US Army Corps of Engineers
Water Resources Support Center
Institute for Water Resources

AD-A271 803

(2)

ANNOTATED BIBLIOGRAPHY: VALUE OF ENVIRONMENTAL PROTECTION AND RESTORATION

February 1993

IWR Report 93-R-4

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
4 February 1993

3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE
Annotated Bibliography: Value of Environmental Protection and Restoration

5. FUNDING NUMBERS

6. AUTHOR(S)
Victoria Klein, Thomas P. Fiock, Edward M. Pettit, and Timothy D. Feather

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources, Fort Belvoir, Virginia 22060-5586

8. PERFORMING ORGANIZATION REPORT NUMBER
IWR Report 93-R-4

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
CECW-PD
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for Public Release: Distribution Unlimited

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

This Annotated Bibliography contains brief summaries, including key words, for 73 recently published articles and reports concerning ecological modelling and environmental evaluation. It was prepared as background material to support the development of the White Paper, First Steps in the Development of a Method for Evaluating Environmental Restoration Projects, (IWR Report 92-R-9, December 1992). It is being published separately, because of its potential use as source material for Corps Planners and others concerned with environmental evaluation issues.

14. SUBJECT TERMS
Bibliography, Environmental Valuation, Economic Models, Ecoystem Models

15. NUMBER OF PAGES
75

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	Same as Report

ANNOTATED BIBLIOGRAPHY: VALUE OF ENVIRONMENTAL PROTECTION AND RESTORATION

by:

Victoria Klein
Thomas P. Fiock
Edward M. Pettit
Timothy D. Feather

Planning and Management Consultants, Ltd.
Rt 9 Box 15 (Highway 51 S)
P.O. Box 1316
Carbondale. IL 62903
(618) 549-2832

for:

U.S. Army Corps of Engineers
Institute for Water Resources
Fort Belvoir, VA 22060

February 1993

IWR Report 93-R-4

PREFACE

This annotated bibliography was prepared as part of the U.S. Army Corps of Engineers (COE) Evaluation and Formulation of Environmental Projects Work Unit, within the Planning Methodologies Research Program. Mr. William Hansen and Mr. Darrell Nolton of the COE Water Resources Support Center (WRSC), Institute for Water Resources (IWR), manage this Work Unit under the general supervision of Mr. Michael Krouse, Chief, Technical Analysis and Research Division; Mr. Kyle Schilling, Director, IWR; and Mr. Kenneth Murdock, Director, WRSC. Mr. Robert Daniel, Chief, Economic and Social Analysis Branch (CECW-PD) and Mr. Brad Fowler, Economist (CECW-PD) served as Technical Monitors for Headquarters, COE.

The work was performed by Planning and Management Consultants, Ltd. (PMCL), under Task Order 0032, Contract No. DACW72-89-D-0020. The authors are Mr. Thomas Fiock, Mr. Edward Pettit, and Dr. Timothy Feather, all of PMCL, in collaboration with Ms. Victoria Klein, of the Vanderbilt Institute for Public Policy Studies, Vanderbilt University.

The annotated bibliography was prepared as background material to support the development of the White Paper, First Steps in the Development of a Method for Evaluating Environmental Restoration Projects (IWR Report 92-R-9, December 1992). The White Paper was prepared under the same contract noted above by PMCL in collaboration with Dr. Clifford Russell, also of the Vanderbilt Institute for Public Policy Studies, Vanderbilt University, who served as principal investigator and primary author. Although the annotated bibliography was prepared, primarily, to support development of the White Paper, it is being published as a separate report because of its potential use as source material for Corps planners and others concerned with environmental evaluation issues.

TABLE OF CONTENTS

REFERENCE LIST OF COMPLETED ANNOTATIONS

1. Angermeier, P. L., Neves, R. J., & Nielson, L. A. (1991). Assessing stream values: Perspectives of aquatic resource professionals. North American Journal of Fisheries Management, 11, 1-10.

2. Baker, K. A., Fennessy, M. S., & Mitsch, W. J. (1991). Designing wetlands for controlling coal mine drainage: An ecologic-economic modelling approach. Ecological Economics, 3, 1-24.

3. Bardecki, M. J. (1989). The economics of wetland drainage. Water Quality Bulletin, 14, 76-80, 103-104.

4. Berger, J. J. (Ed.). (1990). Environmental restoration: Science and strategies for restoring the Earth. Washington, D.C.: Island Press.

5. Burtraw, D. (1991). Compensating losers when cost-effective environmental policies are adopted. Resources for the Future, 104.

6. Connell, J. H., & Sousa, W. P. (1983). On the evidence needed to judge ecological stability or persistence. The American Naturalist, 121, 789-824.

7. Costanza, R. & Daly H. (1992). Natural capital and sustainable development. Conservation Biology, 6(1), 37-46.

8. Costanza, R., Farber, S. C., & Maxwell, J. (1989). Valuation and management of wetland ecosystems. Ecological Economics, 1, 335-361.

9. Costanza, R., & Maxwell, T. (1991). Spatial ecosystem modelling using parallel processors. Ecological Modelling, 58, 159-183.

10. Costanza, R., Sklar, F., & White, M. (1990). Modeling coastal landscape dynamics: Process-based spatial ecosystem simulation can examine long-term natural changes and human impacts. BioScience, 40(2).

11. Crocker, T. (1985). On the value of the condition of a forest stock. Land Economics, 61(3), 244-254.

12. Dietz, F. J., Van Der Ploeg, F., & Van Der Straaten, J. (Eds.). (1991). Environmental Policy and the Economy. New York: North-Holland.

13. Dower, N. (Ed.). (1989). Ethics and Environmental Responsibility. Vermont: Gower.

14. Erickson, P. A., Camougis, G., & Robbins, E. J. (1978). Highways and ecology: Impact assessment and mitigation (FHWA-RWE/OEP-78-2). Washington, DC: Federal Highway Administration.

15. Ewel, K. C. (1990). Multiple demands on wetlands: Florida cypress swamps can serve as a case study. BioScience, 40(9), 660-665.

16. Folmer, H., & van Ierland, E. (Eds.). (1989). Valuation methods and policy making in environmental economics. New York: Elsevier.

17. Fulmer, D. G., & Cooke, G. D. (1990). Evaluating the restoration potential of 19 Ohio reservoirs. Lake and Reservoir Management, 6, 197-206.

18. Goicoechea, A., Hansen, D., & Duckstein, L. (1982). Multiobjective decision analysis with engineering and business applications. New York: John Wiley & Sons.

19. Hammack, J., & Brown, G. M., Jr. (1974). Waterfowl and wetlands: Toward bioeconomic analysis. Baltimore: Johns Hopkins University Press.

20. Harris, L. D. (1988). The nature of cumulative impacts on biotic diversity of wetland vertebrates. Environmental Management, 12, 675-693.

21. Hayden, F. (1987). Instrumental valuation indicators for natural resources and ecosystems. Journal of Economic Issues, 25, 917-935.

22. Hoehn, J. P. (1991). Valuing the multidimensional impacts of environmental policy: Theory and methods. Amer. J. Agr. Econ., 290-299.

23. Hughes, R. M., Larsen, D. P., & Omerik, J. M. (1986). Regional reference sites: A method for assessing stream potentials. Environmental Management, 10, 629-635.

24. Hunt, R. L. (1976). A long-term evaluation of trout habitat development and its relation to improving management-related research. Transactions of the American Fisheries Society, 105, 361-364.

25. Jassby, A. D., & Powell, T. M. (1990). Detecting changes in ecological time series. Ecology, 71, 2044-2052.

26. Johnson, R. L., & Johnson, G. V. (Eds.). (1990). Economic valuation of natural resources. San Francisco: Westview Press.

27. Jones, C. A. (1989). An economic model to assess fish-kill damages. Resources for the Future, 97.

28. Jorgensen, S. E. (Ed.). (1983). Application of ecological modelling in environmental management, Part A, (pp. 455-483). New York: Elsevier.

29. Jorgensen, S. E. (Ed.). (1983) Application of ecological modelling in environmental management, Part B. New York: Elsevier.

30. Kennedy, J. O. S. (1986). Dynamic programming applications to agriculture and natural resources. New York: Elsevier.

31. Kneese, A., Lee, D., Paulsen, C., & Spofford, W., Jr. (Eds.). (1988). Design of studies for development of Bonneville power administration fish and wildlife mitigation accounting policy. Washington D.C.: Resources for the Future.

32. Kusler, J. A., & Kentula, M. E. (Eds.). (1990). Wetland creation and restoration: The status of the science. Washington, D.C.: Island Press.

33. Lee, C. S., & Ang, P., Jr. (1991). A simple model for seaweed growth and optimal harvesting strategy. Ecological Modelling, 55, 67-74.

34. Leopold, A. (1990). Means and ends in wildlife management. Environmental Ethics, 329-332.

35. Manes, C. (1988). Philosophy and the environmental task. Environmental Ethics, 75-82.

36. Measuring Change in Ecosystems: Research and Monitoring Strategies.

37. Mikesell, R. F. (1987). Resource rent and the valuation of environmental amenities. Resources Policy, 98-102.

38. Mikesell, R. F. (1989). Depletable resources, discounting and intergenerational equity. Resources Policy, 292-296.

39. Milhous, R. T., Wegner, D. L., & Waddle, T. (1984). User's guide to the physical habitat simulation system (phabsim) (FWS/OBS-81/43). Washington, DC: Fish and Wildlife Service.

40. Miller, P. (1982). Value as richness: Toward a value theory for an expanded naturalism in environmental ethics. Environmental Ethics, 101-114.

41. Mitsch, W. J., & Gosselink, J. G. (1986). Wetlands. New York: Van Nostrand Reinhold Company.

42. Norton, B. (1982). Environmental ethics and the rights of future generations. Environmental Ethics, 319-337.

43. Norton, B. (1987). Why preserve natural variety?. Princeton: Princeton University Press.

44. Odum, H. (1989). Simulation models of ecological economics developed with energy language methods. Simulation, 69-75.

45. Pimentel, D. et al. Environmental and economic effects of reducing pesticide use: A substantial reduction in pesticides might increase food costs only slightly. BioScience, 41(6), 402-408.

46. Randall, A. (1987). Resource economics: An approach to natural resource and environmental policy. New York: John Wiley & Son.

47. Resource Pricing and Valuation Procedures for the Recommended RPA Program.

48. Rhind, D. (1991). Geographical information systems and environmental problems. ISSJ, 130, 649-668.

49. Robinson, J. (1991). Modelling the interactions between human and natural systems. ISSJ, 130, 629-647.

50. Rolston, H., III. (1986). Philosophy gone wild: Essays in environmental ethics. New York: Prometheus Books.

51. Sagoff, M. (1985). Fact and value in ecological science. Environmental Ethics, 99-116.

52. Sagoff, M. (1981). Do we need a land use ethic? Environmental Ethics, 293-308.

53. Sagoff, M. (1986). Process or product? Ethical priorities in environmental management. Environmental Ethics, 121-138.

54. Scherer, D., & Attig, T. (Eds.). (1983). Ethics and the environment. New Jersey: Prentice-Hall.

55. Scodari, P. F. (1990). Wetlands protection: The role of economics. Washington D.C.: Environmental Law Institute.

56. Shabman, L. A., & Batie, S. S. (1987). Mitigating damages from coastal wetlands development: Policy, economics and financing. Marine Resources Economics, 4, 222-248.

57. Shuter, B. J., Wismer, D. A., Regier, H. A., & Matuszek, J. E. (1985). An application of ecological modelling: Impact of thermal effluent on a smallmouth bass population. Transactions of the American Fisheries Society, 114, 631-651.

58. Silberman, J., Gerlowski, D., & Williams, N. (1992). Estimating existence values for users and nonusers of New Jersey beaches. Land Economics, 68(2), 225-236.

59. Smith, J. B. (1986). Stochastic steady-state replenishable resource management policies. Marine Resource Economics, 3(2), 155-168.

60. Smith, V. K. (1992). On separating defensible benefit transfers from "smoke and mirrors." Water Resources Research, 28, 685-694.

61. Starfield, A. M., & Bleloch, A. L. (1986). Building models for conservation and wildlife management. New York: Macmillan.

62. Straškraba, M., Mitsch, W. J., & Jørgensen, S. E. (1988). Wetland modelling—An introduction and overview. In W. J. Mitsch, M. Straškraba, & S. E. Jørgensen (Eds.), Wetland Modelling (pp. 1-8). New York: Elsevier.

63. Straškraba, M., Mitsch, W. J., & Jørgensen, S. E. (1988). Summary and state of the art of wetland modelling. In W. J. Mitsch, M. Straškraba, & S. E. Jørgensen (Eds.), Wetland Modelling (pp. 1-8). New York: Elsevier.

64. Tisdell, C. A. (1990). Natural resources, growth, and development: Economics, ecology and resource scarcity. New York: Praeger Publishers.

65. Toman, M. A. (1992). The difficulty in defining sustainability. Resources for the Future, 106.

66. U.S. Army Corps of Engineers, Los Angeles District. (1985). Upper Santa Ana River Flood Storage Alternatives Study. Appendices, 2. Washington, D.C.: U.S. Governmental Printing Office.

67. U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources (1991). Economic and Environmental Considerations for Incremental Cost Analysis in Mitigation Planning (IWR Report 91-R-1). Washington, DC: U. S. Government Printing Office.

68. U.S. Fish and Wildlife Service. (1980). Habitat evaluation procedures (HEP) (ESM 102). Washington, DC: U.S. Government Printing Office.

69. Walker, B. H. (1992). Biodiversity and ecological redundancy. Conservation Biology, 6, 18-23.

70. Walters, C. (1986). Adaptive Management of Renewable Resources. New York: MacMillan Publishing Company.

71. Walters, C. J., & Holling, C. S. (1990). Large-scale management experiments and learning by doing. Ecology, 71, 2060-2068.

72. Westman, W. E. (1990). Managing for biodiversity: Unsolved policy and science questions. BioScience, 40(1), 26-32.

73. Wilson, C. B., & Walker, W. W., Jr. (1989). Development of lake assessment methods based upon the aquatic ecoregion concept. Lake and Reservoir Management, 5(2), 11-20.

1

Angermeier, P. L., Neves, R. J., & Nielson, L. A. (1991). Assessing stream values: Perspectives of aquatic resource professionals. North American Journal of Fisheries Management, 11, 1-10.

Key Words: ecological, economic, environment, policy, value, natural resources

The authors use a multiattribute judgement technique to identify features of streams and rivers that confer ecological and fishery values as perceived by aquatic resource professionals.

Professionals were surveyed, including fishery managers, aquatic biologists, and fish ecologists. Each professional assigned scores indicating value to a series of hypothetical streams that varied by six predetermined factors. The relationships between the factors and the scores were then examined using regression techniques.

The authors observed that importance to rare and endemic species and species richness were determinants of perceived economic value, whereas fishery value was largely determined by species composition, aesthetic quality, and fish size. Perspectives on fishery value were found to be more discordant than perspectives of ecological value. The authors suspect that variations in fisheries managers' views of fishery-related value results from the lack of a cohesive framework for fisheries management policy. They also suggest that this work illustrates how analytical techniques developed in the social sciences may help fisheries managers assign priorities in their research and management activities.

This work presents a technique for evaluating assessments of ecological and fishery values. It is noted that criteria for assessing value must be explicitly stated for management programs to be focused effectively regardless of natural resources policy.

2

Baker, K. A., Fennessy, M. S., & Mitsch, W. J. (1991). Designing wetlands for controlling coal mine drainage: An ecologic-economic modelling approach. Ecological Economics, 3, 1-24.

Key Words: wetlands, ecotechnology

A simulation model is developed to predict the efficiency and economics of an application of ecotechnology using a created wetland to receive and treat coal mine drainage. The model examines the role of loading rates of iron on treatment efficiencies and the economic costs of wetland versus conventional treatment of mine drainage. Data are from an Ohio wetland site and verified from multisite data from Tennessee and Alabama. The model predicts that iron removal is closely tied to loading rates, and that the cost of wetland treatment is less than expected. A wetland to achieve these conditions would cost approximately $50,000 annually, according to the model. When higher loading rates exist and higher efficiencies are needed, wetland systems are more costly than conventional treatment.

Coal mine drainage is a serious environmental and economic problem because it forms an insoluble ferric hydroxide precipitate that coats the bottoms of streams, decreasing aquatic species diversity, lessening recreational and aesthetic attributes, and corroding iron and steel structures and equipment. Clearly, this drainage is an environmental cost borne by the public rather than by those who extract coal resources.

Since the mid-1970s, constructed wetland systems have been used by coal companies as a low-cost, self-maintaining solution to the mine drainage problem. Conventional treatment of mine drainage involves reducing or diverting flows, raising the pH of the effluent by adding chemicals, and precipitating metals via aeration. The alleged advantages of the wetland system include recreational and aesthetic benefits, and minimal maintenance.

