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Sustainability as Intergenerational Equity: The Challenge to Economic Thought and Practice

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SUSTAINABILITY AS INTERGENERATIONAL EQUITY: THE CHALLENGE TO ECONOMIC THOUGHT AND PRACTICE

Richard B. Norgaard

ABSTRACT

Richard B. Norgaard is Associate Professor, Energy and Resources Program, University of California (Berkeley, California 94720). He wrote this discussion paper as a Visiting Research Fellow in the Office of the Chief Economist of the Asia Region in early 1991. Richard B. Howarth, an economist with the Applied Science Division of the Lawrence Berkeley Laboratory, prepared the models presented in Appendices 2 and 3, wrote the text of Appendix 3, and contributed generally as the coauthor of earlier articles from which many of the points in this discussion paper follow. The paper evolved in response to the challenging reactions of numerous Bank staff who attended two seminars based on early drafts and of the attendees of a Department of Economics seminar at the University of California at Davis and at the workshop on sustainable agriculture sponsored by the Science Council of Canada and Canadian Agricultural Economics and Farm Management Society held in Winnipeg. Sarma Jayanthi produced the graphics.

SUSTAINABILITY AS INTERGENERATIONAL EQUITY: THE CHALLENGE TO ECONOMIC THOUGHT AND PRACTICE

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SUSTAINABILITY AS INTERGENERATIONAL EQUITY: THE CHALLENGE TO ECONOMIC THOUGHT AND PRACTICE

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"Our theories ... are rays of light, which illuminate a part of the target, leaving the rest in darkness. ... It is obvious that a theory which is to perform this function satisfactorily must be well chosen; otherwise it will illumine the wrong things. Further, since it is a changing world that we are studying, a theory which illumines the right things at one time may illumine the wrong things at another."

John R. Hicks (Wealth and Welfare: Collected Essays on Economic Theory. 1981. pp. 232)

EXECUTIVE SUMMARY

0.1. This paper presumes the international discourse on the sustainability of development is concerned with a) the rights of future generations to the services of natural and produced assets and b) whether formal and informal institutions which affect the transfer of assets to future generations are adequate to assure the quality of life in the long-run. Sustainability is primarily an issue of intergenerational equity. The noneconomic discourse on sustainability is clearly about caring for the future.

0.2. Conversely, this paper contests the implicit premises of economics as now practiced. First, in the face of the sustainability debate, many academic and practicing economists still assume that technology will offset resource depletion and environmental degradation. Technological optimism may or may not be appropriate, but it is not inherent to economic reasoning. Second, existing theory on intertemporal resource allocation, oft cited to justify practice, tacitly assumes that current generations hold all rights to assets and *should* efficiently exploit them. Third, there has been an implicit assumption that the mechanisms affecting the maintenance and transfer of assets to future generations are both working optimally and are unaffected by current economic decisions. The interplay between institutions and environmental management is now well recognized, but analyses to date have only addressed market distortions and the internalization of externalities. While new technologies have dramatically increased people's ability to use resources and degrade ecosystems, no analyses have been undertaken of the adequacy of institutions for protecting the rights of future generations. This paper addresses each of these working premises of economics.

0.3. Different intergenerational distributions of assets are associated with different efficient allocations of resources. This paper is informed by three overlapping generations models. The first, available in the academic literature, is a partial equilibrium model which illustrates how alternate distributions of rights to a stock resources across generations affects the efficient allocation of resources. The second, presented in Appendix 2, is a general equilibrium model which illustrates a stock resource economy in which concern for the future is achieved through income transfers to future generations. The third, presented in Appendix 3, is a general equilibrium model which illustrates a renewable resource economy in which concern for the future occurs through the older generation's utility from the utility of the younger generation as well as its own. These models demonstrate how resource use, consumption, and prices, including interest rates, change with different levels of concern for the future.

0.4. While environmental, forestry, and resource economics are concerned with the long-term, this concern has been rooted in the presumption that market failures prevent the maintenance of resources for future generations. Hence improvements in long-term allocation have been pursued in terms of internalizing environmental externalities. While environmental externalities are no doubt a problem, suboptimal allocations due to inappropriate distribution between generations cannot be solved solely by correcting externalities. Indeed, internalizing externalities without protecting the future can hasten resource exploitation.

0.5. Intertemporal general equilibrium models incorporating overlapping generations and resource constraints demonstrate that the efficient allocation of resources is a function of intergenerational distribution. While this "finding" is theoretically elementary, it is at odds with the understandings about allocation and valuation developed through partial equilibrium modeling undertaken in environmental, forestry, and resource economics. A few economists are now admitting that economies may not achieve sustainability because sustainability is a matter of equity rather than efficiency. But to date, these economists advocate achieving equity through imposing environmental and resource constraints on economic efficiency conceived in a partial equilibrium framework. The models informing this discussion better illumine the problem and provide new insights by incorporating equity into a general equilibrium model and observing how equity affects efficiency. While maintaining natural capital through constraints might protect the future, thinking of the problem as one of how this generation expresses its concern for the next highlights the importance of institutions and social values affecting bequests and other mechanisms.

0.6. Many economists, as well as environmentalists, have noted that discounting the benefits received and costs borne by future generations in project analysis is contradictory with a concern for sustainability. While lower discount rates give greater weight to the future, using rates different than market rates, or what market rates would be without distortions, results in inefficient use of capital. One of the insights from framing sustainability in a general equilibrium model is that with a transfer to future generations the efficient allocation of resources results in new levels of savings and investment, a shift in the types of in-

vestments, and a different rate of interest. Thus the discount rate, rather than being an instrumental variable for protecting the future, varies as the future is protected.

0.7. A distinction must be made between investments to improve the welfare of current generations given their consumption time preference and social decisions to transfer more resources to future generations. The benefits from changing from one level of protecting future generations to another are not discounted. Cost-effectiveness criteria are used to determine the optimal investment package to meet intergenerational transfer goals to protect future generations.

0.8. Markets themselves do not provide for intergenerational equity any more than they provide for intragenerational equity. "Trickle Ahead" is no more suitable as an operating norm for development than is "Trickle Down". There is certainly good reason to believe that historic asset transfer mechanisms, to the extent that they have not been broken down by development, are not adequate under modern technologies, current population levels, and global economic interconnectedness. While adequate levels of assets have been transferred from one generation to the next in many cultures over long time periods, very little is known about the cultural mores and institutional mechanisms which have facilitated transfers. Modern capital markets may fail to both maximize the welfare of the current generation given its consumption time preferences and meet the current generation's goals of transferring assets to future generations. Redistributive failure may occur because private redistribution has public good aspects. In addition, savers are probably unable to determine or control whether they are receiving a return from investments which will be transferred to future generations or from investments which are depleting the assets that might have been transferred to future generations. This implies that asset monitoring and guidance mechanisms are needed to supplement capital markets.

0.9. The determination of the optimal intergenerational distribution of rights to assets is impossible without an intergenerational welfare function. The widespread acceptance of sustainability as an objective of development, however, indicates that sustainability itself can be treated as a minimum criterion of intergenerational equity. Economics can assist in the interpretation of what sustainability as a minimum criterion means in practice, the extent to which it is being met, and the viability of the institutions which assure that it is being met. Economic reasoning and empirical methodologies can assist in analyses of historic and current levels of asset transfer, in analyses of whether the quantities of assets transferred meet minimal sustainability criteria, and analyses of changes in and the current viability of institutions affecting the formation, maintenance, and transfer of natural and other assets. While there is considerable scope for economic analysis to inform social decisions with respect to sustainability, economists need to be careful that they do not fallaciously critique redistributions to future generations based on efficiency arguments which implicitly assume the current generation has no responsibilities to the future.

0.10. Economists' historic emphasis on efficiency, implicitly taking the existing distribution of assets as a given, has limited their ability to perceive and respond to the challenge of sustainability. This emphasis logically evolved through economists' participation in progressive institutions established, in part, to circumvent the "irrational" politics of distribution. Accepting the existing distribution of income also justifies the use of data generated by markets, thereby giving economic reasoning empirical grounding and scaling. Economists can participate more effectively in the diverse social decisonmaking arenas in which intergenerational equity decisions are being made if they use economic analysis to complement other types of analysis rather than assume that economic reasoning is a sieve through which other forms of reasoning must pass.

0.11. From the operational perspective of development assistance agencies, addressing the sustainability of development would further the shift away from project analysis toward country level and policy analysis as well as toward increased country dialogue. At the level of project analysis, emphasis would need to be given to how projects affect the formation, maintenance, and transfer of assets to future generations as well as to efficiency analyses.

0.12. Pursuing sustainability as intergenerational equity leads to questions with respect to whether capital markets can facilitate both investments to meet the current generations consumption time preference and transfers to meet its concern for future generations. Such an exploration reinforces the concerns expressed by theorists investigating intertemporal general equilibrium and exhaustible resource allocation that sufficient actors must have a global view for things to work out right. Such a global view must incorporate knowledge from the natural sciences and information generally beyond that provided by markets to avoid being myopic. International development agencies as major actors with excellent access to global information should play a key role in the synthesis and use of such a global view.

0.13. The paper presents sociological explanations of how economics evolved to help identify how it became the way it is and to give perspective on how sustainability challenges the discipline. The footnotes also provide considerable commentary and extensive reference to the socio-economic literature outside of the technocratic progressive or neoconservative stances that economists typically take towards politics.

SUSTAINABILITY AS INTERGENERATIONAL EQUITY: THE CHALLENGE TO ECONOMIC THOUGHT AND PRACTICE

1. THE CHALLENGE TO DEVELOPMENT POLICY

1.1. In Western and westernized societies, the primary promulgators of values, knowledge, and collective action are separate institutions. And yet linkages between church, science, and the state are necessary in spite of the principle of separation. How could governmental agencies, unable to return to their governing bodies on every decision, determine what should be done without appealing to values, and, apart from science, ascertain how best to do it? For questions of economic development, such linkages were effectively made through the first half of the 20th century by progressive technocrats -- engineers, agricultural scientists, foresters, and, later, professional planners. The public sanctioned these professionals to act -- to combine publicly-held values with scientific knowledge -- on its behalf. This sanctioning was rooted in a common vision of progress and a shared faith in how Western science and technology could accelerate development.[1]

1.2. Economists, with their more encompassing definition of efficiency and explicit belief in positivism, helped fill the void after World War II. Economists rapidly assumed positions in the machinery of government in democratic and authoritarian, and capitalist and socialist states alike. During this same period, economists' progressive optimism for the possibilities of material plenty for all the people of the world also carried them, naively for sure, to the head of the global pursuit for economic development.[2] A repertoire of practical economic experience and understanding as well as arguments developed to justify practice rapidly accumulated. The international discourse on the sustainability of development challenges these understandings and beliefs accumulated since World War II.

1.3. The style of international economic development that actually unfolded was a product of a myriad of different factors in different places, but economists assumed the burden of try-

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1. I use the term "progressive technocrat" in the sense formalized by the thinking of Auguste Comte (A General View of Positivism, 1848) and as implemented in Western countries beginning with the progressive era at the last turn of the century. The term incorporates the general belief that much of the "subjective" folly of politics can be avoided by the use of technical experts who provide "objective" knowledge with respect to what can be done and then implement legislative decisions effectively, rationally following established rules or scientific laws. For an interpretation of the evolution of progressive thinking in economics as a material, earth-bound, extension of Judeo-Christian progressive beliefs, see Robert H. Nelson (Reaching for Heaven on Earth: The Theological Meaning of Economics, 1991).

2. For reflections on the rise of economists in governments throughout the world including in international development agencies, see Joseph A. Pechman (ed) (The Role of Economists in Government: An International Perspective, 1989).

ing to guide, explain, and rationalize the development process. Their representations were soon challenged, however, by others, typically with natural science training, who interpreted the development process quite differently. In the late 1960s and early 1970s, scientists concerned with population growth[3] and resource scarcity[4] argued that the number of people could not keep doubling and that the course of development, for rich and poor nations alike, had to become more resource conserving. While these interpretations incorporated technological change, they did not optimistically assume that endogenously generated technological change would automatically be sufficient to resolve whatever problem might arise. As the decade of the 1970s progressed, problems in environmental management were beginning to become obvious to more and more people. Technologies initiated for developing nations conflicted with understandings recently acquired in the industrialized nations. Green revolution technologies, for example, with their greater need for fertilizers and pesticides, were being adopted in developing countries at the same time as concerns over energy scarcity and the misuse of toxics in developed nations were rising. New technologies finally seemed to be propelling third world development about when people in the industrialized North realized that new technologies can be expected to have unforeseeable, undesirable consequences. And the unforeseen and undesired which appeared in the South seemed especially so.

1.4. In other cases, development seemed to be propelled along an environmentally and culturally destructive course due to a multitude of interactive causes within and between poor and rich nations. The causes of deforestation in the tropics, for example, have been both very complex and specific to different locations and time periods. Even though instigated by a confluence of different interactive causes in different places, the rise in deforestation rates matched a growing public awareness in industrialized nations of the importance of biodiversity. Similarly, the rise in conflicts with tribal peoples coincided with a rising interest in the cultural survival of the few traditional peoples still on the globe.

1.5. It is important to keep in mind that both the dominant vision of what development could be, commonly attributed to economists, and the stance of its critics, customarily thought of as environmentalists, are broadly based and rather amorphous. The historic roots of each intertwine with Western traditions, religion, philosophy, and science, and with the experience of developed nations. Recently, each has also acquired new roots springing from the traditions and experience of the cultures and environments of developing nations. Neither economic nor environmental reasoning starts with axioms engraved in stone. Most people eclectically ascribe to a mix of both patterns of thinking and perceive both economic gains and environmental losses. And yet, as the debate over the course of development took public form during the 1980s, one could rightfully interpret "economism" and "environmentalism" as separate, incon-

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3. Paul R. Ehrlich (The Population Bomb, 1968) and Paul R. Ehrlich and Anne Ehrlich (The Population Explosion, 1990).

4. Donella H. Meadows, et al. (The Limits to Growth, 1972).

gruous secular religions.[5] While they are most noted for their differences with respect to values, it is also important to bear in mind that each is backed by different combinations of Western science and understanding, different interpretations of the prospects for and consequences of new technologies, and different judgments as to the appropriateness of alternative responses to uncertainty.

1.6. During the 1980s, there was a positive feedback between how development unfolded, the rise of new understandings, the shift in public views toward environmentalism, and increased acceptance and demand for more participatory approaches to development planning.[6] These mutually reinforcing phenomena provided the political base for environmental activists to challenge the most visible development institutions and most unsustainable development projects. The World Bank assumed the brunt of the attack for its participation in the Polonoreste Project located in Brazil's region of the Amazon tropical rainforest in the State of Rondonia.[7] During the clashes of the 1980s, both economists and environmentalists pursued parts of their strategy successfully. Economists effectively pressed the case for free markets to increase efficiency and enhance the ability of developing countries to meet their debt obligations. At the same time, environmentalists successfully convinced national governments to establish biological reserves to protect key species, areas of unusual biodiversity, and unique ecosystems. Without resolving primary conflicts, development activities assumed a bimodal nature -- part conventional development, part biological conservation.

1.7 During the 1980s, however, many environmentalists began to acknowledge that hungry people could neither live by nor leave biosphere reserves alone. With this realization, some environmentalists began to accept the challenges of designing and implementing alternative development strategies.[8] Simultaneously, many in the international development community

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5. Wilfred Beckerman (Economists, Scientists, and Environmental Catastrophe, 1972) and Daniel B. Luten (Ecological Optimism in the Social Sciences, 1980) explore the dichotomous positions from the perspective of social and natural scientists respectively.

6. The trend from a progressive to participatory approach in politics and administration parallels the trend in science from the belief that the sciences would progressively merge into one correct way of understanding an objective, static reality to the understanding that knowing is a human activity with multiple logical patterns of thinking about the complexities of a world we have shaped and are continuing to shape. The importance of this epistemological shift to economics is elaborated by Robert H. Nelson (op cit, chapter 7) and by Richard B. Norgaard (The Case for Methodological Pluralism, 1989).

7. Stephen Schwartzman (Bankrolling Disasters: International Development Banks and the Global Environment, 1986).

8. This transition might best be demarcated by the decision of the International Union for the Conservation of Nature and Natural Resources (IUCN) to design and implement conservation strategies in cooperation with national governments (IUCN, World Conservation Strategy: Living Resource Conservation for Sustainable Development, 1980). The IUCN effort soon encountered the difficult questions of equity which they addressed in a major international conference on

(continued...)

began to openly acknowledge the environmental consequences of conventional development. Yet a third factor contributed to the changing dynamic. Development planning and implementation continued to gradually shift in two apparently contradictory directions. At the project level, it clearly moved away from progressive technocratic toward more participatory approaches. The international development agencies began to work directly with nongovernmental organizations and to encourage the governments of developing countries to use them both for advice and project implementation.[9/] At the same time, the emphasis of development agencies shifted away from projects toward institution building, policy dialogue at the highest levels of government, and economic restructuring to meet lending criteria. The combination of these factors diffused much of the debate between the two secular religions, transforming the conflict into a prolonged discourse on the meaning of and possibilities for sustainable development. The seminal work of the World Commission on Environment and Development institutionalized the exchange of views.[10/] During this period, international aid agencies as well as most national governments adopted the objective of sustainable development.[11/]

1.8. A decline of faith in the inevitability of progress is an important component of the international discourse on sustainability.[12/] Obviously if people had retained the faith they had in progress over the past several centuries, they would not be concerned about sustainability. Whether one believes in progress or not, of course, has little impact on whether sustainability is actually a problem. Loss of faith is attributed in the developing world to the excessive

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8.(...continued)
that theme, (Peter Jacobs and David A. Munro Conservation with Equity: Strategies for Sustainable Development, 1987). IUCN is currently negotiating a new document that better incorporates the diverse concerns and knowledge of representatives and experts from the developing countries (Caring for the World: A Strategy for Sustainability, draft 1990).

9. This shift is confirmed and elaborated by Wilfried P. Thalwitz and Moeen Qureshi, two senior vice presidents of the World Bank (Participatory Development: A New Imperative of Our Times, 1991).

10. World Commission on Environment and Development (Our Common Future, 1987).

11. The World Bank established an environmental unit in 1971, initiated projects with environmental objectives in 1974, President Clausen (Sustainable Development: The Global Imperative, 1981) and President Conable (xxx, 1986) spoke to the ecological basis of sustainability in their earliest speeches, and by 1987 sustainability was an announced policy (Philippe Le Prestre, The World Bank and the Environmental Challenge, 1989; World Bank, 1987).

12. Only 36% of Americans in early March 1991, at the peak of enthusiasm after "winning" the war with Iraq, thought the future for the next generation will be better than life today, up from 28% in June 1990 (Robin Toner, "Poll Finds Postwar Glow Dimmed by the Economy"). While critiques of the idea of progress date from the writing of Georges Sorel at the turn of the century (The Illusion of Progress, 1908) on through to Christopher Lasch in the present (The True and Only Heaven: Progress and Its Critics, 1991), attention to the decline in faith is relatively recent (Almond, Gabriel A., Marvin Chodorow, and Roy Harvey Pearce (eds) Progress and Its Discontents, 1982; and Robert Nesbit (A History of the Idea of Progress, 1980).

promises of development relative to the results and in both the developing and the industrialized worlds to the recognition that new technologies inevitably have unforeseen, and perhaps catastrophic, environmental and social consequences.

