Global Sustainability: Toward Definition

Article *in* Environmental Management · January 1987

DOI: 10.1007/BF01867238

4 authors, including:

Diana Liverman
The University of Arizona

Robert Merideth
The University of Arizona

FORUM
Global Sustainability: Toward Definition

BECKY J. BROWN
MARK E. HANSON
DIANA M. LIVERMAN*
ROBERT W. MERIDETH, Jr.
Institute for Environmental Studies
University of Wisconsin–Madison
Madison, Wisconsin 53705, USA

ABSTRACT / Sustainability is increasingly viewed as a desired goal of development and environmental management. This term has been used in numerous disciplines and in a variety of contexts, ranging from the concept of maximum sustainable yield in forestry and fisheries management to the vision of a sustainable society with a steady-state economy. The meaning of the term is strongly dependent on the context in which it is applied and on whether its use is based on a social, economic, or ecological perspective. Sustainability may be defined broadly or narrowly, but a useful definition must specify explicitly the context as well as the temporal and spatial scales being considered. Although societies differ in their conceptualizations of sustainability, indefinite human survival on a global scale requires certain basic support systems, which can be maintained only with a healthy environment and a stable human population. A clearer understanding of global sustainability and the development of appropriate indicators of the status of basic support systems would provide a useful framework for policy making.

Sustainability is clearly becoming a popular word in the environmental policy and research arena. "Sustainable development," "sustained use of the biosphere," and "ecological sustainability" are terms increasingly used by institutions and individuals concerned with the relationships between humans and the global environment. [For examples of these terms, see IUCN (1980), Repetto (1985), and Caldwell (1984).]

Groups such as the International Union for the Conservation of Nature and Natural Resources, the Global Tomorrow Coalition, and the World Resources Institute establish sustainability as a desired goal of environmental management, development, and international cooperation. Reports such as *Global 2000* (CEQ 1980), *Blueprint for Survival* (Goldsmith 1972), and the Worldwatch Institute's annual *State of the World* (Brown 1986) marshal a wide range of data to suggest that we are on unsustainable development paths.

In recent years, much attention of the scientific and policy-making community has become focused on global sustainability (Clark 1986). For example, the Man and the Biosphere Program of UNESCO is concerned with integrated approaches to global natural resources management, particularly in and around designated biosphere reserves. The International Geosphere–Biosphere Program of the International Council of Scientific Unions (ICSU), the Earth Systems Science Program of the National Aeronautics and Space Administration (NASA), and the Global Environmental Monitoring System of the United Nations Environment Programme (UNEP) have designed multinational and multidisciplinary research and monitoring programs. A strong focus on global environmental policy making comes from the World Commission on Environment and Development of the UN; the Population, Resources, and Environment Program of the American Association for the Advancement of Science (AAAS); the Program on Analyzing Biospheric Change of the International Federation of Institutes for Advanced Study (IFIAS); and the program on Ecologically Sustainable Development of the Biosphere of the International Institute for Applied Systems Analysis (IIASA).

Given such a prominent and increasing level of attention directed toward these issues, exactly how is sustainability being defined in these and other studies? Is it rapidly becoming one of those transcendent terms, like "appropriate technology" or "environmental quality," which are cornerstones of environmental policy and research, but difficult to measure and rarely defined explicitly?

In this article, we examine the concept of sustainability, review some of the ways in which it has been defined, and attempt to clarify the use of the terms *sustainable, sustained,* and *sustainability* in the global context.

KEY WORDS: Global sustainability; Ecologically sustainable development; Sustainable use of the biosphere

*Address correspondence to D. M. Liverman, Institute for Environmental Studies, University of Wisconsin–Madison, 1007 WARF Building, Madison, Wisconsin 53705, USA.

Use of the Word Sustainability

While much of the current literature describes the necessary conditions for sustainability, or ways of achieving sustainability, or what sustainability is not, few writers actually define the term.

