The SAGE Handbook of

Environmental Change

۲



5654-Matthews-Vol-II-FM.indd i

SAGE has been part of the global academic community since 1965, supporting high quality research and learning that transforms society and our understanding of individuals, groups, and cultures. SAGE is the independent, innovative, natural home for authors, editors and societies who share our commitment and passion for the social sciences.

۲

Find out more at: www.sagepublications.com



۲

The SAGE Handbook of Environmental Change

۲



Edited by

۲

John A. Matthews, Editor-in-Chief Patrick J. Bartlein, Associate Editor Keith R. Briffa, Associate Editor Alastair G. Dawson, Associate Editor Anne De Vernal, Associate Editor Tim Denham, Associate Editor Sherilyn C. Fritz, Associate Editor Frank Oldfield, Associate Editor



Los Angeles | London | New Delhi Singapore | Washington DC

۲

Chapter 1 and Editorial Arrangement © John A. Matthews, Patrick J. Bartlein, Professor Keith R. Briffa, Alastair G. Dawson, Anne De Vernal, Tim Denham, Sherilyn C. Fritz, Frank Oldfield 2012 Chapter 2 © Stephan Harrison 2012 Chapter 3 © Keith Alverson 2012 Chapter 4 © Frank M. Chambers 2012 Chapter 5 © Mike Walker 2012 Chapter 6 © Reto Knutti 2012 Chapter 7 © John A. Dearing 2012 Chapter 8 © Jane Francis, Alan Haywood, Daniel Hill, Paul Markwick and Claire McDonald 2012 Chapter 9 © Ian D. Goodwin and William R. Howard 2012 Chapter 10 © Shawn Marshall 2012 Chapter 11 © Wim Z. Hoek 2012 Chapter 12 © Alison J. Smith 2012 Chapter 13 © Joseph A. Mason 2012 Chapter 14 © Tim Denham 2012 Chapter 15 © Eugene R. Wahl and David Frank 2012 Chapter 16. © Cary J. Mock 2012 Chapter 17 © Paul Bishop 2012 Chapter 18 © Elisabetta Pierazzo and H. Jay Melosh 2012 Chapter 19 © André Berger 2012 Chapter 20 © Siwan M. Davies and Anders Svensson 2012 Chapter 21 © Raimund Muscheler and Erich Fischer 2012 Chapter 22 © Mathias Vuille and René D. Garreaud 2012 Chapter 23 © Thomas F. Pedersen and Rainer Zahn 2012

Chapter 25 © Sietse O. Los and Jamie Williams 2012 Chapter 26 © Craig Miller and Iain Gordon 2012 Chapter 27 © Richard W. Battarbee, Helen Bennion, Peter Gell and Neil Rose 2012 Chapter 28 © Ben Daley 2012 Chapter 29 © Kevin J. Noone 2012 Chapter 30 © Mark B. Bush and William D. Gosling 2012 Chapter 31 © Xiaoping Yang 2012 Chapter 32 © Miryam Bar-Matthews 2012 Chapter 33 © Matt McGlone, Jamie Wood and Patrick J. Bartlein 2012 Chapter 34 © Pavel E. Tarasov, John W. Williams, Jed O. Kaplan, Hermann Österle, Tatiana V. Kuznetsova and Mayke Wagner 2012 Chapter 35 © Marianne S.V. Douglas 2012 Chapter 36 © Martin Beniston 2012 Chapter 37 © Patrick Nunn 2012 Chapter 38 © Simon P. E. Blockley, Ian Candy and Stella M. Blockley 2012 Chapter 39 © Deborah M. Pearsall and Peter W. Stahl 2012 Chapter 40 © Georgina Endfield 2012 Chapter 41 © Donald R. Nelson 2012 Chapter 42 © Matthew Baylis and Andrew P. Morse 2012 Chapter 43 © Katie Moon and Chris Cocklin 2012 Chapter 44 © Chris J. Barrow 2012

Chapter 24 © Jemma L. Gornall, Andrew J. Wiltshire and Richard A. Betts 2012

First published 2012

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the Copyright, Designs and Patents Act, 1988, this publication may be reproduced, stored or transmitted in any form, or by any means, only with the prior permission in writing of the publishers, or in the case of reprographic reproduction, in accordance with the terms of licences issued by the Copyright Licensing Agency. Enquiries concerning reproduction outside those terms should be sent to the publishers.

