IMPACTS OF INCREASING CLIMATE VARIABILITY ON LIVESTOCK PRODUCTION: The Perfect Storm?

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Livestock producers are faced with the fundamental question: "What risks and opportunities lie in my future because of climate change?" Within this question is a whole sequence of important questions. Everyone knows weather is of huge importance to agriculture, that too much precipitation at the wrong times delays plantings and compromises harvests but at the right time produces bumper crops, that severe weather events kills animals and destroys crops and facilities and that droughts stunt forages and crops across an entire region. What, if anything, is climate change adding to these old threats? What else will it impact, either directly or indirectly? Cow health due to environmental stress? Animal and crop diseases? Will the survival of new vectors lead to different diseases? How will feed stuff availability and nutritional content of feedstuffs change? Will invasive species, both plant and animal, appear? Questions abound.

The first step to answering these questions is gaining an understanding of the facts of climate change itself. Concern about the economic, social and environmental effects of climate change and how to best mitigate these are clearly major issues from both public and scientific perspectives worldwide. Evidence of these concerns is the staggering amount of information that is emerging in both the electronic and print media. Googling "climate change" returns over a forty million hits, "global warming" over thirty million. Searching Amazon.com with the same terms yields 61,000 and 45,000 books respectively. Granted, many of these are useless fluff at best or potentially dangerous disinformation at worst. Searching the Web of Science literature database with the same terms yields 52,493 and 12,568 scientific papers respectively with 7,438 and 1,710 published in 2008 alone. A similar search of the more medically-oriented (but freely available) PubMed yields 6,075 respectively with 1,370 published in the last year. Recognizing that these PubMed and Web of Science searches were "quick and dirty" and thus likely missed a large amount of relevant scientific literature, the results from both search systems presents an impressive stack.

In addition to more conventional Internet resources such as websites, the internet search engines such as Google and the on-line literature databases such as PubMed and Web of Science noted above, the rapidly evolving electronic social networking technology, particularly wikis, blogs, twitters and the on-line resource sharing systems CiteUlike, Connotea, del.icio.us and Zotero, provide anyone with an Internet-connected computer unprecedented ability to find, contribute and share information. Until two decades ago information was a scarce commodity at the farm level, being limited to printed materials primarily "pushed" by publication schedules. Now an absolute flood of information is available 24/7 on demand, "pulled" on a need to know basis. This poses the immense problem of specificity, identifying the wheat among all the chaff. How does one best acquire and maintain the understanding needed for making correct and timely decisions? The purpose of this paper is to identify resources, many on-line, and to provide background for developing an understanding of climate change and its potential threats and opportunities for livestock producers.

Climate change information resources targeted specifically at agricultural producers, similar to traditional agricultural extension products, are appearing in the electronic media. An example is "Climate Change and Northeast Agriculture", a website established by a consortium between Cornell, the University of Vermont and Clean Air-Cool Planet. It includes information on understanding climate change, the impacts of climate change on agriculture and strategies for mitigating that impact. Another is

Washington State University CSANR's "Climate Friendly Farming" website. National websites include "Australia's Agriculture - Impacts of Climate Change".

For several reasons, developing a good understanding of global climate change, its causes and potential approaches to mitigations is surprisingly difficult. Besides the fact that climate has incredibly complex interactions with much variability and lagged feedbacks is the fact that global climate change presents very contentious public policy issues. Because many potential mitigations involve profound changes impacting major economic sectors, particularly those producing or consuming large amounts of fossil fuel products, and will have differing impacts upon the many constituencies of elected officials, the issue is intensely political at local, national and international levels. Depending on mitigation approaches, different groups will be major winners or losers and the big losers particularly want to maintain the status quo. For example, US Congressman John Olver stated "As a scientist, I believe climate change is the single most critical environmental issue of the 21st century" (Oliver, 2006). In contrast, US Senator James Inhofe called "the threat of catastrophic global warming the "greatest hoax ever perpetrated on the American people" and stated that "man-induced global warming is an article of religious faith" (Inhofe, 2005) and his staff produced "'Consensus' Exposed: The CRU Controversy" (Dempsey and Lungren, 2010). Who is right?

