Environmental Management in Practice

Managing the Ecosystem

Volume III

Edited by
B. Nath, L. Hens, P. Compton and D. Devuyst

ENVIRONMENTAL MANAGEMENT IN PRACTICE: VOLUME 3

Methods of environmental management, and especially the 'tools' of environmental management, are increasingly being relied upon world-wide to deliver a degree of sustainability in all human activities. A thorough understanding of the nature, capabilities and limitations of these 'tools', as well as the conditions under which they can be best applied, is essential for students, researchers and practitioners within the field of environmental management.

Environmental Management in Practice presents three comprehensive volumes containing the most up-to-date research and practical applications in the field. Spanning the four main aspects of environmental management: instruments, compartments, sectors and ecosystems, this three-volume work contains over sixty contributions from leading specialists in each field and offers the first major source of contemporary international research and application within environmental management in practice.

Volume 1: Instruments for Environmental Management, focuses on the instruments and tools currently available to the environmental manager. A theoretical background to the instruments is given together with an overview of those instruments that are in common use today, with particular attention to the physical, economic, legislative and communication instruments.

Volume 2: Compartments, Stressors and Sectors, deals with the problems that occur in the three 'compartments' of the environment—namely, air, water and soil. The contributors also address the socio-economic sectors of industry, traffic, energy, agriculture and tourism.

Volume 3: Managing the Ecosystem, focuses on those ecosystems in which human intervention has been or continues to be predominant, specifically within cities and rural areas.

Packed with accessible and up-to-date information, these three volumes provide a comprehensive overview of environmental management for those studying, researching and practising in the field.

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B.NATH, L.HENS,
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PREFACE AND ACKNOWLEDGEMENTS

Environmental management draws its knowledge base from across the spectrum of disciplines—the natural, social and medical sciences, the humanities and engineering. It aims to maintain a harmonious relationship between the environment and human society, and in its approach to this adopts a holistic, interdisciplinary stance. Since value judgements are an integral part of environmental management, it is as much an art as a science in its methodology and application.

The growth of interest in environmental management is relatively recent. It reflects a widely held perception of accelerating environmental deterioration caused by the pressure of human activities, as evidenced by worsening problems of pollution and the destruction of natural landscapes and habitats. These concerns can be traced back to the 1960s, when the interconnectedness of nature was vividly demonstrated by the way in which seemingly benign activities such as the chemical control of pests could, by diffusing through the food chain, produce adverse environmental effects in regions ostensibly untouched by man's activities.

As our knowledge of the global environment has grown, other worrying effects have come to light. The emission of greenhouse gases is linked to global warming and climate change. Although we do not fully understand the probable effects of this, it may well result in greater temperate aridity and so jeopardise the world grain supply, with potentially disastrous consequences. Moreover, resultant changes in sea level could submerge major coastal sites of population.

There is also the well-established connection between CFC emissions, the depletion of upper atmosphere ozone, and increased ultra-violet radiation at the planet's surface. This has negative implications not only for human health but also for the well-being of other species. Likewise, the destruction of the tropical rain forest is seen as a grave threat to biodiversity and the world's gene pool. The fact that these hazards are the subject of internationally agreed measures of amelioration (albeit implemented with variable commitment by individual countries) testifies to the potential gravity of global warming, ozone depletion and loss of biodiversity.

These global issues also raise concerns at the level of ecosystems. The effects of modern agricultural practices on environmental quality are a case in point. Pesticide and fertiliser residues pollute the groundwater; animal and plant habitats are destroyed as hedgerows are removed and wetlands drained in the interest of intensive cultivation; soil structure is broken down, creating problems of soil erosion. Now, in addition, intensive rearing of plants and animals is even causing concern for the safety and wholesomeness of the food produced. Populations are no longer willing to accept assurances from experts that genetically engineered crops are safe, or that it is right to feed natural herbivores, such as cattle, protein supplements derived from the rendered remains of other animals.

Of course it is not only agriculture that is problematic. Urban living and its associated activities can be just as destructive of the environment; not least, the creation of built environments where residential, commercial and industrial areas and communications infrastructures either obliterate or radically change pre-existing landscapes and ecosystems. Moreover, urban systems depend upon the mobility of people and goods for their effective functioning, and so create the traffic problems associated with further detrimental effects on the environment. The problems caused by excessive use of energy and natural resources in production and consumption, and their implications for future generations, also have to be tackled. Measures to ensure effective waste disposal and the curbing of air and water pollution are vital for the maintenance of environmental quality.

