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Norman W. Thorson
University of Nebraska-Lincoln, nthorson1@unl.edu

Harry A. Spencer
University of Nebraska-Lincoln

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By
Norman W. Thorson
Judge Harry A. Spencer Professor of Law
University of Nebraska-Lincoln
233 Law College
Lincoln, NE 68583-0902
(402) 472-1206
NTHORSON1@UNL.EDU

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Introduction

Global warming seems destined to become one of the defining issues of the twenty-first century. Most scientists now agree that measurable increases in average global mean temperatures over the past decades cannot be explained by natural temporal variations in the earth's climate. Instead, global warming appears to be a fact that can be attributed to human induced changes in the composition of greenhouse gasses in the earth's atmosphere. Moreover, if the trend toward ever increasing temperatures continues, consequences for the earth's environment will be dramatic, and perhaps irreversible. Growing concern over the potential for human activities to alter the earth's climate has precipitated a flurry of proposals designed to address the problem. Most notably, an international agreement to address the issue, the Framework Convention on Climate Change,[1] was adopted in 1992. That agreement, and the fact that it has been signed and ratified by most nations on earth, including the United States, is testament to the significance and seriousness of the issue.

The Greenhouse Effect and its Vulnerability to Human Induced Changes

Earth's climate is warmed and moderated by gases in the atmosphere that trap the sun's heat, notably water vapor and carbon dioxide. These gases allow radiant energy from the sun in the form of visible light to pass through and reach the earth's surface where it is converted into heat. Some of this heat is reflected from the earth's surface in

[*] Judge Harry A. Spencer Professor of Law, University of Nebraska
[1] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, 31 I.L.M. 849 (1992).

the form of infrared radiation. Certain gasses, including carbon dioxide, absorb a portion of this heat energy and reradiate it back toward the surface of the earth, much as a greenhouse allows sunlight to enter and heat the interior, but where the roof and walls retain the heat. The greenhouse effect is critical to maintaining life on the planet. Absent greenhouse gasses, heat energy would be reflected back into deep space and average planetary temperatures would be some 60 degrees Fahrenheit colder than they are today.

That so-called greenhouse gases play a significant role in moderating earth's climate is not a recent scientific development. The ability of certain atmospheric gasses to form a heat-retaining dome around the planet was first hypothesized by the noted chemist Fourier. Fourier began musing about the ability of the planet to retain heat when he accompanied Napoleon's forces to Egypt in 1798, and he had fully developed his theory by 1820.[2] The greenhouse effect was thus discovered coincident with the advent of the industrial revolution in Europe.

Not only is the greenhouse effect a principle long accepted by science, but the possibility that the climate might be warmed as a consequence of burning fossil fuels also is not a new scientific theory. In 1896, the Swedish chemist and Nobel Prize winner Arrhenius first advanced the theory that carbon dioxide emissions from the combustion of coal could cause the earth's climate to warm.[3] Building on the work of Fourier, Arrhenius noted that combustion of coal and other fossil fuels releases large amounts of carbon dioxide into the atmosphere. Since carbon dioxide is a greenhouse gas, Arrhenius

[2] When he returned to France in 1801, he began to develop theories to describe the movement of heat within a body and at the boundary of a body. By 1820, he had turned his attention to the question of why the earth remained warm enough to support life. Why wasn't heat generated by the suns rays lost after being reflected off the surface of the earth? Fourier hypothesized that certain atmospheric gasses acted as an invisible dome that absorbs some of the heat reflected from the surface and reradiates it back downward again. *See generally* G. CHRISTIANSON, GREENHOUSE 1-12 (1999).
[3] *Id*. at 105-115.

hypothesized that humans might alter the earth's climate by burning fossil fuels such as coal.[4]

Greenhouse gases whose concentrations can be affected by human activity are known as anthropogenic greenhouse gasses. Carbon dioxide is the most significant anthropogenic greenhouse gas.[5] It is the potential impact of humans to alter the concentration of greenhouse gasses in the atmosphere that is the subject of current concern. Today, there is no dispute about the fundamental science of heat retention and reflection by atmospheric gasses. Nor is there any dispute that the concentration of greenhouse gasses in the atmosphere has been increasing. Measurements taken on Mauna Loa in Hawaii and from polar ice cap samples confirm that the concentration of greenhouse gasses in the atmosphere has increased dramatically over pre-industrial revolution levels.[6] Moreover, a growing mountain of evidence suggests that the earth's climate is beginning to heat in response to these increased concentrations of greenhouse gasses.[7]

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[4] Although Arrhenius correctly hypothesized that the release of greenhouse gases through human activity could lead to global warming, he seriously miscalculated the rate at which greenhouse gases would accumulate in the atmosphere. His estimated that it would take 3,000 years for carbon dioxide concentrations in the atmosphere to double, a level now expected to be reached by the middle of the twenty first century. *Id*. at 115.

[5] Other significant anthropogenic greenhouse gasses include methane (NH_4), nitrogen oxides (NO_x), and chlorofluorocarbons (CFC's). In addition, three trace gasses (hydrofluorocarbons (HCFC's), perfluorocarbons (PFC's), and sulfur hexafluoride (SF_6)) would also be subject to regulation under the Kyoto Protocol. Historically, carbon dioxide has been viewed as the most significant anthropogenic greenhouse gas. CO_2 emissions are expected to contribute approximately 50 percent of the increase in global temperatures expected during the next 60 years. J. Justus & S. Fletcher, *IB89005: Global Climate Change*, (Congressional Research Service, Library of Congress, 2001).

[6] Concentrations of carbon dioxide in the atmosphere have increased by about one-third during the last one hundred years. *Id*. This concentration is higher than at any time during the previous 420,000 years.

[7] Global average surface temperatures increased approximately .6° C. during the twentieth century, and is expected to warm another 1.4 to 5.8° C by the end of the twenty first century. *See* WORKING GROUP II OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: IMPACTS, ADAPTATION, AND VULNERABILITY 3 (2001). Although these numbers seem small, the planet would be warmer than it has been since the age of dinosaurs. Similarly, cooling of the same magnitude would trigger another ice age.

