### Contents

<table>
<thead>
<tr>
<th>Contributors</th>
<th>Preface</th>
<th>Acknowledgments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>xiii</td>
<td>xvii</td>
</tr>
<tr>
<td></td>
<td></td>
<td>xxi</td>
</tr>
</tbody>
</table>

#### 1 Disturbance and Succession
*Edward A. Johnson and Kiyoko Miyanishi*

<table>
<thead>
<tr>
<th>Introduction</th>
<th>Disturbance as the Nemesis of Succession</th>
<th>The Chronosequence Basis of Succession</th>
<th>Coupling Disturbance and Vegetation Processes</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>10</td>
</tr>
</tbody>
</table>

#### 2 The Turbulent Wind in Plant and Forest Canopies
*John J. Finnigan*

<table>
<thead>
<tr>
<th>Introduction</th>
<th>The Structure of the Atmospheric Boundary Layer</th>
<th>Characteristics of Turbulent Flow In and Above Plant Canopies</th>
<th>Effects of Topography and Heterogeneity</th>
<th>Implications of This Velocity Structure for Canopy Disturbance</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>17</td>
<td>22</td>
<td>36</td>
<td>49</td>
<td>54</td>
</tr>
</tbody>
</table>
### 3 Microbursts and Macrobursts: Windstorms and Blowdowns

*Mark R. Hjelmfelt*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>59</td>
</tr>
<tr>
<td>Convective Storms and Downbursts</td>
<td>60</td>
</tr>
<tr>
<td>Vertical Equation of Motion</td>
<td>68</td>
</tr>
<tr>
<td>Climatology</td>
<td>71</td>
</tr>
<tr>
<td>Downdrafts, Mesocyclones, and Outflows</td>
<td>75</td>
</tr>
<tr>
<td>Microbursts</td>
<td>80</td>
</tr>
<tr>
<td>Large-Scale Systems</td>
<td>87</td>
</tr>
<tr>
<td>Summary</td>
<td>95</td>
</tr>
</tbody>
</table>

### 4 Understanding How the Interaction of Wind and Trees Results in Windthrow, Stem Breakage, and Canopy Gap Formation

*Christopher P. Quine and Barry A. Gardiner*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>103</td>
</tr>
<tr>
<td>Theoretical Core</td>
<td>107</td>
</tr>
<tr>
<td>Applied Force</td>
<td>110</td>
</tr>
<tr>
<td>Resistive Force</td>
<td>123</td>
</tr>
<tr>
<td>Direct Consequences</td>
<td>128</td>
</tr>
<tr>
<td>Subsequent Impact of Windthrow, Stem Breakage, and Gap/Patch Formation</td>
<td>137</td>
</tr>
<tr>
<td>Summary and Conclusions</td>
<td>141</td>
</tr>
<tr>
<td>Appendix 1: Glossary and Definitions</td>
<td>153</td>
</tr>
</tbody>
</table>

### 5 Meteorological Conditions Associated with Ice Storm Damage to Forests

*Kaz Higuchi and Amir Shabbar*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>157</td>
</tr>
<tr>
<td>Synoptic Conditions for Freezing Rain</td>
<td>158</td>
</tr>
<tr>
<td>Climatology of Freezing Rain in Canada</td>
<td>167</td>
</tr>
<tr>
<td>Meteorological Evolution of Ice Storm '98</td>
<td>169</td>
</tr>
<tr>
<td>Possible Changes in Ice Storm Frequency Under a Warming Climate</td>
<td>176</td>
</tr>
<tr>
<td>Summary</td>
<td>177</td>
</tr>
</tbody>
</table>

### 6 The Effect of Icing Events on the Death and Regeneration of North American Trees

*David F. Greene, Kathleen F. Jones, and Olga J. Proulx*

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>181</td>
</tr>
<tr>
<td>The Biomechanics of Branch Breakage During Ice Events With and Without Wind</td>
<td>185</td>
</tr>
</tbody>
</table>
Ice Measurements in the Field 200
A Review of the Literature on Tree Damage Caused By Icing Events 201
The Population Consequences of Major Ice Events 206

