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The Ecological Economics of Sustainability: Making Local and Short-Term Goals Consistent with Global and Long-Term Goals

Robert Costanza
Ben Haskell
Laura Cornwell
Herman Daly
and
Twig Johnson

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The authors are Robert Costanza , Associate Professor at the Center for Marine and Estuarine Studies, University of Maryland, and Ben Haskell and Laura Cornwell, who are both Research Associates at the same Center. Herman Daly is Senior Economist in the Environmental Policy and Research Division of the World Bank, and Twig Johnson is Acting Director at the USAID Office of Forestry, Environment and Natural Resources Department. Together they were the organizers for the 'Ecological Economics of Sustainability' Conference, the abstracts of which are presented here.

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INTRODUCTION

This catalog is a research tool. It presents the abstracts, classified by topic, of nearly 200 current works in Ecological Economics with authors' address and institutional affiliation. The process that generated this document was not a library search, because the field is too new. Nor is it a random sample of work in progress at various research institutions. Rather it was generated by a conference called by the International Society for Ecological Economics (ISEE)[1]. The conference was held at the World Bank in Washington, D.C. on May 21-23, 1990. Major funding was provided by the Pew Charitable Trusts. Additional funding was provided by the Jessie Smith Noyes Foundation, the World Bank and US AID. Additional sponsors of the conference included the Aspen Institute, the Coastal and Environmental Policy Program of the University of Maryland, the Center for Policy Negotiation, the Coastal Society, the International Society for Ecological Modeling, the World Wildlife Fund/Conservation Foundation, the Nature Conservancy, the Global Tomorrow Coalition, and the World Resources Institute.

The theme of the conference was "The Ecological Economics of Sustainability: Making Local and Short Term Goals Consistent with Global and Long Term Goals." Over 370 people from all over the world attended, many others had to be turned away for lack of space. Because of the intense and widespread interest in this subject, which we feel accurately measures its importance, the ISEE and the World Bank have decided to make these abstracts available in this form. It is our hope that by doing so we will facilitate communication and the formation of a network or community among many researchers in different disciplines who have converged in identifying "The Ecological Economics of Sustainability" as a top priority for the policy research agenda.

The statement of aims and scope for the conference, to which these abstracts were a response, was as follows:

> *There is increasing awareness that our global ecological life support system is endangered Decisions made on the basis of local, short-term criteria can produce disastrous results globally and in the long run. There is also increasing awareness that traditional economic and ecological models and concepts fall short in their ability to deal with these problems.*
>
> *The International Society for Ecological Economics is concerned with extending and integrating the study and management of "nature's household" (ecology) and "humankind's household" (economics). Ecological Economics studies the ecology of humans and the economy of nature, the web of interconnections uniting the economic subsystem to the global ecosystem of which it is a part. It is this larger system that must be the object of study if we are to adequately address the critical issues that now face humanity.*

This international, interdisciplinary conference focused on these concerns and provided a forum for work on these topics from around the globe to be presented and discussed.

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[1]For information about joining ISEE contact: Dr. Robert Costanza, Coastal and Environmental Policy Program, Center for Environmental and Estuarine Studies, Univirsity of Maryland, Box 38, Solomons, MD 20688-0038. Phone: (301) 326-4281 FAX: (301) 326-6342.

Organization of This Catalog

This catalog is organized similarly to the conference. It begins with a list of all the papers presented, organized by topic. Each day had a morning session with invited talks on a general topic and in the afternoon, several concurrent contributed sessions on several related subtopics. The authors' names, addresses, and the titles of their papers are listed alphabetically under each topic in the first section of this catalog, beginning on page 4.

Following this list of authors and papers by topic are the abstracts of all the papers presented alphabetically by author. The invited abstracts are in the first group, beginning on page 19. These are followed by the contributed abstracts, beginning on page 34. An index of authors follows the abstracts, beginning on page 88. The page numbers in the index refer to those places in the document where the author's name appears, either in the list of topics (the first number or numbers in the index) or in the list of abstracts (the last number or numbers).

A list of all participants who attended the conference completes the catalog, page 91.

The invited papers will appear in book form in early 1991. Selected contributed papers will be published in special issues of the journal *Ecological Economics* in 1991. If you wish to receive copies of the full papers before these publications appear, *write directly to the authors*.

AUTHORS AND TITLES BY TOPIC

Invited Session 1: An Ecological Economic World View

BOULDING, KENNETH E.; Institute of Behavioral Science, University of Colorado at Boulder, Campus Box 484, Boulder, Colorado 80309
What Do We Want to Sustain? Environmentalism and Human Evaluations

DALY, HERMAN E.; Environment Department, World Bank, 1818 H. Street, NW Washington, DC 20433
Towards an Environmental Economics

EHRLICH, PAUL R.; Department of Biological Sciences, Stanford University, Stanford, California 94305, and **DANIEL, LISA M.**; Bureau of Economic Research, Federal Trade Commission, U.S. Department of Commerce
Outgrowing the Planet

FABER, M.; and **MANSTETTEN, R.**; *Alfred Weber- Institut, Department of Economics, Universität Heidelberg, Grabengasse, 6900 Heidelberg, Federal Republic of Germany, and* **PROOPS, J.L.R.**; *Department of Economics and Management Science, University of Keele, Staffordshire, ST5 5BG, United Kingdom*
Towards an Open Future: Ignorance, Novelty and Evolution

FUNTOWICZ, SILVIO O.; Institute for Systems Engineering, Joint Research Centre, Commission of the European Communities, 21020 Ispra(VA), ITALY, and **RAVETZ, JERRY R.**; Department of Philosophy, The University, Leeds LS2 9JT, United Kingdom
A New Scientific Methodology for Global Environmental Issues

HARDIN, GARRETT; Department of Biological Sciences, University of California, Santa Barbara, CA 93106
Paramount Positions in Ecological Economics

JANSSON, ANN-MARI; Department of Systems Ecology, University of Stockholm, S-10691, Stockholm
On the Significance of Open Boundaries for an Ecologically Sustainable Development of Human Societies

MARGALEF, RAMON; Department of Ecology, University of Barcelona, Diagonal 645, Barcelona 08028, SPAIN
Reconsideration of Basic Themes in Ecology Might Clarify Relations with Economics

MARTINEZ-ALIER, JUAN; Department of Economics and Economic History,.Universitat Autònoma de Barcelona, Bellatera, E-08193, Barcelona, SPAIN
Ecological Perception, Environmental Policy and Distributional Conflicts: Some Lessons from History

NORGAARD, RICHARD B.; and **HOWARTH, RICHARD B.**; Department of Agricultural and Resource Economics, Energy and Resources Group, University of California, Berkeley, California 94720
The Conservationist's Dilemma Revisited

NORTON, BRYAN; School of Social Sciences, Georgia Institute of Technology, Atlanta, GA 30332
Ecological Health and Sustainable Resource Management

TIEZZI, ENZO; **MARCHETTINI, N.**; and **ULGIATI, S.**; Department of Chemistry, University of Siena, Pian dei Mantellini, I-44-53100 Siena, Italy
Biomass and Entropy

Contributed Sessions - An Ecological Economic World View

Ecological Economics of Sustainable Agriculture

DIETZ, FRANK; *Department of Public Administration, Erasmus University, P.O. Box 1738, Rotterdam, The Netherlands, and* **HOOGERVORST, NICO;** *Agricultural Economics Research Institute, P.O. Box 29703, 2502 LS Den Haag, The Netherlands*
Towards a Sustainable Use of Nutrients in Agriculture

FLORES RODAS, JOSÉ G. and **SCHLICHTER, TOMAS M.;** *Centro Agronomico Tropical De Investigacion Y Enseñanza, Turrialba, Costa Rica*
What is Sustainability and How do We Achieve it? A Case in the Central American Tropics

HALL, CHARLES, CORNELL, JOSEPH; *SUNY ESF, Syracuse NY, and* **LEVITAN, LOIS;** *Cornell University, Ithaca, NY*
Land and Energy Constraints and the Future of Costa Rica Agriculture

NINAN, K.N.; *Institute for Social and Economic Change, Nagarbhavi P.O., Hangalore 560 072 India*
Economics of Shifting Cultivation in India

HUGHES, DAVID; PENARANDA, WALTER; and **BUTCHER, WALTER;** *Washington State University,* **JARADAT, ABDULLA;** *Jordon University of Science and Technology,* and **DAY, JOHN;** *Economic Research Services, USDA*
Economic Analysis of Farming Practices that Increase Sustainable Production in the Barley Cropping Area of Jordan

IGOE, JIM ; *Department of Anthropology, Boston University, 232 Bay State Road, Boston, MA 02215*
The Ecological Basis of Economic Policy for Maasai Livestock Systems In Kenya

JIANG, XUEMIN; *Department of Agricultural Economics, Huazhong Agricultural University, Wuhan City, China*
Some Fundamental Principles on Eco-economics of Agricultural

POMAREDA, CARLOS F.; *Agricultural Policy and Planning, Inter-American Institute for Cooperation on Agriculture (IICA); P.O.Box 55 - 2200 Coronado, San José, Costa Rica*
Institutional Challenges in the Achievement of Sustainable Agriculture .

SHORTLE, JAMES S. and **MUSSER, WESLEY N.;** *Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park, PA 16802*
Economic Foundations of Low-Input Sustainable Agriculture

SESHADRI, C.V. and **HOON, C.V.;** *Shri A.M.M. Murugappa Chettiar Research Centre, Tharamani, Madras 600 113 India*
The Ecological Economics of Sustainability: Lessons Learned form Isolated Communities

YOUNGMAN, R.R.; *Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Va.m and* **ERVIN, R.T.;** *Department of Agricultural Economics, Texas Tech University, Lubbock, TX 79409*
Virginia Corn Producers' Use of Insecticides to Control Corn Rootworms Even Though They Rotate Their Crops: A Case Study

ZWAHLEN, ROBERT; *Ecosens Ltd., Environmental Management Consultants, P.O. Box CH-8042, Zurich, Switzerland*
Failure of Irrigation Projects and Consequences for a Different Approach: A Case Study

Ecological Economics of Sustainable Development

ANDREASSON-GREN, INGE-MARIE ; *The Swedish University of Agricultural Sciences, Department of Economics, Box 7013, S-75007 Uppsala, Sweden*
Wetlands and Sustainable Development in the Swedish Island Gotland

BLANCO, SERGIO;
Department of City and Regional Planning, The University of Pennsylvania, Philadelphia, Pennsylvania
The Eutrophication of Local Economies

BINFORD, MICHAEL W.; *Graduate School of Design, Harvard University, 48 Quincy St., Cambridge, MA 02138,* **KOLATA, ALAN R. ;** *Department of Anthropology, University of Chicago, 1126 E. 59th St., Chicago, IL 60637, and* **BRENNER, MARK ;** *Florida Museum of Natural History, University of Florida, Gainesville, FL 32611*
Rehabilitating Ancient Raised Fields in the Bolivian Altiplano: Paleoecological and Archaeological Evidence for Sustainable Agriculture.

BOJÓRQUEZ-TAPIA, LUIS A.; and **FLORES-VILLELA, OSCAR**
Centro de Ecología, UNAM. Apartado Postal 70 275, Mexico 04510
A Method For Land-Use Planning and Conservation in Mexico

BROWN, PETER G. ; *School of Public Affairs, Morrill Hall, University of Maryland, College Park, MD 20742*
Intergenerational Costs and the Greenhouse Effect

ERSKINE, J. M.; *Institute of Natural Resources, University of Natal, P.O. Box 375, Pietermaritzburg 3200, South Africa*
Environment, Agriculture and Economics: Achieving Sustainable Development in the Less Developed Rual Areas of Southern Africa

GUPTA, ANIL K.; *Indian Institute of Management, Vastrapur, Ahmedabad, India*
Sustainable Development of Indian Agriculture: Green Revolution Revisited

KLINK, FEDERICO AGUILERA; GUTIERREZ, CARLOS CASTILLA; and **PADRON, MIGUEL SANCHEZ ;** *Departamento de Economía Aplicada, Universidad de La Laguna, 38071 La Laguna, Tenerife, Islas Canarias Spain*
Interpreting Ecological Economics in a Postmodernism Era: Sustainable Development Versus the Lack of Development Towards an International Ecological Order.

MONK, TRACIE E.; *1917 S. Randolph St., Arlington, VA 22204*
Conflicting Priorities: The Struggle for Sustainable Development in Indonesia

NICHOLSON, GUY ; *Bioplan, 6 Indwa Place, K loof 3610 South Africa*
An Approach to the Environmental Planning of Growing Third World Cities that is Compatible with Ecological Sustainability

SADLER, BARRY ; *Institute of the NorthAmerican West, Victoria, British Columbia, Canada*
An Impact Compensation Theory of Sustainable Development

TOBEY, JAMES A.; *United States Department of Agriculture, Economic Research Service, 1301 New York Avenue, NW Room 508, Washington, DC 20005-4788*
Opportunities for Environmental Sustainability in OECD Agriculture

VAN PELT, MICHAEL J.F., KUYVENHOVEN, ARIE; *Netherlands Economic Institute, Rotterdam/Wageningen Agricultural University, Rotterdam, The Netherlands, and* **NIJKAMP, PETER;** *Free University of Amsterdam, Amsterdam, The Netherlands*
Sustainability and Project Appraisal in Developing Countries: Methodological Challenges

Developing and Ecological Economic World View: Theories

AMIR, SHMUEL; *Department of Applied Physics and Mathematics, Soreq Nuclear Research Center, Yavne 70600, Israel*
Thermodynamics, Economics, and Ecology: An Analogy

CARPENTER, STANLEY R.; *Philosophy of Technology, School of Social Sciences, Georgia Tech, Atlanta, Ga 30332*
Sustainability and Forms of Life

ROCHELEAU, DIANNE E.; *Department of Geography, Clark University, Worcester, Ma*
Indigenous Ecological Economics: Projecting the Long Term View from Local Space

SHOGREN, JASON F.; *Department of Economics, Iowa State University, Ames, Iowa 50011, and* **NOWELL, CLIFFORD ;***Department of Economics, Weber State College, Ogden, Utah 84403*
Economics and Ecology: Comparison of Experimental Methodologies and Philosophies

SODERBAUM, PETER ; *Swedish University of Agricultural Sciences, Department of Economics, Box 7013, S-75007 Uppsala, Sweden*
Neoclassical and Institutional Approaches to Development and Environment

TOMAN, MICHAEL and **COSSON, PIERRE;** *Resources for the Future, 1616 P Street, N.W., Washington, D.C. 20036*
The Different Dimensions of Sustainability: A Review

UNDERWOOD, DANIEL A. ; *International Center for Water Resources Management, Central State University, Wilberforce, Ohio 45384*
Lessons From Adaptability Theory For Sustainable Environmental Management

VIEDERMAN, STEPHEN ; *President, Jessie Smith Noyes Foundation, 16 East 34th St., New York, NY 10016*
Building the Field of Ecological Economics

Developing and Ecological Economic World View: Debate

ALLEN, P.M.; CLARK, N. and **PEREZ-TREJO, F.;** *International Ecotechnology Research Centre, Cranfield Institute of Technology, Cranfield Bedford MK43 OAL, UNITED KINGDOM*
Change and Sustainability: The Evolution of Wisdom

COMMON, M.S.; *Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia*
A Pragmatic Approach to the Development of an Ecological Economics

LILL, J. LLOYD JR.; *Empire State College, S.U.N.Y. , Canandaigua, NY 14424*
The Economic Trade Off-Growth vs the Environment

MACPHERSON, D.K. AND THOMAS, J.F.; *CSIRO Division of Water Resources, Private Bag, PO Wembley, Western Australia 6014*
An Intelligent Data Base for Ordering an Ecological-Economics Debate

MAIER-RIGAUD, GERHARD; *Institute for European Environmental Policy, Aloys-Schulte-Str. 6, 5300 Bonn*
Interventions in Nature or Economy? On the Scientific Background of a Conflict

Questioning Basic Assumptions

BAINES, J.T. ; *Principal in James Baines & Associates,PO Box 8620, Otautahi,Christchurch, Aotearoa,New Zealand,* and **PEET, N.J.** ; *Senior Lecturer in the Department of Chemical & Process Engineering, University of Canterbury, Otautahi,Christchurch, Aotearoa,New Zealand.*
Sustainable Development and Stock Resources: Is There a Contradiction? (Energy Policy Within a Framework of Sustainable Development)

ERIKSSON, KARL-ERIC and **MANSSON, BENGT A.;** *Institute for Physical Resource Theory, University of Goteborg and Chalmers University of Technology, S-41296, Goteborg, Sweden*
Physical Concepts in Ecological Economics

LOWE, IAN; *Division of Science and Technology, Science Policy Research Centre, Griffith University, Nathan, Brisbane, Queensland, Australia, 4111*
Economics of Sustainability: A Case Study

LOZADA, GABRIEL A.; *Department of Economics, Texas A&M University, College Station, TX 77843-4228*
Limitations on the Scope of Neoclassical Resource Economics

NAREDO, JOSE MANUEL; *C/Eladia Lopez Vilches, 12, 29033 Madrid, Spain*
From the Economic System Towards the Economics of Systems

REES, WILLIAM E.; *The University of British Columbia, School of Community and Regional Planning, 6333 Memorial Road, Vancouver, B.C., Canada V6T 1W5*
Why Economics Won't Save the World

SMITH, GERALD ALONZO; *Center for a Human Economy, Mankato State University, Mankato, MN 56001*
What Rationality? Whose Efficiency?

Managing the Commons for Sustainability

BERKES, FIKRET; *Institute of Urban and Environmental Studies, Brock University, St. Catharines, Ontario L2S 3A1, Canada*
Sequential Exploitation and the Ecological Economics of Living Resources

CAPISTRANO, A.D. and **KIKER, C.F.;** *University of Florida, Food and Resource Economics, Gainesville, Florida 32611*
Global Economic Influences on Tropical Closed Broadleaved Forest Depletion

CASTILLO, SERGIO; *PRMC, CATIE , 7170 Turrialba, Costa Rica, Central America*
Management of an Ecosystem as a Multiproduct Asset in a Developing Country Context

CHOPRA, KANCHAN and **KADEKODI, GOPAL K.;** *Institute of Economic Growth, Delhi, India*
People's Participation and Common Property Resources: Some Refelections

HAMMER, MONICA; *Askö Laboratory, Department of Natural Resource Management, Stockholm University, S-106 91 Stockholm, Sweden*
Marine Ecosystem Support in Relation to Fisheries Management

MAY, PETER H.; *R. Paissandu, 269/103, 22210 Rio de Janeiro, RJ, Brazil*
Savage Capitalism: International Market Alliances to Conserve Neotropical Forests

SWART, R.J. and **MAAS, R.J.M.;** *National Institute for Public Health and Environmental Protection, Bilthoven, The Netherlands*
From Global to National Climate Policy

Invited Session 2: Accounting, Modeling and Analysis

BRAAT, LEON C.; *Institute for Environmental Studies, Free University Amsterdam, P.O.Box 7161, Amsterdam, 1007 MC Netherlands*
Ecological-Economic Models for Sustainable Regional Development

CLARK, COLIN W.; *Institute of Applied Mathematics, The University of British Columbia, Vancouver, V6T 144, British Columbia, Canada*
Biases Against Sustainable Development

CLEVELAND, CUTLER J.; *Department of Geography and Center for Energy and Environmental Studies, Boston University, 675 Commonwealth Ave., Boston, MA 02144*
Natural Resource Scarcity and Economic Growth Revisited: Economic and Biophysical Perspectives

d'ARGE, RALPH C. and **SPASH, CLIVE R.;** *Department of Economics, Box 3985, University Station, University of Wyoming, Laramie, Wyoming 82071*
Compensating Future Generations for Adverse Economic Impacts

EL SERAFY, SALAH; *The World Bank, 1818 H Street, N.W. Washington, DC 20433*
The Environment as Capital

HANNON, BRUCE; Department of Geography, University of Illinois, Urbana, IL 61801
A General Accounting Framework for Ecological Systems

HUETING, ROEFIE; *Netherlands Central Bureau of Statistics, Princess Beatrixlaan 428,m 2270 AZ Voorburg*
Should National Income be Corrected for Environmental Losses? A Theoretical Dilemma, But a Practical Solution

MCGLADE, JACQUELINE; *Theoretical Ecology Working Group, KFA, Juelich, Federal Republic of Germany*
The Invisible Crisis: The Need for New Modes of Analysis in Modeling Coastal Resources

MITSCH, WILLIAM J.; *School of Natural Resources, The Ohio State University, Columbus, Ohio 43210*
Ecological Engineering - An Environmental Methodology for Sustainability and Biodiversity

PESKIN. HENRY M.; *Edgevale Associates, Inc., 1210 Edgevale Road, Silver Spring, MD 20910*
Alternative Environmental and Resource Accounting Approaches

PROOPS, J.L.R.; *Department of Economics and Management Science, University of Keele, Staffordshire, ST5 5BG, United Kingdom,* **FABER, M.;** and **MANSTETTEN, R.;** *Alfred Weber- Institut, Department of Economics, Universität Heidelberg, Grabengasse, 6900 Heidelberg, Federal Republic of Germany*
National Accounting, Time and the Environment

ULANOWICZ, ROBERT E.; *University of Maryland Chesapeake Biological Laboratory, Solomons, MD 20688-0038*
Discounted Values of Ecosystem Resources

Contributed Sessions - Accounting, Modeling and Analysis

Ecological Economic Approach to Natural Resource Accounting

BECK, ROGER; HARRIS, KIM and **KRAFT, STEVEN;** *Department of AgriBusiness Economics, Southern Illinois University, Carbondale, Ill. 62901 U.S.A.*
Establishment of a National Wildlife Refuge from an Economist's Perspective: Methodological Insights

CUNNINGHAM, A. B; and **FRIEDMAN, M.;** *Institute of Natural Resources, University of Natal, P.O. Box 375, Pietermaritzburg 3200, South Africa*
Prime Movers: Women and Wild Plant Resources

FEITELSON, ERAN ; *Apogee Research Inc., 4350 East-West Highway, Suite 600, Bethesda, Maryland 20814*
An Alternative Role for Economic Instruments: Sustainable Finances for Environmental Management

FRIEND, ANTHONY M.; *Institute for Research on Environment and Economy, University of Ottawa, Ottawa, Canada*
Natural Resources Accounting (NRA) and the System of National Accounts (SNA): Synergism or Antagonism?

GILBERT, ALISON ; *IES - Free University, P.O. Box 7161, 1007 MC Amsterdam, The Netherlands*
Satellite Accounts for Botswana - Theory and Logistics

GHOSH, SOUMENDRA; *New Mexico State University, Las Cruces, New Mexico, 88003*
Efficient Food Production and Natural Resource Management Through Improved Credit Access to Women: Case Studies in Kenya

GROENFELDT, DAVID J.; *World Wildlife Fund, 1250 24th Street, N.W., Washington, D.C. 20037*
In Search of Sustainable Watershed Development Strategies for Local Management in South and Southeast Asia

JOHNSON, RICHARD L. and **DOUGLAS, AARON J.;** *U.S. Department of the Interior, Fish and Wildlife Service, National Ecology Research Center, 4512 McMurray Avenue, Fort Collins, CO 80525-3400*
Conceptual Problems in Estimating the Social Returns to Nonmarket Water Resources

KING, DENNIS M.; *ICF Incorporated, 9300 Lee Highway, Fairfa, VA 22031*
Bio-Economics of Wetland Restoration: A Framework for Applied Research

KLEMAS, V.; *College of Marine Studies, University of Delaware, Newark, Delaware 19716,* **OTT, J.S.;** *Environmental Research Institute of Michigan, Ann Arbor, MI 22209,* **GROSS, M.F.;** *Gettysburg College, Gettysburg, PA 17325,* **HARDISKY, M.A.;** *University of Scranton, Scranton, PA 18510*
Mapping Coastal Marshes and Determining Their Health on a Global Scale Using Satellite Remote Sensors

PILLET, GONZAGUE; Paul Scherrer Institute, Villigen & University of Fribourg, Fribourg, Switzerland, **BARRANZINI, ANDREA;** Department of Economics, University of Geneva, Geneva, Switzerland, **HALL, CHARLES;** State University of New York at Syracuse ESF, Syracuse, New York, **GREPPIN, HUBERT;** Department of Botany, University of Geneva, Geneva, Switzerland , **SANDOZ-TERRAZ, SYLVIE;** Department of Geography, University of Geneva, Geneva, Switzerland
Assessing Some Economic and Ecological Evaluations on Environmental Issues with Special Reference to Switzerland

TOLEDO, VICTOR M.; *Centro de Ecologia, UNAM, APDO 70-275, Mexico*
A Conceptual Framework for the Ecological-Economic Analysis of Rual Production

THRUPP, LORI ANN; *Energy and Resources Program, University of California, Berkeley, California 94720*
The Political Ecology of Natural Resource Strategies in Costa Rica

Modelling Ecological Economic Systems

ALDEN, DAVID; *Department of Economics, University of Keele, Keele, Staffordshire, ST5 5BG, United Kingdom*
The 'Greenhouse Effect' and World Agriculture: Using Computable General Equilibrium Models to Examine the Implications of Climate Change for Agriculture

BANKS, STEVEN M.; *Department of Geography-Geology, Illinois State University, Normal, Illinois*
Natural Resource Booms and Third World Development: Modelling the Response of Export Agriculture Via the Expansion Methodology

CHARLES, ANTHONY T.; *Saint Mary's University, Department of Finance and Management Science, Halifax, Nova Scotia B3H3C3 CANADA*
Sustainable Fisheries: Management Paradigms and Bio-Socio-Economic Models

CONNER, J. R.; STUTH, J. W.; HAMILTON, W. T. and **SHEEHY, D. P.;** *Dept. of Agricultural Economics, Texas A&M University, College Station, Texas, 77843*
An Integrated Ecologic-Economic Model for Planning Sustainable Grazing Animal Production Systems

GROSS, LORNA S.; *Keene State College, 229 Main Street, Keene, NH 03431*
The Production Specification in Economic Growth Models

IKEDA, SABURO ; *Inst. of Socio-Economic Planning, University of Tsukuba, Tsukuba, Ibaraki 305, Japan*
An Empirical Model Framework for Sustainable Resource and Environmental Management in Coastal Area

LEE, DANNY and **PAULSEN, CHARLES;** *Resources for the Future, 1616 P Street NW, Washington, DC, 20036.*
Integrated Ecological and Economic Modelling for Fisheries Planning in the Columbia River Basin

MCKONE, THOMAS E.; *University of California, Lawrence Livermore National Laboratory, P.O. Box 5507, L-453, Livermore, CA 94550*
Tracking the Global Fate of Industrial Emissions on a Macintosh Using STELLA

GURMAN, VLADIMIR I. and **SAFONOV, PAUL I.;** *Program Systems Institute, Institute Control Sciences, USSR Academy of Sciences, Profsoyuznaya,117806,Moscow, USSR1*
Interactive Modelling of the Ecologic-Economic Regional Development

SAVORY, ALLAN; *Center for Holistic Resource Management, 800 Rio Grande Boulevard, N.W., Suite 10, Albuquerque, New Mexico 87104*
The Holistic Resource Management Model

SKLAR, FRED H.; Belle W.Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Georgetown, SC 29440, and **COSTANZA, ROBERT;** *Center for Environmental and Estuarine Studies, University of Maryland, Box 38, Solomons, MD.*
Modeling Natural and Human Impacts on Wetlands

SOUTHWORTH, FRANK HILLSMAN, EDWARD L. DALE, VIRGINIA H FROHN, ROBERT H. JIMENEZ, BRAULIO D.and O'NEILL, ROBERT V.; *Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831*
Modeling Land Tenure Patterns, Highway Infrastructure Policies and the Ecological Impacts of Deforestation in Rondonia, Brazil

WALKER, ROBERT; *Department of Geography, Florida State University, Tallahassee, FL 32306*
A Behavioral Model of Tropical Deforestation Under the System of Concession Logging

VAN DEN BERGH, JEROEN and **NIJKAMP, PETER**; *Free University Amsterdam, P.O. Box 7161, 1007 MC Amsterdam, The Netherlands*
Aggregate Economic-Ecological Models for Sustainable Development

Energy Analysis and Ecological Economics

COULTER, JOHN; *Entropy Management Services Pty Ltd, 7 Yarabah Crescent, Shailer Park, Brisbane 4128, Australia*
Economic Activity on an Energy Landscape

DENZLER, ERIC; *Center for Energy and Environmental Studies, Boston University, 675 Commonwealth Avenue, Boston, MA 02215*
Energy and Economic Analysis of Phosphorous Scarcity and the United States Phosphate Rock Industry

FAUCHEUX, SYLVIE; *Centre-Économie-Espace-Environnement, Université de Paris I. Panthéon-Sorbonne, 90, Rue de Tolbiac, Paris.*
Sustainability in Light of an Eco-Energetic Analysis

GIAMPIETRO, MARIO; *Instituto Nazionale della Nutrizione, Rome, Italy, and* **PIMENTEL, DAVID**; *College of Agriculture and Life Sciences, Cornell University, Ithaca, New York*
Energy Efficiency : Assessing the Interaction between Humans and their Environment

HERENDEEN, ROBERT A.; *Illinois Natural History Survey, 607 East Peabody Drive, Champaign IL 61801*
Monetary Costing of Energy-Related Environmental Effects: Examples from Several States and from Norway

KAUFMANN, ROBERT; *Center for Energy and Environmental Studies, 675 Commonwealth Avenue, Boston University, Boston, MA 02215*
Emission of Carbon Dioxide From Economic Activity: The Fuels, Sectors and Nations of Origin

KOHLMAIER, G.H. and **LÜDEKE, M.K.B.**; *Institut für theoretische und physikalische Chemie der Johann-Wolfgang-Goethe Universität, Niederurseler Hang, D-6000 Frankfurt/Main 50, West Germany*
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MAYUMI, KOZO; *Research Fellow, Department of Applied Mathematics and Physics, Faculty of Engineering, Kyoto University, Kyoto 606 Japan*
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ODUM, HOWARD T. and **ARDING, JAN**; *Environmental Engineering Sciences and Center for Wetlands, University of Florida, Gainesville, Florida*
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PATTEN, BERNARD C.; *Department of Zoology and Institute of Ecology, University of Georgia, Athens, Georgia 30602*
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ABLER, DAVID G. and **SHORTLE, JAMES S.**; *Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park, PA 16802*
Environmental, Trade and Farm Commodity Policy Linkages

EVERETT, MICHAEL D.; *Department of Economics, East Tennessee State University, Johnson City, TN 37601*
The Political Economy of Environmental Movements

BLITZER,CHARLES R.; *World Bank, 1818 H Street, Washington D.C.,* **ECKAUS, RICHARD S.;** *Massachusetts Institute of Technology, Cambridge Massachusetts, 02139,* **LAHIRI, SUPRIYA;** *University of Lowell,* and **MEERAUS, ALEXANDER;** *GAMS Development Corporation*
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HARRIS, JONATHAN M.; *Economics Department, Boston University, 270 Bay State Road, Boston, MA 02215*
Global Institutions and Ecological Crisis

LINES, MARJI and **TAMARO, MARCO;** *Faculty of Economics and Department of Environmental Science, University of Venice, Venice, Italy*
Atrazine: A Non Point Source Pollution Problem

PASTUK, MARILIA; *MONASA, Ltd., R. Teixeira de Freitas, 31, 7o. andar, Rio de Janeiro, RJ, Brazil*
Ecology and Social Inequality in Brazil

SOUSA, CLARA DE and **PERKINS, PATRICIA E.;** *Faculdade de Economia, Universidade Eduardo Mondlane, Maputo, Mozambique*
Environmental Effects of the IMF Economic Program in Mozambique, 1987-1990

Measurement and Valuation of Natural Resources

BERGSTROM, SOREN; *Assistant Professor, Stockholm University, Stockholm, Sweden*
Sustainable Development Accounting: Taking Advantage of Rigorous Theory

BISHNOI, S. and **GAUTAM, D.D.;** *Laboratory of Plant Ecology, P.G. Department of Botany, Dungar (Autonomous) College, Bikaner - 334 001 (Raj.), India.*
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FOLKE, CARL; *Asko Laboratory, University of Stockholm, S - 106 91, Stockholm, Sweden*
The Societal Value of Wetland Life-Support

GOTTFRIED, ROBIN; *Department of Economics, The University of the South, Sewanee, Tennessee 37375*
The Value of a Watershed as a Series of Linked Multiproduct Assets

JOHN, KUN H.; WALSH, RICHARD G. and **MOORE, CHESTER G;** *Dept. of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO 805233*
Comparison of Alternative Nonmarket Valuation Methods For An Economic Assessment of A Public Good

KETKAR, KUSUM; *Associate Professor of Economics, School of Business, Seton Hall University, South Orange, NJ 07079-2692*
Hazardous Waste Sites and Property Values in the State of New Jersey

VAN DER STRAATEN, JAN; *Tilburg University , P.O. Box 90153, 5000 LE Tilburg/Holland*
The Policy of the Netherlands Regarding Acid Rain in a Single Internal Market.

Invited Session 3: Institutional Changes

BORA, GYULA; *University of Economics and Political Science, Dimitrov t tér 8, Budapest H-1050, Hungary*
Contradictions in the Environmental Policy of Eastern Europe: the Case of Hungary

CAVALCANTI, CLOVIS; *Fundacão Joaquim Nabuco, Rua Dois Irmaos, 92' Recife, PE52071, Brazil*
Government Policy and Ecological Concerns: Some Lessons Learned From Brazil

CHRISTENSEN, PAUL; *Department of Economics, Hofstra University, Hempstead, New York 11550*
Increasing Returns and the Management of Sustainability

CLARK, MARY E.; *Department of Biology, College of Sciences, San Diego State University, San Diego, CA 92182-0057*
Rethinking Ecological and Economic Education: A Gestalt Shift

COSTANZA, ROBERT; *Center for Environmental and Estuarine Studies, University of Maryland, Box 38, Solomons, MD.*
Implementing Institutions to Assure Sustainability of Ecological Economic Systems

CUMBERLAND, JOHN H.; *Director, Bureau of Business and Economic Research, University of Maryland, College Park, MD*
Intergenerational Transfers and Ecological Sustainability

FARBER, STEPHEN; *Economics Department, Louisiana State University, Baton Rouge, Louisiana 70803*
Economic Incentives for Preventing and Adapting to Ecological Changes

GOODLAND, ROBERT J.; *The World Bank, Washington, D.C. 20433*
Sustainability of Hardwoods from Tropical Moist Forests

PAGE, TALBOT; *Environmental Studies, Brown University, Providence, Rhode Island 02912*
Environmentalists and Economists and Philosophers and Biologists

PERRINGS, CHARLES A.; *Department of Economics, University of Auckland, Private Bag, Auckland 1, New Zealand*
Technological Change, Uncertainty, and Time in Environmental Management

VARSHNEY, C. K.; *School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, 110 067 India*
Indian Agriculture and Sustainability

ZUCCHETTO, JAMES J.; *National Academy of Sciences, Washington, D.C.*
Ecological Economics and Education

ZYLICZ, TOMASZ; *Ministry of Environment, Wawelska 52154, 00-922, Warsaw Poland*
The Role for Economic Incentives in International Allocation of Abatement Efforts

Contributed Sessions - Institutional Changes

Incentives and Disincentives for Achieving Sustainability

ALESKEROV, FOUAD T.; *Institute of Control Sciences, 65 Profsoyuznaya, Moscow 117806 USSR*
Tax Formation For Improvement of the Ecological Situation in a Region

COLBY, MICHAEL E.; *2104 North Quantico Street, Arlington, Virginia 22205*
Economics and Environmental Management: The Case for Environmental Taxes

CRAIG, PAUL P..; DUNLOP, BETH; CONLEY, CRAIG and **GLASSER, HAROLD**; *Sustainable Futures Research Group, Department of Applied Science, University of California, Davis, CA 95616*
Apparent Consumer Discount Rates

HEDMAN, SUSAN; *School of Public Affairs, University of Maryland, College Park, Maryland 20742*
Reversibility as a Weighting Factor in Integrated Least Cost Planning Methodologies

JOHN, KUN H.; WALSH, RICHARD G. and **KLING, ROBERT W.**; *Dept. of Agricultural and Resource Economics, Colorado State University , Fort Collins, CO 80523*
The Le Chatelier's Effect in Environmental Economics: A Critical Evaluation of Environmental Policies for Sustainable Resource Management

LONERGAN, STEPHEN and **HARTE, MICHAEL**; *Department of Geography, University of Victoria, P.O. Box 1700, Victoria, B.C. V8W 2Y2 Canada*
Market Oriented Strategies for Reducing CO_2 Emissions: Taxes, Price Inducements and Regional Impacts

MCKELVEY, ROBERT; *Mathematical Sciences Department, University of Montana, Missoula, MT 59812*
A Bayesian Approach to the Conservation of Biological Diversity

MUNROE, MARTIN J.; *Lyndon B. Johnson School of Public Affairs, University of Texas, Austin, Texas 78711*
Public Policy and Biomass Transportation Fuels: Economically Useful Information From Energetics

PETERSON, STEVEN. C.; *Ecology & Environment, Inc., 368 Pleasantview Drive, Lancaster, New York 14086*
Economics of Global Warming Abatement: Contributory Value of Forest Ecosystems as Carbon Sinks

PEZZEY, JOHN; *Department of Economics, University of Bristol, 40 Berkeley Square, Bristol BS8 1HY*
Charges vs Subsidies vs Marketable Permits as Efficient and Acceptable Methods of Effluent Control: A Property Rights Analysis

SHOEMAKER, ANDREW R.; *University of Virginia School of Law* , and **TOWNSEND, KENNETH N.**; *Hampden-Sydney College, Hampden-Sydney, Virginia 23943*
The Chinese Environment: An Analysis of Environmental Policy Problems within The People's Republic of China

TIETENBERG, TOM; *Dept of Economics, Colby College, Waterville, Maine 04901*
Managing the Transition to Sustainability: The Potential Role for Economic Incentive Policies

Ecological Economic Solutions to Environmental Degredation

BOJÓRQUEZ-TAPIA, LUIS A. and **ONGAY, ENRIQUE**; *Centro de Ecología, UNAM, Apartado Postal 70 275, 04510 Mexico, D.F. Mexico*
International Lending and Resource Development in Mexico: Can Environmental Quality be Assured?

CHAN, ARTHUR H. and **MILLS, SHERRY K.**; *College of Business and Economics, New Mexico State University, Las Cruces, New Mexico 88003*
An Energy Content-Based Information System for Municipal Solid Waste Management

FENTON, ROBERT and **BROWN, WILSON**; *University of Winnipeg, Winnipeg, Canada, R3B 2E9*
The Uncertainty and Externalities of Catastrophic Loss: Measurement, Interpretation, and Decisions

HEMPEL, LAMONT C.; *Associate Director, Center for Politics and Policy, The Claremont Graduate School, Claremont, California 91711*
Implications of International Carbon Dioxide Abatement Strategies for Sustainable Development

KAUFMANN, ROBERT; *Center for Energy and Environmental Studies, 675 Commonwealth Avenue, Boston University, Boston, MA 02215*
Emission of Carbon Dioxide From Economic Activity: The Fuels, Sectors and Nations of Origin

KOZLOFF, KEITH; *Department of Agricultural and Applied Economics, University of Minnesota, 1994 Buford Avenue, St. Paul, MN 55108*
The Political Economy of Information in Targeting Measures to Reduce Nonpoint Source Water Pollution

KÜMMEL, REINER and **SCHÜSSLER, UWE**; *Physikalisches Institut der Universitat Wurzburg, D-8700, Wurzburg, FRG*
Heat Equivalents of Noxious Substances: A Pollution Indicator for Environmental Accounting

MOREHOUSE, WARD; *Council on International and Public Affairs; Intermediate Technology Development Group of North America; School of International Affairs, Columbia University, New York, NY.*
Equity and Ecology in the Great Global Clean-Up: A Superfund for Toxic Workers

RAPPORT, DAVID J.; *Institute for Research on Environment and Economy, Simard Hall, University of Ottawa, Ottawa KIN 6N5 Canada, and* **HILDEN, MIKAEL**; *Statistics and Economics Section, Finnish Game and Fisheries Research Institute, P.O. Box 202, SF-00151 Helsinki, Finland*
Patterns of Temporal/Spacial Propagation of Ecosystem Pathology in the Gulf of Bothnia

MARTIN, LARRY; *1442 Harvard St., NW Washington, DC 20009*
The Gross National Waste Product

SHARP, BASIL M.J.; *Department of Economics, University of Auckland, New Zealand*
Global Pollution: An Assessment of Transferable Permits

SIMONIS, UNO E.and LEIPERT, CHRISTIAN; *Wissenschaftszentrum Berlin fur Sozialforschung, Reichpietschufer 50, D-1000 Berlin, Federal Republic of Germany*
Environmental Damage and Environmental Protection Expenditures: The Example of the Federal Republic of Germany

VAN DER STRAATEN, JAN; *Tilburg University , P.O. Box 90153, 5000 LE Tilburg/Holland*
The Policy of the Netherlands Regarding Acid Rain in a Single Internal Market.

WEBER, JEFF and **MEISTER, ANTON**; *Department of Agricultural Economics, Massey University, Palmerston North, New Zealand*
Managing Natural Resources, Institutional Change, and Sustainability in New Zealand: A Case Study

Ecologically Integrated Technology

ANGERER, GERHARD; *Fraunhofer-Institut for Systems and Innovation Research, Karlsruhe ,West Germany*
Capability of New Technologies for Future Environmental Protection - The Example of Air Pollution

ANNAN, ROBERT H.; *Photovoltaic Technology Division, U.S. Department of Energy, 1000 Independence Avenue S.W., Room 5F-081, Washington D.C. 20585,* **BURR, RALPH**; *Geothermal Technology Division, U.S. Department of Energy, 1000 Independence Avenue S.W., Room 5H-065, Washington, D.C. 20585, and* **CABRAL, ANIL**; *Meridian Corporation, 4300 King Street, Suite 400, Alexandria, VA 22302-1508*
Rational Power Development: The Integrated Electric Utility

CONLEY, CRAIG and **CRAIG, PAUL P.**; *Ecology Graduate Group, University of California, Davis, CA 95616*
The True Cost of Electricity: Implications for Least-Cost Electricity Resource Planning

DALE, BRUCE E.; HOLTZAPPLE, MARK A. and RYKIEL, EDWARD J.; *Texas A&M University, College Station, Texas, 77843 USA*
A New Technology for Sustainable Production of Food and Fuel from Biomass: Energy, Economics and Ecology.

