

## GLOBAL RESOURCES AND THE ENVIRONMENT

In the past few decades, sustainability of natural resources and the social and environmental issues that surround them have become increasingly topical. This multidisciplinary book discusses the complex relationships between society, natural resources, and the environment. Major resources including water, agriculture, energy, minerals, and forests are considered, as well as different facets of the environment including climate, landforms, and biodiversity. Each resource is discussed in the context of both environmental and socioeconomic factors affecting their present and future distribution and demand. Presenting a balanced, comprehensive overview of the issues surrounding natural resources and sustainability, this accessible volume will be of interest to policymakers, resource managers, graduate students and researchers in the natural and social sciences.

CHADWICK DEARING OLIVER is the Pinchot Professor of Forestry and Environmental Studies and Director of the Global Institute of Sustainable Forestry at Yale. His research focuses on global issues of landscape management, and he has considerable experience advising public and private forest resource organizations in the United States and abroad. He is the senior author of the highly cited book, *Forest Stand Dynamics*, now in its second edition.

FATMA ARF OLIVER was a statistical consultant for the Boeing Company until her retirement in 2000. She is the author of a number of scientific and technical papers.

“Since the United Nations Conference on Environment and Development in Rio during 1992, international agencies, national governments, non-governmental organizations, academic institutions, the media, and the public have recognized the significance of the interactions between social, environmental, and economic needs and problems. Considerable research, development, and application have emerged but interdisciplinary approaches to problems have often been lacking. This book provides a comprehensive and integrative approach to the dynamics of natural resources, the concept of sustainability, the needs and impacts of humans, and the roles of climate and biodiversity. This substantial tome is a major contribution to broader understanding and cooperation, written by outstanding authors, and will be a fundamental resource for policy-makers, managers, and academics for many years.”

– *Professor Jeff Burley, Oxford Forestry Institute*

“In a world with increasing specialization and more well-articulated interest-groups than ever, the Olivers’ book provides the opposite of the mainstream and fragmented flows of news and information. An overview and key figures describing the main components of our global production and consumption of resources are presented, analyzed, and conclusions are drawn – not only to describe problems and challenges, but mainly to illuminate potentials and possible solutions to support a highly needed sustainable development of our world society and its expected 9 billion people by 2050. Suggestions for the reader: read it, learn from it, expand your knowledge, and continue to upgrade analytical skills using this important book as your solid platform.”

– *Professor Palle Madsen, Forest and Landscape College, IGN, University of Copenhagen*

“Chad and Fatma Oliver have written a magisterial work – fact-filled, comprehensive, and illuminating. I am in admiration of their accomplishment. There is nothing else like it, and it will fill a real need.”

– *James Gustave Speth, founder and former President of World Resources Institute, and former Dean of Yale School of Forestry and Environmental Sciences*

“*Global Resources and the Environment* is a labor of love and a wonderful achievement. It spans widely across the natural and the social sciences, as well as economics, synthesizing a huge amount of relevant literature for scientists, policymakers, and the general reader. It is also admirably positive, while clear-sighted, in its future predictions: there are still enough resources in the world, provided they are equitably distributed and managed with greater reverence and care. A wholly recommended tour de force.”

– *Edward Davey, Project Director, World Resources Institute*

“This book is an extremely helpful and timely contribution for the current or would-be professional at the international scale. It provides thorough information on the world and by region, and presents it using smart, easy-to-understand figures and graphs that synthesize a broad spectrum of knowledge. Using copious data analysis, this work carefully balances current theories and empirical lessons to propose doable actions and a promising future, but not without paying attention to dead ends and misconceptions.”

– *Dr. Gerardo Segura, Senior Natural Resources Management Specialist, World Bank*

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CHADWICK DEARING OLIVER

*Yale University*

and

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*Former engineer at the Boeing Company, Seattle*



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We dedicate this book to our children (\*) and their families:

\* Elif Kendirli

\* Doa Kendeerlee

\* Chadwick Cahit Oliver and Julie Hanrahan, and our grandchildren (\*\*)

\*\* Eli Thomas Oliver

\*\* Aisha Ann Oliver

\* Renin Hilary Oliver

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## Preface

People often feel anxious when advanced to a new job – when a politician moves to a higher office, a businessman takes on more responsibility, or an athlete turns professional. Over time, they learn to be more comfortable with their new situation and feel less overwhelmed.

