

## **A bibliometric review of the impacts of logging in forests in semi-arid zones**

### **Abstract**

Forest massifs in semi-arid zones play an essential role in maintaining ecological balances and the livelihood of local communities. However, unsustainable logging in these regions can have devastating ecological, economic and social consequences. This bibliometric review aims to synthesize the available evidence regarding the impacts of logging in semi-arid ecosystems. Analysis of publication trends reveals a significant increase in research from 2008, reflecting a growing awareness of the issues related to sustainable forest management. The United States, Canada, Australia and China stand out as the most prolific countries in this field. Analysis of emerging thematic groups highlights major concerns related to climate change, clear-cutting, interactions with demographic dynamics and biogeochemical cycles. However, gaps remain, including lack of data specific to semi-arid areas, limited understanding of the complex interactions between different dimensions of impacts, and insufficient integration of local perspectives and traditional knowledge. This review highlights the need to continue interdisciplinary and collaborative research efforts to ensure sustainable management of semi-arid forests in the face of current and future environmental challenges.

**Keywords:** logging, semi-arid zones, social impacts, bibliometrics, sustainable forest management

## **1. Introduction**

Forests in semi-arid zones, characterized by irregular rainfall and low levels of productivity, play an essential role in maintaining ecological balances and the livelihood of local communities [1,2]. These fragile ecosystems provide a multitude of ecosystem services, including the regulation of the hydrological cycle, the preservation of biodiversity, carbon sequestration and the production of woody and non-woody resources [3,4]. However, unsustainable logging in these regions can have devastating ecological, economic and social consequences. Numerous studies have highlighted the ecological impacts of this overexploitation, including land degradation, loss of biodiversity, soil erosion and disruption of biogeochemical cycles [3, 4]. Economically and socially, the depletion of forest resources undermines the viability of local livelihoods, exacerbates poverty and can lead to land use conflicts [5,6]. Additionally, the impacts of logging on the structure and composition of semi-arid forests may compromise their resilience to future climate change [3]. Economically, although the exploitation of wood and non-wood forest products constitutes an important source of income for local populations [7], unsustainable management of these resources can lead to their depletion and the loss of these long-term benefits [5]. Additionally, forest degradation can negatively impact other economic sectors such as agriculture and tourism [8]. Finally, the social impacts of logging in semi-arid areas are often overlooked but can be considerable. Reduced access to forest resources can affect the livelihoods and food security of local communities, thereby exacerbating poverty and inequality [6]. Furthermore, conflicts over the use and ownership of forest resources can be exacerbated by unsustainable exploitation [9].

Although many studies have addressed these impacts in isolation, little work has attempted to comprehensively and systematically synthesize the available evidence regarding the ecological, economic and social effects of logging in semi-arid areas. Some reviews have focused on specific aspects such as land degradation [10] or impacts on biodiversity [11], while others have taken a broader perspective but without examining specifically the context of semi-arid zones [12, 13].

A recent bibliometric review by [14] mapped research trends on the environmental impacts of logging, highlighting the importance of this topic but not comprehensively covering the economic and social dimensions. Additionally, this review did not specifically target semi-arid areas, which present unique challenges due to their aridity and vulnerability to climate change.

Thus, despite these previous synthesis efforts, there remains a lack of comprehensive and integrated understanding of the multiple impacts of logging in semi-arid ecosystems. A bibliometric and systematic review aimed at filling this gap would help guide sustainable management strategies in these vulnerable areas. By mapping trends, assessing available evidence and identifying knowledge gaps, this review would make a significant contribution.

This study aims to : (i) analyze research trends related to the impacts of logging, (ii) analyze the major emerging themes linked to the impacts of logging, (iii) identify knowledge gaps and future research needs on the impacts of logging in semi-arid forest areas.

## **2. Methods**

### **2.1.Data collection**

A search strategy that included search terms from a data source to collect most relevant references was carried out. The first step consists of defining a search string taking into account the keywords and terms linked to the PICO (Population, Interventions, Comprator and Outcome) elements [15]. The data source will be the Scopus database (<http://www.scopus.com/search/>). This database was chosen

because it includes a wide range of high-impact international academic journals [16] and mainly records scientific articles, reviews, and books, but also other documents such as reports conferences, etc.

