## Contents

### Part I  Ecological Settings

1  **Introduction**  .................................................................................................................. 3  
   A. Osawa and O.A. Zyryanova  
   1.1  Permafrost Forest Biome  .......................................................................................... 3  
   1.2  The Environment and Ecology  ..................................................................................... 5  
   1.3  Natural Regions of Siberia  ............................................................................................ 7  
   1.4  Main Region of Study  .................................................................................................. 8  
   1.5  Brief History of Investigation  ...................................................................................... 11  
   References  .......................................................................................................................... 13  

2  **Floristic Diversity and its Geographical Background in Central Siberia**  .................................. 17  
   O.A. Zyryanova, A.P. Abaimov, H. Daimaru, and Y. Matsuura  
   2.1  Introduction  .................................................................................................................. 17  
   2.2  Regional Landforms Near Tura, Central Siberia  ......................................................... 18  
     2.2.1  Geological Setting  .................................................................................................... 18  
     2.2.2  Slope Landforms  ...................................................................................................... 18  
     2.2.3  Fluvial Landforms  ................................................................................................... 24  
   2.3  Soils in Permafrost Region of Siberia  .......................................................................... 25  
     2.3.1  Permafrost Distribution in Siberia  ............................................................................. 25  
     2.3.2  Unique Soil Characteristics  ..................................................................................... 26  
     2.3.3  Revised Knowledge on the Circumpolar Biomes  ................................................. 27  
   2.4  Geographical Patterns of Floristic Diversity in Central Siberia  ................................. 27  
   2.5  Plant Species Diversity of Larch Association  .............................................................. 34  
     2.5.1  Description of Species Diversity  ............................................................................. 34  
     2.5.2  Observed Patterns and Interpretations  ................................................................. 34  
   2.6  Conclusions  ................................................................................................................. 36  
   References  .......................................................................................................................... 36
3 Geographical Distribution and Genetics of Siberian Larch Species ............................................................................. 41
A. P. Abaimov

3.1 Introduction ........................................................................................................ 41
3.2 Systematic Position and Present Status of Siberian Larch Species ......................... 42
3.3 Geographical Distribution of Siberian Larch Species ............................................. 45
3.3.1 Larix sibirica Ledeb. ...................................................................................... 45
3.3.2 Larix gmelinii (Rupr.) Rupr. ........................................................................... 47
3.3.3 Larix cajanderi Mayr. .................................................................................... 48
3.4 Morphological and Ecological Features of Siberian Larch Species ......................... 49
3.4.1 Larix sibirica Ledeb. ...................................................................................... 50
3.4.2 Larix gmelinii (Rupr.) Rupr. ........................................................................... 52
3.4.3 Larix cajanderi Mayr. .................................................................................... 54
3.5 Conclusions ........................................................................................................ 55
References ................................................................................................................... 55

4 Wildfire Ecology in Continuous Permafrost Zone .................................................. 59
M.A. Sofronov and A.V. Volokitina

4.1 Introduction ........................................................................................................ 59
4.2 Approaches to Study Wildfire Ecology ................................................................. 60
4.3 Vegetation Fuel .................................................................................................... 63
4.4 Seasonal Conditions of Fuel Moistening, Drying, and Burning ......................... 64
4.5 Wildfire Spread over the Territory ..................................................................... 65
4.6 Causes of Wildfire and Areas of Wildfire Occurrence ....................................... 66
4.7 Wildfire Impact on Larch Regeneration .............................................................. 67
4.8 Ecological Effects of Wildfires .......................................................................... 69
4.8.1 Soil Temperature ............................................................................................ 72
4.8.2 Summer Soil Thawing Depth ........................................................................ 72
4.8.3 Influence of Fires on Growth of Larch Trees ................................................. 77
4.9 Conclusions ........................................................................................................ 79
References ................................................................................................................... 80

5 Recovery of Forest Vegetation After Fire Disturbance ........................................ 83
O.A. Zyryanova, A.P. Abaimov, T.N. Bugaenko, and N.N. Bugaenko

