



# Forest entrepreneurship: A bibliometric analysis and a discussion about the co-authorship networks of an emerging scientific field<sup>☆</sup>

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## ABSTRACT

Forest management has been recognized as a significant challenge for various scientific fields, namely because the difficulties in creating employment and economic dynamics in the forestry sector. Actually, it is not easy to generate more returns, in this sector, for the land owners, in addition to the production of wood after several years, depending on the produced species. In general, these difficulties lead to the land abandonment and a large set of associated problems like the forest fires. The main objective of this research is therefore to highlight the main insights from the literature related with the forest entrepreneurship, as supports for the several stakeholders, namely the policymakers, stressing the main gaps in the current scientific literature. In this paper, we have developed a bibliometric analysis through the VOSviewer software, complemented with a literature review, considering 83 articles obtained from the Web of Science (core collection) and Scopus related with the topic of 'forest' and 'entrepreneurship'. We detailed the networks of Journals, Countries, Terms and Authors that have been researching and publishing in the scientific domains of 'forest entrepreneurship'. Additionally, we studied measures of social networks analysis for each case. This kind of analysis for these topics has a particular novelty, because there is still a significant scarcity of studies addressing these approaches. In fact, searching, for example, in WOS (all databases) for the topics 'forest', 'entrepreneurship' and 'bibliometric' we found zero documents (the same for Scopus platform, considering the article title, abstract and keywords). We concluded that the recent field of 'forest entrepreneurship' has allowed a higher level of co-authorships and a lower level of centrality in the citations' network. We identified, also, that there are some gaps in the scientific literature, namely related with the few multidisciplinary networks outside the forest sciences in these topics. Finally, we observed that these topics are related with authors who, on average, published with 9 co-authors along their career and that authors working on the most generic topic of 'forest' tend to have 17 different co-authors, reinforcing the characteristics of 'forestry entrepreneurship' as a relevant but emerging scientific field.

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## 1. Introduction

Forest entrepreneurship has been pointed as a promising solution for some of the problems in the forestry sector, in which it is

not easy to increase the socioeconomic dynamics, bringing more economic activities and creating more employment (Shyamsundar et al., 2020), including a higher support in the markets promotion (Wulandari and Kurniasih, 2019). In general, forest land manages to

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produce wood after, often, great periods of income absence and sometimes interrupted by biotic (diseases and pests) and abiotic (forest fires) weaknesses. These contexts lead to, frequently in a vicious cycle, to land abandonment and to the loss of dynamics in the sector. The great challenge is therefore to find new ideas and bring innovation and entrepreneurship to the sector in a framework of multifunctional forest management, where the production of wood may be complemented with the production of other goods and services (Martinho, 2017).

Bibliometric analyses are appropriate approaches to highlight the main outcomes from the literature in a structured way (Guan et al., 2019) and to reveal the main knowledge gaps (Leal et al., 2019). However, through a preliminary analysis, it seems that few researches stressed the main insights from the literature about the topic “forest entrepreneurship” in a systematic and quantitative way.

In this context, it seems promising to highlight the main insights produced by the scientific literature about forest entrepreneurship around the world, supporting the several stakeholders to find and implement new ideas in the forest land. On the other hand, these insights may be considered as the basis for the design of more adjusted policies for the sector. Actually, forest policies are usually more concerned with the problem of forest fires in a reactive perspective (creating new and in a greater number of policy instruments after relevant damages from big forest fires). More proactive forest policies, namely directed for a more multifunctional forest management, will be more effective in the prevention of forest fires, because they are able to bring more investors to the forest and reduce the fuel load (Mourao and Martinho, 2019).

It is, also, objective of this research to reveal the main gaps in the literature related with the forest entrepreneurship, giving challenging perspectives for future works that may be performed to improve the knowledge and information.

To achieve these objectives, this work is based on a bibliometric analysis, complemented with a literature review. For that, all articles obtained from the Web of Science (2019) were analyzed firstly, through the VOSviewer (2019) software and after explored through a systematic literature review. These articles were obtained from the Web of Science for the following topic fields: ‘forest’ and ‘entrepreneurship’. All information available were considered by 30th of June of 2019 and was restricted to articles published in English. Scientific information from the Scopus (2019) database was also considered, using the same keywords. The bibliometric analysis for the issues related with the primary sector was performed by authors such as, for example, Martinho (2018, 2019). These works stressed the importance of the bibliometric analysis, not only to bring an enlarged insight about the topics addressed, but also to better perform and organize the literature survey. Additionally, we wanted to analyze an emerging scientific field, as we will prove through the remaining document, with the potentialities that only a systematic bibliometric review can enhance. Highlighting the most dominant journals in the literature, the most productive authors in the field or the most used terms (namely in the articles’ titles, abstracts and keywords) can enlighten us about the trend the research is taking.

After this introduction, the remaining parts of this study are dedicated to the history of scientific thought regarding entrepreneurship, forest studies and the derived field – forest entrepreneurship. Section 3 provides the bibliometric analysis and the test of our two major hypothesis – the scientific novelty of Forest Entrepreneurship leads to particular characteristics of the associated networks of authors and co-citations, namely the existence of a lower number of central authors (H1) and to a higher number of co-authorships (H2). Section 4 provides conclusions, challenges

and implications.

## 2. Forest & entrepreneurship – the late marriage of two engaged dimensions

### 2.1. From ‘forest’ and ‘entrepreneurship’ to ‘forest entrepreneurship’ – an attempted scientific genealogy

‘Entrepreneurship’ is a mature scientific field in Social Sciences. Actually, we can identify as one the oldest related publications the Schumpeterian book of 1911 ‘Theory of Economic Development’. Here, in our paper, we identify as Entrepreneurship the capacity of individuals and their groups of generating different opportunities of resources and processes able to increase either the quality of life of the community as the value of the distributed income. Regarding bibliometric studies focused on Entrepreneurship, we have to recognize entrepreneurship as a transversal topic that crosses several disciplines and in the scientific literature it is possible to find studies applied to the various dimensions of the science, considering several approaches, including bibliometric assessments (Gartner et al., 2006). Emerging areas – as Social entrepreneurship – have, alternatively, gained their own relevance in the scientific literature (Rey-Marti et al., 2016).

Bibliometric analysis, named for the issues related with the agroforestry sector, gained relevance in recent times (Aleixandre-Benavent et al., 2017), opening new perspectives of analysis (Aleixandre-Benavent et al., 2018), allowing researchers to assess new trends in the fields of research (Bullock et al., 2018) and providing additional ways for future works (Bullock and Lawler, 2015).

These approaches bring new tools that may support better organizations of the literature review (Leal et al., 2019). On the other hand, there are, yet, gaps in these fields that justify more studies for the agroforestry and related subjects, considering bibliometric analysis (Arbelaez-Cortes, 2013). The forest ecosystems (Aznar-Sanchez et al., 2018) or the ecosystems services in general (Droste et al., 2018), are, for example, relevant issues where the bibliometric analysis may bring stimulating insights.

