Building the Biocarbon Economy: How the Northwest Can Lead

The Biocarbon Imperative: Reaching Target 350

The science of emerging climate feedbacks driving the urgent need for atmospheric carbon reductions

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UPSETTING THE CARBON BALANCE

Carbon is at the center of the community of life, one of its three basic constituents along with hydrogen and oxygen. Life first appeared in the oceans and its carbon remains accumulated on the seabed, where it was drawn into the Earth as tectonic plates slid under one another. When that carbon was pushed into the atmosphere by volcanic eruptions, it thickened the atmosphere sufficiently to trap the solar heat that made life on land possible.

Atmospheric carbon levels have varied greatly over millions of years and with them, global temperatures. But over the long-term, natural biological and geological processes have absorbed carbon dioxide (CO_2) from the air. **Fossil fuels – coal, oil and natural gas – are in essence fossilized photosynthesis.** The CO_2 that pours out vehicle tailpipes and power station smokestacks today was drawn out of the atmosphere millions of years ago by hungry plants. They combined $C0_2$ with water and sunlight to grow and nourish themselves. Natural forces buried plant biomass, and then it was refined by Earth's heat and pressure into fossil fuels. **Now humanity has upset the balance by digging and pumping the carbon stored in fossil fuels and returning it to the atmosphere in a geological eye blink.**

Before the industrial revolution when humanity began to drive civilization on massive fossil fuel burning, carbon dioxide in the air ranged between 180-300 parts per million for around 2.1 million years.[1] We know this by analyzing ice cores,which trap bubbles of the atmosphere as new layers of ice are frozen, and fossil shells in ocean sediments, which contain chemical signals of CO_2 levels from the time they were formed.[2] These CO_2 concentrations may seem tiny, but their small variations signaled the difference between ice ages and warmer periods. **In 2009 CO_2 concentrations**

[1] Intergovernmental Panel on Climate Change Working Group I, *Summary for Policymakers*, 2007
[2] *Science Daily*, Carbon Dioxide Higher Today than Last 2.1 Million Years, June 21, 2009

reached 390 ppm, up nearly two ppm from 2008, and growing at an accelerating rate.[3]

CO_2 and other greenhouse gases such as methane and nitrous oxide trap heat from sunlight as it reflects from the planet's surface. While greenhouse gases (GHGs) exist only in trace amounts, they make all the difference. In past eras when greenhouse gas concentrations were low, much of Earth was frozen. When they were high, tropical conditions existed in the Arctic. In the 10,000 or so years since ice age conditions faded from Earth, the capacity of GHGs to trap solar radiation has made possible the growth of agriculture and civilization.

But that fragile balance has been overturned by humanity's GHG emissions. **The Earth has warmed around one degree Fahrenheit over the past century, and the rate of warming has accelerated over recent decades.** Strong scientific agreement exists that most of this warming is traceable to the effect growing GHG concentrations have in thickening the heat-trapping blanket around the Earth.[4]

The greater part of the global warming challenge is about dumping ancient carbon into the atmosphere faster than nature can reabsorb it. So it remains in the air for extended periods accumulating more solar energy. Significantly, the second greatest source of GHGs is release from natural carbon sinks through deforestation and agricultural development. But even so, **plant growth is still absorbing a net of one billion metric tons (MT) of the 8.5 billion MT in fossil carbon that human activities release annually**.[5]

Another three billion MT are entering oceans. **Increasing ocean acidification as a result of direct chemical absorption of CO_2 into seawater is a global impact of fossil fuel burning only beginning to be addressed.** In 2010 The National Research Council reported that average pH of ocean surface waters has decreased by 0.1 to 8.1 over the past 250 years. Increasing acidity is already reducing the ability of corals, plankton and shellfish to build shells and skeletons. Corals are the center of ocean biodiversity, plankton are a critical link in biological absorption of CO_2 in oceans, and shellfish are an economically valuable product in many regions including the Northwest. Oceans are projected to drop in pH another 0.2-0.3 units this century. **The rate of change exceeds any known to have occurred in at least 800,000 years**, NRC reports.[6]

Working with nature to increase carbon storage through plant growth reduces ocean acidification and atmospheric warming.