When viewed over a longer time-scale, however, the environmental picture is somewhat less gloomy. For example, popular coverage might lead one to suppose that human activity is the only cause of climatic change: the evidence does, after all, appear compelling, with the atmospheric content of the major greenhouse gas, carbon dioxide, having risen progressively since the start of industrialisation in the seventeenth century. But the record also shows that the world's climate has fluctuated markedly both in the recent geological and even historical past, and scientists still disagree on whether the rise now observed in global temperature should be attributed solely to greenhouse emissions. That this rise may be part of a natural progression readily absorbed by global systems cannot be ruled out at this stage.

It is also worth bearing in mind that ever since the domestication of plants and animals and the discovery of fire, human beings have moulded their natural surroundings to suit their purposes. During the medieval period, for instance, much of the forest that once covered the continent of Europe was destroyed (a process analogous with the present destruction of the tropical rain forest), without any apparent harmful consequences in the long term. Moreover, it was the agricultural and industrial revolutions that created those environmental conditions we consider 'natural' and with which we are comfortable. It is debatable, in other words, whether any truly natural landscapes and ecosystems remain—they have all to a greater or lesser extent come under human influence.

For most of human history our attitude to the environment has been purely exploitative: nature was there to be conquered, and the resource endowment to be used in the furtherance of human development. Little or no attention was paid to the possibility of detrimental environmental impacts—indeed, in most instances these were simply not appreciated because the complex relationships and linkages of environmental systems were not understood. It is only in this century that this attitude—of man as the conqueror of nature—has changed (indeed in Eastern Europe it persisted, with disastrous consequences, right up until the demise of communism). We now think more in terms of stewardship, whereby humans owe a duty of care to the environment, and in terms of sustainability. However, it is still invariably the case that when choices have to be made economic self-interest wins the day.

The broad scope of environmental management creates its own particular problems. The information on which it relies is scattered across disciplines isolated from one another by the traditional boundaries that demarcate major branches of academic endeavour. It follows from this that relevant advances in the natural sciences may not be appreciated by those working from a social science perspective, and so on. It is therefore a major objective of this book to bring together the expertise found within the diverse fields of environmental management, with the aim of providing an accessible overview of its content and methods. The treatment is biased towards environmental management as practised at the regional level—the so-called meso-scale. Global issues such as climate change and loss of biodiversity lie outside the scope of this book and so receive only incidental mention.

The idea for this book came initially from the involvement of the four editors in environmental training programmes in Eastern Europe, and a book was duly published by the Free University of Brussels Press in 1993. This publication is a revised, improved and extended edition of that earlier version and is presented in three volumes. The theoretical principles of environmental management are illustrated with the use of up-to-date examples and case studies, and self-assessment questions are included to aid students who may wish to use it as a textbook. It should also be of interest to policy-makers and researchers seeking information about the management of today's environmental problems.

Volume 1 considers the instruments for environmental management under four main headings— predictive and scientific instruments; economic instruments; legal instruments; and instruments for environmental communication and education. It not only covers relatively long-established instruments of management, such as environmental impact assessment and risk assessment, but also introduces more recently developed approaches such as material flow analysis and life-cycle assessment. Volume 1 aims at up-to-date, comprehensive coverage and includes discussion of such important topics as the concept of sustainable development, environmental legislation in the European Union and the USA, and the management of environmental conflict.

Volume 2 is devoted to the environmental management of compartments, stressors and sectors. It covers the impact of population and the way environmental information is processed and interpreted through the filter of human culture. Soil, air and water are the environmental compartments referred to in this volume. They are subject to stress through overuse and pollution, and the manner in which these stressors should be managed constitutes a major strand of enquiry. The sectors referred to are agriculture, forestry, industry, transport and tourism, and how these should be managed in the interests of preserving environmental quality.

The theoretical and practical considerations involved in the appropriate management of major natural ecosystem types—wetlands, tropical forests, desert areas, the coastal margin, river and inland water environments—are discussed in Volume 3. These are, of course, 'natural' ecosystems only in a relative sense; the question of management arises precisely because of human impacts. Of equal importance are those environments created entirely by human activities, and in recognition of this Volume 3 also deals with rural and urban environments, as well as human ecosystems under threat, and the management of archaeological sites.

The three volumes of this textbook contain over sixty chapters written by more than eighty authors. This large project would have been impossible without the support and active contributions of many colleagues whose names are not mentioned in the individual chapters. We would like to thank especially the secretarial staff of the Human Ecology Department, Free University of Brussels (VUB) for their excellent work; especially Mr Glenn Ronsse, who was responsible for the final formatting and overall secretarial management of the project. Sincere thanks are due to the peer reviewers of the chapters.

