Earthscan Studies in Natural Resource Management

THE BIOECONOMY AND NON-TIMBER FOREST PRODUCTS

Edited by
Carsten Smith-Hall and James L. Chamberlain

The Bioeconomy and Non-timber Forest Products

The Bioeconomy and Non-Timber Forest Products provides the first investigation into the role of these products in supporting a transition from business-as-usual to a forest-based bioeconomy.

While the bioeconomy is a new concept, more and more countries throughout the world are actively pursuing a transition to this contemporary economic model, and transitioning to a bioeconomy will influence the way forests are managed and conserved. The present book brings together critical analysis from diverse countries, products, and experiences, learning from research and practices, and providing insights into transition pathways. The introductory chapter presents key concepts and issues, followed by three parts. The first part establishes where we are using examples from five continents to assess how non-timber forest products are integrated into bioeconomic strategies. In the second part, chapters present how we move forward by delving into transition pathways and providing examples of activities supporting sectors and countries in moving towards the bioeconomy. Finally, chapters in the third part uncover tools and technologies to help transitions. Each chapter concludes with key messages for the bioeconomy and non-timber forest products, with the final chapter highlighting central findings and discussing ways forward.

The book is an essential resource for academics, professionals, and policymakers interested in learning about and supporting a transition to a forest-based bioeconomy, including students and scholars of forest and natural resource management, bioeconomics, circular economy, and ecological economics more widely.

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Foreword

The bioeconomy is a new approach to promoting the sustainable development of human society and the economy. It integrates sustainable and renewable biological resource uses with economic development, providing employment opportunities and creating wealth while facilitating sustainable management of resources and environmental protection. Non-timber forest products, or NTFPs, are the biological resources produced by plants, fungi, lichens, and animals and used by humans for a diverse range of purposes, including food, fuel, and medicine, all constituent parts of the bioeconomy. In the context of climate change, landscape degradation and other environmental challenges, the pursuit of a sustainable bioeconomy is a global issue. However, there is insufficient awareness and action on integrating NTFPs into the bioeconomy, and national level evaluations of NTFPs are missing or of low quality.

To fully understand whether and how NTFPs have been integrated into global and national efforts to transition to and expand the bioeconomy, and how such efforts can be supported, the IUFRO Task Force "Unlocking the Bioeconomy and Non-Timber Forest Products", with more than 70 outstanding scientists around the world, has done a great deal of research on this topic. Based on a wide range of case studies, under the leadership of Carsten Smith-Hall and James Chamberlain, the Task Force Coordinators, the Task Force completed this seminal book.

This book provides the first comprehensive global assessment of the bioeconomy with NTFPs. Building on reviews and new empirical findings from five continents, the book explores bioeconomy transition pathways integrating NTFPs and provides insights on tools and technologies that can facilitate the bioeconomy transition.

As the IUFRO Vice-President for Task Forces, Special Programmes, Projects and IUFRO-led Initiatives, I express my sincere gratitude and congratulations to the authors excellent work. The book will be of great value to anyone concerned with the bioeconomy, from researchers to students and policymakers, practitioners, and investors. It will contribute to increasing public recognition of the importance of the bioeconomy and the roles of NTFPs in facilitating bioeconomy transitions and encourage forestry and

other natural resource institutions to take actions to develop the effective integration of NTFPs into local, regional, and national policies.

Shirong Liu
IUFRO Vice-President for Task Forces, Special Programmes, Projects and IUFRO-led Initiatives
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Preface and Acknowledgements