The consequences of global warming are somewhat speculative, but potentially severe. Among the possible impacts of global warming are rises in ocean and sea levels, altered marine ecosystems, destruction of coral reefs, spread of disease vectors, especially for insect born infectious diseases, more intense and severe weather patterns, regional changes in agricultural production potential, altered patterns of precipitation and other changes in the hydrologic cycle, increased desertification, increased forest loss, and substantial loss of biodiversity.[8] Moreover, small changes in average temperature can have a dramatic impact.[9] Atmospheric chemistry, however, is exceedingly complex. In particular, the capacity of the planet to adapt to increasing concentrations of greenhouse gasses is not clearly understood. Global warming, for instance, can be expected to increase cloud cover. Water vapor in clouds is itself a greenhouse gas that contributes to global warming. At the same time, enhanced cloud cover exerts a cooling effect by preventing some of the sun's radiant energy from striking the surface of the planet. Determining the precise impact of these, and other, feedback loops is a matter of continuing study.[10]

Implications of the Carbon Cycle

Carbon is an essential element for all life on earth. It is found in the atmosphere in various forms; it is dissolved in the oceans; and it is a major component of many soils and rocks. Carbon is cycled continuously through the biosphere, the atmosphere, the

[8] *See generally, e.g.*, D. HUNTER, J. SALZMAN, & D. ZAELKE, INTERNATIONAL ENVIRONMENTAL LAW & POLICY 616-621 (1998).
[9] *See generally*, *id*. at 9-17.
[10] Complexity is also illustrated by trying to determine the effect that regulating CFC's will have on global warming. The use of CFC's is banned by international agreement because these substances precipitate the destruction of stratospheric ozone. Ozone is another greenhouse gas, however, as are CFC's. Consequently, the elimination of CFC's is likely to affect the concentration of greenhouse gasses in the atmosphere, but in ways that are difficult to predict with great accuracy. Banning CFCs will reduce one greenhouse gas overtime, but eventually it will lead to the accumulation of another greenhouse gas.

soils and the oceans as a result of natural forces. Understanding the carbon cycle is essential to understanding the causes and cures of climate change.

> The atmosphere is a critical part of two carbon cycles, which distribute a chemical raw material required by all living organisms. In the shorter cycle carbon is fixed in green plants and in certain microorganisms, such as algae, through the process of photosynthesis. This process takes place when sunlight is absorbed by chlorophyll, which powers a process that breaks down CO_2 from the atmosphere to form organic molecules, such as glucose and amino acids, that accumulate in the biomass of the plants. Animals, which are not capable of photosynthesis, obtain the carbon they need to produce energy for maintaining their bodily processes by eating plants or other animals that are the primary or secondary consumers of plants. Carbon is returned to the atmosphere in the form of CO_2 through the cellular respiration of living plants and animals and their decomposition upon death. The carbon in vegetation is also released to the atmosphere when it's burned, as in forest and range fires or slash-and-burn farming. The oceans absorb and release vast quantities of CO_2 and thus serve as a buffer that keeps the level of CO_2 in the atmosphere relatively stable.
>
> There is also a geological carbon cycle that takes place naturally on a much longer scale of time. The cycle begins when organic material from plants and animals slowly becomes locked into sedimentary deposits, where it may remain for hundreds of millions of years in the form of either carbonates contain the shells of marine organisms or organic fossils, such as coal, oil, and natural gas. Some of the carbon is eventually released when the geological formations in which it is locked are exposed to weathering and erosion. Human beings have greatly accelerated the release of this carbon by mining and drilling large quantities of fossil fuels and burning them to produce energy while in the process emitting CO_2.[11]

One implication of the carbon cycle is that humans can alter the natural flows of carbon through the carbon cycle in a way that causes a disproportionate amount of carbon to be stored in the atmosphere, thereby accentuating the greenhouse effect. The principle

[11] M. SOROOS, THE ENDANGERED ATMOSPHERE 31 (1997).

human activity that alters the carbon cycle in a way that increases carbon dioxide concentrations is the combustion of fossil fuels.[12]

A second implication of the carbon cycle is that atmospheric concentrations of carbon also can be affected by activities, such as deforestation, that reduce the capacity of the planet to absorb additional greenhouse gasses. Tropical rain forests, for instance, have the capacity to capture and remove significant quantities of carbon from the atmosphere storing it in vegetation. Processes and mechanisms capable of removing greenhouse gases from the atmosphere are known as sinks. Converting tropical rain forests to farmland eliminates the carbon sink and, if the forest is burned, releases additional CO_2 to the atmosphere. Alternatively, if the wood residue is allowed to decay, another greenhouse gas, methane, will be released to the atmosphere from termites that assist in the decomposition process. Other human activities that contribute to increased concentrations of greenhouse gases in the atmosphere include various agricultural cropping practices, the production of livestock, and the use of internal combustion engines.[13]

Although the primary focus of this paper is on carbon, other anthropomorphic gases play a significant role in global warming.[14] Greenhouse gasses vary in their global warming potential and in their persistence. Carbon dioxide, the most important by volume, is less potent than other gasses. Methane has 56 times the global warming

[12] Energy related activities are the primary source of man-made greenhouse gas emissions, representing about 85 percent of the total man-made carbon emissions in the United States in 1998. National Energy Policy Development Group, Reliable, Affordable, and Environmentally Sound Energy for America's Future 3-10 (Report to the President of the United States submitted May 16, 2001).
[13] Tillage practices affect the release of carbon from soil; livestock are significant source of methane; and internal combustion engines release nitrous oxides, another greenhouse gas.
[14] Six greenhouse gases are identified and regulated under international agreements that address climate change. A seventh, CFC's, are regulated under international agreements that regulate ozone depleting substances.

potential of carbon dioxide, nitrous oxides have 280 times the global warming potential of carbon dioxide, and CFC's have global warming potential thousands of times greater than that of carbon dioxide. Despite its relative lack of potency, carbon dioxide is thought to be responsible for at least 50 percent of the global warming attributable to man-made sources. Greenhouse gasses also vary as to how long they persist in the atmosphere. Carbon dioxide, for instance, has an atmospheric life of 50 to 100 years. In contrast, methane persists for only 12 years, but some other anthropogenic greenhouse gases may persist for thousands of years. The differences in persistence and global warming potential of the various greenhouse gases have important policy implications. First, a common unit of currency must be found. To account for varying potencies, it is common practice to refer to greenhouse gases in terms of carbon equivalents. Second, persistence of greenhouse gases in the atmosphere means that the climate is currently affected by activities that occurred generations ago and stabilizing greenhouse gas emissions will not prevent the further buildup of greenhouse gas concentrations in the atmosphere.

