



EUROPEAN ATLAS OF FOREST TREE SPECIES

Publication details

The preferred citation for the chapters in this document is provided in each specific chapter (see also the Appendix "Information on copyright, citation and disclaimer", p. 200).

The full version of each chapter (expanded and fully peer-reviewed) will be published in the online version of the Atlas in the Forest Information System for Europe web site (permanent url <https://w3id.org/mtv/FISE-Comm/v01/>). The online version of each chapter is the recommended version to cite.

Citing individual chapters should be the preferred option. To refer to the entire book as opposed to individual chapters, please cite as:

San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), 2016. **European Atlas of Forest Tree Species**. Publication Office of the European Union, Luxembourg. ISBN: 978-92-79-36740-3. DOI: 10.2788/038466

In order to refer to the online fully peer-reviewed version of each chapter (as recommended), please consult the recommended citation format at <https://w3id.org/mtv/FISE-Comm/v01/>. This is the URL to access the index of the online version of the Atlas, where you may easily find the chapter of interest.

© European Union, 2010-2016

The information and views set out in this book are those of the authors and do not necessarily reflect the official opinion of the European Union. Neither the European Union institutions and bodies nor any person acting on their behalf may be held responsible for the use which may be made of the information contained therein.

Reuse is authorised, provided the source is acknowledged. The reuse policy of the European Commission is implemented by a Decision of 12 December 2011¹.

The general principle of reuse can be subject to conditions which may be specified in individual copyright notices. Therefore readers are advised to refer to the copyright notices of the individual documents (including individual images, diagrams, ...). Reuse is not applicable to documents subject to intellectual property rights of third parties.

Published by the Publications Office of the European Union, L-2995 Luxembourg, Luxembourg.

European Atlas of Forest Tree Species

Printed version

ISBN 978-92-79-36740-3

doi:10.2788/4251

Catalogue number LB-04-14-282-EN-C

Online version

ISBN 978-92-79-52833-0

doi:10.2788/038466

Catalogue number LB-04-14-282-EN-N

2016–200 pp.–30.1 x 42.4 cm

Printed in Luxembourg.

Printed on elemental chlorine-free bleached paper (ECF).

References

[1] European Commission, *Official Journal of the European Union* **54**, 39 (2011).



Front cover image: Photograph of a holm oak (*Quercus ilex*) taken in Despeñaperros Natural Park (Andalusia, Spain) a Natura 2000 site, in which a LIFE project was implemented for the conservation of protected species such as the Iberian imperial eagle, the Iberian lynx, the black vulture and the black stork. The open holm oak forest in the area favours the production of a multiplicity of forest ecosystems such as game, timber, range, cattle feed and acorns, and sustains a high level of animal and plant biodiversity. (Copyright Alfonso San Miguel: CC-BY)



Back cover images:
Top: Copyright Giovanni Caudullo, CC-BY
Centre row far left: Copyright Valentin Sabau, CCO, <http://archive.is/GyEvu>
Centre row middle left: Copyright Alfonso San Miguel, CC-BY
Centre row middle right: Copyright Alfonso San Miguel, CC-BY
Centre row far right: Copyright Alfonso San Miguel, CC-BY
Bottom: Copyright Alfonso San Miguel, CC-BY

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- one copy:
via EU Bookshop (<http://bookshop.europa.eu>);
- more than one copy or posters/maps:
from the European Union's representations (http://ec.europa.eu/represent_en.htm);
from the delegations in non-EU countries (http://eeas.europa.eu/delegations/index_en.htm);
by contacting the Europe Direct service (http://europa.eu/eurodirect/index_en.htm) or calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

(* The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (<http://bookshop.europa.eu>).

WANT TO LEARN MORE ABOUT THE EU?

More information on the European Union is available on the Internet at:

<http://europa.eu>

Europe Direct is a service to help you find answers to your questions about the European Union:

Freephone number (*): 00 800 6 7 8 9 10 11

(* The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Legal Notice

Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of the following information.

Cartographic Representations

Underlying cartographic features depicted on the maps in this atlas are derived from the Digital Chart of the World and Lovell Johns Cartographic Base. These data do not have any explicit legal status; hence, no legal aspects should be derived from the information depicted on any of the maps in this publication.

http://en.wikipedia.org/wiki/Digital_Chart_of_the_World
www.lovelljohns.com

Disclaimer of Liability

The European Commission has taken considerable care in preparing the information presented in this atlas. The political boundaries shown on the maps are only indicative. The European Commission assumes no responsibility for the information contained in this publication.

Design and graphic support

Final design and graphic support by Lovell Johns Limited, 10 Hanborough Business Park, Long Hanborough, Witney, Oxfordshire, OX29 8RU, United Kingdom.

<http://www.lovelljohns.com>



Contributors

Editorial Board

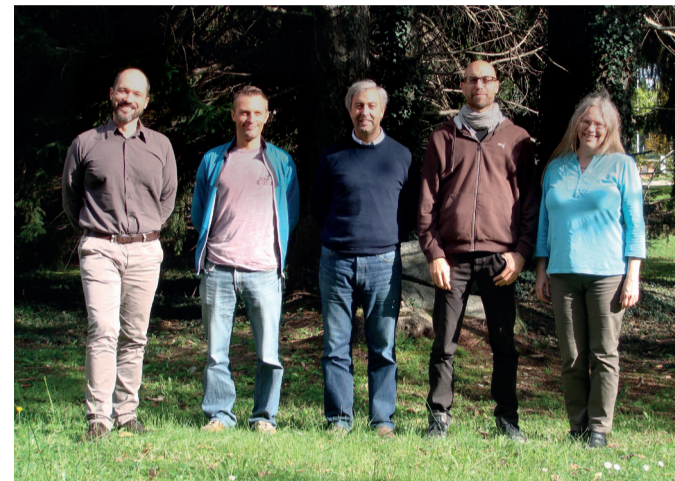
Jesús San-Miguel-Ayanz

Daniele de Rigo

Giovanni Caudullo

Tracy Houston Durrant

Achille Mauri



The editorial board (Daniele, Achille, Jesús, Giovanni, Tracy).

Scientific board

H. John B. Birks, University of Bergen, Department of Biology, Bergen, Norway

Giovanni Caudullo, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Daniele de Rigo, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Dave Durrant, Forestry Commission, Forest Research, Farnham, United Kingdom (retired)

Giorgio Guariso, Politecnico di Milano, Dipartimento di Elettronica, Informazione e Bioingegneria, Milan, Italy

Tracy Houston Durrant, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Achille Mauri, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Sandra Oliveira, University of Lisbon, Institute of Geography and Territorial Planning, Lisbon, Portugal

Salvatore Pasta, National Research Council, Institute of Biosciences and Bioresources, Palermo, Italy

Jesús San-Miguel-Ayanz, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Willy Tinner, University of Bern, Institute of Plant Sciences and Oeschger Centre for Climate Change Research, Bern, Switzerland



(Copyright go2life, pixabay.com: CCO)

"Mighty oaks from little acorns grow"

This QR code points to the full online version of the Atlas, where the most updated content may be freely accessed.



Authors

Jesús San-Miguel-Ayanz, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Daniele de Rigo, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Giovanni Caudullo, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Tracy Houston Durrant, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Achille Mauri, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Willy Tinner, University of Bern, Institute of Plant Sciences and Oeschger Centre for Climate Change Research, Bern, Switzerland

Dalibor Ballian, University of Sarajevo, Faculty of Forestry, Sarajevo, Bosnia Herzegovina

Pieter Beck, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

H. John B. Birks, University of Bergen, Department of Biology, Bergen, Norway

Edward Eaton, Forestry Commission, Forest Research, Centre for Sustainable Forestry and Climate Change, Farnham, United Kingdom

Cristian Mihai Enescu, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Department of Soil Sciences, Forestry Specialization, Bucharest, Romania

Salvatore Pasta, National Research Council, Institute of Biosciences and Bioresources, Palermo, Italy

Ioana Popescu, Drury University, Biology Department, Springfield Missouri, USA

Cesare Ravazzi, National Research Council, Institute for the Dynamics of Environmental Processes, Milano, Italy

Erik Welk, Martin Luther University Halle-Wittenberg, Department of Geobotany and Botanical Garden, Halle (Saale), Germany

Raul Abad Viñas, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

João C. Azevedo, Polytechnic Institute of Bragança, Agrarian School, Department of Environmental and Natural Resources, Bragança, Portugal

Anna Barbati, University of Tuscia, Department for Innovation in Biological, Agro-Food and Forest Systems, Viterbo, Italy

José I. Barredo, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Suzanne E. Benham, Forestry Commission, Forest Research, Centre for Ecosystem, Society and Biosecurity, Farnham, United Kingdom

Roberto Boca, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Claudio Bosco, Loughborough University, Civil and Building Engineering, Loughborough, United Kingdom

Maria C. Caldeira, University of Lisbon, Forest Research Centre, School of Agriculture, Lisbon, Portugal

Sofia Cerasoli, University of Lisbon, School of Agriculture, Forest Research Centre, Lisbon, Portugal

Gherardo Chirici, University of Florence, Department of Agriculture, Food and Forestry Systems, Firenze, Italy

Arne Cierjacks, University of Hamburg, Biocenter Klein Flottbek, Department of Biodiversity of Useful Plants, Hamburg, Germany

Marco Conedera, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Insubric Ecosystem Research Group, Bellinzona, Switzerland

Flavio Da Ronch, University of Padova, Department of Agronomy, Food, Natural resources, Animals and Environment, Legnaro (PD), Italy

Margherita Di Leo, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Juan Ignacio García-Viñas, Technical University of Madrid, ECOGESFOR Research Group, Department of Natural Systems and Resources, ETSI Montes, Forestales y del Medio Natural, Madrid, Spain.