The use of forests is as old as humankind. For tens of thousands of years, forests have been cleared, modified, and used for food, shelter, and warmth, with "barely a tool or weapon that did not have a wooden part" (Williams, 2003: 26), in temperate and tropical parts of the world, on six continents (Roberts et al, 2017). Non-timber products were widely used and important in everyday life, including utensils, food, and medicine. The 5000-year-old Tyrolean Iceman found in the European Alps had a bow and an axe handle made from yew, a knife with an ash wood handle, arrows with viburnum and dogwood shafts, arrowheads fixed with birch-bark-tar, and carrying dry deer meat and a prune, roe deer antlers, birch bark baskets, and fungi for medicinal and fire-making purposes (Capasso, 1998; Wierer et al, 2018). The use of non-timber forest products throughout the world has continued to the present day, with more than five billion people using them (Shackleton and Vos, 2022). Contemporary patterns of use and importance vary, from occasional subsistence use in Western Europe (Lovrić et al, 2020) to being of central economic importance to rural livelihoods around the Serengeti National Park in East Africa (Jiao et al, 2019); different ways of carrying on uses of non-timber forest products that started before the first village on the planet came into being.

On the other hand, the bioeconomy, and in particular the forest-based bioeconomy, here considered "the set of economic activities to grow, harvest, process, reuse, recycle, and sell forest products and associated forest ecosystem services" (Piplani and Smith-Hall, 2021: 3) is a phenomenon of the 21st century. The linkages between non-timber forest products and the bioeconomy are unexplored and enigmatic. Uncovering, describing, and making these connections visible is an opportunity to make forests relevant to contemporary global challenges – curbing deforestation, mitigating climate change, halting biodiversity losses, and reducing poverty. This book contributes significantly to this effort, providing for the first time explicit analyses of non-timber products and the forest-based bioeconomy. Going beyond academic rigour and sharing the state of knowledge, each chapter ends with key messages for the bioeconomy and non-timber forest products, emphasising policy relevance.

The book results from a large global collaborative effort coordinated by the International Union of Forest Research Organisations (IUFRO) Global Task Force on "Unlocking the bioeconomy and non-timber forest products". It represents the collective output of 48 experts from six continents with diverse backgrounds, leaving their comfortable disciplinary silos to engage with the challenges of understanding and sharing linkages between non-timber products and the forest-based bioeconomy.

We thank the many IUFRO Global Task Force members and the hundreds of participants in the Task Force's monthly webinars – the talks and the discussions are inspiring. We are grateful to the IUFRO leadership for their support in establishing the Task Force and implementing its work. We also extend our thanks to the reviewers of individual chapters and the entire book manuscript. Finally, we thank Hannah Ferguson and Katie Stokes at Routledge for their support – and patience – during the publication process. The finalisation of the book manuscript was financially supported by the Independent Research Fund Denmark (Grant No. 0217 – 00158B).

Carsten Smith-Hall and James Chamberlain
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Acronyms and Abbreviations

AAFC	Agriculture and Agri-Food Canada
AEZ	Agro-ecological zone
BC	British Columbia
CAD	Canadian dollar
CCFM	Canadian Council of Forest Ministers
CDMX	Mexico City
CIFOR	Center for International Forestry Research
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CNTR	Centre for Non-Timber Resources
CO_2	Carbon dioxide
EC	European Commission
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FFU	Research Committee for Development Research of the Danish Ministry of Foreign Affairs
FBWG	Forest Bioeconomy Working Group
ForestAr	Strategic Forestry and Industrial Forest Plan Argentina 2030 Initiative
GDP	Gross Domestic Product
GIS	Geographic Information System
HH	Household
HDI	Human Development Index
IBF	International Bioeconomy Forum
IBGE	Instituto Brasileiro de Geografia e Estatística
ICRAF	World Agroforestry Centre
IICA	Inter-American Institute for Cooperation on Agriculture
INBAR	The International Bamboo and Rattan Organisation
IRR	Internal Rate of Return
IUFRO	International Union of Forest Research Organizations
Luke	Natural Resources Institute Finland
MPBA	Map of Argentine Bioeconomy Potential