Current Legal Framework

General Background

Regulation of greenhouse gases is still in a nascent state. The regulatory challenge is complex because climate change is a global problem. The problem also is complex because anthropogenic greenhouse gases are emitted as a consequence of activities that generally are conceded to be essential to economic development. Furthermore, the problem is complex because greenhouse gas emissions are widely scattered across the planet.

The fact that climate change is a global issue means that no nation can capture the benefits of regulation for its own citizens absent cooperation of the international community. A nation has no incentive to engage in costly regulatory programs if the purported benefits of the program can be thwarted by another nation that increases its emissions of greenhouse gases. Conversely, even if general international cooperation is achieved, relatively small emitters have an incentive to eschew costly regulatory measures because they can benefit from the collective action of others without having to bear any of the costs of those actions, a classic free-rider problem. Finally, the impacts of global warming are not spread equally across the planet. Some low-lying island nations face the prospect of becoming submerged if sea levels rise even modest amounts. On the other hand, some nations would probably benefit from global warming in the short run as growing seasons and precipitation patterns change. The problem is one that cannot be resolved without achieving general consensus, but general consensus will be extraordinarily difficult to achieve.

The fact that greenhouse gas emissions are associated with economic activity means that the cost of greenhouse gas abatement likely will be significant. It also brings into sharp focus the differences between the developed world and the developing world. The world's developed economies are highly dependent on energy consumption, much of it derived from fossil fuels. Developing countries are poised to greatly increase their consumption of energy, and hence their contribution of greenhouse gases to the atmosphere, as they strive for economic equality with the developed world. Developing nations like China have an enormous potential to increase emissions of greenhouse gases as their economies grow; understandably, such nations are unwilling to forgo growth to

contribute to a solution to a global warming problem that they see being caused largely by consumption of energy in the developed world. Other developing nations see their economic future tied to conversion of forest land to agricultural land, much as occurred previously in Europe and North America. This potential loss of sinks has the same impact as increasing emissions from burning fossil fuels. Still other nations have economies that are almost entirely dependent on providing the fossil fuels that fuel the development of the world, but which cause so much of the buildup of greenhouse gasses in the atmosphere.

Finally, the fact that greenhouse gas emissions are widely dispersed across the planet means that one cannot achieve success solely by forging an agreement between the 10 or 12 largest emitters, particularly when so many developing countries have the potential to greatly increase their contribution to the buildup of greenhouse gases in the atmosphere. The international agreements that have been negotiated to date, and the national programs that have been proposed, are all of recent vintage and all reflect the difficulties discussed above. The legal environment is necessarily evolving as nations struggle with the complexities of global warming. Not surprisingly, many of the emerging legal rules are frustratingly vague and incomplete.

Preliminary International Consensus-The Framework Convention

In 1988, the United Nations Environmental Programme and the World Meteorological Organization created the Intergovernmental Panel on Climate Change (IPCC). The IPCC is organized into three working groups that focus respectively on the science of the climate system, the impacts of climate change and policy options for response, and the economic and social dimensions of climate change. One of the IPCC's

first tasks was to assess the scientific, technical and economic basis of climate change policy in preparation of the United Nations Conference on Environment and Development, the so-called "Earth Summit" held in Rio de Janeiro in 1992. In 1990, the panel recommended a climate change convention modeled after the Vienna Convention for the Protection of the Ozone Layer.[15] The goal was to draft a document that would gain the largest number of adherents. Many of the difficult issues were put aside to be addressed in subsequent annexes and protocols.

The Framework Convention on Climate Change was one of the landmark agreements in international environmental law that was adopted at the Earth Summit. The United States signed the Convention on June 12, 1992, together with 153 other nations. The United States Senate consented to ratification on October 7, 1992, and President Bush signed the instrument of ratification on October 13, 1992. The United States thus became one of the first nations to ratify the Convention. The agreement entered into force on March 24, 1994, having been ratified by the requisite 50 nations. Currently, the convention has been ratified by 186 nations.

[15] 26 I.L.M. 1529 (1987). International efforts to address ozone depletion have been remarkably successful. The potential role that CFC's play in ozone depletion was first raised in 1974. The Vienna Convention, opened for signature in 1985, was a modest document in which the parties agreed to take "appropriate measures" to prevent ozone depletion and to cooperate in the conduct of research and scientific assessments. Shortly after the Vienna Convention adjourned, British scientists reported discovery of an "ozone hole" over Antarctica. Two years later, parties negotiated the Montreal Protocol to the Convention, and parties agreed to first freeze, and then significantly reduce CFC consumption. As additional information was generated from research, subsequent Conferences of the Parties further amended the protocol to first accelerate planned reductions in consumption, and later to ban consumption of some substances entirely. Additional ozone depleting substances were also identified and made subject to regulation. The international response to the ozone problem is widely hailed as a triumph of modern diplomacy, and consequently, it is no surprise that drafters sought to model the Framework Convention on Climate Change after the Vienna Convention. In many ways, however, ozone depletion was an easier problem to come to grips with than climate change. First, no one benefits from ozone depletion, although some are harmed more than others. Second, replacements for CFC's were soon developed, so economic impacts of regulation were minimized. Third, production was concentrated in a way that permitted successful actions in the short run if agreement could be reached among a relatively small number of parties.

A framework convention sets out general objectives, principles, and commitments made by parties to the convention, but it lacks the level of detail that will be required to solve the problem addressed by the agreement. Framework conventions are flexible documents that are intended to be modified or supplemented by protocols as additional information becomes available. Ongoing research and regular meetings are typically a feature of framework conventions.

The general objective of the climate change agreement is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at the level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within the time frame sufficient to allow ecosystems to adapt naturally to climate change, to insure that food production is not threatened and to enable economic development to proceed in a sustainable manner."[16] In their actions to achieve the objective of the convention parties should be guided by five principles: 1) developed country parties should take the lead in combating climate change;[17] 2) special circumstances of developing country parties should be given full consideration;[18] 3) parties should take precautionary measures to anticipate, prevent or minimize the causes of climate change and mitigate adverse effects;[19] 4) economic development is essential for adopting measures to address climate change;[20] and 5) measures taken to combat climate change should not constitute a means of arbitrary or unjustifiable discrimination against or a disguised restriction on international trade.[21]

[16] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, *supra* note 1, art. 2.
[17] *Id*. art. 3 .1.
[18] *Id*. art. 3 .2.
[19] *Id*. art. 3 .3.
[20] *Id*. art. 3.4.
[21] *Id*. art. 3.5.