Aitor Gastón González, Technical University of Madrid, ECOGESFOR Research Group, Department of Natural Systems and Resources, ETSI Montes, Forestales y del Medio Natural, Madrid, Spain.

Francesca Giannetti, University of Florence, Department of Agriculture, Food and Forestry Systems, Firenze, Italy

Núria Guerrero Hue, Independent researcher

Natalia Guerrero Maldonado, Estudios Europeos de Medioambiente S.L., Departamento de Biodiversidad y Conservación, Madrid, Spain

Marcelo Javier López, Fundación Global Nature, Madrid, Spain

Ragnar Jonsson, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Patrik Krebs, Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Insubric Ecosystem Research Group, Bellinzona, Switzerland

Diego Magni, Independent researcher

Sarah Mubareka, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Gráinne Mulhern, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Paula Nieto Quintano, University of Edinburgh, School of Geosciences, Edinburgh, UK

Sandra Oliveira, University of Lisbon, Institute of Geography and Territorial Planning, Lisbon, Portugal

João S. Pereira, Forest Research Centre, School of Agriculture, University of Lisbon, Portugal

Mario Pividori, University of Padova, Department of Land, Environment, Agriculture and Forestry, Legnaro (PD), Italy

Minna Rätty, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Francesca Rinaldi, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Santiago Saura, Technical University of Madrid, ECOGESFOR Research Group, Department of Natural Systems and Resources, ETSI Montes, Forestales y del Medio Natural, Madrid, Spain.

Richard Sikkema, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Tommaso Sitzia, University of Padova, Department of Land, Environment, Agriculture and Forestry, Legnaro (PD), Italy

Giovanni Strona, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Claude Vidal, European Commission, Joint Research Centre, Institute for Environment and Sustainability, Ispra (VA), Italy

Lara Vilar, Spanish National Research Council, Institute of Economics, Geography and Demography, Madrid, Spain

Barbara Zecchin, Independent researcher

Acknowledgements

This publication is the culmination of a fruitful collaboration between the European Commission's Joint Research Centre and numerous forest and vegetation experts from institutions and universities across Europe. The completion of this Atlas would have not been possible without their contribution. The exhaustive knowledge on environment, forest ecosystem and tree species of Claude Vidal, Günther Seufert, Ola Sallnäs, Anne Ghisla, and Franz Starlinger was crucial for adding new insights on the preparation of the Atlas chapters. In particular, the JRC is grateful for the support and commitment offered by the forestry administrations in the member states that provided the necessary data for the preparation of the Atlas. A list of contributors is shown below.

The Editors wish to extend their gratitude to the anonymous referees, to Grainne Mulhern and the army of other proof-readers for their ability to spot errors and inconsistencies through the Atlas. This led to an improved scientific soundness, readability and standardisation of the atlas. In addition, the authors are grateful for the assistance of William Adnams and in particular, Ian Dewsbery at Lovell Johns Ltd (UK) whose patience, understanding and high professional standards have significantly added to the quality of this publication. Thanks also to Arlette Goergen of the EU Publications Office for her assistance in coordinating the printing process and to Matteo Cassanelli for providing support through the publication process.

Finally, the Editorial Board has put every effort to credit all contributors and trace all copyright holders. We apologise for any unintentional omission, for which we would be pleased to rectify in future editions or online versions of the atlas.

Data contributors

Austria (Dr. Klemens Schadauer)

Czech Republic (Mr. Martin Pospíšil)

Denmark (Ms. Vivian Kvist Johannsen, Annemarie Bastrup-Birke)

Estonia (Mr. Veiko Adermann, Mr. Mati Valgepea)

Finland (Kari T. Korhonen)

France (Claude Vidal, Jean-Marc Frémont)

Germany (Dr. Heino Polley)

Hungary (Mr. Laszlo Kolozs)

Ireland (Mr. John Redmond)

Italy (Mrs. Patrizia Gasparini, Mr. Enrico Pompei)

Latvia (Ms. Ieva Licite, Mr. Toms Zālītis)

Lithuania (M. Albertas Kasperavicius)

The Netherlands (Mr. Jan Oldenburger)

Portugal (Ms. Ferreira Maria Conceição, Ana Paula Dias)

Romania (Mr. Gheorghe Marin)

Sweden (Dr. Jonas Fridman)

Slovak Republic (Ms. Zuzana Kmetova)

Spain (Mr. Santiago Saura Martínez de Toda, Iciar Alberdi Asensio, Mr. Guillermo Fernandez Centeno, Roberto Vallejo Bombín)

United Kingdom (Mr Mark Lawrence)

Norway (Mr. Stein Tomter)

Switzerland (Mr. Adrian Lanz)

Forest Focus/Monitoring dataset, BioSoil dataset, European Forest Genetic Resources (EUFORGEN), European Information System on Forest Genetic Resources (EUFGIS) - www.eufgis.org, Geo-referenced Database of Genetic Diversity (GD)² - www.evoltree.eu (see also the Chapter "The European Atlas of Forest Tree Species: modelling, data and information on forest tree species", p. 40)