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LIST OF ABBREVIATIONS

ADMADE	Administrative Management Design for Game Management Areas, Zambia
AIA	Archaeological Impact Assessment
AIDS	Acquired Immune Deficiency Syndrome
BOD	Biological Oxygen Demand
CAMPFIRE	Communal Areas Management Programme For Indigenous Resources, Zimbabwe
CAP	Common Agricultural Policy
CBNRM	Community Based Natural Resources Management, Namibia
CDRS	Charles Darwin Research Station
CE	Council of Europe
CEC	Commission of the European Communities
CZM	Coastal Zone Management
EA	Environment Agency
ECNC	European Centre for Nature Conservation
EIA	Environmental Impact Assessment
EN	English Nature
ESA	Environmentally Sensitive Area
EU	European Union
FAO	Food and Agricultural Organization (of the UN)
GIA	Geomorphological Impact Assessment
GIS	Geographic Information System
GNP	Gross National Product
GNPS	Galapagos National Park Service
HYRROM	UK Institute of Hydrology's lumped catchment model
IBP	International Biological Program
ICZM	Integrated Coastal Zone Management
IFIM	Instream Flow Incremental Methodology
ILO	International Labour Organisation
INIA	Illinois, USA Natural Areas Survey
IRBM	Integrated River Basin Management
ITCZ	Inter Tropical Convergence Zone
IUCN	International Union for Conservation of Nature and Natural Resources
IUCN-CNPPA	(IUCN) Commission on Natural Parks and Protected Areas
KNP/FR	Kilimanjaro National Park and Forest Reserve
LAs	Local Authorities
LFA	Less Favoured Area
LPAC	London Planning Advisory Committee
MAFF	Ministry of Agriculture, Fisheries and Food, UK
NBPP	North Branch Prairie Project, Illinois, USA
NGO	Non-Governmental Organisation
NOAA	National Oceanographic and Atmospheric Administration

NRMP	Natural Resources Management Programme, Botswana
OEA	Organization of the American States
OECD	Organization for Economic Co-operation and Development
OPP	Orangi Pilot Project, Karachi, Pakistan
P	Phosphorus
PACD	Plan of Action to Combat Desertification
PLA	Port of London Authority
PP	Paniculate Phosphorus
RIVPACS	River Invertebrate Prediction and Classification System
RSPM	Resource Systems Planning Model
SARD	Sustainable Agriculture and Rural Development
SCP	Selous Conservation Programme, Tanzania
SEA	Strategic Environmental Impact Assessment
SRCP	Serengeti Regional Conservation Programme, Tanzania
SRP	Soluble Reactive Phosphorus
TGLP	Tribal Grazing Land Policy
TP	Total Phosphorus
UNCED	United Nations Conference on Environment and Development (Rio de Janeiro, Brazil 1992)
UNCOD	United Nations International Conference on Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNSO	United Nations Sudano-Sahelian Office
USFWS	United States Fish and Wildlife Service
WCED	World Commission on Environment and Development
WCMC	World Conservation Monitoring Centre
WHO	World Health Organization
WRI	World Resources Institute (New York)
WWF	World Wide Fund for Nature (formerly World Wildlife Fund)

LIST OF UNITS

Prefixes to the names of units

G	giga (10^9)
M	mega (10^6)
k	kilo (10^3)
d	deci (10^{-1})
c	centi (10^{-2})
m	milli (10^{-3})
µ	micro (10^{-6})
n	nano (10^{-9})
p	pico (10^{-12})
f	femto (10^{-15})

Units

a	annum
Å	ångstrom (0.1 nm)
atm	atmosphere
bbl	billions of barrel
boe	barrels of oil equivalent
Bq	becquerel
°C	degree Celsius or centigrade
cal	calorie
d	day
dB	decibel
g	gram
Gtce	gigatons of coal equivalent
Gwe	gigawatt electricity
h	hour
ha	hectare
hrs	hours
Hz	hertz
J	joule
K	degree absolute (kelvin)
l	litre
m	metre
M	molar (mol/litre)
min	minute
P	phon
Pa	pascal (unit of pressure; 100 kPa=1 bar)
pe	percentage
PM_{10}	fraction of particulates in air of very small size (≤ 10 µm)
S	sone
s	second
t	tons
Tcf	tons of carbon fuel
TW	terawatt
Twyr	terawatt per year
V	volt
W	watt
yr	year

Other abbreviations

kg_{bw}	kilogram body weight
ln	logarithm (natural, base e)
log	logarithm (common, base 10)
n or N	total number of individuals or variates
ppb	parts per billion
ppm	parts per million
ppmv	parts per million (volume)
s^2	sample variance

INTRODUCTION

Richard J.Huggett and Paul A.Compton

Human civilisations have always 'managed' ecosystems to a greater or lesser degree. Before the eighteenth century, humankind tended to take a responsible attitude towards Nature (see Merchant, 1982; Sheldrake, 1990). The rise of a mechanistic world-view bred an exploitative attitude, at least in the western world and its fast-growing colonies. Ecosystem riches were plundered profligately, with little heed to conservation or sustainability. The result was an unprecedented transformation of the biosphere, a radical shift in land cover. Dissenting voices against the rape of the Earth first cried out during the second half of the nineteenth century. However, only since 1945, with the rise of modern environmentalism, has a large body of people spoken with one voice to demand the judicious use of ecosystems.

