PUBLIC COMMENT

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in Response to the Environmental Protection Agency's Advanced Notice of Proposed Rulemaking on Regulating Greenhouse Gas Emissions Under the Clean Air Act, Docket ID No. EPA–HQ–OAR–2008–0318

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EXECUTIVE SUMMARY

In the Advanced Notice of Proposed Rulemaking (ANPR), published on 30 July 2008, the Environmental Protection Agency (EPA) solicited comment on analyses and policy alternatives regarding greenhouse gas (GHG) effects and regulation under the Clean Air Act (CAA). In particular, the EPA Administrator invited comment on "all issues relevant to making an endangerment finding, including the scientific basis supporting a finding that there is or is not endangerment under the CAA, as well as the potential scope of the finding (i.e., public health, welfare, or both)."

For several *decades* now, personnel in our organization have been working and publishing on matters related to earth's rising atmospheric carbon dioxide (CO_2) concentration as they pertain to both the climate and biology of our planet. During the course of that endeavor, we have examined literally *thousands* of peer-reviewed scientific journal articles, the results of which examination have led us to conclude that increasing atmospheric CO_2 concentrations will exert a relatively benign influence on earth's climate, while simultaneously providing manifold benefits to humanity and nature alike.

Support for this thesis has been presented by us via the publication of *CO_2 Science*, an online journal created in 1998 by the non-profit Center for the Study of Carbon Dioxide and Global Change (www.co2science.org), where we have published editorials on topics of current concern and mini-reviews of recently published peer-reviewed scientific journal articles, books, and other educational materials. During that time we have amassed an incredible amount of material, arguably the largest database of its kind on the Internet, all of which material has been archived in a massive *Subject Index* that presently contains hundreds of topics and sub-topics relevant to the global warming debate.

Although it is impossible for us to reproduce the volume of information contained in our website that supports our thesis here, we have elected to present a subset of the topics and issues we feel will be most helpful to the EPA Administrator in making a ruling on the Endangerment Issue. Many of the studies we cite are not referenced in the Endangerment Technical Support Document (TSD) to the ANPR, which makes it particularly important for the Administrator to review this material in order to ensure, as stated in the ANPR, that the "totality of the observed and projected effects that result from current and projected [greenhouse gas] concentrations" have indeed been investigated.

To assist the EPA in its evaluation of such materials, we have included hyperlinks throughout this document by which the Administrator may locate additional information on a given topic, as posted on our website, via the simple act of clicking a computer mouse. We begin by presenting a list of key findings as contained in the TSD's Executive Summary (**bolded typeface for ease of identification**), followed by our bulleted response to those findings, which are then fully addressed in the chapters of our submitted report below.

Comments on the Key Findings in the TSD Executive Summary

The global average net effect of the increase in atmospheric GHG concentrations, plus other human activities (e.g., land use change and aerosol emissions), on the global energy balance since 1750 has been one of warming.

The majority of future reference-case scenarios (assuming no explicit GHG mitigation actions beyond those already enacted) project an increase of global GHG emissions over the century, with climbing GHG concentrations and rising net positive radiative forcing.

Through about 2030, the global warming rate is affected little by different scenario assumptions or different model sensitivities.

All of the U.S. is very likely to warm during this century, and most areas of the U.S. are expected to warm by more than the global average.

- Today's state-of-the-art climate models suffer from a number of major inadequacies stemming from both the treatment and *non*-treatment of pertinent phenomena, some of which deficiencies could alter even the *direction* of projected climate change.
- The set of problems that currently restricts our ability to properly model a whole suite of cloud-related processes likewise restricts our ability to simulate future climate with any degree of confidence in the accuracy of the results.
- Climate models have failed to accurately reproduce observed patterns and magnitudes of various other important climate-related parameters.
- Numerous scientific studies suggest that the model-derived sensitivity accepted by the Intergovernmental Panel on Climate Change (IPCC) is far too large, and that feedbacks in the climate system could reduce it to values that may be an *order of magnitude* smaller.
- Biologically-driven phenomena could totally compensate for the warming influence of all anthropogenic CO_2 emissions experienced to date, as well as all those that are anticipated to occur in the future.
- Numerous studies in the scientific literature suggest that the climatic cooling effect of aerosols has been underestimated. In fact, the *negative* radiative forcing of aerosols may be as large as, or larger than, the *positive* radiative forcing due to anthropogenic CO_2 emissions.
- Atmospheric methane has remained nearly constant since the late 1990s. This is a most important finding, because methane's contribution to anthropogenic radiative forcing, including direct and indirect effects, is about half that of CO_2.
- As the air's CO_2 content -- and possibly its temperature -- continues to rise, we can expect to see a significant increase in the rate of methane removal from earth's atmosphere, which should help to reduce the potential for further global warming.

Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level. Global mean surface temperatures have risen by 0.74°C (1.3°F) over the last 100 years.

- Several glaciers have experienced little or reduced rates of melting, with some actually *advancing*, over the past quarter-century, a period of time in which it is claimed that the earth has warmed to its highest temperature of the past thousand or more years.
- Sea ice area and extent have continued to *increase* around Antarctica over the past few decades.
- Evidence shows that much of the reported thinning of Arctic sea ice that occurred in the 1990s -- *if real*-- was *not* the result of CO_2-induced global warming. Rather, it was a natural consequence of changes in ice dynamics caused by an atmospheric *regime shift*, of which there have been several in decades past and will likely be several in the decades to come, totally irrespective of past or future changes in the air's CO_2 content. Whether *any* portion of past sea ice thinning was due to anthropogenic CO_2 emissions is currently unknown, for temporal variability in Arctic sea-ice behavior is simply too great to allow such a small and slowly-developing signal to be detected yet.
- The entire history of anthropogenic CO_2 emissions since the inception of the Industrial Revolution has had *no discernable impact* on Greenland air temperatures.

Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations.

- Based on a synthesis of real-world data, the claim that temperatures over the latter part of the 20th century were higher than those experienced at any other time over the past one to two millennia is found to be false. Thus, the corollary claim that anthropogenic CO_2 emissions from the burning of fossil fuels have caused the planet's current "unprecedented" warmth cannot be substantiated; because late 20th-century temperatures are *not* unprecedented, falling well within the range of natural millennial-scale variability. Consequently, there is no compelling reason to believe that the historical rise in the atmosphere's CO_2 concentration had any significant impact on 20th century temperatures, since it was warmer than it is now fully 1000 years ago, when there was 25% less CO_2 in the air than there is today.

Widespread changes in extreme temperatures have been observed in the last 50 years across all world regions including the U.S.

- Air temperature variability almost always *decreases* when mean air temperature *rises*, be it in cases of temperature change over tens of thousands of years or over mere decades, or even between individual cooler and warmer years when different ENSO states are considered. The claim that global warming will lead to more extremes of climate and weather, including more extremes of temperature itself, is not supported by real-world data.

Observations show that changes are occurring in the amount, intensity, frequency and type of precipitation.

- There is no support for the model-based projection that precipitation in a warming world becomes more variable and intense. In fact, some observational data suggest just the opposite, and provide support for the proposition that precipitation responds more to cyclical variations in solar activity than to anything else.

Intensity of precipitation events is projected to increase in the U.S. and other regions of the world, increasing the risk of flooding, greater runoff and erosion, and thus the potential for adverse water quality effects.

- Claims of floods and droughts becoming more extreme and erratic in response to global warming are not supported by real-world observations. If anything, the data tend to suggest just the *opposite*.
- In the vast majority of cases, observed trends in streamflow characteristics appear to be just the *opposite* of what is predicted to occur by climate models, leading to less frequent and severe flood and drought conditions.
- Studies of observed frequencies and maximum intensities of tropical cyclones show no consistent upward trend. In fact, many studies have actually found yearly hurricane numbers to *decline* as temperatures rise.

There is strong evidence that global sea level gradually rose in the 20th century and is currently rising at an increased rate.

- The mean rate of global sea level rise has *not* accelerated over the recent past. If anything, it's done just the *opposite*.

By the end of the century, sea level is projected to rise between 0.18 and 0.59 meters relative to around 1990.

- There is considerable uncertainty associated with a number of basic parameters that are related to the water balance of the world's oceans and the meltwater contribution of Greenland and Antarctica; and until these uncertainties are satisfactorily resolved, we cannot be confident that we know what is happening in terms of phenomena related to the vertical displacement of the upper surface of the world's oceans.

Sea level is rising along much of the U.S. coast, and the rate of change will increase in the future, exacerbating the impacts of progressive inundation, storm-surge flooding, and shoreline erosion. Storm impacts are likely to be more severe ...

