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Efficient use of timber resources in Mexico: Historical development and current challenges

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Abstract

The use and consumption of wood has always captured the attention of forest researchers, mainly from the point of view of forest management and the sustainable processing of raw materials. For this reason, the wood industry has not only been concerned with the maintenance of forests, but also with efficient processing. The objective was to identify, analyse and discuss the main elements that influence the efficient use of natural timber resources at a global, regional and local level, providing a historical and current perspective of the industrial forestry sector in Mexico. Historically, the wood industries worldwide have been concerned with applying intensive silvicultural treatments in native and artificial forest stands, in search of satisfying the demand of a growing market. In this context, industries evolved as processes needed to be more efficient. Therefore, efforts were made to reduce and take advantage of forest residues, at the same time various historical events generated additional needs. At present, the integration of silviculture and forest transformation allow to increase and improve the quality of the products generated. Through the application of intensive silvicultural treatments, products of a single species are obtained. However, it is possible to direct production to a specific market as the forest mass develops. For its part, selective treatments in uneven-aged forests maintain a constant production of diverse products for different specialized markets. In Mexico, it is imperative to analyse and generate innovative or competitive products derived from wood to improve the efficiency of forest harvesting.

Keywords: forest residues; intensive silviculture; selective silviculture; transformation and processing; wood industry; wood products

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Introduction

Historically, forests have provided human society with essential goods and services for livelihood and income generation. Long before modern wood-cutting techniques and tools were developed, humans gathered food, medicine, and other resources that met their basic needs in forests (Sheppard *et al*., 2020), ecosystems where natural resources with important economic, cultural and ecological values are still extracted (Cardenas *et al*., 2018). For this reason, the forestry sector is usually economically important in countries endowed with forests (Lundmark *et al*., 2021; Rascón-Solano *et al*., 2022a; Hernández *et al*., 2023).

Currently, some activities are challenged by low-value wood products (Townsend *et al*., 2019), high costs of extraction of wood or limitations in operational productivity (Holzfeind *et al*., 2021), and changes in the used and installed capacity of forest industries (Fuentes *et al*., 2006). On the other hand, the need to establish strict policies and regulations regarding the use of forest resources in a sustainable manner (Ayala-Mendivil and Sandoval, 2018) and the structure, competitiveness, and diversification of the market (Coelho Junior *et al*., 2019) are factors that add complexity to industrial activities. In this sense, Hurmekoski and Hetemäki (2013) emphasized that the success of the forestry sector in meeting these challenges depends on improving its performance and competitiveness, as well as on the development of new products, improved technologies, and the ability to adapt to changing market conditions.

It is important to mention that the natural potential and proper management of forests allows the increase in the harvest of raw material, to ensure the growing demand of the timber industry (Tymendorf and Trzciński, 2020). In this regard, silvicultural treatment is one of the most important approaches in forest management (Martínez-Meléndez *et al*., 2021). For years, various silvicultural treatments have been implemented around the world to maximize productive yields (Halbritter, 2015), with the goal of supplying, through sustainable forest management, the tangible needs of forest products required by society (Rojas, 1995). Accompanied by the above, supply chain planning in the forest products industry covers a wide range of operations and decisions strategic and operational (Bredström *et al*., 2010).

Since forest resources are of great global and national importance, strong forest governance and a balance of interests between timber harvesting and the forest industry are necessary (Trishkin *et al*., 2014). To what has been described above, it is added that the business environment of the forest industries has undergone drastic changes (Lähtinen and Toppinen, 2008). Due to these changes, maintaining competitiveness and acceptable business success, especially in traditional sawmilling, is more challenging than ever before (Lähtinen et al., 2008). Changes in production and consumption patterns (Hetemäki and Hurmekoski, 2016), industrial processes, final product demands and management practices (Lauri et al., 2021) are factors that challenge the sustainability of the current forestry industry (Borz *et al*., 2021).