The goal of this paper is to quantify the chemical, ecological and economic dynamics of a wetland, treating mine drainage through the development of a dynamic simulation model. The objectives are (1) to develop a model of the fate of iron in a constructed wetland receiving mine drainage in an attempt to understand the cleansing processes of the wetland, and (2) to compare costs of a wetland treatment system with traditional environmental engineering approaches under various loadings and removal efficiencies.

The model shows that the use of ecotechnology such as wetland treatment systems can provide low-cost solutions to some expensive pollution problems. Wetland treatment systems not only offer treatment efficiencies better or equal to conventional treatment systems but are economically cheaper in most cases where high efficiencies are not required. Wetlands are natural systems that are self-maintaining, eliminate the need for costly chemical treatments, and provide aesthetics, wildlife habitat and recreation.

3

Bardecki, M. J. (1989). The economics of wetland drainage. Water Quality Bulletin, 14, 76-80, 103-104.

Key Words: wetlands, value, rationality

Wetlands are valued for flood protection, improving water quality, protecting against erosion, climatic and atmospheric benefits, education, research, recreation and aesthetics.

The traditional view of wetlands has emphasized their real estate value and use as property, primarily for agriculture. The most significant aspect of wetland valuation is distribution of benefits. Those owning wetland areas bear the costs of ownership but cannot realize the full benefits that accrue from preserving the wetland (e.g.: migratory bird habitat, nursery habitat for aquatic organisms). Thus, the benefits of wetland preservation are likely to be outweighed by the benefits that could be internalized by its conversion to some other use even if the net public benefit may be reduced by such an action.

Traditional economic theories of rational choice suggest it is logical to choose the course of action that permits the attainment of greatest utility. However, the presumption that economic rationality leads to allocative efficiency of resources lies in the assumption that all benefits and costs are reflected in the decision. Motivated by economic interest, the individual landowner's decisions cannot reflect public and environmental interests.

While wetlands are recognized to provide many ecological and aesthetic benefits, their traditional use has been economic. Because owners of wetlands cannot internalize intangible ecological benefits, they find it more profitable to convert the land to agricultural or commercial property. Such economic motivation is rarely in the public interest.

4

Berger, J. J. (Ed.). (1990). Environmental restoration: Science and strategies for restoring the Earth. Washington, D.C.: Island Press.

Key Words: environmental restoration, ecosystems, mitigation

Environmental problems today are unprecedented in nature and magnitude. Rapid industrialization, militarization, and population growth are destroying not only the quality of life but the Earth's very capacity to support life. While more than 50 percent of the wetlands in the United States have already been destroyed, we are still losing more than 400,000 acres annually. The added effects of air pollution, deforestation, desertification, surface mining, and endangerment of species, are significant contributors to rapid environmental degradation. The papers in this book present a variety of strategies and ideas for restoring the environment to a healthy state. The authors document the need for and feasibility of restoring a wide variety of natural resources including deserts and barrens, wetlands, forests, mined lands, and lakes and streams.

In part 2, Robert Coats and Philip Williams state that successful wetland restoration projects require (1) clearly defined objectives, (2) site-specific analysis of hydrologic, geomorphic and biological variables, (3) review and feedback by the design team during construction, and (4) post-construction monitoring. Two major problems with project design are the use of a numerical model with field verification and use of empirical geomorphic relationships. The discussion of wetland systems continues with articles using case studies to demonstrate the successes and failures of current methods.

5

Burtraw, D. (1991). Compensating losers when cost-effective environmental policies are adopted. Resources for the Future, 104.

Key Words: environmental policy, cost effectiveness, compensation

The purpose of this article is to present arguments in favor of compensation for parties economically harmed when cost-effective environmental policies are implemented. Burtraw begins by defining two approaches to environmental regulation. The command-and-control approach to environmental regulation prescribes detailed measures for achieving a stated level of environmental quality. Cost-effective methods such as incentive-based regulation typically allow flexibility in how a given level of quality is to be achieved.

The government may offer compensation to provide benefits for those suffering losses from a policy change or to gain political support for the policy change, particularly when losers are easily identifiable and well organized, and gainers are dispersed and poorly organized. Compensation also can be justified as a means to achieve economic efficiency. This would occur if individuals oppose policies whose total benefits exceed total costs if they are unsure whether they will personally receive benefits in excess of the costs. The amount of compensation considered justifiable likely will reflect the degree to which the policy change was anticipated and the degree of deviation from current policy.

Monetary compensation is not without its drawbacks, however. The policy may create a moral hazard where anticipation of compensation may discourage potentially injured parties from avoiding or minimizing harm. Adverse selection also may result where an offer of compensation invites individuals to misrepresent their qualifications to claim compensation intended for others. Finally, it typically is difficult to place a fair dollar value on harm.

Linked compensation is suggested as an alternative policy in which the form of compensation directly addresses the form of harm. This has the advantages of being less expensive than monetary transfer and of being politically beneficial, since monetary transfer may be construed as extortion or bribery. Furthermore, subjective comparisons between similar objects are easier to make than comparisons of dissimilar objects as required in monetary compensation.

This article discusses the costs and benefits of monetary and linked compensation for individuals harmed by the implementation of environmental protection programs.

6

Connell, J. H., & Sousa, W. P. (1983). On the evidence needed to judge ecological stability or persistence. The American Naturalist, 121, 789-824.

Key Words: ecological stability, persistence, modeling, resistance, adjustment

The aim of this article is to describe the types of evidence one would need to obtain from natural populations or communities in order to decide whether they are stable or persistent. One aspect stressed is whether any given real community exists in multiple stable states in different places at the same time, or in the same place at different times. When considering changes in natural populations and communities, the authors discuss two viewpoints. One view is concerned with the degree of constancy in the numbers of organisms. In contrast is the view that concentrates not on the constancy of numbers but on presence or absence. The authors state that past work has confused these two viewpoints. Therefore, they define and discuss the terms used in this paper, but they do not seek to contribute here to the theory of stability in model ecosystems. The intent is to address the question of whether, under the same average climatic regime, populations are stable or persistent in the face of discrete, punctuated events.

Stability is defined and the quantitative viewpoint of stability is discussed in terms of inertia, persistence, resistance, constancy, conservatism, endurance, adjustment, elasticity, and resiliency. Scales of observation appropriate for judging stability or persistence of real ecological systems are discussed. Research concerning multiple stable states in ecology using mathematical models is reviewed in order to determine if there is good evidence for the existence of multiple stable states in actual populations or communities. Several examples cited in this research are discussed.

Studies that follow populations for at least one complete turnover are examined for stability or persistence. The purpose is to assess whether, from census data alone, it is possible to distinguish a subset of populations or communities that exist in an equilibrium state. Research in the area of evidence of adjustment stability is surveyed. The authors conclude that ideas of population or community stability based upon the existence of equilibrium states have seldom, if ever, been tested adequately because of the difficulty of defining the equilibria, measuring the length of the disturbing forces, and measuring the rate or degree of recovery in natural communities. If a balance of nature exists, it has proven exceedingly difficult to demonstrate. To learn whether real ecosystems are stable, equilibria must be identified. An analysis of census data from many long-term studies revealed a continuum of temporal variability in the dynamics of natural populations and communities.

Questions of stability or persistence are central to modeling the effects of human intervention on an ecosystem. Although this article does not attempt to contribute to ecosystem modeling, it does provide background that could be relevant in developing ecosystem models that reflect human interventions in the natural world.

7

Costanza, R., & Daly, H. (1992). Natural capital and sustainable development. Conservation Biology, 6(1), 37-46.

Key Words: sustainability, natural capital, technology

"A minimum necessary condition for sustainability is the maintenance of the total natural capital stock at or above the current level." Society must maintain a "constancy of total natural capital" as a minimum means for assuring sustainability, to be relaxed only when sufficient evidence proves such action is safe.

Natural capital provides a significant portion of the real goods and services of the ecological economic system. Thus, failure to properly account for natural capital results in serious misrepresentations of the economy's condition. The opposing views of technological optimists and skeptics illustrate the need for an accurate measure of natural capital stocks and the impact of human activities. Technological optimists believe technology will eliminate all resource constraints to growth and development. Conversely, technological skeptics see a limited scope for technology and fear irreversible damage to natural resources. Through this debate, the authors criticize the common assumption of near perfect substitutability between human-made and natural capital for having little practical basis. In fact, the substitutability of human-made for natural capital is very limited and typically the two are complementary factors of production.

Valuation of natural capital is necessary for aggregation and determination of the optimal scale of human activities. Costanza finds the common tool of discounting inadequate for measuring resource values for future generations because it is based on present preferences and, therefore, causes value distortions. The following principles are offered for sustainability: limit human activity to a level that, if not optimal, is within the carrying capacity of the existing natural capital and is, therefore, sustainable; and develop technology to increase efficiency rather than output. In conclusion, the following policy is proposed: Hold the use of natural capital at current levels; tax natural capital consumption, especially energy, very heavily; and raise public revenue from the natural capital depletion tax and compensate by reducing income tax.

The maintenance of a constant capital stock is critical to sustainability, both economic and ecological. Technology can only complement nature, not replace it. Costanza suggests a framework for sustainability that does not rely on the inadequate method of discounting.

8

Costanza, R., Farber, S. C., & Maxwell, J. (1989). Valuation and management of wetland ecosystems. Ecological Economics, 1, 335-361.

Key Words: wetlands, valuation, ecosystems, energy analysis, willingness-to-pay

The paper studies wetland values in coastal Louisiana using willingness-to-pay and energy-analysis based methodologies. According to the authors, there exist two key problems to valuing nature in the marketplace: (1) the common-property nature of ecosystems makes it impossible to exclude those who do not pay for their use, and (2) observed preferences and prices are a function of types and levels of personal endowments. Thus, consumers who are geographically separated from wildlife areas can internalize benefits of natural resource trade while externalizing the cost of habitat destruction.

The study develops a model of the commercial value of wetlands for fish and wildlife harvesting as well as less tangible benefits such as recreation and storm protection using willingness-to-pay and energy analysis. Drawbacks to each method are discussed and the authors emphasize that efforts to estimate the productivity of wetlands must distinguish between the wetlands' natural productivity and productivity resulting from human inputs used in harvesting the wetlands.

The authors recommend implementing a fees and subsidies system based on models of the ecological impact of human activities. The majority of financial damages would fall on the parties profiting from ecological exploitation. Such a program would induce ecotechnological innovation, which would make preservation the most economically attractive option to producers. In addition, it is felt that the discount rate is more significant in ecological valuation than any other factor and should consequently be lower for renewable natural resources than for other aspects of the economy.

Costanza examines the application of willingness-to-pay and energy-analysis techniques to wetland valuation in Louisiana. He develops some basic models to value commercial fish harvests, delineates the weaknesses of each valuation method, and makes policy recommendations to induce ecological preservation.

9

Costanza, R., & Maxwell, T (1991). Spatial ecosystem modelling using parallel processors. Ecological Modelling, 58, 159-183.

Key Words: Ecosystem, modelling, parallel spatial processors

Spatial system modeling of ecosystems is essential in order to develop a realistic description of past behavior and predictions of alternative management policies on future ecosystem behavior. Development of these models has been limited in the past by the large amount of input data required and difficulty in dealing with large spatial arrays. In addition, recent efforts to describe landscapes have involved intensive computational indices. This paper describes the extent of computer development and how computers may now be used to build and run dynamic spatial ecosystem models.

A spatial modeling workstation is presented. This workstation consists of a combination of hardware and software tools that allow development, implementation and testing of spatial ecosystem models. The system links commercially available Geographic Information Systems (GIS) with a commercially available general dynamic simulation system and a spatial modeling package (SMP). The SMP was developed for linking the unit models into a spatial array, handling horizontal exchanges, and running the array as a spatial model. Resulting time series maps are readable by the GIS system for further display and analysis.

The hardware and software of the system are described along with a hypothetical model of simple diffusion over a landscape. A practical application of the system to spatial modeling of long-term habitat succession in the Louisiana region is presented.

The authors find that parallel hardware and software are now developed enough to allow their use in ecosystem modeling. Furthermore, the authors surmise that parallel systems are particularly well suited to spatial modeling, allowing complex models to be executed over a relatively high-resolution spatial array at reasonable cost and speed.

10

Costanza, R., Sklar, F., & White, M. (1990). Modeling coastal landscape dynamics: Process-based spatial ecosystem simulation can examine long-term natural changes and human impacts. BioScience, 40(2).

Key Words: ecosystems, preservation, computer models

Predicting how human modifications will impact ecological systems is a primary goal of ecosystem ecology. Coastal ecosystems are threatened by such human activities as oil and gas exploration, and urban development. "Protecting and preserving these ecosystems requires the ability to predict the direct and indirect temporal and spatial effects of proposed human activities, the ability to separate these effects from natural changes, and the ability to appropriately modify the short-term incentive structures that guide local decision making to better reflect these impacts." The creation of such ecosystem models requires sophisticated computer simulation landscape models. The objectives of landscape modeling are to "predict changes in land cover patterns across large geographic regions, over long time scales as a result of various site-specific management alternatives and natural changes."

The original tool for this type of modeling was process-based dynamic spatial ecosystem simulation models. However, this method results in large, complex models that are expensive to design and have limited application. These limitations are decreasing as the availability of remote sensing data and super computers increases.

This article discusses a process-based spatial simulation model developed for the Atchafalaya/Terrebonne marsh/estuarine system in southern Louisiana called the coastal ecological landscape spatial (CELSS) model. The CELSS model consists of 2,479 interconnected square cells, each containing a dynamic ecosystem simulation model and connected to its four nearest neighbors by the exchange of water and suspended materials. Inputs are specified in the form of time series during the simulation period. Ecosystem succession occurs in the model when the physical conditions in a cell become appropriate to a different ecosystem type. The process is fairly new and expensive, but its creators plan to improve the model to eventually allow both "scaling up for global ecosystem modeling to assess the impacts of global climate change and scaling down to assess local effects in more detail." Currently, the model is being applied to coastal area studies in Louisiana, Maryland and South Carolina.

In the continuing effort to design a flexible ecological model, Costanza discusses the development of the coastal ecological landscape spatial (CELSS) model and its advantages over previous computer-based ecological models as a predictive tool.

11

Crocker, T. (1985). On the value of the condition of a forest stock. Land Economics, 61(3), 244-254.

Key Words: value, benefit-cost analysis, ecosystems, land management, contingent valuation

This paper uses a contingent valuation survey to derive the economic values that a sample of self-selected outdoor recreationists place on alternative air pollution-induced health states in a Southern California national forest.

The current literature on the biological impacts of air pollution reflects widespread concern about its effect on forests but includes no research on the potential economic losses resulting from such pollution. The most common example is the San Bernardino National Forest in Southern California. This paper assesses the economic implications of air pollution on the existing stock of ponderosa and Jeffrey pine trees, the most dominant vegetation types in the most popular forest areas, and the consequent effect on outdoor recreation.

The author develops a model that assumes the individual annually engages in a two-stage budget process in which the total income allocated is a combination of money income and leisure time. In the first stage, income is allocated between recreational activities and other commodities such that the necessary and sufficient conditions for weak separability are fulfilled. In the second stage, the individual decides how the income devoted to recreation will be allocated among various specific activities. The model ultimately indicates that the coefficient attached to the air pollution damage variable implies an elasticity of approximately -0.52, meaning that annual visit frequency is not highly sensitive to air pollution damages.

12

Dietz, F. J., Van Der Ploeg, F., & Van Der Straaten, J. (Eds.). (1991). Environmental Policy and the Economy. New York: North-Holland.

Key Words: environmental policy, environmental-economic modeling, valuation

This volume presents a collection of articles that focus on the role of environmental-economic modeling in ecological valuation and policy development. The articles specifically address models concerning pollution, contingent valuation methods, wilderness valuation as applied to the Krutilla-Fisher model, and the legal, political and economic consequences of environmental policy.

"An Inquiry into the Nature and Causes of the Wealth of Planet Earth," by Henk Peer, develops a world economic model examining the viability of sustainability. The relevant parameters in sustainability of growth are the production elasticities of capital, exhaustible resources and labor, the global rate of technical progress, the rate of depreciation of the world's capital stock, the rate of growth of the world's population, the elasticity of marginal utility with respect to consumption, ethical values represented by the discount factor, and world abatement costs as a percentage of world production. With these parameters, six different growth scenarios are created. Peer concludes that these models show that economic growth on a global scale is possible.

In chapter 5, Crocker and Shogren challenge the key assumption in contingent valuation that people recognize their preferences for nonmarket goods. They model a process of endogenous information acquisition about own-preferences in order to evaluate a trade-off between current consumption utility and preference learning that can increase future utility. An individual determining her preference ordering is shown to place a weakly greater value on current consumption than she would with full preference knowledge. The authors conclude that the amount an individual is willing to pay for knowledge about the potential utility value of a commodity should not be mistaken for measures of the consumption value of that commodity.

Hanley and Craig investigate land-use changes in wilderness areas in a case study of afforestation in the Flow Country in Scotland. A contingent valuation survey is used to show that the damage caused by afforestation outweighs the benefits of a new forest.