The convention divides the parties into three categories: a) all parties; b) Annex I parties, composed of all industrialized countries; and c) Annex II parties, which consists of all industrialized countries except the transitioning economies of the former Soviet Union. All parties to the Framework Convention make ten general commitments which include mandates to develop national inventories of greenhouse gas emissions by sources and removals by sinks,[22] to formulate and implement national and regional programs containing measures to mitigate climate change,[23] and to promote conservation and enhancement of sinks and reservoirs.[24] Annex I parties made additional commitments. They include a mandate to adopt national policies and take corresponding measures to mitigate climate change by limiting anthropogenic emissions of greenhouse gases and by protecting and enhancing greenhouse gas sinks and reservoirs.[25] Although no specific targets were included in the convention, Annex I parties committed to provide detailed information on their policies and on projected carbon emissions with an aim of returning to 1990 levels of carbon emissions.[26] Finally, Annex II parties agreed to provide new financial and technical assistance to developing country parties.[27]

In addition to setting forth the general objectives, principles, and commitments, the framework convention established an institutional framework to facilitate day-to-day operations[28] and procedures for refining national commitments by the adoption of protocols or amendments.[29]

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[22] *Id*. art. 4.1 (a).
[23] *Id*. art. 4.1 (b).
[24] *Id*. art. 4,1 (d).
[25] *Id*. art. 4.2 (a).
[26] *Id*. art. 4.2)(b).
[27] *Id*. arts. 4.3- 4.5.
[28] *Id*. arts. 7-8.
[29] *Id*. arts. 16-17.

The framework convention achieved remarkable international consensus on a wide variety of issues. First, parties agreed on the need to stabilize the amount of greenhouse gases in the atmosphere. To accomplish their goal, there are two choices. Either man- made emissions of greenhouse gases must be reduced or the ability of the planet to remove and sequester greenhouse gases from the atmosphere must be enhanced, or both strategies must be pursued simultaneously. The framework convention repeatedly recognizes management of emissions, sinks, and reservoirs as crucial to the successful resolution of climate change issues.[30]

Second, climate change is a global issue. An increase in carbon sequestration anywhere on the planet or a reduction in carbon equivalent emissions anywhere on the planet will have a positive effect on stabilizing the level of greenhouse gasses in the atmosphere. Consequently, there are many efficiency gains to be achieved from collective action.

Third, the agreement recognizes that a significant political split exists between developing countries poised to greatly increase their carbon emissions, and developed countries whose economies already depend on consumption of fossil fuels. In many ways this split reflects a fundamental difference of opinion in how the planet's capacity to absorb greenhouse gases ought to be allocated. Developing countries argue for an equitable allocation of this capacity;[31] some developed countries essentially argue that capacity has already been allocated under principles of prior appropriation. The Convention, however, makes it clear that developed countries must take the lead in

[30] *See*, *e.g.*, *id*. *Preamble*; arts.3.3; 4.1(b),(d); 4.2 (a)-(c).
[31] What constitutes an equitable allocation is also not free of controversy. An equitable allocation of absorption capacity might be calculated on a per capita basis, a per acre basis, or on a per unit of GDP basis.

efforts to stabilize greenhouse gas concentrations in the atmosphere. At the same time, the convention recognizes that greenhouse gas controls must be adopted with economic sensitivity. The fact that climate change is a global problem and the resolution of the problem must proceed in a way that does not destroy the world economy, or individual national economies, suggests that markets may play a significant role in solutions.

Fourth, the convention recognizes that the impact of implementing response measures, as well as the impact of anticipated global warming, will vary from nation to nation. Among the groups of nations facing special problems, the convention identifies a) small island countries; b) countries with low-lying coastal areas; c) countries with arid and semiarid areas, forested areas and areas liable to forest decay; d) countries with areas prone to natural disasters; e) countries with areas liable to drought and desertification; f) countries with areas of high urban atmosphere pollution; g) countries with areas with fragile ecosystems, including mountainous ecosystems; h) countries whose economies are highly dependent on income generated from the production, processing and export, and/or on consumption of fossil fuels and associated energy intensive products; and i) landlocked and transit countries.[32]

Finally, the convention recognizes that implementation measures must be developed at national, regional, and local levels. To date, most of the legal activity with respect to greenhouse gas abatement has been at the international level. The United States, for instance, does not regulate greenhouse gas emissions.[33] In other countries, however, momentum to minimize greenhouse gas emissions is mounting.

[32] UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, *supra* note 1, art. 4.8.
[33] Although the United States does regulate emissions of nitrogen oxides and ozone depleting substances, both are regulated for reasons other than their global warming potential. Carbon dioxide, however, is not currently regulated as an air pollutant.

Adding Details-The Kyoto Protocol

The Kyoto Protocol to the United Nations Framework Convention on Climate Change[34] was an attempt to enact binding emissions limitations for a group of 38 industrialized nations that are identified in Annex I of the Framework Convention.[35] Although the United States signed the Kyoto protocol, it has not been submitted to the United States Senate for its consent to ratification. In fact, a Senate resolution adopted without dissent makes it clear that the Senate will not be receptive to a submission in its current form.[36] The protocol remains important, however, because it is the first attempt to craft detailed commitments within the Framework Convention, and because any future international efforts are likely to embody many of the principles of the Kyoto agreement. The limits set out in the Kyoto Protocol apply to emissions of fixed greenhouse gases measured over the period from 2008 to 2012.[37] Annex I parties are required to demonstrate progress toward meeting commitments by 2005.[38] The net changes in greenhouse gas emissions by sources and removals by sinks are used to meet commitments under the protocol.[39] In other words, a commitment reduction can be met

