

Animal deformities due to pollution

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The industrial age has brought millions of pounds of toxic contaminants into our environment. Pollution, synthetic chemicals, pesticides, heavy metals and even chemicals from household products are now pervasive in our water, air and soil. This toxic legacy poisons wildlife and our future. Widespread toxic contamination of ecosystems and exposure to wildlife is well documented. A 10-year government study revealed that more than 90 percent of the nation's tested waters and fish are contaminated with pesticides. These chemicals also make their way into people's water supplies, significantly affecting our health. Independent research has found more than 200 chemicals, many of them known toxins, in the blood of newborns. In both humans and animals — including the California condor, green sturgeon, Tehachapi slender salamander and polar bear — toxic chemicals increase cancer rates, cause reproductive problems and contribute to a wide range of other health problems. OUR CAMPAIGN The Center's Toxics and Endangered Species Campaign employs a broad range of tools to reduce the harmful contamination from pesticides, endocrine disruptors, lead, mercury, coal, uranium mining and fracking. Through strategic litigation, creative media, policy advocacy, scientific reports, coalition building and outreach to our members, the Center has mounted an effective campaign to target some of the most harmful toxins in our environment. Pesticides Pesticides, by design, are toxic to plants and wildlife. Their use, degradation and mixtures in the environment have resulted in pervasive water-quality contamination. The Center's Pesticides Reduction Campaign aims to secure programmatic changes in the pesticide registration process and stop toxic pesticides from getting into fish and wildlife habitats. Toxic contamination of polar bears is a good example of how pervasive pesticide pollution has become. Pesticides approved for use and applied in the continental United States are transported in the atmosphere, in the ocean and along biological pathways, eventually ending up in the Arctic, where they endanger the health of the entire ecosystem. Endocrine Disruptors Endocrine disruptors are chemicals that interfere with natural hormone functions and affect the reproduction, development and growth of fish and wildlife, as well as people. Pesticides, pharmaceuticals, plasticizers, cleaning agents, cosmetics, antibiotics and drugs introduced into waterways and aquatic habitats act as endocrine disruptors. As drinking-water sources and aquatic wildlife habitats are being increasingly and unnecessarily contaminated by endocrine disruptors, the effects on imperiled species are profound. The Center continues our campaign to control endocrine disruptors and reduce their impacts on our environment. Lead Lead is still entering the food chain through widespread use of lead hunting ammunition and fishing tackle, poisoning wildlife and even threatening human health. The Center's national Get the Lead Out campaign is devoted to replacing lead-based ammunition and fishing tackle with safer, nontoxic alternatives. We also work to clean up historic lead pollution. Lead-based paint at federal facilities on Midway Atoll kills up to 10,000 Laysan albatross chicks each year and also threatens the endangered Laysan duck. As a result of a settlement with the Center, the U.S. Fish and Wildlife Service announced a plan to clean up this toxic lead contamination to protect wildlife in the northwestern Hawaiian Islands. Mercury Two-thirds of the toxic mercury in our oceans is a result of manmade pollution from metal production, pulp industries, waste handling and coal production. The Center is also seeking innovative ways to reduce mercury exposure and increase awareness of mercury contamination. The primary source of mercury exposure for humans in the United States is contaminated seafood, and one-third of mercury exposure comes from consumption of tuna. The Center has petitioned the U.S. Food and Drug Administration to implement stricter regulations to protect women, children and all people who eat fish from mercury in seafood. Past mercury use has left a toxic legacy that can be resurrected through modern mining practices. Suction dredge mining in waterways not only directly hurts habitat for sensitive, threatened and endangered fish and frogs, but can also pollute waterways with toxic plumes of mercury leftover from the Gold Rush. The Center has worked through litigation and legislation to ban suction dredge mining in California. Coal In addition to the direct physical impacts of coal mining itself, there are severe toxic impacts of air pollution from coal-fired power plants, the waste from coal-mining tailings and coal ash slurry. The Center's campaign to fight the harmful effects of coal energy takes on these threats. Coal combustion produces a number of hazardous byproducts, including mercury, selenium, CO₂, nitrogen dioxide, sulfur dioxide and methane — which pollute the environment, exacerbate climate change and contribute to smog and acid rain. The Center, along with a coalition of environmental groups, filed a formal petition with the U.S. Environmental Protection Agency to establish, for the first time ever, limits on air pollution from coal mines throughout the United States. The Center has also worked to challenge individual coal production plants that pose particular threats to wildlife and ecosystems. Mountaintop-removal coal mining is exceptionally devastating to ecosystems and wildlife. The toxins from mining wash downstream, poisoning animals that manage to survive in the toxic environment and tainting the drinking water of downstream communities. Uranium Uranium mining has left a toxic and radioactive footprint across many areas of the West. All phases of uranium development — exploration, mining, milling and disposal — pose unique threats to species, ecosystems and human communities. Uranium ends up in the food chain and causes irreversible pollution of waters. It can contaminate aquatic ecosystems for hundreds of years, threatening downstream communities and fish and wildlife. Even minute amounts of uranium can poison fish, accumulate in the food chain, and cause deformities and reproductive problems for aquatic species. The Center is engaged in a broad based campaign to fight uranium mining on our public lands and to limit uranium's toxic legacy, including our campaign to stop Grand Canyon uranium mining. Fracking Fossil-fuel drilling involving high-pressure hydraulic fracturing, or "fracking," is a highly controversial and dangerous oil-drilling method linked to water contamination and methane production. Recent reports show that fracking has resulted in more than 1,000 documented cases of groundwater contamination, either through the leaking of fracking fluids and methane into groundwater or from aboveground spills of contaminated wastewater. The Center has worked to fight fracking in California to protect watersheds and wildlife. An assessment of the toxicological significance of anthropogenic contaminants in Canadian arctic wildlife. Fisk AT, de Wit CA, Wayland M, Kuzyk ZZ, Burgess N, Letcher R, Braune B, Norstrom R, Blum SP, Sandau C, Lie E, Larsen HJ, Skaare JU, Muir DC, Fisk AT, et al. Sci Total Environ. 2005 Dec 1;351-352:57-93. doi: 10.1016/j.scitotenv.2005.01.051. Epub 2005 Sep 12. Sci Total Environ. 2005. PMID: 16154621 Review. For the last two decades, strange things have been happening to frogs. Some frog populations have high rates of limb deformities, while others have high incidences of what is known as "intersex" — traits associated with both males and females, such as male frogs whose testes contain eggs. David K. Skelly, professor of ecology at the Yale School of Forestry & Environmental Studies, set out to discover what was causing these deformities, which some researchers were attributing to the use of an agricultural pesticide called atrazine. Skelly launched an experiment in ponds throughout Connecticut, studying frogs in four landscapes: forests, agricultural areas, suburbs, and cities. And what he found was surprising — the highest rates of deformities were not occurring in and around farmlands, but in cities and suburbs. In an interview with Yale Environment 360 contributing writer Carl Zimmer, Skelly described what chemicals may be causing these abnormalities in frog populations, and explained why this phenomena may have troubling implications not only for amphibians, but for other vertebrates, including humans. One thing seems clear: The deformities showing up in frogs are almost certainly not caused by a single chemical, but rather by a whole suite of substances — including medicines excreted by humans into the environment — that act in concert to mimic hormones like estrogen or cause other ill effects. "The fact that these kinds of estrogens out in the environment can have this kind of effect on a vertebrate — many people would say that that alone is a basis for us to be concerned," says Skelly. Yale Environment 360: You came to the question of pollution not as a medical researcher but as a wildlife biologist — you studied frogs. Tell us how that happened. David Skelly: Well, as an ecologist, I start with the animals. When I started on this project I really didn't know whether I was going to be studying pollution or what. I started off trying to understand where sexual deformities in amphibians came from in the environment. There had been some laboratory work that did in fact use pollutants and figure out whether exposure through pollutants like pesticides might cause these kinds of deformities. But to me, the cart was before the horse because we really didn't understand the natural history of reproductive deformities in many groups. e360: When did people first notice that there was something weird going on with these frogs? Skelly: Really the laboratory work in this case came first. About ten years ago people started doing laboratory experiments with amphibians, and some work on atrazine, a pesticide, was important because it was showing that extremely low concentrations of the pesticide might lead to these kinds of deformities. e360: And what deformities are you talking about? Skelly: The deformities in particular are traits that are associated with animals that have characteristics of both males and females. And there are lots of different possibilities. The ones that we've been concentrating on and the ones that are most clear are, say, a frog that looks like a male and has testes, but when you look inside the testes there are eggs growing in there. That's an attribute that you can say suggests intersex, a condition in between male and female. So then after these lab results came out people started going out into the field and, lo and behold, they found these deformities sometimes to be quite common in natural populations. That was interesting because certainly in the past we've known about these deformities for a hundred years. And in fact, a lot of what we know about sexual development in animals, and invertebrates in particular, was worked out in amphibians as a model system. And people have looked for them in natural populations before, but until this recent spate of work starting about ten years ago they hadn't been found to be common in too many places. What we found more recently is that in a variety of studies people are finding them to be quite common. What worried me about the work that had been done so far is that because the laboratory work had been focusing on agricultural pesticides, people went out and basically looked at gradients of agricultural intensity, or just worked in agricultural landscapes. e360: So they think because atrazine in the lab can cause intersex