The purpose of this book is to examine the interrelationship between environmental policy and economics. The three articles of main interest discuss sustainability, contingent valuation, and wilderness value.

13

Dower, N. (Ed.). (1989). Ethics and Environmental Responsibility. Vermont: Gower.

Key Words: environmental ethics, future generations

This book is a collection of six papers concerning environmental ethics. The two articles of principle interest are "What Is Environmental Ethics?" by Nigel Dower and "Do Future Generations Matter?" by J. R. Cameron.

Dower's article explains the environmental crisis and its consequences in terms of Earth's finite resources. This finiteness is evident in nonrenewable resources, the carrying capacity of the world, and the limited areas that produce renewable resources. According to Dower, the central issues for an environmental ethic are (1) universal support for environmental protection because everyone will benefit, and (2) accepting responsibility for the unintended results of actions and/or policies that may affect the global community, future generations and/or nonhuman life.

Dower also considers how environmentalism may affect the economy and standard of living. While environmentalists support no-growth policies for developed nations, Dower argues that this should not lessen one's quality of life, which depends on lifestyle rather than affluence. Furthermore, the pursuit of long-term economic and environmental success may involve some degree of financial sacrifice in the short term. However, only a change in people's goals, the means necessary to achieve these goals, or the external conditions of the choices themselves will induce changed behavior. Thus, an environmental ethic does not oppose development

Instead it challenges the view that equates progress with economic growth. Cameron's article argues that society has a moral responsibility to future generations for the social and natural environment they will inherit. The article examines moral theories based on human interests, intrinsic social contracts among generations, utilitarianism, justice, and respect for fellow humans. The following observations conclude the paper: (1) Society must not deplete or degrade the environment in the pursuit of its happiness and pleasure while condemning future generations to less pleasant conditions; (2) our responsibility to posterity is a shared one; and (3) sustainability must be the primary goal of an environmental ethic.

14

Erickson, P. A., Camougis, G., & Robbins, E. J. (1978). Highways and ecology: Impact assessment and mitigation (FHWA-RWE/OEP-78-2). Washington, DC: Federal Highway Administration.

Key Words: highway, ecology, wildlife, terrestrial environment, aquatic environment, impact, wetland, mitigation measures

With the passage of the National Environmental Policy Act of 1969 (NEPA), highway professionals are now required to consider the effects of highway projects, highway operations, and highway maintenance on natural resources. These effects occur at both the biological and ecological level. This report uses an ecosystem approach for impact assessments. The components and dynamics of terrestrial, aquatic and wetland ecosystems are described, as are potential biological and ecological impacts. The intent is to outline the relationship between highways and ecology.

This analysis is broken down into pre-design, design, construction, and operation and maintenance phases. Discussion on methods of mitigating adverse impacts and enhancing the existing biological resources are included. Case studies and references are used to provide a more in-depth review of potential impacts on terrestrial, aquatic, and wetland environments.

The authors conclude the following:

- The ecosystem concept continues to be a powerful tool for highway professionals.
- The mitigation and enhancement of ecological impacts depend on an understanding and control of highway impacts on biotic and abiotic components of ecosystems.
- The success of any mitigation and enhancement measure depends on a careful evaluation of site-specific conditions and on the highway professional's understanding of those factors.
- Many mitigation and enhancement measures can be undertaken at relatively small cost.
- Mitigation and enhancement measures are continually developing arts and sciences.

- It is increasingly clear that highway professionals have rapidly come to recognize that many important environmental objectives are integral to sound highway operation.

This report emphasizes mitigation and enhancement methods, and impacts from highway development. The potential impacts of activities common to highway construction are discussed, but a model to predict these impacts is not presented.

15

Ewel, K. C. (1990). Multiple demands on wetlands: Florida cypress swamps can serve as a case study. BioScience, 40(9), 660-665.

Key Words: ecosystem values, wetlands, ecosystem development

This article reviews the consumptive and nonconsumptive uses of wetlands, as well as their incompatibilities, to demonstrate the importance of evaluating more than one alternative in decision making.

Cypress swamps demonstrate the potential for land-use conflicts and the important considerations for their resolution because the swamps provide benefits both with and without exploitation. These benefits include wildlife habitat, groundwater recharge, flood control, water quality control, and wood products. The problem of multiple demands causes conflicts between competing goals such as exploitation of wood products and maintenance of the wetland as a wildlife preserve. Clearly, there exists substantial conflict between public and private interests.

According to Ewel, the direct and indirect effects of various management policies must be considered to determine whether and how extracting certain benefits may preclude other benefits that may be more valuable in the long run. For example, the use of swamps for flood control and wood products significantly diminishes their values as wildlife habitats. Therefore, ecology must stress the role of wetland ecosystems within a landscape of neighboring terrestrial and aquatic ecosystems as well as nearby cities and agricultural fields.

Folmer, H., & van Ierland, E. (Eds.). (1989). Valuation methods and policy making in environmental economics. New York: Elsevier.

Key Words: environmental economics, valuation, cost-benefit analysis

The potentially harmful side effects of production and consumption have created the need among scientists and policy makers to measure and protect environmental amenities. Indeed, it is recognized that the external effects of economic activities are so potent that unregulated free markets will lead to large scale, irreversible environmental damage. Consequently, federal and state governments are forced to develop instruments and policy frameworks and to investigate the costs and benefits of specific environmental projects and policies. This volume examines in-depth valuation methods, cost-benefit analysis, and policy making in environmental economics.

Each chapter develops a model based on a case study to address a particular aspect of environmental economics and policy including water quality, recreational values, acid rain, and air pollution. Techniques such as site valuation, market valuation, contingent valuation, and willingness-to-pay are used throughout to determine value.

Folmer and van Ierland draw two conclusions based on the articles: (1) The optimal allocation of labor, capital and natural resources in production depends on the correct valuation of the environment, given the correct prices for capital and labor; and (2) the four categories of valuation techniques are direct and surrogate markets, contingent valuation method and nonmarket behavior procedures. No definitive ordering of these was found to be possible based on reliability, completeness or data requirements.

This volume examines the interrelationship of economics, ecology and policy making in terms of specific case studies and contingent valuation. Contingent valuation is costly and time consuming, and subject to bias from both the researcher and the respondent. Consequently, CVM may contribute to the understanding of environmental value, but, because the degree of completeness depends on the researcher, it is not entirely reliable or accurate.

Fulmer, D. G., & Cooke, G. D. (1990). Evaluating the restoration potential of 19 Ohio reservoirs. Lake and Reservoir Management, 6, 197-206.

Key Words: lake restoration, ecoregions, eutrophication, attainable water quality, trophic state, lake management

This report suggests a method for determining the restoration potential of reservoirs based on ecoregional differences in attainable stream nutrient concentrations. These differences in the practical lower or attainable limits to which stream and, thus, lake nutrient concentrations can be decreased are used to estimate the restoration potential of some reservoirs by comparing each reservoir's actual trophic state to an estimate of its attainable trophic state. The greater the amount by which the actual trophic state exceeds the estimated attainable trophic state, the greater the potential to improve stream water quality and, thus, improve lake water quality. The restoration potentials of reservoirs are not ranked by the degree of eutrophication but by the degree to which they deviate from the trophic state expected for their morphometry, hydrology, and ecoregion.

The trophic statuses of 19 Ohio Department of Natural Resources (ODNR) state park reservoirs were determined. The lakes were repeatedly sampled to increase the accuracy of the mean and reduce the variance of the in-lake phosphorus concentrations. The sampling method that was used is discussed in detail in the article. The reservoirs with the greatest restoration potential were determined by comparing the 1989 actual lake trophic state in the lacustrine zone to the estimated attainable trophic state, assuming phosphorus limitation of algal biomass. The actual and attainable phosphorus concentrations were transformed into index numbers, using the Carlson Trophic State Index, to describe the reservoir conditions expected for those phosphorus concentrations.

The ecoregion approach dictates attainable lower nutrient concentration limits by grouping watersheds with similar characteristics and studying streams least affected by human activities in each ecoregion. These least affected streams are considered to have the lowest amount of cultural loading and are used to estimate the level to which the cultural loading to more heavily impacted streams and lakes can be decreased. But the elimination or significant reduction of cultural loading is essential for the restoration of a lake or reservoir to its previous condition.

The ecosystem model presented in this article links human intervention, cultural loading, to an output that is relevant to the public's thinking about the environment, water quality. However, no method is now available to predict attainable reductions in cultural loading.

18

Goicoechea, A., Hansen, D., & Duckstein, L. (1982). Multiobjective decision analysis with engineering and business applications. New York: John Wiley & Sons.

Key Words: multiobjective analysis, preferences, stochastic methods, optimization

This textbook presents a comprehensive discussion of continuous and discrete multiobjective decision-making techniques. An attempt is made to identify, classify and review the multitude of techniques developed in the last 20 years as (1) solutions generating, (2) techniques that rely on prior articulation of preferences by the decision maker, (3) those that rely on progressive articulation of preferences, and (4) techniques with posterior articulation of preferences. Such a classification system recognizes the comparative advantage of bringing the decision maker's preferences into the different stages of an analysis so the various alternative solutions can be ranked.

Both continuous and discrete methods are discussed since continuous techniques are useful in problem situations characterized by an infinite number of alternative solutions or plans, while discrete methods are best suited for situations involving the development, evaluation and comparison of a finite number of proposed plans. This flexibility is intended to allow application of the concepts and methods of multiobjective analysis to a variety of fields.

The 12 chapters of this book cover concepts in multiobjective analysis, methods for generating the nondominated set, continuous and discrete methods with prior and progressive articulation of preferences, group decision making, and applications to water resources planning and land reclamation.

19

Hammack, J., & Brown, G. M., Jr. (1974). Waterfowl and wetlands: Toward bioeconomic analysis. Baltimore: Johns Hopkins University Press.

Key Words: waterfowl, wetlands, bioeconomic, migratory, recreation

The goal of this text is to provide information in support of waterfowl when making rational decisions concerning the creation or draining of wetlands. The critical factor in sustaining waterfowl populations is the amount of nesting grounds, which has declined as prairie wetlands continue to be lost. Alternative methods of valuing outdoor recreational resources are discussed, and a theoretical framework for the valuation of waterfowl is presented. Empirical results are based on the valuation model. Biometric relationships are assumed and tested with mallard data and crude cost benefit analyses are made. The questions of appropriate population of waterfowl and wetlands areas also are addressed.

In establishing a theoretical framework for the valuation of waterfowl, the authors discuss the Davis method of consumer's surplus, the travel and transfer cost methods, and the Pearse method. Valuing a recreational component also is discussed. A model is presented in the form of a mathematical formulation where consumer's surplus is a function of income, measures of taste, one hunter's bagged waterfowl for the season, and the number of days the individual hunted during the season. To apply the equation, data from questionnaires sent to 4,900 hunters were collected. Complementing the discussion of the valuation theory is an analysis of waterfowl supply, specifically mallards, with an emphasis on biometrics. Production relationships, a physical balance equation, and maximum physical yield are discussed and quantified from a theoretical perspective. The model is then compared to that used by the U.S. Bureau of Sport Fisheries and Wildlife. The authors present an exercise that suggests that the waterfowl valuation figure can be used with other waterfowl data for evaluating parcels of wetlands.

The model presented by the authors represents the first effort to join economic and physical relationships to determine the optimal number of ponds, breeders, and season kill. Several model inadequacies are discussed along with the need for additional research.

The authors present a model for valuing waterfowl, but this model does not accept variables reflecting human interventions as inputs. The physical balance equation does include a measure of wetlands suitable for wildfowl production. The output of the valuation model, consumer's surplus, is related to, if not directly affected by, the public's thinking about the environment.

20

Harris, L. D. (1988). The nature of cumulative impacts on biotic diversity of wetland vertebrates. Environmental Management, 12, 675-693.

Key Words: cumulative impacts, landscape ecology, vertebrate biodiversity, wetland habitat, wetland impacts

The important effects that cumulative impacts have on wetland vertebrates have been illustrated in many recent studies. Interactions of species diversity and community structure produce a complex pattern in which environmental impacts can play a highly significant role. Legislation dictates the performance of cumulative impact analysis prior to specific environmental manipulations. While it may not be possible to predict cumulative impacts a priori, they exist, can be described, and are critically important. To be effective, assessment of cumulative impacts on vertebrate communities must be done at a landscape or regional scale of analysis. This article presents descriptions of how wetlands maintain vertebrate biotic diversity and of some ways that various impacts have accumulated to reduce biodiversity.

At least four issues are integral to the assessment of cumulative impacts on a wetland habitat: specialist vs. generalists species; alpha, beta, and gamma diversity; component vs.

compound ecosystems; and the need of animals to move. Examples of each issue are provided. Based on current knowledge, the direct consequences of habitat fragmentation on biodiversity may be assigned to one of the following categories: loss of large, wide-ranging species; loss of area-sensitive or interior species; loss of genetic integrity from within species or populations; and increase in abundance of habitat generalists characteristic of disturbed environments. The ultimate result of these four classes of impacts is that each region loses its unique and distinguishing biological characteristics and acquires the generalist species already common throughout the human-dominated landscape.

Alteration of food chain support is discussed in detail. The authors state that only analyses that consider the habitat and wildlife content of the component wetland against the temporal and spatial context within which the wetland occurs will be fruitful. Assessing the accumulation of impacts is addressed and several examples are used to represent the fundamentally different ways that wetland vertebrate communities accumulate and/or manifest impacts of different sorts. The authors conclude that loss of genetic diversity within species may be as serious as loss of species themselves, loss of diversity at the landscape level may well lead directly to loss of the species themselves, and, because of the complexity of trophic interactions, the results of three or more different perturbations cannot be predicted. The best approach for managers and decision makers to take may be a heightened awareness of the history of impacts and alert to parallels with them. In order to assure the maintenance of wetland biodiversity, a system of replicate wetland reserves needs to be established and allowed to function in an interactive landscape context.

Although this work does not address ecosystem modeling directly, it does present information on the effects of multiple impacts on ecosystems. This information on biotic diversity would be useful in building ecosystem models that reflect human interventions in the natural world.

21

Hayden, F. (1987). Instrumental valuation indicators for natural resources and ecosystems. Journal of Economic Issues, 25, 917-935.

Key Words: valuation, indicators, instrumental methodology, policy analysis

The purpose of this article is to present a general instrumental method for determining value indicators for natural resources and ecosystems. The article is based on the work of instrumentalists, those who reject the possibility of valuation via a market price criterion and who support transactional valuation. The intent of this research is to develop a set of methods for determining valuation measures. The authors advance the notion that policy indicators should be developed that are consistent with the problem, the relevant system, and the social belief criteria.

Indicator design standards are discussed, and a policy analysis model for designing indicators intended to serve the purposes of public policy is presented. The major categories of the model are beliefs and ethics, legal authority, primary criteria and goals, socioecological models, and secondary criteria and indicators. Social indicators are designed as the secondary criteria for the more primary criteria of social policy goals. These goals, as the author sees it, follow directly from societal beliefs, values, and ethical standards. The kind of indicators compiled depends on the socioecological model or method utilized. Indicators also are categorized from a system point of view.

To accomplish the goals of the primary criteria, numerous measures must be developed. Neither one measure nor one category of measures is sufficient to express or value system goals, but, before indicators can be found, models of the real world must be used. The valuation methods designed here employ the Social Fabric Matrix because it can be used to detail the entities that contribute to a system. The purpose of valuation is to determine what is better and worse, what is improvement, and what is degradation. The author states that, "This article has designed valuation methods to fulfill instrumental criteria as they apply to the evaluation of socioecosystems and natural resources."

This article presents a process for developing ecosystem models. A number of socioecosystem criteria concerns and norms are discussed, including norms and control properties, biodiversity valuation, stability valuation, ecodevelopment valuation, and restoration costs. The intent is to develop valuation techniques so instrumentalists can develop inquiry procedures, skills, and workmanship to inform policy makers on issues of sociosystem valuation.

22

Hoehn, J. P. (1991). Valuing the multidimensional impacts of environmental policy: Theory and methods. Amer. J. Agr. Econ., 290-299.

Key Words: air quality, benefit cost analysis, contingent valuation, environmental policy, national parks, nonmarket valuation

---

A theoretically consistent framework is developed for valuing the multidimensional impacts of environmental policy. Conventional benefit estimates are shown to be biased because of the presence of substitution and complementarity effects in valuing policy impacts. Procedures are developed for implementing a valid framework. Consistent with theory, empirical results indicate significant substitution effects in valuing environmental conditions across different geographic regions. Valuation concepts in the context of local recreation sites have not been extended to the general problem of valuing the benefits and costs of multidimensional environmental policy. The author makes the point that conventional benefit cost design is conceptually and empirically flawed.

Conventional and valid valuation designs are outlined and examined with respect to environmental impacts caused by a change in public policy. These impacts may include changes in physical resource flows, characteristics of the legal and social environment, or altruistic services such as those leading to existence value. The prospect of substitution and complementarity between policy components is examined. Procedures for implementing the valid design with contingent valuation are derived. Finally, valid bid functions are estimated, and the empirical significance of substitution in valuing regional environmental quality conditions is tested.