MINCyT	Ministry of Science, Technology and Productive Innovation of the Nation
MS-NFI	Multi-Source National Forest Inventory
MX$	Mexican peso
NFI	National Forest Inventory
NGO	Non-Governmental Organisation
NPV	Net Present Value
NTFPs	Non-timber forest products
OECD	Organisation for Economic Co-operation and Development
PAGE	Partnership for Action on Green Economy
PPP	Purchasing power parity
PROFEPA	Procuraduría Federal de Protección al Ambiente
PSMNR	Program for the Sustainable Management of Natural Resources
RMB	Renminbi (the official currency of the People's Republic of China)
SAGARPA	Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación
SCLU	Social, Cultural, and Land Use
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
SDGs	Sustainable Development Goals
SFM	Sustainable forest management
SIDRA	Sistema IBGE de Recuperação de Dados Agregados
SMEs	Small and medium-sized enterprises
SNIF	Sistema Nacional de Informações Florestais
SWOT	Strengths, weaknesses, opportunities, threats
Spp.	Species pluralis
UNDP	The United Nations Development Programme
UNEP	The United Nations Environment Programme
UNRN	Universidad Nacional de Rio Negro
USD	United States dollar
USUBI	Uso sustentable de la biodiversidad
WEF	World Economic Forum
WoS	Web of Science
WWF	World Wildlife Fund

Introduction

1 Why focus on non-timber forest products in the bioeconomy?

Carsten Smith-Hall and James Chamberlain

Reality check: hidden products and emerging opportunities

We know little about most forest products in the world. Production of a limited number of commercial (mainly timber) species is well investigated and supported by detailed inventory data, silvicultural systems and specific management guidelines, with well-established value chains. But the distribution, ecology, and management of most species supplying forest products remain poorly understood, as do the associated production networks. For instance, of more than 50,000 plant species used for medicine globally, about 2500 are internationally traded in value chains that are, for the most part, unknown, with very few species in cultivation (Schippmann et al, 2006). For almost all wild-harvested species (mainly non-timber), there is no or little data on harvest volumes, available stock, possible yields, or sustainable harvest levels. Knowledge about management interventions, production network structures, and demand drivers is severely lacking. This is true, even though more than 1.6 billion people in the world are forest-proximate (Newton et al, 2020), that forest income makes up an astonishing 22% of total household income for rural people in the tropics and subtropics (Angelsen et al, 2014), and that forest products may be important in filling income gaps and providing safety nets (Wunder et al, 2014). The generation of species-level data is impaired by the objectives and financial limitations of many research studies leading to the collection of aggregated data, e.g. on fuelwood income, not allowing breakdown to the species level. This is further compounded by the difficulties in collecting data on a wide variety of products available at different times of the year, although recent advances in developing methods at the household and national levels (Angelsen et al, 2011; FAO, 2016) are evident. The result is that most species and associated products remain invisible. Consequently, and paradoxically, most species and products are overlooked when developing forest-related policies and programmes. This is true also for recent advances to define and implement the bioeconomy.

The result is a lack of focus on emerging opportunities. Unlocking the bioeconomy to include all forest products and users may contribute to solving global challenges. Arguably, making non-timber forest products (NTFPs)

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visible would increase the value of standing forests, which could reduce deforestation and biodiversity losses, adverse climate effects, and decreases in environmental incomes. Existing bioeconomic strategies pay limited attention to combining economic growth and sustainable natural resource management (Georgeson et al, 2017) while forests continue to be degraded and disappear (Vancutsem et al, 2021), with tropical forest carbon loss a major source of global emissions (Feng et al, 2022) and driving biodiversity decline (Maxwell et al, 2016). As many as five billion people may use NTFPs (Shackleton and Vos, 2022), and these products provide significant income sources in tropical and temperate regions (Angelsen et al, 2014; Lovrić et al, 2020). This provides a solid argument for doing better with what we have – non-timber forest products have a substantial and unrealised role in contributing to a greener and more sustainable future.

Much more than the current approach: the allure of a forest-based bioeconomy

Interest in the bioeconomy is increasing rapidly, as evident by the annual number of peer-reviewed publications in the past decade (Fig. 1.1). This interest is found across a large number of (Web of Science) categories, dominated by green sustainable science technology, environmental sciences, biotechnology applied microbiology, and energy fuels. Also, there is increasing interest in the bioeconomy within forestry, with the annual number of forest-based bioeconomy publications rising from 0 in 2014 to 40 in 2020.