The main databases used for the bibliometric analysis are often the Web of Science and the Scopus (Aznar-Sanchez et al., 2019), but, also, Google Scholar, for example (Boanares and de Azevedo, 2014). There are several approaches and tools to perform bibliometric assessing such as, for example, BibExcel, VOSviewer and HistCite (Guan et al., 2019). The search of the terms in these assessments is one of the first steps and is crucial for the robustness of the analysis (Liu et al., 2011).

Sometimes, the bibliometric analysis is combined with other approaches, such as, for instance, the literature review (Zhang et al., 2019a) and often is performed to assess the outcomes from several world countries, authors, and publications, and to analyze citations, co-authorships and terms co-occurrence (Zhang et al., 2019b).

For the agricultural sector, previous attempts of bibliometric analysis revealed that it is possible to identify different groups related to heterogeneous skills, strategies and relations with the community (Dias et al., 2019). For rural entrepreneurship, previous studies showed that the creative rural development has emerged as an objective of research for some European authors affiliated, namely, with British and Spanish institutions (Pato and Teixeira, 2016). For female entrepreneurship it has also been possible to find clusters associated with the profile, conceptualizations and surrounding contexts (Santos et al., 2018).

The different dimensions of the entrepreneurship gained more relevance in recent years and are related with management and economics approaches that benefit from more integrated research

(Landstrom et al., 2012).

This importance of entrepreneurship increased with the unemployment associated with financial and economic crises, where the creation of the own business and self-employment appear as important alternatives (Palomares-Montero et al., 2019).

More recently, the field of 'forest entrepreneurship' appeared (Beaudoin et al., 2009). We can pinpoint the work of Bherer et al. (1989) as one of the founding ones of this field.

As checked, the forest has a natural (Illia and Zamparini, 2016) environmental, social and economic dimension that needs to be properly managed. Therefore, Forest Entrepreneurship has emerged as the ability of forest actors (individuals or communities) to value forest resources, to create new processes of a sustainable forest production and its valuation.

The sustainability of the forestry sector also depends on adjusted and well-designed forest management plans (Boncina and Cavlovic, 2009). Sometimes economic dimensions are overvalued in these plans, relative to the social and ecological contexts (Katila, 2017). The social dimensions, for example, should be a concern for the diverse stakeholders that operate in forestry (Wulandari and Kurniasih, 2019) and in related activities (Thompson et al., 2010). The diversity of forest owners (attitudes, objectives and behavior) is, often, a big challenge for forest policymakers and planners (Ficko et al., 2019), because different forest owners have diverse expectations (Malovrh et al., 2011). Green entrepreneurship, including that supported by crowdfunding, may be a relevant ingredient of these sustainable management plans (Buttice et al., 2019), stressing the importance of international research networks and multidisciplinary approaches for the design of appropriated plans (Martinic et al., 2007).

Entrepreneurship is a concept interrelated with many others, as complex human dimensions (Xu et al., 2018). In this way, for successful entrepreneurial plans the human capital development, the leadership and the communities' involvement may make the difference, namely in sectors with specific characteristics as those developed in rural regions (Beckley and Reimer, 1999), as well as the economic values and the social capital (Fleischman et al., 2010). Leadership is one of the most important determinants for effective governance (Evans et al., 2015). The same importance may be given for other factors such as, for example, age, gender and population mobility (Beckley et al., 2002). Or even for dimensions like attitudes favoring creativity and proactivity. The local citizens' involvement in the several processes and strategies' design for the communities appears as an alternative to the top-down approaches and may contribute to the success of management plan implementation (Dare, 2013). In these contexts, the confidence and trust between the several actors is crucial (Hiedanpaa and Borgstrom, 2014), as well as the organization's legitimacy (Kraft and Wolf, 2018) and the information dissemination among the entrepreneurs (Nonic et al., 2012). In turn, these aspects are, also, influenced by other factors, such as personal, institutional and geopolitical relations (Xue and Liu, 2015). Similar relevant importance can be found for the related institutions' involvement in policy design and implementation (Hermansen et al., 2017).

Following authors like Acharya et al. (2015) or Sorensson and Dalborg (2017), the appearance of the field of 'forest entrepreneurship' cannot be dissociated by the socio-economic set of stimuli.

Forest certification, for example, has been pointed to as one major factor to promote forest innovation and entrepreneurship (Acharya et al., 2015). Forest and rural policies also play a determinant role (Hermansen, 2015), namely, creating conditions to attract more entrepreneurial women to the forestry sector (Appelstrand and Lidestav, 2015), through adjusted support instruments (Sorensson and Dalborg, 2017). Forest policies and

legislation are, in fact, crucial to promote entrepreneurship in sectors around the world (Bunei, 2017). The influence of the rural policies in the dynamics of the rural sectors is, also, visible in the European Union, in consequence of the several policy instruments from the Common Agricultural Policy framework (Rogelja et al., 2018). Policymaking, policy analysis and assessment are other fields of interest for several stakeholders, namely for the researchers (Winkel and Leipold, 2016). They also stress the relevance of local rules, practices (Silva et al., 2015) and specific contexts (Singh et al., 2008) for the forest management framework. However, sometimes there is a complex way to make compatible the transnational policies and those from local initiatives (Jodoain, 2017) and to deal with potential conflicts between policies for different sectors (van Oosten et al., 2018). Inside the institutional framework, the multistakeholder approaches have become more associated with other relevant initiatives, of which, for instance, the Forest Stewardship Council may be an example (Moog et al., 2015). Between institutional entrepreneurship, the cooperative plays a fundamental role (Mahzouni, 2019). The institutional framework and its dynamics (conflicts, stability, etc.) are crucial in the several interrelationships and performances in any sector (Zietsma and Lawrence, 2010).

Another perspective in these frameworks is about to combine the concepts of entrepreneurship and bioeconomy (considering bioresources for the economy). These interrelationships may open new business opportunities in the forest dynamics (Bauer et al., 2017). In fact, sustainable approaches create new opportunities for innovation and entrepreneurship in several economic sectors (Chowdhury et al., 2017) and the inverse is, also, true (Hall et al., 2019). Another tendency is the attempt to make compatible the concepts of ecology and economy (Hibbard et al., 2019). Nonetheless, forest entrepreneurship depends on forest owners' entrepreneurial characteristics (Mahapatra and Shackleton, 2012), namely the individual attitude to identify business opportunities and to take risks (Lunnan et al., 2006). The property of the land (Salka et al., 2006) and the perspective of several stakeholders about the contexts related with forestry (Nichiforel and Schanz, 2011) were, also, aspects that influenced the dynamics in the sector (Serenari et al., 2017), claiming, sometimes, alternative approaches (Paudel, 2012).

