



Gaps in diversity representation and data insufficiencies in the U.S. forest sector workforce analysis

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ABSTRACT

When comprehensive and accurate data on diversity and representation is available, it significantly enhances our understanding of business challenges, thereby bolstering policy decisions and strategy formulation across all organizational tiers. Using the U.S. forest sector as a case study, we illustrate that there are significant gaps in diversity and representation within the private forest sector, particularly in terms of gender and race. These disparities exist across various domains and categories, including different forest industries, job roles, and business ownership structures. Our analysis brings to light the inadequacies of the current workforce data, emphasizing their limitations in keeping pace with the changing socio-economic landscape. We examine these areas of oversight and emphasize the profound implications they have for guiding both research and practices aimed at cultivating a sustainable and inclusive workforce.

Introduction

Our ability to progress on several Sustainable Development Goals (SDGs) depends on reducing inequalities between demographic groups based on, for example, gender, race, and ethnicity. Public and private organizations play a central role in improving representation of people from minoritized groups in the workforce. By increasing intentional efforts to remove barriers that these groups face, they can have a greater opportunity to move through organizational hierarchies. Workplace diversity also generates benefits for organizations, since evidence suggests that more diverse organizations achieve a greater level of performance (Aghazadeh 2004; Gomez and Bernet 2019; Hossain et al., 2020; Van Knippenberg et al. 2020). Workplace diversity is therefore a societal imperative that responsible organizations must take seriously.

Within this backdrop, the lack of diversity in the U.S. forest sector in particular, and the natural resource sector in general, has been a recurring topic of conversation (Arenas et al., 2023; Batavia et al., 2020; Bosworth, 2006; Brown et al., 2010; Hartshorn et al., 2023; Westphal

et al., 2022; Sharik et al., 2015; Taylor 2022). The natural resources sectors are perceived as lacking representation, potentially leading to reduced labor availability, reduced innovation, or even the potential irrelevance of the sector in relation to other sectors (Batavia et al., 2020; Bullard et al., 2023). Furthermore, this lack of representation raises questions about equity and social and environmental justice regarding who benefits from the goods and services provided by nature (Batavia et al., 2020). The motivations underlying the push for increased diversity have not been extensively studied (Ville et al., 2023; Batavia et al., 2020). By challenging assumptions about gender or equality in general, it can spark discussions “about what society needs from the forest, and what the forest needs from society” (Ville et al., 2023).

In essence, the factors contributing to the underrepresentation of women or minoritized groups in forest-related disciplines and organizations are complex and varied. They encompass multifaceted institutional and personal elements, making it difficult to pinpoint a singular root cause and its corresponding remedy (Batavia et al., 2020; Lippe et al., 2022; Westphal et al., 2022).

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For example, within the broader economic context, the link between the perceived status of occupations and gender-based segregation is weak (Lippa et al., 2014; Blackburn et al., 2001; Melkas and Anker 1997). Nowadays, differences in earnings between men and women cannot be attributed to biological differences, but to the division of unpaid caregiving and household labor (Goldin, 2014).

Meanwhile, women and minorized groups in the forestry and natural resources fields report harassment, lower job-satisfaction, and gender-based discrimination more frequently than their male counterparts (Johansson et al., 2018; Sjølie et al., 2023). They often endure an unwelcoming atmosphere, grapple with the perception that forestry is a primarily a “male” profession, struggle to feel a sense of belonging, and perceive limited career opportunities (Sjølie et al., 2023; Crandall et al., 2020; Baublyte et al., 2019; Larasatie et al., 2019; McGown 2015). These challenges are likely to become more pronounced for individuals with intersecting identities encompassing race, women gender, ethnicity, citizenship status, disability and sexuality (Collins and Bilge 2020).

Managing diversity actively has shown its benefits in retaining a workforce (Lippe et al., 2022; Sachdeva et al., 2023). However, industry or sector-level initiatives aimed at establishing transparent data and monitoring systems to measure and monitor progress have been limited (Lippe et al., 2022; ECE 2018). The ongoing development of data and monitoring initiatives provides valuable guidance for creating such systems within shifting societal and environmental contexts, enabling a more comprehensive understanding of variations in workforce trends.