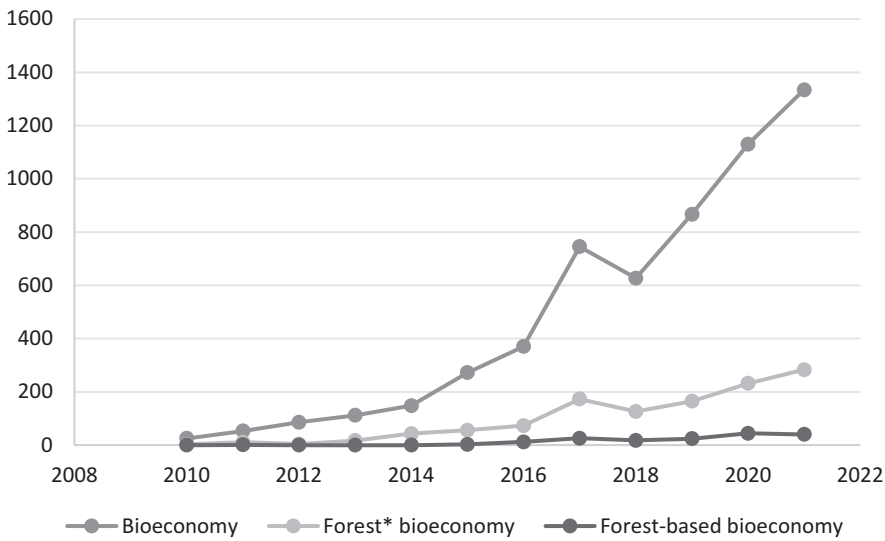

Figure 1.1. The number of publications registered in Web of Science 2010–2021 on "bioeconomy" (n=5769), "forest* bioeconomy" (n=1186), and "forest-based bioeconomy" (n=168).

Despite the growing interest in the bioeconomy, it is not well defined. This has advantages and disadvantages. The main benefit is that many different stakeholders can identify with the concept that is then applied across a wide range of sectors (D'Amato et al, 2017), resulting in broader attention to the bioeconomy. The main disadvantage is that two bioeconomy studies (or researchers) may focus on topics so far apart that it is hard to spot common ground. For instance, two of the most cited bioeconomy publications are Vaaje-Kolstad et al (2010), describing an enzyme acting on the surface of crystalline chitin, and McMichael (2012), providing a Marxist inspired criticism of neoliberal responses to rising food prices. The bioeconomy can thus appear in many guises, ranging from being indistinguishable from the regular market economy to being an integrated part of a decoupling circular economy concept, addressed by widely different lines of thinking and methods from both the natural and social sciences.

This book focuses on the emerging subject of the forest-based bioeconomy, recently defined as "the set of economic activities to grow, harvest, process, reuse, recycle, and sell forest products and associated forest ecosystem services" (Piplani and Smith-Hall, 2021: 3). This is more operational and tangible than wider bioeconomy definitions, including that proposed by the European Union (EU, 2018) leading to the above-outlined difficulties in creating a common understanding of the bioeconomy, while still allowing for a broad range of approaches. Piplani and Smith-Hall (2021) identified five distinct approaches to a forest-based bioeconomy, varying across seven variables (the paradigmatic belief system, public policy goals, final product or service sold, key stakeholders, transition pathways, the informal economy, and the strength of the link to environmental sustainability). Approaches range from the technocratic biotechnology school emphasising economic growth, development of new high-value products, large companies, and weak sustainability linkage to the eco-society school focused on degrowth, organic products, sustainable consumption, and strong sustainability attention. However, the past focus in the forest-based bioeconomy literature has been overwhelmingly on biotechnological approaches (Jankovský et al, 2021).