The questions related with the property of the forest land and its influence on the forestry dynamics have also assumed special importance in countries that adhered to the European Union more recently, namely since 2004 (Sikora and Nybakk, 2012), where, sometimes, private owners were not higher performers or prone to entrepreneurship. In any case, the importance of Forest entrepreneurship which enlarged the number of associated studies (Sikora et al., 2016) has been recognized, as, for instance, Croatia (Sporcic et al., 2017). In these countries as well as in others around the world (the former Soviet Republic, for example) the specific domestic circumstances have been found as influencing the contextual conditions for entrepreneurship (Wegren and Maximov, 2012). The changes in family farming are also an endogenous example of a specific context inside the agroforestry sector that motivated the appearance of the conceptualization of 'Forest Entrepreneurship' (Ruiz Jimena and Flavio, 2015).

## 2.2. Scientific trends in emerging scientific fields

The system leading to scientific production, as noted by Sharma (2012), tends to receive the main stimulus from three foundational entities that arouse the interest of researchers/academicians and of course their informal groups or formal aggregations (like Research Centers and Nuclei or Scientific Laboratories). These three entities are the State, the Civil society and the Business world. Thus, the

development of new fields within the fields established in the scientific domains comes, as discussed by [Bachelard \(2008\)](#), from the pressures and challenges launched by the three entities, in conjunction with the dynamics of scientific development composed, in turn, by the dimensions of Social Problems, Endogenous Challenges and the identification of areas of knowledge poorly covered by the established fields.

The complexity of these interactions has a long course of discussion, from debates of [Bachelard \(2008\)](#) to current versions of [Sharma \(2012\)](#). For the present case, it is interesting to note which features stand out in the emerging scientific fields, both in the teams that collaborate in these emerging scientific fields and the resulting products.

As [Shaw \(1956\)](#) shows, the emergence of derived or emerging fields within established scientific domains results, on the one hand, from the recognition of the dominant currents giving explanations considered unsatisfactory to the specific problems left by Society, the State and the Academies themselves, but also to the authors' own limits or to the exhaustion/interest of Teams working in the mainstream of the dominant areas. However, in most scientific development processes since the 19th century, the 'scientist' differs from the 'inventor' (majorly and also) in risk aversion ([Krause, 2019](#)), which is explained by the limited space left to the scientist by sponsorship systems from the State and Society; in parallel [Levins \(2003\)](#) points out that the scientific method itself beacons and conditions scientific behavior, leaving it with a smaller risky space, a space which tends to be larger to 'inventors.' So when scientists try to study problems perceived as touching 'border areas' or 'nobody's land' they prefer to do so in sharing the effort, risk and eventual benefits. As a consequence, authors like [Nevin et al. \(2011\)](#) argue that co-authoring work is more frequent in emerging areas than in established scientific areas.

Turning again our attention to Forest Entrepreneurship, we became stimulated by two Research Questions (Q1 and Q2) after this discussion:

Q1: "Are the topics of Forest Entrepreneurship less concentrated/dominated by few authors?"

And.

Q2: "Being Forest Entrepreneurship an interception of scientific fields, do their topics tend to have a higher proportion of co-authored works?"

As expected – and in line with [Vaidhyanathan and Tamizhchelvan \(2017\)](#) – established scientific fields, with pioneering publications produced several decades ago – or even centuries ago – tend to be characterized by authors and publications with a significant number of citations in continuous time. It will be a tautology but we must say that established scientific fields have many works with many citations while emerging scientific fields have few works that stand out in the number of citations between them.

Therefore, and considering we have identified the field of 'forest entrepreneurship' as an emerging scientific field, we posit our two hypotheses:

**H1.** "Most recent scientific topics tend to be less concentrated/dominated by few authors."

**H2.** "Topics from the interception of scientific fields tend to have a higher proportion of co-authored works."

The next section will exhibit our methodological procedures toward a convenient test of these hypotheses.

### 3. Bibliometric analysis

#### 3.1. Rationale for a bibliometric analysis for testing these hypotheses

For a proper test of the previously enunciated hypotheses, we have to recur to a set of bibliometric analysis' stages.

Following [HAYASHI and LETA \(2013\)](#), [Andrés \(2009\)](#) or [Haddow \(2013\)](#), bibliometric studies have several strengths. Among these strengths, these authors highlight the analysis of publications and quotes/citations. According to [Severino \(2016\)](#), the primary sources – like journals/articles, books and reports – are the primary data of bibliometric analyses. Upon the detailed study of these primary sources, the bibliometric analysis allows the identification of trends observed in the topics, terms and sub-fields of a given scientific domain. Depending upon the intention of the researchers, other analyses can emerge within, namely the networks of authors and/or of their citations and co-citations.

#### 3.2. Preliminary stages

We started by selecting the two most used sources of scientific publications – Web of Science/Clarivate and Scopus ([Mongeon and Paul-Hus, 2016](#)). In the respective search boxes, we got the following list of outcomes for the topic fields 'forest' and 'entrepreneurship': 83 items/articles (including 8 reviews). The search was done by 30th of June of 2019 and was restricted to articles published in English.

After this first stage, we checked whether there were duplicates; we found there were none and so we kept the initial 83 items. As next screening criteria, we included 'forest' and 'entrepreneurship' for the complete text data in Titles and in Abstracts. For bibliographic data, we included 'forest' and 'entrepreneurship' for being searched in Titles, Abstracts, Keywords, References and Citations. After this second step of screening, we kept the 83 articles. Synthesizing the characteristics of the final selection, we can state we have identified 83 publications, published between 1998 and 2019. These publications have been signed by 239 Authors, and they have appeared in 58 journals. The 239 Authors were affiliated with 151 institutions from 41 countries.

For the bibliometric analysis through the software VOSviewer, text data and bibliographic data were considered. With text data we analyzed co-occurrences between terms (presented in the articles title and abstract), where each term is usually represented by a circle (sized by the corresponding frequency) and the respective label in the maps. The dimension of the circle is related with the number of occurrences and the distance between circles represents the relatedness between the respective terms ([van Eck and Waltman, 2019](#)), meaning that smaller distances are associated with a greater number of co-occurrences. Considering only the terms presented in the articles title and abstract reduce the risks from the repetition of terms in different parts of the documents.

With bibliographic data we performed the following type of analysis: co-authorship (the relatedness of items is based on the number of co-authored documents), citation (the relatedness of items is based on the number of times they cite each other), bibliographic coupling (the relatedness of items is based on the number of references they share) and co-citation (the relatedness of items is based on the number of times they are cited together) ([van Eck and Waltman, 2019](#)).

In these network visualization maps obtained with the VOSviewer software, each color represents one cluster. These clusters were built by the software following the methodology described by, among others, [van Eck and Waltman \(2019\)](#). Other concepts presented in the following figures and tables are, also, explained in this



composed of the most cited sources). This phenomenon is not unusual in bibliometric analysis (Schramme, 2019) and it relates to a certain preference for journals publishing articles that cite other works within a few groups of journals, especially close among themselves in terms of Impact Factor (Selmer, 2018).