The *Oxford English Dictionary* defines *sustainable* as "capable of being upheld; maintainable," and *to sustain* as "to keep a person, community etc. from failing or giving way; to keep in being, to maintain at the proper level; to support life in; to support life, nature etc. with needs." The etymology of the terms originates in the French verb *soutenir,* "to hold up or support."

Sustainable Biological Resource Use

In resource management, the concept of maximum sustainable yield has been used by foresters and fisheries biologists since the early years of this century (Steen 1984). Tivy and O'Hare (1982) define sustainable yield as the "management of a resource for maximum continuing production, consistent with the maintenance of a constantly renewable stock." This definition is applied to biological resources, which are seen as naturally self-renewing. The World Conservation Strategy defines nonsustainable utilization as "overharvesting of a plant or animal to the point . . . when the species is so depleted that its value to man will be severely reduced or lost" (Talbot 1984). Sustained yield has also been used as a management goal in range management and water resource use (Tivy and O'Hare 1982).

In forestry, maximum sustainable yield is obtained by maximizing annual harvest while ensuring that the rate of felling equals the rate of replacement in a given area. Exact rates for sustained yield are very difficult to estimate because of the variability of natural regeneration rates due to climate, soils, and disease, and because biomass harvest removes nutrients from the site.

In fisheries, maximum sustainable yield is even more difficult to manage because of problems in assessing fish stocks, and because the oceans are a common property resource. Often the first sign of unsustainable harvests is a drop in fish catch, a decrease in fish size, or an increase in fishing costs.

Sustainable Agriculture

The emphasis in agriculture is gradually shifting from a goal of maximizing production in the short term to a perspective that also considers long-term maintenance (that is, sustainability) of production. Conway (1985) defines agricultural sustainability as "the ability of a system to maintain productivity in spite of a major disturbance," and he points out that there may be trade-offs between the goals of maximizing production and maximizing sustainability. Sustainable agriculture must conserve the land resource base without degradation and must be economically viable and socially acceptable as well. Recent volumes on sustainable agriculture discuss the importance of soil and water conservation, genetic diversity, and appropriate technologies in insuring a continued supply of food, a reasonable quality of rural life, and a healthy environment (Douglass 1984, Jackson and others 1984, Lawrence and others 1984, Edens and others 1985).

Carrying Capacity

Many people have defined sustainability in terms of carrying capacity, a concept long used to describe the maximum population size that the environment can support on a continuing basis. The concept of carrying capacity was developed in the field of population biology, and can be transferred to human systems only by analogy. Although the concept has generated considerable interest, "investigators have experienced difficulty defining the term [and] . . . there is no . . . standard approach of how it should be calculated" (Mitchell 1979).

Human carrying capacity has been defined simply as the "number of people that a given amount of land can support" (WRI/IIED 1986). Nevertheless, Watt's (1977) reference to an optimum, sustainable quality of life "within the carrying capacity set by the milieu of local, regional, and even international resources" suggests the complexity of this concept when applied to human systems.

Odum (1983) attempted to clarify the meaning of the concept by distinguishing between maximum and optimal carrying capacity. He defined maximum carrying capacity as the maximum allowable population size that, while theoretically sustainable, exists at the threshold and is vulnerable to even small changes in the environment. Optimal carrying capacity, on the other hand, is a smaller, more desirable population size that is less vulnerable to environmental perturbations. Ophuls (1977) writes that a sustainable level of human demand on the environment is "perhaps as little as half" the maximum carrying capacity. He argues that the carrying capacity has already been exceeded "whenever one can observe dangerous levels of pollution, serious ecological degradation, or widespread disturbance of natural balances."

It is important to recognize that the carrying capacity of any given region is subject to change. It may be increased through investment of capital and technology, or through imports of energy and materials from outside the region (Brown 1987). Studies of national carrying capacities are often flawed because they do not consider the exchanges between countries (WRI/IIED 1986). Urban–industrial zones, in particular, depend on much larger land areas for their maintenance. To estimate carrying capacity, one should take into account the total area necessary to support a given region. The outside areas that provide the inputs necessary to sustain a population have been called "ghost acres" (Borgstrom 1969).