This debate extends to the courts, with several states suing the federal government over the U.S. EPA's failure to regulate CO_2 as a pollutant. Ruling in favor of the states, the US Supreme Court stated "the harms associated with climate change are serious and well recognized. The Government's own objective assessment of the relevant science and a strong consensus among qualified experts indicate that global warming threatens, *inter alia*, a precipitate rise in sea levels, severe and irreversible changes to natural ecosystems, a significant reduction in winter snowpack with direct and important economic consequences, and increases in the spread of disease and the ferocity of weather events" (US Supreme Court, 2007). Will it? Because public concern about the potential impact of climate change appears to be reaching a "tipping point" (Gladwell, 2002), the ferocity of this debate will likely increase as opponents press their battles across the three arenas of the legislatures, the courts and the public media in which such wars are fought.

Although a healthy scholarly debate continues, scientific evidence on climate change and its causes is considerably better established than most public policy debates and much popular media coverage suggest. Most of the major national scientific societies have on-line climate change position statements and provide on-line resource collections including special reports. The National Academy of Sciences, the premier U.S. science organization, maintains such a website. Its mission as stated on this site is to "perform an unparalleled public service by bringing together committees of experts in all areas of scientific and technological endeavor. These experts serve pro bono to address critical national issues and give advice to the federal government and the public." Its National Academies Press provides cumbersome but free on-line access to most of these reports; many of those relating to global climate change are grouped under "Climate Change Topics". These reports undergo a rigorous peer review process performed by experts both within and outside of the Academy. The NRC "Nutrient Requirements of Dairy Cattle" is an example of one of its publications. Since 2005 the U.S. National Academy of Sciences and the equivalent national science organizations of seven other nations issued joint statements on climate change. The 2005 statement, titled "Joint science academies' statement: Global response to climate change" and available on-line as a pdf begins "Climate change is real. There will always be uncertainty in understanding a system as complex as the world's climate. However there is now strong evidence that significant global warming is occurring. . . . It is likely that most of the warming in recent decades can be attributed to human activities (IPCC 2001). This warming has already led to changes in the Earth's climate." The 2007 joint statement is titled "Joint science academies' statement on growth and responsibility: sustainability, energy efficiency and climate protection," pdf, the 2008 statement "Joint Science Academies' Statement: Climate Change Adaptation and the Transition to a Low Carbon Society,"

pdf, and the 2009 statement "G8+5 Academies' joint statement: Climate change and the transformation of energy technologies for a low carbon future," pdf.

The American Association for the Advancement of Science (AAAS), another premier US science organization and publisher of the highly ranked, most widely read scientific journal *Science*, has a webpage "Global Climate-Change Resources" that includes a link to a short pdf file titled "AAAS Board of Directors Statement on Climate Change". Approved December, 2006, the statement begins "The scientific evidence is clear: global climate change caused by human activities is occurring now, and it is a growing threat to society. . . . The pace of change and the evidence of harm have increased markedly over the last five years. The time to control greenhouse gas emissions is now." The 11,000 member American Meteorological Society posted a longer document titled "Climate Change: An Information Statement of the American Meteorological Society", adopted February, 2007, and also available as a pdf. It is "intended to provide a trustworthy, objective, and scientifically up-to-date explanation of scientific issues of concern to the public at large." The statement closes "Despite the uncertainties noted above, there is adequate evidence from observations and interpretations of climate simulations to conclude that the atmosphere, ocean, and land surface are warming; that humans have significantly contributed to this change; and that further climate change will continue to have important impacts on human societies, on economies, on ecosystems, and on wildlife through the 21st century and beyond. . . . ."