'Links' relate to biunivocal relations between a source and the remaining set of sources. Therefore, a link relates to citations of the published articles from a source plus citations from that source. The strength of a link indicates the number of cited references two publications have in common. However, we highlight the higher value obtained in the Forest Policy and Economic for Total Links Strength, which shows its articles are significantly cited as long as other well-cited references focused on forest entrepreneurship.

### 3.3. Bibliometric outcomes

3.3.1.1. *Citation of sources.* In this case the relatedness of items is based on the number of times journals cite each other. Fig. 2 shows that the Forest Policy and Economics (9 studies) and Sumarski List (6 works) are the sources with more co-cited documents. On the other hand, the relatedness is particularly high between the sources 'Forest Policy and Economics' and, for example, the sources 'Scandinavian Journal of Forest,' S'eefor – South-East European Forestry,' 'iforest – Biogeosciences and Forestry,' 'Chinese Management Studies,' 'European Journal of Forest Research' and 'Austrian Journal of Forest Science.' The relatedness is pronounced, also, among the sources 'Sumarski List' and 'Nature Conservation – Bulgaria'. These networks seem to reveal a weak multidisciplinary linkage, because the more pronounced relatedness is between journals of the same specialty (Forest), with the exception being the Chinese Management Studies.

### 3.3.2. Terms

Fig. 3 shows that, considering 5 as the minimum number of occurrences of a term, the several terms presented in the 83 articles may be grouped into 3 clusters (each color represents a cluster).

The cluster in the top left of the figure (with the green color) relates to the importance of innovation in the industry related with the forestry sector, namely to improve the economic dynamics in the transition framework as that we assist today around the world at several levels as, for example, those related with social, personal, professional, cultural and environmental dimensions.

The cluster in the bottom left of the figure (blue) highlights the

**Fig. 1.** Network visualization map based on bibliographic data (bibliographic coupling, journal).

**Table 1**  
Journals publishing articles about Forest Entrepreneurship.

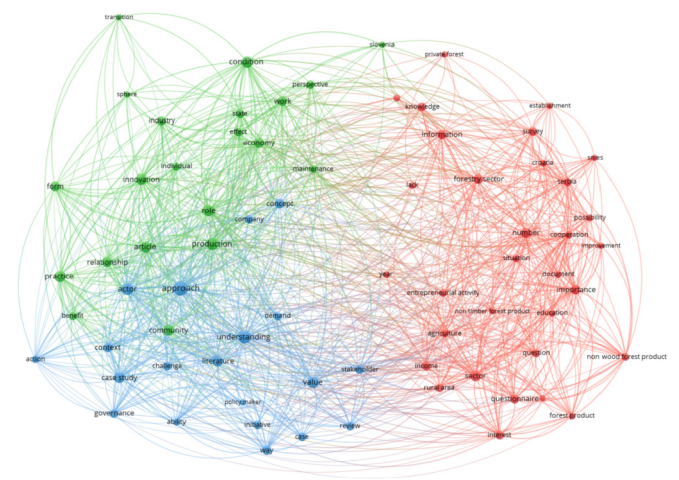
Title	Cluster	Links	Links Strength	Total Citations	Avg. Pub. Year	Avg. Citations (per article)
Journal of cleaner production	3	585	7415	881	2017.65	20.02
Journal of business ethics	3	670	14523	491	2016.88	14.44
Academy of management annals	3	463	3493	337	2016	84.25
Forest policy and economics	6	536	3700	303	2017.30	6.18
Land use policy	1	438	1609	261	2017.14	9.32
Journal of management	2	464	2829	249	2017.25	31.12
Ecological economics	3	292	1087	200	2017.12	25
Global production networks: theorizing economic development in an interconnected world	1	337	820	175	2015	175
Journal of rural studies	1	348	1239	156	2016.62	9.75
International journal of supply chain management	6	179	360	146	2018.2	29.2
Tourism management	2	270	1039	135	2017	13.5
Journal of world business	3	241	835	129	2017.4	25.8
Journal of sustainable tourism	2	375	1395	121	2016.90	11
Technological forecasting and social change	5	519	2712	120	2017.06	7.5
Journal of travel research	2	223	1352	120	2016.6	24
The politics of evidence-based policy making	1	103	437	119	2016	119
Policy studies journal	1	96	536	109	2016.75	27.25
Industrial marketing management	8	324	2292	100	2016.6	20
Journal of business venturing	2	401	2368	99	2017.66	11
Journal of management studies	3	411	1772	99	2016.33	33
International journal of entrepreneurial behavior and research	2	398	1604	92	2017.62	11.5



**Fig. 2.** Network visualization map based on bibliographic data (citation, sources). Legend: The size/width of each node ('ball') or of each link ('line') are proportional to the link strength of the node or of the link.

importance of terms like governance, policymakers and the other stakeholders for forest entrepreneurship.

Finally, the cluster in the right part of the figure (with the red color) presents the relevance of the information, the dimensions of



**Fig. 3.** Network visualization map based on text data. Legend: The size/width of each node ('ball') or of each link ('line') are proportional to the link strength of the node or of the link.

the investigated private forests, education, entrepreneurial activities, relationships with the agricultural sector, the production of non-wood products and the contributions from the forestry sector for rural sustainable and integrated development.

Table 2 exhibits these terms listed according to the descending order of the links.

Observing [Table 2](#) we confirm a relevant heterogeneity of terms as we have already checked in [Fig. 3](#). We interpret it following [Nakauchi et al. \(2003\)](#) – the dynamics of certain emerging fields – like the case of forest entrepreneurship – motivate the authors to use terms more general than specific items. It is also not surprising that many of the exhibited terms are primarily associated with ‘production’ or ‘forest economics’ because these fields are more aged in forestry research. The highlighted terms in [Table 2](#) also have a relevant number of occurrences, which show their frequency in the scientific discourse in the observed field ([Garcia et al., 2019](#)). Finally, it is also relevant to observe that the articles exhibiting the term ‘innovation’ are associated with a higher value of citations, which show the potentiality of the combined discussion of forest and entrepreneurship for getting a sustained interest of the community of researchers.

### 3.3.3. Countries

Scientific networks of researchers are common. These collaborations allow exchange of experiences and knowledge, which are fundamental to improving scientific dynamics.