SAGE Publications Ltd 1 Oliver's Yard 55 City Road London EC1Y 1SP

۲

SAGE Publications Inc. 2455 Teller Road Thousand Oaks, California 91320

SAGE Publications India Pvt Ltd B 1/I 1 Mohan Cooperative Industrial Area Mathura Road, Post Bag 7 New Delhi 110 044

SAGE Publications Asia-Pacific Pte Ltd 33 Pekin Street #02-01 Far East Square Singapore 048763

Library of Congress Control Number: 2011923232

British Library Cataloguing in Publication data

A catalogue record for this book is available from the British Library

ISBN 978-0-85702-360-5

Typeset by Cenveo Publisher Services Printed in India at Replika Press Pvt Ltd Printed on paper from sustainable resources

Contents

VOLUME 2 HUMAN IMPACTS AND RESPONSES

۲

List of Figures List of Tables		ix xiii	
SEC	TION IV HUMAN-INDUCED ENVIRONMENTAL CHANGES AND THEIR IMPACTS ON GEO-ECOSYSTEMS	1	
25	Monitoring Global Land Cover Sietse O. Los and Jamie Williams	3	
26	Human Impacts on Terrestrial Biota and Ecosystems Craig Miller and Iain Gordon	25	
27	Human Impacts on Lacustrine Ecosystems Richard W. Battarbee, Helen Bennion, Peter Gell and Neil Rose	47	
28	Human Impacts on Coastal and Marine Geo-Ecosystems Ben Daley	71	
29	Human Impacts on the Atmosphere Kevin J. Noone	95	
SEC	TION V PATTERNS, PROCESSES AND IMPACTS OF ENVIRONMENTAL CHANGE AT THE REGIONAL SCALE	111	
30	Environmental Change in the Humid Tropics and Monsoonal Regions Mark B. Bush and William D. Gosling	113	
31	Environmental Change in the Arid and Semi-Arid Regions <i>Xiaoping Yang</i>	141	
32	Environmental Change in the Mediterranean Region Miryam Bar-Matthews	163	

۲

CONTENTS

33	Environmental Change in the Temperate Forested Regions Matt McGlone, Jamie Wood and Patrick J. Bartlein	188
34	Environmental Change in the Temperate Grasslands and Steppe Pavel E. Tarasov, John W. Williams, Jed O. Kaplan, Hermann Österle, Tatiana V. Kuznetsova and Mayke Wagner	215
35	Environmental Change in the Arctic and Antarctic Marianne S. V. Douglas	245
36	Environmental Change in Mountain Regions Martin Beniston	262
37	Environmental Change in Coastal Areas and Islands Patrick Nunn	282
SEC	TION VI PAST, PRESENT AND FUTURE RESPONSES OF PEOPLE TO ENVIRONMENTAL CHANGE	299
38	Testing the Role of Climate Change in Human Evolution Simon P. E. Blockley, Ian Candy and Stella M. Blockley	301
39	The Origins and Spread of Early Agriculture and Domestication: Environmental and Cultural Considerations Deborah M. Pearsall and Peter W. Stahl	328
40	Complexity, Causality and Collapse: Social Discontinuity in History and Prehistory <i>Georgina Endfield</i>	355
41	Vulnerabilities and the Resilience of Contemporary Societies to Environmental Change Donald R. Nelson	374
42	Disease, Human and Animal Health and Environmental Change Matthew Baylis and Andrew P. Morse	387
43	Policy and Management Options for the Mitigation of Environmental Change <i>Katie Moon and Chris Cocklin</i>	406
44	Socioeconomic Adaptation to Environmental Change: Towards Sustainable Development <i>Chris J. Barrow</i>	426
	Index	447

