

S.Happer

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REBUTTALS TO: Polasky, Hanemann, Abraham, Dessler, Gurney

p.4 "contention that "the temperature increase for doubled CO2 levels appears to be close to the feedback-free doubling sensitivity, which is about $\Delta T = 1 \text{ K}$ O2. But no strong feedback mechanism has yet been validated..."

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p.6 IRIS

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p.12 "Yes, the overwhelming evidence indicates that a moderate amount of warming – a couple of degrees K – will improve crops, lengthen growing seasons, reduce winter heating bills without increasing summer cooling costs much (because the effects of warming will be more pronounced in the winter than the summer)."

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p.13 "the Earth is currently in a CO2 famine, with levels dramatically *lower* than during most 5 of the last 550 million years, the Phanerozoic Eon.

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pp.20-21 Problem with figure and its misleading citation

D.Happer, p.103: Figure 8: Greening of the Earth as observed by satellites.

"Satellite observations like those of Fig. 8 from R. J. Donohue [19] ...

[19] R. J. Donohue, M. L. Roderick, T. R. McVicar, and G. D. Farquhar, Impact of CO2 fertilization on maximum foliage cover across the globe's warm, arid environments, Geo- physical Research Letters 40, 3031-3035 (2013)."

R.Gurney. pp.24-25 showed Donohue et al(2013) lacked any such figure and that "paper arrives at a far narrower set of conclusions regarding CO2 fertilization concluding that a "...14% increase in atmospheric CO2 (1982-2010) led to a 5 to 10% increase in green foliage cover in warm, arid environments."

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See pp.27-30 for material added to disentangle this misleading reference, followed by another.

OAH Docket No. 80-2500-31888

MPUC Docket No. E-999-CI-14-643

Sur-Rebuttal Report of

Professor William Happer

September 10, 2015

PROFESSOR WILLIAM HAPPER

OAH 80-2500-31888

MPUC E-999/CI-14-643

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1 **Happer Sur-Rebuttal**

2 **Q: Are you the same William Happer who has testified previously in this**
3 **proceeding?**

4 A: Yes, I am.

5 **Q: How do you intend to organize your testimony?**

6 A: I will address the following points:

- 7 • The most recent climate science indicates a low equilibrium climate sensitivity
- 8 and climate models do not account for it;
- 9 • the hiatus in warming is real; and
- 10 • the effects of moderate warming are generally beneficial.

11 **I. Climate Models**

12 **Q: Some of the opposing witnesses accuse you of “cherry-picking” the data to**
13 **support your conclusions. What do you say to that?**

14 A: I think the opposite is true. I am using all available information to judge how well
15 climate models comport with the observational data over the past two decades. All the data
16 points in the same direction, and it shows that the computer models have exaggerated the
17 warming caused by additional CO₂ by several hundred percent. These flawed models have
18 predicted several times more warming than has actually occurred. As scientists, we need to
19 follow what the data says. We need to look at the observational data and what the planet is
20 telling us.

1 **Q: Dr. Dessler criticizes your testimony on equilibrium climate sensitivity (“ECS”),**
2 **noting sources suggesting “values nearer to the top of the IPCC range.” Do you agree with**
3 **his criticism?**

4 A: No. Dr. Dessler criticizes me for my contention that “the temperature increase for
5 doubled CO₂ levels appears to be close to the feedback-free doubling sensitivity, which is about
6 S= 1 K.”¹ Dr. Dessler points to recent studies which suggest “ECS values nearer to the top of the
7 IPCC range,” and he argues that “none of the credible peer-reviewed literature cited supports ...
8 those claims [of low ECS].” There is actually plenty of peer-reviewed literature that supports a
9 climate sensitivity much lower than S = 3 °C. For Dr. Dessler, “credible peer-reviewed
10 literature, apparently means any papers that argue for a climate sensitivity near the top of the
11 IPCC range. Peer-reviewed papers that consider the most straightforward explanation for the
12 lack of warming over the past 15 years – a climate sensitivity much less than S = 3 K – are not
13 credible, by his definition.

14 To the contrary, as I explained in my testimony, the direct effect on temperatures of
15 doubling atmospheric CO₂ concentrations is roughly one degree K. Only by finding some sort of
16 positive feedback mechanism (principally water vapor) are global warming proponents able to
17 predict sensitivity values of S = 3 K or higher for doubling CO₂. But no strong feedback
18 mechanism has yet been validated, despite vigorous attempts by global warming proponents to
19 do so. If there were a strong positive feedback, we would not have experienced a lack of surface
20 warming for the past 15 or more years.

¹ It does not matter whether one uses Kelvin or Celsius in describing a change in temperature, as we are for climate sensitivity (S): 1 K = 1 °C.

1 Without a feedback mechanism, the entire claim for a high sensitivity value from
2 doubling CO₂ collapses. At this time, the existence of a strong feedback mechanism must be
3 regarded as an apparently failed hypothesis. I note that Dr. Hanemann's direct testimony refers to
4 "the scientific uncertainty that exists regarding this parameter [climate sensitivity] which is the
5 key to summarizing the response of the global climate system to increased radiative forcing from
6 the accumulation of GHGs in the atmosphere." (Hanemann Direct 46:18-20.) Dr. Polasky's
7 direct testimony similarly admitted: "There is uncertainty regarding how much the global
8 temperature will increase from greater CO₂ concentrations." (Polasky Direct 10:2-3.)

9 The most recent peer-reviewed literature and scientific understanding is questioning the
10 level of feedback mechanisms assumed by climate models. The strong feedback mechanisms
11 assumed by the models have not been identified and proven. As I explained in my initial
12 testimony (at 7:13-8:2), the most recent scientific understanding validates low levels for
13 feedbacks, placing ECS close to 1 K, rather than to 3 K.

14 **Q: Can you list some of those sources?**

15 A: I have done so in my responses to discovery, which were included as Exhibit 2 to my
16 rebuttal testimony. I would also indicate the sources Prof. Lindzen has cited as well.

17 **Q: Do you rely on "credible peer-reviewed literature"?**

18 A: Yes. I have cited many such sources in my direct and rebuttal testimony. I have
19 demonstrated that "credible peer reviewed literature" shows that climate models have predicted
20 far too much warming for years because of excessively high ECS values. One example of such
21 as study is J. C. Fyfe, N. P. Gillett, F. W. Zwiers, Overestimated Global Warming over the Past
22 20 Years, Nature Climate Change 3, 767 (2013).

1 The recent work by Mauritsen and Stevens (2015), which revisits the “iris effect” of
2 Professor Lindzen², is especially impactful. The first portion of their abstract reads: “Equilibrium
3 climate sensitivity to a doubling of CO₂ falls between 2.0 and 4.6 K in current climate models,
4 and they suggest a weak increase in global mean precipitation. *Inferences from the observational*
5 *record, however, place climate sensitivity near the lower end of this range* and indicate the
6 models underestimate some of the changes in the hydrological cycle.” (Emphasis added.) I
7 would add that the observational evidence of little or no warming for almost 20 years is more in
8 accord with Professor Lindzen’s estimate of an equilibrium sensitivity of about S = 1 K.

9 Note that Figure 5 in my original testimony (Happer Direct, Ex. 2 (Report) at 7 (Fig. 5))
10 is from *Nature* and makes the same point as the non-peer reviewed graph in Figure 4. The chart
11 (reprinted below)³ is based on data from the UK’s chief weather office, and it shows that climate
12 models are woefully off-target in predicting temperature. The hatched red area is where the
13 observational data are. The grey bars are where the models are.

This paper has long been refuted many times.

The IRIS effect claimed that clouds would lessen in the tropics, allowing more longwave radiation to escape, and thus be a negative feedback, but in fact, less clouds also means that more shortwave energy enters.