- As the earth has warmed over the past hundred and fifty years, during its recovery from the global chill of the Little Ice Age, there has been no significant increase in either the frequency or intensity of stormy weather. In fact, most studies suggest just the *opposite* has likely occurred.
- Storm surges have definitely *not* increased in either frequency or magnitude. In the majority of cases investigated, in fact, they have actually tended to decrease.

Climate warming may increase the possibility of large, abrupt, and unwelcome regional or global climatic events (e.g., disintegration of the Greenland Ice Sheet or collapse of the West Antarctic Ice Sheet).

- The results of several research studies argue strongly against predictions of future catastrophic disintegration of the Greenland or Antarctic Ice Sheet caused by CO_2-induced global warming. In fact, in the case of Antarctica, they suggest just the *opposite*, i.e., that CO_2-induced global warming would tend to *buffer* the world against such an outcome.

Severe heat waves are projected to intensify in magnitude and duration over the portions of the U.S. where these events already occur, with likely increases in mortality and morbidity, especially among the elderly, young and frail.

- Global warming will likely *reduce* the number of lives lost to extreme thermal conditions, as many more people die from unseasonably cold temperatures than from excessive warmth.
- Global warming reduces the incidence of cardiovascular disease related to low temperatures and wintry weather by a much greater degree than it increases the incidence of cardiovascular disease associated with high temperatures and summer heat waves.
- Claims of malaria expanding across the globe and intensifying *as a result of CO_2-induced warming* are not supported in the scientific literature.
- There is ample reason to believe that the historical increase in the air's CO_2 content has played a prominent role in enhancing many aspects of human health over the course of the Industrial Revolution, and that its continued upward trend will provide ever more of the same benefits, not the least of which is *increased longevity*.

- From what has been learned about plant proteins, antioxidants and the few medicinal substances that have been investigated, there is ample evidence to suggest they may well be present in significantly *greater* concentrations, and *certainly* in greater *absolute amounts* in a CO_2-enriched world of the future than they are currently.

Disturbances like wildfire ... are increasing and are likely to intensify in a warmer future with drier soils and longer growing seasons.

- Although one can readily identify specific parts of the planet that have experienced both significant increases and decreases in land area burned over the last two to three decades of the 20th century, *for the globe as a whole* there was absolutely *no* relationship between global warming and total area burned over this latter period, during which time it is claimed the world warmed at a rate and to a degree that were both unprecedented over the past several millennia.

Moderate climate change in the early decades of the century is projected to increase aggregate yields of rainfed agriculture by 5-20% in the U.S., but with important variability among regions.

- A 300-ppm increase in the air's CO_2 content typically raises the productivity of most herbaceous plants by about *one-third*; and this positive response occurs in plants that utilize all three of the major biochemical pathways (C_3, C_4, CAM) of photosynthesis. For woody plants, the response is even *greater*.
- The productivity benefits of CO_2 enrichment are also experienced by aquatic plants, including freshwater algae and macrophytes, and marine microalgae and macroalgae.
- Although atmospheric CO_2 enrichment tends to increase the growth of plants under a wide range of soil nitrogen concentrations, including some that are very low, considerably greater CO_2-induced enhancements are possible when more soil nitrogen is available.
- The ongoing rise in the air's CO_2 content is a powerful antidote for the deleterious biological impacts that might possibly be caused by an increase in the flux of UV-B radiation at the surface of the earth due to any further depletion of the planet's stratospheric ozone layer.
- Many peer-reviewed studies suggest that as the CO_2 content of the air rises, plants may not necessarily exhibit photosynthetic acclimation, even under conditions of low soil nitrogen; for if a plant can maintain a balance between its sources and sinks for carbohydrates at the whole-plant level, acclimation should not be necessary. In addition, because earth's atmospheric CO_2 content is rising by an average of only 1.5 ppm per year, most plants should be able to either (1) adjust their relative growth rates by the small amount that would be needed to prevent low nitrogen-induced acclimation from ever occurring, or (2) expand their root systems by the small amount that would

be needed to supply the extra nitrogen required to take full advantage of the CO_2-induced increase in leaf carbohydrate production. However, in the event that a plant cannot initially balance its sources and sinks for carbohydrates at the whole-plant level, CO_2-induced acclimation represents a beneficial secondary mechanism for achieving that balance through redistributing limiting resources away from the plant's photosynthetic machinery to strengthen sink development or enhance other nutrient-limiting processes.