The situation itself does not change. Rather, with more detailed knowledge, people learn to organize their tasks in context – what is likely to happen and what is not likely; what is important and needs tending and what is less urgent and can be delayed; and in what sequence things are expected to occur.

Many people are becoming anxious over the environmental situation because they are bombarded at a fast pace with a large number of individual facts and assertions but with little overarching context. The purpose of this book is to put the numerous aspects of the environment, resources, and people into perspective so that readers will feel less overwhelmed. The book is based on the premise that much in-depth knowledge can be presented simply, thoroughly, and succinctly. The intended audience for this book is advancing, mid-career professionals, policymakers, managers, academicians, and anyone else who works with or is interested in environmental/resource issues. Even those with a focus on one issue will benefit from a broader knowledge of the subject as a whole.

If people understand the present conditions, and likely (and unlikely) changes in the environment and resources, they can craft effective economic, social, business, and technical policies.

The book intends to educate the reader thoroughly but, more importantly, give him/her a perspective as knowledge changes. It is not intended for skim-reading. The chapters and sections are relatively independent and may be read selectively.

To the academician, the book complements the trend of increasing specialization. The emphasis on specialization is creating much new knowledge but there is a need to integrate and understand broad perspectives. The changes in a given resource are generally more affected by changes in other resources than by actions taken by specialists in the target resource.

A hope is that this book will be adopted for graduate courses. Students would need to take several courses to learn about the environmental and resource systems covered in this single volume; they would then have less time to take more courses in their chosen specialty.

The book is a monograph, not an edited collection of papers. Consequently, we have been forced to deepen our own understanding of each resource and how it interacts with the others and the environment. Economics is not discussed directly but we set the bounds of reasonable futures within which economic solutions can be constructed and debated.

The interactions among the environment, resources, and people are best understood from the perspective of complex, dynamic systems and sustainability, described in the first section of three brief chapters. Then nine sections follow, of two to four short chapters each, on people, major environmental systems, and major resources. The environmental systems are climates, landforms, and biodiversity. The resources are water, agriculture, energy, rocks/minerals, and forests. Except for water, aquatic systems are only minimally covered and oceanic resources are not covered at all. Soils are covered as part of landforms. Disturbances have been well studied recently, but are treated as one “change” that is part of dynamic systems – not as a separate subject.

The book’s figures provide more global information subdivided by world regions that cannot be completely covered in the text. These figures allow the reader to extend his/her understanding of specific regions beyond the text.

Resources and the environment are covered globally because both are global issues; what is done in one part of the world affects all others. Described first are the underlying scientific principles of each resource/environmental topic and what makes each important; then, how it is distributed globally and managed; and finally, what future scenarios and options exist for maintaining, changing, or mitigating it.

The book predicts neither a “gloom and doom” nor a “glowing” environmental/resource future. Our future depends partly on how we manage the present. The book promotes an informed dialogue about future directions for the world’s environment and resources. It is not a motivational book, but it does not shy away from pointing out obvious “dead ends” and possible actions when analyses lead to such insights.

The book is a result of our common global perspective. It was inspired and informed by the synergies of Chad’s practical experiences and knowledge of resources and Fatma’s analytical perspective and interest in systems theories. More than forty years ago we met and married when Chad was in graduate school at Yale University and Fatma was teaching mathematics at the University of New Haven. Our different backgrounds and perspectives – Chad from a small town in South Carolina, USA, and Fatma from Istanbul, Turkey – have stimulated fascinating discussions ever since. We both enjoy traveling and have done it extensively.

Our travels and discussions with local people have made this book better. As colleagues that we visited in other countries learned of our writing the book, they became excited, offering us various insights, informed discussions, and tours with local resource professionals. Beforehand, we would study the area and frame mentally the resources, environment, and people as a system. Subsequent observations and discussions on the visit would show discrepancies between our mental model and our hosts’, which led to fruitful discussions and learning. It soon became obvious that energy policies affected agriculture as much as agronomists; that the condition of forests was less impacted by forest managers



than by agriculture policies; and that water policies were affected strongly by agriculture, energy, and urbanization. Consequently, it became apparent that one needs to understand all resources to make informed decisions.