CAST, the Council for Agricultural Science and Technology, a national scientific organization of particular relevance to agriculture, has a website. Comprised of 38 scientific societies representing some 170,000 scientists, CAST's mission is assembling, interpreting and disseminating information on agricultural issues through the publication of reports and papers written by task forces of scientists assembled for that purpose. One of its recent publications is task force report 141 "Climate Change and Greenhouse Gas Mitigation: Challenges and Opportunities for Agriculture", May 2004. In the Interpretive Summary of the report, available as a pdf, is the paragraph "Atmospheric concentrations of three gases—carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4)— have risen dramatically during the past century, accounting for more than 80% of human-induced global warming from atmospheric buildup of GHGs. Agriculture is linked directly to atmospheric concentrations of these gases through basic soil-plant-animal processes, and increased GHG concentrations in turn impact agriculture and other sectors of society because of their potential to promote rapid and undesirable changes in climate."

While the above statements justify developing an understanding of global climate change, recognize that new reports will be published and that these statements will evolve as scientific findings emerge and either solidify or change paradigms about how climate works. Clearly, many scientists in major scientific organizations believe that we are facing a serious problem worthy of considerable attention.

Several publishers of major scientific journals also maintain websites providing materials related to climate change. The American Association for the Advancement of Science, publisher of *Science*, provides the website "Global Climate-Change Resources". "Nature Reports: climate change" at is maintained by the Nature Publishing Group that publishes *Nature*, the other major science journal equivalent to AAAS's *Science.* As described on the site, it "covers the news behind the science and the science behind the news of global climate change, arguably the most far-reaching challenge of this century. The site is dedicated to authoritative in-depth reporting on climate change and its wider implications for policy, society and the economy." The publisher of *New Scientist* maintains "New Scientist Environment".

The above not withstanding, within the primary research journals the scientific equivalent of considerable debate continues on the details, particularly about impacts and mitigations. Critical to understanding both the nature and the necessity of this debate is an understanding of the philosophy of science; that is, how science works in terms of the strength of empirical evidence, the underlying logic of the scientific method and the necessary process of scientific publishing in peer-reviewed primary

literature, including anonymous peer review. Considerable confusion results from the differences between the scientific and public understanding of concepts represented by the words law, proof, theory, and uncertainty. As guidance for federal judges the Federal Judicial Center publishes the Reference Manual on Scientific Evidence, which includes a chapter "How Science Works," pdf. Two easily accessible starting points are the Wikipedia pages "Philosophy of science" and "Scientific method", which provide extensive references and links to additional on-line resources. Wikipedia includes the wikis Scientific opinion on climate change and Climate change consensus. Because of its open and transparent editing and history keeping processes and its 24/7 on-line availability, for many topics Wikipedia provides an excellent means of acquiring a quick first synopsis as a basis for identifying, finding and using stronger resources on that topic. On the other hand, stopping there puts ones understanding of the topic at unknown risk, which is particularly important if ones interest is beyond casual.

The debate about whether a scientific consensus sufficient for action exists among scientists, most particularly climatologists, on the questions surrounding global climate change continues to be a heated one occurring primarily in political arenas and in the newer electronic media formats, such as blogs. For example, considerable debate centers around a *Science* paper by Dr. Naomi Oreskes, professor of history and Director of the Science Studies Program at University of California, San Diego, in which she stated "This analysis (of 928 papers) shows that scientists publishing in the peer-reviewed literature agree with the IPCC, the National Academy of Sciences, and the public statements of their professional societies" (Oreskes, 2004). Googling the terms "blog "Naomi Oreskes" climate consensus" yields some 7,300 hits. Her subsequent responses include blog comments, testimony before a U.S. Senate Committee (Oreskes, 2006), a hearing that included dissenting testimony, and a chapter in a recent book (Oreskes, 2007). Currently available as a pdf file in a blog archive, this chapter includes discussion of the logic behind the scientific process for developing global climate change evidence that alone make it worth reading. Other starting points for understanding this debate are the Wikipedia pages "Global warming controversy" and "Climate change denial." Several on-line resources address the specific points of the debate, such as Gristmill's "How to Talk to a Climate Skeptic". Some of the most interesting and likely more informative blogs are those maintained by active climate scientists themselves. Ten climate scientists engaged in climate change research maintain "RealClimate", posting pieces on new findings of theirs and others, explaining fundamentals, debating skeptics and responding to reader's comments on their postings. The now defunct blog "Climate Science", maintained by Dr. Roger Pielke's research group at Colorado State University, operated in a similar fashion but with a somewhat more contrarian perspective. His son, a University of Colorado faculty member maintains a blog addressing climate science and policy issues. Interblog "debates" often occur between the scientists in the comment sections of their blogs. A recent development is the Alltop blog aggregator with its "Climate Change" collection of the top climate change blogs and their recent posts.