**Table 2**  
Identified terms in the articles about forest entrepreneurship.

Terms	Cluster	Links	Total link strength	Occurrences	Avg Year Public.	Avg. Citations
understanding	3	65	189	20	2014.65	20.9
economy	2	64	131	13	2014.231	5.46
approach	3	63	158	24	2014.167	8.79
sector	1	63	141	13	2013.846	4.92
role	2	61	160	18	2014.444	23.33
production	2	61	131	17	2013.059	3.47
value	3	60	124	15	2013.333	9.53
forestry sector	1	60	116	11	2013.727	7.09
condition	2	59	130	16	2013.938	22.43
number	1	59	135	13	2013.23	5.84
innovation	2	58	131	14	2014	25.85
literature	3	58	114	14	2015.71	10.35
actor	3	57	138	17	2015.35	26
information	1	57	113	10	2011.9	8.5
importance	1	56	129	11	2013.54	6.27
way	3	56	101	10	2013.8	10.7
concept	3	55	104	11	2014.90	5.45
state	2	55	95	9	2011.55	35.88
questionnaire	1	54	104	10	2013.8	5
question	1	54	96	8	2014	8.5
serbia	1	54	103	8	2013.87	3.87
stakeholder	3	53	89	9	2014.55	4.66

Now, we are going to observe the scientific network, which has been working on forest entrepreneurship, but highlighting the nationalities of co-authorships.

Fig. 4 presents that several countries were grouped in five clusters. The countries with more co-authored documents are the USA (14 studies) and Finland (11 works). These analyses for the several co-authorships reveal the international cooperation between authors from different nationalities and affiliations in the topics here explored and related with forest entrepreneurship.

Table 3 exhibits these countries listed by a descending order of the number of documents.

As expected, the network of collaborations between different nationalities has a positive correlation with the co-citation of works (Liu and Chen, 2012). Table 3 also shows that certain countries – like Sweden, Brazil and Poland – had hosted researchers publishing in these fields of forest entrepreneurship more recently than countries like the USA, Finland or Canada. Actually, Table 3 shows Sweden, Brazil and Poland have as Average Year of the associated publications the years of 2016 and 2017, significantly distinct from the years of 2013 and 2014 (associated with the Average Years of the works signed by North-American, Finnish and Canadian researchers).

### 3.3.4. Authors/co-citations

To bring more insights about if the most recent scientific topics tend to be less concentrated/dominated by a few authors, it is important to analyse in this subsection the most productive authors, the co-authorships and the co-citations.

Following, it is going to be presented the single authors with the highest number of publications returned from our search focused on forest entrepreneurship. Fig. 5 shows the network of these authors and Table 4 details the available indicators.

Commenting simultaneously on Fig. 5 and Table 4 we verify that

the authors with more than 6 identified single works are:

Gerhard Weiss (current affiliation is the Institute of Forest, Environmental and Natural Resource Policy, Vienna);

Y Zhang (current affiliation is Chinese Academy of Sciences, Beijing);

Milos Hitka (current affiliation is Technical University in Zvolen, Slovakia);

Y Li (current affiliation is Chinese Academy of Sciences, Beijing);

Alice Ludvig (current affiliation is the Institute of Forest, Environmental and Natural Resource Policy, Vienna);

J Zhang (current affiliation is National University of Singapore).

All of these authors have a high Average Year of Publication, which shows how they continue to work and publish on these topics.

**3.3.4.1. Co-authorship.** Now, we are going to detail the co-authorship network of these authors. For these links the relatedness of items is based on the number of co-authored documents. Fig. 6 shows the network visualization map for these items and reveals that the several authors were grouped in five clusters.

In these clusters the authors with more co-authored documents are Jelena Nedeljkovic and Dragan Nonic with 4 studies each, and Gerhard Weiss with 3 works.

Table 5 also details the number of citations of the most productive groups of co-authors. Following authors like Liao et al. (2018), a higher value of citations reveals the quality of a document for supporting the discussion of other scientific documents (Liao et al., 2018). Table 5 shows the most co-cited articles about forest entrepreneurship for the observed period.

It is also noted that the revealed articles by Gerhard Weiss and Jelena Nedeljkovic have been published in the journals 'Forest Policy and Economics' 'Forests' 'Croatian Journal of Forest Engineering' 'Austrian Journal of Forest Science' or 'Wood Material Science and Engineering'. It is meritorious to be mentioned that the most common journal of these publications – "Forest Policy and Economics" – is in the ranking of the outlets that have published more articles in this area of research (Table 1).

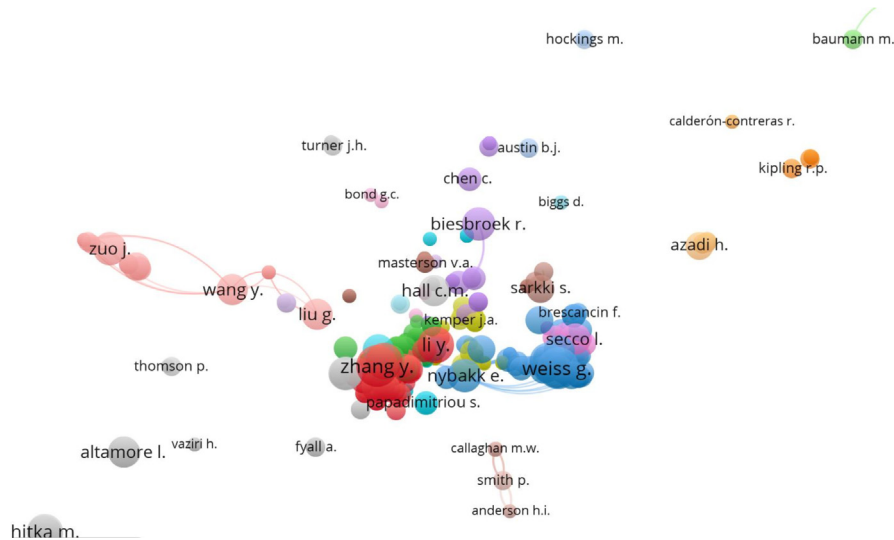
These articles focus on comparative analysis across European



**Fig. 4.** Network visualization map based on bibliographic data (co-authorship, countries). Legend: The size/width of each node ('ball') or of each link ('line') are proportional to the link strength of the node or of the link.

**Table 3**  
Countries from the authors' affiliations.

Country	cluster	Links	Total link strength	Documents	Citations	Avg. Pub. Year	Avg. Citations
USA	1	10	12	14	150	2013.21	10.71
Finland	2	11	15	11	83	2013.92	7.55
Norway	3	5	7	7	85	2014.28	12.14
Serbia	2	8	15	7	31	2014.71	4.42
Austria	2	10	16	6	49	2015.83	8.16
Canada	3	6	6	6	346	2009.83	57.67
Croatia	5	4	6	6	17	2012.66	2.83
Slovenia	2	10	13	6	38	2014.66	6.33
Australia	1	6	7	5	47	2015.2	9.4
England	1	6	7	5	91	2013.8	18.2
Germany	1	5	5	5	69	2014.4	13.8
Italy	2	2	2	5	14	2015.8	2.8
Sweden	2	7	7	5	36	2017.4	7.2
Brazil	3	5	5	4	34	2015.5	8.5
Poland	3	2	4	4	21	2015.5	5.25
Bosnia & Hercegovina	1	5	5	2	4	2012.5	2
Macedonia	2	4	6	2	12	2015	6
Romania	1	4	4	2	20	2012.5	10
Spain	4	5	5	2	19	2016	9.5
Chile	1	1	1	1	8	2017	8



**Fig. 5.** Most Productive Authors.

Legend: The size/width of each node ('ball') or of each link ('line') are proportional to the link strength of the node or of the link.

countries' policies of the Forestry sectors, about different types of forest ownership and innovation methods and social innovation in the context of Forest Entrepreneurship.

