A Brief Guide to Conservation Biology Resources.

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January, 2000 for Joel Pagel of Region 5, USDA Forest Service.

There has been a veritable explosion of resources over the past 10 years for conservation biologists. What follows is not meant to be a comprehensive list. Instead, this constitutes what we think are highlights in a very large literature. In particular, the journal articles cited are a combination of classic or benchmark papers in the field and a somewhat more eclectic suite of recent papers that represent examples of the application of various conservation strategies.

1. Journals

General Conservation Journals:

Biodiversity and Conservation. Bi-monthly. Chapman & Hall, London.
http://www.wkap.nl/jrnltoc.htm/0960-3115

Biological Conservation. Monthly. Elsevier, Oxford, England..

Conservation Biology. Quarterly. Blackwell Scientific Publications, Cambridge, MA.
Journal of the Society for Conservation Biology.

Conservation Ecology. Electronic journal of the Ecological Society of America.
http://www.consecol.org/Journal/

Ecological Applications. Quarterly. Ecological Society of America.
http://www.jstor.org/journals/10510761.html

Journal of Applied Ecology. Blackwell Scientific Publications Oxford [Eng.].
Journal of the British Ecological Society

Journal of Biogeography. Bimonthly. Blackwell Scientific Publications, Oxford, Eng.

Restoration Ecology. Quarterly Blackwell Scientific Publications. Cambridge, MA.
Journal of the Society for Ecological Restoration.

In addition, many taxon specific journals publish lots of conservation. For example:

Aquatic Conservation. Quarterly, Wiley, New York.
http://www.interscience.wiley.com/jpages/1052-7613/

Aquatic Ecology. Quarterly. Kluwer Academic Publishers, Dordrecht.
http://www.wkap.nl/jrnltoc.htm/1386-2588

Audobon Wildlife Report. New York: National Audubon Society, (Annual)

The Auk. Quarterly. American Ornithologists Union, Washington, D.C.

Herpetologica. Quarterly.

Journal of Insect Conservation. Quarterly. Kluwer, London.
http://www.wkap.nl/jrnltoc.htm/1366-638X

Journal of Wildlife Management. Journal of the Wildlife Society.

Madrono. Quarterly.: California Botanical Society, Berkeley.
.

The Wilson Bulletin. Quarterly. Wilson Ornithological Society Columbus, OH.
.

Wings: Essays on Invertebrate Conservation. Semi-Annual. Journal of the Xerxes Society.

There are also numerous region specific journals that publish conservation research. For example:

Great Basin Naturalist. Irregular. Brigham Young University. Provo, UT.

Northwest Science. Quarterly. Washington State University Press. Pullman, WA.

There are also journals targeted toward conservation managers, such as:

Natural Areas Journal. Quarterly. Natural Areas Association, Rockford, IL.

Restoration and Management Notes. Semi-annual. University of Wisconsin Press Madison, WI

Many useful statistics packages exist. Here are a couple that are easy to use and cheap:

JMP, Version 3.1. North Carolina: SAS Institute Inc., 1995
This software lets you use an extraordinary graphical interface to display and analyze data. JMP is software for interactive statistical graphics and includes: a spreadsheet; a broad range of graphical and statistical methods; options to highlight and display subsets of data; data management tools; a calculator for each column; a facility for grouping data and computing summary statistics; special plots, charts and communication capability; tools for moving analysis results between applications and printing; and a scripting language for saving frequently used routines.

Statistix for Windows. Tallahassee, Florida: Analytical Software.
Statistix is a very fast, easy-to-use data analysis program designed to encourage you to "play" with your data. Manipulating data becomes simple and straightforward, allowing you to focus on your research and not your software.

Simulations are often used to project scenarios or predict future population. While these can be dangerous when used inappropriately, several packages are available to help. Here are a couple examples.

Ecobeaker 2.0. Ithaca, NY: (Eli Meier, 1998.) (Uses Quicktime software from Apple)
This is the premier program for teaching ecology, conservation biology, and evolutionary biology at the university level. It lets students see population and community level dynamics on screen while performing the kinds of experiments done by practicing ecologists.

RAMAS: Generalized Age- and Stage-based Modeling for Population Dynamics. New York: Applied Biomathematics, 1990
RAMAS is a microcomputer implementation that simulates discrete-time age- or stage-structured population dynamics. It predicts the behavior of population trajectories driven by stochastic

environmental variables and estimates demographic risks associated with these trajectories such as the probability of extinction or population explosion.

2. Books

In recent years many, many books have emerged on Conservation. In particular, Island Press publishes many books in this area. Other academic presses (e.g., Oxford Univ. Press, Cambridge Univ. Press, Univ. of Chicago Press, Academic Press, Blackwell Scientific, Prentice & Hall) also have books series on conservation. Here is a list of some recent books that you may find useful. I group them into (A) General Conservation; (B) General Ecology; (C) Monitoring; (D) Policy and Law; (E) Restoration; and (F) Other.

(A) General Conservation

Meffe, Gary K. and C. Ronald Carroll. Principles of Conservation Biology. Massachusetts: Sinauer Associates, Inc., 1994.

This text addresses some introductory concepts in conservation biology and biodiversity, then addresses population- and system-level concerns, and lastly goes over practical applications and human concerns, including management, restoration, and economics.

Noss, Reed F. and Allen Y. Cooperrider. Saving Nature's Legacy: Protecting and Restoring Biodiversity. Washington D.C.: Island Press, 1994.

Provides explicit guidelines on inventorying biodiversity, selecting areas for protection, designing regional and continental reserve networks, managing forest, rangeland and aquatic ecosystems, establishing monitoring programs, and setting priorities.

Pickett, S. T. A., et al., eds. The Ecological Basis of Conservation: Heterogeneity, Ecosystems, and Biodiversity. New York: Chapman and Hall, 1997

Conservation policy is shifting away form the preservation of single endangered species toward conservation and management of the interactive networks and large-scale ecosystems on which species depend. This book offers a scientific framework for this new approach, providing a solid basis for future research and development of stronger links between ecology and public policy.

(B) General Ecology

Gotelli, Nicholas J. A Primer of Ecology. Massachusetts: Sinauer Asso., 1995.

This work includes mathematical models in population biology and ecology including exponential, logistic and age-structured population growth, along with models on metapopulation dynamics, competition, predation, and island biogeography.

(C) Monitoring

Goldsmith, F. B., ed. Monitoring for Conservation and Ecology. New York: Chapman and Hall, 1991

Experts summarize the monitoring of a wide range of different plants and animals. This book identifies the need for long-term surveying in a standardized way, reviews work in progress, and recommends procedures for recording various taxa.

Heyer, W. Ronald, Ed., et al. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Washington: Smithsonian Institution, 1994.

Herpetologists recommend ten standard sampling procedures for measuring and monitoring amphibian and many other populations. They provide a detailed protocol for each procedure's implementation, a list of necessary equipment and personnel, and suggestions for analyzing the data.

Spellerberg, Ian F. Monitoring Ecological Change. Cambridge: Cambridge University Press, 1994.

This is a practical introduction to the subject of monitoring ecological and biological change. It discusses the role of different organizations which implement monitoring programs using a wide range of examples, and ends with a focus on the application of ecological monitoring.

Sutherland, William J., ed. Ecological Census Techniques: A Handbook. Cambridge: Cambridge University Press, 1999

This text outlines clearly, with worked examples, the main techniques used by field ecologists to enumerate plants and animals. Each taxonomic group is treated separately, with detailed descriptions of appropriate census methods; their advantages, disadvantages, and biases.

Wilson, Don E., Ed., et al. Measuring and Monitoring Biological Diversity: Standard Methods for Mammals. Washington: Smithsonian Institution, 1996

Manual for designing and implementing inventories of mammalian biodiversity, emphasizing formal estimation approaches. It begins with brief natural histories of mammals, then details field techniques for different species. It provides guidelines for study design, discusses survey planning, describes statistical techniques, and outlines methods of translating field data into electronic formats. Includes extensive appendices.

