

## Klimakatastrophes (Climate Disasters)

Review



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**Abstract :** Humankind has entered an era of mutually interacting disasters due to overconsumption, resource scarcity, overpopulation, and greenhouse gas emissions that exceed Earth's assimilative capacity. If assimilative capacity for carbon dioxide is exceeded, the gas will accumulate in the atmosphere and produce an alien planet that differs markedly from the climate in which humankind developed and flourished. Other life forms that collectively comprise the biospheric life support system have already been impoverished (nearly one-third of biodiversity is already lost) with catastrophic consequences. Resources are already being used well beyond Earth's regenerative capacity, which is being reduced by rapid climate change. The cornucopian perception of Earth, which has never really been justified, is no longer viable on a finite planet with finite resources that will diminish in an era of klimakatastrophe. Immediate action on greenhouse gas emissions is urgently needed since the rate of climate change greatly exceeds initial predictions because the effects of positive feedbacks are now better understood. At present, nation-states are unable to protect their citizens from klimakatastrophes because they have no robust global goals to reduce greenhouse gas emissions to match Earth's assimilative capacity for them. Inevitably, the situation will worsen until greenhouse gas emissions and assimilative capacity are brought into balance.

**Key words :** Climate disasters, Resource wars, Food shortages, Sovereignty, Overconsumption, Greenhouse gas emissions, Environmental mitigation.

*If we do not change direction, we are likely to end up exactly where we are headed..* **Chinese Proverb**

*How wonderful it is that nobody need wait a single moment before starting to improve the world.*

**Anne Frank**

*In a world of obvious climate snap (i.e. violent change), any obstruction, any delay, from any quarter, is hands down a crime against humanity.*

**Mike Tidwell**

*If climate change is not controlled before we meet critical "tipping points" in natural systems the impact will be catastrophic, with large parts of the world becoming uninhabitable for current populations by the middle of the century.* **Nick Mabey**

*Klimakatastrophe* – the 2007 word of the year of the Society of the German Language — conveys a sense of urgency not conveyed by the generally used term *global warming* or even by James Lovelock's term *global heating*. Climate change has given rise to increased global food prices, which consequently have sparked a number of protests in recent weeks, highlighting the worsening of global hunger (Goodman, 2008). Food riots have erupted in Haiti, Niger, Senegal, Cameroon, and Burkina Faso, and protests have flared in Morocco, Mauritania, Ivory Coast, Egypt, Mexico, and Yemen. Global food shortages and price increases are linked to human-driven climate change, the soaring cost of oil, and a Western-driven focus on biofuels. Brown (2008) of the Earth Policy Institute remarks:

The world has not experienced anything quite like this before. . . . the social order is beginning to break down in some countries. In several provinces in Thailand, for instance, rustlers steal rice by harvesting fields during the night. In response, Thai villagers with distant fields have taken to guarding ripe rice fields at night with loaded shotguns. In Sudan, the U.N. World Food Programme (WFP), which is responsible for supplying grain to 2 million people in Darfur refugee camps . . . [has had] During the first three months of this year, 56 grain-laden trucks high jacked. . . . raising the specter of starvation if supply lines cannot be secured.

Arguably, Brown's (2008) most disturbing point is that "After seven years of drawing down stocks, world grain carryover stocks in 2008 have fallen to 55 days of world consumption, the lowest on record. . . . With grain stocks at an all-time low, the world is only one poor harvest away from total chaos in the world grain markets."

French President Nicolas Sarkozy clearly realizes that urgent action is needed since he "told the world's biggest carbon polluters . . . that global warming was becoming a driver of hunger, unrest and conflict, with the war in Darfur a concrete example" (Staff Writers, 2008a). Sarkozy stated: "If we keep going down this path, climate change will encourage immigration of people with nothing towards areas where the population does have something, and the Darfur crisis will be only one crisis among dozens of others" (Staff Writers 2008a). To prevent the situation from worsening, the UN agency "charged with relieving world hunger made an appeal for \$US256 million (161.62 million Euros) more in funds to cope with sharp rises in food prices. . . . request came on top of another 'extraordinary emergency appeal' of \$US500

million made by the agency in March to top up its 2008 budget. . . . Food prices have been spiraling higher globally due to rising populations, strong demand from developing countries, the use of certain foods in biofuels to combat global warming, and the increasing frequency of floods and droughts as a result of climate change" (Staff Writers, 2008b).