- The ongoing rise in the air's CO_2 content likely will *not* favor the growth of weedy species over that of crops and native plants.
- The growth of plants is generally not only enhanced by CO_2-induced increases in net photosynthesis during the light period of the day, it is also enhanced by CO_2-induced decreases in respiration during the dark period.
- As the air's CO_2 content continues to rise, earth's plants will likely respond by reducing the amount of nitrogen invested in rubisco and other photosynthetic proteins, while still maintaining enhanced rates of photosynthesis, which consequently should increase their photosynthetic nitrogen-use efficiencies. In addition, enhanced rates of photosynthetic carbon uptake invariably lead to greater biomass production, which often occurs without proportionally increasing soil nitrogen uptake and thus enhances plant nitrogen-use efficiency as well. Hence, as overall plant nitrogen-use efficiency increases with the ongoing rise in the atmosphere's CO_2 concentration, it is likely that plants will grow ever better on soils containing less-than-optimal levels of this important soil nutrient.
- The rising CO_2 content of the air will likely enhance the development of more extensive plant root systems that will extract enhanced amounts of mineral nutrients from the soils in which the plants are rooted.

Recent studies indicate that climate change scenarios that include increased frequency of heat stress, droughts and flooding events reduce crop yields and livestock productivity beyond the impacts due to changes in mean variables alone.

- As the air's CO_2 content continues to rise, plants will likely exhibit enhanced rates of photosynthesis and biomass production that will *not* be diminished by any global warming that might occur concurrently. In fact, if the ambient air temperature *rises*, the growth-promoting effects of atmospheric CO_2 enrichment will likely rise right along with it, becoming more and *more robust*.
- The amount of carbon plants gain per unit of water lost – or *water-use efficiency* – typically rises as the CO_2 content of the air rises, greatly increasing their ability to withstand drought. In addition, theCO_2-induced *percentage* increase in plant biomass production is often *greater* under water-stressed conditions than it is when plants are well-watered.
- Atmospheric CO_2 enrichment helps ameliorate the detrimental effects of several environmental stresses on plant growth and development, including high soil salinity, high

air temperature, low light intensity and low levels of soil fertility. Elevated levels of CO_2 have additionally been demonstrated to reduce the severity of low temperature stress, oxidative stress, and the stress of herbivory. In fact, the percentage growth enhancement produced by an increase in the air's CO_2 concentration is often even greater under stressful and resource-limited conditions than it is when growing conditions are ideal.

Climate change is expected to lead to increases in regional ozone pollution, ... tropospheric ozone has significant adverse effects on crop yields, pasture and forest growth and species composition.

- Elevated CO_2 reduces, and nearly always *completely overrides*, the negative effects of ozone pollution on plant photosynthesis, growth and yield.
- The ongoing rise in the atmosphere's CO_2 concentration will lead to ever greater reductions in atmospheric isoprene concentrations, a highly reactive *non-methane hydrocarbon* (NMHC) that is emitted in copious quantities by vegetation and is responsible for the production of vast amounts of tropospheric ozone.

Climate variability and change also modify the risks of pest and pathogen outbreaks.

- Rising atmospheric CO_2 concentrations may reduce the frequency and severity of pest outbreaks that are detrimental to agriculture, forests and grasslands, while not seriously impacting herbivorous organisms found in natural ecosystems that are normally viewed in a more favorable light.
- The ongoing rise in the air's CO_2 content will *not* result in greater damage to earth's vegetation by insects inhabiting the planet. If anything, it could well *reduce* the damage they cause.
- Atmospheric CO_2 enrichment asserts a greater influence on *infected* as opposed to *healthy* plants. Moreover, it would appear that elevated CO_2 has the ability to significantly ameliorate the deleterious effects of various stresses imposed upon plants by numerous pathogenic invaders.
- Elevated CO_2 generally tends to reduce the negative effects of parasitic infection, so that infected host plants continue to exhibit positive growth responses to elevated CO_2. Thus, it is likely that whatever the scenario with regard to parasitic infection, host plants will fare better under higher atmospheric CO_2 conditions than they do currently.

Although recent climate trends have increased vegetation growth, continuing increases in disturbances are likely to limit carbon storage, facilitate invasive species, and disrupt ecosystem services.