**3.3.4.2. Co-citation.** For the links focused on co-citation the relatedness of items is based on the number of times they are cited together. Fig. 7 presents that, for example, Rametsteiner, E. and Weiss, G. are the most co-cited authors (22 and 16 citations, respectively). Other authors with a significant number of citations and with pronounced relatedness are Pettenella, D., Nybakk, E. and Niskanen, A. (all with 11 citations), or Nonic, D. and Gluck, P. (10 citations). We also highlight the presence of the European Commission and of the FAO between the authors.

This analysis confirms that the multidisciplinary linkage in the works related with the forest entrepreneurship could be increased, creating more networking with authors from other fields outside the forest sciences.

#### 3.4. Analysis of the networks of authors publishing on the topics of 'forest entrepreneurship'

After the previous sub-sections in which we followed most of bibliometric studies using VosViewer (Castillo-Vergara et al., 2018; Jeong and Koo, 2016; Efren et al., 2019), we intend to provide a further step in this set of bibliometric studies. Taking advantage of the possibility of exporting the identified networks as 'pajek' files (van Eck and Waltman, 2019), we can study each network following a standard Network Analysis.

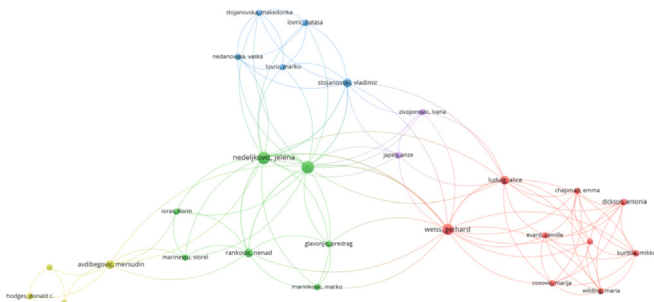
Therefore, after exporting the identified networks of Authors as a set of three pajek files (\*.net; \*.clu; \*.vet), we can study them considering several dimensions, namely the intensity of relations, the possibility of connectiveness, or the centrality of the involved authors.

Following the notion of Giuffrè (2013), a (social) network is any organization of actors changing values/messages among themselves. In our specific paper, so far, we have analyzed networks of



**Table 4**  
Most productive authors.

Label	cluster	Links	Total link strength	Documents	Citations	Avg. Pub. Year	Avg. Citations
Weiss G.	3	360	7414	9	39	2018	4.33
Zhang Y.	1	374	1868	9	3	2018.55	0.33
Hitka M.	26	39	1866	7	6	2018.42	0.85
Li Y.	1	455	1265	7	8	2018	1.14
Ludvig A.	3	309	3081	7	31	2017.71	4.42
Zhang J.	1	396	1616	7	8	2018.57	1.14
Biesbroek R.	5	240	2625	6	10	2018.66	1.6
Crescimanno M.	19	215	1418	6	19	2018	3.16
Galati A.	19	215	1418	6	19	2018	3.16
Lidestav G.	3	249	8748	6	33	2018.33	5.5
Lorincová S.	26	39	1838	6	6	2018.5	1
Nybakk E.	3	600	7328	6	42	2017.5	7
Prayag G.	1	318	2673	6	33	2018.16	5.5
Zuo J.	10	48	1860	6	109	2017.5	18.16
Altamore L.	19	24	1077	5	15	2017.4	3
Bacarella S.	19	24	1077	5	15	2017.4	3
Chironi S.	19	24	1077	5	15	2017.4	3
Hall C.M.	31	128	1189	5	29	2017.8	5.8
Ingrassia M.	19	24	1077	5	15	2017.4	3
Krott M.	3	109	1702	5	14	2017.6	2.8
Li J.	6	490	2252	5	20	2018.2	4



**Fig. 6.** Network visualization map based on bibliographic data (co-authorship, authors).

Legend: The size/width of each node ('ball') or of each link ('line') are proportional to the link strength of the node or of the link.

Authors. Countries. Terms and Sources/Journals focused on the exchange of collaboration (co-authorship) or of recognition (citations) of the innovative topics of 'forest entrepreneurship'. However, given the central role of Researchers on the scientific development of these fields, we will only study the networks of co-authorships and of citations, without neglecting the relevance of running similar analyses on the networks of Countries, Terms, and Sources/Journals (suggested for further challenges).

We recall our hypotheses:

**H1.** "Most recent scientific topics tend to be less concentrated/dominated by a few Authors."

**H2.** "Topics from the interception of scientific fields tend to have a higher proportion of co-authored works."

Therefore, for empirically testing our hypotheses. We have some well-detailed and well-studied measures of networks analysis, which are appropriate to test our hypotheses (Giuffrè, 2013; Hanneman and Riddle, 2005).

These indicators are the following eight (Heath et al., 2018; Giuffrè, 2013):

"Average Degree" - The degree of an Author in our networks is the number of relations (co-authorships or citations) that s/he has with the other Authors. Therefore, the Average Degree is the mean of these relations observed in each network.

"Betweenness Centrality" - this measure indicates the proportion of Authors that is expected to be central other Authors. i.e., the proportion of Authors who are expected to intermediate two random other Authors.

"Density" - relates to the portion of the potential connections in a network that are actual connections.

"Closeness or Closure" - this is a measure of the degree to which an Author is directly connected with all other Authors in our networks.

"Average Distance" - the mean value of connections between a random pair of Authors (e.g., two directly connected Authors have a Distance of 1).

"Standard Deviation of the Distances" - although this measure is self-explicative, meaning that it is the Standard Deviation of all the distances between the Authors in one network (in our case, between the Authors), we add that higher values in this indicator are associated with larger networks.

"Compactness" - Average of all the reciprocal distances (0 - zero when the network is entirely composed of isolate Authors and 1 - when the network is known in Social Networks Analysis as a click - all players are adjacent).

