Monitoring Ecological Change

The state of ecosystems, biological communities and species are continuously changing as a result of both natural processes and the activities of humans. To be able to detect and understand these changes, and the factors that influence them, it is essential to have effective ecological monitoring programmes. This book offers a thought-provoking introduction to the topic of ecological monitoring and provides both a rationale for monitoring and a practical guide to the techniques available. Written in a non-technical style, the book begins by considering the relevance and growth of ecological monitoring and the organizations and programmes involved. Coverage then moves to the science of ecological modelling, including such aspects as spatial scales, temporal scales, indicators and indices. The latter part of the book focuses on the assessment of methods in practice, including many examples from monitoring programmes around the world. Building on the success of the first edition, this new edition has been fully revised and updated with two additional chapters covering the relevance of monitoring to reporting the state of the environment, and the growth of community-based ecological monitoring.

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Second edition

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Foreword

Ten years ago, when I wrote the Foreword to the first edition of this book, monitoring of the environment was in a paradoxical state. On the one hand, it was an obvious necessity. On the other hand, monitoring all the species in an ecosystem is overwhelmingly demanding – especially since we have grounds for believing that only about a tenth of the species on Earth have been described by science. As I wrote then, in everyday life nobody would think of buying a car without speedometer, fuel gauge, temperature indicator and warning lights. Yet vastly more complicated environmental systems were being perturbed by human impact, and managed in what people hoped was the right way, with very little effective monitoring of how they were actually responding to our interference. Indeed, there was no agreement on what systems of monitoring were likely to be most effective – what warning lights should be fitted to the global juggernaut so that we could at least step on the brakes if it looked like running away. And – here lay the central paradox – while everyone saw that monitoring was essential, at the same time it was not highly regarded as a scientific activity. It appeared to lie a long way from the cutting edges of theoretical ecology and the unravelling of genomes.

The first edition of this book was very timely. It appeared a year before the unprecedented gathering of heads of state and government in Rio de Janeiro for the so-called 'Earth Summit' – the United Nations Conference on Environment and Development. That Conference adopted a massive action plan for global sustainable development – Agenda 21 – and also saw the signature of two global Conventions, on climate change and biodiversity. The impact of excessive combustion of fossil fuels on world climate was ringing alarm bells, and monitoring data, especially from Hawaii, which showed the steady increase in the concentration of carbon dioxide in the atmosphere, provided the evidence on which those concerns rested. The loss of rain forests across the tropics, again revealed by monitoring, was a major stimulus to the negotiation of the Convention on Biological diversity.

Since Rio, many countries have adopted biodiversity action plans. A number have also taken steps to evaluate what climate change may mean for their environment, agriculture, forests, wildlife and human lifestyles. Action against the environmental problems of previous decades – the pollution of air, waters, soil and sea and the wasteful degradation of natural resources – has continued. As Ian Spellerberg notes in the Preface to this second edition of his book, the result has been to swell the number of state of the environment reports, stimulate community-based environmental and ecological monitoring and tie monitoring closely to the need to meet the reporting requirements nations incur under international agreements and conventions. Several international organizations are publishing regular reports that purport to evaluate the overall state of the planet and the intensity of the human footprint. Many governments depend on national monitoring schemes to assess the efficacy of their laws, action programmes and enforcement measures. Systematic, dependable and coordinated monitoring has been recognized as an essential foundation for all these activities.

However, as I said in the Foreword to the first edition, it is easy to assert the need for systematic and well-designed monitoring, but much harder to do it. What should be monitored out of all the bewildering complexity of nature? It is not possible to measure everything: choice is imperative. Very often, that choice falls on physical attributes that are relatively easy to measure, such as temperature or the concentration of essential nutrients or pollutants. The result can all too easily be an impressive table of data whose biological meaning is obscure.

Biological monitoring starts at the other end. Its logic rests on the fact that living organisms integrate the impact of many variables and that their abundance, productivity and reproductive success can provide an indication of the overall health of the ecosystems of which they are part. Understanding of ecosystems can allow the choice of indicator species whose performance reflects that of the larger whole. Since we commonly manage the environment in order to sustain particular biological features – whether it be the production of crops, forests or fisheries or the diversity of wildlife – the direct surveillance of those biological parameters is likely to be the best way to establish whether management plans are working. The more we comprehend the system, the more effective we are likely to be in choosing the best things to record.