(D) Policy and Law

Clark, Tim W., Richard P. Reading, and Alice L. Clarke, eds. Endangered Species Recovery: Finding the Lessons, Improving the Process. Washington D. C.: Island Press, 1994.

Case studies of prominent species recovery programs are presented in an attempt to explore and analyze their successes, failures, and problems, and to begin to find new ways of improving the process.

National Research Council. Conserving Biodiversity: A Research Agenda for Development Agencies. Washington D.C.: National Academy Press, 1992

This is an agenda addressing, first, the biological aspects of conservation, including biological surveys, inventory, and monitoring, conservation research, information needs, and human resources. Secondly, it describes the socioeconomic context, including project- or community-level research, international economic research, and global macroeconomic research. Finally, it describes the cultural context, including local management systems, adapting and promoting local knowledge, and priority groups. It ends with a series of recommendations.

Snape III, William J. ed., Biodiversity and the Law. Washington D. C.: Island Press, 1996.

Topics covered include: Scientific and policy foundations of biodiversity protection; domestic efforts to establish an effective endangered species protection regime; international biodiversity protection; biodiversity as a genuinely public entity; and the future of biodiversity law.

(E) Restoration

Bowles, Marlin L. and Christopher J. Whelan, eds. Restoration of Endangered Species: Conceptual Issues, Planning and Implementation. New York: Cambridge University Press, 1994

Ecologists discuss the ideas of a synthetic approach to ecological research and discuss its implications both for ecology and for the practice of habitat restoration providing a basis for a stronger and more productive relationship between ecological theory and practice.

Jordan III., William R., Michael E. Gilpin, and John D. Aber, Eds. Restoration Ecology: A Synthetic Approach to Ecological Research. Cambridge: Cambridge University Press, 1993

Ecologists explore the idea of a synthetic approach, empirical and theoretical, to ecological research, and discuss its implications both for ecology and for the practice of habitat restoration.

(F) Other

Boyce, Mark S. and Alan Haney, eds. Ecosystem Management: Applications for Sustainable Forest and Wildlife Resources. New Haven: Yale University Press, 1997.

Leading experts in the field clarify key elements of sound ecosystem management and offer concrete prescriptions for implementing them.

Costanza, Robert, Bryan G. Norton, Benjamin D. Haskell, eds. Ecosystem Health: New Goals for Environmental Management. Washington D. C.: Island Press, 1992.

This book brings together leading ecologists, philosophers, and economists to analyze the issues surrounding the concept of health as it relates to ecosystems. Both theoretical and practical aspects of what constitutes a healthy ecosystem are examined—philosophical and ethical underpinnings as well as implications for public policy and ecosystems management.

Daily, Gretchen C., ed. Nature's Services: Societal Dependence on Natural Ecosystems. Washington D.C.: Island Press, 1997.

This book describes how nature's benefits, like timber, pest control and soil fertility, are delivered, how important they are to society, and how their value can be incorporated into decision making.

Falk, Donald A. and Kent E. Holsinger, eds. Genetics and Conservation of Rare Plants. New York: Oxford University Press, 1991.

This book begins with a focus of the biology and genetics of rare plant species, and then describes the broad biological principles that are fundamental to the design of any conservation program for rare plants. It then addresses the management and assessment of off-site collections. The final section describes conservation strategies of genetic diversity.

Fiedler, Peggy L. and Subodh K. Jain, eds. Conservation Biology: The Theory and Practice of Nature Conservation Preservation and Management. New York: Chapman and Hall, 1992.

A collection of essays combining theory, lessons learned from the past, and current measures underway to further our understanding of the planet's resources. It addresses this shift in attitude, why it has occurred, and what is to be done about conserving biological resources.

Forey, P. L., C. J. Humphries, and R. I. Vane-Wright, eds. Systematics and Conservation Evaluation. New York: Oxford University Press, 1994.

This collection of essays reflects the wide range of views that are held about what constitutes biodiversity; from its perception in terms of species numbers, categorization of landforms, or different ecological levels, to the view that biodiversity is a dynamic and socio-political necessity for our own survival.

Frankel, Otto H., Anthony H. D. Brown, and Jeremy J. Burdon. The Conservation of Plant Biodiversity. Cambridge: Cambridge University Press, 1995

This book gives an evolutionary perspective stressing the need to explore current and long-term issues, highlighting different conservation strategies. It addresses several controversial issues facing conservation biology and their underlying scientific principles.

Hayek, Lee-Ann C and Martin A. Buzas. Surveying Natural Populations. New York: Columbia University Press, 1997.

A user-friendly primer to the essential survey methodologies of quantitative field ecology, or paleoecology, integrating the intuitive approach of the field researcher with the rational analytical tools of the statistician. It is a step by step guide to estimating population densities, determining adequate sample sizes, estimating the relative abundance of species, and measuring and modeling diversity.

Peck, Sheila. Planning for Biodiversity: Issues and Examples. Washington D.C.: Island Press, 1998

This book provides an accessible introduction to ecological concepts for planning professionals and students. It synthesizes and explains important ecological concepts and represents a guide for planners that clearly details how to incorporate conservation plans into their work.

Schwartz, M.W., ed. Conservation in Highly Fragmented Landscapes. Chapman & Hall, New York. 1996.

This edited volume focuses on setting the stage for a case study of conservation in the highly agricultural Midwest. The first several chapters describe the primary ecosystems, the second section describes how common conservation issues, such as fire management and genetics of small populations. The final section focsuses on describing conservation programs that address these issues.

Soulé, Michael E., ed. Conservation Biology: The Science of Scarcity and Diversity. Massachusetts: Sinauer Associates Inc., 1986.

This is a synthesis of the scientific foundation for the protection and management of biological diversity. Its six sections include: Fitness and Viability of Populations; Patterns of Diversity and Rarity; Their Implications for Conservation; The Effects of Fragmentation; Community Processes; Threats and Management of Sensitive Habitats and Systems; and Dealing With the Real World.

Annotated bibliography to Conservation Biology Literature
Grouped by subject

1.0 Species as Targets of Conservation

Caughley, G. 1994. Directions in conservation biology. J. of Animal Ecology 63:215-244
Suggests that too much emphasis has been placed on the attributes of species declining toward extinction and not enough emphasis on the processes that cause populations decline and their cures.

Mace GM, Lande R. 1991. Assessing extinction threats: toward reevaluation of IUCN threatened species categories. *Cons. Biol*. 5:148-57.
Provides quantitative criteria for assessing endangerment based on the probability of extinction within 100 years. This and more recent modifications are becoming the standard for assessing extinction threat and defining threat categories both nationally and internationally

Sidle JG. 1998. Arbitrary and capricious species conservation. *Cons. Biol.* 12:248-9.
Reviews recent legal actions associated with the USFWS and implementation of the ESA through listing. In particular, the USFWS is under intense political pressure to save species through other means than the ESA. Several recent decisions not to list have countered consistent recommendations by all biologists involved, leaving the courts to feel that the USFWS may be acting capriciously in listing.

Simberloff, D. 1988. The contribution of population and community biology to conservation science. Annual Review of Ecology and Systematics 19:473-511.
A must read for conservation biologists reviewing island biogeographic theory, simple IUCN reserve design rules, minimum population sizes, the 50/500 rule, fragmentation, corridors, and metapopulations.