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GLASSER, HAROLD and CRAIG, PAUL P.; *Applied Science Department, University of California, Davis, CA 95616*
Problems with Plastic Trees and Ways to Think About Recycling Them

KHALIL, ELIAS L.; *New School for Social Research, Springfield, MO*
Beyond the Widow's Curse and Marie Antoinett's Folly: A Physical Model of Production and Resources

MACLEAN, JOHN C.; *548 Massachusetts Avenue, Boston, MA 02118*
Factoring Environmental Externalities into Electric Power Supply Decision-Making

MROZEK, CARL; *College of Environmental Science and Forestry, Syracuse University, Syracuse NY 13210*
TV/Video: The Magic Box for Mixing Environmental Education with Development

RUBINO, MICHAEL C.; *Bluewaters Inc. and Palmetto Aquaculture, 4350 East West Hwy, Suite 600, Bethesda, MD 20814*
Sustainable Aquaculture: Shrimp Farming

VYASULU, VINOD; *Professor and Head, Social Services Management Unit, Institute for Social and Economic Change, Bangalore 560072, India*
On Choosing Environmentally Sound and Self-Reliant Technologies: Reflections on Indian Experience

ZIPARO, ALBERTO; *Center for European Economic Studies, Northeastern University, Boston, Mass.*
The Environmental Planning of Energy Projects

Institutions To Sustain Biological Resources

CALE, WILLIAM G.; *Indiana University of Pennsylvania, Indiana, Pennsylvania 15705 , and* **KATZMAN, MARTIN T.;** *Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831*
International initiatives for the long-term preservation of tropical forests.

FRAZIER, J.; *Universidad Nacional, Apartado 1353, Heredia, Costa Rica*
Ecological Economic of Marine Turtles: Challenges in Sustainable Exploitation of a Resource Which is Both Local and International

IÑIGO-ELIAS, EDUARDO; *Centro de Estudios Para La Conservacion de los Recursos Naturales, A.C, Chiapas, Mexico*
Ecological and Socio-Economic Implications of the Trade with Wild Parrots: The Mexican-USA Case

JANSEN, DORIS J.; *WWF Multispecies Project, P.O. Box 8437 Causeway, Harare, Zimbabwe*
Sustainable Wildlife Utilization in the Communal Areas of Zimbabwe: Economic, Ecological and Political Tradeoffs

SOUTHGATE, DOUGLAS; *Department of Agricultural Economics and Rural Sociology, Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210-1099*
How To Promote Tropical Deforestation: The Case of Ecuador

T SAS-ROLFES, MIKE; *23 Eton Park, 6 Eton Road, 2196 Sandhurst, South Africa*
The Economics of Rhino Conservation

WEBER, A.W.; *Wildlife Conservation International, Bronx, New York 10460*
Nature Tourism in Rwanda: The Extension and Limits of Gorilla Economics

Individual Responsibilities in Achieving Sustainability

DAY, LINCOLN H.; *Department of Demography, Australian National University, Canberra, A.C.T., Australia*
Departing from Resource-Intensive Lifestyles: Problems and Possibilities

FRIEDMAN, M.and POLLETT, E. A.
Institute of Natural Resources, University of Natal, P.O. Box 375, Pietermaritzburg 3200, Republic of South Africa
The Possibilities of Achieving Sustainable Rural Livelihoods in the Context of a Migrant Labour System: Some Lessons From an Integrated Rural Development Project in Kwazulu, South Africa

HITCHNER, BENJAMIN; *Center for Economic Education, Glassboro State College, Glassboro, NJ 08028-0761*
Man Centered Economics

HAENKE, DAVID; *The Ecological Society Project of The Tides Foundation, Inc., Rt. 1, Box 20, Newburg, Mississippi 65550*
Economics as the Gaian Disease: The Diagnosis and Cure Through Ecological Economics

PHILOMENA, ANTONIO Fundação Universidade do Rio Grande, Laboratório de Ecologica, rua Alberto Torees 161, Porto Allegro, Brazil
What should be Taught in Ecological Economics?

PEET, N. J.; *Department of Chemical and Process Engineering, University of Canterbury, Christchurch, New Zealand, and* **PEET, K. M.;** *New Zealand Workers' Education Association, Inc., Canterbury, New Zealand*
With People's Wisdom: Community Based Perspectives on Sustainable Development

SCHROYER, TRENT. *Ramapo College of New Jersey, 505 Ramapo Valley Road, Mahwah, NJ 07430*
Ecological Economics of Sustainability

WELLE, PATRICK G.; *Department of Economics, Bemidji State University, Bemidji, MN 56601*
Translating Household Stewardship Values Into Ecological Stewardship Goals: Some Empirical Evidence

INVITED ABSTRACTS

BRAAT, LEON C.
Institute for Environmental Studies, Free University Amsterdam, P.O.Box 7161, Amsterdam, 1007 MC Netherlands

Ecological-Economic Models for Sustainable Regional Development

In the course of the 1980's, the concept of 'sustainable development' became the key concept in areas such as economic planning and environmental protection. In most definitions sustainable development combines two basic notions, i.e. ecological sustainability and economic development. Ecologically sustainable economic development is defined as those changes of economic structure, organization and process towards maximum welfare which can be sustained by the resource systems which the economic system has access to.

At the global, biosphere level, sustained development is constrained by the total of resources present on earth and the energy supplied by the sun. Ecological-economic systems at a level below the world system, however, have the opportunity to add to their own resource base through trade and exchange. This network and resulting regional interdependencies offer possibilities to broaden the sustainable development base and to decrease discrepancies between regions.

In the paper two questions related to the issue of regional sustainable development are addressed: 1) what is the optimal, sustainable combination of uses, and at which level of intensity, of a region's own resource base? and 2) what are the consequences of expanding the economic production and consumption levels beyond the original regional carrying capacity? The first question pertains to the dynamics of resource systems as well as to the potential and problems of multiple use of resources. The second question suggests a focus on degradation of ecosystems through excess exploitation to support export flows necessary to pay for imports and through environmental stress, such as pollution, as a consequence of excess productivity and consumption. The paper introduces a generic regional model, presents explorations of the dynamics, constraints and consequences of various economic development scenarios, and illustrates several of these issues with a case study in the Netherlands.

BORA, GYULA
University of Economics and Political Science, Dimitrov t tér 8, Budapest H-1050, Hungary

Contradictions in the Environmental Policy of Eastern Europe: the Case of Hungary

In spite of existing measures and valid acts for environmental protection in Eastern European Countries, the state of the environment is getting worse and worse. The reasons for these contradictions are political, economic and societal.

To improve understanding we have to reconsider the three theoretical arguments and approaches often cited as guarantees of an effective environmental policy. These are: social ownership of means of production, mechanisms of planned economies, and the system of political institutions.

In planned economies the state is the principal owner of the means of production and it runs and regulates the economy at the macro level. But socialist economies can be characterized by limited sources and unlimited demands, therefore the capital allocations are decided by a set of different priorities, which are motivated mainly by political and subjective factors. First of all, the infrastructure for environmental protection has suffered from a low priority in the process capital allocation.

On the other hand, socialist ownership, from an economic and organizational point of view, means that enterprises have relative autonomy. Enterprises also have definite economic tasks and goals, first of all to maximize their output. Often the efforts and interests of the enterprise to fulfill this goal contradicts with ecological interests. State intervention is necessary to regulate the enterprises in order to produce environmentally benign behavior. In the case of Hungary the basic principle of state intervention is that the polluter should pay. This is realized by emission standards, fines, and penalties. But because of the misfunctioning of the political/institutional system, this basic principle can't operate in an effective way. The outlook for the future is more optimistic because of the changing political and economic system.

BOULDING, KENNETH E.
Institute of Behavioral Science, University of Colorado at Boulder, Campus Box 484, Boulder, Colorado 80309

What do we want to Sustain? Environmentalism and Human Evaluations

The sustainability of biological evolution on this planet, punctuated as it seems to have been by catastrophes from which it recovered, is a fascinating story of which we have very imperfect knowledge. There seems little doubt, however, that the human race is an ecological catastrophe, simply because its intelligence has enabled it to spread over the whole planet and to produce very large numbers of artifacts which have an impact on biological populations. Most evolutionary catastrophes seem to have been followed by an increase in the complexity of organisms, perhaps because of the empty niches created by the catastrophe itself, and one wonders whether this is a possible guide to the future.

The unique characteristic of the human race is its capacity for forming complex images not only of its immediate environment but of the whole planet, and its ability to put evaluations over these larger images. Environmentalism as an ideology involves putting human evaluations over the possible future states of the total planet. If these evaluations are adverse, suggesting a worsening of the state of the planet, then the question arises, what changes in human behavior and institutions may result? We already see some changes in individual behavior, like concerns for recycling and biodegradability and the cutting back on fluorocarbons because of the ozone effect. These changes affect only a small part of the human race and a critical question is whether the learning can be much further extended to change the behavior of those whose actions are constrained only by their perception of their immediate benefit. It is worth asking what new institutions might be necessary to achieve these objectives, even though the answers may not be easy to find.

The role of economic institutions in this process is obviously of great importance, but also hard to identify. An important question here is the extent to which the institutions of society feed back on the perceived welfare of decision makers and the overall effect of their decisions on the total system. Market institutions have the advantage that decisions the result of which are not favorably regarded by potential purchasers have fairly rapid feedback. Under central planning feedback is much slower and disastrous decisions can be made without the consequences falling on the decision maker. This perhaps may account for the present disillusionment with central planning. It may be that we are looking for some optimum combination of political or threat power, economic power, and what I have called "integrative power," to lead us either away from catastrophe or towards a situation in which catastrophe will actually sustain the evolutionary process.

CAVALCANTI, CLOVIS
Fundacão Joaquim Nabuco, Rua Dois Irmaos, 92' Recife, PE52071, Brazil

Government Policy and Ecological Concerns: Some Lessons Learned From Brazil

The paper is an attempt to offer some empirical background for discussion about what should be done to attain genuine human progress in Brazil and the entire planet. It starts from two situations of reference (the historical formation of Brazil and the Amazon's recent development) to show what kinds of governmental policy were conceived and implemented, and the ecological concerns they aroused. No exhaustive list of possible defining elements of the policies is given, but a synthetic vision of reality is suggested by an examination of relevant environmental issues. The overall conclusion of the paper stresses the unsatisfactory way (to say the least) that ecological problems were delt with in Brazil since colonial times. Some explanations for that behavior are considered.

CHRISTENSEN, PAUL
Department of Economics, Hofstra University, Hempstead, New York 11550

Increasing Returns and the Management of Sustainability

The neoclassical economic theory which dominates resource and environmental analysis and policy is based on atomistic and mechanistic assumptions about individuals, firms, resources, and technologies which are inappropriate to the complex and pervasive classical production theory, for example, entirely neglects (1) any physical specification of the materials, energy, and information inputs (including the "machines" which transform energy, materials, and information), (2) the physical connectivity (complementarity) between these inputs within production techniques, and (3) the sequential nature of production activities (geophysical and biological production

systems and the stages of extraction, processing, and fabrication in economic systems). It also neglects (4) the implications of energetic and information processes for the non-equililbrium, self-reinforcing behavior of economic systems. Partly for ideological reasons and partly for reasons of mathematical tractability, neoclassical theory has confined itself within a world characterized by diminishing returns and negative or self-limiting feedback. Since the industrial revolution, economic activity has combined technological and information replication and innovation with the large-scale exploitation of environmental and "stock" resources (including fossil fuels). As the classical economists, Alfred Marshall, Allyn Young, Gunnar Myrdal, and Nicholas Kaldor well knew, internal or sectoral economic relations are often characterized by increasing returns, positive feedback or self-reinforcing processes of disequilibrium growth.

The older classical tradition of economic theory, which was set out from a nascent materials and energetic foundation, developed an asymmetric analysis of diminishing returns in extraction and agricultural sectors and increasing returns in manufacturing. The latter was based on the assumption that machines and skills could be replicated over time. A reinterpretation of this framework from a bio-physical and information perspective can provide a "new" interpretation of the operation of production and market processes in relation to resource availability (and environmental sustainability). Since resource prices in this approach are driven by macro demand and technology and move with the business cycle, the view that market prices provide an index of scarcity is considerably weakened. Increasing returns in the economic core reinforces the view that resource, economy, and environmental interactions must be managed to preserve ecosystem integrity and function. A physical approach to resource and environmental management is given support against the excessive reliance of neoclassical theory on extending the sphere of market interactions and private property rights.

CLARK, COLIN W.
Institute of Applied Mathematics, The University of British Columbia, Vancouver, V6T 144, British Columbia, Canada

Biases Against Sustainable Development

The speed with which the phrase "sustainable development" has been adopted indicates widespread recognition of the necessity of achieving sustainability, as well as tacit recognition of the likelihood that much existing development may be far from sustainable. The problem of understanding the social and economic forces ranged against sustainability therefore assumes major importance. This paper analyzes the implications of the three major biases against sustainability: common property externalities, future discounting, and uncertainty. These interrelated, synergistic biases are very firmly imbedded in our contemporary way of life, based on the demand for ever increasing economic growth. Overcoming them promises to be difficult indeed.

Certain pre-agricultural societies succeeded in maintaining sustainable use of resources, for example by employing various religious taboos, and also through defense and expansion of hunting territories. Nowadays there are few opportunities for expansion of territories, and religious taboos have long been forgotten. Yet some method must be found to induce modern society to recognize and appreciate the intrinsic economic values of natural capital - values that are automatically equated to zero for common-property resource assets, and often severely underestimated for privately owned resource assets, because of discounting and uncertainty. The depletion of natural capital can yield tremendous profits for exploiters, but these private profits frequently correspond to severe social losses, generated by reducing the base stock of natural capital. Much of apparent economic growth may in fact be an illusion based on a failure to account for reductions in natural capital (Daly and Cobb, 1989).

The socioeconomic biases against sustainable development must somehow be overcome if the goal of sustainability is to be reached. Unfortunately very little attention has yet been paid to how these biases may be defeated.

CLARK, MARY E.
Department of Biology, College of Sciences, San Diego State University, San Diego, CA 92182-0057

Rethinking Ecological and Economic Education: A Gestalt Shift

Neoclassical economic theory is based on only limited recognition of two boundary conditions that in the long-run constrain all economic systems: limits of the environment and limits of the human psyche. This short-run thinking has brought us face-to-face with long-run consequences, both environmental and societal. We require a new understanding of the purposes and consequences of economic activity. This will require more than simply restructuring our economic thinking to accommodate environmental and sociopyschological limits. We cannot solve

our impending crises just by inventing a single value system that will incorporate cost-benefit trade-offs in the environment and in our social institutions. Such trade-offs presume some kind of facile substitutability among all the identified components in the ledger, making comparisons between quantifiable aggregate outcomes the basis for decisions. It is a prescription for disaster. An alternative approach is to project a desired set of social and environmental goals and ask, what sorts of economic activities would most likely lead to these goals? This requires a gestalt shift in the assumptions underlying Western approaches to economics, ecology, and social psychology.

For this shift to occur, the education of planners and decision-makers -- and of the general populations they represent -- must include the following:

1. Grounding in ecological principles of sustainable systems, to which ecologists have paid too little attention;
2. Grounding in psychosocial factors creating stable societies -- and in approaches to self-generated change, which most societies must undertake to become "sustainable";
3. Training in critiquing the limitations of present economic theory, thus bridging from present to future gestalts;
4. Training in identifying the appropriate socio-economic entities for establishing local, bioregional, and global sustainability, and their interaction.

This amalgamation of the disciplines will require abandoning many assumptions in current Western thinking, which so dominates today's international arena.

CLEVELAND, CUTLER J.
Department of Geography and Center for Energy and Environmental Studies, Boston University, 675 Commonwealth Ave., Boston, MA 02144

Natural Resource Scarcity and Economic Growth Revisited: Economic and Biophysical Perspectives

The neoclassical model of production assumes that capital and labor are primary inputs to production. Consistent with this assumption, the neoclassical model of natural resource scarcity assumes that real resource prices or capital-labor extraction costs are the appropriate empirical indicators of scarcity. In their seminal work, Barnet and Morse found that capital-labor costs per unit of extractive output declined throughout most of this century, a trend they attributed to "self-generating" technological change. A biophysical model of the economic process assumes that capital and labor are intermediate inputs produced ultimately from the only primary factor of production: low entropy energy and matter. A biophysical model of scarcity posits that direct and indirect energy costs of resource extraction increase with depletion because lower quality deposits require more energy to locate, upgrade, and otherwise transform into useful raw materials. I repeated Barnett and Morse's from a biophysical perspective using energy costs to measure changes in the quality of extractive output in U.S. agriculture, forestry, fishing, and mining industries. In most cases, energy costs per unit of output increases with depletion. Results show that labor and capital costs declined because large quantities of surplus fossil fuel substituted for and increased the productivity of labor and capital. Substantial increases in energy costs were found in agriculture, fisheries, and the mining of metals and fossil fuels. I discuss possible trends for future costs in light of the result that the energy cost of fossil fuels themselves is also rising.

COSTANZA, ROBERT
Center for Environmental and Estuarine Studies, University of Maryland, Box 38, Solomons, MD.

Implementing Institutions to Assure Sustainability of Ecological Economic Systems

Assuring sustainability of ecological economic systems depends on our ability to make local and short term goals and incentives (like economic growth and private interests) consistent with global and long term goals (like sustainability and global welfare). Traditional sustainable cultures have used systems of taboos, religious mores, etc. (arrived at largely through trial and error) to bring long term goals and constraints into the local, short term decision making process. Our global environmental crisis is such that we don't have the time or the flexibility to use trial and error or to comprehensively instill the appropriate taboos and mores. We must develop institutions that can use our current, uncertain, scientific understanding of the possible future implications of current activities to adjust the local, short term decision making process quickly and effectively. We should:

Establish a *hierarchy* of national and global economic planning goals (with sustainability as the primary long term goal) to replace the current GNP mania. Economic growth in this hierarchy is a valid goal only to the extent that it is consistent with sustainability and other goals further up the hierarchy. Ecological economists can help develop and popularize these goals. They can be operationalized by having them accepted as part of the political debate, and implemented in the decision making structure of institutions that affect the global economy and ecology (like the World Bank).

Develop better *global ecological economic modeling* capabilities to allow us to see the range of possible outcomes of our current activities. Ecological economists must play a major role in this.

Adjust current prices to reflect long run, global costs, *including uncertainty*. To paraphrase the popular slogan, we should: model globally, adjust local incentives accordingly. In addition to traditional education, regulation, and user fee approaches, a flexible assurance bonding system is proposed to deal specifically with uncertainty.

Allow no further decline in the stock of *natural capital*. This policy will encourage the technological innovation that optimists are counting on while conserving resources in case the optimists are wrong.

CUMBERLAND, JOHN H.
Director, Bureau of Business and Economic Research, University of Maryland, College Park, MD

Intergenerational Transfers and Ecological Sustainability

Neither market economies nor centrally directed economies will necessarily maintain stocks of non-renewable resource and environmental-ecological systems at levels adequate to assure intergenerational sustainability. The prevention of long-run decline in welfare may require making intergenerational transfers. Planning effective means for making transfers to future generations must be centered not only upon monetary and fiscal measures, but more importantly upon real resources relevant to ecological sustainability. Among the sustainability-relevant resources which might be transferred are capital equipment, knowledge, genetic stocks and reserves of non-renewable resources. Transfers of these kinds of assets will probably be necessary for sustainability, but they may not be sufficient to assure intergenerational equity. Another type of sustainability-relevant transfer which should be explored is that of large-scale complex functioning ecologies such as estuaries, rain forests, game preserves, and river basins. The protection of these ecologies and their transfer to future generations would involve costs and benefits whose intragenerational as well as intergenerational distribution both merit detailed evaluation. A public choice approach is suggested in order to develop transfer policies which are scientifically valid, economically efficient and distributionally equitable between regions, interest groups, and generations.

d'ARGE, RALPH C. AND SPASH, CLIVE R.
Department of Economics, Box 3985, University Station, University of Wyoming, Laramie, Wyoming 82071

Compensating Future Generations for Adverse Economic Impacts

In previous papers, the authors have argued that there are likely to be adverse economic effects to future generations resulting from tropospheric warming d'Arge, Schulze, and Brookshire (1982), Spash and d'Arge (1989). It has also been proposed that on intergenerational equity grounds, transfers of real resources are needed among generations to bring about compensation for losses in the future. Spash and d'Arge (1990). In this paper, these results are extended to the case where there are both gainers and losers in the future. In this case, the represent can, at least propose, that part of the future loss be offset by part of the future gain.

If individuals in present society gain in knowing they have tried to compensate future generations, then the optimal strategy for the present is to start a climate compensation fund now even though there are uncertainties as to the magnitude of losses or the distributions of gainers or losers. This is an application of the Andreoni "warm glow" hypothesis appropriate to certain classes of public goods Andreoni (1989). It is argued that intergenerational climatic impacts are one type of "warm glow" public goods.

The general conclusions of this paper is that based on intertemporal efficiency consideration, there should be an intergenerational transfer of resources for compensation unless the present generation severely restricts the buying of fossil fuels and introduces other practices that will eliminate anthropogenically induced climatic warming. If this is impossible, compensation is justified by most ethical and economic principles. Because of classical and new problems in valuing public goods, it is currently impossible to quantitatively estimate the amount of optimal compensation. Thus, a problem exists of estimating actual necessary compensation which should be based on: actual damages to future generations, reliable wealth or commodity transfer mechanisms, and the value to the current generation of the transfer.

DALY, HERMAN E.
Environment Department, World Bank, 1818 H. Street, NW Washington, DC 20433

Towards an MACRO- Environmental Economics

Environmental economics, as it is taught in universities and practiced in government agencies and development banks, is overwhelmingly microeconomics. The theoretical focus is on prices, and the big issue is how to internalize external environmental costs so as to arrive at correct full-cost prices. Once prices are right the environmental problem is "solved"--there is no macroeconomic dimension. Cost/benefit analysis in its various permutations is the major tool for estimating full-cost prices, so in practice as well as theory we remain within the domain of microeconomics. There are, of course, very good reasons for environmental economics to be closely tied to microeconomics, and it is not my intention to argue against that connection. Rather I want to ask if there is not a neglected connection between the environment and macroeconomics.

A search through the indexes of three leading textbooks in macroeconomics reveals no entries under any of the following subjects : environment; natural resources; pollution; depletion. One of the three does have an entry under "resources", but the discussion refers only to labor and capital, which, along with efficiency, are listed as the causes of growth in GNP--natural resources are not mentioned. Evidently GNP growth is thought to be independent of natural resources. Is it really the case, as prominent textbook writers seem to think, that macroeconomics has nothing to do with the environment? How can this situation be understood historically and methodologically? If there is no such thing as environmental macroeconomics, should there be? Do parts of it already exist (revised national accounts, input-output tables)? What needs to be added (carrying capacity as a macroeconomic concept)? What policy implications are visible?

EL SERAFY, SALAH
The World Bank, 1818 H Street, N.W. Washington, DC 20433

The Environment as Capital

Inasmuch as the environment contributes to the productive process, even when it is not appropriable, it should be considered as a factor of production. The paper will consider the contribution the environment makes to production, and examine the substitutability between environmental elements and factors of production, notably capital. The paper will emphasize the necessity of keeping environmental capital intact, for proper national income measurement, while distinguishing between renewable and non-renewable resources. To keep renewable environmental capital intact, provision should be made for its depreciation. Depreciation, however, is inappropriate for depletable resources, and the paper will explain why. The paper will end with a recommended approach to integrating these capital conservation concerns in environmental accounting, stressing that we should proceed without delay to incorporate ascertainable environmental degradation into national accounting, however imprecisely, fully realizing that such an approach will remain partial, but is bound to be expanded gradually as our knowledge of the facts improves, and as we bring more environmental concerns "into relation with the measuring rod of money"

EHRLICH, PAUL R.
Department of Biological Sciences, Stanford University, Stanford, California 94305
DANIEL, LISA M.
Bureau of Economic Research, Federal Trade Commission, U.S. Department of Commerce

Outgrowing the Planet

Recent decades have seen rapid economic growth on a global scale, accompanied by a rise in per-capita standards of living. Growth, unfortunately, has been accompanied by a monotonic decline in the functioning of the ecosystems that support the human economy. This decline can be seen (among other places) in rates of soil erosion, in the depletion of Ice-Age groundwater supplies, in the loss of biodiversity, and in the changing composition of the atmosphere.

This decline in the capacity of life-support systems is neither new nor newly noticed. Nonetheless, with a few outstanding exceptions, economists have turned a blind eye to the correlation between growth and environmental deterioration. Many ignore the problem because they do not recognize the degree of damage ecosystems are suffering or because they do not see the relationship of that damage to economic growth. some apparently do not even

recognize that infinite physical growth on a finite planet is impossible. But most economists, if and when they consider the problem of growth, fall back on the notion that limits exist somewhere, "out there," but believe those limits are so far in the future as to be of no concern at present.

Economists are buoyed by the notion that resources are either infinite or infinitely substitutable and that, at least to a large degree, growth can spare the environment provided appropriate social policies and technologies are in place.

In this paper we examine the assumptions that limits are so far in the future that they can be ignored, and that growth can be greatly extended in the future through accelerating innovation, making appropriate technological choices, and selecting proper sectors of the economy for growth. We conclude these assumptions are false.

FABER, M. and **MANSTETTEN, R.**
Alfred Weber- Institut, Department of Economics, Universität Heidelberg, Grabengasse, 6900 Heidelberg, Federal Republic of Germany
PROOPS, J.L.R..
Department of Economics and Management Science, University of Keele, Staffordshire, ST5 5BG, United Kingdom

Towards an Open Future: Ignorance, Novelty and Evolution

What attitude has led humankind to the continued endangering of nature and thus of its own livelihood? In Part I: 'Closure and Openness in the Present World' we characterize the driving force of this attitude, and its consequent economic dynamics. This results in the attempt to create a human world which is closed against the influence of uncontrollable nature. We therefore examine how present (western) humankind experiences (a) the natural world, and (b) how it treats time, and in particular the future. This attempt at closure has naturally led to a lack of awareness of openness. We deal particularly with the scientific attitude which is associated with these two experiences. In Part I we treat closure and openness in an encompassing way. In contrast to our general approach in Part I, our endeavor in Part II: 'Scientific Conceptualization of Openness', is to develop a scientific basis for the analysis of some of the problems mentioned in Part I. To this end we offer a conceptualization of closure and openness within an evolutionary framework. In particular, we are concerned with the notions of novelty and ignorance, as well as their relevance for what we can know, what we can control and what we can do. In Part III: 'Policy Implications of an Attitude of Openness for Evolving Systems', we outline some of the consequences of such a new attitude could have for environmental policies. In particular we shown that resource use will tend to be less of a problem than pollution, because of the different types of novelty these two activities generate.

FARBER, STEPHEN
Economics Department, Louisiana State University, Baton Rouge, Louisiana 70803

Economic Incentives for Preventing and Adapting to Ecological Changes

The concept of sustainability at a macro level refers to the ability of a joint economic and environmental system to continue to provide an undiminished level of satisfaction indefinitely. This does not imply that both the economic and environmental systems must be separately sustainable, nor that there must be local sustainability everywhere. Trade-offs between sustainability of economic and environmental goods and services, as well as trade-offs between regional systems may exist. Because of these trade-offs, the concept of sustainability requires that some ecological changes should be prevented, while some should be accepted and economic systems forced to adapt to them.

Society must choose between prevention and adaptation to ecological changes. Some ecological changes caused by the economic system could have such devastating effects on sustainability of flows of economic or environmental goods and services, or be so costly to adapt to, that they must be prevented. On the other hand, some ecological changes may be less costly to adapt to than to prevent. This suggests that, in addition to recognizing trade-offs between economic and environmental sustainability, the costs of preventing and adapting to ecological changes must be compared in order to attain sustainability goals in a cost-effective manner.

Whatever the social decisions regarding economic-environmental trade-offs and prevention-adaptation strategies, policy instruments must be used to implement those decisions. The paper will focus on economic incentive policy instruments that can be used to direct economic activity toward cost-effective sustainability goals. These will include instruments designed to attain appropriate economic-environmental trade-offs, and to attain optimal prevention-adaptation strategies. A thorough survey will be made of the actual use of such instruments, particularly in the US. Their advantages and disadvantages, both theoretically and practically, will be discussed.

FUNTOWICZ, SILVIO O.
Institute for Systems Engineering, Joint Research Centre, Commission of the European Communities, 21020 Ispra(VA), ITALY
RAVETZ, JERRY R.
Department of Philosophy, The University, Leeds LS2 9JT, United Kingdom

A New Scientific Methodology for Global Environmental Issues

The extreme uncertainty that affects many of the issues in coping with the disturbed global environment makes our traditional scientific methodologies less applicable to current problems. The use of computer models, inherently untestable but yet the best tool available, illustrates our dilemmas.

We use a simple diagram based on two attributes, "decisions stakes" and "systems uncertainties", to illustrate a threefold classification of kinds of science. First is the Applied Science reminiscent of Kuhnian puzzle-solving, and then Professional Second Order Science, characteristic of the new sciences of cleanup and survival. In this last case, facts are uncertain, values in dispute, stakes high and decisions urgent. We may describe such sciences as being involved when, paradoxically, "hard" policy decisions depend on "soft" scientific inputs.

A new methodology for Second Order Science will require "extended peer communities", for the quality assurance of its facts involves participants outside the classic peer communities of experts, including investigative journalists and laypersons as well. Similarly, "extended facts" will be relevant, including evidence that is initially anecdotal as well as information that is of restricted publicity for one reason or another. By these extensions Second Order Science can lead to greater democracy in the scientific endeavor, complementary to that of the diffusion of science by traditional popularization.

GOODLAND, ROBERT J.
The World Bank, Washington, D.C. 20433

Sustainability of Hardwoods from Tropical Moist Forests

The International Tropical Timber Organization, an increasing number of foresters, and most environmentalists realized that current hardwood logging from tropical moist forest is unsustainable. Tropical forests are being lost so fast that consumer boycotts and other trade constraints aim to reduce this irreversible damage. The Tropical Forest Action Plan, on the other hand, in its present form, seeks a massive increase in such logging. In some countries, logging is one of the major causes leading to deforestation. We present the case for a phased transition to hardwood plantations, while improving the sustainability of selective logging as a temporary expedient, until such plantations mature. The transition should be rapid in those countries where forests are rapidly disappearing and where logging is the main cause. The transition is less urgent where tropical moist forests are stable.

HANNON, BRUCE
Department of Geography, University of Illinois, Urbana, IL 61801

A General Accounting Framework for Ecological Systems

Accounting of material and energy flows has long been an important tool in ecosystem ecology. But each material is usually handled separately and independently. The connections *between* materials, energy, and plants, animals, etc. have not been incorporated into the accounting framework, and "service" or information flows (such as flower pollination by bees) are usually ignored. We developed a general accounting framework that addresses this deficiency. In our framework, each connection (both physical and information) can be unambiguously assigned, quantified and qualified, and an input-output balance is easily checked and maintained for each product. Costly independent data collections can be integrated into this common framework to amplify their original usefulness and provide the investigator or ecosystem manager with enhanced understanding of the entire ecosystem from which they were taken. The integrated data also allows various ecosystem models to be constructed efficiently, without unnecessary and costly duplication of effort. I present detailed guidelines for construction of such a framework, followed by examples and applications.

HARDIN, GARRETT
Department of Biological Sciences, University of California, Santa Barbara, CA 93106

Paramount Positions in Ecological Economics

In data-rich ecology and economics purely empirical research is inefficient, and even misleading. E.T. Whittaker has shown the necessity of such "impotence principles" as the Second Law. These cannot be proved true; they place the burden of proof on those who deny them. In certainty they range from the Second Law of Thermodynamics to Parkinson's Law. Acceptance of them is the "default position" of a progressive science.

"No free lunch" belongs to a family of conservation laws that traces back to Epicurus, 3rd century B.C. The theoretical development that came to physics in the 19th century had to wait until the 20th in economics. Delay was caused by two factors: the apparent magic of technology, and the illusion that usury creates wealth. It remained for Soddy (who was championed by Daly) to show that only debt can increase exponentially.

Conventional measures of income and wealth are built on the myths of GNP and GDP. Many people are now working to replace these myths with material truths. Until this replacement is made all economic policy is built on sand--hence the conflict between environmentalism and economics. This paper offers a concise roster of the default positions that should guide a truly ecological economics.

HUETING, ROEFIE
Netherlands Central Bureau of Statistics, Princess Beatrixlaan 428,m 2270 AZ Voorburg

Should National Income be Corrected for Environmental Losses? A Theoretical Dilemma, But a Practical Solution

Increase in production as measured in national income is generally called economic growth, identified with increase in welfare and conceived as the indicator for economic success. It obtains the highest priority in the economic policy in all countries of the world. At the same time across the world increase in national income in accordance with the present pattern is accompanied by the destruction of the most fundamental scarce, and consequently economic good at man's disposal, viz. the environment. The paper will 1. outline which information should be given in the publications of the National Accounts in order to avoid misinterpretation of the changes in the level of national income by politicians and the public. 2. Examine whether it is possible to correct national income for environmental losses. 3. Come to the conclusion that such a correction runs up against the impossibility to construct shadow prices for environmental functions which are directly comparable with the market prices of goods and services produced by man (the valuation problem). 4. Propose a practical and well defensible solution for this problem, viz. estimating the costs of the measures - including direct decrease in activities - that are necessary to meet standards for a sustainable use of the functions of the environment. 5. Sum up the advantages and disadvantages of this solution.

JANSSON, ANN-MARI
Department of Systems Ecology, University of Stockholm, S-10691, Stockholm

On the Significance of Open Boundaries for an Ecologically Sustainable Development of Human Societies

This paper addresses the question of how natural and artificial boundaries affect environmental quality and performance of systems of nature and humanity. The point is made that a sustainable design of a region is one with free flows of energy, money, and information between nations. When countries with different resources, cultures and specialities are able to interact through an open exchange, development constraints due to limiting resources in single countries can be released. Examples are drawn from the Baltic region, where recent weakenings of political boundaries have led to increased movements of capital, people and ideas between the seven littoral states. This will open up new possibilities for international cooperation to solve problems of resource scarcities and environmental pollution in a mutually rewarding way. Increased compatibility of economic systems may facilitate self-organizing processes that increase the efficiency of resource use and pollution control. Only by developing feedbacks that enhance the life-supporting capacity of the regional ecosystems can be industrial society be successfully maintained.

MARGALEF, RAMON
Department of Ecology, University of Barcelona, Diagonal 645, Barcelona 08028, SPAIN

Reconsideration of Basic Themes in Ecology Might Clarify Relations with Economics

Ecological and economic systems contain replicable subsystems. Economics deals with markets, prices, and scarce resources, as now most of them are. Interaction coefficients in the models cannot be constant: they change as a consequence of the effectiveness of life in recovering, as information, a fraction of the energy (entropy) exchanged in the systems and in their surroundings. Information grows as a power of the dimensions of its unified support, computed over space and time; thus, size and persistence may be advantageous. It is cheaper to copy information than to create it through natural selection. Evolution and succession are not only necessary to explain how nature is becoming, but they cannot stop if life shall continue. Acquisition of information never ceases and no machine, biological or otherwise, can turn twice remaining exactly the same. Systems change combines 1) slow and self-organizative wandering towards complexity, and 2) a non differentiable fall in the unknown, as response to external and unpredictable disturbance. Nothing can be anticipated about the configuration of each actual sequence of disturbances. The actors in a system carry on separate sampling programs over a common set of events of interaction. Ecologists need theoretical frames to deal with money, external energy, and generation of regular long term change.

MARTINEZ-ALIER, JUAN
Department of Economics and Economic History,.Universitat Autònoma de Barcelona, Bellatera, E-08193, Barcelona, SPAIN

Ecological Perception, Environmental Policy and Distributional Conflicts: Some Lessons from History

Ecological awareness is socially moulded in the social sciences, we know that neither history nor geography have paid much attention to ecology, but there have been some critiques of economics from the ecological point of view. Such critiques have been directed against both mainstream and Marxian economics. Economic values assigned to diachronic externalities (such as exhaustion of non-renewable resources, global warming, or radioactive pollution) would be so arbitrary that they cannot serve as a base for rational environmental policies. Lack of economic commensurability exists not only in market economies but also in centrally planned economies (as Otto Neurath pointed out in the 1920s). Externalities, defined as uncertain social costs transferred to other social groups, or to future generations, must be perceived before they are valued. The notion of "positional goods" is also discussed. The paper argues,therefore, against environmental policies based upon a presumed economic rationality. On the other hand, it also argues against the new attempts by international eco-managerialism to base policies only on an ecological rationality (in terms of carrying capacity norms or"sustainability"). Such attempts are blatantly ideological because they forget that the differences in the exosomatic consumption of energy and materials in the human species, and the territorial distribution of the human species in the globe, are not explained by ecology.

MCGLADE, JACQUELINE
Theoretical Ecology Working Group, KFA, Juelich, Federal Republic of Germany

The Invisible Crisis: The Need for New Modes of Analysis in Modeling Coastal Resources

The dynamical character of natural ecosystem exploitation reflects the combined effect of the limited nature of resources, interannual variability, and the play of economic forces under open and free access conditions. Common features within these systems are perverse cycles, with periodic gluts and human distresses. Because of free access, people enter the system easily, especially when resource levels are high. But with heavy investment of capital and a reduction in means theses same individuals cannot leave so readily when their numbers exceed those that can be sustained by simultaneously shrinking resource productivity. The process of desertification, with its ratchet effect on human population, is not restricted to arid lands, but extends into exploitation of any natural resource. In this paper, it it argued that without property rights the economic growth that is stimulated by free access can never be truly controlled to create an opportunity for sustainable development. Under limited access and individual property licences, economic growth can be seen to be well described by a more "reductionist approach"; technological innovations can be seen to allow increased control over the living organisms and hence permit intensification in the use of living resources such as those found in the coastal zone. A series of models are shown for marine resources

throughout the world ranging from small pelagic fishes to high priced luxury shrimps. These models demonstrate the need for integration through horizontal exchanges between the ecosystem and independent and specialized producers and consumers. The use of market mechanisms achieves a more generalized efficiency in the allocation of the factors of production (land, labor, and capital) by facilitating their use in proportion to their relative scarcity. It is concluded that without a radical shift in the theoretical framework for development, the crisis that is already present in the coastal zone mode of exploitation will go unseen until it goes beyond the critical stage.

MITSCH, WILLIAM J.
School of Natural Resources, The Ohio State University, Columbus, Ohio 43210

Ecological Engineering - An Environmental Methodology for Sustainability and Biodiversity

Traditional approaches to the control of environmental pollution involve large commitments of technology and long-term investments that make their continual use an economic, energetic, and possibly an environmental liability in a sustainable economy. Ecological engineering has been defined as the design of human society with its natural environment for the benefit of both. It is the prescriptive rather than descriptive discipline of ecology in that it utilizes ecological principles, the self-design or self-organizational capabilities of natural ecosystems, and the sustainability of solar based ecosystems rather than fossil fuel based technologies to achieve environmental quality. The concept of ecological engineering has co-evolved in both the United States (unsustainable, industrialized moderately-populated economy) and China (partially sustainable, agrarian heavily populated economy). Examples of ecological engineering from each culture will be presented and overall approaches will be compared. Each approach has different ecological principles guiding it and each approach is built on different economic and social structure. There are possibilities of merging of the two approaches into an ecological engineering approach for long-term sustainability of environmental quality. Conserving biodiversity and ecosystem health in the landscape supports ecological engineering applications. Conversely, ecological engineering conserves biodiversity by giving it clear economic value.

NORGAARD, RICHARD B.. AND HOWARTH, RICHARD B.
Department of Agricultural and Resource Economics, Energy and Resources Group, University of California, Berkeley, California 94720

The Conservationist's Dilemma Revisited

Though high interest rates discourage the long term management of slow growing resources (forests) and the protection of long term environmental assets (biodiversity), high interest rates also discourage investment in projects which transform environments (dams) and in projects which are necessary to extract resources (oil wells). Thus the relationship between interest rates and conservation, protecting the interests of future generations, and sustainable development is ambiguous.

We show that the conservationist's dilemma results from a misspecification of the problem. Economists heretofore have not distinguished between decisions concerning the efficient use of this generation's resources and decisions concerning the reassignment of resource rights to future generations. All decisions over time have been simply treated by economists as investment questions, as if all resources were always this generation's resources. We properly specify the economic questions involved, clearly distinguishing between equity and efficiency, and then show why discounting is appropriate with respect to the efficient use of this generation's resources but is inappropriate when this generation is primarily concerned with redistributing resource rights to future generations. Further, we show that when rights are reassigned between generations, interest rates themselves change. We conclude that the assignment of rights to the future is the instrument of conservation and sustainability; interest rates are derivative.

NORTON, BRYAN
School of Social Sciences, Georgia Institute of Technology, Atlanta, GA 30332

Ecological Health and Sustainable Resource Management

A contextual approach to environmental management requires a distinction between Resource Management, the management of a resource-producing cell such as a field or fishery, and Environmental Management, which involves concern for the lager systems which environ those cells. Mainstream natural resource economics defines sustainability mainly by reference to undiminished outputs of economically marketable products and emphasizes productivity criteria in judging management regimens. This approach is appropriate in many cases for guiding Resource Management but, taken alone, it provides no guidance regarding the protection of the larger, environmental context of resource-producing activities.