Based on the above, the objective was to identify, analyze and discuss the main elements that influence the efficient use of natural timber resources at a global, regional and local level, providing a historical and current perspective of the industrial forestry sector in Mexico. It assumes that the availability of resources, forest management methods, industrial capacity and the available market are factors that determine the sustainable use of timber resources in Mexico.

Materials and Methods

Despite the socioeconomic importance of the timber industry in Mexico, the information available on this activity is mostly fragmented and incomplete. For this reason, for this review, information from 90 investigations related to forest management oriented to timber harvesting and the timber industry was considered. Preference was given to studies that presented precise information on the activities carried out in the development of the timber activity and it was discussed how processes and products can be adapted to the conditions of the forestry sector in Mexico at an international level. A total of 23 works published between the years 1914 and 2021 were selected, these investigations mention how the historical management of forests for timber purposes has been given. We consider a total of 14 papers published between 1930 and 2022 that describe the historical evolution of the timber industries. In relation to the use of solid waste resulting from the transformation of wood, 6 publications covering the year 1926 to 1997 were selected. We analyzed 16 articles to describe the challenges and opportunities for Mexico in relation to intensive forestry and the products to be generated in the industry, works published between 2008 and 2022 were considered. Finally, to describe the products generated from mixed forest and the challenges presented for Mexico, 31 investigations published between 1999 and 2022 were reviewed.

Results and Discussion

Historical development of silviculture for industrial purposes

The management of forest resources during the last two centuries has been mainly oriented towards the generation of sustainable production schemes for goods with market value, focused on wood (Aguirre, 1997). For this reason, the wood industry has not only been concerned with sustaining forests, but also with the efficient transformation (AHEC, 1995). However, Dávalos (1996) indicates that the waste of timber forest resources has had and will have unfortunate consequences for forest sustainability.

Timber industries worldwide have been based mainly on the application of intensive silvicultural treatments in native and planted forests (Kruger and Everard, 1997; Zwolinski, 1998) by integrating tree management and improvement practices (Daniels, 1984), seeking to satisfy the demands of a growing market (Clapp, 1995). Initially, it was suggested that natural forests have the capacity to produce the raw material for all the wood industries (Korstian, 1914; Guthrie, 1925; Cox, 1976). However, the intensive management of forest plantations has played an increasingly important role for timber production (Sedjo, 1984) and bioenergy products (Anderson *et al*., 1983).

In Mexico, there have been historically quite stringent government restrictions to control logging on private land (Meyer, 1939). However, the first experiences of timber harvesting began at the beginning of the 20th century in the state of Chihuahua (Estrada and Rodríguez, 2021), where clearcutting was practiced to install the railroad tracks that passed through the forest massifs (Musalem, 1982). While forest management was already widespread in Europe during the 1980s, Mexican silviculture was not yet highly developed (Moreno, 1988). In contrast, Mexican timber harvesting has focused mainly on low-intensity selective felling (Islas *et al*., 1988), followed by intensive management with the treatment of regeneration cuttings (Rodríguez, 1997). Furthermore, harvesting has been based on the implementation of the Mexican Forest Management Method (MFMM) for virgin forests (Ramírez-Maldonado and Romahn de la Vega, 1999) and the Mexican Method of Management of Irregular Forests (MMMIF) for uneven-aged stands (Gadow and Puumalainen, 2000), both cases with selective felling. Additionally, for even aged forests, intensive felling has been applied. In this regard, the Silvicultural Development Method (SDM) (Valencia, 1992) and to a lesser extent the Silvicultural Conservation and Development System (SICODESY) were applied (Ramírez-Maldonado and Romahn de la Vega, 1999). Primarily, forestry management has been implemented for commercial purposes from a principle of environmental and ecosystemic sustainability (Dávalos, 1996; Aguirre-Calderón, 2015).