1.1 <u>50/500 rule</u>

Abenspurg-Traun, M., and G. T. Smith. 1999. How small is too small for small animals? Four terrestrial arthropod species in different-sized remnant woodlands in agricultural Western Australia. Biodiversity and Conservations 8(5):709-726. *Sometimes small remnant habitats are useful, both as stepping-stones or as adequate habitat for small animal populations, despite what the 50/500 rule predicts.*

Meffe, G. K., and C. R. Carroll (eds.). 1994. Principles of Conservation Biology. Sinauer Associates, Inc.: Sunderland, MA, pp.170-172. *This is a definition and critique of the 50/500 rule, a strictly genetic view of the effective populations size.*

Templeton, A. R. 1994. Biodiversity at the molecular genetic level: experiences from disparate macroorganisms. Philosophical Transactions of the Royal Society of London Biological Sciences 345(1311):59-64. *This reviews how genetic diversity, the basis of adaptive flexibility, is measured molecularly. The measures are then linked to the 50/500 rule, emphasizing that 'universal' rules like the 50/500 rule are misleading and should not be applied.*

1.2 <u>Metapopulations</u>

Hanski, I. 1994. Patch-occupancy dynamics in fragmented landscapes. TREE 9: 131-135 *Reviews math and empirical results of studies assessing the behavior of patchy populations and whether or not they function as metapopulations*

Hastings A, Harrison S.1994. Metapopulation dynamics and genetics. (ed.) DG Fautin. Ann. Rev. Ecol. Syst. 25:167-188.

1.3 Minimum viable populations / Population viability analysis

Akcakaya, H. R., and M. G. Raphael. 1998. Assessing human impact despite uncertainty: viability of the northern spotted owl metapopulation in the northwestern USA. Biodiversity and Conservation 7(7):875-894. *How does uncertainty effect an analysis of viability of the northern spotted owl?*

Beissinger SR, Westphal MI. 1998. On the use of demographic models of population viability in endangered species management. *J. Wild. Manag*. 62:821-41.*The most comprehensive and understandable review of the variety of methods available for estimating population viability published in a journal. The work mostly focuses on vertebrate examples.*

Botsford, L. W., and J. G. Brittnacher. 1998. Biability of Sacramento River winter-run Chinook salmon. Conservation Biology 12(1):65-79. *Several Pacific salmon population characteristics are described and used in viability analysis to create a model that is specific for salmon in the Sacramento River*

Doak, D., P. Kareiva, and B. Klepetka. 1994. Modeling population viability for the desert tortoise in the Western Mojave Desert. Ecological Application 4(3):446-460. *By analyzing the tortoise's status in conjunction with demographic models, potential management measures are evaluated.*

Gilpin, M. E., and M. E. Soule. 1986. Minimum viable populations: processes of species extinction. Pp. 19-34, in Conservation Biology. M. E. Soule (ed.). Sinauer Associates, Inc.: Sunderland, MA, 684pp. *By introducing the use of population vulnerability analysis (PVA) to estimate the minimum viable population (MVP) of a given species, demographic stochasticity, genetic stochasticity, environmnental stochasticity, habitat fragmentation, and catastrophes are made more predictable.*

Groom MJ, Pascual MA. 1998. The analysis of population persistence: an outlook on the practice of viability analysis. In *Conservation Biology for the Coming Decade*, ed. PL Fiedler, PM Kareiva, pp 4-27. New York: Chapman and Hall. 533 pp.
A review of methods for population viability analysis. This chapter, along with the Beissinger paper can really bring anyone up to speed on the methods used currently and the problems with the current methods.

Kynard, B. 1997. Life history, lattitudinal patterns, and status of the shortnose sturgeon, *Acipenser brevirostrum*. Environmental Biology of Fishes 48(1-4):319-334.
Anthropogenic impacts, like dams, fish harvest, dredging, flow regulation, and pollution, have caused shortnose sturgeon populations to fall well below the MVP of 1000 adults for five out of 11 populations. The release of stock cultured fish into the wild populations is not recommended.

.Johnson, K. H., and C. E. Braun. 1998. Viability and Conservation of an Exploited Sage Grouse Population. Conservation Biology 13(1):77-84. *With 23 years of populations survey data, the viability of this population is analyzed and the current pressures of hunting and habitat degradation are considered in the recommendations.*

Menges, E. S. 1990. Population viability analysis for an endangered plant. Conservation Biology 4(1):52-62. *This is an example of how to use demographic modeling to discover the lon- term, population viability of a perennial plant species.*

Morris, W., Doak, D., Groom, M., Kareiva, P., Fieberg, J., Gerber, L., Murphy, P. and D. Thomson. 1999. A Practical Handbook for Population Viability Analysis. The nature Conservancy. *Reviews population viability analysis techniques as well as assesses when a formal PVA is called for, versus situations where simple time-series modeling would be preferable.*

Shaffer, M. L. 1981. Minimum population sizes for species conservation. BioScience 31:131-134.
The paper that started the whole thing by conceptualizing the idea that viable populations ought to be the management objective for conservation.

Snyder, N. F. R., S. R. Derrickson, S. R. Beissinger, J. W. Wiley, T. B. Smith, W. D. Toone, B. Miller. 1996. Limitations of captive breeding in endangered species recovery. Conservation Biology 10(2):338-348. *The limitations of captive breeding include: high cost,*

poor success in reintroduction, displacement of ecosystem protection programs, etc. Despite the seriousness of these limitations, captive breeding programs are on the rise, and for good reason..

Books that address the topic of population viability analysis

Soule ME, ed. 1987. *Viable Populations for Conservation*. Cambridge: Cambridge Univ. Press.

Tuljapurkar S, Caswell H, ed. 1996. *Structured-Population Models in Marine, Terrestrial and Freshwater Systems*. New York: Chapman & Hall.643 pp.

1.3 Genetics of conservation

Brownlow CA. 1996. Molecular taxonomy and the conservation of the red wolf and other endangered carnivores. *Cons. Biol*. 10:390-96.*Deals with the tricky issue of whether a species of hybrid origin ought to be protected under the Endangered Species Act and the broader implications of molecular taxonomy used in endangered species biology.*

Fenster, C.B. and M. R. Dudash. 1994. Genetic considerations for plant population restoration and conservation. Pages 34- 62 in Restoration of Endangered Species: Conceptual Issues, Planning, and Implementation., (Bowles, M. L. and Whelan, C. J., eds). *A very good review of general genetic issues related to small populations sizes. This is focused on plants, but pertains to all species and is relevant to conservation as well as restoration.*

Hamrick, J.L. and M.J.W. Godt. 1990. Allozyme diversity in plant species. In Plant Population Genetics, Breeding, and Genetic Resources (Brown, Clegg,Kahler and Weir, eds). Sinauer, Sunderland, MA. *The first in a series of papers where this set of authors analyze the distribution of genetic variation in plants. In particular, they show that certain life history attributes (e.g., dispersal syndrome) are related to genetic diversity. With respect to conservation, this paper shows that there is a pattern whereby rare species tend to have lower overall genetic variation than common ones.*

O'Brien SJ, Roelke ME, Yuhki N, Richards KW, Johnson WE, et al. 1990. Genetic introgression with the Florida panther *Felis concolor coryi*. *Nat. Geog. Res*. 6:485-94.*Deals with the problem of introgression from non-native genotypes and whether this sullies the ability of the ESA to protect the Florida panther.*

Books that address the topics of genetics and endangered species protection.

Landweber, L.F., and A.P. Dobson (Eds.). 1999. Genetics and the extinction of species; DNA and the conservation of biodiversity. Princeton Univ. Press.

1.4 Population fragmentation

Bolger DT, Scott TA, Rotenberry JT. 1997. Breeding bird abundance in an urbanizing landscape in coastal Southern California. *Cons. Biol*. 11:406-21.*Bolger et al have used the scrub fragments in San Diego to examine how fragment size and age relates to the ability of these fragments to protect native species diversity. In this paper they look at this issue with respect to breeding birds.*

Bolger DT, Alberts AC, Sauvajot RM, Potenza P, McCalvin C, et al. 1997. Response of rodents to habitat fragmentation in coastal southern California. *Ecol. Appl*. 7:552-63.*Bolger et al have used the scrub fragments in San Diego to examine how fragment size and age relates to the ability of these fragments to protect native species diversity. In this paper they look at this issue with respect to small rodents.*

Fahrig, L. and Merriam, G. 1994. Conserving fragmented populations. Conservation Biology 8:50-59. *Argues that general models of fragmentation are not sufficient because they do not include the spatial structure of the patches and that this is of critical importance. Also argues for*

a direct empirical link in modeling efforts so as to focus models on critical attributes such as the dispersal capabilities of the target organism.

