NEW SCIENCE DEMONSTRATES NEED FOR AGGRESSIVE CAP ON CARBON POLLUTION

By Amanda Staudt, Ph.D.
National Wildlife Federation
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Overwhelming scientific evidence supports reducing carbon pollution that causes global warming as much as possible and as quickly as possible. Global warming is happening faster than predicted even several years ago, with many natural systems already seriously impacted. Sea-level rise by the end of the century may be two to three times previous projections. Arctic sea ice is melting faster than anticipated even a few years ago. Northern forests are under attack from heat, drought, insects, and fires. And, many of the changes in our climate may be with us for hundreds and thousands of years.

New scientific findings indicate that holding further increases in global temperatures to no more than 2°F above today's levels, which many believe will allow us to avoid dangerous interference with the climate system, may not be enough to protect people and the planet from significant harm after all. Furthermore, a target of 450 ppm CO_2, widely thought to be sufficient for keeping warming below 2°F, only gives us a 50 percent chance of keeping warming that low. More alarming are the early warning signs that we could be approaching tipping points that would cause global warming to accelerate even faster. The United States and the international community must come to terms with an increased sense of urgency to address climate change.

On the Verge of Dangerous Interference with the Climate System

We are living in a warming world. It is not something that is far into the future. It is here and now. Scientists documented major changes to natural systems around the planet in the 2007 report of the Intergovernmental Panel on Climate Change (IPCC).[1] New science published after the IPCC report has shown how global warming is happening faster than anticipated. Sea-level rise may be accelerating, Arctic sea ice is rapidly melting, and forests are being transformed. It is fair to say that some people and species around the globe are already experiencing global warming impacts that could be deemed "dangerous."

Sea-level Rise Rates Larger Than Previously Projected.
Sea-level rise as a consequence of global warming is a foregone conclusion. It only remains to be seen how much and how quickly. The 2007 IPCC report projected global average sea-level rise of 7 to 23 inches by the 2090s.[2] This calculation did not take into account compelling new evidence of recent rapid melting in Greenland and Antarctica,[3] that if continued could lead to sea-level rise of 5 or 6 feet this century (see Figure 1).[4] That much sea-level rise would cause havoc for coastal communities and ecosystems, especially as population and development in coastal regions continue to grow.

A major challenge in projecting sea-level rise is the potential for destabilization and rapid melting of ice sheets, most notably the West Antarctic Ice Sheet (WAIS). Indeed, new data shows that Antarctica has been warming more than previously thought.[5] Complete melting of the WAIS would cause 16 feet of sea level rise globally, and it would expose the United States to even more. A new study shows that if the WAIS collapses, the resulting changes in gravitational pull would cause water to slosh northward, adding another 4.3 feet of potential sea-level rise along northern continents.[6]

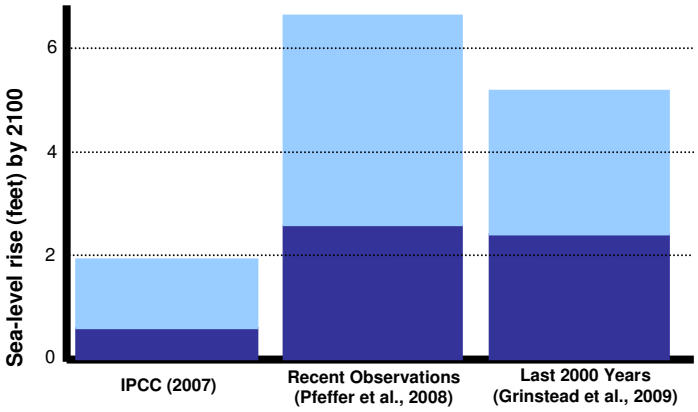

Figure 1: Sea-level rise projections from (1) the IPCC models, (2) the analysis of recent melting in Greenland and Antarctica by Pfeffer and colleagues, and (3) a correlation between sea level and temperatures for the last 2000 years by Grinsted and colleagues. Dark and light blue bars show low and high ends, respectively, of the range of projections.

Widespread Forest Mortality

A 2009 study by Philip van Mantgem and colleagues found that some unmanaged old-growth forests in western North America have recently experienced increased tree mortality due largely to warming and associated drought stress.[7] New seedlings are not keeping pace with this loss of trees, foreshadowing sparser forests in the coming decades. Warmer and drier conditions are also conducive to widespread beetle and other insect infestations.[8] For example, recent reports estimate that more than 32 million acres in western Canada have been decimated by mountain pine beetle infestations since 1999.[9]

It is not surprising that higher temperatures and tree mortality have led to a rapid increase in western wildfires. Warmer springs and longer summer dry periods are linked to a 4-fold increase in the number of major wildfires and a 6-fold increase in the area of forest burned, compared with wildfires between 1970 and 1986.[10]

The loss of these forests not only stops their conversion of carbon dioxide to oxygen and wood products, but also releases the huge quantities of carbon they store into the atmosphere. Forest fires in the United States already release about 80 million tons of carbon to the atmosphere every year.[11] We must find ways to restore our forests and maintain their ability to sequester huge quantities of carbon—even as global warming makes it more challenging.

