

Comment

## They fought the law and the law won

Gregory A Petsko

Address: Rosenstiel Basic Medical Sciences Research Center, Brandeis University, Waltham, MA 02454-9110, USA.

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Australia used to have a cane beetle problem. The cane beetle was slowly destroying the country's sugar cane crops, and there seemed to be no way to get rid of it. Then, in 1935, someone had the bright idea to import a box of cane toads from the Hawaiian Islands, where the large frogs (which were 25 cm long and up to 4 kg in weight) supposedly kept the pest in check. So, 102 cane toads were delivered to Gordonvale, just south of Cairns, where after a few rounds of captive breeding to increase their numbers, they were released into the sugar cane fields. Then the fun began. It turned out that cane toads can't jump very high so they did not eat the cane beetles, which tended to reside on the upper stalks of the cane plants. But they were able to eat just about anything else: dog food, mice, the insects that native Australian frogs eat, the native Australian frogs themselves, and so on. They bred like flies: a pair of cane toads can lay 33,000 eggs per spawning. They proved resistant to herbicides that would normally kill frogs and tadpoles. And they are deadly poisonous; so they had no natural predators. (Australian museums have exhibits of snakes that were killed by toad toxin so fast that the toads are still in their mouths.) The cane toad has turned out to be one of Australia's worst environmental disasters. Since 1935, it has spread across most of Queensland, the entire Northern Territory, and down the coast of New South Wales. So now Australia has a cane toad problem. Oh yes, and it still has a cane beetle problem.

The cane toad is one of the more spectacular examples of the only scientific law for which there is no exception: The Law of Unintended Consequences. Loosely stated, the Law says that all human actions can produce unforeseen effects, and these are often more momentous, and frequently damaging, than the original problem those actions were meant to solve. It has been expressed colloquially in many forms; my favorite is "when you are up to your ass in alligators, it is difficult to remember that your initial objective was to drain the swamp." The late, great sociologist Robert K Merton was fascinated by it; in his book *On Social Structure and Science*

(The University of Chicago Press, 1996), he listed five causes of the law:

1. Ignorance (it is impossible to anticipate everything, thereby leading to incomplete analysis).
2. Error (incorrect analysis of the problem, or following habits that worked in the past but may not apply to the current situation).
3. Immediate interest, which may override long-term interests.
4. Basic values may require or prohibit certain actions, even if the long-term result might be unfavorable (these long-term consequences may eventually cause changes in basic values).
5. Self-defeating prophecy (fear of some consequence drives people to find solutions before the problem occurs; thus, the non-occurrence of the problem is unanticipated).

He left out the most significant one besides ignorance: arrogance, our persistent belief that we are smart enough to plan for all possible consequences.

The Law of Unintended Consequences shows up in all aspects of human endeavor. A familiar example would be the attempt by moral reformers in the 1920s to curb the evil of alcohol consumption by banning all such beverages in the United States ('prohibition'), which neither curbed excessive drinking nor increased public morality. What it did increase, of course, was crime: organized crime was born in the 1920s to cash in on the lucrative market for illegal drink. The law also abounds in time of war - look at how the disastrous invasion of Iraq, which was intended to improve the security of Western nations, has actually turned that land into a breeding ground for terrorists. But where it really seems to come into play is whenever mankind monkeys around with

the environment or the ecosystem. Australia's cane toad story is by no means the only example. In the US, gypsy moth caterpillars were imported into New England by one Leopold Trouvelot in the hope of starting a new silk industry. That idea failed, but some of the moths escaped, and over the past 150 years their periodic outbreaks have led to the deforestation of millions of acres of trees and shrubs.

You'd think that after a couple of centuries of disasters like this, we would know enough not to tamper with the natural order. But hubris has no sense of history. The power of genomics has led to numerous bioengineering projects to improve food crop yields, increase disease and pest resistance in many plants, and express foreign proteins in farm animals and tobacco. The altered organisms have been carefully confined for the most part, but I'm sure that's what Trouvelot would have said about his gypsy moths. I'm not fond of quoting Stephen Spielberg - I think he's an antisience opportunist philosophically - but he's right when he has the character Ian Malcolm state, in the movie *Jurassic Park*, that "if there is one thing the history of evolution has taught us, it's that life will not be contained. Life breaks free. It expands to new territories, it crashes through barriers, painfully, maybe even dangerously, but, uh, well, there it is!" (Now, don't get me wrong; I'm not opposed to genetic engineering of crops or to genetically modified foods. I think both can have important benefits, especially in countries where agriculture is difficult and famine is frequent. But given the difficulty of containment, I would argue that it behooves us to do everything possible to perform such activities with as much foresight as possible.)

So I hope you will understand why the new science of geo-engineering gives me the willies. Geo-engineering doesn't try to alter a few corn plants; it aims to tinker with the entire planet. It was born out of a desire to do something about global warming. You're going to be hearing a lot more about it, I'm afraid, because it could mean a lot of money for some companies and it is very appealing to conservatives, who have always had an exaggerated faith in our ability to manage the environment. Geo-engineering involves using deliberate human acts, based on novel technologies, to slow down or reverse the climate change being driven by technology-produced greenhouse gasses. Unlike conservation efforts, which are motivated by a desire to roll back the damaging effects of human activities, geo-engineering is based on the notion that ultimately we can actively manipulate the planet to have any climate pattern we want. Some of the more astounding ideas that geo-engineers have put forward lately include fertilizing the sea with iron particles to create explosions of plankton, which take CO<sub>2</sub> out of the atmosphere; erecting giant mirrors above the earth to reflect the sun's energy; and dropping clouds of sulfur particles from high-altitude balloons to do the same. You may laugh, but this is no laughing matter - people are really serious about doing these things. A

scientific meeting on iron fertilization was held at the end of September at the Woods Hole Oceanographic Institute, and while no one there could agree on the likely consequences of such intervention, no one was laughing about doing it, either. It isn't clear that a company or private organization that wanted to try this on a massive scale could even be prevented from doing so - the maritime laws don't really cover such things and there's an awful lot of water to patrol. It might well be profitable, too, since a company that seeded the production of lots of plankton could, in theory, sell carbon sequestration credits to other, polluting companies.

But the Law of Unintended Consequences makes any such efforts frightening, to say the least. Some of the long-term consequences of a massive, engineered plankton bloom might actually be an increase in global warming, since the dead plankton may give off nitrous oxide, which is an even worse greenhouse gas than CO<sub>2</sub>. Iron particles also will react with oxygen dissolved in the seawater; the resulting oxygen depletion may kill off countless fish, although no one knows for sure. The problem is that a number of people are getting very serious about trying this and other massive environmental engineering projects, and it's a sure bet that genome biologists are going to be asked to join such efforts (creating, for example, plankton that are more efficient in utilizing iron, or in absorbing carbon dioxide).

I think we should resist such siren calls, and indeed, campaign for a moratorium on all such geo-engineering projects. Some scientists are already calling for that, until an assessment of the likely consequences can be produced. But I would argue that there is no way we can ever assess all of the likely consequences; that the history of environmental tinkering should convince us that the probability of disaster is so high as to require that we prohibit this sort of nonsense forever. I would feel differently if there were no Law of Unintended Consequences. But Australia used to have a cane beetle problem, and now it has a cane toad problem and a cane beetle problem because there is such a law, and that law constantly winks at us, from those dark corners where our ignorance and our arrogance meet.