Historical background of the timber industry

The use and consumption of wood has always captured the attention of forest researchers, mainly from forest management and the transformation of raw materials. The first literary reference to a working sawmill comes from a fourth-century Roman poet, Ausonius, who describes a watermill cutting wood (Ritti *et al*., 2007). Later, in the 11th century, hydraulic and animal-drawn sawmills were in widespread use in the Islamic world, from Spain and North Africa to Central Asia (Lucas, 2005).

The first sawmills were powered by wind power, around the 13th century. In Germany the first sawmills powered by hydraulic power appeared as early as 1322 (Peterson, 1973). Works such as those carried out by Boissiere (1991) and Szasz (1991) indicate, that in central and eastern Europe, the beginnings of timber were based on the production of charcoal for the forges and the carving of logs for medieval construction until the 16th century. During the industrial revolution at the end of the 18th century and the middle of the 19th century, wood undoubtedly acquired greater relevance, as it was closely related to some of the most significant processes of economic change (De Molina and Alier, 2001). Part of this change was the construction of tracks and the manufacture of wagons, the production of crates for agricultural products, and urbanization to provide support and cladding for the construction of buildings (Zapata, 2002).

In North America, during European colonization in the mid-17th century, the first sawmills installed in Virginia state simply adapted the circular saw to mechanical power, generally driven by water currents to speed up the process. Later on, forestry companies integrated steam-powered double-disc sawmills that were implemented in the 18th century. Thereafter, in the 19th century, the band saw industries were powered by electric motors (Peterson, 1973). The first sawmills in Mexico were put into operation in the pine forests of the state of Michoacán at the end of the 19th century (Musalem, 1982). As for the north of the country, in 1880, the first sawmill was built in Coahuila to supply the mining industry. Shortly after, the first timber industry was installed in the state of Durango in 1893 (Aylor, 1930). For its part, the state of Chihuahua began the transformation of pine wood in sawmills on railcars intended to increase the length of the train tracks. Subsequently, there was the presence of American lumber companies in 1905, to which the state government granted a concession for the installation of sawmills, a paper mill and a furniture factory (Estrada and Rodríguez, 2021). Additionally, Zavala (1996), Tamarit *et al*. (2021) and Rascón-Solano *et al*. (2022a) indicates that the degree of technological advancement and adaptation of the wood industry in Mexico has been slow or even lagged behind in some regions of the country (Escárpita, 2002).

Origin of solid waste processing

Regarding the management and transformation of waste from timber processing, Courtnage (1926) reports that portable sawmills were 10 % less efficient than static ones. Besides, they produced significant amounts of waste that were not used or transformed into other products, due to high transportation costs. Later in Germany, at the end of the 1940's, the particle board industry emerged, due to the shortage of sawn timber and the need to rebuild cities during the postwar period (Borgin, 1958).

Sawing cuttings are processed to obtain a wide variety of wood products, including pallets, boxes for agricultural products, and pulp for papermaking (Aylor, 1930). Gisborne (1929) mentions that the pulp industry was expected to replace the sawmill industry because it was more efficient and generated less volume of waste, since the bark was the only waste, this transition has not occurred in Mexico. As for the bark, which constitutes up to 20% of round wood, it was regularly used as fuel for sawmills and boilers for drying wood (citation). Moreover, bark was used to produce soil fertilizer and soil nutrients (AHEC, 1995).

Subsequently, at the end of the 20th century, there is practically no waste in the timber industry anymore, thanks to the increasing research to optimize wood processing (Kauman, 1997). Furthermore, the development and introduction of machines using lasers and scanners, have contributed significantly to the improvement of quality control and the efficient use of wood supplies (AHEC, 1995).

