Seeking Sustainability in an Age of Complexity

By Graham Harris

Cambridge University Press, New York, 2007,
ISBN 978-0-521-87349-9, 366pp., Hard Cover, $US 130.

Book reviewed by Charles Schafer[1]

[1]In the preamble (Chapter 1) of his book, Graham Harris argues that humans are now *the dominant planetary engineers* that, collectively, have exploited *just about every corner of the globe.* Presently, this perspective is reflected by population growth, changes to global biogeochemical cycles, the information technology revolution, and by the globalization of science to name but a few. Recognizing the contemporary setting as a time of increased complexity and uncertainty – and a growing consensus that the next 50 years or so are going to be critical – Harris devotes the remaining 22 chapters of the book to a careful evaluation of factors that modulate the degree to which *true* sustainability can be achieved. His aim seems to be to help the reader gain an in depth understanding of *the complexity of it all* and what form and pathway possible solutions might take in attempting to balance the six key forms of *capital* (natural, physical, financial, human, social, and knowledge). He feels that many textbooks of ecology are ignoring the issue of information flows between the human and natural worlds, and that community development literature appears to have remained more focused on social and economic factors and has tended to discount environmental linkages. In his view, true sustainability requires a balanced account consisting of all forms of capital.

Chapters 2, 4 and 5 focus on the complexity of the environment. Complex adaptive systems (CAS), emergence, aggregate complexity, highly optimized tolerance (HOT) systems, non-linearity, and non-equilibrium systems and their *trajectories* are among the topics addressed by the authour to show the intimately interconnected character and behaviour of natural systems. Harris argues that the CAS's found in nature feed on variability and that, in the world of CAS, variability is not noise, *it is signal* i.e., *a real measure of systems dynamics* and an indicator of unknown processes. As such, the resulting systems display variability over a wide range of scales, often showing a spectrum of responses without displaying any single characteristic or easily identifiable periodicity. These features have major implications for the ways that we study and monitor natural systems. Regardless of how conservative our approach may be (Harris proposes several strategies in the later chapters of his book), the fact remains that natural CAS's, with their high degree of non-linearity – and the complexity of their internal interactions at various scales – will always leave us with surprises, points of no return and

[1] Emeritus Scientist, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, NS., B2Y 4A2.
E-mail: charlestschafer@hotmail.com.

hysteresis. Harris appears to view the issue as one in which the properties of complex systems evolve continuously over time (i.e., *a world of trajectories not states*), and that many small-scale entities are, in fact, responsible for many globally-significant processes[2] (e.g., biofilms and nutrient recycling in ocean surface waters). As such, the effective management of CAS's requires acceptance that the past is no guide to the future.

Chapters 3 and 11 explore the tools, perspectives and science that will be needed to gain useful knowledge about CAS's. Instead of a classical emphasis on balance and equilibrium, the author's new science approach targets non-linearities, dynamic interactions, contexts, network structures, and emergent properties that develop as the result of interactions between *agents*. His approach also engages the community in a debate about values, purposes and outcomes to a much greater degree than what has been witnessed up to this point. According to Harris, [environmental] *science is not now seen as a source of truth but more as an argument and partial explanation.* He points out that the natural world, which demands variability and change, is presently at odds with capital and resource markets that are concerned with security and predictability. Correcting this dilemma poses significant challenges with respect to how we monitor and sample the system - which has implications in regard to manpower and budgets. If interaction and variability are as important as Harris believes, then looking at the natural world in terms of averages and equilibria will obviously no longer suffice.

System complexity is characterized by the authour as being exacerbated by the inter-penetration of the biosphere and the anthroposphere because of connections between natural processes and human activities across a range of scales. This situation poses questions such as how do we actually exploit the natural variability at a site for both increased profit *and* sustainability? Part of the answer can be found in the authour's support for a new model of science (*postnormal* science) which depends on greater levels of collaboration among other things. He also calls for new approaches in data collection that stress *when* we collect data, at what frequency and over what scales of space and time. In analyzing ecological systems, Harris views classical approaches as lacking the power to detect changes in means and variances over time, or to pinpoint changes in the sign and character of generating functions. He seems to consider many of the current suite of numerical models as not being able to capture the fine-scale dynamics of ecological systems because they must usually rely on a *lumped* representation of the ecosystem and its constituent species (e.g., the phytoplankton box in aquatic models is very often defined as the biomass of all species as estimated by chlorophyll "A" concentration). Harris believes that data gathering in the field has not kept pace with the conceptual revolution in sustainability science [21st century satellite arrays and underwater cable networks now under development should help to alleviate a good part of this problem].