The author finds that a conventional benefit-cost design ignores the contextual nature of value data. Where resources are substitutes in valuation, a conventional benefit cost estimate exceeds the valid measure of net benefits. Where complementarity is present, a conventional benefit cost estimate understates the valid valuation.

The areas of interest addressed in this article are environmental valuations in response to policy change and the capabilities of contingent valuation methods.

23

Hughes, R. M., Larsen, D. P., & Omerik, J. M. (1986). Regional reference sites: A method for assessing stream potentials. Environmental Management, 10, 629-635.

Key Words: streams, control sites, watershed, regions, terrestrial variables

Field assessments of impacted streams require a control, or at least an unbiased estimate of attainable conditions. Control sites have proven inadequate for assessing attainable ecological conditions where the control streams differ naturally from the impacted streams or where different disturbances exist than those being studied. Relatively undisturbed reference sites with watersheds in areas having the same land-surface form, soil, potential natural vegetation, and land use as are predominant in large, relatively homogeneous regions are suggested as alternative control sites. The logical basis for developing regional reference sites lies in the ability to group watersheds and common stream types into regions by integrating available maps of terrestrial variables that influence streams. Based on this, the purpose of the article is to describe a more objective method for selecting this type of regional reference site.

Seven approaches for estimating attainable conditions of streams are discussed and the limitations of each approach are made. The authors state that, ideally, control sites should be as little disturbed as possible, and that these sites may serve as reference sites for a number of streams in a region. Past research addressing the question of what constitutes a region is then presented.

A process of delineating regions and selecting reference sites that builds on past research is outlined in three phases: determining regions and their typical areas, determining candidate watersheds and reference sites, and selecting reference sites to be sampled. The authors state that these regional reference sites provide water resource managers with a series of relatively undisturbed sites that are typical of a large area, and that these sites may be useful for several purposes. A series of relatively undisturbed regional reference sites can provide examples of the attainable community structure, dominant and intolerant species, species richness, and habitat conditions, and the spatial variations of those variables in each region. These sites also can be used to refine biological use classifications and ecological standards, and to locate sites for monitoring stream quality or ecological integrity. The limitations of this approach also are discussed, including size of the watershed and anomalous stream ecosystems.

A method for establishing a control for stream ecosystem modeling is presented in this article. Human interventions are considered explicitly. Since this work focuses on establishing control sites, model outputs are not considered.

24

Hunt, R. L. (1976). A long-term evaluation of trout habitat development and its relation to improving management-related research. Transactions of the American Fisheries Society, 105, 361-364.

Key Words: habitat development, trout, aquatic systems, morphometric measurements

Responses of a wild brook trout population to in-stream habitat development in a 0.7 km reach of Lawrence Creek, Wisconsin were monitored for 7 years and compared with population data for the 3-year period before development. Primary aims of the development project were to narrow and deepen the stream channel, increase pool area and overhanging streambank shelter for trout, and accentuate channel sinuosity by constructing a series of 86 paired bank covers and current deflectors. Cover-wings were constructed from 38,000 board feet of oak planking and 6,000 tons of rock.

Data on the brook trout population in this portion of Lawrence Creek were tested against comparable data from this section obtained during the three years preceding development. Electrofishing gear was used to conduct Petersen mark and recapture estimates of the trout population each April and September. Annual production by each age-structure group was calculated as the product of the monthly instantaneous growth rate and mean monthly biomass. Statistical differences between 3-year mean values for standing stock and production data were tested.

Several significant increases in brook trout population were documented. Three-year mean numbers of legal-sized brook trout in April increased from 562 (1961-1963) to 1,130 (1965-1967) to 1638 (1968-1970). Stream bank and channel alterations were initiated in March and completed in October 1964. Annual production, a parameter that integrates the number of trout and their rate of growth, also continued to improve throughout the post-development period compared with earlier years. Diagnostic parameters of prediction were less responsive to habitat changes than were indices of biomass and numbers of legal-sized brook trout. The author proposes that greater use of planned waiting periods be given more serious consideration in studies of aquatic ecosystems, especially where responses of wild populations of fish are to be used in the evaluation process. A planned procedure of starting, pausing, then restarting collection of data should be a means of obtaining more valid results.

This article discusses a method for improving stream habitat but does not provide a model for predicting the response of the stream to the human interventions. This work does provide insight into the timing of data collection that will be required to implement ecosystem models.

25

Jassby, A. D., & Powell, T. M. (1990). Detecting changes in ecological time series. Ecology, 71, 2044-2052.

Key Words: time series, principle component analysis, ecology, perturbation

---

The focus of this article is on objectively determining whether a time series has changed after a perturbation has occurred. The question is similar to asking if the series is stationary, although only certain types of nonstationarity are examined. The emphasis is on presenting practical comments on selected techniques for analyzing series that are changing. Reducing multivariate sets of data to univariate methods that require fewer data, and use of eigenvector analysis to reduce the dimension of problems involving multiple variables. Techniques for detecting trends and changes in oscillatory behavior are discussed. Unusual events, such as short-term, substantial discontinuities in the underlying behavior of a time series, are discussed. Inference regarding causation between time series is examined. The issues of autocorrelation and serial correlation are addressed. The authors stress that statistical evaluations must be accompanied by a variety of independent measurements supporting a plausible mechanism.

Some practical techniques are discussed for analyzing time series whose statistical properties are changing with time. The authors conclude that flexibility is an indispensable feature of any attempt to investigate changing time series. A classical analysis has been emphasized where the series is decomposed into a trend, seasonality, long-term cycles, and residual fluctuations or unusual events. However, the less formal approaches to modeling the unperturbed series are instructive.

This work examines techniques for time series analysis that may be useful in modeling ecosystems. Models for ecosystem analysis are not presented, but examples show the application of time series techniques for ecosystem analysis.

26

Johnson, R. L., & Johnson, G. V. (Eds.). (1990). Economic valuation of natural resources. San Francisco: Westview Press.

Key Words: natural resource valuation

The challenge and current methods of natural resource valuation are the basis for these articles with a focus on the contingent valuation method (CVM).

Bishop and Heberlein argue that, while contingent valuation is the most flexible of the valuation techniques, questions exist concerning its validity. First, CVM does not provide accurate values if the data gathering and subsequent analysis are not adequately designed and executed. In addition, if CVM has inherent flaws, even the most carefully done study will not produce accurate values. A successful contingent valuation study must address six issues: population definition, product definition, payment vehicle definition, alternative ways to ask valuation questions, supplementary data needs, and analysis. The question of validity essentially revolves around interviewer or respondent bias. Despite such drawbacks, however, the authors conclude that contingent valuation provides an adequate representation of environmental values.

In chapter 7, Hoehn addresses two methodological difficulties with assessing the reliability of CVM: (1) situations that allow a direct statistical comparison between CV results and other observable measures of value are scarce, and (2) relatively few systematic concepts are available to guide empirical research and hypothesis testing. In discussing these difficulties, the author presents both a choice context for obtaining statistically precise value estimates using CV and demand-based techniques, and three empirical hypotheses exploring the relationship between CV and demand-based results. His study concludes that given the constraints of the contingent choice context, individuals tend to underestimate gains and overvalue losses. Consequently, CV data are satisfactory but not optimal benefit-cost indicators.

Wildlife valuation strives to generate data that are useful for resource management. To this end, Samples and Hollyer claim that the usefulness of existing wildlife value estimates is limited and can be applied only to specific policy measures that formed the original basis for valuation. The limited range of wildlife valuation is attributed to its foundation in partial equilibrium valuation frameworks and unique ceteris paribus conditions. The authors further find that wildlife valuation estimates vary with the presence of substitutes or complements for the resource and recommend that additional research might remedy this situation.

27

Jones, C. A. (1989). An economic model to assess fish-kill damages. Resources for the Future, 97.

Key Words: recreation, travel cost

The Michigan Department of Natural Resources has filed suit against a 1.8 million kW hydropower plant located on Lake Michigan. The department claims that the facility has substantially harmed the lake's recreational fishing resources and it is using a demand model to help assess the damages. The model relies strongly upon the travel cost valuation method and cites replacement costs as a proxy for lost nonuse value.

28

Jorgensen, S. E. (Ed.). (1983). Application of ecological modelling in environmental management, Part A, (pp. 455-483). New York: Elsevier

Key Words: ecological modeling, environmental management, computer models, ecosystem processes

Chapter 11, "Modelling the Distribution and Effect of Toxic Substances in Aquatic Ecosystems," by S.E. Jorgensen, attempts to quantify the impact of toxic substances such as heavy metals, oil, and pesticides in aquatic ecosystems. Many water constituents are toxic at certain concentrations and interact directly with ecosystems, causing death or severe stress and limiting the use of water resources. Increased industrialization and a steadily increasing number of new toxic compounds demands the development of water quality models that can be used for the prediction of safety levels and the establishment of water quality criteria. The basis for modeling the distribution and effect of toxic substances in an aquatic ecosystem is ecosystem dynamics.

Jorgensen examines the processes described in models of aquatic ecotoxicology. The three types of toxicology models currently in use are (1) food chain or food web models, (2) simplified food chain models, or (3) trophic level models. Food chain models are similar to eutrophication models with the addition of state variables for the description of the concentrations of toxic substances. While they provide great flexibility and can describe relatively complicated food webs, such models often become unmanageable and require comprehensive data sets to be calibrated and validated. Simplified versions require less data and are more generally applicable but are less accurate and informative.

The three types of models are presented, their advantages and disadvantages discussed, and specific case studies and examples given. Since both the models and current knowledge of the effects of toxic compounds and their concentrations are uncertain, it is necessary to apply high safety standards to water quality criteria. The predictive value of these models is less than other ecosystem models because the processes and parameters are less researched, and the amount of data available for each case study is more limited. The advantages of models of toxins in aquatic ecosystems are (1) the model can easily be tested against real data, (2) the quality and quantity of data can be stated, and (3) it is possible to determine the accuracy required for parameters and for the quantitative description of ecosystem processes.

29

Jorgensen, S. E. (Ed.). (1983). Application of ecological modelling in environmental management, Part B. New York: Elsevier.

Key Words: unit processes, heavy metals, pesticides, air quality, freshwater wetlands, wetland forests

---

Wetland modeling is relatively new compared to modeling of aquatic and terrestrial ecosystems. This lack of research is due to the recent recognition of wetlands as distinct and ecologically critical systems, the lack of concise wetland classifications, spatial heterogeneity, and the combination of aquatic and terrestrial characteristics. Seven types of wetland models exist and are discussed in chapter 11: energy/nutrient ecosystems, hydrology including ecosystem, regional and hydrodynamic transport, spatial ecosystem, tree growth, process, causal, and regional energy.

Chapter 12 presents a simulation of management alternatives in wetland forests. In the past 300 years, wetland forests in the United States have been greatly altered and reduced with the original composition of the forests remaining unknown. In cases where the original forest has been extensively damaged, wildlife managers are interested in restoring the forest to its original condition. This chapter describes a wetlands forest simulator and illustrates its use to examine the consequences of management techniques intended to increase or decrease the importance of selected species. A model is presented that specifically simulates possible scenarios for management of forest succession in the Great Dismal Swamp National Wildlife Refuge in Virginia.

Chapter 13 presents mathematical models of rocky shore ecosystems. It describes the rocky shore ecosystem as an extreme spatial and temporal habitat with dramatic, though often predictable, shifts in the physical environment over short vertical distances. The rocky shore is considered ideal for experimental studies because small stretches often are accurate microcosms for ecosystems with much larger spatial dimensions. The author then presents a model of the rocky shore ecosystem followed by a model of the distribution and abundance of benthic algae, model applications, and goals for future research.

30

Kennedy, J. O. S. (1986). Dynamic programming applications to agriculture and natural resources. New York: Elsevier.

Key Words: dynamic programming, agriculture, natural resources, linear programming, management

This book explores dynamic programming as a means of learning about the dynamics of natural processes. The author makes the point that dynamic optimization can be explained more simply with dynamic programming than with other approaches and provides a means of solving dynamic and stochastic resource problems numerically. Conditions for the optimal management of a resource can be derived using the logic of dynamic programming.

Techniques of dynamic programming are explored and a general resource problem is set out. The results are related to the discrete maximum principle of control theory. Dynamic programming arguments are then used to derive optimal conditions for particular resources, including agricultural and natural resource applications. The agricultural applications that are addressed include crop management, livestock management and scheduling, replacement and inventory management. The dynamic programming applications to natural resources include land management, forestry management, and fisheries management.

The need for an operational approach for solving dynamic problems is well noted. Although many research applications of dynamic programming to agricultural and natural resource problems are mentioned in this book, there are few reports of the commercial use of dynamic programming. One reason for the lack of operational use of dynamic programming may be that it cannot be used to answer the practical questions faced by resource managers.

Dynamic programming, as discussed in this text, provides examples of land, forestry and fisheries management. Variables reflecting human intervention are included, but examples of ecosystem management are not presented.

31

Kneese, A., Lee, D., Paulsen, C., & Spofford, W., Jr. (Eds.). (1988). Design of studies for development of Bonneville power administration fish and wildlife mitigation accounting policy. Washington D.C.: Resources for the Future.

Key Words: wildlife mitigation, valuation

This book is a collection of technical papers addressing fish and wildlife mitigation necessitated by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The articles are divided according to the following topics: (1) modeling the salmon and steelhead fisheries of the Columbia River Basin, (2) models for cost-effectiveness analysis, and (3) ocean fisheries harvest management. This volume presents Phase II of the three-phase project and includes the results of research aimed at providing a comprehensive program design based on development of needed methodologies, identification of data needs and potential sources, and a plan for the program's execution.

Phase II entailed completion of three separate work tasks. The first task was to investigate the feasibility of and propose a plan to develop a system model that would estimate loss in fish productivity caused by development and operation of the hydroelectric system and would include the hydrologic, ecologic and economic components of the Columbia River system. Task two required an assessment of alternative procedures for allocating responsibility for fish productivity (1) to the federal hydroelectric project, (2) between federal and nonfederal hydroelectric projects, or (3) to system-wide loss caused by the hydroelectric system but not attributable to any single project. The final task was an inventory of available monitoring and accounting options, and an evaluation of their suitability for measuring mitigation progress.

Part Two of this report discusses the economics of fish mitigation strategies. Two methods of cost-effectiveness analysis are presented. The first is an assessment and comparison of the cost and fish production implications of a prespecified set of alternative mitigation strategies. The second form of analysis involves the design of cost-effective fish mitigation strategies by means of a systematic search procedure obtained through mathematical programming.

Kusler, J. A., & Kentula, M. E. (Eds.). (1990). Wetland creation and restoration: The status of the science. Washington, D.C.: Island Press.

Key Words: wetland restoration

This book is a preliminary evaluation of the status of wetland creation and restoration in the United States. The U.S. Fish and Wildlife Service estimates that 30-40 percent of the original wetlands in the United States have been lost and that destruction continues at a rate of 300,000 to 400,000 acres annually. Wetland restoration and creation consequently have been recommended to (1) reduce the impacts of activities in or near wetlands, (2) compensate for additional losses, (3) restore or replace wetlands already degraded or destroyed, and 4) serve various new functions such as wastewater treatment, aquaculture, and waterfowl habitat.

The report is presented in two parts, Part One is a series of regional reviews. Each review summarizes wetland creation and restoration experiences in broadly defined wetland regions, including freshwater marshes, kettle and pothole wetlands, riparian wetlands, and seagrass systems. The papers in this section summarize the available information, identify what has and has not been learned, and recommend research priorities. Part Two is a series of twelve theme papers covering a wide range of topics such as wetland evaluation, wetland dynamics, and long-term evaluation of wetland creation projects.

In "Long-Term Evaluation of Wetland Creation Projects," Charlene D'Avanzo develops six criteria for wetland assessment: (1) comparison of vegetation growth characteristics in artificial and natural wetlands after two or more growing seasons, (2) habitat requirements of plants invading the created site, (3) success of planted species, (4) comparison of animal species composition and biomass in human-made and natural wetlands, (5) chemical analyses of artificial wetland soils compared to natural wetlands, and (6) evidence of geologic or hydrologic changes with time. She concludes that many creation projects fail because of improper hydrology. Indeed, the existence of an appropriate and functional hydrologic system is essential for the establishment and development of the specific wetland species. The goal of creating persistent functional wetland systems is considered more important than the creation of wetland types since the present structure of a wetland may be only a temporary expression of the future wetland.

The editors conclude that limited practical experience and scientific data, unspecified goals in wetland creation and restoration projects, and lack of project monitoring have contributed to frequent partial project failure. The study indicates that, while some wetland functions may be approximated, duplication of a naturally occurring system is impossible. Successful restoration or creation varies with the type of wetland and target functions, and it depends upon the long-term ability to manage, protect and manipulate wetlands and their surrounding buffer areas. Fourteen recommendations are made to resolve these problems including multidisciplinary planning and supervision, site-specific project goals, and a general policy of restoration before creation.

