No More Excuses[1]

Lauren Hartzell, Kirsten Oleson, and Michael D. Mastrandrea
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Introduction

Climate change is now a much discussed and researched issue. This paper offers insight into the need and nature of immediate actions required to prevent dangerous climate change. We engage in what we are calling quantitative natural resource ethics. This approach weaves together normative and positive methods of inquiry. We hope to demonstrate that applying this integrated method to certain aspects of the problem of global climate change can lead to new avenues of deliberation and insights. In particular, we feel our discussion in this paper makes explicit what many people seem to already believe: that inaction by key players with respect to climate change is no longer acceptable or justified. We pull together recent scientific evidence to argue that immediate action by key players is required to prevent dangerous climate change. We further discuss several moral issues that arise from this argument. We argue that the immediacy and nature of the problem of dangerous climate change must take priority over some moral considerations because it is essential that dangerous climate change be avoided. Moral considerations, however, should guide policy making within the confines of the practical realities of what *must* happen for dangerous climate change to be avoided. We hope that our integrated argument is more convincing to policy-makers, especially in the key nations we identify, than purely scientific arguments seem to have been, and more immediately policy-relevant than purely ethical arguments often seem to be.

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Part I: Dangerous Climate Change—The Scientific Evidence

In the first section of this paper, we draw upon the latest scientific evidence to: (i) explain how greenhouse gas emissions cause climate change; (ii) enumerate the types, extent, and timing of impacts that we can expect from climate change; (iii) given these impacts, argue for one definition of “dangerous” climate change and establish a threshold temperature increase that we must not cross to successfully avoid most dangerous climate change; (iv) correlate this threshold temperature with a stabilization level of atmospheric carbon and with the total global cumulative emissions between now and 2050. The 2050 cut-off is arbitrary in terms of climate change, but we have chosen it because it is the timeframe that is currently being debated in policy arenas (Lieberman-Warner Climate Security Act[2] and the IPCC Bali Action Plan[3]). Additionally, as we present below, there is good scientific reason to believe that if we act meet certain emissions goals by 2050, we can likely prevent dangerous climate change from occurring. This section basically summarizes the current scientific consensus that drastic and immediate reductions are required in global cumulative emissions if we hope to avoid one conception of “dangerous” climate change.

Emissions cause climate change

Three physical relationships are important to understand to grasp the basic physical processes of climate change. These are also crucial to understanding the Intergovernmental Panel on Climate Change’s (IPCC) projections that we will use as our main body of evidence. The first is the relationship of systems to temperature, the second is the relationship between atmospheric

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[2] Senate Bill S. 2191, “America's Climate Security Act of 2007,” 18 October 2007

[3] UNFCCC, *Bali Action Plan*: www.unfccc.int/meetings/cop_13/items/4049.php

greenhouse gas concentrations and mean global temperatures, and the third is the relationship between greenhouse gas emissions and atmospheric greenhouse gas concentration.

Many systems are responsive to temperature changes. We see evidence of this at all scales. In our backyard gardens, bulbs will only bloom after spring temperatures rise. If the bulb's threshold temperature is reached in early January, the bulb will sprout. At small and large scales, the biological system is inextricably linked to the physical system. Ecosystems react to changes in the physical environment. Similarly, different physical systems react to one other. Drawing a steaming bathtub heats up and humidifies the bathroom's air. Adding cold milk into a hot cup of coffee causes temperature gradients and mini-currents in the mug. Ice melts faster in a glass of warm liquid than cold. These sorts of relationships also occur at the global scale. The warming of the ocean causes increased evaporation, the warming of the oceans and air melts ice faster, and an increased influx of cold water into the ocean causes changes in currents. In short, a change in temperature can affect many systems, and this relationship holds at the global scale.

The second relationship has to do with what causes temperatures to rise at a global scale. The earth's warmth is provided by the sun's energy. How much of the sun's energy the earth receives is based on properties of the earth's atmosphere and surface, because these determine how much energy gets reflected, emitted, and absorbed. There is solid scientific evidence that the earth's energy budget has changed since the pre-Industrial era.[4] A key factor in the altered energy budget is the concentration of greenhouse gases in the atmosphere. These gases prevent escape of the energy that the earth would otherwise have reflected back into space. Another key factor changing the energy balance are aerosols in the atmosphere that both reflect and absorb

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[4] Solomon, S., D. Qin, M. Manning, M. Marquis, K. Averyt, M. Tignor, H. Miller, Z. Chen (2007) *Climate change 2007 – The physical science basis. Contribution of Working Group 1 to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press. (Hereinafter referred to as AR4, WG1)

solar radiation. The effect that these two factors cause in the energy balance is technically called "radiative forcing".[5] Positive forcing warms the earth, and negative forcing cools it. Both positive and negative forcings are occurring due to climate change (for instance, increased greenhouse gas concentration traps more energy while higher aerosols reflect more energy), and there are numerous positive and negative feedbacks. But the balance is decidedly positive forcing. Indeed the IPCC states "warming of the climate system is unequivocal…"[6]

Putting these two relationships together, we know that physical systems react to temperature changes and temperature changes are a result of increased atmospheric greenhouse gas concentrations.