Trenberth, K. E., Y. Zhang, and J. T. Fasullo, 2015: Relationships among top-of-atmosphere radiation and atmospheric state variables in observations and CESM. *J. Geophys. Res.*, 120, 10,074-10,090, doi:10.1002/2015JD023381. <http://onlinelibrary.wiley.com/doi/10.1002/2015JD023381/full>

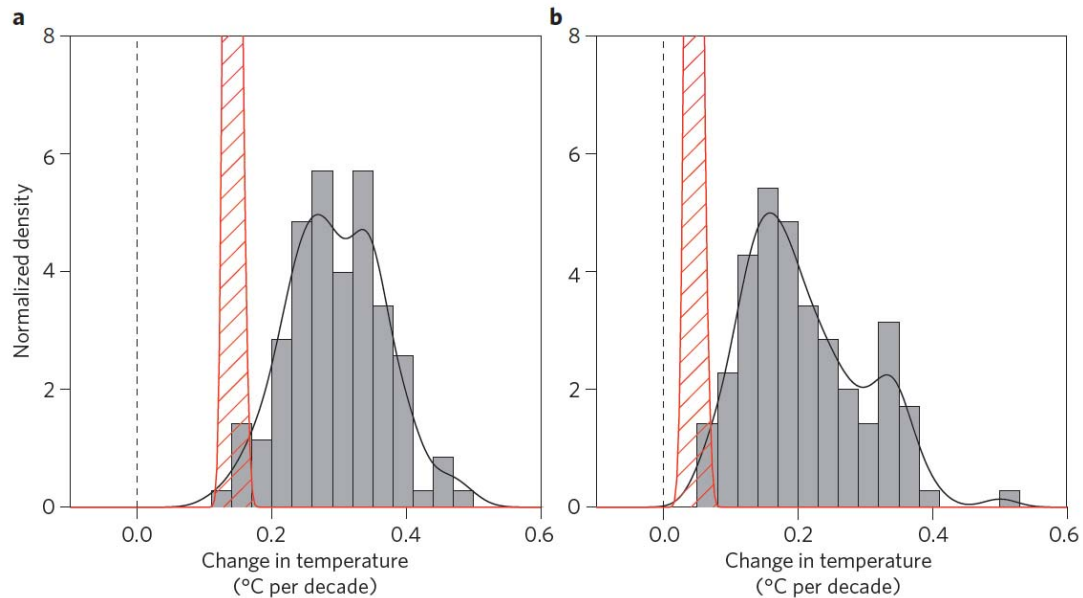
More accessibly, Andrew Dessler reviewed IRIS and Mauritsen and Stevens (2015):

<http://www.realclimate.org/index.php/archives/2015/04/the-return-of-the-iris-effect>

"What they find is that, even though cloud cover is reduced as the climate warms, it does not generate a strong negative cloud feedback. While reducing cloud cover does indeed let more infrared energy out, it also lets more sunlight in."

² R. S. Lindzen, R. S. Chou and A. U. Hou, *Does the Earth have an adaptive infrared iris?* *Bull. Am. Meteorological Soc.* **82**, 417-432 (2001).

³ *Id.*



Trends in global mean temperature. **a.** 1993-2012. **b.** 1998-2012. Histograms of observed trends (red hatching) are from 100 reconstructions of the HadCRUT4 data set <http://www.metoffice.gov.uk/hadobs/hadcrut4/>. Histograms of model trends (gray bars) are based on 117 simulations by climate models, and black curves are smoothed versions of the histograms. The ranges of the observed trends represent observational uncertainty and errors, whereas the ranges for the models' trends reflect forcing uncertainties, as well as differences in model responses to external forcing (the climate sensitivity).

Q: Do climate models accurately account for observational data?

A: No. The models continue to use inappropriate values for ECS of 3 K or higher, which the observational data do not support.

Q: Are climate models accurate if they can “backcast” past climatic conditions?

A: Not really. Looking at past climate records is not the same as predicting the future. Looking backward is an exercise in curve-fitting, not prediction. In other words, scientists can adjust models and change parameters to make sure the models accurately fit the graphs of past temperature data. To be useful, a model must demonstrate that it can predict future temperatures. Climate models have predicted about three times more warming from 1998 to 2012 and they

1 have predicted about 2 times more warming from 1993 to 2012 than has been observed (Happer
2 Testimony, Ex. 2 (Report) at 7 (Fig. 5)). For times earlier than 1993, models fit observations
3 perfectly, but that is a fit, not a prediction.

4 **Q: Do you have any suspicions where that error comes from?**

5 A: Yes. I do not think it is a coincidence that the value used by most models for ECS (S
6 $=3$ K) is about three times larger than the feedback-free ECS value of $S = 1$ K. In my judgment,
7 the models run three times too warm because they have assumed a warming for doubling CO_2
8 that is at least three times larger than the real value.

9 **Q: What about the Interagency Working Group (“IWG”)? Does it consider all**
10 **relevant data?**

11 A: Not at all. Indeed, Dr. Dessler himself would need to defend the IWG from that
12 accusation: the IPCC has ignored *all of the science published after 2007* and refused to re-
13 evaluate its chosen ECS value of $S = 3$ K, despite numerous papers showing a great deal of doubt
14 in that number—including the IPCC AR5, which no longer offers $S = 3$ K as a “best guess.” For
15 example, at one point Dr. Dessler says, “Dr. Happer is also relying on a source that is several
16 years old....” (Dessler Rebuttal 26:17-18.) Dr. Hanemann’s direct testimony said, “It would be
17 unreasonable to base a current estimate of the SCC on earlier versions of the IAMs, just as it
18 would be unreasonable to base a scientific assessment of climate change on an old IPCC
19 Assessment Report rather than the current Assessment Report.” (Hanemann Direct 74:7-10.)
20 Those criticisms apply in spades to the IWG.

21 **II. Warming Hiatus**

22 **Q: Some of the opposing witnesses dispute the existence of a hiatus in warming.**
23 **How do you respond?**

1 A. A hiatus of somewhere between 18 and 20 years is widely accepted among climate
2 scientists. In fact, I note that Dr. Dessler's rebuttal testimony states: "Figure 1 shows that Dr.
3 Spencer is correct: beginning around 2000, the uncertainty in the trend expands and begins to
4 encompass zero. Thus, it is correct to say that there has been no statistically significant warming
5 since 2000." (Dessler Rebuttal 15:5-7.) At another point, Dr. Dessler testified:

6 Q. Has the rate of warming slowed down over the last decade or so?

7 A. Yes. Figure 1 shows that the warming since the beginning of the 21st
8 century has been smaller than that since the 1990s (although the differences are
9 not statistically significant).
10 (Dessler Rebuttal 21:3-6.)

11 **Q: Dr. Abraham points to heating in the ocean, giving it as "the clearest evidence**
12 **that the Earth is warming." Do you agree such heating exists?**

13 A: No, and in fact a recent paper rebuts the argument that heat from global warming is
14 somehow "hiding" in the ocean. Wunsch and Heimbach⁴ estimate that the oceans are absorbing
15 heat at a much lower rate than climate models predict – only about 0.2 watts per square meter,
16 rather than 0.6 watts per square meter (or even higher) as many climate models predict. This
17 means that, like the atmosphere, the oceans are warming about 3 times less rapidly than climate
18 models predict. The computer models are predicting about three times more warming than
19 observed temperatures for both the atmosphere and oceans.

20 **Q: What does Dr. Abraham's work on the subject show?**

21 A: Wunsch and Heimbach found that "[a] total change in heat content, top to bottom, is
22 found (discussed below) of approximately 4×10^{22} J in 19yr for a net heating of $0.2 \pm 0.1 \text{ W m}^{-2}$,

⁴ C. Wunsch and P. Heimbach, Journal of Physical Oceanography, **44**, 2014 (2014).

1 smaller than some published values ..., but indistinguishable from the summary Fig. 14 of
2 Abraham et al. (2013).”⁵ In other words, Dr. Abraham’s own work corroborates that the energy
3 stored in the oceans is increasing at approximately one-third the rate predicted by models.

4 **Q: Dr. Gurney takes issue with your choice of the 1998 to 2014 time scale to show**
5 **there has been no warming. Do you believe that was a credible time scale to choose?**

6 A: Yes. Dr. Gurney specifically argues that my analysis starts “curiously” after the end of
7 a very large El Nino year which saw an unusually high global mean temperature. The actual
8 chart (Happer Testimony, Ex. 2 (Report) at p. 5 (Fig. 3)) begins in 1979, not 1998. *Based on that*
9 *longer time scale*, I drew the conclusion – supported by the chart – that there had been no
10 appreciable warming since 1998. Dr. Gurney distorted the presentation of the chart to attempt to
11 discredit it. Exactly the same conclusion, negligible warming since 1998, can be drawn from two
12 more figures (Happer Testimony, Ex. 2 (Report) at p. 6 (Fig. 4) and p. 7 (Fig. 5). Evidently, the
13 peer reviewers for the Fyfe, et al. (2013) paper from which Fig. 5 was reproduced, saw no
14 problem with a time interval beginning in 1998 or with the paper’s title (“Overestimated Global
15 Warming over the Past 20 Years”), which is in full agreement with my testimony.

16 **Q: Dr. Dessler takes issue with your comparison of observed temperature to an**
17 **ensemble of models over a short term, citing to Dai et al. (2015) and Huber and Knutti**
18 **(2014). Do you agree that those sources support his argument?**

19 A: No. Dr. Dessler misses the point of the studies showing divergence between models
20 and observed temperatures.

⁵ *Id.* at 2017. The “Abraham et al. (2013)” paper cited is: Abraham, J. P., et al., 2013: A review of global ocean temperature observations: Implications for ocean heat content estimates and climate change. *Rev. Geophys.*, 51, 450–483, doi:10.1002/rog.20022.

1 Dai et al. (2015), begin their abstract with exactly the proposition Dessler rejects:
2 “Despite a steady increase in atmospheric greenhouse gases (GHGs), global mean surface
3 temperature (T) has shown no discernable warming since about 2000, in sharp contrast to model
4 simulations, which on average project strong warming.”⁶ It is known that atmospheric aerosols
5 have been hypothesized as cancelling a lot of the predicted warming by reflecting heat back out
6 into space. Yet as air over the Northern Hemisphere has gotten cleaner and left fewer aerosols to
7 reflect sunlight back to space, there has been no corresponding increase in temperature as the
8 models would predict. Dai et al. attempted to explain this phenomenon by asserting that natural
9 variation kept the climate cool for *15 years*. But models worked well before 2000, so one would
10 have to accept the bizarre proposition that there was no natural variation before 2000 and then a
11 sudden onset of natural cooling. One could equally well assume that the warming from 1980 to
12 2000 was due to natural heating. The models worked before 2000 because they were *fitting*
13 known past temperatures, not *predicting* unknown future temperatures.