1.9. The transition in beliefs led ethicists to ponder questions of intergenerational equity and the responsibilities of current generations to future generations.[13] John Rawls' "veil of ignorance" is often invoked with the question: "if you could not choose the generation into which you would be born, what rule for environmental and resource management would you choose?" If we accept the premise of environmental scientists that planet earth is fit for people because of the way nature evolved, all but incurable gamblers would choose a rule that assured that the natural patrimony stays intact between generations. Each generation would have the right to enjoy the services from natural assets, but the assets themselves must be passed on to the next generation. And in fact such rules already exist for visitors to national parks, holders of riparian water rights, tenants of farmland and buildings, and beneficiaries of charitable trusts.[14] Environmental ethicists argue that the wide acceptance of the idea that development must be sustainable implies an extension of such contractual relations to the biosphere as a whole. Edith Brown Weiss integrates questions of intergenerational equity with issues of the rights of other species in an encompassing notion of "planetary trust" which assures communal and generational, rather than individual, rights. Her planetary trust concept accepts that people live in a global, intertemporal commons and have responsibilities to others as well as rights. Individual rights may be the best operational approach for specific cases, but Weiss makes a strong case that the notion that nature can be divided into parts and over time and generally assigned as individual rights is inappropriate as an initial, overarching framework for approaching intergenerational equity.[15]

1.10. Thus, during this final decade of the 20th century, there is a pastiche of dialogues between people with different economic, environmental, and ethical understandings working in international agencies and academic institutions. Joined by leaders of national governments, nongovernmental organizations, and traditional cultures, from industrial and developing nations

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13. See, for example: Ernest Partridge (Responsibilities to Future Generations: Environmental Ethics, 1981), Bryan G. Norton (Environmental Ethics and the Rights of Future Generations, 1982), J. Baird Callicott (Intrinsic Value, Quantum Theory, and Environmental Ethics, 1985), Christopher Stone (Earth and Other Ethics: The Case for Moral Pluralism, 1987), Thomas Berrry (The Dream of the Earth, 1989), and J. Ronald Engel and Joan Gibb Engel (Ethics of Environment and Development: Global Challenge, International Response, 1990).

14. John A. Rawls' (A Theory of Justice, 1971).

15. Rawl's veil of ignorance is used by Edith Brown Weiss (In Fairness to Future Generations: International Law, Common Patrimony, and Intergenerational Equity, 1989) in the derivation of her ethical position. See also: Anthony D'Amato (Do We Have a Duty to Future Generations to Preserve the Global Environment?, 1990), Lothar Günding (Our Responsibility to Future Generations, 1990), and Edith Brown Weiss (Our Rights and Obligations to Future Generations for the Environment, 1990).

alike, this discourse is steadily transforming our understanding of the desirable and the possible.[16] At the same time, novel joint efforts between development agencies and nongovernmental environmental organizations such as the Tropical Forestry Action Plan are providing new, shared experiential knowledge.[17] Thus to a large extent the political challenge of sustainable development is past. Sustainable development is accepted as policy. Elaborating policy goals into practice, however, still presents a considerable conceptual challenge in light of how earlier political and institutional environments affected the evolution of economic reasoning.

1.11. An important caveat is in order. While there is considerable agreement that development must be sustainable, there is now less agreement on what development should be and how "it" might be achieved. This uncertainty is affecting the public's perception of the nature of the problems which economists should address and the social environs in which economists work. The conceptual solution advocated in this paper for understanding sustainability, for example, has implications for how economists work with the political process. Thought and practice need to evolve in the context of three key factors.

1.12. First, with the decline in faith in progress, many peoples are expressing less interest in joining the "modern project" and more interest in defining development locally and in terms of their own cultures. The rising respect for cultural diversity is providing safer haven for tribal peoples while the revitalization of traditional cultures threatens the very existence of key nations. The search for sustainable development itself, furthermore, is leading in many directions. And there is reason to argue that a culturally more diverse world might be more sustainable because it would not have "all of its eggs in the same basket." The environmental ravages of war stemming from cultural differences and the increased likelihood of ecoterrorism, however, could very easily more than offset this gain. In any case, the reculturalization of the world will affect how the benefits of different courses of development are perceived, the technologies used and hence environmental impacts to be avoided, and the pressures on particular resources.

1.13. Second, the dramatic rise of non-governmental organizations is partly due to the inabil-

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16. World Bank staff assumed a major role in this discourse. Key works by Bank staff and consultants include: Yusuf Ahmad, Salah El-Serafy, and Ernst Lutz, (Environmental Accounting for Sustainable Development, 1989), Michael E. Colby (Environmental Management in Development: The Evolution of Paradigms, 1990), Herman E. Daly and John B. Cobb (For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future, 1989), Robert Goodland and George Ledec (Neoclassical Economics and Principles of Sustainable Development, 1987), and John Pezzey (Economic Analysis of Sustainable Growth and Sustainable Development, 1989).

17. The Tropical Forestry Action Plan was initiated in 1985 by the World Resources Institute with the help of the Rockefeller Foundation and joined by UNFAO, UNDP, the World Bank and eventually a wide variety of non-governmental organizations, national governments, and bilateral aid organizations. TFAP's chaotic evolution and mixed experience are leading to a major reorganization (Robert Winterbottom, Taking Stock: The Tropical Forestry Action Plan After Five Years, 1990).

ity of national governments and international agencies to design and implement projects technocratically from capital cities. Some interesting symbioses have evolved between large, central agencies and small, dispersed non-governmental organizations. And yet non-governmental organizations are also political forums for greater participation. With reculturalization and greater participation, projects are increasingly being designed to meet the minimum criteria of diverse parties rather than designed to meet a single efficiency criteria.

1.14. Third, progressive scientists and resource managers, responding to the summons to more fully manage environmental systems, discovered that their knowledge is highly fragmented and not readily linked. While economists contemplated the optimal application of pesticides, agronomists could not show the relationship between rates of use and crop yield, soil scientists and hydrologists could not predict how much pesticide would actually end up in groundwater aquifers, and agricultural chemists could not explain how pesticides broke down in soils and beyond. Many have argued the need for a substantial increase in environmental monitoring, yet to the extent our knowledge really is fragmented, we have little basis for determining what should be measured. Well before the international development agencies accepted sustainability as a development criteria, an accumulation of experience was forcing them to be increasingly cognizant of interrelations between objectives and sectors as well as more aware of the cultural contextuality of the development process. Concern for environmental linkages seriously compounded the number of interconnections that needed to be considered. And yet the fragmented nature of our knowledge is a fact that has not gone away. Economic analysts have to interact with environmental scientists directly to assess the level of knowledge available in the design and analysis of projects.[18] Economic theory needs to develop in consonant with our increased awareness of our limited understanding of the fragmented nature of knowledge rather than assume coherence.

1.15 In light of the above, it is probably best to think of the participants in the discourse on sustainability as being either "progressives" or "environmentalists". Both "progressives" and "environmentalists" agree that there is an unacceptably high likelihood that development as now implemented is unsustainable. This unsustainable development path is illustrated in Figure 1 as the "consensus" path. But there is disagreement on the course of action. "Progressives" believe that sustainability will come through pushing the modern project to completion; most assume a technocratic approach. They argue that sustainability will require a significant expansion in agricultural, forestry, and other research to implement more environmentally compatible technologies, significantly more environmental monitoring and assessment, and design new institutions to internalize external costs. They envision sustainability as a matter of fully optimizing people's interaction with nature. Environmentalists view the challenge sustainability poses the modern project quite differently. Environmentalists are split be-

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18. The nature of environmental science and how systems are understood is elaborated in Norgaard (Environmental Science as a Social Process, 1990).

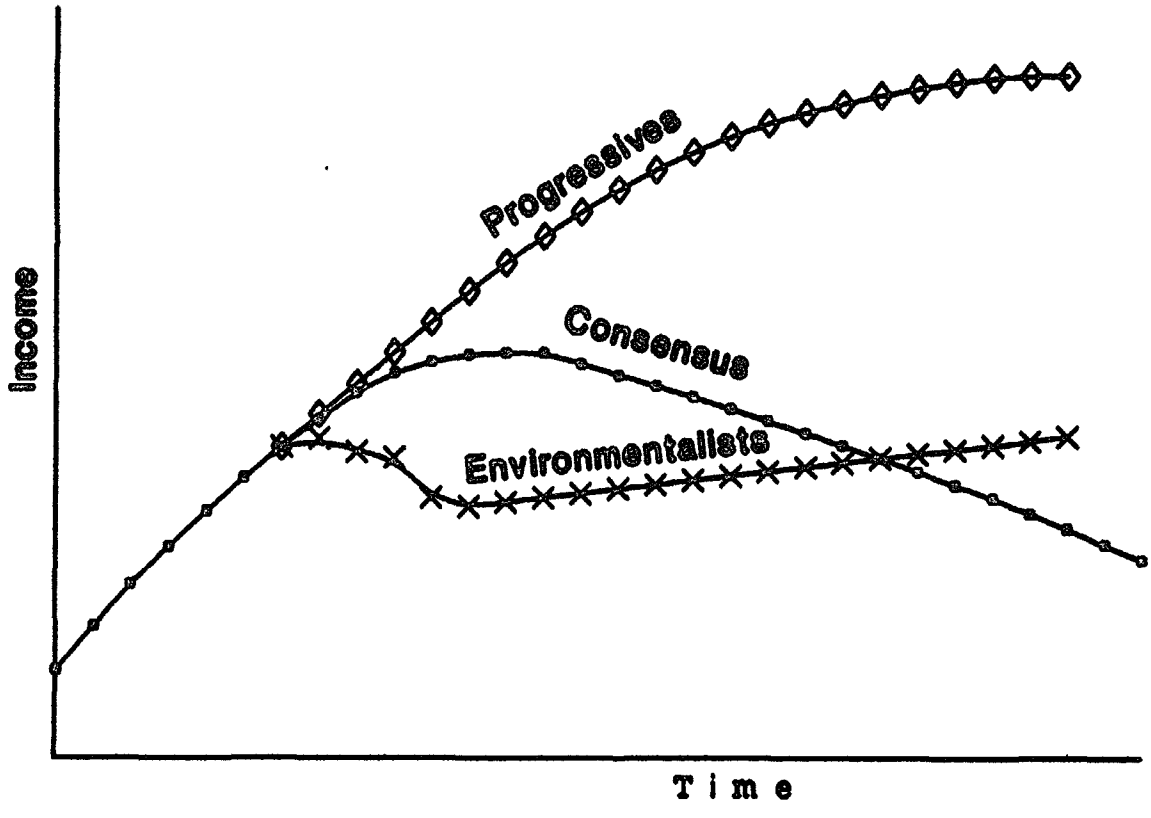

Figure 1

tween technocrats who think the new environmental scientists have reasonable answers and populists who put more emphasis on changing values, reculturization, and developing traditional knowledge. Technocratic environmentalists argue that there is little hope for achieving the optimization required with higher levels of economic activity in light of the inadequacies of current environmental management institutions and weaknesses in systemic ways of understanding and manipulating the environment. Populist environmentalists argue for new lifestyles with less technocratic hierarchy. From both environmental perspectives, however, sustainable development is only seen as possible by reducing the overall level of economic activity, redistributing wealth to the poor so that they will not become worse off in the process, and then developing truly new technological and organizational alternatives through which development might be sustained.

1.16. Economists devised their theory to fit the way questions were asked within the technocratic social structure in which they worked. The rise in participation, the trend toward reculturization, and new epistemological understandings are affecting how economic problems are being defined and the organizational milieu in which economists operate.

2. THE CHALLENGE TO ECONOMIC THOUGHT

2.1. For some economic sectors, the course to sustainable development is clear. International assistance agencies, for example, are having little difficulty deciding the appropriate direction for energy sectors. Increasing the efficiency of power plants, transmission systems, and end-use appliances, while important to the reduction of greenhouse gases, is frequently justified on narrow economic efficiency grounds alone. The opportunities to invest in improved efficiency are considerable, giving us some time before we must determine how much additional investment is justified to stem global climate change. The sheer mass of opportunities for conservation certainly challenges the ability of the international community to mobilize sufficient capital, expertise, and technology. Going from policy to practice in the energy sector, however, presents few challenges to economic thought and practice.

2.2. In the case of tropical rainforests, on the other hand, the current period of transition between opposing world views to a pragmatic understanding of sustainable development is far more challenging. It is intellectually exciting, even emotionally inspiring, to be among the economists and ecologists exploring the multitude of relationships between economic and environmental systems.[19/] But it is also a period of residual tensions, heightened appreciation of the inherent weaknesses of every conceptual construct for thinking about development, and acute awareness of the need to reach a consensus on how to once again make the connections between values, knowing, and ways of organizing. Because of the local ecological and cultural complexities of tropical rainforests and because of their global importance to biodiversity and climate, picking and following a course of action has been especially difficult. The special challenges of tropical rainforests are explored in Appendix 1.

2.3. At first, economists presumed that this challenge could readily be met through minor elaborations on existing theory. Neoclassical economics is surprisingly malleable. It has been successfully applied to every sector of the economy, every factor of production, as well as to behavioral analyses from the level of the household through bureaucratic organization, and on to national and international politics. Since the market model has also aided our understanding of environmental management and the use of stock resources, achieving sustainable development was perceived as a matter of more fully using and extending thinking along these lines. There seemed to have been good reason to believe that by giving sustainability appropriate emphasis, an economics of sustainability would readily unfold.

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19. Such intellectual excitement can be found in the International Society of Ecological Economics (ISEE) which was formed in 1988 to further understanding between economists and ecologists and develop patterns of thinking and methods of analysis which go around current impasses (Robert Costanza <ed> Ecological Economics: The Science and Management of Sustainability, 1991). This group sponsors the journal Ecological Economics. The World Bank hosted the first international conference of ISEE in May, 1990 and published summaries of the presentations (Robert Costanza <ed>, The Ecological Economics of Sustainability, 1990).

2.4. Efforts to date at combining economic reasoning with sustainability reasoning, however, have not been very satisfying. In other applications, the concept of efficiency has helped explain how an objective can best be attained. But efficiency, at least as understood currently in the economics profession, rather than indicating something about the best way to achieve sustainability, frequently appears to conflict with the goal of sustainability. There is still a strong sense among economic policy makers that environmental objectives are reached at the expense of economic objectives rather than being included among economic objectives. This apparent conflict between efficiency and sustainability has thwarted the advancement of an economics of sustainable development.

2.5. Tropical rainforests provide some of the best examples of this apparent conflict. Of more than 800 million hectares of tropical forests designated for timber production, only about 1 million hectares are now managed on a sustainable basis.[20/] From a narrow economic perspective, the reasons are clear. It is more profitable to cut without managing tropical rainforests for sustainable production because of a combination of factors including: 1) the low number of valuable tree species in the natural forest mix of species, 2) the difficulties of regenerating a reasonably natural mix of species or of controlling the mix at all, 3) slow rates of tree growth, and low prices due to 5) the relatively large global supply of rainforest resources and 6) the substitutability of timber and other rainforest wood products with temperate forest wood products. Thus from a conventional economic perspective, it is wiser to deplete the forest and to invest the returns in more productive ventures. From this perspective, it is efficient to exploit forests in an unsustainable manner. Sustainability and efficiency, as economists typically understand them, seem to conflict.

2.6. Environmental economists argue that much of the contradiction between sustainability and efficiency is due to excessively narrow economic quantification. By including the goods and services provided by rainforests beyond those that are marketed, sustainable management may be the most profitable strategy. The revenues that timber owners and lease holders receive are less than the total benefits of the forest hence they do not manage them to their full potential. Sustainable management, they argue, is more likely viable if external benefits are included in benefit-cost analsyis.

2.7. Thus attempts have been made to measure the values of products used by indigenous peoples[21/], of soil and watershed protection services[22/], and of the future options maintained

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20. Poore, Duncan et al. (No Timber without Trees: Sustainability in the Tropical Forest, 1989, p.196).

21. Charles M. Peters, Alwyn H. Gentry, and Robert O. Mendelsohn (Valuation of an Amazon Rainforest, 1989).

22. Douglas D. Southgate and Robert Macke (Soil Conservation in Hydroelectric Watersheds, 1989).

The sense of a "trade-off" between sustainability and economic efficiency is pervasive, from academe to operating economists and on through to economic reporting to educated laymen. As an academic, economist William Nordhaus has argued publicly that few of the steps proposed to offset potential global climate change have benefits greater than their costs (Greenhouse Economics: Count Before You Leap, The Economist 316<7662> July 7, 1990 pages 21-24). Within working documents of the World Bank, the conflict is expressed in terms such as: "It is possible that it is both economically and financially advantageous to harvest the forest as rapidly as possible. A fundamental question is whether (or under what conditions) 'sustainability' is on the whole economically justified, or does it involve a national sacrifice, and if so, how much?" (Initiating Memorandum, Malaysia Forestry Sector Review, Oct 23, 1990 draft, p. 17). In an article for educated laymen on the possibilities of an international treaty to control greenhouse gas emissions, the "Economist" argues that "The best treaty will aim at the smallest loss in world welfare." (The Economist, January 26th, 1991, page 59). One analysis of the World Bank indicates a synthesis is needed: "The development issue addressed here is whether the concept of 'economic efficiency' should have been defined more clearly and comprehensively to include sustainable growth" (Operations Evaluation Department, Renewable Resource Management in Agriculture, 1989, page xii).

Text Box 1

by protecting biological diversity.[23] In some cases, expanded benefit-cost analyses indeed seem to show that sustainable forest management is efficient.[24] And yet while internalizing externalities certainly increases efficiency, it need not increase sustainability. In the United States, for example, major petroleum resources in the public domain have been left undeveloped, not so much because Americans want to save resources for future generations, but because no settlements have been reached on how to compensate those among the current generation who would most directly bear the environmental costs.

2.8. But even in the cases where more efficient management leads to sustainability, there is a fundamental conceptual contradiction. Valuations of non-market goods and services are based on the preferences of the current generation and benefits accruing to future generations are discounted in net present value calculations to reflect what they are currently worth. to the extent expanded benefit-cost analyses "make the case" for sustainable forest management, they do so on the basis of the interests of current generations. Sustainability reasoning, on the other hand, weights current and future generations more or less equally. It is this key difference that suggests it will be far more effective to think of sustainability as a matter of intergenerational equity.

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23. Jeffrey A. McNeely (Economics of Biological Diversity, 1988) and John A. Dixon and Paul B. Sherman (Economics of Protected Areas: A New Look at Benefits and Costs, 1990).

24. Charles M. Peters, Alwyn H. Gentry, and Robert O. Mendelsohn (Valuation of an Amazonian Rainforest, 1989); Gregory Hodgson and John A. Dixon (Logging versus Fisheries and Tourism in Palawan, 1988).

3. SUSTAINABILITY AS INTERGENERATIONAL EQUITY

3.1. The apparent conflict between sustainability and efficiency is resolved by thinking of sustainability as a matter of intergenerational equity. Different intergenerational distributions of rights result in new efficient allocations of resources and environmental services, different patterns of consumption and investment, and different factor and commodity prices including different interest rates. The appearance of a conflict is an artifact of a long history of not incorporating equity in economic thinking. The overlap between economic and equity reasoning is illustrated in Figure 2. Environmental, forestry, and resource economists to date have basically tried to work only in the area that is diagonally striped, ignoring the horizontally striped area that includes equity considerations. Clearly the overlap between economic and environmental reasoning is greater when equity considerations are included.

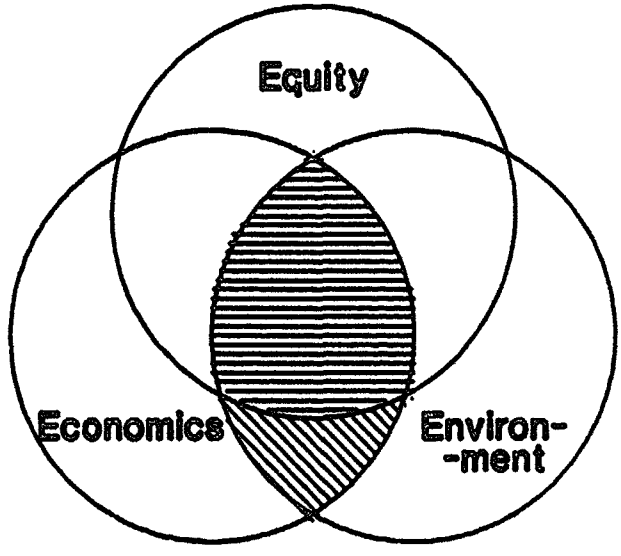

Figure 2

3.2. While economists have concentrated their efforts on the efficient use of resources, environmentalists have consistently argued that societies need to consider how much resources they are leaving for future generations. The dialogue is over the distribution of rights to resources and environmental services between generations, not over how efficiently this generation exploits its current rights.[25] Thus the dialogue appears to juxtapose questions of efficiency and questions of equity. But by acknowledging that the efficient intertemporal allocation of resources depends upon the intergenerational distribution of rights to resources, this apparent conflict disappears.