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[3] Atmosphere Monthly, Feb. 2010

[4] Intergovernmental Panel on Climate Change.

[5] James Hansen, *Storms of My Grandchildren: The Truth About the Coming Climate Catastrophe and Our Last Chance to Save Humanity*, Bloomsbury USA, New York, 2009, p.118-120

[6] National Research Council, Ocean Studies Board. *Ocean Acidification: A National Strategy to Meet the Challenges of a Changing Ocean*, National Academies Press, 2010

TARGET 350 TO STABILIZE POLAR ICE AND SEA LEVELS

A few years ago, scientists and policymakers targeted a doubling of CO_2 to around 550 ppm as the limit to halt dangerous climate change. As knowledge about how Earth's ecosystems behaved under different CO_2 concentrations in the past grew, that target was refined downwards to 450 ppm. But **now a number of leading scientists are recommending a target of 350 ppm and below.**

The most prominent of those scientists is James Hansen of NASA Goddard Institute of Space Studies. In 2008 Hansen and a team of leading climate scientists published an article which changed the entire climate change dialogue: "Target Atmospheric CO_2: Where Should Humanity Aim?" [7] The scientists made a compelling case based on the state of the planet **in past geologic eras when GHG concentrations were similar to today's. The geologic record shows much higher sea levels based on massive polar ice melt.** They concluded that unless humanity dials back atmospheric CO_2 concentrations to 350 ppm, a similar fate will befall our era. Their work now sets the goalpost for much of the movement to stabilize the climate.

Writes the Hansen team, **"If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted**, paleoclimate evidence and ongoing climate change suggest that **CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm."**[8]

The 350 ppm goal was also supported in a groundbreaking 2009 scientific paper. It brought together 29 scientists to answer the question, **"**What are the non-negotiable planetary preconditions that humanity needs to respect in order to avoid the risk of deleterious or even catastrophic environmental change at continental to global scales?"

Scientists conclude that ". . . **humanity has already transgressed" the climate boundary, and pointed to 350 ppm as the target to restore a "safe operating space for humanity."**[9]

Hansen and other scientists analyzed data from the time when the planet cooled enough to allow ice sheets to appear in Antarctica around 34 million years ago. Prior to that CO_2 concentrations were higher than today, but they slowly declined as nature absorbed the carbon. Hansen and his fellow scientists concluded that **Antarctic glaciers most likely appeared when CO_2 concentrations declined to 450 ppm.**

Another study published in *Science* in 2009 looked at a period between around 14-20 million years ago when the Earth's temperature was 3-6° C hotter and ocean levels were 80-130 feet higher than today. Using natural markers in tiny fossil shelled organisms,

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[7] James Hansen, "Target Atmospheric CO2: Where Should Humanity Aim?," *Open Atmos. Sci. J.* (2008), vol. 2, pp. 217-231
[8] Hansen et al, p.1
[9] Johan Rockstrom et al, "Planetary Boundaries: Exploring the Safe Operating Space for Humanity," *Ecology and Society* 13(2): 32

scientists found they were around 400 ppm.[10] At the current rate that level will be reached this decade.

"What we have shown is that **in the last period when CO_2 levels were sustained at levels close to where they are today, there was no icecap on Antarctica and sea levels were 25-40 (meters) higher**," lead researcher Aradhna Tripati told the BBC. The UCLA scientist added, "At CO_2 levels that are sustained at or near modern day values, you don't need to have a major change in CO_2 levels to get major changes in ice sheets." [11]

Such studies strongly suggest that the tipping point which sets the course toward an ice-free planet, where sea levels are around 250 feet higher than today, is not far. The process, once started, will not be easy to stop because it feeds itself. Water from melting ice eats down into the ice and melts more, while meltwater also takes in solar heat more effectively than ice. **Where reflective white ice is replaced by heat-soaking blue ocean, far more solar energy is absorbed.** This is known as ice-albedo feedback.