14 I believe that adding more CO₂ will warm the earth, but I am persuaded that the warming
15 from CO₂ will be a factor of 3 (or more) *less* than predicted by the IPCC or the IWG and will be
16 net beneficial, within the parameters discussed in my direct and sur-rebuttal reports. The most
17 plausible explanation for the lack of warming since 2000 is that models have assumed too large a
18 value for the climate sensitivity, and that natural cooling cancelled most of any modest warming
19 from CO₂ from 2000 until the present. Natural warming (not caused by human CO₂ emissions)
20 probably added to the modest warming from CO₂ from 1980 to 2000.

⁶ Dai, A., J. C. Fyfe, S.-P. Xie, and X. Dai (2015), Decadal modulation of global surface temperature by internal climate variability, *Nature Clim. Change*, 5, 555-559, doi: 10.1038/nclimate2605, available at <http://www.nature.com/nclimate/journal/v5/n6/abs/nclimate2605.html> - supplementary-information.

Huber and Knutti (2014) also begin their abstract with a proposition Dessler rejects:
“Global mean surface warming over the past 15 years or so has been less than in earlier decades
and [less] than simulated by most climate models.”⁷ Like Dai et al., Huber and Knutti attribute
the hiatus to natural variability. Also like Dai et al., Huber and Knutti give the illusion of
agreement by fitting model curves to past observations (e.g., Fig. 3). Huber and Knutti should
have predicted the future warming, say for the next 20 years. Then we would be able to tell if
their model is more than a curve-fitting exercise.

III. The Benefits of CO₂

Q: Will moderate warming be beneficial to the Earth?

A: Yes, the overwhelming evidence indicates that a moderate amount of warming – a
couple of degrees K – will improve crops, lengthen growing seasons, reduce winter heating bills
without increasing summer cooling costs much (because the effects of warming will be more
pronounced in the winter than the summer). Humanity, as well as the ecosystem, will benefit
from more CO₂ in the atmosphere, as described in my direct and sur-rebuttal testimony. Even
Dr. Gurney states that “[a]ll available scientific evidence supports the general concept of a CO₂
fertilization effect.” (Gurney Rebuttal 3:5-6.) The IPCC Fifth Assessment Report, Working
Group II, Chapter 7 on “Food Security and Food Production Systems” concludes in the
Executive Summary: “Evidence since AR4 confirms the stimulatory effects of carbon dioxide
(CO₂) in most cases.”

Q: Have climate models accurately quantified the benefits of moderate warming?

⁷ Huber, M., and R. Knutti (2014), Natural variability, radiative forcing and climate response in the recent hiatus reconciled, *Nature Geosci.*, 7, 651-656, doi: 10.1038/ngeo2228, available at <http://www.nature.com/ngeo/journal/v7/n9/abs/ngeo2228.html> - supplementary-information.

1 A: No. As I contended in my opening testimony, they have not, and if they did, they
2 would find the “costs” of carbon to be negative. (Happer Testimony at 11:21-12:8.) As I
3 explained in my rebuttal, theories about “catastrophic events” and “tipping points” obscures the
4 fact that the Earth is currently in a CO₂ famine, with levels dramatically *lower* than during most
5 of the last 550 million years, the Phanerozoic Eon. Because the models incorporate the
6 likelihood of hypothetical catastrophic events, which have never happened during the much
7 higher CO₂ levels that prevailed over most of the Phanerozoic Eon, but largely ignore the proven
8 benefits of CO₂ enrichment, they cannot accurately quantify the benefits of moderate warming.

9 **Q: Dr. Dessler pointed out that the 2003 heat wave in Europe was merely 3 °C above**
10 **average but caused thousands of deaths. Does that show that moderate warming can have**
11 **catastrophic effects?**

12 A: Dr. Dessler confuses climate and weather. As he points out, “it is not just the
13 magnitude of the warming but also the rate of warming that is of concern.” The heat wave – a
14 *weather* event – took place suddenly and lasted over an extended period. Even if the IWG is
15 correct that 3 K is the correct ECS (which I dispute), the Earth’s *climate* will not approach that
16 degree of warming until closer to 2100, assuming no attempts at abatement or mitigation are
17 taken, according to the IPCC.⁸ Assuming Dr. Dessler’s science is otherwise correct (which I
18 dispute), there would be much more time to adapt to moderate warming from CO₂ emissions
19 than there were to the 2003 heat wave. The importance of accounting for adaptation to climate
20 (as opposed to localized weather events) is demonstrated by the first multi-climate, multi-nation
21 survey on temperature-related mortality, conducted by a coalition of researchers led by the

⁸ Intergovernmental Panel on Climate Change, *AR4 Synthesis Report* at 46 (Fig. 3.2) (2008). I cite to AR4 here because it is the last IPCC Assessment Report to give 3 °C as its central value – the outdated value used by the IWG.

1 London School of Hygiene & Tropical Medicine. This study showed that cold temperatures are
2 much more dangerous than hot regardless of whether the overall climate is cold or hot.⁹

3 **Q: Is there other evidence that moderate warming will benefit other parts of the**
4 **biosphere?**

5 A: Yes. Both ocean and land animals show not only better adaptation to changing
6 climatic conditions than expected, they also show some benefits:

- 7 • Researchers from the Wildlife Conservation Society found that the impacts of
8 warming and acidification on corals are more complex than models assume, and
9 corals can withstand more stress than expected.¹⁰ Further, researchers from Singapore
10 and the Woods Hole Oceanographic Institute found that ocean acidification is driven
11 much more by changes in ocean currents than anthropogenic CO₂.¹¹ Many productive
12 parts of the ocean today have variations in their pH, which measures the degree of
13 acidity or alkalinity from high values, say pH = 8.1 in the late afternoon, when
14 photosynthesis has removed much of the dissolved CO₂ and converted it to organic
15 matter, to pH = 7.9 by dawn, after a nighttime or reloading the ocean water with CO₂
16 respired by the organisms living in the water.¹²

⁹ Antonio Gasparrini, *et al.*, *Mortality Risk Attributable To High And Low Ambient Temperature: A Multicountry Observational Study*, *Lancet* (May 21, 2015), available at [http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736\(14\)62114-0.pdf](http://www.thelancet.com/pdfs/journals/lancet/PIIS0140-6736(14)62114-0.pdf).

¹⁰ Timothy R. McClanahan, *et al.*, *Regional Coral Responses To Climate Disturbances And Warming Is Predicted By Multivariate Stress Model And Not Temperature Threshold Metrics*, 129 *Climatic Change* (April 19, 2015), available at DOI: 10.1007/s10584-015-1399-x.

¹¹ Goodkin, N. F., *et al.*, *Ocean Circulation and Biogeochemistry Moderate Inter-annual and Decadal Surface Water pH Changes in the Sargasso Sea*, 42 *Geophys. Res. Lett.* (2015), available at DOI: 10.1002/2015GL064431.

¹² G. E. Hoffmann *et al.* *High-Frequency Dynamics of Ocean pH: a Multiecosystem Comparison*, *PLoS ONE*, December 2011 | Volume 6 | Issue 12 | e28983.

- 1 • A study of corals found that “research to date has largely neglected the individual and
2 combined effects of OA and seawater temperature.” These shortcomings undermine
3 many of the predictions of harm from climate change.¹³
- 4 • Researchers found that certain kelp species have benefitted from warming
5 temperatures, keeping a “a positive relationship between in situ temperature and
6 thermal optima for performance.”¹⁴
- 7 • Researchers tested whether climate change would increase stress levels to animals.
8 By studying animal species in different stress environments outside of their local
9 climate zones, the research reports that the animals “exposed to novel climatic
10 conditions did not display a detectable stress response, nor did the novel climate
11 depress immune function in the transplanted populations”¹⁵
- 12 • Researchers found that certain species that have been thought to “be vulnerable to
13 climate warming” actually can adapt very well. In many areas “microclimates within
14 a landscape may allow species to exist in regions where the general climate appears to
15 be unsuitable for them.”¹⁶

¹³ Levas, S., Grottoli, A.G., Warner, M.E., Cai, W.-J., Bauer, J., Schoepf, V., Baumann, J.H., Matsui, Y., Gearing, C., Melman, T.F., Hoadley, K.D., Pettay, D.T., Hu, X., Li, Q, Xu, H. and Wang, Y. 2015. Organic carbon fluxes mediated by corals at elevated pCO₂ and temperature. *Marine Ecology Progress Series* 519: 153-164.