deformities, let's go look at places where these pesticides are used, like on farms? Skelly: Yeah. On one level that makes a lot of sense. But on another level it can be misleading. You can tend to reach a conclusion that isn't warranted because if you say I'm just going to go look in agricultural landscapes and I find these deformities there, and I've done the laboratory work to show that exposure to the pesticide can lead to these deformities, you might just wipe your hands and say we're done here. But what we didn't know is what about all these other landscape types? Are deformities showing up in those landscapes as well? And that was really our goal — to ask very broadly, how often is this happening? Where is it happening? What does the landscape of amphibian intersex look like? And what we found was pretty surprising. e360: Where did you go and what did you do to do the study? Skelly: The prior work on amphibian intersex had primarily been done in the West and the Midwest. There was a study down in Florida. Nobody had looked at all in the northeastern United States and that's where I'm based. So we worked in Connecticut, specifically in the Connecticut River Valley, and one of the nice things about Connecticut is that it's got a pretty We find intersex frogs in agricultural landscapes, but in suburban and urban landscapes at three times the rate." compact size but there is pretty high diversity of land-cover types. So there is an active agricultural landscape in Connecticut, there are certainly a lot of suburbs. There are urban areas and there are still a lot of forests in Connecticut. Connecticut ranks third or fourth in the nation for population density, and it ranks third or fourth in the nation for the proportion forested. We can take advantage of that. So we worked in a set of land cover types: agricultural; undeveloped, which in Connecticut means forested; suburban, people with lawns and houses and schools and that sort of stuff; and urban, mostly around Hartford. So essentially we took the entire state and categorized areas around small ponds as fitting into one of those categories and then sub-sampled them randomly. And what we found is that we can find intersex frogs in a variety of landscapes. We find them in agricultural landscapes, but we find them in suburban and urban landscapes at three times the rate. So if they're concentrated anywhere, they're concentrated in these more densely settled places — places where people live and work. We didn't find them in wooded landscapes, these undeveloped landscapes. e360: So whatever is happening has something to do with human activity, since you're not seeing it in the wooded landscapes. Skelly: Right. So we feel very confident at this point that whatever is going on seems to be associated with some kind of human activities and we are finding it in agricultural landscapes so it's not that whatever goes on in agricultural landscapes is inconsistent with it happening... [But] I think the fact that we found that in those kinds of landscapes where corn is being grown, the great majority of the ponds we sampled didn't have any deformities at all. It suggests to me that whatever is going on in those landscapes compared with the suburban and urban ones, we're not getting a signal that strongly points towards agricultural pesticides. Not at this point — we've got more work to do. But one of the striking things is that almost all the ponds in the suburbs and urban landscapes have deformities in them. So this is something that is practically ubiquitous in those places and yet is showing up in a much more spotty manner in agricultural landscapes. e360: So if atrazine is not the only factor, what are your suspicions about what else might be going on? Skelly: Well it's pretty well known that amphibians, fish, and frankly vertebrates in general can be influenced by hormones that are just out there in the environment. There are actually whole biological systems that depend on that happening naturally. But it's also clear that we put a lot of hormones into the environment. And in particular we know that estrogen exposure can lead to the kinds of deformities we are seeing. So we would be irresponsible if we didn't at least explore that avenue. It seems like a pretty reasonable set of hypotheses at this point just to imagine that there's a bunch of estrogens out in the environment and perhaps atrazine is one of them. There are dozens of chemicals that humans create to actually act as estrogen. Birth control pills are a perfect example. The estradiol people take as birth control or as prostate medicine, it goes through our bodies, it may get complexed with something, and then we excrete it and it can become active again in the environment. I mean that's not hype, that's it is widely accepted that the way that toxins work in the environment is often in concert." absolutely been shown to happen as a matter of course. So that's a very potent estrogen. And those molecules are reasonably durable. But there are many other chemicals that were not created to be estrogens and yet can act like estrogens once they're out there. So one that many people may have heard of is Bisphenol A. That's the chemical BPA and there was federal legislation to remove it from baby bottles. It's a plasticizer. So it's an industrial chemical that's supposed to help us create something and then as a totally unintentional byproduct it can have this other kind of biological activity. And it turns out there's a variety of chemicals with molecules shaped such that they can bind to receptors on our cells, or in cells of frogs that are intended to receive estrogen molecules. And when these receptors bind with these other chemicals they turn that into a signal that says, okay, some estrogen just arrived. And if that happens often enough there are physiological responses in our bodies that in a frog's testes could lead it to start