The third relationship is between atmospheric greenhouse gas concentration and greenhouse gas emissions. The dominant contributor to positive forcing is increased atmospheric greenhouse gas concentrations, and these increases are predominantly a result of a long history of human activities such as fossil fuel consumption, cement manufacturing, land use change, and agriculture. The IPCC Fourth Assessment Report states: "global atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased markedly as a result of human activities since 1750…"[7] These activities emit heat-trapping gases into the atmosphere, increasing atmospheric greenhouse gas concentration. Nine major greenhouse gases contribute 97% of the radiative forcing (in order of contribution to radiative forcing): carbon dioxide, methane, nitrogen oxide, and chlorofluorocarbons 11 and 12.[8] Carbon dioxide emissions constitute about 63% of the radiative forcing, 85% of which derives from fossil fuel combustion

[5] AR4 WG1:21
[6] AR4 WG1:5
[7] AR4 WG1, Summary for Policy Makers (SPM):21
[8] D. J. Hofmann *et al.*, Tellus B **58**, 614 (2006). Updated: www.esrl.noaa.gov/gmd/aggi/

and industrial processes.[9] Other major sources of greenhouse gases are agricultural (including livestock) production and deforestation.[10]

Many greenhouse gases are long-lived, so while there is some "natural" removal, they persist in the atmosphere for decades or centuries. This implies that current emissions will affect the climate of people living anywhere from next year to centuries from now. The inertia of the climate system implies that we are committed to a certain amount of climate change despite any action that we take today. This concept becomes important later in our paper when we discuss the need for immediate action. Based on historical records such as ice cores, we know that pre-industrial carbon dioxide concentrations were about 280 parts per million in pre-industrial times (around 1750). In 2005, they 379 parts per million, and that concentration is rising at a historically unprecedented rate of more almost 2 parts per million per year.[11]

We are now prepared with enough science to understand the impacts that climate change might induce and what types of actions are required to curb climate change.

Types, extent, and timing of impacts

Increased annual temperatures impact natural, economic, and human systems. We are already experiencing changes in some systems in certain regions of the world due to rising mean temperatures.[12] For example, evidence is mounting of glacial retreat and instability in sea-ice biomes. Some hydrological systems' flows are occurring earlier, and many lakes are warming.

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[9] M. R. Raupach *et al.*, "Global and regional drivers of accelerating CO_2 emissions." Proc. Nat. Acad. Sci. U.S.A. **104**, 10288 (2007).
[10] M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, Eds. (2007) *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group 2 to the Fourth Assessment Report of the IPCC* (Cambridge Univ. Press, Cambridge), Summary for Policy Makers (SPM). (Hereinafter referred to as AR4 WG2.)
[11] AR4 WG2 SPM:25
[12] AR4 WG2 SPM:9-11

Many terrestrial plant and animal species are migrating northward and exhibiting springtime characteristics earlier in the year. Marine systems, too, are affected: fish migrations are earlier, and many areas have different algal, plankton, and fish abundance than before. Scientists also are confident that agricultural and forest systems are changing, necessitating earlier plantings and increased irrigation by farmers and changing ecosystem functions.

Projections of the types of impacts we can expect from climate change include both *direct* and *indirect* impacts. Direct impacts are deaths, injuries, disease, and other changes in well-being that climate change events directly cause, such as from sea level rise or reduced precipitation. Indirect impacts are effects such as migration that are caused by stress on systems, such as agricultural areas, from climate change. Indirect impacts will affect far more people than direct impacts. Whether people will suffer from climate change depends greatly upon where they live. Impacts will vary greatly across regions, not just because of the differential warming and the associated physical changes across the globe, but because of variation in system adaptability. A decrease in annual rainfall may not be a huge loss to an American homeowner with municipal water supplied to their home, but the same decrease could be devastating to a subsistence farmer in Africa. It is not surprising, then, that the IPCC projects much greater negative direct and indirect impacts in developing nations. These nations will not only bear the greatest physical impact of climate change, they are also less capable of dealing with the associated indirect impacts.

How well human and natural systems will adapt to climate change highlights the crucial role of timing. If human and natural systems have enough time to figure out ways to compensate for or adjust to the changes that climate change will cause, then the force of the impacts could be less than anticipated. On the other hand, if these natural and human systems do not react as quickly or with as much agility as expected, the impacts will be more severe. We return to the issue of timing throughout this paper because the force of climate change's impacts depends both on how bad the impacts are as well as how quickly they are likely to occur. When we discuss what constitutes dangerous climate change, we return to this.

We align our description of impacts with those described in the IPCC Fourth Assessment Report. These impact projections represent the most current science, and are based on scientific understanding of the climate system, historical observations, and model projections. We highlight some – but not nearly all – of the projected future impacts below. We feel that this list is sufficient to make our argument. For a more exhaustive listing, we refer the reader to the IPCC FAR. In most cases, we cite the IPCC's "confidence" of the impact. This represents the consensus opinion of the scientists. Very high confidence means that there is at least a 9 out of 10 chance of being correct; high confidence implies an 8 out of 10 chance; and medium confidence implies that there is a 5 out of 10 chance – in other words, it is a coin toss.[13]

Climate change already contributes to the global burden of disease (e.g., the European heat waves in 2003 and 2007). With high confidence, millions more people worldwide will be affected by exposure to future climate-related changes. Changes in social and natural systems affect humans in a variety of ways both directly and indirectly. Direct impacts on human health will occur from changed weather patterns. Increased direct exposure to heat waves, fires, storms, floods, and droughts will increase many people's risk of injury, disease, and death, and increases in the frequency and/or intensity of many of these events are already being observed, a trend projected to continue into the future. These events will occur with more frequency and intensity for a variety of reasons. Increased temperatures provide more energy for storms and the potential

[13] AR4, WG2, p 21.

for prolonged and more intense heat waves. Less precipitation and shifting ecosystems can lead to conditions amenable to forest fires and extended drought. Changes in hydrologic patterns can alter the timing and flow of run-off.

Indirect impacts on health will occur from changes in water, air, food, ecosystems, agriculture, and the economy. With high confidence, climate change's alteration of freshwater supplies will result in numerous major indirect impacts on human health. Increasing water stress in already arid areas can potentially force people to walk long distances to get drinking water, reduce land appropriate for agricultural production, and, in extreme cases, fuel conflicts. Summer and autumn runoff will decline as glaciers retreat and snow pack declines; altering the freshwater access of many the globe's inhabitants. In high latitudes and wet tropical areas, river run-off will increase, endangering settlements in flood plains, causing people to migrate. A second and related indirect impact of altered freshwater supplies is malnutrition. With high confidence, an increase in malnutrition will occur with significant negative effect on human health.[14] Changes in agricultural water supplies, sea level rise, increased risks of fire, pests, and disease, extinction of local fish stocks, and decreased crop yields in seasonally dry and tropical regions will all contribute to reduced global food security.