The carrying capacity of an area may decrease as a result of declines in the biological productivity of the land. The *Global 2000 Report* (CEQ 1980) describes the feedback loop that leads to continuous declines in human carrying capacity through complex interactions of social and economic factors. In this process, population pressure causes environmental degradation, which results in poor living conditions. This creates a situation in which it is not possible to reduce fertility rates, and population tends to increase even more, leading to a vicious feedback cycle.

On a global scale, human carrying capacity is finite. Although much recent discussion has focused on whether the global human population has exceeded its limit, it is generally agreed that the available data are not comprehensive or accurate enough to precisely calculate the number of people the planet could support (WRI/IIED 1986, Meadows and others 1982).

Although the term carrying capacity is not precisely defined, the concept has been applied in several empirical studies that link human population with resource use. UNESCO's Man and the Biosphere Program has undertaken studies of the relationship between population density and resources in several regions of the world (di Castri and Glaser 1986). The UN Food and Agriculture Organization assessed the carrying capacities of 117 developing countries by estimating the maximum food-producing capability of each nation (FAO 1984). The World Bank (1985a) determined the carrying capacity of seven West African countries on the basis of available fuelwood and food supplies.

Sustainable Energy

The term sustainable has not been widely used in the energy literature, perhaps because it is antithetical to the concept of entropy. The concept of sustainability in energy is, however, discussed in terms of renewable energy and nondepletable or unlimited energy as well as in terms of the transition that must be made from our current exhaustible sources of energy to renewable or practically unlimited sources (Lovins 1979, Cooke 1976). Anderer and others (1981) refer to this as a "transition from a global energy system based on consuming depletable fossil fuels to a sustainable system based on non-depletable fuels."

Sustainability has been the focus of concern in a number of energy studies in response to the rapid depletion of fossil energy resources (stored solar energy) that is occurring on a global scale. Fossil energy resources, particularly oil, natural gas, and coal, have been characterized as capital stocks, recognizing that these resources can be used to produce goods and services, and are finite in extent. As these capital stocks are used, in conversion devices that provide either mechanical energy or heat, higher quality or concentrated energy is dissipated. Because all activity requires an energy supply, the fossil stocks on which human activity is overwhelmingly reliant must eventually be replaced by other energy sources.

In a recent book on energy, Gever and others (1986) make considerable use of the terms sustainable and unsustainable. They initially define unsustainable resource use in terms of exceeding carrying capacity, which is the use of resources "faster than they are created or when we begin to deplete high-quality stocks." They go on to argue that unsustainable resource use, and in particular fossil fuel use, can only be a temporary phenomenon, as global carrying capacity will necessarily limit population and economic activity. The issue becomes whether the adjustment from unsustainable use will be smooth or with serious economic disruption.

Sustainable Society and Sustainable Economy

A more general vision of a sustainable society is provided by Brown (1981), who sees a sustainable society as "an enduring one, self-reliant and less vulnerable to external forces" and identifies its basis in harvest regulation, renewable and efficient energy use, soil and water conservation, and a stationary, dispersed population with less affluent lifestyles. Likewise, Daly (1973) views sustainable conditions as those which ensure the existence of the human race on the earth for as long as possible. He suggests that such sustainability will be promoted by zero population growth and what he terms a "steady state" economy in which consumption is reduced and more equally distributed.

Goldsmith (1972) presents conditions for a stable society, "one that to all intents and purposes can be sustained indefinitely while giving optimum satisfaction to its members," as: minimal ecological disruption, conservation of energy and materials, zero population growth, and sense of individual freedom. Pirages' (1977) design for a sustainable society includes taking into account the physical and social limits to economic growth, outlining sustainable preferred futures as positive visions, developing strategies to reach these futures, and implementing these strategies. He discusses a concept of *sustainable growth,* which is "economic growth that can be supported by physical and social environments for the forseeable future," specifically supported by available sources of energy. Milbrath (1984) suggests a value structure for a sustainable society in which the central value, innate human selfishness, is modified by empathy, compassion, and a sense of justice for all. This value structure differs from one in which the central value is modified by aggression and competitiveness, which he suggests characterize a nonsustainable society.