In addition to blogs, some climate scientists also maintain traditional websites. Dr. Jim Hansen, a Columbia University climate scientist long at the center of considerable controversy, maintains a personal website that contains links to many of his papers, commentaries and testimony. A useful site providing background material on climate change is the extensive one maintained (the site appears static since 2005) by Dr. Stephen Schneider, Stanford University.

Much, but not all, of the controversy appears to be driven more by the economic and political agendas of advocacy groups on both sides of the issue rather than just science-based differences between experts. As in any large group, even among the experts a few members appear to create controversy by nature and others appear to enjoy the confusion that results from them doing so. Many of these controversies deteriorate away from dispassionate critical thinking into dogmatic, emotional "straw man" and ad hominem arguments with labels such as "denier", "alarmist", "cornucopian", "fatalist", "stooge" and "doomer" being applied. One means of identifying the potential hidden agendas of individuals and groups weighing in on such public issues is the SourceWatch wiki maintained by the Center for Media and Democracy. It includes a wikipage titled "Global warming skeptics". Prior to using this resource

users should read the SourceWatch wikipages "Center for Media and Democracy" on the center itself, "How to research front groups" and "Global warming", which can be found by pasting these titles into the website search function on the left side of the page.

Some controversies appear to be maintained by otherwise credible scientists whose cherished hypothesis on a given question was empirically refuted by peer-reviewed research performed by other investigators to the satisfaction of researchers in the field, which is the scientific equivalent of loosing a debate. Some, after their evidence supporting their hypothesis published in refereed scientific journals was subsequently convincingly refuted continue to maintain it through publishing reviews in non-refereed journals of questionable credibility or elsewhere. This is the scientific equivalent of walking away from the debate and does not advance science. Others publishing in non-refereed sources masquerade behind scientific degrees, such as PhD's, but have little research productivity in the area or credibility in the community of climate science researchers. One way of determining scholarly productivity is by searching Google Scholar, PubMed or the Web of Science for publications bearing their name. Such individuals often complain loudly that due to bias against them their work was rejected by primary refereed journals or that because of bias they could not obtain sufficient grant funding to pursue their hypotheses further. In fairness, the perception that the more heretical an idea, the stronger the evidence supporting it must be for it to be accepted by that research community is likely true. On the other hand, heretical hypotheses about perpetual motion are far more common than the one about plate tectonics.

An important component for understanding climate change is to understand the history of climate science, particularly the sequence of the findings and the evolution of the technology that enabled these, that led to the current scientific paradigm. One of the best histories is the review by Dr. Spencer Weart, Director of the Center for History of Physics at the American Institute of Physics (AIP) and a historian specializing in the history of modern physics and geophysics who also has a PhD in physics and astrophysics. He maintains the hypertext website "The Discovery of Global Warming" and published a book by the same title (Weart, 2008). He writes "The tangled nature of climate research reflects nature itself. The Earth's climate system is so irreducibly complicated that we will never grasp it completely, in the way that one might grasp a law of physics. These uncertainties infect the relationship between climate science and policy-making." Most interesting is that the first research evidence that man could influence global climate appeared 150 years ago and the first calculation of the amount of warming just over 100 years ago. He writes in the webpage titled "Timeline of Milestones" "1859 - Tyndall discovers that some gases block infrared radiation. He suggests that changes in the concentration of the gases could bring climate change. 1896 - Arrhenius publishes first calculation of global warming from human emissions of CO_2." Due in part to concerns about the recurrence of an ice age, the consequences of a warming climate were initially believed to be entirely beneficial. The first negative consequence is noted in his timeline as "1968 - Studies suggest a possibility of collapse of Antarctic ice sheets, which would raise sea levels catastrophically". In the recent decades the increasing recognition of the potential for significant negative consequences from global warming has become the driving force. Under "Links" he provides a list of seven recommended books as well as many links to other on-line sources.