Aldo Leopold, and most environmentalists following him, have applied a contextual approach in which resource-producing cells are understood as subsystems of larger, slower-changing (but still dynamic) ecological systems. According to this approach, Resource Management should be limited when resource-producing activities approach a threshold beyond which they alter larger systems and instigate rapid change in environing systems. Metaphorically, this result is referred to as "illness" in the ecological community, but the rules and criteria for describing these limits have never been stated precisely in ecological terms. A definition of "ecosystem health", based on biologically formulated criteria for judging larger ecological systems, will be proposed and integrated into a hierarchiacal approach to environmental management.

PAGE, TALBOT
Environmental Studies, Brown University, Providence, Rhode Island 02912

Environmentalists and Economists and Philosophers and Biologists

One of the lessons that biologists have taught us in the last 150 years is that there are no sharp boundaries between us (humans) and other species. Further, the notion of the individual itself has blurred, both from below and from above, from studies of genetics and evolutionary biology and from studies of primate and other animals' social behavior.

These two insights are usually offered as positive, descriptive, or explanatory statements about the way the world is. But they have important implications for our value theories and policy prescriptions.

One approach is to extend the traditional moral concepts of rights, duties, utility, etc. from humans to other species. But a problem with this approach is that these traditional moral concepts are individualistic. An alternative approach is to run the extension the other way and ask what happens to the traditional moral concepts when the individual and species lines blur.

The purpose of this paper is to explore the alternative approach. I suggest that for the world the biologists describe value concepts less highly individuated become relatively more useful and important, for example concepts of opportunity and sustainability. It also becomes clearer why some policy questions, which are often viewed as problematic in current economic analysis, are indeed problematic in the traditional framework. These problems include one of optimal population, species preservation, and intergenerational equity.

PERRINGS, CHARLES A.
Department of Economics, University of Auckland, Private Bag, Auckland 1, New Zealand

Technological Change, Uncertainty, and Time in Environmental Management

Many of the most intractable environmental problems are those in which the utilization of environmental resources in novel ways has effects that are highly uncertain in both their spread and duration. The greater the uncertainty as to the effects of technologically innovative use of environmental resources, the greater is the difficulty in evaluating associated environmental damage or estimating the marginal social costs of resource use for the purpose of setting corrective taxes. The wider and more durable are the environmental effects of economic activities, the less is the scope for a market solution involving the allocation of property rights. Problems involving uncertain environmental effects that may be global in spread or may endure for generations accordingly require responses that go beyond existing evaluation techniques, instruments and institutions. This paper discusses the scope for extending the role of economic incentives in these circumstances, without prejudicing the interests of future generations. It considers the institutional requirements of an iterative approach to the evaluation of environmental damage which maintains flexibility in the face of a rapidly changing data base, but ensures against a purely reactive response. The main case addressed here is that where the probability of distant but potentially catastrophic environmental damage is admitted, but is thought to be very low. It is this case which existing approaches are least capable of addressing.

PESKIN. HENRY M.
Edgevale Associates, Inc., 1210 Edgevale Road, Silver Spring, MD 20910

Alternative Environmental and Resource Accounting Approaches

In response to perceived inadequacies in the ability of the national economic accounts to provide adequate measures of social and economic performance in the face of environmental and natural resource degradation, a number of strategies have been suggested. Some are rather conservative in that they call for only minor adjustments to the current presentation of data while others call for substantial changes in accounting frameworks.

After reviewing the major weaknesses in the ability of conventional economic accounting systems to reflect environmental and natural resource degradation, each of the proposed approaches is described and evaluated. The evaluation is both in terms of the ability of the approach to address deficiencies with conventional accounting systems and in terms of the demands on data and skills needed for implementation.

This evaluation leads to two principal findings. First, it is apparent that none of the proposed systems is able to address the full scope of concerns with conventional accounting systems. Indeed, there are certain concerns - specifically those that relate to the failure of the economic accounts to accomodate the interests of future generations - that are not addressed by any of the suggested systems. Secondly, it is clear that these systems differ widely in their costs of implementation.

The implication of both these findings is that there is no best system. Adoption of any of these alternatives will depend on which environmental and natural resource concerns have the higher priorities and on the willingness to devote effort towards data development.

EL SERAFY, SALAH
The World Bank, 1818 H Street, N.W. Washington, DC 20433

The Environment as Capital

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The implication of both these findings is that there is no best system. Adoption of any of these alternatives will depend on which environmental and natural resource concerns have the higher priorities and on the willingness to devote effort towards data development.

PROOPS, J.L.R.
Department of Economics and Management Science, University of Keele, Staffordshire, ST5 5BG, United Kingdom
FABER, M. and MANSTETTEN, R.
Alfred Weber- Institut, Department of Economics, Universität Heidelberg, Grabengasse, 6900 Heidelberg, Federal Republic of Germany

National Accounting, Time and the Environment

National accounting is an area of controversy. In this paper we explore the conceptual foundations of these difficulties. The fundamental requirement of a system of national accounts is that national income equal national product. This requires strong assumptions about the nature of price formation if the use of ad hoc 'balancing' items is to be avoided. In particular, if balance is to be achieved then the prices used must be the shadow prices derived

from an optimizing economy. That balancing items are generally necessary therefore reflects the deviation of real economies from the neoclassical ideal. An important element in final demand is capital goods, whose function is to enhance consumption possibilities in the future. To achieve accounting balance, the shadow price of capital accumulation must be established. This implies the even stronger condition that for national accounts to be, and to remain, in balance, the quantities and prices used must derive from intertemporal optimization in the economy. The necessity of taking time into consideration in conceptualizing national accounts becomes even more clear when the productive role of the natural environment is considered. The appropriate valuation of the stocks and flows of the natural world must be an intertemporal valuation if they are not to add to the problems of national accounting. Our analysis of national accounts is illustrated with input-output tables derived from a neo-Austrian model of intertemporal choice and production.

TIEZZI, ENZO, MARCHETTINI, N.; and ULGIATI, S.
Department of Chemistry, University of Siena, Pian dei Mantellini, I-44-53100 Siena, Italy

Biomass and Entropy

Today the role of entropy and the limits of nature induces us to reconsider our conceptions of evolution, progress and construction of material things. The correct use of science does not consist in dominating nature, but rather in living in harmony with it. Economic free trade and Marxist thought are forced to admit their limits. Traditional economists continue to think of unlimited growth and trust blindly in technology; but nature has cycles that follow other rules and other times. Traditional economists think of specialization as a positive value and a source of efficiency; but nature teaches us that specialization is a threat to the stability of living systems.

Economics and industry have demonstrated their total incapacity to think in terms that transcend details and short term thought. Thermodynamics and biology impose a transition on us towards a state of minimum production of entropy and conservation of resources. Therefore it is necessary to maintain the energy flow at a low level, slowing down the entropic process, favoring decentralization and thinking on a small scale, as well as using renewable resources.

The production of energy and chemicals from biomass in an integrated agro-industrial system is a good example of this idea. Indeed the organization of an integrated system requires the definition of the optimal "exchange area" between agriculture, industry, by-products recycling and returning of organic matter to the soil. The choice of the basic parameters of the project (time, scale, distance) can minimize the use of non-renewable energy sources and materials and maximize the use of solar energy. An integrated system, that will fit to the production capacity and requirements of a given area, is less vulnerable to market fluctuations, inflation and macroeconomic factors: therefore its stability is increased, due to minor semplification.

Flow analysis of the exchanges taking place in the system makes it possible to plan and legislate, evaluating socioeconomic and environmental advantages over traditional systems of production.

ULANOWICZ, ROBERT E.
University of Maryland Chesapeake Biological Laboratory, Solomons, MD 20688-0038

Discounted Values of Ecosystem Resources

Hannon and Costanza previously have shown how value can be assigned to ecosystem constituents once the values of the exogenous inputs are known. A difficulty with such "supply-side" analyses is that the values of primary inputs are usually ambiguous at best. The values of some ecosystem outputs, however, are set by the commercial markets in which the harvests are sold, or can be reasonably estimated in other ways (e.g., total effort and expenditures devoted to a recreational fish catch). A "demand-side" calculation of the discounted values of ecosystem components (in-situ) heretofore has been considered unfeasible because what appeared to be of unavoidable inconsistencies in the units used to measure the various exchanges. However, it is possible to identify a basis of elements common to all system components that avoids comparing "apples with oranges" and facilitates the calculation of values as they are discounted down the trophic web. That is, given a particular ecoystem output of known value, what is the contributory value of all ecosystem components that went into producing the final output value.

The calculations also reveal which primary inputs are controlling the kinetics of the system, thereby affording valuable information to aquatic ecosystem managers who must decide upon appropriate nutrient control strategies.

VARSHNEY, C. K.
School of Environmental Sciences, Jawaharlal Nehru University, New Delhi, 110 067 India

Indian Agriculture and Sustainability

Increase in food production to keep pace with rapidly growing population generates enormous pressure on agricultural and environmental systems. Like any other sector, sweeping changes have occurred since World War II in agricultural production technology. Modern agriculture, apart from sunlight, places heavy demands on fossil fuel energy. Growing inputs of energy subsidy, fertilizers and pesticides have far reaching ecological and environmental consequences both at local and global levels. Some of the complex problems of environmental decay appear to be directly related to the currently practiced strategies of agricultural production. In view of the finite stocks of fossil fuels the growing requirement of agricultural inputs in terms of energy subsidy and agro-chemicals present serious problems for sustainable development, which has been advocated by the World Commission on Environment and Development. Systematic understanding of the coupling among agriculture, energy and environment is necessary for developing sustainable agriculture. This paper attempts to evaluate the trends of energy subsidy input in Indian agriculture and highlights its environmental consequences.

ZUCCHETTO, JAMES J.
National Academy of Sciences, Washington, D.C.

Ecological Economics and Education

This brief paper addresses the emerging concerns that exist regarding the environment, economic development, and education in the United States. In discussing these issues, it points to needs that are required at various levels of education, from the public school system on up to high school, to undergraduate and graduate level education. In this discussion, attention is focused on incorporating an ecological economic perspective into the curricula, on training teachers in such an area, on the problems doing interdisciplinary work and attaining tenure for junior faculty, and on attracting students into such cross-cutting endeavors. The paper is qualitative. It is still difficult to define what ecological economics might mean in the context of education and hence to recommend actions that might be taken to introduce such material into different educational levels.

ZYLICZ, TOMASZ
Ministry of Environment, Wawelska 52154, 00-922, Warsaw Poland

The Role for Economic Incentives in International Allocation of Abatement Efforts

There is a large body of literature on how to optimize the allocation of abatement efforts within a state or a homogeneous region. It has been proved that under the standard assumptions the least cost solution can be arrived at by means of imposing charges (subsidies) or trading permits. The efficiency proof rests, among other things, on the assumption that there exists an agency granted with the authority to tax or to initially allocate permits. Coasian bargaining may offer a solution in the absence of such an agency, but it applicability is limited. Thus, as long as a group of countries is lacking an appropriate supranational authority, the only viable emission reduction programs are those based on voluntary reductions from an historical reference level. The 30%-Club of European countries reducing their SO2 emissions and the planned 50%-Club of the Baltic countries serve as examples here. A similar solution has been adopted in the case of limiting (freezing) NOx emissions. On the other hand the policy towards CFCs favors developing countries vis a vis the developed ones and grants the former with less stringent constraints on future use of these chemicals. In any case the implicit allocation of abatement effort does not have to comply with a supranational efficiency criteria. A question arises whether an incentive scheme could be applied in order to push these programs towards an optimum, i.e. beyond the point accessible by means of voluntary reductions. The author explores such possibilities discussing them in a broader context of institutional reforms in todays world.

CONTRIBUTED ABSTRACTS

ABLER, DAVID G. and **SHORTLE, JAMES S.**
Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park, PA 16802

Environmental, Trade and Farm Commodity Policy Linkages

Environmental impacts of agricultural production practices are becoming increasingly important, and yet little is known about linkages between environmental, trade, and farm commodity policies. This paper studies how governments can better account for these environmental impacts. It analyzes the economic efficiency and political viability of restrictions on agricultural chemicals in the E.C. and U.S. under various farm trade and commodity policy scenarios. A partial equilibrium simulation model of agriculture is constructed, with four regions: the E.C., the U.S., other major grain exporters, and the rest of the world. Economic efficiency for each region is evaluated by adding up the estimated monetary value of changes in producer surplus, consumer surplus, government revenue, and environmental quality. Political viability is evaluated by constructing a public choice function. The function is a weighted sum of the four variables used to evaluate economic efficiency, with weights based on the estimated political importance of each variable. The paper also analyzes economic and political incentives for the E.C. and the U.S. to cooperate in jointly reducing the use of agricultural chemicals. Environmental policymaking in the E.C. and U.S. is modeled in two ways, first as a noncooperative game and then as a cooperative game.

ALDEN, DAVID
Department of Economics, University of Keele, Keele, Staffordshire, ST5 5BG, United Kingdom

The 'Greenhouse Effect' and World Agriculture: Using Computable General Equilibrium Models to Examine the Implications of Climate Change for Agriculture

The 'Greenhouse Effect" will have substantial, and economically important, implications for world agriculture in the coming decades. Changing patterns of climate will lead to changes in possible global crop patterns, and also to changes in market prices for agricultural commodities. This paper explores these effects within a general equilibrium framework. A simple computable general equilibrium model of a hypothetical world is used to illustrate this approach. Possible crop yield changes, resulting from a number of climate scenarios, are used to drive the model. The outputs from the model are likely crop production and the corresponding market-clearing prices. These suggest the necessary types of market-intervention required to 'manage' the transition in the long-term.

ALESKEROV, FOUAD T.
Institute of Control Sciences, 65 Profsoyuznaya, Moscow 117806 USSR

Tax Formation For Improvement of the Ecological Situation in a Region

The achievement of general goals of ecologic-economic systems functioning should be based on a permanent solution of control problems. An important role between them plays the construction of adequate economic mechanisms allowing to make local and short-term goals consistent with global and long-term goals.

The different ways of tax formation are included in control mechanisms. Taxes allow to regulate anthropogenic impacts on the environment, stimulate the nature conservation measures and the development of wasteless technologies to be fulfilled, ensure the rational using of resources.

Let us describe how, e.g. the taxes on factories which pollute the atmosphere can be formed on the regional level. The difficulty of this problem depends on different composition of exhausts of different factories, on the fact that even if the amount of exhausts of each factory is on admissible level the summarizing effect of pollution can be out of this range. Finally it is necessary that the taxes do not depend on the errors of initial data, i.e. the tax formation procedure is to be robust in some sense.

The other important factor which make the solution of the problem much more difficult is the necessity to take into account the permanent exhausts as well as the probability of sudden ones arising because of the faults of purification devices.

In the paper the mechanism of tax formation on the factories is described including this above-mentioned factors as well as such features of a region as relief, wind rose, the distribution of population on territory subject to pollution.

The properties of the tax formation mechanism and the behavior of participants using this mechanisms during a long period are studied.

ALLEN, P.M.; CLARK, N. and PEREZ-TREJO, F.
International Ecotechnology Research Centre, Cranfield Institute of Technology, Cranfield Bedford MK43 OAL, UNITED KINGDOM

Change and Sustainability: The Evolution of Wisdom

Ecological structure results from the evolutionary process. It is characterized by a resilience which arises from the diversity which both drives and is generated by evolution. Recent advances in our understanding and simulation of such processes tell us that not only is short term optimization harmful, but long term optimization cannot be defined because of the intrinsic uncertainties of the evolutionary process. In this case, what should guide us in our actions? Sustainability has two faces. The first seeks the way to a stationary system, where man's exploitation is simply balanced by natural growth. It corresponds to a dangerous illusion a resuscitation of the concepts of 'maximum sustainable yield' that has dogged fisheries science for so long. The second view of sustainability corresponds to an acceptance of change as being inevitable, but supposes that wisdom can prevail in human actions. Such wisdom, rather than opposing change, can only be associated with constant monitoring of events, a greater understanding of the processes and mechanisms that organize and create ecosystems, and an ability to consider the complex consequences of our actions. This in turn requires a reconsideration of both our value systems, and the social and economic mechanisms through which they act. In this paper we present an approach to such wisdom based on the concepts of ecotechnology - the application of scientific knowledge to a problem and its context.

AMIR, SHMUEL
Department of Applied Physics and Mathematics, Soreq Nuclear Research Center, Yavne 70600, Israel

Thermodynamics, Economics, and Ecology: An Analogy

This study shows that neoclassical economic theory and classical thermodynamics are analogous theories. In addition to challenging a prevalent observation, analogizing economic theory to mechanics, the significance of this viewpoint is twofold. First, concepts and principles used by one field are easily transferable into the other. In this way familiar concepts gain new meanings. Second, given the structural analogy that exists between economic and ecological systems, these concepts and principles become cornerstones of ecosystem analysis as well. Steady state properties of any system, economic or ecological, can be analyzed assuming the system behaves as if it maximizes a constrained "objective" function. This approach identifies thermodynamic potentials with efficiency (present value) prices and market "equilibrium" (steady state) prices with thermodynamic potentials. The analysis demonstrates, however, that the theory cannot determine the exact form and specifications of the "objective" functions. "Objective" functions are the analogs of "wealth", and they are classified into three categories: internal energy-like, free energy-like, and entropy-like functions. The "wealth" of any system, thermodynamic, economic, or ecological, in steady state is constant, but global "wealth" may remain the same, decrease or increase according to the above mentioned classes. This change in global "wealth" gives rise to the discounting phenomenon. The discount rate is the relative time rate of change of "wealth". This rate must be the same for all the components of the system provided the system behaves efficiently when governed by the "right" accounting medium, called "wealth". Although the "right" function must be determined empirically, the analogy is powerful. For example, it proves that any thermodynamically irreversible (all real) system that works according to an internal energy-like criterion cannot work simultaneously according to an entropy-like (or free energy-like) criterion. This implies that Prigogine's principle regarding the minimization of entropy generation in the steady state may not be general. Moreover, this analysis proves that inefficiencies will develop in the interface between the economy and the ecosystem whenever only one system behaves as if it is guided by an internal energy-like function. Since the economic theory of value and the thermodynamic theory of state functions are shown to be a single theory, it is suggested that further research at the interface of economics and thermodynamics may open up promising perspectives for analyzing the optimal use of natural resources.

ANDREASSON-GREN, INGE-MARIE
The Swedish University of Agricultural Sciences, Department of Economics, Box 7013, S-75007 Uppsala, Sweden

Wetlands and Sustainable Development in the Swedish Island Gotland

In Gotland, located in the Baltic, the main limitation to economic growth is the supply of an acceptable quality of drinking water. Due to farmers' use of fertilizer the concentrations of nitrate in ground water are high. The farmers are important not only in an environmental perspective but also economically. Agriculture accounts for a considerable part of gross regional product. A reduction in the use of fertilizers, i.e. acceptable water quality, is therefore achieved at the expense of economic growth for the entire island. However, restoration of wetlands is shown to be a cheap measure for reducing the leakage of nitrogen into the ground water. The purpose of this paper is therefore to analyze the importance of wetlands for sustainable growth in Gotland. Preliminary results are presented from a dynamic optimization model where the wealth of current and future generations is maximized subject to restrictions on the use of water. The long run goal is

converted into short term goals by means of a social accounting matrix, where wetlands are functioning both as flow and stock effects. The stock effects provide environmental investment for future generations.

ANGERER, GERHARD
Fraunhofer-Institut for Systems and Innovation Research, Karlsruhe ,West Germany

Capability of New Technologies for Future Environmental Protection - The Example of Air Pollution

The global endangering of our life support system has reached a level which forces responsible scientists to voice serious warnings. The pollution of air, water and soils, the depletion of stratospheric ozone, the alteration of greenhouse radiation equilibrium, and climatic changes due to deforesting of tropical rain woods are at present the major environmental problems.

In front of this background, possibilities and measures to stop intolerable anthropogenous environmental impacts are a major subject of public discussion. The proposed paper is intended to give a small contribution to this topic and will show for the FRG, whether, and to what extent, the pollution of air may be reduced with the help of new technologies.

In the FRG air pollution by SO_2 and dust has been considerably reduced already. A reduction of the NO_2 level in the forthcoming years is in sight, mainly because of the overdue decision to force the use of catalytic reduction for waste gas of automobiles (see Fig. 1). But for other agents the situation is not similarly favorable. Among these are heavy metals and organic compounds like chlorofluorocarbons (CFC), chlorinated and non-chlorinated solvents, benzole, polychlorinated dioxines, polycyclic aromatic hydrocarbons and polychlorinated biphenyls.

In a recent study, sponsored by the Federal Ministry of Research and Development, our institute analyzed the potential contribution of new environmental technologies, developed up till now, to reduce the emissions into the air of a number of agents. The results are extremely interesting. They show that for many sources powerful technologies are available to control emissions, but on the other hand also technology gaps became visible, which must be closed in the forthcoming years. Fig. 2 shows the situation for four toxic heavy metals. The height of each column represents the emission quantity relative to that in 1986. The figures on the columns give the emissions absolutely in metric tons per year. The left row of columns shows the emissions for 1986, the middle row the emissions expected in 1995, and the right one gives the emission levels which could be achieved if available environmental technologies were used consistently. One can easily see that a technology gap exists for the control of mercury, whereas considerable reduction potentials are present for the others. In the proposed paper these findings will be substantiated and discussed in more detail and for additional agents.

All in all, one can say that new technologies will play an important role in future efforts for environmental protection and the repair of already existing damages. They offer a real chance to get progressive environmental loadings under control, without essentially losses of the achieved welfare and life standard. Nevertheless, technology use must be accompanied by the necessary behavior changes, and it should not be forgotten that technology use will tie up considerable monetary resources.

ANNAN, ROBERT H.
Photovoltaic Technology Division, U.S. Department of Energy, 1000 Independence Avenue S.W., Room 5F-081, Washington D.C. 20585
BURR, RALPH
Geothermal Technology Division, U.S. Department of Energy, 1000 Independence Avenue S.W., Room 5H-065, Washington, D.C. 20585
CABRAL, ANIL
Meridian Corporation, 4300 King Street, Suite 400, Alexandria, VA 22302-1508

Rational Power Development: The Integrated Electric Utility

This paper discusses a recently initiated a program for integrating renewable energy technologies into the electric power sector in developing countries. This program offers a near-term opportunity for achieving an economic, environmentally cleaner power supply system using currently commercial technologies.

An integrated electric utility consisting of an optimal mix of traditional and renewable energy power systems has significant advantages over conventional electrification methods. Renewable energy power plants can significantly reduce or eliminate the production of harmful waste products. They can be built quickly in response to demand, and in smaller increments. They can be sited close to demand centers to serve mini-grids and off-grid applications thus reducing the impacts and costs of extending the grid. But, very few developing countries are using these technologies. The reasons include unfamiliarity; no satisfactory planning methodologies; limited technology performance information; no capability to design, evaluate, implement, operate, or manage these projects; and no suitable financing mechanisms.

Recognizing that a multi-disciplinary approach is needed to overcome these obstacles, the Department of Energy initiated the multi-agency Integrated Electric Utility Program in 1989. The program addresses information and training

needs, financing, technical assistance, and methodology development. Proof of concept is provided by a U.S. model utility.

BAINES, J.T.
Principal in James Baines & Associates,PO Box 8620, Otautahi,Christchurch, Aotearoa,New Zealand
PEET, N.J.
Senior Lecturer in the Department of Chemical & Process Engineering, University of Canterbury, Otautahi,Christchurch, Aotearoa,New Zealand.

Sustainable Development and Stock Resources: Is There a Contradiction? (Energy Policy Within a Framework of Sustainable Development)

This paper describes a framework for interpreting sustainable development, and applies it to a discussion of energy policy. Its main purpose is to integrate concepts and link arguments that are usually treated in quite separate debating arenas.Our approach to this topic begins by accepting that the process we call development is a dynamic environment-society process. Social and economic development are possible as a result of managing the natural environment, but this environment is not itself under social control. Its manipulation involves risks. If society is to continue to benefit from exploiting natural resources, we must appreciate better the environmental repercussions of our activities, and recognize ecological principles more forcefully in our institutions for resource management.It is this perspective that provides the context for interpreting "ecological" relationships - society as part of the biosphere, not apart from it.The integrated conceptual framework that we use enables us to draw connections between the physical, social and political aspects of the development process, and indicates the institutional requirements for making short term, local objectives consistent with long term, global goals. The paper goes on to examine the important topic of nonrenewable energy resources, and concludes with some proposals for the management of stock resources such as energy. Economic instruments are seen as necessary but not always sufficient components of the institutional arrangements required to implement sustainable development policy.

BANKS, STEVEN M.
Department of Geography-Geology, Illinois State University, Normal, Illinois

Natural Resource Booms and Third World Development: Modelling the Response of Export Agriculture Via the Expansion Methodology

Models used in social science research, including those employed in natural resource analysis, assume that the parameters of a specified model remain stable even as the contexts in which the model is applied, changes. That is, we build models, explore relationships between variables, and prescribe policy solutions under the assumption that there is underlying spatial and temporal stability in the parameters of our models. However, there is no reason to assume such stability. This study introduces the Expansion Methodology to the field of natural resource and environmental analysis, as both a conceptual paradigm and a methodological technique. The Expansion Method provides a quantitative technique to empirically estimate the effects of variations in the contexts in which models are applied. A case study of the impacts of the petroleum boom in Nigeria upon the stagnation of the exports of agricultural commodities is provided. By employing the Expansion Method as a research tool, the true complexity of natural resource booms on other subsectors of an economy are revealed. The results of the study suggest that petroleum exports have had differential impacts upon agricultural exports, simultaneously stimulating the growth rate of some, while stagnating the growth rate of others.

The focus of the paper is on the use of the Expansion Method as a new tool for research in natural resource analysis, and the operationalization of the methodology via the Nigerian case study.

BECK, ROGER; HARRIS, KIM and **KRAFT, STEVEN**
Department of AgriBusiness Economics, Southern Illinois University, Carbondale, Ill. 62901 U.S.A.

Establishment of a National Wildlife Refuge from an Economist's Perspective: Methodological Insights

Using secondary data and economic theory, the authors participated in the environmental assessment of a proposed national wildlife refuge. The development of the economic component of the environmental assessment revealed a number of challenges confronting economists. The paper discusses a number of these challenges and offers suggestions for meeting them. The challenges include the collection of data relevant for the assessment of unique ecological areas, the estimation of how benefits and costs change in relation to the size and configuration of the proposed refuge, the assessment and integration of consumptive and nonconsumptive benefits and costs, and the analysis of primary and secondary impacts in sparse economic regions.

BERGSTROM, SOREN

Stockholm University, Stockholm, Sweden

Sustainable Development Accounting: Taking Advantage of Rigorous Theory

Sustainable Development Accounting is a research project where we apply traditional double entry accounting and an ecological model structure[1] on the problem of sustainable development. The main advantages of using a rigorous accounting framework are: 1) it forces consistent and comprehensive classification of data, and 2) it promotes creative construction of key indicators for efficiency and wealth.

In the paper it is stressed that economic analysis mainly is a question of how to organize information in a goal-oriented way. It is showed that the business firm analogy works without any need for reduction to a unified measure, i.e. money.

Various solutions on general accounting problems are discussed in relation to sustainable development. Some of these problems are:

- Defining the accounting unit. Equivalents to ownership, unit of operation or unit under single command should be specified.
- Equivalents to business events. Processes, to be recorded, will be identified according to other standards than those in business firms.
- Strategic relevance vs. reliability. Traditional monetary accounting is often good on reliability and questionable on strategic relevance. Here it is more the other way around.
- Creative use of the accounting structure. An array of key indicators on sustainable development are presented.

1 Originally from Daly, H., Steady State Economics, Freeman, San Francisco, 1978.

BERKES, FIKRET
Institute of Urban and Environmental Studies, Brock University, St. Catharines, Ontario L2S 3A1, Canada

Sequential Exploitation and the Ecological Economics of Living Resources

A general pattern of "sequential exploitation" -- from the more accessible to less and less accessible areas, and from the most valuable to the less and valuable species -- appears to be a common feature of many cases of living resources development. The idea of a succession of resource exports from successive geographical frontiers was initially formulated to explain the development history of Canada's major resource exports, fur, fish and forest products.

It appears, however, that the sequential exploitation of living resources is not a phenomenon unique to Canada. Rather, the pattern fits the development history of a large number of resources, from whales to wild orchids.

Resource users involved in sequential exploitation behave as if discount rates were infinitely high. This then makes it rational to deplete stocks of living resources over the short-term and move on to new resource frontiers. Living resources are thus used as if they were non-renewable, instead of being used . The management challenge is to find ways to discourage sequential exploitation, and to encourage user behavior consistent with low discount rates. A critical factor is the management regime under which the resource is held because users behave differently under different regimes.

BINFORD, MICHAEL W.
Graduate School of Design, Harvard University, 48 Quincy St., Cambridge, MA 02138
KOLATA, ALAN R.
Department of Anthropology, University of Chicago, 1126 E. 59th St., Chicago, IL 60637
BRENNER, MARK
Florida Museum of Natural History, University of Florida, Gainesville, FL 32611

Rehabilitating Ancient Raised Fields in the Bolivian Altiplano: Paleoecological and Archaeological Evidence for Sustainable Agriculture.

All definitions of sustainability include long time periods, which are expressed in terms of several human generations. A few ancient civilizations carried out agricultural practices that apparently sustained population growth for more than ten generations. Rehabilitation of these methods is sometimes proposed to increase food production, but the ecological and institutional systems that allowed long periods of high yield are usually unknown. We use quantitative paleoecological and archaeological methods to test the hypothesis that the establishment of ancient raised fields resulted in a decrease in agroecosystem degradation, and as a consequence provided long-term, sustainable food yields for an increasing population. Physical evidence indicates that raised fields that were in production over nearly 1000 years in the Lake Titicaca basin captured or produced biologically available nutrients that would have otherwise been transported to the lake, increased heat conservation in a system that is subject to nocturnal freezes year-round, and probably prevented soil salinization due to lake-water intrusions or irrigation practices. Archaeological evidence indicates that the culture was highly organized to manage the labor-intensive raised field systems, and had sophisticated, empirical understanding of hydraulic engineering and agriecosystem ecology. We argue that this widespread form of ancient agriculture is a potentially

sustainable practice, and that interdisciplinary paleoecological and archaeological studies are important tests of the sustainability of other proposed techniques.

BISHNOI, S. and GAUTAM, D.D.
Laboratory of Plant Ecology, P.G. Department of Botany, Dungar (Autonomous) College, Bikaner - 334 001 (Raj.), India.

A Case Study of Arid Zone (Rajasthan) Economic-Ecologic Conflicts vs Harmony Under the Impact of the Indira Gandhi Canal Project

Arid regions are areas which tend themselves particularly well to the investigation of problems. Rajasthan lies approximately between 24 degrees and 30 degree latitude and 60 degree and 78 degree longitude occupying an area of about 3,58,150 sq. km. North Western part of this state is desert locally known as Thar.

The Indira Gandhi Canal aims to usher in a new era for the people living in the desert and will convert the barren land into a large granary. The man made desert will be converted to green again by man made river, Indira Gandhi Canal.

A case study is being conducted around Bikaner to know the impact of Indira Gandhi Canal Project (IGCP) on desert ecosystem under following headings:

1. New equilibrium of herbaceous vegetation, the primary producers and the basis for the range management under post irrigational ecosystem.
2. Change in microclimate and fauna and flora of the desert.
3. Seepage and water logging will cause capillary rise of salts.
4. New ecological balance and parametric study of economic growth of this canal irrigated areas.

With the flow of Canal water hydrophitic and mesophytic weeds like *Eichornia crassipes, Typha angustata,* and *Saccharum spontanium* will become the order of the day, leading to the fast evapotranspiration of the stored and logged water.

The race of urbanization and granary based township shall lead to a development of economic capital of IGCP in this area.

BLANCO, SERGIO
Department of City and Regional Planning, The University of Pennsylvania, Philadelphia, Pennsylvania

The Eutrophication of Local Economies

This paper has the intention of providing ecological perspectives on economic activities. Economic processes will be described in ecological terms.

In Nature, eutrophication is a slow and gradual process that converts lakes into grasslands or forests. Accelerated eutrophication however, occurs with human intervention. Large amounts of chemical fertilizers spread on agricultural soils is carried by running waters to lakes where these nutrients produce a blooming of the algae. Since dead algae are food for existing aerobic bacteria, these bacteria begin to multiply very rapidly. The rapid increase of aerobic bacteria depletes the available dissolved oxygen in the water, producing the collapse of the aquatic system.

Similar processes occur in native cultures when economic aid comes from external sources to raise local standards of living. This process of economic eutrophication transforms self-reliant people, who live in relative sustainable equilibrium with their surroundings, into participants of the world market system. The price for this access to new abundance of consumer goods is often paid with the destruction of their local sustainable resources.

This paper will observe similar repercussions of foreign economic aid on local cultures from an ecological - not developmental- perspective.

BLITZER,CHARLES R.
World Bank, 1818 H Street, Washington D.C.
ECKAUS, RICHARD S.
Massachusetts Institute of Technology, Cambridge Massachusetts, 02139
LAHIRI, SUPRIYA
University of Lowell
MEERAUS, ALEXANDER
GAMS Development Corporation

A General Equilibrium Analysis of Policies to Reduce Carbon Emissions Through Increase in Efficiency

Policies designed to deal with environmental hazards must take into account the direct and indirect effects on overall economic performance. This requires a "general equilibrium" analysis which traces all the consequences of such policies for economic decisions. The paper is a demonstration of the potential in using this approach in investigating a particular type of environmental policy, rather than a definitive study.

The particular policies that will be investigated are reductions in carbon emissions through increases in the efficiency of use of petroleum fuels. A multisectoral, intertemporal, programming model embodying substitution possibilities in production and consumption will be used for the analysis. The model to be used was not originally designed for the present purpose and the setting of the model is rather special. For these reasons, the numerical results should be interpreted as only illustrative.

The analysis will differentiate between two sources of increases in efficiency: (1) those that are essentially costless, requiring only improvements in the quality of adjustments and maintenance of equipment, and (2) increases in efficiency that require "retrofitting" of equipment. Because the model distinguishes a number of sectors and a number of technologies within each sector, it will be possible to be selective in the specification of the location of the changes in efficiency and in the costs involved.

It will be demonstrated, through alternative solutions of the model, that it is possible to project the potential reductions in carbon emissions and the consequences for aggregate economic growth of such policies, as well as the implications for particular sectors.

BOJÓRQUEZ-TAPIA, LUIS A.. and ONGAY, ENRIQUE
Centro de Ecología, UNAM, Apartado Postal 70 275, 04510 Mexico, D.F. Mexico

International Lending and Resource Development in Mexico: Can Environmental Quality be Assured?

Mexico, as other developing countries, needs foreign capital to counter the current economic crisis. Large developmental projects are currently being planned and executed. Regulation of rapid economic expansion is fundamental for sensible development. However, the international banking community is interested in individual and profitable projects, so environmental impact assessments (EIA) are conducted after major planning decisions are already taken. Thus, development is not the result of holistic planning, but the aftermath of the "trigger" effect of particular projects.

This paper examines the changes needed for appropriate EIA and regional land-use planning for the protection of environmental quality in Mexico. A new definition for environmental quality is proposed: the losses caused to society for the execution of a project, different from any possible loss due to its intrinsic function. Also, the capacity of the Mexican environmental legislation to protect biodiversity is examined. Since critical obstacles exist for bioconservation within the current legislation, modifications to the environmental law are suggested.

BOJÓRQUEZ-TAPIA, LUIS A. and FLORES-VILLELA, OSCAR
Centro de Ecología, UNAM. Apartado Postal 70 275, Mexico 04510

A Method For Land-Use Planning and Conservation in Mexico

A large proportion of the Mexican natural biodiversity is at risk by large internationally financed forestry projects. Although they have been proposed as a new natural resource development strategy, with respect to bioconservation, the projects reflect lack of sufficient land-use planning and environmental impact assessments. A method has been designed to provide useful biological information for sensible land-use planning and impact assessments. The approach identifies centers of diversity by combining data obtained from a computer data base, the UNIRBMEX,and from published maps (climate, topography, and lithology) through a geographical information system. In essence, the method is a modification of the gap analysis; major changes are: the use of endemic species, the scale of the maps, and the use of multivariate statistics to analyze the distribution patterns of the centers of diversity. The centers of diversity are then proposed for the creation of multiple use modules, which form the base of a network of natural protected areas.

BROWN, PETER G.
School of Public Affairs, Morrill Hall, University of Maryland, College Park, MD 20742

Intergenerational Costs and the Greenhouse Effect

Economic approaches to intergenerational aspects of greenhouse effect are evaluated and found wanting. Difficulties with these approaches include discounting, and motivational assumptions about how persons in the present value the future. An alternative framework to market approaches that emphasizes man's evolutionary origins and fiduciary responsibilities is presented.

CALE, WILLIAM G.
Indiana University of Pennsylvania, Indiana, Pennsylvania 15705
KATZMAN, MARTIN T.
Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831

International initiatives for the long-term preservation of tropical forests.

Tropical forests are the storehouse of the bulk of the earth's species, critical to worldwide climate control, atmospheric gas exchange, regional hydrology patterns, and representative of the most complex living systems on earth. They are being destroyed at a rate in excess of 100,000 km2 per year, an area about the size of Great Britain. External pressures to preserve these forests are doomed to fail because none of these provides an incentive structure for members of the sovereign states which contain them. Even recent ideas involving "debt-for-nature" swaps contain no guarantees beyond the good will of the regime in power, and no certainty that the next government would not find it in its interest to exploit those areas presumed to have been preserved. This paper challenges these pressures and proposals. An alternative is offered which would create a multinational consortium of nations contributing to long term annuities payable to nations holding tropical forests in trust. An example is offered for Brazilian Amazonia. This plan would cost approximately 2% of present United States foreign aid. It would provide funds for acquisition, administration, research, and enforcement to preserve 10% of Brazilian Amazonia for 50 years. A yearly flow of cash, jobs, and an annuity valued in the hundreds of millions of dollars provide the incentive for any government to honor the agreement over the long term.

CAPISTRANO, A.D. and **KIKER, C.F.**
University of Florida, Food and Resource Economics, Gainesville, Florida 32611

Global Economic Influences on Tropical Closed Broadleaved Forest Depletion

The paper reviews major global economic developments which may have encouraged the depletion of tropical forests from 1967 to 1985. Data from 45 tropical developing countries are used to quantify the influence of changes in real exchange rate, debt service payments, cereal self-sufficiency, wood and agricultural export prices, income and population on forest depletion. The magnitude of industrial logging in natural closed broadleaved forests is used as an indicator of forest depletion. The study period is divided into four subperiods. The influence of global economic conditions on the relationship between forest depletion and the above variables in each subperiod is tested using Chow's test for structural change. Results indicate that international economic conditions figured significantly in the depletion of tropical forests during the study period. Agricultural expansion into forested lands in response to food self-sufficiency needs was a major factor explaining forest depletion in the 1970s. Real exchange rate devaluations in the late 1970s and early 1980s led to the "mining" of tropical forests. Contrary to popular belief, higher income was associated with more, not less, forest depletion.

CARPENTER, STANLEY R.
Associate Professor, Philosophy of Technology, School of Social Sciences, Georgia Tech, Atlanta, Ga 30332

Sustainability and Forms of Life

During the latter half of the twentieth century, philosophers of science have had a lot to say about the incommensurability of competing scientific theories. This paper applies elements of these discussions to the concept of "sustainability." The issue of the relative superiority of stable-state economic theories to growth-oriented models of economic policy, vis-a-vis the "sustainability" issue is addressed in terms of the incommensurability thesis. While it is not argued that intra-theoretic incommensurables prevent meaningful discussions between rival models it is argued that any consensus that is achieved involves more than technical adjustments to he competing economic versions (by renegotiating the limits of the "marginal social product", for example). Rather, the Wittgensteinian point is defined that coming to understand the issues in the "sustainability" debate involves "grasping the point" of each competing approach. It will be argued that "sustainability" , as an example of an incommensurable concept as it functions in rival economic theories, can

best be analyzed as a "form of life". This move will be shown to involve normative factors which are missing from the technical disputes over model adequacy but which need to be included if incommensurable views of "sustainability" are to be grasped and genuine attempts at reconciliation attempted.

CASTILLO, SERGIO
PRMC, CATIE , 7170 Turrialba, Costa Rica, Central America
GOTTFRIED, ROBIN
Department of Economics, The University of the South, Sewanee, Tennessee 37375

Management of an Ecosystem as a Multiproduct Asset in a Developing Country Context

Several difficulties exist in the economic literature on the value of an ecosystem. First, few authors rigorously address the interrelations between the goods and services provided by an ecosystem. Second, economists tend to approach ecosystem value in terms of consumer and producer surplus, concepts particularly difficult to measure in developing countries. Finally, the literature generally has not viewed ecosystem values from the perspective of the role of the system in development.

This paper attempts to develop a methodology which treats the ecosystem as a multiproduct asset and which enables one to examine the implications for development of various types of ecosystem utilization. The paper utilizes a recursive linear programming model which maximizes the net present value of the flows of the entire package of interrelated ecosystem goods and services over time subject to various biophysical, socioeconomic and ecological constraints. The model assumes that all the human productive activities in the entire ecosystem can affect in various ways the quantity of ecological goods and services produced by any one parcel in the system. The ecological outputs of a parcel in turn constitute an input to the economy's production of goods and services. People also consume a subset of the ecological outputs indirectly without the use of economic inputs. The paper discusses how to include uncertainty, risk and sustainability considerations in the constraints and ends with a discussion of the advantages and shortcomings of the model.