Keywords and terms selected for searches in the main bibliographic databases were derived from the POS elements detailed in Table 1

**Table 1:** Element PIO

Element	Keywords	Synonymous	Syntax
Population (P)	<i>Forest massif</i>	Forest ecosystems, semi-arid forest	“Forest ecosystems” OR “Semi-arid forests”
I (Intervention)	<i>Lumbering</i>	Logging, Wood cutting, etc.	“Forest exploitation” OR “Timber harvesting” OR “Tree felling”
O (Outcome)	<i>Effect</i>	Effect, impact, consequences	“Impacts” OR “Consequences” OR “Effects” OR “Outcomes”

Each element was compared by the Boolean operators OR[15, 17] and their combinations by the Boolean operator AND. The terms made it possible to establish the search chain (Search by titles, keyword summary) as follows:

( TITLE-ABS-KEY ( "Massif Forestier" OR "Forest massif" OR "Forest ecosystems" OR "Semi-arid forests") AND TITLE-ABS-KEY ( "Forest exploitation" OR "Timber harvesting" OR "Tree felling" ) AND TITLE-ABS-KEY ( "Impacts" OR "Consequences" OR "Effects" OR influence ) )

## 2.2.Data analysis

A total of 313 documents were retained from the Scopus data source. These documents were exported respectively to CSV formats, then submitted to R software to carry out bibliometric analyses. Bibliometric analysis is a rigorous and objective approach to literature analysis that allows the identification, evaluation and interpretation of all available studies relevant to a research question in a specific or related area of study. to a specific problem of interest. Thus, the publication trend analysis, the analysis of countries or regions having a strong contribution in the field was carried out using bibliometrix R-Tool via the bibliophagy interface [18], a recent R package that facilitates more comprehensive bibliometric analysis by employing specific tools for quantitative bibliometric and scientometric research. Also, the analysis of the contents of the documents was carried out with the VOSviewer software.

A descriptive bibliometric analysis was carried out, involving the examination of publications and citations over time, the assessment of the quality of the publications and the impact of the authors on the subject studied.

Using biblioshiny, a thematic analysis was carried out to highlight the major thematic groups as well as their evolution over time. The level of importance of the themes was assessed using Callon's centrality index, while their degree of development was assessed by Callon's density, according to the methodology of [19]. These two indicators were used to construct the strategic diagram illustrated in Figure 2, thus making it possible to assess the temporal performance of the identified themes.

### **3. Results and discussion**

#### **3.1. Analyze research trends related to the impacts of logging**

Analysis of the trends in studies on the impacts of logging between 1979 and 2023 (figure 1) reveals a dynamic in two distinct phases. The first, extending from 1979 to 2008, is characterized by modest scientific output and from 2008 to 2023. The two distinct phases observed in the evolution of research on the impacts of logging reflect changes in priorities and the concerns of the scientific community over time. The modest scientific output during the first phase (1979-2008) can be attributed to several factors.

