Racing to identify species as biodiversity shrinks

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Without significant changes, more than 50 percent of the world's marine species may be perched on the brink of extinction by 2100, according to UNESCO. Credit: Dan Norton

A little more than 39 years ago, on December 28, 1973, the Endangered Species Act was enacted to conserve threatened and endangered species and their ecosystems. To honor this anniversary, Daphne Fautin of the

National Science Foundation answered questions about biodiversity.

As a marine biologist, Fautin has literally gone to the ends of the Earth—from the poles to the tropics—to study marine life. She is currently a program manager at the National Science Foundation, a professor of ecology and evolutionary biology at the University of Kansas, and a commissioner with the International Commission on Zoological Nomenclature, which produces rules on giving scientific names to animals.

What is biodiversity?

Biodiversity—short for "biological diversity"—is the variety and abundance of plants, animals and other living things on Earth and in particular locations. Biodiversity is absolutely essential to ecosystem health. And human survival depends on the health of our planet's ecosystem.

Rain forests and coral reefs are known for their biodiversity. Why is so much biodiversity concentrated in these types of ecosystems?

More than 25 percent of the world's fish species and between nine and 12 percent of all of the world's fisheries are associated with coral reefs. More than half of the world's plant and animal species live in rainforests.

We don't know for sure why rain forests and coral reefs harbor so much biodiversity. One idea is that these ecosystems occur in tropical climates, and so they are quite climatically consistent year-round.

According to this idea, tropical organisms diverged because they don't have to deal with the climatic extremes that organisms at higher latitudes (and altitudes) do. A rabbit, for example, that lives in a non-tropical place must be able to eat certain plants in the summer and certain other plants in the winter. Therefore, it must remain a generalist to survive.

By contrast, a rabbit that lives in the tropics may specialize in eating certain plants that are available year-round; at the same time, other species of rabbits (or other organisms) may evolve that specialize in eating other plants. Such specialization promotes diversity.

But some evidence does refute this idea—such as the fact that not all groups of plants and animals demonstrate more diversity in the tropics than at higher latitudes. So, many other ideas have also been proposed to explain the extraordinary biodiversity of the tropics.

Insects account for a large proportion of the biodiversity on Earth. Why?

Many statistics bear out the biodiversity of insects. For example, more than 850,000 insect species have been named. And the total estimated weight of just ants in the Amazon is four times the estimated weight of all land vertebrates in the Amazon—including all mammals, birds, reptiles and amphibians!

We don't really know why insects account for so much of the Earth's biodiversity. That is one of the questions that is being studied by entomologists—the people who research insects.

One idea is that insects began to diversify when flowering plants evolved on Earth, and so insects evolved along with flowering plants because they are so important in the pollination of plants.

Insects tend to be small and specialized: So there may be a certain insect that sucks out the cell sap from the stems of a particular plant; other insects that eat that plant's leaves; other insects that feed on that plant's nectar; and other insects that feed on that plant's pollen and pollinate the plant in the process. So as flowers evolved, many insects evolved as well.

This idea about the evolutionary connections between flowering plants and insects is consistent with what we see in the oceans: Relatively few species of flowering plants live in the oceans, and relatively few species of insects live in the oceans.

(By the way, NSF recently issued a press release that identified some interesting reasons why humans need insects—even pesky ones.)

How many species have been described and named by scientists, so far?

The Encyclopedia of Life estimates that there are 1.9 million known eukaryotic organisms. (Eukaryotic organisms are those that are made of one or more cells with a nucleus; bacteria and viruses are not eukaryotic organisms.)

How many species exist on Earth?

Estimates range from 2 million species to 10 million species.

A recent estimate of 8.7 million species received a lot of press, in part, I suspect, because of its supposed accuracy and because it corresponds quite well to the often-bandied figure that 80 percent of the Earth's biodiversity has yet to be discovered/named. The *Encyclopedia of Life* states that "at least four times" the number of known species exist on Earth. Based on its own figures, this translates to around 8 million species.

A paper estimating the number of marine species (which I contributed to) was recently published. According to this paper, 226,000 species that live in the ocean have been named and described by scientists, and 72,000 additional species are in collections waiting to be named and described.

But who knows what hasn't been collected yet? And of course, as I previously mentioned, oceans have few insects, but insects account for the bulk of biodiversity.

How can scientists estimate the total number of species on Earth when it is obviously impossible to count what has not yet been counted. In other words, how can we know what we don't know?