Laurance WF, Yensen E. 1991. Predicting the impacts of edge effects in fragmented habitats. *Biol Cons*. 55:77-92. *The definitive work on setting criteria by which to assess edge effects in forests. Deals principally with plants, but can be generalized to all species.*

Saunders, D.A., Hobbs, R.J., and Margules, C.R. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5:18-32. *Reviews critical attributes of fragments (time since isolation, size, shape, connectivity, distance to matrix, distance to other patches) and discusses the management implications of these attributes.*

1.6 Complex Interspecific Interactions

Polis GA, Anderson WB, Holt RD. 1997. Toward an integration of landscape and food web ecology: The dynamics of spatially subsidized food webs. *Ann. Rev. Ecol. Syst*. 28:289-316. *A critical review of the application of food web ecology as a conceptual basis for understanding species interactions in multi-species communities.*

1.7 Demographic Studies

Schemske DW, Husband BC, Ruckelshaus MH, Goodwillie C, Parker IM, et al. 1994. Evaluating approaches to the conservation of rare and endangered plants. *Ecology* 75:584-606. *By surveying recovery plans for vascular plants, the authors argue that there is not nearly enough attention devoted toward collecting basic demographic information on endangered species. The authors propose some simple models to remedy these shortcomings.*

Silvertown J, Franco M, Menges E. 1996. Interpretation of elasticity matrices as an aid to the management of plant populations for conservation. *Cons. Biol*. 10:591-97. *Summarizes the results from 84 plant species to suggest general patterns among different life histories that predict sensitive life stages for conservation management.*

1.8 Recovery Planning and Habitat Conservation Plans

Clark, T.W. 1996. Appraising threatened species recovery efforts: practical recommendations. Pages 1-22 in Back from the Brink: Refining the Threatened Species Recovery Process (S. Stephens and S. Maxwell, eds.). Surrey Beary and Sons. *Suggests an alternative conceptual model for developing plans for recovering endangered species. These include a formal problem orientation and a mechanism for appraising success or failure. By doing this, one can formalize the process of learning from actions taken and offer concrete recommendations for future management.*

Shilling F. 1998. Do habitat conservation plans protect endangered species? *Science* 276:1662-63. *An empirical example of the way Habitat Conservation Planning can be used to thwart conservation.*

Smallwood, K. S., B. Wilcox, R.Leidy, K. Yarris. 1998. Indicator assessment for habitat conservation plan of Yolo County, California, USA Environmental Management 22(6):947-958. *With the goal of maintaining the integrity of a given HCP, these authors have created a method for planners to rank land parcels based on their ecological integrity, collateral value, and conservation potential. Examples of how this technique can be applied to a HCP are given.*

Tear, T.H., J.M. Scott, P.H. Hayward and B. Griffith. 1995. Recovery plans and the endangered species act: are criticisms supported by data? Conservation Biology 9:182-195.*Evaluated a set of recovery plans to show that recovery plans are typically data deficient. The authors suggest reasons for patterns in attributes of recovery plans and recommend changes in how recovery plans are written.*

1.9 Translocation of species

Gordon, D.R. 1994. Translocation of species into conservation areas: A key for natural resource managers. Natural Areas Journal 14:31-37. *Presents a dichotomous key to aid land managers to make decisions regarding potential translocation projects to augment species conservation efforts. This is particularly useful for plants, but applies to any species.*

Pavlik, B.M., Nickrent, D.L. and Howald, A.M.1993. The recovery of an endangered plant. I. Creating a new population of *Amsinckia grandiflora*. Conservation Biology 7:510-526. *One of the best empirical examples of a well-conceived translocation project.*

1.9.1 Management units

Bevill, R. L., S. M. Louda, and L. M. Stanforth. 1999. Protection from natural enemies in managing rare plant species. Conservation Biology 13(6):1323-1331. *A low-cost, small-scale manipulation is a potentially successful way to protect plant populations from herbivory.*

Parker, K. M., R. J. Sheffer, and P. W. Hedrick. 1999. Molecular variation and evolutionarily significant units in the endangered gila topminnow. Conservation Biology 13(1):108-116. *Genetic data from four populations of the Gila topminnow are compared and evaluated in conjunction with the historical and physical differences between their separate watersheds. Management recommendations are made.*

2.0 Communities as Targets of Conservation

Herkert JR. 1997. Nature preserves, natural areas, and the conservation of endangered and threatened species in Illinois. In *Conservation in Highly Fragmented Landscapes*, ed. MW Schwartz, pp 395-406. New York: Chapman & Hall. 436 pp. *Describes the conservation acquisition programs in Illinois where the basis for protection has traditionally been at the habitat or community level.*

Schwartz MW. 1994. Conflicting goals for conserving biodiversity: issues of scale and value. *Nat. Areas J*. 14: 213-16. *Describes how conservation objectives at the community level may conflict with species or ecosystem goals. As a result, this paper suggests explicit delineation of conservation goals in order to develop plans.*

Shugart H, West D. 1981. Long-term dynamics of forest ecosystems. *Am. Sci*. 69:647-52. *Not really a conservation paper at all, but it briefly describes the way plant ecologists view forest communities and sets the stage for how conservation strategies for communities would be different than those for species.*

Books describing communities as targets for conservation and how to prioritize them

Grossman DH, Faber-Langendoen D, Weakley AW, Anderson M, Bourgeron P, et al. 1998. *International Classification of Ecological Communities: Terrestrial Vegetation of the United States. Volume I: The National Vegetation Classification Standard*. Arlington: The Nature Conservancy.

Noss RF, LaRoe ET III, Scott JM. 1995. *Endangered Ecosystems of the United States: A Preliminary Assessment of Loss and Degradation*. Biological Report 28. National Biological Service, Department of Interior, Washington DC. 58 pp.

2.1 Community integrity

Fisher, R. N., and H. B. Shaffer. 1996. The decline of amphibians in California's great Central Valley. Conservation Biology 10(5):1387-13. *The authors present a historical approach for the assessment of changing patterns in amphibian communities.*

Moyle, P. B. and P. J. Randall. Evaluating the biotic integrity of watersheds in the Sierra Nevada. Conservation Biology 12(6):1318-1326. *100 watersheds in the Sierra Nevada were evaluated for health using an index of biotic integrity developed by the authors. Low scores were attributed to a combination of the presence of dams, exotic fish species, high road density, and high land use intensity.*

Smallwood, S. K. 1994. Site invasibility by exotic birds and mammals. Biological Conservation 69(3):251-259. *The eradication of exotics may not actually improve the integrity of reserve systems; instead, it may just be an expensive and useless attack on the symptom of low integrity rather than actual integrity.*

Taft, J.B., G.S. Wilhelm, D. Ladd, and L.A. Masters. 1998. Floristic quality assessment for vegetation in Illinois: A proposed method for assessing vegetation integrity. Erigenia. *You won't find this paper in any libraries, but it is very important. Basically, the authors develop a method first proposed in The Flora of the Chicago Region by Swenk and Wilhelm that suggested that one can assess the biological integrity (or quality) of a site by looking at the constituent plant community. If plant species vary in their sensitivity to degradative forces (bad disturbances), then the lack of these species from otherwise intact sites implies habitat degradation. The authors propose a systematic metric for quantifying this through rating all plant species*