33

Lee, C. S., & Ang, P., Jr. (1991). A simple model for seaweed growth and optimal harvesting strategy. Ecological Modelling, 55, 67-74.

Key Words: seaweed biomass, optimal harvesting strategy, accumulated yield, logistic growth

The interest in seaweed growth and harvesting has increased in recent years as new uses have been developed for many species. Research has shown that to manage this renewable resource a long-term management policy is preferred over a short-term policy. This paper attempts to use a simple logistic model with time-dependent periodic growth and death rates and coefficients to model qualitatively the growth of seaweed biomass. The intent is to determine the harvesting rate that renders the maximum average annual sustainable yield. Based on previous work, an optimal annual harvesting strategy is presented.

The authors present equations for the biomass, harvesting rates, and accumulated yield of a species of seaweed as a function of time. For simulation purposes, values are chosen for the parameters used in the equations. Based on these parameters, the optimal harvesting strategy is determined. Predicted growth and accumulated yield over a period of 10 years are presented graphically.

The authors conclude that the model addresses the questions, "What is the pattern of biomass increase of a species of seaweed and, given such a pattern, how should we harvest optimally every year?" They note that it would be interesting to determine the effect of harvesting strategies other than the constant rate assumed in this model.

This article presents a model that could be applied to a species of seaweed. The authors state that the model could be extended to other organisms that follow a logistic growth pattern. The model is of a segment of an ecosystem and does include variables reflecting human interventions but the model is untested against data from the field.

34

Leopold, A. (1990). Means and ends in wildlife management. Environmental Ethics, 329-332.

Key Words: wildlife value, ethics

The thesis of this discussion paper is that wildlife value is a combination of scarcity value and artistic value. Unlike agriculture, no universal standard exists by which to judge ecosystem outputs. While wildlife managers recognize the existence of nature's invisible interdependencies, the difficulty in isolating these variables leads to a broad range of opinion concerning preservation techniques and priorities.

35

Manes, C. (1988). Philosophy and the environmental task. Environmental Ethics, 75-82.

Key Words: environmentalism, ethics

Environmentalism is a biocentric philosophy based on two ethical options: the idea that inherent value bestows equal moral integrity on all life forms, or that the value of nonhuman entities is judged against established moral, intellectual and aesthetic standards. We must recognize that "mankind has no privileged status in the web of life," and that nature's value is greater than its usefulness to humans. On this basis, if our ethics demand that people not be treated as mere objects of use, then the same principle must apply to nature. Thus, we must recognize that the usefulness of nature is not simply the economic value assigned to it.

Manes asks whether environmentalism is a philosophy or a task. While philosophy seeks to understand the conditions of its own possibility, a task "brackets off ontological foundations and responds to social practices." Instead of seeking the "irreducible source" of a valuation framework, environmentalists should focus on the preservation and expansion of wilderness and create an agenda resistant to the power relations motivating such conduct.

"Environmental ethics are a revolutionary ethics" and cannot be legitimized on the basis of either the traditional stewardship model or phenomenology. Manes therefore concludes that "environmental ethics can only offer an ethics of resistance, a negative ethics."

36

Measuring Change in Ecosystems: Research and Monitoring Strategies.

Key Words: ecosystem monitoring

In this article, four strategies are discussed and recommended to improve the nation's ability to anticipate ecosystem failure and landscape changes in response to natural and human perturbations.

The following strategies are presented: (1) establish the principle of maintaining ecosystem and landscape integrity and sustainability as an integrative management policy; (2) select indicator variables of ecosystem integrity and sustainability on a regional or landscape basis; (3) develop standard methods of data collection and analysis for ecosystem monitoring; and (4) establish an integrated, large-scale, long-term national program for regionally focused ecosystem monitoring, research and risk assessment.

Key elements of this program are the inventory and monitoring of critical ecosystem attributes that reflect ecosystem conditions. Such attributes include elemental dynamics, energy dynamics, trophic dynamics, species density, biodiversity, critical species such as keystone species, genetic diversity, dispersal and migration, natural disturbance, and ecosystem development.

37

Mikesell, R. F. (1987). Resource rent and the valuation of environmental amenities. Resources Policy, 98-102.

Key Words: environmental valuation, resource valuation

The purpose of this article is to determine how the social value of a development project in a wilderness area should be compared with the value of the wilderness amenities that would be destroyed or severely harmed by such development. Environmental economists claim that the social benefits of wilderness can be categorized as a value output. The difficulty lies in determining whether and by how much this value outweighs the value of developing the natural resources of the area. Mikesell presents a methodology for resolving this dilemma and emphasizes the social risk entailed by the irreversibility of development.

The standard measure of comparison is net present value (NPV) of the annual social benefits of the wilderness area with the NPV of the commercial project. The contribution of the natural resource to the social product should be measured by its economic rent since only a positive resource rent indicates a contribution to the national product. "It is this contribution that should be measured in comparing the social value of the environmental amenities with development." Furthermore, the irreversibility of development relative to the reversibility of preservation is a key factor in determining the social value of the benefits of alternative uses.

The author concludes that the value of commercial development in a wilderness area is equal to its resource rent or "the probability adjusted NPV of the development project." In addition, since the social risks outweigh investment risks in development, they "should be reflected in the probability coefficients applied to the NPV of the social product of developing a wilderness area."

Using net present value, the author seeks to measure and compare the values of development and wilderness amenities. He determines that economic rent is the best indicator of value because it reflects the contribution to national product of either development or preservation.

Mikesell, R. F. (1989). Depletable resources, discounting and intergenerational equity. Resources Policy, 292-296.

Key Words: resource depletion, intergenerational equity, sustainability, social discounting

By viewing natural resources as capital assets and their depletion as capital consumption rather than income, society can reconcile the discounting of future benefits with intergenerational equity and sustainable development.

The use of benefit-cost analysis to manage depletable natural resources has been severely criticized because discounting future benefits encourages current consumption without regard for future generations. Discounting future benefits also is considered incompatible with sustainable development. While the use of artificially low discount rates to reconcile these issues has been suggested, Mikesell points out that "the use of arbitrary discount rates destroys the logic and consistency of the valuation process." The solution is to view the income from natural resources in the same manner as rents from man-made capital assets. Sustainable output from depletable resources depends on reinvesting the portion of resource rent due to depletion in order to avoid capital consumption. "In the case of renewable resources, depletion can be reinvested in a way that maintains the value of the resource itself; in the case of non-renewable resources, the depletion can be reinvested in other ways that maintain the original capitalized value of the net revenue from the resource."

Illustrations are provided for the management of virgin forests, mineral resources, agricultural resources and wilderness amenities. For example, if a virgin forest is publicly owned, Mikesell recommends reinvestment of the income from development in tree planting; if it is privately owned, a tax on timber harvest that declines with the age of the trees would minimize harvesting. Sustainable policies for minerals, agriculture and wilderness revolve around the author's conclusion that natural resources should be considered social capital whose depletion is not recorded as income available for consumption.

Mikesell criticizes cost-benefit analysis and discounting as measures of environmental value and, instead, recommends that natural resources be considered capital assets and their depletion seen as capital consumption.

39

Milhous, R. T., Wegner, D. L., & Waddle, T. (1984). User's guide to the physical habitat simulation system (phabsim) (FWS/OBS-81/43). Washington, DC: Fish and Wildlife Service.

Key Words: flow regime, physical habitat structure, water quality, watershed, energy inputs, aquatic habitat, suitability curves, hydraulic simulation

This manual attempts to compile and consolidate information on the use of the physical habitat simulation (PHABSIM) system models. The objectives are to provide information to the user on how to use PHABSIM efficiently, to describe the capabilities and limits of PHABSIM, and to develop the understanding that the quality of PHABSIM is not static but varies with the quality, quantity and assumptions of data input. The manual has been organized to give the user an overview of the PHABSIM system and specific descriptions of the theory and organization of the programs making up PHABSIM. Numerous appendices contain directions for the use of particular programs or for specialized applications of the programs. This document is intended for use by those who have completed the Instream Flow Computer Analysis Short Course. Each December, updates of both the computer programs and the manual will be made.

The PHABSIM system was developed to simulate a physical habitat in relation to flow regime, water quality and the physical structure of streams. The existing system has been applied to both fisheries and water management. In many water management activities, the objective is to determine the best of two or more possible management alternatives. The current PHABSIM system is useful in making regional comparisons if the biologist, ecologist or recreation specialist is of the opinion that the natural energy sources are similar and the sediment load is not drastically different from stream to stream in the region.

The PHABSIM system is a combination of components that are linked together to provide a definition of the physical aquatic habitat. The two basic components are the hydraulic and the habitat simulation of a stream reach utilizing defined hydraulic parameters and habitat suitability criteria. The PHABSIM system uses three hydraulic simulation programs, IFG-1A, water surface profile (WSP) and IFG-4. Users are required to develop and maintain their own suitability curves that directly relate to species preferences in their study areas. PHABSIM is intended for use in those situations where the flow regime is the major determinant controlling the fishery resource and field conditions are compatible with underlying theories and assumptions. This method has application to the quantification of instream flow requirements, negotiation of water delivery schedules and impact analysis.

This work does not develop ecosystem models but explains the use of programs for hydraulic simulation using the water surface profile and IFG-4 model, habitat simulation, curve management, linking, plotting, and time series.

40

Miller, P. (1982). Value as richness: Toward a value theory for an expanded naturalism in environmental ethics. Environmental Ethics, 101-114.

Key Words: environmental ethics, value

Miller proposes that "the value of the natural world is not restricted to its utility to humankind, but contains an independent intrinsic worth as well." Since our relationship with the natural world is not exclusively utilitarian, intrinsic value must include the conscious lives of humans and animals as well as the richness of the inanimate world.

In support of these claims, Miller examines action theory, which "categorizes responsible agents" and value theory, which acknowledges the presence of values regardless of awareness of them. The value theory is expanded to include five complementary dimensions of richness: resources, development, diversity, integrity and utility. Miller's "theory of value as richness" presents a "plausible nonpsychological theory of value that accommodates environmentalist convictions as well as more traditional value concerns."

At best, we have developed a management ethic for the use of the environment but not an ethic of the environment. To do this, we must define aesthetic categories that identify positive values with such things as "harmonious composition of elements that may exhibit some intensity of contrasts and some structured dynamism or development" and include inanimate as well as animate nature.

Miller's article is an ethical discussion of the value of nature, and he concludes that its worth must not be measured solely in terms of the conscious world of humans.

41

Mitsch, W. J., & Gosselink, J. G. (1986). Wetlands. New York: Van Nostrand Reinhold Company.

Key Words: wetland ecosystems, valuation, ecosystem management.

This book describes the coastal and freshwater wetland ecosystems in the United States and their management as natural resources. Wetlands are uniquely important ecosystem components valued as critical fish and wildlife habitats as well as areas of water management and conservation. The authors present a dual picture of wetland ecology: (1) a general view of principles and components of wetlands that have broad application to many wetland types, and (2) a specific ecosystem view that examines the structure and function of dominant wetland types.

The introduction presents an overview of wetland science, a definition and discussion of distinguishing wetland features and values, and a review of wetland types and their status in the United States. The authors continue in the next eleven chapters to discuss in detail the general ecological dynamics of wetland hydrology, biogeochemistry, biological adaptation, and development, as well as the specific characteristics of coastal and inland wetlands. Coastal wetlands include tidal salt marshes, tidal freshwater marshes and mangrove wetlands; inland wetlands include freshwater marshes, northern peatlands and bogs, southern deepwater swamps, and riparian wetlands. Each chapter discussion on a wetland type summarizes its geographical extent, geomorphology and hydrology, chemistry, ecosystem structure and function, and ecosystem models used in its analysis.

The final three chapters discuss wetland management and specifically wetland values and valuation, protection and management, and classification and inventory. Wetland values are given as timber, fish and waterfowl harvests, wildlife refuge, flood mitigation, storm abatement, aquifer recharge, water quality maintenance, and aesthetics. These values can be quantified and evaluated using scaling and weighting approaches, common denominator approaches, or replacement value measures. Wetland management includes both alteration and protection. Wetland alteration has been the traditional form of management in the varying forms of dredging, filling, drainage, hydrologic modification, mineral extraction, and water pollution. With the recent recognition of wetland values, federal and state governments have instituted protection measures. Consequently, wetlands are now managed in a more natural state for the purposes of fish and wildlife enhancement, agricultural and aquaculture production, water quality improvement and wastewater management, and flood control and recharge. Finally, wetland classification is accomplished by identifying systems and subsystems that identify a wetland class. System categories include marine, estuarine, riverine, lacustrine, and palustrine, and they are accompanied by a series of eight subsystem categories.

Wetlands presents a comprehensive review of wetland ecosystems, models, management and valuation. It is an excellent basis for any wetland research project.

42

Norton, B. (1982). Environmental ethics and the rights of future generations. Environmental Ethics, 319-337.

Key Words: environmental ethics, preservation, future generations

This paper is based on a previous article by Derek Parfit in which he proposed that a policy of resource depletion implies no harm to existing individuals, present or future, since present individuals benefit only from utility maximization and future individuals do not yet exist to claim their rights. Norton exposes gaps in the logic of preserving the environment as an obligation toward future generations. He further claims that "all interests and rights must be assignable to an individual and all individuals must be identifiable."

The article discusses whether rights exist for future generations, whether future individuals currently possess rights that impose obligations on the present population, and, if so, can an ethic of environmental preservation be based on such a concept. Two major problems exist with this philosophy: (1) An ethic for future generations will deprive current generations of acceptable standard of living, and (2) an ethic "based on rights of only immediately successive generations will not generate long-term obligations to protect the on-going, holistic ecosystem." Thus, advocates of the future generations theory either "assign a special status to immediately successive generations, discounting the claims of the farther future, or they avoid such discriminations and insist upon equal rights for all future individuals."

Norton argues that the individualistic rights and interests of future generations fail to provide a comprehensive and theoretically sound basis for the idea that the integrity of nature should be preserved. Indeed, purely individualistic ethical systems are inadequate because they ignore our intuitively felt obligations concerning environmental protection. The obligation to provide for future generations cannot rest on obligations to individuals since these individuals do not exist. The only acceptable and meaningful basis for an environmental ethic lies in understanding and appreciating the inherent value of the natural world.

43

Norton, B. (1987). Why preserve natural variety?. Princeton: Princeton University Press.

Key Words: environmental ethics, biodiversity, preservation, intrinsic value, priorities

---

Norton addresses two questions in this book: (1) What reasons can be given for a policy of preserving species, and (2) given the most reasonable answer to the first question, what should be done if financial and personnel resources are insufficient to protect all species. The four sections of this book address demand values, intrinsic values and transformative values as related to species preservation, and preservation priorities. The particular topics include the value of ecosystems and species, diversity and stability, amenity values, anthropocentrism, and priority systems.

According to Norton, preservation and management documents fall into one of four categories: (1) considerations concerning the degree of endangerment and possible success of recovery programs, (2) taxonomic considerations deriving from the comparative phylogenetic isolation of the species, (3) considerations of the ecological value, and (4) considerations based on a range of cultural and socio-economic values. Only priority decisions based on 1 and 2 avoid controversial value judgments about species. He further distinguishes between formal and substantive priority criteria. Species ranking is formal if it is accomplished without reference to characteristics of individual members of the species in question. It is substantive if it requires reference to and value judgments regarding characteristics of the individual members of the species under consideration.

Norton's research yields the following conclusions: Preservation of biological diversity should not be reduced to protecting remnant populations of threatened species, species should be seen as having an independent existence drawing upon resources available in the natural ecosystems to which they also contribute, and habitat or ecosystem protection provides a more promising approach to preserving species than programs designed to protect individual species.

44

Odum, H. (1989). Simulation models of ecological economics developed with energy language methods. Simulation, 69-75.

Key Words: energy circuit language, transformity, emulation, ecological economics, systems ecology, ecoenergerics, mini model simulation

---

A method of modeling ecological systems based on a set of energy-based rules is presented in this article. The energy-systems language method is used to model and simulate the transfer of homologous concepts between levels of the hierarchies of nature. The mathematics of self-organization is applied to the new fields of ecological economics and ecological engineering. The intent here is to use energy language to develop overview models relevant to public policy for developing nations. A model of a developing nation is presented as an example with simulations for alternative policies.

To explain the method, a simple minimodel is presented. The mathematics of the model are loosely based on electrical circuit theory and control feedback theory. Equations are derived, numerical values are written, and graphic results are shown for the minimodel. The model includes the flows of money, materials, energy, and human services based on a diagram. The example starts with classic textbook macroeconomic equations diagrammed with realistic resource limits. An explanation of the thought processes as one overviews the network is given for the model. The diagram indicates energy-hierarchical position, defined with a new thermodynamic parameter. Solar transformity of a storage or flow is defined as the solar energy required and transformed to generate one unit of energy in that storage or flow. Solar energy required for a flow is termed its solar emergy (spelled with an "m") by the author .