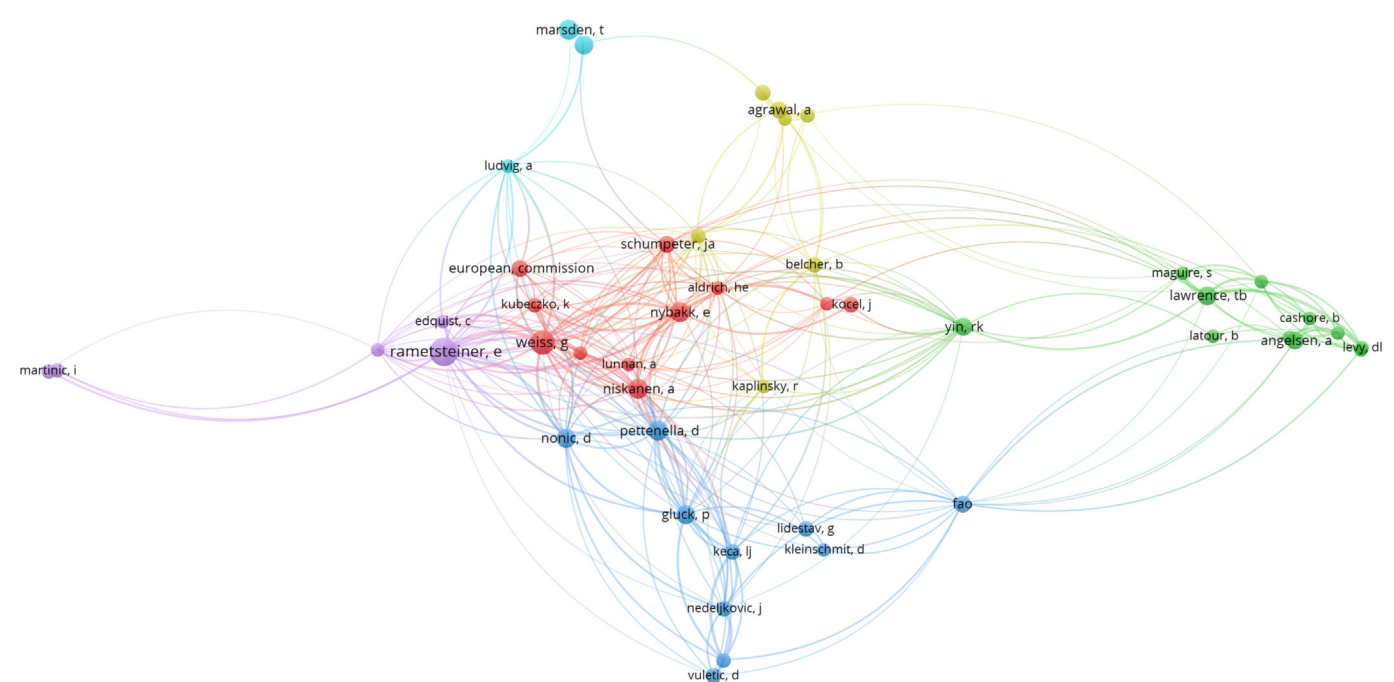
"Breadth" - it is equivalent to the difference between 1 and the compactness proportion.

Therefore, for properly analyzing the network of 'forest entrepreneurship' we have to compare it with the two other networks - the network of 'forest' and of 'entrepreneurship' well-established networks in the scientific domains (the network of 'Forest' has the Average Year of Publication of 2012 and it has as the oldest identified publication 1955; the network of 'Entrepreneurship' has the Average Year of Publication as 2014 and it has the oldest identified publication of the Schumpeterian book as 1911 (Theory of Economic Development). Additional indicators regarding these networks of 'forest' and 'entrepreneurship' are available upon request.

For the construction of these networks, we also followed the steps observed in the construction of the network of 'forest entrepreneurship': we searched the databases of Web of Science and of Scopus with the terms 'forest' and 'entrepreneurship' included in Titles, Abstracts and Keywords. The searches were restricted to articles published in English. Additional details are available upon request.

**Table 5**  
List of most productive co-authors.

Label	Co-authored works	Citations	Avg. Pub. year	Avg. citations
nedeljkovic, jelena	4	19	2014	4.75
nonic, dragan	4	19	2014	4.75
weiss, gerhard	3	33	2015	11
avdibegovic, mersudin	2	4	2012.5	2
ludvig, alic	2	28	2016.5	14
rankovic, nenad	2	7	2013	3.5
stojanovski, vladimir	2	12	2015	6
chapman, emma	1	18	2016	18
cosovic, marija	1	18	2016	18
dickson, antonia	1	18	2016	18
evard, camille	1	18	2016	18
glavonjic, predrag	1	5	2012	5
hodges, donald c.	1	2	2011	2
ioras, florin	1	2	2014	2
japelj, anze	1	10	2017	10
kurttila, mikko	1	18	2016	18
lovric, marko	1	2	2013	2
lovric, natasa	1	2	2013	2
malovrh, spela pezdevsek	1	2	2011	2
maric, bruno	1	2	2011	2
marinescu, viorel	1	2	2014	2
marinkovic, marko	1	5	2012	5
nedanovska, vaska	1	2	2013	2
stojanovska, makedonka	1	2	2013	2
tahvanainen, veera	1	18	2016	18
wilding, maria	1	18	2016	18
zivojonovic, ivana	1	10	2017	10



**Fig. 7.** Network visualization map based on bibliographic data (co-citation, cited authors).  
Legend: The size/width of each node ('ball') or of each link ('line') are proportional to the link strength of the node or of the link.

Considering the three networks of Authors (publishing in 'forest entrepreneurship' in 'forest' and in 'entrepreneurship'), we got Table 6.

Let us detail our observations from Table 6 and discuss the results. Comparing the three networks of "Co-Authorship" we observe the minimum Average Degree was recorded for the network of "Entrepreneurship". Following Giatsidis et al. (2013), the degree of a node corresponds to the number of edges that start

from or point to a node. In these networks, an edge represents a co-authorship; therefore, we can claim that the topics of 'forest entrepreneurship' are associated with authors who, on average work with 9 co-authors during their academic career. Authors working on the most generic topic of 'forest' tend to have 17 different co-authors.

However, given the relative youth of the network of Authors focused on 'forest entrepreneurship' this network has the least

**Table 6**  
Network Indicators for the scientific fields of 'forest entrepreneurship', 'forest' and 'entrepreneurship'.

Indicator	Co-Authorship			Citations		
	Forest Entrepren.	Forest	Entrepreneurship	Forest Entrepren.	Forest	Entrepreneurship
Avg. Degree	9.985	17.787	4.571	15.812	6.800	6.207
Betweenness Centrality	0.171	0.252	0.184	0.146	0.283	0.2039
Density	0.076	0.029	0.025	0.071	0.200	0.017
Closure	0.707	0.503	0.581	0.336	0.167	0.167
Avg. Distance	3.561	3.5	6.3	2.556	2.8	4.7
SD Distance	1.483	1.3	2.8	0.772	1.5	1.5
Breadth	0.656	0.667	0.788	0.560	0.523	0.751
Compactness	0.354	0.333	0.212	0.440	0.477	0.249

significant Degree of Centrality among the three studied networks (0.171, against 0.252 of 'forest' network and against 0.184 of 'entrepreneurship' network). This suggests to us that there are more direct, 'one hop' connections each node of 'forest entrepreneurship' has to other nodes within the network if compared to the other two networks of Authors. Also following this evidence, the network of authors working in 'forest entrepreneurship' has the greatest Closeness and the least significant Breadth. Following Golbeck (2013), we recall that a high score for Closeness, positively associated with the transitivity of a network, measures a high number of ties between nodes. Breadth is an indicator of the 'proportion' of isolated nodes, i.e., of Authors who published without co-authors in their entire list of publications. This follows Proctor and Niemeyer (2019) and proves that a more recent scientific field like 'forest entrepreneurship' tends to have more co-authored publications and the Authors – given the youth of the topics and the relatively small number of participants – tend to have more collaborating ties between them.