People have used various creative methods to estimate the total number of organisms on Earth. For example, there was a very large estimate made years ago by a scientist who went to the jungles of Panama and used insecticide to spray a tree in the jungle. Then, lots of insects died and fell from the tree to the ground. And the scientist and his colleagues identified and counted as many of these fallen insects as they could, and the rest were counted as unknown. Then, the scientist extrapolated from the proportion of species in that one tree that were known vs. unknown to produce a global estimate of known vs. unknown species.

It was good first try. But a lot of people point to the fact that in many parts of the world, the proportion of known species to unkown species is higher than it is in Panama. So this fact would suggest that the estimate may be excessive.

In 2011, an NSF-funded researcher provided the first empirical evidence of what had been long suspected: That biodiversity promotes water quality. **What are some of the other reasons why need biodiversity?**

We need biodiversity to eat, we need to preserve species that we use as food, including fish from the sea. We also need to preserve those species that serve as food for the fish we eat, so that our food supply persists. And we also need to preserve all the species that create the habitat that enables all of these needed species to live, spawn, and raise their young.

So, there are all of these connections in the great "web of life" that we don't even know yet. And these connections support all of the species on Earth, including species that provide us with food and clothing.

Also, 50 percent of the oxygen we breathe is produced by microscopic plants that live in the ocean and the other 50 percent is produced by plants that live on land.

(If you want to learn more about the ways in which the various species of plants help humans survive, watch this dynamic, upbeat video produced by NSF.)

Daphne Fautin searches for new organisms while conducting a marine survey. Credit: Rita Tan of www.wildsingapore.com

The planet's ecosystem is sometimes compared to an airplane. You can lose one rivet from an airplane, and the airplane will probably fly. You can lose two rivets for an airplane and the airplane will still probably fly. But eventually, if you lose too many rivets (how many?), the plane will crash.

The same principle applies to ecology: You can lose some species without major harm. But no one knows how many species can be lost before the planet's ecosystem will crash.

What does it mean to discover a new species?

A new species is one that hasn't yet been formally described and named according to scientific procedures—not one that is newly evolved.

People on the street or people in the jungle may have a name for it. But if we haven't followed the internationally recognized rules of nomenclature for describing and naming a species, it doesn't exist for certain scientific purposes.

When we have discovered a new species, it means we have finally found and gone through the procedures of formally describing it (distinguishing it from other species) and giving it a name following the rules of nomenclature.

How many new species are named each year?

Between 15,000 and 20,000 new species are named each year.

A species may be discovered and collected before it is described and named. But it isn't recognized as a new, distinct species until it is described and named.

How many species go extinct each year?

We don't know. The World Wildlife Fund's Web site says that experts have calculated that between .01 percent and .10 percent of all species on Earth go extinct each year.

But because we don't know how many species there are, we don't know how many species those percentages actually represent. And so, if the low estimate of the number of species on Earth is true—if there are around 2 million species on our planet—then between 200 and 2,000 extinctions occur each year.

But if, in fact, there really are 10 million species on Earth, then between 10,000 and 100,000 extinctions occur each year.

What would you say to naysayers who argue that newly discovered species offset species losses, and so there really is no extinction crisis?

"New" species are not newly evolved. They evolved a long time ago. They are simply being newly discovered by science. They may be very well known to the people living in the areas where they live. So they aren't new in that sense; they are only new to those of us who name them.

What does the process of naming a species involve?

It can be long, protracted and difficult process that can take many years. First, you want to be sure that the animal or plant hasn't been named before.

This can be difficult for a variety of reasons. For one thing, many descriptions that were prepared in the early days were very vague. And usually, only small groups of experts have the specialized expertise to know what has and hasn't been described before.

And in order to name a species, you also have to describe it. To do this, you have to know what kinds of features are used to identify species, and figure out what distinguishes the "new" species from known species. This is important, because at least according to the rules of zoological nomenclature, when you publish a description of a new species, you have to write out what makes it different from everything that is already known—including organisms that are not closely related to it, but that look like it anyway.

For example, suppose you have an organism that has a red spot; then you have to distinguish your "new" species from everything that is red-spotted, even if those other red-spotted species are not closely related to your species. That way, when somebody comes across your species, they can say, "AHA! This is another one of those red-spotted organisms that is covered by that new name; it's not another thing with red spots."

Other rules in the codes of nomenclature require you to name species in Latin or make them sound like Latin. You also have make sure a specimen of your species is deposited in a natural history collection (typically in a museum or herbarium). If the "new" species is an animal, you may also have to register the name in ZooBank.

And then you have to publish your description of the species in a scientific journal, so that other scientists can look at it and agree that it is correct.

