At Chernobyl and Fukushima, radioactivity has seriously harmed wildlife

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White storks on road near Chernobyl, Ukraine. Many parts of the Chernobyl region have low radioactivity levels and serve as refuges for plants and animals. Tim Mousseau, Author provided

The largest nuclear disaster in history occurred 30 years ago at the Chernobyl Nuclear Power Plant in what was then the Soviet Union. The meltdown, explosions and nuclear fire that burned for 10 days injected enormous quantities of radioactivity into the atmosphere and contaminated vast areas of Europe and Eurasia. The International Atomic Energy Agency estimates that Chernobyl released 400 times more radioactivity into the atmosphere than the bomb dropped on Hiroshima in 1945.

Radioactive cesium from Chernobyl can still be detected in some food products today. And in parts of central, eastern and northern Europe
many animals, plants and mushrooms still contain so much radioactivity that they are unsafe for human consumption.

The first atomic bomb exploded at Alamogordo, New Mexico more than 70 years ago. Since then, more than 2,000 atomic bombs have been tested, injecting radioactive materials into the atmosphere. And over 200 small and large accidents have occurred at nuclear facilities. But experts and advocacy groups are still fiercely debating the health and environmental consequences of radioactivity.

However, in the past decade population biologists have made considerable progress in documenting how radioactivity affects plants, animals and microbes. My colleagues and I have analyzed these impacts at Chernobyl, Fukushima and naturally radioactive regions of the planet.

Our studies provide new fundamental insights about consequences of chronic, multi-generational exposure to low-dose ionizing radiation. Most importantly, we have found that individual organisms are injured by radiation in a variety of ways. The cumulative effects of these injuries result in lower population sizes and reduced biodiversity in high-radiation areas.

**Broad impacts at Chernobyl**

Radiation exposure has caused genetic damage and increased mutation rates in many organisms in the Chernobyl region. So far, we have found little convincing evidence that many organisms there are evolving to become more resistant to radiation.

Organisms' evolutionary history may play a large role in determining how vulnerable they are to radiation. In our studies, species that have historically shown high mutation rates, such as the barn swallow
(Hirundo rustica), the icterine warbler (Hippolais icterina) and the Eurasian blackcap (Sylvia atricapilla) are among the most likely to show population declines in Chernobyl. Our hypothesis is that species differ in their ability to repair DNA, and this affects both DNA substitution rates and susceptibility to radiation from Chernobyl.

Much like human survivors of the Hiroshima and Nagasaki atomic bombs, birds and Error! Hyperlink reference not valid. at Chernobyl have cataracts in their eyes and smaller brains. These are direct consequences of exposure to ionizing radiation in air, water and food. Like some cancer patients undergoing radiation therapy, many of the birds have malformed sperm. In the most radioactive areas, up to 40% of male birds are completely sterile, with no sperm or just a few dead sperm in their reproductive tracts during the breeding season.

Tumors, presumably cancerous, are obvious on some birds in high-radiation areas. So are developmental abnormalities in some plants and insects.

Given overwhelming evidence of genetic damage and injury to individuals, it is not surprising that populations of many organisms in highly contaminated areas have shrunk. In Chernobyl, all major groups of animals that we surveyed were less abundant in more radioactive areas. This includes birds, butterflies, dragonflies, bees, grasshoppers, spiders, and large and small mammals.

Not every species shows the same pattern of decline. Many species, including wolves, show no effects of radiation on their population density. A few species of birds appear to be more abundant in more radioactive areas. In both cases, higher numbers may reflect the fact that there are fewer competitors or predators for these species in highly radioactive areas.
Moreover, vast areas of the Chernobyl Exclusion Zone are not presently heavily contaminated, and appear to provide a refuge for many species. One report published in 2015 described game animals such as wild boar and elk as thriving in the Chernobyl ecosystem. But nearly all documented consequences of radiation in Chernobyl and Fukushima have found that individual organisms exposed to radiation suffer serious harm.


There may be exceptions. For example, substances called antioxidants can defend against the damage to DNA, proteins, and lipids caused by ionizing radiation. The levels of antioxidants that individuals have available in their bodies may play an important role in reducing the damage caused by radiation. There is evidence that some birds may have adapted to radiation by changing the way they use antioxidants in their bodies.

**Parallels at Fukushima**

Recently we have tested the validity of our Chernobyl studies by repeating them in Fukushima, Japan. The 2011 power loss and core meltdown at three nuclear reactors there released about one-tenth as much radioactive material as the Chernobyl disaster. Overall, we have found similar patterns of declines in abundance and diversity of birds, although some species are more sensitive to radiation than others. We have also found declines in some
insects, such as butterflies which may reflect the accumulation of harmful mutations over multiple generations.

Our most recent studies at Fukushima have benefited from more sophisticated analyses of radiation doses received by animals. In our most recent paper, we teamed up with radioecologists to reconstruct the doses received by about 7,000 birds. The parallels we have found between Chernobyl and Fukushima provide strong evidence that radiation is the underlying cause of the effects we have observed in both locations.

Some members of the radiation regulatory community have been slow to acknowledge how nuclear accidents have harmed wildlife. For example, the UN-sponsored Chernobyl Forum instigated the notion that the accident has had a positive impact on living organisms in the exclusion zone because of the lack of human activities. A more recent report of the United Nations Scientific Committee on the Effects of Atomic Radiation predicts minimal consequences for the biota animal and plant life of the Fukushima region.

Unfortunately these official assessments were largely based on predictions from theoretical models, not on direct empirical observations of the plants and animals living in these regions. Based on our research, and that of others, it is now known that animals living under the full range of stresses in nature are far more sensitive to the effects of radiation than previously believed. Although field studies sometimes lack the controlled settings needed for precise scientific experimentation, they make up for this with a more realistic description of natural processes.

Our emphasis on documenting radiation effects under “natural” conditions using wild organisms has provided many discoveries that will help us to prepare for the next nuclear accident or act of nuclear
terrorism. This information is absolutely needed if we are to protect the environment not just for man, but also for the living organisms and ecosystem services that sustain all life on this planet.

There are currently more than 400 nuclear reactors in operation around the world, with 65 new ones under construction and another 165 on order or planned. All operating nuclear power plants are generating large quantities of nuclear waste that will need to be stored for thousands of years to come. Given this, and the probability of future accidents or nuclear terrorism, it is important that scientists learn as much as possible about the effects of these contaminants in the environment, both for remediation of the effects of future incidents and for evidenced-based risk assessment and energy policy development.