Moving now to the second set of columns in Table 6, we will detail these indicators for the networks composed by the identified Authors citing other colleagues in 'forest entrepreneurship', in 'forest', or in 'entrepreneurship'. Now, we observe that the constructed network for 'forest entrepreneurship' has the highest value for the Average Degree and the smallest value for Centrality among the three networks of citations in Table 6. This shows that the youth and the size of the network of Authors citing topics in 'forest entrepreneurship' leads the identified authors to cite more different researchers than in the networks of 'forest' and of 'entrepreneurship'; the low value of centrality shows there are still not so many 'dominating'/'concentrating' researchers as in the competing networks (which tend to have more commonly 'top-cited' papers). Correlated with the previous observation, we also found the Average Distance and its Standard Deviation are the smallest for the network of Authors cited in the topics of 'forest entrepreneurship'. The highest value for the Closure means that the network of citations has more identified Authors who are closer to all the remaining academicians working on the topic, i.e., who more probably cite the other participants in the same network. The other two networks – more established and larger – tend to make this more difficult.

Now, we will discuss the previous observations. The network of 'Forest Entrepreneurship' is clearly a scientific network characterized by its youth when compared to the two other networks focused on Table 6 (the network of scientific co-authorship and citations on 'Forest' and the network of scientific co-authorship and citation on 'Entrepreneurship'). As clarified in Table 6, authors publishing in 'Forest Entrepreneurship' are more connected than those publishing in 'Forest' or 'Entrepreneurship'. As Table 6 shows, the score computed for Betweenness Centrality has the minimum value across the columns for Co-Authorship as well as the Closure, the Compactness or the Density have the highest values. Overall,

these observations converge with the validation of the youth of the network of Co-Authorship, a network in which Authors do not have clear dominating pairs and so they tend to work more together than in the compared networks. This follows Barabasi (2003) who studied the differentiated profiles of scientific networks of co-authorships and co-citations, emphasizing how recent topics follow the pattern here identified.

Regarding the network of co-citations, once again the previous youth of the field of 'Forest Entrepreneurship' is highlighted. The average degree has the maximum among the three networks; the average centrality has the minimum score; and the closure has the highest score. This proves the paired distribution of the available citations as well as the limited set of identified co-citations, a proper characteristic of emerging networks (Merton, 1968).

In sum, and in terms of our Hypotheses. We can claim that actually most recent scientific topics – like the one here highlighted related to 'forest entrepreneurship' – tend to be less concentrated/dominated by a few Authors (H1). We also observed that Topics from the field of 'Forest Entrepreneurship' tend to have a higher proportion of co-authored works (which validates our H2).

#### 4. Conclusion. Policy implications and further challenges

This paper is an original research focused on a bibliometric analysis of the publications about forest entrepreneurship. After detailing the roots of this topic coming from the literature focused on entrepreneurship and forest, we observed the field of forest entrepreneurship is a recent scientific field. As an emerging field, we intended to test two major hypotheses. These hypotheses imply most recent scientific topics tend to be less concentrated/dominated by few Authors (H1) and Topics from the interception of scientific fields tend to have a higher proportion of co-authored works (H2).

For properly testing these hypotheses, we started by running a bibliometric analysis, taking advantage of the features provided by the software VosViewer.

Considering the bibliometric analysis with text data and the literature review, the research here performed, for the topics related to 'forest entrepreneurship' highlights the importance of the following main aspects: innovation; forest industry; governance; policies; information; non-wood products and sustainability.

The new ideas and, consequently, innovation may play a determinant role to create more employment and value added in the forestry sector and the associated activities, namely in the downstream industry of the forest. On the other hand, forest planning and policies should be designed to promote adjusted and sustainable forestry management and a more entrepreneurial environment. Here the idea of a common forest policy in the European Union, for example, could bring interesting outcomes for the European forest entrepreneurship. Finally, the level of

education and vocational training of the several related stakeholders may make the difference in these entrepreneurial contexts, especially when it is intended to attract more non-wood activities for the forest.

The bibliometric analysis with bibliographic data shows that, in general, the authors publish the research performed for these topics in journals related with the forest fields that cite other journals from the same domains and usually cite authors from the same continent. In turn, the more co-cited authors are from the forest sciences. These frameworks reveal that the multidisciplinary networking for outside the forest sciences may be improved and increased with potential benefits for the domains related with forest entrepreneurship. This is a gap in the literature that deserves special attention from the several stakeholders. Specifically, from the researchers and policymakers.

Further challenges emerge from a dense work, as this is. First, we suggest extending this analysis by comparing it with the bibliometric analysis of terms like 'Forest Innovation' or 'Forest Development' two other examples of emerging fields in the Forestry Sciences. Innovation in Forestry sectors is another promising field to be included in a derived study of this work – not only the presence of Innovation as a key-word for a bibliometric refreshment of Forestry studies – but also as a promising and emerging field in the Forestry Scientific fields. Second, we want to explore the dynamics of the authors/co-authors' networks by studying them in different periods/years. Such analysis would enlighten us about the different rhythms of collaboration in the emerging scientific fields. We are aware that journals that published the topic earlier are often received higher citations. This introduces bias to the results. For example, we can see most of the journals that have average publication years the years of 2015 and 2016 have more average citations than journals that have as average publication year the period of 2017. To address this, the VOSviewer program has another option which is the average normalized citations, which should be considered for further researches in improving the validity of the results. Finally, we want to deepen the analysis of the homophily hypothesis among authors/journals, by specifically testing the importance given by these authors/journals in this field to work with authors/journals exhibiting similar patterns of impact factor or focused research fields. It is our intention, also, to explore further the importance of the forest entrepreneurship for a cleaner and sustainable production, not only in the agroforestry sector, but also in the other sectors, as the industry, for example.

In any case, the outcomes here obtained are promising contributions for the several stakeholders promoting and designing more sustainable and cleaner production systems around the world, with the contribution of a more entrepreneurial forest.

## Declaration of competing interest

The authors declare no conflict of interest.

## CRediT authorship contribution statement

**Paulo Reis Mourao:** Conceptualization, Investigation, Methodology. **Vitor Domingues Martinho:** Investigation, Methodology.

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