A forest-based bioeconomy is thus much more than the opportunity to use bio-based materials to replace fossil energy sources or wood products to substitute greenhouse gas-intensive products. A forest-based bioeconomy is an opportunity to rethink, reinvent, and reposition the forest sector in relation to the global mega-challenges – halting biodiversity losses and eliminating poverty. This menu of possible positive outcomes makes a forest-based bioeconomy attractive. Realising these positive outcomes requires a renewed focus on sustainable forest management, sustainable forest incomes and industries, and sustainable forest products consumption (recognising that an important initial step is the need to develop and agree on operational sustainability measures). These sustainability outcomes cannot be achieved as long as most forest products are ignored. Increased attention must be paid

to the vast group of non-timber forest products. There are isolated examples of the nationwide economic importance of NTFPs, including shea (*Vitellaria paradoxa* C.F. Gaertn.) nuts in Burkina Faso (Wardell et al, 2021) and the Chinese caterpillar fungus in the Himalayas and Tibet (Smith-Hall and Bennike, 2022). But these have not been integrated into any explicit bioeconomic thinking or analysis.

We can do better with what we have! A forest-based bioeconomy with non-timber products

We acknowledge the widespread dissatisfaction with the term "non-timber forest products". While this term (and its allied versions, such as non-wood forest products) has been used for decades to group a wide range of products, ranging from fungi to medicinal plants and firewood, there is no common agreement on definitions and what products are/should be included. There have been many attempts to clarify the term (Belcher, 2003; Ahenkan and Boon, 2011; Muir et al, 2020) and move towards a unified definition (Mantau et al, 2007; Shackleton et al, 2011). However, challenges remain. For instance, the sectoral limitation of the term to forests is artificial for many products harvested both inside and outside forests, particularly in places where the latter may be significantly more important such as in sub-Saharan West Africa (Pouliot and Treue, 2013). However, resolving the NTFP definitional issue is not the purpose of this book. Our emphasis is on investigating the links between non-timber products and a forest-based bioeconomy, not providing a general delimitation of the NTFP term. The product cases included in the chapters of this book are all forest harvested. The authors of this chapter view NTFPs as "all biological materials other than timber which are extracted from forests for human use" (De Beer and McDermott, 1996: 24), while subsequent individual chapters may present other (allied) definitions. Following the Global Forest Resources Assessment 2020 (FAO, 2018: 4), this book considers forests as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use".

While being used throughout the world (e.g. Shackleton et al, 2011; Angelsen et al, 2014; Lovrić et al, 2020), NTFPs are mostly not considered in official policies (Laird et al, 2011; Muir et al, 2020). Hence, the NTFP Paradox. As many as five billion people may use NTFPs (Shackleton and Vos, 2022), their global annual value has been conservatively estimated at USD 7.7 billion (FAO, 2020), and rural household-level NTFP income in the tropics and subtropics is almost as important as agricultural income (Angelsen et al, 2014) – so why are these products not given more attention? Part of the explanation lies in the huge number of products; their aggregated importance may be high, although individual product groups and species may be

of low importance. For instance, in a study of 8000 households in 24 countries, Hickey et al (2016) found that 77% were involved in wild food collection even if the wild food income only averaged 4% of total household income. Also, products are dispersed spatially and temporally and thus hard to capture in surveys. This makes official estimates too low, whether in national or global statistics. In addition, many NTFP uses and values are hard to capture, such as for sacred goods (Wunder et al, 2011). Coupling NTFPs to the emerging forest-based bioeconomies around the world is an opportunity to improve the collection of their statistics to make these products more visible and integrate them into new initiatives receiving recognition and funding.