CHAN, ARTHUR H. and **MILLS, SHERRY K.**
College of Business and Economics, New Mexico State University, Las Cruces, New Mexico 88003

An Energy Content-Based Information System for Municipal Solid Waste Management

It is a well-established proposition that in order to select the proper method, or combination of methods, of waste disposal, feasibility studies must include an analysis of the quantity and content of waste currently generated. The accuracy of this analysis is indispensable in projecting future waste generation and developing a flexible solid waste management program. However, given the disparate nature of materials commonly found in the municipal waste stream, the prevailing practice of estimating and reporting total waste and its composition in terms of weight (tons) or volume (cubic yards) will give rise to imprecision and difficulty in interpreting the data that are gathered. This could result in neglecting to select or implement the most effective waste management strategy. This paper will suggest analyzing waste by establishing a different data reporting system based on measuring the energy content of waste materials. This alternative system will allow municipal decision makers to better evaluate different methods of waste disposal by specifically integrating energy/resource conservation into the waste disposal management decisions. Examples will be provided in the paper to demonstrate the usefulness of the energy content measure. In addition, capital budgeting techniques and economic and accounting concepts of opportunity costs and replacement costs will be applied to the examples to show the entire evaluation process.

CHARLES, ANTHONY T.
Saint Mary's University, Department of Finance and Management Science, Halifax, Nova Scotia B3H3C3 CANADA

Sustainable Fisheries: Management Paradigms and Bio-Socio-Economic Models

The concept of "sustainability" has a lengthy history in fishery management. While in reality, mismanagement of fishery resources is all too common, the idea of "sustainable yields" is essentially universal in fishery thinking. With sustainability now becoming a stated objective of society as a whole, it is important to understand, and to draw lessons from the management paradigms and analytical models prevalent in fisheries and other renewable resource industries. On the one hand, natural limitations on resource use by these industries have been better recognized than, say, limitations on soil, air and water quality. On the other hand, the very reference to "resource use" highlights the treatment of fish, trees and wildlife as material which takes on value only through human exploitation. This dichotomy in the approach to renewable resource management produces a range of differing philosophies, reflected by the Conservation, Rationalization and Social/Community paradigms. Each of these paradigms emphasizes a different societal objective; maintaining ecosystem health, generating economic wealth, and expanding the social fabric of resource communities. This paper explores these objectives and paradigms, emphasizing the role they play in current conflicts over fishery management and development.

The case is made that full implementation of a "sustainable fisheries" policy necessitates the creation of broad new multi-objective perspectives, which in turn can be useful in other sectors of the economy. There is more need than ever for suitable scientific methods to aid in implementing new approaches, but major changes are required in the prevalent methods for analyzing fishery systems. Existing models, essentially uni-disciplinary in nature, must make way for integrated bio-socio-economic approaches. Recent fishery research on this theme will be presented, together with broader implications for the modelling of sustainability.

CHOPRA, KANCHAN and **KADEKODI, GOPAL K.**
Institute of Economic Growth, Delhi, India

People's Participation and Common Property Resources: Some Refelections

Participation is the introduction of a new set of people into the decision making process with regard to resource allocation or distribution. The public goods characteristics and high policing and preservation costs of state management make participatory management of common property resources as a possible alternative.

A distinction is made between participation as a process and an institution. As an evolutionary process, it embodies the dynamics of introduction and understanding or norms, of persuasion, conflicts and violation of rules. Simultaneously, the degree of participation and its measurement make it an institution.

Two case studies of participatory development, one based on sharing of common property resource management between government and village communities, and the other on pooling of private property resources into common property are studied. The links between common and private property management, the importance of catalysts such as common problems and leadership, and the possibilities of replication are evaluated. Depending upon the possibilities of sharing or pooling of resources and their linkages, the participatory model is sustainable as an alternative to other models of rural development.

COLBY, MICHAEL E.
2104 North Quantico Street, Arlington, Virginia 22205

Economics and Environmental Management: The Case for Environmental Taxes

It is commonly perceived that the conventional legal approaches to environmental management of the past 20 years — "command and control" types of pollution regulation such as bans or restrictions, quality standards, emission standards, product standards, technology prescriptions, and environmental impact statements — have been unduly expensive (inefficient) and in many cases disappointingly ineffective in preventing the most serious and widespread types of "environmental" problems. In the pursuit of sustainable development, new, more efficient, and more effective mechanisms for integrating sound environmental management into economic development are being sought.

This paper discusses the differences in economic and environmental effects between conventional regulation, market mechanisms, and a third approach, "environmental taxes." Distinctions between the three approaches are made, the case of tropical deforestation is reviewed, "environmental taxes" defined, and examples of such taxes and their advantages are given. Special attention is given to the concept of a "greenhouse gas" tax, focussing on steering effects and issues of indexing and equity between industrial and developing nations. A summary of criteria for the design of environmental taxes is provided.

COMMON, M.S.
Centre for Resource and Environmental Studies, Australian National University, Canberra, Australia

A Pragmatic Approach to the Development of an Ecological Economics

The processes by which social decisions affecting the natural environment are made will remain political in nature, with all participants influenced generally by ideas and information from a variety of sources. Decision makers require analytic and factual inputs on particular problems. One motivation for an ecological economics is the perception that at neither the general nor the particular levels is extant economics a satisfactory framework, though at both levels it is influential. In Australia the Federal Government has established the Resource Assessment Commission as a standing body to which it can refer particular issues for advice and recommendations. The first reference was made in December 1989 and concerns "options for the use of Australia's forest and timber resources", which have been vigorously debated in recent years. Using the task facing the Commission as a particular example, the paper models its essentials, reviews the extant economic approach, and argues that its individualist foundations are inappropriate. It is suggested that more progress will be made by way of modelling for the constrained optimization of a properly social objective function. The nature and form of the function would itself be a matter for political consideration and debate, as would many of the constraints. It is argued that looking at a variety of particular problems in this way represents a pragmatic approach to the development of an ecological economics.

CONLEY, CRAIG and CRAIG, PAUL P.
Ecology Graduate Group, University of California, Davis, CA 95616

The True Cost of Electricity: Implications for Least-Cost Electricity Resource Planning

The goal of least-cost electricity resource planning is to provide energy service at the lowest-cost. The definition of least-cost is expanding to include not just traditional economic costs (e.g., fuel and equipment costs) but also social costs or externalities (e.g., air emissions and habitat impacts). Recent attempts to value emissions suggest that accounting for these costs in dollar terms will have significant impacts on true least-cost strategies. This paper describes a framework for evaluating the environmental costs associated with electricity production over the typical electric utility planning horizon of 20 years. Further, this paper explores how this framework might be incorporated into traditional least-cost planning approaches. Issues associated with placing dollar values on intangible costs associated with electricity production and with incorporating these costs into resource planning are discussed. Key issues include the assumptions made in the valuation of emissions, the implications of different valuation approaches and levels, and institutional barriers to social least-cost planning.

CONNER, J. R.; STUTH, J. W.; HAMILTON, W. T. and SHEEHY, D. P.
Dept. of Agricultural Economics, Texas A&M University, College Station, Texas, 77843

An Integrated Ecologic-Economic Model for Planning Sustainable Grazing Animal Production Systems

The Resource Systems Planning Model (RSPM) is designed to facilitate planning for sustainable land resource use at the local land management unit level. The model first integrates soil and climatic conditions with forage inventories and analyses to determine ecologically based herbivore carrying capacity. Socio-cultural goals and constraints and the ecologically based animal carrying capacity are then used to design sustainable livestock production systems. RSPM uses this information with information on local production practices, costs and product prices to analyze economic feasibility of conversion from the current to an alternative sustainable production system.

Data obtained from use of RSPM with a representative sample of local land management units can be used to design and/or adopt region-wide policies, programs and institutions to facilitate implementation of ecologically and economically sustainable grazing land production systems.

The first use of RSPM was in the USA where it has been adopted by the USDA-SCS for use nation-wide as their Grazing Land Applications (GLA) decision support system. Currently, pilot studies are underway to illustrate its potential for use in stemming the rapid ecological decline and desertification of the grass steppe, ecosystem in the Inner Mongolian Autonomous Region of China.

COULTER, JOHN
Entropy Management Services Pty Ltd, 7 Yarabah Crescent, Shailer Park, Brisbane 4128, Australia

Economic Activity on an Energy Landscape

Economics today begs new approaches. In this paper the crisis is economics is reviewed and the causes delineated. It is shown how fundamental aspects of economic activity were subsumed by early economists simply because they seemed so obvious and invariable, and why, through developments in technology and scales and scope of economic activity, these aspects have now become significant and in some cases dominant parameters which must be included when measuring, predicting and regulating economic activity.

A new approach, viewing economic processes taking place on an energy landscape, is proposed. Here, the activity of "production" is perceived in a quite different way. In this approach, boundaries in space, normally in the form of cubic cells, are accredited with the attributes of the energy levels that can be identified within them, and this is metaphorically condensed to an "energy landscape" where high forms of energy continuously level off with lower energy forms in neighboring cells. Economic activity is gauged as a mere adjunct of this natural, universal phenomenon. It is concluded that while economic actors will still determine their plan of action using money terms to measure and compare their outputs and others" inputs in markets, they, and more pertinently the economic analysts and policy makers who would hope to regulate the economy, should recognize that the direction of all natural action and human activity in transforming matter is dependent on a trend that can be explained as a levelling of energy. Strategies should be directed toward sensibly managing optimal benefits of the degradation, rather than pretending that the laws of physics can be rescinded, and that processes of "production" within a tolerable latitude of neat and marginal self-adjustment, are sustainable.

CRAIG, PAUL P..; DUNLOP, BETH; CONLEY, CRAIG and GLASSER, HAROLD
Sustainable Futures Research Group, Department of Applied Science, University of California, Davis, CA 95616

Apparent Consumer Discount Rates

Ecological sensitivity mandates minimization of environmental impact associated with resource use. Economic guidelines urge decision making based on minimal total cost. Neither orientation offers a comfortable explanation of decisions by American consumers on appliance purchases. Numerous studies show that consumer decisions can be interpreted in economic terms only by assuming discount rates approaching or exceeding 100% per year. Even ecologically sensitive individuals often appear to make appliance decisions on the basis of needs of the moment. Failure of both the ecological and the economizing paradigm appear to relate to poor availability of information, need to make decisions on short notice [e.g. if a refrigerator or water heater fails], or total lack of control [need to use whatever appliances are provided in rental apartments. Less often mentioned are impatience and lack of self-discipline. A direction for resolution may be found in Kenneth Arrow's suggestion that ethical considerations play a critical constructive role in economics. For the US culture the prognosis is less than promising.

CUNNINGHAM, A. B; and FRIEDMAN, M.
Institute of Natural Resources, University of Natal, P.O. Box 375, Pietermaritzburg 3200, South Africa

Prime Movers: Women and Wild Plant Resources

This paper explores the role of women as resource managers in rural areas in south-eastern Africa and the possibilities that exist for plant resource conservation under existing ecological and socio-economic conditions.

In this region, women are major gatherers of wild fruit and greens, harvesters of fuelwood, thatch grass, and craftwork resources (grasses, sedges). They also fill an important social role as diviners (izangoma) using specific medicinal plants. Men, however, traditionally are hunters and herders, using plants as palm wine tappers, palm basket weavers and for hut building. Unlike diviners, most traditional doctors (izinyanga) are men, often using a different range of medicinal plants. These differences can be ascribed to a variety of factors including sexual differentiation of roles, and increasingly, social changes wrought by the migrant labour system, which has affected a high proportion of households in certain areas. In such cases, women have increasingly had to take over tasks such as hut building, thatching and palm wine tapping as well as informal sector trading (crafts, palm wine, medicinal plants) which have become marginal activities for men. Thus women, who have always been major users of plant resources, play an even greater role in harvesting plants than ever before, as wild plant resources contribute to the subsistence survival of most rural households. This harvesting can have a devastating effect on plant resources vulnerable to over-exploitation. As resource users, however, women are often fully aware that their resource base is being depleted, but are forced to do so in order to stay alive. Implementation of resource management programs has to involve rural women, taking into account alternative economic options open to them as well as the long term consequences of resource depletion. This has happened all too rarely in the past, and is a necessity for successful conservation and resource management programmes in the future.

DALE, BRUCE E.; HOLTZAPPLE, MARK A. and RYKIEL, EDWARD J.
Texas A&M University, College Station, Texas, 77843 USA

A New Technology for Sustainable Production of Food and Fuel from Biomass: Energy, Economics and Ecology.

The world is beset with the growing list of interrelated problems: debt, deforestation, carbon dioxide buildup, decreased biodiversity, soil erosion, soil and water contamination, air pollution, and trash disposal. These and other problems are connected by powerful interactions among energy, economics and ecology. A recent technical innovation which promises to be a major factor in the mitigation of these problems is the ammonia fiber explosion (AFEX) process. The AFEX process unlocks the vast reservoir of food and fuel in biomass such as trees, crop residues, grasses and the organic portion of trash including newspaper. This discussion explores the potential impacts of AFEX technology on energy, economics and ecology, using conversion of grasses to protein foods and fuel ethanol as the case study. Some key results are as follows.

Energy: If perennial grasses such as coastal Bermuda grass are used in an integrated AFEX treatment process, we can expect to produce 1,000-5,000 kg of protein and 2,000-10,000 liters of fuel ethanol per hectare per annum depending on climate and cultivation practices. Since the major energy input is renewable solar and since we can assign a portion of the overall energy requirements to food production, the overall energy efficiency is at least 10 units of liquid fuel (ethanol) produced per unit of liquid fuel input. In many countries, including the U.S., there is sufficient excess arable land to replace all transportation fuels with biomass ethanol.

Economics: The AFEX process is profitable: return on investment (ROI) is 50-80% when waste materials are upgraded to ruminant animal feeds and ROI is up to 30% with ethanol at $0.26/liter (octane enhancer value) when protein is a coproduct or with tipping fees for trash disposal. If indirect costs of fossil fuel combustion or balance of payment costs are added to ethanol values, much higher ROIs result.

Ecology: Production of fuel using the AFEX process is ecologically benign compared to fossil fuel production and contributes little to CO_2 buildup in the atmosphere. Because AFEX can deal with a variety of biomass feedstocks, processing plant design and operation can be integrated with local ecological systems. The case study demonstrates that fuel needs can be met with processes that are compatible with both short- and long-term ecological considerations. Perhaps most importantly, AFEX demonstrates that ecological and environmental values can be meaningfully integrated with economics and energy demands to foster sustainable development.

DAY, LINCOLN H.
Department of Demography, Australian National University, Canberra, A.C.T., Australia

Departing from Resource-Intensive Lifestyles: Problems and Possibilities

Any attempt to ensure a sensible response to adverse environmental impacts or to redirect human behavior along less environmentally deleterious channels, must necessarily clear a formidable array of obstacles. These range from (1) the physical (e.g., road systems and the layouts of towns and cities) through (2) the institutional (e.g., the economic system and the system of social stratification) to (3) the ideational (e.g., people's assumptions and priorities about what is acceptable or unacceptable, good or bad, desirable or undesirable). Each is in one way or another conducive to the continuation of resource-intensive practices.

Yet, countervailing forces do exist; if not to a degree that justifies much optimism, at least to one that justifies cautious hope. These relate to (1) the turnover of both physical stocks and human generations, (2) the possibilities that exist for informing people and changing their values, and (3) certain possibilities that the political structure affords for controlling or preventing various types of resource-intensive activity.

I propose, in this paper, to discuss both these sets of conditions: the obstacles to making human behavior less environmentally destructive and the possibilities for overcoming these obstacles.

DENZLER, ERIC
Center for Energy and Environmental Studies, Boston University, 675 Commonwealth Avenue, Boston, MA 02215

Energy and Economic Analysis of Phosphorous Scarcity and the United States Phosphate Rock Industry

In this paper, an argument is developed for the increasing economic scarcity of phosphorous from commercially produced phosphate rock using biophysical and standard measures for resource scarcity. The importance of phosphorous for cellular activity in biological organisms is noted, as is the economic importance of phosphorous as an agricultural fertilizer. The history of the phosphate rock industry within the United States is briefly explored, looking at production for signs for decreasing physical quality. I then look at the economic effort of production expended by the industry as measured by inputs of labor, capital, and energy. The results of this empirical analysis indicate that average ore grade for United States mine production of phosphate rock has been declining since the mid-1960's. While combine costs of labor, capital, and energy per unit of output declined rapidly from 1919 through the 1940's, costs per unit output leveled off through the 1950's and 60's, and began to exhibit increases in cost per unit output during the 1970's and early 1980's. The implications of possible increasing economic scarcity within the phosphate rock industry are then discussed.

DIETZ, FRANK
Erasmus University, Department of Public Administration, P.O. Box 1738, Rotterdam, The Netherlands
HOOGERVORST, NICO
Agricultural Economics Research Institute, P.O. Box 29703, 2502 LS Den Haag, The Netherlands

Towards a Sustainable Use of Nutrients in Agriculture

The application of nutrients in agricultural (plant) production has caused serious environmental problems. In various regions of Europe, instances of eutrophication of surface water, high levels of nitrates in groundwater and acidifying depositions of ammonia have been related to the agricultural use of phosphate and nitrogen. The present application levels of these substances (contained in chemical fertilizers and animal manure) are not in accordance with an ecologically sustainable agriculture. The objective of sustainable agriculture can be obtained by developing standards for nutrient application which are in accordance with the carrying capacity of the local environment. This paper presents a concrete proposal for the development of such standards. It will also elaborate on the way in which these standards can be implemented in European agriculture. In this respect it is suggested that systems for nutrient accounting at farm level are being developed. This will provide information about the magnitude of nutrient losses (or emissions) to the environment. Nutrient accounting could also serve as a basis for environmental policies containing a mix of charges, subsidies, standards, permits and action prescriptions. The proposed approach will be illustrated with an application for agriculture in the Netherlands.

ERIKSSON, KARL-ERIC and MANSSON, BENGT A.
Institute for Physical Resource Theory, University of Goteborg and Chalmers University of Technology, S-41296, Goteborg, Sweden

Physical Concepts in Ecological Economics

Processes in ecosystems and in economic systems have important physical aspects which are essential for forming a theory. These processes involve conversion of energy and materials and formation or breakdown of structure. The conversion processes are of physical necessity dissipative, i.e., they involve production of entropy. Structure formation/breakdown can be conveniently described in information theory terms. Information theory is closely tied to statistical mechanics and can be considered as a physical theory.

Materials/energy balances have a tradition within ecology and within economics; the description frame including also entropy and structure is developed in the paper. This is done first for stationary and periodic processes, secondly for processes for which time dependence is essential.

In ecological economics it is essential to treat the societal systems as distinct from the natural systems in which they are embedded. Moreover, in the societal systems the human sphere must be treated as distinct from the technosphere.

Besides this "kinematics" of ecological economics, there are other physical aspects of a dynamical nature. In the studies of dynamical systems, a new theory is emerging, and some results of special interest to ecological economics are reviewed, in particular theory of synergetic processes.

ERSKINE, J. M.
Institute of Natural Resources, University of Natal, P.O. Box 375, Pietermaritzburg 3200, South Africa

Environment, Agriculture and Economics: Achieving Sustainable Development in the Less Developed Rual Areas of Southern Africa

As an agricultural sector expands and adopts new technology or a population involved in subsistence agriculture enlarges rapidly, there are often adverse environmental consequences. Examination of land use trends in southern Africa indicates that soil erosion, deforestation, pollution of surface and ground water, and destruction of wildlife habitat are serious problems in the less developed rural areas of the region. Causes of the problems include population pressures, inadequate markets, poverty, and the effects of government policies.

This paper reviews some of the evidence on agricultural development and abuse of the environment in the less developed rural areas of southern Africa and, with reference to specific case studies, discusses it from an economic perspective. This is followed by an examination of development policies, both those which have contributed to environmental degradation (for example, "betterment" planning) and those which have attempted to maintain or improve environmental quality (for example, integrated rural development and establishment of rural service centres). A research framework is presented for analyzing alternative environmental management policies based on the use of a systems approach, integrated catchment systems modeling. This approach can be used to examine economic, institutional, and environmental relationships within a subdrainage area of a river basin and to analyses strategies for addressing several environmental problems - soil erosion, deforestation and water pollution - either singly or in combination, and for mitigating the environmental damages of small-scale agriculture. A prime advantage of the approach is that institutional change can be rapidly examined since the human impacts on the environmental quality of the catchment serve as a feedback loop for changes in the social system.

EVERETT, MICHAEL D.
Department of Economics, East Tennessee State University, Johnson City, TN 37601

The Political Economy of Environmental Movements

As scientists and pressure groups reassert their concern about possible environmental limits to rapid economic and technological growth they face a number of political economy issues: How do major environmental movements which result in substantial environmental protection come about? How do opposing forces arise and counter environmental movements? What net impact do these two forces tend to have on long run environmental quality?

Economic models of political behavior can provide some insights to these questions. This paper will utilize a very basic, easy-to-follow model and apply it to the history of environmental movements up to the present to illustrate some of the theoretical insights. As such, scientists working on environmental problems may find the paper of interest, although it will make no effort to rigorously test postulates of public choice models.

FAUCHEUX, SYLVIE
Centre-Économie-Espace-Environnement, Université de Paris I. Panthéon-Sorbonne, 90, Rue de Tolbiac, Paris.

Sustainability in Light of an Eco-Energetic Analysis

Our paper explains in what respect the eco-energetic approach is a plausible tool for implementing the concept of sustainability.

1- Sustainable Development: The Connection of "Economically Real" and "Ecologically Real" Dimensions.

1.1- Sustainability must be perceived in real terms, or more exactly in terms of what we designate as "economically real" and "ecologically real" dimensions, two concepts which we'll explain.

1.2- Eco-energetic valuation, which cannot be reduced to monetary valuation, constitutes a relationship between the "economically real" and the "ecologically real" dimensions. In more, management tools can be developed for both "finitude" and "entropy" (according to the terms used by H.E. Daly), using eco-energetic analysis as a starting point.

2- Eco-energetic Analysis as a Tool for Implementation of Sustainability.

2.1- A number of eco-energetic indicators for sustainability can be introduced :

a) from an ecological point of view, such as:

- Available "Energy" Surplus (AES) which allows to measure and to guide sustainability as opposed to the limit imposed by "finitude";
- Generation of Minimal Entropy (Nm), from which, by subtracting the Effective Entropy Emitted (Ne), one may obtain an indicator of sustainability as opposed to entropy.

b) from an economic point of view, such as Energy Surplus (Sr).

2.2- Equipped with these types of indicators, we can draw a typology of the various degrees of sustainability and we can establish the main heads of a macroeconomic model for sustainability in eco-energetic terms, which is the topic of research which we are actually pursuing within the EEC's Fast Economy-Biosphere Program.

FEITELSON, ERAN
Apogee Research Inc., 4350 East-West Highway, Suite 600, Bethesda, Maryland 20814

An Alternative Role for Economic Instruments: Sustainable Finances for Environmental Management

Economic instruments, such as effluent fees and tradable discharge permits (TDP), have often been suggested by economists as efficient or cost effective means to control pollution. In recent years such instruments have received increasing attention due to their growing political acceptability. Still, their usage in practice has been tentative.

The interest in possible application of such instruments has led to a set of studies regarding their practical potential. These studies indicate that economic instruments require substantial government involvement, entailing high administration cost, require restrictions so as to prevent significant deterioration in receptor areas, and have ambivalent effects on innovation adoption. Consequently, the efficiency gains from such instruments may besmaller than potential gains identified in earlier studies. In addition, the distributional impacts of such instruments and their possible adverse effect on market contestability reduce their attractiveness in some cases. These finding raise the question: what is the desired role of economic instruments for environmental goals?

In recent years the demand for environmental services has increased dramatically. Current legislation and studies indicate that desired environmental expenditures are likely to increase. At the same time environmental programs face increasing competition from other programs for a declining pool of general revenues. One outcome of these processes has been the search for alternative sources of funds for environmental programs. Furthermore, as the competition for general revenue funds increases, the allocation of such funds for environmental programs becomes less predictable. This may endanger many long term environmental programs which require stable funding.

This paper suggests that economic instruments may prove one source of dedicated funds for many environmental goals. Consequently, studies of environmental program financing as well as studies of economic instruments may well explore the possible role of economic instruments as financing tools. Some examples of the potential of such tools for estuary cleanup programs are discussed.

FENTON, ROBERT and BROWN, WILSON
University of Winnipeg, Winnipeg, Canada, R3B 2E9

The Uncertainty and Externalities of Catastrophic Loss: Measurement, Interpretation, and Decisions

Catastrophic losses, frequently pollution-related, are sudden, significantly reducing GNP. The challenge of securing funds for investments to prevent or attenuate such losses arises from the difficulty of measuring and interpreting the benefits, problems themselves rooted in positivistic economics, the informational difficulties of facing catastrophe, and large externalities.

In an attempt to make a judgmental decision a positive one, most evaluation schemes seek a "single figure" based on expected values or actuarial figures. Subjective probabilities yielding a range of answers, are manipulated to get a single figure; so doing leads to suppressing high- and low-range probability estimates. Convenience also demands risk neutrality, often yielding an unexpectedly modest result.

Governments hold back information for fear it could in itself trigger the catastrophe. Doing so distorts both contingent value market and expert panel studies.

The normal expected value calculations fall sharply once the preventable catastrophe has occurred and a system set in place to prevent a recurrence. The difference between preventing a catastrophe and preventing its recurrence is usually significant, requiring an optimal timing model.

Because the catastrophe can arise from several sources, investment in correcting a single source may not reduce overall probabilities sufficiently to warrant that investment, leaving significant unrealized externalities.

FINNELL, JANINE A.; KENNEDY, TED G.; DEGROAT, KEVIN and CABRAL, ANIL
Meridian Corporation, 4300 King Street, Alexandria, Virginia

Considering Social Costs in Utility Decision Making: Alternative Approaches and Implementation

Historically, market energy prices have not fully accounted for all resultant costs imposed on society. Due to increased environmental impacts, interest in these costs is growing. This paper synthesizes existing approaches to social costing; including 1) Characterization of impacts; 2) Relative ranking and weighting of technologies; 3) Adapting emission abatement costs as a proxy for valuing indeterminate social costs; and 4) Full economic accounting.

Specific cost calculations are summarized, and illustrate the significant changes in technology cost competitiveness that results. Options and issues for introducing this information into decisionmaking are discussed. For both domestic and international implementation, valuing external costs of energy production ultimately requires resolution of larger conceptual issues:

. the equity and competitiveness issues of applying social costs to sectors in isolation;
. the capabilities of individual utilities to effectively implement the information;
. the influence that the existence and strength of a regulatory mandate will have on methodology selection.

Because of the relatively immature state of the science and current lack of mandate, a moderate hybrid approach is suggested to introduce reasonable social cost estimates into the resource acquisition process while facilitating a policy consensus. Additionally, incorporating these criteria into resource decisions heightens the importance of operating characteristics such as dispatchability and diversity, requiring additional planning adjustments.

FLORES RODAS, JOSÉ G. and SCHLICHTER, TOMAS M.
Centro Agronomico Tropical De Investigacion Y Enseñanza, Turrialba, Costa Rica

What is Sustainability and How do We Achieve it? A Case in the Central American Tropics

Despite many other definitions of sustainability, this paper considers the subject in ecological, economic, social and institutional terms. The purpose of this article is to present a strategy for the sustainable development of the diverse ecosystems of the Central American Tropics, based on these elements. The strategy consists of a domain of field activities in the Central American Region that focus on the use of conservation for sustainable development activities in various demonstration areas. These demonstration areas are located in the mangroves of the Pacific Coast of Nicaragua, the Atlantic coastal resources of Panama, the Biosphere Reserve of Talamanca, Costa Rica, and in the newly created Biosphere Reserve of the Petn in Guatemala. Despite the diversity of these ecological, economic, social and institutional systems, there are some common methodologies being applied, such as those of comprehensive natural and human resource surveys, rapid appraisals, and economic evaluations, that help identify and establish priorities among sustainable development options. An integral part of this strategy is the active participation of grass-root organizations and communities, that live in and around these ecosystems, in the survey, planning, execution and training processes involved. Although the strategy is being implemented in its initial phase, this paper presents some of the preliminary results that show exciting and promising opportunities of sustainable development for these demonstration areas, including such options as mangrove management and utilization, propagation and agronomic practices of understory promising species, among others.

FOLKE, CARL
Asko Laboratory, University of Stockholm, S - 106 91, Stockholm, Sweden

The Societal Value of Wetland Life-Support

The societal value of a Swedish wetland system was analyzed with respect to the functional roles for economic activities such as cleansing nutrients and pollutants, maintaining the level and quality of drinking water, processing sewage, serving

as a filter to coastal waters, sustaining genetic materials and preserving endangered species. Due to extensive exploitations the major part of the life-support functions have been lost. We evaluate the loss of life- support in terms of reduced solar energy fixing ability (Gross Primary Production) and deterioration of stored environmental capital, and compare it with the total use of industrial energies in the economy aimed at replacing the wetland's production of environmental goods and services. Such substitutes include irrigation dams, water transports, well drilling, water purification, sewage treatment plants, fertilizers, fish farming, and efforts to save endangered species. The annual industrial energy cost of 20-45 TJ is approaching the annual loss of Gross Primary Production of 45-110 TJ, expressed in units of the same energy quality (fossil fuel equivalents). However, the environmental capital - the stored peat - has been deteriorated with an annual loss of 7985 TJ, or about 175- 400 times the costs of fossil fuels. We emphasize that ecosystems perform a lot of valuable and necessary work for free, and that fossil fuel based technologies should be developed to supplement and enhance this support instead of trying to replace it when it has been destroyed, thereby reallocating scarce fossil fuels to other parts of the economy and at the same time reducing environmental degradation.

FRAZIER, J.
Universidad Nacional, Apartado 1353, Heredia, Costa Rica

Ecological Economic of Marine Turtles: Challenges in Sustainable Exploitation of a Resource Which is Both Local and International

Marine turtles have become a *cause celebre* in conservation circles; large, distinctive, and essentially harmless to people, they are emotionally attractive to view. Although there are only eight species, a vast international community of biologists, cum conservationists, dedicates tremendous time, effort, and resources to protecting these animals and their habitats.

However, in both developed and undeveloped countries, the difficulties in managing economically sustainable populations are increasing unbridled. Several problems are fundamental: conflicts with other financially lucrative activities (e.g. shrimp fisheries and tourist hotels); high economic incentives for products from common resources - notable in distressed economics (e.g. poaching for eggs and skins in Pacific Latin America); and major habitat perturbations which incidentally - but insidiously - threaten marine turtles (e.g. rampant marine pollution).

The economic value of marine turtle products is frequently overlooked. In small, Third World countries where consumption is national, annual values may be tens of thousands of dollars; in Mexico local consumption of just turtle eggs is over one million dollars yearly. Where turtle products are exported from the country of origin (e.g. tortoise shell and skins), other factors further increase the economic value, at the same time confounding the chances of sustainable exploitation.

FRIEDMAN, M.and POLLETT, E. A.
Institute of Natural Resources, University of Natal, P.O. Box 375, Pietermaritzburg 3200, Republic of South Africa

The Possibilities of Achieving Sustainable Rural Livelihoods in the Context of a Migrant Labour System: Some Lessons From an Integrated Rural Development Project in Kwazulu, South Africa

This paper will investigate the constraints to and possibilities of achieving sustainable rural livelihoods in the context of an economic system which is to a large extent based on migratory labour. The paper argues with Kramer (1988) that there are multiple levels of sustainability, and that we can't discuss what sustainability is, or how we can achieve it without also asking whose sustainability we are talking about and at what level it can occur.

The sustainability of entire systems is not only limited by the least sustainable level (Kramer, 1988), the lowest level is also critically affected by conditions perpetuated at the highest level. This paper defines what is meant by sustainability and draws from the experience of an integrated rural development project in a rural Bantustan of South Africa to examine the relationships between a micro-level project and the macro-level economy.

The constraints posed by the broader economy will first be contextualised and the criteria necessary for sustainability at the rural local level identified. A small scale integrated rural development project will then be scrutinised to see what is possible at the micro level operating within this context. Some suggestions are made with respect to the tension that exists between short term survival needs of rural people and the longer term goal of enabling the development of sustainable natural resource and human management systems.

FRIEND, ANTHONY M.
Institute for Research on Environment and Economy, University of Ottawa, Ottawa, Canada

Natural Resources Accounting (NRA) and the System of National Accounts (SNA): Synergism or Antagonism?

The first part of the paper will explore the relationship between NRA and the SNA from the perspective of fundamental concepts of income, production, and capital accumulation. Although NRA is often described as complementary to the SNA, being in essence the "physical accounting" of the stock/flow of natural products, the choice of concepts of income could make these two accounting systems incompatible. How critical is this? Can Norgaard's "pluralistic approach" accommodate this essential antagonism? Or are they of so fundamental a nature that they may require drastic reformulations of national income accounting concepts themselves?

These questions will be explored by distinguishing natural resource stocks in terms of three kinds of flows; (i) material-energy flows into economic processes, such as minerals and fossil fuels, (ii) environmental service flows, such as those generated by ecosystems, hydrological systems, and atmospheric cycling, and (iii) pluralistic or mixed flows in the sense that they can be treated either as services and/or material inputs, mostly biological stocks such as forests, fisheries, and agricultural stocks. In this context the paper will analyze the implication of different evaluation methods to link the physical accounts with national aggregates of income and wealth, e.g., social discounting, shadow prices, and inter-generational transfers.

The second part will explore the NRA-SNA synergistic potential, which presupposes answers to questions of the type, for whom? and for what purpose? The experience in developing a NRA framework for forest and forestland in Canada will be drawn upon for a more pragmatic assessment. Examples will be taken from recent disputes on the use and management of Canadian forests. The paper will conclude with an analysis of the NRA-SNA dichotomy in terms of theoretical, accounting and institutional characteristics and the data needs for sustainable development objectives.

GHOSH, SOUMENDRA
New Mexico State University, Las Cruces, New Mexico, 88003

Efficient Food Production and Natural Resource Management Through Improved Credit Access to Women: Case Studies in Kenya

Using Kenya as an example, this study examines the effects of increased efficiency at the micro (in this case, the farm) level on the long-term resource conservation and sustainability of agricultural development of a developing economy. The important role of women-operators are analyzed in the context of a resource scarce, heavily populated agrarian economy. By quantifying the measures of production efficiency at the micro level, the model developed here allows us to analyze the impact of several policy alternatives on, among other things, long-term natural resource conservation and the agricultural development of a developing economy.

Specifically, two case studies: a) Land terracing and b) Wild-game ranching complemented with Livestock management are analyzed in order to quantify the efficiency levels of various factors of production. The impacts of different values of the efficiency parameter(s) are then studied in the context of the present institutional set©ups for achieving long-term goals of a developing economy. It is proposed that successful achievement of the target goals (i.e. sustained agricultural development) is only possible by introducing significant changes in the institutions that govern resource allocation.

GIAMPIETRO, MARIO
Instituto Nazionale della Nutrizione, Rome, Italy
PIMENTEL, DAVID
College of Agriculture and Life Sciences, Cornell University, Ithaca, New York

Energy Efficiency : Assessing the Interaction between Humans and their Environment

The energetic analysis of societal process faces major problems if input/output ratios are considered. In fact the simple measurement of quantity of energy does not assess values for analyzed energy flows (1,000 kcal of manure worth less than 1,000 kcal of gasoline). An approach based on the thermodynamic of non equilibrium is proposed to describe the dynamic interaction between human society and ecosystem's natural processes.

The society is considered a dissipative structure taking energy from the environment and investing energy into the environment (in form of applied power), in an iterative loop. In this way concepts like work, capital, efficiency, level of organization, can be described and quantified by energetic parameters.

Using this approach efficiency can be defined both in terms of stability of human society (sustainability of human activity in the long run) and in terms of direct return for humans (speed of rotation of the energetic investment within the society). Numerical examples are provided.

GILBERT, ALISON
IES - Free University, P.O. Box 7161, 1007 MC Amsterdam, The Netherlands

Satellite Accounts for Botswana - Theory and Logistics

National economic accounting was developed in response to governments' concerns to understand the changes in the overall size and composition of their economies. This reflected a realization that the economy could to some extent, be manipulated through fiscal and monetary policy. The resulting System of National Accounts (SNA) and its aggregate economic indicators are now an integral pat of macroeconomic policy-making. The rationale for natural resource accounting is usually couched in terms of the deficiencies of these national accounts and their indicators. It is now widely recognized that economic development cannot take place in disregard of the environmental effects of that development. More importantly for resource-dependent economies, no economy can secure sustainable development if it "lives off its capital".

Botswana's economic growth has been heavily dependent on the exploitation of non-renewable resources, particularly diamonds. Meanwhile, approximately 80% of the population live in rural areas and are dependent on traditional crop cultivation and livestock production. Substitution of the diamond sector as the main source of income, and sustainable use of land and rangelands to meet the short and long term needs of rural residents are two crucial development issues for Botswana.

The potential value of natural resource accounts was assessed as part of the preparation of Botswana's National Conservation Strategy. The following uses of NRA were identified: database; monitoring; conflict identification and resolution; and integration. A design for natural resource accounts was proposed. The particular features of the design are:

1. satellite accounts which present data on resource and monetary flows in a mixture of units;
2. a structure for these accounts such that they can be used to modify he national input-output model (MEMBOT); and,
3. accounts which document stock changes, in physical units.

GLASSER, HAROLD and **CRAIG, PAUL P.**
Applied Science Department, University of California, Davis, CA 95616

Problems with Plastic Trees and Ways to Think About Recycling Them

The discussion on the relationship between thermodynamics and sustainable economics has focused heavily upon fundamental second law analogies. It has been characterized by an intellectual zealousness to associate the theoretical implications of entropy growth for closed systems with a logical imperative for steady state (entropy minimizing) economic systems here on earth. An underlying assumption has been the desire to maximize the "efficient" use of resources. Most analyses have failed to apply their conclusions to examine "real world" systems.

We examine the broad meaning of efficiency and extend it to delve into the relationship between the efficient use of energy and resources and environmental degradation. We have developed an index of the wastes (both commercial and residential) associated with the present functioning of U.S. society. Mass and energy balance calculations have been performed to assess the maximum potential of recycled materials. In addition, indices for energy efficiency, CO2 emissions, and capital cost associated with processing facilities have been developed. The utility of applying a multiobjective optimization procedure to assess optimally efficient systems is examined. Our analysis concentrates on clarifying the role of recycled materials and energy efficient processes for promoting sustainable economic systems.

GOTTFRIED, ROBIN
Department of Economics, The University of the South, Sewanee, Tennessee 37375

The Value of a Watershed as a Series of Linked Multiproduct Assets

This paper views ecosystems as long-lived multiproduct factories. Increased use of one ecosystem good or service (function) often affects the supplies of other ecosystem functions. The relationships between these functions can be modeled in terms of key variables related to ecosystem management. Thus, the analyst can determine the different mixes of functions an ecosystem can perform.

A watershed can be viewed as a series of ecosystems linked spatially and temporally by the downward flow of water. Changes in the mix of upstream ecosystem functions change the mix of downstream ecosystem functions. What is the value of this system of interlinked, multiproduct assets?

The paper presents an approach to valuing an ecosystem as a multiproduct factory using consumer and producer's surplus. The author then proceeds to apply the same methodology to a watershed viewed as a series of linked multiproduct assets. Because an ecosystem is a natural system with rather arbitrarily drawn boundaries, a watershed can be treated as one unit and valued accordingly. However, this approach obscures a question of particular interest. If erosion in an upstream ecosystem causes it to lose value, but in turn causes the wetland downstream to gain value, does the value of the watershed

rise or not? The paper examines this issue in some depth and discusses the pros and cons of maximizing watershed value. The author concludes with a discussion of value in the context of long time horizons, uncertainty and sustainability.

GROENFELDT, DAVID J.
World Wildlife Fund, 1250 24th Street, N.W., Washington, D.C. 20037

In Search of Sustainable Watershed Development Strategies for Local Management in South and Southeast Asia

Efforts to develop a single sector of a watershed, such as irrigation, forestry, or upland agriculture, often fail to achieve their targets do to an overly narrow focus. On the other hand, multi-component development efforts face difficulties of cross-cutting jurisdiction of government agencies. Local management of watershed resources offers a way of meeting multi-sectoral interests, while strengthening local institutions. Drawing on cases from Pakistan, India, Sri Lanka, Thailand, Indonesia and the Philippines, this paper identifies common problems, and elements of failure and success in fostering local management of watershed resources.

GROSS, LORNA S.
Keene State College, 229 Main Street, Keene, NH 03431

The Production Specification in Economic Growth Models

Economists responded to the sustainability issues raised by such events as the publication of The Limits to Growth in 1972 primarily by combining traditional economic growth models with an exhaustible resource stock or a pollution-productivity linkage. This paper assesses the first type of model.

The issue of whether economic growth is sustainable in this case depends on the way in which the role of the exhaustible resource is modeled. In this paper, the resource is treated simply as an aggregate factor of production, whose role in the production of material goods is subject to two implications of thermodynamics: conservation of mass and imperfect efficiency of conversion. An aggregate production function called the materials-balance production function is developed. It is contrasted with two other similar attempts to incorporate conservation of mass, and with neoclassical production functions in general.

The materials-balance production function is then applied to a standard economic growth model, and the results compared with those derived using a simple Cobb-Douglas production function (which violates principles of thermodynamics). Several extensions are made, such as allowing for recycling and technical progress. Each of these, however, is modeled with an eye toward thermodynamic constraints. Specifically, 100% recycling is ruled out, as well as ongoing exponential resource-augmenting technical progress. In contrast to the Cobb-Douglas case, a feasible steady state consistent with physical constraints does not exist.

To further illustrate the differences between the Cobb-Douglas and materials-balance aggregate production specifications, some simple dynamic optimal planning models are developed and analyzed. Such models are commonly found in the resource literature, and are capable of describing desirable paths of variables over time. A number of differences are found, supporting the conclusions that with a Cobb-Douglas specification, resources are not as necessary in production, but are far more useful. A good deal more output can be produced from a given stock, and the stock can be extended over a substantially longer time.

GUPTA, ANIL K.
Indian Institute of Management, Vastrapur, Ahmedabad, India

Sustainable Development of Indian Agriculture: Green Revolution Revisited

The story of technological change in India has been narrated many times but the political and institutional context in which the change took place still remains to be properly understood. The challenges which are emerging in sustaining the green revolution and extending it to hitherto untouched rain fed regions are discussed in this paper.