Photo Credits

A. Steven Munson, Aanjhan Ranganathan, Achille Mauri, Agnieska Ovaskainen, Agnieszka Kwiecień (Nova), Alan Gregg, Alan Semper, Aldo De Bastiani, Aleksasfi, Alessio Sbarbaro (Yoggysot), Alexander Cahlenstein, Alexej Potupin, Alfie Ianni, Alfonso San Miguel, Allie Caulfield, Alpes de Haute Provence, Alpo Roikola, Andreas Rockstein (AnRo0002), Andrew, Andrew_Writer, Andrew Zharkikh, Angela Benito, Anssi Koskinen, Arnaud 25, Arnstein Rønning, Ashley Basil, Atif Rafik, Axel Kristinsson, Benedikt, benet2006, Bernt Rostad, Bjschoenmakers, Botaurus stellaris, Bri Weldon, Brian Gratwicke, Bruce Kirchoff, Budmac, cafepampas, Carl Mueller, Caroline Sada, Cesare Ravazzi, Chris De Wit, Chris M. Morris, Christa Regina, Christinamari, claude05alleve, Claudio Bosco, Crusier, Dalibor Ballian, Dan Nordal, Daniele de Rigo, Danielgrad, Dave Durrant, Dave Hamster, David Friel, David Nicholls, David Wright, Davide Fumagalli, davidgsteadman, Dezidor, Doc Searls, Domenico Salvagnin, Donald Hobern, Drahrub, echoe69, Elin, Emma Silviana Mauri, Enrico Romani, Entomart, Eran Finkle, Estormiz, Ettore Balocchi, F. Delventhal, F. Lamiot, Forest & Kim Starr, Forestry Commission, Francesco Ciabatti, Francesco Gasparetti, Francisco Antunes, Franco Caldararo, Franco Giordana, Franco Rossi, Frank Vassen, Franz Josef, Frauke Feind, Fredi Bach, Free Photos, Gary Houston, Gaston Aitor, Georgi Kunev, Giallopolenta, Giancarlo Pasquali, Gianluca Nicoella, Gian-Reto Tarnutzer, Giovanni Caudullo, Giovanni Trentanovi, Giulia Corradini, Giuseppe Milo, Göranssons Åkeri AB i Färila, Graham Calow, gravitat-OFF, Graziano Propetto, Guilhem Vellut, Hannu, Hans Braxmeier, Hans Fransén, Harald Deischinger, Hauke Musicaloris, Horla Varlan, Huskarl, Ian Andrews, IKB, ilovebutter, Inga Vitola, ioa8320, Irina Kazanskaya, I Seneca, J. Kelley, J.R. Pinho, Jan Homann, Ján Sokoly, Jannik Selz, Javi MF, Javier Martin, Jean Latour, Jean-Baptiste Bellet, Jean-Pol Grandmont, Jennifer Slot, Jeremy Atkinson, Jevgenij Voronov, Jevgenijs Šlihto, jez.atkinson, Jim Ferguson, Jiří Berkovec, Jiříček72, Jo Simon, John Tann, Jongleur100, Jonson22, Jorge Franganillo, Jose Luis Cernadas Iglesias, Josh Egan-Wyer (je_wyer), Juan Ignacio García Viñas, Karl Brodowsky, Kenraiz, Kimberly Vardeman, László Szalai, Leonid Mamchenkov, lifar, liz west, Lukasz Szmigiel, Magnus Manske, Maher27777, Mahlum, Maja Dumat, MajaDumat, Manfred Gut, Marilyn Peddle, Marina Torres, Marinella Zepigi, MarioM, Marion Schneider & Christoph Aistleitner (Mediocrity), Mattivirtala, MemoryCatcher, Michael Kranewitter, Michael Simoncini, Michael Wunderli, Miguel Vieira, Mihai Enescu, Miltos Gikas, Miquel Llop, Molekuel, mornarsamotarsky, MrT HK, Murray B. Henson, Nacho, NASA, NatureServe, Neil McIntosh, NH53, Nicholas A. Tonelli, Nicolas Raymond, Niki.L, Ninara, No-author, Nociveglia, Noel Feans, Norlando Pobre, Nova, NTNU Faculty of Natural Sciences and Technology, Nuno Lavrador, Pablo, Pancrazio Campagna, Paolo da Reggio, Patrice, Patrik Krebs, Paul Schulze, Pavel Buršik, Pedro Dias, Peter Smith, Peter Trimming, Phil Sellens, Pieter Beck, Ptelea, Ragnar Jonsson, Rainer Lippert, Richard Allaway, Richard Sikkema, Rob Hille, Robert Anders, Roberta Alberti, Roberto Verzo, Roland Tanglao, Ronnie Nijboer, Rosendahl, Rosenzweig, Ruben Holthuijsen, S. Rae, Sallyofmayflower, Samuel Killworth, Santos Cirujano Bracamonte, Sarah Millar, Sarang, Schwabe90, Sean MacEntee, Sergey Norin, Sergio Piccolo, Shankar S., Silvano Radivo, Soldatnytt, Somepics, Son of Groucho, Stan, Stanislav Doronenko, Stefano Zeraushek, Stefanst, Sten Porse, Steven Gill, Stewart Black, Superior National Forest, Sven Scheuermeier, Svičková, Takeshi Kuboki, Tanaka Juuyoh, Tara2, Taxelson, Thomas Quine, Thomas Richter, Tom Brandt, Tomás Royo, Tomasz Proszek, Tracy Houston Durrant, tree-species, Umberto Salvagnin, US Forest Service, Valentin Sabau, Vasile Cotovanu, Vassil, Velella, Verollanos93, Victor M. Vicente Selvas, Vince Smith, Vito Buono, Vlad Butsky, weisserstier, Wendy Cutler, William Warby, Willow, Willy Tinner, Wojciech Przybylski, Wolfgang Staudt, Wouter Hagens, Xemenendura, Yuri Timofeyev, Zseeee.

Contents



Preambles	2
Publication details	2
Contributors	2



Introduction	5
Preface on the European Atlas of Forest Tree Species	6
The European Union Forest Strategy and the Forest Information System for Europe	7
Forest resources in Europe: an integrated perspective on ecosystem services, disturbances and threats	8
Forest bio-based economy in Europe	20
European forests: an ecological overview	24
European forest classifications	32
European Forest Types: tree species matrix	34
Past forests of Europe	36



Tree species	40
The European Atlas of Forest Tree Species: modelling, data and information on forest tree species	40
How to read the Atlas	46
<i>Abies alba</i> Silver fir	48
<i>Abies spp.</i> Circum-Mediterranean firs	50
<i>Acer campestre</i> Field maple	52
<i>Acer platanoides</i> Norway maple	54
<i>Acer pseudoplatanus</i> Sycamore or sycamore maple	56
<i>Aesculus hippocastanum</i> European horse-chestnut	60
<i>Ailanthus altissima</i> Tree of heaven	61
<i>Alnus cordata</i> Italian alder	62
<i>Alnus glutinosa</i> Common or black alder	64
<i>Alnus incana</i> Grey alder	66
<i>Alnus viridis</i> Green alder	68
<i>Betula sp.</i> Birches	70
<i>Carpinus betulus</i> Common hornbeam	74
<i>Carpinus orientalis</i> Oriental hornbeam	76
<i>Castanea sativa</i> Sweet chestnut	78
<i>Celtis australis</i> Nettle tree	80
<i>Chamaecyparis lawsoniana</i> Lawson cypress	81
<i>Cornus mas</i> Cornelian cherry	82
<i>Cornus sanguinea</i> Common or red dogwood	84
<i>Corylus avellana</i> Common or European hazel	86
<i>Cupressus sempervirens</i> Mediterranean cypress	88
<i>Eucalyptus globulus</i> Tasmanian blue gum	90
<i>Euonymus europaeus</i> Spindle tree	92
<i>Fagus sylvatica</i> European beech	94
<i>Frangula alnus</i> Alder buckthorn	96
<i>Fraxinus angustifolia</i> Narrow-leaved ash	97
<i>Fraxinus excelsior</i> Common ash	98
<i>Fraxinus ornus</i> Manna ash	100
<i>Ilex aquifolium</i> European holly	102
<i>Juglans regia</i> Common walnut	103
<i>Juniperus communis</i> Common juniper	104
<i>Juniperus oxycedrus</i> Prickly juniper	105
<i>Juniperus phoenicea</i> Phoenician juniper	106
<i>Juniperus thurifera</i> Spanish juniper	107
<i>Larix decidua</i> European larch	108
<i>Olea europaea</i> Olive	111
<i>Ostrya carpinifolia</i> European hop-hornbeam	112
<i>Picea abies</i> Norway spruce	114
<i>Picea omorika</i> Serbian spruce	117
<i>Picea sitchensis</i> Sitka Spruce	118
<i>Pinus cembra</i> Arolla pine	120
<i>Pinus halepensis and Pinus brutia</i> Aleppo pine and Turkish pine	122
<i>Pinus mugo</i> Dwarf mountain pine	124
<i>Pinus nigra</i> Black pine	126
<i>Pinus pinaster</i> Maritime pine	128
<i>Pinus pinea</i> Stone pine	130
<i>Pinus sylvestris</i> Scots pine	132
<i>Populus alba</i> White poplar	134
<i>Populus nigra</i> Black poplar	136
<i>Populus tremula</i> Eurasian aspen	138
<i>Prunus avium</i> Wild cherry	140
<i>Prunus cerasifera</i> Cherry plum	142
<i>Prunus mahaleb</i> Mahaleb cherry	143
<i>Prunus padus</i> Bird cherry	144
<i>Prunus spinosa</i> Blackthorn	145
<i>Pseudotsuga menziesii</i> Douglas fir	146
<i>Quercus cerris</i> Turkey oak	148
<i>Quercus frainetto</i> Hungarian oak	150
<i>Quercus ilex</i> Holm or evergreen oak	152
<i>Quercus palustris</i> Pin oak	154
<i>Quercus pubescens</i> Downy or pubescent oak	156
<i>Quercus pyrenaica</i> Pyrenean oak	158
<i>Quercus robur and Quercus petraea</i> Pedunculate oak and sessile oak	160
<i>Quercus suber</i> Cork oak	164
<i>Robinia pseudoacacia</i> Black locust	166
<i>Salix alba</i> White willow	168
<i>Salix caprea</i> Goat willow	170
<i>Sambucus nigra</i> Black elderberry	172
<i>Sorbus aria</i> Common whitebeam	174
<i>Sorbus aucuparia</i> Rowan or Mountain ash	176
<i>Sorbus domestica</i> Service tree	178
<i>Sorbus torminalis</i> Wild service tree	180
<i>Tamarix spp.</i> Tamarisks	182
<i>Taxus baccata</i> European or English yew	183
<i>Tilia spp.</i> Limes (Linden)	184
<i>Ulmus spp.</i> Elms	186



Glossary

190



Appendices

194

The European Commission

194

Information on copyright, citation and disclaimer

196



Spring foliage of Norway maple (*Acer platanoides*).
(Copyright Jiricek72, pixabay.com: CC0)

Preface

Dear readers,

Over the past 200 years, Europe's forests have been in a period of recovery after centuries of deforestation and degradation. Today, forests and other wooded lands cover some 40% of the European Union's landmass.

They are remarkable ecosystems, a precious natural resource and a source of income and wealth. Forests capture and store carbon, prevent soil erosion, protect us from floods and landslides, provide habitats for plants and animals, and support leisure and recreation – as well as providing timber and other forest products.

