Appendix 5.1

The following material is Appendix 5.1 for Chapter 5 of: Fowler, C.W. 2009. Systemic Management: Sustainable Human Interactions with Ecosystems and the Biosphere. Oxford University Press

1 Science is inadequate for management

The following is a list of references and statements regarding the inadequacy of science and the need for an improved conceptual foundation or new paradigm to meet our needs. In reading through these observations, keep in mind that part of what is being identified here, is the problem of mismatch between science and management, or the lack of consonance between patterns science can observe and the management questions to which they correspond. The authors are not necessarily conscious of this problem as much as they are expressing symptoms of it. Problems are being identified in the conventional approach depicted in the top row of Figure 1.1.

Another part of what is being treated is the fact that there are not fields of science to explore many of the components, relationships, and dynamics of complex systems. The lack of a full acceptance of natural selection at the species level is part of this problem. The following comments also relate to the impossibility of achieving the integrative quality of consonant patterns by other means. We are always confined to reductionism, and attempts to recombine nonconsonant reductionistic information always encounter the impossibility of such efforts (the Humpty Dumpty syndrome described elsewhere in this book).

Allen and Hoekstra (1992):

"Business as usual has been distinctly incremental in recent years. Theory has been barely relevant to field practitioners, who have therefore been forced to take up the slack as best they can." "…complexity is hard to manage not because there are too many parts to track, but because of our limitations in conceiving the whole."

Botkin (1990):

"It is imperative to develop what I have referred to elsewhere as the new science of the biosphere as well as other ecological sciences."

Brown (1981):

"Despite two decades of intensive investigation, Hutchinson's question remains largely unanswered." "The relationship between species diversity, functional organization, and stability of communities remains a challenging problem." Many community ecologists "…seem to feel that ecological theory has promised far more than it has delivered".

Brown and Maurer (1989):

"…ecology has become increasingly microscopic and experimental in its approach." "Without a complimentary emphasis on large-scale phenomena, there is little basis for determining which results simply reflect the idiosyncrasies of individual species in particular sites and which reflect the operation of more universal processes."

Costanza *et al.* (1992b):

"At least some theory is necessary if we are to explain why the measures we choose to indicate states of ecosystem health are not arbitrary."

Ehrlich (1989):

"A lack of both agreement on models and of empirical tests has limited the application of mathematical community ecology to practical problems." "But, if we do not begin to shape…theory, the future of technological *Homo sapiens* seems dim indeed. Theory, remember, is not just useful when it is providing specific predictions, but also when it supplies an overall frame work that is useful in policy making."

Haefner (1977):

"Until systems ecologists produce a theory that explains the evolution of the biological units they describe, it does not appear feasible for them to use the theorems and modeling constraints provided by evolutionary theory."

Hagen (1992):

"The final report on the I.B.P. … in 1975 concluded that no major breakthrough in ecological theory or biome level perspectives had resulted…to date."

Kareiva (1989):

"Past mistakes and the fact that no grand unified theory is on the horizon should not detract from the contributions models are likely to make to ecology."

Lawton (1974):

"Ecology suffers from a surfeit of fascinating but apparently unrelated observations, superimposed upon an acute shortage of general theories."

Levin (1989):

"We must develop a theory for the response pattern of different ecosystems to stresses. We must develop standards of comparisons among ecosystems, based on the identification of common, functionally important processes and properties. Such understanding can emerge only from theoretical syntheses based on a comprehensive program of microcosm research and experimental manipulation coupled with the retrospective studies."

Margalef (1963):

"Present day ecology is extremely poor in unifying and ordering principles."

Maynard Smith (1988):

"For some years, people have been measuring energy flow in ecosystems, but, so far, what has emerged is a description, not a causal theory."

Norton (1986):

"It was overwhelmingly agreed that the lack of scientific knowledge regarding ecosystem functioning is deplorable." (See also McGowan 1990.)