[34] KYOTO PROTOCOL TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, FCCC/CP/1997/L.7/Add. 1 (open for signature December 11, 1997, not yet entered into effect).
[35] *Id*. art 3.1. Reduction commitments embodied in the Kyoto protocol are specified in Annex B and range from a decrease of 8 percent from the 1990 base year levels for most European countries, to an increase of 10 percent over the 1990 levels for Iceland. The United States agreed to reduce its greenhouse emissions by seven percent from 1990 levels. *Id*., Annex B.
[36] The so-called Byrd-Hagel resolution, Sen. Res. 98, was passed the United States Senate on July 25th 1997 by a 95-0 vote. In the resolution, which had 64 co-sponsors, the Senate states that the United States should not be a party to any protocol that fails to apply emissions limitations to developing countries as well as developed countries. It also calls for an economic impact statement to accompany in the submission of a protocol to the Senate for ratification.
[37] Emission limitations contained in the protocol are intended to be met during a five-year commitment from 2008-2012. KYOTO PROTOCOL, *supra* note 29, art. 3.7.
[38] *Id*. art. 3.2.
[39] *Id*. art. 3.3. The Protocol authorizes only a limited number of land use related activities that qualify for removal credits. They are afforestation, reforestation, and deforestation (a negative removal credit) since 1990. *Id*. Unfortunately, the terms *afforestation*, *reforestation*, and *deforestation* are not defined in the Protocol. The Conference of the Parties to the Protocol, however, is authorized to decide on rules and guidelines that would allow other human induced sink enhancement activities, including removals by

by reducing emissions or by engaging in activities that enhance removals of greenhouse gasses from the atmosphere by sinks.[40]

Because greenhouse gas emissions cause global impacts, it does not matter, from an environmental perspective, where reductions in emissions or removals from sinks occur. This would suggest that least cost removal and reduction activities should be pursued without regard to national borders. The protocol contains three market-oriented mechanisms designed to allow Annex I parties to reduce the cost of complying with emissions limits, joint implementation,[41] a clean development mechanism,[42] and international emissions trading.[43] A fourth mechanism, joint fulfillment,[44] allows groups of Annex I parties to enter into agreements that redistribute total reduction commitments among themselves. The four market oriented mechanisms thus are designed to reduce the cost of complying with national commitments without loss of any environmental benefits.

Joint fulfillment was initially included in the Protocol to allow the European Union to redistribute commitment obligations among member states as long as total emission reduction commitments are satisfied. The effect of joint fulfillment is to place a bubble over contracting states with compliance satisfied as long as net emissions from the bubble are within limits specified by the protocol. However, once the joint

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agricultural soils and land use changes, to qualify for credits against emission limitation commitments. *Id*. art. 3.4. The extent to which nations can claim credit for carbon absorbed by forests and agricultural lands has been a contentious issue at subsequent Conferences of the Parties, with the issue often pitting the United States against the European Union. *See generally* S. Fletcher, *RL30692: Global Climate Change* 4-7 (Congressional Research Service, Library of Congress, 2001).

[40] The goal of the Protocol is to reduce the net discharge of greenhouse gasses to the atmosphere. This can be accomplished by reducing the direct emission of greenhouse gasses from sources or by engaging in activities that enhance the ability of sinks to remove greenhouse gasses from the atmosphere. For example, if a forest were planted where none existed before (afforestation), the net carbon removal from the atmosphere by the biomass of the trees would be credited against emission reduction commitments.

[41] *Id*. art. 6.

[42] *Id*. art 12.

[43] *Id*. art 17.

[44] *Id*. art. 4.

fulfillment contract is deposited with the Secretariat, the obligations contained in the contract become binding on individual nations under the protocol.

Joint implementation allows Annex I parties, or authorized legal entities such as brokers or corporations,[45] to transfer to or acquire from other Annex I parties emission reduction units derived from specific projects designed to reduce emissions or enhance sinks of greenhouse gases.[46] For example, an acquiring party might agree to finance a project that produces greenhouse gas reduction benefits in exchange for some or all of the greenhouse gas reduction benefits that can be derived from the project. The precise allocation of reduction benefits is a matter for contractual allocation among the participating states. The party acquiring emission reduction units can increase carbon equivalent emissions above its Kyoto commitments. Similarly, the party transferring emission reduction commitments must subtract the amount transferred from its allowable emissions to remain in compliance with Kyoto obligations.

The clean development mechanism authorized by the Protocol parallels joint implementation described above, except that reductions in greenhouse gas emissions are achieved by sponsoring projects in non-Annex I countries. The goal of the clean development mechanism is to promote sustainable development in developing countries while assisting developed countries in meeting their commitments under the Kyoto protocol.[47] Certified emission reduction units obtained from clean development

[45] *Id*. art.6.3.
[46] *Id*. art 3.1. The transfer of emission reduction units is contingent on project approval by both parties, on the project providing reduction or enhancement benefits that otherwise would not occur, and on the acquiring party being in compliance with other responsibilities under the protocol. The acquisition of emissions reduction units must also be supplemental to domestic actions taken to comply with the emission limits specified in the protocol. *Id*.
[47] *Id*. art. 12.2.

mechanism projects can be used by Annex I parties to help meet their reduction commitments.[48]

Emissions trading, in contrast to joint implementation and the clean development mechanism, is not project based. Rather, it permits parties to buy and sell the right to emit greenhouse gases.[49] For instance, a party in a position to reduce greenhouse gas emissions at relatively low-cost might undertake projects that generate more reductions that would be required under the Kyoto obligations. Those excess credits could be sold to other parties that face greater economic challenges in meeting the Kyoto commitments. The effect of emissions trading would be to reduce emissions in the selling country below the level anticipated by the Kyoto agreement or to permit emissions in the purchasing country to exceed the level anticipated in the Kyoto agreement.

There are many contradictions and unanswered questions in the Kyoto mechanisms. For example, while legal entities can participate in joint implementation or clean development projects, it is not clear that they are authorized to engage in emissions trading. Similarly, the extent to which land use changes and other carbon sink enhancing activities can serve as the basis for satisfying trade mechanisms varies from mechanism to mechanism. Removals by sinks are specifically mentioned with respect to joint implementation in Article 6.[50] In contrast, the clean development mechanism authorized in Article 12 makes no mention of sinks. Articles 6 and 17 provide that transfers of emission credits must be supplemental to domestic actions taken to meet Annex B

[48] *Id*. art. 12.3(b).
[49] No details of a permissible trading regime were included in the draft of the Protocol. The Protocol provides that the Conference of the Parties will develop principles, modalities, rules and guidelines. *Id*. art. 17.
[50] *Id*. art. 6.1.

commitments.[51] Similarly, article 12 provides that certified emissions reductions can only be used to meet part of the protocol commitments.[52] With respect to joint implementation and clean development mechanism projects, parties are required to demonstrate that the projects produce emissions reductions in excess of those that would have occurred absent the project.[53] Additional unanswered questions included how the commitments under the protocol are to be enforced, penalties for failure to achieve commitments, and who bears the risk of nonperformance when part of the nation's performance depends on reductions generated within the borders of another emission.[54]