3.3. For non-economists, the relationship between equity and efficiency can be illustrated as follows. Imagine two developing countries with identical land resources, produced capital goods, population levels, and educational levels. In country A, capital, land, and education are distributed relatively equally among the populace, while in country B they are distributed very unequally. Imagine that markets work perfectly in each country so that resources are efficiently allocated to produce the goods demanded in each country. But because of the differences in the distribution of resources, levels of income vary more in country B, resulting

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25. Quite a few economists have approached the question of the long term but most have backed away. Talbot Page is one of the few economists who has seriously contemplated economics over multiple generations (Conservation and Economic Efficiency, 1977).

in different goods demanded. Resources, for example, might be allocated to the production of rice, chicken, and bicycles consumed widely by all in country A while in country B resources are allocated to beans for those with few resources and to beef and cars for those with many. Both economies are efficient, but the efficient allocation of resources to goods and services depends on the initial distribution of resources among people.

3.4. Many economists ignore the fact that there are multiple efficient solutions depending on how rights are distributed and have repeatedly referred to "trade-offs" that have to be made between efficiency and equity. There are certainly trade-offs between who benefits under one distribution and who benefits under another. Efficiency, however, is a measure of how well a goal is being met. Different goals such as growth regardless of equity or growth within certain equity constraints can each be met efficiently or not. The conflation in the literature has occurred because economists have implicitly assumed that maximum growth of GNP notwithstanding of the inadequacy of the measure, of how it is generated, and of who receives it is the primary goal and that greater efficiency allows you to reach that goal. Any other goal is then seen as a constraint on the primary goal and hence a limitation on efficiency. This is then referred to as a trade-off between efficiency and the other goal. While this conflation has become customary in economic discourse, it is theoretically incorrect. In political discourse it relegates all societal goal besides raw GNP growth to a secondary status, as things which conflict with efficiency which is always best.

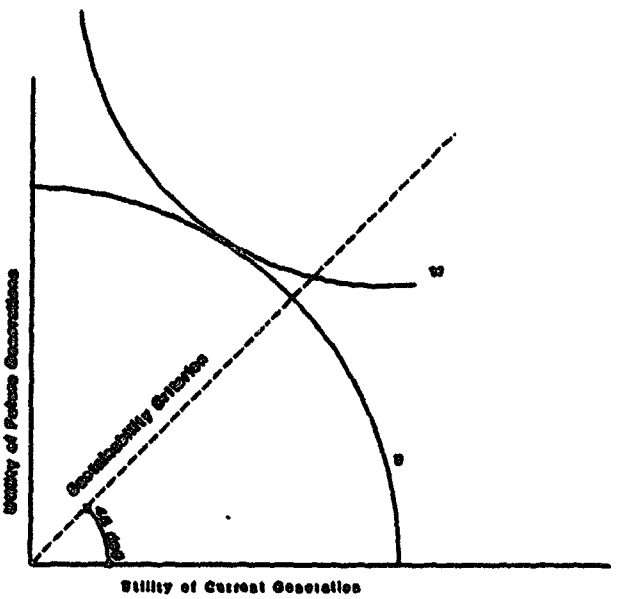

Figure 3

3.5. The relation between intertemporal allocative efficiency and the intergenerational distribution of resource and environmental rights is illustrated in Figure 3.[26] The utility possibility frontier U indicates the highest utility possible for people in future generations for any given utility of people in the current generation, and vice versa. Each point on this frontier results from an efficient allocation of resources associated with different distributions of resource rights of caring between generations. Points within the frontier represent inefficient allocations of resources. Clearly, there are many possible efficient allocations. Where a society is located

26. This diagram is the final step in a more complete elaboration developed by Francis Bator (The Simple Analytics of Welfare Maximization, 1957) graphically illustrating the sequence of relationships between distribution, production, utility, and welfare.

on U is determined by the initial distribution of rights to productive assets, including natural assets. While Figure 3 is limited to only the present and the future, the relationships between distributional equity and allocative efficiency are fully elaborated in Appendices 2 and 3 through mathematical models of overlapping generations. These models, of course, are also simplifications, but they explicitly document that while efficiency is important in that it puts society on the utility frontier, the sustainability of development is entirely a matter of whether it is above the 45° line, i.e. a matter of the distribution of productive assets or caring across generations.

3.6. While Figure 3 is very simple, it illustrates an important point. Nearly all of the economic literature to date on sustainability stresses the importance of internalizing externalities. Development is conceived as a process of spurring economies to go faster; sustainability is conceived as a process of perfecting how economies work. Perfecting how economies work, however, will move the economy toward the efficiency frontier but may not make it any more sustainable. Thus we have the unfortunate situation where economies are still being stimulated, even the already developed economies, while sustainability waits for a perfection of market performance that has never yet been achieved and is unlikely to lead to sustainability if it is.

3.7. A few economists, realizing that sustainability is a matter of intergenerational equity, advocate constraints on the use of resources and environmental systems by the current generation.[27] The constrained optimization advocated, however, is analogous to moving toward the efficiency frontier illustrated in Figure 4 but stopping at a vertical line, the environmental constraint on the current generation. To be effective, the constraint must be with respect to what is passed on to future generations. The current generation should be constrained to operate above the 45° line.

3.8. The best point on the U frontier in Figure 3 or 4 would be at the tangency with an intergenerational welfare function. Such a welfare function, of course, has never been revealed to economists. When it comes to equity decisions, economists must work with politics. The tenor of the political discourse certainly indicates that sustainability is at least a minimum intergenerational criterion on which there is broad consensus. While economists cannot determine how resource and environmental rights should be distributed across generations, they can more effectively engage in policy dialogue and assist countries make their own decisions if they understand sustainability as a matter of assuring that assets are available to future generations.

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27. Herman Daly advocated limiting resource use throughput and impositions on the environment beginning in the early 1970s and was roundly criticized for being an environmental determinist (Toward a Steady State Economy, 1973). In the late 1980s, David Pearce, writing with numerous other authors (see bibliography), began to argue that sustainability and efficiency were not necessarily compatible and that efficiency should be constrained by environmental and resource limits to protect future generations. By taking up the argument later and not being specific about what the constraints might be, Pearce seems to have avoided the attacks absorbed by Daly.

3.9. This distinction between treating sustainability as an intergenerational equity objective rather than as a technical constraint may appear to be unnecessarily subtle, but it is quite important for several reasons. The intergenerational framing elaborated through general equilibrium models in the next section documents how the apparent conflict between economic and environmental reasoning is to a large extent an artifact of the particular course along which economic thinking evolved. Treating sustainability as an equity objective rather than as a technical constraint constructively reframes environmental, forestry, and resource economics (elaborated in section 4) as well as capital theory (sections 6 through 8). Economic understandings which appear to conflict with the goal of sustainability are eliminated by taking an intertemporal general equilibrium approach which incorporates intergenerational equity and the nature of resources together. This approach, furthermore, identifies the importance of bequest and other motives and their supporting institutions for maintaining environmental systems and conserving natural capital.

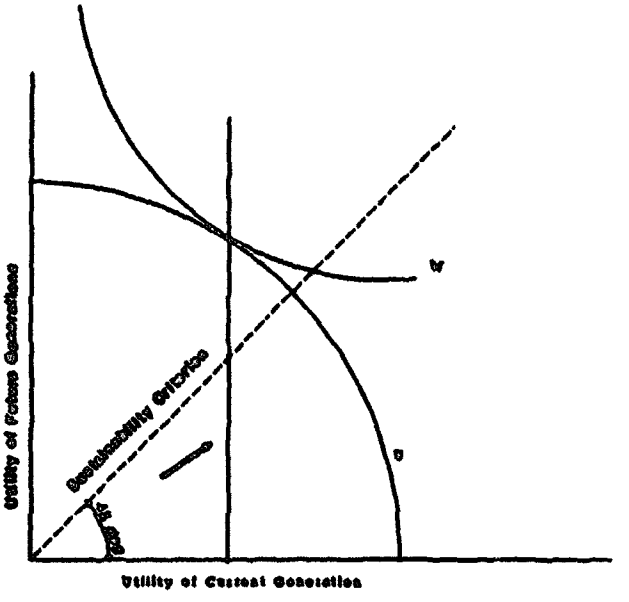

Figure 4

4. REFRAMING ENVIRONMENTAL, FORESTRY, AND RESOURCE ECONOMICS

4.1. Economic theory and practice will take some time to evolve around the broader, intergenerational equity framework outlined in Section 3. While the particular ways in which theory and practice might evolve are difficult to predict, the equity framework clearly identifies how prior thinking and practice in economics evolved too narrowly. The most powerful contribution of the broader framing is the perspective it provides for critically assessing the evolution of the subdisciplines of economics most directly concerned with resource use.

4.2. While agricultural, environmental, forestry, and resource economics respond to public concerns for the long run, they do so without questioning the existing intergenerational distribution of rights. In the context of Figure 3, these subdisciplines have primarily addressed inefficiencies in resource allocation due to market imperfections which leave the economy operating within the utility frontier. Solving such imperfections will in some case move the economy toward sustainability, in other cases not. Indeed, corrections of market failures and other exercises in "getting the prices right" that are undertaken without redistributing rights to the future, under some circumstances, actually could reduce social welfare.

4.3. Since L.C. Gray's article in 1913 and Harold Hotelling's formulation of 1931, economists have pondered how exhaustible (stock or depletable) resources should be used over time. With the energy crisis of 1973/4, economists renewed their attention to the efficient allocation of exhaustible resources. Students of resource economics are now well aware of the "Hotelling Rule" that the rent from a stock resource being exploited "optimally" increases at the rate of interest.[28] The logic behind this rule is simply that a rational resource owner will maximize the net present value of the resource. If all owners deplete their resources rapidly, prices and rents fall. If all leave the resource in the ground, prices and rents rise rapidly. A solution results relative to other investment opportunities. If resource rents are increasing more slowly than the rate of interest over time, resource owners would be better off depleting the resource faster and putting the rent into other investments which yield the rate of interest. If rents are increasing faster than the rate of interest, than leaving the resource in the ground is the best investment. Given these incentives, the equilibrium solution results in rents increasing at the rate of interest. As a "thought experiment" and pedantic device for getting students to think about resource use over time, Hotelling's argument has been extremely effective. But with modest complications in the assumptions, rents no longer rise at the rate of interest. Furthermore, efforts to explain historic mineral prices on the basis of Hotelling's reasoning have been unsuccessful.[29]

4.4. The literature repeatedly refers to the path of extraction from such "thought experiments" as the optimal path. The paths explored to date, however, have been merely efficient paths associated with the existing intergenerational distribution of rights to resources. Howarth and Norgaard recently demonstrated with a partial equilibrium, overlapping generations model how the efficient path of resource exploitation changes under different distributions of resource rights between generations.[30]

4.5. A general equilibrium, overlapping generations model elaborated in Appendix 2 demonstrates how the efficient path of depletable resource exploitation relates to transfers of income from one generation to the next. This model uses multiple overlapping generations to explore the effect of different levels of transfers between generations on allocative efficiency. The model includes a depletable resource, produced capital, and labor. Table 1 presents numeric results with a simple two generation, three time period model with different levels of transfers

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28. Rents, also referred to as royalties, are revenues minus costs.

29. Hartwick, Kemp and Ngo (Set Up Costs and the Theory of Exhaustible Resources, 1986), Robert D. Cairns (Geological Influences, Metal Prices, and Rationality, 1990), Gabriel Lozada (Irreversible Investment and the Conservationist's Dilemma, 1991), and Hossein Farzin (The Time Path of Scarcity Rent in the Theory of Exhaustible Resources, 1991) demonstrate how quickly the "Hotelling Rule" breaks down. T. D. Agbeygbe (Interest Rates and Metal Prices Movements, 1989; The Stochastic Behavior of Mineral-Commodity Prices, 1991) and Halvorsen and Smith (A Test of the Theory of Exhaustible Resources, 1991) document how poorly the Hotelling Rule fits historical data for non-renewable resources.

30. Richard B. Howarth and Richard B. Norgaard (Intergenerational Resource Rights, Efficiency, and Social Optimality, 1990).

from the first generation to the second. Each solution is efficient, but different levels of transfers (*TR*) result in different allocations of the stock resource (*R*), with correspondingly different resource price schedules (ρ) and hence different levels of consumption (*C*) for each generation for each time period and utility (*U*). While the differences in the price paths appear to be modest, with no transfer resource prices increase nearly 300% over the three periods, while with considerable transfer they increase only about 60%. As modeled, the transfer needs to be at a level of at least 1.5, or approximately 65% of the second generations consumption, for utility to be sustained.

Table 1
Three Period, Two Overlapping Generation, Stock Resource Economy Under Alternative Income Transfers Between Generations

TR	0	0.5	1	1.5	2	2.5	3	3.5
U_1	1.73	1.53	1.32	1.10	0.89	0.68	0.46	0.24
U_2	0.19	0.52	0.83	1.13	1.43	1.72	2.00	2.28
C_{11}	1.40	1.25	1.09	0.93	0.75	0.58	0.40	0.21
C_{12}	2.14	1.86	1.59	1.32	1.05	0.79	0.53	0.28
C_{22}	0.14	0.42	0.70	0.97	1.24	1.51	1.78	2.05
C_{23}	0.27	0.66	1.00	1.33	1.64	1.95	2.25	2.54
R_1	2.26	2.07	1.92	1.79	1.67	1.57	1.48	1.41
R_2	1.62	1.64	1.66	1.69	1.72	1.74	1.77	1.79
R_3	0.12	0.29	0.42	0.53	0.61	0.69	0.75	0.81
ρ_1	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27
ρ_2	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.35
ρ_3	0.58	0.48	0.45	0.44	0.44	0.44	0.44	0.44

4.6. One of the most interesting and contentious issues of natural asset management over time has centered on the question of "when should trees be cut?" In 1849, Faustmann determined the "optimal" rotation period for logging a forest by reasoning that the landowner "should" maximize the net return to forest land. This results in the following formula:

$$\max \pi(t) = p_e V(t) e^{(-it)} - \int_0^t r e^{(-is)} ds$$

where t is time or rotation period, p_e is the expected stumpage price, V(t) is the biological production function (or yield) function for standing timber, i is the landowners discount rate, r is the annual rental return on the land and s is a variable of integration.[31] The formula has been expanded to incorporate, among other things, changing demand for timber, the possibilities for shifting between species, technological change, and non-market factors. But the initial premise of net present value maximization from which the basic formula and subsequent elaborations derive implicitly assumes that the current generation holds the land rights, unencumbered by obligations to or concern for future generations. The Faustmann formula has the property that if the value of the resource does not grow, on average, faster than the rate of interest, then harvest without replacement is optimal. This, indeed, is characteristic of tropical rainforests. but if future generations have rights to particular species, to species diversity, or even to the availability of timber at all, from the forest, then the current generation would have to maximize its net present value subject to these constraints imposed by the rights of future generations.

4.7. A general equilibrium model of an economy is presented in Appendix 3 consisting of a renewable asset that grows like trees (*R* for the stock, *H* for the harvest), human produced capital (*K*), and labor. The model is run for twenty generations overlapping through twenty-one periods. Net present value criteria are used to efficiently plan consumption (*C*) and savings invested in both trees and produced capital. Though net present value criteria are used, concern for future generations is modelled by including a fraction of the utility of the younger generation in the utility of the older generation. Some of the results for selected years are presented in Table 2. An income transfer (*TR*) is made from old to young each time period which maximizes net present value of utility. While each solution is efficient, capital and trees accumulate over time and the consumption of subsequent generations is higher when "relative concern" for the next generation is higher.

4.8. While this is simply a numeric example, the three cases very nicely illustrate that if people do not care very much about the next generation (0.5), assets get used up. When they care a little more (0.75), consumption is sustained. And when they care equally (1.0), substantial and sustainable growth takes place. Note how the path of the price per unit of harvest resource, *p*, is different with different levels of caring for the future. The model also

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31. This formula is elaborated further in a paper summarizing forest economics prepared for the World Bank by William F. Hyde and David H. Newman (Forest Economics in Brief -- and Nine Summary Observations for Forest Policy Analysts, November 1990).

Table 2.
Renewable Resource Economy with 20 Overlapping Generations Over 21 Periods

period→	0	4	8	12	16	20
Older Generation's Utility Augmented by 0.5 of Younger Generation's Utility						
C_1	0.47	0.19	0.13	0.11	0.09	0.09
C_2	0.94	0.37	0.26	0.21	0.19	0.19
S	0.61	0.20	0.14	0.11	0.10	0.00
K	1.00	0.24	0.15	0.11	0.10	0.07
R	2.00	1.10	0.72	0.53	0.41	0.15
H	1.04	0.58	0.38	0.28	0.22	0.15
p	0.32	0.30	0.34	0.38	0.43	0.48
TR	0.57	0.13	0.08	0.06	0.05	-0.01
Older Generation's Utility Augmented by 0.75 of Younger Generation's Utility						
C_1	0.41	0.40	0.40	0.41	0.42	0.55
C_2	0.54	0.53	0.54	0.54	0.55	0.73
S	0.97	0.93	0.94	0.93	0.86	0.00
K	1.00	0.93	0.94	0.93	0.89	0.49
R	2.00	2.19	2.21	2.21	2.11	1.03
H	0.77	0.87	0.89	0.89	0.92	1.03
p	0.40	0.36	0.35	0.35	0.34	0.26
TR	0.92	0.87	0.87	0.87	0.89	0.15
Older Generation's Utility Augmented by Full Amount of Younger Generation's Utility						
C_1	0.20	0.40	0.63	0.90	1.26	2.11
C_2	0.20	0.40	0.63	0.90	1.26	2.11
S	1.43	3.82	6.19	7.46	6.40	0.00
K	1.00	3.18	5.67	7.30	6.98	2.62
R	2.00	2.79	2.86	2.84	2.73	1.55
H	0.57	0.95	1.00	1.01	1.06	1.55
p	0.48	0.51	0.61	0.64	0.62	0.34
TR	1.22	3.50	5.93	7.38	6.69	1.31

illustrates that with development based on renewable resources, concern for the next generation can be sufficient to assure sustainability. Unlike the Faustmann formula which is solved for a single growth period which is always optimum, this model harvests trees of different age at different time periods. The model is further explored in Section 5 in the context of the discount rate controversy and is more fully elaborated in Appendix 3.

4.9. Biological resources can be exploited in a non-renewable manner since extinction is not reversible. Exploitive patterns of renewable resource use are frequently associated with the breakdown of institutions for common property management. The literature in environmental economics, however, also identifies the conditions under which it is "socially" efficient to exploit a species to extinction.[32/] Environmental, forestry, and resource economists have argued that efficiency rules may err in favor of excessive use by the present generation due to the existence of non-market factors. There is now a well developed literature on methods for valuing non-market environmental services and numerous applications have been undertaken.[33/] Such approaches frequently do show that non-market goods and services have considerable value and that when these are included in economic analyses, the efficient path of resource use frequently shifts towards the future. But as a general means for assuring resources for future generations, expanding economic analysis to incorporate how this generation values non-market goods and services will not necessarily result in their being saved for the future. The coincidence between method and policy outcome may be largely due to the prior decision with respect to which non-market goods and services are valued and included in the expanded analysis. In any case, ultimately, we are concerned with maintaining natural assets for future generations because we sense that <u>they</u> will need these assets, not because <u>we</u> somehow value them.[34/]

4.10. Many societies, however, have already determined, largely by noneconomic reasoning, in other social decisionmaking arenas that future generations have rights in particular species,

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32. Peter Berck (Open Access and Extinction, 1979); Anthony C. Fisher and W. Michael Hanemann (Endangered Species: The Economics of Irreversible Damage, 1985), and David W. Pearce and R. Kerry Turner (<u>Economics of Natural Resources and the Environment</u>, 1990, pp.268).

33. Maynard M. Hufschmidt, David E. James, Anton D. Meister, Blair T. Bower, and John A. Dixon (<u>Environment, Natural Systems, and Development: An Economic Valuation Guide</u>, 1983).

34. This raises the awkward question as to the extent to which <u>we</u> value natural assets is already a reflection of our concern for the needs of future generations. Perhaps survey techniques could be used to determine the willingness of people in this generation to save natural assets so that future generations, rather than current generations, could utilize them. In some sense, the attempts at "option" valuation have this characteristic. On the other hand, environmental economists are least confident of deriving benefits for things which people themselves do not experience and about which they are unlikely to be informed (V. Kerry Smith, Can We Measure the Value of Environmental Amenities, 1990). More importantly, even if people could express such "values", are they not better considered a reflection of the welfare function than something that should be included in an efficiency analysis?