¹⁴ Mohring, M.B., Wernberg, T., Wright, J.T., Connell, S.D. and Russell, B.D. 2014. Biogeographic variation in temperature drives performance of kelp gametophytes during warming. *Marine Ecology Progress Series* 513: 85-96.

¹⁵ Refsnider, J.M., Palacios, M.G., Reding, D.M. and Bronikowski, A.M. 2015. Effects of a novel climate on stress response and immune function in painted turtles (*Chrysemys picta*). *Journal of Experimental Zoology* 323A: 160-168.

¹⁶ Visinoni, L., Pernollet, C.A., Desmet, J.-F., Korner-Nievergelt, F. and Jenni, L. 2015. Microclimate and microhabitat selection by the Alpine Rock Ptarmigan (*Lagopus muta Helvetica*) during summer. *Journal of Ornithology* 156: 407-417.

- Researchers found that through natural selection, “thermal adaptation is a widespread phenomenon in organisms that are exposed to variable and extreme environments.”¹⁷
- Researchers found that “tropical seagrasses can increase their photosynthetic rates, adjust photosynthetic performance and increase growth rates in response to CO₂ enrichment,” which suggests that “they will thrive under future scenarios of climate change.”¹⁸
- Researchers found that arguments about “coral bleaching” have overestimated their negative impacts. They instead report that “it is clear that white colonies are physiologically healthy and that the number of white *M. cavernosa* occurring in the surveyed reefs is high enough to notably contribute to an over-estimation of coral bleaching.”¹⁹ elsewhere: <http://www.sciencemag.org/news/2016/04/survey-confirms-worst-ever-coral-bleaching-great-barrier-reef>
- None of these findings are surprising, since much of life on earth is better adapted to the much higher CO₂ levels (several thousand ppm) that have prevailed over most of the past 550 million years of the Phanerozoic²⁰ than to the current low levels of CO₂ (about 400 ppm).

Q: Are rising CO₂ concentrations beneficial for plant life?

¹⁷ Narum, S.R. and Campbell, N.R. 2015. Transcriptomic response to heat stress among ecologically divergent populations of redband trout. *BMC Genomics* 16: 10.1186/s12864-015-1246-5.

¹⁸ Gasparrini, A., Guo, Y., Hashizume, M., Lavigne, E., Zanobetti, A., Schwartz, J., Tobias, A., Tong, S., Rocklöv, J., Forsberg, B., Leone, M., De Sario, M., Bell, M.L., Guo, Y.L.L., Wu, C.F., Kan, H., Yi, S.M., de Sousa, Z., Coelho, S. M., Saldiva, P.H., Honda, Y., Kim, H. and Armstrong, B. 2015. Mortality risk attributable to high and low ambient temperature: a multi-country observational study. *The Lancet*: 10.1016/S0140-6736(14)62114-0.

¹⁹ Cruz, I.C.S., Leal, M.C., Mendes, C.R., Kikuchi, R.K.P., Rosa, R., Soares, A.M.V.M., Serodio, J., Calado, R. and Rocha, R.J.M. 2015. White but not bleached: photo-physiological evidence from white *Montastraea cavernosa* reveals potential overestimation of coral bleaching. *Marine Biology* 162: 889-899.

²⁰ R. A. Berner and C. Kothavala, *Geocarb:III, a revised model of atmospheric CO₂ over the Phanerozoic time*, *American Journal of Science*, 301, 182 (2001).

1 A: Yes. As Dr. Gurney acknowledges, “All available scientific evidence supports the
2 general concept of a CO₂ fertilization effect.” (Gurney Rebuttal 3:5-6.) I also wish to point out
3 the import of the analysis of rubisco and stomatal growth in my initial testimony (at 10:5-11:11).
4 There is a scientific, biological mechanism to explain why more CO₂ would benefit plant life.

5 **Q. Aren’t the harms of warming already “evident,” as the opposing witnesses**
6 **contend?**

7 A: No, they’re not. The Earth hasn’t warmed for 18-20 years. That said, history shows
8 that the Earth’s climate is naturally always changing. Natural variability dwarfs human-induced
9 changes. The overwhelming majority of climate change in the Earth’s history is not attributable
10 to man-made CO₂. For example, over the past millennium, California has experienced much
11 more severe droughts than the current one, and those prior droughts can’t be blamed on CO₂.²¹

12 **Q: Hasn’t rising CO₂ had other effects, like melting glaciers?**

13 A: Not provably. When John Muir, founder of the Sierra Club, went to Glacier Bay in
14 Alaska in 1879, most of the glaciers described in the 18th century were already gone: a chart
15 drawn barely a century before showed no trace of the bay because it was still frozen glacier
16 then.²² In other words, over 90% of Alaska’s Glacier Bay melting occurred prior to 1900, so it
17 can’t be attributed to global warming. Dr. Patrick Moore, a founder of Greenpeace, recently
18 made the same point in an op-ed for the Wall Street Journal.²³ The most dramatic changes in
19 Alaskan glaciers occurred before humans had released enough CO₂ to cause appreciable
20 warming.

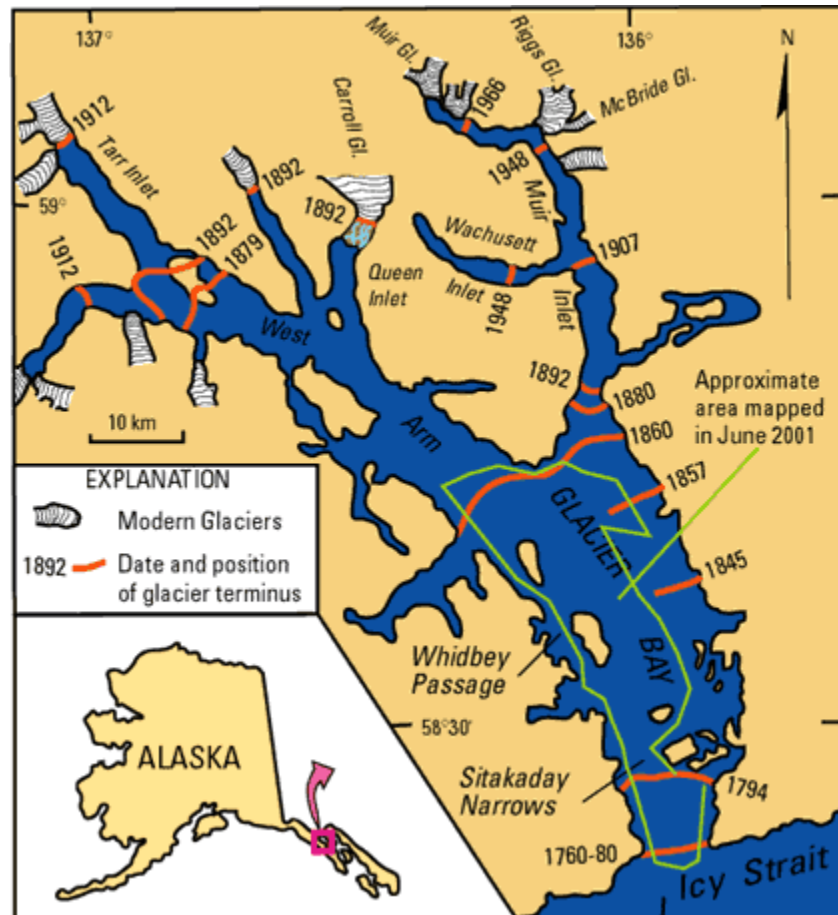
²¹ E. R. Cook et al., *Long-Term Aridity Changes in the Western United States*, VOL 306, p.1015, SCIENCE (2004).

²² John Muir, *Travels in Alaska* (Houghton Mifflin 1915). The full text is available at http://vault.sierraclub.org/john_muir_exhibit/writings/travels_in_alaska/ and <http://www.gutenberg.org/files/7345/7345-h/7345-h.htm>.

²³ Patrick Moore, “Obama’s Half-baked Alaska,” The Wall Street Journal, 4 September (2015).

1 Sketched below is a map published by the USGS that shows retreat of ice in Glacier Bay.

2 The vast majority of the ice was gone by 1907.²⁴



6 Glaciers have been retreating or advancing for millions of years, and they will continue to
7 do so, even if we stopped emitting CO₂ entirely. The snows of Kilimanjaro are disappearing
8 because of less snowfall at the summit rather than temperature changes. The lesson is that ice
9 sheets often come and go more because of changes in local precipitation patterns rather than
10 changes in temperatures. One theory is that deforestation around Mount Kilimanjaro has

²⁴ Paul Carlson and Peter Barnes, "Spring Multibeam Cruise in Glacier Bay Provides Spectacular Images," *Sound Waves* (July 2001), available at <http://soundwaves.usgs.gov/2001/07/fieldwork2.html>.

1 reduced snowfall at the summit. Ironically, if the communities around Kilimanjaro used more
2 coal rather than denuding the mountain slopes of forest for fuel wood, water transpiration from
3 newly grown-forest would probably allow the glaciers on the summit to advance again.