The assessments of global climate change and its impacts receiving the most attention are those of the Intergovernmental Panel on Climate Change (IPCC). The four assessments are available in print and on-line, the final part of the fourth assessment "Climate Change 2007" having just been completed, reviewed, accepted and published. The synthesis report, titled "The AR4 Synthesis Report", is presented as pdf files of 6 Topics. Providing a flavor of the assessment contents, the six topics are: 1) summary of observed changes in climate and their effects on natural and human systems, 2) assessment of the causes of the observed changes, 3) projections of future climatic change and related impacts under different scenarios, 4) adaptation and mitigation options over the next decades and their interaction with sustainable development, 5) conceptual basis of relationship between adaptation and mitigation on a longer term basis and 6) summaries of the major robust findings and remaining key uncertainties in this assessment.

To give a sense of this massive undertaking, the following are some selected details from the three working group reports. The Working Group I Report, titled "The Physical Science Basis", is presented as 11 pdf chapters as well as a summary for policy makers, a FAQ extracted from the chapters and annexes. Each chapter is standalone, having a table of contents, an executive summary, a listing of the lead and contributing authors and references. This report includes chapters with titles such as "Historical Overview of Climate Change Science" (pdf), which is 36 pages long of which 5 are references, "Climate Models and Their Evaluation" (pdf), 74 pages of which 14 are references, and "Understanding and Attributing Climate Change" (pdf), 84 pages of which 10 are references. Approximately 530 people are listed as authors and another 660 as reviewers. The Working Group II Report, titled "Impacts, Adaptation and Vulnerability", is presented as 20 chapters and is 976 pages long. Chapter 8 of the Working Group III Report "Mitigation of Climate Change", titled "Agriculture" (pdf), is 44 pages long and has 2 Coordinate Lead Authors, 10 Lead Authors, 8 Contributing Authors and 2 Review Editors.

Having a sound understanding of how the IPCC operates is important because of the attention that its assessments receive. The IPCC was established in 1988 by the World Meteorological Organization, a United Nations agency, and the United Nations Environment Programme. Of particular note is that the IPCC is only concerned with science and does not establish policies, such as the Kyoto Protocol, which is done through treaties originating within the UN Framework Convention on Climate Change (UNFCCC). The current IPCC Chairman is Dr. Rajendra K. Pachauri, holder of two Phd's (economics and industrial engineering) from the University of North Carolina and head of The Energy and Resources Institute in New Delhi, India. The "About IPCC" webpage contained the following mandate: "The IPCC was established to provide the decision-makers and others interested in climate change with an objective source of information about climate change. The IPCC does not conduct any research nor does it monitor climate related data or parameters. Its role is to assess on a comprehensive, objective, open and transparent basis the latest scientific, technical and socio-economic literature produced worldwide relevant to the understanding of the risk of human-induced climate change, its observed and projected impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they need to deal objectively with policy relevant scientific, technical and socio economic factors. They should be of high scientific and technical standards, and aim to reflect a range of views, expertise and wide geographical coverage."

The IPCC structure is described as follows: "The IPCC has currently 3 Working Groups and the Task Force on National Greenhouse Gas Inventories. The Working Groups and the Task Force have clearly defined mandates as agreed by the Panel and their activities are guided by two Co-chairs each. They are assisted by a Technical Support Unit and the Working Group or Task Force Bureau. Working Group 1 deals with "The Physical Science Basis of Climate Change", Working Group 2 with "Climate Change Impact, Adaptation and Vulnerability" and Working Group 3 with "Mitigation of Climate Change". The main objective of the Task Force is to develop and refine a methodology for the calculation and reporting of national GHG emissions and removals. In addition to the Working Groups and Task Force, further Task Groups and Steering Groups may be established for a limited or longer duration to consider a specific topic or question."