Natural systems will directly be affected by disturbances from climate change, such as temperature change, floods, droughts, wildfires, and ocean acidification. With these threats, the services that ecosystems provide to humans will also be endangered. Changes in species' composition, migration patterns, biological clocks, calcification, and so forth will alter ecosystem functions. Coastal wetlands will, with high confidence, be disturbed by sea level rise;

[14] AR4 WG2 Technical Summary (TS)

and coastal areas will be exposed to higher risks of erosion and storms. Corals will increasingly bleach from higher mean sea surface temperature.

With medium confidence, a sustained rise in temperature will cause the Greenland and West Antarctic ice sheets to at least partially melt. A huge amount of the earth's freshwater has, for many, many years, been trapped in these ice sheets (the WAIS is 11,000 years old, while the GIS is over 110,000 years old). These reservoirs of ice serve multiple physical functions. They store water and reflect sunlight, and their melting will disrupt ocean and climate circulation. A number of large-scale impacts would result from the loss of these ice sheets. Their complete melting could cause a sea level rise of up to 12 meters; partial melting, predicted to occur over centuries, could cause a sea level rise of up to 6 meters. This rise would permanently flood many coastal and low-lying areas, including New Orleans, the Netherlands, Bangladesh, and most low-lying, small island nations. This would affect any nation with a coast, or which depends upon coastal infrastructure for its survival (such as ports in nearby nations or trading partners). In particular, nations that do not have adaptive capacity to deal with rising sea levels will be disproportionately affected. Secondly, the influx of freshwater could change global ocean circulation. Warm seawater is less dense than cooler water, and saltwater is denser than freshwater. Climate change-induced melting of ice will affect water density by causing an influx of less dense freshwater. Similarly, stratification of the ocean's water will be fortified by warming of surface water. This stratification prevents mixing. Further exacerbating the problem, the ocean is one of the planet's most important carbon sinks. Ocean circulation regulates the contact of deep ocean water with the atmosphere, governing carbon uptake by the ocean. An alteration of this carbon exchange will decrease the amount of carbon dioxide taken out of the atmosphere by the ocean. The third widespread impact caused by the partial loss of the ice sheets is loss of snow cover. Loss of snow cover causes a positive feedback by reducing the Earth's reflective capacity, therefore causing more of the sun's heat to be absorbed. This feedback will accelerate climate change.

"Dangerous" climate change

The concept of "dangerous" climate change originated in the United Nations Framework Convention on Climate Change (UNFCCC).[15] The Framework establishes that parties to the Framework Convention should avoid "dangerous anthropogenic interference" with the climate system. No specific definition of what constitutes "dangerous" is delineated in the UNFCCC, in part because what constitutes "dangerous" climate change is based on differing world views and values. Furthermore, as we explained above, impacts of climate change will not be equally distributed around the globe. Some regions may experience severely negative impacts that are locally quite "dangerous" long before another (and some may even benefit from climate change while others suffer), depending on the differential physical impacts of climate change, reactions in ecological and economic systems, and the ability of human institutions to adapt. Moreover, when impacts are likely to occur may be relevant to how we define dangerous climate change. If impacts will not occur for hundreds of years, some may not consider those at all dangerous. On the other hand, some people may be more risk averse (or more vulnerable), and not be willing to accept an increased risk no matter when the impacts are projected to occur. All of this makes defining "dangerous" climate change a difficult – and inherently normative – task.[16] Before

[15] United Nations Framework Convention on Climate Change (UNFCCC, 1992); www.unfccc.int
[16] AR4 WG2

presenting our definition of dangerous climate change, we need to spell out the ways in which it is a normative concept and why it is thus bad and ought to be avoided.

The definition of dangerous climate change is inherently normative because it is stated in reference to impacts that will have negative effects on human welfare; this is what makes them dangerous. What makes dangerous climate change bad, then, is that it threatens human welfare. We consider human welfare to be normatively valuable and worth protecting, now and into the future. We also consider the lowering of human welfare to be bad, and the lowering of human welfare below a bare minimum to be especially bad. This bare minimum corresponds to individuals' ability to access essential services such as food, clean water, and basic health care. The value of services essential to human welfare could be morally defended in many different ways (e.g. by utilitarians or deontologists). We will not take on that project here. We will, however, defend the general claim that (for a diversity of reasons) it would be very bad for essential services to be lost or destroyed without the possibility of replacement, restoration, or the possibility of being compensated for. We understand this claim to be about sustainability in the sense that it would be unsustainable for essential services to be lost as they would should dangerous climate change ensue. Human welfare depends on the sustainability of essential services. Our argument that dangerous climate change is bad thus rests on a principle of sustainability. The principle of sustainability that we appeal to is that services essential to human welfare must be maintained in order to protect the welfare of present and future generations. In economic terms, the ultimate aim of sustainability is to ensure human well-being, and resources are simply a means to that end.[17] [18]

[17] Goodland, R. and H. Daly (1995). Environmental Sustainability. Environmental and Social Impact Assessment. F. Vanclay, and D.A. Bronstein. Chichester, Wiley**:** 303-322.

The way in which we define dangerous climate change, and what makes it dangerous in our minds, is the fact that it involves changes that threaten the sustainability of services essential to human welfare such that no replacements are available. Dangerous climate change will threaten unique and threatened systems, and people depend on such systems for their welfare (e.g. watersheds, agriculture, etc.). Dangerous climate change will also increase the risk of extreme weather events, which we have seen can have significantly negative impacts on peoples' welfare, even in developed countries. Dangerous climate change will also likely have widespread negative market impacts. Finally dangerous climate change is associated with increasing risks of large-scale discontinuities, which would threaten human welfare in unpredictable, though likely extreme and widespread, ways. What is bad about dangerous climate change is thus that it threatens the sustainability of services essential to human welfare.