### **The Century of Declines**

Heinberg (2007, notes: ". . . the general picture is inescapable: it is one of mutually interacting instances of overconsumption and emerging scarcity." He further notes (Heinberg 2007):

This realization (abundance of many things based on cheap energy) is strengthened as we come to understand that it is no happenstance that so many peaks are occurring together. They are all causally related by the historic reality that, for the past 200 years, cheap, abundant energy from fossil fuels has driven technological invention, increases in total and per-capita resources and extraction and consumption (including food production), and population growth.

Heinberg (2007) concludes: "As available energy declines, our ability to alter the environment will do so as well. However, if we make no deliberate attempt to control our impact on the biosphere, the peak will be a very high one and we will do an immense amount of damage along the way." Heinberg (2007) explains the current situation:

The subtitle of this book, *Waking up to a Century of Declines*, reflects my impression that even those of us who have been thinking about resource depletion for many years are still just beginning to awaken to its full implications. And if we are all in various stages of waking up to the problem, we

are also waking up *from* the cultural trance of denial in which we are all embedded. . . . Holding that fabric together is one master illusion, the illusion that somehow what we see around us today is *normal*. . . . The reality of cars, television, and fast food is calmly taken for granted; if life has been like this for decades, why shouldn't it continue, with incremental developmental changes, indefinitely?

### **Looking Out for #1**

Although a gradual, sometimes imperceptible, increased awareness of global heating, peak oil, and other global problems seems to be emerging, the awareness lags over a decade behind reality. A common, quite understandable position is an egocentric one: "I'm looking out for #1." A common response is to recognize the problems of pollution, overpopulation, and increasing global climate change, but not recognize them as urgent problems. Most people do not expect any serious problems while they are alive, but they do expect some in the future. Even though most individuals do care about the future of their grandchildren, responses show that they have obviously not thought that their grandchildren's future would be markedly different from the life each of them enjoyed as young people. A recent Gallup Poll (2008) indicates that, while 61% of Americans believe that the effects of global heating have already begun, just a little more than one-third indicate that they worry about it a great deal, a percentage that is roughly the same that Gallup measured 19 years ago. Perhaps more important, only a little more than one-third of Americans indicate that immediate, drastic action is needed in order to maintain life as it currently exists on the planet.

### **Immediate Action Urgently Needed**

Tidwell (2008) believes that the world's scientists have been very wrong about the

speed with which climate is changing and that they have failed society completely on this issue. I strongly disagree with this statement. The general public and the politicians who represent it have not taken appropriate action on the robust scientific evidence — why should scientists risk attacks from well funded, special interest groups by speculating on an unprecedented positive feedback loop for which robust scientific evidence is just beginning to appear? In the United States, the "war on science" and scientists has been unrelenting. For example, "on February 18, 2004, 62 prominent scientists, including Nobel laureates, . . . numerous members of the National Academy of Sciences, and other well known research investigators released a statement titled *Restoring Scientific Integrity in Policy Making* . . . the scientists charged the Bush administration with widespread 'manipulation of the process through which science enters into its decisions.' This statement has now been signed by more than 12,000 scientists" (Union of Concerned Scientists, 2004).

Climate change is documented in many reports of the Intergovernmental Panel on Climate Change, and the US National Academy of Sciences and its counterparts elsewhere have fully endorsed the basic climate change concepts. Yet prominent US politicians, such as former Florida Governor Jeb Bush, are "skeptical that humans are causing global warming" (Koenig, 2008). This situation illustrates the present problem in the United States — a politician with no robust scientific credentials makes a statement contrary to the preponderance of scientific evidence and the news reporters fail to ask what evidence formed the basis for this person's judgment.

Another problem is that American science rewards the publication of peer-reviewed research, but offers little incentive for scientists to communicate and translate what they know to the general public (Mooney, 2006).

Moreover, more than half the Environmental Protection Agency's (EPA) scientists who responded to an independent survey noted that they had witnessed political interference in scientific decisions at EPA during the past five years (Lee, 2008). Former Vermont Governor, Dean (2004) noted in his column as a physician that "The Bush Administration has declared war on science. In the Orwellian world of 21<sup>st</sup> century America, two plus two no longer equals four where public policy is concerned, and science is no exception. When a right-wing theory is contradicted by an inconvenient scientific fact, the science is not refuted, it is simply discarded or ignored." In my opinion, politicians and the general public have let science down. Science did not fail the public completely as Tidwell (2008) claims, and all humankind is paying the price — klimakatastrophe.