4 **Q: Have other extreme events been documented as a result of warming?**

5 A: While many events have been attributed to warming (and sometimes specifically to
6 anthropogenic warming), those attributions are incorrect, as documented by John Christy in his
7 testimony before Congress,²⁵ and as I pointed out in my initial testimony (at 9:18-20). Dr.
8 Dessler criticizes me for “relying on a source that is several years old, not published in the peer-
9 reviewed literature, and widely disputed by the scientific community.” (Dessler Rebuttal at
10 26:17-19.) The testimony is from 2012, which is still five years more recent than IPCC’s most
11 recent ECS value. Dr. Christy’s credentials speak for themselves: the Earth System Science
12 Center at the University of Alabama in Huntsville, and recipient of NASA’s Medal for
13 Exceptional Scientific Achievement. Even if it was not itself peer-reviewed, his testimony was
14 based on his experience as a climate scientist, his publication record, and his knowledge of the
15 literature in the field. With Dr. Roy Spencer, Dr. Christy developed the satellite microwave
16 sounding units that give the most comprehensive and reliable measurements of the temperature
17 of the earth’s atmosphere.

18 R. Boehm²⁶ in a study of European climate variability that was recently published in a
19 rigorously peer-reviewed journal, reached the same conclusion as Dr. Christy. In the abstract to
20 his paper, Dr. Boehm states: “The first result of the study is the clear evidence that there has been

²⁵ J. R. Christy,
<http://energycommerce.house.gov/sites/republicans.energycommerce.house.gov/files/He112-IF03-WState-ChristyJ-20120920.pdf>.

²⁶ R. Boehm, *Changes of regional climate variability in central Europe during the past 250 years*, Eur. Phys. J. Plus (2012) 127: 54; DOI 10.1140/epjp/i2012-12054-6

1 no increase of variability during the past 250 years in the region.” Later he states: “So the
2 *résumé* of our analysis based on discrete 30-year normal periods is as follows. The recent GHG-
3 forced normal period 1981–2010 does not show higher interannual/interseasonal variability than
4 the preceding 200 and more years of the instrumental period. For temperature it is less variable
5 recently – but only in one case significantly at the 95% level. For air pressure and for
6 precipitation there is a slight majority of lower variability but none of these significant.”

7 Climate variability has not increased in recent years.

8 **Q: Drs. Gurney and Hanemann argue that you and other witnesses depend**
9 **excessively on laboratory studies. Do you agree that weakens your argument?**

10 A: No. Those laboratory experiments are crucial for showing not just anecdotal evidence,
11 but the biological mechanism at stake. It is not a theory that CO₂ benefits plants and makes them
12 better able to withstand higher temperatures or drought. That mechanism has been demonstrated
13 time and time again. This is the importance of my initial testimony regarding rubisco and the
14 CO₂ famine plants currently face, and which none of the opposing witnesses take issue with.
15 (Happer Testimony, Ex. 2 (Report) at 8-11.)

16 **Q: Dr. Gurney points to a graph you included in your original testimony (Happer**
17 **Testimony, Ex. 2 (Report) at 11 (Fig. 8)) as an example of “confusion” that “raise[s] serious**
18 **questions about the reliability” of your testimony as a whole. Do you agree with his**
19 **conclusion?**

20 A: Not in the least.

21 **Q: Where did Fig. 8 come from?**

22 A: Fig. 8 was drawn from the press release of the Commonwealth Scientific and
23 Industrial Research Organization (CSIRO), the research organization sponsoring the paper

Had Happer actually cited the press release at CSIRO, anyone could have seen that it contradicted his claims of certainty.

"Similar" is a vague term, and many of the charts describe limits from water, temperature or light, but nothing is really the same as this chart, which apparently comes from a press release. At best, this is absurd scholarship.

1 cited.²⁷ The chart does not appear in the main study, but similar charts appear in the supporting
2 material published with the report.²⁸ What is apparent is that CSIRO – the organization credited
3 with the study – published the figure separately from the report published in *Geophysical*
4 *Research Letters*. The source of this figure is a PowerPoint presentation by Professor Ranga
5 Myneni for the 2013 Probing Vegetation Conference From Past to Future.²⁹ Professor Ranga
6 Myneni was a lead author on the IPCC Fifth Assessment Report, Working Group I, Chapter 6,
7 “Carbon and other Biogeochemical Cycles.” The figure is an up-to-date analysis of a policy
8 relevant issue, made by a lead author of the IPCC.

False. See pp.27- , PPT attached here.

Happer misrepresents Myneni and the IPCC. See pp.27-

9 **Q: Does its separate publication weaken the conclusion of the article?**

10 A: No. The organization publishing the article still stands by it, and the author still
11 distributes it.³⁰ When I inquired about the origin of the figure in April, 2015, Dr. Donohue
12 replied by e-mail: “There’s no publication from which it comes. Instead I produced it for an
13 AGU media release that accompanied our GRL paper. Unfortunately I discovered after the
14 media release that I had given AGU the 1982 to 2006 trend map, not the 1982 to 2010 one as
15 stated in the caption. So please find attached the proper ‘1982 to 2010 GIMMS3g derived
16 relative trend in fractional cover’ image. Please feel free to use this map, and if you could state
17 the source as R.Donohue/CSIRO, that would be excellent. Thanks also for chasing me down to
18 get the correct source. Much appreciated. I hope you find it useful!”

<http://news.agu.org/press-release/elevated-carbon-dioxide-making-arid-regions-greener/>

Happer did not do so, but in fact kept falsely citing GRL paper at least through 12/08/15, 8 months after he knew better.

CSIRO <http://www.csiro.au/en/News/News-releases/2013/Deserts-greening-from-rising-CO2>; read Transcript there.

²⁷ CSIRO, “Deserts ‘Greening’ from Rising CO₂,” *CSIRO.au* (July 3, 2013), available at [http://www.csiro.au/en/News/News-releases/2013/Deserts-greening-from-rising-CO₂](http://www.csiro.au/en/News/News-releases/2013/Deserts-greening-from-rising-CO2).

²⁸ Donohue, *et al.*, Supporting Materials, *Impact of CO₂ Fertilization on Maximum Foliage Cover Across the Globe’s Warm, Arid Environments*, 40 *Geophys. Res. Letters* 3031, at 5 (June 28, 2013), available at http://onlinelibrary.wiley.com/store/10.1002/grl.50563/asset/supinfo/Auxiliary_Material_text02.pdf?v=1&s=9fc8fe6e17b44f88eacff2b37892443a57680cea.

²⁹ <http://probing.vegetation.be/sites/default/files/pdf/dag1/1100-Ranga%20Myneni-myneni-probing-vegetation-talk-2.pdf>

³⁰ Personal Correspondence, Randall Donohue to Richard Min (Aug. 24, 2015).

Q: How does Dr. Gurney respond to the article's conclusion?

A: Dr. Gurney cited to the IPCC's "overview of the processes hypothesized to remove CO₂ from the Earth's atmosphere into the land" (Gurney Rebuttal at 23:4-6). He concluded that "CO₂ fertilization is only one contributor to the global 'greening' observed from satellites and inferred from other measurement and modeling approaches." (Gurney Rebuttal at 23:18-20.)

Q: Is Dr. Gurney's response correct?

A: No. The Donohue et al. (2013) study specifically assesses and rejects alternate potential causes. The study excludes seasonal changes, changes in drought conditions, and changes in disturbance regimes as potential causes.³¹

Q: Dr. Gurney notes that "the Donohue et al. paper arrives at a far narrower set of conclusions regarding CO₂ fertilization concluding that a '....14% increase in atmospheric CO₂ (1982-2010) led to a 5 to 10% increase in green foliage cover in warm, arid environments.'" (Gurney Rebuttal at 22:4-7.) Do you agree that the conclusion is narrower than yours?

A: No. Dr. Gurney omitted crucial context around that quotation. The full quotation should read:

Using gas exchange theory, we predict that the 14% increase in atmospheric CO₂ (1982–2010) led to a 5 to 10% increase in green foliage cover in warm, arid environments. Satellite observations, analyzed to remove the effect of variations in precipitation, show that cover across these environments has increased by 11%. Our results confirm that the anticipated CO₂ fertilization

³¹ Donohue, et al., *Impact of CO₂ Fertilization on Maximum Foliage Cover Across the Globe's Warm, Arid Environments*, 40 Geophys. Resch. Letters 3031, 3033-34 (June 28, 2013), available at http://onlinelibrary.wiley.com/store/10.1002/grl.50563/asset/supinfo/Auxiliary_Material_text02.pdf?v=1&s=9fc8fe6e17b44f88eacff2b37892443a57680cea [hereafter, "Impact"].

1 **effect is occurring alongside ongoing anthropogenic perturbations to the**
2 **carbon cycle and that the fertilization effect is now a significant land surface**
3 **process.**³²

4 I have placed in bold the portions Dr. Gurney omitted, and italicized portions that show how
5 those omissions distorted the conclusions Donohue et al. reached: the researchers expected only
6 a 5-10% increase, but found an 11% increase instead. Donohue et al. clearly believe the result is
7 significant: “Overall, our results confirm that the direct biochemical impact of the rapid increase
8 in C_a over the last 30 years on terrestrial vegetation is an influential and observable land surface
9 process.”³³ Dr. Gurney found the *prediction* to be narrower, not the *conclusion*.