A key aspect of the unsustainable nature of dangerous climate change is the *irreversibility* of the changes it would involve. Future generations will not be able undo its damaging effects. This is especially significant since dangerous climate change will irreversibly affect essential services that future generations will need to maintain their welfare. They will thus not only have a reduced scope of available options, but their existence and fundamental well-being will be threatened. What is bad about climate change, and why it ought to be avoided, is thus that it threatens to have significant and widespread negative effects on human welfare. Its impacts would unsustainably impact services essential to human welfare. This argument could, of course, be spelled out in more detail, but we believe that the conclusion that dangerous climate change ought to be avoided is uncontroversial enough to motivate the rest of our paper. The

[18] Solow, R. M. (1992). An almost practical step toward sustainability. Resources for the Future 40th Anniversary Lecture, Washington, D.C.

more pressing argument that we will make now is that immediate action must be taken to prevent dangerous climate change.

Returning to our positive discussion, we now present one definition of dangerous climate change. We follow the precedent set by the IPCC and a number of recent scholarly articles suggesting a definition of dangerous climate change using five Reasons for Concern.[19] [20] The first presentation of these Reasons for Concern appeared in the IPCC Third Assessment Report.[21] They provide a useful framework for thinking about the impacts of climate change because they take into account all of the considerations discussed above, namely the extent, timing, and types of impacts.

The five Reasons of Concerns in the IPCC report are:

(1) Risks to unique and threatened systems, including loss of coastal habitat due to sea level rise, coral bleaching due to sea temperature increases, loss of wetlands from reduced precipitation, and melting of the Artic ice and permafrost.

(2) Risk of extreme weather events, including increasingly intense and frequent heat waves, storms, floods, and droughts.

(3) Distribution of impacts, which is an assessment of whether the impacts of climate change will be negative in most regions of the world;

(4) Aggregate Impacts, whether the aggregate effects will, on net, be negative for all metrics; and

[19] Luers, A., M. Mastrandrea, K. Hayhoe, and P. Frumhoff. 2007. “How to Avoid Dangerous Climate Change: A Target for U.S. Emissions Reductions.” Union of Concerned Scientists (Cambridge, MA).
[20] Mastrandrea, M., A. Luers, P. Frumhoff, K. Hayhoe, L. Shultz, D. Boucher, G. Heal, S. Schneider (2008) “Reducing Greenhouse Gas in the United States: How far and how fast” (in preparation).
[21] Watson, R. (2001) *Climate Change 2001: Synthesis Report* (Cambridge Univ. Press, Cambridge).

(5) Risks of large-scale discontinuities, such as melting of the West Antarctic and Greenland Ice Sheets.

The IPCC defines the point when we are likely to experience "severe risk" in each of these Reasons for Concern. Roughly, within each Reason for Concern, severe risks are those when the impacts are likely to be wide-scale in geographic scope and great in magnitude. In other words, we risk losing many unique and threatened ecosystems globally; we risk large increases in the frequency and intensity of extreme weather events; we risk incurring widespread negative impacts at the global scale; we risk incurring far more negative than positive impacts; and we increase the risk of large-scale discontinuities.[22] [23]

This framework provides us with a way to designate what constitutes "dangerous" climate change. These studies describe the point where we will likely experience "severe risk" in three of the five categories: unique and threatened systems, extreme weather events, and distribution of impacts.[24] An alternate threshold might be where all five reasons presented severe risks. We agree with these authors, however, that three out of five is alarming enough and warrants serious concern. In fact, perhaps using these three is allowing too many impacts to occur. By accepting severe risks in these three, we are talking about widespread negative impacts to natural and human systems across the globe. (The addition of the fourth and fifth would mean that on aggregate any positive effects of climate change would be negated by concurrent negative impacts, and the risks of large-scale discontinuities would be more widespread.) In all, we think that the three-out-of-five definition is a good starting point. If we were to choose one-out-of-

[22] Watson et al (2001)
[23] M. Mastrandrea and S. Schneider (2005) "Probabalistic integrated assessment of "dangerous" climate change and emissions pathways." *Science* Vol. 304, No. 5670: 571-575.
[24] Luers (2007) and Mastrandrea (2008)

three, it makes little difference to the force of our argument. As we will show, the action required to avoid three is equal to the action required to avoid just one because the temperature change we need to avoid is equivalent for each. If we were to choose five-out-of-five, the action required might be slightly less drastic, but not by much. We might also choose to take issue with the severe risk threshold. Long prior to reaching severe risk, some extremely dangerous climate change will be underway for some populations (e.g. Arctic communities, polar bears). Because we are trying to make a compelling argument to policy-makers, setting the threshold much lower would not serve our purposes.

Assuming that we need to avoid severe risks in three categories, what is the threshold temperature change? The IPCC Reasons for Concern analysis relates the temperature change in 2100 (relative to pre-industrial levels) to the risk of expected impacts. It is clear that the more the temperature rises, the more likely we are to experience more risk in each Reason for Concern. As we noted above, the first presentation of these Reasons for Concern was in 2001. The 2007 IPCC Fourth Assessment Report updated the information based on increased scientific understanding of the expected impacts from temperature increases. This update presents an alarming story: evidence is mounting that the 2001 estimates were far too optimistic, and that we will actually experience much greater risk from the same amount of temperature rise. For example, recent studies have shown that both ice sheets are melting more quickly than historical trends predict, leading scientists to conclude that existing ice sheet models underestimate the rate of sea level rise possible due to ice sheet melting.[25] The conclusion from the growing body of evidence is that levels of warming well below previous estimates pose substantial risks.