The difficulties of interpreting valuations of non-market goods undertaken in the context of the current intergenerational distribution of property rights can be illustrated as follows. One might propose to assess how people value biodiversity by undertaking an investigation of the willingness of tourists to pay the costs of travel to see the wildlife in the game reserves of east Africa or the tropical forest reserves of Costa Rica. But if future generations really had rights to biodiversity, it would be very difficult to assure their rights without drastically reducing the emission of greenhouse gases, hence reducing international travel. The ways in which a few rich people now enjoy biodiversity may be significantly restricted if future generations had biodiversity rights. Such travel cost valuations would provide interesting insights into how much people were willing to pay today, but what is there meaning in a sustainable world?

One thing is clear. If sustainability is being chosen, rights are being reassigned, and ecotourism will not be significant in a sustainable future, then certainly investments should not be made in ecotourism today based on the willingness of people to pay under the current distribution of rights.

Text Box 2

leaving the current generation without the right to exploit these species to extinction. International accords to protect endangered species and other agreements have also been made which limit the rights of and impose responsibilities on current generations. Whether it is "optimal" to extinguish a species is not simply a matter of determining whether its net present value is positive. While economic valuations provide insight, such values result from how economies operate within rules which are constantly changing through an interplay of decisions made within social arenas using different value systems, patterns of reasoning, and criteria.

4.11. The valuation of non-market goods and services is very important for assessing projects and policies from a public perspective. If the public's perspective, however, is that future generations should have more rights than they do now, then valuation should be undertaken in the context of how the economy would behave if those rights were honored. The models developed in the Appendices and presented in Tables 1 and 2 in this section have different prices, and hence values reflected in areas under demand curves, in accordance to how much people care about the future. Economic values derive from how markets work under alternative institutional situations. When societies choose which institutions they prefer, values can be assessed. Values determined under inappropriate institutions tell us little about what institutions are appropriate. This is somewhat analogous to the current practice in benefit-cost analysis of valuing inputs and outputs at the costs and prices that would occur if the economy were not distorted by inappropriate government policies. The prices that result under inappropriate governmental policies only inform us of the need for appropriate policies relative

to the prices that would occur under appropriate policies.[35]

Expanding benefit-cost analysis by incorporating non-market values better informs the investment decision but does not correct the market failure. If the market failures are actually corrected or internalized, the economy will behave in such a way that the social benefits will actually be realized. Internalizing externalities results in all prices changing somewhat in response to the new good on the market. Thus expanded benefit-cost analysis is helpful, but internalizing externalities is even more helpful because the economy adjusts and becomes more efficient.

The situation is similar with the transfer of rights to future generations. Imagining how the economy would operate if future generations had more rights facilitates better project analysis and helps distinguish between investments and transfers. Actually transferring the rights and letting the economy adjust to the distribution of rights is even more effective. Ultimately, sustainable development requires the actual transfer and enforcement of rights of future generations or equivalent concern for the future that affects current behavior.

Text Box 3

4.12. Efficiency and caring for the future are not incompatible. The use of a general equilibrium model incorporating the relationship between intergenerational rights to assets and efficiency opens up environmental, forestry, and resource economics to a new framing of the future. These subdisciplines have implicitly constrained their analyses historically to the existing distribution of rights. As suggested in the introduction, this selective use of theory was compatible within the progressive institutional context in which economists found themselves during most of this century. The discourse over sustainability, however, is changing economic objectives as well as the institutional contexts in which economists work.

5. THE DISCOUNT RATE CONTROVERSY

5.1. The international discourse on sustainable development was initiated by natural scientists, environmentalists, and others concerned with the maintenance of favorable environmental conditions over the long run. While the long run might be as little as ten to twenty-five years in most economic analyses, the long run for geologists is millennia and for biologists it is at least many generations. The discourse was joined by people concerned with cultural survival who also think in terms of multiple generations. This difference in outlook toward the future is critical. Participants in the discourse over sustainability are intensely aware that the standard economic practice of discounting benefits received and costs borne in the future automatically closes off the future. By framing sustainability as intergenerational equity, economics opens

35. Both the use of "equity" prices and "efficiency" prices raise analogous issues with respect to the use of comparative statics when the real challenge is to determine the best path of adjustment.

up to the future. With this reframing, the discount rate itself can be shown to be a function of how each generation cares about the next.

5.2. No doubt there exists an economist who has never experienced the slightest moral qualm over discounting the benefits to be received and the costs to be borne by future generations. Both the academic literature and discussions within development agencies, however, reflect considerable unease.[36] With lower discount rates, it appears more investments in forestry and a larger stock of standing forests would be justified, favoring sustainability. Similarly, it appears on preliminary analysis that lower rates of discount favor using stock resources more slowly. Thus many people concerned with the environment see a strong link between the rate of discount, resource conservation, and the sustainability of development.

5.3. Two strong theoretical arguments have been developed with respect to why society should use a discount rate that is lower than the interest rates observable in private markets. First, the rate used may be too high because market interest rates include individual risk factors which are frequently only transfers between individuals from the perspective of society.[37] Second, transfers to future generations may have a public good quality. Parents who assure that their own offspring have access to resources in effect assure the availability of these resources to their offspring's spouses and children and to the economy overall.[38] These and other arguments have led many economists to conclude that lower discount rates may be appropriate.

5.4. Within development agencies there has been particular concern for forestry projects. Many trees take a long time to grow. Tropical forests can regain nearly their natural diversity after harvest, but a century may be needed. Because many species of trees reproduce at less than current rates of interest, it is financially unprofitable to grow them. Thus foresters and environmentalists concerned with sustainable forestry have advocated using lower rates of interest to evaluate forestry projects.

5.5. The arguments against using lower rates of discount in order to favor future generations appear equally strong. Resource use and environmental transformations are undertaken in conjunction with produced capital. Labor used in resource development and environmental transformation is also treated as a capital cost since the development or transformation is seen

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36. The wide felt concern about discounting distant future benefits and costs was recently documented in The Economist (Anonymous, What Price Posterity?, 1991). The academic literature on discounting is reviewed in the context of the question of sustainability in a World Bank working paper by Anil Markandya and David Pearce (Environmental Considerations and the Choice of Discount Rate in Developing Countries, 1988), in several of the various recent books coauthored by Pearce, and by Richard B. Norgaard and Richard B. Howarth (Sustainability and Discounting the Future, 1991).

37. Kenneth Arrow and Robert C. Lind (Uncertainty and the Evaluation of Public Investment, 1970).

38. Stephen A. Marglin (The Social Rate of Discount and the Optimal Rate of Investment, 1963).

as capital. Thus lower rates of interest make resource development and environmental transformation relatively less expensive and hence likely to be accelerated.[39] Low interest rates favor the investments necessary to transform diverse tropical rainforests into single species plantations. A low interest rate policy benefits future generations about the same way that a cheap food policy benefits the poor when most of the poor are farmers.

5.6. By reframing questions of the future in terms of the intergenerational distribution of rights to natural and other assets, the case for using lower discount rates to protect future generations becomes moot. If societies want to protect future generations, they should assure their rights or otherwise care for them more. When they do, the investment opportunities for and savings of current generations, and hence the interest rate, change accordingly. The interest rate is endogenous in the economy based on a stock resource exploitation simulated in Appendix 2 and the economy based on renewable resource presented in Appendix 3. In theory, the rate of interest may increase or decrease in the transition to sustainable development, but this is unimportant for interest is simply an equilibriating price. What is important is that the types of investments and transfers to future generations change. For the models derived in Appendices 2 and 3, Table 3 and 4 below shows that interest rates decrease with the transition to sustainability.

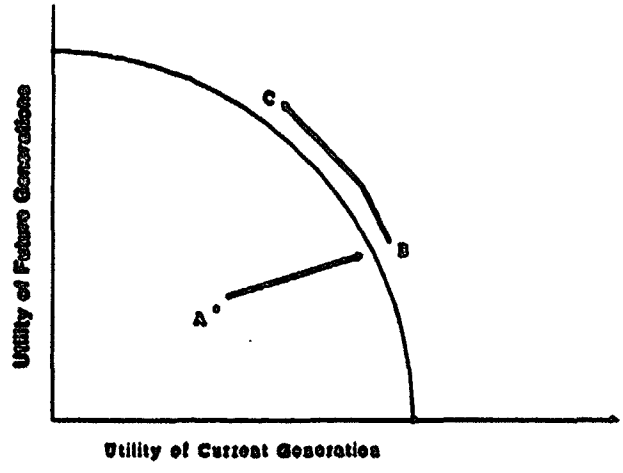

Figure 5

5.7. Transfers of rights to future generations are equity decisions, movements along the efficiency frontier from point B to point C in Figure 5, made in accordance with social welfare criteria. For the simulated economies, these would be movements from one level of transfer or caring to another. The benefits to future generations from shifting from one level of concern to another are not discounted. When comparing projects intended as investments, the returns are discounted.

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39. Since stock resources are usually exploited in conjunction with capital, lower interest rates can lower the cost of capital and thereby lower the cost of production such that more is consumed in early time periods relative to if interest rates are higher, see: Richard L. Gordon (Conservation and the Theory of Exhaustible Resources, 1966); Y. Hossein Farzin (The Effect of the Discount Rate on Depletion of Exhaustible Resources, 1984); John M. Hartwick, Murray C. Kemp, and Ngo Van Long (Set-Up Costs and the Theory of Exhaustible Resources, 1986); and Gabriel A. Lozada (Irreversible Investment and the Conservationist's Dilemma, 1991).

Table 3
Endogenous Rates of Interest in Stock Exploitive Economy

TR	0	0.5	1	1.5	2	2.5	3	3.5
U_1	1.73	1.53	1.32	1.10	0.89	0.68	0.46	0.24
U_2	0.19	0.52	0.83	1.13	1.43	1.72	2.00	2.28
r_1	0.44	0.43	0.41	0.40	0.40	0.39	0.38	0.37
r_2	0.53	0.49	0.45	0.42	0.40	0.37	0.35	0.33
r_3	0.96	0.57	0.44	0.37	0.32	0.29	0.26	0.24

Table 4
Endogenous Rates of Interest in Renewable Resource Economy

period→	0	4	8	12	16	20
Older Generation's Utility Augmented by 0.5 of Younger Generation's Utility						
C_1	0.47	0.19	0.13	0.11	0.09	0.09
C_2	0.94	0.37	0.26	0.21	0.19	0.19
r	0.34	0.72	0.87	0.92	0.94	1.09
Older Generation's Utility Augmented by 0.75 of Younger Generation's Utility						
C_1	0.41	0.40	0.40	0.41	0.42	0.55
C_2	0.54	0.53	0.54	0.54	0.55	0.73
r	0.31	0.33	0.34	0.34	0.35	0.54
Older Generation's Utility Augmented by Full Amount of Younger Generation's Utility						
C_1	0.20	0.40	0.63	0.90	1.26	2.11
C_2	0.20	0.40	0.63	0.90	1.26	2.11
r	0.28	0.15	0.11	0.09	0.09	0.20

5.8. The models presented in this and the previous section demonstrated that there is nothing intrinsic about economies that ensures that living standards will continue to improve over time or even remain at current levels. The future will unfold from the choices, including sacrifices, made by our ancestors and those we make ourselves. The on-going discussion within the profession of economics and international development agencies as to whether sustainable development and intergenerational equity can be addressed through ad hoc manipulations of the discount rate are rooted in an inappropriate theoretical framing of the choices before us.

Matters of equity should be treated as such. If we are concerned about the distribution of welfare across generations, then we should transfer wealth, not engage in inefficient investments. Transfer mechanisms might include setting aside natural resources and protecting environments, educating the young, and developing technologies for the sustainable management of renewable resources. Some of these might be viewed as worthwhile investments on the part of this generation, but to the extent their intent is to function as transfers, then they should not be evaluated as investments.

The possibility that public issues with respect to the use of resources over time are issues of the distribution of assets across generations has been contemplated but not pursued. Economists on approaching the question of intergenerational distribution have typically reverted back to arguments with respect to the choice of discount rate. Stiglitz (1974:139), for example, argues:

> There is, of course, no presumption that the intertemporal distribution of income which emerges from the market solution will be 'socially optimal' (although in the absence of market failure, the market allocation will be Pareto optimal), just as there is no presumption that the distribution of income among individuals at any moment is 'socially optimal'. But this is a problem which is not peculiar to the allocation of natural resources over time; indeed, if there were no other sources of 'market failure' and <u>if the government correctly controls the rate of interest</u> (emphasis added), then there would be no objection to the competitive determination of the rate of utilization of our natural resources.

Robert Solow (1974:10) also raised the issue of intergenerational distribution and retreated to an argument with respect to the discount rate:

> The intergenerational distribution of income or welfare depends on the provision that each generation makes for its successors. The choice of social discount rate is, in effect, a policy decision about that intergenerational distribution.

Stiglitz argues once again (1979:61):

> ...the appropriate instruments to use for obtaining more equitable distribution of welfare (if one believes the present distribution is not equitable) are general instruments, for example, monetary policy directed at changing the market rate of interest.

The profession's emphasis on the relationship between discounting and future generations took a new twist in a recent reanalysis of discount rates and public investment by Robert Lind (1990: 8-24):

> ... if we are to avoid the type of paradox that in some cases can lead to total neglect of the interests of generations in the distant future, we need to look to new welfare foundations for <u>our theory of discounting</u>" (emphasis added).

Text Box 4

5.9. Distinguishing between investments to meet this generation's consumption time preference and transfers to the next generation will not be easy. To the extent that the distinction can be made, there will be new reasons for concessional aid, especially for the very poor who will not be able to both assure the rights of future generations and provide for their own basic needs. The use of investment criteria based on meeting this generation's consumption time preference is theoretically unjustifiable when it is the future's needs that are at stake.

6. INTERGENERATIONAL ASSET TRANSFERS THROUGH CAPITAL MARKETS

6.1. Economists think of development as a process of accumulating productive capacity. Mathematical models have been derived to explore the conditions necessary between savings, investment, and the productivity of capital to keep an economy on an equilibrium growth path. Institutionally, the development agencies were initially established to transfer produced and human capital. Thus ideas about capital and capital markets are thoroughly embedded in economic understanding of the process of development. The discourse on sustainability is further enriching this understanding of development as capital accumulation.

6.2. In the models developed in the appendices and presented in the foregoing sections of the paper, all markets, including capital markets, work efficiently. With no market failure built into these models, they nonetheless show how the allocation of resources varies with the level of concern for future generations. Even with all markets working perfectly, unsustainable development is possible. Capital markets are working perfectly on all of the points on the utility frontier of Figures 2-4, but only those above the 45° line from the origin are sustainable. Even after environmental externalities are corrected, the existence of perfect capital markets will not assure sustainability.

6.3. And yet, the effectiveness with which assets are transferred to future generations does have something to do with the nature of capital markets. In modern societies, parents forego consumption, save in capital markets, and pass both real assets and financial claims on to their children. Countries with tropical rainforests frequently argue that by cutting the forests down, they can invest in education and industry, diversifying their portfolio, and effectively transfer more to their children. If capital markets are not working perfectly, or in a manner that people presume they are working, then transfers to future generations will not be made as effectively as desired. How well capital markets work can affect how intergenerational transfers are made.

6.4. The theoretical arguments developed in the context of the discount rate controversy by Arrow and Lind with respect to private *vs* public risk and by Marglin with respect to the public good aspect of private transfers (Section 5.4) imply private capital markets may not be as effective as they should be for making intergenerational transfers. The underinvestment indicated by the argument of Arrow and Lind occurs because banks consider private rather than

social risk. This means that the growth of capital and hence the level of transfers of assets between generations is less than optimal. The Arrow and Lind argument suggests that we should be especially concerned with those types of lending that are clearly directed at intergenerational transfers. Loans to help parents educate their children, for example, have higher private than social risk and may deserve special treatment. Marglin's argument that people's concern for their own children benefits other people's children also can affect the sustainability of development. For the renewable resource economy simulated in Appendix 3, greater concern for the next generation is critical to the achievement of sustainability. If people only weight the benefits received by their own children in their utility function rather than the benefits to all in the next generation, the likelihood of sustainability is reduced.

6.5. Comparing the complexity of capital markets today with those of simpler economies indicates an additional problem. Capital markets may not distribute assets to future generations without mechanisms for assuring that assets, especially natural assets, are not being depleted. Imagine a society of near subsistence farmers with rights to land. Parents can improve the quality of the land they transfer to their children by planting tress. Some of the returns from investing in trees are enjoyed by the parents, others go to their children. Whether consumption is foregone and investments are made to increase the parents' welfare or to meet the parents' objective with respect to a transfer to their children would be difficult to distinguish. Wealth, of course, does not simply accumulate continuously. Some parents choose to cut trees and transfer less to their children than they had themselves received from their own parents. Natural disasters and war set the process back periodically. And the total amount that can be accumulated at any given time is limited by the cultural knowledge, technologies, and nature of cooperation in the society.

6.6. A new element must be added to the parable. Parents might save in order to invest in a bigger saw with which they could easily harvest all of their trees. Note that the saw as capital is rather different than trees. The saw provides a return by reducing natural tree capital whereas trees provide services while maintaining themselves. The parents might choose to reduce their consumption in early time periods to buy the bigger saw in order to have more consumption in later time periods, but they would not invest in more saw-capital if they were interested in accumulating assets to transfer to their children. Most importantly, parents know whether they are investing in trees which will provide a transfer to their children or in saws which will not and can readily monitor the effects of their choices on their cumulative assets.

6.7. The parable, of course, is highly stylized. In reality, social relations are always more complex and vary dramatically between societies. The story is too simple. But the point remains that people in simpler societies are typically closer to the resources they seek to manage and in a better position to monitor the overall set of assets on which they depend.

6.8. Western style development -- whether capitalist, socialist, or mixed -- distances savers from their investments through complex, roundabout chains of markets and/or planning and

control systems.[40] In modern societies, transfers of real assets in terms of land, housing, and factories still constitute a significant portion of the total, but individuals are increasingly trying to meet their transfer objectives through financial claims to assets or through the state. Do financial markets and state-managed transfer mechanisms in modern societies serve the dual role of pooling and allocating savings to enhance the utility of current generations given their consumption time preferences and of pooling and allocating their savings to meet their transfer objectives as well? Parents investing in financial markets basically only see interest rates, not whether real assets actually still exist to transfer to their children. One might argue that the value of a corporation's stock would decline as it cuts its trees, but corporations can and do move on to other forests to deplete. No one sees the global picture like the stylized farmers in the parable. The discourse on sustainability is about the global picture. Even if all parents individually realize they are investing in saws which are deforesting on net, they may continue to do so if they have no alternative but to hope that the returns from their investment can be reinvested again to the benefit of their children even if they can see that all in the further future are losing on net.

6.9. Economists frequently argue that as particular resources become relatively scarce, their prices will rise, signalling consumers to use less and investors to invest in their regeneration or the production of substitutes. In the case of natural resources, whether or not markets function in this manner efficiently depends on resource allocators having a global overview of resource availability, technology, and future demand.[41] As noted in section 5, the efficient price paths explored theoretically in the literature to date assume the current generation holds all of the rights and does not redistribute to future generations. How investors might foresee future demand given that they are both investing to meet their own commodity time preference and investing to transfer to future generations, thereby changing future demand, presents an interesting dilemma.

6.10. Nevertheless, one might still argue that those who are especially concerned about the welfare of their children can invest directly in and hold natural resources themselves. Those who are more worried can take care of their own children, and if their worries are justified,

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40. The theme that modern economies are complex and things get done by "roundabout" processes was an important element of economic thinking between 1880 and 1930. In particular, Böhm-Bawerk and other Austrian capital theorists stressed the concept in an effort to incorporate time in their production functions (summarized by K. H. Hennings, Roundabout Methods of Production, 1990). Kenneth Boulding writing as a broad-thinking economist (The World as a Total System, 1985) and Anthony Giddens writing as a sociologist (The Consequences of Modernity, 1990) argue that "distancing" in space and time of people from the consequences of their actions is a key characteristic of modernity.