Although these and many other complex issues must be addressed if the international community is to succeed in stabilizing the concentration of greenhouse gases in the atmosphere, a general outline of the process to be used in regulating emissions can be discerned. First, caps are placed on net emissions of greenhouse gasses on a country-by-country basis with the cap based on historical experience. Second, emissions allowances are the difference between the amount of greenhouse gasses emitted and any new removals by sinks. Consequently, emissions controls and land use measures may each be valid ways of achieving emission reduction goals. Third, emissions allowances may be increased or decreased by a variety of voluntary transfers. Fourth, precisely how a nation chooses to meet its emissions reductions commitments is a matter of domestic, not international, law. Finally, and very controversially, emissions caps have not been placed on developing countries, an issue that makes it unlikely that the United States will ratify the Protocol unless it is modified.

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[51] *Compare id*. art 6.1(d) *with* art. 17.
[52] *Id*. art. 12.3(b).
[53] *Compare id*. art. 6.1(b) *with* art. 12..5(c).
[54] For an analysis of the risk of nonperformance, see D. Goldberg, S. Porter, N Lacasta & E. Hillman, *Responsibility for Non-Compliance under the Kyoto Protocol's Mechanisms for Cooperative Implementation* (Center for International Environmental Law, 1998).

Kyoto's Accounting Procedures for Permitted Greenhouse Gas Emissions

To fully appreciate the complexity of the emissions capping mechanism incorporated into the Kyoto agreement, it is necessary to examine the accounting procedures in more detail. The Kyoto protocol sets qualified emission limitations for individual developed countries.[55] These limitations are calculated as a percentage of the emissions that occurred during a base year, generally 1990.[56] The United States, for instance agrees to cap its emissions at 93% of the amount that was emitted in 1990; most European nations are capped at 92% of the base year emissions.[57] Qualified emissions limitations can be viewed as emission allowances. To give parties time to implement measures that will permit reductions in emissions, the allowances do not become binding until the first commitment period, which extends from 2008 to 2012,[58] although parties are expected to demonstrate progress toward meeting the reduction goals by 2005.[59] To provide additional flexibility, parties are given a bulk allocation of allowances during the five-year commitment period, calculated by multiplying the annual qualified emission limitation by five.[60] This allows a party's emissions to vary from year to year during the commitment period without a nation falling out of compliance as long as the total aggergate amount of emissions allowances are not exceeded during the five year commitment period. A party can increase its assigned maximum allowance beyond the qualified emission limitations by securing emission reduction units as part of a joint

[55] These are set forth on a country-by-country basis in Annex B of the Protocol.
[56] KYOTO PROTOCOL, *supra* note 34, art. 3.7. Transitioning economies, notably the nations of the former Soviet Union, were permitted to select an alternate base year. *Id*. art. 3.5. Any party can use 1995 as a base year for certain enumerated tract greenhouse gases. *Id*. art 3.8.
[57] *Id*., Annex B.
[58] *Id*. art. 3.1. 2008 to 2012 is the first commitment period. By implication, additional commitment periods with new, and presumably more stringent, reduction goals would follow.
[59] *Id*. art. 3.2.
[60] *Id*. art. 3.7.

implementation project,[61] by securing certified emissions from a clean development mechanism project,[62] or by purchasing surplus emission allowances from willing sellers.[63] Conversely, any party transferring emission reduction units as part of a joint implementation project or any party selling surplus emission allowances will have their permissible allowances reduced by the amount of the transfer.[64] If emissions during the commitment period are less than a nation's assigned allowance, the surplus can be carried forward to future commitment periods.[65]

Domestic Implementation of International Commitments

Once a nation has committed to capping greenhouse gas emissions at certain prescribed levels, it must adopt domestic programs to achieve those goals. Apart from the emissions caps contained in the Kyoto Protocol, Annex 1 Parties have an independent duty under the Framework Convention to limit emissions of greenhouse gases and protect and enhance sinks.[66] A wide variety of alternative approaches can be hypothesized. They can be divided into two groups, policies designed to reduce emissions of greenhouse gases and policies designed to protect and enhance sinks.

Policies Designed to Reduce Emissions

Nations have a variety of strategies that they might pursue in attempting to discourage the emission of greenhouse gases. Because fossil fuel consumption is the greatest source of greenhouse gas emissions, emissions control strategies will likely be directed toward the energy sector. Several options are available. A nation might enact a carbon tax that would be assessed on the basis of carbon emissions. To avoid or

[61] *Id*. art. 3.10.
[62] *Id*. art. 3.12.
[63] *Id*. art. 3.10.
[64] *Id*. art. 3.11.
[65] *Id*. art. 3.13.
[66] FRAMEWORK CONVENTION, *supra* note 1, art. 4.2(a).

minimize the tax owed, emitters would have an incentive to switch fuel sources, to improve efficiency, and to adopt conservation measures. Historically, the United States has been reluctant to implement pollution taxes.

As an alternative, a nation might adopt technology forcing emissions standards that would apply to classes and categories of emitters. This is the strategy used in the United States to control conventional pollutants under the Clean Water Act. A variation on the theme requires that products manufactured for resale attain certain specified efficiency standards. Examples include efficiency standards for appliances, water use standards for toilets, and CAFE standards for automobiles. Closely related to efficiency standards are command and control regulations that mandate the use of certain technologies to minimize emissions. Examples could include a requirement that landfills or large confinement feedlots capture and reuse methane generated from normal operations. The difficulty with command and control regulations is that they tend to be inflexible and are often inefficient. At least some command and control regulation, however, is likely to be a feature of domestic greenhouse gas legislation.

A third alternative approach is a cap and trade system where the emissions of individual emitters are capped at some level that forces an aggregate decrease in emissions, but where parties are allowed to trade allowances among themselves. The United States has had great success with such a program with respect to sulfur dioxide under the Clean Air Act. To the extent that caps are placed on greenhouse gas emissions by particular emitters, emissions allowances might be created that can be freely traded permitting reductions to occur at the least cost. A cap and trade system at the national level would mirror the system being put in place under the Kyoto Protocol at the

international level. Given its strong advocacy of market based solutions during international negotiations, it is likely that a cap and trade system would be a component of any sophisticated climate change regulatory program adopted in the United States.

