ECOSYSTEM SUBSIDIES OF FOSSIL FUELS

DAVID R. HODAS*

I. INTRODUCTION

Of all the services ecosystems provide, the service of collecting, concentrating, and storing solar energy is most central to the human story. Not only do ecosystems collect and store solar energy in biomass, but the world's ecosystems transform biomass into fossil fuels such as coal, petroleum, and natural gas.[1] These fossil fuels "are energy from the Sun, stored within the earth."[2] In the process of doing that, the world's ecosystems produced an oxygen rich atmosphere and enveloped the globe in a blanket of greenhouse gases that warm the earth to a level temperate enough to support life as we know it. Yet the value of these ecosystem services is ignored by our legal and economic regimes. By taking these services for granted the law allows the market to value the earth's fossil fuel manufacturing services at $0.00. We treat oil, coal, and natural gas fossil fuels and our chlorophyll-based biota as glorious, inexhaustible, unconditional gifts.

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* Professor of Law, Widener University School of Law.

1. Coal, petroleum, and natural gas (methane or CH4) are commonly referred to as fossil fuels because they are made by the same geologic process as fossils — sedimentary pressure over millions of years. Ecosystems collect solar energy and convert that energy into plant and animal life. Over tens or hundreds of millions of years the dead plant and animals accumulated by the ecosystems become part of the sedimentary process. In the case of fossil fuels, the ancient plant and animal material is "cooked" by the heat from the sedimentary pressure. The particular fossil fuel made depends on the biologic input, the temperature at which it is cooked, and the kind of pot (geologic formation) it is cooked in. Methane, although located in large underground deposits generally associated with oil and coal, can also be naturally created over short time frames by bacteria acting on organic material such as garbage in dumps, bacteria in the stomachs of ruminants such as cows, and other anaerobic decomposition of organic matter such as in rice paddies, swamps, and even mulch piles. However, the gigantic underground pools of natural gas we exploit were created over millions of years in geologic formations that trapped the methane. DAVID GOODSTEIN, OUT OF GAS: THE END OF THE AGE OF OIL 23—24, 32—33 (2004).

2. *Id.* at 24.

Even the emerging field of ecosystems services science, policy, and law does not address it. Although "[*e*]*cosystem services* are the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life,"[3] the leading scholarship in the field does not include energy in its list of critical ecosystem services. Daily's list of thirteen ecosystem services necessary to support life, and which we ordinarily take for granted, is lengthy, but does not mention energy,[4] even though energy supports all of them. Other than a brief acknowledgement that ecosystem services are "driven by solar energy,"[5] Daily takes energy for granted.

A survey by leading scientists of the history of the idea of ecosystem services contains but one oblique mention of energy: "[a]n energy-based approach to ecosystems studies" (emergy or embedded energy concepts of ecology) in "Odum's classic textbook in 1953."[6] According to Mooney and Ehrlich, by no later than 1981 the name of the field as "ecosystem services" was established and the list of nature's services that comprised the field was complete[7]:

- Pest Control
- Insect Pollination
- Fisheries
- Climate Regulation
- Soil Retention
- Flood Control
- Soil Formation
- Cycling of Matter
- Composition of the Atmosphere
- Maintenance of Soil Fertility
- Maintenance of a Genetic Library

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3. *See, e.g.,* Gretchen C. Daily, *Introduction: What are Ecosystem Services?, in* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS 3 (Gretchen C. Daily ed., 1997).

4. *Id.* at 3-4. The list is comprised of (1) purification of air and water, (2) mitigation of floods and droughts, (3) detoxification and decomposition of wastes, (4) generation and renewal of soil and soil fertility, (5) pollination of crops and natural vegetation, (6) control of the vast majority of potential agricultural pests, (7) dispersal of seeds and translocation of nutrients, (8) maintenance of biodiversity, from which humanity has derived key elements of its agricultural, medicinal, and industrial enterprise, (9) protection from the sun's harmful ultraviolet rays, (10) partial stabilization of the climate, (11) moderation of temperature extremes and the force of winds and waves, (12) support of diverse human cultures, and (13) providing aesthetic beauty and intellectual stimulation that lifts the spirit.

5. *Id.*

6. Harold A. Mooney & Paul R. Ehrlich, *Ecosystem Services: A Fragmentary History, in* NATURE'S SERVICES: SOCIETAL DEPENDENCE ON NATURAL ECOSYSTEMS 13 (Gretchen C. Daily ed., 1997).

7. *Id.* at 14—15.

The collection, concentration and storage of solar energy is not on the list.

Similarly, the important, provocative 1997 article by Robert Costanza et al.[8] that presented an estimated monetary value of the earth's ecosystem services contributions to human welfare does not include energy collection and storage services among the seventeen categories of ecosystem services and goods analyzed:

1. Gas regulation — Regulation of atmospheric chemical composition
2. Climate regulation — Regulation of global temperature precipitation, and other biologically mediated climatic processes at global or local levels
3. Disturbance regulation — Capacitance, damping and integrity of ecosystem response to environmental fluctuations
4. Water regulation — Regulation of hydrologic flows
5. Water supply — Storage and retention of water
6. Erosion control and sediment retention — Retention of soil within an ecosystem
7. Soil formation — Soil formation processes
8. Nutrient cycling — Storage, internal cycling, processing and acquisition of nutrients
9. Waste treatment — Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds
10. Pollination — Movement of floral gametes
11. Biological control — Trophic-dynamic regulations of populations
12. Refugia — Habitat for resident and transient populations
13. Food production — That portion of gross primary production extractable as food
14. Raw materials — That portion of gross primary production extractable as raw materials
15. Genetic resources — Sources of unique biological materials and products
16. Recreation — Providing opportunities for recreational activities

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8. Robert Costanza et al., *The Value of the World's Ecosystem Services and Natural Capital*, 387 NATURE 253, 254 (1997).

17. Cultural — Providing opportunities for non-commercial uses

Fossil fuels are not mentioned as an ecosystem good.

Nor does the legal literature on ecosystem services address ecosystem services that made fossil fuels. Although some 375 law related articles mention "ecosystem services," no article uses "fossil fuels" and "ecosystem services" in the same sentence, only two use the terms in the same paragraph, and only ten use "ecosystem services" and "energy" in the same sentence.[9] Only one article even mentions an analytical link between ecosystem services and fossil fuels. That article, which analyzes the relationship between sustainable development and national security, uses the example of fossil fuel use by the United States as a case study in the security—sustainable development discussion.[10] Even the groundbreaking work in the *Stanford Environmental Law Journal* devoted to ecosystem services only mentions fossil fuels once, and then only in a footnote that places fossil fuels on the non-renewable side of the natural capital ledger.[11]

The most recent major work on ecosystems services is the Millennium Ecosystem Assessment (MEA), a monumental global study of the state of the world's ecosystems. MEA defines *ecosystem services* as "the benefits people obtain from ecosystems . . . includ[ing] provisioning services such as food and water; regulating services such as regulation of floods, drought, land degradation, and disease; supporting services such as soil formation and nutrient cycling; and cultural services . . . ."[12] Although fuels are not mentioned in the definition, the study does include a chapter on Timber, Fuel, and Fiber. However, this discussion is limited to biomass fuels (firewood, charcoal, etc.) as the relevant ecosystem services. Fossil fuels are only mentioned as the world's primary source of fuel, which renewable fuels must compete with and replace when "the availability of fossil fuels declines,"[13] and that "[b]urning fossilized biomass (fossil fuels)" releases carbon into the

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9. Westlaw search of TP-ALL database by author on 24 January 2007.