Current challenges in the intensive silviculture and the timber industry of Mexico

Regarding the management of forest resources, different silvicultural interventions provide a wide range of forest products. Figure 1 shows a hypothetical example of the various industrial products that can be obtained from the application of intensive silvicultural treatments in even-aged pine stands, such as the treatment of seed trees using the Silvicultural Development Method. Once regeneration has developed, the first stand intervention is carried out to adequately distribute the trees, increase forest productivity and reduce competition for resources by managing stand density through thinning. At this stage, the forest generates biomass that must be used to generate bioenergy through pellets. Thus, short (3 to 6 years) and medium (5 to 7 years) rotation plantations have been included in bioenergy generation programs (Santangelo *et al*., 2015; Ouyang *et al*., 2022), with the main objective of producing fuel to generate heat and electricity (Aylott *et al*., 2008). However, this alternative has not yet been widely explored in Mexico and other Latin American countries (Borrego-Núñez *et al*., 2022).

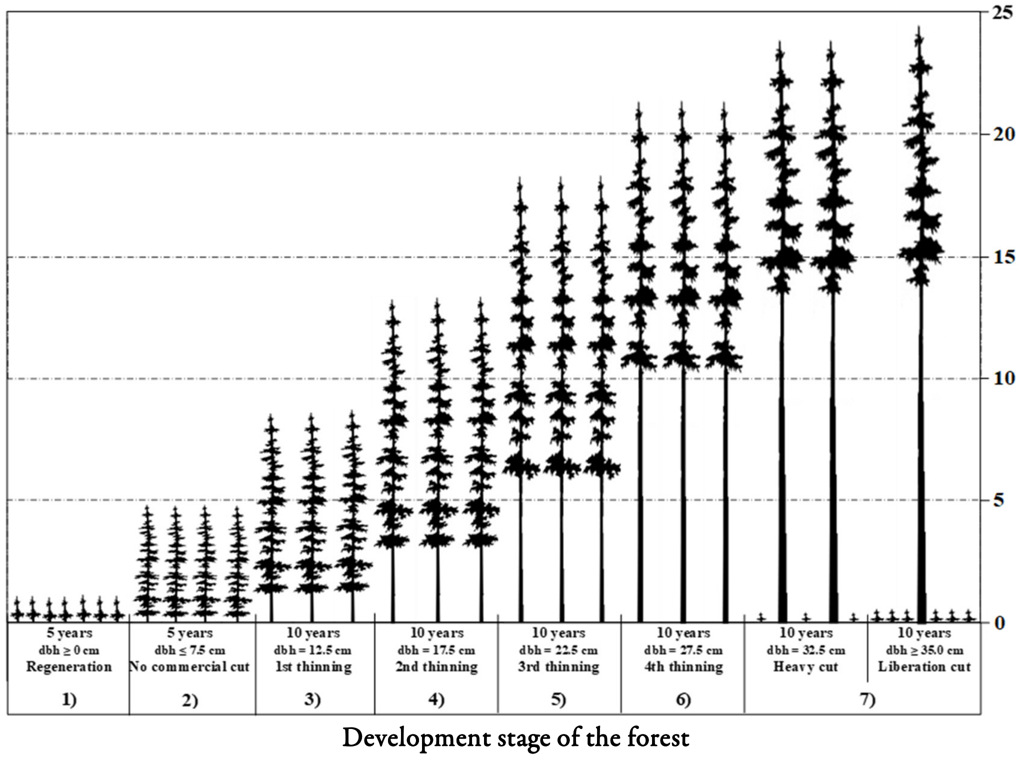

Figure 1. Potential primary wood products as a result of different silvicultural treatments in even-aged coniferous forest stands of Mexico. The mentioned years correspond to the time period between the silvicultural interventions. The DBH (diameter at breast height) mentioned is reached at the point in time of intervention. 1) tree regeneration (non-existent raw material); 2) biomass and material enabled for broomstick; 3) biomass and material enabled for broomstick, impregnated stakes for the agricultural sector and impregnated beam; 4) biomass, impregnated stakes for the agricultural sector, thin diameter sawing logs , secondary products, fibers for boards, particles for boards and bark for bioenergy; 5) biomass, thin diameter sawing logs, secondary products, fibers for boards, particles for boards and bark for bioenergy; 6) biomass, thin diameter sawing logs, thick diameter sawing logs, pole for electrification, fibers for boards, particles for boards and bark for bioenergy; and 7) biomass, roundwood for boards, pole for electrification, thick diameter sawing logs, thin diameter sawing logs, secondary products, fibers for boards, particles for boards and bark for bioenergy