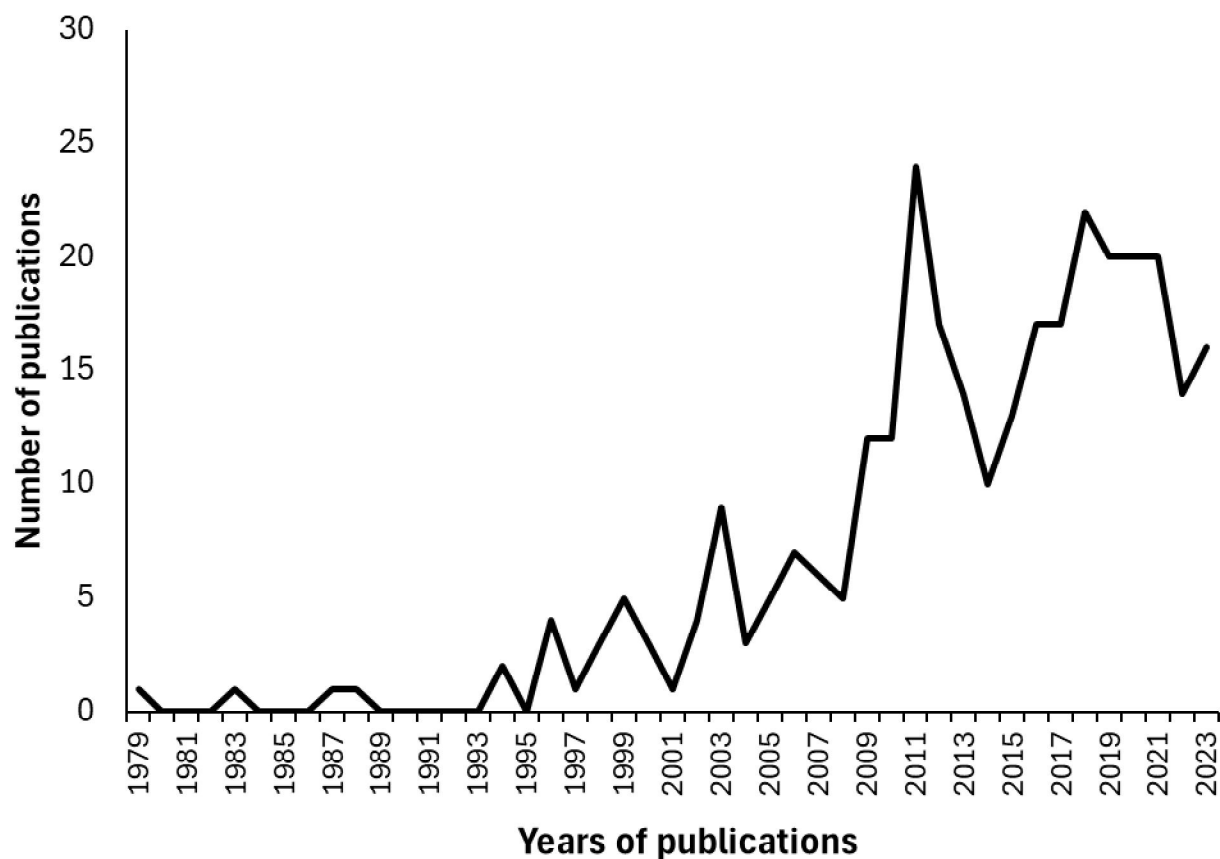
First, the issue of the impacts of logging may not have been seen as an urgent priority at that time, with environmental concerns more focused on other issues such as industrial pollution or the conservation of iconic biodiversity. .

Second, the methodologies and analytical tools needed to comprehensively study the impacts of logging, including remote sensing and ecological modeling techniques, may have been less developed or accessible during this period.

However, it is important to note that this initial phase laid the foundations for future research, allowing pioneers in the field to explore new avenues and raise key questions which were then explored further.

From 2008 onwards, the significant increase in scientific production and the influence of published articles can be attributed to several concomitant factors. On the one hand, the growing awareness of the issues linked to deforestation and forest degradation, amplified by concerns linked to climate change, has probably stimulated the interest of the scientific community in this subject. On the other hand, improved Earth observation technologies and modeling capabilities have allowed researchers to study the impacts of logging more thoroughly and precisely. Finally, repeated calls from international bodies and policy makers for sustainable forest management have likely prompted researchers to become more engaged in this area, in order to provide sound scientific information to inform policies and management practices.

The slow but steady evolution observed during this second phase suggests that the impacts of logging have become a major and lasting concern for the scientific community, reflecting the growing importance given to the preservation of forest ecosystems and sustainable management. of these valuable resources.



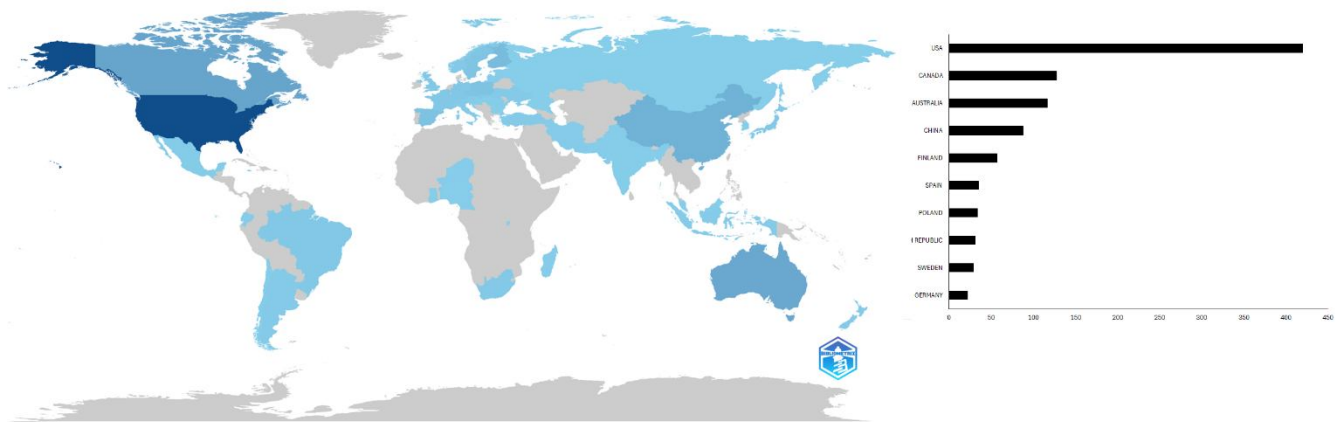
**Figure1:**Publication trend on the theme