As one of goals of the IPCC is complete transparency of its operations, the IPCC website contains a great deal of information. To accomplish its mission, the IPCC operates under detailed guidelines for establishing the expert groups, assembling and evaluating the relevant scientific literature and for reviewing and approving the reports. Procedural details are currently found in five pdf files under "Organization" > "Procedures". Because these procedures have been the focus of considerable controversy, of particular note is the 15 page pdf document titled "Procedures for the Preparation, Review, Acceptance, Adoption, Approval and Publication of IPCC Reports". This document describes in detail how the authors and reviewers are selected, how the report components are reviewed by both outside experts and government scientists and how the acceptance process operates. Again, an excellent

starting point for understanding of the IPCC is the extensive description of the IPCC, its processes, findings and additional comments available on the Wikipedia page "Intergovernmental Panel on Climate Change". In early 2010 considerable controversy led the UN Secretary General requested that InterAcademy Council, comprised of 15 national academies of science and organizations, review IPCC processes and procedures.

At the federal level, the interagency U.S. Global Change Research Program is mandated under Section 106 of the Global Change Research Act of 1990 to produce scientific assessment reports of global change including impacts on the environment and on socioeconomic sectors for congress and the administration at least every 4 years. The most current full report, accessed from the US Climate Change Science Program website, is divided into 5 goals and 21 sections. For agriculture, a 252 page report titled "The effects of climate change on agriculture, biodiversity, land, and water resources" was produced. Although mandated by law, this assessment process has somewhat of a checkered history (See Nisbet, 2007, Piltz, 2007). Sponsored by the Government Accountability Project, a former member of the USCCSP, Rick Piltz, has created the website "Climate Science Watch" with the mission of "holding public officials accountable for the integrity and effectiveness with which they use climate science and related research in government policymaking, toward the goal of enabling society to respond effectively to the challenges posed by global warming and climate change." The U.S. Government Accountability Office recently surveyed a sample of NASA, NIST and NOAA scientists and reported that "policies guiding the dissemination of scientific research from selected agencies should be clarified and better communicated" (GAO, 2007).

In addition to local, state, regional, national global climate change impact assessments performed by scientific groups such as CAST, assessments are also being issued by advocacy, industry and government groups or collaborations between them. Several examples are the following. The Northeast Climate Impacts Assessment, covering the northeastern U.S., is a collaboration between the Union of Concerned Scientists and 50 experts. McKinsey & Company, a major management consulting firm, maintains a website as part of its "Climate Change Special Initiative" and recently released an extensive report titled "Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?" (McKinsey & Co., 2007). The report was sponsored by a collaboration of industry and advocacy groups. Such collaborative efforts between stakeholders from different poles of the issues are important because of the consensus for the best ways forward that may emerge.

Otherwise, indirect effects of social origin but originating from a scientific basis, however indirectly, may present a significant risk of economic and regulatory impacts on producers related to climate change. For example, the Factory Farming Campaign of the Humane Society of the United States, claiming to represent 1 in 30 US citizens, is calling for a 10% reduction in animal consumption, a refinement of choice to those products raised in extensive rather than intensive systems and to replace animal origin products with vegetarian options (HSUS, 2007). One set of facts on which this call is based are that animal agriculture is responsible for 18% of CO_2-equivalent greenhouse gas emissions, specifically 37% of methane emissions and 65% of nitrous oxide emissions, which is more than the transportation sector's 14%. The two page document, titled "Animal Agriculture & Climate Change", contains 22 citations to USDA, EPA and FAO sources as well as one *Lancet* paper and an international forestry research center. Friends of the Earth produced a similar 10 page document titled "Food and climate change" that describes the science and then urges consumer actions such as eating more cereals and vegetables and less meat and dairy and urges enacting governmental policies that reverse the trend toward more intensive livestock rearing by promoting organic and extensive farming systems (Friends of the Earth, 2007). One quote is "A kilogram of beef is responsible for more greenhouse gas emissions and other pollution than driving for 3 hours while leaving all the lights on back home." This quote is indirectly science-based, being from a *New Scientist* article titled "Meat is murder on the environment" summarizing and interpreting the results of a life cycle analysis of the Japanese beef cow-calf system recently reported in the journal of the Japanese Society of Animal Science. On a webpage titled "Climate

change and a responsible diet" a Swiss vegetarian website highlights the connection between dietary choices and climate change by providing quotes from a number of organizations that include the FAO, the University of Chicago and government departments (Vegetarismus, 2007). The 4th IPPC assessment "Climate Change 2007" will likely serve as the basis for more of these.