For example, The Inclusive Data Charter (IDC) advocates for the design of inclusive and intersectional data approaches to identify inequalities within and between groups of people based on various factors of identity (Bolton et al., 2023; Global Partnership for Sustainable Development Data, 2023). Although data approaches tailored to specific contexts and co-designed with affected individuals or groups are generally preferred, there exist broadly applicable principles. These include acknowledging and involving individuals at risk of marginalization and discrimination in all aspects of data systems at both individual and systemic levels. These principles can be implemented across various geographies and institutions (Bolton et al., 2023; Global Partnership for Sustainable Development Data, 2023).

An inadequate information management system poses a barrier to formulating evidence-based policy advice and adaptable strategies for steering the development of the forest sector in a direction that resonates with potential employees with diverse demographic and cognitive backgrounds (Lippe et al., 2022). This is particularly significant in the context of the U.S. forest sector, considering the continued importance of both public and private sector organizations as employers (Bullard et al., 2023).

Data-driven work from the U.S. public sector (e.g., Westphal et al., 2022) showed that during the period 1995–2017, the overall size of the USDA Forest Service (USFS) shrunk by about 20 %, and a greater decline happened in the number of women employees relative to men employees. As a result, the USFS became less gender diverse during this period. The proportion of American Indian/Alaska Native workers also declined, whereas the proportion of Black employees remained largely unchanged, and the proportion of Hispanic/Latino employees slightly increased (Westphal et al., 2022).

Westphal et al. (2022), also found that efforts to improve diversity have been successful at the leadership level within the USFS, but the same improvements in Research and Development (R&D) and frontline positions have not happened. In another study, Sachdeva et al. (2023) found that career performance (advancement or termination) within the Forest Service varied significantly based on race and gender. Dockry et al. (2022), analyzed approaches to improve diversity within the USFS. Their analysis revealed that, although trainee and internship programs yield positive outcomes, with a majority of interns transitioning to permanent roles, they alone do not exert a sufficient impact on long-term employee diversity within the USFS. It is worth noting that Black and Hispanic interns were five and three times more likely than

their White counterparts to secure permanent positions with the agency after completing their internships (Dockry et al., 2022). Locke et al. (2023) examined demographic profiles of the USFS workforce at each workplace in comparison to the population of the surrounding community. Their findings revealed striking disparities, prompting questions about the organizations’ overall representativeness, as well as the ability for individuals from historically underrepresented groups to succeed within the USFS.

Studies have also been conducted at the private-public interface. Deak et al. (2023), recently explored the extent and magnitude of workforce-intensive forestry contracts conducted on National Forest System lands. Their study investigated the businesses engaged in these contracts, their geographical distribution, the nature of work undertaken, and the distances covered by these businesses between 2001 and 2020. Throughout this period the contracts totaled \$12.9 million for workforce-intensive forestry operations, with a predominant focus on wildfire-related activities. Geographically, the businesses were primarily situated in western states, and non-minority-owned businesses received 84 % of contracts. Among minority-owned businesses, Hispanic American-owned businesses obtained the highest number of contracts by 11.5 % share. Native American or American Indian received 3.6 %, Black American 0.5 %, and Asian Pacific or Subcontinent Asian (Asian Indian) American 0.5 %. In terms of total funding, women-owned businesses received 7 % of the total funding and 93 % went to businesses owned by men.

While there is legislative and policy support, as demonstrated by Equal Employment Opportunity (EEO), Affirmative Action (AA), and Justice40 initiatives, there remains a gap in the systematic development and utilization of diversity across diverse fields, industries, and stakeholders. Currently, efforts are underway to bridge this gap in the forest sector, with several initiatives addressing workforce considerations and catering to the interconnected interests and needs of various stakeholders. An example is *Women’s Forest Congress*, which is about developing strategies and solutions for forests, shaping the latest innovations through a women’s perspective. *Women Owning Woodlands* is an association that brings topical, accessible, and current forestry information to woodland owners and forest practitioners to support women in forest leadership. *Forest and Wood Products Inclusion Council* was formed to bring forest sector leaders together with experts in Diversity, Equity, and Inclusion (DEI) to address racial and gender inequities in the sector. The Council includes representatives from public, private, not-for-profit, academic, and Indigenous organizations in the forest sector. Additionally, *Sustainable Forestry and African American Land Retention Network* was developed for creating a sustainable system of support for African American forest owners that significantly increases the value of African American owned forests, land retention, and asset development for Black families in the U.S. South.