The remaining 17 chapters of the book cover a range of scientific and philosophical topics from micro-interactions to environmental flows and from catchment form and function to managing environmental systems. They are aimed at demonstrating exactly

why a change in how we approach natural science problems is needed if society is to make progress in achieving new levels of *true* sustainability over the next 50 years. In Chapter 12, Harris stresses that, in many environmental matters, we are beyond *risk* (system behaviour is known) and that the situation is usually at least *uncertain* (system parameters are not known) or *indeterminate* (causal chains, networks and processes are open and defy prediction). He observes that some experts suggest that we often fool ourselves into thinking that events are more predictable than they really are and that the risks are contained when, in fact, they are not. These issues auger for a new scientific perspective which Harris refers to as *Mode III* science. Mode III science *works with and through various forms of natural, social and human capital to achieve outcomes.* It is transdisciplinary in character and acknowledges that reason is not a sufficient guide to our actions. Previous science paradigms are viewed as neglecting inconveniently small scales of pattern and process that are often responsible for the major environmental changes that we have witnessed (e.g., small-scale stochastic effects that drive the large-scale dynamics of ecosystems). In Chapter 7, the authour concentrates on *sense of place.* Here Harris notes how all of us have a deep sense of *place* that is built around landscape, ecology and biogeography. As such, we are seen as having preferences for particular scales (e.g., road widths, building sizes) and have imposed these preferences on the landscape through *generations of tinkering.* As a consequence, we fail to see landscape degradation *until it hits us in the face* and are often unable to distinguish between natural and created landscapes – thereby making it difficult to see early warning indicators of change. According to the authour, it is our *sense of place* that causes society to pay most attention to the 0.26% of the world's water that resides in lakes and rivers i.e., only a very small and transient part of the whole water picture.

A number of the later chapters in the book touch on restoration issues. For example, in Chapter 14, Harris points out that, in general, much of the small-scale pattern in landscapes is produced by self-organization and self-generated complexity (SGC) through local interactions that, in turn, promote maximum water and nutrient use efficiencies on the part of the entire system. These pattern and process relationships begin to change at about a 50% reduction (i.e., clearing) in natural cover. Reversing this trend requires the design of new landscape and waterscape *mosaics* where sustainability, as he frames it, *is not achieved on every hectare, but an overall ensemble approach to a more sustainable solution is realized.* In urban (as opposed to rural) settings, progress is being made through advances in various technologies (e.g., information technology applications, water recycling, desalination). However, Harris worries that globalization is driving patterns of social and economic change that overrides the natural scales of heterogeneity which underlie the natural production process. As an example of an improved organizational structure for addressing sustainability issues in rural settings, he mentions Australia's Hartlands Program. This program brings together an array of scientific teams (crop scientists, hydrologists, ecologists etc.) who are charged with the responsibility of providing decision support tools for farmers and regional communities that desire to achieve a more sustainable landscape.

Two chapters (9 and 10) explore catchment issues such as the interaction of landscapes and waterscapes and the impacts of human interference (i.e., ecosystem responses). In

addition to anthropogenic forcing, natural disturbances and climate variability are viewed as sufficient to compromise the effectiveness of the internal compensation and recycling mechanisms of natural systems. Fire, for example, totally alters catachment water and nutrient balances for long periods. On the anthropogenic side, sulphur and nitrogen emissions (and fertilizer use) are causing acid rain, catachment exports of nutrients, and the enrichment of surface waters in lakes and rivers. Harris remarks that, *although there is an intimate connection between land use and water quality, new work shows that these systems are highly heterogeneous at very small scales, a finding that has fundamental importance for our ability to model and predict the outcomes of our actions.* Impacted systems do not usually recover easily and often show strong hysteresis effects. Manipulations such as the removal of top predators from ecosystems can have a major impact on ecosystem biodiversity and function. Consequently, the ecosystems that we know today are very much modified compared to those that existed as little as 50 to 100 years ago.

In the remaining 7 chapters, the authour turns his attention to a number of other terms in the *true* sustainability equation. In Chapter 17 (Values and Beliefs), Harris argues that achieving more sustainable outcomes involves ethics and trust as well as communication and collaboration between people and cultures. In his view, community ownership and empowerment is the best and most sustainable solution to the management of resources. When it comes to the management of environmental, social and economic systems (Chapter 18), he stresses the demand for integration, systems thinking and trans-disciplinary science; *scientists with a strong reductionist and narrow disciplinary focus may never manage it.* Finding ways to understand and to manage the interactions of the many forms of capital that lead to sustainability is treated in Chapter 19. Harris predicts that a new world of systems thinking is emerging which is characterized by a different set of values than found in the *instrumentalist, corporatist world of globalization, economic efficiency, profit, and shareholder value.* Systems thinking is seen as an approach that exploits complexity and variability instead of trying to control or eliminate it i.e., a world in which CAS's are understood.