When presenting the commercial diameters, a first thinning is carried out (Stage 3), which consists of reducing the density in conglomerate groups. This stage has a greater number of products that can be extracted from the forest. For instance, it is possible to generate rustic beams for construction and stakes for agricultural use, while the preservation of the products allows their prolonged use. As described by Román *et al*. (2014), individuals with dimensions similar to those shown, have the potential to produce poles, firewood and rural constructions. Furthermore, juvenile wood is associated with shrinkage and a high probability of warping and cracking in the final products (Ruano and Hermoso, 2021; Ruano *et al*., 2022). Therefore, they are not regularly integrated into traditional industrial processes. Hence, logging residues cannot be easily transformed into products such as sawn wood. However, they fulfill ecological functions such as maintaining adequate levels of biomass in the process of being reintegrated into the soil, when left or returned to forest stands (Villela-Suárez *et al*., 2018).

Secondary wood products for processing are obtained at the earliest during the second or third thinning (Stages 4 and 5), when the forest stand has reached a certain maturity. During these operations, raw materials are obtained for the thin-diameter sawmill industry, medium-density fiberboard and particleboard industry, as well as for the supply of cellulose pulp to the paper industry. In addition, impregnated beams can be the product of silvicultural interventions during these stages. In addition, small-sized logs have the potential to produce pallets in secondary sawmills (Taipe and Rivas, 2021; Haro *et al*., 2015). According to Eisenbies *et al*. (2021) and Latterini *et al*. (2022), the demand for lignocellulosic biomass has increased for different paper industrial purposes.

Conventional wood products are obtained from even-aged stands during the fourth thinning. In northern Mexico (Stage 6), this treatment is applied when the forests have an average age of 50 years approximately. With the harvested individuals that present the best phenotype, priority should be given to the generation of poles for electrification and telecommunications. In accordance with Corvalán (2020), this product requires a specific silvicultural scheme to satisfy the market. The main industries that must be benefited with supply are medium density fiber boards and the sawmill industries of thin and thick diameters. Referring to this, mature forests as potential producers of raw material for the manufacture of fiberboard and sawmilling (Grigsby *et al*., 2015); Borz *et al*., 2021). However, Lauri *et al*. (2021) mention that this mainly depends on the demand of the market.

During the seventh stage of forest management to supply the forestry industry (Stage 7), the aim is to promote the emergence of natural regeneration or to assist the forest through planting and subsequently, remove the upper layer made up of mature trees and cultivate this juvenile tree stand. Firstly, with regeneration felling, a large volume of biomass from large individuals is planned to be removed; secondly, regeneration release logging plans to remove all adult individuals. High-quality raw material is obtained from these treatments, since intensive silviculture promotes self-pruning and the development of straight stems in the stock (Ruano and Hermoso, 2021). Priority should be given to the plywood industry due to the high quality of the raw material, followed by the sawmill industry for thick and thin diameters. Kallakas *et al*. (2020) and Fekiač *et al*. (2021) mention that the main industry to be supplied at the end of the shift from intensively managed forests is plywood, due to the high quality of the logs and a low percentage of knots. Finally, the secondary products of the sawmill and the production of particle boards based on sawdust and chips will benefit from the primary transformation. In this way, Mirski and Dziurka (2011) indicate that chipboards are an essential element in improving the integral use of wood. Harvesting residues, such as the tops of the trees and crowns, have the potential to be transformed into pellets for bioenergy. Villela-Suárez *et al*. (2018) mention similar functions for harvesting residues. The bark obtained after the transformation has an energetic potential. AHEC (1995) proposes to use bark as fuel for the boilers that dry the wood or to produce fertilizers (Ayipio *et al*., 2021). Additionally, the bark is also an important source of nutrients for the forest, in addition, it is captured carbon that has the ability to integrate into the soil.