Despite recent strides made in research and in practice, a significant research gap persists in understanding and analyzing representation within the private forest sector in the U.S. This gap encompasses the nuanced dimensions of workforce representation and how these are accounted for in data and monitoring efforts intended to support diverse stakeholders reliant on workforce.

In this study, we set out to explore the state of diversity in the private forest sector in the U.S. This is the first attempt of its kind to collect, systematize, and analyze quantitative diversity data from across all publicly accessible data sources. In this research we examine three well-established forest industries: forestry and logging, the wood products manufacturing industry, and the paper manufacturing industry. Further insights into these industries are elucidated in greater detail in the subsequent section.

Data and methods

For this study, we assimilated diverse data sources and organized the data presentation across three interconnected levels: industry,

occupation, and business ownership.

At the industry level, our focus extended to three sectors—forestry and logging (113), wood products manufacturing (321), and paper manufacturing (322)—as per the North American Industry Classification System (NAICS). These industry-level data are aggregated to encompass all occupations within each industry, providing an overview of the varied tasks within forest value chains, spanning administrative roles, ecosystem management, logging, sales, and R&D positions.

Occupational group data are derived from the Current Population Survey (BLS 2023) and classified under the standard occupational classification system (SOC). Our exploration covers the *natural resources occupational group* (SOC-45 000), which includes farming, fishing, and forestry occupations. Within this group, we detailed three forest sector-related occupations: first-line supervisors, forest and conservation workers, and logging workers. The *management occupational group* (SOC 11–0000) includes roles like chief executives, legislators, managers, administrators, and directors. Within this group, we spotlight the detailed occupation of conservation scientists and foresters. Although in the SOC classification they fall under “Life, physical, and social science occupations” (SOC 19–0000), we opted for the management occupation as a more encompassing reference group due to the intradisciplinary leadership roles often faced by forest and conservation scientists. The *production occupational group* delves into tasks related to the mechanical, physical, or chemical transformation of materials, substances, or components into new products (SOC 51–0000). Business ownership data are presented for employee firms classified under the relevant industries in the study (NAICS 113, 321, and 322). Large private sector companies are members of American Forest and Paper Association (American Forest and Paper Association, 2023), National Alliance of Forest Owners (NAFO, 2022), or listed as TOP100 Global Forest, Paper & Packaging Industry companies (PricewaterhouseCoopers, 2016).

For a comprehensive understanding of data levels and demographic coverage, refer to Table 1a and b for descriptions and sources, and Appendix A for detailed descriptions of individual occupations.

Additionally, we conducted comparisons between private forest sector data and the total manufacturing sector (NAICS 31 – 33) or the employed U.S. civilian workforce. The share of women and the age structure in the forest industry is compared to the total manufacturing sector, while racial and ethnicity data are mostly compared to the civilian U.S. workforce (Table 1b). These comparisons offer a broader context to understand how the forest sector aligns with overall

Table 1a
Description of the data reporting at industry, occupational and business ownership levels. See appendix A for more detailed occupation descriptions.

Reporting level	Description
Industry level	Industry level statistics are aggregate numbers for all employees in occupations within the industry. Data are reported for the wood product manufacturing industry, paper product manufacturing industry, logging and forestry.
Occupational level	We present data for three occupational groups (i–iii) and detailed forest sector related occupations under each group (<i>italicized</i>). i) Natural resources occupations group <i>first-line supervisors, forest and conservation workers and logging workers.</i> ii) Management occupations group <i>conservation scientists and foresters.</i> iii) Production occupations group <i>paper machine workers, woodworking machine workers, sawing machine workers, other woodworkers.</i>
Business ownership level	Ownership by gender, race, and ethnicity of forest sector employer firms

Table 1b
Description of workforce representation dimensions, temporal data coverage and data sources.