10 Empirically, the growth rate of plants is found to be approximately proportional to the
11 square root of atmospheric CO₂ levels. The square-root “law” implies that a 14% increase of
12 atmospheric CO₂ from 1982 to 2010 should have increased the growth rate by a factor of
13 $(1.14)^{1/2} = 1.068$ or 6.8 %. The observed increase in green foliage observed by Donohue is
14 consistent with the square-root law.

15 Many other remote-sensing studies reach the same conclusion as Donohue et al. For
16 example, a few months ago, Piao et al.³⁴ published their studies of the recent greening of China
17 where they state: “Rising atmospheric CO₂ concentration and nitrogen deposition are identified
18 as the most likely causes of the greening trend in China, explaining 85% and 41% of the average
19 growing-season LAI (= Leaf Area Index) trend estimated by satellite datasets (average trend of
20 0.0070 yr, ranging from 0.0035 yr to 0.0127 yr , respectively.”

³² *Id.* at 3031 (emphasis added). Global Change Biology (2015), doi: 10.1111/gcb.12795

³³ *Id.* at 3034.

³⁴ S. Piao et al. *Detection and attribution of vegetation greening trend in China over the last 30 year,s*
Global Change Biology (2015), doi: 10.1111/gcb.12795

1 **Q. Dr. Rom has submitted rebuttal testimony arguing that increased CO2 will lead**
2 **to asthma and other respiratory problems. What is your response to that?**

3 A: As I noted in my initial report, CO2 at atmospheric concentrations has no adverse
4 effects on human health. For example, exhaled human breath typically consists of 40,000 ppm to
5 50,000 ppm of CO₂. I have personally measured that CO₂ levels in crowded classrooms of
6 Princeton University often reach 1200 ppm with no apparent ill effects. The U.S. Navy tries to
7 keep CO₂ levels in submarines below 5000 ppm to avoid any measurable effect on sailors. Even
8 if atmospheric CO₂ levels double to 800 ppm, which would take centuries, there will be no
9 harmful health effects.

10 Dr. Rom's claim that global warming will lead to more asthma and respiratory illness is
11 backwards; it will actually reduce them. For example, one study found that, after controlling for
12 secular and seasonal trends, weather, air pollution and other confounding factors, there was a
13 significant negative correlation between asthma hospitalizations and daily mean temperature
14 (DMT), "with lower temperatures associated with a higher risk of hospital admission for
15 asthma," wherein "the cold effect appeared to be relatively acute, with duration lasting several
16 weeks, while the hot effect was short-term." "Warmer temperatures were not associated with
17 asthma hospital admissions."³⁵

18 Another study found that hospitalization rates for asthma and severe allergies were
19 substantially higher in cold weather.³⁶ The study found that "[c]old effects generally appear
20 higher than heat effects in most cities." The authors report there were very significant increases
21 in hospitalizations when comparing the admissions at 2 °C with those at 15 °C, which increases

³⁵ Zhang, Y., Peng, L., Kan, H., Xu, J., Chen, R., Liu, Y. and Wang, W. 2014. Effects of meteorological factors on daily hospital admissions for asthma in adults: A time-series analysis. *PLOS ONE* 9: e102475.

³⁶ Son, J.-Y., Bell, M.L. and Lee, J.-T. 2014. The impact of heat, cold, and heat waves on hospital admissions in eight cities in Korea. *International Journal of Biometeorology* 58: 1893-1903.

1 amounted to 50.5%, 43.6 % and 53.6% for allergic diseases, asthma, and selected respiratory
2 diseases, respectively.

3 Two more studies concluded that the wider variety of pollens and microbes that could
4 result from CO₂ fertilization in a slightly warmer world will actually *decrease* incidence and
5 severity of asthma and respiratory complications by increasing resistance.³⁷

6 Other research demonstrates the net benefits to human health from warmer temperatures:

- 7 • When adaptation was considered, there were only 0.7 death per million people per
8 year due to warming in the hottest part of the year, but a decrease of fully 85
9 deaths per million people per year due to warming in the coldest part of the year,
10 for a lives-saved to life-lost ratio of 121.4: 1.³⁸
- 11 • Cold-related mortality is expected decrease due to global warming from 61 to
12 approximately 42 deaths per 100,000 population per year in the UK.³⁹
- 13 • In a study of diurnal temperature range conducted for the entirety of China based
14 on data collected from 479 weather stations for the period 1962 to 2011, cold
15 temperature extremes are responsible for far more deaths around the world than
16 are warm temperature extremes, suggesting that if the Earth warms there should
17 be a significant decrease in temperature-related human mortality.⁴⁰

³⁷ Markus J. Ege, et al. "Exposure to environmental microorganisms and childhood asthma." *New England Journal of Medicine* 364.8 (2011): 701-709; Dick Heederik and Erika von Mutius. "Does diversity of environmental microbial exposure matter for the occurrence of allergy and asthma?." *Journal of Allergy and Clinical Immunology* 130.1 (2012): 44-50.

³⁸ Christidis, N., Donaldson, G.C. and Stott, P.A. 2010. Causes for the recent changes in cold and heat-related mortality in England and Wales. *Climatic Change* 102: 539-553.

³⁹ Vardoulakis, S., Dear, K., Hajat, S., Heaviside, C., Eggen, B. and McMichael, A.J. 2014. Comparative assessment of the effects of climate change heat- and cold-related mortality in the United Kingdom and Australia. *Environmental Health Perspectives* 122: 1285-1292.

⁴⁰ Shen, X., Liu, B., Li, G., Wu, Z., Jin, Y., Yu, P. and Zhou, D. 2014. Spatiotemporal change of diurnal temperature range and its relationship with sunshine duration and precipitation in China. *Journal of Geophysical Research: Atmospheres* 119: 13,163-13,179.

- Although studies have provided estimates of premature deaths attributable to either heat or cold in selected countries, none has so far offered a systematic assessment across the whole temperature range in populations exposed to different climates. Researchers quantified the total mortality burden attributable to non-optimum ambient temperature, and the relative contributions from heat and cold and from moderate and extreme temperatures. They found that most of the temperature-related mortality burden was attributable to the contribution of cold and that cold weather kills 20 times as many people as hot weather does.⁴¹

Finally, ill-conceived policies that would raise the price of energy and harm those on fixed incomes would aggravate asthma and other respiratory diseases, which are highly associated with poverty and socio-economic status,⁴² as well as with poor indoor air quality,⁴³ also correlated with poverty.

⁴¹ Antonio Gasparrini, et al, "Mortality risk attributable to high and low ambient temperature: a multicountry observational study," the *Lancet*, Volume 386, No. 9991, p. 369–375, 25, July 2015.

⁴² Acevedo, Nathalie, et al. "Particular characteristics of allergic symptoms in tropical environments: follow up to 24 months in the FRAAT birth cohort study." *BMC Pulmonary Medicine* 12.1 (2012): 13.

⁴³ Heinrich, Joachim. "Influence of indoor factors in dwellings on the development of childhood asthma." *International Journal of Hygiene and Environmental Health* 214.1 (2011): 1-25.

Following added by JRM 05/23/16 to show (charitably) incompetent scholarship at best, or deceptive false citation at worst. Academics need to cite proper sources, so people can verify, but Happer did not do that, and then he tried to explain it away. D.Happer p.103 said: "water. Satellite observations **like** those of Fig. 8 from R. J. Donohue [19] have shown a very pronounced "greening" of the Earth as plants have responded to the modest increase of CO₂ from about 340 ppm to 400 ppm during the satellite era." R. J. Donohue, M. L. Roderick, T. R. McVicar, and G. D. Farquhar, Impact of CO₂ fertilization on maximum foliage cover across the globe's warm, arid environments, *Geo-physical Research Letters* 40, 3031-3035 (2013). 1) R.Gurnev pp.24-25 challenged this. and then S.Happer pp.20-23 tried to explain reference to paper that did **not** contain the image.