- CO_2-induced increases in plant photosynthetic rates and biomass production will likely result in more organic carbon being returned to the soil.
- The *aerial fertilization effect* of the ongoing rise in the air's CO_2 concentration (which greatly enhances vegetative productivity) and its *anti-transpiration effect* (which enhances plant water-use efficiency and enables plants to grow in areas that were once too dry for them) are stimulating plant growth across the globe in places that previously were too dry or otherwise unfavorable for plant growth, leading to a significant *greening of the Earth*.
- The ongoing rise in the air's CO_2 content, as well as any degree of warming that might possibly accompany it, will not materially alter the rate of decomposition of the world's soil organic matter. Hence, the rate at which carbon is sequestered in the world's soils should continue to increase, as a joint function of the rate at which the productivity of earth's plants is increased by the aerial fertilization effect of the rising atmospheric CO_2 concentration and the rate of expansion of the planet's vegetation into drier regions of the globe that is made possible by the concomitant CO_2-induced increase in vegetative water use efficiency.
- Research conducted to date strongly suggests that the CO_2-induced enhancement of vegetative carbon sequestration will not be reduced by any future rise in air temperature, regardless of its cause. In fact, it is likely that in a CO_2-eriched atmosphere, any increase in temperature will actually *enhance* biological carbon sequestration.
- Continued increases in the air's CO_2 concentration and temperature will *not* result in massive losses of carbon from earth's peatlands. Quite to the contrary, these environmental changes – if they persist – would likely work together to *enhance* carbon capture by these particular ecosystems.
- The combination of greater root growth at elevated CO_2 combined with a decrease in root decomposition will lead to a longer residence time of carbon in the soil and, therefore, higher carbon storage or sequestration.
- Earthworms and soil nematodes respond to increases in the air's CO_2 content, via a number of plant-mediated phenomena, in ways that further enhance the positive effects of atmospheric CO_2 enrichment on plant growth and development, while at the same time helping to sequester more carbon more securely in the soil and thereby reducing the potential for CO_2-induced global warming.

Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases.

Over the 21st century, changes in climate will cause species to shift north and to higher elevations and fundamentally rearrange U.S. ecosystems.

- With respect to plants, as long as the atmosphere's CO_2 concentration rises in tandem with its temperature, most of them will not "feel the heat," as their physiology will change in ways that make them better adapted to warmer conditions. Hence, although earth's plants will likely spread poleward in latitude and upward in elevation at the cold-limited boundaries of their ranges in response to a warming-induced opportunity to do so, their heat-limited boundaries will probably remain pretty much as they are now or shift only slightly. Consequently, in a world of rising atmospheric CO_2 concentration, the ranges of most of earth's plants will likely *expand* if the planet continues to warm, making terrestrial plant extinctions even *less* likely than they are currently.

- In response to increases in atmospheric temperature and CO_2 concentration, land animals tend to migrate poleward and upward, where cold temperatures prevented them from going in the past, as they follow earth's plants, while the heat-limited boundaries of their ranges are often little affected, allowing them to also expand their ranges.
- With respect to marine life – and especially that of calcifying organisms such as corals and coccolithophores – neither increases in *temperature*, nor increases in atmospheric *CO_2 concentration*, nor increases in both of them *together*, have had any ill effects on the important processes of calcification and growth. In fact, out in the real world of nature, these processes have actually responded *positively* to the supposedly unprecedented concomitant increases in these two parameters.

Climate change impacts in certain regions of the world may exacerbate problems that raise humanitarian and national security issues for the U.S.

- The aerial fertilization effect of the increase in the air's CO_2 content that is expected to occur by the year 2050 will be *just barely sufficient*, in the mean, to assure the agricultural productivity required to prevent mass starvation in many parts of the globe without usurping what little of the natural world would remain at that time.
- Letting the evolution of technology take its *natural* course, with respect to anthropogenic CO_2 emissions, would appear to be the only way we will ever be able to grow enough food to support ourselves in the year 2050 without taking unconscionable amounts of land and freshwater resources from nature and decimating the biosphere in the process.
- Growing crops for biofuel production leads to a number of unintended consequences. Not only does it limit the ability of the world's poor to purchase the food they so desperately need to sustain themselves, it does *irreparable harm* to "wild nature," as native plants and animals lose ever more habitat and freshwater resources to the biofuels enterprise, which is rapidly advancing the time of their ultimate disappearance from the face of the earth, as they are inexorably driven to extinction.