Another set of alternatives involves public efforts to make fundamental changes in the sources of energy used in a country. A nation might choose to invest in or subsidize the development of energy sources that don't result in significant emissions of greenhouse gases. Hydropower, nuclear power, and power from various renewable energy sources such as solar power and wind power would be favored. A nation might also increase research efforts designed to develop alternative sources of energy such as hydrogen fuel cells or fusion power.

Finally, a nation might choose to discourage emissions by regulating or taxing activities that directly or indirectly cause such emissions. For example, a nation might subsidize mass transit and tax private automobiles. It is likely that most nations would pursue a variety of approaches in attempting to minimize the emission of greenhouse gases, although it is too early to anticipate specific programs.[67] Given the potential significant economic impact of controls, particularly carbon controls, it is likely that nations will search for innovative, cost effective measures.

Policies Designed to Protect and Enhance Sinks

A nation might also attempt to meet its commitments by undertaking activities that enhance the ability of sinks to remove greenhouse gases from the atmosphere. Most of these efforts involve land use choices or restrictions. Historically, in the United States,

[67] For a summary review of emerging plans from the EU, Denmark, France, Germany, the Netherlands, Norway, the United Kingdom, Australia, and Canada see J. Cameron, D. Robertson & P Curnow, *Legal & Regulatory Strategies for GHG Reductions—A Global Survey*, 15 NAT. RESOURCES & THE ENVIRON. 176 (2001).

most land use regulatory decisions have been deemed to be within the purview of state and local governments, rather than the federal government. Although there would be a clear constitutional nexus for regulating land uses to achieve greenhouse gas abatement goals at the federal level, it seems likely that states will play a greater role in such efforts than they would with respect to emissions policies.

To date, most of the attention regarding enhancement of sinks has been directed toward forestry practices. That is not surprising because forests have a great potential to sequester carbon. Nations that are engaged in deforestation by, for instance, converting forestland to agricultural land, are contributing to the buildup of greenhouse gasses through their land use policies. Moreover, the Kyoto protocol specifically refers to deforestation, reforestation, and afforestation, although the terms are not defined.[68] Generally, deforestation is the permanent removal of the forest, reforestation is replanting a forest where one previously existed (or perhaps, in a more limited sense, replanting a forest immediately after harvest), and afforestation is a change in land use from non-forest to forest. Halsey National Forest would be a clear example of an afforestation project. A nation might attempt to gain credit for sink enhancing activities by mandating sustainable forest practices, by subsidizing tree planting efforts, or by regulating or otherwise discouraging the conversion of forestland to non-forestland.

The Kyoto protocol also recognizes that non-forest related sinks, including other land use changes and removals by agricultural soils, might also be enhanced in ways that help stabilize the level of greenhouse gases in the atmosphere.[69] Studies suggest that

[68] KYOTO PROTOCOL, *supra* note 34, art. 3.3.
[69] *Id*. art. 3.4.

agricultural cropland[70] and rangeland[71] have great potential to sequester carbon. The United States Department of Agriculture estimates that the total carbon sequestration and fossil fuel offset potential of U.S. cropland is estimated at 154 million metric tons of carbon per year or 133% of the total emissions of greenhouse gases by agricultural and silvicultural activities.[72] Policies that might be adopted to enhance the potential of agriculture to sequester carbon include subsidizing, encouraging, or mandating farming practices that encourage carbon retention in soils, or by mandating or subsidizing conservation activities, such as minimum tillage or no tillage, that produce greenhouse gas abatement benefits.[73] Farmers could be compelled to adopt such practices as a condition of participating in the farm program or they could be encouraged to engage in such practices as voluntary transactions with emitters who are seeking carbon sequestration offsets for planned emissions. Additional benefits could be gained from preventing or discouraging the conversion of prairie lands to croplands. In many cases, carbon sequestration benefits could be achieved by returning marginally productive lands to natural uses, such as wildlife habitat, by restoring degraded soils, by preserving wetlands, and planting windbreaks. A number of existing USDA conservation programs produce carbon sequestration benefits including the Conservation Reserve Program, the Wetlands Reserve Program, and the Conservation Buffer Strip Initiative. Land use measures have two principle advantages as a tool for addressing climate issues. First,

[70] See R. LAL, J. KIMBLE, R. FOLLETT & C. COLE, THE POTENTIAL OF U.S. CROPLAND TO SEQUESTER CARBON AND MITIGATE THE GREENHOUSE EFFECT (1999).
[71] See R. FOLLETT, J. KIMBLE & R. LAL, THE POTENTIAL OF U.S. GRAZING LANDS TO SEQUESTER CARBON AND MITIGATE THE GREENHOUSE EFFECT (2001).
[72] *Soil Carbon Sequestration: Frequently Asked Questions*, USDA Global Change Fact Sheet, USDA 2001.
[73] In addition to conservation tillage, other beneficial management practices include optimum management of crop residues and application of manures, soil fertility optimization through site specific management, elimination of summer fallow, and use of winter cover crops. *Id*.

land use measures likely are a least cost alternative to meeting emissions reduction goals, at least in the short term. Second, land use measures produce synergistic benefits in the form of enhancing biodiversity, enhancing water quality by reducing runoff and maintaining wetlands, and preserving landscapes. At the same time, use of sink enhancements to meet greenhouse abatement goals has been controversial. Some feel that too liberal use of sinks would make it possible for governments to claim credit for policies that they would have pursued even in the absence of global warming concerns. Others raise a series of technical objections.

Technical Objections to Sink Enhancement Projects

Much of the controversy with respect to using sink enhancement projects to satisfy qualified emission limits revolves around three technical issues.[74] First, can the new volume of greenhouse gasses captured in the sink be accurately measured, a problem of verifiability. This is a particularly difficult issue where sink enhancement benefits are claimed for activities in developing countries. Even in developed countries, verification is a difficult issue, especially for soil sequestration. Even at a national level, it may not be cost effective to measure sequestration benefits over a period as short as five years if the stocks are large and the change in stocks is small by comparison,. At the farm level, stringent measurement requirements might well doom a program.