10. Sanford E. Gaines, *Sustainable Development and National Security*, 30 WM. & MARY ENVTL. L. & POL'Y REV. 321, 357 (2006) ("In other words, the United States fully uses not only the ecosystem services of the United States itself but takes an equal amount of the world's ecosystem services from the peoples of other countries.").

11. Geoffrey Heal et al., *Protecting Natural Capital Through Ecosystem Service Districts*, 20 STAN. ENVTL. L.J. 333, 334 n.1 (2001).

12. MILLENNIUM ECOSYSTEM ASSESSMENT, VOL. 1, ECOSYSTEMS AND HUMAN WELL-BEING: CURRENT STATES AND TRENDS: FINDINGS OF THE CONDITION AND TRENDS WORKING GROUP 27 (Rashid Hassan et al. eds., 2005).

13. *Id.* at 260—61.

atmosphere.[14]

To be sure, the adverse effects of burning fossil fuels have significant impact on the ecosystem services. These externalities have been well studied and documented,[15] drive environmental regulation,[16] and are the subject of much ongoing concern.[17] However, except for the brief discussion of biomass in the MEA, the fundamental ecosystem service of providing usable energy to society is missing from ecosystem services literature and discussion. Without understanding this ecosystem service we cannot hope to deeply understand current energy based ecosystem challenges, to knowledgeably analyze and critique current law and policy, or to develop effective, durable solutions. At present we cannot even adequately articulate, or even envision, what the law and policy of energy ecosystem services should be.

As this Article will attempt to show, the current international and national energy laws are fundamentally flawed from an ecosystem service perspective. These flaws underlie some of the most challenging threats ecosystems and human society face. By failing to recognize the enormous public ecosystem services values embedded in fossil fuels, we have not questioned the prevailing national sovereignty—private property legal paradigm that controls the law and policy of fossil energy. These embedded ecosystem services values follow the laws of physics and thermodynamics; the existing legal paradigm does not. In our world, dominated by the intensive use of fossil fuels, we ignore these energy ecosystem services (and the laws of physics) at our grave peril.

Why have we so studiously avoided the energy ecosystem services question? For all of us, the role of fossil fuels is so deeply and finely woven into our lives that we do not see it. We simply take it for granted, until a storm knocks out the power—then all we care about is that the company we send our monthly check to fixes the problem, and fast. All most of us know about electricity is that it comes out of an outlet in the wall and is controlled by an on/off switch. Most of us do not know the basic science of how electricity is generated, the fundamental properties of electricity, or how the electricity in our house or office was made, let alone what energy

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14. *Id.* at 360.

15. *See, e.g.*, RICHARD L. OTTINGER ET AL., ENVIRONMENTAL COSTS OF ELECTRICITY (1990).

16. *See, e.g.*, Clean Air Act regulation of sulfur dioxide emissions from coal-burning electric power plants to mitigate acid precipitation, 42 U.S.C. §§ 7651—7651o (1990), and motor vehicle emissions and fuel standards, 42 U.S.C. §§ 7521—7554 (1990); and the Oil Pollution Act, 33 U.S.C. §§ 2701—2761 (1990).

17. For instance, the ongoing debate over how to address carbon dioxide emissions from the combustion of fossil fuels, the most significant driver of global warming.

source was used to generate it. All we care about is that the electricity is always available, that it is inexpensive, that we don't get electrocuted using it, that a power generating station is not in our backyard, and that working in a coal mine or on an offshore oil rig is hard, dangerous work. For gasoline, diesel fuel, aviation fuel, and heating oil we know that a hose is used to move it from a supply tank to the user's tank, that refineries have something to do with making the fuels, that we do not have one in our backyard, and that spills of oil from tanker ships are bad. All we care about is that the fuel is low-cost and limitlessly available.

Even preeminent ecosystem scholars take energy for granted[18], or perhaps feel so daunted by the prospect of addressing energy ecosystem services, that they give up.[19] It is hard to question a paradigm that allows us to easily use a few gallons of petroleum,[20] which nature spent a hundred million years manufacturing, when those few gallons contain "the energy equivalent of the work a [person] could do in one year."[21]

II. ENERGY AND HUMAN SOCIETY

Beginning with the discovery of fire, the history of the improvement of human welfare is the story of the human ability to harness energy, almost all of which is the product of ecosystem services. At first, all human activity was driven by human muscle, which got its energy from plant and animal food. The beneficial effects of the efficiency gained by exploiting the earth's storehouses energy have been dramatic:

> Simply harnessing oxen, for example, multiplied the power available to a human being by a factor of 10. The invention of the vertical waterwheel increased productivity by another factor of 6; the steam engine increased it by yet another order of magnitude. The

18. *See*, Comm. On Assessing & Valuing the Services of Aquatic & Related Terrestrial Ecosystems, Nat'l Research Council, VALUING ECOSYSTEM SERVICES: TOWARD BETTER ENVIRONMENTAL DECISION-MAKING 17 (2004) (omitting energy from the list of life support functions ecosystems provide).

19. *See, e.g.,* EDITH BROWN WEISS ET AL., INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 758 (2d ed. 2007) ("While technically hydrocarbons are renewable, the time scale of hundreds of thousands of years makes them nonrenewable" in the context of legal regimes for renewable resources. The authors also note that hydrocarbons raise the question of what legal obligations we have towards future generations in our present use of fossil fuels. Readers are referred to the philosophical materials that introduce the book.).

20. We still rate our car and truck engines by horsepower, a subtle reminder of where we would be without petroleum.

21. JOSE GOLDEMBERG ET AL., ENERGY FOR A SUSTAINABLE WORLD 5 (1988).

> use of motor vehicles greatly reduced journey times and expanded human ability to transport goods to markets.
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> Today the ready availability of plentiful, affordable energy allows many people to enjoy unprecedented comfort, mobility, and productivity. In industrialised countries, people use more than 100 times as much energy, on a per capita basis, as humans did before they learned to exploit the energy potential of fire.[22]

More than ninety-four percent of society's usable energy is derived from ecosystem services; and in countries that do not derive energy from nuclear power, ecosystem services account for one hundred percent of all energy used.[23] Moreover, in our fervor to maximize our use of fossil fuels, we blithely harm a wide range of ecosystems despite the valuable services they provide.

At every step along the path, from locating the energy to using it, the law is blind both to the ecosystem services that made the energy available in a useful, concentrated form, and to the external costs we impose in obtaining and using the energy. Our laws and our market-based system of economics are not consistent with the unbendable laws of thermodynamics—entropy *always* increases when energy is used, or as my grandfather would say, "there is no free lunch." Yet, when it comes to fossil fuel energy, we pretend it is free and inexhaustible, and that disposing of the low value energy after we use it is free. If ever there existed a fundamental market failure, this is it. So, we overuse fossil fuels with reckless abandon. And, why not? It is virtually free, and because the price of using it does not include the ecosystem service of concentrating solar energy into fuel or the human health and environmental costs inflicted by our vast efforts to obtain, transport and use the energy, the rational economic person would be irrational not to exploit such a low priced good.

Unfortunately, we face increasingly compelling evidence that

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22. UNITED NATIONS DEVELOPMENT PROGRAMME, WORLD ENERGY ASSESSMENT: ENERGY AND THE CHALLENGE OF SUSTAINABILITY 3 (Jose Goldemberg et al. eds., 2000) [hereinafter WORLD ENERGY ASSESSMENT).