Current challenges in the uneven-aged silviculture and the timber industry of Mexico

Unlike even-age management methods, selection treatments in uneven-aged stands have the potential or deficiency, depending on the manager or industrial interest, to produce a wide variety of raw materials, as diverse as the tree stand is complex. The hypothetical example shown in Figure 2 contains a common structure of uneven-aged forests in northern Mexico, where the genera *Pinus* and *Quercus* predominate, followed by the genera *Juniperus*, *Arbutus* and occasionally the genus *Alnus* (Rascón-Solano et al., 2022b). These types of forests offer a solution to climate change by storing carbon, providing ecosystem services and sustainable products (Lo Monaco *et al*., 2022; Başkent and Kašpar, 2022; Saklaurs *et al*., 2022). On the other hand, they have the potential to produce soft and hard wood, with which it is possible to supply different markets at the same time. Likewise, the presence of trees in different stages of development supplies different industries interested in the raw materials contained therein.

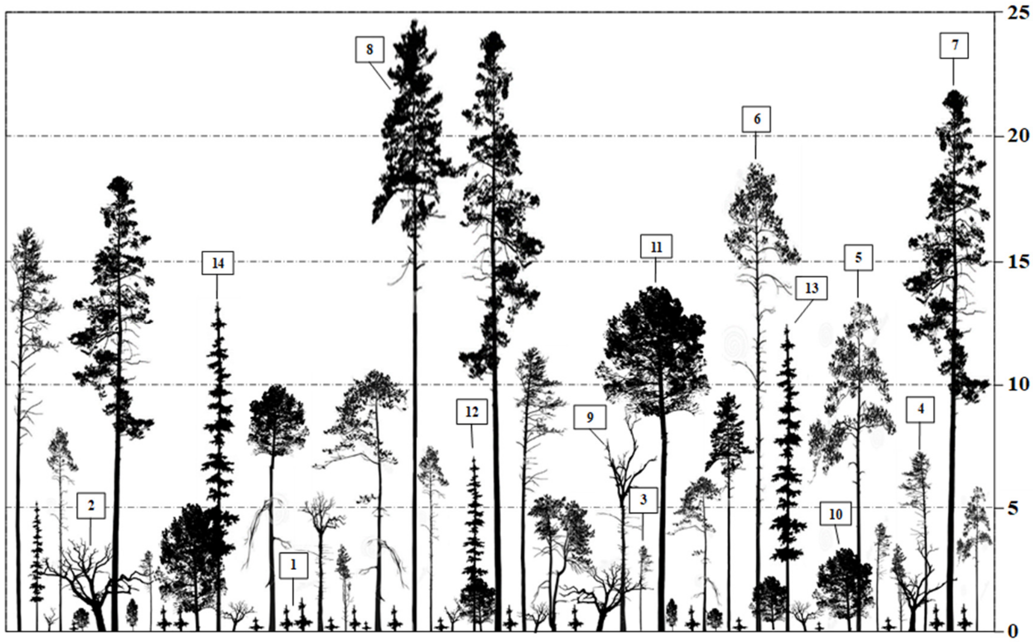

Figure 2. Potential primary wood products as a result of selective silviculture in uneven-aged mixed pine-oak forest stands in Mexico. 1) regeneration (non-existent raw material); 2) biomass; 3) biomass and broomstick enabled fabrication; 4) Biomass broomstick enabled fabrication, impregnated agricultural poles and impregnated beams; 5) biomass, impregnated beams, thin diameter sawing, secondary products, fibers for boards, particles for boards and bark for bioenergy or gardening; 6) biomass, thin diameter sawing, secondary products, fibers for boards, particles for boards and bark for bioenergy or gardening; 7) biomass, thin diameter sawing, thick diameter sawing, secondary products, fibers for boards, particles for boards and bark for bioenergy or gardening; 8) biomass, round logs for boards, thick and thin diameter sawing, secondary products, fibers for boards, particles for boards and bark for bioenergy or gardening; 9) biomass, fibers for boards, charcoal and domestic fuel; 10) biomass and domestic fuel; 11) biomass, thick and thin diameter sawing, secondary products, charcoal and domestic fuel; 12) biomass, domestic fuel and impregnated agricultural poles; 13) biomass, impregnated agricultural poles, thick diameter sawing and thin diameter sawing; and 14) biomass, thick diameter sawing and thin diameter sawing.

As previously mentioned, regeneration in establishment does not have an industrial potential. Nevertheless, it will become the main source of biomass in this type of stands. Additionally, it is important to mention that the genus *Pinus* has been widely used in various countries, and the products obtained from its management are similar or even the same as those indicated in this study. On the other hand, Figure 2 shows species that have not been used commercially, such as the genus *Arbutus*, because their stems tend to have an irregular shape that is difficult to handle in the industry. However, individuals of this species have the potential to be destined mainly for the energy industries, for the production of composite pellets with other genera from the same ecosystem. Tovar-Rocha *et al.* (2014) mention that despite the fact that *Arbutus* is a genus of ecological importance, it has been little studied and its wood is mainly used for the manufacture of handicrafts. For this reason, there is a lack of management of this genus. Sub-indices 9 and 12 in the Figure 2 illustrate the dead softwood and hardwood trees in these forest stands, due to competition, climate change and the attacks by pests and diseases (Pimienta *et al.