In part one of the paper, macro economic indicators are reviewed with specific reference to the declining productivity of inputs which raises questions about the viability of the current policy thrusts.

In part two, historical overview of technological change is presented particularly with reference to the large scale violence experienced in the country in the early seventies. Sudden increase in the social disparities triggered violence followed by policies to diffuse the tensions.

In the last part the issues for further research for sustainable development are listed.

GURMAN, VLADIMIR I. and **SAFONOV, PAUL I.**
Program Systems Institute, Institute Control Sciences, USSR Academy of Sciences, Profsoyuznaya,117806,Moscow, USSR1

Interactive Modelling of the Ecologic-Economic Regional Development

The system is intended for building investigation macro-models for ecologic-economic processes using simulation methods and original methods and algorithms of optimal control based on Krotov's sufficient conditions of optimality. The basic model within the system is the multisectoral balance model, including special block for environmental factors dynamics forecasting. The economic development impact on natural resources depletion is studied. The system includes: Subsystem of model building, providing models specification, identification and linking from model-blocks created by User; Data Base Management Subsystem for information input,correcting and restructurization in the form of multidimensional arrays of various data types; Scenarios Setting Subsystem, providing numerous man-machine tools for creating different variants of the control variables set in terms convenient to the User; Computational Subsystem, providing interactive simulation and optimization experiments with the complex of models; Information Reflection Subsystem, which is used while interactive identification, scenarios building and also while modelling simultaneously with computations. Different layout forms can be designed in accordance with the User's requirements using specific generators of graphics and tables; Dialogue Monitor, providing user-friendly dialogue interfaces, Context-Sensitive Multilevel Help Service; and efficient algorithms of processes and data management within the MS DOS operating system. The System is implemented for 16 and 32-bit IBM compatible computers.

HAENKE, DAVID
The Ecological Society Project of The Tides Foundation, Inc., Rt. 1, Box 20, Newburg, Mississippi 65550

Economics as the Gaian Disease: The Diagnosis and Cure Through Ecological Economics

The paper uses the biological understandings suggested by the Gaia Hypothesis of James Lovelock to discern that the Earth's ongoing crisis as being principally caused by human economics--as presently practiced--operating as a planetary disease, disrupting planetary ecosystemic integrity much like cancer. The same ecological principles which order natural systems are advanced as the means to understand the real nature of economics, wealth, money, "the bottom line", and to determine that economics has no reality outside ecology. These ecological principles also generate a whole new theory and practice of economics: ecological economics, or "eco-economics". Eco-economics corrects the misdirections and omissions of both Marx and Adam Smith, finally answering the question, "What regulates, no matter what the political-economic system, all economic activity?" Thus eco-economics generates the means (such as the "ecological audit") for diagnosing and healing the disease in its macro- and micro-phases. The "cure" is in economic activity scaled down as much as possible to the ecosystemic and bioregional levels, operating cooperatively with nature's economy and under her rules. Also suggested is a new ethic for the "ownership" of land, the "Earth Trust".

HALL, CHARLES and **CORNELL, JOSEPH**
SUNY ESF, Syracuse NY
LEVITAN, LOIS
Cornell University, Ithaca NY

Land and Energy Constraints and the Future of Costa Rica Agriculture

The concept of sustainable development implies that it is possible for growing human populations to live on lands of modest potential without having to rely upon intensive agricultural inputs. We examine that hypothesis for the country of Costa Rica for the period 1950 to 2050. Currently, Costa Rica produces 80% of the kilocalories consumed by its population and buys the other 20%; primarily with the proceeds from high-value agricultural exports, most importantly coffee. Costa Rica also services its foreign debt with the proceeds from these agricultural exports. We use a computer simulation model to predict the yield of the five most important food and export crops as a function of land quality, the addition of chemical fertilizers, and area under cultivation (including both planted and fallow lands). Our model also simulates the growth of the Costa Rican population and the amount of food that must be produced to feed that population at three levels of agricultural self-sufficiency. Several possible agricultural policies are examined to explore what agricultural strategy Costa Rica might employ to feed its population and service foreign debt. We conclude that regardless of strategy it will not be possible for Costa Rica to be agriculturally self-sufficient beyond about 2040 if the human population continues to increase at its present rate. Instead, Costa Rica must continue to produce high-value export crops (or increase indebtedness) to pay for both food imports and intensified inputs to agriculture. We consider this strategy to be necessary, even though it is highly sensitive to the price of petroleum (and its derivatives) relative to the price of agricultural products.

HAMMER, MONICA
Askö Laboratory, Department of Natural Resource Management, Stockholm University, S-106 91 Stockholm, Sweden

Marine Ecosystem Support in Relation to Fisheries Management

Marine ecosystems provide the economy with essential renewable resources, produced by complex ecological processes driven by solar energy. The relationships between fish production in the marine ecosystems and fish processed and traded in the Swedish economy was examined. Energy analysis was applied to estimate the use of natural resources in the economy and the support of ecosystems necessary for the traded fish products. Compared to the economic import surplus shown in Sweden's fish trade, the import surplus expressed in energy terms was found to be approximately 3 times larger. The results illustrate that Sweden is dependent on much larger non-indigenous ecosystem support areas performing necessary work than is reflected in standard economic accounting. The importance of considering such ecosystem support in economic decision making and management of indigenous and foreign living marine resources is necessary for making local and short-term goals consistent with global and long-term goals.

HARRIS, JONATHAN M.
Economics Department, Boston University, 270 Bay State Road, Boston, MA 02215

Global Institutions and Ecological Crisis

Rapidly escalating environmental problems of the late twentieth century have a common characteristic: their increasingly global nature. Much attention has been directed to the destruction of the ozone layer and the global warming effect. But these are only the most immediately evident of an array of ecological threats which will increase in intensity as we move into the twenty-first century. The degradation of soil productivity,groundwater pollution and overdraft, deforestation and desertification, acid precipitation, and the exponentially rising generation of toxic wastes by industrial processes, are all global phenomena. They threaten alike the stability of industrialized nations and the growth prospects of the developing world. There is good basis for the assertion that these issues will be the dominant factors in shaping economic activity in the next century.

In this context, the analysis of the institutional basis of economic activity takes on a renewed importance. The concepts of growth management and sustainable development have emerged as responses to the perceived environmental costs associated with both market and state-led economic development. These are consistent with ecological and institutional analyses of the production process. But if they are to be applied on the scale necessary to avert ecological catastrophe, they require a transformation of existing national and international institutions. The future world economic system will need to be based on a kind of global ecological Keynesianism, with significant social direction of capital flows, demand management, and technological choices,to promote ecological sustainability.

HEDMAN, SUSAN
School of Public Affairs, University of Maryland, College Park, Maryland 20742

Reversibility as a Weighting Factor in Integrated Least Cost Planning Methodologies

Energy planners, particularly in the electric utility field, are developing methods to measure and compare both the economic and environmental costs associated with energy supply and demand-side options. This specialized form of cost-effectiveness analysis is known as integrated least cost planning. There are two distinct approaches to integrated least cost planning--those that express environmental costs in economic terms and those which do not monetize. This paper develops a least cost planning methodology that uses weighted, scaled scores instead of monetization. Significantly, the system of weighting factors reflects the degree to which different types of costs are reversible.

HEMPEL, LAMONT C.
Associate Director, Center for Politics and Policy, The Claremont Graduate School, Claremont, California 91711

Implications of International Carbon Dioxide Abatement Strategies for Sustainable Development

This paper examines and compares the environmental, political, and economic implications of two separate strategies for reducing carbon dioxide emissions associated with the burning of fossil fuels: (1) the creation of a market for internationally tradeable carbon emission offsets from powerplants, and (2) the development of international corporate average fuel economy (CAFE) standards for passenger vehicles.

Each proposed strategy is evaluated in terms of its potential for global carbon reduction and its political feasibility in terms of international cooperation. The strategies are then compared in terms of their potential contributions to the goal of sustainable development.

Sustainability is defined in four basic ways -- environ- mental, social, cultural, and economic: environmental sustainability requires that industrial and agricultural development conform to the changing carrying capacities of biotic communities; social sustainability requires that just and informed citizens participate in the governance and improvement of human communities; cultural sustainability requires that people respect the political limitations and educational opportunities inherent in a multicultural, multilingual world; and economic sustainability, finally, requires that environmental costs be included in consumer prices, and that wealth be shared more equitably.

HERENDEEN, ROBERT A.
Illinois Natural History Survey, 607 East Peabody Drive, Champaign IL 61801

Monetary Costing of Energy-Related Environmental Effects: Examples from Several States and from Norway

An overall, comprehensive theory method for linking ecology and economics has not yet emerged. Progress is, however, evident in several state utility commissions, which are considering, or in the process of, institutionalizing the monetary valuation of less environmentally damaging electricity production (e.g., solar thermal) vs. more damaging technology (e.g., coal burning). The State of Illinois is evaluating these and other approaches for implementation in its biennial State Electricity Plan, due in 1991. I will summarize and criticize the several approaches according to a consistent set of criteria such as conceptual system boundary, time horizon, implied spatial extent of affected area and economy, needed vs. expected degree of accuracy, political palatability, and comparison with effects of saving the energy instead of producing it. I will also compare comparable costing efforts in Norway, particularly taxation of road fuel, in which a portion of the tax is explicitly identified as the cost of the car's negative impacts.

HITCHNER, BENJAMIN
Assistant Professor and Director, Center for Economic Education, Glassboro State College, Glassboro, NJ 08028-0761

Man Centered Economics

It seems most inappropriate in these times of disastrous environmental degradation that the economic education of most college undergraduates contains little or no meaningful references to the complex relationships between man's economic decision making and the global quest for environmental sustainability. These relationships are now recognized to form a dyadic system, that is, naturally opposed. Our future leaders in business, government and education are trained to think that environmental matters are external to the economic process. This suggests as excuse to avoid the difficulties in directing organizational changes to meet the long term social need of environmental sustainability.

In the evolution of economic thought, the enabling and fundamentally determinant role that the earth's natural systems have on economic organization and systemization has been excised. The discipline approach to teaching and learning of economics is obsolete. The discipline approach has served its purpose which was to focus on the quest for economic growth and development. It removed the cultural impediment, man's obligation to sustain ecological systems, which had been taught in myth and tradition. The early progenitor of economic thought Aristotle, established the common good, environmental protection, to be primary in the economy of the household. Since modern economics, dated to Seventeenth century Sir William Petty, economic thought has become totally "man centered". The economic paradigm that man alone matter, and that the forces of market equilibrium will accommodate the needs of future generations is, presently, undergoing revolutionary change. The restructuring of Introductory Macroeconomics and Microeconomics to serve the educational needs for global ecological sustainability is critically important.

HUGHES, DAVID; PENARANDA, WALTER and BUTCHER, WALTER
Washington State University
JARADAT, ABDULLA
Jordon University of Science and Technology
DAY, JOHN
Economic Research Services, USDA

Economic Analysis of Farming Practices that Increase Sustainable Production in the Barley Cropping Area of Jordan

Agriculturist in developing countries are often under extreme pressure to meet short and intermediate run food and income goals. The agricultural economics portion of the USDA-funded project, Technologies for Soil and Moisture Management, seeks cropping patterns, land use practices, and policies that will be not only attractive to farmers, but also will conserve soil resources and sustain productivity for an indefinite period of time.

A case study is made of soil and moisture management alternatives,including conserving (sustainable) technologies for semi-arid farming in the Mafraq region of Northeastern Jordan. Wind and water erosion in the area may be

exceeding rates required for sustainable agriculture. Erosion is being accelerated by extensive use of conventional tillage techniques instead of conservation farming methods. Livestock grazing of crop residue as opposed to incorporation of residue into the soil is also leading to significant resource depletion.

A mathematical model of a typical Mafraq farmer's decision making process is used to evaluate acceptability (perceived profitability) of soil and soil moisture conserving practices. Entered into the model are crop yield predictions for various weather conditions, cropping patterns, and farming practices as given by the Erosion Productivity Impact Calculator (EPIC) model. The EPIC model is also used to predict erosion rates resulting from wind and water and to calculate the effect of erosion on crop yields in the future. Preliminary results indicate that conserving and incorporating crop residues increase grain yield and conserve soil, but involve a tradeoff with livestock production due to reduction of aftermath feed supply.

Policy implications are discussed in light of model results. Lastly, the situation in Jordan is compared and contrasted to the more formidable problems encountered in attempting to analyze sustainable agriculture alternatives in the Sahel region of West Africa.

IGOE, JIM
Department of Anthropology, Boston University, 232 Bay State Road, Boston, MA 02215

The Ecological Basis of Economic Policy for Maasai Livestock Systems In Kenya

This paper examines Kenya's effort to bring pastoral herders into the national beef market , through the specific example of the Maasai. Two reasons are given for this effort: a decline in national beef production which has decreased Kenya's beef exports, and overgrazing, which has resulted in the desertification of arid and semiarid lands. The Kenyan government has attempted to solve these problems with commercial ranching schemes, destocking programs, and government marketing boards. To date, most of these programs have been unsuccessful.

These programs have failed in part, because current government programs do not account for the relation between traditional livestock systems and their environment. This relation relies on one important fact: economically valuable pastureland does not occur naturally. Rather, it is "produced" and "maintained" by the interaction among pastoralists, their animals, and the environment. The "production" and "maintenance" of pastureland allows me to use the concepts of sustainability, energy return on investment, and the maximum power principle to evaluate government strategy. This analysis indicates that government policies violate traditional techniques regarding migration and water use that ensure the availability of pastureland.

The failure to understand management techniques is exacerbated by economic policies that discourage market participation by the Maasai. Government pricing policies, combined with inadequate market facilities have provided few incentives for herders to market their cattle. The lack of alternative investments induce the Maasai to reinvest in their herds what little cash they earn from the market.

The final section of the paper explores some policies that may alleviate both the poor management techniques pushed by the government and the policies that now discourage participation in the market by the Maasai. An important first step would be improved marketing and transport facilities, and government sponsored programs, which would allow the Maasai to enter both of these sectors. Other programs might include micro-processing industries and retail marketing outlets. These types of programs would enhance the local economy, make alternative investments available to the Maasai, and provide consumer goods for local consumption. It is extremely important however, that such programs are implemented in such a way as to elicit the participation of the Maasai, because this has been an essential missing ingredient in previous government programs.

IKEDA, SABURO
Inst. of Socio-Economic Planning, University of Tsukuba, Tsukuba, Ibaraki 305, Japan

An Empirical Model Framework for Sustainable Resource and Environmental Management in Coastal Area

This paper is concerned with methodological aspects of resource sustainability and environmental management in face of multiple uses of coastal resources. In Japan, the coastal area has been one of the most critical sites for both sustainable resource development and environmental preservation. Industry requires a water-front location for transportation and production. Fishery has kept traditionally fishing wrights to occupy fairly large portion of sea area. Public demand for bathing, sport fishing and other marine amenities is rapidly increasing. Municipality seeks not only the sites of waste disposal, but also new land for urbanization by reclaiming the coastal area.

So far these demands in Japanese coastal and bay areas seem to have reached at a physical and biological limit in terms of resource sustainability. The management problem , thus, needs such a new approach that can accommodate the issue of "multiple use" of coastal resources within some levels of resource sustainability and environmental capacity.

In this paper, we propose an empirical framework of solving multiple resource utilization emerged from resource sustainability and environmental preservation. The case of eutrophication management in "Seto-Inland-Sea" located in the western part of Japanese islands is used to illustrate the applicability of our proposed methodological framework.

IÑIGO-ELIAS, EDUARDO
Centro de Estudios Para La Conservacion de los Recursos Naturales, A.C, Chiapas, Mexico

Ecological and Socio-Economic Implications of the Trade with Wild Parrots: The Mexican-USA Case

Of all animal and plant species involved in the wildlife trade, birds are probably the most exploited. The psittacine family, which includes parrots, macaws, cockatoos, and parakeets, has been the group most directly exploited by humans for hundreds of years. During the last 20 years this demand for wild birds has increased to sustain local an international pet markets. Mexico has been considered to be of the 10 major exporters of wild birds in the world. In this essay we discuss the importance of psittacine birds as a tropical resource, and how this has been over exploited. In particular, we address the ecological and conservation problems (e.g., population densities, excessive harvesting, habitat destruction, etc.) and the socio-economical issues (e.g., contrasting profits between bird trapers and pet dealers) to properly manage in a sustainable bases this resource.

JANSEN, DORIS J.
WWF Multispecies Project, P.O. Box 8437 Causeway, Harare, Zimbabwe

Sustainable Wildlife Utilization in the Communal Areas of Zimbabwe: Economic, Ecological and Political Tradeoffs

This paper analyzes the benefits, costs and pitfalls associated with the implementation of the Campfire program (Communal Area Management Programme for Indigenous Resources) in rural communities of Zimbabwe. The Campfire program is an extension of an important policy introduced in Zimbabwe's 1975 Parks and Wildlife Act, which gave private landowners the responsibility for the conservation and use of wildlife on their lands, subject only to certain broad controls.

Campfire extends this approach to the rural communities (communal areas) and gives these communities "appropriate authority" over their wildlife. They thus for the first time (in this century) have the right to decide how, and whether they want to conserve wildlife and habitats, and the ability to benefit from them if they do.

Two communities were granted appropriate authority in January 1989 and the paper discusses the economic, ecological and political constraints and tradeoffs that the author observed during the implementation of the Campfire Program in these areas during 1989.

JIANG, XUEMIN
Department of Agricultural Economics, Huazhong Agricultural University, Wuhan City, China

Some Fundamental Principles on Eco-economics of Agricultural

Eco-economics of agriculture, a frontier subject, involves the study of eco-economic principles and their applications in agricultural production. Kinds of ecological and economic factors: population, consumption (demand) production (supply), ecological resources and agricultural environment. These factors are connected in an eco-economic network through agricultural techniques and labor by energy, matter, and flow of funds. In the production process, ecological, economic and social effects need to be coordinated, and to be profitable it must be based on ecology that is balanced. The following are other new concepts in applying principles of agricultural economics to ecology: eco-economic elasticity, eco-economic effect, eco-economic multidimensional of agricultural communities, integrative farm production and the balance between ecological supply and economic demand. According to ecological laws, agricultural land, inland water, pasture land, forests, hilly areas and mountainous regions are all parts of an ecological system to supply regimented resources for agricultural production. If the demand for production exceeds the regenerative strength of the natural resources, the ecological balance might be destroyed, along with the opportunity for profitable agriculture. This is the fundamental principle of ecological economics.

JOHN, KUN H.; WALSH, RICHARD G. and **MOORE, CHESTER G.**
Dept. of Agricultural and Resource Economics, Colorado State University, Fort Collins, CO 805233

Comparison of Alternative Nonmarket Valuation Methods For An Economic Assessment of A Public Good

Environmental effects of insect-pest control may be ecologically very wide-ranging, encompassing effects on non-target species and health. Finding ecologically optimum level of control encounters a great complexity and uncertainty. But a local economic optimum would be found at the level where the marginal control costs equal marginal benefits. This paper

compares the expenditure function approach and the contingent valuation method in an economic assessment of a public environmental program, mosquito abatement.

The expenditure function approach (EFA) is to value environmental quality indirectly from consumption information on related market goods and assuming expenditure minimization behavior. Although environmental goods are not transacted in the market place, the attributes or characteristics are an argument in an individual's utility behavior along with other ordinary goods.

Then, based on the Mäler technique, the demand for mosquito abatement is derived by taking the derivative of the expenditure function with respect to the quality of environment. Benefits are estimated by taking the integral of the derived demand curve for the relevant range of environmental quality.

Compared to EFA, the behavior intention based contingent valuation method (CVM) surveys directly individual willingness to pay for the posited quality of environment in the hypothetically created contingent market. Depending on the respondent's attitude and the payment vehicle used, the resulting valuation may be biased upward or downward.

EFA is considered practical in a sense that it uses real market data instead of hypothetical, and is consistent with the basic microeconomic theory of consumer preferences. However, the assumption of a competitive market situation and homothetic utility are required for the results to be valid. Also the results of the EFA are sensitive to the model and to the functional form of the response surface to be estimated.

JOHN, KUN H.; WALSH, RICHARD G. and **KLING, ROBERT W.**
Dept. of Agricultural and Resource Economics, Colorado State University , Fort Collins, CO 80523

The Le Chatelier's Effect in Environmental Economics: A Critical Evaluation of Environmental Policies for Sustainable Resource Management

The Paretian measure of consumer surplus neglects the possibility that the state of individual welfare is conditioned by an economic parameter, especially in the case of nonmarketed environmental goods. The Le Chatelier's principle shows that the equilibrium values, such as elasticities of input substitution are displaced when auxiliary constraints are imposed.

In the world of competitive markets for private commodities, Le Chatelier's effect will be the same for all economic agents because firms and individuals face the same auxiliary condition. However, in the world of environmental goods, the situation is different because environmental goods are not traded in the market. As a result, economic agents face different Le Chatelier's effects on price elasticity, inputs substitution, and expenditure elasticities due to differences in environmental quality.

Hence, own price elasticity and elasticity of substitution become inelastic. Correspondingly, the expenditure elasticity (i.e., the relative responsiveness of the input to changes in total expenditure) of related market goods will become larger as environmental quality becomes worse.

The importance of Le Chatelier's effect is its implications in enforcing environmental policies for resource management. Since input shares of individual household economy vary with the quality of environment, policies which are not targeted to directly improve the quality of environment could not raise the welfare situation of individuals living in degraded environment as much as a targeted policy could with the same policy costs.

JOHNSON, RICHARD L. and **DOUGLAS, AARON J.**
U.S. Department of the Interior, Fish and Wildlife Service, National Ecology Research Center, 4512 McMurray Avenue, Fort Collins, CO 80525-3400

Conceptual Problems in Estimating the Social Returns to Nonmarket Water Resources

Instream flow benefits are market and nonmarket benefits generated by the freely flowing waters of the nation's rivers and streams. They include social benefits provided by recreational uses, private and social benefits provided by hydro-power, and private returns to navigational uses. Offstream or diversionary benefits are derived primarily from the private returns to various market oriented consumptive uses of river water including municipal uses, agricultural uses, and private manufacturing uses for activities such as paper manufacturing, pulpwood production, and brewing. Market returns to the use of water in private activities are an adequate social metric for allocation of water resources among various private consumptive uses. But the sizeable nonmarket benefits provided by various instream flow benefits are difficult to estimate and preserve for two reasons: instream flow benefits are often highly complementary among various activities and locales (e.g., upstream versus downstream locales often receive identical benefits from stream flows), and nonmarket benefits are difficult to estimate.

In this paper, we argue that a major river water use--the municipal use(s)--that has typically been classified as an offstream use, has important instream components. The river channel serves as a low cost transport conduit for moving surface water from the countryside, where it has low marginal social value, to the urban areas where it has high social marginal value. The social opportunity cost of moving large bulk amounts of surface water from the countryside to the city is foregone rural social benefits. Therefore a major (often sole) component of this "new" instream flow benefit is the difference between the marginal social value of urban and rural water. We call this new benefit the instream flow transport benefit; it is generated by the thinness of water markets, which allow for major disparities in the price of urban and rural

water. The social benefits provided by the instream flow transport function can be estimated by highly aggregated national data as well as the more familiar use of data for a given streamreach. In the concluding section of the paper, we discuss our future research efforts to quantify these benefits.

KAUFMANN, ROBERT
Center for Energy and Environmental Studies, 675 Commonwealth Avenue, Boston University, Boston, MA 02215

Emission of Carbon Dioxide From Economic Activity: The Fuels, Sectors and Nations of Origin

This paper describes ongoing effort to model the release of carbon dioxide by nation, sector, and fuel. Demand equations are estimated for coal, oil, natural gas, and electricity for each of five sectors: agriculture, industrial, commercial, transport, and residential. Four equations are estimated for each sector simultaneously using seemingly unrelated regression techniques because interfuel substitution implies that the error terms are related.

The ability of the new model to forecast emission of carbon dioxide is evaluated by comparing a "backcast" of carbon dioxide emissions with the historical records. This backcast is generated by choosing four nations France, South Korea, India, and Poland, estimating the equations for fuel intensity, using these equations to backcast final energy demand, translating final energy into primary energy demand, and calculating the amount of carbon dioxide released. This integrity of this validation is insured by an out of sample backcast, and comparing the results with an independent estimate for the release of carbon dioxide that is based on data for energy supply that is complied by Rotty and Marland. The validation indicates that the model can backcast the release of carbon dioxide accurately. The success lays the foundation or a much larger effort, in which the process described above will be repeated for 78 nations.

KAUFMANN, ROBERT
Center for Energy and Environmental Studies, 675 Commonwealth Avenue, Boston University, Boston, MA 02215

An Analysis of the Energy/GDP Ratio in the Big Five: Confirming Biophysical Principles, Rejecting Neoclassical Principles

This paper attempts to differentiate between the biophysical and neoclassical conclusions regarding the relation between energy use and economic activity by using the biophysical model to analyze the energy/GDP ratio in the Big Five: Federal Republic of Germany, France, Japan, the United Kingdom and the United States. Econometric analyses indicate that the fuel mix, household energy consumption, and fuel prices account for most of the variation in the energy/GDP ratio.

The results of this econometric analysis can be used to make some general conclusions about the relation between energy use and economic activity and reject some of the conclusions made by neoclassical analyses. The types of fuel used account for most of the change in amount of energy used to produce a unit of output over time. From a biophysical perspective, this results implies that technological change is driven by using fuels of higher quality, by replacing coal with petroleum and petroleum with electricity. Changes in the amount of fuel consumed by households is the most important type of sectoral change. This conclusion contradicts claims made by neoclassicial economists that reductions in smokestack industries and the rise of the service sector reduce the energy/GNP ratio. Finally, the results of this analysis indicate that neoclassical economists have overestimated the degree to which changing energy prices can decouple the link between energy use and economic activity. This result indicates that a reduction in the supply of high quality fuels could retard economic activity.

KETKAR, KUSUM
Associate Professor of Economics, School of Business, Seton Hall University, South Orange, NJ 07079-2692

Hazardous Waste Sites and Property Values in the State of New Jersey

The citing of hazardous waste sites in densely populated urban areas can be considered an additional disamenity that is expected to discourage a household to reside there. It is argued that in urban areas, the market value of a given property is determined not only by the structural characteristics of the property but also by the amenities (or disamenities) that the areas has to offer. The relationship between hazardous waste sites and property values is examined using data from the State of New Jersey. The state is not only home to a number of polluting industries but also there is the largest concentration of hazardous waste sites in the United States. Moreover, the state hosts the largest number of persons per square mile and they are also the earners of one of the highest per capita incomes in the union. The empirical analysis in the papers takes into account the effects of a number of non-environmental factors like job opportunities, ease of transportation, quality of education and other public services, concentration of industries, racial mix, etc. Finally, policy implications for the distribution of burden of clean-up costs are drawn from the empirical findings.

KHALIL, ELIAS L.
New School for Social Research, Springfield, MO

Beyond the Widow's Curse and Marie Antoinett's Folly: A Physical Model of Production and Resources

I construct a physical model which assumes 100% recyclability, zero growth rate, and non-noxious by-products. In its light, I conclude that sustainable, everlasting reproduction is impossible when recyclability is costlier than appropriation of fresh inputs, and when standards of living are held constant.

My conclusion is contrary to the argument of some hard-core "green" economists, who argue that if inputs are appropriated within limits, the resource base of an economy is inexhaustible. I call this perspective the "widow's cruse," where, according to the Bible, the level of oil in the widow's lantern is replenished spontaneously after each time it is lit.

My conclusion is also contrary to the argument of some hard-core neoclassical (NC) economists], who argue that resource depletion can be taken care of through price adjustment and substitution. However, in light of the physical model, depletion of resources is across the board. That is, the problem is not that a certain resource has no substitutes, like the ozone layer. Rather, the problem is that all resources as a whole are declining. In this light, it makes little sense to suggest a la NC theory that resource depletion could be solved via substitution. I call the NC solution the "Marie Antoinette's Folly," who, according to popular fiction, in response to the complaints about the high price of bread, suggested biscuits as a substitute.

Georgescu-Roegen has reached similar conclusions related to "green" and NC economics. He failed, though, to see technology as a viable and practical solution, since he erroneously identified production and resources with the entropy law.

KING, DENNIS M.
ICF Incorporated, 9300 Lee Highway, Fairfa, VA 22031

Bio-Economics of Wetland Restoration: A Framework for Applied Research

Despite earnest efforts to conserve wetlands, some critical wetland areas will continue to be lost due to intentional and unintentional acts of man and natural events, such as flooding and sea level rise. Other wetland areas, although protected, may be functioning well below their natural capacity because of historical degradation or continued water deprivation. In such cases, the development of cost-effective methods to create and restore wetlands provides an opportunity to at least partially offset wetland losses and perhaps even increase wetland values.

For most types of wetlands, restoration research is already beyond the basic science and engineering stage to the point where experimentation and testing allow some basis for comparing different restoration methods. For some relatively simple types of wetlands, established restoration methods already exist and specialized materials and techniques are under development. The appropriate criteria for comparing various methods and refining the methods that seem most promising are cost and performance. The appropriate framework for analyzing how general methods and specific tasks affect the cost and performance of a wetland restoration project is bio-economic production analysis

Bio-economic production analysis, which is already responsible for tremendous advances in modern agriculture, fisheries, and more recently in aquaculture, is an important new area for applied wetland research. t provides the framework for combining scientific, technical, and economic information about wetland restoration in a way that facilitates project evaluation and policy development and helps identify promising research areas. This is especially useful because case studies of previous wetland restoration projects reveal more about regulatory issues and the link between haphazard project development and project failure than they reveal about the scientific, technical, and economic factors that influence our ability to restore wetland functions.

As an area of environmental economics, the application of bio-economic production analysis to wetland restoration should be viewed separately from attempts to place economic values on wetlands or to measure the social benefits of wetland functions. The first area of research focuses on basic questions about the cost and effectiveness of restoration activities and is founded on long-standing, well-tested microeconomic principles. The second area focuses on more interesting questions about social choice, but is founded on modern concepts of "non-market valuation" that are controversial and are still being tested. The two areas of economic research will no doubt converge sometime, but for now, questions about how much we need to spend to restore wetlands and questions about how much we should be willing to spend to protect or restore wetlands can and should be addressed separately.

KLEMAS, V.
College of Marine Studies, University of Delaware, Newark, Delaware 19716
OTT, J.S.
Environmental Research Institute of Michigan, Ann Arbor, MI 22209
GROSS, M.F.
Gettysburg College, Gettysburg, PA 17325
HARDISKY, M.A.
University of Scranton, Scranton, PA 18510

Mapping Coastal Marshes and Determining Their Health on a Global Scale Using Satellite Remote Sensors

As pollution and encroaching development threaten wetlands worldwide, it is critical that natural resource managers be able to evaluate man-made and natural changes, and accurately measure the health of these vital resources. An accepted indicator of salt marsh health is biomass, a term biologists use to refer to the dry weight of plants. The amount of biomass not only indicates plant health, it is a measure of how much food is available for plant-eating animals. The amount of wetland plant biomass may also influence the production and exchange of trace gases between wetlands and the atmosphere. One of these gases, methane, is involved in the greenhouse effect; another, dimethyl sulfide, may influence for formation of clouds.

The traditional method of measuring leaf and stem, or aboveground, biomass is to clip the plants at the soil surface, dry them in an oven, then weight them. This method is both destructive and time consuming. A technique has been developed that uses satellite data to measure salt marsh vegetation biomass rapidly and nondestructively. Green vegetation absorbs red light for use in photosynthesis and reflects near-infrared light. Therefore, by measuring how much red and near-infrared light is reflected by vegetation, it was possible to estimate the quantity of aboveground biomass.

Accurate aboveground biomass measurements of smooth cordgrass and other wetland plants using remote sensing have been obtained. Their measurements are within 10 percent of those made using the traditional harvesting techniques. The measurements of reflected light are made several hundred miles above the earth's surface by orbiting satellites, which transmit images back to earth. These images are analyzed using computers to estimate biomass for entire marshes.

Light does not penetrate soil, making it impossible to measure root biomass directly from satellite imagery. However, our team found that the amount of smooth cordgrass leaf and stem biomass is strongly related to the amount of root biomass. Consequently, satellite data can be used to estimate the amount of aboveground biomass; this estimate, in turn can be used to measure belowground biomass. Informed decisions on wetland use and value should be easier now that the capability exists to compare biomass and productivity within and between marshes.

KLINK, FEDERICO AGUILERA; GUTIERREZ, CARLOS CASTILLA and PADRON, MIGUEL SANCHEZ
Departamento de Economía Aplicada, Universidad de La Laguna, 38071 La Laguna, Tenerife, Islas Canarias Spain

Interpreting Ecological Economics in a Postmodernism Era: Sustainable Development Versus the Lack of Development Towards an International Ecological Order.

This paper questions the works on Sustainable Development whose scope of application is mainly microeconomic and centered in the Third World.Curiously enough,these works very rarely take into account the ideas and approaches found in the development literature.Thus,the position that emphasize the need to study Third World countries present problems in the context of their relationship with developed countries is usually ignored by the Sustainable Development approach.The later provides a one-sided and a historical view as it overlooks the origin and reproduction of the social and economic structures which contribute to the generation of poverty and dependence in the Third World.

We interpret this decontextualization as a typical feature of postmodernism.However,as A.Sen's study have admirably shown,famine cannot be solely attributed to scarcity.The literature in which the subject of Natural Resources has been studied from an institutional standpoint and Sen contribution is taken as point of departure to show how Sustainable Development analysis can be enriched by taken a broader view.Only within an institutional and structural framework which provides for the management of the Earth as a single unit and which consequently encourages cooperative solutions as opposed to competitive ones,will it be possible to bring about a situation of Sustainable Development.

KOHLMAIER, G.H. and LÜDEKE, M.K.B.
Institut für theoretische und physikalische Chemie der Johann-Wolfgang-Goethe Universität, Niederurseler Hang, D-6000 Frankfurt/Main 50, West Germany

On a Synergetics Approach to Lorenz Distribution Curves of Income on the Basis of Microstate Statistics

Counterintuitive to expectations the distribution of a limited quantity of energy among a large number of molecules with equal properties leads to the famous Boltzmann law, in which the molecules with zero energy have the greatest probabilities while those in higher states fall off exponentially. The Boltzmann law can be derived within the

framework of statistical mechanics in which the logarithm of the statistical weight Í (or W = Wahrscheinlichkeit) of different energy distributions of microstates is maximized under the
condition that both the number of molecules and the total energy is constant, using the method of Lagrangeian multipliers.

Around the turn of the century Vilfredo Pareto published his well known "Courbe de la répartition de la richesse", based on a statistical evaluation of incomes. In later publications of economic science the unequal distribution of income have been presented mostly in the form of Lorenz curves, in which the fraction of the total income is plotted as a function of the fraction of total population. The reasons for the apparent disparity are mostly sought in the socio-economic conditions of a given society, while we should like to suggest here that additionally a basic statistical law of distribution of a limited resource within a large population is to be considered. Naturally, the basic distribution will be modified by the given boundary conditions of a society.

We show here that any exponential distribution {exp(-ax)} of income, independent of the exponent and of the average income, leads to the same Lorenz curve. Similarly, we find that the generalized Maxwell-Boltzmann distributions {x^m*exp(-ax)}, of which the original Pareto distribution is a special case, are again independent of the parameter a in the Lorenz graph, however, dependent on m. We will try to interpret the Maxwell-Boltzmann distributions which for m > 0 are closer to the line of equal distribution in terms of statistical-mechanical and economic analogues.

KOZLOFF, KEITH
Department of Agricultural and Applied Economics, University of Minnesota, 1994 Buford Avenue, St. Paul, MN 55108

The Political Economy of Information in Targeting Measures to Reduce Nonpoint Source Water Pollution

An instrument of government policy that has gained credence among agricultural and environmental interests is the offer of financial incentives to landowners for retiring erodible cropland or otherwise restricting land management practices. One of the primary goals of these instruments is environmental protection, including reduction of agricultural nonpoint source water pollution. As with other environmental control mechanisms, the social efficiency of this policy instrument depends in part on its ability to differentiate among polluting agents with respect to the relative social costs and benefits of land management restrictions. Economic theory suggests that cost effectiveness is maximized when the marginal costs associated with the information used to differentiate the application of the policy instrument among agents are equated with the marginal benefits of the differentiated policy instrument.

This paper examines the benefits and costs of using information to spatially target the application of economic incentives to control agricultural nonpoint source water pollution. Targeting is accomplished here by collecting disaggregated information about physical and economic variables that affect the benefits and costs of adopting control practices on individual parcels of land. The paper offers a framework for analyzing efficiency gains from targeting nonpoint source control measures, presents results from simulating different targeting schemes in a Minnesota watershed, and discusses institutional implications.

KROTOV, VADIM F.
Institute of Control Sciences, The USSR Academy of Sciences, Profsoyuznaya, Moscow, 117806, USSR

The Optimal Control Laboratory

The basic spheres of investigation Variational Calculus and Mathematical Theory of Optimal Control Computer Methods of admissible and optimal control syntheses & Applied optimal control problems of mechanics, physics, economics, ecology. Design of Complex of Macroeconomic multisectoral models and, Optimal Inventory Policy Models for Industrial Enterprises Decision Support Systems and Interactive Simulation-Optimization System (based on IBM, DEC 1& &IBM PC) &Variational principles of the mechanics and physics&Relativistic mechanics of the continuum, relative elasticity.Investigation of the relations to electrodynamics, quantum theory, gravitation theory

KÜMMEL, REINER and **SCHÜSSLER, UWE**
Physikalisches Institut der Universitat Wurzburg, D-8700, Wurzburg, FRG

Heat Equivalents of Noxious Substances: A Pollution Indicator for Environmental Accounting

The energy requirements of pollution control in fossil fuel and nuclear power plants and the resulting heat emissions are computed in first order waste heat analysis. We investigated the purification of the flue gases of hard coal power plants from NOx, SO2, and CO2 by selective catalytic reduction of NOx, desulphuration by various techniques, especially wet limestone scrubbing, and pressure assisted refrigeration of CO2 with subsequent storage in the deep ocean. For consumed radioactive nuclear fuel rods from boiling water reactors a fictitious disposal into interstellar space via electromagnetic launching by mass drivers is discussed. The heat emissions associated with pollution control are an environmental burden, although the most benign one for the time being. They can be considered as a thermodynamic indicator of the (minimum) pollution potential of a given energy carrier and its appropriate energy conversion process. In

this sense, environmental accounting with respect to a reference state can be done with the help of the heat equivalents of noxious substances (HEONS). They are defined as the waste heat generated by pollution control in a production process of given utility output divided by the primary energy input into a not pollution controlled production process of the same utility output; pollution control in this sense has to guarantee that injection of the noxious substances into the biosphere remains below limiting values determined by risk assessment and social consensus. In the discussed scenarios, the HEONS are about 0.7% for 80% NOx reduction, 1% - 4.4% for 60% - 95% desulphuration, 38% for 66% CO2 removal and storage, and 0.08% - 3% for the disposal of radioactive nuclear fuel rods. The relative primary energy required for the indicated processes of pollution control is equal to the HEONS with the exception of the nuclear fuel rods where 0.02% - 0.9% have to be added for the energy lost in space. Relating this energy to the useful electricity output via the conversion efficiencies of 38% for coal power plans and 33% for nuclear input of about 18 kW for NOx reduction, 26 - 116 kW for desulphuration, 1 MW for CO2 removal and storage, and 3 - 118 kW for nuclear fuel rod disposal. Similar to the oxygen equivalents of organic waste water pollutants in the German sewage levy law, the heat or energy equivalents of noxious substances may serve as one criterion for charging taxes and levies to energy carriers.

LEE, DANNY and **PAULSEN, CHARLES**
Resources for the Future, 1616 P Street NW, Washington, DC, 20036.

Integrated Ecological and Economic Modelling for Fisheries Planning in the Columbia River Basin

Hydroelectric development and operations in the Columbia River Basin off western North America have reduced substantially the number of adult salmon and steelhead trout returning to the basin each year. Federal and regional agencies currently are involved in a massive effort to mitigate the biological impacts of the hydroelectric system and enhance the capability of the basin to sustain harvestable run sizes of anadromous fish. But mitigation and enhancement at this scale comes at a large price in terms of capital expenditures and foregone hydropower production. Integrated economic and ecological models are needed to identify cost-effective strategies for managing the system to meet conflicting power demand and fish production objectives. This report will review current efforts to develop an integrated suite of models to meet this need and present results from prototype models that are being used in ongoing planning exercises.

LILL, J. LLOYD JR.
Empire State College, S.U.N.Y. , Canandaigua, NY 14424

The Economic Trade Off-Growth vs the Environment

The environmental crisis and its cost to society have thrust center stage the economic and ecological issues facing society. The debate is no longer that the threat is real, but what path we want to take and at what cost.

The growth and technology over the past two centuries has created today's euphoria, one of unlimited wants and conspicuous production. The scarcity of resources and environmental pollution has dramatically altered options and amplifies such environmental problems as: (1) Global warming. (2) The depletion of the ozone layer. (3) Population growth in the Third World countries. (4) Industrial pollution concentrated in the industrialized countries but moving quickly to Third World countries. (5) Acid rain.

This paper will begin with an examination of economic growth and technology from a historical perspective followed by an evaluation of business growth in America. Benefit-cost analysis treatment of industrial pollution will be critiqued. Two changes being emphasized in this paper, include a shift in economics from one that emphasized growth and employment, to one that integrates economics with sustainability and self-reliance. Because disruptions will be severe, a second change would be in our value system, from our current maximizing, optimizing and satisfying society, to one that aims at a economic justice.

LINES, MARJI and **TAMARO, MARCO**
Faculty of Economics and Department of Environmental Science, University of Venice, Venice, Italy

Atrazine: A Non Point Source Pollution Problem

Environmental concern with pesticide fate from agricultural production has drawn the attention of economists, who have found the policy question in non point source pollution challenging. Effluent charges and markets for pollution vouchers, useful in point source problems such as factory residue dumping and air pollution may not be feasible when monitoring costs are high. Alternative policies proffered, such as input taxes, or incentives (and penalties) for achieving (or not) given environmental quality goals have been formulated in a general or partial equilibrium framework.