Many economists dismiss these notions of sustainability. Economic growth is seen as the inevitable result of population growth, the acquisitive nature of people, and technological innovation. Thurow (1980), reflecting the attitude of mainstream economists, states that "worries about natural resource exhaustion are hard to rationalize from the point of view of economics." He goes on to argue that a zero economic growth (ZEG) society would lead to unemployment, greater inequality, and a threat to peace.

A dissenting minority of economists, including Georgescu-Roegen (1971), Daly (1980), and Boulding (1966), refer to the second law of thermodynamics and the concept of entropy as a major obstacle to continued economic growth. Thus, a distinct split exists between economists who view continued growth as an essential element of a sustainable economy and those who view a steady-state economy or zero economic growth as essential.

Sustainable Development

The World Resources Institute (Repetto 1985), among others, sees sustainable development as a "development strategy which manages all assets—natural and human resources, as well as financial and physical assets—for increasing wealth and wellbeing." Stating that "sustainable economic development depends on sound environmental management," the World Bank (1985b) has outlined environmental criteria it says will be systematically integrated into its projects.

Tisdell (1985) notes that, while sustainable development is an important goal of the World Conservation Strategy, "sustainability is not defined." Pearson (1985) feels that the concept of sustainable development is "elusive, ... [but] important and does deserve attention." He indicates that "the core of the idea of sustainability is the concept that current decisions should not damage prospects for maintaining or improving living standards in the future." O'Riordan (1985) believes sustainable utilization ". . . to be an ambiguous concept . . . with no time, space, ecological, technological, or managerial dimension." And Caldwell (1984) states that the concept of ecologically sustainable development can be easily stated in theoretical detail, "but the ecological and economic complexities of any actual situation are almost certain to make the reality different from, and more difficult than, theory."

Another concept often used interchangeably or in parallel with sustainable development is that of *ecodevelopment.* This term is defined by UNEP (Holdgate and others 1982) as "ecologically sound development, a process of positive management of the environment for human benefit." Dasmann (1985) identifies three components of ecodevelopment: fulfillment of basic needs (food, clothing, and shelter), self-reliance, and ecological sustainability. He defines sustainability as "a symbiotic relationship with nature," or ". . . development . . . within the constraints of local ecosystems" and suggests that the search for sustainable development needs to focus on the ideas of local, ecologically balanced, culturally sensitive ecodevelopment."

Alternative Perspectives on Sustainability

Emerging from this broad review of the uses of sustainability are several general perspectives, or contexts, in which the term is used:

A social definition of sustainability might include the continued satisfaction of basic human needs—food, water, shelter—as well as higher-level social and cultural necessities such as security, freedom, education, employment, and recreation [that is, as suggested by Maslow (1970)]. The social perspective is often more concerned with individuals than with nations or the species. Hence, socially defined sustainability might specify the survival and happiness of the maximum number of people, or the provision of minimum needs to even the poorest groups. On the other hand, some feel that it is against the long-term social good to aim at sustaining everyone because certain social groups are too weak or are unwilling to control their populations (Hardin and Baden 1977).

The ecological definition of sustainability focuses on natural biological processes and the continued productivity and functioning of ecosystems. Long-term ecological sustainability requires the protection of genetic resources and the conservation of biological diversity (Iltis 1983, BioScience 1986, Wilderness Society 1986). In many cases, short-term natural variability is necessary for the long-term sustainability of the ecosystem. By attempting to reduce this variability through technology and management, we may, in fact, threaten the long-term persistence of the system. The classic example is the way in which attempts to control and stabilize spruce budworm populations have actually led to a potentially vulnerable ecosystem (Holling 1978).