23. I do not include nuclear power as an ecosystem service because radioactive materials were not produced by ecosystems. Fuel grade uranium is a product of remarkable human ingenuity—a few nations have the technical expertise to concentrate the trace amounts of U235 in U238 into fuel pellets containing fuel grade uranium (about three percent U235). Whether one considers geothermal power to be an ecosystem service depends on whether geologic phenomena such as volcanoes are within the definition of ecosystems. Except for a few special locales, such as Iceland, geothermal energy is so small a portion of the world's energy use that how it is categorized is irrelevant.

the current rate of consumption of fossil fuels—sources of energy derived from natural processes of decay and compression of once living plants and animals—while improving the quality of life, is beginning to significantly change the world's environment. Ironically, the rapid release of CO_2 represents humanity's global attempt to exploit part of the carbon cycle metabolism that created our fossil fuels. However, our experiment accelerates the process about a million fold. The rate at which society consumes fossil fuels far outstrips the time it took for fossil fuels to be created. Over the last century or two, by burning fossil fuels, we have released carbon into the atmosphere that had been slowly removed by nature over tens to hundreds of millions of years.[24] In a little more than a century we have consumed about 1.5 trillion barrels of oil, about half of the total supply of oil.[25]

While the presence of some greenhouse gases in the atmosphere is necessary, the increase in their concentration since the Industrial Revolution is rapidly changing the global climate and the world's ecosystems. The essence of the global warming problem is that the current rate of burning fossil fuels releases enormous quantities of CO_2 into the atmosphere with relative suddenness.[26] Fossil fuel formed when the carbon that the earth removed from the atmosphere over millions of years and stored underground as the remains of ancient plants and animals that had been buried under conditions of enormous pressure over such long periods of time that the carbon comprising their structures was converted into coal, oil, or natural gas.[27] Fossil fuels are renew-

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24. Since 1950, the nations of the world have emitted some 780 billion tons of carbon dioxide; of this amount the U.S. has contributed 212 billion tons and Europe 292 billion tons. WORLD RESOURCES INSTITUTE, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, CLIMATE AND ATMOSPHERE 2005, *available at* http://earthtrends.wri.org/pdf_library/data_tables/cli1_2005.pdf.

25. GOODSTEIN, *supra* note 1, at 24-30; KENNETH S. DEFFYES, HUBBERT'S PEAK: THE IMPENDING WORLD OIL SHORTAGE (2001).

26. For instance, the United States annually burns about a billion short tons of coal, or about 2030 Tg CO2 Eq., to make electricity, about 2390 Tg CO2 Eq. of petroleum for transportation, heating, and industry, and 1200 Tg CO2 Eq of natural gas. U.S. ENVTL. PROT. AGNCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990—2000 2-3—2-4, fig.2-2 (2002). *Tg CO2 Eq*. (teragrams — trillion grams - carbon dioxide equivalent) is the international standard established by the Intergovernmental Panel on Climate Change (IPCC) for reporting fossil fuel use and greenhouse gas emissions. *Id.* at 1—10, 21. *See also,* REVISED 1996 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES (1997).

27. Humans also consume other carbon-based sources of energy, especially wood. Large portions of developing countries rely on wood for fuel, either directly, or after converted into charcoal. In those regions, so much wood is used so inefficiently as fuel that demand for wood far exceeds the rate that forests can be regenerated. However, compared to fossil fuels, forest can be regrown in a relatively short time (decades to a century for forests compared to tens of millions of years for fossil fuels). WORLD ENERGY ASSESSMENT, *supra* note 22, at 65—68, 370.

able solar fuels; it just takes tens or hundreds of millions of years for the used fuels to be replaced.

Today, the world annually burns about 3.4 billion tons of oil, 4.5 billion tons of coal (2.22 billion tons of oil equivalent), natural gas in an amount equivalent to 2.02 billion tons of oil; and wood and other forms of traditional biomass at a rate equivalent to 0.9 billion tons of oil. Taken all together, the burning of these forms of collected, mostly ancient, sources of energy accounts for more than eighty-nine percent of all human energy use[28] and releases about 6.3 ± 0.4 billion tons of carbon dioxide into the atmosphere annually;[29] carbon dioxide "is the dominant human-influenced greenhouse gas" and accounts for about sixty percent of the atmosphere's increased heat trapping over the past 150 years.[30]

Although this consumption of our energy capital (fossil fuels) has allowed the developed world[31] to prosper,[32] securing and burning fossil fuels is not a harmless, cost-free activity.[33] Ecosystems are harmed by oil exploration and drilling, by oil spills associated with the transportation of oil from wellhead to end use, by oil refineries located along ocean and river coastal zones, by coal mining (both surface strip mining and underground), by electricity transmission lines, emissions from coal-fired power plants, coal trains, etc. Some of the pollutants created by burning fossil fuels are in-

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28. *Id.* at 6 tbl.1, 34-35. Large hydro supplies about 2.2%, renewables (wind, geothermal, small hydroelectric dams, photovoltaic, modern biomass, etc) supply about 2.2%, and the remaining major source of energy is from nuclear power plants, which supply about 6.5% of our primary energy consumption.

29. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC), CLIMATE CHANGE 2001: THE SCIENTIFIC BASIS 39 tbl.2 (J.T. Houghton et al. eds., 2001) [hereinafter IPCC, CLIMATE CHANGE 2001].

30. *Id.* at 39.

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> [T]raditional electricity, based on central—station generation and a monopoly franchise, has been successful enough to make electricity services such as electric light, electric motive power, and electronics essential to modern industrial society. However, traditional electricity has failed to reach one-third of humanity . . . . Its key technologies — large dams, coal-fired and nuclear power generation, and long high-voltage transmission lines — all face increasingly severe financial and environmental problems.

UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP), ENERGY FOR SUSTAINABLE DEVELOPMENT: A POLICY AGENDA 9 (Thomas B. Johansson & Jose Goldemberg eds., 2002).

32. This consumption of capital is problematic if we do not reinvest the wealth generated by this capital consumption in the development of replacement energy sources for the future. Unfortunately, even complete replacement of the energy capital is impossible because it takes additional energy to organize low value (high entropy) energy into a useful form.

33. Nor is burning wood or charcoal harmless. The indoor pollution from using wood for heating and cooking and the increasing shortage of locally available of wood increases poverty and diminishes public health. WORLD ENERGY ASSESSMENT, *supra* note 22, at 69.

herently harmful and impose external costs on society.[34] Other emissions from fossil fuel combustion, such as carbon dioxide (CO_2), are themselves benign.[35] However, in the atmosphere, CO_2, together with water vapor,[36] methane,[37] nitrous oxide,[38] and other trace gases,[39] have the ability to trap heat in the atmosphere. The

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34. Sulfur in fossil fuels, when burned, is emitted as SO2 (sulfur dioxide), which causes adverse respiratory effects and can be converted into acidic compounds that fall to the earth as acid precipitation. High temperature combustion results in the creation of nitrogen oxides (NOx), which can be noxious in their own right, and when combined with volatile organic compounds, humidity, and sunlight can result in ground level (tropospheric) ozone (O3), the major component of smog, with its adverse health effects. Burning fossil fuels can also release soot and fine particulates, which pose a health risk to people with asthma, and which can carry heavy metals, SO2, mercury, and carcinogens into human lungs. These pollutants also have adverse effects on the health and viability of ecosystems worldwide.