5.1 Introduction ........................................................................................................ 83
5.2 Approaches to Study Vegetation Recovery ........................................................... 84
5.3 Patterns of Vegetation Development After Fire .................................................. 86
5.3.1 Sites with Complex Microtopography ........................................................... 86
5.3.2 Sites Without Microtopography .................................................................... 88
5.4 Conclusions ........................................................................................................ 93
References ................................................................................................................... 94
## Part II  Ecosystem Dynamics and Function

### 6  Biomass and Productivity of Siberian Larch Forest Ecosystems

T. Kajimoto, A. Osawa, V.A. Usoltsev, and A.P. Abaimov

- **6.1** Introduction .......................................................... 99
- **6.2** Data Source and Analysis ........................................... 100
  - **6.2.1** Study Site .......................................................... 100
  - **6.2.2** Estimation of Above- and Below-Ground Biomass ....... 103
  - **6.2.3** Estimation of Aboveground Net Primary Production .... 105
- **6.3** Biomass ........................................................................ 107
  - **6.3.1** Aboveground Biomass ......................................... 107
  - **6.3.2** Belowground Biomass .......................................... 112
- **6.4** Net Primary Production .............................................. 113
  - **6.4.1** Aboveground Production ....................................... 113
  - **6.4.2** Belowground Production ....................................... 116
- **6.5** Carbon Allocation Pattern .......................................... 117
- **6.6** Conclusions ........................................................... 119

### References ......................................................................... 120

### 7  Development of Stand Structure in Larch Forests

A. Osawa and T. Kajimoto

- **7.1** Introduction ........................................................... 123
- **7.2** Approaches to Describe Stand Development in Larch Forests ........................................................................ 124
  - **7.2.1** Study Site .......................................................... 124
  - **7.2.2** Measurement of Chronosequence Plots ................... 124
  - **7.2.3** Measurement of Additional Stands ......................... 126
  - **7.2.4** Yield-Density and Yield Table Data ....................... 126
  - **7.2.5** Reconstructing Past Stand Structure ..................... 127
- **7.3** Yield-Density Relationship ......................................... 128
- **7.4** Yield Table Data ...................................................... 131
- **7.5** Chronosequence Data ................................................. 132
- **7.6** Reconstructed Stand Structure in the Past .................... 133
  - **7.6.1** Height Growth ................................................... 134
  - **7.6.2** Tree Mortality .................................................... 135
  - **7.6.3** Reconstructed Stem Slenderness and Stand Density ... 136
  - **7.6.4** Reconstructed Stem Size Distribution ..................... 139
  - **7.6.5** Reconstructed Total Stem Volume and Stem Volume Growth ................................................................. 139
  - **7.6.6** Consideration on Accuracy of the Reconstruction Method ................................................................. 143
- **7.7** Conclusions ........................................................... 145

### References ......................................................................... 146
8 Soil Carbon and Nitrogen, and Characteristics of Soil Active Layer in Siberian Permafrost Region .............................................. 149
Y. Matsuura and M. Hirobe

8.1 Introduction ............................................................................................................. 149
8.2 Approaches to Describe Soil Properties .............................................................. 150
  8.2.1 Soil Carbon and Nitrogen Storage, and Carbon Budget ...................... 150
  8.2.2 Soil Properties Along a Toposequence ...................................................... 152
8.3 Soil Carbon and Nitrogen Storage ...................................................................... 153
  8.3.1 Carbon storage in Forest Ecosystems ......................................................... 153
  8.3.2 SOC Storage and C/N Ratio in Central and Northeastern Siberia .......... 154
8.4 Soil Properties Along a Toposequence in a Larch Forest ............................... 156
  8.4.1 Thickness of Soil Active Layer and Forest Floor, and Characteristics of Canopy Cover ......................................................... 156
  8.4.2 Soil Chemical Properties ............................................................................ 156
  8.4.3 Forest Structure and Soil Nutrient Properties ......................................... 158
8.5 Conclusions ........................................................................................................ 161
References .................................................................................................................. 161