### 3.2.Distribution of publications between countries/regions of the world

The number of publications and citations per country on a topic reflects the country's interest in the topic and the influence of its work on current scientific developments. In all of the 333 publications obtained, the impact of exploitation in forest areas has generated more research interest in the USA, Canada, Australia and China (Figure 2.). The USA comes first with a frequency of 450 publications followed by Canada (150 publications) and Australia (125 publications) (Figure 2). Although some African countries have shown interest in the subject, publication efforts are still weak across the continent. In Africa, the countries that have sparked this interest are Niger, Benin, Nigeria, Ivory Coast and South Africa (figure 2).

The geographical distribution of publications and citations reflects both the research capacities of different countries, but also the priorities and specific challenges they face in terms of management of forests and forest areas. Countries that occupy the top positions, such as the United States, Canada, Australia and China, generally have strong research infrastructures, substantial funding and recognized expertise in the field of forestry and ecology. However, beyond these research capacities, the preponderance of publications from these countries may also reflect the importance of the issues linked to forest exploitation on their territories. The United States, Canada, and Australia are home to large areas of forests, some of which are under significant logging pressures. Similarly, China, facing increasing demand for forest resources and reforestation challenges, has likely intensified its research efforts in this area. On the other hand, the relatively low number of publications from African countries

can be explained by several factors. First, research capacities in these countries are often limited by constraints in funding, infrastructure and researcher training. Second, some African countries may place a lower priority on logging research due to other, more pressing social, economic or environmental issues. However, it is encouraging to note that some African countries, such as Niger, Benin, Nigeria, Ivory Coast and South Africa, are starting to become more involved in this area of research. This reflects the growing awareness of the importance of sustainable forest management on the African continent, rich in biodiversity and facing major environmental challenges. To strengthen research capacities and promote more sustainable management of forests in Africa, it will be essential to encourage international collaborations, the transfer of knowledge and technologies, as well as the financing of local research projects. A better understanding of the impacts of logging in these regions will make it possible to better guide policies and management practices adapted to the specific contexts of African countries.



**Figure2:** Spatial distribution of publications on wetland ecosystems from the period 1979 to 2023

### 3.3. Scientific impact of the authors

By jointly analyzing bibliometric indicators such as the number of publications, citations, as well as the H and G indices, three authors stand out as the most influential in the field of research on the impacts of logging in forest massifs : WILLIAMS MR, CHEN J., and LINDENMAYER DB During the period studied, WILLIAMS MR emerges as the most prolific and cited author on this subject, with 6 publications, 67 citations, and H indices (5) and G (6) the highest (Table 2). However, it is important to note that its contribution seems to have been one-off, concentrated around the year 2011 (Figure 3). CHEN J. and LINDENMAYER DB also stand out as influential authors, with high publication and citation counts, as well as respectable H and G indices, reflecting their substantial and lasting contribution to this area of research.