Each of these pollutants has a different mechanism, range, and scale of action. For instance, some pollutants, such as mercury and other heavy metals, are directly toxic and long lasting. Other pollutants, such a tropospheric ozone and acid precipitation, result from the interaction of fossil fuel emissions with other atmospheric influences and chemicals to produce adverse regional effects, which may last only hours, days or months until the emissions or atmospheric conditions abate, but many may be transported in the air for long distances causing damage far from their source of burning. RICHARD L. OTTINGER ET AL., ENVIRONMENTAL COSTS OF ELECTRICITY (1989); WORLD ENERGY ASSESSMENT, *supra* note 22, at 63—85.

35. The carbon cycle and CO2 are central components in the web of life. In very simplistic terms, CO2 is released when we metabolize our food to obtain the energy to live. Green plants use CO2 in photosynthesis to create carbohydrates, cellulose, and other woody or fibrous structures and release oxygen, which animals and plants use to convert food into energy. Some of the carbon is absorbed by the oceans, and some is stored in soil. The remainder, about half of the original emissions, remains in the atmosphere for up to 200 years. The carbon cycle, in its rich complexity, is described in I.C. Prentice et al., *The Carbon Cycle and Atmospheric Carbon Dioxide*, *in* IPCC, CLIMATE CHANGE 2001, *supra* note 29, at 185-213.

36. Water vapor is the largest natural contributor to the greenhouse effect, but the amount of water vapor in the atmosphere is not directly affected by anthropogenic emissions of water vapor. However, human activity can increase atmospheric water vapor concentration indirectly by the emission of other greenhouse gases, such as carbon dioxide that warm the atmosphere, thereby increasing the rate of evaporation; this increased evaporation increases water vapor, which further accelerates global warming. WORLD ENERGY ASSESSMENT, *supra* note 22, at 86.

37. Methane (CH4), the major component of natural gas, is anthropogenically released into the atmosphere from coal mining, leaking natural gas pipelines, ruminant livestock such as cows, rice paddies, and solid waste facilities.

38. Nitrous oxide, N2O, is produced both naturally in soil and water, and by human activity in agriculture, energy, industrial, and waste management activities. According to the U.S. EPA, "agricultural soil management accounted for 70 percent of U.S. N2O emissions" in 2000 and "[f]rom 1990 to 2000, emissions from this source increased by 11 percent as fertilizer consumption, manure production, and crop production rose." U.S. ENVTL. PROT. AGNCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2000, ES-20 (2002) [hereinafter GREENHOUSE GAS INVENTORY]. N2O is also produced when fuels are burned at high temperatures, in the manufacture of adipic and nitric acid, and in the context of management of human and animal wastes. N2O accounts for 6.1% of US greenhouse gas emissions. *Id.* at ES-4. Globally, "the atmospheric concentration of nitrous oxide has increased by 16 percent since 1750, from a pre industrial value of about 270 ppb to 314 ppb in 1998, a concentration that has not been exceeded during the last thousand years." *Id.* at 5.

39. Hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride

greater the concentration of greenhouse gases in the atmosphere, the more heat is trapped, and the warmer the earth becomes.[40]

III. CLIMATE CHANGE THREATS TO ECOSYSTEM SERVICES

The precise breath and depth of potential loss of biodiversity and ecosystem resilience due to global warming remains subject to scientific inquiry. But that global warming is adversely affecting biodiversity is now well recognized. The Convention on Biological Diversity *Ad Hoc Technical Expert Group on Biological Diversity and Climate Change* catalog of ecosystem modifications associated with global warming includes: (1) changes in the timing of periodic biological phenomena (e.g., flowering, breeding, and migration), (2) changes in species distribution, (3) changes in the form and structure (morphology), behavior, and physiology of many birds, plants and insects, (4) enlargement of the range, frequency, and intensity of pests and diseases, (5) altered patterns of precipitation, floods, droughts, water temperature, stream flows, and water quality which will adversely affect "biodiversity and the goods and services ecosystems provide," (6) modifications in the length of growing seasons and alteration of species composition in high northern latitude ecosystems, (7) increased mortality of adult penguins, (8) alterations of weather and temperature sensitive coastal and marine ecosystems such as coral reefs, some fish populations, and Pacific and Arctic marine birds and mammals.[41]

Of course, independent of climate change, biodiversity is already decreasing because of human activity. Ecosystems are already stressed by human population growth, ever more intense land-use patterns and associated ecosystem loss, pollution stresses, and the invasive human spread of exotic species into new ecosystems. Climate change is yet an additional significant pres-

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(SF6). HFCs are non-ozone depleting chemicals that are used as a replacement for stratospheric ozone depleting chemicals known as halocarbons (CFCs, HCFCs, methyl chloroform, carbon tetrachloride, bromine halons, methyl bromine, and hydrobromofluorocarbons) that are regulated under the Montreal Protocol on Substances that Deplete the Stratospheric Ozone Layer and its Amendments. *See* 26 I.L.M. 1550 (1987); UNEP/OzL.Pro.2/3 (Annexes I,II,III) (1990); and Copenhagen Amendment to the Montreal Protocol, 32 I.L.M. 874 (1993). PFCs and SF6 are emitted by aluminum smelting, semiconductor manufacturing, electric power transmission and magnesium casting. Taken together, HFCs, PFCs, and SF6 are trace gases that only contribute a very small portion of global warming; however, these powerful greenhouse gases have extremely long lifetimes in the atmosphere and are being emitted in growing quantities. GREENHOUSE GAS INVENTORY, *supra* note 38 at 5-6.

40. IPCC, CLIMATE CHANGE 2001 *supra* note 29, at 87-90.

41. CONVENTION ON BIOLOGICAL DIVERSITY, SUBSIDIARY BODY ON SCIENTIFIC, TECHNICAL AND TECHNOLOGICAL ADVICE, BIOLOGICAL DIVERSITY AND CLIMATE CHANGE 31-32 (Sep. 30, 2003).

sure on already stressed ecosystems.[42]

The Technical Expert Group predicts that ecosystem services will be lost due to climate change, and with it human welfare will suffer due to global warming driven ocean warming, sea-level rise, and increased frequency in intense storms that will endanger the very existence of some coastal communities and threaten other coastal communities (those not destroyed) with the loss of the benefits of marine biodiversity, fisheries, and shoreline protection. Wetlands (ranging from reefs, atolls, estuaries and mangroves, to prairies, tropical and boreal forests, and polar and alpine ecosystems) are "natural systems especially vulnerable to climate change because of their limited adaptive capacity, and are likely to undergo significant and irreversible change."[43] The panel also expects presently eroding beaches and barriers to erode further as the climate changes and sea level rises.

One could drill down still further to evaluate potential biodiversity impacts by regions. For instance, Africa's important biodiversity will be threatened by climate change.[44] Much of Africa is forest (five million km^2), and trees and shrubs (twelve million km^2). Semi-arid and sub humid woodlands and savannahs are at risk from reduced rainfall (increased fires) and more intense land use due to population pressure. Global warming will adversely affect ecosystem services such as water regulation, carbon sequestration, soil fertility, and habitat formation.