This book synthesizes existing knowledge, amalgamates different fields, and comes up with integrating observations. The world's information is now so vast, complicated, and rapidly changing that many things in this book will no doubt be out of date by the time it reaches print – just as many things changed while writing it. Since the book began about ten years ago, the calculated time of a previous Ice Age (not the present one) was changed by over 100 million years; and the time when North and South America joined has been adjusted by a few million years. A colleague at Yale who showed scientifically why Neanderthals could never breed with *Homo sapiens sapiens* has been proven wrong. Locations of different landforms are inconsistent among authorities. This is, and will be, the future of science: no person or generation has perfect knowledge. The future will be about learning details, synthesizing, comparing, measuring, and experimenting; forming thoughtful, flexible mental models; and continuing to learn from and adjust them.

We have tried to use the latest, most accurate data. Some things reported earlier have not been updated with new data. Some recent data have not been consistently posted. Sometimes, an analysis with new data would delay the book but would not show meaningful differences. Consequently, sometimes we show trends that are several years old. Copious online data sets were used. Some of the data is imperfect or incomplete; however, it is preferable to err by commission and use imperfect data rather than to err by omission, for two reasons:

- Out of respect for people who need to make decisions, we prefer to state an educated observation, rather than shy away on the basis of imperfect knowledge or data. Sometimes the data shortcomings are pointed out.
- Fatma's experience with data sets as an engineer has shown that the best way to improve data is to use it.

Hopefully, the reader will appreciate the dynamic nature of knowledge and use this book as a basis to adjust from, rather than as a static authority.

We also hope that environmental and resource knowledge will become more integrative and holistic. This book is designed to encourage that trend.

All units are metric.

## Acknowledgments

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Many others invited us to travel abroad in various capacities. They became interested and very helpful in regard to the global, integrating nature of the book and selflessly spent time with us to make it better. **Africa:** John Kakonga, UNDP; the Forest Service of Liberia; and Wangari Maathai, Kenya. **Alaska:** Bernard Bormann, University of Washington; and Robert Deal, USA Forest Service. **Armenia:** Jeff Masarjian, Armenia Tree Project; and Zack Parisa, SilviaTerra, LLC. **Australia:** Keith Jennings, retired forester, Brisbane; Chadwick C. Oliver, Melany, Queensland. **Bhutan:** Pema Gyametsho, Maungmoe Myint, Kinley Tshering, Younten Phuntsho, Ministry of Agriculture and Forests. **Brazil:** Daniel Piotta, Federal University of Southern Bahia. **Chile:** Christian Salas, University of Frontera, Temuco. **China:** Yaji Song, Yale University; Xuemei Han, Department of Management and Budget, Fairfax County, VA, USA; Jianping Ge, Rumei Xu, Qingxi Guo, Xiaojun Kou, Po Mu, Paul Mou, Tianming Wang, and Liming Feng, all at Beijing Normal University; Yu Tian, Chinese Research Academy of Environmental Sciences; Kezhen Guo, Ministry of Water Resources, Hahot; Shang Hua, Dalian University of Technology; Qingxi Guo, Northeast Forestry University; Ge Sun, Chinese Academy of Forestry; and Chun Fu, Nanchang University. **Ecuador:** Glenn Galloway, University of Florida. **Europe:** Dietlef Kraft, Prince of Thurn and Taxis Forests; Gabriella Nossowitz, formerly Freiburg University; Patrice Harou, University of Nancy. **India:** P. P. Bhojvaid and Mahabir Sharma, Indian Forest Service; Alark Saxena, Yale University; Rajendra Pachauri, TERI, New Delhi. **Japan:** Edwin Miyata, USA Forest Service; Takao Fujimori, Japan Forest Technology Society; Akira Osawa, Kyoto University. **Mexico:**

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Chad taught an international silviculture class at the University of Washington, where the students and professors gave him very helpful input.

At the Yale School of Forestry and Environmental Studies, Chad also taught a class with the same title as this book. Fatma sat in on the classes and researched specific subjects. The class gave many insights, data, ideas, and corrections that are in the book. Shilo Tilleman-Dick generated the idea for Tables 6.1 and 6.2 as a class project. He graciously allowed me to expand and modify it and use the result here. Maungmoe Myint offered many helpful suggestions. Jason Rauch gave insights into minerals. And Vaaruni Eashwar provided insights and information about organic farming.

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