The simulation results illustrate some of the consequences of public policy and offer some insight into current world problems. Simulations are presented without exports or external investment, without outside monetary investments, with large monetary investments, with a rising price of external imports relative to sales, and with declining world availability of cheap energy and minerals. The use of overview minimodels for simulating history and considering the future is suggested. The author states that, by expressing policy decisions in energy circuit language, more precision is introduced into decision making.

Since 1967 energy circuit language has been used for synthesis, analysis and simulation of ecological systems. The model used here represents a continued development of the language.

Although the model, as presented in this article, does not focus on ecosystems, it does relate environmental resources to human behavior. The use of overview models for simulating history is also discussed.

45

Pimentel, D. et al. Environmental and economic effects of reducing pesticide use: A substantial reduction in pesticides might increase food costs only slightly. BioScience, 41(6), 402-408.

Key Words: environment, pesticides, agriculture

This article attempts to estimate the potential agricultural and environmental effects of reducing United States pesticide use by approximately 50 percent. To estimate the costs and benefits, the author examines current pesticide use patterns in approximately 40 major U.S. crops, evaluates current crop losses to pests, estimates the agricultural impacts of reduced pesticide use by substituting currently available biological, cultural and environmental pest-control technologies for selected current pesticide practices, and examines the public health and environmental effects of reduced pesticide use.

Of the estimated 434 million kg of pesticides used annually, 69 percent are herbicides, 19 percent are insecticides, and 12 percent are fungicides. Since 1945, the use of synthetic pesticides has increased 33 times due largely to changes in agricultural practices and cosmetic standards. While some new pesticides are at least ten times as potent than older products, crop production has not shown a proportional rise due to several major changes in agricultural practices. These changes include an increase in pests resistant to pesticides, planting certain crop varieties that are more susceptible to insect pests, and the destruction of natural enemies of certain pests, which necessitates increased pesticide treatments.

Pimentel concludes that pesticides cause serious health problems and considerable damage to agricultural and natural ecosystems. These findings confirm previous reports that it is feasible to reduce pesticide use by half at a cost of approximately $1 billion. Such a reduction would require substituting nonchemical alternatives for chemical pest control and improving the efficiency of pesticide application technology. If pesticide use were reduced by half without any decline in crop yield, the total price increase in purchased food due to increased costs of alternative controls is calculated to be only 0.6 percent.

46

Randall, A. (1987). Resource economics: An approach to natural resource and environmental policy. New York: John Wiley & Son.

Key Words: resource economics, environmental policy, scarcity, degradation

This textbook is about natural resource and environmental policy with a special focus on the role of economic analysis in informing, analyzing, evaluating and assisting in the development of that policy. Resource economics is so completely policy oriented that it would not exist if all resource-related decisions were made by the decentralized, profit-seeking entrepreneurs of competitive microeconomic theory, and the outcomes of such decisions were regularly and predictably efficient and just. While economics is the focus of discussion, the natural sciences and legal, political and administrative issues also are presented.

Five principle parts of the book address the integration of environmental policy and economics, the institutional framework for policy formation, project and program evaluation, and case study applications of resource economics policy. The specific subject areas covered include the historical basis and need for natural resource and environmental policy, economic and intertemporal efficiency, property rights, sources of inefficiency, legislative and judicial processes, benefit-cost analysis, conservation and preservation, applications to exhaustible resources, biological resources, and water resources.

47

Resource Pricing and Valuation Procedures for the Recommended RPA Program.

Key Words: resource valuation, present net value

This report contains information on the economic analysis of the National Forest System portion in the Recommended 1990 RPA Program. Present net value (PNV) is used to measure economic efficiency. Efficiency may be constrained by efforts to meet environmental and legal requirements, reduce government spending, increase government revenues, maintain or improve the productivity and environmental quality of forests and range lands, and promote sound local economies.

Three accounting stances were used to calculate resource prices for the economic analysis: (1) existing fees, which provide a benefit estimate in terms of returns to the U.S. Treasury; (2) market-clearing price, which approximates the price a good would sell for in a competitive market; and (3) market-clearing price plus consumer surplus, which estimates the total social benefit of a good in excess of the cash exchanged.

Also included is a discussion of the method used to calculate present net value in the efficiency analysis. "PNV is a valuable integrator of numerous costs and benefits that are spread across time into one index. A positive PNV indicates that dollar-measured benefits of the program are greater than the costs." The remainder of the report is a listing of the actual prices used in the economic analysis for the 1990 program.

This report presents an application of present net value to measure the economic efficiency of resource development. It includes a discussion of how the resource prices were estimated as well as actual price tables.

48

Rhind, D. (1991). Geographical information systems and environmental problems. ISSJ, 130, 649-668.

Key Words: environmental monitoring, earth system, globalization, ecosystem modeling and prediction

---

This article attempts to review some of the problems in environmental monitoring and prediction, describes the basics of Geographical Information Systems (GIS) and provides examples of its use at three different levels of detail, including within the European Commission's Environmental Information System (CORINE). The author also attempts to summarize what is known about processes in the natural environment, which he/she derived chiefly from the Earth System Science: a Program for Global Change, 1988 (ESSC). The primary concern is with changes occurring over time spans from minutes to centuries and from spatial wavelengths from about 1 meter to about 100 km.

The primary data source for this article is the ESSC. This information includes a conceptual model of earth system processes operating on timescales of decades to centuries. The author states generally known facts then discusses them in the context of the global environment and ESSC model on earth system process. In describing the basics of GIS, the author begins by discussing the uses, environmental applications at the local scale, the national and continental scale (the CORINE project), and the global scale (NASA and Global Environmental Monitoring System/Global Resources Information Database (GEMS/GRID)).

Based on the discussion of GIS, technical aspects and problems are discussed in the context of remote sensing as a data collection process, and the data problem and partial solutions.

In this article, much of the emphasis is on the natural science aspects of environmental monitoring and prediction. The author concludes that, for geographers, all of these aspects need to be woven together to anticipate the likely spatial patterns of the effects of massive change, the redistributions in trade, health and wealth that they bring about, and the 'knock on' effects these consequences themselves will have on society and the environment. A result of this is that, with the globalization of markets, environmental monitoring and prediction is a matter of considerable significance for social scientists. Global Information Systems is an integrating technology in terms of both data and fields of science.

This article discusses the potential of applying GIS to ecosystem modeling. The ESSC model is on the global spatial scale and on a temporal scale of decades to centuries. The model does accept human activities as inputs. The outputs of the model include climate change impacts, impacts of human activities, and ecological impacts.

49

Robinson, J. (1991). Modelling the interactions between human and natural systems. ISSJ, 130, 629-647.

Key Words: environmental modeling, human systems, information network, physical systems, global change, backcasting

---

The purpose of this article is to discuss the modeling capabilities that might be required to support the analysis to be undertaken in the Human Dimensions in Global Change (HDGC) Programme. The focus is general and conceptual. No attempt is made to discuss specific models that might serve particular purposes within the HDGC Programme. Rather, this article proposes a conceptual framework in terms of which modeling priorities could be developed for the various substantive research foci of the HDGC Programme.

The subject of the HDGC Programme is the human causes and consequences of those global environmental changes that are the subject of study in the International Geosphere-Biosphere Programme (IGBP) on Global Change. The HDGC Programme must address the linkage between those systems that are the subject of the IGBP and the human systems that help to create and feel the effects of environmental change. The methodological challenge is to develop analyses that integrate the different fields of study relevant to the concerns of the programme. A holistic transdisciplinary approach is required. Two views of the relationship between human and natural systems are considered, one focusing on the physical flows of matter and energy and the other emphasizing the flows of information and decision making that characterize our attempts to address the problems presented by global change issues.

A physical-flow view is a necessary component of any research intended to come to grips with the human dimensions of global change problems. However, a pure physical-flow view of the world, by itself, provides an inadequate basis for remedial and corrective responses. This is because such a view does not include human decision-making activities or institutional issues related to behavior and policy making. The actor system is suggested as one view that focuses on relationships, and attempts are made to combine the physical flows and the actor system. A discussion is presented that provides a proposed framework to incorporate the relationships between human and natural systems. The author makes the point that any model intended to address the interactions between these systems must be capable of long-term analysis, 20-100 years. A scenario analysis method called backcasting is presented that could be used for such long-term nonpredictive analysis. Backcasting involves working backwards from a desired future end point to the present.

This article does not develop or review ecosystem models but instead presents a conceptual framework under which modeling in support of the HDGC Programme can be undertaken. Such a framework implies an approach to modeling—the design approach—that is different from conventional approaches to long-term modeling.

50

Rolston, H., III. (1986). Philosophy gone wild: Essays in environmental ethics. New York: Prometheus Books.

Key Words: environmental ethics, philosophy, value, ecological ethic

---

The following questions form the basis for Rolston's examination of environmental ethics: Do humans have a responsibility to nature or simply a duty to people concerning natural things? What sort of human domination of nature is proper? Do we have duties toward animals or endangered species? In what ways can and should people submit to nature? Is nature only a human resource possessing mere instrumental value, or do intrinsic values exist? Is nature's value subjective or objective?

In his discussion of value in nature, Rolston distinguishes between economic, life support, recreational, scientific, aesthetic, life, diversity and unity, stability and spontaneity, dialectical, and sacramental values. Economic value is typically assigned to nature only after human ingenuity has transformed it into a valuable and useful resource. Thus, economic value is a function of the state of science as well as a function of valuable natural properties that humans convert and to which they assign value. Scientific value occurs only because humans have found nature interesting enough to study. However, it is typically odd, useless, and rare things that have high scientific value.

Life value depends on one's definition of life. A staunch humanist may claim that only personal life has value, making every other life form tributary to our interests, while a naturalist will realize that such a view is callous and anthropocentric selfishness. Rolston argues that those who cannot find organic, aesthetic or intelligible justifications for valuing nature cannot deny it an interest value. Because life is both rare and natural, it is of interest. Indeed, while lower life may be sacrificed for higher forms, it is still a principle goal in ethics for humans to find a suitable place for the integrity of other life forms.

Through both subjective and objective analyses of nature, Rolston argues and ultimately concludes that nature is both a concept and entity beyond mere human grasp and value. The instrumental value of nature supports only our economies and societies, while the true value of nature can only be discovered in its wildness, solitude, and life-giving power.

51

Sagoff, M. (1985). Fact and value in ecological science. Environmental Ethics, 99-116.

Key Words: ecology, ethics, ecosystems

The application of ecological science entails the dual responsibility of providing services and protecting processes. Ecology strives to offer two kinds of knowledge and, thus, two kinds of power. The first provides a scientific framework in which to manage ecosystems to maximize the goods and services they provide. This type of knowledge advances environmental management by enhancing our power over nature. The second type of knowledge provides a scientific framework in which to appreciate the qualities of ecosystems and evaluate policies concerning them. This promotes environmental protection by enhancing our respect for nature and, therefore, our power over ourselves.

The role of ecological science is twofold: to intervene in healthy ecosystems to make them economically more valuable or efficient and to maintain and restore the normal health and functional capacity of these systems by preventing illness and curing disease. Since the integrity of biological systems is not a measurable quantity, ecologists should seek to quantify various kinds of injury, insult, and distress. Furthermore, a healthy ecosystem should not be defined as one that efficiently produces the goods and services humans demand. Indeed, environmental protection "reflects an ethical concern with the intrinsic . . . integrity of ecosystems considered . . . independently of the needs and uses of human beings."

While the author concludes that sound moral reasoning must not be replaced by the extreme utilitarian argument requiring preservation of all species regardless of their low marginal values or high maintenance costs, he requests from ecologists guidance in understanding and defining the health of nature independently from the welfare of man.

This article examines the ethical relationship between ecology and economics. The author illustrates his thesis with examples from Chesapeake Bay and saltmarsh studies.

52

Sagoff, M. (1981). Do we need a land use ethic? Environmental Ethics, 293-308.

Key Words: ethics, land use, value

In this article, Sagoff criticizes the popular economic requirement that land use policies reflect a perfectly efficient land market. Traditional views of economic efficiency are inappropriate for land use and result in excessive commercial development that "appalls ethical judgement and aesthetic taste." Sagoff, therefore, recommends that aesthetic principles supplement land use policies.

Our current economic approach to land use leads to, or may justify, the destruction of remaining waterfront and wilderness areas even if fragile values and the problem of the commons are considered. In fact, economic approaches to environmental policy succeed only to the extent that they satisfy consumer demand. The conversion of the natural into the economically efficient conflicts with many principles that ought to influence environmental policy. These principles, which are conceptually unrelated to economic efficiency, may require the protection of even so-called useless endangered species and their habitats.

The Judeo-Christian tradition and Locke's property theory are blamed for fostering the current anthropocentric view of the natural world since both advocate man's domination of nature. Locke's theory further fails to promote social equality and justice, to conserve for future generations and to account for finite natural resources. These philosophies form the basis for the concept of rational self-interest, which is supposed to guide rules governing competition and enhance cooperation that benefit all. However, this attitude is economically based and is not relevant to environmental policy.

Shadow pricing of nature's intangible properties is an attempt to price interests, principles and beliefs as market externalities and confuses society's ideals with its consumer preferences. According to Sagoff, a land use ethic should "elaborate categories for public policy beyond those of efficiency and even equality" by introducing to environmental law "a concept of dignity to balance the concept of price."

This paper examines the ethical distinction between intrinsic and instrumental value; that is, objects that are valuable as individual things, and objects that have value because of the purpose they serve. Sagoff concludes that "ethics and aesthetics as well as economic principles are needed to guide policies governing the use of land."

53

Sagoff, M. (1986). Process or product? Ethical priorities in environmental management. Environmental Ethics, 121-138.

Key Words: ecosystem valuation, ethics, public policy

Sagoff examines the approach of biotechnologists and bioconservatives toward environmental valuation. Biotechnologists value the environment for "the wants it satisfies or the uses to which it may be put" and believe nature can be improved by technology to maximize the benefits that it offers man. Bioconservatives value the environment's intrinsic qualities and would like to restrict technological interventions into the environment. These two views reflect two different concepts of valuation: to value an object for its useful characteristics or to value a particular person or object in itself.

Biotechnologists are criticized for advocating economic efficiency. Sagoff refers to the use of hybrid corn in agribusiness as an advance that ultimately harmed the farming industry. While perfectly competitive markets are neutral, voluntary and autonomous, they effect society's consumer demands rather than satisfaction derived from the goods and consequently distort a responsible allocation of resources. Indeed, "economic prosperity . . . is a macroeconomic goal which has no demonstrated connection . . . with a microeconomic approach to resource policy cast in terms of efficiency in the allocation of resources."

Sagoff recommends a policy requiring incremental improvements in environmental quality and the preservation of ecosystem integrity. Such an approach would "appeal most strongly to our national conscience while remaining sensitive to costs." Environmental "offsets," mitigation strategies, negotiation and a ranking of ecosystems according to historical, cultural and biological criteria will be critical to the policy's success. Specifically, legislators must allow "minor environmental damage to be offset by greater gains in environmental quality obtained elsewhere at less cost."

This paper is an ethical discussion of views of ecological valuation as seen by biotechnologists and bioconservatives. Sagoff critiques biotechnology and presents a policy approach sensitive to both economic costs and ecological preservation.

54

Scherer, D., & Attig, T. (Eds.). (1983). Ethics and the environment. New Jersey: Prentice-Hall.

Key Words: environmental ethics

This book is a collection of articles addressing first the formation of an environmental ethic and, second, specific concerns and applications related to this ethic.

Part One presents nine articles that address the conceptual issue of whether the character of an ethic must be redefined to include environmental considerations. The writers challenge traditional human-centered beliefs by asking whether the environment has more than instrumental value and how humanity might be more sensitive to its environment.

The authors in Part Two discuss specific concerns in light of the following questions: What values should be reflected in human land use? What are the strengths and weaknesses of using cost-benefit analyses for determining environmental policies? What values, individual or collective, should inform public choices concerning environmental policy?

Of principle interest are articles in Part One by Aldo Leopold, Mark Sagoff, Holmes Rolston III, and John Rodman. Leopold views the Earth as an organism and suggests that the environment possesses intrinsic values worth preserving. For Sagoff, self-definition in terms of our heritage, history and culture is impossible except in relation to nature. Rolston claims that humans are only one element in a vast ecological order and proposes that the value of human life emerges from the ecological setting. Finally, Rodman reviews the historical development of four key attitudes toward the environment: conservatism, preservationism, moral extensionism, and ecological sensibility.

55

Scodari, P. F. (1990). Wetlands protection: The role of economics. Washington D.C.: Environmental Law Institute.

Key Words: wetlands, ecological protection, ecological economics, valuation

This report examines how economic analysis can be used to strengthen wetland protection efforts. It concludes that current economic assessment methods fail to accurately account for the wetland values destroyed by development. Scodari relates his discussion specifically to the Corps of Engineers' valuation procedures, and he examines the scientific, economic and political flaws in their methods. He continues with both a scientific and economic discussion of wetland valuation, specific case studies from the Corps' valuation and damage assessment projects, and recommendations for methodological improvements.