2.2 Disturbance / fire in natural systems

Hobson, K. A., and J. Schieck. 1999. Changes in bird communities in boreal mixedwood forest: harvest and wildfire effects over 30 years. Ecological Applications 9(3):849-863. *Even after 28 years following disturbance, there was a lack of bird community convergence, meaning that the maintenance of biodiversity by foresters is an extremely long-term task.*

Schwartz MW, Hermann SM. 1997. Midwestern fire management: prescribing a natural process in an unnatural landscape. In *Conservation in Highly Fragmented Landscapes*, ed. MW Schwartz, pp. 213-33 New York: Chapman & Hall. 436 pp. *Generally reviews the ways by which applying a managed fire regime may act as a surrogate for natural disturbance, but also cautions against thinking that managed fire is a full surrogate for natural fire as managed burning programs are constrained by safety and practicality such that they are not likely to reach the full spectrum of variation in natural fire regimes.*

Siemann E, Haarstad J, Tilman D. 1997. Short-term and long-term effects of burning on oak savanna arthropods. *Am. Midl. Nat*. 137:349-61. *Examines the effects of a managed fire regime on the persistence of savanna insects.*

2.3 Edge Effects

Suarez AV, Bolger DT, Case TJ. 1998. Effects of fragmentation and invasion on native ant communities on coastal southern California. *Ecolog*y 79:2041-56. *More of the work from Bolger's group working on the fragments in San Diego. This group has used a group of different sized and aged scrub fragments to assess the effects of edge and fragment size on a variety of groups of organisms.*

Suarez AV, Pfennig KS, Robinson SK.1997. Nesting success of a disturbance-dependent songbird on different kinds of edges. *Cons. Biol*. 11:928-35 *More of the work from Bolger's group working on the fragments in San Diego. This group has used a group of different sized and aged scrub fragments to assess the effects of edge and fragment size on a variety of groups of organisms.*

3.0 Ecosystem Targets of Conservation

Daily GC. 1997. Introduction: what are ecosystem services?. In *Nature's Services: Societal Dependence on Natural Ecosystems*, ed GC Daily. pp 1-10. Washington DC: Island Press. 392 pp. *Introduction to the idea that the services that ecosystems provide are a suitable target for conservation action.*

Franklin JF. 1993. Preserving biodiversity: species, ecosystems, or landscapes? *Ecol. Appl*. 3:202-5. *A treatment that ostensibly asks the question of the appropriate organizational scale for conservation, but really argues for conservation at the ecosystem scale.*

Books that focus on ecosystem conservation

Edwards PJ, May RM, Webb NR, ed. 1994. *Large-Scale Ecology and Conservation Biology*. Oxford: Blackwell Scientific Publications. 375 pp.

Redford KH. et al. 1997. *Geography of Hope: Guidelines for Ecoregion-Based Conservation*. The Nature Conservancy, Arlington VA.

3.1 Ecosystem Health

Armitage, M. H. 1999. The euryhaline gobiid fish, Gillichthys mirabilis Cooper 1864, second intermediate trematode, Pygiopsoides spindalis Martin 19511. Bulletin Southern California Academy of Sciences 98(2):75-79. *In this example, trematodes are used as indicators of Mugu lagoon ecosystem health.*

Costanza, R. 1992. Toward an Operational Definition of Ecosystem Health. Pp. 239-256, in Ecosystem Health. R. Costanza, B. G. Norton, and B. D. Haskell, eds. Island Press; Covelo, CA, 269 pp. *Summarizes concept definitions of Ecosystem Health, then attempts to develop a practical definition encompassing vigor, organization, and resilience within the system (Table 2).*

Fitch, L., B. W. Adams. 1998. Can cows and fish co-exist? Canadian Journal of Plant Science 78(2):191-198. *Empirically links riparian structure and vegetation to livestock grazing. Recommendations for healthy riparian grazing strategies are given for the Southern Alberta area.*

Rothley, K. D. 1999. Designing bioreserve networks to satisfy multiple, conflicting demands. Ecological Applications 9(3):741-750. *Compromise between connectedness, area, and rare species representation is incorporated into a technique for ranking and choosing reserve alternatives in a relatively systematic manner.*

Wolfe, M., D. Norman. 1998. Effects of waterborne mercury on terrestrial wildlife at Clear Lake: Evaluation and testing of a predictive model. Environmental Toxicology and Chemistry 17(2):214-227. *Mercury (Hg) contamination is assessed through the analysis of mammalian and avian tissues. The results confirmed the accuracy of a predictive model that could be used for other aquatic systems containing mercury.*

Books on Ecosystem Health as the Criteria for Conservation Management

Costanza R, Norton BG, Haskell BD, ed. 1992. *Ecosystem Health: New Goals for Environmental Management*. Washington DC: Island. 269 pp. *Book that gives a general overview and sets the stage for this emerging field.*

3.2 Range of Variability

Aplet GH, Keeton WS. 1999. Application of historic range of variability concepts to biodiversity conservation. In *Practical Approaches to the Conservation of Biological Diversity*, ed. RK Baydack, H Campa III, JB Haufler, 71-86. Washington DC: Island Press. 313 pp. *A*

general summary of how to apply historic range of variability as a concept for ecosystem management.

Fule, P. Z., W. W. Covington, M. M. Moore. 1997. Determining reference conditions for ecosystem management of southwestern ponderosa pine forests. Ecological Applications 7(3):895-908. *Because of fire exclusion, tree density has gone from 148 tree/ha in 1883 to 1265 trees/ha and a very different species composition. "The comparison shows that the contemporary forest is well above the range of presettlement variability in forest density".*

Landres, P. B., P. Morgan, and F. J. Swanson. 1999. Overview of the use of natural variability concepts in managing ecological systems. Ecological Applications 9(4):1179-1188. *Discusses the use and misuse of natural variability concepts for ecosystem management.*

Richter, B. D., J. V. Baumgartner, R. Wiginhton. 1997. How much water does a river need? Freshwater Biology 37(1):231-249. *Here is a methodology for setting streamflow management targets using RVA, 'Range of Variability Approach.*

Swetnam, T. W., C. D. Allen, and J. L. Betancourt. 1999. Applied historical ecology: using the past to manage for the future. Ecological Applications 9(4):1189-1206. *"These examples of applied historical ecology emphasize that detection and explanation of historical trends and variability are essential to informed management."*

3.3 Core-buffer area concepts

Dodd, C. K. Jr., and B. S. Cade. 1998. Movement patterns and the conservation of amphibians breeding in small, temporary wetlands. Conservation Biology 12(2):331-339. *Amphibians need terrestrial habitat as well as wetlands for breeding. By simply concentrating on wetlands, conservation efforts will fail.*

Koopman, M. E., J. H. Scrivener, and T. T. Kato. 1998. Patterns of den use by San Joaquin kit foxes. Journal of Wildlife Management 62(1):373-379. *Because kit foxes use an average of 11.8 dens throughout a year, both active and inactive kit fox dens should be conserved.*

Noss R. 1993. A bioregional conservation plan for the Oregon Coast Range. *Nat. Areas J.* 13:276-90. *Application of the core-buffer area concept in conservation planning.*

Noss, R. F., and A. Y. Cooperrider. 1994. Saving Nature's Legacy. Island Press: Covelo, CA. Pp.147-156. *Definition of core reserve and buffer reserve.*

Key papers not included in the binder

Noss RF, Harris LD. 1986. Nodes, networks, and MUMs: preserving diversity at all scales. *Env. Manag*. 10:299-309. *An early presentation of the general idea of using core-buffer areas for conservation planning.*

Schultz, C. B. 1998. Dispersal behavior and its implications for reserve design in a rare Oregon butterfly. Conservation Biology 12(2):284-292. *Examines the relative benefits of increasing protection by adding dispersal corridors, more habitat patches, or increasing buffer and size of existing protected patches.*