Sub-Saharan Africa contains unique ecosystems whose flora and fauna face risk from climate change. Critical flora biomes include Cape Floral Kingdom, Madagascar, Cameroon, and mountain habitats from Ethiopia to South Africa. Important fauna in danger includes savannah and forest species (ninety percent of the world's antelope and gazelle species are in Africa) and birds, whose habitat and migratory patterns are in danger from climate change. Biodiversity in Africa is an important source of food, fiber, shelter, fuel, medicine, and income from tourism. Climate change will affect the major mammal migrations in east and southern Africa, as well as bird migration. Important heat-sensitive African habitats, such as the mountain habitat that runs from Ethiopia to South Africa at elevations above 2000 meters and the Cameroon mountain habitats will be impaired as temperature increases. The South African Cape floral kingdom, with 7300 species of which about

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42. *Id.* at 33-35.
43. *Id.* at 37.
44. The following summary of African biodiversity impacts is taken from David R. Hodas, *Climate Change and Land Use in Africa, in* LAND USE LAW FOR SUSTAINABLE DEVELOPMENT 45, 54 (Nathalie J. Chalifour et al eds., 2007)

sixty-eight percent only exist there, will be changed by rainfall patterns, warming and the potential appearance of fires due to reduced rain.

IV. THE LEGAL CHALLENGE

From an ecosystems services perspective, the use of fossil fuels represents a profound market failure. Not only are the fossil fuel production services taken as a gift, they also receive significant economic and tax subsidies,[45] but major environmental externalities are not captured in the price. By comparison, the cost of electricity generated by photovoltaic or wind power includes the cost of collecting the solar energy and converting it into electricity. Now that's a tough hurdle to overcome. The challenge for the law is how to minimize the market failure.

V. ENERGY COLLECTION AND CONCENTRATION

The fundamental elements of energy ecosystem services are the collection, concentration and storage of solar energy. In theory, fossil fuels could be renewable resources of energy—if we used the fuels at a rate no faster than the rate at which the earth manufactures replacement fuels. Suppose the earth held about three trillion barrels of petroleum and it takes one million years to make a barrel of oil (actually it takes about one hundred million years). Then we could use three million barrels of oil annually forever. In actuality, we now use almost eighty-four million barrels per day (about thirty billion barrels per year), and have already used about 1.5 trillion barrels since about 1900.[46] At current rates (assuming demand does not rise in developing and developed nations, and that price increases do not reduce demand—silly, but handy assumptions) the last drop of the remaining 1.5 trillion barrels will be used up in about fifty years. In other words, in about 150 years human society will have consumed the supply of petroleum that it took the earth's ecosystems about one hundred million years to make. Additionally, during those 150 years we will have released

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45. *See* Roberta F. Mann, *Waiting to Exhale: Global Warming and Tax Policy*, 51 AM. U.L. REV. 1135 (2002); Roberta F. Mann, *On the Road Again: How Tax Policy Drives Transportation Choice*, 24 VA. TAX REV. 587 (2005); Roberta F. Mann, *Another Day Older and Deeper in Debt: How Tax Incentives Encourage Burning Coal and the Consequences for Global Warming*, 20 GLOBAL BUS. & DEV. L.J. (forthcoming 2007); Doug Koplow & John Dernbach, *Federal Fossil Fuel Subsidies and Greenhouse Gas Emissions: A Case Study of Increasing Transparency for Fiscal Policy*, 26 ANN. REV. ENERGY ENVTL. 361 (2001).

46. *See* Energy Information Administration, Basic Petroleum Statistics, http://www.eia.doe.gov/neic/quickfacts/quickoil.html (lasted visited July 5, 2007).

to the atmosphere the carbon that the earth's ecosystems removed a hundred million years ago, a release that is and will continue to overwhelm the earth's ecosystem service of climate and temperature regulation.

A parallel story could be told for coal, with the major difference being that the supply size varies and our rate of use is lower than oil, so the gift of coal will last at current usage rates for hundreds of years instead of decades. Coal is primarily used today to fire steam generation in electric power plants.[47] It faces serious transportation challenges in that it must be shipped over land by rail, an infrastructure that in the United States is near its limit. Also, mining and burning coal results in very serious adverse environmental and human health effects, running from black lung and other pulmonary diseases, to acid precipitation and global warming, to mining's impact on land and water resources.[48]

What has lead to this situation? Quite simply, the cost of fossil fuels does not include the cost of collecting, concentrating, and storing solar energy into a useable form. In contrast, if one were to harness the potential solar energy in water power, the collection and storage costs must be paid by us up front in the form of a hydroelectric dam. The same is true for wind power (a form of solar energy), photovoltaic and other form of renewable energy. The financial cost of constructing facilities to capture the solar power must be paid for by the developer with funds obtained in a competitive capital market. As a result the cost of these renewable energy facilities, although dropping as technology improves, remains higher than the cost of fossil fuels. This difference is especially wide in the transportation sector, where liquid fuels such a gasoline dominate the market. The cost of storing electric energy in a motor vehicle battery is many magnitudes greater than the cost of the stored solar energy in gasoline. Remember, the cost of energy storage in gasoline is zero, because nature did it. Except for hydroelectric dams, which have their own problems, current forms of renewable energy, such as wind generated electricity, must be used instantaneously.[49] So the cost of fossil fuels, which

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47. *See e.g.* Energy Information Administration, How Coal is Used, http://www.eia.doe.gov/kids/energyfacts/sources/non-renewable/coal.html (last visited July 5, 2007).

48. *See e.g.,* Union of Concerned Scientists, How Coal Works, http://www.ucsusa.org/clean_energy/coalvswind/brief_coal.html (last visited July 5, 2007).

49. New technologies such as plug-in hybrid vehicles which are charged by plugging the car into an electric outlet and have the capability of going about forty miles using the battery alone are promising and may help bridge the electricity storage gap. However, the cost and weight of large lithium ion batteries needed for the new technology to store the energy remains prohibitively expensive, and will require a new generation of battery technology to be viable. *See* JAMES KLIESCH & THERESE LANGER, PLUG-IN HYBRIDS: AN ENVIRONMENTAL AND ECONOMIC PERFORMANCE OUTLOOK T061 (American Council for an Energy

does not include the cost of making the resource, nor the external cost of global warming (except partially in the E.U.) or the external costs of residual pollution after existing environmental laws are met (assuming they are met, and that countries have environmental laws) is broadly subsidized by the earth's ecosystem services. In contrast, wind and other solar power includes the full cost of collecting the energy and has little if any adverse environment effects—essentially all costs of production and use are internalized in these sources of renewable energy. Hence the true cost of energy is reflected in renewable energy, and is far higher than using fossil fuels.

VI. THE NATIONAL SOVEREIGNTY — PRIVATE PROPERTY ENERGY LAW PARADIGM

If fossil fuels are an ecosystem gift, which no person made, who owns (or should own) the product of these ecosystem services? Ownership and control of ecosystem goods and services is a legal problem across the spectrum of this field. With respect to fossil fuels, as natural resources they are owned by the sovereign nation whose land happens to sit above the reserve, and exploitation rights within our neoclassical market system flows to the property owner. A nation may either control and own the resource itself, as in the case of Saudi Arabia and many other nations, or they allocate the rights to private property owners that own the land above the resource. National and state law may permit owners to further rationalize their interests by separating the property into different alienable interests—surface, mineral, etc.[50] In all cases the

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Efficient Economy 2006) (a copy of the report is available for purchase at www.aceee.org).