vi

CONTENTS

۲

VOLUME 1 APPROACHES, EVIDENCE AND CAUSES

List List Note	of Figures of Tables s on Contributors	ix xv xvii
Intro	duction	
1	Background to the Science of Environmental Change John A. Matthews, Patrick J. Bartlein, Keith R. Briffa, Alastair G. Dawson, Anne De Vernal, Tim Denham, Sherilyn C. Fritz and Frank Oldfield	1
SEC	TION I APPROACHES TO UNDERSTANDING ENVIRONMENTAL CHANGE	35
2	Philosophical and Methodological Perspectives on the Science of Environmental Change Stephan Harrison	37
3	Direct Observation and Monitoring of Climate and Related Environmental Change <i>Keith Alverson</i>	53
4	Reconstructing and Inferring Past Environmental Change Frank M. Chambers	67
5	Dating Environmental Change and Constructing Chronologies Mike Walker	92
6	Modelling Environmental Change and Developing Future Projections <i>Reto Knutti</i>	116
7	Approaches to Understanding Long-term Human–Environment Interactions: Past, Present and Future John A. Dearing	134
SEC	TION II EVIDENCE OF ENVIRONMENTAL CHANGE AND THE GEO-ECOLOGICAL RESPONSE	163
8	Environmental Change in the Geological Record Jane Francis, Alan M. Haywood, Daniel Hill, Paul Markwick and Claire McDonald	165
9	Evidence of Environmental Change from the Marine Realm Ian D. Goodwin and William R. Howard	181
10	Evidence of Environmental Change from the Cryosphere Shawn Marshall	211

۲

CONTENTS

11	Evidence of Environmental Change from Terrestrial Palaeohydrology Wim Z. Hoek	239
12	Evidence of Environmental Change from Terrestrial and Freshwater Palaeoecology Alison J. Smith	254
13	Evidence of Environmental Change from Aeolian and Hillslope Sediments and Other Terrestrial Sources Joseph A. Mason	284
14	Environmental Change and Archaeological Evidence <i>Tim Denham</i>	305
15	Evidence of Environmental Change from Annually Resolved Proxies with Particular Reference to Dendrochronology and the Last Millennium <i>Eugene R. Wahl and David Frank</i>	320
16	Early-Instrumental and Documentary Evidence of Environmental Change Cary J. Mock	345
SEC	CTION III CAUSES, MECHANISMS AND DYNAMICS OF ENVIRONMENTAL CHANGE	361
17	Plate Tectonics, Continental Drift, Vulcanism and Mountain Building <i>Paul Bishop</i>	363
18	Extraterrestrial Causes of Environmental Catastrophes Elisabetta Pierazzo and H. Jay Melosh	384
19	Astronomical Theory and Orbital Forcing André Berger and Qiuzhen Yin	405
20	Millennial-Scale Climatic Events During the Last Glacial Episode Siwan M. Davies and Anders Svensson	426
21	Solar and Volcanic Forcing of Decadal- to Millennial-scale Climatic Variations <i>Raimund Muscheler and Erich Fischer</i>	444
22	Ocean–Atmosphere Interactions on Interannual to Decadal Time Scales Mathias Vuille and René D. Garreaud	471
23	Responses of Biogeochemical Cycles in the Sea to Environmental Change Thomas F. Pedersen and Rainer Zahn	497
24	Anthropogenic Drivers of Environmental Change Jemma L. Gornall, Andrew J. Wiltshire and Richard A. Betts	517
	Index	537

viii

List of Figures

	(* colour figures)	
25.1	Comparison of global albedo derived from the Matthews and	
	Wilson-Henderson-Sellers land-cover classifications	7
25.2*	Mean monthly NDVI for December and June	9
25.3*	Deviations in NDVI from the mean Austral summer NDVI (DJF) during	
	warm El Niño Southern Oscillation (ENSO) events (1982, 1986, 1987	
	and 1997)	10
25.4*	(a) Landsat TM subscene of an area in Rondonia, Brazil in 1986. (b) Mean	
	annual NDVI for the region with 200–400 mm mean annual rainfall	18
26.1	(a) The estimated proportion of all genera extinct at the boundary of the	
	five big extinction periods. (b) The extinction intensity of marine mammals	28
26.2	(a) The saline and arid landscape of Mingin County, China.	
	(b) A farmer confronting salinisation, New South Wales, Australia	30
26.3	Introduced brushtail possum (<i>Trichosurus vulpecula</i>) and ship rat (<i>Rattus rattus</i>)	
	eating song thrush nestlings (<i>Turdus philomelos</i> – also introduced)	31
26.4	Conceptual stock-and-flow model depicting a three-level predator-prey system	38
26.5	Graphical representation of the behaviour of the predator–prey system model	39
27.1	Summary diatom diagram of Lake of Menteith	51
27.2	Comparison of pH reconstruction outputs and annual measured pH	55
27.3	Declining representation of thalassic diatoms in the Ramsar wetlands	
	on the lower River Murray	60
27.4	Temporal trends of Pb and Hg concentrations, and ΣDDT and $\Sigma PBDE$ fluxes	
	from the sediment record of Lochnagar, Scotland	63
28.1	Dugongs caught in Hervey Bay, Queensland, Australia, c. 1937	77
28.2	Corals taken from the Great Barrier Reef, Australia, c. 1940	80
29.1	Monthly mean CO ₂ concentration measured at Mauna Loa observatory	
	in Hawaii, USA	98
29.2	Mauna Loa CO ₂ data together with data from Lüthi, D. et al. (2008)	
	EPICA Dome C Ice Core 800 ka carbon dioxide data	99
29.3	Mean ozone levels at Halley station for the months of February and October	100
29.4	Ozone concentrations above the NOAA South Pole station for 22 August	
	and 25 October in 2008	101
29.5*	Spatial distributions of (a) NO ₂ , (b) non-sea-salt sulfate, (c) methane and	
	(d) carbon dioxide	103
29.6*	Annual average pH of rainwater at the global scale	105
30.1	(a) Exposed continental area during the Last Glacial Maximum.	
	(b) Eustatic sea-level change during the transition from glacial to	
	interglacial conditions	116