In October 2009, at the end of the summer melt season, Arctic sea ice coverage reached the third lowest level since satellite observations began in 1979 -- 25 percent below the 30-year average. The lowest was in 2007 and second lowest in 2008.[12] In May 2010 the extent of Arctic ice decreased at the fastest May melt rate in the satellite record.[13]

One of the strongest indications that ice-albedo feedback is already feeding global warming came in an Australian study published in *Nature* in April 2010. Increased temperatures during spring and summer are lengthening the melt season, so more sea ice is being melted. Researchers found that **declining sea ice is opening up wide areas of dark ocean, so more heat is being absorbed.**[14]

"The findings reinforce suggestions that strong positive ice-temperature feedbacks have emerged in the Arctic, increasing the changes of further rapid warming and sea ice loss," conclude researchers James Screen and Ian Simmonds of the University of Melbourne.

Abnormally high melt rates are also being observed across regions drained by Greenland's three major glaciers: Kangerlussuaq and Helheim on the east coast, and Jakobshavn on the west, as well as ice sheets at the island's northern end. At the vital ocean outlets where ice accumulations over water slow glacier flow, around 350 square miles were lost from the 34 widest glaciers.[15]

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[10] Aradhna K. Tripati et al, "Coupling of CO_2 and Ice Sheet Stability Over Major Climate Transitions of the Last 20 Million Years," *Science*, Dec. 4 2009, Vol. 326. no. 5958, pp. 1394 - 1397

[11] Richard Black, 'Scary' climate message from past," BBC News website , 10 October 2009

[12] http://www.arctic.noaa.gov/reportcard/seaice.html

[13] National Snow and Ice Data Center, "Arctic sea ice extent declines rapidly in May," June 8, 2010, http://nsidc.org/arcticseaicenews/ viewed June 24, 2010

[14] Lauren Morello, "Ice loss accelerates warming in the Arctic – study," Energy & Environment Climate Wire, April 29,2010

[15] http://www.arctic.noaa.gov/reportcard/greenland.html

"Ice sheet contributions to sea level rise today are small, but **accelerating ice mass loss observed on Greenland and Antarctica make dubious any assumption that the ice sheets would survive for centuries**" if GHG concentrations remain at current levels, the Hansen team writes.[16] They note that the geologic record shows less powerful global warming events have brought on sea level changes of several meters per century.[17]

RELEASING NATURAL CARBON – FEEDBACK DANGERS

Release of natural carbon storehouses which dwarf humanity's annual emissions represent another grave concern. This could create climate feedback loops that evade any possibility of human control. **Carbon stores in rapidly warming northern regions are already releasing GHGs, setting up potential for runaway global warming.**[18]

A dramatic warming event that took place 55 million years ago was caused by the release of around 3,000 billion MT of methane hydrates from the ocean floor, scientists believe. Methane is a GHG 30 times more powerful than CO_2. Today that storage of methane in ice form has rebuilt to 5,000 billion MT.[19] **Researchers are discovering methane hydrate deposits are already releasing their carbon.**

In late 2009 scientists reported, "More than 250 plumes of gas bubbles have been discovered emanating from the seabed of the West Spitsbergen continental margin, in a depth range of 150–400 m(492-1,312 feet) . . ." The emissions, mostly methane, came from depths where hydrates are normally stable. "**Warming of the northward-flowing West Spitzbergen current by 1°C over the last thirty years is likely to have increased the release of methane from the seabed. . .** "[20]

More recently, scientists have discovered that hydrates on the continental shelf off eastern Siberia are perforated and leaking seven MT of methane from 100 hot spots.

"The amount of methane currently coming out of the East Siberian Arctic Shelf is comparable to the amount coming out of the entire world's oceans," said lead researcher Natalia Shakhova of the University of Alaska. **"Our concern is that the subsea permafrost has been showing signs of destabilization already."**[21]

"The release to the atmosphere of only one percent of the methane assumed to be stored in shallow hydrate deposits might alter the current atmospheric burden of methane up to

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[16] Hansen et al, p.14
[17] Hansen et al, p.5
[18] Fred Pearce, *With Speed and Violence: Why Scientists Fear Tipping Points in Climate Change*, Beacon Press, Boston, 2007, p.77-85
[19] Hansen, *Storms*, p.161-3
[20] Graham K. Westbrook et al, "Escape of methane gas from the seabed along the West Spitsbergen continental margin," Geophysical Research Letters, Vol. 36, L15608, 5 Pp., 2009
[21] National Science Foundation, "Methane Releases From Arctic Shelf May Be Much Larger and Faster Than Anticipated," Press Release 10-036, March 4, 2010

three to four times," Shakhova said. "The climatic consequences of this are hard to predict."