This book offers a practical approach to the evaluation of the state of ecosystems at local, national and global levels, and through them to an assessment of the viability of trends in human societies, economies and technologies. It provides both a rationale for biological monitoring and a guide to the techniques that are available and the parameters it makes best sense to monitor in particular situations.

There are no short-cuts in the sphere of environment, and biological monitoring is not a miraculous cure-all. Its results can be hard to interpret, because it can be a big step from observing change to understanding cause. However, biological changes are important indicators of the fundamental processes of our planet and can provide important warnings society needs to heed. The arguments and approaches set out in this book need to be taken very seriously, and used effectively, by those seeking to manage the environment. Good ecological monitoring can greatly increase the efficiency (and hence the cost effectiveness) of environmental management.

The monitoring of ecological change is directly relevant to fundamental decisions about the human future. With all our technological skills, we remain components of wider ecosystems and we depend totally on the biological productivity of the planet. As has been said many times, 'the world's economy is a wholly owned subsidiary of the world's ecology'. Today, 13 years after Rio's Earth Summit, and in the wake of its successor conference in Johannesburg, the emphasis at world level has shifted from protecting the environment to the alleviation of poverty and human suffering. Yet these social goals can only be achieved through sustainable development, which, in turn, can only be achieved if people live within the limits set by the environment and conserve the diversity and productivity of nature. The monitoring of ecological change remains fundamental, as a source of understanding of how well – or badly – we are doing in pursuing these fundamental and interlinked goals.

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Union for the Conservation of Nature and
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Preface

It is just over a decade since *Monitoring Ecological Change* was first published. During that time there have been a number of developments that have implications for ecological monitoring in theory and in practice. Three developments in particular stand out as being relevant to ecological monitoring. They are not new but there appears to have been a growth in activity of both. One is in the area of state of the environment reports; the second is in the area of community-based environmental and ecological monitoring; and, third, there is the extent of ecological and environmental monitoring that takes place because of international agreements and conventions.

The quality, health or state of the environment seems to be of increasing concern. Despite many effort over the last few decades to curb impacts on the environment, there seems little doubt that environmental degradation continues to get worse. Not surprisingly, many countries have published state of the environment reports and there has been much discussions about the nature and purpose of such reports. As well as national state of the environment reports, there has been a steady growth in the number of region reports that deal with environmental monitoring and environmental quality. Ecological monitoring has a role to play in these state of the environment reports.

Community-based environment monitoring has become widespread practice in many countries. In part, this has been the result of environmental organizations encouraging local communities to take a role in collection and analysis of environmental and ecological data. There also seems to have been considerable initiative on behalf of local communities to take ownership of monitoring programmes. Another contributing factor is the possibility that community-based environmental monitoring may be less expensive.

The 1992 Earth Summit gave rise to several products that in turn, have brought about demands on countries to monitor many environmental variables.

These range from carbon stocks to forest cover and the number of threatened species to levels of specific air pollutants. There has been a growth in international environmental and ecological reporting.

There have been other notable developments over the last 10 years. Long-term ecological monitoring sites have become firmly established along with an appropriate infrastructure to support such sites and networks of monitoring sites. The establishment of these sites has required the development and implantation of protocols and standards for monitoring.

Ecological monitoring and environmental monitoring appears more often in the curriculum and there are now many courses being offered in the area of assessment and monitoring. Interestingly, there has been a steep rise in the use of Environmental Change Network datasets in the UK by higher education. Furthermore, there seems to have been resurgence in the number of scientific meetings about ecological monitoring and long-term ecological research (although long-term ecological research is not necessarily ecological monitoring).

There have been many examples of the establishment of protocols for ecological monitoring. These include the adoption of standardized methods. In addition, objectives for ecological monitoring have often referred to the need to defend data scientifically and measure the effectiveness of the programmes.

Finally, there is no doubt that we live in a time of environmental change. That change is a combination of natural events and human intervention. It occurs at global, regional and local levels. The range of activities addressing the effects of that change is intriguing – from attempts to achieve international conventions about addressing the drivers of environmental change to investigations as to how climate change will affect private gardens. There is now no doubt that ecological monitoring has an ever increasing important role to play as we attempt to use nature in a sustainable and equitable manner in an ever-changing environment.