An economic definition of sustainability is more elusive. Economists tend to assume the inevitability of economic growth and do not, for the most part, address the issue of sustainability. When they do, they must resolve the limitations that a sustainable society must place on economic growth and must deal with nonmarketable and often unquantifiable values of ecosystems and long-term global health (Goldsmith 1972, Ehrenfeld 1976).

Many discussions of sustainability give no explicit definition of the spatial scale under consideration, and the implicit time scale is usually forever. Clark (1985) has identified many problems in the study of environmental futures which originate in a confusion of different time and space scales. Sustainability may have a different definition and different measures, depending on the scale of concern.

For example, social concerns might include a special focus on certain minority, age, race, culture, or income groups, sometimes in relation to specific geographic regions. Biologically, one may set out requirements for sustainable resource units as small as a forest or lake, or as large as a watershed, biome, or the whole planet. The economist often focuses on the nation, on economic groups within nations, or on global level interactions between national economies. Hence, any study of sustainability must make both contextual as well as time and space assumptions explicit, especially where it involves the measurement of conditions at different time periods and geographic scales, or from different perspectives.

Essential Elements in Defining Sustainability

There are obviously many ways of defining sustainability. Among the studies discussed above, the common themes that emerge include:

- The continued support of human life on earth
- Long-term maintenance of the stock of biological resources and the productivity of agricultural systems
- Stable human populations
- Limited growth economies
- An emphasis on small-scale and self-reliance
- Continued quality in the environment and ecosystems

If one accepts an anthropocentric view of sustainability, with the focus being on indefinite and global sustainability, then there is a range of ways in which to construct a definition from the essential elements.

In the narrowest sense, global sustainability means the indefinite survival of the human species across all regions of the world.

A broader sense of the meaning specifies that virtually all humans, once born, live to adulthood and that their lives have quality beyond mere biological survival.

Finally, the broadest sense of global sustainability includes the persistence of all components of the biosphere, even those with no apparent benefit to humanity.

Implications

Having defined a sustainable world as one in which humans can survive without jeopardizing the continued survival of future generations of humans in a healthy environment, what will ensure a sustainable future?

Human survival requires sufficient food, potable water, uncontaminated air, adequate shelter and clothing, energy, and minerals. These needs are closely tied to the continued functioning of the supporting ecological systems which maintain nutrient, air, and water cycles, and to the maintenance of renewable biological resources such as forests and fisheries stocks. Beyond the basic, biological survival needs, however, there are variations in social and cultural perspectives on what is needed for a quality existence and in ecological perspectives on what is needed for a sustainable biosphere.

We emphasize that each of the conditions for survival has its own complex set of support systems which must be sustained. Adequate food requires an agricultural system which can function on a continuing basis without losses of land area, soil fertility, soil moisture, resistance to pests and disease, or nutritional quality. Safe water requires functioning natural or manufactured supply and distribution systems, as well as natural or manufactured waste-water treatment systems for removal of contaminants. Long-lasting shelter and clothing are necessary for those living in harsh environments; and clean air combines with safe water and a nutritious diet to improve health, decrease infant mortality, and increase life expectancy.

To maintain the operation of these basic support systems, sufficient inputs of energy and other minerals are necessary. At all scales, food, water, air, shelter, and clothing can be very closely linked to the sustained functioning of natural ecosystems. It is important to recognize that widespread provision of even basic survival needs will become increasingly unsustainable if population growth is not controlled. In stating the goal of sustainability to be the survival of virtually all humans to adulthood, the caveat "once born" recognizes that, without controlling birth rates, sustainability is unlikely.

Finally, with population spreading across an earth of diverse physical environments and varying resources, a sustainable future, in terms of widespread human survival, must have social institutions to distribute the basic needs, particularly to less advantaged geographic regions or social groups. Thus, sustainability also implies the existence and operation of an infrastructure (transportation and communication), services (health, education, and culture), and government (agreements, laws, and enforcement) that will encourage and support the sustainable use of the biosphere and equitable resource use.

Conclusions

Is global sustainability merely a utopian ideal, or is it actually something which is achievable? How would we know if global sustainability were achieved, and how would we know if we were following a sustainable path?