Attention to NTFPs in the forest-based bioeconomy has increased in the last couple of years. The Food and Agriculture Organization of the United Nations (FAO) recently published a report on forest products in the global bioeconomy (Verkerk et al, 2022); while the emphasis is on timber and related traditional products such as wood pulp, the report includes a box on NTFPs and a section dedicated to global resin production, trade, and consumption. The Center for International Forestry Research (CIFOR) report on the forest-based bioeconomy in sub-Saharan Africa (Rosa and Martius, 2021) found NTFPs to constitute an important pathway to the bioeconomy, noting challenges in terms of governance structures, the informality of tenure and trade, widespread rent-seeking, and lack of skills to promote sustainable production networks. NTFPs in the EU bioeconomy have been briefly treated in Wolfslehner et al (2019) and touched upon for the Czech Republic in Purwestri et al (2020), while Di Cori et al (2022) progress to propose a framework for quantifying the bioeconomic importance of NTFPs in the EU. The body of knowledge that combines NTFPs and the bioeconomy is minimal, while there is considerable separate literature on NTFPs and bioeconomies, indicating substantial scope for learning using existing studies by bringing these fields together in joint analyses.

The purpose of this book

This book provides the first explicit in-depth investigation of how non-timber forest products are part of local, national, and global bioeconomies, and a concerted effort to identify interventions to support the transition to a forest-based bioeconomy. Each chapter ends by drawing out the key messages for the bioeconomy with NTFPs.

The book examines three central themes:

- Theme 1: Where are we? Using examples from five continents, this assesses approaches to integrating NTFPs into bioeconomic strategies and provides national and supranational level overviews of the current acknowledgement and importance of NTFPs in the bioeconomy. The theme details recent advances as well as ongoing changes.

- Theme 2: How do we move on? Using examples from Africa, Asia, and Latin America, this part delves into transition pathways, providing examples of bundles of NTFP related activities that support sectors and countries in moving towards the bioeconomy.
- Theme 3: What tools and technologies can help transitions? These texts identify and exemplify interventions supporting NTFP-based transitions to the bioeconomy, such as integrating NTFP and timber objectives in forest management or using mobile technologies to increase production.

The book has four distinctive features relative to the existing literature:

- It enters and maps unknown territory as scholarship on the bioeconomy with non-timber forest products is virtually non-existent.
- Through its integrative approach (covering and integrating assessment of bioeconomy resources and strategies, identifying and describing bioeconomic transition pathways, and presenting tools and technologies to assist transitions) and inclusion of diverse studies, it moves beyond the dominant biotechnological approach to the bioeconomy, expanding scholarship to other ways of thinking about and approaching the bioeconomy.
- Through its global coverage, the book expands the scholarship on the bioeconomy beyond the current primary focus on Western and Northern Europe.
- The methods in the chapters are centred on literature reviews that combine knowledge on NTFP-bioeconomy linkages and/or new empirical in-depth data at a fine scale. The book thus grounds advances in new reviews and empirically derived knowledge, explicitly focusing on operationalising a forest-based bioeconomy, including sustainable forest management interventions and embracing social and cultural integrity issues.

The book is built around a string of (empirical) cases from five continents that engage with the bioeconomy relative to non-timber forest products: (i) *theoretically*, to define and characterise the role of these products in transitioning to a bioeconomy; (ii) *empirically*, through analysis of how and to what degree the products contribute to a bioeconomy, and; (iii) *practically*, by identifying interventions to support the integration of the products into bioeconomy strategies.

The primary audience is professionals interested in non-timber forest products and the sustainable management of these resources to enhance the biological and economic dynamics of their harvests, in this process contributing to establishing a bioeconomy that embraces more than the wood products from forests. This may include students, researchers, forestland managers, and policymakers interested in interdisciplinary studies, across the natural and social sciences divide. In terms of disciplines, the book is relevant to agronomists, anthropologists, economists, environmental scientists, foresters, geographers, and other resource management fields.

A secondary audience is practitioners in government agencies, international aid agencies, and NGOs involved in project implementation. The book speaks directly to policymakers working toward integrating NTFPs into the sustainable management of forests and promoting a forest-based bioeconomy.

