Over the last three decades we have witnessed the environmental devasta-
tion caused by military conflict in the wake of the Vietnam War, the Gulf
War, and the Kosovo conflict. This book brings together leading interna-
tional lawyers, military officers, scientists, and economists to examine the
legal, political, economic, and scientific implications of wartime damage to
the natural environment and public health.

The book considers issues raised by the application of humanitarian
norms and legal rules designed to protect the environment, and the destruc-
tive nature of war. Contributors offer an analysis and critique of the existing
law of war framework, lessons from peacetime environmental law, means of
scientific assessment and economic valuation of ecological and public health
damage, and proposals for future legal and institutional developments.

This book provides a contemporary forum for interdisciplinary analysis
of armed conflict and the environment, and explores ways to prevent and
redress wartime environmental damage.

Jay E. Austin is Senior Attorney with the Environmental Law Institute,
Washington, D.C.

Carl E. Bruch is Staff Attorney with the Environmental Law Institute,
Washington, D.C.
Contents

List of illustrations page ix
List of tables xi
List of contributors xiii
Acknowledgements xvii
Foreword by Klaus Toepfer xix

Introduction 1

Jay E. Austin and Carl E. Bruch

Part I · General principles

Introduction 13
Carl E. Bruch

1. The environment in wartime: an overview 16
Christopher D. Stone

Part II · The legal framework

A · Existing and emerging wartime standards

Introduction 39
Carl E. Bruch

2. The law of war and environmental damage 47
Adam Roberts

3. War and the environment: fault lines in the prescriptive landscape 87
Michael N. Schmitt
## Contents

4. The inadequacy of the existing legal approach to environmental protection in wartime 137  
   **Richard Falk**

5. United States Navy development of operational–environmental doctrine 156  
   **Captain John P. Quinn, Captain Richard T. Evans, and LT. Commander Michael J. Boock**

6. In furtherance of environmental guidelines for armed forces during peace and war 171  
   **Arthur H. Westing**

B · Lessons from other legal regimes

Introduction 183  
   **Jay E. Austin**

7. Peacetime environmental law as a basis of state responsibility for environmental damage caused by war 190  
   **Silja Vöneky**

8. Environmental damages under the Law of the Sea Convention 226  
   **Thomas A. Mensah**

9. The place of the environment in international tribunals 250  
   **David D. Caron**

10. Civil liability for war-caused environmental damage: models from United States law 264  
    **Jeffrey G. Miller**

Part III · Assessing the impacts – scientific methods and issues

A · Ecological and natural resource impacts

Introduction 297  
   **Jessica D. Jacoby**

11. Scientific assessment of the long-term environmental consequences of war 303  
    **Asit K. Biswas**
12. The Gulf War impact on the terrestrial environment of
Kuwait: an overview 316
SAMIRA A. S. OMAR, ERNEST BRISKLEY, RAFAF M. MISAK, AND ADEL A. S. O. ASEM

13. War-related damage to the marine environment in the
ROPME Sea Area 338
MAHMOOD Y. ABDULRAHEEM

14. War and biodiversity: an assessment of impacts 353
JEFFREY A. MCNEELY

B · Public health impacts

Introduction 379
JESSICA D. JACOBY

15. Tracking the four horsemen: the public health approach
to the impact of war and war-induced environmental
destruction in the twentieth century 384
JENNIFER LEANING

ALASTAIR W. M. HAY

17. The impact of military preparedness and militarism
on health and the environment 426
VICTOR W. SIDEL

18. War and infectious diseases: international law and
the public health consequences of armed conflict 444
DAVID P. FIDLER

Part IV · Valuing the impacts – economic methods and issues

Introduction 469
ERIC FELDMAN

A · Ecological and natural resource damages

19. Restoration-based approaches to compensation for natural
resource damages: moving towards convergence in US and
international law 477
CAROL A. JONES
Contents

B · Public health damages

20. Valuing public health damages arising from war
   Mark Dickie and Shelby Gerking
   501

21. Valuing the health consequences of war
   W. Kip Viscusi
   530

Part V · Prospects for the future

Introduction
   Jay E. Austin
   559

22. Protecting specially important areas during international armed conflict: a critique of the IUCN Draft Convention on the Prohibition of Hostile Military Activities in Protected Areas
   Richard G. Tarasofsky
   567

23. The Chemical Weapons Convention: a verification and enforcement model for determining legal responsibility for environmental harm caused by war
   Barry Kellman
   579

24. International legal mechanisms for determining liability for environmental damage under international humanitarian law
   Jean-Marie Henckaerts
   602