However, forests are under pressure. Storms, fires and pests are expected to damage forests more frequently and more intensely as a result of climate change. Unsustainable management practices have resulted in habitat and biodiversity loss. And continued high nitrogen depositions are a concern.

In order to continue providing European citizens with their wide range of economic, environmental and social benefits, but also to protect them and keep them in good condition, it is crucial that our forests are managed sustainably – and this requires improving our knowledge. Knowing how forest tree species are distributed across the EU is vital for making decisions about forest management, the protection of areas of high nature value, the selection of species for afforestation and the measures for adapting to climate change.

This European Atlas of Forest Tree Species is the first report to compile and make this essential information available to forest managers, researchers, citizens and policy makers.

An enormous amount of work has gone into creating this Atlas, involving collaborations with national forest services, research organisations, universities and international institutions dealing with the many different aspects of forest life; the botanical sciences, soils, biodiversity, vegetation and pests for example.

I believe that this European Atlas of Forest Tree Species will soon become an important reference text for this rich European resource. By learning more about our trees and forests, we can truly appreciate their critical role in our environment, our economies and our lives.

Happy reading!



Karmenu Vella
European Commissioner for
the Environment, Maritime
Affairs and Fisheries



Tibor Navracsics
European Commissioner for
Education, Culture,
Youth and Sport



☼☼☼ Rainbow over Sierra Morena (southern Spain).
(Copyright Alfonso San Miguel: CC-BY)



☼☼☼ Field maple (*Acer campestre*) in a rapeseed (*Brassica napus*)
cultivation near Dorchester (Dorset, UK).
(Copyright Ian Andrews, www.geograph.org.uk: AP)

The European Union Forest Strategy and the Forest Information System for Europe

J. San-Miguel-Ayanz

Sustainable Forest Management (SFM) is a key objective of all European countries. A commitment to SFM forms the basis of the Ministerial Conferences on the Protection of Forests in Europe (Forest Europe¹), which were held in Strasbourg (1993), Lisbon (1998), Vienna (2003), Warsaw (2007), Oslo (2011) and Madrid (2015). As part of the Forest Europe process, countries report national information on a series of forest criteria and indicators every four years. This information is used to assess the sustainable management of forests in the different regions of Europe and to elaborate the series of reports on the State of Europe's Forests, the latest of which was published in 2015. While the information contained within this series of reports is very valuable, it does not lend itself to a more detailed assessment of environmental processes as the reports are made at national rather than local or regional scales.

It is difficult to produce detailed harmonised information on forests at European level. As countries have their own national or regional forest information systems, and often their own definition of forests, a compilation of national datasets does not provide a reliable pan-European assessment of the state of the forests. For this reason, it is necessary to harmonise national information at the European scale so as to derive pan-European forest information.

Within the European Union, a series of regulations were established over the years to collect information on forests and to ensure their sustainable management. Chronologically, Regulation EEC No 3528/86² and Regulation EEC No 2157/92³ helped establish information systems for the monitoring of air pollution in forests and for forest fire prevention. Both regulations were substituted by the Forest Focus regulation⁴ during the period 2003–2006, which facilitated the establishment of common European forest information systems for air pollution (the Forest Focus database^{5, 6}) and for forest fires (the European Forest Fire Information System (EFFIS)⁷). However, with the expiration of the Forest Focus regulation in 2006, European countries are currently under no obligation to report information on forest resources to European forest information systems.

Although there is no comprehensive common European forest information system to which countries report, most countries in Europe have their own systems in place to collect information about their forests. The most common systems are the National Forest Inventories (NFIs). While NFIs are very different in most countries, they collect ground data and forest parameters that can be processed to obtain harmonised European forest information. Initiatives to support this harmonisation process were first financed through the Forest Focus regulation. Several projects were financed for the harmonisation of different forest parameters, including forest area, carbon stocks, forest protection indicators in mountain regions, etc. The largest of these was the BioSoil project^{8, 9}, as part of which a soil survey was conducted in 22 EU countries, and biodiversity data were collected in standardised plots in 19 countries. The information from these projects was incorporated and is available in the Forest Focus database of the Joint Research Centre. Additionally, research initiatives on the harmonisation of reporting activities from NFIs were launched in the form of Cooperation in Science and Technology (COST) Actions. Although essential for the process of harmonising forest information from NFIs, the COST Actions do not in themselves produce harmonised European datasets (which would be necessary to assess the state of forest resources at the European level), but instead develop definitions and methods that may allow for the derivation of these datasets.

Attempts to establish common information systems at the European level were launched through the EFICS regulation (1989)¹⁰ and followed by the setting up of a European Forest Information and Communication Platform (EFICP)¹⁰. However, the lack of standardised forest information systems across countries and the difficulties faced in establishing common protocols for data transmission impeded the successful establishment of a common forest information system in Europe. Although a common EU Forest Strategy had existed since 1998, little progress was made in setting up a comprehensive common European forest information system. However, initiatives to bring together European forest-related information systems were still ongoing¹¹.

In 2005, an agreement between several Commission services and the European Environment Agency led to the creation of 10 environmental data centres. The responsibility for the establishment of two of these centres, those dealing with forests and soils, was given to the JRC. These environmental data centres were named EFDAC (European Forest Data Centre) and ESDAC (European Soil Data Centre). In order to further support the collection of harmonised information on forest resources in Europe, the JRC set up a four-year Framework Contract in 2009 for the provision of data and services to EFDAC. A second four-year Framework Contract was established in 2012. In this context, the European Commission has been collaborating with European NFI services to produce harmonised forest datasets at European level, and datasets on forest basal areas, forest biomass and the distribution of forest tree species have been compiled. The latter dataset is one of the core datasets used for the production of the European Atlas of Forest Tree Species.

The adoption of the new EU Forest Strategy¹² by the European Commission in 2013 opened a new opportunity for the establishment of a common European forest information system. Within this strategy, the European Commission and the EU Member States are establishing a Forest Information System for Europe (FISE). FISE is currently under development, and a prototype is already available at <http://fise.jrc.ec.europa.eu>. The development of FISE builds on existing European systems such as EFDAC, EFFIS and the Forest Focus database, and aims to become the focal point for information on forest resources in Europe.

The forest-based sector plays a crucial role within a growing bioeconomy in terms of value-added, job creation, and (through the sequestration of carbon and providing a substitute for fossil-fuel-based materials and energy) climate change mitigation. Different EU policies affect the forest-based sector (and therefore European forests), including the Climate and Energy Framework, the EU Biodiversity Strategy & Natura 2000. To ensure coherence among policies, their impacts need to be modelled. The establishment of FISE is at the core of the EU Forest Strategy as the instrument to assess progress towards the targets established in the cross-sectorial policies that affect forests and forest resources, and to ensure the sustainable management of forest resources in Europe.



••• Spruce forest surrounding the Atorno Lake (Belluno, Italy).
(Copyright Domenico Salvagnin, www.flickr.com: CC-BY)



••• Autumnal foliage of the horse-chestnut (*Aesculus hippocastanum*).
(Copyright Hans Braxmeier, pixabay.com: CCO)

References

- [1] Ministerial Conference on the Protection of Forests in Europe, Forest Europe - growing life (2016). <http://www.forest-europe.org>.
- [2] Council of the European Union, *Official Journal of the European Union* **29**, 2 (1986).
- [3] Council of the European Union, *Official Journal of the European Union* **35**, 3 (1992).
- [4] Council of the European Union, *Official Journal of the European Union* **1**, 1 (2003).
- [5] R. Hiederer, et al., *Forest focus monitoring database system - Validation methodology*, vol. EUR 23020 EN (Office for Official Publications of the European Communities, 2007).
- [6] T. Houston Durrant, R. Hiederer, *Journal of Environmental Monitoring* **11**, 774 (2009).
- [7] J. San-Miguel-Ayanz, et al., *Approaches to Managing Disaster - Assessing Hazards, Emergencies and Disaster Impacts*, J. Tiefenbacher, ed. (InTech, 2012), chap. 5.
- [8] R. Hiederer, T. Houston Durrant, E. Micheli, *Evaluation of BioSoil Demonstration Project - Soil Data Analysis*, vol. 24729 of EUR - Scientific and Technical Research (Publications Office of the European Union, 2011).
- [9] T. Houston Durrant, J. San-Miguel-Ayanz, E. Schulte, A. Suarez Meyer, *Evaluation of BioSoil Demonstration Project: Forest biodiversity - Analysis of biodiversity module*, vol. 24777 of EUR - Scientific and Technical Research (Publications Office of the European Union, 2011).
- [10] D. Tilsner, et al., *International Journal of Spatial Data Infrastructures Research* **2**, 112 (2007).
- [11] J. San-Miguel-Ayanz, G. Schmuck, R. Flies, E. Schulte, I. Seoane, *Database and Expert Systems Applications, 2005. Proceedings. Sixteenth International Workshop on (IEEE, 2005)*, pp. 669–673.
- [12] European Commission, *COMMUNICATION FROM THE COMMISSION* pp. 1–17 (2013).