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[25] AR4 WG1

Using the most recent estimates of the temperature changes correlated with severe risk for each Reason for Concern,[26] we can estimate that in order to avoid severe risk in three of the five (unique and threatened systems, extreme weather, and distribution of impacts), we cannot exceed an average global warming of over 2 degrees. (To avoid severe risk in the aggregate impacts, we cannot exceed 3 degrees warming. To avoid severe risk in the last, we cannot exceed 3.5 degrees warming.)

Temperature change, stabilization level, and global emissions

This now brings us to the question: What stabilization level of atmospheric greenhouse gas concentrations will ensure we do not exceed the 2 degree temperature threshold? The answer to this question depends on the climate sensitivity, that is, how much warming will occur given a rise in atmospheric greenhouse gas concentrations. Based on the IPCC's best estimate of climate sensitivity, if we stabilize concentrations at or below 450 ppm CO_2eq, we have a 50-50 chance of not exceeding the 2-degree threshold, and it is very unlikely that we will exceed 3 degrees. This arguably seems like a reasonable stabilization level to avoid dangerous climate change: we have an even chance of severe risk in three categories, and we avoid severe risks in two.

The third physical relationship comes to bear here: the relationship between atmospheric greenhouse gas concentration and greenhouse gas emissions. Current atmospheric greenhouse gas concentrations are already over 450 ppm CO_2eq, and rising at almost 3 ppm per year.[27] This implies that even if we could halt all future atmospheric greenhouse gas emissions, we are still committed to a 2 degree rise in temperature.

[26] Mastrandrea (2008)
[27] Hoffman (2007)

Needless to say, we will overshoot this concentration in the short-term, because we cannot expect all emitting activities to halt, but eventually, we will have to return to the 450 threshold. To do so, our anthropogenic emissions will have to be less than natural gas-capturing processes so that, on balance, the atmospheric concentration declines after the overshoot.[28] Luers cites several studies indicating that long-term stabilization at 450 ppm CO_2eq implies a global cumulative emissions budget of 1,700 gigatons CO_2eq over the period fifty-year period starting in 2000. In other words, the total amount of global emissions during those 50 years should not exceed this amount. According to Luers this would require global cumulative emissions to be 50% less than they were in 2000 by 2050. Put another way: we need to halve global emissions by 2050 to avoid dangerous climate change.

Part II: Preventing Dangerous Climate Change

At this point we have argued that we ought to prevent dangerous climate change, and we ought to do so without delay or it will be too late. In the second part of this paper we argue that in order for dangerous climate change to be prevented, key states must take immediate action to reduce their greenhouse gas emissions and/or implement strategies to curb future emissions. We will also discuss the moral implications and justifications of this argument. We have suggested that a global emissions threshold must not be crossed in order to prevent dangerous climate change, but how should policy-makers respond to this information? What role should equity considerations play in policies aimed to prevent dangerous climate change? If so, how can we justify limiting our attention to and focusing responsibility for immediate action on a select group of key players? These are not easy or straightforward questions to answer. In the

[28] Luers (2008)

remainder of this paper we will weigh in on these questions and related issues, but we cannot possibly resolve all issues that arise in setting dangerous climate change policies.

In our discussion we build on a report put out by the Union of Concerned Scientists entitled, "How to Avoid Dangerous Climate Change: A Target for U.S. Emissions Reductions."[29] This report focuses on U.S. emissions targets relative to the aim of preventing dangerous climate change, though it also raises questions and has implications for thinking about global policies for preventing dangerous climate change. The authors of this report recognize, as we do, that discussions of the most equitable way to allocate global emissions reductions could go on for some time. But, as they say, "Unfortunately, the world no longer has the luxury of engaging in a persistent stalemate."[30] Though they do also stress that we need rapid consensus on "equitable and effective allocation of emissions among nations,"[31] implying that equity concerns continue to be important despite the now pressing nature of the problem. Our approach is to first emphasize the practical realities of what must happen to prevent dangerous climate change in light of how and where equity and other theoretical moral considerations come into play. In this section we will argue that dangerous climate change cannot be avoided without immediate action by key states. We define key states as those that either currently have the highest emissions or those that will have the highest emissions by 2050 if they follow current growth trends. We show that unless all these key nations act together, we will not achieve the required reductions by 2050.

Key States Need to Take Immediate Action

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[29] Luers *et al* (2007)
[30] Luers *et al* (2007): 9.
[31] Luers *et al* (2007): 9.

We argue in this section that states, and especially a few key states, are the appropriate unit of analysis—actors—for climate change policy. Our argument for this claim is more practical than theoretical. We have established, and will further elaborate later in this section, that dangerous climate change is a very real and immediate threat. If significant actions are not taken in the very near future, dangerous climate change will ensue. In an ideal case we would further deliberate about what actors should be responsible to take action by considering a wide range of moral considerations, but the practical reality is that certain key states must take action in order for dangerous climate change to be prevented. Given our intention of making positive contributions towards understanding the immediacy and nature of climate change policies, we focus on the practical realities of what needs to happen in order to prevent dangerous climate change.

One of our primary reasons for arguing that states, and in particular the key states we identify, are the appropriate unit of analysis for climate change is that key states are the only actors who will be able to effectively act in the ways that will be required to prevent dangerous climate change. This is due to the practical collective action problem that no individuals or individual states can effectively halt or significantly impact the degree of climate change that will occur on their own. Collective action challenges make it difficult for individual actors to find it rational to take extreme, or even moderate, measures to reduce climate change, especially when such measures have negative short-term consequences for those who act. This is exacerbated by the current lack of international cooperation on climate change. There is no current system of global governance powerful enough to affect and enforce the actions necessary to prevent dangerous climate change. Furthermore, individuals, NGOs, corporations and the like similarly lack effective power and are ill-equipped to incite the necessary changes. Even if one wanted to argue that collectively individuals, NGOs, corporations, international organizations, alliances of small states, or any set of individuals or groups of individuals do have the combined ability to incite the necessary changes, the practical challenges posed by collective action are too big to be overcome in the necessary time frame.