9 Soil Respiration in Larch Forests ........................................................................ 165
T. Morishita, O.V. Masyagina, T. Koike, and Y. Matsuura

9.1 Introduction ............................................................................................................. 165
9.2 Approaches to Study Soil Respiration .............................................................. 166
  9.2.1 Study Site ..................................................................................................... 166
  9.2.2 Measurement of Soil Respiration ............................................................... 167
  9.2.3 CO₂ Analysis and Calculation of Soil Respiration Rate ......................... 168
  9.2.4 Climate Condition of the Measurement Period ........................................ 168
9.3 Soil Temperature, Moisture, and Respiration Rate ........................................ 168
9.4 Relationship Between Soil Respiration and Soil Temperature and Moisture ... 170
9.5 Seasonal Changes of Soil Respiration ............................................................... 171
9.6 Comparison of Soil Respiration in the Growing Season ............................... 172
9.7 Dynamics of Other Trace Gases in Larch Forests of Siberia ......................... 174
  9.7.1 Methane (CH₄) .......................................................................................... 174
  9.7.2 Nitrous Oxide (N₂O) .................................................................................. 175
9.8 Conclusions ........................................................................................................ 175
References .................................................................................................................. 179

10 Net Ecosystem Exchange of CO₂ in Permafrost Larch Ecosystems ..................... 183
Y. Nakai

10.1 Introduction ........................................................................................................... 183
10.2 Study Site for Micrometeorological Measurements ......................................... 184
## Contents

10.3 Meteorological Condition and Features of the Measurement Site. 190
10.4 Intensity and Seasonal Variations in Net Ecosystem Exchange and Larch Tree Phenology ........................................ 192
10.5 Conclusions............................................................................. 199
References.......................................................................................... 199

### 11 Behavior of Dissolved Organic Carbon in Larch Ecosystems 205
A.S. Prokushkin, S. Hobara, and S.G. Prokushkin

11.1 Introduction.................................................................................. 205
11.2 Approaches to Study Dissolved Organic Carbon ...................... 206
  11.2.1 Site Description...................................................................... 206
  11.2.2 Soil and Water Sampling and Analyses............................... 207
11.3 DOC Content and Release in Soils............................................. 210
  11.3.1 Soil Organic Matter Stocks and WEOC Content in Soils........ 210
  11.3.2 Soil DOC Concentrations and Fluxes.................................. 212
11.4 Export of Terrestrial DOC to Riverine System.......................... 218
  11.4.1 Seasonal Patterns of Riverine DOC Concentrations............. 218
  11.4.2 Implication for Global Change .......................................... 224
11.5 Conclusions................................................................................ 225
References.......................................................................................... 226

### 12 Soil Nitrogen Dynamics in Larch Ecosystem 229
N. Tokuchi, M. Hirobe, K. Kondo, H. Arai, S. Hobara,
K. Fukushima, and Y. Matsuura

12.1 Introduction.................................................................................. 229
12.2 Approaches to Examination of Soil Nitrogen Dynamics and Status................................................................. 230
  12.2.1 Study Sites ........................................................................... 230
  12.2.2 Soil N Mineralization, Leaching, and Status....................... 231
12.3 Soil Nitrogen Dynamics............................................................... 232
  12.3.1 Soil Inorganic N Pool ......................................................... 232
  12.3.2 Soil N Mineralization ............................................................ 234
  12.3.3 Controlling Factors on Soil N Dynamics............................ 235
  12.3.4 Inorganic N leaching in Soil................................................ 237
12.4 Soil Nitrogen Status in Larch Forest in Central Siberia.............. 237
  12.4.1 Available N ........................................................................ 237
  12.4.2 The Possibility of N Limitation of Larch Forest in Central Siberia................................................................. 237
  12.4.3 N Source of Larch Forest in Central Siberia Based on Isotopic signature ....................................................... 238
12.5 Conclusions................................................................................ 240
References.......................................................................................... 241
Contents