This is an extended summary of the chapter. The full version of this chapter (revised and peer-reviewed) will be published online at <https://w3id.org/mtv/FISE-Comm/v01/e012228>. The purpose of this summary is to provide an accessible dissemination of the related main topics.

This QR code points to the full online version, where the most updated content may be freely accessed.

Please, cite as:

San-Miguel-Ayanz, J., 2016. **The European Union Forest Strategy and the Forest Information System for Europe**. In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), *European Atlas of Forest Tree Species*. Publ. Off. EU, Luxembourg, pp. e012228+



Forest bio-based economy in Europe

S. Mubareka, R. Jonsson, F. Rinaldi, J. Azevedo, D. de Rigo, R. Sikkema

A bio-based economy may be defined as one using "... production paradigms that rely on biological processes and, as with natural ecosystems, use natural inputs, expend minimum amounts of energy and do not produce waste as all materials discarded by one process are inputs for another process and are reused in the ecosystem."¹

The transition towards a more sustainable primary production and resource efficiency will certainly benefit the environment but also induce a number of significant economic benefits, such as stimulating the economy through encouraging innovation and building new and competitive industries through the emergence of new sectors such as biomaterials and green chemistry.

The bioeconomy in Europe already exists, and has been estimated at 2.4 billion Euro for 2012, employing more than 22 million people². The Commission's bioeconomy strategy and action plan aims at further shifting the European economy towards a greater and more sustainable use of renewable resources; however the transition towards a true bioeconomy relies on a series of breakthroughs in technology and cost effectiveness, as well as the pure availability of biomass².



... Pine logs, Cannock Chase, UK.
(Copyright Jeremy Atkinson, CC-BY, <https://archive.is/q6jvZ>)

Forests and Europe's economy

The forest-based sector plays an important role within the European Union (EU) in terms of value added, trade balance, and job creation. The forest industry includes products such as buildings (see box on "Wood in modern urban construction"), books, magazines and newsprint, furniture, food (see box on "The importance of non-wood forest products in Europe"), textiles, packages, energy (see box on "Forest-based energy") and bio-based products (see box on "Forest resources in bio-based products"). The values of sales for these products total to more than 200 billion Euro³.

Overall, 58% of harvested EU wood biomass is processed by EU forest-based industries, which represents approximately 7% of EU manufacturing GDP and nearly 3.5 million jobs. The remaining 42% is exploited for energy and accounts for about 5% of the total energy consumption in EU⁴.

As an example, some 101 million m³ of sawnwood were produced in the EU-28 in 2013, close to two thirds of which came from the five largest producing EU Member States; namely Germany (21.3%), Sweden (16.2%, 2012 data), Finland (10.1%), Austria (8.8%) and France (8.0%)⁵.

The volume of roundwood produced is strongly linked to the value added to the raw material (see Figure 3).

The important role of forests in reaching the EU's Renewable Energy Directive targets, which include the production of energy from renewable sources in the EU, has raised questions about the sustainability of mobilising biomass for these purposes and the forest economy-environment-energy nexus.

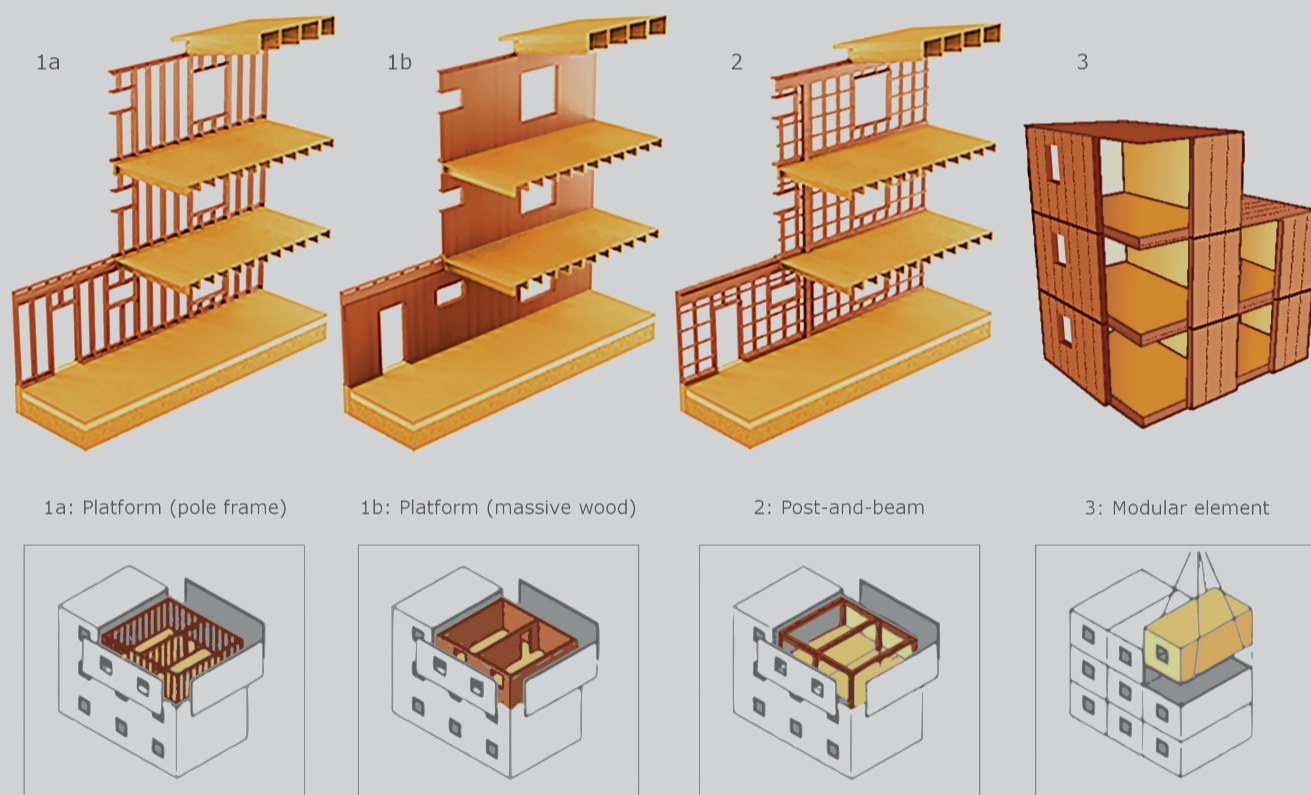
Box 1: Wood in modern urban construction

Many countries across Europe, encouraged by EU policies, have set targets to reduce carbon dioxide emissions and are adopting legislative methods to ensure that buildings and materials satisfy the requirements implicit in individual country targets. In many cases this has led to an increased use, or at least consideration, of wood as an alternative to conventional construction materials such as steel and concrete⁶.

Until the late 1980s, wood-framed buildings with more than two storeys were prohibited by building regulations in most European countries, due to the negative perceptions arising from historic city fires. However, national building regulations are being revised towards functional criteria as opposed to prescriptive criteria, driven by the Construction Products Directive adopted in the EU in 1988. Thus, a larger number of storeys with a wooden frame is being allowed throughout Europe⁷.

As a result of the adoption of functional building regulations and technological development, the share of wood-frame in multistorey construction is on the rise, particularly so in the Nordic countries, the UK, Ireland and the Alpine region of Europe⁷. In Sweden wood-frame multistorey construction (WMC) already has a market share of around 10%⁶, and also in Finland WMC is approaching a ten per cent market share⁷.

In the UK, the market share of wood-frame in residential construction increased from 8% in 1998 to 25% in 2008, but there are as yet no data on the WMC segment specifically. However, residential WMC has made a breakthrough in the UK as a result of environmental policies, the rising interest towards WMC among the developers, and the lightness of wood making it possible to utilise building sites that could not sustain corresponding buildings made of concrete. Also in Ireland, the building practice has been changing from on-site construction to wood-frame off-site construction. However, while the overall market share of wood-frame in all construction increased from 1% in 1990 to 30% in 2007, the market share in the WMC segment is still rather small. In Austria, wood-frame is common in the single-family housing sector, with a 40% market share, yet the regulations and attitudes towards wood use vary from one province to another, and on average the market share of WMC has remained low. Likewise, in Germany and Italy, there are regional differences in the attitudes towards WMC. In Southern Germany, the use of wood for construction has been increasing in the 2000s, and it has been suggested that the market share of WMC could increase from 2% to 10% towards 2030⁷.