Researchers have alarming evidence that the frozen Arctic floor has started to thaw and release long stored methane gas (Mrasek, 2008). The results could be a catastrophic warming of Earth, since methane is a far more potent greenhouse gas than carbon dioxide. Gas hydrates stored in the Arctic Ocean floor — hard clumps of ice and methane, conserved by freezing temperatures and high pressure — could become unstable and release massive amounts of methane into the atmosphere (Mrasek, 2008). In the permafrost bottom of a 200-meter-deep sea, enormous stores (estimated 540 billion tons) of carbon lie in the ice-and-methane mixture; they were once regarded as stable, but could be released if warming continues. Zabarenko (2008) reports that measurements of both atmospheric carbon dioxide and methane were up sharply in 2007. Can anyone really doubt that the frozen methane will be released and worsen the current catastrophe?

## **Can Nation-states Protect Their Citizens?**

Humankind is obviously not effectively protecting itself from self-inflicted harm (e.g., climate change, energy shortages). The United States suffers from numerous stresses: (1) millions of home foreclosures, (2) devaluation of the US\$, (3) "outsourcing" jobs to other nations, (4) moving factories to other nations, (5) making education increasingly expensive, (6) making health care too expensive for many families. These stresses indicate that nation-states cannot protect humankind either.

The world was poorly prepared for the global food crisis that has just erupted. Mittal (2008) notes that, in the last 30 years, developing countries that previously were self sufficient in food supplies have turned into large food importers. Of course, overpopulation and climate change are important factors in this situation. Unfortunately, the poorest countries have been driven into a downward spiral by actions such as opening their agricultural markets to giant, multinational companies and by dismantling their marketing boards and specializing in exportable cash crops such as coffee, cocoa, cotton, and even flowers (Mittal, 2008).

This situation will become even more dangerous if science is suppressed, ignored, or censored because of political ideology (Snape, 2008). Klare (2008) discusses probable emerging geopolitical alliances. Energy will undoubtedly restructure power balances in the 21<sup>st</sup> century. However, what happens when the cheap, abundant fossil fuels are expensive and scarce? If the 2009 grain harvest is markedly diminished by drought and other effects of climate change and energy costs have a major deleterious effect on agribusiness, another billion or more people will be starving and malnourished. This disaster could easily destabilize many, possibly all, of the planet's social systems.

## **Resource Wars**

War markedly increases resource depletion, often without benefiting the country that started the war. World War II was a resource war, which did not benefit either Germany or Japan. Often, resource wars are not so labeled. For example, Klare (2004) states: “After examining a number of recent wars in Africa and Asia, I came to a conclusion . . . that *resources*, not differences in civilizations or identities, are at the root of most contemporary conflicts.” Mabey (2008) states: “Conflict over natural resources, whether driven by need or greed, has always been a part of human society . . . The coming decades will see rising resource scarcity, greater environmental degradation and increasingly disruptive climate change at levels never experienced before in human history. In an increasingly uncertain world these trends are disturbingly predictable.”

## **Speculative Worst-Case Scenario**

If a bad, global grain harvest occurs in summer 2008, over 3 billion people will be starving and many will attempt to migrate to countries perceived as having more food than their home country. Food riots in both the crowded refugee camps and large cities will strain police forces beyond their limits. Mabey (2008) remarks: “Muslin countries will be among the hardest hit by climate change. If frustrated by inaction to slow climate change (or one might add “to supply food”), radical environmental movements may spawn eco-terrorist groups in a parallel with the evolution of extreme left-wing movements in the 1970s.” In short, terrorists will take advantage of any disequilibrium to strike. If a resource war is in progress, further strain on resources will result. Terrorist attacks result in deaths and damage, but the consequences of klimakatastrophen will be a major problem if business as usual continues (Cairns, 2008). Finally, multiple outbreaks of disease may

occur, possibly including a pandemic disease, and the medical systems of the planet will be in a chaotic state.