In what follows we use a case study of the pesticide atrazine (a cheap herbicide applied to corn) in the province of Veneto, to indicate that there are cases for which input taxes will be ineffective in reducing the use of the target pesticide. That is, no feasible levy will induce a profit-maximizing farmer, in a partial equilibrium context, to reduce the quantity of atrazine applied per hectare to a desired goal. Furthermore, it is seen that in a more realistic expected loss approach, the

necessary levy would be even more unacceptable. Given that market disincentives are of questionable relevance for atrazine and other cheap agricultural chemicals, the authors suggest that at least in the case of Veneto and Italy in general, a refocusing of already existing subsidies could do a great deal towards reducing the dangers that such substances pose to the local population.

LONERGAN, STEPHEN and **HARTE, MICHAEL**
Department of Geography, University of Victoria, P.O. Box 1700, Victoria, B.C. V8W 2Y2 Canada

Market Oriented Strategies for Reducing CO_2 Emissions: Taxes, Price Inducements and Regional Impacts

The Energy Options Advisory Committee was established by the Canadian government in 1987 to examine energy issues and options for the future. In their recently submitted report, the committee recommended the adoption of market-oriented regulatory policies to promote environmental goals and a move towards "full cost energy pricing." In the transportation sector alone, this would amount to an additional cost of over $3000 per automobile. Other countries have considered similar measures with respect to reducing carbon dioxide emissions as on element in an overall strategy to lower greenhouse gas emissions. Sweden, for example, is considering 3.8 cent per kilogram carbon tax. Others have estimated that 5.5 cents per kg is the minimum tax that should be implemented. This paper will address the issue of full cost energy pricing by concentrating on the carbon emission tax issue and providing an initial assessment of the regional economic costs of imposing such a tax.

The purpose of this paper will be threefold. First, to review emission taxes and pricing inducements presently being considered internationally to reduce greenhouse gas emissions. This will include a discussion of appropriate tax levels and the offered for these levels. Second, to discuss the need for, and utility of, setting emission taxes and incorporating all costs in energy pricing. And third, to present the preliminary results of an input-output study aimed at assessing the impacts of a carbon tax on the British Columbia economy. The presentation will end with a brief discussion on the potential costs of climate change to society and what level of carbon emission tax is appropriate.

LOWE, IAN
Division of Science and Technology, Science Policy Research Centre, Griffith University, Nathan, Brisbane, Queensland, Australia, 4111

Economics of Sustainability: A Case Study

Tasmania is one of the states of Australia. It is also an island. Although its economy is complicated by being part of a federal system, its geographical separation facilitates treating Tasmania as an isolated unit: inputs and outputs are well documented. Increasing environmental awareness and an unusually democratic electoral system have combined to give Tasmania a parliament in which the balance of power is held by a group of Green Independents. One of the consequences has been the commissioning of a study of the organizing principles which could be used to convert the economy of Tasmania into an ecologically sustainable system.

Tasmania is by any criteria a small economic unit. The state is roughly 70,000 square kilometres in area, and its population is only 500,000. The climate is, by Australian standards, cool and wet. The state already has a very strong commitment to the use of renewable energy; the entire electrical system, apart from one small back-up generator is hydro-electric, and wood is the principal heating fuel for half the residents. The economic strategy has traditionally been based on the principle of using cheap energy to attract energy-intensive industry, but this strategy has not been a conspicuous success. Tasmania has suffered more than most other Australian states from the application during the 1980s of conventional economic theories, having an unemployment rate above 8% and a steady loss of young people to other states. Principal industries are minerals, forestry and tourism.

The development of a sustainable economic strategy has been based on identifying activities which could be developed without damage to the biophysical system. Thus, industries which conserve natural resources, such as insulating buildings or harnessing renewable energy, were considered preferable to exploitative activities. Cradle-to-grave accounting has been deployed to ascertain the total environmental impact of various activities. The overall conclusion is that an ecologically sustainable system actually offers economic prospects which are at least as good, even by conventional measures, as the traditional approach of trusting the market. Development of a strategy for sustainable development and associated policy measures will be described as a case study in the application of the principles of ecological economics.

LOZADA, GABRIEL A.
Department of Economics, Texas A&M University, College Station, TX 77843-4228

Limitations on the Scope of Neoclassical Resource Economics

There has been very little communication between the neoclassical and non-neoclassical "camps" of resource economists, and even less has there been a clear delineation of the circumstances under which one approach or the other is valid. This paper shows that the scope of neoclassical exhaustible resource economics is limited to problems in which the exhaustible resource is not essential to production. Since problems concerning resources which are essential is precisely what the non-neoclassical school concerns itself with, it is clear when the approach of one school is appropriate and when the approach of the other school has to be used.

To demonstrate the neoclassical approach's limitations, suppose the demand curve does not intersect the price axis; for example let price p be related to quantity Q by $Q = 1/\ln p$ for large p. If extraction costs are, say, zero, then competitive equilibrium occurs when the resource price rises exponentially at the rate of interest. Combining this with the demand curve gives quantity at time t as $1/(rt + \ln po)$. However, if quantity grows in such a fashion then total quantity extracted will eventually exceed any finite deposit size, which is infeasible.

MACLEAN, JOHN C.
548 Massachusetts Avenue, Boston, MA 02118

Factoring Environmental Externalities into Electric Power Supply Decision-Making

Electric utilities needing new power supply sources are acquiring additional capacity by soliciting power supply proposals from small and independent power producers. State regulatory commissions are establishing guidelines which utilities must follow in procuring and evaluating these new power supply options. In several states, regulators are beginning to require utilities to explicitly account for environmental externalities in evaluating power supply options. The New York Public Service Commission is requiring that up to 1.4 cents/kwh be added to the cost of certain, primarily fossil fuel based, supply options to represent external costs of air and water pollution and other environmental impacts. In Wisconsin, regulators established a 15% "non-combustion" credit to account for impacts of combustion driven power and reduce the relative costs of non-combustion options, including conservation, for determining implementation priorities. In Illinois, Oregon, Maine, Vermont, and Virginia, utility commissions are developing or promulgating guidelines for factoring environmental externalities into power supply decision-making. This paper reports on the policies and methodologies that State PUC's are establishing in this area, identifies conflicts and difficulties these nascent guidelines face in their further development and enforcement, and speculates on the impact which their true enforcement can have on our energy future, especially on conservation and renewables.

MACPHERSON, D.K. AND THOMAS, J.F.
CSIRO Division of Water Resources, Private Bag, PO Wembley, Western Australia 6014

An Intelligent Data Base for Ordering an Ecological-Economics Debate

Economic and environmental modellers have traditionally been numerically oriented. Yet policy debates often hinge upon conceptual distinctions (e.g. utility versus sustainability); referential boundaries (e.g. partial versus general); assumptions (e.g. ceteris paribus, existence of catastrophic surfaces, substitutional behavior or technical change); stance (e.g. positive or normative); and above all the interplay of relevant opinions. Nearly all attempts to resolve differences of this kind rely on natural language argument. When simulation is exhausted, policy resolution is widely accomplished by interaction of viewholders. These may be expert, or not; and their arguments may be rigorous, informal or rhetorical.

This paper argues that soft-systems techniques can promote the derivation of acceptable plans based on ecological-economic analysis. They may also lead to the reformulation of problems in ways that alter the mode of analysis.

MAIER-RIGAUD, GERHARD
Institute for European Environmental Policy, Aloys-Schulte-Str. 6, 5300 Bonn

Interventions in Nature or Economy? On the Scientific Background of a Conflict

Environmental policy is still confronted with the conflict between economy and ecology. Numerous attempts of reconciliation have resulted in a sort of political compromise. This paper is an investigation into the logical source of the conflict. It is stressed that even what we call ecological damages or threats are the outcome of natural sciences. The interpretation of such findings as a problem is, on the one hand, due to scientific understanding of the assimilative capacity of nature and on the other hand due to prevailing ideas on economic adjustment capacities. An environmental problem

would not exist if scientific findings would state either an infinite assimilative capacity of nature or perfect adjustments of the economy to environmental challenges.

All compromises in environmental policy are, therefore, based on current hypothesis as to the adaptability of the natural and economic systems.

This reveals fundamental questions of the validity of scientific findings. Are the prevailing empirical methods of scientific discovery a solid base to determine threshold levels of pollution? And what about evidence in economics? What do we actually know about the driving forces behind economic development and endogenous structural processes How solid can judgements of economists be as far as tolerable environmental charges on the economy are concerned?

From this point of view, the guiding line of environmental policy should first of all be the acceptance that all our knowledge is preliminary. Therefore, in order to preserve the ecological basis of mankind we have to minimize interventions up to a yet unknown degree. Ecological economics can contribute by withdrawing those obstacles which have been planted in our minds during the history of economic analysis.

The result shows that the conflict hypothesis is obsolete. But even more important is that the conservation of the natural basis of life becomes the primary concern of economic activity. Environmental policy turns from being a burden or a restriction of economic activities into a very economical end.

MARTIN, LARRY
1442 Harvard St., NW Washington, DC 20009

The Gross National Waste Product

The GNP measure of aggregate purchases is widely viewed as an indicator of economic health and thus social welfare. The case is made that the escalating price of waste management and pollution control is representative of increasing disutilities none-the-less calculated as contributing ever more to our measure of economic "health." Western business strategy founded on increasing the flow of resources in the economy to generate utility has overshot its Pareto optimum and now also produces disutility. Waste management and pollution control are illustrative production externalities (and disutilities) whose costs are transferred to the public and household sectors (harming these sectors). Internalization of costs is possible, but requires severe structural adjustments to mature economies. The adjustment must in large part come in the form of reducing the flow of resources through the economy. This is done by simultaneously increasing the utility of resources (products, services, etc...) and so avoiding any net loss of wealth (capital) in the economy at any point in time. Products are made to last longer, be more easily repaired or upgraded, and more easily recycled. The economy becomes more decentralized, at least geographically, as repair and maintenance services become more important. Products are designed to last and to allow their materials to be recovered when discarded. Cities become the mines and mills of tomorrow as waste is recovered for its material resource value. Although many jobs will be transferred from primary and secondary production to service, it is possible that reducing production will lead to decreased overall traditional employment. This necessitates revisiting the distribution of wealth. Increasing the role and autonomy of the local economy in product service and resource recovery decentralizes the economy, and is more responsive to participatory democracy. Strong local economies can be better structured to provide for people's basic needs (than can national or global economies), and free their time to develop their creative potential. A thorough quantification of waste's contribution to the economy is made, and initial formulations assigning waste's opportunity costs against the changes outlined above presented.

MAY, PETER H.
R. Paissandu, 269/103, 22210 Rio de Janeiro, RJ, Brazil

Savage Capitalism: International Market Alliances to Conserve Neotropical Forests

Improbable as they are, the recently emerged alliances between social movements of forest peoples and progressive international entrepreneurs investing in new markets for tropical forest products represent an important phenomenon in the struggle to preserve the Amazon and indigenous cultures. This paper traces trends and probable results of these alliances with regard to both tropical resource conservation and the participation of marginal social groups in national economic development. Producers' level of organization and control over resources are posited to determine the direction of these outcomes. The trade-off between capitalist objectives and distributive proposals of forest peoples illustrate possible contradictions in sustainable development. Nevertheless, these international alliances represent a new, perhaps widely replicable model of global cooperation to manage threatened common pool resources. Such alliances recognize forces driving modern capitalism--profits, growth and income enhancement--while at the same time respect the value of conserving indigenous knowledge, irreplaceable gene pools and pristine ecosystems.

MAYUMI, KOZO
Research Fellow, Department of Applied Mathematics and Physics, Faculty of Engineering, Kyoto University, Kyoto 606 Japan

The Law of Diminishing Returns Radically Reconstructed: Its Physio-Chemical Foundation and Implication for the Resource and Environmental Constraint in the Future Economy

The essential theme of this study focuses on the large scale matter-energy transformation in the present world and its plausible consequence upon the future economy in terms of four variations of the law of diminishing returns, one of which is that of traditional economics. These four variations will help us to face up to the unnoticed physico-chemical reality, which has been the source of motive power in the present industrial world, so to speak, but has not attracted economists' attention for a long time.

After touching upon the history of the law of diminishing returns with the domain of economic science in Section I, Section II first introduces a thermodynamic analysis initiated by Georgescu-Roegen in order to appreciate not only the physico-chemical reality of economic process but also the resource and environmental limitation threatening our future existence on the earth. Then two types of efficiency in physical terms will be introduced in order to appreciate the tremendous speed of matter-energy degradation in the present industrial world. Efficiency of Type I (EFT1) refers to the ratio of output to input. EFT1 leaves time required out of consideration. On the other hand, Efficiency of Type 2 (EFT2) refers to output per unit time. EFT2 leaves the amount of inputs out of account. There is an optimal combination of EFT1 and EFT2 under some technical criterion. However, the present state of technology appropriates EFT2 much more than EFT1--we call this situation of the modern technological matrix EFT2 fetishism--and the high level of EFT2 is guaranteed by low entropy resources, especially fossil fuels, stored in the past. The rationale that Georgescu-Rogen proposed the Fourth Law of Thermodynamics will also be presented in terms of EFT2 fetishism. Section III reconsiders the views of two great minds, Justus von Liebig and Karl Marx, who both had prophetic visions concerning EFT2 fetishism of modern agriculture and its possible outcome in the future economy. Section IV deals with four variations of the law of diminishing returns through which we can see the true picture of our resource and environmental constraint due to the present EFT2 fetishism. Three examples are also presented how these laws are now threatening our economy as a whole. Section V considers some implications of these laws for the future generations.

MCKELVEY, ROBERT
Mathematical Sciences Department, University of Montana, Missoula, MT 59812

A Bayesian Approach to the Conservation of Biological Diversity

A regulatory decision, involving endangered species or degraded ecosystems, may be posed as a trade-off between incommensurates: a balancing of levels of survival expectations against competing socioeconomic goals, with no common currency available for measuring the utility of the trade-off. A common practice in multicriterion environmental regulation is to mandate minimum standards for the environmental criteria, and then to optimize socioeconomic benefits within these constraints.

A similar approach to conservation of biodiversity is complicated by irreversibility, incomplete information, and inherent uncertainty: by the vast gaps in our present understanding of the stability and resilience of natural biological systems, and the certain irreversibility of extinctions should we misjudge; by uncertainties in anticipating future environmental conditions, and in appraising future benefits of preserving biological diversity.

Bayesian decision theory is a well-developed methodology to guide rational regulatory decisions in the face of incomplete information and uncertainty. I outline here a formal Bayesian approach to sequential decision-making in conservation biology. I then apply the general approach to an analysis of the conflict over the harvest of old-growth timber in the Pacific Northwest, and its implications for the continuing viability of the Northern Spotted Owl.

MCKONE, THOMAS E.
University of California, Lawrence Livermore National Laboratory, P.O. Box 5507, L-453, Livermore, CA 94550

Tracking the Global Fate of Industrial Emissions on a Macintosh Using STELLA

Using information collected under the Superfund Reauthorization Act, the Environmental Protection Agency has revealed that some 2.4 billion pounds of toxic chemicals are released annually to the atmosphere from industries in the U.S. This type of information has focused attention on the behavior of chemicals released from modern economies into the environment. Many of these chemicals can be transported over long distances in the troposphere and stratosphere or through rivers and oceans. We know that such long-range transport can lead to acid precipitation and climate modification. However, these findings also raise questions about the health and environmental risks attributable to the transport and transformation patterns of the thousands of chemicals produced or mobilized by human activities. The goals of this paper are to (1) review the state of the art in modelling multimedia transport and transformation processes for industrial residuals, (2) quantify the associated human and ecosystem exposures, and (3) consider the types of models and measurements needed to define pathway exposure factors, which relate an industrial source to levels of human or ecosystem contact with contaminants. Using the STELLA simulation model, I will examine a test case estimate of exposure to chlorinated volatile organic chemicals released to a air, soil, and water. I will examine how chemical properties effect both the ultimate route and quantity of human and ecosystem exposure. Finally, I will assess the uncertainties in estimates of exposure and identify sources of uncertainty.

MONK, TRACIE E.
1917 S. Randolph St., Arlington, VA 22204

Conflicting Priorities: The Struggle for Sustainable Development in Indonesia

For Indonesia, attempts to achieve environmental and other long-term objectives are often thwarted by the conflicting national priorities aimed at reducing poverty, unemployment and population growth and promoting industrialization and economic growth. Ecological sustainability is considered by many decision makers to be a luxury that the country can not yet afford.

The focus on short-term interests means that enforcement of Indonesia's environmental standards and regulations is often minimal. Corruption is also commonplace in government and business circles, further aggravating attempts by Indonesia's Minister for Environment and Population, Emil Salim, and others to steer the nation toward environmentally sound development.

With the move in 1988 placing the Environmental Ministry directly under the President, supporters hoped that Indonesia's critical environmental problems would receive more weight in government decision making. The outcome of the country's first environmental lawsuit and environmentalists' 'empty victory' over Scott Paper's proposed US$650 million pulp and paper investment, however, illustrate the slow progress of sustainable development within Indonesia.

This paper discusses the complexities surrounding ecologically sustainable development in developing countries. It investigates the various roles of Indonesia's government agencies, courts, non-government organizations (NGOs), and corporations in formulating and enforcing ecologically sound policies. It also discusses how, for Indonesia, the most important players in the current movement toward sustainability may be the international donor community.

MOREHOUSE, WARD
Council on International and Public Affairs; Intermediate Technology Development Group of North America; School of International Affairs, Columbia University, New York, NY.

Equity and Ecology in the Great Global Clean-Up: A Superfund for Toxic Workers

The 1990s are increasingly being recognized as the decade of the Great Global Clean-Up if we really want to preserve the biosphere from irreversible environmental damage. A critical element in moving from rhetoric about the need to clean up the environment to concrete action lies in designing measures that are economically feasible and politically possible.If we really are serious about this clean-up, steps taken so far are a pale shadow of what must still be done. Lots of workers in polluting industries-- from chemicals to mining and metal working--will lose their jobs if we really do get serious. But it is not fair that the burden of this clean-up which benefits all of us should fall so heavily on one segment of the population--namely, the workers in these industries. Unless we can find ways of achieving a more equitable distribution of those burdens, there will inevitably be strong resistance to such a clean-up. What is needed is the opportunity for those displaced toxic workers to retool themselves for the more demanding, higher skill jobs of the 1990s and beyond which are at the same time environmentally benign. This will mean in most instances an extended period of training, leading where appropriate to a university degree or some similar professional qualification. At least some of these displaced toxic workers may be encouraged to prepare themselves for positions in education and other social and community services that forecasters tell us will be so hard to fill in the years ahead, especially in the industrialized countries, but also in varying degrees in developing countries too.In the USA, there is already in place a Superfund to clean up toxic waste dumps. And there is likely soon to be in place as well comprehensive oil-spill legislation, the main feature of which is the establishment of a $1 billion industry-financed fund to pay for spill clean-up and damages. It is time for a Superfund for toxic workers to enable them to prepare for a very different kind of future.The design of such an initiative in the USA is presented, including projections of displaced workers ranked by the severity of the environmental pollution caused by different categories of industry, likely costs for retraining said workers, and alternative methods of financing. Parallel experiences and possibilities in other countries, both industrialized and developing, will also be examined.

MROZEK, CARL
College of Environmental Science and Forestry, Syracuse University, Syracuse NY 13210

TV/Video: The Magic Box for Mixing Environmental Education with Development

Television has been much maligned, especially by the intelligentia, as an "opiate for the masses", "idiot box", creator of "couch potatoes"... However, this socially endorsed egg-throwing ignores the tremendous successes it has spawned in the area of educational/informational programming, especially in the sciences. Public TV, in the US, and BBC 1, in Britain, have been the purveyors of much of the best of this genre with series like Nova, Nature, National Geographic Presents, Cosmos, The Living Planet, 3-2-1 Contact, etc.

A growing body of research has been linking the viewing of such programming with knowledgeability and interest in the sciences, and in environmental issues, particularly among certain age groups. In a survey of 10th and 12th

graders in 33 states, Perkes and Bohl (1976) found 42% and 39% of their respondents using TV as their primary information source. While Richmond and Morgan (1977) found 48% of senior high school students relying on the mass media as their primary source of environmental information. Studies such as these testify to the important role which mass media-TV plays in shaping attitudes on environmental issues at the local to the global levels.

While this type and quality level of programming is readily available in North America, Europe, Japan, etc., what about the rest of the world? Can television play a comparable role in the dissemination of environmental information in Equador?, in India?, in Mexico?. My presentation will provide an overview of environmental programming efforts in the "developing world" and suggest ways in which the information-dissemination role of TV may be expanded soon via technology transfer, and via better use of existing technology.

MUNROE, MARTIN J.
Lyndon B. Johnson School of Public Affairs, University of Texas, Austin, Texas 78711

Public Policy and Biomass Transportation Fuels: Economically Useful Information From Energetics

The development of appropriate public policy toward production and use of biomass derived ethanol as an alternative transportation fuel requires more information than the conditions for financial viability of the industry or a mere listing of sparely documented benefits: air quality, job creation, primary energy independence, debt reduction, and national security. By using suitable energy conversion factors, the full extent of social energy investments in the ethanol production process, including the agricultural phase of corn and sugarcane feedstocks, is compared with the macroeconomic value of the energy of ethanol and byproducts as practical information for use by policy advisors. Our estimate of the energetics output/input ratio for ethanol production is 0.74 (feedstocks grown within Texas' border) to 1.4 (feedstocks purchased from other states). Although this information suggests the near-term productivity of the Texas economy cannot be sustained by the large scale production of ethanol, the potential importance of fuels that originate from biomass is addressed under the emerging scenario of reduced fossil fuel availability.

NAREDO, JOSE MANUEL
C/Eladia Lopez Vilches, 12, 29033 Madrid, Spain

From the Economic System Towards the Economics of Systems

First of all, the differences arising between, on the one hand, the approach to the the purpose of study that are peculiar to ecology and, on the other, those relating to standard economics, are analyzed, so as to set forth, with full knowledge of the facts, the reasons behind the lack of understanding that so often springs up between the practitioners, and the militants, of the two disciplines, not forgetting the gap between different fields of reasoning: the physical and the monetary, local, and short-term goals and global and long-term goals. Let it be said in passing that, paradoxically, the same Greek root, oikos, is used to name the respective disciplines.

Afterwards, the trends aimed at applying economic analysis to the management of our physical surroundings, in which human societies develop, are considered, bringing out two different ways of going about it. The first of these, known as Ecological Economics, tries to establish "new theoretical connections between ecological and economic systems" (EE, no. 1). Here, reasoning is based on an economics of systems rarely seen in standard economics. In the latter case, reasoning is usually based on the single notion of an economic system, whose figures are the daily bread of those of our midst who are involved in national accounting.

The second, known as Environmental Economics, attempts to broaden the conceptual tools of standard economics to the treatment of problems deriving from the management of physical surroundings. The clarification of these topics is considered essential when it comes to establishing firm foundations on which to build an ecological economics system that precludes the above mentioned gaps right from the start.

NICHOLSON, GUY
Bioplan, 6 Indwa Place, K loof 3610 South Africa

An Approach to the Environmental Planning of Growing Third World Cities that is Compatible with Ecological Sustainability

It is proposed that managing the rapid growth of third world cities has important implications for achieving the goal of ecological sustainability. A promising approach is being developed in rapidly growth Durban (South Africa).

In this approach a conceptual model is formulated which integrates environmental quality, environmental production and human functions into a single metropolitan system. Geographic information systems are derived from the conceptual model and these systems are transplanted into process models consisting of planning pathway options, guidelines and scenarios that are relevant to both urban planners and the newly urbanized people. The roles attitude surveys

and education play in influencing planning pathway choices is described and the relationship between changes in the quality of life of the inhabitants of a region and the ecological sustainability of the system they are part of is suggested.

NINAN, K.N.
Assistant Professor, Institute for Social and Economic Change, Nagarbhavi P.O., Hangalore 560 072 India

Economics of Shifting Cultivation in India

Shifting cultivation is one of the factors contributing to the ecological degradation such as declining forest cover, soil erosion of many regions including north-east India. It is obvious that efforts to prevent further decline in the forest cover and other forms of ecological degradation in these regions also depend upon the success of measures to curb or stop the practice of shifting cultivation. This will largely depend upon how far alternate and viable sources of livelihood such as settled cultivation are provided to shifting cultivators.

This paper, therefore, analyses the economics of shifting (or Jhum) cultivation vis-a-vis settled (terrace) cultivation in north-east India, with the help of micro-level data and information available in the studies conducted by some agro-economic research centers. The study indicates that settled (terrace) cultivation is not as remunerative as shifting cultivation.

The paper argues that the strategy for hill area development which has hitherto focussed on the narrow issue of shifting (Jhum) versus settled cultivation should shift its emphasis to the lager and more relevant issue of diversification of economic activities in the hill regions, which holds the key to the future and economic prosperity of hill and tribal regions.

ODUM, HOWARD T.
Environmental Engineering Sciences and Center for Wetlands, University of Florida, Gainesville, Florida

A Comparison of EMERGY (spelled with an "M") Analysis and Input Output Embodied Energy Accounting

A 3 sector energy-economic network is used to make numerical calculations of EMERGY and of embodied energy by the matrix inversion method of calculating embodied energy. The network used has typical distribution of energy flow, materials flow, and dollar flows, where energy flow is largest in low transformity sectors, money circulation is largest in the high transformity* sector, and materials are more uniform. Embodied energy with the input-output method differs depending on what data (energy, materials, or money) are used as the basis for assigning the input energy. Results of EMERGY analysis are different from those of input-output embodied energy accounting. Criticisms are made of the use of Input-output methods for evaluating environmental and resource contributions to wealth and the gross economic product. (*Transformity is defined as the Energy of type one required per unit of another type and is a measure of position in energy hierarchy).

ODUM, HOWARD T.. and **ARDING, JAN**
Environmental Engineering Sciences and Center for Wetlands, University of Florida, Gainesville, Florida

EMERGY Analysis of Shrimp Mariculture and Foreign Trade in Ecuador

EMERGY (spelled with an "M") evaluation of the shrimp aquaculture industry in Ecuador was made by summing the inputs each represented in solar emjoules, the energy of one type (solar EMERGY) previously required for these inputs. With sale of shrimp higher EMERGY is delivered to the market than is paid back, even within Ecuador. When exported, much greater contribution is made to the wealth of the buying country than the selling country for two reasons: (1) money pays only for the human service component of the sales, and (2) the EMERGY/$ ratio is much higher than that of the developed market countries causing a 4 fold difference in buying power of exchanges involving International dollars.

Because of the high intensity of the pond operations, the costs are too high for sale in Ecuador so that the pond operators and middlemen become and enclave of foreign economies with higher standard of living at the expense of the displaced people that formerly used the estuarine EMERGY now largely diverted to raise standard of living of developed countries. Discussion includes alternative policies for international development to aid underdeveloped countries and a better foreign policy for the United States. Suggestions are made for an EMERGY basis for recalculating international debts.

PATTEN, BERNARD C.
Department of Zoology and Institute of Ecology, University of Georgia, Athens, Georgia 30602

Input-Output Approach to an Ecological Utility Theory

In a conservative flow-storage network (energy-matter in ecology, currently in economics) of i, j = 1, 2, ..., n interconnected nodes, instantaneous *direct utility* $D = (d_{ij})$ can be defined as the throughflow-weighted difference between income to i from j and loss to j from i. This signed (positive or negative) quantity at each node in the network can be propagated to dissipation by the series $\sum m=0,\infty K^m$, which converges if the absolute values of the eigenvalues of D are all less than 1 The convergent matrix, U = (I - D)-1, measures the integral utility transmitted directly and indirectly over the network to each i from each j. Measures D and U, and their throughflow-dimensioned counterparts, are demonstrated for several simple networks, and two issues of network design - "structure feasibility" and "network mutualism"--are identified and discussed.

PEET, N.J.
Senior Lecturer, Department of Chemical and Process Engineering, University of Canterbury, Christchurch, New Zealand
PEET, K.M.
President, New Zealand Workers' Education Association, Inc., Canterbury, New Zealand

WIth People's Wisdom: Community Based Perspectives on Sustainable Development

Governments normally obtain their policy advice from a small elite of experts, mainly economists, in government departments and academic institutions. In "developed", western countries, that advice is usually mediated through perceptions derived from the individual based neoclassical economic world view. The goal of sustainable development will require governments around the world to make substantial changes in institutional and economic structures, in order to address collective global problems. In this paper, we discuss aspects of a recent exercise in resource management law reform in Aotearoa New Zealand, by comparing and contrasting advice sourced from the neoclassical perspective with that from the modern scientific "systems thermodynamic" perspective. In the event, most of the debate involved government and academic elites. The views of People were generally limited to making submissions or responding to opinion polls. In our opinion, the process largely failed to tap into, let alone interpret and use, a vast resource of personal and collective knowledge.In our discussion, we draw attention to the Treaty of Waitangi, which provides the base for relationships between the indigenous Maori people of Aotearoa New Zealand and subsequent settlers. We make suggestions, with illustrations and models from other countries, as to ways in which nongovernment organizations can assist the involvement of people in participatory processes of policy development. We discuss the need for recognition and resourcing of these processes, by governments. The skills required for this approach are markedly different from those conventionally involved in policy development, in that determining the hopes and aspirations of people is mainly an interpretive exercise. Experts must see themselves as resource persons who contribute to but may not control the process. The outcomes of such participation include the building of better democracy and government, and more sustainable societies.

PASTUK, MARILIA
MONASA, Ltd., R. Teixeira de Freitas, 31, 7o. andar, Rio de Janeiro, RJ, Brazil

Ecology and Social Inequality in Brazil

It is necessary in societies such as Brazil that environmental problems be considered as connected with the "styles" of development adopted. Although it is a necessary condition that Brazil possesses a National Environmental Policy, with a range of complementary instruments, and an advanced Constitution in relation to the theme in question, this is not sufficient to ensure that concrete changes may be achieved in the manner in which the nation deals with environmentally related concerns.

In most cases, when analyzing the impacts anticipated from an individual project, it is difficult to separate the rational economic problem inherent to the conjuncture in which the nation finds itself, from the environmental problem strictu sensu. This is true because at the moment in which the project is initiated, a "perverse" social situation frequently arises, not always the fault of the project itself, but due rather to the conditions of misery that afflict the majority and which draw them to a project in the hope of compensation for broader social ills. Nevertheless, in the majority of cases, projects become responsible for such problems, by dislocating or otherwise harming those affected by them.

PETERSON, STEVEN. C.
Ecology & Environment, Inc., 368 Pleasantview Drive, Lancaster, New York 14086

Economics of Global Warming Abatement: Contributory Value of Forest Ecosystems as Carbon Sinks

Recent concern over global warming has heightened awareness that deforestation contributes up to 20% of the annual increase in atmospheric carbon dioxide. The economic valuation of forests can be extended in order to account for the contributory value (sensu Norton, 1986) of forest ecosystems in terms of global warming abatement. One way to express the economic value of carbon accumulated in vegetation is in terms of the estimated cost to society of mitigating carbon dioxide emissions caused by the combustion of fossil fuels. Recent estimates of these emission reduction costs are minimally $50 per ton of carbon. The world's forests are currently a net source of from 400 to 1600 million tons of carbon annually. While there may be economic costs involved in reducing net deforestation to zero, the benefit of doing so in terms of avoiding the cost of alternative forms of carbon emissions reduction is on the order of $20 to $80 billion annually. This concept is applied to a regional land use problem: second home development in the Adirondack Park of New York State.

PEZZEY, JOHN
Department of Economics, University of Bristol, 40 Berkeley Square, Bristol BS8 1HY

Charges vs Subsidies vs Marketable Permits as Efficient and Acceptable Methods of Effluent Control: A Property Rights Analysis

Under perfect competition, both combined charge-subsidy schemes and marketable permit schemes for effluent control can achieve short and long run efficiency, and also political acceptability, provided that both schemes embody effluent baselines that are treated as full property rights. The resulting symmetry between charge-subsidies and marketable permits, a symmetry overlooked in the literature because of the entry-exit assumptions automatically made for most subsidy schemes, opens up a useful choice between the two schemes that may have practical relevance in controlling global pollution. A change in terminology from 'subsidy' to 'compensation' might help in arguing the case for charge-subsidies

PHILOMENA, ANTONIO
Fundação Universidade do Rio Grande, Laboratório de Ecologica, rua Alberto Torees 161, Porto Allegro, Brazil

What Should Be Taught in Ecological Economics?

In order to establish a good basis for the development of Ecological Economics, the author proposes two teaching approaches to be discussed: 1) one is a minimum central core of interdisciplinary courses which reflects many ethics and philosophical principles responsible for the beginning of this new field. An understanding of these roots enable us to visualize the historical confluence of a multitude of fields such as ecology, economy, information and sociology, all resultant of a necessity to solve today's most prominent problem: the relationship between man and nature. At this basic central core, courses like History of Ecological and Economic Thoughts, World Problems, Environmental Ethics, Ecotechnology and Development, and Energy and Material Processes are fundamental; 2) here is the area where the field will develop in the near future, and due to its dynamics, it can develop differently according to the vocational effort of each group, institution, or country. Since Ecological Economics is just developing, it is very opportunistic to discuss and map new frontiers that are being opened. Here courses should be balanced between reductionist and holistic scope. The author proposes that a list of new courses can be discussed and arranged during his presentation.

PILLET, GONZAGUE
Paul Scherrer Institute, Villigen & University of Fribourg, Fribourg, Switzerland
BARRANZINI, ANDREA
Department of Economics, University of Geneva, Geneva, Switzerland
HALL, CHARLES
State University of New York at Syracuse ESF, Syracuse, New York
GREPPIN, HUBERT
Department of Botany, University of Geneva, Geneva, Switzerland
SANDOZ-TERRAZ, SYLVIE
Department of Geography, University of Geneva, Geneva, Switzerland

Assessing Some Economic and Ecological Evaluations on Environmental Issues with Special Reference to Switzerland

According to our interpretation, the perspectives for the environmental and public policy of the nineties involve two main issues that we will analyze in this paper, with special attention to some case studies concerning Switzerland. The first one concerns *natural environments* which "are akin to stocks of nonrenewable resources that are consumed once and for all" (Fisher and Peterson, 1976), but are much more than just nonrenewable resources in being unique. The second one deals with *energy analysis of environment and economic processes* derived from systems ecology which is used to "demonstrate that economic and environmental problems can be evaluated according to a common measure: The energy (or solar equivalents) generated by the system" (Odum, 1983, 1988; Pillet and Odum, 1987). The two issues are closely related to the evaluation of natural environments. The first, being economics-oriented, i.e. oriented by human preferences, deals with the use of natural resources that potentially are in the marketplace and with the natural environments that voluntarily are preserved. The second issue is systems ecology-oriented, i.e. oriented by energy webs and processes, and deals with assessing the work of natural ecosystems contributing to economic processes. For both issues, the fundamental question is: How much are natural environments worth to the economic world?

Consequently, our task in this paper is to go back and forth from the economy to the environment. In part I we consider alternative uses of natural environments. In part II economic production processes are analyzed from an ecological-economic viewpoint.

POMAREDA, CARLOS F.
Agricultural Policy and Planning, Inter-American Institute for Cooperation on Agriculture (IICA); P.O.Box 55 - 2200 Coronado, San José, Costa Rica

Institutional Challenges in the Achievement of Sustainable Agriculture .

The paper highlights that Achieving Sustainable Agriculture requires a fundamental change in attitudes of people and institutions to better value the future and thus to make a commitment with future generations. Achieving sustainability requires efforts that are multidisciplinary, multipartidary, multisectorial and multinational. Thus, a conceptual framework and an operational scheme is required for institutions to complement their expertise; for public and private entities to work in partnership; for urban and rural organizations (public and private) to assume their responsibilities and the cost of the externalities for which they are responsible and for nations and international organizations to promote and commit to global goals.

Because of the current scenario, the situations of indebtness, the challenge to alleviate pressing conditions of poverty, etc., people and institutions are fundamentally concerned with managing the present and, the very short run policies are, therefore, primarily oriented to guide the accommodations of decisions to the market performances. However, the current workings of the market may have to be challenged as an effective means to achieve sustainable agriculture. On the other hand the role of the state is being reconsidered and the capability of public entities is severely questioned to undertake specific responsibilities in a renewed "market economics with social responsibility". The institutions need fundamental reforms, motivations and a different conception to be useful means through which governments can constitute to achieve sustainable agriculture.

RAPPORT, DAVID J.
Institute for Research on Environment and Economy, Simard Hall, University of Ottawa, Ottawa KIN 6N5 Canada
HILDEN, MIKAEL
Statistics and Economics Section, Finnish Game and Fisheries Research Institute, P.O. Box 202, SF-00151 Helsinki, Finland

Patterns of Temporal/Spacial Propagation of Ecosystem Pathology in the Gulf of Bothnia

Spatial and temporal development of symptoms of environmental degradation were studied at various spatial scales in the northern region of the Baltic Sea (Gulf of Bothnia). The response to stress from human activities has resulted in the development and spread of what is here termed "ecosystem pathology" at all spatial scales. The temporal sequence of

signs of ecosystem degradation varies. In some cases the effects of stress were propagated from local to regional levels, and then to basin wide impacts. In other cases a basin disturbance has propagated to impact local regions (bays, estuaries). The pattern of propagation is dependent on the mode of impact of the stresses and ecosystem characteristics. Damage to "centers of ecosystem organization" appear to play a crucial role in determining the spatial and temporal spreading of disturbance. The implications of the case study for the design of monitoring programs on changes in the state of environment are discussed.

REES, WILLIAM E.
The University of British Columbia, School of Community and Regional Planning, 6333 Memorial Road, Vancouver, B.C., Canada V6T 1W5

Why Economics Won't Save the World

Humankind is no different from other species in being dependent for life on material and process resources extracted from the ecosphere. Thus, in ecological terms, all material economic "production" is actually consumption, at best involving the conversion of ecological capital into man-made capital. From this perspective, such persistent global environmental trends as ozone depletion and greenhouse gas accumulation indicate that current consumption already exceeds the long-term productive capacity of the ecosphere. They also challenge prospects for future material growth.

"Proper" resource pricing, free markets, and incentive-based economic mechanisms are currently being embraced by policy-makers as the most effective means to address the emerging ecological crisis and achieve sustainable development. However, neo-classical economics assumes a world of static equilibria, smooth change, and mechanical reversibility, while the ecosphere is a non-equilibrium system characterized by lags, thresholds, and thermodynamic irreversiblity. This reality introduces an intractable risk factor which limits economic incentives to facilitating more efficient resource use. The fundamental questions of how much "natural capital" can be marketed and what mix of natural capital stock must be preserved to ensure ecological security remain subject to political intervention informed by inadequate science and individual judgement.

ROCHELEAU, DIANNE E. Department of Geography, Clark University, Worcester, Ma

Indigenous Ecological Economics: Projecting the Long Term View from Local Space

The World Commission on Environment and Development speaks optimistically of a common future, of a shared stake in maintaining the ecological basis for continued growth and a just world order. This implies that growth and equity are compatible and further assumes the existence of a global concensus on the shape and texture of a single future across gender, class, race, ethnic and national boundaries. This paper suggests that a common future is likely to reflect the interests and vision of the dominant forces in the current world order. It argues instead for a multiplicity of shared futures that maintain and create rather than foreclose options in rural landscapes.

An example form Kenya serves as a point of departure. Stories from rural women's work and lives in Machakos district illustrate: (1) the complementarity of women's and men's knowledge and experience; (2) the changing functional, structural and spatial division of labor; and (3) women's interests in biodiversity and the "domestication" of whole ecosystems in rural landscapes. Women's experience and analysis of the drought and famine of 1984-1985 show how crucial it is to support rural people's efforts to create space and maintain options for a multiplicity of unfolding economic and ecological futures.

RUBINO, MICHAEL C.
Bluewaters Inc. and Palmetto Aquaculture, 4350 East West Hwy, Suite 600, Bethesda, MD 20814

Sustainable Aquaculture: Shrimp Farming

Worldwide aquaculture production is projected to double during the next decade as seafood demand continues to increase and wild catches in many areas decline. Aquaculture can be environmentally destructive; alternatively, it can be conducted in a sustainable manner that minimizes environmental impacts and maximizes the use of natural production inputs. Shrimp is one of the most lucrative and widely cultivated species. Shrimp aquaculture poses several sustainable development issues: 1) selection of production methods that follow sustainable development principles; 2) the commercial profitability of sustainable aquaculture methods; 3) government regulation of the use of or protection of natural resources; and 4) public and private sector cooperation for aquaculture development. These issues are analyzed in this article using shrimp aquaculture in South Carolina as an example. Additional examples are drawn from shrimp farming in South America and Asia. The issues raised by shrimp aquaculture apply to other forms of coastal aquaculture.

SADLER, BARRY
Institute of the NorthAmerican West, Victoria, British Columbia, Canada

An Impact Compensation Theory of Sustainable Development

This paper builds on previous analyses that place the concept of sustainability in a decision making framework. Sustainable development is envisaged as a commonwealth of environmental, economic and social values that can be formally translated into policy goals and choice criteria. However specified, these criteria cannot be maximized simultaneously in decision making and must be adjusted through a political process of 'negotiated' trade-offs. This is not to restate the paradigm of sustainability as business as usual; it implies instead a balance and disciplined accommodation of environment and economic considerations

Quite obviously, this balance a) will be difficult to determine, and b) will vary with conditions and circumstances. It is at this point that environmental thresholds become of fundamental importance. Because ecological limits are finite and characterized by irreversibilities, they represent the enabling condition for sustainable development.