Workforce representation dimension	Temporal coverage	Source (Survey/ Database)	Section where data are presented
Industry level General workforce trends in the forest industry	2005–2021	(U.S. Bureau of Labor Statistics, 2023a)	3.1.
Age distribution of the workforce in the forest industries compared to the total manufacturing sector	2021	(U.S. Bureau of Labor Statistics 2023a)	3.1.2.
Representation of women (% of the workforce) in forest industries compared to the total manufacturing sector	2005–2021	(U.S. Bureau of Labor Statistics, 2022a)	3.2.
Representation of racial and ethnic diversity in the forest sector	2005, 2021	(U.S. Bureau of Labor Statistics, 2022a)	3.3.
Foreign employees in a sample of forest sector companies based on H-1B visas		(H-1B Employer Data Hub 2022)	
*See formative work by Blinn et al. (2021) and Russell et al. (2023) for H2B visa holders.	2015–2021	(H-1B Salary, 2022; H-1B Employer Data Hub, 2022)	3.5.1
The geographical distribution of H1B visas	2021	(H-1B Salary, 2022; H-1B Employer Data Hub, 2022)	3.5.1.
Occupational -level General workforce trends by occupational groups and detailed forest sector occupations	2005, 2010, 2015, 2021	(U.S. Bureau of Labor Statistics, 2022a)	3.1.1
Black, Asian, White and Hispanic or Latino Race/ Ethnicity representation in natural resources, production and management occupation groups and in detailed forest sector related occupations	2005, 2021	(U.S. Bureau of Labor Statistics 2023b)	3.1.1
Foreign workforce in natural resources, production and management occupations groups and detailed forest sector related occupations	2005, 2021	(U.S. Bureau of Labor Statistics, 2023b)	3.2 and 3.5
Business ownership -level Business ownership by gender and race. Some intersectional data are available.	2020	(U.S. Census Bureau, 2022)	3.4

workforce development trends. Some overlap exists between forest industries and the total manufacturing sector, as wood product and paper product manufacturing currently constitutes 6 % of the total manufacturing workforce (BLS 2023). Drawing a comparison between the private forest industry and the manufacturing sector provides a contextual understanding, assuming that both are influenced by comparable market and regulatory conditions.

The U.S. civilian employed workforce includes individuals 16 years of age and older residing in the 50 states and the District of Columbia, excluding active-duty military personnel, institutional individuals, agricultural workers, and federal government employees (DOL 2023). By comparing the forest sector data to the U.S. civilian workforce, we gain insights into how the forest industry and forest-related occupations align with general workforce trends.

All data are managed and stored and tables produced in Microsoft Excel, while figures are generated in R software using tidyverse and

viridis packages.

Workforce representation dimensions covered in this study include race/ethnicity, gender, age, and native- and foreign-born status as the diversity assessment criteria (Table 1b). Race and ethnicity mostly include Black, Asian, White, Hispanic/Latino, because limited data were available for American Indian and Alaska Native, as well as intersectional data for gender and race. Foreign-born status includes legally-admitted immigrants, refugees, temporary residents, such as students and temporary workers, and undocumented immigrants. *Minority* in this report refers to a culturally, ethnically, or racially distinct group that coexists with but is less powerful to a more dominant group. Some of the data were available for a longer time horizon (e.g. women-gender composition) than others.

Our primary objective was to identify the most suitable and representative data, with a specific focus on the timeframe spanning from 2005 to 2021. This time window was selected to encompass a significant portion of recent history and ensure data consistency. Changes in diversity representation were gradual, and in some cases, we presented only years 2005 and 2021. A comprehensive dataset, including additional data points, are available on request.

This research is chiefly descriptive and explanatory. Its analytical value lies in assessing the importance and scrutinizing the implications of the analysis carried out using up-to-date numerical data. The study involves identifying blind spots and discussing implications, with a focus on the data and monitoring perspective.

Results

General workforce trends in the forest industry 2005–2021

The private forest industry workforce has experienced a significant decline in size since 2005, as shown in Fig. 1; between 2005 and 2010, the workforce shrunk by 27 %. The total workforce employed in the U.S. forest industry (NAICS 113, 321, 322) in 2021 was approximately 865,000 employees.