41. These critically important conditions for efficient exhaustible resource markets are well stated in the treatise by Partha Dasgupta and Geoffrey Heal (Economic Theory and Exhaustible Resources, 1979) and the text by Anthony C. Fisher (Resource and Environmental Economics, 1981). When such an global overview is not available, the price path is not stable. These conditions and their consequences are not discussed in the important new text by David W. Pearce and R. Kerry Turner, op cit.

their children will be wealthy indeed. Private markets will still work so long as some people are concerned, and these people will demonstrate how others should best behave. In response to this position, however, it is clear that individuals cannot easily directly own the diverse different types of resources from around the world on which modern life depends, to say nothing of also having sufficient control of the technologies and organizations necessary to combine them into products. While we think of capitalism as a system which promotes individualism, in fact our fates and those of our children are highly interconnected through complex webs over which we have no control. This interconnectedness speaks to the need for collective monitoring, and perhaps collective guidance, of the stock of assets.[42]

6.11. There is nothing in the nature of market economies *per se* which guarantees that investors seeking to accumulate assets will not deplete the natural capital they would choose to transfer to their children if they could monitor and guide the global situation. This argument addresses the same issues of those concerned that natural assets and their depletion do not appear in the system of national accounts.[43] Their concern is that planners and/or the electorate who guide the economy ought to know through the accounting system how development decisions made in the recent past actually affect options for the future. If they do not, then the current generation could be living well at the expense of future generations about whose welfare they are really concerned.[44] The two arguments can be thought of as market and planning "duals" of each other. In unguided economies, distributive failure could stem from specialization and trade combined with the difficulty of achieving two objectives, meeting one's own commodity time preferences and meeting one's intergenerational distributive objectives through a single market with basically a single signal. In guided economies, planners can just as likely overinvest in "saws" and underinvest in "trees" if they only look at returns on investments and fail to monitor the mix of the stock of assets.

6.12. Existing arguments for not relying on markets to protect future generations include: 1) environmentally related market failures, 2) the welfare of future generations as a public

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42. Ironically, as centrally planned economies switch to markets, general equilibrium theorists posit that for markets to work efficiently over time with exhaustible resources, allocators must either depend on a central planner for correct and coordinated information or sufficient of them must themselves have a central planner's global view of resources, technologies, and demand well into the future.

43. Yusuf Ahmad, Salah El Serafy, and Ernst Lutz (Environmental Accounting for Sustainable Development, 1989; see especially the chapter by El Serafy), Herman Daly and John Cobb (For the Common Good: Redirecting the Economy Toward Community, the Environment, and a Sustainable Future, 1989), and Robert Repetto *et al* (Wasting Assets: Natural Resources in the National Income Accounts, 1989). The United Nations Statistical Office is currently taking the lead on the development of environmental accounting.

44. This problem is not unique to natural assets. A society could also be investing in acetylene torches to "mine" the steel in highway bridges or investing in bureaucracies which employ people with doctorate degrees in ways which result in their losing the capabilities they had acquired.

good, and 3) the problems of irreversibility and the advantages of maintaining a breadth of options for future generations whose preferences are unknown. Distributive failure may exist apart from and in addition to any of the the foregoing. The likelihood of distributive failure implies that the full gains from specialization and exchange, whether through capitalist or socialist institutions, cannot be obtained without asset monitoring, and probably guidance as well, to assure that distributive objectives are met. It must be borne in mind, however, that the information and management costs of asset monitoring and guidance necessary for the sort of optimization typically envisioned by economists may imply that alternative institutions or a mix of institutions less oriented toward optimization may achieve higher levels of welfare.

6.13. As elaborated in Appendix 4, international development agencies are already monitoring and guiding the use of natural assets. The concept of distributive failure presented in this section indicates that more intensive monitoring may well be justified. Equally importantly, the development agencies as participants in the planning of investments in both "saws" and "trees" and the multinational banks as the holders of financial assets and participants in the investment decisions of their member countries should systematically develop and base their decisions on a global view.

7. THE TRANSFER OF NATURAL AND OTHER ASSETS TO FUTURE GENERATIONS

7.1. The simple diagram of Figure 3 can be modified to that presented in Figure 6 to elaborate how the transfer of assets between generations may have declined. Historically, the vast majority of natural assets were transferred from one generation to the next because people simply did not have the technology to deplete resources. But the transfer also occurred because parents knew their children's survival depended on the same resources as did their own. Institutions also helped assure the sustainable management of resources used in common. Thus, in addition to the transfer of natural assets, the transfer of cultural assets -- human produced capital, knowledge, and successful ways of organizing -- from generation to generation also assured sustainabil-

Figure 3.2

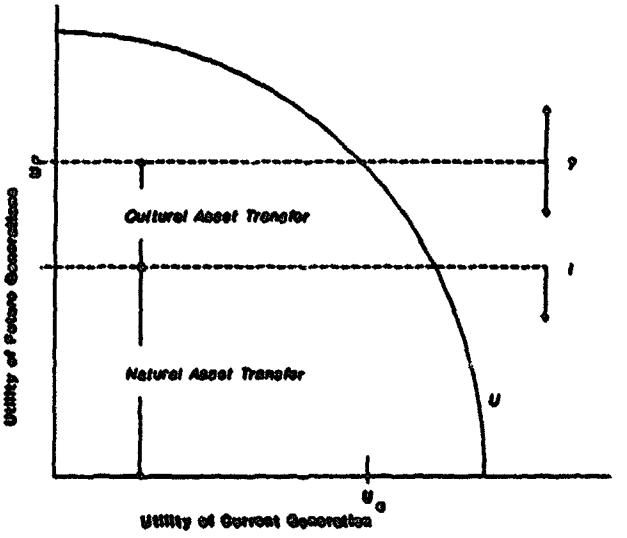

Figure 6

ity.[45] While not every culture was sustainable historically, many were for long time periods. For these societies in these periods, the combination of natural and cultural assets transferred put them to the left of the 45° line.

7.2. When economists have pondered whether future generations will have adequate resources, they have argued, with few exceptions, that each generation thus far has become better off materially in spite of resource depletion, largely because of new technologies. In the context of Figure 6, the argument has been that cultural asset transfers more than outweighed any loss in natural asset transfers. As the best quality resources are used up, new technologies allow people to exploit lower quality resources or substitute to other materials. A famous analysis by Barnett and Morse seemed to document that the cost of obtaining resources had declined for nearly a century, indicating that resources were becoming more available rather than less, at least through 1957.[46] Though studies undertaken during the late 1970s and early 1980s indicated that resource costs and prices had begun to increase, apparently indicating increasing scarcity, economists still frequently cite the study by Barnett and Morse to justify technological optimism.[47]

7.3. Though the use of arguments using economic indicators of resource scarcity is commonplace in economics, such arguments are logically fallacious. Costs or prices can only be interpreted as indicators of scarcity in the contexts of the resource extraction models of Ricardo or Hotelling respectively. These models assume resource allocators are informed of resource scarcity. If they are informed, than their allocations and the resulting costs or prices will reflect the scarcity. If allocators are informed, however, economists could simply ask them whether resources are scarce or not. If allocators are not informed, the indicators will reflect their ignorance. There is no way to determine whether allocators are informed of resource scarcity or not unless those undertaking the analyses know themselves whether resources are scarce, which, is the very answer they hope to attain by the analyses in the first place.[48]

7.4. The general equilibrium framing developed in this paper indicates another reason why price or cost paths say little about scarcity. The multiple efficient solutions described in the models presented in section 4 have different price and cost paths in accordance with how

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45. The illustration in Figure 6 and the argument in the text suggests that natural and cultural assets are additive and that one can substitute for the other. Within limits this may be true, but certainly some of each are ultimately necessary.

46. Harold Barnett and Chandler Morse (Scarcity and Growth: The Economics of Natural Resource Availability, 1963).

47. The key later studies include Margaret E. Slade (Trends in Natural Resource Commodity Prices: An Analysis of the Time Domain, 1982); and Darwin C. Hall and Jane V. Hall (Concepts and Measures of Natural Resource Scarcity with a Summary of Recent Trends, 1984).

48. Richard B. Norgaard (Economic Indicators of Resource Scarcity: A Critical Essay, 1990).

much people care about the future. The transfers made by parents, the forest conservation policies of national governments, and other factors affect economic indicators. For this reason, it is inappropriate to look to economic indicators to see whether resources are scarce. The indicators may not reflect scarcity, not because resources are not scarce, but because people have established institutions to redistribute resources in light of their scarcity. If those institutions are weakened because economists interpret their beneficial affect on prices as the absence of scarcity, resource use will accelerate and sustainability will suffer.

7.5. Early empirical work on the contribution of natural assets to current income in developing and developed countries is suggestive if not definitive with respect to the sustainability of development.[49/] A study by Repetto *et al* of petroleum depletion, deforestation, and soil loss in Indonesia indicates that what appears to be a steady four fold increase in gross domestic income in Indonesia between 1971 and 1984 may actually have been a highly erratic though apparently declining income after resource depletion is included in the analysis.[50/] Daly and Cobb argue that sustainable economic welfare in the United States probably deteriorated slightly between 1970 and 1980 and appears to have deteriorated by somewhat more than 1% per year in the 1980s.[51/]

7.6. Thus whether societies are transferring more or fewer assets to future generations is still very much an empirical question in search of an adequate conceptual framing. The evidence is mixed. Certainly technology has advanced. But industrial development, modern lifestyles, and even modern ways of organizing are closely tied to the net oxidation of hydrocarbons at the heart of the problem of global climate change. Thus much of the cultural assets available to future generations are likely to be inappropriate. Many resources are not being

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49. One of the major difficulties in environmental accounting is that resource qualities and technology are closely interrelated. One can only be defined in the context of the other. As technology changes, qualities which were not appreciated before, and hence not thought of and inventoried as resources, become resources; see Richard B. Norgaard (Resource Scarcity and New Technology in U.S. Petroleum Development, 1975) and Richard B. Norgaard and Gwo Jiun Leu (Petroleum Assessibility and Drilling Technology: A Case Study of U.S. Petroleum Development from 1959-1978, 1986).

50. This study by Repetto, Magrath, Beer and Rossini (op cit) valued assets in terms of current market rents, i.e. current market prices less production costs. Income after adjusting for resource depletion varied tremendously due to oil price changes, so much so that the adjusted income losses all meaning. The problem is that relatively minor changes in market prices, when applied to the full stock of resources, result in very large changes in calculated income. Clearly, when supply and/or demand for a natural resource product are inelastic, relatively small changes in supply or demand will have large effects on price. Such price changes are necessary to equilibrate the market in that time period, but yearly price changes should not be used to value natural assets. Indeed, the price of farmland does not vary as much as the price of farm products, especially after deducting production costs, because investors in farm land realize most price changes are temporary. This study highlights one of the complexities of valuation.

51. Herman E. Daly and John B. Cobb (op cit, appendix).

transferred now because we have the technologies and levels of population to degrade resources we could never degrade heretofore. New technologies, ways of organizing, and population levels have created a need for transfer institutions which were not needed before. What little theoretical work has been done on the importance and nature of intergenerational transfers is probably insufficient to support significant empirical forays.[52]

7.7. Social scientists are beginning to formally document how colonization followed by efforts at Western style development broke down both the traditional mechanisms of managing resources. Many have argued that the new institutions and technologies which replaced the earlier cultural capital hastened the rates of exploitation, assuring that there would be less to transfer. Colonial, and later national, governments assumed central control over forest resources in particular, both opening them up to commercial exploitation for international markets and closing them down to use by local peoples. The introduction of market incentives into village life shifted the incentive from savings in the form of land maintenance and improvement to savings in the form of monetary assets and Western-style human capital.[53]

8. SUSTAINABILITY AND CAPITAL THEORY: DILEMMAS OF ASSET AGGREGATION

8.1. This discussion paper, like many other economic treatments of sustainability, argues that the assets -- the natural, produced, and human capital -- in each time period or generation must be at least as productive as that in the preceding period or generation. While this formulation has great intuitive appeal, aggregating capital, even simply produced capital, has proven difficult for numerous reasons. If knowing whether development is sustainable depends on

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52. Ralph C. d'Arge and Clive Spash (Economic Strategies for Mitigating the Impacts of Climate Change on Future Generations, 1991) John Cumberland (Intergenerational Transfers and Ecological Sustainability, 1991) and Talbot Page (*op cit*, Sustainability and the Problem of Valuation, 1991) seem to be the only other economists beginning to frame questions in this manner.

53. The number of social scientists working in this area is now sufficiently large that there are established, though still very much overlapping, schools of thought. The largest focuses on institutions, typically at the community level, which have historically managed common property resources. Economists have worked actively with sociologists in this effort, reviewed in a World Bank Discussion Paper by Daniel Bromley and Michael Cernea (The Management of Common Property Resources, paper #57, 198x). A second group, under the rubric of political ecology, concentrates on national and international institutions. Representative works include: Piers Blaikie (The Political Economy of Soil Erosion in Developing Countries, 1985), Michael Redclift (Sustainable Development: Exploring the Contradictions, 1987) and Vandana Shiva (Staying Alive: Women, Ecology, and Development 1988). A third group, who have assumed the name of "environmental history" combine the thinking of the first two and concentrate on historical documentation. The works by Ramachandra Guha (The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya, 1990; Madhav Gadgil and Ramachandra Guha, An Environmental History of India, 1991) are excellent examples from the developing world of the work underway in the area of environmental history. Donald Worster (The Ends of the Earth: Perspectives on Modern Environmental History, 1988) and Carolyn Merchant, The Death of Nature: Women, Ecology, and the Scientific Revolution, 1980) are leaders in the field in the developed world.

actually determining whether aggregate capital is increasing, a review of the controversies in capital theory is in order.

8.2. Capital is heterogeneous. Some assets have short lives, some long; some produce evenly over time and then suddenly expire, some produce proportionately less over time and whither away; some, like trees, have long start up times, produce different products over their lifetimes, and then can be harvested during any of a number of years. The typical approach to aggregating across capital of different lifespans and productivity time paths entails summing the net present values of each of the assets over their lifetimes. This method fits our understanding of how sales prices for corporations with multiple capital assets are determined. This approach, however, runs into difficulties when applied to economies as a whole.[54]

8.3. The Cambridge-Cambridge controversy is still unresolved. Though empiricists have yet to find the argument significant, the controversy has highlighted the fact that aggregation rules are necessarily based on assumptions about the nature of economic systems which may prove contentious.[55] In particular, the controversy highlights the complexities introduced by the relationships between production techniques and capital aggregation, complexities which parallel the difficulties of valuing natural assets independently of technology. How can things be valued and compared when they are inherently interrelated, i.e. not separate things? New conventions will have to evolve to work with the dilemmas of measuring and comparing separate natural, produced, and human assets when they, in fact, are inseparable.

8.4. The Cambridge-Cambridge controversy stressed how values change moving between equilibria points. On the presumption that the transition to sustainability will entail a significant shift in the economy, this aspect of the controversy is important. Thinking back to the utility frontiers between current and future generations of earlier diagrams, the measurement of aggregate capital at an interior point (such as A), the closest efficient point (B), and the welfare maximizing point (C) will all be different because they use different rates of interest and prices.

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54. Richard B. Norgaard (Three Dilemmas of Environmental Accounting, 1989) and Norgaard (Linkages between Environmental and National Income Accounts, 1989). Many of the same issues appear in Henry M. Peskin with Ernst Lutz (A Survey of Resource and Environmental Accounting in Industrialized Countries, 1990).

55. Joan Robinson argued that since the total quantity of capital in an economy at a particular time, how capital is used over time, and how capital services are aggregated all depend on the rate of interest, there is a possibility that the relationship between aggregate capital and the rate of interest is not monotonic. When this phenomena is combined with the possibility of backward bending supply curves for labor, the relationship between the capital intensity of different techniques used at different interest rates is not smooth. There is, in effect, the possibility of switching and reswitching between techniques of production as interest rates decline or rise relative to wages. And if this is the case, very different, i.e. incomparable, bundles of capital are being discussed at only somewhat different interest rates. The Cambridge-Cambridge controversy is reviewed from at least half a dozen perspectives in John Eatwell, Murray Milgate, and Peter Newman (eds) (The New Palgrave: Capital Theory, 1990).

At point B, the total assets passed on to the next generation will be less than those enjoyed by the current, at point C the total assets passed on to the next generations are greater than those enjoyed by the current, but one cannot compare the aggregate values of assets at points B and C as they would be measured at their respective points. Due to price effects associated with the scarcity of natural assets and the change in the rate of interest, the aggregate value passed to the next generation at B could be greater than the value at C and yet B clearly would still not be sustainable. The net present value of assets can stay the same or even increase when both the flows and the rate of interest decrease. Thus environmental and resource accounting relies on a monotonic relationship between capital and the rate of interest much the same as does the concept of aggregate capital for aggregate production functions.

8.5. Aggregating capital may blur whether sustainability is possible for another reason. Generation One might pass trees on to Generation Two with a net present value equal to the assets Generation One received. But if these trees need to grow another 30 years and can only have the stipulated value if they in fact are not used until Generation Three, then the rule does not lead to sustainable development. In short, the time period during which capital can be used is critical to our understanding of sustainability but are blurred through aggregation.

8.6. From the perspective of sustainability, emphasis must be placed on the continuity of flow, not some measure of aggregate value. In this sense, each generation is obligated to pass on to the next a mix of assets which provides equal or greater flows to the next generation without greater effort on that generation's part to provide the same for the next. Given a choice between several possible assets, the appropriate question is "how well does an asset's flow of services match with those of existing assets to meet the welfare objectives for each generation?"

8.7. Following the energy crisis of 1973-4, several economists used growth models with both aggregate physical capital and exhaustible resources to explore the conditions for sustainability. Out of these explorations emerged what has become known as the "Hartwick" rule which states that consumption can remain constant in the face of declining availability of exhaustible resources so long as the rents from the exhaustible resource are invested in renewable capital.[56] While these models were touted at the time and have been since as evidence that the development can be sustained in the face of natural resource exhaustion, in fact, closer analysis reveals that these models only identify the importance of substitutability. So long as a renewable form of capital can substitute for the depleted natural capital for all pro-

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56. See: Robert M. Solow (Intergenerational Equity and Exhaustible Resources, 1974), John M. Hartwick (Substitution Among Exhaustible Resources and Intergenerational Equity, 1978), A. Dixit, P. Hammond, and M. Hoel (On Hartwick's Rule for Regular Maximin Paths of Capital Accumulation and Resource Depletion), and Partha Dasgupta and T. Mitra (Intergenerational Equity and Efficient Allocation of Exhaustible Resources, 1983). Salah El Serafy arrived at effectively the same rule starting from accounting principles (The Proper Calculation of Income from Depletable Natural Resources, 1989, and letter of April 19, 1991 to El Serafy from Hartwick).

ductive purposes, development can be sustained.[57] Common sense indicates that if something is not essential, its demise is not critical. These growth models illustrate why the role of natural capital in sustainability often hinge on the extent to which natural capital is special.

8.8. For economists, comparison and aggregation are greatly simplified by valuation. Sustainability requires, however, that equal attention must be given to the mix of specific assets and the timing of their flow of services. Though the aggregate measures of economists will no doubt assist in the overall assessment, the limitations of capital aggregation explored in this section provide excellent justification for sustaining development in part through the protection and transfer of particular types of assets as determined by noneconomic reasoning.

9. THE CHALLENGE TO ECONOMIC PRACTICE

9.1. The practice of economics and the organizational environment in which economists work evolves with social concerns and the theory used to address them. There is every reason to believe that economic practice will evolve to the extent sustainability is a matter of designing new and bolstering existing institutions to transfer assets. And yet the history of the practice of economics documents that the methodological stance of positivism has clearly selected against serious involvement with questions of equity. Sustainability challenges the profession to better adapt to work in the political arenas in which many of the decisions about which assets should be saved for future generations and how institutions should be augmented to maintain and transfer assets are being made.

9.2. The international development agencies were initially conceived in the progressive vision as mechanisms for transferring knowledge, technology, and capital from industrial nations to the less developed world. In this formulation, the United Nations agencies provided advice on specific issues and the international banks assessed specific development projects proposed for loans. Economists helped select, on the basis of efficiency criteria, what should be presented to agency governing bodies and developing governments for consideration. Unique recommendations are obtained, most typically, by implicitly assuming the current distribution of rights, both within and across generations. Development economists were initially seen as working apart from politics, independently assessing and advising on separate things, with the flow of information clearly going from North to South. The evolution of environmental, for-

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57. For stock resources which do not have substitutes, economists have built models in which resource use asymptotically goes to zero and output is maintained, but these rely on a Cobb-Douglas specification in which the average product of the stock resource goes to infinity as use goes to zero. Harold J. Barnett and Chandler Morse (op cit) also argue that substitution has been a key factor relieving scarcity. Following this argument, some economists have argued that resources with high elasticities of substitution cannot by definition be scarce. Paul R. Ehrlich tackles economists' reliance on substitution arguments from the perspective of environmental science (The Limits to Substitution: Meta-resource Depletion and a New Economic-Ecological Paradigm, 1989).

estry, and resource economics in North America took place in a very similar organizational environment. Interpreting sustainability as a matter of correcting market failures fits nicely within this organizational role. Taking the existing distribution of assets as given, of course, has been an equity stance, but few among the public at large knew sufficient economics to effectively expose this position.