7 Disturbance Processes and Dynamics in Coastal Dunes 215
Patrick A. Hesp and M. Luisa Martínez
Introduction 215
Dune Types and Disturbance Types and Processes 216
Conclusion 240

8 Coastal Dune Succession and the Reality of Dune Processes 249
Kiyoko Miyanishi and Edward A. Johnson
Introduction 249
Traditional Dune Succession Hypothesis 252
Problems with the Dune Succession Hypothesis 255
Process-Response Alternative to Traditional Succession Hypothesis 261
Conclusion 273

9 Fluvial Geomorphic Disturbances and Life History Traits of Riparian Tree Species 283
Futoshi Nakamura and Satomi Inahara
Introduction 283
Geomorphic Classification of Riparian Zones and Disturbance Regimes in a Catchment 286
Disturbance, Reliability of Regeneration Habitat, and Life History of Dominant Tree Species 290
Conclusion 304

10 Water Level Changes in Ponds and Lakes: The Hydrological Processes 311
Masaki Hayashi and Garth van der Kamp
Introduction 311
Water Balance 312
Case Study: Northern Prairie Wetlands 329
Conclusions 334
11 Development of Post-Disturbance Vegetation in Prairie Wetlands
Arnold G. van der Valk
Introduction 341
Wet-Dry Cycles 344
Marsh Ecology Research Program 345
Coenocline Development: Same Pre- and Post-Disturbance Water Levels 348
Coenocline Development: Different Pre- and Post-Disturbance Water Levels 357
Models of Coenocline Development 362
Conclusions 366

12 Modeling Heating Effects
Geoffry N. Mercer and Rodney O. Weber
Introduction 371
Conservation Laws 372
Simple Examples 373
Application to More Realistic Scenarios 382
Case Study: A Model of Seed Survival 387
Conclusion 392
Appendix: Notation 393

13 Fire Effects on Grasslands
Paul H. Zedler
Introduction 397
The Grass Growth Form 399
Regeneration from Seed 403
Grasses as Fuel, Mulch, and Forage 405
Drought Disturbance: A Primary Driver 413
Direct Fire Effects 415
Grassfire and Nutrients 424
Grasses and Woody Plants 425
A Final Caution—Grasses and Fires 430

14 Wildfire and Tree Population Processes
Sheri L. Gutsell and Edward A. Johnson
Introduction 441
Wildfire Processes and Characteristics 443
Local Populations and Processes 455
Regional Populations and Processes 471
Conclusions 477
15 Insect Defoliators as Periodic Disturbances in Northern Forest Ecosystems

Barry J. Cooke, Vincent G. Nealis, and Jacques Régnière

Introduction 487
Defoliating Insects as a Distinct Class of Forest Disturbance 491
The Process of Insect Disturbance 495
Population Dynamics of Foliage-Grazers 502
Conclusion 518

16 Dynamics of Mountain Pine Beetle Outbreaks

Justin Heavilin, James Powell, and Jesse A. Logan

Introduction 527
Derivation of the Red Top Model 531
Results of the Fully Developed Model 547
Discussion and Conclusion 550

17 Relationship Between Spruce Budworm Outbreaks and Forest Dynamics in Eastern North America

Hubert Morin, Yves Jardon, and Réjean Gagnon

Introduction 555
History of Spruce Budworm Outbreaks Over the Past 8600 Years 559
Variation in Temporal and Spatial Dynamics of Outbreaks: Reflection of Changes in Forest Structure 564

18 Impact of Beaver (Castor canadensis Kuhl) Foraging on Species Composition of Boreal Forests

Noble T. Donkor

Introduction 579
Herbivory in Boreal Forests 581
Temporal Changes in Beaver Populations 582
Traditional Understanding of Beaver Foraging Impact on Plant Community Structure 585
Understanding Beaver Foraging Impacts on Composition and Dynamics of the Boreal Forest 588
Conclusion 597
19 Beaver, Willow Shrubs, and Floods
J. Dungan Smith

Introduction 603
Background 607
Theory for Interaction of Flow and Shrubs 622
Model Results 638
Discussion 648
Summary and Conclusions 667

Index 673