creating eggs. So the biology of all that is pretty well worked out. It doesn't mean there aren't other possibilities for what might be going on, but we know that these estrogens are out in the environment. We know that a species like frogs can respond to them. What we need to do is see whether the dots connect and whether the exposure happens in these ponds. And then as a follow-up to that, if all that comes together, then another step we need to take is do experiments — not in the laboratory, but out in the natural environment, and see whether we can actually create this kind of a cycle where there's exposure going on and we can see inside of a natural pond. So the way that you would nail this down is by experimentally exposing some animals in the field to this kind of cocktail of chemicals that we can first demonstrate are out there in the field, and then see what kind of biological responses we get. That's the way we can with great certainty figure this out. And it's important to be pretty certain about it because we're talking about a variety of chemicals that are in the environment because they're useful. You know these are people's medications, they are industrial chemicals, they're not out there for no reason. And we're not going to be able to change people's minds about them unless we have very good evidence suggesting that these effects are happening. And then the question is, what do you do about it? e360: When you hear that frogs are having these sexual deformities, it sounds creepy. But does it have an actual ecological impact? I mean does the fact that it may be changing the nature of these frogs actually mean something to the wildlife itself? Skelly: I think these results are important in two very different ways. Beyond being creepy, the fact that these kinds of estrogens out in the environment can have this kind of effect on a vertebrate — many people would say that that alone is a basis for us to be concerned. Because there are many other species that share some of the same biological pathways that frogs have. And that includes people, where we don't want the possibility of this going on. So you can get precautionary about it and just say this isn't about frog population viability. This is about not wanting to have chemicals that have that kind of biological activity out there. e360: So back when Rachel Carson was writing Silent Spring, she was focusing on DDT and there was a certain clarity there where she could focus on one pollutant. And here we have a situation today where you have to think about atrazine and all these other chemicals that each individually might have an impact on these frogs and on people, or maybe together cumulatively have an impact. It makes the problem more complicated. How do you deal with that? Skelly: It is complicated. And I think we're still grappling, maybe struggling is a better word. The EPA [Environmental Protection Agency] and ecotoxicologists in general have been trying to figure out how to deal with mixtures for some time. So it is widely accepted that the way that toxins work in the environment is often in concert. But the paradigm that you described where beginning with Rachel Carson we were thinking about one chemical at a time — people like the clarity that comes from that. It's clean and if you do this in the lab you get beautiful results. This standard of pure clear repeatable results has kind of gotten in the way of thinking about how bad things happen out in nature. One thing that I can see on the horizon is that people are thinking about looking at biological pathways. So we've been talking about pathways where estrogens get turned into physiological responses. And instead of thinking about one chemical at a time, what are the chemicals out there that could cause that, and shouldn't we be managing those as a group? Because we're talking about medications, we're talking about industrial chemicals, we're talking about pesticides. I think first what we need to do is come up with clear field-based cases where you can show very clearly that it is mixtures causing this and that managing chemicals one at a time isn't going to work... It's ironic you mentioned Rachel Carson because she started with a natural history phenomenon and then followed her nose to figure out what was going on, and traced it to a single chemical. It could have easily been traced to a group of chemicals and perhaps the history of environmental regulation would have rolled out differently. e360: And so we would conceivably be regulating these chemicals in groups? I mean, wouldn't somebody who makes the birth control pill say, well, we only contribute a tiny amount to this problem so why are you picking on us? Skelly: I think that if we do get into thinking about and regulating mixtures of chemicals based on their action, as opposed to their intended use and their origin, it's going to be an incredibly hairy regulatory problem. And I don't pretend to understand how to deal with that except to say that there are a couple of bright hopes in this particular example. The first is that we can deal with a lot of chemicals regardless of their origin and regardless of their intent by changing how we manage waste. Right now a state-of-the-art sewage treatment plant has three stages. And what comes out the back end of that includes a lot of organic molecules, including estrogens, that really don't get molested by the sewage treatment activities very much. If we could add a fourth stage — charcoal, sand bed, or something like that — that could remove a whole suite of things without thinking about what they are. The other way that we can deal with this is to build it into the front end. To build it into research and development of these chemicals so that we're trying to think about could you create a plasticizer that works like BPA, but doesn't act like a steroid?

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