Article 9 - **Scientists Fear Climate Change Tipping Points**

A year ago James Hansen, Director of NASA's Goddard Institute for Space Studies, published a study in the journal Atmospheric Chemistry and Physics concluding that just 10 more years of business as usual emissions from the burning of coal, oil and gas will make disastrous global results all but impossible to avoid. The study described various climatic possibilities called tipping points.

These tipping points, also called non-linear events, both accelerate climate change and are accelerated by climate change. Scientists fear these events because they are almost impossible to predict before they occur, but once they occur they could rapidly outstrip humankind's ability to adapt.

Nonlinear Events

Scientists describe events as non-linear when a small cause creates a disproportionately large effect. A simple example of a non-linear event is unplugging your freezer. After an hour the temperature goes from 20 degrees to 25 degrees and not much changes with the frozen food. After another hour the temperature goes from 25 degrees to 30 degrees and there still isn't much change in what is in your freezer. If you didn't know what to expect, you would be very surprised when just one more hour and five more degrees caused a huge change as all your ice cream melts.

Dr Robert Steneck of the University of Maine studies natural processes. He told *The Garden Island*, "I think most complex natural systems behave in non-linear ways. Invariably they surprise us because we tend to consider things linearly."

Vanishing Arctic Sea Ice

Climate change has done the equivalent of unplugging the freezer in the deep arctic which has no underlying land continent, just a large floating sheet of ice at the top of the world between Canada, Siberia, and Greenland. And the Arctic sea ice has declined dramatically over the past thirty years. Scientists believe the critical threshold when ice will completely disappear in the Arctic summer may be between 0.5 to 2 degrees Celsius above the current average global temperature, but could already have been passed.

The albedo effect of the presence of white ice floating in the Arctic Sea reflecting sunlight back into space has a significant cooling effect on the whole planet. When the ice is absent, sunlight hitting the dark ocean causes up to ten times as much heat to be absorbed. The practical impact is once the Artic Sea's ice finally melts, the open ocean water will absorb enough additional heat to prevent the summer sea ice from coming back. Mark Serreze, Senior Scientist at the University of Colorado's National Snow and Ice Data Center told *The Garden Island,* "Once we lose the summer sea ice, we can't really get it back. Even our earliest climate models, developed 30 years ago, were telling us that the Arctic would be the first to respond to higher levels of greenhouse gases. The changes we are seeing in the Arctic are just what we expected - they are just unfolding a lot faster than we thought possible."

Burning Tundra
"Tundra" brings to mind ice and snow, not wildfires, but last summer more than 350 square miles of tundra north of Alaska's Brooks Mountain Range burned. That's more acreage burned than the last fifty years combined. And Dr Philip Higuera of Montana State University believes last year's burn may be a preview of what is coming. While tundra fires have been rare, occurring less frequently than once every 250 years, ancient sediment core samples Higuera studied show climate warming causes much more frequent fires.

Increased fires in these cold regions are much more than an oddity because about thirty percent of the world's carbon is currently locked up in tundra and high-latitude boreal forests. Fires there have the potential to release huge amounts of CO2, further accelerating climate change. Dr Gaius Shaver, Senior Scientist at the Woods Hole Marine Biological Laboratory told *The Garden Island* these fires are another climate change tipping point. He said, "It is a big deal, and more fires are expected. The major potential impacts are on permafrost and on carbon now stored in peat."

Collapsing Greenland Ice Sheet
There is enough ice covering Greenland to raise global sea level by twenty-three feet if it all melts. Scientists' models predict warming of about three degrees Celsius will cause the ice sheet to melt within 300 years.

Scientists see signs the ice over Greenland is melting at an accelerating rate. First, surface temperatures over Greenland are warming more than global averages. And glacier outlets are rapidly losing ice lowering altitude at their periphery, which further increases surface temperature and further speeds up melting. Scientists are seeing large rivers and streams forming on top of ice sheets. Instead of running to the ocean, these rivers disappear into holes in the glaciers called moulins. This water is carried down to the base of the glacier where it lubricates the glacier's travel and speeds the movement of ice into the ocean.

Experts rate the melting Greenland ice sheet as one of the two tipping points we should be most concerned about. Although the melting will take hundreds of years to complete, once the threshold is passed and the melting starts, there is nothing that can be done to stop it.

Melt descending into a moulin, a vertical shaft carrying water to ice sheet base. Photo source: Dr Roger Braithwaite, University of Manchester (UK)

West Antarctic Ice Sheet Collapse

Scientists see the collapse of the West Antarctic Ice Sheet (WAIS) as another climate tipping point, impossible to reliably predict, unstoppable once it starts, and with catastrophic consequences. If WAIS does collapse, it will raise the sea level by almost twenty feet around the world and speed global warming even more. Recent gravity measurements show that the ice sheet is losing mass.

WAIS is at additional risk because of its unique nature. Most of the ice sheet is grounded below sea level with its frozen structure anchored to the bottom of the sea. In some places it dips thousands of feet below sea level. As other climate changes raise sea level, buoyancy forces ice around the edges of WAIS to float higher, allowing warmer ocean water under the sheet further weakening its hold on the bottom, leading to more sea level rise. Scientists believe WAIS is particularly vulnerable to rapid disintegration once this cycle starts.

Others Tipping Points

The February 2008 Proceedings of the Natural Academy of Sciences included a summary article, *Tipping Elements in the Earth's Climate System* which identified all these and other critical tipping points.

A warming of three to five degrees Celsius could collapse the Atlantic Ocean currents carrying heat from the tropics north.

A similar rise in global temperature could lead to "large-scale dieback of the boreal forests" within 50 years. This vast green swath, encircling the Northern Hemisphere from Siberia to Newfoundland, ties up vast amounts of carbon in trees, soil and permafrost.

The Amazon may be approaching a tipping point, where drier conditions caused by deforestation will reduce rainfall enough to transform the humid tropical forest into a giant savanna and releasing perhaps 100 billion tons of carbon into the atmosphere — equal to 10 years' worth of total global emissions.

Manage the Unavoidable

Many of the suggestions to cope with climate change are about human kind adapting to the inevitable; for example, developing new crops more resistant to heat and drought, moving cities and infrastructures away from coasts, and relocating populations from areas before they are submerged. These approaches all assume the impacts of climate change will be gradual, almost evolutionary in nature.

Avoid the Unmanageable

In Dr Timothy Lenton's Natural Academy article he warned that "Society may be lulled into a false sense of security by smooth projections of global change." The tipping points identified in that research are anything but gradual. They have the potential to create rapid and unmanageable changes – global temperature rises of a dozen degrees, catastrophic release of atmospheric CO2 far in excess of what we are currently generating burning oil and coal, and rapid sea level rises of tens of feet. Climate experts, citing the unpredictable nature of these tipping points, urge that we also focus on climate mitigation to avoid additional global climate change that might trigger tipping points.