Increased complexity markedly increases the fragility of a system (Tainter, 1990). The US military system is currently strained by over five years of war. Worn equipment needs to be replaced and personnel need rest. The US infrastructure, such as water supply systems, roads, bridges, dams, and levees all badly need repair and/or replacement. The US federal and personal debts are at all time highs. Mortgage foreclosures are up, and middle-class purchasing power is down. The United States is not only first among the top ten military spenders, but it also spends more than the other nine top spending entities combined (Johnson, 2008). This situation is not new, but has been increasing for a very long time, due to “military Keynesianism — the determination to maintain a permanent war economy and to treat military output as an ordinary economic product, even though it makes no contribution to either production or consumption” (Johnson, 2008).

Global society is not prepared for a series of interlocking catastrophes. The worst case scenario might well result in billions of deaths. The 30+% ecological overshoot means that Earth’s natural resource base is being used far beyond its capacity, indicating that any recovery from multiple catastrophes will not be swift. In fact, those systems for which tipping points have been passed will never return to “normal,” but rather to some new dynamic equilibrium state. Predictions are impossible for how much time is needed to reach the new equilibrium or how hospitable the new conditions will be for humans. Highly variable conditions will probably characterize the transition period.

## **Biotic Impoverishment**

Catastrophes and extended post-catastrophe periods will almost certainly result in a massive loss of species. Invasive species

able to tolerate harsh conditions will probably flourish, especially when the number of species competing for limited resources declines. When a quasisteady state is reached, these highly competitive species will be able to flourish in a particular ecological niche. Since most food sources characteristic of the pre-catastrophe period will diminish or disappear, to be replaced by new sources, a return to a hunter/gatherer society seems essential for human survival if the worst case scenario occurs. The present human condition was built from a one-time bonanza of old growth forests, other abundant natural resources, surface minerals, and thick topsoil. These treasures will most likely not be available to future societies, so any attempts to keep or improve present conditions are prudent. John Engler, former Michigan governor and President of the National Association of Manufacturers, states that the leading global heating legislation in the United States is far too costly: "I think you end up with a lose-lose proposition for the American worker and the environment" (Mufson, 2008). Consequently, humans can follow Engler's advice and create an inhospitable, alien planet and have their pockets stuffed with depreciating US dollars. It's the American way!

### **An Old Threat-Multiplier Returns**

Borlaug (2008) warns of a looming catastrophe. New strains of wheat stem rust, called Ug99 because they were discovered in Uganda in 1999, are much more dangerous than those that, 50 years ago, destroyed as much as 20% of the American wheat crop. Borlaug (2008) deplores the fact that the US State Department is recommending ending American support for the international research centers that helped start the Green Revolution, including money for wheat research. He (Borlaug, 2008) also notes that significant financial cuts have been proposed for important research centers, including the US Department of Agriculture's essential rust research

laboratory in St. Paul, MN. Just what is needed during a global food crisis!

### **The Best-Case Scenario**

Much can be done to improve the prospects for a "soft landing" from the present circumstances without depending upon technologies that do not yet exist (e.g., carbon sequestering from wastes from steam-electric power plants). As a start, nation-states must stop shipping food all over the world in huge quantities. Rosenthal (2008) cites one superb example: "Cod caught off Norway is shipped to China to be turned into filets, then shipped back to Norway for sale." Using local foods would reduce both variety of foodstuffs and greenhouse gas emissions. A change in lifestyles is long overdue to protect the biospheric life support system. Still, the conventional wisdom is that climatologists still have too much uncertainty in their predictions — they are not "practical" as are economists. However, humans are very adaptable once they are convinced of a need for change. Human society needs to be told the truth by individuals or groups they trust. Winston Churchill's famous message to the British people during the darkest days of World War II : "I have nothing to offer you but blood, sweat, and tears" had a tonic effect on the British people, who had already endured much. Churchill did not tell citizens what they wanted to hear, but what they needed to hear — the truth!

People are, on their own initiative, finding creative ways to cut costs on routine items such as groceries and clothing (Barbaro and Dash, 2008). Though seemingly small, the daily tradeoffs they are making – more pasta and less red meat, more video rental and fewer movie tickets – amount to an important shift in consumer behavior. Consumers are well aware that prices for houses are sliding; wages are stagnant; job losses are growing; and the Standard & Poor's 500-stock index, a broad measure of stock performance, is down 6% in

the last year (Barbaro and Dash, 2008). People are becoming wary of rosy predictions of the future. For example, nine years ago, *The Economist* published a story on oil, which was then selling for US\$10 per barrel. The magazine warned that this cost per barrel of oil might not last. Instead, it suggested, oil might well fall to US\$5 per barrel (Krugman, 2008). In any case, *The Economist* asserted, the world faced “the prospect of cheap, plentiful oil for the foreseeable future” (Krugman, 2008). Pielke *et al.* (2008) assert that the technological advances needed to stabilize carbon dioxide emissions may be greater than once thought. Two-thirds or more of all energy efficiency improvements and decarbonization of energy supply required to stabilize greenhouse gas emissions are already built into the Intergovernmental Panel on Climate Change reference scenarios (Pielke *et al.*, 2008).