Getting together. The IUFRO Global Task Force: unlocking the bioeconomy and non-timber forest products

In June 2019, the Board of the International Union of Forest Research Organizations (IUFRO) commissioned a Global Task Force to investigate whether and how non-timber forest products have been integrated into global and national efforts to transition to and expand the bioeconomy and how such efforts can be supported. The Global Task Force comprises over 70 experts (from more than 20 countries) charged with reviewing the state of knowledge, identifying research gaps, advancing empirical analysis, examining challenges and opportunities, and developing recommendations to advance the harmonised integration of non-timber forest products into the national and global bioeconomies. More than 40 authors from six continents, primarily drawn from this pool of experts representing the leading scholars in this area, have contributed to this book. The task force is facilitating dialogue with a global interdisciplinary and cross-sectoral network of researchers working on the interfaces of markets, products, policies, and forest resources and engaging colleagues in discussions and examinations of issues related to non-timber forest products and the bioeconomy, including through an open monthly webinar series.

Structure and content of this book

Changing a country's economic trajectory to embrace elements of the bioeconomy is challenging. Nations and people must seek new ways to produce and consume resources sustainably. The forest-based bioeconomy offers an opportunity to reduce the environmental impacts of economic growth through science-based management facilitating sustainable utilisation, including of NTFPs. In pursuit of this, the book focuses on the above three themes. Fig. 1.2 presents an overview of bioeconomic themes, chapters, featured NTFPs, geographical coverage, and methods.

Theme 1 presents studies looking into the present state of the bioeconomy in a range of locations (countries or regions) to visualise and illustrate the importance of NTFPs and the linkages between these products and the bioeconomy. In Chapter 2, Marko Lovrić and co-authors draw on work on NTFPs in Europe, from Portugal to Russia, to identify commonalities and patterns that can inform the integration of NTFPs into the ongoing work to develop European bioeconomies. In Chapter 3, Sen Wang and co-authors document the lack of focus on NTFPs in developing the Canadian

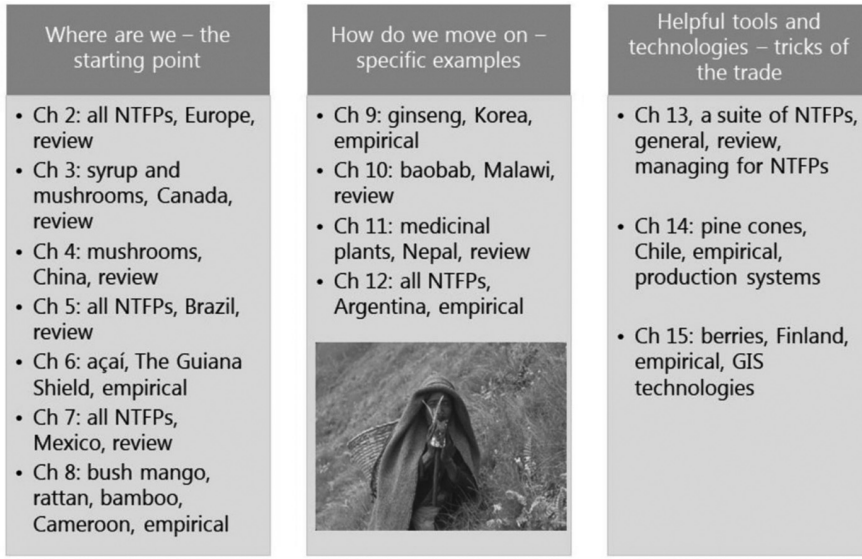

Figure 1.2. Overview of bioeconomic themes, chapters, featured NTFPs, geographical coverage, and methods (photo: © Carsten Smith-Hall).