The notion of carrying capacity in relation to development activities takes us closer to an operations grasp of environmental sustainability. It may be defined as the constancy of natural capital, i.e. resource stocks and flows plus the ecological processes which support their productive (source) and/or assimilative (sink) functions. Strictly interpreted, this sustainability criterion amounts to a requirement for zero environmental damage or no net loss of natural capital. As it stands, the criterion is unacceptable (except to deep ecologists) because it would effectively halt all forms of exploitive development. At the regional (or program sector) level, however, the nonet loss of natural capital criterion becomes much less onerous; it allows for intensive site and project specific development (subject) to appropriate terms and conditions) but calls for residual impacts to be offset or compensated by environmental rehabilitation or resource enhancement within contingent areas of the regional ecosystem. This formulation frames the operational terms of reference for decision making for sustainable development and is suggestive of the process related changes which will be necessary.

SAVORY, ALLAN
Center for Holistic Resource Management, 800 Rio Grande Boulevard, N.W., Suite 10, Albuquerque, New Mexico 87104

The Holistic Resource Management Model

A number of civilizations have fallen due to the erosion of their ecological foundations. Four ecological processes sustain economies and all life: biological succession, water cycling, mineral cycling and solar energy flow. No economic model can be sound without this foundation.

A "holistic" model, based on this foundation and catering as well for social and monetary factors, has been under development for over 25 years. It is now used by land managers (both private and public), researchers, extension advisors and others in five languages (English, French, Arabic, Spanish, Navajo). The model is universal, applying across cultures, economic and political systems, environments and climates. Used in four modes--management, policy analysis, problem diagnosis and research orientation--the model is throwing new light on old problems. It shows why current efforts in economic modeling, in halting desertification and global warming cannot succeed. It also indicates a promising path to solutions. Its use has enabled land managers to achieve measured reversal of desertification while simultaneously generating new wealth.

We are seeking economists to work with us in using this model as a base for new thinking in economic modeling.

SCHROYER, TRENT
Professor of Sociology-Philosophy, Ramapo College of New Jersey, 505 Ramapo Valley Road, Mahwah, NJ 07430

Current research in sustainable development has been oriented to resource depletion and the avoidance of environmental degradations. Another dimension of sustainability that is being advocated in the new economics movement, as well as those concerned about alternatives to structural adjustment for debtor nations in Latin America and Africa, is social and cultural sustainability. Focusing on the importance of sustaining social communities and indigenous cultural practices and stocks of knowledge is one of the major dimensions of the "new economics movement" as that has been represented in The Other Economic Summit (TOES) projects -- for example, as collected by Paul Ekins (Editor), The Living Economy. I propose to present a paper interpreting how the practitioners and advocates for a new economics, brought together by past TOES events (12984-89), have presented the importance of social and cultural sustainability as part of an ecologically viable economics. This systemic interpretations will end with an explication of how this theme is being used to structure the counter-summit in Texas in July of 1990. As Program Director for this event, I offer this interpretations as both a history of a forming social movement and as invitation for participation in the coming event.

SESHADRI, C.V. and **HOON, C.V.**
Shri A.M.M. Murugappa Chettiar Research Centre, Tharamani, Madras 600 113 India

The Ecological Economics of Sustainability: Lessons Learned form Isolated Communities

Sustainable and self-reliant development is only possible if the ecological balance of resource use within an ecosystem is maintained. Isolated tribal communities often know how to maintain this balance. This paper presents findings from two detailed studies conducted by the authors. (1) a human ecology of Himalayan transhumance and nomadism. 2. An energy and resource use survey of an island in the Indian Ocean. These societies live in relative isolation. They have had limited interaction with "development processes" until recently. The societies are in transition now. The younger semi-educated members reject the traditional life style. Government policy seems to have encouraged dependence and since imports of energy are subsidized and guaranteed, these areas have become non-self reliant and have opted for a non-sustainable life style. At the same time an energy analysis of the traditional life style of the Himalayan nomads has shown that pastoral nomadism is the most appropriate way of living in the marginal mountain environment. Not only does it lead to sustainable development of the mountain environment but also contributes to the national economy. An analysis using Odum's transformity ratios bears out the intuitive conclusions just stated. Data will be presented from both studies and analyzed to substantiate the conclusions. An attempt is made to appreciate the ecological economics of sustainablilty by learning from the wisdom of traditional societies.

SHARP, BASIL M.J.
Department of Economics, University of Auckland, New Zealand

Global Pollution: An Assessment of Transferable Permits

Significant global environmental issues confronted the international community during the 1980s. Pollution of the earth's atmosphere will be one of the foremost environmental issues in the 1990s. Global atmospheric pollution is characterized by uncertainty, distant time horizons, valuation problems, different distributions of costs and benefits, conflicting domestic policies, a variety of political systems, divergent economic interests and the pressures of sovereignty. The relative merits of transferable pollution permits have ben quite extensively examined in the context of domestic environmental policy and a country's comparative advantage in the global economy. This paper examines the use of transferable permits in the context of global pollution. A system of international transferable pollution rights will require a unique institutional structure. While contributing to the reduction of pollutants there is little likelihood of uncoordinated action leading to efficient solutions. Incentives will exist for governments to free ride on the benefits derived from the actions of others. Governments pursuing a domestic policy targeted at reducing emissions, without recognizing the relative costs and benefits of the policy to he local community, will impose excessive costs on its citizens. International cooperation is necessary. The thesis of the paper is that the costs and benefits of international cooperations are a function of the institutional arrangements that comprise global initiatives. An institutional structure for an international system of transferable pollution permits is proposed. Particular attention is given to the task of establishing initial entitlements among governments, adjustments to aggregate global entitlements, incentives, monitoring and enforcement.

SHOEMAKER, ANDREW R.
University of Virginia School of Law ,
TOWNSEND, KENNETH N.
Hampden-Sydney College, Hampden-Sydney, Virginia 23943

The Chinese Environment: An Analysis of Environmental Policy Problems within The People's Republic of China

The People's Republic of China, with its rapid development under the leadership of Deng Xiaoping, is experiencing environmental problems very similar to that of the developed countries during their early stages of growth and development. While the Chinese appear to be attempting to internalize many pollution externalities and limit growth of population, there exist structural and governmental barriers that they must overcome to head off environmental problems of epic proportions. With the liberalization of the economy brought about by changes in economic policy during the last fifteen years, the Chinese appear to be attempting to follow a well-worn, but perhaps impassable path to development. Although a rapidly growing industrial sector suggests that China is capable of replicating the "Pacific Rim miracle" made famous with the rapid industrialization of Japan, Korea, and Taiwan, scale problems associated with the sheer size of China's population, as well as problems with the legal incentive structure associated with China's environmental protection apparatus bid fair to disrupt China's development plans, with potentially disastrous ecological spillover effects threatening the environments of neighboring countries.

Currently the largest borrower from the World Bank, China boasts a level of investment equal to 30 percent of total GNP; by comparison, the United States' investment if approximately sixteen percent of total GNP. China's imports and exports total $80 billion per year, more than ten times the level of a decade ago. As a fraction of GNP, Chinese exports

have grown even faster than Japan's (Lardy, 3 August 1988). With 400,000 new enterprises (XuQing Hua, 8 August 1988) and 163,000 new investment projects (*Far Eastern Economic Review* 120), China has the fastest growing economy in the world with a growth rate in GNP of eight-to-nine-percent per year. Although economic liberalization has obviously benefitted China in many ways it has consequently imposed an immense new burden on an environment already encumbered with the pressures of absorption of tremendous amounts of simple domestic effluents.

SHOGREN, JASON F.
Department of Economics, Iowa State University, Ames, Iowa 50011
NOWELL, CLIFFORD
Department of Economics, Weber State College, Ogden, Utah 84403

Economics and Ecology: Comparison of Experimental Methodologies and Philosophies

Views of the proper role of experiments in economics and ecology has evolved quite differently. Economics has devoted the majority of effort developing abstract theory, with experimentation coming in a distant second. Kagel quotes a colleague who illustrates a common perception among economists. "I am a 'true believer' in microeconomic theory, and as a result I am perfectly willing to accept mathematical proofs without experimental evidence." In contrast, ecology has focused on observation-based experiment as the primary tool of research, almost separate from the development of abstract theoretical ecology. As a consequence, Kareiva notes that the "sad truth is that ecological theory exists largely in a world of its own, unnoticed by mainstream ecology."

The purpose of this paper is to explore how and why the divergence of views has developed and persisted over the decades. Our goal is to provide insight into the different methodological approaches to experimentation, thereby creating another bridge of communication between the two camps. The paper examines general methodologies and philosophies of the disciplines, rather than actual experimental design techniques. As economists, our obvious bias is toward experiments in environmental economics. Highlighting the economic viewpoint allows economists to see how their approach differs from ecology, and it also allows ecologists room to point out how their discipline can assist in economic decisions by ensuring that major variables are identified and uncertainties indicated.

SHORTLE, JAMES S. and **MUSSER, WESLEY N.**
Department of Agricultural Economics and Rural Sociology, The Pennsylvania State University, University Park, PA 16802

Economic Foundations of Low-Input Sustainable Agriculture

Modern agricultural production methods are criticized increasingly for the impacts on food safety, environmental quality, farm worker safety, long-term agricultural productivity, and the structure of agriculture. Low input/sustainable agricultural (LISA) production practices have captured the interest of farm groups, environmental groups, and others as a means by which to help solve these problems. There is, however, considerable debate about the profitability of these practices, the adequacy of research and development related to them, and appropriate public policy for fostering their adoption. The purpose of this paper is to help structure the debate on LISA along constructive conceptual and empirical lines. Specific issues include: (1) the policy-relevant meaning LISA production practices and LISA relevant research; (2) the technical and conditions under which low input practices could in fact be equally or more profitable than conventional practices given existing technology, with special emphasis on identifying systematic vs. nonsystematic factors explaining variations in profitability; and (3) firm level vs. aggregate level impacts of LISA technology of adoption and policy implications the analysis are developed.

SIMONIS, UNO E. and **LEIPERT, CHRISTIAN**
Wissenschaftszentrum Berlin fur Sozialforschung, Reichpietschufer 50, D-1000 Berlin, Federal Republic of Germany

Environmental Damage and Environmental Protection Expenditures: The Example of the Federal Republic of Germany

It is argued that the conventional economic accounting systems have not played an enlightening role in statistically revealing the actual damage to the environment. They can, however, be methodologically improved; and they must be complemented by assessments of the ecological costs of the production process.

In the paper statistical evidence is provided on the level and structure of environmental damage and protection expenditures in the Federal Republic of Germany, i.e., on the environmental damage itself and on the environmental protection investments by industry and government, the capital stock for environmental protection, the total costs of and expenditures for environmental protection.

SKLAR, FRED H.
Belle W.Baruch Institute for Marine Biology and Coastal Research, University of South Carolina, Georgetown, SC 29440
COSTANZA, ROBERT
Center for Environmental and Estuarine Studies, University of Maryland, Box 38, Solomons, MD.

Modeling Natural and Human Impacts on Wetlands

Wetland resources are diminishing as a result of the cumulative impacts of both natural and antropogenic alterations to the environment. Wetlands suffer from pesticide runoff, subsidence, oil and gas extraction, and eutrophication, to name a few problems. Computer models can be used to predict wetland response to environmental change. The objective of a landscape model is to simulate the synergistic interactions between external forces such as sea level rise, and intricate internal processes such as primary production, across large geographic regions and long time scales. We can use lancscape models to study ecological principles, evaluate cumulative impacts, mitigate environmental alterations, and prevent large scale human "mistakes" from degrading wetland functions.

SMITH, GERALD ALONZO
Center for a Human Economy, Mankato State University, Mankato, MN 56001

What Rationality? Whose Efficiency?

At the beginning of every text in economics is a crucial discussion on rational behavior and/or efficiency. This initial discussion sets the boundaries within which economics explores the intellectual terrain. And although these definitions of efficiency and rationality are frequently passed over quickly and in a perfunctory manner, they are crucial in determining the impact of the economic system upon the environment. If economic solutions are to be consistent with global and long-term goals, we must reexamine these fundamental assumptions. That is the task of this paper.

Together these two definitions decree that the desires of consumers are the final arbitrators of what is of value. This is crucial because if all desires become final goals in themselves, then economic growth has to be the primary goal for an economy because it is only through economic growth that more such desires are fulfilled. However, such a goal leads societies and economies and the natural environment that nurtures them to destruction. Such a goal excludes from its consideration the possibility: 1) that the environment may be of inherent value in itself; 2) that non-economic qualities (such as community, self-respect, sense of beauty and awe, love of others, etc.) have any value; and 3) that future generations have value beyond what the current generation decides.

SODERBAUM, PETER
Swedish University of Agricultural Sciences, Department of Economics, Box 7013, S-75007 Uppsala, Sweden

Neoclassical and Institutional Approaches to Development and Environment

Paradigmatic pluralism is suggested as a fruitful attitude for economists approaching public policy issues. A dialogue between advocates of different perspectives such as neoclassical and institutional economics is judged necessary in relation to environmental and developmental issues. It is also argued that a scholar with preferences for a specific perspective will benefit from comparing this perspective with alternatives in a dialectic manner.

An attempt is made to discuss some of the characteristics of environmental and development problems such as the irreversibility of many processes concerning ecosystems and the ethical or ideological nature of decision making in these areas. A discussion of the main differences between the neoclassical and institutional approaches then follows and it is suggested that the relationship between the two approaches is sometimes complementary, sometimes competitive.

Differences between neoclassical and institutional economics is then dealt with with respect to view of economics (reductionist and holistic), views of development and progress (emphasis on GNP growth versus an open attitude to other development views such as sustainability), approaches to decision making (cost-benefit analysis versus positional analysis), information and accounting systems (conventional accounting in business and at the national level versus alternatives) and views of social and institutional change (public choice theory versus actor-network approach).

It is clear that some of the above mentioned subfields will be emphasized more than others. The paper concludes with policy proposals from the point of view of various actor categories and at the national level, based upon the previous analysis and discussion.

SOUSA, CLARA DE and **PERKINS, PATRICIA E.**
Faculdade de Economia, Universidade Eduardo Mondlane, Maputo, Mozambique

Environmental Effects of the IMF Economic Program in Mozambique, 1987-1990

Mozambique's economy, devastated by war since 1982, has been subjected to new pressures by the IMF-sponsored Programa de Reabilitacao Economica (PRE), instituted in 1987. The PRE incorporates a dramatic shift in emphasis from

income-equalizing to distribution-worsening policies. The effects for the country's environment -- viewed broadly, as is necessary in one of the world's poorest countries -- have been disturbing. This paper provides specific examples of how industrial, agricultural, and human pollution problems have worsened in Mozambique under the PRE. It also addresses the issue of how environmental concerns could be better handled through supportive international policies.

SOUTHGATE, DOUGLAS
Department of Agricultural Economics and Rural Sociology, Ohio State University, 2120 Fyffe Road, Columbus, Ohio 43210-1099

How To Promote Tropical Deforestation: The Case of Ecuador

The conversion of Ecuador's lowland, humid forests into cropland and pasture has been accelerating and the country's agricultural frontier now traverses fragile land with important non-agricultural values. Malthusian explanations of deforestation in the country do not suffice, rural population growth being modest in many areas where land clearing is rapid. Instead, deforestation is largely a consequence of inappropriate tenurial arrangements, governmental interference with price signals, and inadequate investment in research and extension. These three causes of excessive land clearing must be addressed simultaneously, both in Ecuador and in other Latin American countries where the policy environment is similar.

SOUTHWORTH, FRANK; HILLSMAN, EDWARD L.; DALE, VIRGINIA H; FROHN, ROBERT H.; JIMENEZ, BRAULIO D.and O'NEILL, ROBERT V.
Oak Ridge National Laboratory, P.O. Box 2008, Oak Ridge, Tennessee 37831

Modeling Land Tenure Patterns, Highway Infrastructure Policies and the Ecological Impacts of Deforestation in Rondonia, Brazil

Tropical deforestation is a major issue for global change because it affects global biodiversity and atmospheric concentration of CO and, thus, climate change. Brazil contains the planet's largest tropical forest in terms of both area and biomass, but this forest is being cleared at an increasing rate. Most of the deforestation results from road development and the associated clearing for agriculture.

The state of Rondonia in Brazil has had numerous colonization projects and, as a result, large-scale deforestation has taken place over the past two decades, as a result of slash and burn agriculture, often followed by cattle ranching. We present a modeling approach that links a settlement diffusion and land tenure model to highway infrastructure and ecological damage models. The initial objective of this model building exercise is to simulate this spatial and temporal diffusion of forest clearance in Rondonia, and to understand the relationships between forest clearance, different settlement and road building policies, and the ecological damage that results from these activities. Satellite images of the region provide the basis for calibration and evaluation of the model predictions, requiring that a geographic information system become an integral part of the model-building exercise.

SWART, R.J. and MAAS, R.J.M.
National Institute for Public Health and Environmental Protection, Bilthoven, The Netherlands

From Global to National Climate Policy

Over the last few years the anticipated climate change has captured a prominent position on the political agendas. Internationally, UNEP and WMO established the Intergovernmental Panel on Climate Change. Joining forces with the US Environmental Protection Agency, the Netherlands' National Institute for Public Health and Environmental Protection (RIVM) developed emission scenarios for greenhouse gases within the framework of the Response Strategies Working Group of this panel. These scenarios can be used to review different international response options. To limit risks associated with climate change and facilitate sustainable development strategies have to be adopted that will not only deeply change the world's energy system, but may also influence global economic growth as defined in the classic way. At the national level in the Netherlands global environmental problems play an important role in formulating national policy goals. This importance is reflected RIVM's 'Concern for Tomorrow' the national environmental survey 1985-2010 that formed the basis of the National Environmental Policy Plan (NEPP 1989). After thorough economic, political and environmental evaluation of different policy options stabilization of in 2000 at the average 1989/1990 level was included as a political goals in the NEPP. Depending on international developments this policy wold be upgraded in the near future. Economic-technological scenarios indicate that a 20 to 30 % CO_2-emission reduction in 2010 could be combined with a doubling of the GNP, even when CO_2-measures would only be taken in the Netherlands and the competitiveness of the Netherlands' industry would worsen.

THRUPP, LORI ANN
Energy and Resources Program, University of California, Berkeley, California 94720

The Political Ecology of Natural Resource Strategies in Costa Rica

This paper analyzes natural resource management strategies and sustainable development dilemmas in Central America, concentrating on the case of Costa Rica. It is argued that although Costa Rica has a reputation of having "successful" environmental policies and has made some progress in conservation efforts, the natural resource strategies actually have major constraints and weaknesses, such as insufficient attention to the environmental needs of the poor, perpetuating the domination of U.S. interests, and failure to address political-economic roots of the problems. Moreover, resource degradation problems have accelerated. Using a political ecology approach, this analysis explicitly reveals contradictions of mainstream preservationists strategies. In the end of the paper, lessons are derived from the Costa Rican experience, and alternative actions are suggested, emphasizing the need for strong political changes.

TIETENBERG, TOM
Dept of Economics, Colby College, Waterville, Maine 04901

Managing the Transition to Sustainability: The Potential Role for Economic Incentive Policies

Environmental regulators and lobbying groups with a special interest in environmental protection in the United States have traditionally looked upon the market system as a powerful and potentially dangerous adversary. That the market unleashed powerful forces was widely recognized and that those forces clearly acted to degrade the environment was widely lamented. Meanwhile growth proponents have traditionally seen environmental concerns as blocking projects that had the potential to raise living standards significantly. conflict and confrontation became the modus operandi for dealing with this clash of objectives.

The climate for dealing cooperatively and effectively with both concerns has improved dramatically within the past few years. Not only have growth proponents learned that in may cases short-term wealth enhancement projects which degrade the environment are ultimately counterproductive, but environmental groups have come to realize that poverty itself is a major threat to environmental protection. Sustainability has become an important, if still somewhat vaguely defined, criterion for choosing among alternative paths. Rather the focus has shifted toward the identification of policies or policy instruments which can promote the alleviation of poverty while protecting the environment.

One approach that is generating a great deal of interest is known generically as an economic incentives approach to environmental regulation. By changing the incentives an individual agent faces, that agent can use his or her typically superior information to select the best means of meeting his or her assigned responsibility.

How can economic incentives be used to provide the kinds of signals that will make sustainable development possible? Perhaps the best way to answer this question is to share a few examples of how this approach has worked in practice in an international context and how it might be used in the future. That is the focus of this paper.

TOBEY, JAMES A.
United States Department of Agriculture, Economic Research Service, 1301 New York Avenue, NW Room 508, Washington, DC 20005-4788

Opportunities for Environmental Sustainability in OECD Agriculture

Greater attention is now being paid to environmental problems arising from agricultural production practices in industrialized countries. Following a brief survey of the types of environmental stress that agricultural production generates, the structural changes in agriculture that have contributed to these forms of environmental stress are explored. Some important changes include the growth in fertilizer and pesticide chemical inputs per acre of cropland, and domestic agricultural policy that has encouraged both intensive and extensive agricultural production.

The paper identifies three broad categories of environmental policies toward agriculture that policymakers in OECD countries have considered to ameliorate the environmental problems associated with conventional agricultural productions systems. These include policies directed at agricultural inputs, practices, and products. The extent that OECD countries have implemented policies in these three categories is explored.

Finally, to illustrate the direct and indirect effects of agricultural commodity policy and environmental policy toward agriculture on environmental quality, a simple three sector general equilibrium model of the U.S. economy is developed. Policy simulations show that commodity policy is highly inconsistent with environmental quality objectives.

TOLEDO, VICTOR M.
Centro de Ecologia, UNAM, APDO 70-275, Mexico

A Conceptual Framework for the Ecological-Economic Analysis of Rual Production

In any form of rural or agrarian production (agriculture, cattle raising, forest extraction, fisheries); producers utilize natural resources as the basic and irreplaceable means of production; rural inhabitants are primary producers facing both natural and social forces. They are economic actors within an ecological and economic context. Therefore, any analysis of rural production must include both ecological and economic variables that affect this process. Contrarily to this basic assumption, economists examine the phenomena of rural production separately from its environmental context, and human (or cultural) ecologists reduce the process to energetic exchanges.

Intending to overcome the above, this paper is proposing and discussing a conceptual framework to the integrated ecologic-economic analysis of rural production. Based on the idea that rural production can be empirically reduced to flows of materials, energy, labor, commodities and information, and that all these flows take place in the concrete space, the paper offers an appropriate way to the integrated analysis. After defining the main concepts utilized in the framework, the paper presents a discussion of its theoretical implications. The paper finishes showing some examples where, through the use of empirical data, this conceptual framework has been applied.

TOMAN, MICHAEL and **COSSON, PIERRE**
Resources for the Future, 1616 P Street, N.W., Washington, D.C. 20036

The Different Dimensions of Sustainability: A Review

This paper begins with the premise that sustainability is an issue that is both important and far from fully understood. In particular, sustainable economic development involves far more than environmental protection, the focus of much recent sustainability discussion, and it is more than correcting errors in resource valuation and allocation. Sustainability rests on fundamental ethical precepts whose implications have not yet been fully assessed; it depends critically on the nature of the technologies humankind uses for transforming resources; and achieving it poses a strong challenge to economic and other social institutions.

The paper is divided into three parts. The first two draw upon recent literature in an effort to more precisely identify the scope of the sustainability issue and the magnitude of efforts needed to achieve global sustainability over the longer term. Included in this discussion are the principles of intergenerational equity that underlie sustainability; the problems in ascertaining what bundles of capital stocks should form the endowments of successive generations; the nature of inherent limits faced in substituting other inputs for natural resources (including environment) as these grow scarce; and the role of knowledge and innovation in ameliorating scarcity. The last section of the paper summarizes research needs for advancing understanding of sustainability, and offers some preliminary observations on policy directions.

T SAS-ROLFES, MIKE
23 Eton Park, 6 Eton Road, 2196 Sandhurst, South Africa

The Economics of Rhino Conservation

The drastic decline in rhinoceros populations in Africa has been a cause for concern for some time. Efforts to control poaching have been largely unsuccessful, and at the current rate of exploitation, African rhinos could be extinct in the wild by the year 2000.

This paper examines some of the underlying economic forces driving the predicament, and questions whether current government policies are appropriate. Research undertaken reveals that government policy has often exacerbated the problem, by creating incentives for the public to exploit rhinos rather than conserve them. By recognizing private rights to rhinos, and by allowing the use and trade of rhino products, governments could create incentives for private concerns to start rhino farming.

If commercial exploitation of rhinos was allowed in Africa, they would be no more endangered than domestic cattle, ostriches or crocodiles. Such commercialization has not taken place in the past, simply because government regulation has either discouraged it of forbidden it altogether. I argue that it is still not too late to save rhinos from extinction. A regulated return to a market controlled system of rhino production could provide the solution.

UNDERWOOD, DANIEL A.
International Center for Water Resources Management, Central State University, Wilberforce, Ohio 45384

Lessons From Adaptability Theory For Sustainable Environmental Management

This article provides insight into the investigation of sustainable environmental management strategies by integrating fundamental behavioral structures from adaptability theory. A conceptual model is developed that makes

possible examination of institutionally driven econospheric adaptation to an environment adversely affected by economic activity. Interaction between econosphere and environment results from the ecological impact of resource-use patterns upon the environment. A qualitative diminution in the environment changes both the ecological and institutional parameters that direct econospheric evolution. The problem is to develop a structure to evaluate alternative technological and institutional responses to uncertain environmental conditions. Such a general strategy must satisfy near term demands for environmental services without sacrificing long term adaptability (sustainability) to uncertain future environmental conditions. Adaptability depends upon potential utilization of free energy from compartmental elements within the econosphere and from the natural environment. Adaptability is enhanced by independence between elements. Independence increases the potential modifiability of components in response to uncertain changes in the environment, i.e., there are multiple pathways to obtain free energy. Hence, there is a positive relationship between the degree of dependance between elements and the cost of energy flow disruptions. A number of strategic insights for sustainable environmental management are derived from this analysis.

VAN DEN BERGH, JEROEN and **NIJKAMP, PETER**
Free University Amsterdam, P.O. Box 7161, 1007 MC Amsterdam, The Netherlands

Aggregate Economic-Ecological Models for Sustainable Development

In this paper we concentrate on the structure of simple models that can be used in clarifying sustainable development issues and may provide a basis for analyzing sustainable development in an operational context. The aim is to develop a general integrated aggregate dynamic model for sustainable development that will both be simple of structure and summarize the main objectives, processes and constraints applying to sustainable development in closed economic-ecological systems. The models focused on in the paper provide simple and highly aggregate representations of economic-ecological systems, which means that they: have no subdivision in regions; take similar entities (industries, ecosystems decisionmakers) together in one aggregate variable; distinguish between a very limited number of subsystems in the real world system; represent such real world subsystems by a simple description of that dynamic feature of the real world system, which is regarded as being most essential or central in it; and include a minimum of interactions between subsystems. The most general implications for models arising from the notion of sustainable development are discussed, thereby concentrating on the following list of considerations: 1. an integrated rather than a partial approach; 2. allowing for feedback from the ecology to the economy; 3. inclusion of intergenerational considerations; 4. possibility of describing qualitative changes; 5. inclusion of finiteness of available material and certain types of energy; 6. limitations of substitution, technological progress and population growth; and 7. the openness of the global economic-ecological system. Some of these considerations will make it possible to distinguish models for sustainable development from many other models that are used for dealing with economic-environmental problems. In the light of the conclusions, short descriptions of some representative analytical models that have arisen in theories on economic growth with renewable and non-renewable resources and pollution are critically looked upon. Also attention is paid to simple aggregate models that take an alternative point of view on growth and development. The next step is to provide additional elements and ideas for constructing a general economic-ecological model for sustainable development. For this reason we consider the suitability of inclusion in simple models of several concepts originating from economics, ecology and physics. A complete simple economic-ecological model for sustainable development is formulated in that way summarizing all discussions. Simulation is used to trace the characteristics of this model

VAN DER STRAATEN, JAN
Tilburg University , P.O. Box 90153, 5000 LE Tilburg/Holland

The Policy of the Netherlands Regarding Acid Rain in a Single Internal Market.

It is often argued that a freer internal market will increase economic welfare. In the Cecchini Report - which is the basis of European harmonization - this line of reasoning is dominant. But hardly any attention is given, however, to environmental problems. This approach neglects the important effects which the environment has upon economic welfare. Clean air may be defined as a collective property resource, which is affected by acid rain. An international approach may solve this problem and so economic welfare may increase. An analysis of the most recent Dutch policy can give more insight into the international aspects of Dutch policy and the possibilities of the Single Internal Market. The polluting substances are emitted by oil refineries, electric power plans, motorcars and intensive farming. The abatement of these emissions has been hampered by the well organized interests of the industries concerned. This is especially the case with oil refineries and intensive farming. The conclusion can be drawn that the Dutch policy has not been aiming at a welfare optimum regarding acid rain; they protected their own polluting industries. So, harmonization of environmental policies in Europe will be very difficult.

VAN DER STRAATEN, JAN
Tilburg University, P.O. Box 90153, 5000 LE Tilburg Holland.

Harmonization of Environmental Rules in the Single Internal Market: The Case of the Scheldt

In the Cecchini Report it is argued that a further harmonization of rules and measures in the European Community would increase production and employment. However, the harmonization of environmental rules has not received adequate attention.

Economic welfare, however, is influenced by the level of environmental deterioration. With increasing production in Europe, the international abatement of environmental deterioration will be of greater importance than ever before. We can get an idea about the possibilities of harmonizing the environmental rules in the Common Market by investigating an important international problem as the water pollution in the Scheldt River.

This pollution occurs mainly in Belgium, as a result of which the water quality of the Scheldt in the Netherlands is rather inferior. There are only two bargaining states: The Netherlands and Belgium. The

VAN PELT, MICHAEL J.F. and **KUYVENHOVEN, ARIE**
Netherlands Economic Institute, Rotterdam/Wageningen Agricultural University, Rotterdam, The Netherlands
NIJKAMP, PETER
Free University of Amsterdam, Amsterdam, The Netherlands

Sustainability and Project Appraisal in Developing Countries: Methodological Challenges

The paper critically examines the potential of two groups of project appraisal methods (viz. the OECD/World Bank variant of cost-benefit analysis and multicriteria analysis), to satisfactorily treat some of the most pressing sustainability issues in third world countries. The aim is to contribute to answering the question which method is most suitable for which sustainability issue.

VIEDERMAN, STEPHEN
President, Jessie Smith Noyes Foundation, 16 East 34th St., New York, NY 10016

Building the Field of Ecological Economics

The economics profession pays little attention to ecological economics. The "so-called" leading economics departments neither have nor are seeking faculty with a serious interest in the field. Graduate students committed to the field. Graduate students committed to the field are at risk of being poorly trained, not being taken seriously and not being employable. Young faculty members may have difficulty obtaining tenure. In institutions such as the World Bank and the United States Government, incentives to apply ecological economics are, at best, limited. How can institutional interest and commitment be developed to expedite the development of ecological economics? What constitutes institutional commitment? How can economists who know that their work is incomplete be encouraged to meet the challenge of developing ecological economics, responding to the world we live in and not the fiction that economists have created by omitting nature? What are the incentives to encourage social and professional acceptance for students and professionals? What tools--texts, internships, journals, etc.--are needed for the field to prosper? Can the field overcome the problems that have hindered other inter-, multi-, transdisciplinary programs?

VYASULU, VINOD
Social Services Management Unit, Institute for Social and Economic Change, Bangalore 560072, India

On Choosing Environmentally Sound and Self-Reliant Technologies: Reflections on Indian Experience

This paper explores the political economy approach in choosing environmentally sound and self-reliant technology in class societies, using India as an example. The term technology as used in this paper refers not only to technical knowledge or engineering blue prints, but also to the institutional forms through which such knowledge is profitably used; in capitalist society - commercialized. Also, technology and environment are seen as being closely intertwined. Each technology has some impact on the environment. The configuration of classes and societies will influence the nature of such environmental impact.

The paper uses two case studies, both drawing upon the experiences of Karnataka State in India. One is with the experience of diffusing a locally developed appropriate technology - a highly efficient wood burning stove - as opposed to the State's sponsored program of diffusing technology through imports. The second case study draws on the debate on energy planning in Karnataka, contrasting the conventional supply obsessed approach with a new development focussed paradigm which promotes both environmental soundness and self-reliance. This is followed by a discussion of the role of

the working class in choosing environmentally sound technology using examples of certain choices that need to be made in India in the near future. The paper illustrates the point that issues of technical choice from the environmental and self-reliance point of view form a part of the political economy of sustainable development.

WALKER, ROBERT
Department of Geography, Florida State University, Tallahassee, FL 32306

A Behavioral Model of Tropical Deforestation Under the System of Concession Logging

Deforestation in tropical countries commonly occurs when forest farmers follow logging roads, built by concession loggers, into cutover forests and appropriate land. A model of this process of land use conversion, resulting from logger-forest farmer interaction, has appeared in the literature. This model, however, suffers from several weaknesses that limit its utility as both an explanatory device and an instrument for policy formulation. The present paper offers a criticism of this model, which is wholly deterministic and relies on an unrealistically long planning horizon for concession loggers. A behavioral model is presented in which forest exploitation is conceptualized as a spatial process with Markov decision-making. Conditions under which forest is preserved are developed as is the explicit relationship between future contract forfeiture and deforestation. An important category of costs omitted from the deterministic model, namely those involving settlement pressure, is introduced into the present formulation. Management implications of the behavioral framework are indicated.

WEBER, A.W.
Wildlife Conservation International, Bronx, New York 10460

Nature Tourism in Rwanda: The Extension and Limits of Gorilla Economics

Nature tourism is increasingly cited as an appropriate form of development in tropical rain forests. Under the heading of ecotourism, controlled visits by small groups with specialized viewing interests (e.g. primates, birds) are thus believed to represent a potentially significant source of revenue which can be sustained with minimal environment impact.

The African nation of Rwanda has more than 10 years of experience with nature tourism focused primarily on the endangered mountain gorilla. This problem is reviewed with regard to its economic and conservation impact, both of which have been highly positive. This success, however, must be tempered with certain caveats pertaining to the distribution of tourism benefits as well as to the continued potential for negative impacts. It is further questioned whether the unique characteristics of gorilla tourism seriously reduce its value as a model for extension elsewhere. Initial results of a tourism project in Rwanda's Nyungwe forest nevertheless indicate that significant visitation rates and revenues can be achieved in a forest environment without gorillas, provided there are alternative attractions and as well-developed network of trails and support personnel.

The potential for extension of the Rwandan models of nature tourism to other rain forest environments is considered to be very real, yet limited. In most cases, additional economic and non-economic values will be required in support of conservation efforts.

WEBER, JEFF and MEISTER, ANTON
Department of Agricultural Economics, Massey University, Palmerston North, New Zealand

Managing Natural Resources, Institutional Change, and Sustainability in New Zealand: A Case Study

Towards the end of 1989, the New Zealand government formally introduced Resource Management Bill No. 224-1 into parliament. According to its authors, the central purpose of the bill is to integrate the laws relating to resource management, and to set up a resource management system that promotes sustainable management of natural and physical resources. The bill addresses the management of land, water and soil, minerals and energy resources, the coast, air, and pollution control.

This paper provides an analysis of New Zealand's effort to incorporate the concept of sustainability into natural resource and environmental management. We give particular attention to the proposed changes in institutions and how these could alter the current efforts at natural resource and environmental management. We also address the likely influence on the management of sustainability from the current government's adherence to an economy based on unregulated markets.

We conclude by placing the proposed New Zealand reforms in a framework of ecological economics. Although spokespersons have not used that phrase directly, the New Zealand government's proposed reforms present at least some awareness of ecological economics. This is clearly reflected in the promotion of sustainable management and in the setting of multiple objectives. However, the proposed reforms may not provide enough guidance on the relative weights that national and local administrators should place on each objective.

WELLE, PATRICK G.
Department of Economics, Bemidji State University, Bemidji, MN 56601

Translating Household Stewardship Values Into Ecological Stewardship Goals: Some Empirical Evidence

The establishment and pursuit of global, long-term goals depends upon the processes through which economic, social, and political institutions register the preferences of individuals and households. Economic and political mechanisms founded on individualistic values will most readily incorporate global, long-term goals which reflect individual preferences.

This paper examines individual and household preferences for protecting water quality under scenarios ranging from local to transboundary water pollution. The local case assesses household values toward the quality of the lakes on which the respondents reside. An intermediate case includes lakes within the county or retail trade area. The transboundary case entails the pollution of distant lakes due to acid deposition.

Empirical results are generated from a series of contingent valuation surveys employing similar methods and survey instruments. Economic valuation in the form of willingness to pay and qualitative responses about environmental stewardship are analyzed. The results suggest that preferences for local environmental stewardship translate quite well into stewardship of an ecosystem which is more broadly defined. Conditions which may promote or impede the translation of household stewardship values into global stewardship goals are discussed.

YOUNGMAN, R.R.
Department of Entomology, Virginia Polytechnic Institute and State University, Blacksburg, Va.
ERVIN, R.T.
Department of Agricultural Economics, Texas Tech University, Lubbock, TX 79409

Virginia Corn Producers' Use of Insecticides to Control Corn Rootworms Even Though They Rotate Their Crops: A Case Study

It has been shown that if producers rotate their corn with other crops on an annual basis, the use of a granular insecticide at planting is not needed to control corn rootworms. Corn producers in the state of Virginia USA) were surveyed with respect to their general practice in using granular insecticides at planting during the 1988 and 1989 crop years. A random mailing of 1,200 surveys to the state's corn producers resulted in a response rate of 47.8% (574 surveys) and a usable response rate of 25.2% (302 surveys). The usable responses represented 15,951 acres in 1988: accounting for 3.0% of the state's 530,000 corn acres the same year. Results of the study indicate that approximately 13.20% of the corn grown in the state is grown in rotation with other crops and also has granular insecticides applied at planting. Thus, it is estimated that in 1988 corn producers in Virginia spent $888,492 to control corn rootworms, or an average of $1,198,626 annually from 1979 to 1988. Results also indicate that in 1988 approximately 83,952 pounds of active ingredient were introduced into the Virginia environment, or an average of 113,256 pounds annually from 1979 to 1988. Other factors considered in this study are comparisons between rotation versus continuous corn producers in the number of years experience producing corn, types of granular insecticides used, reasons for using insecticides when rotation is being used or not used, and source of primary acquisition of pest control information. This information is needed to determine: 1. Whether chemicals are being introduced into the environment without justification; 2. Who may be misinforming producers as to the need of applying granular insecticides at planting; and 3. From whom producers are gathering their pest control information. Implications of the potential impact to the Chesapeake Bay estuarine environment are discussed.

ZIPARO, ALBERTO
Center for European Economic Studies, Northeastern University, Boston, Mass.

The Environmental Planning of Energy Projects

The study gives a general evaluation of four different proposals/scenarios of the National Energy Plan in Italy: the Old and the New Government Proposal, that of the Community Party, and the Greens' Proposal. A new National Energy Plan is needed over there after the national referendum that banned atomic energy.

The Old Government Plan had an electric program based on centralized power by using many nuclear and coal-fired plants. The New Proposal of the Italian government incorporated the outcome of the referendum (atomic energy was shut down), but it maintained the same approach as before by shifting almost all production on coal burning plants with very little reduction of the quantity of electricity produced.

The Communist Party's Proposal seeks to reduce the use of coal and the size of the plants by increasing the use of gas and by introducing some saving policies.

Greens proposed an opposite approach; they aimed to overtake what they call the "nukes-cokes trap" (if you stop using nuclear energy, then you need more coal and vice versa) by introducing strategies strongly implementing saving, renewable sources, and decentralization of production with regional balance between demand and supply of energy. The four

plan proposals were broken down by using the Energy Environment Impact Values (EEIV), an indicator of global effects of each model upon the social and environmental systems.

The results of the research show that the Green proposal is clearly the most convenient plan, not only because of environmental issues, but also because of a global economic point of view.

ZWAHLEN, ROBERT
Ecosens Ltd., Environmental Management Consultants, P.O. Box CH-8042, Zurich, Switzerland

Failure of Irrigation Projects and Consequences for a Different Approach: A Case Study

Two examples of irrigation schemes are investigated for reasons of project failure. In one case (Gwelwongo, a small-scale irrigation scheme in southern Burkina Faso), this was due mainly to socio-economic reasons: lack of interest and knowledge of the local population for operation and maintenance of the scheme, to some degree also lack of funds for maintenance work. In the other case (a part of the Wawotobi Irrigation Scheme, a middle-scale irrigation scheme in Southeast Sulawesi, Indonesia), the main reasons were ecological ones: no thorough site selection and/or preparation for irrigated fields in a swampy area. The consequences are briefly discussed.

The primary economic effects are easily visible: the projects do not generate any or at least not sufficient revenues, and therefore the investment can not be paid off. There are secondary effects which are less easily detected and monetarized, but have detrimental effects for the local economy. In both cases, the incidence of malaria among the local population has been increased by unknown amounts, and in the case of Burkina Faso, Schistosomiasis has become a severe problem in an area where it has not been of any importance before. This means not only high costs for medical treatment, but above all a loss of manpower due to illness, which again decreases productivity of the local agriculture. The attempted solutions are mainly technical ones and consist in an improvement of the drainage and in a reconstruction of the decaying structures. This alone however does not bring any guarantee for success. In both cases, insufficient planning has been the ultimate reason for project failure.

It is therefore concluded that a different approach to such projects is necessary, which takes into account not only (and not in the first line) the technical aspects of a possible development, but to a much greater extent the ecological and socio-economical parameters.