It is interesting to note that names that are accepted are frequently later "sunk" for various reasons. For example, when the exhaustive homework that is required for describing and naming a "new" species is not conducted in a comprensive and thorough way, it may ultimately turn out that the "new" species has already been described and named.

Alternatively, a name for a "new" species may be sunk because the difference that was thought to distinguish it from others does not hold up. For example, I have a colleague who described several coral reef fish as "new"—only to ultimately discover that the "new" species was a member of a species for which only one sex had previously identified. So the "new" species was really just a female (or male) of a known species!

Do you have to be a professional taxonomist to

identify and name new species?

About half of the species that are named each year are named by people who aren't employed as taxonomists—whose job isn't in a museum or university. In fact, some of the people with the most expertise and time to do this are not professionals in the field.

For example, I knew a dentist who is one of the world's foremost authorities on tiger beetles. He had earned a master's degree in entomology. And then he realized that if he had gone into academic entomology, he would be spending his time teaching, writing grant proposals and doing administrative work—but he wanted to catch tiger beetles.

And so he went into dentistry so that he could make enough money to take time off each year to catch tiger beetles. He probably thereby ended up being able to spend more time chasing tiger beetles as a dentist than he would have if he had become a professional entomologist.

A new species of frog **was recently identified by an NSF-funded researcher right smack in New York City. Is that common for new species to be discovered in such populated places?**

I think that it is quite common for new species to be found in populated areas.

In the summer of 2012, an NSF-funded researcher named a new coral reef crustacean after Bob Marley**, the singer. Is that unusual for species to be named after celebrities?**

It may be less common than it used to be.

Many years ago, it would be common for a patron to fund the travels of a scientist to exotic places, and then species that were found during those travels would be named for the patron.

Tell me about one of the big problems that is reducing biodiversity in the oceans?

We have depleted the oceans of many of the big fish that we eat.

Part of the reason we are able to overfish is due to technology. We have fish-finders: various types of tracking devices, including sonar equipment, and airplanes that are used to help find schools of fish. And we now know enough about marine biology to predict where fish and crustaceans will be under particular conditions. Fishing is no longer about a fisherman just saying, I'll drop a line here or there." Fishing has become very scientific and methodical.

When we trawl, we drag nets along the ocean floor. And whatever else gets swept by these nets in addition to the target fish is called "bycatch." This bycatch gets thrown back into the ocean because we are not licensed to take it or because it's not profitable to take.

But how many organisms can manage to survive after being caught in a big net, pulled up and then thrown back into the ocean? What's more, trawling destroys habitat; after the ocean floor has been trawled, it may no longer be a suitable home for what is thrown back.

The analogous situation on land would be if we flew an airplane that dragged a big net across the ground to catch grazing cattle. And we would draw up the net periodically—and keep the cattle, but toss back the dogs, trees and everything else that we happened to net in addition to the cattle. That is similar to what we do to the oceans.

Many people assume that it is necessarily better to consume farmed fish and shrimp than wild caught fish and shrimp. But many fish and shrimp farming practices are also harmful to the environment. Just because it is farmed doesn't mean that it is environmentally neutral or preferred over wild caught.

Can you cite any "good news" stories in biodiversity?

I read the other day that we have lost 97 percent of wild tigers in just over a century. Only about 3,200 tigers currently remain in the wild. We can infer that the populations of many smaller species are plummeting just like populations of many large species are plummeting.

But I am happy to say that a few species have come off the endangered species list, like the wolf and the bald eagle, because plans for their recovery were enacted.

Also, there are "good news" stories in the history of whales. Many of them were hunted to the brink of extinction, and then they were listed as endangered. It therefore became legally, socially and economically difficult to harvest whales, and so populations of many whale species have fortunately recovered.

These kinds of successes show that if we stop harvesting species, and if their habitat is conserved, life is resilient and endangered species may recover.

Additional Resources

To learn more about biodiversity and help promote conservation:

- Read about the Endangered Species Act on the websites of the U.S. Fish & Wildlife Service and the National Oceanic and Atmospheric Administration.
- Join citizen science groups that work to identify and track species of birds, butterflies, ladybugs, plants and other creatures, advance our understanding of nature, and increase habitat for wildlife.
- Restrict your seafood purchases in restaurants and stores to ocean-friendly products. Resources provided by the Monterey Bay Aquarium's Seafood Watch Program may help you do so.

More information: Name that Species! A conversation about conserving, finding and naming species with NSF Program Manager Daphne Fautin.

Provided by National Science Foundation

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