In order to overcome this collective action problem, we narrow the playing field to key states that collectively have the ability to effectively prevent dangerous climate change. We believe that action on the part of these states is necessary for the prevention of dangerous climate change for the reasons stated below. Admittedly, there still is a collective action problem insofar as we argue that action must be taken by *all* of the key players, but this problem is much more manageable because the number of players is limited and the actions required of each of them is much clearer and easier to define.

Below, we show that immediate action by key states is required to avoid dangerous climate change. Our case is this: (i) drastic cuts in emissions by the current high-emitters would not be sufficient to meet the global cap, nor would constrained future emissions be from states on an energy-intensive development path. Only in concert will these key states meet the cap; and (ii) delayed action will increase the risk of crossing thresholds leading to dangerous climate change.

Without global reductions, we will not meet the cap. Current global annual emissions are nearing 42 tons CO_2eq. If we keep emitting at this level, then we will hit the cap around 2040, and need to halt all emissions that year. Obviously, this is not an option. However, innumerable emissions pathways can be followed and still meet the 1,700 Gton CO2eq cap. Imagine three scenarios: (1) global emissions level off immediately and decline gradually until 2050; (2) global emissions continue to grow at a rate lower than historical growth, peaking within the next decade or so, then drop fairly quickly; and (3) global emissions continue to climb at the current rate, peaking in a few years, then drop precipitously. These scenarios could all ensure that global emissions between 2000-2050 remain under 1,700 GtCO2eq by following very different pathways. Some require immediate reductions, while others could delay cutting of emissions for a while. The scenarios illustrate that as the peak is extended further into the future, the required annual reduction becomes more drastic.

In this section, we focus exclusively on carbon dioxide emissions from fossil fuel consumption, industrial processes, and cement manufacturing. This narrow focus leaves out some important greenhouse gases and processes. We do capture the majority (~63%) of the radiative forcing.[32] Furthermore, we can focus on the most important anthropogenic forcing flux, carbon dioxide, and thus we are able to narrow our discussion to emissions from a couple of sectors.[33] We need to adjust our cap to reflect the focus on carbon dioxide emissions. For simplicity sake, let us assume that the portion of the radiative flux coming from carbon dioxide should remain the same over the coming decades. Our cap for carbon dioxide emissions should thus be about 63% of the 1,700 gigatons CO_2eq, or about 1,100 gigatons CO_2eq.

Reductions in carbon dioxide emissions by states that are currently the highest emitters will not be sufficient to remain below the 1,100 gigatons CO_2eq cap. If the US, the EU, and Japan kept their emissions to 2004 levels until 2050, their collective emissions would be about 565 gigatons.[34] This leaves less than half of the allocation for all other nations in the globe. If China and India's historic growth rates continue until 2012, the allocation will have been used up by these nations alone by then.

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[32] Rapauch (2007)
[33] Rapauch (2007) and AR4 WG3 SPM
[34] based on emissions data from G. Marland, T. Boden, and R. Andres (2007) available at http://cdiac.ornl.gov/trends/emis/meth_reg.html

Even if the US unilaterally decided today to reduce its emissions by a significant amount below 2000 levels by 2050 (say it reduced emissions by 4% a year), its emissions, combined with the unreduced emissions of India and China would still exceed the cap by 2012. Therefore, the key states must reduce emissions in conjunction with reductions in emissions in China and India.

To meet this stringent cap on cumulative global emissions, the IPCC, Mastrandrea and Luers all emphasize the need for immediate action. According to one recent study, current global emissions exceed the worst-case scenario modeled by the IPCC and the growth trend is faster than anticipated, in fact, the growth rate of greenhouse gas emissions was three times higher in 2000-2005 than in 1990-1999.[35] This trend must be reversed quickly to avoid dangerous climate change. The longer global emissions continue to increase along the recent historical trends, the more extreme future cuts will have to be, and the more likely an overshoot will be.

Differential Responsibilities—Key MDC vs. Key LDC Responsibilities

We have now established the need for immediate action to prevent dangerous climate change. We have also suggested that in order for dangerous climate change to be prevented, action will have to be taken by *both* more developed countries (MDC) and less developed countries (LDC). In this section we will suggest a general way in which the actions required of MDC and LDC can be differentiated in both pragmatically and morally justifiable ways. This discussion can serve to guide policy-makers, though we do not make specific policy recommendations. In our discussion we will refer to key MDC as U.S., E.U. and Japan and key

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[35] Energy Information Agency (2007) *Annual energy outlook 2006 with projections to 2030*. Report #DOE/EIA-0383. (US Department of Energy).

LDC as China and India, per our earlier discussion. Collectively we consider these to be the key states that *must* act in order for dangerous climate change to be avoided.

We follow the Union of Concerned Scientists in distinguishing between the actions that key MDC and LDC should take.[36] But, we aim to justify this distinction in ways the Union of Concerned Scientists fail to explain. The authors of that report discuss the same climate change realities that we have been discussing in this paper and suggest, as we do, that developed and developing nations should have different responsibilities in terms of what their emissions targets should be. Elaborating on the reasons behind distinguishing the differential responsibilities of developed and developing nations, we distinguish between looking forward and looking back with respect to responsibilities for climate change. This leads us to distinguish between historical responsibility and forward-looking responsibility for climate change and for taking steps to prevent dangerous climate change.

First, we identify the key MDC as being required to take immediate action to reduce their emissions and to help make the necessary steps towards preventing dangerous climate changes. These steps might include the development and disbursement of clean energy technologies, supporting programs to minimize deforestation rates, and so on. The key MDC we identify non-coincidentally also have historically emitted large amounts of greenhouse gases and thus bear significant historical responsibility for contributing to climate change, which turns out to be important for morally justifying their responsibility to make immediate emissions reductions.

Second, we identified states that will play increasingly important roles in preventing dangerous climate change in the future. These are the key LDC that are currently on trajectories towards globally significant emissions. We suggest, again following the Union of Concerned

[36] Luers *et al* (2007): 10.