50. Marla E. Mansfield & James E. Hickey Jr., *Oil*, *in* ENERGY LAW AND POLICY FOR THE 21ST CENTURY 7-7—7-8 (2000)

> Unless otherwise stated, a conveyance of land includes the minerals in the land. A deed, however, may convey minerals separately or by reservation or exception remove them from a grant. When one of these activities has taken place, it is said that the minerals are severed from the surface. Generally, if the minerals are truly severed, then two estates in land are created. One is the surface estate and the other the mineral estate. The owner of a mineral estate has the right to develop the minerals, the right of access and use of the surface for this purpose, and the right to lease the minerals and receive the proceeds of a mineral lease.

Id. The same general doctrine applies to coal, although there is the added question of who owns the right to have the surface supported when the coal is removed. *See* Pa. Coal Co. v. Mahon, 260 U.S. 393 (1922); Keystone Bituminous Coal Ass'n v. DeBenedictis, 480 U.S. 470 (1987) (describing the support estate under Pennsylvania law and the operation of the takings clause under the 14th Amendment to the Constitution with respect to state regulations affecting the support estate). More recently, the question of who owns the coal-bed methane released during mining has been disputed. *See, e.g.*, Carbon County v. Union Reserve Coal owner, be it governmental or private, has received a gift from the earth and is not charged for the cost of making the fossil fuel.[51] The seller's cost is the cost of getting the resource out of the ground, processing it, and then shipping it to customers. The selling price is a function of this cost and perceived consumer demand. Depending on where the petroleum is located, the cost of getting it out of the ground can be very low.

Once used, the petroleum is gone; it is not a renewable resource. Unlike forests, we cannot plant coal or oil seedlings that will grow into harvestable resources in decades or a century. In contrast, in the timber industry, the original trees may have been a gift of ecosystem services, but the subsequent new growth is paid for by the timber company that plants and grows the replacement trees—in theory, a true "cycle." To be sure, the timber industry may cause serious harm to forest ecosystems, biodiversity, and water ecosystems, and in some regions of the world forests may be cut without any reforestation effort, but, when regulated effectively, forestry can be sustainable.[52]

Well, one could say, are not fossil fuels treated as any other below ground mineral, such as gold, copper or diamonds? Do we also need to question the underlying national sovereignty—private property for these minerals too? No, at least not from an ecosystem services perspective, because hard rock minerals are fundamentally different than fossil fuels. First, the energy in fossil fuels is a central pillar of modern society; without fossil fuels we would be in the horse and ox driven society and economy of the middle ages. Energy is essential for life, gold and diamonds are not (except in jewelry ads). Second, the matter comprising gold and other minerals does not disappear when used; rather it simply is transformed into a different shape. Gold dust is routinely recovered and melted back into gold. Gold is not concentrated energy. However, coal, when burned, disappears, leaving only pure carbon and

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Co., 898 P.2d 690 (Mont. 1995); Amoco Prod. Co. v. S. Ute Indian Tribe, 526 U.S. 865 (1999).

51. Ironically, the oil industry and many oil lawyers refer to the process of getting oil out of the ground as "producing" oil. They also refer to the one-way trip from discovery of oil in the ground to burning it by the consumer as a "fuel cycle." The cycle is not closed by considering the process of capturing the carbon and transforming it back into petroleum. The fact that the circle is broken is not mentioned, nor is the fact that the metaphor is inapt. *See, e.g.*, Mansfield & Hickey, *supra* note 50, at 7-1—7-4 (explaining that the oil and natural gas "fuel cycle" consists of "production . . . comprised of exploration (prospecting), drilling and recovery;" transportation of the "produced" oil or natural gas to a processing facility or refinery for removal of contaminants and refining into various petroleum products; transportation and distribution of the products to the end user; and finally, the use of the product (heating, motor vehicle fuel, electricity generation, feedstock for the organic chemical industry, etc.)).

52. *See* MILLENNIUM ECOSYSTEM ASSESSMENT, *supra* note 12, at 243—55, 585—621 (reviewing the state of forest ecosystems and the problems they face.).

whatever other elements were in the coal, such as sulfur or mercury. The energy in the lump of coal has been released and has dissipated from a low entropy state to one of high entropy. The energy has changed from being concentrated and useable, to a diffuse, disorganized state, radiating out into the universe. Gone forever. To capture that radiating energy and concentrate it back into a useable form of a lump of coal will require using energy—more energy than the replacement lump of coal will contain. To keep going, society must burn more fossil fuel or capture some of the energy sent to us from the sun and organize that energy into a useable form.

This analysis suggests that society has a considerable public stake in the use of the world's fossil fuel resource. This public interest derives from the ecosystem services that created the fossil fuel—ecosystem services which no one owns and which are not reflected in any market signal. Fossil fuels are almost entirely subsidized by ecosystem services. This price subsidy has led to overuse and waste of the resource in the free market, which would not be occurring if the price of the fossil fuels included the cost of its manufacture.[53]

So, if fossil fuels are so critical to human society's well-being, and ephemeral due to the laws of thermodynamics, why are they treated as private goods? Because we have designed our energy laws using a private property model for allocating ownership rights. At the international level, the principle of national sovereignty grants ownership of fossil fuels to the nation within whose territory the resources are located. Each nation then chooses how it wishes to allocate and exploit its resources. The United States uses a modified law of capture private property model established by state laws subject only to state regulation designed to prevent the waste and overdrilling that ruined oil fields when oil reserves resided under more than one owner's property, and every owner was pumping as hard as he or she could.[54] In other countries the

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53. Interestingly, neoclassical economics was elaborated within the scientific paradigm of mid-19th century physics. However when the early 20th century revolution in physics occurred (quantum mechanics, relativity, etc.) neoclassical economics retained its belief and basis in the abandoned paradigms. This "strange marriage between economic theory and mid-19th century physics" assumes that all resources are inexhaustible or replaceable by other resources or technology, and that there are no biophysical limits to the growth of the market system. ROBERT L. NADEAU, THE WEALTH OF NATURE: HOW MAINSTREAM ECONOMICS HAS FAILED THE ENVIRONMENT 8—11 (2003). Needless to say, the laws of thermodynamics and entropy are not matters of concern within the neoclassical economic system.

54. Mansfield & Hickey, *supra* note 50, at 7-9 — 7-13 (explaining at 7-9 — 7-10 that the pure rule of capture "induced mass production that not only lowered the price of the product, but forced expenditures on wells that were not required to drain the reservoir efficiently. Moreover, when the only concern of any particular developer is speedy recovery to

nation retains ownership.[55] Ultimately, however, the paradigm is grounded in the idea of national sovereignty over underground natural resources. This paradigm selects the winners and losers in the fossil fuel game, dominates global geopolitics, shapes the global economy, has led to a world addicted to the benefits of fossil fuel, supports dictatorships across the globe, supports terrorism, causes the United States to maintain the 7th fleet in the Arabian Sea, looms in the background of the Iraq war, and has been a matter over which terrible wars have been fought.[56] All of this, and more, from failing to account for the ecosystem services embedded in fossil fuels.