... Fig. 1: Three different wood-frame multi-storey construction (WMC) techniques and corresponding key wood elements⁷. 1: Platforms may be based on pole frame structures (1a) or on panel elements (1b). 2: In the post-and-beam technique, massive supporting columns are exploited. 3: Modular elements are instead directly manufactured at the factory, including several final elements such as doors and windows, electricity appliances, or heating. Different WMC techniques imply different industrial workflows. WMC diffusion is dependent on regulatory framework and industry structure⁷. Modified from Hurmekoski, et al.⁷ (Copyright Elias Hurmekoski: AP)



... Timber Bridge Construction in Arbon, Bodensee in Steinach, Canton of St. Gallen, Switzerland.
(Copyright Norlando Pobre, www.flickr.com: CC-BY)



... Traditional timber frame building in the Burgenstraße (Castle Road), southern Germany.
(Copyright Thomas Quine, CC-BY, <https://archive.is/sdvn7>)

Box 2: The importance of non-wood forest products in Europe

Forests systems are responsible for a diversity of very valuable ecosystem services throughout Europe. Among these, Non-Wood Forest Products (NWFPs) such as mushrooms, chestnuts, cork, pine nuts, honey truffles and berries are among the most important from economic and social points of view. The FAO has classified NWFPs into two broad categories: animal and plant products.



••• In several European countries, the Nordic common rights (right of public access to the wilderness, or freedom to roam) grant access for picking non-wood forest products such as berries.
Top: Blueberry picking.
(Copyright Ragnar Jonsson, CC-BY)
Bottom: Understorey of *Vaccinium myrtillus* in a coniferous forest.
(Copyright Yuri Timofeyev, CC-BY, <https://archive.is/D6fqw>)

In northern Europe, the Nordic common rights allow access for picking berries, mushrooms and other non-wood forest products (NWFP), even from private forests. This free access, facilitated by a dense network of forest roads, makes berry and mushroom picking an essential part of the way of life in rural areas of the Nordic countries. Opportunities in the sale and processing of NWFPs to provide additional income vary widely between products, regions and seasons. Earlier interventions to promote NWFP utilisation have included training in identification, picking, processing and marketing of natural products. As an example, in Finland 55 000 commercial mushroom pickers have been trained since the early 1970s. Sales tax and income tax exemptions on selling berries and mushrooms picked by an individual continue to be key incentives for commercial picking. About one-third of berries and some one-tenth of mushrooms picked in the Nordic countries enter the market. In recent years, berries sales have decreased as a result of urbanisation and aging of the rural population, as well as low berry prices. As a result, commercial berry picking has, during the past decade, relied largely on migrant pickers, including workers from neighbouring countries and from as far as SE Asia¹¹.

In the Mediterranean region, non-wood forest products such as mushrooms, cork, pine nuts, chestnuts, resin, honey and truffles are of extreme importance to the economy. Despite this, there is a general lack of regulation of the cultivation of these non-forest wood products¹².

For example, in the Northeast of Portugal, mushrooms have traditionally been picked for self-consumption. This region is one of the few in the country where there is a strong local knowledge concerning wild (and even cultivated) mushrooms. Thanks to this strong tradition and a rich stock of mushrooms, commercial picking has become a very important economic activity in the region since the 1980s. This activity has provided significant income for families and individuals on an annual basis. At the same time, the first studies on mushrooms in the region were conducted with the purpose of assessing diversity, productivity and the economic potential of mushrooms as a forest resource^{13,14}. This activity is still mainly undertaken by locals, usually self-employed or retired elderly woman, individually or in groups of two, and within the limits of the village where they reside or the neighbouring village¹⁵. Almost all the mushrooms picked locally have international markets as final destination including Spain, France, Germany, and Italy. Although no official statistics are available for the production and trade in the region, mushrooms are estimated to contribute 5 to 10 million Euro to the local economy every year. Population in cities have recently developed an interest in wild mushrooms which has led to the organisation of courses, workshops and other training initiatives by forest, agriculture and environment associations. Formal education in mushrooms has been offered in the Polytechnic Institute of Bragança since 1991¹⁶.

Chestnuts are a very important non-wood forest product of forests in Mediterranean countries. The high market price of chestnuts and the low level of inputs required in the chestnut systems have led to the recent expansion of chestnut agro-forestry systems in some Mediterranean regions. This process is favoured by the movement of people from the countryside

to cities in the region and abroad and by the abandonment of traditional agriculture systems. Chestnut diseases such as “ink disease” and “chestnut blight” and the newly arrived “chestnut gall wasp” (*Dryocosmus kuriphilus*) are serious threats to this product. Localised research (for example¹⁷) and forest extension promoted by forest associations has, however, contributed to minimise the effects of these agents.



••• In 1993–2013, the European average production of chestnuts has been 130 000 tonnes per year, i.e. more than 10% of the global production¹⁸.
Top: Chestnut burr.
(Copyright William Warby, CC-BY, <https://archive.is/0qa5n>)
Bottom: Chestnuts.
(Copyright Maja Dumat, CC-BY, <https://archive.is/05xeX>)



••• Variety of mushrooms found in the forests of Priekuļi, Latvia.
(Copyright Inga Vitola, CC-BY, <https://archive.is/5L6W2>)



••• Raspberries.
(Copyright Maja Dumat, CC-BY, <https://archive.is/wqkTZ>)



••• Truffle hunter with his dog, Tuscany, Italy. Italian white truffles are highly sought after and have high value.
(Copyright Michela Simoncini, CC-BY, <https://archive.is/P2xPu>)

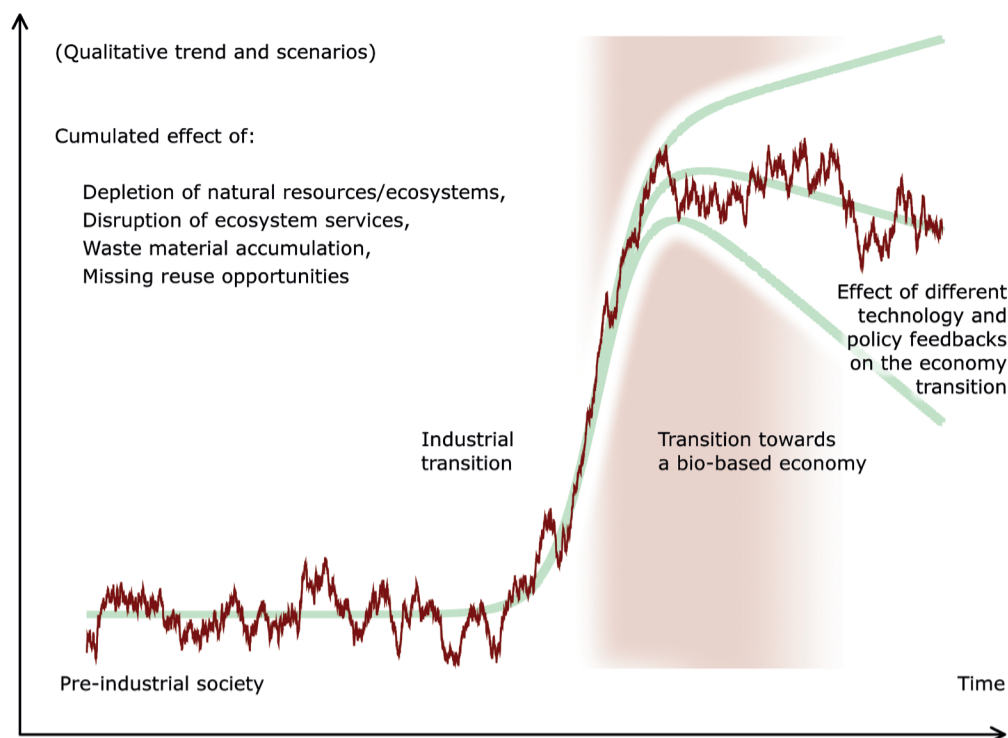


Fig. 2: Qualitative evolution from the pre-industrial society to two subsequent transitions. First, the transition to the industrial society and economy. Then, toward a bio-based economy. The short-term patterns of the actual evolution may be complex since they are subject to several sources of local fluctuations. The qualitative future trend will also depend on the cumulative feedback effect due to different potential technology and policy scenarios.
(Author: Daniele de Rigo)

Box 3: Pulp and Paper Industry

The pulp & paper industry is an important industry within the forest-based bioeconomy of Europe. Using some 150 million cubic meters of wood per annum, this industry provides 1.5 million jobs in the value chain, adding 15 billion euros to the Gross Domestic Product of the European Union. The industry is going through structural changes. Thus, while the consumption trend for graphic paper is a decreasing one, consumption of paper for sanitary and packaging purposes is rising. Recycling plays an important role within this industry. Indeed, paper is the most recycled product in Europe, with a recycling rate that increased from 40% in 1991 to 72% by 2014. Recovered paper make up 54% of the raw material used in the paper industry³⁴.



