

# Contents

Preface, ix

## Section I Climate Change – Past, Present, and Future, 1

### 1 Earth and the Greenhouse Effect, 3

*Introduction, 3*

*The Greenhouse Effect, 3*

*Large-Scale Heat Redistribution, 8*

*Greenhouse Gases, 11*

*Warming Potentials, 19*

*Summary, 20*

### 2 Past Climate Change: Lessons from History, 23

*Introduction, 23*

*Past Climate Change – Six Historic Periods, 24*

*Methods of Determining Past Climates and Ecosystems, 29*

*Rapid Climate Change, 34*

*Lessons of Past Climate Change, 35*

*Summary, 36*

### 3 Recent Climate Change: The Earth Responds, 39

*Introduction, 39*

*Atmospheric Temperatures, 40*

*Water Vapor and Precipitation, 43*

*Clouds and Temperature Ranges, 43*

*Ocean Circulation Patterns, 45*

*Snow and Ice, 46*

*Sea-Level Rise, 48*

*Animal Populations, 49*

*Vegetation, 50*

*Attribution, 51*

*Summary, 52*

### 4 Future Climate Change: The Twenty-First Century and Beyond, 55

*Introduction, 55*

*Global Climate Models, 56*

*Feedback Loops and Uncertainties*, 60  
*Scenario-Based Climate Predictions*, 67  
*Regional Climates and Extreme Events*, 70  
*The Persistence of a Warmer Earth*, 71  
*Summary*, 73

**Section II Ecological Effects of Climate Change, 75**

5 *Effects on Freshwater Systems*, 77  
*Introduction*, 77  
*Surface and Groundwater*, 78  
*Drought and Soil Moisture*, 86  
*Lake and Stream Biota*, 86  
*Human Infrastructure*, 89  
*Wetlands*, 89  
*The Cryosphere*, 89  
*Managing Water*, 93  
*Summary*, 95

6 *Effects on Terrestrial Ecosystems*, 99  
*Introduction*, 99  
*Geographic Shifts in Terrestrial Habitats*, 101  
*Vegetation–Climate Interactions*, 107  
*Effects of Disturbances*, 108  
*Loss of Biodiversity*, 109  
*Implications for Forest Management and Conservation Policy*, 112  
*Summary*, 114

7 *Climate Change and Agriculture*, 117  
*Introduction*, 117  
*Effects of Agriculture on Climate Change*, 118  
*Effects of Climate Change on Agriculture*, 120  
*US Agriculture*, 121  
*Global Agriculture*, 123  
*Summary*, 128

8 *Climate Change and the Marine Environment*, 131  
*Introduction*, 131  
*Sea-Level Rise*, 132  
*Ocean Currents and Circulation*, 135  
*Marine Biogeochemistry*, 138  
*Marine Ecosystems*, 140  
*Summary*, 148

**Section III Human Dimensions of Climate Change, 151****9 Impacts on Human Settlement and Infrastructure, 153***Introduction, 153**Energy, 154**Environmental Quality, 158**Extreme Climatic Events, 159**Human Settlements, 160**Infrastructure, 162**Summary, 167***10 Effects of Climate Change on Human Health, 171***Introduction, 171**Direct Effects of Heat Stress, 172**Infectious Diseases, 174**Air Quality, 179**Interactions and Secondary Effects, 181**Summary, 181***11 Mitigation: Reducing the Impacts, 187***Introduction, 187**Capture or Sequester Carbon Emissions, 187**Reduce Global Warming or Its Effects by Geoengineering, 188**Enhance Natural Carbon Sinks, 190**Convert to Carbon-Free and Renewable Energy Technologies, 191**Conserve Energy and Use It More Efficiently, 201**Adapt to Climate Change, 206**Taking Action, 206**Summary, 208***12 Policy, Politics, and Economics of Climate Change, 211***Introduction, 211**International Cooperation – From Montreal to Kyoto, 212**Meeting Kyoto Targets, 214**Post-Kyoto Developments, 217**The Politics of Climate Change, 220**Kyoto Without the United States, 221**Benefits and Costs of Mitigating Climate Change, 224**The Future – What is Needed?, 227**Summary, 227***Appendixes****A Units, 231****B Abbreviations and Chemical Symbols, 233**

C Websites on Climate Change, 235  
    *General*, 235  
    *Journal Articles and Literature on Climate Change*, 236  
    *Climate Change Education*, 236  
    *Websites by Chapter Subject Area*, 236  
    *Conservation and Environmental Action Groups*, 240  
    *Industry Groups*, 240

Index, 241