VII. THE ORIGIN AND LIMITS(?) OF NATIONAL SOVEREIGNTY

The concept of national sovereignty did not exist until the ending of the ferocious[57] and horribly bloody[58] religious conflict between Catholics and Protestants known as the Thirty Years War with the Treaties of Westphalia in 1648, which, for the first time (based on the ideas of Hugo Grotius and Hobbes) "acknowledged the sovereign authority of Europe's individual princes and nations."[59] The idea of a nation state within an international law context was born. Among the elements of sovereignty that have evolved with the doctrine is a nation's control over the development of the natural resources located within the state's territory. This right of national sovereignty is routinely reiterated in inter-

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avoid oil or gas 'capture' by another, reservoir energy is not conserved. Recovery of the maximum amount of the resource is therefore impossible. Because of [this]… physical and economic waste, limitations on the Rule of Capture arose.").

55. Disputes over ownership status of oil can create serious conflicts, such as in Iraq, where the major oil fields are in the north (Kurds) and south (Shiites) but not in central Iraq, where most of the Sunis reside.

56. For a stark exposition of the dangers we face see NATIONAL COMMISSION ON ENERGY POLICY & SECURING AMERICA'S FUTURE ENERGY, OIL SHOCKWAVE: OIL CRISIS EXECUTIVE SIMULATION (2005), *available at* http://www.energycommission.org/files/contentFiles/oil _ shockwave_report_440cc39a643cd.pdf.

57. About twenty percent of Europe's population may have perished as a result of the war. DAVID J. BEDERMAN, INTERNATIONAL LAW FRAMEWORKS 2 (2001), *reprinted in* BURNS H. WESTON ET AL., INTERNATIONAL LAW AND WORLD ORDER 35 (4th ed. 2006).

58. Hugo Grotius' ideas were motivated by disgust with the slaughter in the wars:

> Throughout the Christian world I observed a lack of restraint in relation to war, such as even barbarous races should be ashamed of; I observed that men rush to arms for slight causes, or no cause at all, and that when arms have once been taken up there is no longer any respect for law, divine or human; it is as if, in accordance with a general decree, frenzy had openly been let loose for the committing of all crimes.

MARK W. JANIS, AN INTRODUCTION TO INTERNATIONAL LAW 162 (3d ed. 1999) (quoting from H. Grotius, *De Jure Belli ac Pacis Libri Tres* 20 (Kelsey trans. 1913)).

59. JANIS, *supra* note 58 at 167.

national environmental law treaties. For instance, the United Nations Framework Convention on Climate Change notes in its preamble that "States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies . . . ."[60] The Convention of Biological Diversity explicitly recognizes the sovereign rights of States over their natural resources.[61]

Since the 1960s, many nonbinding United Nations documents have declared a nation's sovereign right to exploit its own natural resources. For instance, in 1962, in response to concerns of nations that had recently emerged from colonial status that their natural resources were being exploited by foreign corporations, the U.N. General Assembly adopted a resolution espousing a concept of permanent sovereignty over natural resources, which acknowledged "the inalienable right of all countries to exercise permanent sovereignty over their natural resources in the interest of their national development . . . ."[62] A few years later, Principle 21 of the 1972 Stockholm Declaration declared that "States have, in accordance with the Charter of the United Nations and the principle of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies . . . ."[63] Twenty years later, Principle 2 of the Declaration signed by the nations of the world at the 1992 United Nations Conference on Environment and Development reaffirmed States' "sovereign right to exploit their own resources."[64]

However, starting with the 1972 Stockholm Declaration, this seemingly absolute right to exploit resources has become conditioned by countervailing obligations and responsibilities. For instance, 1972 Stockholm Principle 21, 1992 Rio Declaration Principle 2, and the U.N. Framework Convention on Climate Change preamble, after declaring the right, continue by subjecting States to "the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction."[65]

60. United Nations Framework Convention on Climate Change, May 9, 1992, 1771 U.N.T.S. 107.

61. United Nations Convention on Biological Diversity, June 5, 1992, 1760 U.N.T.S. 79, 31 I.L.M.

62. Permanent Sovereignty over Natural Resources, G.A. Res. 1803, U.N. GAOR, at 15, 17th Sess., Supp. No.17, U.N. Doc. A/5217 (Dec. 14, 1962).

63. Stockholm Declaration of the United Nations Conference on the Human Environment, 11 I.L.M. 1416, 1420 (1972) [hereinafter Stockholm Declaration].

64. Rio Declaration on Environment and Development, 31 I.L.M. 874 (1992) [hereinafter Rio Declaration].

65. *Id.* at 877.

Furthermore, in the Stockholm Declaration, it is hard to reconcile Principle 21's sovereignty over resources with the general duty earlier announced in Principle 5 that "[t]he non-renewable resources of the earth must be employed in such a way as to guard against the danger of their future exhaustion and to ensure that benefits from such employment are shared by all mankind."[66] Similarly, the 1992 Rio Declaration follows the sovereign right over resources with the explicit limitation in Principle 3 that "[t]he right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations" and in Principle 8 that "States should reduce and eliminate unsustainable patterns of production and consumption . . . ."[67] Thus national sovereignty over natural resources is not absolute, but is subject to the general duty not to harm other nations, and the duty (which has been enforced in courts)[68] to preserve natural resources for future generations.[69]

National sovereignty may also be subject to the obligation to protect the common heritage of humanity and the need to protect matters of common concern to humanity, such as the atmosphere and biodiversity.[70] For instance, the Climate Change Convention begins by "[*a*]*cknowledging* that change in the Earth's climate and its adverse effects are a common concern of humankind."[71] Similarly, the Convention on Biological Diversity affirms in its preamble "that the conservation of biological diversity is a common concern of humankind," although the following sentence reaffirms that "States have sovereign rights over their own biological resources."[72]

So, as our world gets smaller, and the consequences of our burning fossil fuels becomes greater, it is unclear what national

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66. Stockholm Declaration, *supra* note 63, at 1418.

67. Rio Declaration, *supra* note 64, at 877.

68. *See, e.g.*, Minors Oposa v. Sec'y of the Dep't of the Env't and Natural Res., 33 I.L.M. 173 (1994) (Phil.) (granting standing to some children to sue on their own behalf and on behalf of future generations to bring a case to cancel a timber license and to ban new ones on the grounds the licenses would allow destruction of most of the remaining forests in the Philippines); Waweru v. Republic of Kenya (2006) (Kenya), *as reprinted and discussed in* EDITH BROWN WEISS ET AL., INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 73—74 (2d ed. 2007) ("The High Court of Kenya (the country's second highest court) . . . applied the principle of intergenerational equity to a case of water pollution.").

69. *See* EDITH BROWN WEISS, IN FAIRNESS TO FUTURE GENERATIONS: INTERNATIONAL LAW, COMMON PATRIMONY AND INTERGENERATIONAL EQUITY 26 (1989).

70. *See* Nico Schrijver, *Permanent Sovereignty Over Natural Resources Versus the Common Heritage of Mankind*, *in* INTERNATIONAL LAW AND DEVELOPMENT 87, 95—101 (De Waart et al. eds., 1998), *reprinted in* DAVID HUNTER ET AL., INTERNATIONAL ENVIRONMENTAL LAW AND POLICY 486—489 (3d ed. 2007).

71. United Nations Framework Convention on Climate Change, *supra* note 60, at 851.

72. United Nations Convention on Biological Diversity, *supra* note 61, at 822.

sovereignty over natural resources means, especially with respect to fossil fuels. There is no agreement over energy and sovereignty. Neither the 1992 Rio Declaration nor Agenda 21, the detailed, extensive document outlining a global action plan to achieve sustainable development, mention fossil fuels. Energy issues were too contentious: "Disputes over fuels, especially between oil exporting and importing nations, made it difficult at UNCED to negotiate a comprehensive or meaningful chapter in Agenda 21 regarding energy."[73] In the fifteen years since the Climate Change Convention was signed the world has yet to make much progress in agreeing on how to address the global warming externalities from burning fossil fuels. Nor has any meaningful agreement on sustainable energy emerged from meetings of the Commission on Sustainable Development devoted exclusively to the issue.