Overall, in the period between 2005 and 2021, employment in the wood product manufacturing industry declined by 24 %; in the paper manufacturing industry by 27 %, and in logging and forestry by 40 %. In the wood product manufacturing industry, employment has increased

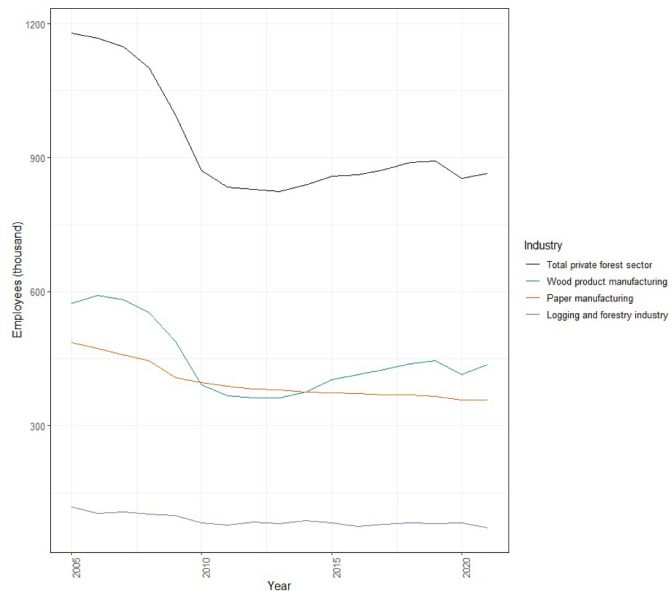


Fig. 1. General trends in employment in logging and forestry, wood product manufacturing industry, paper manufacturing industry 2000–2021 (in thousands of employees).

since 2012.

Trends in workforce composition for selected occupational groups, as well as detailed forest sector-related occupations 2005, 2010, 2015, 2021

We start with a broad look at the industry in general. In the following sections we will break industries down by diversity dimensions. Between 2005 and 2021, natural resources occupations decreased by 9 %, while production occupations declined by 15 %. However, management occupations witnessed an increase of 31 % during the same period. Each of these groups contain a number of occupations, of which the most closely linked occupations are selected for further investigation (Table 2).

Within the natural resources occupational group, our data collection focused on three specific occupations: First-line supervisors, Forest and conservation workers, and logging workers (Fig. 2). The number of first-line supervisors increased from 39,000 to 49,000, indicating a 26 % increase. Forest and conservation workers experienced a larger rise of 50 %, increasing from 14,000 to 21,000. However, one of the most striking changes was the decline in the number of loggers, which decreased by 39 % from 84,000 in 2005 to 51,000 in 2021.

Within the management occupation group, we obtained information on conservation scientists and foresters. The data reveals a decline in their numbers from 28,000 to 23,000, representing an 18 % decrease between 2005 and 2021.

Turning to the production occupations, our analysis included paper machine, woodworking machine, and sawing machine workers and other woodworkers. Overall, the number of workers in production occupations related to the forest sector experienced a decline over the years. Collectively, these occupations witnessed a significant loss of 50 % of jobs during the study period, which is a more rapid decline compared to the average decline in employment in production occupations.

Between 2005 and 2021, paper machine workers experienced a substantial decline of 70 %, reducing from 57,000 to 17,000 employees. Wood machine workers faced a decline of 41 %, with their numbers decreasing from 46,000 to 27,000. Additionally, sawing machine workers witnessed a 52 % decline, from 56,000 to 27,000. The number of other woodworkers decreased by 18 %, from 28,000 to 23,000.

Age diversity in the forest industry workforce

Understanding age diversity in the forest sector is crucial for anticipating the impact of retirement on the workforce. Additionally, age diversity provides insights into whether the sector is attracting and retaining young workers. The figure reveals that the manufacturing industry is experiencing a rapid increase in the average age of its workforce, with a significant portion of employees belonging to +45-year-old age groups (Fig. 3). Similarly, the forest sector demonstrates an even faster aging trend, indicating a higher proportion of older workers compared to the manufacturing industry.