Corrugated cardboard.
(Copyright jaymethunt, CC0, <https://archive.is/cG356>)



Waste paper for recycling.
(Copyright sonja_paetow, CC0, <https://archive.is/BETQX>)

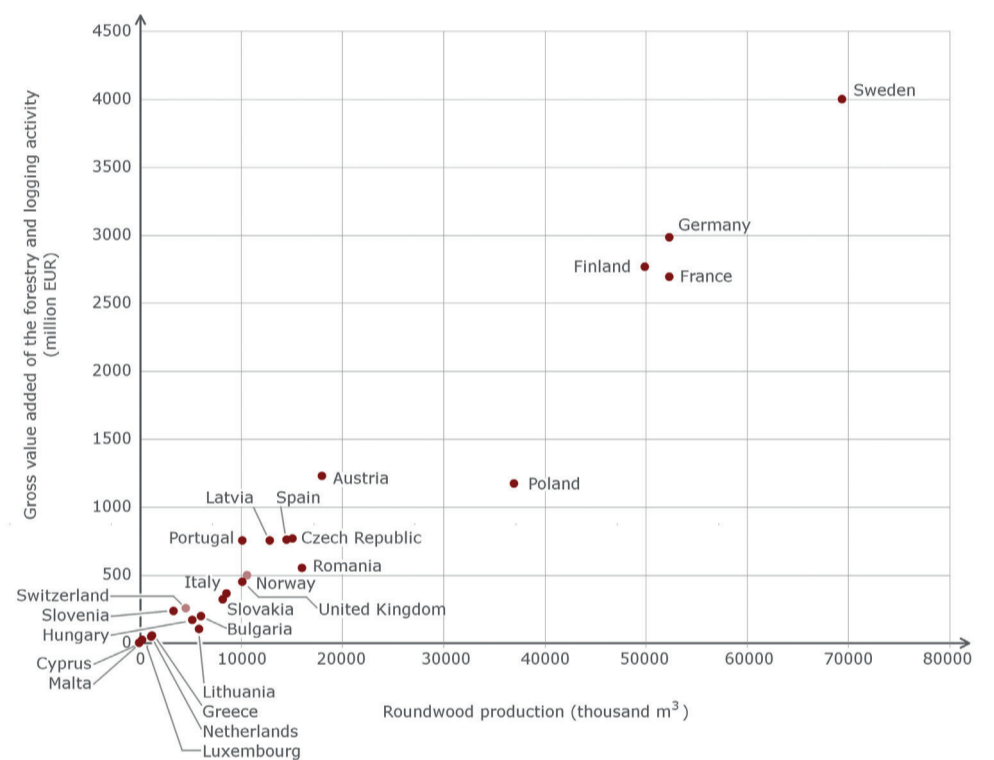


Fig. 3: Roundwood production in 2012 and gross value added of forestry and logging. For Italy, Lithuania and the Netherlands, the available data refer to 2006. For Spain, data refer to 2007. For Hungary and Malta, data refer to 2009. For Greece, Latvia and Luxembourg, data refer to 2011. France, Portugal and Norway data are provisional.
(Source: Eurostat³⁵)

Integrated forest resources management for a bio-based economy

Exploring efficient trade-off between monetary and non-monetary benefits

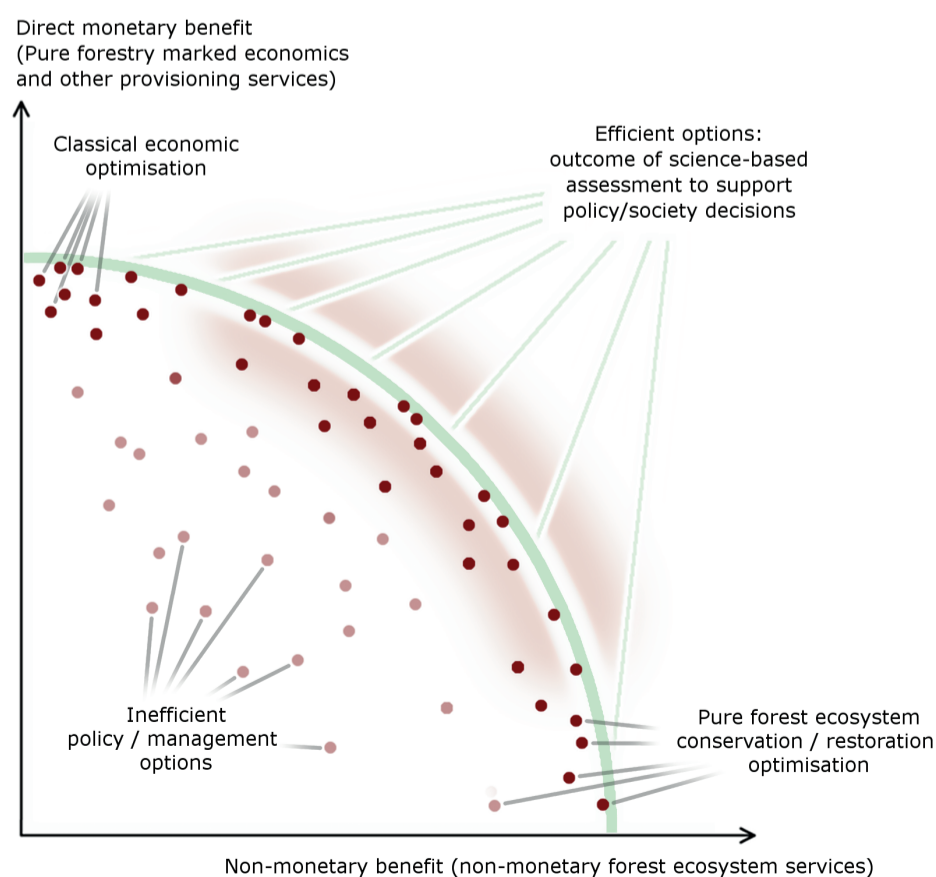


Fig. 4: Integrated forest resources management within the context of a bio-based economy. Qualitative trade-off between monetary and non-monetary benefits. The trade-off emerges considering different optimisation frameworks. Two extreme frameworks optimise policy / management options towards classic economic optimum (forestry marked economics and other provisioning services of forest resources) or instead towards pure forest ecosystem conservation / restoration (maximising non-monetary forest ecosystem services). Intermediate efficient options to support policy and society decisions may emerge with a multi-criteria framework for integrated forest resources modelling and management.
(Author: Daniele de Rigo)

Box 4: Forest-based energy

Forest-based woody biomass is currently the most important source of renewable energy in the European Union (EU), accounting for around half of the total renewable energy consumption. The targets for renewable energy have resulted in a surge in the use of wood pellets within the EU. The EU-28 is the largest global producer of wood pellets, its output reaching an estimated 13.2 million tonnes in 2013; production in the EU-28 rose by 97.6% overall between 2009 and 2013. The EU-28 is a net importer of wood pellets: the level of imports from non-EU Member States rose to 6.4 million tonnes by 2013, which was an overall increase of a staggering 267.6% compared with 2009¹⁹. In countries such as Germany, Austria and Italy, wood pellets are exclusively used in heat production for the residential sector while the industrial use for power generation prevails in the United Kingdom, the Netherlands and Belgium. In Sweden and Denmark, both sectors are well established²⁰. According to the National Renewable Energy Action Plans, biomass used for heating, cooling and electricity would supply about two-fifths of the 20% renewable energy target for 2020. If achieved, the amount of wood used for energy purposes in the EU would be equivalent to today's total wood harvest⁴.

Left: Forest-based production of wood pellets.
(Copyright Richard Sikkema, CC-BY).
Right: wood pellets, detail.
(Copyright Andrew_Writer, CC-BY, <https://archive.is/cv7JF>)



Relationship between bioeconomy and non-monetary aspects of forest ecosystem services

Aside from the monetary value associated with forest resources considering the wide variety of industry products, energy and bio-based assets, forests provide important non-monetary services to the economy and society (see previous chapter).

As discussed, a forest bio-based economy already considers some crucial aspects linked to sustainability and to minimising energy consumption and waste material production; e.g. emphasising the role of chaining processes so that materials discarded by one process become inputs for another process, or so that they can be reused in the ecosystem. In a wider perspective on the overall role of forest resources, the monetary benefits associated with the bioeconomy may be considered together along with the ecosystem services which forests can provide to the society. There is a partial overlap between these two concepts, highlighted by the clear monetary value of some ecosystem services (e.g. recreational activities and the tourism industry/sector). However, a significant part of forest ecosystem services provides a non-monetary benefit which requires a sometimes quite challenging²¹ multi-criteria economic framework to be properly assessed²²⁻²⁴. A few examples of this last category are summarised below.