Deep inside each of us, we all recognize that the use of fossil fuels is now an issue of such international scope that no nation can honestly say that its use of fossil fuels does not adversely effect nations and people beyond its borders. However, the use of energy is so valuable to each of us, that we do not want to give up unlimited control over that right. Instead, we exploit the ecosystem services embedded in the fuels, keeping all the benefits to ourselves and sharing all the consequences with the rest of the world.

Perhaps we are reaching another paradigm changing moment, as occurred in 1648, when Europe, after decades of war, abandoned the previous legal paradigm of feudalism and church-based rule, for the modern idea of national sovereignty. We may be entering another "Grotian moment," a period of "uncertainty and controversy when one framework of world order is being challenged by an alternative framework."[74] In other words, the time has come for us to value the ecosystem services that manufactured fossil fuels, and to find a legal mechanism to internalize that value into the marketplace, either as a cost on the resource or a countervailing subsidy for renewable energy alternatives that seek to harness solar energy and convert it into a usable form. The task of valuation, design of policy instruments, and development, implementation and enforcement of legal regimes that capture these ecosystem services is too huge to address here. Instead, I will try to be practical, and provide at least a small lesson from past field work that might serve as one model, among many, for how to think

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73. Nicholas A. Robinson, *Implementing Agenda 21 Internationally Through Environmental Law*, *i*n AGENDA 21: EARTH'S ACTION PLAN ANNOTATED xxxiv (Nicholas Robinson ed., 1993).

74. BURNS H. WESTON ET AL., INTERNATIONAL LAW AND WORLD ORDER 1269 (4th ed. 2006).

about incorporating ecosystem service values into energy decision-making.

VIII. VALUING FOSSIL FUEL ECOSYSTEM SERVICES

This essay has its roots in work I began in 1988 in attempting to identify all of the environmental externalities caused by the coal-generated electricity industry, all the laws that attempted to internalize those externalities, and what portion of the adverse impact of coal-fired electricity remained externalities after the laws were complied with (assuming that compliance occurs). Needless to say, the outline was extensive, and I am sure, incomplete. This exercise was my introduction into an even larger project—to identify all the environmental costs of generating electricity from all the methods by which electricity could be generated. This was not to be a purely academic exercise, but was to be compiled into a book that would be a resource for the New York Public Service Commission (NY PSC), which wanted to evaluate all new power plant proposals by comparing the full environmental cost of competing approaches—and then choosing that which presented the lowest cost, adding financial and environmental costs together. In my naiveté, I agreed to be a member of the project team. I was to be both an editor and author. As an author, I was assigned the task of identifying and justifying the environmental cost of emitting a ton of CO_2. A year later *Environmental Costs of Electricity* was in print.[75] The NY PSC used it in reforming its integrated resource planning process (IRP), and like a wildfire, the idea spread across the nation, being adopted by well over twenty states in the next few years. The usual rounds of litigation challenging the various state regulatory decisions ensued, but by and large, the state public service agencies prevailed in their argument that they were not engaged in environmental regulation but in prudent economic analysis of future risk to improve the accuracy of the values of the externalities from $0.00. It looked like the idea of internalizing the external environmental costs of electricity was becoming an idea whose time had come. And then, almost out of the blue, some regulators in California decided that electricity markets should be deregulated. Almost in a flash, states across the nation deregulated the generation of electricity, utilities sold off their generating facilities, and the idea of integrated resource planning faded into the background.

About a decade has passed since the electricity deregulation

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75. RICHARD L. OTTINGER ET AL., ENVIRONMENTAL COSTS OF ELECTRICITY (1990).

project began. It has not proven to be the miracle panacea it was touted to be. California suffered an energy crisis. Competition did not emerge, so today many states are discovering that electricity prices are higher than they would have been with regulation. We now have a national energy system that is market driven in virtually all respects. Although I am oversimplifying, public values such as ecosystem services, system reserve capacity, security, equity, and internalizing environmental externalities have largely vanished from the legal and economic decision-making template. IRP, if not gone, is weak. The Federal Energy Regulation Commission has a hands-off policy at the federal level. State Public Service Commissions have little left to regulate since most generating assets have been sold off or spun out of the regulatory arena. A few states, such as California and New York have remained diligent and creative, and are reaping the rewards.[76] But, as a nation we face daunting energy challenges. Unfortunately, there is little law or policy to address how we might move towards a sustainable energy system.

What does this have to do with ecosystem services? Virtually all energy used by human society was transformed into its useful concentrated form by ecosystem services, and virtually all efforts to obtain, transport, and utilize energy has significant local, regional, national and global ecosystem consequences. Therefore we must think in terms of systems: legal, economic, and ecological. Energy is integral to society:

> Modern forms of energy empower human beings in countless ways: by reducing drudgery, increasing productivity, transforming food, providing illumination, transporting water, fuelling transportation, powering industrial and agricultural processes, cooling or heating rooms, and facilitating electronic communications and computer operations, to name

76. *See* OFFICE OF ATMOSPHERIC PROGRAMS, U.S. EVNTL. PROT. AGENCY, CLEAN ENERGY-ENVIRONMENT GUIDE TO ACTION: POLICIES, BEST PRACTICES, AND ACTION STEPS FOR STATES (April 2006), *available at* http://www.epa.gov/cleanenergy/pdf/gta/guide_action_full.pdf, Arthur H. Rosenfeld, *The Art of Energy Efficiency: Protecting the Environment with Better Technology*, 24 ANN. REV. ENERGY & ENV'T 33, 33-42 (1999), *available at* http://www.energy.ca.gov/commission/commissioners/rosenfeld_docs/2000-10_ROSENFELD_AUTOBIO.PDF; Audrey B. Chang et al., *Energy Efficiency in California and the United States*, *in* CLIMATE CHANGE SCIENCE AND POLICY (Schneider, Rosencranz & Mastrandrea, eds., forthcoming 2007), *available at* http://energy.ca.gov/2007publications/CEC-999-2007-007/CEC-999-2007-007.PDF. *See also* NEW YORK STATE ENERGY RESEARCH AND DEV. AUTH., PLANNING NEW YORK'S ENERGY FUTURE: A THREE YEAR STRATEGIC OUTLOOK 2004-2007 (2004), *available at* http://text.nyserda.org/publications/strategicplan.pdf.

just some of them.[77]

We face enormous challenges as developing nations seek to expand energy use and bring modern energy services to the two billion people who have no electricity, while we must protect human health and the environment from the consequences of using fossil fuels and keep the world's economy and politics free from the disaster that ecosystem subsidized fossil fuels threaten. We must evaluate all aspects of our social and economic policies from an energy ecosystems services perspective. We can start with one piece - electricity. Now that 'electricity deregulation 1.0' has been tried, we need a new legal model, not just a tinkered upgrade.

77. Thomas B. Johansson & Jose Goldemberg, *Overview and Policy Agenda, in* ENERGY FOR SUSTAINABLE DEVELOPMENT: A POLICY AGENDA 1 (Thomas B. Johansson & Jose Goldemberg eds., 2000).