Expect the unexpected

The planet is being damaged in ways no one imagined, but there are things we can do to prepare ourselves even if worse is to come, says **William Laurance**

DONALD RUMSFELD, the former US Secretary of Defense, liked to distinguish between "known unknowns" and "unknown unknowns", and for this he was widely ridiculed. But Rumsfeld had a point. We all know, for instance, that global warming is harming cold-adapted species on mountain tops, even if we can't predict the ultimate magnitude of the damage. Yet the really alarming changes are those that come completely out of the blue – the unknown unknowns that we never even imagined.

Consider the explosion of logging in central Africa. That the loggers are seriously impacting the forests is hardly a surprise, but no one ever suspected that logging would threaten sea turtles – a finding my colleagues and I stumbled over while working in Gabon (*Oryx*, vol 42, p 246). There, many thousands of logs are lost as they are being transported downriver to timber yards. The logs float out to sea, but later many of them wash ashore on beaches used by nesting sea turtles, especially the critically endangered leatherback turtle. The logs can cause turtles to abandon their nesting attempt or to nest too close to the waterline, where their eggs are killed by seawater.

Another startling conclusion comes from Justin Brashares, formerly at the University of Cambridge, and his colleagues. They showed that overfishing by European trawlers is harming African terrestrial wildlife (*Science*, vol 306, p 1180). The trawlers are depleting fish stocks in the Gulf of Guinea, which in turn is forcing coastal communities that formerly relied on fishing to hunt more intensively inland. For more than 40 species of wildlife, numbers have plummeted. No one had foreseen connections like this.

Biofuels are also infested with unknown unknowns. In the face of escalating oil prices and energy insecurity, many countries are promoting domestic biofuel industries – sometimes with utterly unexpected consequences. Who would have predicted, for example, that US corn subsidies for biofuel would trigger forest destruction in the Amazon? But as I recently argued, the subsidies are prompting many US farmers to shift from growing soya to corn (*Science*, vol 318, p 1721). This is helping to drive up global soya prices, which in turn is amplifying economic incentives to destroy Amazonian forests and tropical savannahs for soya production. In the last six months, forest destruction and fires have spiked alarmingly.

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The perils of trying to make linear decisions in a non-linear world are perhaps best illustrated by ecological thresholds, also known as tipping points. These occur when a stressed system suddenly goes haywire, with no warning. Take Florida Bay, the triangular stretch of water largely enclosed by the south coast of the mainland and the Florida Keys. In the early 1990s it changed abruptly from a clear-water system that supported seagrasses and manatees to a murky dead zone overwhelmed by plankton blooms. Nobody saw this coming because nothing much had changed: the bay had received a steady stream of pollution from septic systems with little apparent effect, until one day it hit a critical threshold that turned everything upside down.

We should all be scared of tipping points. Many fear, for instance, that the Amazon could soon hit one. Amazonian forests help to generate their own rainfall, because the dense vegetation quickly recycles moisture and returns it to the atmosphere. As deforestation proceeds, however, less water vapour is recycled, so clouds and rainfall decrease. No one knows how far the Amazon can be pushed before it collapses in a rage of droughts and forest fires.

Of course, the scariest of unknown unknowns is global warming. Will the Earth behave as a tame, linear system, changing in simple, predictable ways as the planet gets hotter? Or will non-linearities toss us a bevy of nasty surprises? We just don't know.

Catastrophes like this may be impossible to predict, but we do know some of the factors that make them more likely. One is increasing economic globalisation. I recently argued that rising demand for furniture in the US and Europe is driving an expansion of Chinese furniture manufacturing, which in turn is causing a spike in illegal logging in developing nations in Asia and Africa that export their logs to China (*Science*, vol 319, p 1184). In a complex, interconnected world, yanking on a string in one location can cause painful jolts in far-flung and unpredictable places.

Secondly, we know that unknown unknowns are much more likely to spring surprises when a system is stressed. With our burgeoning population and escalating demand for food, energy and goods, and with seismic changes in the global economy we are now stressing our planet in countless alarming ways.

We need to prepare for these surprises by keeping resources in reserve. Most of all, we need to take our foot off the accelerator. Otherwise we're embarking on a series of life-threatening gambles for which we don't even know the odds.

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