13 Hydrological Aspects in a Siberian Larch Forest ........................................... 245
T. Ohta

13.1 Introduction ........................................................................................................ 245
13.2 Approaches to Study Stand-scale Hydrological Characteristics in a Larch Forest of Northeastern Siberia .......... 246
13.2.1 Study Site for the Stand-scale Investigation ................................................. 246
13.2.2 Measurement of Meteorological and Environmental Variables ...................... 247
13.2.3 Measurement of Water Vapor and Energy Fluxes ........................................... 247
13.2.4 Evaluation of Hydrological Cycles in the Lena River Basin ............................. 248

13.3 Seasonal and Interannual Variation of Energy Partitioning above the Siberian Larch Forest ........................................... 248

13.4 Water Balance of One-dimensional Scale in the Siberian Larch Forest ......................................................... 251
13.4.1 Interannual Variation ..................................................................................... 251
13.4.2 Annual Evapotranspiration and Environmental Variables ............................... 255
13.4.3 Water and Energy Exchange Differences between Non-permafrost and Permafrost Areas of Siberia ......................................................... 257
13.4.4 Water and Energy Exchange in Different Environments and Climates .............. 258

13.5 Evaluation of Hydrological Aspects in Northeastern Siberia ................................ 263
13.6 Conclusions ........................................................................................................ 265
References ................................................................................................................. 266

Part III Tree Physiology and The Environment

14 Photosynthetic Characteristics of Trees and Shrubs Growing on the North- and South-Facing Slopes in Central Siberia ........................................................................................ 273
T. Koike, S. Mori, O.A. Zyryanova, T. Kajimoto, Y. Matsuura, and A.P. Abaimov

14.1 Introduction ........................................................................................................... 273
14.2 Study Site and Measurement of Foliar Ecophysiology .......................................... 274
14.3 Environmental Conditions .................................................................................... 275
14.4 Photosynthetic Production and Shoot Morphology ............................................. 276
14.5 Photosynthesis and Respiration of Trees and Shrubs ......................................... 277
14.5.1 Dominant Tree Species .................................................................................. 277
14.5.2 Nutrient Condition in Needles ....................................................................... 280
14.5.3 Shrubs ........................................................................................................... 280
14.6 Light-Photosynthetic Curves .............................................................................. 281
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>14.7 Chlorophyll Content</td>
<td>282</td>
</tr>
<tr>
<td>14.8 Future Vegetation</td>
<td>283</td>
</tr>
<tr>
<td>14.9 Conclusions</td>
<td>284</td>
</tr>
<tr>
<td>References</td>
<td>285</td>
</tr>
<tr>
<td>15 Respiration of Larch trees</td>
<td>289</td>
</tr>
<tr>
<td>S. Mori, S.G. Prokushkin, O.V. Masyagina, T. Ueda, A. Osawa, and T. Kajimoto</td>
<td></td>
</tr>
<tr>
<td>15.1 Introduction</td>
<td>289</td>
</tr>
<tr>
<td>15.2 Approaches and Measurement System</td>
<td>290</td>
</tr>
<tr>
<td>15.2.1 Study Site</td>
<td>290</td>
</tr>
<tr>
<td>15.2.2 Setting Whole-Plant Chamber</td>
<td>290</td>
</tr>
<tr>
<td>15.2.3 Closed Air-Circulation System</td>
<td>292</td>
</tr>
<tr>
<td>15.2.4 CO₂ Scrubber</td>
<td>293</td>
</tr>
<tr>
<td>15.2.5 Temperature Control</td>
<td>293</td>
</tr>
<tr>
<td>15.2.6 Measurement of Whole-Tree Respiration</td>
<td>293</td>
</tr>
<tr>
<td>15.3 System Response and Estimated Tree Respiration</td>
<td>294</td>
</tr>
<tr>
<td>15.3.1 Temperature Control of the System</td>
<td>294</td>
</tr>
<tr>
<td>15.3.2 Temperature Dependency of Whole-tree Respiration</td>
<td>294</td>
</tr>
<tr>
<td>15.3.3 Size Dependency of Whole-tree Respiration</td>
<td>296</td>
</tr>
<tr>
<td>15.3.4 Estimation of Stand-Level Aboveground Respiration</td>
<td>297</td>
</tr>
<tr>
<td>15.4 Evaluation of Measurement System</td>
<td>297</td>
</tr>
<tr>
<td>15.5 Aboveground Respiration and Production</td>
<td>298</td>
</tr>
<tr>
<td>15.6 Conclusions</td>
<td>299</td>
</tr>
<tr>
<td>References</td>
<td>300</td>
</tr>
<tr>
<td>16 Root System Development of Larch Trees Growing on Siberian Permafrost</td>
<td>303</td>
</tr>
<tr>
<td>T. Kajimoto</td>
<td></td>
</tr>
<tr>
<td>16.1 Introduction</td>
<td>303</td>
</tr>
<tr>
<td>16.2 Data Source</td>
<td>304</td>
</tr>
<tr>
<td>16.2.1 Study Site</td>
<td>304</td>
</tr>
<tr>
<td>16.2.2 Methods of Root System Excavation and Measurements</td>
<td>305</td>
</tr>
<tr>
<td>16.2.3 Parameters of Above- and Below-Ground Space Occupation</td>
<td>306</td>
</tr>
<tr>
<td>16.2.4 Growth Pattern Analysis</td>
<td>308</td>
</tr>
<tr>
<td>16.3 Spatial Pattern of Individual Root System</td>
<td>308</td>
</tr>
<tr>
<td>16.4 Effects of Microscale Soil Condition on Root Distribution</td>
<td>309</td>
</tr>
<tr>
<td>16.4.1 Topography and Soil Temperature</td>
<td>309</td>
</tr>
<tr>
<td>16.4.2 Topography and Soil Water</td>
<td>314</td>
</tr>
</tbody>
</table>
16.5 Temporal Pattern of Root System Development ........................................ 315
  16.5.1 Replacement of Root System .......................................................... 315
  16.5.2 Growth Rate and Pattern of Lateral Root ....................................... 317
16.6 Below-ground Space Occupation by Root System .................................. 321
  16.6.1 Relationship Between Root System and Crown ............................. 321
  16.6.2 Stand-Level Root Network .............................................................. 323
16.7 Linkage with Postfire Permafrost Soil Environment ............................... 323
16.8 Below-ground Competitive Interactions .............................................. 325
16.9 Conclusions ...................................................................................... 326
References ................................................................................................. 327