۲

۲

10/13/2011 5:07:01 PM

LIST OF FIGURES

30.2	Tropical climate systems for: (a) January and (b) July	119
30.3	Block diagram showing inferred lake level in the southern hemisphere	
20.4	tropical Andes and western Amazonia	120
30.4	Early-Holocene antiphasing of selected paleoclimatic records	124
30.5	Farly-Holocene antiphasing of selected paleoclimatic records	124
50.5	from Africa and Asia	125
31.1	Global key regions of drylands and sayannas	143
31.2	On-site evidence of formerly wetter environments in the present-day	
	hyper-arid zones	144
31.3	Synthesis of late Quaternary palaeoclimatic changes in the	
	southwestern Kalahari, Namibia	145
31.4	Schematic picture of morphogenetic stories in northern (a) and	
	southern (b) Africa caused by regional climates	146
31.5	Alternating climatic conditions in the Kalahari and Sahara due to	1 4 7
21.6	Wetter elimete (recognized from locustring processes) in the Telelometer	147
51.0	Desert of China and colder times (recognized from permafrost processes)	140
317	Simplified history of pluvial Lake Mojave fluctuations and aeolian	149
51.7	denositional periods in the Mojave Desert	151
32.1*	Proxy records of the last two interglacial–glacial cycles	167
32.2	$\delta^{18}O_{G ruber}$ from marine cores (a) 9501 SE of Cyprus and (b) 9509 off the	
	Nile plum vs. age superimposed on Soreq Cave speleothems record	168
32.3	$\delta^{18}O_{G,ruber}$ of the last 250 ka from marine core MD84651	169
32.4	δ^{18} O record of Soreq Cave speleothems for the last 180 ka	170
32.5	Alkenones-based paleo SST from (a) various marine cores in the EM and	
	(b) speleothems-based paleotemperatures	171
32.6	Mid-Holocene cultural changes superimposed on the smooth curve of	1.5.5
22.1*	the δ^{15} C record of Soreq Cave speleothems	100
33.1 [*]	Megablomes	190
54.1	(a) The distribution of temperate and tropical grassiands. (b) Mean monthly values of precipitation and (c) mean monthly temperature	216
34.2	Reconstructed shifts in the prairie-forest ecotone during the Holocene	210
34.3	Selected time series of environmental indicators from the	223
0 110	grassland-dominated North American mid-continent	226
34.4	The major pollen types in the Late Glacial–Holocene records from the	
	northern Great Plains	228
34.5	Selected pollen types in the Late Glacial-Holocene records from the	
	grassland-dominated regions of East Europe	230
34.6	Selected Holocene palaeoclimate records from northern Eurasia	232
34.7	Changes in the total area of crop and pasture (a–c) and in the	
24.0	total area of natural grasslands (d–f) reconstructed for the three regions	235
34.8	Temperate grasslands and graminoid and forb tundra simulated by the	227
25 1	BIOWE4 model for four time slices	237
35.1	Polar projection showing various boundaries used to demarcate the Anteretic	247 249
36.1*	Mountains and unland regions	240
36.2*	Changes in the average mass balance of mountain glaciers of	205
-	different continents	266