Modern views on ecosystem management evolved largely in response to the current biodiversity crisis. Biodiversity provided a new rallying point in an ecological world that late twentieth-century theorists had shown to be largely chaotic and unpredictable. Nature may have disturbing, perverse and unpredictable ways, and an abiding ability to evade our understanding, but it is gloriously diverse and still needs our love, our respect, and our help (cf. Worster, 1994:420). By the late 1980s, an ecosystem approach to land management was advocated by many scientists and other people interested in the environment (e.g. Agee and Johnson, 1988). Its ultimate aim is to enhance and to ensure the diversity of species, communities, ecosystems and landscapes.

WHAT IS ECOSYSTEM MANAGEMENT?

Ecosystem management is now a much used term. But what does it mean?

This question is surprisingly difficult to answer. About all that may be said with confidence is that ecosystem management is not the traditional model of resource management. Traditional resource management lays emphasis on maximising production of goods and services through sustained yield from balanced ecosystems. It gives much credence to utilitarian values that regard human consumption as the best use of resources, and that hold a continuous supply of goods for human markets as the purpose of resource management (Cortner and Moote, 1994). This blatant 'resourcism' is patently flawed. It fails to recognise limits to exploitation and, in consequence, a growing number of species, and even entire ecosystems, are currently endangered. But, flawed or not, it persists: even now, ecosystems are viewed by some as long-lived, multi-product factories (Gottfried, 1992), or, if you prefer, as Nature's superstores.

Ecosystem management, though not universally welcomed, is a new and emerging model of resource management. Some of its advocates see their endeavours as an extension of multiple use, sustained yield policies (e.g. Kessler *et al.*, 1992). They prosecute a stewardship approach, in which the ecosystem is seen merely as a human life-support system. In this view, public demands for habitat protection, recreation and wildlife uses are simply seen as constraints to maximising resource output

(Cortner and Moote, 1994). A more radical approach, which seems to be making headway in discussions of ecosystem management, is to accept Nature on its own terms, even where doing so means controlling incompatible human uses (e.g. Keiter and Boyce, 1991). This extreme, but eminently sensible, form of ecosystem management reflects a willingness to place environmental values, such as biodiversity, and social and cultural values, such as the upholding of human rights, on an equal footing.

Ecosystem management is defined in several ways, it embraces many and various approaches, and it has several dimensions. It is intimately linked to radical ideas about humanity's place in Nature. Here is a working definition: 'Ecosystem management integrates scientific knowledge of ecological relationships within a complex socio-political and values framework toward the general goal of protecting native ecosystem integrity over the long term' (Grumbine, 1994:31); it is, at root, 'an invitation, a call to restorative action that promises a healthy future for the entire biotic enterprise' and promises a means of bridging the growing gap between people and Nature in 'a world of damaged but recoverable ecological integrity' (Grumbine, 1994:35).

Ecosystem management involves several dominant themes (Grumbine, 1994). These fall into three categories—ecosystem considerations, management practices and human concerns.

ECOSYSTEM CONSIDERATIONS

Studying all connections in the ecological hierarchy

A tenet of modern ecology is that everything is connected to everything else, so that nothing in Nature can be understood in isolation. Such ecological interdependence has profound management implications: an ecosystem component cannot be altered without effects being felt throughout the system. This is why a solution to one problem often creates new, unforeseen problems. A 'single problem-single solution' approach is ecologically unsound, and may create more problems than it solves. Ecosystem managers should instead opt for solutions that attempt to embrace the gamut of problems (Gerlach and Bengston, 1992). This will normally mean considering connections between all hierarchical levels of the ecosphere—genes, species, populations, communities, ecosystems and landscapes (cf. Kaufmann *et al.*, 1994: 6; Huggett, 1995:13–14).

Including the true ecological boundaries

Ecosystems function on their own scales of space and time. Many are larger than a single administrative or management institution. This was recognised by the first exponents of modern ecosystem management, Frank and John Craighead, whose work showed that the needs of the grizzly bear *(Ursus arctos horribilis)* population could not be met within the confines of Yellowstone National Park (e.g. Craighead, 1979). The management of most ecosystems requires co-operation of managers from several different administrative and political units (Gerlach and Bengston, 1992). It also requires an integrated ecological approach that often demands international action and co-operation. This is true for managing coastal resources (see Alexander, 1993; Ngoile and Horrill, 1993), as well as terrestrial resources. A case in point concerns human impacts acting through terrestrial runoff on coastal marine ecosystems. In managing these impacts, it is useful to adopt the 'marine catchment basin' as a unit of study (Caddy and Bakun, 1994): such catchments may cross regional or even state boundaries.