3.4 Ecosystem Function as a target

Meyer JL. 1997. Conserving ecosystem function. In *The Ecological Basis of Conservation: Heterogeneity, Ecosystems, and Biodiversity*, ed. STA Pickett, RS Ostfeld, M Shachak, GE Likens, pp. 136-45. Chapman & Hall, New York. 466 pp. *Argues that functioning ecosystems are critical and sets a framework for evaluating the natural functioning of ecosystems.*

Schwartz MW, Brigham CA, Hoeksema JD, Lyons KG, Mills MH et al. Linking biodiversity to ecosystem function: implications for conservation ecology. Oecologia In press. *Evaluates data and theory to assert that there is not sufficiently strong evidence for us to make the argument that in order to preserve ecosystem function that we need to conserve natural levels of diversity. Despite the appealing nature of this argument, most ecosystems appear to function at near pristine levels with a small fraction of their natural diversity.*

4.0 Surrogates for Conservation Evaluation

Caro TM, O'Doherty G. 1999. On the use of surrogate species in conservation biology. *Cons. Biol*. *Examines shortcomings of shortcuts for conservation prioritization and the inconsistencies in terminology used.*

Simberloff, D. 1998. Flagships, umbrellas, and keystones: is single-species management passé in the landscape era. Biological Conservation 83:247-257. *Examines problems with the indicator, umbrella and flagship species concepts. Suggests that keystone species may be a more appropriate focus for applying single-species concepts to saving habitats and landscapes. This paper also examines the potential problems with adaptive management and ecosystem management concepts.*

Books on the topic

Shrader-Frechette KS, McCoy ED. 1993. *Method in Ecology: Strategies for Conservation*. Cambridge: Cambridge Univ. Press. *While this does many things, it reviews the use of surrogates quite well.*

4.1 Flagships

Jackmand, R. E., W. G. Hunt, J. M. Jenkins, and P. J. Detrich. 1999. Prey of nesting Bald Eagles in northern California. Journal of Raptor Research 33(2):87-96. *Suggests, through an empirical study, that prey composition makes a good indicator of habitat for flagship species.*

Millsap, B. A., P. L. Kennedy, M. A. Byrd, G. Court, J. H. Enderson, and R. N. Rosenfield. 1998. Review for the proposal to de-list the American peregrine falcon. Wildlife Society Bulletin 26(3):522-538. *Population, numeric goals have been reached for the peregrine falcon while other goals have not been reached* .

White, P. C., K. W. Gregory, P. J. Lindley, and G. Richards. 1997. Economic values of threatened mammals in Britain: a case study of the otter *Lutra lutra* and the water vole *Arvicola terrestris*. *The percieved economic value of conserving these two species is evaluated through a telephone survey. The results suggest that public opinion may be just as important as rarity and endangerment in the allocation of funding.*

4.2 Umbrella Species

Berger J. 1997. Population constraints associated with the use of black rhinos as an umbrella species for desert herbivores. *Cons. Biol*. 11:69-78. *An empirical study of rhinos and associatedAfrican ungulates to assess the utility of rhinos as umbrella species. The results were mixed. Rhinos were good umbrellas in some senses and poor ones in others.*

Fleury, S. A., P. G. Mock, and J. F. O'Leary. 1998. Is the California Gnatcatcher a good umbrella species. Western Birds 29(4):453. *This project, designed in a 52,414 ha study area, suggests that the California Gnatcatcher is only a good umbrella species for species with similar habitat requirements.*

Launer, A. E., and D. D. Murphy. 1994. Umbrella species and the conservation of habitat fragments: a case of a threatened butterfly and a vanishing grassland ecosystem. Biological Conservation 69(2):145-153. *Because of a tenuous linkage between the butterfly's population scale and the scale of its associated plants, the authors conclude that all of the fragments containing these butterflies must be conserved if the butterfly is to be effectively used as an umbrella species.*

4.3 Keystone Species

Robles, C. D. 1997. Changing recruitment in constant species assemblages: implications for predation theory in intertidal communities. Ecology 78(5):1400-1414. *Variability in the keystone predator hypothesis occurs as a result of extreme spatial and temporal patterns. In this case, high wave exposure predicts more intense species interactions.*

4.4 Indicator species

Carroll SS, Pearson DL.1998. Spatial modeling of butterfly species richness using tiger beetles (Cicindelidae) as a bioindicator taxon. *Ecol. Appl*.8:531-43. *One of many studies that use a variety of taxa to act as indicators of broader diversity.*

Chase, M. K., J. T. Rotenbury, and M. D. Misenhelter. 1998. Is the California Gnatcatcher an indicator of bird-species richness in coastal sage scrub? Western Birds 29(4):468-474. *Two years of point count data covering 17 sites in three counties show that the California Gnatcatcher is not a good indicator species.*

Dufrene M, Legendre P.1997. Species assemblages and indicator species: The need for a flexible asymmetrical approach. *Ecol. Monogr.* 67:345-66. *Uses multivariate statistics to find indicators rather than the traditional method of picking a popular group and seeing if it works. Likely to be a much better method than most.*

Landres PB, Verner J, Thomas J W. 1988. Ecological uses of vertebrate indicator species: a critique. *Cons. Biol*. 2:316-28. *A paper that is very critical of the use of indicators for predicting biological diversity.*

Panzer R, Schwartz MW. 1998. Effectiveness of a vegetation-based approach to insect conservation. *Cons. Biol.* 12:693-702. *Shows that the use of plant communities has done a good job of selecting reserves in Illinois despite an historic lack of attention to insects when prioritizing reserve selection.*

Patterson BD. 1987. The principle of nested subsets and its implication for biological conservation. *Cons. Biol*. 1:323-34. *Suggests that a common pattern of diversity exists and that this predictability may help in prioritizing sites for conservation.*

Pearson DL. 1992. Tiger beetles as indicators for biodiversity patterns in Amazonia. Nat. Geog. Res. Expl. 8:116-7. *One of many studies that use a variety of taxa to act as indicators of broader diversity.*

Taggart, J.B. 1994. Ordination as an aid in determining priorities for plant community protection. Biological Conservation 68:135-141.*Ordination has frequently been used to delineate covariation in plant species in order to define communities. Here these researchers use data from savannas of the southeastern US to examine the utility of these data in order to set conservation priorities by identifying sites that ordinate the furthest from already protected sites.*

Key papers not included in the binder

Prendergast JR, Eversham BC.1997. Species richness covariance in higher taxa: Empirical tests of the biodiversity indicator concept. *Ecography* 20:210-16. *Prendergast has had a series of papers on indicators, most of which show that they don't work very well.*

Weaver JC. 1995. Indicator species and scale of observation. *Cons. Biol*. 9:939-42.

4.5 Hotspots and the biogeography of diversity

Balmford A. 1998. On hotspots and the use of indicators for reserve selection. *TREE* 13:409. *Reviews work on testing hotspots (covariation in diversity), and suggests that this may not be the right question to ask when prioritizing sites for protection.*

Dinerstein E, Wikramanayake ED. 1993. Beyond "hotspots": how to prioritize investments in biodiversity in the Indo-Pacific region. *Cons. Biol.* 7:53-65. *A clever way to associate threat and protection with underlying diversity to set protection priorities.*

Dobson AP, Rodriguez JP, Roberts WM, Wilcove DS. 1997. Geographic distribution of endangered species in the United States. *Science* 275:750-52. *Shows that most endangered species are found in areas of high human population density. Thus the protection of large tracts of land may miss the species.*

Mittermeier RA, Myers N, Thomsen JB, Da Fonseca GAB, Olivieri S.1998. Biodiversity hotspots and major tropical wilderness areas: Approaches to setting conservation priorities. *Cons. Biol.* 12:516-20. *A look at hotspots for prioritizing protection programs.*

Prendergast JR, Quinn RM, Lawton JH, Eversham BC, Gibbons DW. 1993. Rare species, the coincidence of diversity hotspots and conservation strategies. *Nature* 365:335-37. *Evaluates hotspots and finds little support in England.*