Second, is sequestration permanent or temporary? For example, planting a forest might generate sequestration benefits for a number of years. Eventually, however, the benefits will be lost if the forest is harvested and not replaced. Decomposition of harvested wood would eventually return stored carbon to the atmosphere. Furthermore,

[74] The issues are thoroughly discussed in B. Schlamadinger & G. Marland, *Forests, Land Management, and the Kyoto Protocol* (Pew Center on Global Climate Change, 2000).

even if the forest is replanted, should the new forest be credited with additional sequestration benefits or should it be deemed carbon neutral, a mere offset to the carbon loss associated with harvest. The problem is particularly difficult from a regulatory perspective if the forest enhancement project is located in a developing country not subject to emissions limitations under the Kyoto protocol. In that case, a developed nation might claim a clean development mechanism credit for carbon sequestration, but there would be no mechanism to account for emissions at the time of harvest because developing countries emissions are not currently limited. A closely related issue concerns the rate of carbon storage, and the fact that reservoirs such as a forests or agricultural soils eventually will become saturated with carbon. These concerns suggest that carbon sequestration may be an appropriate short-term contributor to a greenhouse gas abatement plan, but not a long run solution to the emissions problem.

Third, how do you prevent a sink enhancement project at one location from stimulating sink depleting activities at a different location, particularly one within a different jurisdiction? This problem, known as leakage, is a consequence of the market altering economic impacts of certain sequestration projects. This is a particular problem where developing countries currently are subject to no emission limitations under the Kyoto Protocol. For example, suppose forest preservation measures in one tropical nation cause the price of tropical hardwoods to increase stimulating harvesting activities in another country, particularly a country not subject to emissions limits under the Kyoto regime. Or suppose that returning marginal agricultural soils to conservation uses causes an increase in farm product prices. This might stimulate conversion of forestland to agricultural uses in another country.

A number of issues need to be resolved before carbon sequestration can properly be accounted for in climate change programs. On the other hand, to ignore the benefits of sink enhancement is to ignore the fact that substantial amounts of carbon are sequestered in soil and biomass and that humans can dramatically affect those numbers by the policies that they adopt. Moreover, sinks are a particularly attractive way of meeting emission reduction commitments, especially in the short run, because they can often be implemented at little or no cost and without the need for substantial technological development.

Potential for Developing Markets for Carbon Sequestration Benefits

The range of possible strategies that a nation might employ to achieve greenhouse gas reduction commitments is almost limitless. Presumably most nations will pursue multiple options. The extent to which a nation chooses to rely on voluntary measures to achieve reduction objectives, including free market transactions, as opposed to command and control regulations, is largely a matter of public policy. There is little that can be done by voluntary action that could not be compelled constitutionally by government fiat. Of course, the advantage of voluntary actions is easier public acceptance and the potential for greater economic efficiency in achieving environmental goals. At least in the United States, is likely that any significant greenhouse gas abatement program would incorporate market mechanisms.

No legal impediments prevent the development of markets for carbon sequestration benefits. In fact, numerous examples of early attempts to acquire carbon sequestration offsets or, more often, options for carbon sequestration offsets can be found. For example, in late 1999, IGF Insurance agreed to sell options for 2.8 million

tons of carbon dioxide reductions from American agricultural sources to the Greenhouse Emissions Management Corp, a consortium of major Canadian energy companies.[75] In some cases corporate emitters are positioning themselves to respond to regulation that they feel will be imposed on them in the near future. In other cases, corporations are merely responding to the fact that consumers in some countries have demonstrated an interest in purchasing products that are produced in an environmentally friendly manner, even if the products are offered at higher prices. Eventually, however, markets will not flourish unless there is an appropriate legal and institutional infrastructure to support them.

At a minimum the following structures are probably necessary. First, there must be an effective way to measure or verify the amount of sequestration benefits that can be associated with a given activity. The value per acre of carbon sequestration in soils, for instance, is quite modest. This means that buyers and sellers of carbon offsets will have to rely on average per acre sequestration benefits. Otherwise, transaction costs would exceed the value of the bargain. Second, and closely related, there must be a means of enforcing commitments made in private offset contracts short of litigation. Third, there must be a means of minimizing transaction costs. One possibility is to pool individual landholdings for negotiation purposes. The pool could be privately operated through a broker, organized through a farm organization, or, with an appropriate grant of authority, organized through a Natural Resources District. Finally, there needs to be some way of discovering what is a fair market price for a transfer of carbon sequestration credits.

[75] W. Thomas, D. Basurto & Gray Taylor, *Creating a Favorable Climate foe CDM Investment in North America*, 15 NAT. RESOURCES & THE ENVIRON. 172 (2001). IGF plans to solicit the options from farms in Iowa and eventually, more broadly in the United States. There has been some activity in Iowa by brokers who have been soliciting carbon sequestration options from farmers.

Currently, carbon markets are in their infancy. It is difficult to determine what the fair market value of carbon sequestration benefits is. In part, this is because the regulatory programs that would generate much of the economic value of potential carbon offsets have not yet been enacted. In part, it is a function of imprecision in measurement of the amounts of carbon storage that ought to be associated with certain practices. Equally important, however, is lack of a clearinghouse that reports information on trades. Individuals, in particular, have little basis to decide whether a particular option contract for carbon offsets is a good or bad bargain. The fact that the market for carbon sequestration benefits is clearly an international one both enhances the potential value of carbon offsets and adds to the complications of determining a fair price. In the final analysis, the value of carbon offsets will depend on the cost of achieving the same carbon reduction benefits at any location on the globe.

Conclusion and Policy Considerations

Climate change is a serious problem that will be addressed, though perhaps not through the Kyoto Protocol. Although very critical of the Kyoto agreement, neither the President nor the Congress has suggested that climate change is not an issue that merits immediate attention. The emerging regulatory structure is necessarily proceeding in a top down manner with the international commitments driving domestic commitments and domestic commitments eventually impacting on particular firms and individuals. There is probably little that the state of Nebraska needs to do from a legal perspective to position itself for coming developments, other than to inventory its resources and monitor developments. Three possible alternatives might merit further consideration. First, the legislature might consider granting natural resources districts the power to enter into

contracts on behalf of landowners and/or the power to ensure enforcement of the obligations contained in carbon offset contracts or options. Second, the legislature might consider enacting legislation that requires brokers or others seeking to negotiate carbon offset or option contracts register with the state, and provide sample contract copies with the Department of Agriculture or the Department of Natural Resources. Finally, the legislature or the Governor might want to create a permanent climate change or carbon sequestration task force to monitor ongoing developments.