Orians and Paine (1983):

"It is evident that we suffer from a poverty of both theory and data."

Roughgarden (1989):

"Future theory will not be simple extension of present models. We must remain alert for altogether new metaphors."

Smith (1977):

"…if ecologists fail to examine ecosystems as wholes and fail to determine their emergent properties (emergent not in the computer but in the higher level of organization being considered), then they will fail to advance ecosystem theory."

References

Allen, T.F.H. and T.W. Hoekstra. 1992. *Toward a unified ecology.* Columbia University Press, New York, NY.

Botkin, D.B. 1990. *Discordant harmonies*. Oxford University Press, New York, NY.

Brown, J.H. 1981. Two decades of homage to Santa Rosalia: toward a general theory of diversity. *American Zoologist* 21: 877–888.

Brown, J.H. and B.A. Maurer. 1989. Macroecology: the division of food and space among species on continents. *Science* 243: 1145–1150.

Costanza, R., B.G. Norton, and B.D. Haskell. 1992. Introduction: What is ecosystem health and why should we worry about it? In R. Costanza, B.G. Norton, and B.D. Haskell (eds). *Ecosystem health: new goals for environmental management*, pp. 3–22. Island Press, Washington, DC.

Ehrlich, P.R. 1989. Discussion: Ecology and resource management—is ecological theory any good in practice? In J. Roughgarden, R.M. May, and S.A. Levin (eds). *Perspectives in ecological theory*, pp. 306–318. Princeton University Press, Princeton, NJ.

Haefner, J.W. 1977. Generative grammars that simulate ecological systems. In G. Innis (ed.). *New directions in the analysis of ecological systems, Part 2*, pp. 189–211. The Society for Computer Simulation, La Jolla, CA.

Hagen, J.B. 1992. *An entangled bank: the origins of ecosystem ecology.* Rutgers University Press, New Brunswick, NJ.

Kareiva, P. 1989. Renewing the dialogue between theory and experiments in population ecology. In J. Roughgarden, R.M. May, and S.A. Levin (eds). *Perspectives in ecological theory*, pp. 68–88. Princeton University Press, Princeton, NJ.

Lawton, J.H. 1974. Review of J.M. Smith's models in ecology. *Nature* 248: 537.

Levin, S.A. 1989. Challenges in the development of a theory of community and ecosystem structure and function. In J. Roughgarden, R.M. May and S.A. Levin

(eds). *Perspectives in ecological theory*, pp. 242–255. Princeton University Press, Princeton, NJ.

Margalef, R. 1963. On certain unifying principles in ecology. *American Naturalist* 97: 357–374.

Maynard Smith, J. 1988. *Did Darwin get it right? Essays on games, sex and evolution.* Chapman & Hall, New York, NY.

McGowan, J.A. 1990. Species dominance–diversity patterns in oceanic communities. In Woodwell, G.M. (ed.). *The earth in transition; patterns and processes of biotic impoverishment*, pp. 395–421. Cambridge University Press, New York, NY.

Norton, B.G. 1986. Epilogue. In Norton, B.G. (ed.). *The preservation of species: the value of biological diversity*, pp. 268–283. Princeton University Press, Princeton, NJ.

Orians, G.H. and R.T. Paine. 1983. Convergent evolution at the community level. In D.J. Futuyma and M. Slatkin (eds). *Coevolution*, pp. 431–454. Sinauer Associates, Sunderland, MA.

Roughgarden, J. 1989. The structure and assembly of communities. In J. Roughgarden, R.M. May and S.A. Levin (eds). *Perspectives in ecological theory*, pp. 203–226. Princeton University Press, Princeton, NJ.

Smith, F.E. 1977. Comments revisited—or, what I wish I had said: In G.S. Innis (ed.). *New directions in the analysis of ecological systems, Part 2*, pp. 231–235. The Society for Computer Simulation, La Jolla, CA.