*, 2007; Trigueros *et al.*, 2018). The plans to use this raw material are intended to supply the sawmill industries with logs. In this regard, Löwe *et al.* (2022) found that the use of wood from trees infested with bark beetles without the presence of mold and fungi is not problematic for construction purposes. Hence, the transformation and commercialization of sawn wood from dead trees is feasible (Mackes and Eckhoff, 2015; Loeffler and Anderson, 2018). With the branches and residues of harvesting, domestic fuels are mainly produced, when these residues are not used, they are integrated as biomass in the soil.

Several authors mention that firewood is the main fuel for the communities, depending on the product to supply and cover their daily needs (Quiroz-Carranza and Orellana, 2010; Mozo and Silva, 2022). Currently, there is the possibility of redirecting the raw material to bioenergy and board industries that have promising growth on a global scale. With regard to the industrial management of hardwoods such as the *Quercus* genus, historically the raw material has been destined for the sawmill industry. In the early stages of development of these species it is not possible to supply the sawmills. However, Rogers *et al.* (2022) indicate that silvicultural approaches to hardwoods have varied widely, to meet both, diversifying ecological silvicultural objectives and traditional production. Hence, these juvenile individuals have the potential to be transformed into energy and charcoal. Suchomel *et al.* (2011) mention that the growing demand for juvenile hardwood for bioenergy is an important economic alternative. Subsequently, when the individuals reach commercial size, it is pertinent to supply the sawmilling industry. In this context, recent studies have pointed out that the marketing of hardwoods in the form of sawn timber is an important economic opportunity (Nicholls and Bumgardner, 2018; Hassler *et al.*, 2019). The potential for the use of this wood type has not been increased in Mexico, due to the complexity of processing and the technological limitations of the industries (Zavala, 2003).

Currently harvested genera of low commercial interest such as *Juniperus*, have been consumed by local markets as a priority for the generation of agricultural poles. Similarly, Vaughan and Mackes (2017) mention that this alternative is a further future opportunity to use juniper wood in road railing systems, because it has excellent resistance to natural decay (Ffolliot *et al.*, 1999). The technological wood properties of this conifer species are still largely unknown. However, juniper has the potential to produce high quality sawtimber when individuals reach maturity or supply the bioenergy sector, so its wood properties should be further studied. Forest industries have enrolled in certification of forest management and the chain of custody due to a perceived increase in demand for certified products, and the need to increase the productive efficiency of forest land (Bond *et al.*, 2014; Sjølie *et al.*, 2015; Hyytiä, 2022). Thus, global practices for optimizing the use of forest resources, based on appropriate distribution of products and performance planning of all products to be produced, are directly related to international forest certification guidelines.