Managing ecological integrity

This is the overall goal of ecosystem management. It means protecting the total native diversity (of species, populations, ecosystems and landscapes) and the ecological patterns and processes that maintain them (Norton, 1992). In practice, this normally includes one or more specific goals (Grumbine, 1994: 31):

1 Maintaining viable populations of all native species *in situ,* and reintroducing extirpated species where necessary.
2 Ensuring that, within protected areas, all native ecosystem types are represented. In other words, protecting the full natural range of ecosystem variation.
3 Maintaining ecological and evolutionary processes. This means guaranteeing the

continuance of natural disturbance regimes, hydrological process and ecological processes.

4 Managing ecosystems for long enough periods to maintain the evolutionary potential of species, communities and ecosystems.
5 Accommodating human use and occupancy in the light of the above. This acknowledges the vital, if unsure, role that humans must play in all aspects of ecosystem management.

Ecosystem management should be informed by sound conceptual models of ecosystem structure and function (e.g. Le Roux, 1993; Straskraba, 1993). It is essential to understand natural ecosystem processes before attempting to manage an ecosystem. This means understanding the full gamut of ecological processes and patterns, from trophic relationships between species (e.g. Whitlatch and Osman, 1994) to the principles of landscape ecology (e.g. Agardy, 1994) and the question of disturbance. The ecological role of disturbance is now widely recognised and complicates ecosystem management practice. For instance, an ecological framework of natural disturbance and a knowledge of its component processes and effects provide a sound basis for managing forests as a renewable resource (Attiwill, 1994). The practice of ecosystem management has evolved alongside ecological theory. Traditional ecosystem management draws heavily on the ecological notions of balance and equilibrium. Newer management practices tend to incorporate new ecological ideas that stress imbalance, disharmony, disequilibrium, disturbance and unpredictability (chaotic behaviour). Any new paradigm of ecosystem management must somehow incorporate the principles of ecosystem disequilibrium and chaotic behaviour. A sticky problem is that disequilibrium ecologists are divided among themselves over the advice they should give to society on how to act over the environment. One group, reflecting some of the new disequilibrium thinking, began to challenge the public perception that ecology and environmentalism were the same thing. Some ecologists became disenchanted with trying to conserve a healthy planet. Nature is characterised by highly individualistic associations, they argued, so why attempt to constrain it? This anarchic argument, if taken to the extreme, could have revived social Darwinism and stood in antithesis to the conservation ethic of co-operation and collective action suggested by the older notion of balanced ecosystems. In the event, a mildly anarchic view of Nature was taken by some ecologists. Another group of ecologists, in stark contrast, drew different conclusions from the disequilibrium trends of their discipline. They favoured an environmentalism that was more friendly towards manipulating and dominating Nature, but that tolerated modern technology and progress, and human desires for greater wealth and power (e.g. Botkin, 1990).

Even more problematic is the question of chaotic ecosystem dynamics. The implications of ecological chaos for conservation and ecosystem management are far from clear. How are conservationists and managers to use a chaotic ecological design? Answers to this question have to confront a paradox: a chaotic view of Nature is at once exhilarating and threatening. Chaotic Nature, so irregular and individualistic in character, appears almost impossibly difficult to admire or to respect, to understand or to predict. It seems to be a world in which the security of stable, permanent rules is gone forever, a dangerous and uncertain world that inspires no confidence (Prigogine and Stengers, 1984:212–213). This dark and direful aspect of chaos might promote a feeling of alienation from the natural world, and cause people to withdraw into doubt and self-absorption (cf. Worster, 1994: 413). It might also set people wondering how they should behave in a world where chaos reigns. With natural disturbance found everywhere, why should humans worry about doing their own bit of disturbing? Why not join individuals of all other species and do their own thing without feeling guilty about it? As Worster (1994:413) put it, what does the phrase ‘environmental damage’ mean in a world so full of natural upheaval and unpredictability? However, chaos does not have to be portrayed in such gloomy and doom-laden terms. Chaotic Nature has a bright and edifying aspect, too. In a chaotic world, communities, ecosystems and societies are sensitive to disturbance. Small disturbances can, sometimes, grow and cause the communities, ecosystems or societies to change. Consequently, it is a world in which individual activity may have major significance (cf. Prigogine and Stengers, 1984:313). It is a post-modern world in which increased individuality and diversity encourage a great overall harmony. Moreover, the new-fangled theory of chaotic dynamics is leading to the discovery of hidden regularities in natural processes, the application of which is proving most salutary (e.g. Stewart, 1995). For instance, some forests and fisheries are being better managed through an understanding of their chaotic behaviour.

