**Headline:** How Trophic Cascades Devastate Ecosystems and Endanger Human Health

**Teaser:** Bats and vultures may not be widely loved, but their decline has profound negative implications for humans.

By Leslie Alan Horvitz

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**[Article Body:]**

All organisms in an ecosystem are interconnected, and any imbalance in this complex relationship can have irreversible consequences for both humans and nonhumans. Numerous examples illustrate how the destruction of one species can lead to unforeseen and devastating impacts on others.

“Biodiversity and ecosystem functioning do matter to human beings. … And it’s not always the charismatic and fuzzy species,” said [Eyal Frank](https://www.nytimes.com/2024/07/29/climate/vultures-india-poisoning.html), an environmental scientist and economist at the University of Chicago, in a New York Times interview in July 2024. Frank is one of the authors of the study “[The Social Costs of Keystone Species Collapse: Evidence from the Decline of Vultures in India](https://www.aeaweb.org/articles?id=10.1257/aer.20230016),” published in the American Economic Review in October 2024.

Various studies have shown how this lack of natural harmony has affected biodiversity and human health. For instance, the loss of trees in the United States due to the invasive emerald ash borer [increased human deaths related to cardiovascular and respiratory illnesses](https://www.ajpmonline.org/article/S0749-3797%2812%2900804-5/abstract), according to a 2013 article in the American Journal of Preventive Medicine. The study, conducted in 15 U.S. states from 1990 to 2007, examined the effects of this imbalance on biodiversity and human health.

Another example is the extinction of gray wolves in Yellowstone National Park in the 1920s, which led to an explosion in the elk population. The elks, in turn, devoured the vegetation, triggering a [trophic cascade](https://en.wikipedia.org/wiki/Trophic_cascade) or ecosystem collapse. The loss of prey often forces predators to find new food sources, which can have unpredictable environmental consequences. By definition, [trophic collapse](https://www.nature.com/scitable/knowledge/library/trophic-cascades-across-diverse-plant-ecosystems-80060347/) must affect a minimum of three feeding levels. Trophic cascades frequently occur during periods of climate stress.

“Our results… suggest that increasing environmental stress… as a result of climate change may decouple species interactions,” noted Brian S. Cheng and Edwin D. Grosholz, environmental scientists at the University of California, Davis, in a 2016 [article](https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.1247) in Ecosphere.

The public pays attention when a species considered “[adorable](https://www.wanderlustmagazine.com/inspiration/animal-babies-where-when/)”—like polar bears, dolphins, or pandas—is threatened with extinction. However, the same risks faced by underappreciated species—such as bats and vultures—are often overlooked, underscoring the threat posed by trophic cascades to the world’s ecosystems.

The devastation affecting bat populations in the U.S. and vultures in India has largely escaped notice, as neither species inspires much affection. Instead, they often evoke fear and disgust. However, their decline has dire implications for humanity.

**Healthy Bat Populations Support Human Health**

“[Bats are a fantastic example](https://www.smithsonianmag.com/smart-news/the-surprising-link-between-bats-dying-and-human-infant-mortality-180985034/) of a species that we like to keep a distance from, but that are truly impactful in terms of the role they play in ecosystems,” Frank told the Washington Post in September 2024. He was referring to a study he authored and published in [Science that same month](https://www.science.org/doi/10.1126/science.adg0344). The study documented how biodiversity degradation negatively affects human health.

He found that the declining bat population was linked to an 8 percent increase in infant mortality rate in certain U.S. counties. This link is due to the positive impacts of bat’s diets. Every night, a single bat consumes up to 40 percent of its body weight in insects. In agricultural areas, this means that when bats disappear, farmers might use more insecticides on their fields,” [explained](https://www.smithsonianmag.com/smart-news/the-surprising-link-between-bats-dying-and-human-infant-mortality-180985034/) Rudy Molinek, a fellow at the American Association for the Advancement of Science (AAAS), in a September 2024 article in Smithsonian Magazine.

According to the study, the decline in the bat population resulted in 1,334 infant deaths between 2006 and 2017. Essentially, the loss of bats, which led to a rise in insect populations, directly impacted human health. In areas with a marked decline in the bat population, U.S. farmers increased their use of insecticides by 31 percent.