Arctic Sea Ice Rapidly Melting

In 2007 scientists reported an alarming record low in late-summer Arctic ice. That September the remaining ice was some 39 percent less in area than the average observed from 1979 to 2000.[12] The rapid melting of Arctic ice has outpaced what was projected by models of even a couple years ago (see Figure 2),[13] requiring that the models be revised. Just two years ago the Intergovernmental Panel on Climate Change (IPCC) projected that the Arctic could be ice free during the summer by as early as 2050, but perhaps not until after 2100.[14] In marked contrast to these recent projections, some scientists now say that the Arctic could be ice free in late summer by as early as 2012.[15]

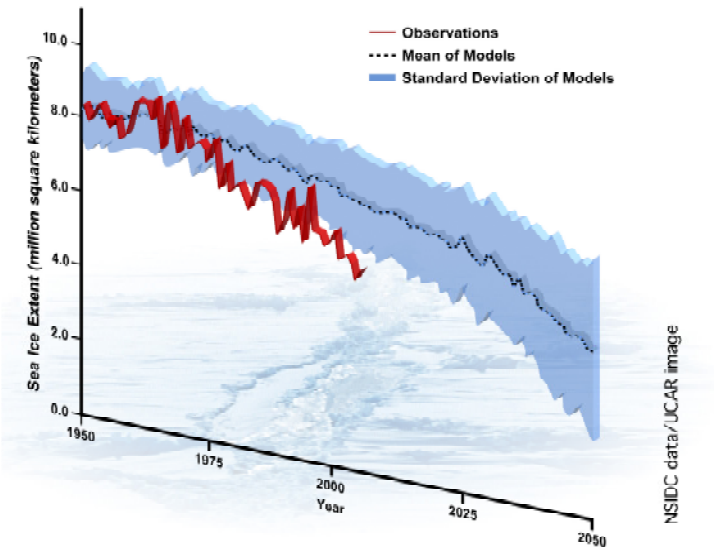

Figure 2: Observations of Arctic September sea-ice extent are significantly below what models from a couple years ago projected. The models are being revised to capture the more rapid melting. Source: NSIDC data/UCAR image.

Carbon Dioxide's Global Warming Capacity is Long-lived

Carbon dioxide (CO_2) already in the atmosphere will contribute to global warming for centuries to come. In a 2009 paper, Susan Solomon and colleagues concluded that long-term CO_2 levels will be significantly above pre-industrial levels, even after emissions have ceased.[16] Furthermore, surface temperatures will decline only slightly from what they are when CO_2 levels peak.

These findings imply that many of the climate changes underway may be essentially irreversible for centuries. For example, shifts in precipitation patterns that are already being observed around the globe could become semi-permanent. This includes a 10 percent decrease in dry-season precipitation in the Southwest United States, a change comparable to what was experienced during the Dust Bowl.[17]

Warning Signs of Triggering Rapid Warming

Some scientists are beginning to raise concerns that we may already be seeing early signs of triggering potential rapid warming. It is possible that global warming could lead to changes in the climate system which in turn cause even more warming. These so-called "positive climate feedbacks"—in particular, those associated with greenhouse gas releases from soils, tundra, or ocean sediments; sea-ice and ice sheet disintegration; and vegetation migration—could make the climate system warm twice as much over the long term than previously calculated by climate models.[18] Furthermore, they could come into play much sooner and more quickly than previously thought.[19]

Melting Permafrost Releasing Methane

Vast areas of permafrost across the northern hemisphere store more than double the amount of carbon already in the atmosphere.[20] Scientists worry that warming in the Arctic—which is proceeding about twice as fast as the global average—will lead to extensive thawing of these frozen landscapes, releasing carbon dioxide and methane, a greenhouse gas about 20-25 times more potent than carbon dioxide.[21] In fact, the permafrost is rapidly degrading. For example, the area of discontinuous permafrost in Canada has increased by a factor of 3 or 4 compared to what it was from 1941-1991.[22] Release of methane from melting permafrost may be one reason that atmospheric methane is on the rise in recent years after staying more or less constant for more than a decade.[23]

Katey Walter and colleagues recently observed a significant source of methane from melting permafrost at the bottom of northern lakes.[24] While still only accounting for about 4 percent of the total methane source, the contribution from lakes is nonetheless worrisome because it could get much larger as warming continues. The lakes in Siberia and Alaska could release an estimated 49 billion tons of methane—10 times more than what is currently in the atmosphere—if they were to thaw completely, a process that could happen within 500 to 1000 years.[25]