Environmental monitoring and data collection

Ecosystem management requires continuing research and data collection, as well as better management and use of existing data. This includes data on modern processes and historical data. An example of the use of modern data is the collection of resource inventory data on abiotic, biotic and cultural components of the Great Lakes shoreline environment, which has enabled key issues and areas of concern to be identified (Lawrence *et al.*, 1993). Historical data on environment, climate and culture in the fragile high Andean puna ecosystems have contributed to their management and preservation (Baied and Wheeler, 1993).

The behaviour of managed ecosystems must be carefully monitored so that the relative success or failure of actions can be tested and adjusted if necessary. Sometimes the remedial measures are more damaging than the problem. This is sometimes the case with marine pollution, and notably with oil slicks (e.g. Mearns, 1993). It is also desirable to know whether environmental assessment objectives have been met. This requires long-term monitoring programmes, as instigated, for example, on streams in the Pacific north-west forests of North America (Wissmar, 1993).

MANAGEMENT PRACTICES

Three facets of management practice are highly pertinent to ecosystem management—adaptive management, interagency co-operation, and organisational change.

Ecosystem management is adaptive in the sense that scientific knowledge is regarded as provisional. New findings, especially from monitoring programmes, may alter advice to managers. Managers must thus remain flexible and adapt to the changeability of 'expert' scientific opinion. Likewise, scientists must adapt to social changes and demands. Ecosystem management calls for all parties to be adaptable. It is claimed, for instance, that the eventual restoration of depleted fish stocks will require adaptive management procedures (Alexander, 1993).

Ecosystem boundaries transgress administrative and political boundaries. National, regional and local management agencies, as well as private parties, must therefore learn to work together and integrate conflicting legal mandates and management goals. An example of this, from the United States, is the National Research Council's *Mandate for Change* report (1990) that, to develop a new paradigm of forestry research, urged close collaboration between forest managers and forest-user groups. Another example is the remedial action plans for Great Lakes water management, where the need for interdisciplinary and intergovernmental participation, and for political and public support, was recognised (MacKenzie, 1993).

Ecosystem management demands that land management agencies change the way in which they operate. This may be done by forming interagency committees or changing profession norms and altering power relationships. There is little doubt that the collaborative decision-making called for by ecosystem management is likely to require extensive revision of traditional management practices and institutions (Cortner and Moote, 1994). Adaptability and flexibility by all parties are the twin keys to success in ecosystem management.

HUMAN CONCERNS

Humans in nature

Ecosystem management accepts that people are part of Nature. Humans exert a profound influence on ecological patterns and processes, and in turn ecological patterns and process affect humans. The connection between the two is largely uncharted territory: interactions between ecosystems and social systems require far more research (Gerlach and Bengston, 1992). However, policies are tending to move away from the 'administrator-as-neutralexpert' approach to policies that engender public deliberation and the discovery of shared values (Reich, 1985). Naturally, such extension of ecological matters to the social and political arena presents difficulties, though these may not be insuperable (e.g. Irland, 1994).

Human values

Ecosystem management accepts that human values must play a leading role in policy decision-making. Conservation strategies must take account of human needs and aspirations (Le Roux, 1993); and they must integrate ecosystem, economic and social needs (Kaufmann *et al.*, 1994). The key players in ecosystem management are scientists, policy-makers, managers and the public. The public, many of whom have a keen interest in environmental matters, are becoming more involved in ecosystem management as professionals recognise the legitimacy of claims that various groups make on natural resources (Cortner and Moote, 1994). In Jervis Bay, Australia, the marine ecosystem is used by many existing and proposed conflicting interests (national park, tourism, urbanisation, military training) (Ward and Jacoby, 1992). Similarly, in the forests of the south-western United States, ecosystem, economic and social needs are considered in policy decision-making concerning ecology-based, multiple-use forest management (Kaufmann *et al.*, 1994) (Figure 0.1).

The human dimension of ecosystem management is encompassed by the notion of sustainable development. This urges that diverse, functioning ecosystems should be preserved without damaging the economy; and that economies and human welfare need preserving as much as the integrity of ecosystems (Gerlach and Bengston, 1992). Integrating human and biophysical factors is a daunting task. Humans interact with Nature through culture, often in symbolic ways that are not comprehended by biological or physical ecosystem models (Gerlach and Bengston, 1992). In other words, humans can generate wants and capabilities of meeting these wants that lie outside the natural ecological order. This is often difficult for scientists to understand, and leads to their focusing on environmental protection and restoration, rather

A definition
A dynamic process in which a co-ordinated strategy is developed and implemented for the allocation of environmental, socio-cultural and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone (CAMPNET, 1989).