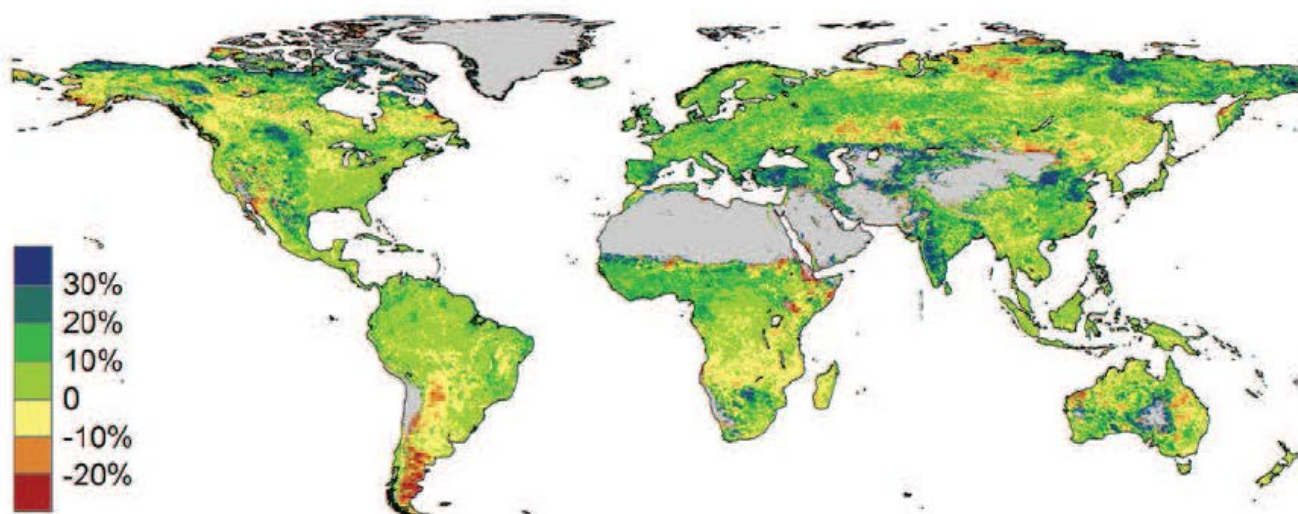


Figure 8: Greening of the Earth as observed by satellites

- 1) The paper and its Supplementary Material are: <http://onlinelibrary.wiley.com/doi/10.1002/grl.50563/pdf>
p.4 "The results reported here for warm, arid regions do not simply translate to other environments where alternative resource limitations (e.g., light, nutrients, temperature) might dominate, although the underlying theory remains valid..."
http://onlinelibrary.wiley.com/store/10.1002/grl.50563/asset/supinfo/Auxiliary_Material_text02.pdf?v=1&s=9fc8fe6e17b44f88eacff2b37892443a57680cea
- 2) D.Happer did not mention the CSIRO press release, which includes 1982-2006 image mislabeled as 1982-2010:
<http://www.csiro.au/en/News/News-releases/2013/Deserts-greening-from-rising-CO2> READ TRANSCRIPT ALSO
'In findings based on satellite observations, CSIRO, in collaboration with the Australian National University (ANU), found that this CO₂ fertilisation correlated with an **11 per cent increase in foliage cover from 1982-2010 across parts of the arid areas studied in Australia, North America, the Middle East and Africa**, according to CSIRO research scientist, Dr Randall Donohue. ...
"On the face of it, elevated CO₂ boosting the foliage in dry country is good news and could assist forestry and agriculture in such areas; however there will be secondary effects that are likely to influence water availability, the carbon cycle, fire regimes and biodiversity, for example," Dr Donohue said.
"Ongoing research is required if we are to fully comprehend the **potential extent and severity of such secondary effects**"
Peabody's argument depended on total certainty via an atomic physicist that greening via CO₂ was a huge plus for **crops**, ignoring CO₂ fertilization of jungles, weeds, kudzu, boreal forests, which all appear as greening, but none of which particularly help **agriculture**.
Happer ignores Liebig's Law (growth limited by least-available nutrient). Donohue mentions side-effects of CO₂-caused global warming, but others include droughts, floods, salt-water incursion from sea level rise.
- 3) A common disinformation tactic starts with a legitimate scientific image (like this), detaches it from surrounding explanations and context and uses it to confuse non-experts. A classic example is the neverending abuse of *IPCC(1990)* Fig 7.1(c):
<http://www.desmogblog.com/2015/01/26/medievaldeception-2015-inhofe-drags-senate-dark-ages>
The CSIRO press release had a (mislabeled) 1982-2006 image, which appears often, often via **false citation**.
www.drroyspencer.com/2014/05/greening-of-planet-earth-a-little-crowdsourcing-project
Labeled "Estimated changes in vegetative cover due to CO₂ fertilization between 1982 and 2010 (Donohue et al., 2013 GRL)."
The image is http://www.drroyspencer.com/wp-content/uploads/co2_growth.jpg
>Search Google for image yields 300+ hits >All sizes This image or variants are widely spread, including several by Happer
co2coalition.org/wp-content/uploads/2015/10/CO2-report-FINALhires102715.pdf Carbon Dioxide Benefits the World: See for Yoursel
p.12 Figure 7 is 1982-2006, correctly labeled, but with Source: Donohue et al, and fn15 gives GRL paper .. 6 months after Happer
<http://www.thebestschools.org/special/karoly-happer-dialogue-global-warming/happer-major-statement/fn53> "The figure was attached to an e-mail from R.J. Donohue to W. Happer, dated **4/27/2015**, where Dr. Donohue states: "I do recognise this image — it is one of mine. **There's no publication from which it comes...**"
<https://youtu.be/5KVTmo2Vxnk?t=2598> Happer testifies at Senator Cruz, and it **falsely cites the GRL paper 12/08/15**.

4) S.Happer p.21 stated:

"The source of this figure is a PowerPoint presentation by Professor Ranga Myneni for the 2013 Probing Vegetation Conference From Past to Future.29 Professor Ranga Myneni was a lead author on the IPCC Fifth Assessment Report, Working Group I, Chapter 6, "Carbon and other Biogeochemical Cycles."

The figure is an up-to-date analysis of a policy relevant issue, made by a lead author of the IPCC."

29 <http://probing.vegetation.be/sites/default/files/pdf/dag1/1100-Ranga%20Myneni-myneni-probing-vegetation-talk-2.pdf>

That seems **another misleading or false citation**. The image is fine, but Happer misrepresents its meaning, contradicted by:

- Donohue et al's paper, Supplementary Materials and CSIRO press release, which are all carefully worded

a) Myneni's PowerPoint, shown on next 2 pages, which certainly do not contain the image.

b) Myneni's clear comments regarding a recent paper.

c) The relevant sections of IPCC AR4 WGI and WGII

a) Myneni used a somewhat more detailed 13-slide set in his actual talk, "'A Greener Earth(?)"

<https://www.youtube.com/watch?v=c54axUt1E2Q>

Both are far more nuanced than Happer's claims, which seem designed for non-experts. His talk ends with:

"Difficulty with robustly detecting the greening trend and its attribution."

https://www.youtube.com/watch?v=pkNdZkz_bo0 Conclusion includes:

Attribution is difficult. is there any CO2 signal? How robust are trends on satellite data?

b) <http://sites.bu.edu/cliveg/> Myneni website for reference

<http://www.nature.com/nclimate/journal/vaop/ncurrent/full/nclimate3004.html>

Greening of the Earth and its drivers, by32 authors, starting with Zaichun Zhu, Shilong Piao, **Ranga B. Myneni**, ...

"Yet how global vegetation is responding to the changing environment is not well established. ...

We show a persistent and widespreadincrease of growing season integrated LAI (greening) over25% to 50% of the global vegetated area, whereas lessthan 4% of the globe shows decreasing LAI (browning). ...

CO2fertilization effects explain most of the greening trends in the tropics, whereas climate change resulted in greening of the high latitudes and the Tibetan Plateau. LCC contributed most to the regional greening observed in southeast China and the eastern United States. The regional effects of unexplained factors suggest that the next generation of ecosystem models will need to explore the impacts of forest demography,differences in regional management intensities for cropland and pastures, and other emerging productivity constraints such as phosphorus availability."

<http://www.bbc.com/news/science-environment-36130346>

"Climate sceptics argue the findings show that the extra CO2 is actually benefiting the planet.

But the researchers say the **fertilisation effect diminishes over time**. They warn the **positives of CO2 are likely to be outweighed by the negatives**. The lead author, Prof **Ranga Myneni** from Boston University, told BBC News the **extra tree growth would not compensate for global warming, rising sea levels, melting glaciers, ocean acidification, the loss of Arctic sea ice, and the prediction of more severe tropical storms**."

<http://phys.org/news/2016-04-co2-fertilization-greening-earth.html>

"The beneficial aspect of CO2 fertilization in promoting plant growth has been used by contrarians, notably Lord Ridley (hereditary peer in the UK House of Lords) and Mr. Rupert Murdoch (owner of several news outlets), to argue against cuts in carbon emissions to mitigate climate change, similar to those agreed at the 21st Conference of Parties (COP) meeting in Paris last year under the UN Framework on Climate Change (UNFCCC). **"The fallacy of the contrarian argument is two-fold**. First, the **many negative aspects of climate change**, namely global warming, rising sea levels, melting glaciers and sea ice, more severe tropical storms, etc. are not acknowledged. Second, studies have shown that **plants acclimatize, or adjust, to rising CO2 concentration and the fertilization effect diminishes over time**," says co-author Dr. Philippe Ciais, Associate Director of the Laboratory of Climate and Environmental Sciences, Gif-suvYvette, France and **Contributing Lead Author** of the Carbon Chapter for the recent IPCC Assessment Report 5."

c) IPCC ... The IPCC teams say the world is greening, but not that it guarantees the vast claims made by the Peabody gang.

