CONTENTS

PREFACE

Introduction ......................................................... xv

PART I. Cork Oak Trees and Woodlands .......................... 7

1. The Tree ..................................................... 11
   Juli G. Pausas, João S. Pereira, and James Aronson
   Biogeography .................................................. 12
   Flowers and Fruits: The Ecological Role of Acorns ....... 15
   Cork Harvest: Nature’s Gift and Weakened Trees? ....... 16
   Surviving Fire: The Ecological Role of Cork .............. 17
   Framework Tree of Natural Ecosystems and Cultural Derivatives ........... 20
   Site Profile 1.1: Akfadou, Algeria ......................... 22
   Mahand Messaoudène and Hachemi Merouani .................

2. Origin and Genetic Variability ............................... 25
   Roselyne Lumaret, Unai López de Heredia, and Alvaro Soto
   Variation and Introgression .................................. 25
   Origins and Migration Routes ................................ 28
   Unresolved Questions ......................................... 30
   Implications for Conservation of Cork Oak Genetic Resources ........... 31

3. Open Woodlands: A Diversity of Uses (and Overuses) .... 33
   Miguel Bugalho, Tobias Plieninger, James Aronson, Mohammed Ellatifi, and David Gomes Crespo
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>A System with Different Names</td>
<td>34</td>
</tr>
<tr>
<td>One System, Multiple Land Uses</td>
<td>36</td>
</tr>
<tr>
<td>Recent Trends of Transformation and Degradation</td>
<td>40</td>
</tr>
<tr>
<td>Conclusions</td>
<td>44</td>
</tr>
<tr>
<td>Site Profile 3.1: Aguelmous, Morocco</td>
<td>46</td>
</tr>
<tr>
<td><em>Mohammed Ellatifi</em></td>
<td></td>
</tr>
<tr>
<td>4. Historical Perspective of <em>Montados</em>: The Example of Évora</td>
<td>49</td>
</tr>
<tr>
<td><em>Teresa Pinto-Correia and Ana Margarida Fonseca</em></td>
<td></td>
</tr>
<tr>
<td>Land Use before the Fifteenth Century</td>
<td>49</td>
</tr>
<tr>
<td>Land Use between the Fifteenth and the Eighteenth Centuries</td>
<td>52</td>
</tr>
<tr>
<td>Land Use in the Eighteenth and Nineteenth Centuries:</td>
<td>53</td>
</tr>
<tr>
<td>Emergence of the <em>Montado</em></td>
<td></td>
</tr>
<tr>
<td>Conclusions</td>
<td>55</td>
</tr>
<tr>
<td>Site Profile 4.1: Machuqueira do Grou, Portugal</td>
<td>57</td>
</tr>
<tr>
<td><em>Nuno de Almeida Ribeiro</em></td>
<td></td>
</tr>
<tr>
<td>5. Cork Bottle Stoppers and Other Cork Products</td>
<td>59</td>
</tr>
<tr>
<td><em>Américo M. S. Carvalho Mendes and José A. R. Graça</em></td>
<td></td>
</tr>
<tr>
<td>Cork as an Industrial Material</td>
<td>59</td>
</tr>
<tr>
<td>Economic History of the Cork Sector</td>
<td>63</td>
</tr>
<tr>
<td>Conclusions</td>
<td>68</td>
</tr>
<tr>
<td><strong>PART II. Scientific Bases for Restoration and Management</strong></td>
<td>71</td>
</tr>
<tr>
<td>6. Coping with Drought</td>
<td>73</td>
</tr>
<tr>
<td><em>João S. Pereira, Cathy Kurz-Besson, and M. Manuela Chaves</em></td>
<td></td>
</tr>
<tr>
<td>The Limits of Survival</td>
<td>74</td>
</tr>
<tr>
<td>Water Deficits and Growth</td>
<td>78</td>
</tr>
<tr>
<td>Water Deficits and Cork Stripping</td>
<td>79</td>
</tr>
<tr>
<td>Conclusions</td>
<td>80</td>
</tr>
<tr>
<td>7. Mycorrhizal Symbiosis and Its Role in Seedling Response to Drought</td>
<td>81</td>
</tr>
<tr>
<td><em>Daniel Mousain, Hassan Boukeim, and Franck Richard</em></td>
<td></td>
</tr>
<tr>
<td>Mycorrhizal Symbiosis Diversity in Mediterranean Oaks</td>
<td>81</td>
</tr>
<tr>
<td>The Role of Mycorrhizal Symbiosis in Drought</td>
<td></td>
</tr>
<tr>
<td>Tolerance of Trees</td>
<td>83</td>
</tr>
<tr>
<td>Cork Oak Response to Drought and ECMs</td>
<td>84</td>
</tr>
<tr>
<td>Conclusions</td>
<td>87</td>
</tr>
<tr>
<td>8. Soil Properties Constraining Cork Oak Distribution</td>
<td>89</td>
</tr>
<tr>
<td><em>Isabel Serrasolse, Marian Pérez-Devesa, Alberto Vilagrosa, Juli G. Pausas, Teresa Sauras, Jordi Cortina, and V. Ramon Vallejo</em></td>
<td></td>
</tr>
</tbody>
</table>
Soil Characteristics 90
Cork Oak on Soils Developed over Carbonate Rocks: 94
The Case of Pinet
Cork Oak Establishment in Contrasted Soils: 95
A Lysimeter Experiment
Conclusions 97
Site Profile 8.1: Espadà, Calderona, and Pinet, Spain 100
Juli G. Pausas and V. Ramon Vallejo