17 Seasonal Changes in Stem Radial Growth of *Larix gmelinii* in Central Siberia in Relation to its Climatic Responses ................................. 331
K. Yasue, J. Kujansuu, T. Kajimoto, Y. Nakai, T. Koike, A.P. Abaimov, and Y. Matsuura

17.1 Introduction ....................................................................................... 331
17.2 Approaches to Study Growth Phenology and Tree-Ring Responses to Climate ................................................................. 332
  17.2.1 Study Sites ..................................................................................... 332
  17.2.2 Observations of Snow Melting, Needle Phenology, and Seasonal Radial Growth ............................................................... 333
  17.2.3 Analysis of Climatic Response of Radial Growth ......................... 334
17.3 Seasonal Changes in Snow Melting, Needle Phenology, and Radial Growth .................................................................................. 337
17.4 Climatic Responses of Radial Growth ............................................... 338
17.5 Conclusions ...................................................................................... 343
References ................................................................................................. 344

18 Dendrochronology of Larch Trees Growing on Siberian Permafrost ............ 347
E.A. Vaganov and A.V. Kirdyanov

18.1 Introduction ....................................................................................... 347
18.2 Experimental Background .................................................................. 348
18.3 Relationships of Tree-Ring Parameters Obtained for Larch Dendrochronological Network ................................................................. 352
18.4 Effects of Climatic Factors on Radial Growth of Larch Trees ................ 354
18.5 Reconstruction of Summer Temperature Based on Regional Chronologies ................................................................. 357
18.6 Effect of Ground Fires on Radial Tree Growth .................................... 357
18.7 Features of Tree-Ring Growth on Siberian Permafrost ......................... 359
18.8 Conclusions ...................................................................................... 360
References ................................................................................................. 361
Part IV  Ecosystem Comparisons and Responses to Climate Change