Chapter Three discusses the economic principles and methods for valuing wetland goods. Scodari maintains that, because wetland owners cannot internalize the value of the benefits wetlands provide to society, the marketplace price per acre does not fully reflect the true exchange value of wetlands relative to other goods and services. Consequently, most wetland owners find it more profitable to convert the wetlands to agricultural uses or to sell the land to developers. The remainder of the chapter presents six economic techniques based on willingness-to-pay methods for valuing nonmarket environmental outputs. The net factor income method measures the appropriate income to natural resources as factors of production in commercial activities by estimating the economic profits of these activities after payment is made to all other factors of production. The travel cost method determines consumer demand for the recreational use of a site by comparing the rate of site visitation with the cost of visitation in order to estimate the value of recreational benefits. Also included are the contingent valuation, hedonic pricing, damage cost, and energy analysis methods.

Scodari envisions a bioeconomic wetland valuation model that would permit quantification of the relationships among wetland characteristics, quantity and quality of wetland outputs, and human use and societal value of those outputs. Unfortunately, the development of such a model is inhibited by its necessary complexity, extensive data requirements, and costs, as well as limited scientific understanding of the linkages among wetland characteristics, functions and outputs. Given these barriers, wetlands must be valued by identifying regional wetland outputs that are readily apparent or generally recognized by ecologists and applying available economic valuation techniques.

56

Shabman, L. A., & Batie, S. S. (1987). Mitigating damages from coastal wetlands development: Policy, economics and financing. Marine Resources Economics, 4, 222-248.

Key Words: Wetlands, management, damage, policy, development

The purpose of this paper is to propose a policy framework for coastal wetland management and damage assessment. Specifically, a policy based upon setting targets for maintaining regional wetland stocks is described, and a management program based upon wetland development fees and banks is outlined.

The technical obstacles to measuring the economic value of a coastal marsh environment are described. The focus of this work is on the absence of scientific understanding and data suitable for sound valuation efforts. The authors also describe the rapid evolution of the nation's wetland management programs.

Shabman and Batie find that the resulting policy has developed without a clear statement of goals and without a cost effective management program. During the past decade, federal and state government regulations have sought to reduce the rate of coastal wetland development.

However, it is uncertain whether these programs can secure mitigation of damages caused by future development. Revision of coastal wetland management programs is needed. The authors recommend setting wetland acreage targets, protecting certain types of wetlands, and requiring developers to pay a fixed wetland development fee that is set in relation to the cost of wetland replacement.

This paper focuses on the role of economics in ecological modeling and valuation of wetlands. Valuation of wetlands is based, in part, on vectors of human services, such as recreation, nutrient cycling and water quality improvement, erosion control, and wildlife and fish habitat. The value of services is then imputed in determining the economic valuation of a wetlands.

57

Shuter, B. J., Wismer, D. A., Regier, H. A., & Matuszek, J. E. (1985). An application of ecological modelling: Impact of thermal effluent on a smallmouth bass population. Transactions of the American Fisheries Society, 114, 631-651.

Key Words: ecology, field simulation, laboratory simulation, thermal effluent, smallmouth bass, computer simulation

---

This article reports on a 20-year integrated field, laboratory, and simulation study of the impact of thermal effluent from a nuclear power plant on the smallmouth bass population in Baie du Dore, Lake Huron. A quantitative model was constructed to forecast the range of likely effects of the plant on the population. The model was based on the findings of 50 years of research on smallmouth bass ecology in Ontario and on 15 years of environmental and biological data collected at Baie du Dore before the power plant became operational. The development of the model is reviewed, and its usefulness as a tool for forecasting the impact of plant operations is evaluated.

The major analytical tool used on the impact study was the computer simulation program. The program was designed to describe the influence of annual temperature cycles on first-year survival of smallmouth bass and to evaluate the effects of changes in such cycles produced by thermal effluent from the power plant. Reasons are presented for focusing the study on the influence of temperature on survival during early life. Field studies began in 1963 and ended in 1982. The data collection methods are detailed in this and previous works by the authors. The authors state that this extensive data allowed them to deal effectively with technical problems that have plagued other studies. A detailed description of the model is provided.

Previous studies of several northern smallmouth bass populations have shown that the year-to-year variation in reproductive success is often shaped by the daily and seasonal variations of water temperature. The authors state that a complete assessment of the effects on reproductive success of a change in the pattern of water temperature variation must be based on a detailed description of the natural pattern of variation and its influence on individual members of the population. Initial impact forecasts are made then compared to observations during the postoperational period. The authors state that changes in the smallmouth bass population can be linked to the presence of the thermal plume, and that the model allowed them to forecast the range of long-term effects likely to be experienced.

This article presents an ecosystem model that accepts data reflecting human intervention, the thermal plume from a power plant, as input and makes long-term predictions for the effects on the smallmouth bass population of the ecosystem.

58

Silberman, J., Gerlowski, D., & Williams, N. (1992). Estimating existence values for users and nonusers of New Jersey beaches. Land Economics, 68(2), 225-236.

Key Words: existence value, willingness-to-pay, recreation value

This study reports empirical evidence on existence value for beach maintenance and compares respondents who intend to use the beach to be nourished and those who do not. Differences are found among the two groups but not among the nonusers. Existence value for those intending to use the beach was found to include a recreation value component. The results of this study support the argument that the *only valid measure* of existence value is the willingness-to-pay amounts of nonusers.

The authors found that the significant variables in the Tobit models used were education, income, distance, and visiting substitute sites. A potential problem was evidence that individual interviewers influenced results. However, the general results support the view that contingent valuation surveys are capable of providing estimates of nonuse value for improving environmental assets. Two policy implications result from this study: (1) The exclusion of existence values from the benefits of improvements to environmental resources would substantially understate their magnitude, and (2) most respondents feel that the federal government should fund recreational projects rather than sharing the costs with state governments.

59

Smith, J. B. (1986). Stochastic steady-state replenishable resource management policies. Marine Resource Economics, 3(2), 155-168.

Key Words: resource uncertainty, social discounting

Smith investigates the application of deterministic golden rule results to the case of resource uncertainty. He considers optimal management programs in which the discount rate of the social planner equals zero and shows that, within a diffusion framework, the optimal steady-state management policy is identical to the optimal management policy outside the steady-state.

It is reasonable to believe that the social planner should realize that economic agents discount the future and generate market interest rates through their market activities. However, there also exist compelling arguments that suggest that the social planner should protect the interests of future generations. Smith proves this claim using a stochastic steady-state model.

According to the author, his results "provide a useful link between steady-state optimal management policies and the quickly developing stochastic resource literature."

60

Smith, V. K. (1992). On separating defensible benefit transfers from "smoke and mirrors." Water Resources Research, 28, 685-694.

Key Words: environment, benefit transfer, economic model, environment, policy

This paper illustrates the need for guidelines for deciding when benefit transfer methods can be used to value changes in environmental resources. The author discusses benefit transfer, how the methods used can influence the answers provided, and whether new models or old models with new methods can improve the transfers used in policy analysis.

The paper begins by discussing applied economic modeling perspectives and relating them to benefit transfers as tools for evaluating policy. The history of benefit transfers is reviewed and summarized. Two analyses of benefit transfers related to limiting industrial effluent discharged into specific rivers are compared in terms of typical assumptions required from the analyst.

An agenda for future benefit transfer research is proposed that includes devising strategies for extending available benefit transfer theory, learning from existing research, and formulating transferable versus "portable" modeling strategies. The author concludes that a protocol for benefit transfers would help define important research issues by identifying modeling judgements that make consensus impossible.

This research focuses on the role of economics in ecological valuation and modeling. More specifically, the emphasis is on evaluating benefit transfers resulting from policy changes in the context of economic modeling.

61

Starfield, A. M., & Bleloch, A. L. (1986). Building models for conservation and wildlife management. New York: Macmillan.

Key Words: conservation, wildlife management, top down analytical models, human intervention, experience-based decision making

---

This text addresses the development and use of models for conservation and wildlife management. Since the processes and mechanisms of these types of systems often are not well understood, the authors have taken a pragmatic approach to modeling, recognizing that the challenge is to develop a structure for a model under such circumstances. Models are built from the top down based on management objectives. Each chapter begins with a management problem then describes how a model can be constructed to address that problem. Possible modifications to the model and what can be learned from the model are discussed. The references are not meant to be exhaustive but have been chosen either because they offer background or develop techniques that have been mentioned.

A simple single-species model for a wildebeest population is presented. The objectives were to help understand declines in the population and to investigate how this decline might be reversed. Field biologists knew the wildebeest population was declining, but their explanations for it were varied and vague. Building a model forced them to establish a mechanism, and that mechanism turned out to be predation. Next a stochastic model is developed for a smaller population of roan antelope. In this situation, chance effects were considered more important, and sensitivity analysis was used to evaluate the model further. A complex single-species model is developed for a lion population with the objective of determining if it is possible to create and maintain areas of low lion density in sensitive areas. While lions have a very important effect on wildebeest, wildebeests are only one component of the lion's diet. Several versions of the lion model are presented and discussed.

A system model for a park (about 25,000 ha) incorporating herbivores, vegetation and rainfall is developed. This results in a relatively large and complicated model. The authors move from simulation models to analytical models, where the aim is to draw conclusions from the mathematics itself. They state that, "The beauty of analytical models is that the connection between the structure we postulate and the results we discover is so clear." Cropping and linear programming provide general guidelines to the manager. Objectives are developed based on problems faced by park managers. These objectives form the basis for a model that contains the barest minimum of ecological detail. Since the model is simple, the results are general principles rather than specific remedies. A rule-enhanced model with age structure is presented for a single species, where data were collected and used to build a model in anticipation of a potential management problem. This type of model uses established relationships in a conventional model but replaces or modifies them with rules that can easily be added. These rules can be used to represent the influence of various types and combinations of environmental conditions. Moving away from a quantitative approach, the authors then discuss decision trees, tables, and expert systems. The intent is to provide structure to experience-based decision making. These non-quantitative approaches may be particularly useful where data are lacking.

This work discusses several ecosystem modeling techniques that include variables reflecting human intervention. Most models are developed based on actual field data. The output of the models is then used to gain a better understanding of the ecosystem.

62

Straškraba, M., Mitsch, W. J., & Jørgensen, S. E. (1988). Wetland modelling—An introduction and overview. In W. J. Mitsch, M. Straškraba, & S. E. Jørgensen (Eds.), Wetland Modelling (pp. 1-8). New York: Elsevier.

Key Words: wetlands, hydrology, ecology, mathematical modeling, biological productivity, human intervention

The editors assembled this volume as a first statement on the state of the art of modeling for the quantitative study of wetlands. This article provides an overview of the ten papers in the volume. The papers presented cover a wide range of hydrologic and ecologic conditions. This volume is based on the ideas that to manage wetland systems properly and to optimize their roles in the landscape, we must understand quantitatively how these systems work and what to expect if they are disturbed or changed. The effects of changes to a part of a wetland on the rest of the wetland and downstream systems also must be understood. The authors state that ecological modeling, which includes both conceptual and simulation modeling, offers a tool to describe, quantify and predict the behavior of these systems.

Wetland models were developed rather late compared with river, lake, or terrestrial models. This work is an outgrowth of the success and interest in mathematical modeling that came out of several international conferences in the early 1980s. Most of the articles contained in this volume are the result of research carried out and models developed since 1984.

Various scientists were invited to write chapters on different aspects of wetland modeling or on a case study characteristic of today's wetland modeling. The contributions are partially the result of the Second INTECOL Wetland Conference held in Trebon, Czechoslovakia. This volume contains modeling approaches for a wide variety of wetlands, including northern bogs, coastal marshes, forested wetlands, freshwater marshes and wet meadows, and shallow reservoirs and lakes. General principles about wetland hydrology as it relates to modeling are covered, and a hierarchical modeling approach to a heterogeneous regional wetland system is described. Several different approaches to wetland modeling are presented, including models with an emphasis on wetland hydrology, models with an emphasis on biological productivity and processes, models used to design and summarize large scale research projects, and models used for wetland management.

This volume presents several wetland ecosystem models that predict the effects of human interventions. The editors took a global view, and the models cover a wide variety of geographic regions and ecosystems.

63

Straśkraba, M., Mitsch, W. J., & Jørgensen, S. E. (1988). Summary and state of the art of wetland modelling. In W. J. Mitsch, M. Straśkraba, & S. E. Jørgensen (Eds.), Wetland Modelling (pp. 1-8). New York: Elsevier.

Key Words: wetlands, aquatic and terrestrial ecosystems, hydrochemical complexity, spatial wetland models, ecotechnologic

---

The approaches to the modeling of wetlands, as described in this book, reflect approaches taken for other aquatic and terrestrial systems. Since wetland modeling was still in its infancy when this work was published, new approaches were combined with the old. The important distinctions and features of wetlands that make them unique systems to model are discussed, including diversity of wetland types, hydrochemical complexity of wetlands, time constants and transitional wetlands, interfaces, and exchanges with adjacent ecosystems.

The state of the art of wetland modeling is discussed with respect to coastal salt marshes and estuaries, mangrove wetlands, northern peatlands, freshwater marshes, forested wetlands, and shallow lakes and reservoirs. The use of spatial wetland models is considered to be a particularly noteworthy advancement. The authors question why there has not been more interest in mangrove wetlands, since these systems dominate many coastal regions of the tropical and subtropical world.

The authors state that more needs to be known about these systems before they can be adequately modeled. Several questions provide direction for future research. The authors conclude with the statement that further assessment of the importance of wetland systems in the landscape and of how our actions affect these systems is needed. This can be done through modeling with economic and ecotechnologic approaches that complement the mathematical approaches.

This article evaluates the status and relative effort of wetland modeling for each of the types of wetlands mentioned and provides an overview of the models presented. Based on this, the needs and directions for future research are discussed.

64

Tisdell, C. A. (1990). Natural resources, growth, and development: Economics, ecology and resource-scarcity. New York: Praeger Publishers.

Key Words: ecological economics, natural resources, economic growth

---

The purpose of this book is to examine traditional issues in economic development within their wider environmental context. Of principle interest are the author's discussion of ecological and economic ethics, sustainable growth, and depletable resources.

Seven reasons exist for why economic development must include ecological protection: (1) Humans depend on nature for food, (2) many essential nonfood commodities are derived from nature, (3) the depletion of nonrenewable resources makes us more dependent on other organisms for our survival, (4) the disposal of production and consumption waste products can adversely effect the environment, (5) natural ecological relationships play an important role in providing environmental conditions suitable for the support of humans, (6) nature is valued for recreation and aesthetic qualities, and (7) since not all organisms have a favorable relationship to humans -- pests and diseases, ecological considerations must be taken into account when determining economic methods to eliminate them. Thus, while sustainable economic development is desirable, it can be achieved only by conserving biological resources. This requires the maintenance of essential ecological processes and their support systems, the preservation of genetic diversity, and the sustainable utilization of species and ecosystems.

Tisdell suggests that the concept of sustainability can be sharpened by relating it to the economic concepts of equilibrium and stability of equilibrium. However, he points out that most economists do not regard equilibrium and sustainability as ideal conditions in themselves. Indeed, cost-benefit analyses based on the popular economic principle of discounted present value imply that, in some circumstances, it is desirable to exhaust a resource. But development means total development of society, not just economic, and includes the interaction of biological, social and economic systems.

Tisdell examines the debate between technological optimists who argue that technological development will offset any damages resulting from environmental degradation, and technological pessimists who argue that technology cannot match society's pace of ecological destruction, and even if it could it cannot replace the lost environmental amenities. He concludes that there is little evidence to support the viewpoint of technological optimists.

65

Toman, M. A. (1992). The difficulty in defining sustainability. Resources for the Future, 106.

Key Words: sustainability, intergenerational equity

The aim of this article is to discuss key issues in defining and applying the concept of sustainability. While sustainability is a concern for both ecologists and economists, their definitions reflect opposing world views. Ecologists equate sustainability with "a harvesting regimen for specific reproducible natural resources that could be maintained over time." Economists view it as "the maintenance and improvement of human living standards, in which natural resources and the environment are important but partial factors."

The first of the three key components is intergenerational equity. Economists typically suggest assigning benefits and costs according to a representative set of individual preferences and discounting the costs and benefits of future generations. In order to specify what will be sustained, we must determine what "social capital" should be intergenerationally transferred and whether compensatory investments for future generations in other forms of capital are feasible. The final factor of importance is the scale of human impact relative to the global carrying capacity.

Toman envisions a "safe minimum standard" defined as "a socially determined dividing line between moral imperatives to preserve and enhance natural resource systems and the free play of resource tradeoffs." In this way, the current society would avoid actions that could result in natural impacts beyond an acceptable threshold of cost and irreversibility. In contrast, environmental economists seek accurate resource valuation using benefit-costs analysis and use economic incentives to achieve efficient resource allocations using their valuations.