Release of Methane in Deep Ocean Ice

Trapped deep in the ocean floor are huge quantities of methane hydrates frozen in ice structures called clathrates. The total amount of marine methane hydrates could be as much as 100 to 2000 times the amount of methane currently found in the atmosphere.[26] If the ocean floor were to warm sufficiently, causing melting or increased underwater landslides, some of this gas could be released and bubble up to the atmosphere, leading to more global warming. A recent survey of the ocean waters above the East Siberian Arctic Shelf may have located the first signs of such methane release. Igor Semiletov and his colleagues measured methane bubbling up at a rate 10 times faster than just a decade ago, contributing to spikes of methane in the atmosphere up to 4 times greater than the global average concentration. [27]

The chances of releasing a large amount of marine methane hydrates are low, and even if some methane were to be released it is still unknown how much would make it through the water column into the atmosphere. But the shear magnitude of the methane stored on the ocean floors—and the radical change

in climate it could provoke—makes the risk of destabilization one we can not ignore. The real possibility of this is demonstrated by the geologic record. Destabilization of methane clathrates found on the ocean floor is suspected as a major contributor to rapid warming about 635 million years ago. [28]

The Loss of Ice Reflectance

The ice covering the Arctic helps regulate our climate, a service that is being lost as more and more ice melts. Ice and snow reflect almost all the sunlight that hits it back to space. In marked contrast, the open ocean, which replaces the melting ice, absorbs nearly all the sunlight hitting it. Thus, as Arctic ice vanishes the region absorbs more of the Sun's energy, causing even more ice to melt in a powerful feedback. Some models show that once average annual temperatures in the Arctic rise to about 23°F or warmer, there will be an abrupt decline of sea ice and acceleration of warming.[29]

Scientists have recently documented how the loss of sea ice translates directly into warmer temperatures as far as 900 miles inland. By looking at the historical record of seasonal sea-ice melt, David Lawrence and his collaborators found that episodes of rapid-sea ice loss were accompanied by warming over adjacent land at a rate 3.5 times more than the average warming expected.[30] This means that sea-ice loss also contributes to thawing permafrost and the release of methane stored in Arctic soils.

The Declining Ability of the Ocean and Terrestrial Biosphere to Store Carbon

Over the last century, the ocean and the terrestrial biosphere have absorbed more than half of the fossil fuel CO_2 emitted to the atmosphere, limiting the warming we have experienced so far. But, these carbon sinks are becoming less efficient. The ocean's ability to absorb additional CO_2 declines as it becomes more and more saturated with it. In fact, the rate of CO_2 absorption by the Southern Ocean has decreased by about 35 percent since 1981[31] and that of the North Atlantic decreased by 50 percent from 1995 to 2005.[32] If emissions continue on a business-as-usual track, the declining ability of the oceans and land to absorb CO_2 will translate into additional warming of more than 1.8°F over the next century.[33]

Gambling with Climate Catastrophe

For the last several years, it has been widely thought that we must keep global warming to no more than 3.6°F (2°C) above pre-industrial levels, or about 2°F above today's levels, to avoid dangerous interference with the climate system.[34] Analyses summarized by the IPCC in 2007 suggest that stabilizing CO_2 at 450 ppm will enable us to meet this goal.[35] However, recent scientific findings on the extent of impacts we are already witnessing, the increasing awareness that many of these impacts will be irreversible, and a closer look at the analyses of emissions scenarios presented in the IPCC report lead to the conclusion that this goal may not be sufficiently aggressive.

The Impacts of a 2°F Warming above Today's Levels

Global warming is causing unsafe impacts today, and continuing on a pathway that more than doubles the warming we have had to date will significantly disrupt communities and habitats worldwide. The extent of climate disruption accompanying a 2-3°F warming is beyond what many may realize. For example:

- As much as a third of species are at increased risk of extinction if global temperatures exceed about 2-3°F above present day levels.[36] These extinctions will be accompanied by major changes in how ecosystems are structured and function.
- If recent projections are accurate, 2-3°F warming could bring about 3 feet of global sea-level rise.[37] This would displace approximately 56 million people in 84 developing countries around the world.[38]
- Global warming will create significant human health threats around the globe, including heat-related illness, worsening air pollution, extreme weather events, and a rise of infectious diseases.