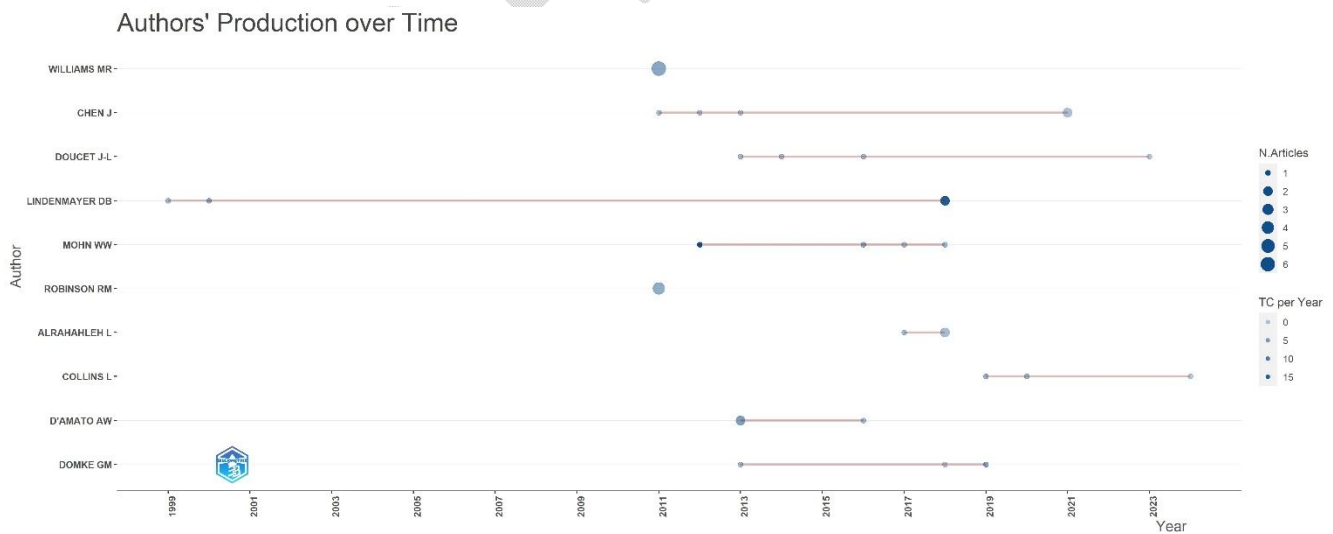
This bibliometric analysis highlights the importance of considering not only the number of publications, but also citations and H and G indices to identify the most influential authors. Although WILLIAMS MR was the most prolific author during the period studied, his impact appears to have been limited over time, unlike CHEN J. and LINDENMAYER DB, who appear to have had a more lasting influence. It is interesting to note that these three authors come from different countries (United States, China and Australia), which reflects the international interest in this research topic and the possible collaborations between researchers from different regions of the world. However, it is important to emphasize that these results should not be interpreted as an absolute measure of the influence or quality of these authors' work. Bibliometric indicators have their limits and only reflect part of the real impact of

research. Factors such as the quality of the journals in which the articles are published, the influence of the work on policy and management practice, and the impact on the training of new researchers must also be taken into account.

Nevertheless, this study provides valuable insight into the structure and dynamics of research on the impacts of logging in forest ranges, highlighting key authors and emerging trends. This information can be useful in identifying potential experts, fostering collaborations and guiding future research efforts in this crucial area for the sustainable management of forest resources.

**Table 2:**H index, G index, total number of citations and number of top ten publications

Element	h_index	g_index	m_index	TC	NP	Year start of publication
WILLIAMS MR	5	6	0.357	67	6	2011
CHEN J	4	5	0.286	49	5	2011
LINDENMAYER DB	4	4	0.154	272	4	1999
MOHN WW	4	4	0.308	301	4	2012
ROBINSON RM	4	4	0.286	56	4	2011
ALRAHAHLEH L	3	3	0.375	26	3	2017
D'AMATO AW	3	3	0.25	90	3	2013
DOMKE GM	3	3	0.25	64	3	2013
DOUCET JL	3	4	0.25	49	4	2013
EVANS SA	3	3	0.115	244	3	1999



**Figure 3:** Evolution of the number of publications and citations of authors. The width of the circle in the figure is proportional to the number of publications and the intensity of the color to the number of citations

### **3.4. Emerging Thematic Groups Related to the Impacts of Logging**

The analysis of the 313 documents made it possible to identify eight major thematic groups linked to the impacts of logging in forest areas. Two major thematic groups stand out as “driving” themes, that is, the most important and most developed in the literature (Figure 4, quadrant 1). These driving themes are organized around two central themes: climate change and clear felling.

The predominance of these two themes reflects the scientific community's major concerns about the potentially devastating effects of excessive logging, particularly clear-cutting, on climate and forest ecosystems. Numerous studies have looked at the impacts of clear-cutting practices on the carbon cycle, biodiversity and the resilience of forests to climate change.

The second quadrant highlights a thematic group related to population density, highlighting the importance of interactions between logging activities and local demographic dynamics. This theme highlights the social and economic issues linked to the exploitation of forest resources by local populations.