"**Release of even a fraction of the methane stored in the shelf could trigger abrupt climate warming," said the National Science Foundation.**

Land-based Arctic permafrost is another worrisome feedback threat. New research doubles the estimate of carbon stored there to 1.5 billion MT.

Study co-author Pep Canadell of CSIRO, Australia, notes. **"All evidence to date shows that carbon in permafrost is likely to play a significant role in the 21st century climate** given the large carbon deposits, the readiness of its organic matter to release greenhouse gases when thawed, and the fact that high latitudes will experience the largest increase in air temperature of all regions."[22]

Radioactive carbon dating already shows **most of the CO_2 escaping from thawing Alaska permafrost was stored thousands of years ago.** This "demonstrates how easily carbon decomposes when soils thaw under warmer conditions," said Professor Ted Schuur, University of Florida and co-author of the study.[23]

Though humans generally do not plan centuries or even many decades ahead, the important point is that **we have already crossed the danger line. The longer we wait to respond, the more difficult it will become to restore a planetary "safe space."**

"Humanity's task of moderating human-caused climate change is urgent," the Hansen team concludes. **"It is likely that the level of atmospheric greenhouse gases capable of causing undesirable, even catastrophic effects, has already been passed."**[24]

PULLING BACK FROM THE BRINK

There is still time to pull back. The situation might be compared to red-lining a manual transmission automobile. You can rev the engine beyond the red line on the RPM dial for a bit, but the longer you stay above the line the higher the risk you will burn out the engine.

The problem is energy imbalance. Human-made greenhouse gases have increased energy retained by the Earth by .0.5-1 watts per square meter per year, or the equivalent of one Christmas tree bulb for every one or two square meters of the planet. Multiplied across the Earth's surface, that adds up. By comparison, orbital cycles cause ice ages by reducing incoming energy by less than 0.25 watts per square meter.

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[22] *Science Daily*, "Super-Size Deposits of Frozen Carbon In Arctic Could Worsen Climate Change, July 6, 2009

[23] Ibid

[24] Hansen et al, p.15

But humanity can reduce CO_2 concentrations to 300-350 ppm and correct the energy imbalance by reducing the heat-trapping capacity of the atmosphere. **The critical issue is how long CO_2 remains higher than 350 ppm**. The longer it does, the more time the energy imbalance is extended and the greater the risk of catastrophic consequences such as irreversible disintegration of polar ice and natural carbon sinks.

If humanity begins now to deeply reduce fossil fuel emissions, and at the same time mobilizes the resources of the plant world to absorb CO_2 through photosynthesis, the odds are we will avoid burning out our planet. **The first requirement is a shutdown of coal-fired power plants that release CO_2 into the air.** The Hansen team calculates that **phasing out coal emissions by 2025 in developed nations and 2030 worldwide would halt CO_2 growth to no more than 425 ppm** (this assumes that oil production will reach a peak due to resource limitations, and unconventional substitutes such as tar sands, oil shales and coal-to-liquids will not grow). Capturing and sequestering carbon from gas-fired power plants could halt CO_2 growth at 400 ppm.

The gap of 50-75 ppm reductions in CO_2 concentrations needed to reach target 350 must be filled by the power of nature in the form of photosynthetic process. Just as plants are the origin of fossil fuels, so must they be mobilized to soak fossil carbon out of the atmosphere. Forests, agricultural soils, even vegetation and soils in developed areas, all have a vital role to play. Bringing the power of photosynthesis to bear fully upon the climate challenge will take changes in land management practices, as well as far more efficient use of biomass to replace fossil carbon and cycle carbon back to the land. **This will require new public policies as well as development of new economic instruments, markets and technologies**. Those are detailed in other installments of this series.