Quinn, R.M., Lawton, J.H., Eversham, B.C. and Wood, S.N. 1994. The biogeography of scarce vascular plants in Britain with respect to habitat preference dispersal ability and reproductive biology. Biological Conservation 70:149-157. *Using the British Ordnance Survey National Grid 10km^2 data set of rare vascular plants to query where centers of loci are for different species and relating these to habitat, species dispersal ability and reproductive biology. Species with poor dispersal ability tend to have more locally clustered distributions than species with good dispersal ability. The authors suggest that reintroduction and translocation should be used to supplement natural dispersal in fragmented landscapes.*

Reid WV. 1998. Biodiversity hotspots. *TREE* 13:275-80. *Reviews empirical studies and suggests a limited utility of the biodiversity hotspot approach.*

Williams P, Gibbons D, Margules C, Rebelo A, Humphries C, et al. 1996. A comparison of richness hotspots, rarity hotspots, and complementary areas conserving diversity of British birds. *Cons. Biol*. 10:155-74. *Williams has developed a global diversity mapping algorithm that has been used to find hotspots and minimum sets to capture diversity. Here is an empirical example.*

4.6 Taxonomic patterns in rarity

Grossman, D. H. et al. (eds.). 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the United States. The Nature Conservancy:, p.6. *Reconsiders the classic debate: "continuum concept" or "community unit concept". Introduces the "systematic unit concept".*

Hughes, A. L. 1999. Differential human impact on the survival of genetically distinct avian lineages. Bird Conservation International 9(2):147-154. *Extinct and threatened avian species tend to be phylogenetically unique species.*

Kunin, W.E. and Gaston, K.J. 1993. The biology of rarity: patterns, causes and consequences. Trends in Ecology and Evolution 8:298-301. *Reviews literature on life history attributes associated with species that are rare because of being geographically limited, habitat specialists, or having small population sizes. Refocuses research effort on delineating these patterns and suggests a distinction between attributes that increase the propensity of a species becoming rare versus attributes that facilitate a species survival despite being rare.*

Master LL. 1991. Assessing threats and setting priorities for conservation. *Cons. Biol*. 5:555-63. *Describes the Nature Conservancies program for prioritizing elements for conservation.*

Milligan, B. G., J. Leebens-Mack, and A. E. Strand. Conservation genetics: beyond the maintenance of marker diversity. Molecular Ecology 3(4):423-435. *DNA sequence variation associated specifically with genealogical analytical techniques may be the most valuable way to use molecular data in conservation biology. This would provide the means for interpreting otherwise unavailable, long-term demographic information for predicting species viability.*

Reid WV. 1994. Setting objectives for conservation evaluation. In *Systematics and Conservation Evaluation*, ed.PF Forey, CJ Humphries, RI Vane-Wright, pp. 1-14. Oxford: Clarendon. 438 pp. *Reid is usually very thoughtful in addressing conservation prioritizes. Here he challenges the notion of what is natural when setting priorities.*

Russell, G. J., T. M. Brooks, M. M. M,Kinney, and C .G. Anderson. 1998. Present and future taxonomic selectivity in bird and mammal extinctions. Conservation Biology 12(6):1365-

1376. *The authors show that rarity is not randomly distributed among taxa. In fact it is highly skewed. Taxonomic groups of mammals and birds with few species tend to be over-represented by rare taxa.*

Wilcove D, McMillan M, Winston KC. 1993. What exactly is an endangered species? An analysis of the endangered species list, 1985-1991. *Cons. Biol*. 7:87-93. *Analyzed recent endangered species listings to estimate average population sizes and the average number of extant populations at the time of listing for different types of species. The authors also assess the taxonomic level of units listed across taxa.*

Wilcove DS, Rothstein D, Dubow J, Phillips A, Losos E. 1998. Quantifying threats to imperiled species in the United States. *Bioscience* 48:607-15. *Shows that habitat loss, alien species, pollution and exploitation are the major threats to US endangered species.*

4.7 Extinction Risk

Lande, R. 1999. Extinction risks from anthropogenic, ecological, and genetic factors. Pp. 1-22 IN Landweber, L.F., and A.P. Dobson (Eds.). Genetics and the extinction of species; DNA and the conservation of biodiversity. Princeton Univ. Press. *Reviews types of stochastic behavior in populations and the population sizes over which they are likely to be an important factor in predicting extinction likelihood. Important because it gives good tangible examples of these factors.*

Reed, J. J. 1999. The role of behavior in recent avian extinctions and endangerments. Conservation Biology 13(2):232-241. *Relevant behaviors can be grouped into the following categories: aggregation, interspecific responses, dispersal, habitat selection, intraspecific behavior, and maladaptive behavior.*

5.0 Designing Protection Programs

Soule ME, Simberloff D. 1986. What do genetics and ecology tell us about the design of nature reserves? *Biol. Cons*. 35:19-40. *A classic review burying the hatchet in the SLOSS debate.*

Books on the topic.

Peck S. 1998. *Planning for Biodiversity*. Washington, DC: Island Press. 221 pp. *A good simple review of biogeographic principles applied to reserve design.*

5.1 Reserve Size / SLOSS

Andersen, M. C., D. Mahato. 1995. Demographic models and reserve designs for the California spotted owl. Ecological Applications 5(3):639-647. *The SOHA plan uses a large number of small reserves, while the HCA plan uses a smaller number of relatively large reserves. The two plans are compared and the HCA plan seems to lead to a more viable population.*

Barrett NE, Barrett JP. 1997. Reserve design and the new conservation theory. In *The Ecological Basis of Conservation: Heterogeneity, Ecosystems, and Biodiversity*, ed. STA Pickett, RS Ostfeld, M Shachak, GE Likens, pp. 236-51. New York: Chapman & Hall. 466 pp.

Diamond J. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. *Biol. Cons.* 7:129-146. *A classic paper that outlined biogeographic principles that suggested reserve design.*

Lamberson, R., B. R. Noon, C. Voss, K. S. McKelvey. 1994. Reserve design for territorial species: the effects of patch size and spacing on the viability of the northern spotted owl. Conservation Biology 8(1):185-195. *Biological necessity vs. economic necessity: these issues effect the Spotted Owl reserve system design.*

Noss, R. 1996. Protected areas: how much is enough? Pp 91-120 in National Parks and Protected Areas (R.G. Wright, ed.). Blackwell Scientific, Oxford. *Argues for aggregating large reserves to protect viable ecosystems.*

Noss and Cooperrider. 1994. Island Biogeography and SLOSS. Pp. 138-142. *Single Large or Several Small, a controversy resolved by changing the "or" to " and" and getting: large and several.*

Pickett STA, Thompson J. 1978. Patch dynamics and the design of nature reserves. *Biol. Cons*. 13:27-37.*Argued for protection of very large sites in order to capture vegetation at various stages of recovery from disturbance.*

Pressey RL, Logan VS.1998. Size of selection units for future reserves and its influence on actual vs targeted representation of features: A case study in western New South Wales. *Biol. Cons*. 85:305-19. *Develops reserve selection algorithms based on presence absence data for sites. Explores the abilities of different algorithms to capture diversity.*

Semlitsch RD, Bodie JR. 1998. Are small, isolated wetlands expendable? *Cons. Biol*. 12:1129-33. *Argues that small and isolated wetlands are of high conservation value because of the species captured within them and their biological uniqueness.*

Schultz, C. B. 1998. Dispersal behavior and its implications for reserve design in a rare Oregon butterfly. Conservation Biology 12(2):284-292. *The dispersal patterns of these butterflies indicates that many small patches of habitat would be a more effective reserve design than would a single corridor.*