It is important to recognize that the answers to these questions depend on how we construct our definitions of sustainability. As we have indicated, there are ranges of contexts and scales in which one can develop these definitions, and it is important that we be explicit about what exactly we are referring to within those ranges.

Most of the definitions we have described either state or imply that the goal of sustainability is human survival and do not accept the desirability of a sustainable biosphere without the existence of *Homo sapiens.* The contexts range from a social or cultural perspective, where quality of life is emphasized, to an economic perspective, with emphasis on a steady-state economy, to a biological perspective, where the emphasis is on the management and maintenance of ecosystems and species survival.

Different societies have different conceptualizations of sustainability as well as different requirements for sustainability (based on varying cultural expectations or environmental constraints). And while it may be desirable, it may not be realistic to expect that every social, economic, or biological system on the planet will be sustainable. Even in the broadest sense, global sustainability may imply sustainability of some portion less than the entire planet.

Setting the priorities for sustaining or being sustained, and at what costs, is a value-laden process that can only be accomplished within the context of a clearly stated definition of sustainability. Deciding what actions and policies should be taken to achieve sustainability can only be accomplished with appropriate measures and indicators of sustainability.

Acknowledgments

We would like to acknowledge Kevin Carroll, Altha Cravey, Bruce Herrick, and Dan York for their invaluable research assistance to the Global Sustainability Project. Also, we would like to recognize our colleagues in the Institute for Environmental Studies at the University of Wisconsin–Madison who contributed their support and advice. This project was supported by funds granted by the William and Flora Hewlett Foundation to the UW–Madison Institute for Environmental Studies.

Literature Cited

Anderer, J., W. Hafele, A. McDonald, and N. Naki. 1981. Energy in a finite world: paths to a sustainable future. Ballinger, Cambridge, Massachusetts.

BioScience. 1986. Biological diversity goes public. *BioScience* 36:708–711 and 715.

Borgstrom, G. 1969. Too many: a study of earth's biological limitations. MacMillan, New York.

Boulding, K. 1966. The economics of the coming spaceship earth. *In* H. Jarrett (ed.), Environmental quality in a growing economy. Johns Hopkins University Press, Baltimore, Maryland.

Brown, L. R. 1981. Building a sustainable society. W. W. Norton, New York.

Brown, L. R. 1986. State of the world. W. W. Norton, New York.

Brown, L. R. 1987. State of the world. W. W. Norton, New York.

Caldwell, L. K. 1984. Political aspects of ecologically sustainable development. *Environmental Conservation* 11:299–308.

Castri, F. di, and G. Glaser. 1986. Interdisciplinary research for the ecological development of mountain and island areas. *In* N. Polunin (ed.), Ecosystem theory and application. John Wiley and Sons, New York.

CEQ (Council on Environmental Quality). 1980. *Global 2000 report to the President: entering the 21st century.* US Government Printing Office, Washington, DC.

Clark, W. 1985. Scales of climate change. *Climatic Change* 7:5–27.

Clark, W. 1986. Unpublished notes and documents on the Sustainable Development of the Biosphere Project. International Institute for Applied Systems Analysis, Laxenburg, Austria.

Conway, G. 1985. Agroecosystem analysis. *Agricultural Administration* 20:31–55.

Cooke, E. 1976. Man, energy, society. W. H. Freeman, San Francisco.

Daly, H. 1973. Towards a steady state economy. W. H. Freeman, San Francisco.

Daly, H. 1980. Economics, ecology, ethics: essays toward a steady-state economy. W. H. Freeman, San Francisco.

Dasmann, R. 1985. An introduction to world conservation. *In*

F. Thibodeau and H. Field (eds.), Sustaining tomorrow. University Press of New England, Hanover, New Hampshire.

Douglass, G. K. (ed.). 1984. Agricultural sustainability in a changing world order. Westview, Boulder, Colorado.