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Glossary of acronyms and abbreviations

ABC	abundance–biomass comparison
AFRC	UK Agriculture and Food Research Council
AMAP	Arctic Monitoring and Assessment Programme
ASPT	average score per taxon
BEWS	biological early warning system
BMWP	Biological Monitoring Working Party
BOD	biochemical oxygen demand
BRC	Biological Records Centre
BTO	British Trust for Ornithology
CALM	circumpolar active layer monitoring
CCAMLR	Convention for the Conservation of Antarctic Marine Living Resources
CCAS	Convention for Conservation of Antarctic Seals
CEH	Centre for Ecology and Hydrology
CEP	Committee for Environmental Protection (Antarctica)
CIS	Countryside Information System (software)
CITES	Convention on International Trade in Endangered Species
COMNAP	Council of Managers of National Antarctic Programmes
CORINE	Co-ordination of Information on the Environment
CRAMRA	Convention on Regulation of Antarctic Minerals Resource Activities
DDT	dichlorodiphenyltrichloroethane
DEFRA	Department for Environment, Food and Rural Affairs
EBCC	European Bird Census Council
ECE	Economic Commission for Europe
EcIA	ecological impact assessment

ECN	Environmental Change Network
EDU	Ecological Data Unit
EEC	European Economic Community
EIA	environmental impact assessment
EMAN	Environmental Monitoring and Assessment Network
EMAP	Environmental Monitoring and Assessment Programme
ENRICH	European Network for Research in Global Change
EPA	US Environment Protection Agency
EQI	environmental quality index
ESCAP	Economic and Social Commission for Asia and the Pacific
ESI	environmental sustainability index
EU	European Union
FAO	Food and Agriculture Organization of the UN
FATE	Feedback and Arctic Terrestrial Ecosystems
FOE	Friends of the Earth
FSC	Field Studies Council
GEMS	Global Environmental Monitoring System
GIS	geograptical information system
GMO	genetically modified organism
GPS	global positioning system
GRID	Global Resources Information Database
GTOS	global terrestrial observing system
IAIA	International Association for Impact Assessment
IASC	International Arctic Science Committee
IBAs	important bird areas
ICP	International Cooperative Programme
ICPB	International Council for Bird Preservation
ICSU	International Council of Scientific Unions
IEEP	Institute for European Environmental Policy
IGBP	International Geosphere–Biosphere Programme
ILO	International Labour Organization
ILTER	International Long-term Ecological Research
INFOTERRA	International Environmental Information Network
IOC	Intergovernmental Oceanographic Commission
ITEX	International Tundra Experiment
IUBS	International Union of Biological Sciences
IUCN	International Union for Conservation of Nature and Natural Resources
IUMS	International Union of Microbiological Sciences

IWC	International Whaling Commission
JNCC	Joint Nature Conservation Committee
LPI	living planet index
LTER	long-term ecological research
MAB	Man and the Biosphere (UNESCO)
MARC	Monitoring and Assessment Research Centre
MARMAP	marine monitoring and prediction
MCI	macro-invertebrate community index
MSC	Marine Stewardship Council
NBN	National Biodiversity Network
NC	Nature Conservancy
NCC	Nature Conservancy Council
NERC	UK Natural Environment Research Council
NGO	non-governmental organization
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NSN	National Science Network
OECD	Organisation for Economic Co-operation and Development
RBP	rapid bioassessment protocol
RIVPACS	River Invertebrate Prediction and Classification System
RSPB	Royal Society for the Protection of Birds
SCAR	Scientific Committee on Antarctic Research
SCEP	Study of Critical Environmental Problems
SCOPE	Special Committee on Problems of the Environment
SEA	strategic environmental assessment
SIGNAL	stream invertebrate grade number average
SMRU	Sea Mammal Research Unit
SoE	state of the environment
SPOT	Systeme Probatoire d'Observation de la Terre
TEMS	terrestrial ecological monitoring sites
TERI	Terrestrial Ecosystem Research Initiative
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Economic, Social and Cultural Organization
UNSO	United Nations Statistical Office
VPA	Virtual Population Analysis
WCED	World Commission on Environment and Development
WCMC	World Conservation Monitoring Centre

WGMS	World Glacier Monitoring Service
WHO	World Health Organization
WHYCOS	World Hydrological Cycle Observing Systems
WMO	World Meteorological Organization
WQI	water quality index
WRC	Water Research Council
WWF	Worldwide Fund for Nature