### **Human Time/Earth Time**

Lovelock (2007) notes: “. . . we are now so abusing the Earth that it may rise and move back to the hot state it was in fifty-five million years ago, and if it does most of us and our descendants, will die. . . . I see the Earth’s declining health as our most important concern, our very lives depending upon a healthy Earth.”

Most non-scientists have no idea that carbon dioxide has such a long residence time in the atmosphere. Even fewer believe that such large bodies of water as the oceans could have anything bad happen to them or realize the important role they play in absorbing carbon dioxide. Very little of the general public really understands exponential growth. These situations are not good for any global crisis or catastrophe.

### **Sovereignty of Nations**

National sovereignty provides little or no protection from the consequences of rapid climate change. If anything, sovereignty as presently understood is an obstacle to reaching an accord on greenhouse gas emissions

reduction. Some powerful politicians and many citizens assert, contrary to robust economic evidence, that the necessary reduction targets would be bad for the economy. However, should human societies collapse, as many have done in the past (Diamond, 2005), their economies would be ruined. Why is this obvious truth of economic ruin following ecological collapse never mentioned?

As Admiral Rickover has noted, powerful nations become so because abundant energy makes the technology of war possible. Most powerful nations realize this truth, which is why energy resource wars are so fierce and prolonged. However, as fossil fuels become less abundant and, therefore, much more expensive, military units based on technology might well decline. In fact, globalization itself requires enormous energy inputs. In the near future, huge nation states may not have the resources to function as they now do. In the 20<sup>th</sup> century and early 21<sup>st</sup> century, emphasis has increased on local and regional food supplies and such changes as local public transportation systems to replace increasingly expensive personal transportation.

However, global climate change will affect all humankind for centuries, and the consequences will worsen (e.g., more catastrophes) unless an effective effort is made to reduce greenhouse gas emissions drastically. Of course, if humankind does nothing, the default position is to let nature restore balance by means of starvation, disease, and massive human deaths. Not a pleasant prospect, which should inspire individuals to make the necessary but painful changes for a soft landing possible. Some illustrative examples follow.

(1) Dramatically reduce greenhouse gas emissions as recommended by the Intergovernmental Panel on Climate Change

(2) Eliminate exponential human population growth and reduce population size to within Earth’s long-term carrying capacity.

This reduction may mean 1 billion people or less people if Earth is made less hospitable for humans if climate catastrophes continue to worsen.

(3) Resources, especially food and energy, must be shared more equitably and fairly or anarchy will erupt.

(4) Humankind must cease depending upon something (usually yet undeveloped technology) or someone (usually a deity) to save it from the consequences of its unsustainable practices. Humans must start using their brains and intelligence for something beyond denial and anger.

(5) The biospheric life support system (Gaia) must be nurtured because it has maintained habitable conditions on Earth for the genus *Homo* for millions of years.

(6) If humankind fails, it should exit the ecological stage of the evolutionary theater peacefully, remembering that humankind had the knowledge that would have enabled it to live sustainably and it failed. It should leave the ecological stage in good condition (i.e., no nuclear wars) for the actors who follow humankind.

## Conclusions

Climate catastrophes resulting from anthropogenic (human) activities are a new phenomenon, so precise information is not available on the consequences of “business as usual.” However, since the evidence clearly demonstrates that catastrophes have already occurred, prudence indicates that steps need to be taken to avoid more of them. Remedial measures that improve the probability of reducing catastrophes and improving the probability of human survival should improve the economy.

## Acknowledgements

I am indebted to Darla Donald for transcribing the handwritten draft and for

editorial assistance. Paul Ehrlich, Karen Cairns, Paula Kullberg, and Richard Rusk called useful references to my attention.