Scientists, that these key LDC should not be required to take immediate action to curb their emissions, but that they should be required to begin reducing them in the near future, 10 to 15 years after the key MDC are required to meet their targets.[37] Combined with immediate emissions reductions in key MDC, these LDC emissions pathways will be key for preventing dangerous climate change to be avoided.

In identifying the key states that must act to prevent dangerous climate change we make a pragmatic argument that in order to dangerous climate change to be prevented these key states *must* act. This argument is pragmatic because it appeals to these key states, and only these key states, *ability* to affect changes significant enough to mitigate dangerous climate change. We further believe that these key states in fact have the ability to take the necessary actions to actually affect this change. That is, they have both the ability to act such that they can meet the emissions targets we argue are necessary for dangerous climate change to be prevented, and they arguably have the ability to pay for these changes. But the distinction between the responsibilities for action on the part of key MDC and LDC also has some moral justification.

Not only do the key MDC we identify have greater abilities to immediately act and pay for the changes that we argue they must take, they also have greater historical responsibility for contributing to climate change. Thus, the pragmatic argument that they must act because they both can act and need to act in order for global emissions targets to be met aligns with the moral argument that they ought to act because of their historical responsibility for contributing to climate change. And, the pragmatic argument that is based on ability to act and ability to pay reasoning that key LDC should be allowed to continue on their emissions pathways for a given period of time before reducing their emissions aligns with the moral argument that these states

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[37] Luers *et al* (2007): 10.

should have such emissions pathways so that their ability to develop is not significantly impeded, given that it is because MDC are more developed and have such high emissions that their emissions cannot continue to grow exponentially if dangerous climate change is to be avoided.

An argument that only focused on the implications of the historical responsibility for climate change would suggest that those most historically responsible for causing climate change should be responsible for both mitigating further climate change and implementing adaptation strategies for dealing with climatic effects that are occurring and will occur. The reasoning behind this argument would be similar to a ‘polluter pays’ principle. It would focus on causal responsibility in identifying what parties ought to be responsible for both addressing the causes and effects of the potentially harmful phenomenon being caused. We believe, however, that while historical responsibility is an important factor in deciding who should be responsible for acting to prevent dangerous climate change (and addressing climate change in general), not only do the pragmatic realities of what *needs* to happen for dangerous climate change to be avoided and who has the *ability* to act need to be considered, but also forward or future-looking considerations should be taken into account as well. Our recommendations on what emissions targets the key players we identify should meet and on what time frame builds in this consideration. Namely, it requires those most historically responsible for climate change—MDC—to take the most drastic and immediate actions. Further it is future-looking insofar as it recognizes the importance of future contributions to climate change, which includes considering the emissions pathways of *both* LDC and MDC.

Developing countries, especially the key LDC we identify, are currently on pathways towards greatly increased greenhouse gas emissions in the future. These emissions pathways, however, are tied to their development pathways. That is, the reason that they are on a path towards greater emissions is that they are on a path towards greater development. The ways in which MDC developed—through a reliance on greenhouse gas emitting activities—are largely to blame for both their historical and current rates of emissions. Thus, equity considerations, it seems, should suggest that LDC should have the same rights and abilities to develop that MDC countries had. The problem that we are discussing here is that if key LDC continue on emissions heavy development paths, dangerous climate change will ensue. LDC participation in long-term emissions reductions and minimization plans are essential for the successful prevention of dangerous climate change. The pragmatic argument that key LDC *must* restrict their future emissions (alter their emissions pathways), thus seems to conflict with the equity argument that they *ought* to be able to develop as MDC did. Our point is that this conflict can at least in part be reconciled by a plan that includes differential responsibilities for acting to prevent dangerous climate change on the part of MDC and LDC.

By allowing key LDC to continue on their emissions pathways for 10 to 15 years after MDC are required to reduce their emissions, LDC will have the opportunity to formulate development strategies that are consistent with long-term emissions reductions. Furthermore, in formulating policies about how to implement our recommendations about preventing dangerous climate change, policy-makers ought to consider the development needs of LDC and implement strategies to promote their development that are consistent with the pragmatic restrictions of delayed emissions reductions. As the authors of the Union of Concerned Scientists report say, "This can be done through a combination of expansion of carbon market mechanisms, technology transfer, direct financial assistance, and other means."[38] In this way policy-makers will be able to decide how much to weight historical responsibility with future-looking

[38] Luers *et al* (2007): 10.

considerations by determining the extent to which MDC must assist LDC in meeting their emissions targets.

Another reason why differentiating the responsibilities of key MDC and LDC in a way that favors LDC is justified relates to the relative welfare impacts of greenhouse gas emissions in these countries. Thinking of the costs of reducing carbon emissions on a global scale would imply a set dollar per ton cost of emissions reduction. The problem is that this fails to capture differences in the welfare impacts of such reductions (or prevented growth). A ton of carbon emissions is generally relatively more valuable in terms of its welfare impacts in LDC than in MDC. In MDC, emissions reductions arguably might have a negative effect on people's access to luxury goods and services, but in LDC such reductions are more likely to impact people's ability to access services essential to their welfare. This again ties back to the fact that MDC are already developed whereas LDC are in the process of developing. MDC are more reliant on greenhouse gas emissions than LDC, but they arguably can tolerate reductions without the welfare, and especially the basic welfare, of their citizens being as dramatically negatively affected as the citizens of LDC would be. Thus, requiring key MDC to make immediate emissions reductions while key LDC do not have to make reductions for several years will lessen the differential welfare impacts of these reduction.

In summary, our recommendation is that attention be focused on the key MDC and LDC that we identify. Policies aimed at preventing dangerous climate change should include a strategy that requires the key MDC to immediately reduce their greenhouse gas emissions and key LDC to reduce their emissions 10 to 15 years later or so. This satisfies the pragmatic argument that action must be taken immediately to prevent dangerous climate change as well as moral considerations of historic responsibility, forward-looking responsibility, and welfare concerns.