9.3. The practice and organization of development economics, however, did evolve. Advice giving agencies have become integrally involved in national planning and institution building as well as in project formulation and implementation. Advice with respect to separate specific things made little sense. Yet in spite of continuing efforts to initiate development projects and policies correctly, it is commonly acknowledged that international efforts to promote development fall short because the institutions established lose direction, knowledge transferred is not retained and disseminated, educational facilities soon lack teachers, and irrigation projects are not maintained. Efforts to address this problem have led the international agencies in contradictory directions -- to try in some cases to devolve responsibility to local communities and nongovernmental organizations and in other cases to assume broader responsibility themselves, centrally directing aid in response to how well nations are managing projects and maintaining institutions.

9.4. Concern over the sustainability of development has accentuated the issue of development maintenance. When environmental institutions have high "decay rates", environmental monitoring and protection will soon be inadequate. Industrial projects require sustained maintenance and management to keep pollution levels low. Forestry projects require a balance between growth and cutting as well as road building and erosion control that can easily tip the wrong way when management is not sustained. Modern agriculture requires sustained research simply to maintain levels of productivity because pests overcome the resistance bred into modern varieties. Sustainable development requires sustained, day to day, appropriate interaction with the complexities of ecosystems. Unlike the progressive vision, development is not a process of figuring things out and setting them up correctly once and for all.[58]

9.5. Formulating sustainability as an equity decision also confronts positivism directly since economists can no longer sort between development possibilities using efficiency criteria rooted in the current distribution of rights between generations. If the economy could be moved from B to C in Figure 5 with a few legislative changes in a matter of years, economists could "wait out" the transition and then undertake conventional efficiency analyses after a new regime of rights was established. In fact, there is no reason to expect the transition to sustainability will be quick.

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58. The significance of sustaining development for the World Bank, for example, has been described by the Operations Evaluation Department (Renewable Resource Management in Agriculture, 1989).

Economists work with at least three different perspectives *vis a vis* politics:

Classical - legislative bodies are necessary for making decisions with respect to equity, economics can inform political decision-makers how alternative legislative decisions will affect different groups and how to improve efficiency given equity decisions. Economics is interactive with politics.

Technocratic Progressive - economics narrows the political agenda by pre-screening inefficient options, encourages good politics by identifying best options, generates objective information for policy-makers, and indicates how to implement legislative mandates efficiently. Economics should replace politics to the extent possible.

Neoconservative - voting and other participation in collective activities is irrational, most "do-gooders" are rent seekers exploiting the public's naive faith in collective action. Economics shows that politics reduces social welfare.

This paper assumes the first stance: that societies are politically viable; that political decision-making is a balancing of moral arguments about the type of future people want, not simply another method of allocating between individual material wants; and that the role of economic analysis is to better inform polities of the economic implications of alternative decisions. The second position, however, is the most common position that economists assume and the stance assumed in benefit-cost analysis. In this view, politics is mostly another way of balancing competing material interests which can be done more effectively by simulating how markets would work. The third position is that of the "new" neoclassical economists such as James Buchanan who assume that moral arguments are simply ways of fooling the public into bending the rules bent to favor particular economic interests.

Text Box 5

9.6. Assuring the rights of future generations will be an on-going, complicated process. To some extent it will be a matter of determining and protecting the local and national mechanisms -- cultural, market, and public -- that already exist for transferring assets to future generations. Legislative decisions to protect individual species, set aside land for national parks, establish soil conservation agencies, and limit pollution can be interpreted as efforts to protect the rights of future generations. Judicial branches of government will reinterpret legislative law and develop rationales for decisions in new areas. International accords such as the Montreal Protocol to protect the ozone shield clearly limit the rights of current peoples in order to protect the assets of future peoples. An international greenhouse gas accord of much greater significance is likely. The international agencies have been mandated to promote sustainable development on a project by project basis. And international agencies, national governments, and non-governmental organizations have joined in the Tropical Forestry Action Plan to save tropical forests for future generations through a complex administrative process. The principle that future peoples have rights to human capital in the form of education and health are equally important and assured by a combination of shared ethics, constitutional clauses, national legislation, and international accords which established United Nations agencies to promote these ends. In

short, the rights of future generations will be protected by an incoherent, constantly evolving, pastiche of formal legislation and informal agreements. Economists might be able to help make them more coherent, but it would be naive to presume that the rights of future generations will be assured by a few simple rules. We can expect the process to be represented by the zig-zag path from A to C in Figure 7.

9.7. Given that many decisions of great economic importance will be made in non-economic decisionmaking arenas, what should be the role of economists? Economists need not be simply reactive, technocratically responding to new rules aimed at intergenerational equity made in other arenas. A higher portion of economists might take proactive roles, closer to the classical liberal view of the interdependence between economics and politics. Economists should actively propose what they think are the best methods for protecting the interests of future generations and question the effectiveness of proposals put forth by others. They should openly participate in the political discourse through which the strategies for achieving sustainability are being selected. This, however, would require a significant shift in the stance these economists take toward political and other social decisonmaking processes.

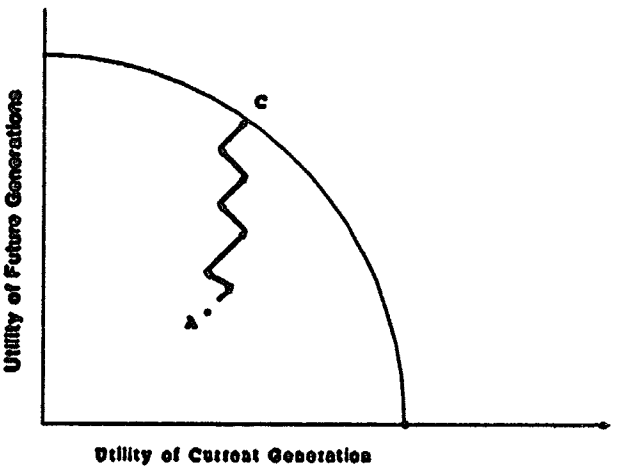

Figure 7

9.8. The technocratic progressive stance, in which economists see their role as keeping politics on track through the use of effiency arguments, is still dominant. In the last decade, there has been a significant rise in the number of neoconservative economists taking the view that any form of collective activity is irrational. More recently, however, some economists have joined with other social scientists to reinvigorate the classical position.[59]. In the classical view, markets, politics, administration, and the judiciary are separate social decisionmaking arenas. Decisions within each of the arenas affect the other arenas. Progressive technocratic and neoconservative economists see all decisionmaking as simply a matter of weighing aggre-

59. Amitai Etzioni (The Moral Dimension: Toward a New Economics, 1988) from the perspective of a sociologist primarily concerned with community and equity and Mark Sagoff (The Economy of the Earth, 1988) from the perspective of a moral philosopher primarily concerned with the environment argue persuasively that politics is a form of moral discourse directed at creating the kind of society people desire. Amitai Etzioni has spearheaded the formation of the Society for the Advancement of Socio-Economics to foster communication between economists and other social scientists and to support a "healthier" attitude among economists toward other social decisionmaking arenas.

gate benefits and costs, a process which markets do for individual consumers automatically and arguably as well as possible. In contrast, the classical view stresses how people participating as citizens engaged in the political process use different procedures, languages of discourse, and criteria than they use as consumers participating in markets. In the reviving classical view, people are not simply utility maximizers but rather think and act in different modes as members of families, as citizens of cities, states, and nations; as laborers, professionals, or capitalists; as participants in judicial procedures; as religious beings; and as consumers. And in each of these modes, rather than thinking of decisionmaking as an informed weighing of given preferences, the reviving classical view stresses shared discourse and learning, that contributes to the development of understanding and formation of preferences.[60]

9.9. Classical interpretations of the interplay between people as consumers satisfying their individual wants and people as citizens striving to reshape the world provides considerable insight into the organizational challenge that sustainability presents to the practice of economics. Economists tend to think that decisions in all arenas should meet tests of economic rationality, of a weighing of benefits and costs. But with benefits and costs a function of how rights are assigned, decisions to change rights cannot possibly be put to an economic test. And yet economists can still participate effectively in these other decision arenas. Economists can still assess how different strategies under consideration would actually work if implemented. Efficiency criteria could not be used, but economists could explore how much the current generation might have to forego in order to assure future income. Economics as a pattern of thinking identifies issues that other social and environmental sciences miss. For example, economists might try to predict how national economies will respond and interact globally to alternative rules for greenhouse gas reduction. Economics is critical, not in the sense that it provides criteria by which other arguments are tested, but as one way among many for seeking a larger understanding.

9.10. At an operational level within the existing structure of economic practice, thinking of sustainability as intergenerational equity suggests that development agencies need to be paying more attention to asset maintenance and transfer. In this light, the practice of economics

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60. This "classical" position is also known as "republicanism" in reference to its support for a republican form of government consisting of active citizen-voters. Christopher Lasch (op cit) draws heavily on this distinction in his new left critique of the old left's politics of materialism, wending these concerns deftly with the current perception that unlimited materialism will also destroy the environment that supports us. Also from the political left, Samuel Bowles and Herbert Gintis (Democracy and Capitalism: Property, Community, and the Contradictions of Modern Social Thought, 1986) argue for an expansion of democratic decisionmaking into what are now the economic and administrative realms in part to elevate workers/consumers from mere preference sorters to learning beings. Key republican revivalists nearer the center of political views include: Robert Bellah and diverse cohorts (Habits of the Heart: Individualism and Commitment in American Life, 1985); William M. Sullivan (Reconstructing Public Philosophy, 1986), and Alan Wolfe (Whose Keeper: Social Science and Moral Obligation, 1989). The concerns for community expressed by Herman Daly and John Cobb (op cit) fit this philosophy as well.

Economists would prefer general rules for attaining intergenerational equity which are consistent with current practice and organization. Treating sustainability as a problem of internalizing externalities fits this criteria. For this reason, economists have also been attracted to using a lower discount rate (which has the quality of giving future generations a greater weight) and meeting an aggregate capital objective during each time period. While each of these have some merit, they are inadequate for the reasons developed in sections 4-8.

In reality, political processes will bolster sustainability through a collage of legislation protecting specific areas and species, prohibiting specific technologies, limiting pollution, encouraging certain types of technologies, changing the broad mandates and structures of organizations, and changing incentives for individual behavior. Economists should interact in this process and argue for fewer, more general rules. But to the extent that resources and environmental systems have few substitutes, general rules break down. And to the extent that sustainability is about this generation's concern for the qualitative direction of development, not simply assuring some abstract bundle of wealth, general rules will be shunned.

If this indeed is the reality, economists might still participate constructively in the political process by informing political actors of the implications of alternative proposals individually and in combination. It will not be possible to rank them by efficiency criteria, but the political process still deserves the understanding economists have of economies as systems.

Text Box 6

needs to shift from concern with efficiency to concern with both efficiency and transfers. Considerable background work is needed which might best start within or be fostered by the international development agencies themselves. These include:

9.10.1 Analyses of Transfer Institutions. Both historical and cross cultural analyses of the effectiveness of alternative institutions affecting how assets have been transferred between generations are needed. Economists, and more recently anthropologists, historians, political scientists, and sociologists, have made very important contributions to our understanding of institutions for managing environmental systems. The linkages between how institutions affect environmental management and how they affect bequests to future generations need to be understood and to become part of political discourse. Such analyses need to be undertaken on a country by country basis and within regions for the larger countries. Economists with other social scientists in international development agencies could initiate such analyses and demonstrate their importance. On-going research might then best be undertaken by academics supported by national governments and nongovernmental organizations. Development strategies should then be designed to favor those institutions which are supporting the transfer of assets and discourage those which are not.

9.10.2. Analyses of Current Levels of Asset Transfer. While there is now widespread con-

cern that development is not sustainable, existing data on services from natural and other assets are inadequate and methods for aggregation are not appropriate. The efforts by the United Nations Statistical Office to develop environmental and resource accounting data and methods could be augmented with greater efforts by other development agencies. Environmental accounting methods and ways of using the data will evolve best through experimentation. As per the arguments developed in Section 8, methods for assessing yearly flows from multiple assets rather than the aggregation of assets are especially needed. Development strategies should be formulated in light of what can be known about the levels of asset transfer.

9.10.3. Evolution of Rules for Appraisal of Projects with Transfer Components. Projects will be seen increasingly as having two components: an investment component which should provide a return to current savings and a transfer component designed to help meet intergenerational equity objectives. The distinction between these two components, however, will rarely be clear. Rules, analogous perhaps to the rules for the division of costs between joint products in financial analyses, will need to be developed through experience and rational discourse within the agencies.

9.11. Increasingly, international development agencies will become involved in transfers of financial capital with the primary aim of promoting intergenerational equity. The objective of the new Global Environmental Facility jointly run by the World Bank, United Nations Development Programme and United Nations Environment Programme is to provide financial transfers from industrialized nations to developing nations to protect biodiversity, limit greenhouse emissions, and protect the ozone layer. If the capital endowment of the Facility is substantially increased, it could become a major player in facilitating the transfers needed for sustainable development.

9.12. Whether participating in political and other decision arenas or working within development agencies, economists will find themselves striving for optima which are not consistent with the limited data, the unreliability of environmental institutions, the vulnerability of managers, and the vagaries of nature. Questions concerning the interactions of social and environmental systems over long time periods are inherently complex, the likelihood that optimization reasoning will err on the unsafe side are high, and the consequences are likely to be very costly. To the extent this characterizes the search for sustainability, there is good reason to seek minimum regret solutions and safe minimum standards.[61]

9.13. In all of these roles, the international agencies can assist by contributing to the global view necessary for the efficient distribution and allocation of exhaustible resources.

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61. S. V. Ciriacy-Wantrup (Resource Conservation: Economics and Policies, 1968) and Charles A. Perrings (Reserved Rationality and the Precautionary Principle: Technological Change and Uncertainty in Environmental Decision-making, 1991).

9.14. At this stage, relatively little is known about how to transfer capital to another nation and assure that global objectives are met. With sufficient North-South transfers or debt cancellation, for example, the tropical rainforest nations may indeed establish very effective controls on deforestation. Northern economies, however, may choose to accelerate economic activity in order to support the transfer. And the transfers may also stimulate energy intensive development in the South. Both effects could contribute even more to global warming and ultimately to the loss of biodiversity. Transfers between generations and between North and South may have little effect in the medium to longer run if there are few new technologies and only a narrow field of development strategies between which nations can choose. There is good reason to believe that transfers can contribute to a solution, but they are probably not a solution in themselves.

9.15. While successful middle and upper income participants in the modern global economy have less control over the process of asset transfer, the poor increasingly simply have nothing to transfer. The more than a billion people, approximately 20% of the world's population, living on less than one U.S. dollar per day must necessarily worry about their immediate needs. About as many people have higher standards of living but insecure title to the resources they manage, reducing their incentive to manage them well for their children. Drought, floods, hurricanes, and earthquakes disrupt the management and accumulation of natural and other assets periodically for many other peoples. And tribal, civil, and regional warfare interrupt resource management, education, and capital accumulation for millions of others. To a large extent, enhancing the transfer of natural and other assets will require substantial improvements for those most vulnerable now. Intergenerational equity and infragenerational equity are complementary objectives.

9.16. During the rise of industrial development, the question of whether this generation's income was at the expense of the next was subsumed by our faith in technological progress. Future generations would be taken care of by a process of "trickle ahead" much like we once believed that the poor would automatically benefit from development through "trickle down". With the weakening in the faith in progress, "trickle ahead" is openly being questioned. Modern societies have not developed institutions to assure the needs of future generations. Quite the contrary, modernity appears to have broken down previous management and transfer institutions. There is a significant possibility that the growth in income associated with development has come from the use of resources that had heretofore been protected for future generations. The provision of "Future Needs" through natural and other asset management and transfer must become a criterion for development on a par with the provision of "Basic Needs".

9.17. The possible arrival of an international "grants economy" suggests a host of new questions that will need to be explored and new types of practices in which economists need to become involved.

APPENDIX 1

THE CHALLENGE OF SUSTAINING TROPICAL RAINFORESTS

A1.1. Tropical rainforests have attracted the most attention during the international discourse on sustainability because they present the most dramatic and intertwined difficulties. While it is somewhat unfair to sharpen a new conceptualization of the relationship between economics and sustainability on the most difficult problem facing development agencies and third world peoples, thinking about sustainability in the context of tropical rainforests quickly identifies the difficulties of implementing the concept.

A1.2. Concern is greatest for the major forests of the Amazon, the Congo, and Southeast Asia including those in Indonesia, Malaysia and in Laos, Cambodia, and Vietnam. Key contributing factors include:

A1.2.1. Biodiversity. Tropical rainforests are the most species diverse of all terrestrial ecosystems. Our understanding of the total number of species on earth and the proportion in tropical rainforests is unfolding in response to recent concern over the forests themselves, yet it is widely accepted that a very large proportion of the total is in the tropical rainforests. There is a growing consensus that sustainable development will be easier for all with a multitude of species with which to experiment. Strong agruments have been developed that a small percentage of species may prove to have extremely valuable properties which could benefit all, but that we have little or no idea now which species these will turn out to be. Plantation forests and agroforestry with equivalent or higher productivities may serve as alternative assets to the natural forest for purposes of producing wood and pulp, but it is difficult to imagine assets that might substitute for the diversity of species itself.[62]

A1.2.2. Management Intensive. The response of tropical rainforest ecosystems to human intervention and to natural variations in climate and other factors are very difficult to predict. The higher uncertainty in tropical rainforest systems, relative to most temperate zone systems, is due to: 1) the diversity of species, 2) the tighter coevolution and hence greater interconnectedness between species, and 3) the relative absence of stocks of nutrients and water stored in soil which buffer ecosystem dynamics. Ecosystem response uncertainties can be narrowed with more intensive management such as better monitoring, deeper understandings of tropical rainforest dynamics, and engaging in multiple activities at lower intensities. Traditional peoples evolved such management techniques. Tropical rainforests have not responded predictably to the technologies, management strategies, and social organization associated with modern development. The unpredictability of tropical rainforest ecosystems immensely complicates their management and utilization and limits their contribution to economic development as it has conventionally been understood.

A1.2.3. Development Periphery. Because the characteristics of tropical rainforests are relatively incompatible with modern social organization and technology, they have remained on the geo-

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62. U. S. Congress, Office of Technology Assessment (Technologies to Sustain Tropical Rainforest, 1984), U.S. Congress, Office of Technology Assessment (Technologies to Maintain Biological Diversity, 1987), and Jeffrey A. McNeely *et al* (Conserving the World's Biological Diversity, 1990).

graphical margins of economic markets and of government influence. This has meant that transport costs to and from national and international markets are relatively high which, in turn, means purchased inputs to production are costly while the prices of forest products are low. This leaves a low margin of profit for a few commercial economic activities and no margin for most. Though many are interested in the possibilities of intensive management for the multiple potential products of the rainforest, by the very nature of the fact that the rainforests are on the development periphery, intensive management is not likely to be commercially feasible. Thus commercial development tends to result in the harvesting of a few species over extended areas. The resulting highgrading shifts the species mix, frequently driving some species to local extinctions.

A1.2.4. Similarly, only a few services from central governments can be maintained continuously, others can be delivered intermittently, and many cannot be provided at all due to the costs of transportation and communication over sparsely populated land far from national capitals. This results in an asymmetry in the distribution of services available from central governments, or justified given the low return per unit area. For similar reasons, local governments find it difficult to interact effectively with distant central governments. High transactions costs reduce the effectiveness of both participatory and progressive technocratic governance, greatly complicating tropical rainforest development and conservation.

A1.2.5. Tribal Peoples. As a result of the incompatibilities between modern technologies and social organization that have left tropical forests on the development periphery, the forests, by default, are home to a significant portion of the remaining people still organized, economically and socially, along tribal patterns. The rights of tribal peoples to forest resources are rarely well specified and even less frequently enforced by national government. How people in developing and developed nations think the rights of tribal peoples should be specified and enforced differ dramatically according to the extent to which they believe tribal peoples should be able to determine their own course of development, building on their own cultural and ecological base, or believe tribal peoples will choose, or must inevitably accept, the cultural premises and environmental transformations of modern development.