19  Characteristics of Larch Forests in Daxingan Mountains, Northeast China ................................................................. 367
    F. Shi, K. Sasa, and T. Koike

19.1  Introduction ........................................................................ 367
19.2  Approaches to Study Biomass, Net Primary Production, and Regeneration ................................................................. 368
19.2.1  Study Sites .................................................................... 368
19.2.2  Estimation of Biomass and Net Primary Productivity ..... 370
19.2.3  Examination of Postfire Forest Dynamics ..................... 371
19.3  Biomass, Productivity, and Stand Density ......................... 371
19.3.1  Biomass and Aboveground Net Primary Productivity in Different Climatic Zones ............................................. 371
19.3.2  Aboveground Biomass and Aboveground Net Primary Productivity in Different Forest Types ......................... 372
19.3.3  Tree Density, Aboveground Biomass, and Aboveground Productivity in Relation to Forest Age .................... 373
19.3.4  Aboveground Biomass and Aboveground Net Primary Productivity of Larch Plantation .......................... 373
19.4  Regeneration of Larch-Dominant Forests after Forest Fires ..... 378
19.5  Synthesis ........................................................................... 379
19.6  Conclusions ........................................................................... 381
References .................................................................................... 381

20  Carbon Dynamics of Larch Plantations in Northeastern China and Japan ................................................................. 385
    M. Jomura, W.J. Wang, O.V. Masyagina, S. Homma, Y. Kanazawa, Y.G. Zu, and T. Koike

20.1  Introduction ........................................................................ 385
20.2  Site Descriptions .................................................................. 386
20.3  Biomass and Net Primary Production .................................. 389
20.3.1  Estimation Procedures .................................................. 389
20.3.2  Biomass, Allocation, and Net primary production .......... 393
20.4  Photosynthesis and Autotrophic Respiration ....................... 397
20.4.1  Data Source .................................................................. 397
20.4.2  Leaf Photosynthesis ...................................................... 397
20.4.3  Cone Photosynthesis ..................................................... 399
20.4.4  Stem Respiration ........................................................... 401
20.4.5  Soil Respiration ............................................................. 401
20.5  Soil Respiration and Environment ....................................... 402
20.5.1  Enriched CO2 experiment ................................................ 402
20.5.2  Effects of CO2 ............................................................... 402
20.5.3  Effects of Plantation Management ................................. 404
## 21 The Role of Ectomycorrhiza in Boreal Forest Ecosystem

L. Qu, K. Makoto, D.S. Choi, A.M. Quoreshi, and T. Koike

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>21.1 Introduction</td>
<td>413</td>
</tr>
<tr>
<td>21.2 Physiology of Ectomycorrhizal Plants</td>
<td>414</td>
</tr>
<tr>
<td>21.3 Ectomycorrhizae in Boreal Forests</td>
<td>415</td>
</tr>
<tr>
<td>21.4 Carbon Flux in Ectomycorrhizal Plants</td>
<td>415</td>
</tr>
<tr>
<td>21.5 Ectomycorrhizae in Permafrost Soils, and after Forest Fires</td>
<td>417</td>
</tr>
<tr>
<td>21.5.1 Ectomycorrhiza in Permafrost Soils</td>
<td>417</td>
</tr>
<tr>
<td>21.5.2 Forest Fires and Ectomycorrhizae</td>
<td>419</td>
</tr>
<tr>
<td>21.6 Ectomycorrhizae and Elevated Atmosphere CO₂</td>
<td>420</td>
</tr>
<tr>
<td>21.7 Conclusions</td>
<td>421</td>
</tr>
</tbody>
</table>