9. Coping with Pests and Diseases 103
Manuela Branco and Ana Paula Ramos
Biotic Factors Affecting Acorns, Seedlings, and 104
Young Plantings
Biotic Factors Affecting Mature Trees 105
Decline and Loss of Productivity in Adult Stands: 109
Forestry Practices and Protection
Conclusions 110
Site Profile 9.1: Maremma, Italy 112
Federico Selvi

10. Natural Regeneration 115
Juli G. Pausas, Teodoro Marañón, Maria Caldeira, 115
and Josep Pons
From Seed to Seedling
Seedling Performance 118
Recruitment Patterns: Three Case Studies 120
Conclusions 123
Site Profile 10.1: Hayouna, Morocco 125
Mohamed Abourouh

PART III. Restoration in Practice 127

11. Germplasm Selection and Nursery Techniques 129
Maria Helena Almeida, Hachemi Merouani, 129
Filipe Costa e Silva, Jordi Cortina, Roman Trubat,
Esteban Chirino, Alberto Vilagrosa, Abdelhamid Khaldi,
Boutheina Stiti, Sidi Lotfi El Alami, and V. Ramon Vallejo
Germplasm Selection 129
Availability and Quality of Initial Acorn Stock 130
Acorn Manipulation, Storage, and Quality Assessment 130
Plant Production and Nursery Practices 131
Conclusions 137
Site Profile 11.1: Aspres and Albères, France 138
Renaud Piazzetta
12. Field Techniques to Improve Cork Oak Establishment
   Jordi Cortina, Marian Pérez-Devesa, Alberto Vilagrosa,
   Mohamed Abourouh, Mahand Messaoudène,
   Nora Berrahmoumi, Luis Neves Silva, Maria Helena Almeida,
   and Abdelhamid Khaled
   Direct Seeding 142
   Seedling Planting 142
   Livestock Management 148
   Conclusions 148

PART IV. Economic Analysis 151

    Region of Portugal
   Inocêncio S. Coelho and Pablo Campos
   Mixed Cork Oak and Stone Pine Woodland Areas 153
   Private Economic Benefits and Cost Valuation Methods 155
   Sustainability and Stewardship of Total Economic Value 159
   Site Profile 13.1: Monchique and Caldeirão, Portugal 162
   José M. D. Rosendo

14. Cork Oak Woodland Conservation and Household
    Subsistence Economy Challenges in Northern Tunisia 165
   Pablo Campos, Paola Ovando, Ali Chebil, and
   Hamed Daly-Hassen
   Case Study: Iteimia 166
   Conclusions 173
   Site Profile 14.1: Maamora, Morocco 175
   Mohamed Abourouh

15. Cost–Benefit Analysis of Cork Oak Woodland Afforestation
    and Facilitated Natural Regeneration in Spain 177
   Paola Ovando, Pablo Campos, José L. Oviedo, and
   Gregorio Montero
   Cork Oak Woodland, Shrubland, Pasture, and Cropland
   Management Scenarios 178
   Present Discounted Values of Capital Income from
   Cork Oak Investment and Noninvestment Scenarios 180
   Conclusions 187

16. Manufacture and Trade of Cork Products:
    An International Perspective 189
   Santiago Zapata, Francisco M. Parejo, Amélia Branco,
   Michele Gutierrez, J. Ignacio Jiménez Blanco,
   Renaud Piazzetta, and Andreas Voth
PART V. Challenges for the Future 201

17. Ecological Planning for Biodiversity Conservation 203
   Nora Berrahmoun, Pedro Regato, Mohammed Ellatifi, Hamed Daly-Hassen, Miguel Bugallo, Sahraoui Bensaïd, Mario Díaz, and James Aronson
   Biodiversity Value and Ecosystem Services 203
   Challenges for Conservation 204
   Reconnecting Environmental, Social, and Economic Interests through Landscape Conservation Planning 213
   Conclusions 216
   Site Profile 17.1: Los Alcornocales Natural Park, Spain 217
   Teodoro Marañón

18. Facing Climate Change 219
   João S. Pereira, Alexandre Vaz Correia, and Richard Joffre
   Rise in Atmospheric CO₂ Concentration 220
   Rising Temperatures 221
   Effects on Communities and Ecosystems 223
   Effects at the Landscape and Regional Scales 224
   Conclusions 225

19. Simulating Function and Vulnerability of Cork Oak Woodland Ecosystems 227
   John Tenhunen, Ralf Geyer, João M. B. Carreiras, Nuno de Almeida Ribeiro, Nguyen Q. Dinh, Dennis O. Otieno, and João S. Pereira
   Function and Productivity as Related to Vulnerability Assessments 228
   The Pixel-Oriented Growth Model for Mediterranean Woodlands 229
   Conclusions 233

20. The Way Forward 235
   V. Ramon Vallejo, James Aronson, Juli G. Pausas, João S. Pereira, and Christelle Fontaine
   Cork Oak Decline 236
   Cork Oak Woodland Products 238
   Management Options 240
Contents

Conservation and Restoration 241
Coping with Uncertainty 242

GLOSSARY 247

REFERENCES 257

EDITORS 285

CONTRIBUTORS 287

SPECIES INDEX 301

INDEX 307