One of the major sources of damage to soil resources in Europe, unfortunately leading to surprisingly high direct and indirect costs, is due to soil erosion by rainfall and runoff and its monetary and non-monetary impacts^{25, 26}. Landslides are also associated with considerable costs^{27, 28} and the impact of both erosion and slope instability hazards may occur together with even greater effects²⁹. The multiple layers of vegetation in a typical forest (canopy, sub-canopy or midstorey, shrub understorey and ground-layers) make a significant contribution to reducing the potential erosion caused by rainfall^{30, 31}. Forest soil and topsoil are also able to reduce the surface runoff mitigating the risk of both erosion and slope instability³².

Moreover, the soil layers of forests have a high filtering capacity regarding most of the chemical components of pollutants³². In Europe, 65% of public water supplies come from groundwater. Part of the remaining water supplies relies on rivers, lakes, water dams and reservoirs, whose water quality critically depends on land use within the catchments³³. Several of the main European cities either obtain a significant proportion of their drinking water from protected forest areas, or explicitly manage forests for watershed protection³³. Furthermore, many European forest authorities explicitly mention watershed functions within their plans³³.

These few examples among many underline the tight relationship between environmental economics and conservation/restoration efforts focusing on key functional aspects of healthy forest ecosystems. Depending on the society and policy needs, these efforts may require an integrated perspective focusing on both monetary and non-monetary aspects. Research innovation on both forest bioeconomy and ecosystem services may thus contribute to integrated modelling and management of forest resources, providing a science-based support to critical policy and society decisions.

Box 5: Forest resources in bio-based products

Products are considered "bio-based" if they are either wholly or partially composed of materials of biological origins. Bio-based materials should be able to replace fossil fuels on a large scale for chemicals and materials applications. Methods such as fermentation and biological catalysts replace traditional chemical approaches, thus increasing efficiency in processing products and ultimately resulting in reduced resource-use and toxic waste production. A shift towards bio-based products can lower our dependence on fossil fuels. According to the European Commission, bio-based products and biofuels represent approximately EUR 57 billion in annual revenue and involve 300 000 jobs.

Large quantities of different types of base or platform chemicals can be isolated or produced from wood, pulping liquors and different types of forest residues in bio-refineries⁸. Forest products can be used in biopolymers; as phenol substitutes through liquefaction or pyrolysis of forest biomass⁹; as injection moulding for musical instruments; for cups, plates and utensils by mixing natural fibres and plastics; in food, drink and cosmetic industries (tree sap). Slowly, anaerobic digestion-based biorefineries may replace our main source of energy and materials: petroleum. This depends on the efficient conversion of feedstocks, often low-value, into high-value biofuels and bio-based products. These range from municipal and industrial organic wastes, to agricultural and forest residues, and energy crops¹⁰.



(Copyright Agnieska Ovaskainen, CC-BY)

References

- [1] European Commission, Directorate-General for Research and Innovation, S. Nebe, *Bio-based economy in Europe: State of play and future potential - Part 2 Summary of position papers received in response to the European Commission's Public on-line Consultation* (Publications Office of the European Union, Luxembourg, 2011).
- [2] N. Scarlat, J.-F. Dallemand, F. Monforti-Ferrario, V. Nita, *Environmental Development* **15**, 3 (2015).
- [3] L. Hetemäki, ThinkForest seminar "Forests and the bioeconomy: future steps", ThinkForest (European Forest Institute, 2014).
- [4] European Commission, *Communication from the commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A new EU forest strategy: for forests and the forest-based sector*, no. COM(2013) 659 final (Communication from the Commission to the Council and the European Parliament, 2013).
- [5] Eurostat, *Statistics Explained* (Eurostat, 2015), pp. 1195+. Revision 253698 of ch. "Forestry statistics".
- [6] R. Jonsson, *Prospects for timber frame in multi-storey house building in England, France, Germany, Ireland, the Netherlands and Sweden*, vol. 52 of *School of Technology and Design Reports* (Växjö University, Växjö, Sweden, 2009).
- [7] E. Hurmekoski, R. Jonsson, T. Nord, *Technological Forecasting and Social Change* **99**, 181 (2015).
- [8] RoK-FOR Project, *Bio-based products* (2015).
- [9] Y. Zhao, N. Yan, *Journal of Biobased Materials and Bioenergy* pp. 465-480 (2014).
- [10] K. C. Surendra, C. Sawatdeenarunat, S. Shrestha, S. Sung, S. K. Khanal, *Industrial Biotechnology* **11**, 103 (2015).
- [11] Y. Gerasimov, et al., *Making boreal forests work for people and nature*, *Tech. rep.* (2012).
- [12] G. Allard, et al., *State of Mediterranean forests 2013* (FAO, 2013). 177 pp.
- [13] J. C. M. Azevedo, *Inventário de macrofungos em povoamentos de castanea sativa em Trás-os-Montes*, Master's thesis, Vila Real (1989).
- [14] A. F. C. Meneses, *Inventário de cogumelos em souts e castiçais de Trás-os-Montes*, Master's thesis, Vila Real (1990).
- [15] M. M. Garcia, M. Carvalheira, J. C. Azevedo, *Anais da Associação Micológica A Pantorra* **6**, 141 (2006).
- [16] J. C. Azevedo, J. P. Cortez, *Ensino em gestão de recursos florestais na Escola Superior Agrária do Instituto Politécnico de Bragança, Portugal* (Universidade de León, León, 2012).
- [17] E. Gouveia, *Vida Rural* pp. 40-41 (2013).
- [18] Food and Agriculture Organization of the United Nations, *FAOSTAT* (Food and Agriculture Organization of the United Nations, Statistics Division, 2015).
- [19] Eurostat, *Statistics Explained* (Eurostat, 2015), pp. 29576+. Revision 225852 of ch. "Forestry statistics in detail".
- [20] R. Sikkema, et al., *Biofuels, Bioproducts and Biorefining* **5**, 250 (2011).
- [21] T. Kirchoff, *Proceedings of the National Academy of Sciences* **109**, E3146 (2012).
- [22] P. C. Baveye, J. Baveye, J. Gowdy, *Ecological Economics* **95**, 231 (2013).
- [23] J. Hausman, *Journal of Economic Perspectives* **26**, 43 (2012).
- [24] K. M. A. Chan, et al., *BioScience* **62**, 744 (2012).
- [25] G. Verstraeten, J. Poesen, *Geomorphology* **29**, 275 (1999).
- [26] D. Pimentel, *Environment, Development and Sustainability* **8**, 119 (2006).
- [27] L. Vranken, P. Van Turnhout, M. Van Den Eeckhaut, L. Vandekerckhove, J. Poesen, *Science of The Total Environment* **447**, 323 (2013).
- [28] M. Klose, L. Highland, B. Damm, B. Terhorst, *Landslide Science for a Safer Geoenvironment*, K. Sassa, P. Canuti, Y. Yin, eds. (Springer International Publishing, 2014), pp. 661-667.
- [29] C. Bosco, G. Sander, *IEEE Earthzine* **7**, 910137+ (2014).
- [30] D. de Rigo, C. Bosco, *IFIP Advances in Information and Communication Technology* **359**, 310 (2011).
- [31] C. Bosco, D. de Rigo, O. Dewitte, J. Poesen, P. Panagos, *Natural Hazards and Earth System Science* **15**, 225 (2015).
- [32] M. Marchetti, M. Vizzarri, B. Lasserre, L. Sallustio, A. Tavone, *Annals of Silvicultural Research* **38** (2014).
- [33] N. Dudley, et al., *Running Pure: The importance of forest protected areas to drinking water* (World Bank / WWF Alliance for Forest Conservation and Sustainable Use, 2003).
- [34] CEPI Key statistics 2014: European Pulp and Paper Industry



Timber stack, Barrow Haven, United Kingdom.
(Copyright David Wright, CC-BY, <https://archive.is/Mqv4W>)

This is an extended summary of the chapter. The full version of this chapter (revised and peer-reviewed) will be published online at <https://w3id.org/mtv/FISE-Comm/v01/e01a52d>. The purpose of this summary is to provide an accessible dissemination of the related main topics.

This QR code points to the full online version, where the most updated content may be freely accessed.

Please, cite as:

Mubareka, S., Jonsson, R., Rinaldi, F., Azevedo, J. C., de Rigo, D., Sikkema, R., 2016. **Forest bio-based economy in Europe**. In: San-Miguel-Ayanz, J., de Rigo, D., Caudullo, G., Houston Durrant, T., Mauri, A. (Eds.), *European Atlas of Forest Tree Species*. Publ. Off. EU, Luxembourg, pp. e01a52d+