**White-Nose Syndrome**

The principal culprit behind the bat die-off is [white-nose syndrome](https://www.usgs.gov/faqs/what-white-nose-syndrome) (WNS), a disease caused by a fungus that attacks bats during hibernation. WNS disrupts the hibernation cycle in winter, leading to energy depletion and death. Researchers first identified the disease in 2006 when they observed dying bats in the Northeast U.S. with white fuzz on their noses, ears, and wings.

It is believed that the fungus responsible for the syndrome, [*Pseudogymnoascus destructans*](https://en.wikipedia.org/wiki/Pseudogymnoascus_destructans), originated in Europe and was transported to the U.S., possibly through [cavers traveling between continents](https://www.biologicaldiversity.org/campaigns/bat_crisis_white-nose_syndrome/white-nose_syndrome.html).

As of November 2024, white-nose syndrome has​​ been [confirmed in 40 states and nine Canadian provinces](https://www.whitenosesyndrome.org/where-is-wns). The disease has wiped out more than 90 percent of three North American bat species. According to the Center for Biological Diversity, [6.7 million bats](https://www.biologicaldiversity.org/campaigns/bat_crisis_white-nose_syndrome/Q_and_A.html) have died from WNS since 2006.

According to [State of the Bats: North America](https://digital.batcon.org/state-of-the-bats-report/2023-report/), a 2023 report by experts from Canada, Mexico, and the U.S., 52 percent of North American bat species are at “risk of severe population decline” through at least 2038 due to various factors, including WNS, habitat loss, climate change, and collisions with wind turbines.

“They need our help to survive,” Winifred Frick, chief scientist at Bat Conservation International, one of the groups that participated in the State of the Bats report, [told](https://apnews.com/article/bats-climate-white-nose-syndrome-turbines-d833545cf15b8e7f1c49a916590ccab7) the Associated Press. “We face a biodiversity crisis globally, and bats play a vital role in healthy ecosystems needed to protect our planet.”

The syndrome’s mortality rate averages around 70 to 90 percent. “In some cases, the mortality rate has been 100 percent, wiping out entire colonies,” [stated](https://www.biologicaldiversity.org/campaigns/bat_crisis_white-nose_syndrome/Q_and_A.html) the Center for Biological Diversity. Researchers are still searching for an effective treatment for it. [Polyethylene glycol 8000](https://www.nytimes.com/2024/09/17/science/bats-white-nose-syndrome.html?campaign_id) has shown promise when applied as a spray to coat fungal spores and prevent their spread. Additionally, a [vaccine](https://www.fws.gov/story/preventing-and-treating-white-nose-syndrome) experimentally used in Wisconsin has reduced infections in affected bat populations.

“Fungal disease killed bats, bats stopped eating enough insects, farmers applied more pesticides to maximize profit and keep food plentiful and cheap, the extra pesticide use led to more babies dying,” Eli Fenichel of Yale University told the New York Times in September. “It is a sobering result.”

Frank told the Guardian that during his research, he ruled out all other causes of infant mortality, including “the opioid epidemic, parental unemployment, genetically modified crops, and even the weather,” Molinek of AAAS reported in Smithsonian Magazine. Frank further stated that the results provide “compelling evidence… that farmers did respond to the decline in insect-eating bats, and that response had an adverse health impact on human infants.”

**Vanishing Vultures Cause Human Deaths to Rise in India**

Bats aren’t the only species that benefit humans—a phenomenon some scientists call “[ecosystem services](https://www.climatehubs.usda.gov/ecosystem-services).” In another study co-authored by Frank, he found that “[[a]fter vultures nearly went extinct in India](https://www.smithsonianmag.com/smart-news/when-vultures-nearly-disappeared-in-india-half-a-million-people-died-too-study-finds-180984837/), an extra 500,000 people died” on the subcontinent between 2000 and 2005.

“Vultures are considered nature’s [sanitation service](https://epic.uchicago.edu/news/how-decline-of-indian-vultures-led-to-500000-human-deaths) because of their important role in removing dead animals that contain bacteria and pathogens from our environment—without them, the disease can spread,” Frank told the BBC.

“Understanding the role vultures play in human health underscores the importance of protecting wildlife, not just the cute and cuddly,” he [added](https://www.bbc.com/news/articles/c28e2pvzn3lo). “They all have a job to do in our ecosystems that impacts our lives.”

