Nothing is so Powerful as an Exponential whose Time has Come

By Donella Meadows

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The reason environmentalists are often so gloomy is that they know what the word “exponential” means.

“A lack of appreciation for what exponential increase really means leads society to be disastrously sluggish in acting on critical issues,” said Dr. Thomas Lovejoy of the Smithsonian Institution in a speech that has been reverberating through the environmental community. “I am utterly convinced that most of the great environmental struggles will be either won or lost in the 1990s, and that by the next century it will be too late.”

What’s he talking about? What does exponential increase mean?

It means growing like this: 1, 2, 4, 8, 16, 32. Doubling and then doubling again and then doubling again. Everyone understands that, right?

Not really, not at a gut level. For example: suppose you agree to eat one peanut on the first day of the month, two peanuts on the second, four peanuts on the third, eight peanuts on the fourth, and keep doubling every day. How long do you think you can keep going? How long will a pound can of shelled peanuts last you?

The first pound of peanuts will be gone on the ninth — you’ll eat half the can that day and feel pretty queezy. On the tenth you’ll eat a whole pound, if you can, which I doubt. By the fifteenth you’ll be scheduled to eat 32 pounds of peanuts. You’ll have to eat roughly your own weight in peanuts by the 17th; on the 21st the total will have risen to one ton; and by the end of the month, assuming a 30-day month, it will be 500 tons.

Just a few doublings add up ferociously fast — that’s what Thomas Lovejoy was saying.

Mexico, with a population of 84 million and a doubling time of 29 years, will, if it keeps that up, grow to 168 million in 29 years and to 672 million within the lifetime of a child born today. That’s nothing compared to Kenya, which has a doubling time of 17 years. If it goes on growing at that rate, in 70 years there will be ten Kenyans for every one today.

Until the 1970s world oil consumption was growing at seven percent per year. That means doubling every ten years. (The doubling time of anything growing exponentially is 70 divided by its annual growth rate — 70 divided by seven percent is a ten-year doubling time.) Every ten years we used as much oil as we had used in all previous history. Every ten years we had to go out and discover as much oil as we had ever discovered before — and then, to keep going, discover twice that much in the next ten years.

We didn’t keep going. We couldn’t have. Exponential growth makes the cupboard bare very fast. Even if the entire earth were filled with nothing but high-grade crude oil, if we used it with an annual growth rate of seven percent, it would be gone in 342 years. There’s still plenty of oil around now, but we’ve been burning it faster than we’ve been discovering it for 20 years now.

You may have heard that we have 1000 years’ worth of coal. If we burn 7 percent more of it each year than the year before (which we may well do, substituting it for the disappearing oil), it will last just 61 years, and it will bring on global climate change much faster than even the worst pessimists are now expecting.

Said Dr. Lovejoy, “I find to my personal horror that I have not been immune to naivete about exponential functions. While I have been aware that the … loss of biological diversity, tropical deforestation, forest dieback in the northern

hemisphere, and climate change are growing exponentially, it is only this very year that I think I have truly internalized how rapid their accelerating threat really is."

You don't get much reaction time when your problems grow exponentially. My favorite story to illustrate that point is ar old French riddle.

Suppose you own a pond on which a water lily is growing. The lily doubles in size each day. If the lily were allowed to grow unchecked, it would completely cover the pond in 30 days, choking off other forms of life in the water. For a long time the plant is almost invisible, and so you decide not to worry about cutting it back until it covers half the pond. On what day will that be?

On the twenty-ninth day.

We are emitting carbon dioxide and several other greenhouse gases in the atmosphere exponentially. We are clearing tropical forest at an exponential rate. The human population is growing exponentially. Human energy use, human production of synthetic chemicals, deserts, and trash are growing exponentially. Our economy is growing exponentially, and we cheer it on, although an economic growth rate of, say, 3.5 percent per year means another whole industrial world plopped down on top of this one in just two decades.

We can't keep it up. If we understood the consequences of exponential growth, we wouldn't even want to try.