conservation, not representatives of specific ecosystems. However, specific issues are often associated with a specific animal. The movement to end seal hunting in the Arctic found its flagship species in the juvenile harp seal. Polar bears are the unchallenged flagship species associated with climate change.

The giant panda is perhaps the most familiar flagship species. Pandas are the global symbol of endangered species and the value of captive breeding.

Quiz

1 Read the sentence from the section "Ecosystem Engineers."

> *Lacking natural predators or abiotic factors to constrain them, these introduced species modify the existing environment in ways that inhibit the growth of the indigenous ecosystem.*

Which two words could BEST replace "constrain" and "inhibit" in the sentence above?

(A) deny; frustrate

(B) force; taboo

(C) pressure; help

(D) restrict; hinder

2 Read the paragraph from the section "Indicator Species."

> *Changes associated with external influences such as water pollution, air pollution or climate change first appear in indicator species. For this reason, indicator species are sometimes known as “sentinel species.”*

What does the word "sentinel" convey in the sentence?

(A) the sense that the species actively fight off threats

(B) the sense that the species are brave and strong

(C) the idea that the species are able to change their habitats

(D) the idea that the species can show initial effects of threats to their habitats

3 How is this article organized? What is the MOST LIKELY reason the author chose this organizational structure?

(A) by category; to explore how the survival of the world's habitats relies on the survival of important species

(B) by chronology; to illustrate how the survival of certain species but not others affects habitats over time

(C) by problem and solution; to demonstrate how humans can help preserve species and their habitats

(D) by compare and contrast; to outline the positive and negative effects of removing species from a habitat

4 Read the following two selections from the sections "Predators" and "Herbivores."

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With elephants to control the tree population, grasses thrive and sustain grazing animals such as antelopes, wildebeests and zebras. Smaller animals such as mice and shrews are able to burrow in the warm, dry soil of a savanna. Predators such as lions and hyenas depend on the savanna for prey.

How effective is the juxtaposition between the two selections?

(A) Very effective; it emphasizes the necessity of both predators and herbivores to balance the environment of a habitat.

(B) Mostly effective; it demonstrates that both predators and herbivores can be the keystone species in a particular area.

(C) Somewhat effective; it compares the roles of predators and herbivores but does not show how they affect a habitat.

(D) Not at all effective; it does not show that the effects of losing these keystone species are meaningful for an area.