х

۲

10/13/2011 5:07:01 PM

LIST OF FIGURES

36.3*	Snow-cover duration as a function of winter (DJF) minimum temperature and precipitation for two Swiss locations under current climate and for the	
27.1	last three decades of the twenty-first century (IPCC A2 emissions scenario)	273
37.1	(a) Late Quaternary sea-level changes. (b) Changes in the geography of southwest Pacific islands	284
37.2	Tossed as though it were a pebble, this giant piece of reefrock (named Kasakania) was thrown 30 m up onto the cliffton of	
	southern Okinawa Island. Janan	287
37 3	Examples of submarine landslides resulting from island-flank collapses	288
37.4	The coast of Niue Island (central Pacific Ocean) exhibits evidence for	200
57.1	recent unlift associated with movement up the flank of a lithospheric flexure	290
37 5	Eroding shoreline of Luamotu Island Funafuti Atoll Tuvalu	291
38.1	Key events in human evolution and dispersal over the last glacial cycle for	-/-
	Africa and Eurasia plotted against the NGRIP and GRIP ice core record	309
38.2	The middle to upper Palaeolithic transition in Europe plotted against the	
	NGRIP ice core record	322
39.1*	Phenotypes of some crops and their progenitors illustrating changes in	
	fruit form, seed dispersal, size, and plant architecture	330
39.2	Overview of the geography of plant domestication	332
39.3	The spread of the West Asian founder crops and sites discussed in the text	333
39.4	The spread of rice agriculture in East Asia and sites discussed in the text	336
39.5	The spread of maize and manioc in the Americas and sites	
	discussed in the text	340
40.1	Hypothetical relationships between climatic events, vulnerability and societal	
	adaptation or collapse	360
42.1	A schematic framework of the effects of climate change on diseases of	
	humans and animals	391
42.2	Projection of the effect of climate change on the future risk of transmission	
	of bluetongue in northern Europe	397
43.1	The four main interrelationships between mitigation and adaptation action	409
43.2	Estimated sectoral economic potential for global mitigation for different	
	regions as a function of carbon price in 2030 from bottom-up studies	419
44.1	Adaptation to environmental change and variability	427
44.2	Linkages for climate change policies responding to climate change and	
	seeking to support sustainable development	440
44.3	Different approaches to linking adaptation and development	441

5654-Matthews-Vol-II-FM.indd xi

xi



List of Tables

25.1	Confusion matrix for five most frequent classes in the Matthews (1983, 1984)	
	classification	6
25.2	Some commonly adopted classification schemes	14
25.3	Comparison of thematic agreement (in %) at nominal 0.5° resolution grid	
	of remotely sensed derived DISCover	15
28.1	Summary of human impacts on coastal and marine geo-ecosystems	72
29.1	Source strength, mass loading, lifetime and optical depth for five major	
	aerosol types	104
30.1	Palaeoenvironmental records	121
31.1	Arid and semi-arid areas of the world $(km^2 \times 10^6)$	142
33.1	Climatic descriptors for moist forest types	189
33.2	North America and Europe. Vegetation history from selected sites and regions	196
33.3	Asia and southern South America. Vegetation history from selected	
	sites and areas	197
33.4	Australasia. Vegetation history for selected sites and areas	198
33.5	Late Quaternary extinctions of megafauna from temperate regions	203
34.1	Linear trends of the annual temperature (TANN) and precipitation (PANN)	
	in the selected regions	223
34.2	Linear trends in northern hemisphere winter (December-February),	
	spring (March-May), summer (June-August) and autumn (September-November	r)
	temperature (°C) calculated in seven bioclimatic regions	235
34.3	Contribution of different seasons to the temperature rise between 1936 and	
	2007 in selected climatic regions	236
34.4	Area of temperate grassland simulated by the BIOME4 model for four time	
	slices in the Last Glacial and Holocene	236
38.1	General timeline of the main species in hominid evolution	304
41.1	Priorities for environmental change policy: Comparing	
	three response typologies	382
42.1	The major diseases transmitted by arthropod vectors to humans and livestock	393
43.1	Similarities and differences between mitigation and adaptation action	410
43.2	Summary of three decision-making cultures	414
43.3	Summary of key greenhouse gas mitigation policy instruments	415
43.4	Key mitigation technologies and practices by sector	418
44.1	Seven Asian rivers, which are highly dependent on glaciers/snowmelt	
	to maintain summer flows, with estimated basin populations	431
44.2	Some reasons for failure to adapt to environmental and other challenges	435

۲

۲