Schwartz, M.W. 1999. Choosing the appropriate scale of reserves for conservation. Annual Review of Ecology and Systematics 30:83-108. *Counters a recent trend to an increasing emphasis on large sites and conservation at higher levels organization to suggest when conservation on small sites is the appropriate strategy, and when species level programs may reasonably take precedence over community or ecosystem approaches.*

Shafer C. 1994. Beyond park boundaries. In *Landscape Planning and Ecological Networks*, ed. EA Cook, HN van Lier, pp 201-223. Amsterdam: Elsevier. *Sets out a series of logical steps to guide selection of reserves based on the fundamental principles described in Diamonds 1975 article modified by 20 years of empirical study.*

5.3 GAP analysis

Caicco SL, Scott JM, Butterfield B, Csuti B. 1995. A gap analysis of the management status of the vegetation of Idaho (U.S.A.). *Cons. Biol*. 9:498-511. *An empirical example of a GAP analysis.*

Flather CH, Wilson KR, Dean DJ, McComb WC. 1997. Identifying gaps in conservation networks: of indicators and uncertainty in geographic-based analyses. *Ecol. Appl*. 7:531-42. *A different take on identifying protection gaps by looking at coincidence of hotspots.*

Kiester, A. R., M. J. Scott, B. Scuti, R. F. Noss, B. Butterfield, K. Sahr, and D. White. 1996. Conservation prioritization using GAP data. Consrvation Biolgy 10(5):1332-1342. *"Total vertebrates sweep endangered, threatened, and candidate species better than unprotected vertebrates do, which in turn are better than vegetation classes."*

Prendergast, J. R., R. M. Quinn, and J. H. Lawton. 1999. The gaps between theory and practice in selecting nature reserves. Conservation Biology 13(3):484-492. *Convenient new tools for designing reserves (like gap analysis) have been largely ignored by planners simply because they are unaware of them. This problem is discussed along with advantages of several of these tools.*

Scott, J. M., and B. Csuti. 1997. Noah worked two jobs. Conservation Biology 11(5):1255-1257. *"[Most] natural areas have been set aside because they have little economic value, because of their scenic appeal, and because the opportunity to designate them presented itself."*

Scott, J. M., H. Anderson, F. Davis, S. Caicoo, B. Csuti, T. C. Edwards, R. Noss, J. Ulliman, C. Groves, and R. G. Wright. 1993. Gap analysis: a geographic approach to protection of biological diversity. Wildlife Monographs 0(123):1-41. *Gap analysis identifies the gaps in*

representation of biological diversity, enabling managers to fill the gaps by improving management plans.

Book on topic (empirical example)

Cox J, Kautz R, MacLaughlin M, Gilbert T. 1994. *Closing the Gaps in Florida's Wildlife Habitat Conservation System*. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida.

5.4 Minimum sets

Ando, A., Camm, J., Polasky, S. and Solow, A. 1998. Species distributions, land values, and efficient conservation. Science 279: 2126-2128. *Several researchers have developed algorithms to maximize efficiency in the capture of rare and endangered species by selecting reserves that contain the largest numbers of unprotected species. In this paper, Ando et al. expand on these methods by altering reserve selection regimes based on cost of land. For example, it may be more efficient to protect two cheaper parcels of land that contain fewer species individually, than it would be to purchase the one parcel with the most species.*

Bedward M, Pressey RL, Keith DA. 1992. A new approach for selecting fully representative reserve networks: Addressing efficiency, reserve design and land suitability with an iterative analysis. *Biol. Cons*. 62:115-25. *A different suite of algorithms set up to maximize coverage of species protection while minimizing area protected.*

Jaarsveld, A.S. van and 10 others. 1998. Biodiversity assessment and conservation strategies. Science 279:2106-2108. *An empirical example of complementarity in sets of species of conservation concern in South Africa.*

Lomolino, M.V. 1994. An evaluation of alternative strategies for building networks of nature reserves. Biological Conservation 69:243-249. *Tests reserve selection using SLOSS to select reserves from small to large, large to small, and a best algorithm using 10 data sets. The results suggest that no one strategy works best.*

Saetersdal, M., Line, J.N., Birks, H.J.B. 1993. How to maximize biological diversity in nature reserve selection: vascular plants and breeding birds in deciduous woodlands, western Norway. Biological Conservation 66:131-138. *Examines accumulation curves for selecting reserves based on endemic plants and birds in Norway. The data show that substantially more area is required to capture habitat for all endemic plants than all endemic birds.*

5.5 Do Corridors Work?

Beier P, Noss RF. 1998. Do habitat corridors provide connectivity? *Cons. Biol*. 12:1241-52. *A critical evaluation of empirical support (or lack thereof) for dispersal corridors.*

Clinchy M. 1997. Does immigration "rescue" populations from extinction? Implications regarding movement corridors and the conservation of mammals. *Oikos*, 80:618-22.

Hess GR.1994. Conservation corridors and contagious disease: A cautionary note. *Cons. Biol*. 8: 256-62. *A unique take on why dispersal corridors may not work so well: competition from residents by mostly male disperers that add nothing to potential numbers of offspring in a location.*

Simberloff D, Farr JA, Cox J, Mehlman DW. 1992. Movement corridors conservation bargains or poor investments? *Cons. Biol*. 6:493-504. *Cites several reasons why corridors may be either not sufficiently helpful to warrant their expense to harmful to the conservation effort. Urges caution in application of corridors.*

6.0 Management Strategies

6.1 Adaptive management

Brunner RD, Clark TW. 1997 A practice-based approach to ecosystem management. *Cons. Biol*. 11:48-58. *An idea paper on how to better construct an adaptive management plan for ecosystem management*

6.2 Ecosystem Management

Beattie M. 1996. Biodiversity policy and ecosystem management. In *Biodiversity and the Law*, ed. WJ Snape III, pp. 11-15. Washington, DC: Island Press. 259pp. *Discusses how the USFWS will use the ESA to do ecosystem management*

Beattie M. 1996. An ecosystem approach to fish and wildlife conservation. *Ecol. Appl*. 6:696-99. *Discusses how the USFWS will use the ESA to do ecosystem management*

Frissell, C. A. 1993. Topology of extinction and endangerment of native fishes in the Pacific Northwest and California (USA). Conservation Biology 7(2):342-354. *The historic range and present status of the Coho Salmon and Chum Salmon is mapped from previously available data. The usefulness of such a map to managers is discussed.*

Grumbine RE. 1997. Reflections on "What is Ecosystem Management?" *Cons. Biol*. 11:41-47. *Reviews 10 major themes of ecosystem management after review with managers.*

Launer, A. E., D. D. Murphy, J. M. Hoekstra, and H. R. Sparrow.1994. The endangered Myrtle's silverspot butterfly: Present status and initial conservation planning. Journal of Research on the Lepiddoptera 31(1-2):132-146. *Data from population surveys of this endangered butterfly persuade scientists that habitat conservation in conjunction with ecosystem management are necessary for its protection.*

Noss, R. F., and J. M. Scott. 1997. Ecosystem protection and restoration: the core of ecosystem management. Pp. 239-264, in Ecosystem Management: Applications for sustainable forest and wildlife resources. Yale University Press: New Haven, 361pp. *This chapter defines Ecosystem Management with the core goals of protection and restoration. It also reviews the definition at several levels and touches on "sustainable use" by humans.*

Roe, Emery. 1996. Why ecosystem management can't work without social science: An example from the California northern spotted owl controversy. Environmental Management 20(5):667-674. *Social science is definitely a part of ecosystem management.*

Paper not in binder

Christensen NL, Bartuska AM, Brown JH, Carpenter S, D'Antonio C, et al. 1996. The report of the Ecological Society of America Committee on the Scientific Basis for Ecosystem Management. *Ecol. Appl*. 6:665-91.

7.0 Restoration Ecology

Haslam, S. M. 1996. Enhancing river vegetation: conservation, development, and restoration. Hydrobiologia 340(1-3):345-348. *To which period should you restore your river vegetation?*

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