A1.2.6. Climate Change. The tropical rainforests contain a significant portion of the global carbon sequestered in living biomass. Deforestation is estimated to contribute 14% of the greenhouse gases that contribute to global climate change.[63] At the same time, reforestation in wet tropical regions is understood to be one of the most cost-effective ways of delaying greenhouse warming. The fact that tropical deforestation is currently a significant source of greenhouse gases while the forest could become a significant sink makes it one of the most interesting variables in the climate models.[64] There is increasing evidence that large scale deforestation affects regional climates as well[65].

A1.3. The difficulties of managing tropical rainforests have been elaborated in the context of the interrelationships between ecological complexity and socio-economic systems. It is important to bear

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63. World Resources Institute (World Resources 1990-91, p.24. 1990).

64. Intergovernmental Panel on Climate Change (Climate Change: The IPCC Response Strategies, 1991)

65. Eneas Salati (The Forest and the Hydrological Cycle, 1987).

in mind that there are many more interrelationships and that many of them entail positive, or amplifying, feedback loops which make prediction, policy prescription, and management extremely difficult.[66]

A1.4. The foregoing characterization of the special features of tropical rainforests highlight the difficulties of assigning resource rights to current generations, let alone future generations. There is an on-going international debate, for example, as to whether nations or all peoples have rights to the benefits of genetic diversity of the rainforest. While this debate rages in part because of different ethical interpretations, there are tremendous practical difficulties of assuring that the gains go to nations or to all peoples as a whole rather than to the multinational corporations that are likely to patent products originating from the biological properties discovered in the rainforest.[67] The importance of biodiversity raises questions such as whether future generations should have rights to genetic properties, individual species, and specific types of ecosystems? Or should future peoples have rights to something more general and, if so, how should this be defined and measured. The existence of tribal peoples dramatically raises the issue as to whether the rights of future generations should be vested in all peoples within a nation or whether particular peoples might be given particular rights, challenging the concept of nationhood itself. And the global importance of the rainforests to climate highlights the problem of whether rights to species will be adequate and whether the rights and responsibilities to future generations will not have to be specified in terms of carbon stored in biomass as well.

A1.5. The complexities associated with our interactions with tropical rainforests challenge the very way in which Western thinking, including neoclassical economic theory, conceive of rights. Many have argued that the concept of obligations which was historically linked to the concept of rights needs to be relinked.[68] Obligations or responsibilities may be expressed as restrictions on rights which merely limit what one can do in the market. Restrictions in themselves run counter to the libertarian evolution of the idea of rights in the West. Regardless of the dominance of rudimentary conceptions of the privileges of property, rights are complex and highly evolved in most societies, developed or not. Obligations, beyond being more highly defined rights, may entail periodic positive benevolent actions in and beyond the market place. Obligations as positive acts may require institutions in addition to markets. Thus, though this paper presents its arguments largely in terms of the "rights" of future generations, rights should not be interpreted too simply. In fact, the concept of rights assumes that nature can be divided up into parts and assigned as property, a preconception that may in fact contribute to the problem.[69]

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66. The complexity of the interrelationships and a number of amplifying feedback loops are elaborated by Norgaard (Sociosystem and Ecosystem Coevolution in the Amazon, 1981). Stephen Bunker has also explained the failure of development in the Amazon in a systems context (Underdeveloping the Amazon, 1985).

67. The difficulties of assigning rights to genetic resources are explored from the perspective of developing countries by Calestous Juma (The Gene Hunters:xxx, 1989)

68. Edith Brown Weiss, *op cit*, and Brian Norton, *op cit*, among others make these points.

69. Richard B. Norgaard (Environmental Economics: An Evolutionary Critique and Plea for Pluralism, 1985).

APPENDIX 2

AN INTERGENERATIONAL COMPETITIVE EQUILIBRIUM MODEL OF A NON-RENEWABLE RESOURCE ECONOMY

A2.1. Consider an economy with an arbitrarily large finite number of overlapping generations $g = 1, 2,... G$, each of which lives for two periods. The first generation is born in period 1 and a new generation is born in each successive period so that the g th generation lives in periods g and $g+1$. For simplicity, assume that each generation consists of homogeneous individuals who can be represent as a single agent. There is a single consumption good C and the consumption levels of the g th generation in periods g and $g+1$ are C_{gg} and C_{gg+1}. Each generation has a utility function $U_g = U_g(C_{gg}, C_{gg+1})$ which is concave, monotonically increasing, and differentiable.

A2.2. A single firm produces a homogeneous output in periods $t = 1,2,...,G+1$ using labor (L_t), capital (K_t), and a nonreproducible natural resource (R_t) according to a constant returns to scale production function $f_t = f_t(L_t, K_t, R_t)$ that is monotonically increasing, differentiable, and concave. Assume further that production is zero when the levels of all inputs are zero so that $f_t(0,0,0) = 0$. Note that the time subscript (t) allows for exogenous technological improvement through changes in the parameters or functional form of f_t over time.

A2.3. Output is distributed between consumption and net capital investment ($K_{t+1} - K_t$). Capital may be freely converted into consumption so that there may be net consumption of the capital stock. Each generation is endowed with a single unit of labor in each period that it supplies inelastically to the firm. The initial stocks of resources (S_1) and capital (K_1) are owned by the first generation and take on strictly positive values. Each successive generation receives an income transfer T_g from its predecessor during the first period of its existence. While in reality intergenerational transfers are effected by both private individuals and by public agencies, here we assume that the transfers are selected and enforced by the government and are thus taken as exogenous to individual decision-making.

A2.4. Intergenerational competitive equilibrium is achieved via the temporary equilibria established through trading between the generations alive in each period subject to their expectations concerning future prices and economic conditions. The conditions that describe the competitive equilibria that arise under alternative income transfer regimes may thus be derived by evaluating the maximization problems faced by each agent. Consider first the profit maximization problem confronting the firm. For the sake of simplicity, assume that the firm is myopic and that there are no futures markets so that trading is limited to goods that are made available during the period in which they are purchased. Defining π_t as the firm's profit in period t, w_t as the wage rate, r_t as the interest rate or price of capital services, p_t as the price of the resource, and taking the firms output as numeraire, the firm's problem is to:

$$Max\ \pi_t = f_t(L_t, K_t, R_t) - w_t L_t - r_t K_t - p_t R_t \qquad (1)$$

subject to $L_t, K_t, R_t >= 0$. Since the firm behaves competitively, this problem generates the first order conditions:

$$w_t = \frac{\partial f_t}{\partial L_t} \qquad (2)$$

$$r_t = \frac{\partial f_t}{\partial K_t} \qquad (3)$$

$$p_t = \frac{\partial f_t}{\partial R_t} \qquad (4)$$

that are necessary and sufficient for the attainment of an interior solution to the profit maximization problem under the restrictions on f_t. The assumption that the production function exhibits constant returns to scale implies that profits are zero in each period.

A2.5. Now consider the utility maximization problem confronting the g th generation in period g. It must choose its period g consumption and net investments in capital and resources based on the prices it observes in period g and the prices it expects for period $g + 1$ so as to maximize its expected intertemporal utility $U_g(C_{gg}, C_{gg+1})$. For simplicity, we assume that each generation has perfect foresight so that its expectations regarding future prices are borne out in reality.

A2.6. The budget constraints may be derived by noting that, since no two generations overlap for more than one period, there are no opportunities for loans, and income must equal expenditure in each period. In period 1, generation 1 makes a payment of $C_{11} + K_2 - K_1$ for consumption and net capital investment while its income from sales of labor, capital services, and resources is $w_1 + r_1K_1 + p_1(S_1 - S_2)$. Note that:

$$S_t = S_1 - \sum_{\tau=1}^{t-1} R_\tau \qquad (5)$$

is the resource stock remaining at the beginning of period t. In period 2, its expected expenditure is C_{12} while its expected income is $w_2 + (1 + r_2)K_2 + p_2S_2 - T_2$. This holds because, at the end of its lifetime, each generation consumes the remainder of its nontransferred capital stock. The period 1 and period 2 budget constraints faced by generation 1 therefore reduce to:

$$w_1 + (1 + r_1)K_1 + p_1(S_1 - S_2) - C_{11} - K_2 = 0 \qquad (6)$$

$$w_2 + (1 + r_2)K_2 + p_2S_2 - T_2 - C_{12} = 0 \qquad (7)$$

A2.7. The budget constraints for generation $g > 1$ are somewhat different in form. Generation g must purchase its stocks of capital and resources for use in period $g+1$ from the preceding generation and/or the firm, so its period g expenditure on consumption, capital, and resources is $C_{gg} + K_{g+1} + p_gS_{g+1}$ while its income from labor sales and the transfer it receives from its predecessor is $w_g + T_g$. In period $g + 1$, its expected expenditure is C_{gg+1} while its expected income is $w_{g+1} +$

$(1 + r_{g+1})K_{g+1} + p_{g+1}S_{g+1} - T_{g+1}$. Hence its period g and period $g+1$ budget constraints are:

$$w_g - p_g S_{g+1} + T_g - C_{gg} - K_{g+1} = 0 \qquad (8)$$

$$w_{g+1} + (1 + r_{g+1})K_{g+1} + p_{g+1}S_{g+1} - T_{g+1} - C_{gg+1} = 0 \qquad (9)$$

A2.8. The problem confronting generation g is to maximize $U_g(C_{gg}, C_{gg+1})$ subject to the budget constraints and the nonnegativity constraints $C_{gg}, C_{gg+1}, K_{g+1}, S_{g+1} >= 0$. In the case of an interior solution, this yields the first order conditions:

$$\frac{\partial U_g / \partial C_{gg}}{\partial U_g / \partial C_{gg+1}} = \frac{P_{g+1}}{P_g} = 1 + r_{g+1} \qquad (10)$$

for $g = 1, 2, \ldots, G$ that are both necessary and sufficient given the assumptions imposed on the utility functions.

A2.9. A competitive equilibrium will exist for this model if we can find a set of prices and quantities that simultaneously satisfies the conditions of utility and profit maximization. Howarth (1989) has shown the existence and Pareto efficiency of equilibria provided that the set of income transfers is technically feasible. The possibility of corner solutions implies that the equilibrium conditions derived above are not completely general, although this technicality need not concern us here.

A2.10. These conditions yield some interesting if familiar interpretations. Along an equilibrium path, the marginal rate of time preference or discount rate of each successive generation must equal the interest rate or return on capital, and the discount rate is always greater than zero provided that the marginal productivity of capital is positive. Moreover, the resource price must rise at the rate of interest over time, confirming the Hotelling (1931) rule.

A2.11. The competitive equilibrium and hence the discount rate, however, depend on the distribution of income across generations, a point that is best illustrated by a numerical example. For simplicity we limit the example to the two generation, three period case. Let the initial capital stock equal one and the initial resource stock equal four. Assume that the utility and production functions take the familiar Cobb-Douglas forms:

$$U_g = (C_{gg}\, C_{gg+1})^{1/2} \qquad (11)$$

$$f_t = (L_t\, K_t\, R_t)^{1/3} \qquad (12)$$

A2.12. In a numeric example we show that unless the transfer from the present to the future generation exceeds about 1.5, or 90 percent of period 2 capital $[(1 + r_2)K_2]$, the hypothetical economy will be unsustainable in the sense that living standards will decline from generation to generation (Pezzey, 1989).

Table A2

Two Generation Cobb-Douglas Equilibria Under Alternative Income Transfers

TR	0	0.5	1	1.5	2	2.5	3	3.5
U_1	1.73	1.53	1.32	1.10	0.89	0.68	0.46	0.24
U_2	0.19	0.52	0.83	1.13	1.43	1.72	2.00	2.28
C_{11}	1.40	1.25	1.09	0.93	0.75	0.58	0.40	0.21
C_{12}	2.14	1.86	1.59	1.32	1.05	0.79	0.53	0.28
C_{22}	0.14	0.42	0.70	0.97	1.24	1.51	1.78	2.05
C_{23}	0.27	0.66	1.00	1.33	1.64	1.95	2.25	2.54
L_1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
L_2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
L_3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K_1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
K_2	0.91	1.03	1.15	1.29	1.43	1.59	1.75	1.91
K_3	0.07	0.24	0.43	0.63	0.84	1.05	1.26	1.48
R_1	2.26	2.07	1.92	1.79	1.67	1.57	1.48	1.41
R_2	1.62	1.64	1.66	1.69	1.72	1.74	1.77	1.79
R_3	0.12	0.29	0.42	0.53	0.61	0.69	0.75	0.81
w_1	0.44	0.43	0.41	0.40	0.40	0.39	0.38	0.37
w_2	0.24	0.25	0.26	0.27	0.28	0.30	0.31	0.32
w_3	0.07	0.14	0.19	0.23	0.27	0.30	0.33	0.35
r_1	0.44	0.43	0.41	0.40	0.40	0.39	0.38	0.37
r_2	0.53	0.49	0.45	0.42	0.40	0.37	0.35	0.33
r_3	0.96	0.57	0.44	0.37	0.32	0.29	0.26	0.24
p_1	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27
p_2	0.30	0.31	0.31	0.32	0.33	0.34	0.35	0.35
p_3	0.58	0.48	0.45	0.44	0.44	0.44	0.44	0.44

A2.13. The model highlights the sensitivity of equilibrium interest rates, wages, and resource prices to the distribution of income across generations determined by the transfers made between generations. The interest rate varies from period to period and may either rise or fall over time, but transfers of wealth from present to future drive down the interest rate in each period. Since the interest

rate in this model is equal to each generation's subjective discount rate, or its marginal rate of substitution with respect to consumption in consecutive periods, we may conclude that the discount rate is a function of the intergenerational welfare distribution. The combined effects of changes in the interest rates and resource prices lead to net conservation of the resource stock as income is transferred from the present to the future. But while this result may seem to confirm the conventional wisdom that low discount rates favor both resource conservation and the welfare of future generations, this conclusion deserves careful qualification. The intergenerational income distribution determines not only the efficient allocation of natural resources but also the discount rate and all other prices and quantities that are relevant to the application of conventional evaluation techniques. Ad hoc manipulations of the discount rate to advance sustainability interest in partial equilibrium analyses may therefore lead to the misallocation of resources. In a numeric example we (Howarth and Norgaard, 1990b) we show that unless the transfer from the present to the future generation exceeds about 1.5, or 90 percent of period 2 capital, the hypothetical economy will be unsustainable in the sense that living standards will decline from generation to generation (Pezzey, 1989).

A2.14. The model and the numeric example highlight the sensitivity of equilibrium interest rates to the distribution of income across generations determined by the transfers made between generations. The interest rate varies from period to period and may either rise or fall over time, but transfers of wealth from present to future drive down the interest rate in each period. Since the interest rate in this model is equal to each generation's subjective discount rate, or its marginal rate of substitution with respect to consumption in consecutive periods, we may conclude that the discount rate is a function of the intergenerational welfare distribution. The combined effects of changes in the interest rates and resource prices lead to net conservation of the resource stock as income is transferred from the present to the future. But while this result may seem to confirm the conventional wisdom that low discount rates favor both resource conservation and the welfare of future generations, this conclusion deserves careful qualification. The intergenerational income distribution determines not only the efficient allocation of natural resources but also the discount rate and all other prices and quantities that are relevant to the application of conventional evaluation techniques. Ad hoc manipulations of the discount rate to advance sustainability interest in partial equilibrium analyses may therefore lead to the misallocation of resources.

A2.15. The discount rate dilemma is effectively resolved by returning to the basic framework of economics. Each distribution of resources or income between people, in our case generations, defines an efficient allocation of resources between end uses and users. Conservation or sustainability cannot be addressed simply through efficiency. While efficiency is important, intergenerational distribution is also important. Both concerns must be addressed, and when they are, the discount rate dilemma is resolved.

A2.16. Prices, including the rate of interest or discount, equilibrate resource allocations at the margin. With different distributions and efficient allocations, new prices arise. One can no more speak of "the" rate of interest when societies are giving major consideration to the sustainability of development than one can speak of "the" price of timber when deciding whether or not to conserve forests for future generations. Redistributions change equilibrium prices. The rate of interest is undoubtedly distorted by market failures just as is the price of timber, and adjustments are thereby in order. But it is inefficient to adjust either the rate of interest or the price of timber for the purposes of achieving distributional goals.

APPENDIX 3

AN INTERGENERATIONAL COMPETITIVE EQUILIBRIUM MODEL OF A RENEWABLE RESOURCE ECONOMY

Richard B. Howarth

A3.1. Policy makers frequently must render decisions regarding the proper intertemporal allocation of natural resources. While decision-making is an inherently subjective process, formal analytical concepts and methods are often useful in reducing problems to their essential structure in a manner that illuminates the decision-making problem. Two sets of normative criteria are often invoked in discussions of natural resource policy. Some argue that resources should be managed according to the present value criterion of cost-benefit analysis. Others assert that the discounting techniques implicit in the cost-benefit approach may lead to the overexploitation of natural resources, so that resources should be managed according to a *sustainability criterion* that ensures an equitable distribution of resources between the present and future generations.

A3.2. This appendix explores the relationship between these two approaches using a model of an abstract intertemporal economy with a renewable resource that is socially managed according to cost-benefit criteria. Consumption and investment decisions are made by private individuals under competitive market conditions. The model illustrates the utility of cost-benefit techniques in achieving an efficient allocation of resources. As we shall see, however, the cost-benefit approach will result in an equitable distribution of welfare between generations only if appropriate transfers of assets are transferred from one generation to the next. In this sense, cost-benefit techniques and sustainability criteria are seen to be complementary rather than contradictory approaches to policy analysis.

A3.3. Consider a discrete-time, finite-horizon model of an intertemporal economy. There are two generations alive at each date $t = 0,1,...,T$ - one "young" and one "old". Each generation lives for two periods, and generation t lives at dates t and $t+1$. It is convenient to assume that each generation consists of a single representative individual, although the model is easily modified to allow for changes in population and heterogeneity between individuals. There is a homogeneous consumption/-investment good, and the consumption levels of the young and the old at date t are C_{yt} and C_{ot} respectively. The old own a stock of capital K_t and earn incomes from the sale of capital services to the production sector. The young hold an endowment of labor L_t that they supply inelastically to producers. The young and the old receive the net (positive or negative) lump-sum transfers T_{yt} and T_{ot} from an independent agency, the "government". There is no explicit altruism between generations, and individuals take the income transfers they receive as fixed.

A3.4. The preferences of the generation born at date t are represented by the utility function $U_t = U_t(C_{yt},C_{ot+1})$, which is assumed to be increasing, differentiable, and concave. The consumption/investment good is taken as the numeraire, and the wage rate and the price of capital services are w_t and r_t respectively. Markets are perfectly competitive, and individuals have perfect foresight regarding future prices and economic conditions. Each generation seeks to maximize its lifetime utility through its consumption and investment decisions subject to the budget constraints:

$$C_{yt} + K_{t+1} = w_t L_t + T_{yt}$$

$$C_{ot+1} = (1 + r_{t+1})K_{t+1} + T_{ot+1}.$$

Under the maintained assumptions, utility maximization yields the first order condition:

$$(\delta U_t/\delta C_{nt})/(\delta U_t/\delta C_{nt+1}) = 1 + r_{t+1}$$

that is necessary and sufficient for the achievement of an interior solution.

A3.5. Production activities are carried out by a single representative firm that uses inputs of capital services, labor, and the harvest of a renewable resource (H_t) according to the production function $f_t(K_t,L_t,H_t)$. The firm holds no assets of its own, but purchases inputs during the period they are used. The production function exhibits constant returns to scale and is assumed to be increasing, differentiable, and concave. Both its parameters and functional form may change over time with the evolution of new technologies. If we take p_t is the price per unit of the resource harvest, profit maximization under perfect competition yields the first order conditions:

$$r_t = \delta f_t/\delta K_t \qquad w_t = \delta f_t/\delta L_t \qquad p_t = \delta f_t/\delta H_t$$

that are necessary and sufficient for the achievement of an interior solution. These conditions hold that, in equilibrium, the marginal productivity of each factor input is equated with its price. The constant returns to scale assumption implies that profits are zero in each period.