The theme in Chapter 20 is on capacity, collaboration, and innovation at both the individual and community levels. Harris reminds us here that wealth is an important driver of sustainability, and that progress on the sustainability front rests on the combination of wealth generation with other forms of capital. This poses a massive challenge to the increasingly globalized and economy efficiency-driven world in which we find ourselves today. The authour's discussion of the features of a new environmental paradigm (Chapter 21) is aimed at defining a mechanism for the management and restoration of *multiple capitals* (e.g., ecosystem structure, biodiversity) among other things, and to apply this technique at regional and watershed scales. He states that this must likely be accomplished in a setting of central government values and beliefs that are typically focused on globalization and the competitiveness of nations i.e., values which are not necessarily those of local and regional communities. The new paradigm involves recognition of the precarious nature of the present state of affairs and offers strategies such as decentralization, systems thinking, ethical considerations of justice, equity, and fairness as the tools necessary for making significant progress. The material in Chapter

22 is concerned with emerging problems and emerging solutions. One novel proposition made by the authour in this part of the book calls for the development of an *ecolophysics*, a new discipline featuring investigative strategies that stress the analysis of high frequency ecological data as a means of elucidating warning signals of impending systems crashes. Ecolophysics recognizes *noise as valuable signal.* The book's final chapter (23) discusses strategies for avoiding ecosystem collapse. It outlines some of the important reasons for ecosystem collapse (e.g., failure to anticipate impending environmental collapse and failure to perceive imminent change because of slow imperceptible change) and provides a list of the great issues of the day that require urgent consideration (e.g., climate change, building from local/regional restoration work to achieve global outcomes, building regional community capacity). Harris calls for a new set of performance measures for *all of nature* (i.e., both developed and more pristine settings) which should encompass social, economic and environmental robustness and resilience. If successful, this strategy leads to an ability to identify system *tipping points* – especially those that lie beyond the scope of both our everyday experience and that of numerical models. Harris seems to concede that the success of this approach will require the analysis of the non-linearities and emergent properties of coupled systems and some hard decisions with respect to tradeoffs. Many of these thoughts are incorporated into what he refers to as *postnormal* science that, by its very nature, is *inescapably radical*. Its aims include the subversion of the *boundary-work* of scientists operating in the policy domain where they have been found to have established a monopoly of expertise on policy problems that feature technical components.

Harris's message is broad and provocative, and one that poses some very significant challenges to 21st century society and science alike. As such, there are numerous important conclusions and recommendations that are scattered throughout the book's 23 chapters. Some worthy of mention are listed below:

- Achieving *stronger* sustainability will require a massive research effort at landscape scales. Much of the knowledge gained will come through empirical research and adaptive experimentation – too complex a task for computer simulation alone.
- A complex world view rests on an appreciation of the inter-penetration of the biosphere and the anthroposphere that reflects complex connections between natural processes and human activities across a range of scales. From the physical separation of financial and natural capitals, we are now considering the emergent forms of multiple types of capital integrating across scales in landscapes and waterscapes.
- A new model of science (i.e., postnormal science) is emerging featuring not just excellence in science, but also excellence in delivery, adoption and innovation. It calls for working with and through others to achieve new understandings about sustainability/economic relationships. This trend requires more complex modes of operation, changes in old (often monolithic) institutions, and new modes of thought and behaviour. Regardless of how successful we are in making this transition, Harris feels that we will always be managing and setting environmental/sustainability policy in a data-poor environment i.e., one that uses limited and uncertain knowledge.

- Slowly but surely, adaptive co-management that exploits forms of knowledge other than pure science – and other institutional frameworks – is being developed around the world to manage common pool resources.
- All institutions (scientific, corporations, government jurisdictions) must realize that a greater focus on ethics is slowly but surely being demanded by an even more skeptical and educated public. Consequently, institutions must engage in new forms of collaborations in pursuing solutions that work *with* the natural world rather than against it.

This concisely written and comprehensively organized book is best digested if the reader has at least an undergraduate background in ecology, biology and/or resource management. Although it is very much a work that appears to be intended for graduate-level students, it will also be of interest to resource managers, green NGO executives and to future-focused politicians as well. The book is, in effect, a course in complex natural systems and postnormal science philosophy that attempts to stand conventional environmental science/management thinking on its end. Each individual chapter is very well referenced and the 17 page index found at the end of the book covers virtually all of the key ideas detailed in the text. Perhaps the most unusual feature of this work is that it is completely devoid of any photos, figures or tables. Nevertheless, I found the writer's propositions to be very thought provoking and, if I were just at the beginning of my research career, Harris's ideas would definitely change the way that I would go about conceptualizing field experiments and survey protocols.