The first reports of the vulture die-off came from villagers in northern India. Hindus consider cows sacred and do not eat their meat; instead, they leave the carcasses for vultures to strip and [consume](https://www.nytimes.com/2001/03/01/world/bombay-journal-in-death-the-unlovely-vulture-is-sorely-missed.html). The people then harvest the bones to make bone meal and fertilizer.

The villagers’ warnings foreshadowed the catastrophe to come. The white-backed vultures, once abundant, are now on the brink of [extinction](https://www.nytimes.com/2001/03/01/world/bombay-journal-in-death-the-unlovely-vulture-is-sorely-missed.html). As they sicken, their long bald necks [droop](https://assets.peregrinefund.org/docs/pdf/research-library/2007/2007-Gilbert-vulture-neck-drooping.pdf) into the shape of nooses; death soon follows. “By the mid-1990s, the 50 million-strong vulture population had [plummeted to near zero](https://epic.uchicago.edu/news/how-decline-of-indian-vultures-led-to-500000-human-deaths) because of diclofenac, a cheap non-steroidal painkiller for cattle that is fatal to vultures. Birds that fed on carcasses of livestock treated with the drug suffered from kidney failure and died,” [stated](https://www.bbc.com/news/articles/c28e2pvzn3lo) a BBC article. According to a New York Times [article](https://www.nytimes.com/2024/07/29/climate/vultures-india-poisoning.html) published in July 2024, vulture populations in India have declined to less than 1 percent of their previous numbers.

The disappearance of vultures has not only resulted in the loss of their critical environmental role but has also had severe consequences for human health and mortality. The “[half a million excess human deaths](https://www.nytimes.com/2024/07/29/climate/vultures-india-poisoning.html)” occurred because rotting livestock carcasses polluted water supplies and contributed to a rise in feral dog populations, which spread waterborne diseases and rabies, according to the New York Times article. “It was ‘a really huge negative sanitation shock,’” said Anant Sudarshan, an economics professor at the University of Warwick in England, who co-authored the study with Frank.

Sudarshan and Frank [compared](https://www.unmc.edu/healthsecurity/transmission/2024/09/10/surprising-new-research-links-infant-mortality-to-crashing-bat-populations/) human death rates in Indian districts that once had thriving vulture populations to those with historically low vulture numbers, both before and after the vulture collapse. They examined rabies vaccine sales, feral dog populations, and pathogen levels in the water supplies. The researchers revealed that human death rates increased by more than 4 percent in districts where vultures had previously thrived. The effect was most significant in urban areas with large livestock populations, where carcass dumps were common.

For years, the cause of [the vulture](https://www.nytimes.com/2001/03/01/world/bombay-journal-in-death-the-unlovely-vulture-is-sorely-missed.html) [deaths remained a mystery](https://www.nytimes.com/2024/07/29/climate/vultures-india-poisoning.html). However, in 2004, researchers identified the culprit: diclofenac, a widely used anti-inflammatory drug.

A decade earlier, the steroid’s patent had expired, leading to the production of cheaper generic versions that farmers began using extensively. This unintentionally triggered a mass extinction of vultures.

In their study published by the [American Economic Association](https://www.aeaweb.org/articles?id=10.1257/aer.20230016), Frank and Sudarshan found a direct correlation between the rise in diclofenac sales and the subsequent collapse of vulture populations. The researchers used range maps to determine where vultures had lived and where they had not, allowing them to draw their conclusions. They discovered that “[i]n districts where vultures had lived, human death rates started ticking up in 1994, the year after the price dropped on diclofenac,” noted the New York Times. Human deaths continued rising over the following years in those districts, in stark contrast to areas where vultures were never present.

Alarmed conservationists [pushed for a ban on the drug’s veterinary use](https://www.nytimes.com/2006/03/28/world/asia/indias-vultures-fall-prey-to-a-drug-in-the-cattle-they-feed-on.html). Although they succeeded in 2006, the 2023 State of India’s Birds report revealed that at least three vulture species in India have suffered [long-term losses](https://www.bbc.com/news/articles/c28e2pvzn3lo) of 91 to 98 percent. In ecological terms, they are now functionally extinct.

The decline of both bats and vultures is already disrupting ecosystems and negatively impacting human health. To prevent further devastation, we must take urgent steps to preserve biodiversity and recognize the far-reaching consequences of our actions on other species.