66

U.S. Army Corps of Engineers, Los Angeles District. (1985). Upper Santa Ana River Flood Storage Alternatives Study. Appendices, 2. Washington, D.C.: U.S. Government Printing Office.

Key Words: water quality, habitat evaluation and impact assessment, cultural resources, biological resources

This appendix presents technical background information concerning existing resources and impact assessment for water quality, biological resources and cultural and paleontological resources for the Upper Santa Ana River as determined in the Flood Storage Alternatives study.

Among the primary objectives of the biological resources study was the determination of mitigation needs and opportunities to compensate for project-related impacts. The key areas of concern regarding the potential project-related impact on biological resources are (1) the amount and value of riparian habitat which would potentially be lost, (2) potential for and significance of effects on endangered or other sensitive species or their habitat, (3) impact of excavations for borrow materials, (4) impact of the relocation of roads, (5) impact of flood inundation and sedimentation on viability of habitat within the reservoir area, (6) impact on fisheries of changes in water quality, flow rate, temperature, and sedimentation, and (7) impact of recreation activities. The criteria used to determine biological values were (1) uniqueness of species, (2) exclusiveness of habitat, (3) abundance and diversity of resident native plant and animal species, (4) resiliency of the native habitat to short- or long-term disturbance, and (5) the presence of economically significant species for recreation and trade.

Habitat evaluation and impact assessment were achieved through incremental evaluation based on a numerical habitat-based procedure. The procedure uses habitat value ratings to calculate habitat units, which are evaluated using the principles of the U.S. Fish and Wildlife Service's Habitat Evaluation Procedure (HEP).

67

U.S. Army Corps of Engineers, Water Resources Support Center, Institute for Water Resources (1991). Economic and Environmental Considerations for Incremental Cost Analysis in Mitigation Planning (IWR Report 91-R-1). Washington, DC: U. S. Government Printing Office.

Key Words: mitigation, cost effectiveness, ecosystem evaluation, incremental analysis

---

This study was undertaken to accomplish the following: (1) describe the underlying problems in achieving cost-effective mitigation plans through incremental analysis, (2) identify basic economic concepts relevant to mitigation planning, (3) identify and review available fish and wildlife habitat measurement techniques, (4) determine which techniques, if any, are applicable to COE project planning for mitigation through incremental analysis, (5) evaluate economic models that provide a framework for use of the measurement techniques in incremental analysis for mitigation planning, and (6) provide conclusions and recommendations for further development of the economic framework.

Several basic economic concepts were investigated for resolving the problems and improving the economic effectiveness of mitigation planning: (1) economic efficiency, (2) cost effectiveness, (3) marginal analysis, and (4) linear, non-linear and dynamic programming. The environmental measurement techniques currently employed in mitigation planning are Habitat Suitability Indices (HSI), Relative Value Indices (RVI), Habitat Quality Indices (HQI), energy analysis, threshold analysis, user-day evaluation procedure, and sustainable yield.

Four ecosystem evaluation frameworks were determined to be potentially applicable and useful to the COE incremental cost analysis for mitigation planning: (1) Habitat Evaluation Procedure (HEP), (2) Pennsylvania Modified Habitat Evaluation Procedure (PAM HEP) (3) Habitat Evaluation System, and (4) Wetland Evaluation Technique (WET). HEP and PAM HEP are species based techniques while HES and WET are habitat based techniques. Both species based techniques measure the quantity of wildlife resources in terms of the Habitat Suitability Index (HSI). HSIs relate attributes of each habitat to the potential biological suitability of that habitat for each species evaluated. A critical review and comparison of the evaluation methods are presented in terms of such criteria as cost of application, biological validity, data requirements and comprehensiveness.

The study concludes that mitigation costs, especially for large projects, could be much higher than necessary since current mitigation planning procedures do not provide an adequate basis for determining the cost effectiveness of a chosen level of mitigation for a project. The Corps needs a method for readily determining the least-cost set of mitigation measures for levels up to 100 percent mitigation and for displaying these plans effectively to the decision makers.

This paper is a comprehensive review of the best available methods for incremental cost analysis for mitigation planning. It presents economic considerations, environmental measurement techniques, and evaluation frameworks as well as a complete review and comparison of the effectiveness of evaluation methods.

68

U.S. Fish and Wildlife Service. (1980). Habitat evaluation procedures (HEP) (ESM 102). Washington, DC: U.S. Government Printing Office.

Key Words: physical habitat, habitat suitability index, available habitat, habitat type, evaluation species, terrestrial, aquatic, estuarine, habitat units, compensation analysis

---

This is the second of three documents and serves as a further refinement of the Habitat Evaluation Procedures (HEP) first developed in 1976. This document describes how the concepts outlined in the first document can be implemented in a standardized procedure for conducting habitat evaluations in the field and discusses some probable applications. HEP is a method that can be used to document the quality and quantity of available habitat for wildlife species. HEP provides information for two general types of wildlife comparisons, the relative value of different areas at the same point in time and the relative value of the same area at future points in time.

The procedures provide a quantification of wildlife habitat that is based on two primary variables: the habitat suitability index (HSI) and the total area of available habitat. The two major changes presented in this document are determining HSI by use of documented habitat models and analyzing individual evaluation species rather than habitat types throughout the analysis. The current HEP methodology has been developed primarily for application to terrestrial and inland aquatic habitats. HEP has not been extensively applied to estuarine systems. The concepts of habitat evaluation may be equally applicable in those systems.

HEP is based on the assumption that habitat for selected wildlife species can be described by the HSI. This index value, from 0.0 to 1.0, is multiplied by the area of available habitat to obtain habitat units (HUs) for each evaluation species. The reliability of HEP and the significance of HUs are directly dependent on the ability of the user to assign a well defined and accurate HSI to the selected evaluation species. An example of a HEP application is provided.

HEP is an ecosystem model that uses compensation analysis to identify measures that would offset HU losses due to a proposed action. This manual provides a detailed guide for applying HEP in the field. The model provides the planner with a framework for maximizing the HUs and evaluating the impact of proposed land and water use changes on the environment.

69

Walker, B. H. (1992). Biodiversity and ecological redundancy. Conservation Biology, 6, 18-23.

Key Words: ecosystem, biodiversity, environment, ethical, conservation, functional groups

---

This paper presents a functional approach to analyzing biological diversity. This relates to the problem of which biota to choose to best satisfy the conservation goals for a particular region in the face of inadequate resources. Biodiversity is taken to be the integration of biological variability across all scales, from the genetic, through species and ecosystems, to landscapes.

The paper asserts that focusing on species is not the best approach. The best way to minimize species loss is to maintain the integrity of ecosystem function. The important questions therefore concern the kinds of biodiversity that are significant to ecosystem function. The amount of redundancy in the biological composition of ecosystems needs to be established.

The author advocates establishing biodiversity based on the use of functional groups of organisms defined according to ecosystem processes. Functional groups with little or no redundancy warrant priority conservation effort. Complementary species-based approaches for maximizing the inclusion of biodiversity within a set of conservation areas are compared to the functional-group approach. In terms of an overall approach to conserving biodiversity, the author states that two issues need to be resolved: (1) how to choose the optimal set of bits of a region or of the world to maximize the biodiversity they include, and (2) how to manage any area or region to ensure the long-term persistence of all its biota. The functional group approach addresses the latter issue.

This article addresses the use of functional groups to analyze biodiversity and provide a basis for ecological modeling and decision making. This work also is applicable to the development of damage evaluations in response to legislation and regulations.

70

Walters, C. (1986). Adaptive Management of Renewable Resources. New York: MacMillan Publishing Company.

Key Words: renewable resources and management, adaptive policy analysis, adaptive environmental assessment, Bayesian theory, systems theory, environmental change, harvest regime, mathematical modeling

---

This book is concerned with ways of dealing with uncertainty in the management of renewable resources, such as fisheries and wildlife. The basic theme is that management should be viewed as an adaptive process: We learn about the potentials of natural populations to sustain harvesting mainly through experience with management itself rather than through basic research or the development of general ecological theory. The intent is to provide general motivation for deliberately treating management as an adaptive process and to bring together a collection of tools for adaptive policy analysis. The introductory and concluding chapters, and chapter introductions are intended to give practicing resource managers and administrators a feeling for the basic issues and concepts. The ensuing sections in chapters 4-10 look more deeply at mathematical tools for analysis. These sections are aimed at analysts who are concerned with the practice of policy design.

Adaptive management is based on the tenet that management involves a continuous learning process that cannot conveniently be separated into functions and never converges to a state of equilibrium involving full knowledge and optimum productivity. The design of adaptive management strategies is discussed in terms of four basic issues: bounding management problems, representation of managed systems, representation of uncertainty, and design of balanced policies. The adaptive environmental assessment (AEA) process is reviewed. Limitations of some of the models that have been used in fisheries analysis to deal with biological and economic processes are discussed. The possibility that resource problems may be represented with simple models resulting from compression of complex models that emerge early in the AEA process is addressed. Uncertainty in general, Bayesian theory, and the recent systems theoretic idea of realization are discussed in particular. Work in the area of stochastic control that address statistical methods of tracking parameter changes over time in relation to unmodeled processes such as environmental change are developed. The problem of finding optimal or at least good harvest regimes is addressed.

The major conclusion of the book is that actively adaptive, probing, deliberately experimental policies should be a basic part of renewable resources management. Design of such policies involves mathematical modeling to pinpoint uncertainties and generate alternative hypotheses, statistical analysis to determine how uncertainties are likely to propagate over time in relation to policy choices, and formal optimization combined with game playing to seek better probing choices.

Although this work does not focus on the development of a particular model, it does provide guidance for the development of ecosystem models. A variety of mathematical techniques are evaluated for use in ecosystem modeling, and several examples illustrate how these techniques are used in ecosystem modeling.

71

Walters, C. J., & Holling, C. S. (1990). Large-scale management experiments and learning by doing. Ecology, 71, 2060-2068.

Key Words: harvesting rates, ecological perturbation, localized vs. large-scale effects, adoptive processes, evolutionary trial and error, passive adaptive processes, active adaptive processes, transient responses, biophysical

Most of the world's ecosystems are affected by harvesting and related activities aimed at resource types or species. But it is not possible to predict with certainty either the ecological effects or the efficacy of the measures aimed at regulating or enhancing these species. Every major change in harvesting rates or management policies is a perturbation experiment with an uncertain outcome. This paper discusses challenges for justifying and designing experimental management programs. These challenges are to demonstrate that a substantial, deliberate change in policy should even be considered, to expose uncertainties and management decision choices, to identify experimental designs that distinguish between localized and large-scale effects, to develop designs that will permit unambiguous assessment of transient responses to policy changes, to develop imaginative priorities for investments in research, management and monitoring, and to design institutional arrangements that will be in place long enough to measure large-scale responses.

There are three ways to structure management as an adaptive process: evolutionary or trial and error, passive adaptive, or active adaptive. There are two fundamental objections to passive adaptive policies: They are likely to confound management and environmental effects, and passive policies may fail to detect opportunities for improvement. Examples are presented where passive approaches have resulted in informative experiments. The design and justification of experimental management plans involve a complex assessment of risks and benefits. The balance of learning and risks often does not favor experimental disturbances in single, unique, managed systems. However, this conclusion changes when there is a collection of similar units. The question of how large an experiment to conduct is illustrated in a hypothetical example.

Adaptive policy design must make effective use of opportunities for spatial replication and control. The authors note that there is a long history of sad experience with the false premise that it is possible to learn by doing through sequential application of different policies to whole systems. In these cases, there is little prospect of resolving the uncertainties through continued monitoring and modest policy change, and policy changes drastic enough to provide unequivocal responses would be socially or economically unacceptable. Most actions do not simply change a managed system from one state to another; rather, they induce transient responses that may be complex. Where replication is possible, the authors see two main challenges: the critical need for research on imaginative ways to set priorities and the need for institutional arrangements that will permit and foster experimental studies that span longer time scales. The authors conclude that two kinds of science influence renewable resource policy and management. The first kind is the science of parts, which is the analysis of specific biophysical processes. It is conservative, unambiguous, and incomplete. The other is the science of integration of parts. It uses the results of the first but identifies gaps, invents alternatives, and evaluates the integrated consequence against interventions in the whole system.

The authors review methods to develop, screen, and evaluate alternatives in a process where management becomes a partner with the science by designing probes that produce updated understanding as well as economic product. Specific ecosystem models are not presented, but guidance is provided for modeling large-scale systems.

72

Westman, W. E. (1990). Managing for biodiversity: Unsolved policy and science questions. BioScience, 40(1), 26-32.

Key Words: biodiversity, sustainability

Westman reviews the broad framework of current biodiversity policy. He considers conflicts between species preservation and multiple use of habitat reserves, exotic species management, and the implications of global warming for preserving biodiversity. Diversity is defined as richness, such as the number of species per unit area, and equitability, namely evenness in relative abundance of species in an area. While environmental policies vary greatly among nations, the key issues can be found in the policies of the United States. These policies specifically address species management for harvest, preservation of endangered species, and habitat preservation.

Particular policy strategies and tactics accompany environmental protection goals. The management of game species for sustained yield requires regulated hunting levels in wildlife preserves, public lands and global commons. It is accomplished through population management plans, harvest quotas and international treaties. Endangered species can be protected by identifying such species and protecting their critical habitat areas with policies that reintroduce species in suitable habitats, manage the habitat to foster species, and propagate species in captivity. Finally, the preservation of balanced species populations in their native habitats demands preservation of wilderness lands, which is possible through land purchases, implementation of a management plan to protect native species, and elimination of exotic species from the area.

While this framework addresses many critical issues, many unresolved questions remain. Policy issues include multiple habitat uses, exotic species management, climate, and climate change. The multiple uses of habitat includes the two separate issues of the extent to which the goal of habitat preservation for species maintenance is tempered by other uses of the habitat and the more controversial concern of the extent to which biological conservationists are prepared to seek a compromise between exploitative uses of habitat and total exclusion of human resource extraction. The problem of exotic species management is crucial because, at present, national and state park agencies routinely remove exotic species at considerable expense. The central question is whether all exotics should be considered equally undesirable thus justifying their removal, or whether meaningful priorities can be found. Climate change is of obvious importance since it could significantly alter ecosystem processes and balance. The scientific community enters the debate by contending that the goal of biodiversity could be greatly advanced through research on the strength of connecting links in food web structure and the strength of functional interdependencies among species. This information could then be used to identify which species play the more critical role in ecosystem function and should therefore be targeted for conservation.

The author concludes that international cooperation would increase understanding of the existence and role of keystone and critical-link species, improve our ability to model the functions of such species, and thus enhance understanding of the relationship between global maintenance and ecosystem processes.

73

Wilson, C. B., & Walker, W. W., Jr. (1989). Development of lake assessment methods based upon the aquatic ecoregion concept. Lake and Reservoir Management, 5(2), 11-20.

Key Words: ecoregion, water quality, eutrophication, watershed, phosphorus loading, sedimentation, retention model, geochemistry

---

This paper focuses on the use of ecoregion data for modeling purposes. State and local resource managers frequently are faced with the task of determining reasonable water quality patterns and providing understandable summaries to a variety of decision makers involved in resource management. This process has been facilitated in Minnesota by using an aquatic ecoregion framework and standard assessment methods. To facilitate preliminary analyses of lake water quality, the Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) was developed. MINLEAP is a computer program designed to predict eutrophication indices in Minnesota lakes based on area watershed, depth, and ecoregion.

MINLEAP has been developed from an ecoregion data set collected by Minnesota Pollution Control Agency (MPCA) staff in a statewide lake sampling program of 90 reference lakes in four ecoregions. The lakes were sampled repeatedly throughout three summers. The program estimates lake water outflow and phosphorus loading. Ecoregion is used to predict regional runoff, precipitation, evaporation, stream phosphorus concentration, and atmospheric phosphorus deposition. Other input variables, including watershed area, lake area, mean depth, and observed lake quality, are lake specific. MINLEAP was calibrated to the ecoregion data set by manually adjusting stream phosphorus concentrations. Calibrated stream concentrations vary with the sedimentation model used for predicting lake phosphorus concentrations. But there is no statistical basis for deciding which retention model is best for Minnesota lakes without direct measurement of loading. Both error and variability estimates have been built into MINLEAP. A case study on Lake Volney in the southern range of the North Central Hardwood Forests ecoregion is presented.

The authors conclude that the framework employed in developing this procedure should be adaptable to other ecoregions in the country. Not all states may have the diversity of lake water quality implied in the development of MINLEAP. The network of models described in this paper are cross-sectional in nature and do not define individual lake variabilities resulting from lake specific biologies and geochemistries. The model is meant to be used as a tool to flag lakes that may deserve further study and resources.

Several measures of human intervention are used as inputs to ecosystem model MINLEAP. These include land usage, such as pasture or urban, and phosphorus concentrations. The authors believe that comparisons of observed water quality measures to regionally predicted values facilitates interpretation by the local lake residents, lake associations, and resource managers.