Representation of women in the private forest sector workforce

In the forest industry, the share of women varies between 5 % in logging and forestry and 24 % in paper product manufacturing industry in 2021 (Fig. 4). While the share of women has decreased in the logging and forestry from 7 % in 2015 to 5.4 % in 2021, the share of women has marginally increased in wood product manufacturing and paper manufacturing, from 14 % to 15.6 % and 21.7 % to 23.6 %, respectively.

Table 2

Workforce trends in natural resources, management, and production occupational groups for the years 2005, 2010, 2015, and 2021.

Group	2005	2010	2015	2021
Natural resources occupations	15,348	13,073	13,733	13,959
Management occupations	49,245	51,743	57,960	64,745
Production occupations	9378	7998	8522	7950

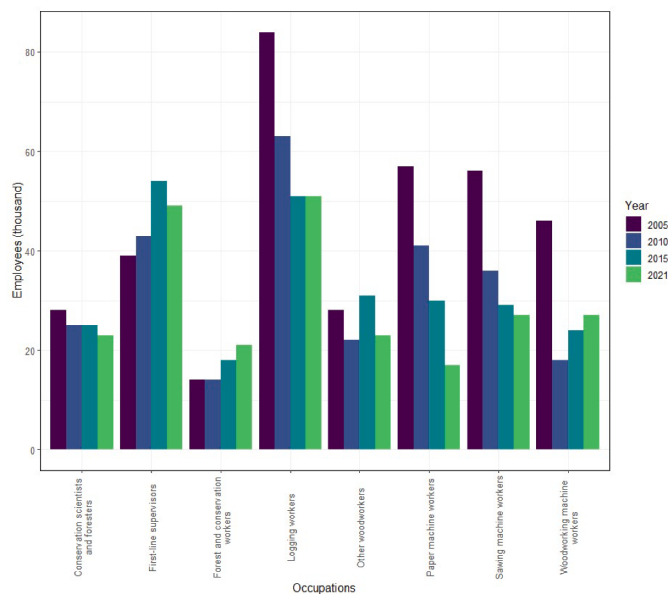


Fig. 2. Employment in forest sector specific occupations 2005, 2010, 2015 and 2021, (thousand employees).

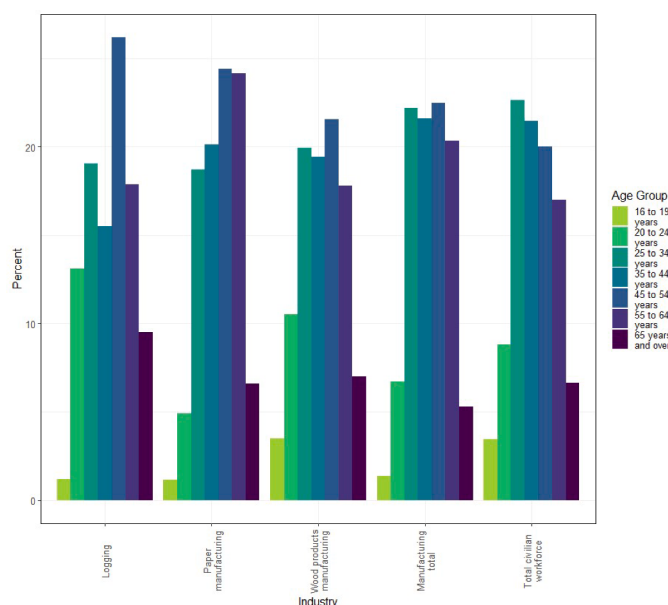


Fig. 3. Age distribution of the workforce in the forest industries compared to the total manufacturing industry and U.S. civilian workforce in the year 2021.

The representation has remained low but stable over the recent years.

Representation of women in selected occupational groups, as well as detailed forest sector-related occupations: a closer look at the years 2005 and 2021

When looking at the general occupational groups, the participation of women in the workforce showed variation across different types of occupational categories. These categories provide a comparison for occupation level evaluation in forest-sector specific occupations (Table 3).