ICZM aims to:	promote sustainable use; balance demand for coastal zone resources; resolve conflicts of use; promote environmentally sensitive use of the coastal zone; promote strategic planning for coasts.
ICZM recognises:	the 'coastal zone' as a unit for planning purposes; that planning and management of coastal land and waters cannot be dealt with separately; the coastal zone as an area that

Figure 0.1 The integration of ecological, economic and social needs in a decision-analysis model

Economic and social needs are tested against an 'ecological filter', which is shown in the shaded box. The aim is to determine economic and social actions that will produce the most desirable balance between biological integrity and ecological, economic and social sustainability. Bowing fully to economic and social needs would lead to species loss and environmental degradation. Bowing fully to ecological needs would lead to social unrest and economic instability. A compromise position allows the maintenance of biological integrity while catering for economic and social needs. The resulting decision model leads to the implementation of an environmental policy. The effects of the policy are carefully monitored and evaluated. If the policy should fail to work as desired, then amendments can be made and the process started anew, until a satisfactory outcome is achieved.

Source: After Kaufmann *et al.*, 1994:11.

than facing the greater challenge of understanding social and cultural interactions with the biophysical world. The very idea of sustainability itself is a curious human construct. Laudable though the idea of sustainability might be, there are problems with it, not the least of which is the lack of a definition. It was originally taken to mean meeting the needs of the present generation without compromising the ability of future generations to satisfy their needs

(World Commission on Environment and Development, 1987), but at least eight interpretations are available (Gale and Cordray, 1991). It is therefore a buzzword that lacks bite. Another problem is its inadvertent arrogance—should the present generation be so presumptuous and foolhardy as to anticipate the needs of future generations? These pithy questions should not be ducked in ecosystem management initiatives.

This introduction has emphasised general philosophical principles and broad management practices connected with ecosystems and is meant to complement the individual chapters in the volume. These are more concerned with the importance of comprehending different natural ecosystems and processes as the only sound basis for making informed decisions about practice. It is only through understanding the complexity and inter-connectedness of the natural world that we may hope to avoid the mistakes of the past and make progress towards protecting the environment for future generations.

Of necessity, the volume adopts a fairly broadbrush approach. Myriad natural ecosystems exist at the micro-level but here it is the continental and even world scales that are emphasised. Hence, individual chapters deal with broad generic types—wetlands, uplands and mountain environments, savannas, river and inland water environments, tropical forest ecosystems, coastal environments and desertification. Although topics were selected for inclusion on the basis of the perceived threat posed by human activities it is recognised that the list is not comprehensive. For instance, high latitude ecosystems like the tundra and the unique environment of Antarctica are not covered, while the specific threats in temperate regions posed, for instance, by agriculture are included in Volumes 1 and 2. Each chapter follows a similar format; the general issues are first identified and then illustrated with material drawn from the individual experience of each author. Management strategies to combat environmental threats are described.

The treatment of natural ecosystems is complemented with a discussion of the human-created environments that exist as cities and rural areas. Cities generate complex energy and material flows with pollution of the air and water, land contamination and the creation of waste being the principal by-products. The traditional means of managing the environmental problems that arise in cities has been through planning regulations but it is now becoming clear that these are inadequate for the task and new approaches involving the concepts of healthy cities and sustainable communities must be seriously considered. Rural environments, by contrast, are different in being the partial creations of human activity and the question is one of finding a more harmonious, less exploitative accommodation with nature. This matter is explored via the interesting but little known case of Vietnam.

The concluding chapters deal with three specific examples of environmental management in human ecosystems. The first of these concerns our archaeological heritage. Although this should, of course, be studied and managed for its own sake, it is also becoming a matter of utilitarian significance in the sense that there may well be lessons to be learned from pre-industrial societies about sustainability, particularly sustainable agriculture. In the second example, a case is made for managing landscapes as a whole, whereby natural ecosystems are integrated with the cultural aspects of human society. The growing sophistication of information technology and the ability to manipulate large amounts of data, within a GIS for instance, now make this a feasible proposition. Lastly, given our concern about the natural environment, there may be a tendency to overlook the human ecosystems that are under pressure. These are discussed in the final chapter 'Disappearing human ecosystems'.

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1

COASTAL ENVIRONMENTS

Julian D.Orford

SUMMARY

The basic ecological principle embodied in the study of physical environment systems is that of continuity of energy and mass among constituent parts of the system. In a coastal context this principle is recognised in the sediment transport linkages that exist between coastal environments. Changes in beach sediment transport rate control the rate at which coasts may alter. The spatial control on sediment continuity defines the structure of coastal cells which offer the ecologically sustainable basis for coastal management programmes. Coastal erosion is only a problem where human activity impinges upon the normal erosional processes of coastal evolution. Coastal protection as a response to erosion is the historical basis for coastal management programmes and is still the mainstay of modern coastal zone management. Most human coastal intervention makes it difficult to base management approaches on ecological principles without considerable adaptation or cost. In this chapter some examples of management policies are examined for evidence of ecological principles at work. Not surprisingly, economic and cultural principles appear still to be the controlling aspects of coastal management policy.