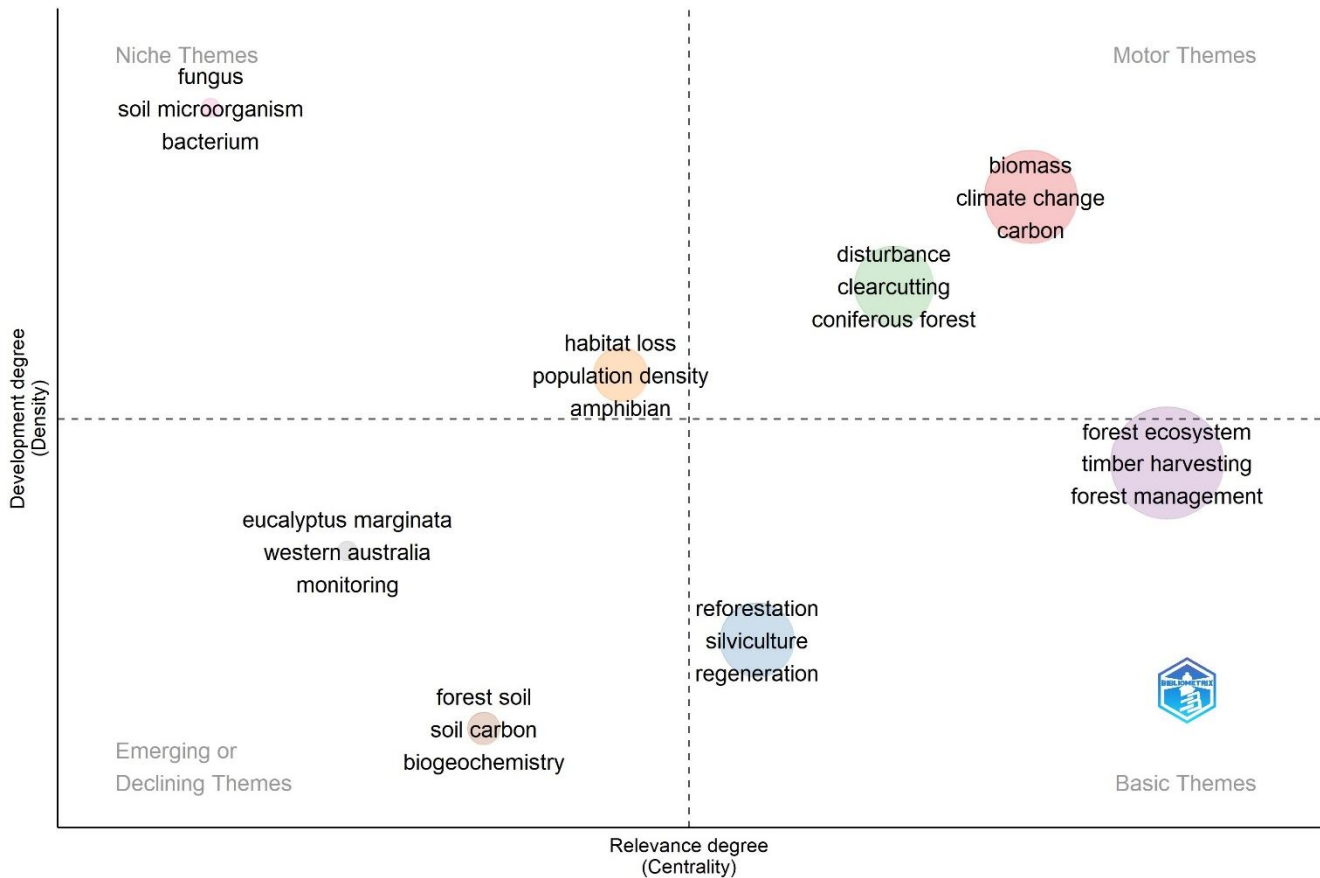
The third quadrant reveals a group of emerging themes, with the central theme of soil carbon. This group reflects the growing interest in studying the impacts of logging on biogeochemical cycles, particularly the carbon cycle, and their role in the context of climate change.

Finally, the fourth quadrant brings together more "basic" thematic groups, with central themes related to silviculture and wood harvesting. These groups represent the more technical and operational aspects of logging, such as stand management methods and harvesting techniques.

This distribution of themes highlights the diversity of concerns and approaches adopted by the scientific community to study the impacts of logging. Although the driving themes focus on major environmental issues such as climate change, other aspects such as social, economic and operational issues are also considered.