Per Capita Emissions—Long-Term Equity Goals

We have thus far focused on the immediacy of the need for key states to take action to prevent dangerous climate change, while arguing that this pragmatic argument aligns with some important moral considerations. Before concluding, however, we would like to point out the fact that further work needs to be done on the long-term goals and priorities of climate change policies. Once the necessary actions have been taken to prevent dangerous climate change, significant questions will remain about the best long-term strategies for addressing both the causes and effects of climate change. The Union of Concerned Scientists suggest that LDC should match emissions reductions of MDC after a 10 to 15 year lag.[39] We believe more thought ought to go into long-term climate change policy, though equity likely should play a significant role in such thought. We will briefly discuss what the philosophical literature suggests equity considerations would imply about such a long-term strategy as a way of highlighting the kinds of considerations that ought to be taken into account when thinking about or formulating long-term climate change policies.

Philosophers Peter Singer and Dale Jamieson come to similar conclusions on the issue of distributing the earth's ability to absorb greenhouse gasses that stress the importance of an equitable system of distribution based on fair per capita emissions that allows for some degree of flexibility through emissions trading.[40] The distributive principle for addressing climate change

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[39] Luers *et al* (2007): 10.

[40] Beckerman and Pasek (2001) also agree that a system of carbon emissions permits allocated on an equal per capita basis would be ideal, all things being equal, but that things are not equal and thus such a solution is not ideal in the real world. Ultimately they conclude that rich nations will have to shoulder a greater proportion of the burden of dealing with anthropogenic climate change. See: Beckerman, W. and J. Pasek. 2001. *Justice, Posterity, and the Environment.* Oxford: Oxford University Press.

that is most plausible to Jamieson "is one that simply asserts that every person has a right to the same level of GHG (greenhouse gas) emissions as every other person."[41] The similar principle of fairness that Singer supports because of its simplicity and consequent suitability as a political compromise is a principle "of equal per capita future entitlements to a share of the capacity of the atmospheric sink, tied to current United Nations projection of population growth per country in 2050."[42] Both of these principles are based on the assumption that no one has a greater claim to greenhouse gas emissions than anyone else. In order to prevent states from being rewarded by population growth, Singer proposes that standards could be set based on the estimated population at a given time and could then be held fixed (for at least some given amount of time). Jamieson also believes it is important to index per capita emissions to some year for the same reasons as Singer, but he is not tied to using any specific future year in the way Singer is.

Both Singer and Jamieson also argue for a system of greenhouse gas emissions trading. Allowing global emissions trading prevents pragmatic arguments against an equitable distribution of greenhouse gasses, such as that such a system would be tremendously dislocating for some nations. Global emissions trading also answers the objection that inefficient production would result from equal per capita shares. Singer concludes, "A well-regulated system of per capita entitlements combined with global emissions trading would, by internalizing the true costs of production, lead to a solution that is both fair and efficient."[43] Jamieson's similarly says, "I propose that we give the Americans what they want—an unrestricted market in permits to emit GHGs—but that we distribute these permits according to some plausible principle of justice,"[44]

~~, 287-307. Cambridge, Mass.: MIT Press: 301.~~
~~. New Haven: Yale University Press: 43.~~

namely a system of justice based on an equitable per capita distribution of allowable greenhouse gas emissions.

Singer and Jamieson's proposals suggest how we ought to distribute the earth's ability to absorb greenhouse gas emissions, once we have determined what this ability is. In this paper we have identified the threshold for dangerous climate change and the corresponding maximum allowable global greenhouse gas emissions, namely a global cumulative emissions budget of 1,700 gigatons CO_2eq for the period 2000-2050. Applying a long-term per capita emissions cap would require determining a maximum allowable annual global emissions cap that would keep anthropogenic emissions at a level no greater than the natural system's assimilation capacity. How this cap should be determined would depend on the goals of the climate change policy being set. If preventing dangerous climate change is the long term goal of a policy, using our analysis an annual global emissions cap would be determined by what emissions cap would keep global greenhouse gas concentrations below 450 ppm CO_2eq.

The reason we suggest considering a per capita emissions proposal as a long-term climate change policy option (for dangerous climate change or climate change in general), but not as a short-term option, goes back to our placing priority on the pragmatic need for immediate action to prevent dangerous climate change. Implementing a per capita emissions strategy, while equitable in the long term, would face both serious collective action challenges and would likely disadvantage LDC since it would require them to meet the same per capita emissions standards as MDC. Emissions trading schemes could offset this disadvantage to a certain degree, but again, such a scheme simply is not pragmatically feasible given the scientific facts about the threats of dangerous climate change and what needs to happen for dangerous climate change to be avoided. We therefore suggest that policy-makers focus on the immediacy of preventing dangerous climate change while aiming for a long-term plan that takes into considerations the kinds of equity considerations that Singer and Jamieson discuss.

Conclusion

Preventing dangerous climate change is a pressing issue because of the nature and immediacy of the problem. In order to avoid dangerous climate change where impacts will be widespread and great in magnitude, key nations must take immediate action. We have identified key players based on their past as well as their future contributions to climate change. Action by a subgroup of these key players will be insufficient to prevent dangerous climate change. Similarly if any of the key players do not take immediate action, dangerous climate change will likely ensue.

Because of the immediacy of the problem, we take the pragmatic argument to be primary, though we suggest that not all moral considerations need drop out of climate change policies. In the short term, ability to effect change, historical responsibility, and ability to pay can all be integrated into climate change policy by giving key LDC more time to start reducing emissions and requiring key MDC to provide assistance and technology transfers to LDC. In the long term, more fundamental considerations about equity and other relevant issues should be integrated into national emissions allocations.

We must get out of the stalemate that we are currently in and which is dooming us to follow a path towards dangerous climate change. We believe we have helped make the case that there are no more excuses for inaction.

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