## 22 From Vegetation Zones to Climatypes: Effects of Climate Warming on Siberian Ecosystems

N.M. Tchebakova, G.E. Rehfeldt, and E.I. Parfenova

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>22.1 Introduction</td>
<td>427</td>
</tr>
<tr>
<td>22.2 Background</td>
<td>428</td>
</tr>
<tr>
<td>22.2.1 Study Area</td>
<td>428</td>
</tr>
<tr>
<td>22.2.2 Mapping Current and Future Climates</td>
<td>428</td>
</tr>
<tr>
<td>22.2.3 Permafrost</td>
<td>429</td>
</tr>
<tr>
<td>22.2.4 Vegetation Zones</td>
<td>429</td>
</tr>
<tr>
<td>22.2.5 Major Forest-Forming Tree Species of Siberia</td>
<td>431</td>
</tr>
<tr>
<td>22.2.6 Distributions of <em>Pinus sylvestris</em> and <em>Larix</em> Species</td>
<td>431</td>
</tr>
<tr>
<td>22.2.7 Mapping Climatypes of <em>Pinus sylvestris</em> and <em>Larix</em> Species</td>
<td>432</td>
</tr>
<tr>
<td>22.3 Effects of Global Warming on Vegetation Shifts</td>
<td>433</td>
</tr>
<tr>
<td>22.4 Effects of Global Warming on Species Distributions</td>
<td>435</td>
</tr>
<tr>
<td>22.5 Effects of Global Warming on Number, Size, and Distribution of Climatypes</td>
<td>438</td>
</tr>
<tr>
<td>22.5.1 <em>Pinus sylvestris</em></td>
<td>438</td>
</tr>
<tr>
<td>22.5.2 <em>Larix sibirica</em></td>
<td>440</td>
</tr>
<tr>
<td>22.5.3 <em>Larix dahurica</em></td>
<td>440</td>
</tr>
<tr>
<td>22.5.4 <em>Larix sukaczewii</em></td>
<td>440</td>
</tr>
<tr>
<td>22.6 Synthesis</td>
<td>441</td>
</tr>
<tr>
<td>22.7 Conclusions</td>
<td>444</td>
</tr>
</tbody>
</table>

References                                                               | 444  |
23 Effects of Elevated CO$_2$ on Ecophysiological Responses of Larch Species Native to Northeast Eurasia ................................................. 447
  T. Koike, K. Yazaki, N. Eguchi, S. Kitaoka, and R. Funada

  23.1 Introduction .................................................................................... 447
  23.2 Growth Characteristics of Larch Species ........................................ 448
  23.3 Photosynthetic Adjustment at Elevated [CO$_2$] ............................... 448
  23.4 Nitrogen and Water Use Efficiency ..................................................... 450
  23.5 Xylem Formation ............................................................................ 451
  23.6 Rehabilitation with Larch Species ..................................................... 451
  23.7 Conclusions .................................................................................... 454

  References ............................................................................................... 454

Part V Synthesis and Conclusion

24 Characteristics of Permafrost Forests in Siberia and Potential Responses to Warming Climate ......................................................... 459
  A. Osawa, Y. Matsuura, and T. Kajimoto

  24.1 Introduction .................................................................................... 459
  24.2 Characteristics of Permafrost Forests in Siberia .................................. 460
    24.2.1 Forest Fire and Dynamics of Ecosystem Development ......... 460
    24.2.2 Ecosystem Carbon Budget ......................................................... 461
    24.2.3 Comparison to Permafrost Forests of North America ......... 464
  24.3 Potential Responses to Warming Climate ......................................... 467
    24.3.1 Ecosystem Structure ................................................................. 467
    24.3.2 Ecosystem Development ......................................................... 472
    24.3.3 Ecosystem Function ................................................................. 474
  24.4 Conclusions .................................................................................... 477

  References ............................................................................................... 478

  Color Plates ............................................................................................. 483

  Illustration and Table Credits ............................................................... 491

  Species Index .......................................................................................... 495

  Subject Index .......................................................................................... 497
Permafrost Ecosystems
Siberian Larch Forests
Osawa, A.; Zyryanova, O.A.; Matsuura, Y.; Kajimoto, T.;
Wein, R.W. (Eds.)
2010, XXVI, 502 p. 10 illus. in color., Hardcover
ISBN: 978-1-4020-9692-1