At the individual tree level (considering mature trees from 25 to 30 meters high), it is possible to obtain product for various industrial uses. Mainly, the production of plywood is obtained from the base of the tree (4.88 meters length), because it is where the largest diameter of the log and the highest quality free of defects occur (Fekiač *et al.*, 2021). High- and medium-quality lumber is derived from the second and third section of the log (9.75 meters length, as larger diameter logs tend to produce a higher volume of quality lumber (Borz *et al.*, 2021; Orozco *et al.*, 2017). The fourth chop section has adequate quality to produce medium density fiberboard (4.88 meters length), the dimensional characteristics and quality of the log result in better economic benefits (Grigsby *et al.*, 2015). Pulp for papermaking is obtained from the penultimate section of the log (4.88 meters length), mainly because the inferior dimensions and low quality of the wood do not advance to the final product (Eisenbies *et al.*, 2021; Latterini *et al.*, 2022). Biomass production for energy generation originates at the tip of the tree, because according to (Villela-Suárez *et al.*, 2018), it is a product that is generally not used and has energy potential.

For Mexico and other countries in Latin America, it is essential to increase certified forest areas (Hernández *et al.*, 2023). In addition, research should focus on the development of new wood-derived products, analyzing them and putting them into practice. Thus, there is great potential to serve attractive international markets, including textiles, solid and liquid biofuels, chemical products, bioplastics, and packaging (Hurmekoski *et al*., 2018).

Conclusions

Over time, the timber industry was able to improve its processing procedures and increase productivity, due to technological progress. For instance, relevant historical events motivated the professionals of the time to look for alternatives, to diversify production, as well as to make efficient use of available resources, especially solid waste from forest management and wood processing.

The availability of resources is crucial for the diversification of wood production and the residues from forest harvesting and wood processing have a high potential to produce alternative products. The management methods largely determine the industry that can be supplied. The use of even-age forest stands is an alternative to focus on high production for one or two specific markets. On the other hand, complex tree structures have the potential to supply a wide variety of products to several markets at the same time. Besides, these types of forests have a high potential for carbon storage, the provision of ecosystem services and the generation of sustainable products. In turn, the installed industrial capacity delimits the production of timber products, and industrial diversification is again one of the factors determining the efficient use of wood resources in each forest region.

The production and market sectors must drive the future of the timber industry in Mexico, based on success stories and international programmes. Domestic and foreign investment needs to be promoted for the development of new products and manufacturing capabilities that can offer highly engineered wood and pulp products. Forestry research institutions should develop advanced processes and emerging products that can be attractive to the market and that allow the transformation of wood harvesting residues.

This revision work allows to exemplify in a simple way the different products that the wood industries of Mexico can produce. It is based on coniferous forests that are management in a large part of the country, considers the most representative species in this type of ecosystem and provides recommendations regarding the sustainable use of the various tree structures found, guiding the diverse use in relation to the stage of forest development.

Authors' Contributions

Conceptualization, J.R.S. and O.A.A.C.; methodology, J.R.S., O.A.A.C. and W.H.; validation, J.A.N.L.; formal analysis, E.A.R., J.J.P. and E.T.G..; investigation, J.R.S. O.A.A.C. and W.H.; resources, J.R.S.; writing-original draft preparation, J.R.S., W.H.; writing-review and editing, O.A.A.C. and J.A.N.L.; supervision, O.A.A.C. All authors read and approved the final manuscript.

Ethical approval (for researches involving animals or humans)

Not applicable.

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Conflict of Interests

The authors declare that there are no conflicts of interest related to this article.

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