WGIIAR5 https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter06_FINAL.pdf

pp.501-504, p.502:Box 6.3: The Carbon Dioxide Fertilization Effect

"Elevated atmospheric CO2 concentrations lead to higher leaf photosynthesis and reduced canopy transpiration, which in turn lead to increased plant water use efficiency and reduced fluxes of surface latent heat. The increase in leaf photosynthesis with rising CO2, the so-called CO2 fertilisation effect, plays a dominant role in terrestrial biogeochemical models to explain the global land carbon sink ..., **yet it is one of most unconstrained process in those models**. ...However, FACE experiments also show the diminishing or lack of CO2 fertilisation effect in some ecosystems and for some plant species. ...

"Nutrient limitation is hypothesized as primary cause for reduced or lack of CO2 fertilisation effect observed on NPP in some experiments ... Nitrogen and phosphorus are very likely to play the most important role in this limitation of the CO2 fertilisation effect on NPP, with nitrogen limitation prevalent in temperate and boreal ecosystems, and phosphorus limitation in the tropics...

Thus, with high confidence, the CO2 fertilisation effect will lead to enhanced NPP, but significant uncertainties remain on the magnitude of this effect, given the lack of experiments outside of temperate climates. "

The IPCC authors are well-published researchers in this field.

Peabody's witnesses are not, but they somehow were absolutely **certain** the benefits to agriculture far exceeded any negatives.

WGIIAR5 https://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap7_FINAL.pdf pp.505-507 Section 7.4

https://www.ipcc.ch/report/graphics/images/Assessment%20Reports/AR5%20-%20WG2/Chapter%2007/WGII_AR5_Fig7-7.jpg

In summary, real experts together think that even with CO2 greening, the overall effects are negative on crops.



The Greening Earth

Prof. Ranga B. Myneni

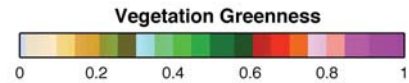
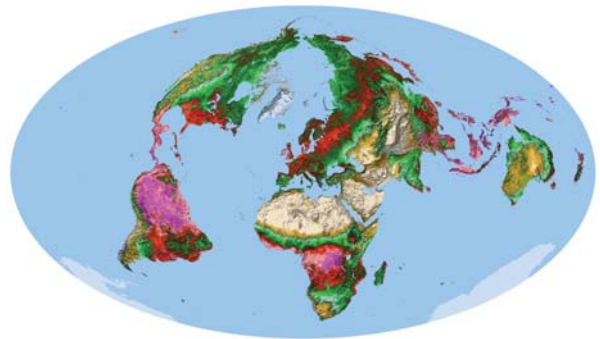
Department of Earth & Environment
Boston University
USA

ranga.myneni@bu.edu
<http://cliveg.bu.edu/>

Probing Vegetation Conference
From Past to Future
July 4-5, 2013
Antwerp, Belgium

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Average Greenness Of Our Planet



4/12

What Happens When Radiation from the Sun Strikes a Green Leaf?



"La Belle Saison"
René Magritte

2/12

How Did The Greenness of Our Planet Change?

- Satellite Vegetation Greenness Data (AVHRR)
- July 1982 to December 2012 (30+ years)
- 8x8 kilometer pixels
- 2 Views a month



"Wooded Landscape"
Sir Anthony Van Dyck

5/12

Monitoring Vegetation From Space



Image Credit: Satellite Imaging Corp.

Pigments in green leaves (notably chlorophyll) **absorb** strongly at **red** and **blue** wavelengths (approximately less than 0.7 microns).

Lack of such absorption at **near-infrared** wavelengths results in strong **scatter** from leaves (approximately greater than 0.8 to 1.2 microns).

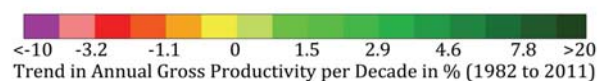
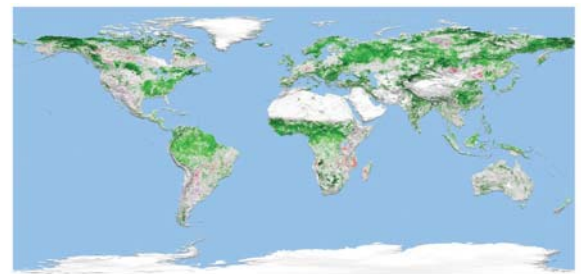
The "**greenness**" of the ground is simply the difference between these two measurable quantities (appropriately normalized).

$$NDVI = (NIR-RED) / (NIR+RED)$$

NDVI = Normalized Difference Vegetation Index

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The Greening Earth



Annual Gross Productivity = Growing Season Total Vegetation Greenness
Statistically significant ($p < 0.1$) based on Vogelsang's t-PS_T test

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These are not claims that more CO2 is all goodness.

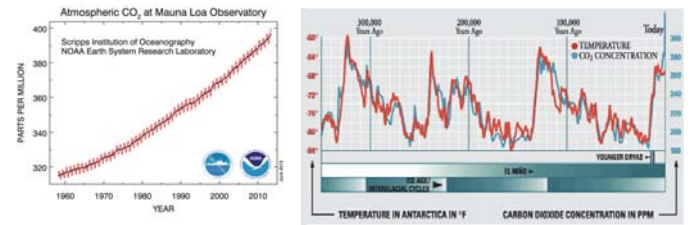
By How Much did the Earth Green over the Past 30 years?

IGBP Land Cover Classes	Area			Productivity		
	G (%)	B (%)	N (%)	I (%)	D (%)	
Evergreen broadleaf forests	5.62	0.15	7.10	2.27	-0.04	
Deciduous broadleaf forests	0.54	0.09	0.95	0.23	-0.05	
Cropland/Natural vegetation mosaics	2.27	0.13	4.30	1.26	-0.09	
Savannas	1.67	0.40	6.03	0.94	-0.16	
Mixed forests	3.56	0.40	8.33	1.96	-0.19	
Woody savannas	2.85	0.05	2.96	1.22	-0.03	
Croplands	3.41	0.21	7.15	1.75	-0.12	
Closed shrublands	1.80	0.19	3.36	0.68	-0.06	
Evergreen needleleaf forests	0.92	0.01	1.15	0.25	-0.00	
Deciduous needleleaf forests	0.18	0.09	1.07	0.11	-0.07	
Grasslands	2.86	0.48	10.53	1.08	-0.18	
Open shrublands	5.18	0.57	13.39	1.80	-0.22	
Total	30.87	2.76	66.32	13.54	-1.21	

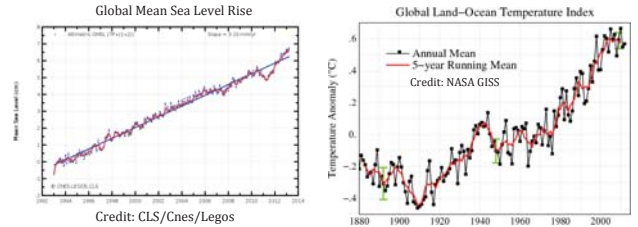
- 31% of the global vegetated area greened
- This greening translates to a 14% increase in gross productivity
- The greening is seen in all vegetation types

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Is this a Good or Bad Development?



Credit: Siegenthaler et al. (2005)



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Elfstedentocht is a long ice-skating race in N. Netherlands, which he obviously expects to disappear.
<https://en.wikipedia.org/wiki/Elfstedentocht>

Elfstedentocht? We Can Forget it!

Why did Our Planet Green?

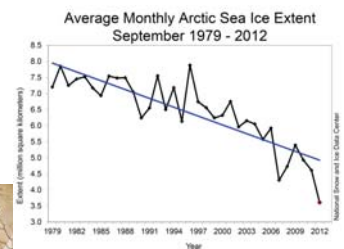


"L'Eveil de la Forêt"
Paul Delvaux

8/12



"Winterlandschap met Schaatsers en een Vogelval"
Pieter Bruegel de Oude

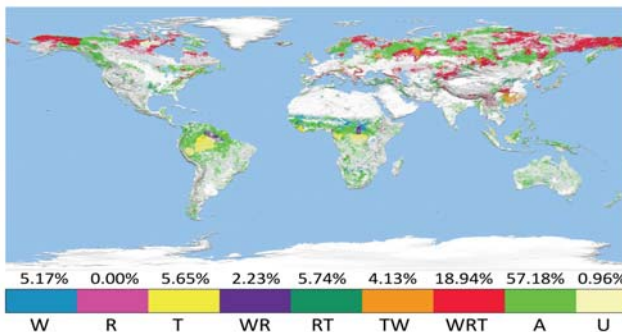


The Arctic could be ice-free in about 30-50 years!

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From the talk he gave, these show constraints:
 Water, Radiation (sun), Temperature, Anthropogenic

Why did Our Planet Green?



Attribution of Increase in Annual Gross Productivity

- 42% can be attributed to relaxation of climatic constraints to plant growth
- 57% to "other" anthropogenic factors
- 1% unknown

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What Can We Do?

- Monitor Changes:** Cost-effectively and accurately with Satellite Sensors
- Action:** Inform the Public & Policy Makers
- Hope:** We can be as happy as these David Teniers II's "Peasants"



"Peasants Merry-Making"
David Teniers de Jonge

12/12