Edens, T. C., C. Fridgen, and S. L. Battenfield (eds.). 1985. Sustainable agriculture and integrated farming systems. Michigan State University Press, East Lansing, Michigan.

Ehrenfeld, D. W. 1976. The conservation of non-resources. *American Scientist* 64:648–656.

FAO (Food and Agriculture Organization of the United Nations). 1984. Potential population supporting capacities of lands in the developing world. FAO, Rome.

Georgescu-Roegen, N. 1971. The entropy law and the economic process. Harvard University Press, Cambridge, Massachusetts.

Gever, J., R. Kaufmann, D. Skole, and C. Vorosmarty. 1986. Beyond oil. Ballinger, Cambridge, Massachusetts.

Goldsmith, E. 1972. Blueprint for survival. Houghton Mifflin, Boston.

Hardin, G., and J. Baden (eds.). 1977. Managing the commons. W. H. Freeman, San Francisco.

Holdgate, M., M. Kassas, and G. White. 1982. The world environment: 1972–1982. United Nations Environment Programme, Dublin.

Holling, C. S. (ed.). 1978. Adaptive environmental assessment and management. John Wiley and Sons, New York.

Iltis, H. H. 1983. What will be their fate? Tropical forests. *Environment* 25:55–60.

IUCN (International Union for Conservation of Nature and Natural Resources). 1980. World conservation strategy: living resource conservation for sustainable development. IUCN, Morges, Switzerland.

Jackson, W., W. Berry, and B. Colman (eds.). 1984. Meeting the expectations of the land: essays in sustainable agriculture and stewardship. North Point, San Francisco.

Lawrence, R., B. Stinner, and G. House (eds.). 1984. Agricultural ecosystems. John Wiley and Sons, New York.

Lovins, A. 1979. Soft energy paths. Harper and Row, New York.

Maslow, A. 1970. Motivation and personality, 2nd edn. Harper and Row, New York.

Meadows, D., J. Richardson, and G. Bruckmann. 1982. Groping in the dark: the first decade of global modelling. John Wiley and Sons, New York.

Milbrath, L. W. 1984. A proposed value structure for a sustainable society. *Environmentalist* 4:113–124.

Mitchell, B. 1979. Geography and resource analysis. Longman, London.

Odum, E. P. 1983. Basic ecology. Saunders College Publishing, New York.

Ophuls, W. 1977. Ecology and politics of scarcity. W. H. Freeman, San Francisco.

O'Riordan, T. 1985. Future directions in environmental policy. *Journal of Environment and Planning A* 17:1431–1446.

Pearson, C. 1985. Down to business: multinationals, the environment and development. World Resources Institute, Washington, DC.

Pirages, D. (ed.). 1977. The sustainable society: implications for limited growth. Praeger, New York.

Repetto, R. (ed.). 1985. The global possible. Yale University Press, New Haven, Connecticut.

Steen, H. K. (ed.). 1984. History of sustained yield forestry. The Society for the International Union of Forestry Researchers, Santa Cruz, California.

Talbot, L. 1984. The world conservation strategy. *In* F. Thibodeau and H. Field (eds.), Sustaining tomorrow. University Press of New England, Hanover, New Hampshire.

Thurow, L. 1980. The zero-sum society. Basic Books, New York.

Tisdell, C. 1985. World conservation strategy, economic policies, and sustainable resource-use in developing countries. *Environmental Professional* 7:102–107.

Tivy, J., and G. O'Hare. 1982. Human impact on the ecosystem. Oliver and Boyd, Edinburgh.

Watt, K. 1977. The unsteady state. University Press of Hawaii, Honolulu.

Wilderness Society. 1986. Conserving biological diversity in our national forests. Wilderness Society, Washington, DC.

World Bank. 1985a. Desertification in the Sahelian and Sudanian zones of West Africa. World Bank, Washington, DC.

World Bank. 1985b. Environmental requirements of the World Bank. *Environmental Professional* 7:205–212.

WRI/IIED (World Resources Institute and International Institute for Environment and Development). 1986. World resources 1986. Basic Books, New York.