ACADEMIC OBJECTIVES

This chapter focuses on the ecological principles of management of the physical development of coastal environments, since the ecological management of coastal biological realms has already received detailed attention elsewhere (Clarke, 1974; Carter, 1988).

On completion of this chapter you should be able to:

- recognise the nature and value of the ecological principles that are important to the dynamics and maintenance of physical coastal environments;
- understand how these ecological principles can be easily broken when humans intervene in coastal environments;
- observe how these principles conflict with the economic and cultural principles that structure human activities at the shoreline;
- understand how coastal managers find it difficult to integrate all of these principles into an effective management programme.

THE NEED FOR COASTAL ZONE MANAGEMENT (CZM)

There has been substantial concern expressed, action undertaken and money spent on issues related to the world's coastlines. One can legitimately question why coastal zone issues and their management have come to concern so many agencies. The management policy of the coastal zone is complex in that practitioners can hold a number of aims as their *raison d'être* (Barrett, 1989). Coastal management can be about (a) protecting man's investment at the terrestrial edge; (b) protecting a series of productive and diverse physical and biological domains worthy in their own right of being protected (conservation); and (c) integrating and adjusting competing demands on those domains (management of resources), Whatever the ethos of coastal management, it can be argued that it would be pointless to examine its nature without considering the role of people and their interaction with the natural systems of the coastal environment (Clark, 1978).

Historically, coastal erosion was, and is still, regarded as an affront to people's superiority over nature, such that losses must be resisted. However, there are other contemporary reasons for CZM. Coastlines' unique resources are coming under new competing pressures which can be loosely split into economic and cultural categories. Economic pressures relate to economic development that uses coasts and cannot be easily (i.e. cheaply) located elsewhere, for example, energy generation dependent on transoceanic sources of fuel. Cultural pressures involve elements of aesthetics and social choice, exemplified by recreation and retirement. These are usually issues of the advanced economically developed world, although a modern phase of coastal management requirement is being generated by the transplanting of recreation demands on to those less economically advanced countries that supply the 'S-requirements' of modern tourism (sun, sand and surf). All these pressures produced a further stimulus for late twentieth-century CZM, that of environmental concern about the coastal zone as a system of physical and biological domains threatened by economic and cultural forces, and in need of conservation for their value *per se* at the interface between land and ocean.

The increasing need for CZM also casts light on a different ethos, consensual rather than confrontational, by which coastal zone problems can be approached. This change, reflecting an ecological perspective on the understanding of coasts, is not a change due solely to the virtues of ecological thinking *per se*. Rather the change is due to the inability of most governments to meet the inexhaustible financial demands of an ever-increasing coastal protection problem (confrontational). Those countries that took centrally directed action over their coastline in the late nineteenth and early twentieth century (e.g. the UK) tended to be economically advanced with a history of coastal investment built on a technological and fiscal base sufficient to confront the perceived coastal protection requirements. However, at the turn of the twenty-first century, a crisis of ability is occurring in these countries, where technology and finances are proving uncertain in the face of continuing coastal pressures (e.g. the USA). Central governments are seeking new approaches to coastal management that will be low cost as well as cost-effective. Such low-cost measures shift the emphasis of people's response to coasts from protection to management, and to manage coasts effectively one has to achieve a better understanding of the processes and elements that define the coastal system.

THE BEACH AS A SYSTEM

Understanding the evolution and variation of beaches is the precursor to coastal management. The mobile nature of a beach acts as a buffer to breaking waves. Without a beach, waves erode land and property damage ensues. Coastal erosion is a natural part of coastal development; only when erosion affects human activity does coastal defence emerge as the central problem of coastal management.

Beaches are formed from material generally 0.1–1 mm in diameter. Sediment greater than 1 mm can form beaches that are known by the dominant particle size, for example, gravel, pebble, boulder. However, the 'protection' definition of a beach can be extended to any unconsolidated material found as an absorbing buffer to ocean forcing. The term 'forcing' covers the sea's power in terms of wave action and tidal action. The action of waves in developing a sand or gravel beach is more obvious than the action of tidally induced currents that can form an energy buffer through the deposition of very fine sediments which in the intertidal zone are often associated with salt-tolerant marsh vegetation. The coarser the natural beach sediment, the more exposed the beach is to wave energy. All sediment regardless of size has value as beach fill material, but coastal managers should remember that the equilibrium between erosion and beach stability is both sediment-size and energy-exposure dependent.

Beach retention should be a major goal of coastal management. In this respect any beach should be viewed as the central element of a coastal system. The keyword to describe beaches and their behaviour is 'continuity'. Continuity has temporal and spatial dimensions that are at the heart of management needs. Spatial continuity reflects the nature of a beach as a conveyor by which sediment is moved alongshore, onshore and offshore. The direction and rate of