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RAVETZ, JERRY R., 4, 26
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RYKIEL, EDWARD J., 17, 45
SADLER, BARRY, 6, 76
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SCHLICHTER, TOMAS M., 5, 49
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SESHADRI, C.V., 5, 77

SHARP, BASIL M.J., 16, 77
SHEEHY, D. P., 11, 44
SHOEMAKER, ANDREW R., 15, 77
SHOGREN, JASON F., 6, 78
SHORTLE, JAMES S., 5, 12, 34, 78
SIMONIS, UNO E., 16, 78
SKLAR, FRED H., 11, 79
SMITH, GERALD ALONZO, 8, 79
SODERBAUM, PETER, 7, 79
SOUSA, CLARA DE, 13, 79
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SOUTHWORTH, FRANK, 11, 80
SPASH, CLIVE R., 9, 23
STUTH, J. W., 11, 44
SWART, R.J., 8, 80
T SAS-ROLFES, MIKE, 17, 82
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THOMAS, J.F., 7, 66
THRUPP, LORI ANN, 11, 81
TIETENBERG, TOM, 15, 81
TIEZZI, ENZO, 4, 32
TOBEY, JAMES A., 6, 81
TOLEDO, VICTOR M., 10, 82
TOMAN, MICHAEL, 7, 82
TOWNSEND, KENNETH N., 15, 77
ULANOWICZ, ROBERT E., 9, 32
ULGIATI, S., 4, 32
UNDERWOOD, DANIEL A., 7, 82
VAN DEN BERGH, JEROEN, 12, 83
VAN DER STRAATEN, JAN, 13, 16, 83, 84
VAN PELT, MICHAEL J.F., 6, 84
VARSHNEY, C. K., 14, 33
VIEDERMAN, STEPHEN, 7, 84
VYASULU, VINOD, 17, 84
WALKER, ROBERT, 11, 85
WALSH, RICHARD G, 13, 15, 58, 59
WEBER, A.W., 18, 85
WEBER, JEFF, 16, 85
WELLE, PATRICK G., 18, 86
YOUNGMAN, R.R., 5, 86
ZIPARO, ALBERTO, 17, 86
ZUCCHETTO, JAMES J., 14, 33
ZWAHLEN, ROBERT, 5, 87
ZYLICZ, TOMASZ, 14, 33

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

David G. Abler
Dept of Ag. Economics and Rural Sociology
The Pennsylvania State University
University Park PA 16802

Myrna Ahlgren
Koochoo, Inc.
P.O. Box 407
International Falls MN 56649

Janie B. Alcorn
Agency for International Development
4813 Morgan Dr.
Chevy Chase MD 20815

David Alden
University of Keele
Department of Economics and Management Scienc
Keele ST5 5BG United Kingdom

Claudia Alderman
Yale School of Forestry & Environ. Studies
1708 19th St. N.W., #3
Washington DC 20009

Susan Alexander
A.I.D.
New State Building, Room 331314
Washington, D.C.

Tania Ammour
Tropical Agriculture Research and Training Center
Turrialba Costa Rica

Ing-Marie Andreasson-Gren
The Swedish University of Agricultural Sciences
Dept. of Economics
Box 7013,
Uppsala 95007 Sweden

Gerhard Angerer
Fraunhofer-Inst. fur Systemtechnik
und Innovationsforschung
Breslauer Strasse 48
D-7500 Karlsruhe West Germany

Zehra Aydin
New School
United Nations Environmental Program
U.N.E.P. 2 U.N. Plaza, 6th Floor
New York NY 10017

Andrea Baranzini
Centre Universitaire d'Ecologie Humaine
9 Route de Troinex
Case Postale 266
1227 Carouge-Geneve Switzerland

Janet Barnes
Chesapeake Biological Laboratory
Box 38
Solomons MD 20688

Pamela Barr
Research Triangle Institute
1717 Mass Ave., NW 503
Washington DC 20008

Joy A. Bartholomew
Center for Policy Negotiation
490 Chippingwood Dr., Suite 1
Port Republic MD 20676

Carl R. Bartone
The World Bank
1818 H St., NW
Washington DC 20433

N. Bedi
Ministry of Natural Resources of Ontario
Whitney Block, Room 3442
Queens Park
Toronto, ONtario Canada MtA 1W3

Soren Bergstrom
Stockholm University
Urvadersgrand 6B
Stockholm University
S-11646 Stockholm Sweden

Fikret Berkes
Institute of Urban and Environmental Studies
Brock University
St. Catharines, Ontario CANADA L2S 2A1

Christine Bernardeau
APOGEE, Inc.
4350 East-West Highway
Bethesda MD

Stephen Bernow
Telus Institute
89 Borad St.

Adriana Bianchi
The World Bank
1818 H Street NW
Washington DC 20433

Michael W. Binford
Graduate School of Design
Harvard University
48 Quincy Street
Cambridge MA 02138

S. Bishnoi
Laboratory of Plant Ecology
P.G. Department of Botany
Dungar College
Bikaner (Raj) 334 001 INDIA

Sergio Bianco
Department of City and Regional Planning
University of Pennsylvania
3600 Chestnut St. Box 698
Philadelphia PA 19104

Luis A. Bojorquez-Tapia
Associate Mexico Program
Conservation International
1015 18th St., N.W., Suite 1000
Washington DC 20036

Gyula Bora
Dept of Economic Geography & Regional Economic
Budapest University
Dimitrov tér 8
Budapest IX HUNGARY

Kenneth E. Boulding
Institute of Behavioral Science
Campus Box 484
University of Colorado
Boulder CO 80309

Rene Bowser
University of Maryland,
Center for Global Change
College Park MD 20742

Leon C. Braat
Free University
Institute for Environmental Studies
Postbus 7161
1007 mc Amsterdam NETHERLANDS

Dennis Bradley
Forest Service, USDA
1992 Folwell Avenue
St. Paul MN 55108

Karin Brann
U. of Gothenburg
Gotgatan 12 A, 75222
Upsala, Sweden

Arthur Braunschweig
Hochschule St. Gallen
Selzstr. 13, CH-9000
St. Gallen Switzerland

Richard Brazee
School of Natural Resources
University of Michigan
2534 Dana Building
Ann Arbor MI 48109

Clemens B. Bribitzer
National Marine Fisheries Service
1335 East-West Highway
Silver Springs MD 20910

Elizabeth Bronson
Institute for Environmental Studies
Haltain Building
University of Toronto
Toronto, Ontario, M5A 1A4 Canada

Peter Brown
School of Public Affairs
Rm 3100 Morill Hall
University of Maryland
College Park MD 20742

Wilson B. Brown
University of Winnipeg
Dept. of Economics
515 Portage Ave.
Winnipeg, Manitoba Canada

Donald Browne
Univ. of California
5532 Boelter Hall
Los Angeles CA 90024-1597

Mathew Buresch

Alan A. Burnett
Dept. of International Relations
Research School of Pacific Studies
Box 4
Canberra 2601 Australia

William G. Cale
Indiana University of Pennsylvania
College of Natural Sciences and Mathematics
305 Weyandt Hall
Indiana PA 15705-1087

David C. Campbell
National Wildlife Federation
1400 16th St., NW
Washington DC 20036

A. D. Capistrano
Food and Resource Economics
University of Florida
Gainesville FL 32611

Armando Carbonell
Ecologia, Inc.
6 Pond Meadow Drive
Marston Mills MA 02648

Stanley R. Carpenter
School of Social Sciences
Georgia Institute of Technology
Atlanta GA 30332

Elisabetta Castellani
Il Manifesto
1420 33rd Street, NW
Washington DC

Sergio Castillo
PRMC
CATIE
Turrialba 7170 Costa Rica

Clovis Cavalcanti
Fundacão Joaquim Nabuco
Rua Dois Irmaos, 92
50.000 Recife, PE 52.07 BRAZIL

Dennis Cengel
Mississippi State University
Forestry Dept., P.O. Drawer FR
Mississippi State MS 39762

Anthony T. Charles
St. Mary's University
Halifax, Nova Scotia Canada

Daniel L. Childers
Baruch Marine Lab
University of South Carolina
Georgetown SC 29442

Paul P. Christensen
Department of Economics, Asst. Professor
Hofstra University
Hempstead NY 11550

Andre Ciaccio
ITALTEENA
1155 Connecticut Ave., NW
Washington DC 20036

Mary E. Clark
Department of Biology
San Diego State University
San Diego CA 92182

Colin Clark
Institute of Applied Mathematics
The University of British Columbia
Vancouver BC V6T 1Y4 CANADA

Cutler J. Cleveland
Dept. of Geography
675 Commonwealth Ave.
Boston University
Boston MA 02215

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

Michael E. Colby
2104 N. Quantico St.
Arlington VA 22205

Michael S. Common
Centre for Resource & Environmental Studies
Australian National University
P.O. Box 4
Canberra, ACT 2601 Australia

Craig Conley
Dept. of Applied Sciences
University of California
Davis CA 95616

J. R. Conner
Texas A&M University
Department of Agricultural Economics
College Station TX 77843-2124

Allison Cook
ASCI Corporation
1365 Beverly Road
McLean VA 22101

Joseph D. Cornell
SUNY Envir. Sci and Forestry
301 Illick Hall
Syracuse NY 13210

Laura Cornwell
CBL
P.O. Box 38
Solomons MD 20688

Robert Costanza
Center for Environmental and Estuarine Studies
Chesapeake Biological Lab
University of Maryland
Solomons MD 20688

M. Gary Costello
191 Sherman ST.
Cambridge MA 02140

Paul Cough
International Resouces Group
527 Greenwich St.
Falls Church VA 22046

John Coulter
Griffith University
7 Yarabain Crescent
Shailer Park
Brisbane, Qld 4128 Australia

Paul P. Craig
Sustainable Futures Research Group
Department of Applied Science
University of California
Davis CA 95616

Pierre Crosson
Resources for the Future
1616 P Street NW
Washington DC 20036

John Cumberland
Department of Economics
University of Maryland
Tydings Hall, Room 4148
College Park MD 20742

Ralph C. d'Arge
Department of Economics
University of Wyoming
P.O. Box 3985, University Station
Laramie WY 82071

Bruce E. Dale
Texas A and M University
Biosystems Research Division
College Station TX 77843-3131

Herman Daly
Environment Department
The World Bank
1818 H. Street, N.W.
Washington DC 20433

Lincoln H. Day
Department of Demography
Australian National University
Canberra, A.C.T.

John C. Day
Economic Research Division
U.S. Dept. of Agriculture
1301 New York Avenue NW
Washington DC 20005

Alice T. Day
1511 22nd Street NW Apt 34
Washington D.C. 20037

Paul DeLong
The Conservation Foundation
1250 24th St., NW
Washington DC 20037

Eric Denzler
Center for Energy and Environmental Studies
Boston University
675 Commonwealth Ave.
Boston MA 02215

John DeVilbiss
USDA, Forest Service
333 Wright Street Apt #304
Lakewood CO 80228

Bert DeVries
RIVM
P.O. Box 1,
Bilthoven 3720BA The Netherlands

Joshua Dickinson
Tropical Research and Development
519 NW 60th St., D
Gainesville FL 32607

Antonio Carlos Diegues
University of Sao Paulo
Rue Rodrigues Guiao 26
Sao Paulo 05429 BRAZIL

Frank Dietz
Erasmus University
Department of Public Administration
P.O. Box 1738
Rotterdam 3000 Dr The Netherlands

Ariel Dougherty
Box 938
East Hampton NY 11937

Andrew K. Dragun
Latrobe University
Bundoora, Victoria Australia

F. Duchin
Institute for Economic Analysis, NYU
269 Mercer ST.
New York NY 10003

Beth Dunlop
Dept. Applied Science
University of California
Davis CA 95616

Frances Eargle
House Committee Merchant Marine Fisheries
House Annex 2, Room 54
Washington D.C. 20003

Richard S. Eckaus
Massachusetts Institute of Technology
Department of Economics
Cambridge MA 02139

Salah El Serafy
The World Bank
1818 H. St., N.W.
Washington DC 20433

Willem G. Engelbrecht
Development Bank of Southern Africa
1020 Wilhelm Road, Eldoraigne
Verwoerdburg, 0157 South Africa

Karl-Erik Eriksson
Goteborg University & Chalmers Univ. of Tech.
Institute of Physical Resouce Theory
Goteborg S-412 96 SWEDEN

Gunnar Eskeland
The World Bank
1818 H St., NW
Washington DC 20433

Michael Everett
East Tennessee State University
Department of Economics and Finance
Johnson City TN 37614

Malte Faber
Sozial u. Staatswissenschaften
University of Heidelberg
Grabengasse 14
Heidelberg, D-6900 FRG

Stephen C. Farber
Economics Department
Louisiana State University
Baton Rouge LA 70803

Sylvie Faucheux
Centre-Economie-Espace-Environnement
Université de Paris I. Panthéon Sorbonne
90 rue de Tolbiac
Paris 75013 FRANCE

Philip Fearnside
National Institute for Research in the Amazon (INPA
C.P. 478
Manaus-Amazonas 69-011 BRAZIL

Eran Feitelson
Apogee Research Inc.
4350 East-West Highway
Suite 600
Bethesda MD 20814

Robert Fenton
University of Winnipeg
515 Portag Avenue
Winnipeg, Manitoba Canada

Martin Fernandez
Fundacion Ambiente & Recursos Naturales
Monroe 2142
Buenos Aires 1428 Argentina

Janine Finnell
Meridian Corp.
4300 King St.
Suite 400
Alexandria VA 22302

Christopher Flavin
Worldwatch Institute
1776 Massachusetts Ave., N.W.
Washington DC 20036

Jean Flemma
Subcommittee on Fisheries, Wildlife Conse
House Annex II, Room 543
Washington DC 20515

Jose G. Flores Rodas
Centro Agronomico Tropical De Investigac
Turrialba COSTA RICA

Gordon Foer
Coastal Resources Center
University of Rhode Island, Bay Campus
Narragansett RI 02882

Carl Folke
Askö Laboratory
University of Stockholm
Stockholm S-106 91 Sweden

George Foy, Jr.
Department of Economics
University of Central Arkansas
Conway AR 72032

Anthony M. Friend
Inst. for Research on Environment and Eco
University of Ottawa
165 Waller St.
Ottawa Ont. K1N 6N5 CANADA

Silvio Funtowicz
Institute for Systems Engineering
Joint Research Centre
Commission of the European Communities
Ispra (VA) 21020 Italy

Christine Fux
Vienna Univ. of Economics and Bus. Admi
Doppelngasse 55
Klosterneuburg 3400 Austria

Mario Giampietro
U. of Special Food Technology
Instituto Nazionale della Nutrizone, via Ard
Cornell University
Roma, 00178 Italy

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

Gene Gibson
1825 Connecticut Ave., N.W.
Washington DC 20009

Alison Gilbert
Institute for Environmental Studies
Free University, Amsterdam
P.O. Box 7161, 1007 MC NETHERLANDS

G.P. Glasby
New Zealand Oceanographic Institute
DSIR, Private Bag, Kilbirnie
Wellington, New Zealand

Harold Glasser
3308 University Avenue
Davis CA 95616

Nicole Gilneur
The World Bank
1818 H Street, NW
Washington DC 20433

Martin Goebel
Conservation International
1015 18th St., N.W., Suite 1000
Washington DC 20036

Robert Goodland
The World Bank
1818 H. Street, N.W.
Washington DC 20433

Neva Goodwin
Center for Study of Global Dev. and Change
11 Lowell Street
Cambridge MA 02138

William Goodwin
USAID
7689 Middle Valley Drive
Springfield VA 22153

Deborah Gordon
Union of Concerned Scientists
1616 P. Street NW
Washington DC 20036

Robert R. Gottfried
The University of the South
Sewanee TN 37375

Marcia Gowen
Winrock International Inst. for Agric. Dev.
1611 N. Kent St., Suite 600
Arlington VA 22209

John Gray
Dept. of Economics
University of Manitoba
Winnipeg, Manitoba Canada R3T 2N2

Stephen Greene
Chronicle of Philanthropy
1255 23rd St., NW
Washington DC 20037

Elaine Grigsby
USAID
American Embassy
APO Miami FL 34020

David J. Greenfeldt
World Wildlife Fund
1250 twenty-Fourth St., NW
Washington DC 20037

Julia Greesman
University of Toronto
18 Madison Ave.
Toronto, Ontario Canada M5R 2S1

Thurman Grove
USAID
Room 403, SA-18
USAID/SST/AGR
Washington DC 20523

Anthony Guglielmi
Center for Popular Economics
12 Grant Avenue
Northampton MA 01060

Carlos Castilla Gutierrez
University de la Laguna
Dept. of Economia Aplicada
38 204 La Laguna
Tenerife Spain

David Haenke
The Ecological Society Project
of the Tides Foundation, Inc.
Rt.1, Box 20
Newburg MS 65550

Otis F. Hall
School of Forestry & Wildlife Sci.
Virginia Tech
Blacksburg VA 24061

Charles A.S. Hall
College of Environmental Science and Forestry
301 Illick Hall
SUNY
Syracuse NY 13210

Robert A. Hamburg
Omega-Alpha Recycling Systems
Rt. 1, Box 51
Orma WV 25268

Pamela Hamilton
Eco-Concerns, Inc.
411 Legation St., N.W.
Washington DC 20015

Monica Hammer
Askö Laboratory
Dept. of Natural Resource Management
Stockholm University
Stockholm S-10691 SWEDEN

Bruce Hannon
Geography Department
220 Davenport Hall
University of Illinois
Urbana IL 61801

Michael Hanrahan
Dev. Alternatives-Fragile Lands Project
624 9th St., #600
Washington DC 20001

Garrett Hardin
University of California at Santa Barbara
399 Arboleda Rd. (home)
Santa Barbara CA 93110

Jonathan M. Harris
Boston University
9Marine Avenue
Cambridge MA 02139

Joseph Harvey
Rocky Mountain Institute
1739 Snowmass Creek Road
Snowmass CO 81654

Ann Hawkins
Cornell University
Warren Hall
Ithaca NY 14853

Stuart Jackson Hayward
Bermuda Government
P.O. Box SN 100, Southhampton
Bermuda SNBX

W. Hediger
Paul Scherrer Institute
CH-5232
Vinnigen PSI Switzerland

Susan Hedman
School of Public Affairs
Morrill Hall
University of Maryland
College Park MD 20742

Lamont C. Hempel
Center for Politics and Policy
The Claremont Graduate School
170 East 10th
Claremont CA 91711

Robert A. Herendeen
Illinois Natural History
University of Illinois
607 E. Peabody
Champaign IL 61801

Alison L. Hess
Office of Technology Assessment
Congress of the United States
Washington, D.C. 20510

T. L. Hill
New Society Publishers
4527 Springfield Avenue
Philadelphia PA 19143

Jeff Himmelberger
Clark University
21 Freeland St., #3
Worcester MA 01603

Benjamin Hitchner
Center for Economic Education
Glassboro State College
Bunce Hall
Glassboro NJ 08028

David Hodas
Widener University School of Law
4601 Concord Pike, Box 7474
Wilmington DE 19803-0424

Lynn Hodgkinson
Department of Economics
University College of North Wales
Bangor, Gwynedd LL57 2DG North Wa

John Holland
Development Bank of Southern Africa
44 Nelimapius Dr.
Irene, 1675 South Africa

Vineeta Hoon
Shri A.M.M. Murugappa Chettiar Research
Tharamain, Madras 600113 India

William L. Hoover
Dept. of Forestry & Natural Resouces
Purdue University
West Lafayette IN 47907

James F. Hornig
Dartmouth College
Hanover NH 03755

Roefie Hueting
Central Bureau for Statistics
Rosiolstraat 6
Den Haag 2596 UN NETHERLANDS

David W. Hughes
Washington State U. Dept. of Agricultural
103G Hulbert Hall
Pullman, Wash. 99164

Susan Hunt
The University of Pennsylvania
The Other Economic Summit-Newsletter Ed
3718 Locust Walk
Philadelphi PA 19104

Jim Igoe
Dept. of Anthropology
Boston University
232 Bay State Rd.
Boston MA 02215

Saburo Ikeda
Institute of Socio Economic Planning
University of Tsukuba
Tsukuba, Ibaraki 305 JAPAN

Eduardo Inigo-Elias
Centro de Estudios para la Conservacion
A.C. Ecosfera, Apdo. Postal 219
C.P. 29200 San Cristobal de las Casas
Chiapas Mexico

David C. Iverson
USDA Forest Service
Intermountain Region
324 25th St.
Ogden UT 84401

Dorie J. Jansen
World Wide Fund for Nature
P.O. Box 8437
Causeway
Harare ZIMBABWE

Ann Mari Jansson
Askö Laboratory, University of Stockholm
Stockholm Sweden

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

Bengt Owe Jansson
Askö Laboratory, University of Stockholm
Stockholm **Sweden**

Jonathan Jeffer
Boston University Center for Energy and Environme
43 Royal St.
Waterton, MA 02172

Xuemin Jiang
Dept. of Agricultural Economics
Kansas State University
Manhattan **KA** 66506

Paul Jivoff

DeWitt John
The Aspen Institute
1333 New Hampshire Ave., N.W.
Suite no. 1070
Washington D.C. 20036

Richard Johnson
U.S. Fish and Wildlife Center
National Ecology Research Center
4512 McMurray Avenue
Fort Collins **CO** 80525

Twig Johnson
Office of Forestry, Environment & Nat. Res.
AID. Room 509 SA-18
Washington **DC** 20523-1812

Gopal K. Kadekodi
Institute of Economic Growth
University Enclave
Delhi, 1100007 **India**

H. Fred Kaiser
DSDA Forest Service
12th St & Independence Ave SW PO Box 96090
Washington DC 20090

Robert Kaufmann
Center for Energy and Environmental Studies
Boston University
675 Commonwealth Ave.
Boston **MA** 02115

Helen M. Kennedy
Office of Enforcement and Compliance Monitoring
U. S. EPA
401 M Street, SW
Washington **DC** 20460

Kusum Ketkar
W. Paul Stillman School of Business
Seton Hall University
S. Orange **NJ** 07079

Elias Khalil
New School for Social Research
1102 E. Elm St., #1
Springfield **MO** 65806

Robert J. King
P.O. Box 12003
Austin **TX** 78711

Dennis M. King
ICF Inc.
9300 Lee Highway
Fairfax **VA** 22031

John Kirton
University of Toronto
Centre for International Studies
18 Madison Ave
Toronto M5R 2S1 **Canada**

Victor Klemas
Center for Remote Sensing
College of Marine Studies
University of Delaware
Newark **DE** 19716

Federico Aguilera Klink
Universidad de la Laguna
Departamento de Economia Aplicada
38204 La Laguna
Tenerife **Islas Canarias, Spain**

Allen V. Kneese
Resources for the Future
1616 P St., N.W.
Washington **DC** 20036

Arthur Koedam
Elsevier
Physical Science and Engineering Division
Sara Burgerhartstraat 25
1055 KV **Amsterdam**

G. H. Kohlmaier
Inst. fur theoretische und Physikalische Chemie
Johann-Wolfgang-Goethe-Universitat
Niederurseler Hang
Frankfurt/ Main 50 D-6000 **WEST GERMANY**

Keith Kozloff
Dept. of Agriculture and Applied Economics
University of Minnesota
1919 Buford Ave
St. Paul **MN** 55108

Steven E. Kraft
Dept. Ag. Bus. Econ.
Southern Illinois Univ.
Carbondale **ILL** 62901

Jeffrey A. Krautkraemer
Resources for the Future
1616 P St., NW
Washington **DC** 20036

John H. Kun
Dept. of Agri. & Rersource Economics
Colorado State University
Fort Collins **CO** 80523

Bruce Larson
ERS
1301 New York Ave, NW, Room 508
Washington **DC** 20005

Douglas J. Lawrence
USDA Soil Conservation Service
P.O. Box 2890
Washington **DC** 20013

Danny C. Lee
Resources for the Future
1616 P Street NW
Washington **DC** 20036

J. Lloyd Lill
State University of New York Empire State College
c/o CCFL
Canadalgua **NY** 14424

Karin Limburg
Cornell University
Section of Ecology & Systematics
Ithaca **NY** 14853

Marji Lines
University of Venice
Department of Economics
Ca Foscari
30123 Venezia **Italy**

Chris H. Livesey
Ministry for the Environment
P.O. Box 10362
Wellington **New Zealand**

Stephen Lonergan
Deparatment of Geography
University of Victoria
P.O. Box 1700
Victoria, B.C. V8S 4K5 **Canada**

Garrell E. Long
Washington State University
Department Entomology
Pullman **WA** 99169-6432

Ian Lowe
Science and Policy Research Centre
Griffith University
Nathan
Brisbane **QLD** 4111 **AUSTRALIA**

Gabriel A. Lozada
Department of Economics
Texas A&M University
College Station **TX** 77843

Rusdian Lubis
Center for Environmental Studies
Hasanuddin University
256 S. 16th St.
Philadelphia **PA** 19102

Jackelyn Lundy
Agroecology Program
University of California
Santa Cruz **CA** 95064

Ernst Lutz
The World Bank
1818 H Street, N.W.
Washington **DC** 20433

John T. Lyle
California State Polytechnic University
3801 W. Temple
Pomona **CA** 91768

John C. MacLean
J.C. MacLean & Co.
548 Massachusetts Avenue
5 th. floor
Boston **MA** 02118

Gerhard Maier-Rigaud
Institute for European & Envi. Policy
Impekovener Str. 4
D-5305 Alfter **FRG**

Nabiel Makarim
Government of Indonesia
Population and the Environment
256 S. 16th St.
Philadelphia **PA** 19102

Thomas Malone
Center for Enviromental & Estuarine Studi
University of Maryland
P.O. Box 775
Cambridge **MD** 21613

Jerre Manarolla
5804 Lenox Road
Bethesda **MD** 20817

Michael Maniates
Radford University
Dept. of Geography
Box 5811
Radford **VA** 24142

Ramon Margalef
Dept. of Ecology
University of Barcelona
Avg. da Diagnol 645
Barcelona e-08028 **SPAIN**

Larry Martin
The Other Economic Summit, North Amerk
1442 Harvard St., NW
Washington **DC** 20009

Juan Martinez-Alier
Dept. Economia i Historia I Economica
Universitat Autonoma de Barcelona
Bellaterra, E-08193
Barcelona **SPAIN**

Geoffrey J. Matthews
World Bank
1818 H. Street
Washington **DC** 20433

Peter H. May
Brazilian Agroforestry Network
R. Paissandu, 269/103
22210 Rio de Janeiro, RJ **BRAZIL**

Kozo Mayumi
c/o Jun Kiniwa 3-2-17
Miyamadai Tarumi-ku
Kobe 655 **JAPAN**

Patrick McCabe
EPA/OPPE
401 M St., S.W. PM 220
Washington **DC** 20460

William McConnell
Clark University
950 Main Street
Worcester **MA** 01610

Jacqueline McGlade
Theoretical Ecology Working Group
ATO, KFA Postfach 1913
Julich D-5170 **West Germany**

Robert McKelvey
Mathematic Sciences
University of Montana
Missoula **MT** 59812

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

Thomas E. McKone
Lawrence Livermore Lab
P.O. Box 5507, L453
Livermore **CA** 94550

Leonid Gr. Melnik
Sumy Department of Kherkov
Polytechnical Institute
Sumy **USSR**

Mary A. Melnyk
Imperial College Centre for Environ. Tech.
48 Prince's Gardens
London SW7 2PE **United Kingdom**

Clark Lee Merriam
The Cousteau Society
930 West 21st St
Norfolk, **VA** 23517

Alden Meyer
Climate Change and Energy Program
Union of Concerned Scientists
1616 P St., NW
Washington **DC** 20036

R. Gregory Michaels
U.S.E.P.A.
401 M St., SW
Washington **DC** 20460

Joseph A. Mihursky
Chesapeake Research Consortium
CBL
Box 38
Solomons **MD** 20688

Tim Miller
University of California
Demography Departament
2232 Piedmont Ave.
Berkeley **CA** 94720

Russell Misheloff
USAID
Bureau for Science & Tech., Room 509
Washington **DC** 20523-1812

William J. Mitsch
School of Natural Resources
The Ohio State University
2021 Coffey Road
Columbus **OH** 43210

Jennie Moehlmann
American Institute of Biological Sciences
6569 Williams Walk
Falls Church **VA** 22042

Tracie E. Monk
Asia/Pacific Operations
1917 S. Randolph St.
Arlington **VA** 22204

Michael Montagna
Maine State Planning Office
184 State Street
Augusta **ME** 04333

Ward Morehouse
Council on International and Public Affairs
777 United Nations Plaza
New York **NY** 10017

Carl Mrozek
Dutcherville Road
Bernhards Bay **NY** 13028

Martin J. Munroe
LBJ School of Public Affairs
University of Texas at Austin
611 South Congress St.
Austin **TX** 28704

Mark P. Murray
Council for Renewable Energy Education
1730 N. Lynn St., Suite 610
Arlington **VA** 22209

Maria Rosa Nachon
P.O. Box 362
North Hampton **MA** 01062

Guy Nicolson
BIOPLAN
6 Indwa Place
Kloof 3610 **South Africa**

Richard B. Norgaard
Energy & Resources Group
Rm 100 Bldg. T-4
University of California
Berkeley **CA** 94720

Bryan Norton
School of Social Sciences
Georgia Institute of Technology
Atlanta **GA** 30332

Clifford Nowell
Weber State University
Ogden **UT** 84403

Ruben Nunez
ABT Asso. Inc.
4800 Montgomery Lsne,Suite 500
Bethesda **MD** 20814

Howard T. Odum
Environmental Engineering Sciences
and Center for Wetlands
University of Florida
Gainesville **FL** 32601

Betty Odum
Santa Fe Community College
P.O. Box 1530
Gainesville **FL** 32602

Raymond C. Offenheiser
The Ford Foundation
320 East 43rd St.
New York **NY** 10017

Martin Ogle
Northern Virginia Regional Park Authority
Potomac Overlook Regional Park
2845 Marlay Road
Arlington **VA** 22207

Stephen Olsen
Coastal Resources Center
University of Rhode Island
South Ferry Road
Narragansett **RI** 02882

Sally Olsen
Coastal Resources Center
University of Rhode Island
South Ferry Road
Narragansett **RI** 02882

Ragnar Overby
ECO-MATIC Services
6027 N. 6th Street
Arlington **VA** 22203

Miguel Sanchez Padron
Universidad de la Laguna
Dept. de Economia Aplicada
38 204 La Laguna
Tenerife **SPAIN**

Talbot Page
Environmental Studies
Brown University
Providence **RI** 02912

Vijay Paranjpye
Ness Wadia College of commerce
Durga 92/2
Earandawane, Gangote Path
Pune 411 004 **India**

Ginger Parker
Boston Parks Dept.
100 Day St.
Jamaica Plain **MA** 02130

Dawn Parks
10 E Madison St., Apt. 1C
Baltimore **MD** 21202

Helen Parris
1054 Spodina Cres. E.
Saskatoon, Saskatchewan **Canada S7K 3H7**

Marilia Pastuk
Brazilian Agroforestry Network
R. Paissandu, 269/103
22210 Rio de Janeiro, RJ **BRAZIL**

Bernard C. Patten
Department of Zoology
University of Georgia
Athens **GA** 30602

Marie Patten
Department of Zoology
University of Georgia
Athens **GA** 30602

Henry Patton
Sustainable Resource Development Group
Chenowith Road
Underwood **WA** 98651

Charles Paulsen
Resources for the Future
1616 P St., N.W.
Washington **DC** 20036

John Peet
Dept. of Chemical & Process Engineering
University of Canterbury
Christchurch 1 **NEW ZEALAND**

Charles A. Perringe
University of Auckland
Department of Economics
Private Bag
Auckland 1 **New Zealand**

Henry M. Peskin
Edgevale Associates, Inc.
1210 Edgevale Rd.
Silver Spring **MD** 20910

E. Dale Peterson
Economics Department
Mankato State University
Mankato **MN** 56001

Steven C. Peterson
Ecology and Environment, Inc.
Buffalo Corporate Center
368 Pleasantview Drive
Lancaster **NY** 14086

John Pezzey
Environment and Behavior Prog.
Campus Box 468
Boulder **CO** 80309

Antonio L. Philomena
FURG
rua Alberto Torres, 161
Porto Alegre, RS 90050 **Brasil**

Gonzague Pillet
University of Geneva
51, Av. du Bois-de-laChapelle
CH1213 Onex-Geneva **Switzerland**

Richard Pinkham
Cornell University
116 Heights Ct.
Ithaca **NY** 14850

John Piotti
Box 390
Albion **ME** 04910

Christopher S. Potter
Agency for International Development
Room 406J, S&T/Agr. AID, SA-18
Washington **DC** 20523

Judith Press
90 Quai de Jemmapes
Paris 75010 **France**

John L.R. Proops
Dept. of Economics and Management Scie
University of Keele
Keele, Staffordshire ST 5 5GB **United K**

Steve Pulaski
Agency for International Developement
Washington, D.C. 20520

Garry Pursell

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

Emilio Quintana-aquirre
INIA
AV de las Torres 37, 4
E-50008 Zaragoza **Spain**

John Ragland
AID/Bifad
Rm 600 State Annex
515 2nd St NW
Washington D.C. 20523

David J. Rapport
University of Ottawa
Inst. for Research on Environment and Economy
165 Waller
Ottawa KIN 6N5

William E. Rees
School of Community and Regional Planning
The University of British Columbia
6333 Memorial Road
Vancouver **BC** V6T 1W5 **CANADA**

Katarina Revstrom
Gottenburg University
Brathallsgatan 20
78142 Borlange **Sweden**

Thomas Robertson
1901 Columbia Rd., NW
Washington **DC** 20009

Dianne E. Rocheleau
Clark University

Helena T. Roland
Pacific Gas and Electric Co.
3400 Crow Canyon Road
San Ramon **CA** 95483

Paul Rothkrug
1998 Broadway, Apt. 806
San Francisco **CA** 94109

Michael C. Rubino
Palmetto Aquaculture Corporation
4350 East West Highway, Suite 600
Bethesda **MD** 20814

Matthias Ruth
Depatment of Geography
220 Davenport Hall
607 South Mathews Avenue
Urbana **IL** 61801

Edward J. Rykiel, Jr.
Center for Biosystems MOdeling
Texas A&M University
College Station **TX** 77843

Nadia Saad
The World Bank
1818 H St., NW
Washington **DC** 20433

Barry Sadler
Institute of the NorthAmerican West
510-750 Cambie St.
Vancouver **BC** V6B 2P2 **CANADA**

Sylvia Sandoz-Terraz
Dept. of Geograpy
Uniersity of Geneva
Geneva **Switzerland**

Dagmar S. Saschek
University of California
444 International House
Berkeley **CA** 94720

Jackie Savitz
Chesapeake Biological Lab
Solomons **MD**

Allan Savory
Center for Holistic Resource Management
Box 7128
Albuquerque **NM** 87194

Tomas M. Schlichter
Tropical Agriculture Research and Training Center
Turrialba **Costa Rica**

Eric Schneider
NOAA
1825 Connecticut Ave.
Washington **DC**

Trent Schroyer
Department of Sociology-Philosophy
Ramapo College of New Jersey
505 Ramapo Valley Road
Mahwah **NJ** 07430

David M. Scienceman
Center for Wetlands
University of Florida
Gainesville **FL** 32611

Basil M.H. Sharp
Centre for Resource Management
University of Canterbury
Christchurch **New Zealand**

Andrew R. Shoemaker
Hampden-Sydney College
P.O. Box 102
Hampden-Sydney **VA** 23943

Jason Shogren
Department of Economics
Iowa State University
Ames **IO** 50011

Jael Silliamn
Noyes foundation
16 East 34th St
NY, NY 10016 **NJ** 07605

David A. Simmons
Caribbean Conservation Assoc.
Savannah Looge, The Garrison
St. Michael **Barbados**

Udo E. Simonis
Wissenschaftszentrum Berlin
Reichpietshufer 50
D-1000 Berlin (West) **30 FRG**

Fred H. Sklar
Baruch Marine Laboratory
University of South Carolina
Georgetown **SC** 29442

Wade B. Smith
The Mitre Corp.
7525 Colshire Drive
McLean **VA** 22102

Gerald Alonzo Smith
Dept. of Economics
Mankato University
Mankato **MN** 56002

Emily Smith
Business Week Magazine
1120 Avenue of the Americas
New York **NY**

Jennifer Smith
World Wildlife Fund
1250 24th St., NW
Wasington **DC**

Peter Söderbaum
Department of Economics and Statistics
Swedish University of Agricultural Sciences
Box 7013
S-750 07 Upsala **SWEDEN**

Clive L. Spash
University of Wyoming
University Station, Box 3985
Laramie **WY** 82071

Wendy Stambler
1316 N. Hampshire Ave., NW #707
Washington **DC** 20036

Oliver Ray Stanton
Chilly
74140, Douvaine
Douvaine **FRANCE**

Klaus Steiner
Vienna University of Economics and Business
BANDG. 2/10
Wien 1070 **Austria**

Karl Steininger
University of California, Berkeley
838 Santa Barbara Rd
Berkeley **CA** 94707

Steven Stone
Cornell University
Dept. of Agric. Econ.
444 N. Tiogh St.
Ithaca **NY** 14850

Jeffrey Sundberg
Lake Forest College
Lake Forest **IL** 60045

Margaret Symington
Agency for Internatioanl Development
LAC/DR/E, Room 2242 NS
Washington **DC** 20523

Barbara Taggart
Research Triange Institute
1717 Mass AVe., NW
Washington **DC** 20036

Jesse Tatum
Michigan Technology Univ.
Science Technology and Society Program

Kenneth J. Taylor
Minnesota Food Association
2395 University Ave., #309
St. Paul **MN** 55414

Stephen Tennenbaum
4305 Rowalt Drive, Apt. 201
College Park **MD** 20740

John F. Thomas
CSIRO Australia
Private Bag,
PO Wembley, WA 6014 **Australia**

James P. Thomas
U.S. Dept. Commerce-NOAA/NMFS
1335 East West Highway
Silver Spring **MD** 20910

Lori-Ann Thrupp
Energy and Resources Program
University of California
Bldg T4, RM 100
Berkeley **CA** 94720

Tom Tichenor
USDA
3427 Oliver St., N.W.
Washington **DC** 20015

Thomas Tietenberg
Colby College
Miller Library 234
Waterville **ME** 04901

Enzo Tiezzi
Director, Department of Chemistry
Universitá di Siena
Pian dei Mantellini
Siena, I-44-53100 **ITALY**

Elizabeth Titus
Tellus Institute
89 Broad St.
Boston **MA** 02110

James Tobey
USDA/Economic Research Service
1301 New York Ave., NW, Room 508
Washington **DC** 20005

Victor M. Toledo
Centro De Ecologia
Universidad Nacional Autonoma de Mexic
APDO 70-275
Mexico DF 04510 **MEXICO**

Michael Toman
Resources for the Future
1616 P Street, NW
Washington **DC** 20036

ISEE Conference Participants, May 21-23, The World Bank, Washington, DC

Kenneth N. Townsend
Hampden-Sydney College
P.O. Box 102
Hampden-Sydney **VA** 23943

Mike Tsas-Rolfes
Dept. Business Economics
University of the Witwatersrand
South Africa

Gene Tyner, Sr.
Tyner and Associates
Oklahoma Institute for a Viable Future
316 South Peters, Box 2607
Norman **OK** 73070

Alyce Ujihara
Resouces for the Future
1616 P St., NW
Washington **DC** 20036

Robert Ulanowicz
Chesapeake Biological Laboratory
University of Maryland
Solomons **MD** 20688

Daniel A. Underwood
Department of Economics
Denison University
Granville **OH** 43203

Gail E. Updegraff
USDA Soil Conservation Service
P.O. Box 2890
Washington **DC** 20013

Jeroen C.J.M. van den Bergh
Free University of Amsterdam
Faculty of Economics
1007 MC Amsterdam **The Netherlands**

Jan van der Straaten
Tilburg University
Postbox 9015
Tilburg 5000 LE **HOLLAND**

Michael J.F. van Pelt
Netherlands Economic Institute
Borchsatelaan 67
Rotterdam 3055 ZG **The Netherlands**

Harvey van veldhuizen
Dames and Moore International
7101 Wisconsin AVe., Suite 700
Bethesda **MD** 20814

C. K. Varshney
School of Environmental Science
Jawahralal Nehru University
New Mehrauli Road
New Delhi 110067 **INDIA**

Amy Vedder
Wildlife Conservation International
712 Locksley
Yorktown **NY** 10598

Stephen Viederman
Jessie Smith Noyes Foundation
16 E. 34th St.
New York **NY** 10016

Rai Vogelsberger
Clark University
21 Freeland St. #3
Worcester **MA** 01603

Gregory B. Votaw
6717 Loring Court
Bethesda, MD 20817

Robert Walker
Department of Geography
Florida State Unviersity
Tallahasse **FL** 32306

Weiping Wang
Iowa State University
520 Forest Glen
Ames **IO** 50010

Jeff Weber
Dept. of Agricultural Economics
Massey University
Palmerston North **NEW ZEALAND**

A. William Weber
Wildlife Conservation International
New York Zoological Society
Bronx **NY** 10460

Patrick Welle
Department of Economics
Bemidji State University
Hickory Hall, Rm. 20
Bemidji **MN** 56601

Tina West
3450 Ordway St., NW
Wasington **DC** 20016

Daphne White
E Magazine
Washington **DC**

Mary White
Coastal Ecology Lab
Louisiana State University
Baton Rouge **LA** 70803

Thomas W. Wilson, Jr.
3317 Q Street, N.W.
Washington **DC** 20007

Judith Winter
The Union Institute
P.O. Box 206
Breenbank **WA** 98253

Rebecca Withers
1145 17th St NW
Washington 20036

Kerri L. Wright
Consultative Group of International Agric. Res.
1818 H St., N.W.
The World Bank
Washington **DC** 20433

Damian Yerbich
U.S. Army Corps of Engineers
1022 Manual St., #7
St. Paul **MN** 55114

Roger R. Youngman
Dept. of Entomology
Virginia Polytechnic Institute
Blacksburg **VA** 24061

Karen Ziffer
1756 Swann Street
Washington D.C. 20007

Mary Beth Zimmerman
Alliance to Save Energy
1725 K Street, NW
Washington **DC** 20006

James Zucchetto
National Academy of Sciences
2101 Constiution Avenue NW
Room JH424
Washington **DC** 20418

Robert Zwahlen
Ecosens Ltd.
P.O. Box
Zurich CH-8042 **Switzerland**

Tomasz Zylicz
Ministry of the Environment
UL. Wawelska 52154
Warsaw 00-922 **POLAND**