25. Waging war against the world: the need to move from war crimes to environmental crimes
   Mark A. Drumbl
   620

Epilogue
   Carl E. Bruch and Jay E. Austin
   647

Index
   665

viii
## ILLUSTRATIONS

<table>
<thead>
<tr>
<th>Illustration</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>The operational continuum</td>
<td>163</td>
</tr>
<tr>
<td>5.2</td>
<td>The sliding scale theory</td>
<td>164</td>
</tr>
<tr>
<td>12.1</td>
<td>Satellite remote sensing applications in the state of Kuwait</td>
<td>318</td>
</tr>
<tr>
<td>12.2</td>
<td>Distribution density of the total number of bunkers, trenches, and weapons pits in selected areas of Kuwait</td>
<td>325</td>
</tr>
<tr>
<td>12.3</td>
<td>Migratory bird attracted by oil lake mistaken for water</td>
<td>327</td>
</tr>
<tr>
<td>12.4</td>
<td>Oil lakes mixed with rainwater after heavy rain showers in 1996</td>
<td>330</td>
</tr>
<tr>
<td>12.5</td>
<td>Some of the military damaged vehicles stacked in designated areas in the southwest and west of Kuwait</td>
<td>331</td>
</tr>
<tr>
<td>12.6</td>
<td>Juaidan farm devastated by the explosion of oil wells in the Burgan oilfield</td>
<td>332</td>
</tr>
<tr>
<td>13.1</td>
<td>Sediment types in the RSA</td>
<td>339</td>
</tr>
<tr>
<td>13.2</td>
<td>World’s major oil spills</td>
<td>342</td>
</tr>
<tr>
<td>13.3a</td>
<td>Levels of PHCs (ng/m³) in PM10 samples collected from Riqqa, Kuwait, 1991</td>
<td>344</td>
</tr>
<tr>
<td>13.3b</td>
<td>Benzo(a)pyrene levels (ng/m³) in particulate matter before and after the Gulf War</td>
<td>344</td>
</tr>
<tr>
<td>13.4</td>
<td>Total hydrocarbons measured simultaneously in Mansouria and Al-Zoor, August 3–4, 1991</td>
<td>345</td>
</tr>
<tr>
<td>13.5</td>
<td>Distribution of PHCs in sediments before and after the Gulf War</td>
<td>347</td>
</tr>
<tr>
<td>13.6</td>
<td>Distribution of PHCs (µg/g) in sediments after the Gulf War, showing breakdown into aliphatic and aromatic compounds</td>
<td>347</td>
</tr>
</tbody>
</table>
List of illustrations

13.7 Levels of metabolites of aromatic compounds (ng/g wet wt.) in bile samples of *Lethrinus kallopterus* species, RSA, 1992 348
13.8 Impacts of oil well fires on solar radiation in RSA 349
19.1 Relationship between primary restoration and interim lost value 481
19.2 Relationship between compensatory restoration and interim lost value 483
21.1 Market process for determining compensating differentials 538
21.2 The market offer curve and the worker’s expected utility locus 540
TABLES

12.1 Facts and figures: the consequences of war on the terrestrial environment of Kuwait 322–3

13.1 Concentrations of selected compounds (g/m³) of oil-well-fire plumes in Kuwait, 1991 343

14.1 Impacts of war on biodiversity 366

14.2 Transfrontier protected areas 377

16.1 Properties of 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin) and 2,4,5-T 404

16.2 Accidents in chemical plants involving the manufacture of chlorinated phenols 406–7

16.3 Soft tissue sarcoma and non-Hodgkin’s lymphoma in forestry workers 408

16.4 Industrial worker mortality and dioxin exposure 410

16.5 Birth defects/miscarriages/agriculture 411

16.6 Service in Vietnam and soft tissue sarcoma 413

16.7 Service in Vietnam and non-Hodgkin’s lymphoma 414

16.8 Birth defects in children of Vietnam veterans 415

16.9 Service in Vietnam: mortality and morbidity 417

16.10 Service in Vietnam and other cancers 419

16.11 Liver cancer and chronic liver disease in Vietnam veterans and the Vietnamese population 421

20.1 Monetized health effects associated with criteria air pollutants 525–6

20.2 Benefit estimates for reductions in morbidity resulting from changes in air quality (value of one-day reduction in symptoms) 527
List of tables

21.1 Summary of value of life estimates based on survey evidence 541
21.2 Summary of valuations of non-fatal health risks 543
21.3 Valuation of incremental risk reductions for household chemicals 551
21.4 Response to risk increases of 1/10,000 for pairs of product risks 552
List of contributors

Richard G. Tarasofsky
Barrister and Solicitor
Senior Associate
Ecologic – Centre for International and European Environmental Research

W. Kip Viscusi
Cogan Professor of Law and Economics
Director of the Program on Empirical Legal Studies
Harvard Law School

Silja Vöneky
Ph.D. (Law)
University of Heidelberg and the Max-Planck-Institute of Public International Law and Comparative Law

Arthur H. Westing
Westing Associates in Environment, Security, & Education

© Cambridge University Press
www.cambridge.org
ACKNOWLEDGEMENTS

This volume is the result of a two-year research project spearheaded by the Environmental Law Institute (ELI), in cooperation with the Smithsonian Institution and the Kuwait Foundation for the Advancement of Sciences. This effort culminated in the “First International Conference on Addressing Environmental Consequences of War: Legal, Economic, and Scientific Perspectives,” held at the Smithsonian grounds in Washington, D.C. in June 1998. Most of the essays published here originally were presented at that Conference; following the Conference, the contributors continued to research and update their material, in particular to take account of developments such as the NATO action in Kosovo. The editors’ gratitude goes first to these authors, who endured weeks of our editorial badgering and in response produced a number of truly outstanding, original contributions.