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Cairns received the PhD and MS from the University of Pennsylvania, an AB from Swarthmore College and completed a postdoctoral course in isotope methodology at Hahnemann Medical College, Philadelphia. He was Curator of Limnology at the Academy of Natural Sciences of Philadelphia for 18 years and has taught at various universities and field stations. Professional certifications include Qualified Fishery Administrator by the American Fisheries Society, Senior Ecologist by the Ecological Society of America, and the Academy of Board Certified Environmental Professionals.

Among his honors are Member, National Academy of Sciences; Member, American Philosophical Society; Fellow, American Academy of Arts and Sciences; Fellow, American Association for the Advancement of Science; Foreign Member, Linnean Society of London; Founder's Award of the Society for Environmental Toxicology and Chemistry; United Nations Environmental Programme Medal; Fellow, Association for Women in Science; U.S. Presidential Commendation for Environmental Activities; Icko Iben Award for Interdisciplinary Activities from the American Water Resources Association; Phi Beta Kappa; B. Y. Morrison Medal (awarded at the Pacific Rim Conference of the American Chemical Society); Distinguished Scientist Award, American Institute of Biological Sciences; Superior Achievement Award, U. S. Environmental Protection Agency; Charles B. Dudley Award for excellence in publications from the American Society for Testing and Materials; Life Achievement Award in Science from the Commonwealth of Virginia and the Science Museum of Virginia; American Fisheries Society Award of Excellence; Doctor of Science, State University of New York at Binghamton; Fellow, Virginia Academy of Sciences; Fellow, Eco-Ethics International Union; Twentieth Century Distinguished Service Award, Ninth Lukacs Symposium; 2001 Ruth Patrick Award for Environmental Problem Solving, American Society of Limnology and Oceanography; 2001 Sustained Achievement Award, Renewable Natural Resources Foundation; Morrill Chapter, Alpha Zeta, Class of 1944 as of 13 March 2002. Cairns has served as both vice president and president of the American Microscopical Society; has served on 18 National Research Council committees, two as chair; is presently serving on 14 editorial boards; and has served on the Science Advisory Board of the International Joint Commission (U.S. and Canada) and on the USEPA Science Advisory Board. The most recent of his 63 books are **My Quest for Sustainable Use of the Planet**, 2005; **Eco-Ethics and Sustainability Ethics, Book 2, Part 2**, 2004; **Handbook of Ecotoxicology**, Second Edition, 2003; **Ecological and Sustainability Ethics**, 2003; **Eco-Ethics and Sustainability Ethics, Book 2, Part 1**, 2003; **Goals and Conditions for a Sustainable Planet**, 2002; Japanese edition of **Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy**, 1999

Service on National Research Council (the operating arm of the National Academy of Sciences and National Academy of Engineering) Committees:

1. Panel on Freshwater Aquatic Life and Wildlife, **Water Quality Criteria 1972**, 594 pp.
2. Committee for the Working Conference on Principles of Protocols for Evaluating Chemicals in the Environment, **Principles for Evaluating Chemicals in the Environment**, 1975, 454 pp.
3. Committee for Study of Environmental Manpower, Commission on Human Resources, **Manpower for Environmental Pollution Control**, 1977, 427 pp.
4. Military Environmental Research Committee (Installation Renovation Subcommittee), 1977-79
5. Geophysics Study Committee, Geophysics Research Council Board (to produce report **Scientific Basis of Water Resource Management**), 1979
6. Five-Year Research Outlook (Chapter 8 - Water Resources)
7. Committee for Water Supply Reviews
8. Committee on Ecotoxicology (Chairman), **Testing for Effects of Chemicals on Ecosystems**, 1981, 103 pp; **Working Documents for Testing for Effects of Chemicals on Ecosystems**, 1981, 157 pp.
9. Committee on Application of Ecological Theory to Applied Problems, 1982
10. Environmental Studies Board (September 1980-October 1982)
11. Task Force on the Ecological Classification System for Implementing Environmental Quality Evaluation Procedures, 1981
12. Water Science and Technology Board (Founding Member), 1982-85
13. Chair, Committee on Restoration of Aquatic Ecosystems: Science, Technology and Public Policy, 1989-92
14. Committee on U.S. Geological Survey Water Resources Research, 1991-93
15. Committee on Waste Disposal Options, 1992-93
16. Board on Environmental Studies and Toxicology (BEST), 1992-93
17. Correspondent, National Academy of Sciences Committee on Human Rights, 1991-1998
18. Report Review Committee (Final approval of all National Academy Press Publications), 1992- 1998