For example, extremely hot days that now happen only once every 20 years will take place about every 3 years over most of the continental United States by the 2050s.[39]

- Severe drought will affect many regions of the world, including parts of the United States. By the 2050s, 670 million to 2.76 billion more people around the world may be experiencing water stress, depending on how fast population grows.[40]
- Coral reefs will be even less diverse and lose their carbonate structures, in part due to warmer water and ocean acidification.[41]

450 ppm CO_2 is a Gamble

Even if we are willing to accept the inevitable impacts associated with a 2°F warming above today's levels, it is by no means certain that stabilizing CO_2 at 450 ppm will enable us to keep warming that low. In fact, stabilizing at 450 ppm CO_2 provides only a 50 percent chance of holding warming to less than 2°F.[42] To reduce the likelihood of exceeding 2°F to less than 30 percent, we would need to stabilize CO_2 at 350 ppm (see Table 2). This lower goal presents significant challenges because we are already at 384 ppm of CO_2. Nonetheless, some scientists are now making a compelling case that we should aim to stabilize CO_2 at 350 ppm.[43]

Scientists are only beginning to consider the pathways that might get us to stabilization targets below 450 ppm CO_2. There will obviously need to be a period of "overshoot," during which CO_2 levels exceed the long-term target, and questions remain as to how long we can afford to overshoot without triggering more catastrophic changes. And, if the overshoot period needs to be shorter, there is the challenge of how to remove CO_2 from the atmosphere more rapidly than the slow draw down that oceans and terrestrial biosphere would naturally do.

Table 2: Likelihood of exceeding temperature thresholds for different CO_2eq stabilization targets[44]

CO_2eq Stabilization target	Chance of exceeding 2°F warming above today	Chance of exceeding 3.8°F warming above today
350 ppm	0-30%	0-20%
450 ppm	25-75%	10-60%
550 ppm	65-100%	40-90%

Note: Emissions scenarios do not include an overshoot of the stabilization target.

CO_2 Emissions Continue to Climb

Even as we witness climate change impacts, CO_2 emissions are increasing faster than anyone expected. In the 1990s, CO_2 emissions increased at a rate of about 1.3 percent per year. From 2000 to 2006, they grew at 3.3 percent per year.[45] Continuing on this path could bring atmospheric CO_2 levels to 650 ppm (or higher)[46] and near certainty of exceeding 2°F warming above today's levels.[47] There is no doubt that the impacts associated with this much warming would radically affect human societies and ecosystems as we know them.

The longer we wait, the more we lock into fossil fuel infrastructure that has a lifespan of decades. Not only will we continue to put CO_2 into the atmosphere, but we will make it more difficult and expensive to meet long-term targets, especially if it means that we will need more rapid and drastic emissions cuts in the future.[48] The bottom line is that we cannot afford to delay taking action much longer.

The Time for Action is Now: Recommendations for Congress

Congress must heed the scientific evidence of global warming and take effective action to minimize its extent and impacts as soon as possible. With emissions of CO_2 continuing to rapidly increase, and the consequences of warming adding up, action is needed now. Scientific information should play a prominent and explicit role in the design of global warming legislation, especially in determining the caps for CO_2 emissions.

Overwhelming scientific evidence supports reducing carbon pollution that causes global warming as much as possible and as quickly as possible. Global warming is happening faster then predicted even several years ago, with many natural systems already seriously impacted. New scientific findings indicate that holding further increases in global temperatures to no more than 2°F above today's levels may not be enough to protect people and the planet from significant harm. Furthermore, a target of 450 ppm CO_2, widely thought to be sufficient for keeping warming below 2°F, only gives us a 50 percent chance of keeping warming that low. More alarming are the early warning signs that we could be approaching tipping points that would cause global warming to accelerate even faster. The United States and the international community must come to terms with an increased sense of urgency to address climate change.

The potential impacts on humans and ecosystems must be explicitly considered in setting carbon emission targets. We need to continue the tradition of setting environmental standards to address adverse public health and welfare impacts, based on the latest science. The current policy dialogue has muddled the consideration of what we need to do to protect the planet, with the emissions reductions that currently available technologies are expected to deliver. Leading with technology, versus what the science dictates, makes it all too likely that emission reduction targets will be insufficient to prevent major and irreversible impacts to humans and the natural resources upon which we depend.

Investments in new technologies are required to achieve the necessary emission reductions to avoid worst-case scenarios. Solving the climate crisis will require innovation in every sector of society, from how we produce and use energy to how we supply drinking water and build our homes, to what products we buy. History has repeatedly shown that setting standards based on what is necessary to protect human health and safety has spurred development of previously non-existing technology, in some cases enabling us to meet environmental standards at lower cost than originally estimated. In fact, putting a clear and stable regulatory framework in place provides industry with the long-term assurance of a market for new technologies and is a strong force for generating private and public investment dollars.

An explicit process for periodically reviewing the science and adjusting emission caps as needed is essential. As we learn more about how the climate system is responding to added carbon dioxide and other greenhouse gases in the atmosphere, and possibly confront unanticipated abrupt climate changes, it will be critical to have the ability to adjust the caps accordingly. Scientific reviews should be mandated about every 5-10 years and the Administration should be required to respond with revised emissions reduction targets or a clear rationale for keeping the existing caps.

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