However, it is important to note that this thematic analysis only reflects the general structure of the existing literature and does not capture all the richness and complexity of the interactions between these different themes. An interdisciplinary and integrated approach remains essential to fully understand the multiple facets of the impacts of logging.

In addition, the emergence of new themes, such as that linked to soil carbon, underlines the importance of remaining attentive to scientific developments and adapting to the new issues and challenges that arise in this constantly evolving field. .



**Figure4:** Thematic map on the impact of logging in forest areas

### 3.5. Content analysis

The analysis of keyword co-occurrences made it possible to identify five major thematic clusters associated with the impacts of logging in scientific publications (Figure 5).

The first cluster, represented in green, focuses on concepts related to forest ecosystems, such as biodiversity, forest structure, as well as ecological processes. This cluster reflects the importance given by researchers to the effects of exploitation on the integrity and functioning of forest ecosystems.

The second cluster, in red, is associated with silviculture concepts, encompassing forest stand management techniques and harvesting methods. This thematic group highlights the attention paid to the operational and technical aspects of logging.

The third cluster, in blue, is defined by forest management in a broader sense, including policies, strategies and approaches to sustainable forest management. This cluster highlights the importance of an integrated and long-term vision to ensure responsible forestry.

The fourth cluster, in yellow, is characterized by factors influencing forests, such as climate change and natural disturbances. This thematic group highlights the need to consider the multiple factors that interact with logging and shape ecosystem dynamics.

Finally, the fifth cluster, in purple, is linked to ecosystem services from forests, encompassing the economic, social and environmental benefits that these ecosystems provide. This cluster highlights the importance of taking into account the multiple values and functions of forests in exploitation strategies.

This distribution into thematic clusters reflects the multidimensional and interdisciplinary nature of research on the impacts of logging. Researchers have approached this issue from different angles, ranging from fundamental ecological aspects to socio-economic and management considerations.

However, it is important to note that these clusters are not isolated silos, but rather interconnected areas that overlap and interact. A holistic and integrated approach, taking into account the complex links between these different aspects, is essential for a thorough understanding of the impacts of logging and for developing effective sustainable management strategies.

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Furthermore, despite the efforts of this review to highlight the different facets of impacts (ecological, economic and social), the complex interactions between these dimensions remain insufficiently explored. A truly interdisciplinary and integrated approach, capable of understanding these interconnections in all their complexity, is sorely lacking. Only such a holistic approach will make it possible to propose sustainable solutions taking into account all the issues linked to logging in semi-arid zones.

In addition, the impacts of this exploitation on the resilience of semi-arid ecosystems to future climate change deserve particular attention. In-depth research on adaptation and resilience-building strategies is essential to ensure the sustainability of these fragile ecosystems in a context of major environmental upheavals.

Another aspect that is too often overlooked concerns local perspectives and traditional knowledge. Indeed, existing studies mainly focus on scientific and technical aspects, but neglect the knowledge and expertise of indigenous communities in the sustainable exploitation of semi-arid forests. The integration of this ancestral knowledge into research could, however, greatly enrich our understanding of the impacts and management strategies best suited to the realities on the ground.

Finally, a thorough assessment of the effectiveness of current policies and regulatory frameworks in semi-arid areas is required. Although some studies address aspects of forest management and policies, few of them rigorously analyze the relevance and real impact of the measures in force. However, such an assessment would be crucial to guide future reforms and promote truly sustainable exploitation of forest resources in these regions.

These significant gaps strongly underline the need to actively pursue research efforts in this crucial area, by adopting innovative interdisciplinary approaches, promoting indigenous knowledge and strengthening collaboration between researchers, policy makers and local communities. Sustained investments in research and development of new methodologies and technologies adapted to the specificities of semi-arid zones are also essential to meet the complex challenges of sustainable management of forest areas in these vulnerable regions.

## **Conclusion**

This bibliometric review made it possible to explore in depth the current state of knowledge on the impacts of logging in forests in semi-arid zones. While the results obtained highlight the growing awareness of the scientific community regarding these crucial issues, numerous gaps persist. Additional research, adopting resolutely interdisciplinary approaches and integrating indigenous knowledge, is essential. Only a holistic understanding of the ecological, economic and social impacts of logging, as well as a rigorous evaluation of the regulatory frameworks in force, will make it possible to develop truly sustainable management strategies adapted to the specific context of semi-arid zones. Faced with current and future environmental challenges, the sustainability of these fragile ecosystems depends on it.

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