bioeconomy in the past two decades, paying particular attention to the potential for supporting the livelihoods of the First Nations. In Chapter 4, Jun He highlights the importance of indigenous institutions and knowledge in relation to the sustainable use of commercial NTFPs in promoting bioeconomy development in southwest China. In Chapter 5, Sandra Afonso and co-authors supply insights into the main NTFPs relevant to the Brazilian bioeconomy and identify activities that can integrate the two. Staying in South America in Chapter 6, Janaína Diniz and Nathalie Cialdella use the example of the conservation and trade of the açaí palm in French Guiana, Surinam, and northern Brazil to shed light on the importance of cultural aspects and market dynamics to facilitate the development of a bioeconomy that benefits marginalised local populations. In Chapter 7, María Teresa Pulido Silva and Daniela Ortega Meza review more than two decades of official NTFP statistics in Mexico and find that the official reporting system needs revision, as does the approach to the bioeconomy, needing to pay more attention to issues of poverty alleviation, resource sustainability, and secondary processing. Lastly, in Chapter 8, Jude Kimengsi and co-workers provide empirical insight into the forest-based bioeconomy of Cameroon, focusing on bush mango, rattan, and bamboo, identifying challenges linked to the NTFP-based bioeconomy transitioning.

Theme 2 contains four studies examining how to facilitate the transition to an NTFP inclusive bioeconomy. In Chapter 9, Mi Sun Park and Hansol Lee use the case of wild-simulated forest-grown ginseng in South Korea to

identify a three-phased activity-based pathway to revitalise the ginseng industry and transit to a forest-based bioeconomy, focusing on developing a stable production system, improving value chains and export conditions, and supporting the development of the ginseng biotechnology-based industry. In Chapter 10, Dietrich Darr and co-authors examine the production, processing, and commercialisation of baobab in East Africa, focusing on how innovative bio-based products, the principles of cascading use, renewable energy, and the circularity of nutrients constitute pathways to move toward the forest-based bioeconomy. In Chapter 11, Meenakshi Piplani and Carsten Smith-Hall present a framework for analysing the transitioning to the forest-based bioeconomy and apply it to the case of commercial medicinal plants in Nepal, identifying four bioeconomic transition pathways: cultivation, decentralised resource management, developing the domestic processing industry, and establishing regional collaboration. The theme ends with Chapter 12, where Sandra Sharry, Patricia Boeri, and Natalia Raffaeli provide a specific example of the process of integrating NTFPs into the Argentinean bioeconomy at the national and sub-national levels.

Theme 3 presents three examples of tools and technologies that can assist in a forest-based bioeconomy transition. In Chapter 13, Michelle Balasso and co-authors integrate the concepts and principles of forest management, NTFPs, and the bioeconomy, arguing that the transition can be facilitated through combining silvicultural management of non-timber and timber species with the use of governance mechanisms that consider socio-economic and legislative actions. In Chapter 14, Verónica Loewe-Muñoz and Claudia Delard investigate the economics of stone pine nut production under different management schemes in Chile, arguing that cultivation incentives and fostering stakeholder involvement to reach a critical production area and volumes, supported by science-based technological innovation, facilitate the transition to a bioeconomy. Lastly, in Chapter 15, Rainer Peltola and co-authors show how citizen science and GIS-based approaches and tools can be combined and applied to increase the production of wild berries and strengthen the integration of NTFPs into the Finnish bioeconomy.

Key messages for the bioeconomy and NTFPs

- Integrating NTFPs into the bioeconomy presents opportunities to make their values more visible, reinvent thinking and approaches in the forest sector, and increase forests' contributions to global challenges like biodiversity conservation and poverty eradication.
- These opportunities have not been realised. Characterising, defining, and developing the forest-based bioeconomy concept is still emerging, and there is almost no consideration of the bioeconomic role of NTFPs.
- The potential of a (forest-based) bioeconomy goes beyond the current dominant emphasis on biotechnology and the geographical limitation to northern and western Europe.

- This book provides the first global approach to thinking about and integrating NTFPs into a forest-based bioeconomy. Based on a diversity of studies, it covers and integrates the assessment of bioeconomy resources and strategies, identifies and describes bioeconomic transition pathways, and presents tools and technologies to assist transitions.

Note

The findings and conclusions in this publication are those of the author(s) and should not be construed to represent any official USDA or U.S. Government determination or policy.

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An operational transition pathway to a forest-based bioeconomy: lessons from the wild-simulated ginseng industry

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The potential of non-timber forest products to contribute to the bioeconomy transition: the example of baobab (Adansonia digitata L.) in Malawi

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