Finally, because of the complex interrelationships in the natural, economic and social systems in which livestock production is imbedded, change in one part of a system often leads to unexpected consequences elsewhere. When each component of these systems becomes better understood, almost everything seems to be connected to almost everything else. Our world seems to have many rising issues including globalization and its economic impacts, the steadily increasing global human population requiring food, the increasing scarcity of petroleum relative to demand, the tightening of fresh water supplies and, finally, impending global climate change (see Brown, 2004, Evans, 1998, Leathers and Foster, 2004, Nielsen, 2006). Will these merge into livestock's "Perfect Storm"? Only time will tell.

References:

Brown, LR. 2004. Outgrowing the Earth: The Food Security Challenge in an Age of Falling Water Tables and Rising Temperatures. WW Norton, New York. On-line version accessed 11/26/07.

Demsey M, D Lungren 2010. 'Consensus' Exposed: The CRU Controversy. United States Senate Committee on Environment and Public Works Report Minority Staff Report. Pdf accessed 3/10/10.

Evans, LT. 1998. Feeding the Ten Billion: Plants and population growth. Cambridge University Press, New York.

Friends of the Earth. 2007. Food and climate change. Pdf accessed 11/26/07.

GAO. 2007. GAO-07-653: Policies Guiding the Dissemination of Scientific Research from Selected Agencies Should Be Clarified and Better Communicated. Pdf accessed 11/26/07.

Gladwell, M. 2002. The Tipping Point: How Little Things Can Make a Big Difference. Little, Brown and Company. Boston.

HSUS. 2007. Animal Agriculture & Climate Change. Pdf accessed 11/26/07.

Inhofe, J. 2005. Climate Change Update. Senate Floor Statement by U.S. Sen. James M. Inhofe (R-Okla) January 4, 2005. Accessed 11/25/07.

Leathers, HD, P Foster. 2009. The World Food Problem: Toward Ending Undernutrition in the Third World, 4th ed. Lynne Rienner Publishers, Boulder, CO.

Nielsen, R. 2006. The Little Green Handbook: Seven trends shaping the future of our planet. Picador, New York (author's website accessed 11/26/07).

McKinsey & Co. 2007. Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost? Executive summary and full report accessible at report website, accessed 12/1/07.

Nisbet, C. 2007. An Inconvenient Assessment. *Bulletin of the Atomic Scientists*, 63(6):40-47, 63. Pdf accessed 11/26/07

Olver, J. 2006. Olver speaks out on urgent need to address climate change caused by global warming, April 12, 2006, accessed 11/25/07.

Oreskes, N. 2004. Beyond the ivory tower. The scientific consensus on climate change. *Science* 306(5702):1686, 2004. Accessed 11/25/07.

Oreskes, N. 2006. Testimony before Full Committee Hearing on Climate Change and the Media, U.S. Senate Committee on Environment and Public Works, December 6, 2006. Pdf accessed 11/25/07.

Oreskes, N. 2007. The Scientific Consensus on Climate Change: How Do We Know We're Not Wrong? Chapt. 4, pgs. 65-99 in: Climate Change: What it Means for Us, Our Children, and Our Grandchildren. JFC DiMento and P Doughman, eds. MIT Press, Cambridge MA. Pdf accessed 11/25/07.

Piltz, R. 2007. Testimony Of Rick Piltz, Director, Climate Science Watch, Government Accountability Project, before the Committee on Oversight and Government Reform, U.S. House of Representatives, January 30, 2007. Pdf accessed 11/26/07.

U.S. Supreme Court. 2007. No. 05-1120 Massachusetts et al. v. Environmental Protection Agency et al., April 2, 2007. Cornell Legal Information Institute version, accessed 11/25/07.

Vegetarismus. 2007. Climate change and a responsible diet, accessed 11/25/07.

Weart, SR. 2008. The Discovery of Global Warming, 2nd ed. Harvard University Press, Cambridge MA.