The editors also would like to acknowledge the assistance of the Conference’s Advisory Committee, which included honorary members Dr. Mostafa Tolba, Justice Christopher Weeramantry, and the late Admiral Elmo Russell Zumwalt, Jr.; working group members Dan Bodansky, Laurence Boisson de Chazournes, Michael Bothe, Richard Falk, Philippe Sands, Richard Tarasofsky, and Arthur Westing (Law and Policy); Asit Biswas, Joseph Brain, Sylvia Earle, Ruth Etzel, and Samira Omar (Science); and Carol Jones, Paul Portney, V. Kerry Smith, and Robert Stavins (Economics). Many of these scholars contributed to the present volume, and all were generous with their time and candid advice on how to think about and refine such an inherently broad and unruly topic.

Thanks also are due to the Conference Executive Committee, in particular Adel Asem, Hadi Abdal, Mahmood Abdulraheem, Karen Kerr, Irene Pereira, and Scott Schang, for their input and steady support; to I. Michael
Acknowledgements

Heyman, Secretary of the Smithsonian Institution, and his efficient and patient staff; and to Conference keynote speakers President Oscar Arias, President Mikhail Gorbachev, and Bobby Muller for lending their considerable reputations to inspire and publicize new work in this field. Finally, we would like to acknowledge our colleagues at ELI, especially Bill Futrell, Elissa Parker, Eric Feldman, Jessica Jacoby, and Steve Dujack, for their contributions and their willingness to devote substantial institutional resources to an atypical, but highly rewarding, project.
FOREWORD

In the last three decades of the twentieth century, the world community started focusing on global environmental challenges and the ways in which such challenges could be effectively addressed. The 1972 United Nations Conference on the Human Environment, which resulted in the establishment of the United Nations Environment Programme, and the 1992 United Nations Conference on Environment and Development were landmarks in setting the global agenda to protect the environment and pursue sustainable development. States and people have joined forces to tackle common environmental challenges such as: global climate change; loss of biological diversity; destruction of the ozone layer; desertification; and transboundary impacts of persistent toxic substances. Further globalization in the new century will accelerate trans-border cooperation in environmental and sustainable development issues, which, in any case, do not respect any boundaries.

These decades also witnessed devastating damage to people and the environment as a result of inter-state wars and armed civil conflicts. Defoliants were used in Southeast Asia as a means of war, causing long-term hazards to human health and the environment. In the Gulf, deliberate oil burning and discharge were used in hostilities, which seriously damaged the marine and coastal environment, caused transboundary air pollution and contaminated soil and groundwater. The human environment, people's livelihoods, was the target of aggression during conflicts in Kosovo. Armed conflicts in Afghanistan and West and Central Africa forced millions of people to become refugees, posing significant stress to the environment. Weapons of mass destruction – nuclear, chemical or
biological – could cause devastating environmental consequences and such weapons have continued to be in the arsenals of a number of states.

If we are to take the path towards sustainable development in the years to come, we must address the root causes that prevent us from achieving it. The ambivalence between increasing global environmental cooperation and intensified environmental damage associated with armed conflicts is one of the major points in that regard. In a wider context, the inter-linkages between environmental degradation and security require more attention. Environmental damage caused by war or by maintaining preparedness for war could be a factor for further instability and insecurity. From the environmental perspective, unsustainable patterns of consumption of raw materials, land or energy, unsustainable forms of development, or competition for the use of shared natural resources could threaten international peace and security. Consideration of such inter-linkages would require an holistic approach to target a range of key issues such as poverty, inadequate economic or development policies, injustice, and inequalities in multi-racial and multi-ethnic societies.

It is our responsibility to protect and enhance the environment, which enables people to enjoy a healthy and productive life in harmony with nature. As part of the process towards sustainable development, we need to consider issues associated with the environmental consequences of war, and identify realistic, innovative policy responses. A solution to this challenge will provide us with a key to the gate leading to a peaceful and sustainable world that we owe to future generations. The collection of articles in this book should enhance our understanding of the issues at stake, and are a valuable contribution to the discussion on the environmental consequences of war.

Klaus Toepfer
Executive Director
United Nations Environment Programme