A3.6. The pre-harvest stock of the renewable resource at date t is Q_t, and the stock grows over time according to the concave, continuous function $Q_{t+1} = g_t(Q_t,H_t)$. We shall assume that g_t is increasing in Q_t and decreasing in H_t, so that resource utilization decreases future resource availability. The resource harvest may not exceed the existing stock, so $H_t \leq Q_t$. There are no harvest costs, and the government manages resource harvests using conventional cost-benefit criteria, maximizing the present value benefits of resource utilization defined by the formula:

$$\sum_{t=0}^{T} \alpha_t \int_0^{H_t} p_t(z)\,dz.$$

Here $p_t(H_t)$ is the inverse demand function for the resource harvest, or the price that prevails when the harvest is set equal to H_t. α_t is the discount factor applied to net benefits accruing t periods into the future. We shall assume that the government sets the discount rate equal to the market rate of interest so that $\alpha_{t+1} = \alpha_t/(1 + r_{t+1})$ where $\alpha_0 = 1$. This maximization problem implies the first order condition:

$$p_{t+1} = \frac{p_t(1+r_{t+1})\,(\delta g_{t+1}/\delta H_{t+1})}{(\delta g_t/\delta H_t)\,(\delta g_{t+1}/\delta Q_{t+1})}$$

that is necessary and sufficient for the attainment of an interior solution provided that the resource demand function is downward sloping so that the integral defining the surplus associated

with resource utilization in each period is concave in H_t.[70] This condition states that the present-value benefit generated by a marginal shift in resource consumption from one period to the next, while holding harvests constant in all other periods, must be equal to zero. Because there is no value in preserving the resource stock at the terminal date, the resource stock is fully exhausted in the final period so that $H_t = Q_t$.

A3.7. To complete the model, a set of income transfers $\{T_{yt}, T_{ot}: t = 0,1,\ldots,T\}$ must be specified satisfying the constraint $T_{yt} + T_{ot} = p_t H_t$ so that the government's budget is balanced in each period. In general, there are many income transfer regimes that will satisfy this property and thus many potential competitive equilibria. While one might explicitly model the government's choice of the transfer regime, we shall for the moment take income transfers as given in order to assess the welfare implications of the potential alternatives.

A3.8. One question to ask is whether the cost-benefit approach to renewable resource management results in to a competitive equilibrium that is Pareto efficient. In an intergenerational context, an allocation is efficient if it is impossible to improve the welfare of one generation without rendering one or more other generations worse off. While we shall not go through the details of the derivation, it may be shown that an allocation is efficient if it satisfies the conditions:

$$(\delta U_t/\delta C_{yt})/(\delta U_t/\delta C_{ot+1}) = 1 + \delta f_{t+1}/\delta K_{t+1}$$

$$\frac{\delta f_{t+1}}{\delta H_{t+1}} = \frac{(\delta f_t/\delta H_t)\,(1+\delta f_{t+1}/\delta K_{t+1})\,(\delta g_{t+1}/\delta H_{t+1})}{(\delta g_t/\delta H_t)\,(\delta g_{t+1}/\delta Q_{t+1})}$$

$$H_T = Q_T.$$

It is straightforward to show that these conditions are satisfied by competitive equilibria if and only if the discount rate is equated with the market rate of interest. The cost-benefit approach to resource management therefore results in an efficient allocation of resources provided that this condition is met.

A3.9. We should also like to know if there anything in the structure of the model that ensures an equilibrium is sustainable in the sense that living standards are nondecreasing from period to period. To facilitate the analysis of this issue, we focus on a specific version of the model and compare the equilibria that result under alternative income transfer regimes. Suppose there are 21 periods ($T = 20$) and that the production and utility functions are $f_t = (K_t L_t H_t)^{1/3}$ and $U_t = \ln(C_{1t}) + \ln(C_{2t+1})$ while the resource growth equation is $Q_{t+1} = 2(Q_t - H_t) - (Q_t - H_t)^2/4$. The ini-

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70. It is worth pointing out that because the firm's production function exhibits constant returns to scale, its demand function for resource inputs is not well-defined. But although the derivation of a resource planning equation is useful for heuristic purposes, the equation itself may be justified on the basis of marginalist arguments that do not depend in the formal maximization problem outlined above. This difficulty is therefore unimportant to the results developed in the paper.

tial stocks of capital and the renewable resource are $K_0 = 1$ and $Q_0 = 2$, and the labor endowment is $L_t = 1$ in each period. These assumptions are maintained strictly for illustrative purposes; there is no presumption that they are "realistic" in any sense.

A3.10. At this point we shall focus our attention on income transfer regimes that maximize the social welfare function:

$$W = \sum_{t=1}^{T} \beta^{t+1} U_t$$

for various values of ß, a positive constant that defines the weight attached to the welfare of future generations in comparison with the present. While this functional form is frequently employed in both theoretical and applied work, its ethical foundations are easily questioned, and other formulations are possible. This function, however, allows us to vary the weight attached to the welfare of future generations, and this is sufficient for the purpose at hand. Table 1 shows the equilibria that result for values of ß of 0.5, 0.75, and 1.0. Solution values are given for alternate years only to simplify the presentation of the results.

A3.11. The results of this exercise indicate that the model is very sensitive to the choice of ß and thus to the choice of the income transfer regime. When little weight is attached to the welfare of future generations (ß = 0.5), the stocks of capital and natural resources are rapidly diminished to satisfy the wants of the current generation, and living standards decline precipitously over time. Increases in the value of ß, and hence in the transfer of assets from the present to the future, raise the capital and resource stocks and shift the balance between present and future consumption. For the intermediate case (ß = 0.75), a nearly constant consumption standard is maintained over time, while the extreme case of ß = 1.0 results in explosive growth in consumption.

A3.12. The transfer of assets from present to future tends to lower equilibrium interest rates and hence the rate at which future costs and benefits should be discounted in cost-benefit evaluations. While this result might seem to support the view that low discount rates should be used to favor the interests of future generations, in fact such a conclusion is not justified. A sustainable development path in this model is achieved through the choice of intergenerational transfers that ensure future generations the assets they need to live fruitful an productive lives. Given the set of intergenerational transfers, cost-benefit analysis is helpful in achieving an efficient allocation of resources if the discount rate is set equal to the market rate of interest. If, however, the discount rate is not equated with the interest rate, the result will be inefficient resource allocation - not intergenerational equity.

Table A3.1. Competitive equilibria under alternative income transfer regimes.

t	0	2	4	6	8	10	12	14	16	18	20
					$\beta = 0.5$						
T_{1t}	0.74	0.34	0.21	0.16	0.14	0.12	0.11	0.10	0.10	0.09	0.02
T_{2t}	-0.40	-0.11	-0.04	-0.02	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.05
C_{1t}	0.47	0.26	0.19	0.15	0.13	0.12	0.11	0.10	0.09	0.09	0.09
C_{2t}	0.94	0.52	0.37	0.30	0.26	0.23	0.21	0.20	0.19	0.18	0.19
K_t	1.00	0.41	0.24	0.18	0.15	0.13	0.11	0.11	0.10	0.09	0.07
Q_t	2.00	1.44	1.10	0.88	0.72	0.62	0.53	0.47	0.41	0.33	0.15
H_t	1.04	0.76	0.58	0.46	0.38	0.32	0.28	0.24	0.22	0.20	0.15
w_t	0.34	0.23	0.17	0.14	0.13	0.11	0.11	0.10	0.09	0.09	0.07
r_t	0.34	0.55	0.72	0.82	0.87	0.90	0.92	0.93	0.94	0.96	1.09
p_t	0.32	0.30	0.30	0.31	0.34	0.36	0.38	0.40	0.43	0.45	0.48
					$\beta = 0.75$						
T_{1t}	1.07	1.03	1.02	1.02	1.02	1.02	1.02	1.01	0.96	0.83	0.28
T_{2t}	-0.76	-0.72	-0.71	-0.71	-0.71	-0.71	-0.71	-0.69	-0.65	-0.52	-0.02
C_{1t}	0.41	0.40	0.40	0.40	0.40	0.40	0.41	0.41	0.42	0.44	0.55
C_{2t}	0.54	0.54	0.53	0.54	0.54	0.54	0.54	0.54	0.55	0.59	0.73
K_t	1.00	0.95	0.93	0.93	0.94	0.94	0.93	0.92	0.89	0.80	0.49
Q_t	2.00	2.13	2.19	2.21	2.21	2.22	2.21	2.19	2.11	1.88	1.03
H_t	0.77	0.84	0.87	0.88	0.89	0.89	0.89	0.90	0.92	0.98	1.03
w_t	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.26
r_t	0.31	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.35	0.38	0.54
p_t	0.40	0.37	0.36	0.35	0.35	0.35	0.35	0.35	0.34	0.31	0.26
					$\beta = 1.0$						
T_{1t}	1.35	2.45	3.74	5.05	6.23	7.15	7.70	7.72	7.02	5.25	1.58
T_{2t}	-1.08	-2.05	-3.26	-4.50	-5.63	-6.53	-7.05	-7.07	-6.37	-4.63	-1.05
C_{1t}	0.20	0.30	0.40	0.51	0.63	0.75	0.90	1.06	1.26	1.54	2.11
C_{2t}	0.20	0.30	0.40	0.51	0.63	0.75	0.90	1.06	1.26	1.54	2.11
K_t	1.00	1.96	3.18	4.47	5.67	6.65	7.30	7.47	6.98	5.55	2.62
Q_t	2.00	2.58	2.79	2.85	2.86	2.86	2.84	2.81	2.73	2.50	1.55
H_t	0.57	0.84	0.95	0.99	1.00	1.00	1.01	1.02	1.06	1.18	1.55
w_t	0.28	0.39	0.48	0.55	0.59	0.63	0.65	0.66	0.65	0.62	0.53
r_t	0.28	0.20	0.15	0.12	0.10	0.09	0.09	0.09	0.09	0.11	0.20
p_t	0.48	0.47	0.51	0.55	0.60	0.63	0.64	0.64	0.61	0.53	0.34

A3.13. While cost-benefit criteria may be helpful in achieving an efficient allocation of natural resources over time, the allocation that is judged to be socially efficient depends on the transfers of assets that are effected between the present and future generations. An allocation that is judged to be "optimal" from the standpoint of cost-benefit criteria may be unsustainable in the sense that it leaves an impoverished world to members of future generations. This result underscores the

need to supplement the cost-benefit approach with criteria defining an appropriate distribution of welfare between present and future. In this sense, cost-benefit and sustainability criteria are properly viewed as complementary rather than contradictory, addressing fundamentally different aspects of the intertemporal planning problem.

A3.14. The model used to illustrate these results is a considerable abstraction and simplification of reality. Many interesting issues - the relationship between living standards and population growth (Eckstein et al, 1988), the implications of uncertainty (Howarth, 1991), potential errors in the formation of expectations (Graham-Tomasi et al, 1986), and the inefficiencies that may arise in infinite-horizon overlapping generations economies, for example - are omitted from consideration in order to simplify and clarify the structure of the problem under consideration. One matter of direct relevance concerns the institutions that govern the transfer of assets from present to future. Intergenerational transfers are a pervasive aspect of economic reality. Parents care for their offspring and render bequests to them upon dying. Public institutions provide education and, in some societies, health and welfare services to the young. Governments invest in research and development activities that may take many decades to generate useful technologies.

A3.15. While private altruism is one source of intergenerational transfers, there are both theoretical and practical concerns that suggest a potential role for government is ensuring the welfare of future generations. If, for example, individuals care not only about their own children but also about other future individuals, the welfare of future generations takes on the characteristics of a public good, and a *laissez faire* policy would result in asset transfers from present to future that all individuals would find to be undesirably small (Howarth and Norgaard, 1991). The rhetoric of intergenerational equity plays an important role in public debates concerning the environment, education, the economy, and other policy issues. To the extent that economists seek to illuminate and contribute to policy discussions, it is therefore important that they fully address the dimensions and implications of the sustainability criterion.

Appendix 4

CURRENT MONITORING AND INTERGENERATIONAL DISTRIBUTIVE INSTITUTIONS

A4.1. In the industrialized countries, institutions have been established to assure that future generations have access to parklands, that natural areas are protected, and that endangered species do not go extinct. Forest management agencies were established with the objective of assuring continued supplies of timber. Many energy resources in the public domain in the United States and Canada were not exploited until long after their existence became well documented. Comparable resource management agencies in developing countries also typically are mandated to manage resources for future generations. Concern for future generations and the design of institutions, albeit inadequately, for long term resource management clearly predate the current concern with the sustainability of development and the recent developments this concern has stimulated in economic thinking. Indeed, it can be argued that the goals of the conservation movement at the end of the 19th century and beginning of the 20th century and the institutions established at that time have been undermined by the rise of economic arguments about efficiency which ignored intergenerational equity.

A4.2. At the international level, numerous institutions have evolved during the latter half of the twentieth century in response to the needs of developing countries and more recently which collect some of the pertinent information and affect the maintenance of natural capital. Since sustainable development as an international issue is still evolving politically and conceptually, it is not yet apparent how existing institutions will fit into an ultimate pattern of institutions to fulfill the need for the assesment and guidance of resource transfers to future generations. The newly established Global Environmental Facility could evolve into a very effective institution for this task, but its funding to date is relatively insignificant and its procedures are only beginning to be established. In an effort to spark further thinking about institutions in the future, this section very briefly assesses the situation with respect to tropical rainforests in particular.

A4.3. Data on tropical rainforest timber resources are collected by individual nations and assembled by the Forestry Department of the U.N. Food and Agricultural Organization. Coordination with respect to variables for which data are collected has occurred over the years through FAO assistance to individual nations for forestry inventories. Such data, however, are very limited in scope even for the narrow goal of assessing timber resources and are not known for their quality or availability with respect to more recent years. Data on tropical timber resources are especially difficult because only a few species of trees may be of commercial interest in any given year, but the number and types of species of interest is rapidly changing. Non-timber species utilized by indigenous and local peoples are not identified in any coordinated data set. Many still hope that remote sensing and electronic storage and sorting techniques will overcome these limitations. Others emphasize that the quality of tropical forests are a function of many interacting factors. Furthermore, it is not the forests that need to be continuously assessed as much as the threats to the forest that need to be continuously assessed. The immense fire in the tropical rainforest of Kalimantan in 198x after several years of drought highlights the importance of entirely new types of information with respect to the interactions between climate and human activities on a global scale. Such factors will be even more critical in

light of climate predictions.

A4.4. Issues of complexity, contextuality, and the need for information with respect to threats are even more relevant for non-timber species and forest ecosystem functions where the quality of the available data are far worse. The International Union for the Conservation of Nature and Natural Resources maintains information on threatened species. This information, however, is biased towards particular types of species, and collection largely occurs through the haphazard efforts of uncoordinated field researchers. The number of species, to say nothing of ecosystem characteristics and functions, about which information might be collected is daunting.

A4.5. Given the quality of data and the difficulties of improving them, the diverse national and international agencies and disparate non-governmental organizations which have assumed various aspects of the task of assessing the status and future of tropical rainforests are understandably contentious. While views on particulars differ dramatically, there is an apparent consensus, however, that deforestation must be reversed, that a significant portion of the remaining virgin tropical rainforest must be saved to protect biodiversity and indigenous peoples, and that improved technologies and social organization must be developed. The Tropical Forestry Action Plan (TFAP) emerged in the mid-1980s around this consensus, providing a series of linkages between international agencies, national governments, and non-governmental organizations around national action plans. The linkages, aimed at attaining these objectives, were not backed by sufficient new financial resources or committment from those with existing financial resources to make an apparent difference. Most national action plans and decisions continued to favor commercial timber production while paying "lip service" to other uses of the forests and both local and global interests. Since TFAP was inititated, concern for biodiversity has continued to increase while the importance of forests to global climate maintenance has begun to be realized. The combination of poor results and greater importance at coordination has led to considerable evaluation and proposals for the redesign of TFAP.

A4.6. In 1985 the International Tropical Timber Agreement, an agreement between nations which produce tropical timber and nations which import tropical timber, came into effect. The International Tropical Timber Organization (ITTO) was formed to fulfill the terms of the agreement to: promote the expansion and diversification of international trade in timber, to improve the structural conditions of the tropical timber market, to promote and support research and development on improved forest managment and wood utilization, improve market intelligence, encourage timber processing in timber producing countries, encourage members to support reforestation and forest management, and improve the marketing and distribution of tropical timber exports. What makes this agreement especially interesting is the final objective [Article 1 (h)]: "To encourage the development of national policies aimed at sustainable utilization and conservation of tropical forests and their genetic resources, and at maintaining the ecological balance in the regions concerned". While the agreement and ITTO are still primarily directed at timber and wood export products exclusive of the multitude of other forest uses and forest interests, ITTO could play an important, constructive role in the global monitoring and management of tropical rainforests. The terms of the agreement are broader and suggest a greater interest in cooperating to reach global environmental goals than any commodity agreement heretofore. Indeed, one of the first decisions of ITTO was to commission a study of the

sustainability of tropical forestry.[71] International agencies including the World Bank have already relied on this study for data and assessment of the prospects for sustainable tropical forestry.

A4.7 The World Resources Institute, United Nations Environment Program, and International Union for Conservation of Nature and Natural Resources are initiating a Biodiversity Conservation Strategy which is being joined by numerous international agencies including the World Bank and numerous non-governmental organizations. Since tropical rainforests house a significant portion of the total number of species, the efforts of the Biological Cosnervation Strategy to develop biological data and assessments of the causes of the loss of biodiversity could affect our understanding of the importance of tropical forests for future peoples and our understanding of the options available for managing forests.

A4.8. Concern over global climate change sustains a global modeling and assessment effort and diverse networking between researchers and policy makers which may result in international accords which could have a major impact on forest maintenance and perhaps regeneration.

A4.9. The administrations of the seven leading Western industrial nations known as the G-7 periodically hold Economic Summit meetings to discuss common concerns. Among an expanding range of issues in the new world disorder, global environmental concerns are absorbing an increasing portion of the Economic Summit agenda. An extensive statement reflecting considerable anxiety emerged from the Paris meeting in the summer of 1989. At the Houston meeting during July 1990, a weak consensus toward action emerged with respect to global climate change and an experimental step was initiated to curb deforestation in the Amazon. The G-7 asked Brazil to prepare a proposal to stem tropical deforestation with the financial and other cooperation of industrial nations. A proposal is currently being drafted with the assistance of the World Bank.

A4.10. The Global Environmental Facility (GEF) developed through an agreement among a group of countries to establish a fund administered by the World Bank to be dispensed as concessional loans designed and approved by the Bank, UNEP and UNDP. The GEF is a pilot program designed to provide concessional lending to developing countries for projects which alleviate global environmental problems. Limiting the emissions of greenhouse gases and protecting biodiversity are two of the four priority areas for funding. Both of these objectives interrelate with tropical forestry policies. The GEF is just beginning operation but could evolve into an extremely important institution for facilitating transfers between nations which will assure the transfer of rights to tropical rainforest resources to future generations.

A4.11. In response to the belief that current cooperative efforts to protect tropical rainforests are ineffective, local and national governments in Germany and the Netherlands have voluntarily stopped buying products made from tropical timbers. The European Parliament proposed a ban on imports which was rejected by the European Commission. Trade agencies in Europe and the United Kingdom have adopted voluntary codes of conduct and proposed tariffs to restrain imports. Numerous indigenous groups and non-governmental organizations in developed and developing countries have directly interferred with logging, processing, and trade in an effort to reduce deforestation. These

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71. Duncan Poore, *op cit.*

individual actions are clearly not optimal, but neither is the status quo optimal.[72]

A4.12. In summary, there is a pastiche of evolving resource monitoring and assessment institutions working at an international level with considerable potential for affecting the management and transfer of tropical rainforest resources to future generations. Economists tend to look at the development of these institutions as in opposition to economic institutions, but this perspective is inappropriate. Economic optimization, whether through markets or planning, requires just the sort of global monitoring and assessment these environmental institutions strive to provide. The environmental science bases on which these institutions reason is needed, since if they to looked to economic reasoning and the market, the reasoning would be too circular. New and old institutions will evolve more appropriately if the potential complementarities are appropriately understood. The diverse implications of thinking of sustainability as an equity will hopefully help in this respect. Considerable work is needed on how the environmental institutions might best be augmented, how economic institutions might best utilize the information they generate, and what additional accords and perhaps new management directives are needed to sustain development.

72. Condensed from Robert J. A. Goodland, Emmanuel O.A. Asibey, Jan C. Post, and Mary B. Dyson (Tropical Moist Forest Management: The Urgency of the Transition to Sustainability, 1990).

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