The representation of women in natural resources occupations experienced fluctuations between 2005 and 2021. The representation of women in forest and conservation workers has shown an upward trend, increasing from 21 % in 2005 to 33 % in 2021. In 2021, the logging industry exhibited a significantly low representation of women of 4 %

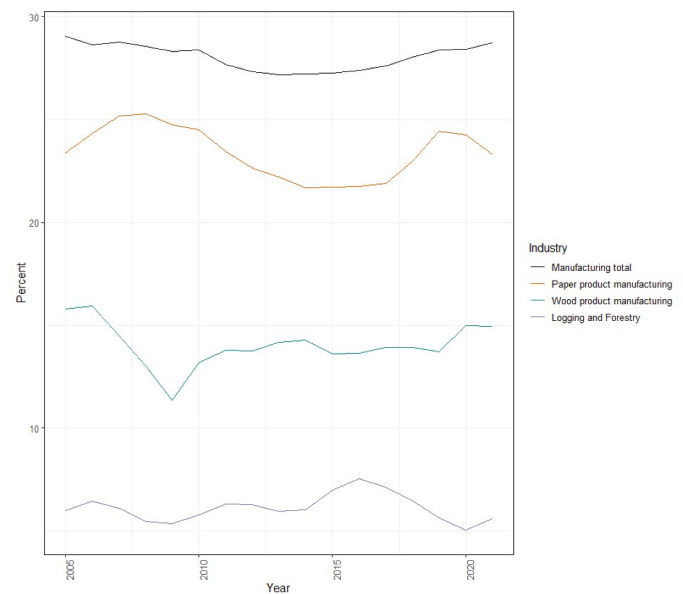


Fig. 4. Women's representation (% of the workforce) in forest industries compared to the average manufacturing sector from 2005 to 2021.

Table 3

Women's representation in the years 2005 and 2021 in management, natural resources, and production groups (bolded), as well as detailed forest sector occupations (% of employees).

Occupation	2005	2021
Natural resources occupations	5	6
Logging workers	1	4
Forest and conservation workers	21	33
First-line supervisors	8	6*
Management occupations	51	52
Conservation scientists and foresters	21	36
Production occupations	30	28
Sawing machine workers	11	12
Woodworking machine workers	20	13
Other woodworkers	7	9
Paper machine workers	29	38

*In 2020, the proportion of women was 13 %, but declined rapidly during the COVID-19.

but it was up from 1 % in 2005. In 2005, women comprised 8 % of first-line supervisors, but this percentage decreased to 6 % in 2021, likely influenced by the COVID-19 pandemic (e.g. Hayes and Lee 2023).

The share of women in management occupations was 52 % in 2021, which is almost the same as in 2005, when the share of women was 51 %. In conservation scientists and foresters occupations, the percentage of women increased from 21 % in 2005 to 35 % in 2021.

In production occupations overall, the share of women was 30 % in 2005 and 28 % in 2021. Overall, the representation of women in forest industry-related production occupations remains low, ranging from 9 % in woodworkers to 38 % in paper machine workers in 2021 (Table 3). The production occupation data exhibit variability over time, making it challenging to depict clear trends in terms of diversity representation in these occupations. Generally, the share of women has either declined or remained relatively stable.

Representation of racial and ethnic diversity in the private forest industry in the years 2005 and 2021

This section presents an analysis of the workforce composition, specifically focusing on the proportions of Black or African American employees, Asian employees, White employees, and Hispanic or Latino

employees in both the total employed civilian workforce and various forest industries (as outlined in Table 4).

The divergence in racial and ethnic representation within forest industries can be seen in Table 4 when compared to the broader civilian workforce. In logging and forestry, the representation of Black or African American workers remains notably low, whereas in paper manufacturing, it more closely resembles the demographics of the civilian labor force. In 2021, the percentage of Black and African American employees ranged from 2.8 % in forestry to over 11 % in the paper manufacturing industry.

Asian workforce representation is consistently lower in all forest industries when compared to the representation in the overall civilian workforce. Asian workforce representation exhibited variation, ranging from nearly 1.5 % in forestry to 4 % in the paper manufacturing industry. Conversely, the share of Hispanic or Latino workers is higher in wood and paper manufacturing industries. In 2021, the representation of Hispanic or Latino ethnicity varied from 8 % in logging to 20 % in wood products manufacturing. The representation of Latino and Hispanic workers has increased in logging and wood product manufacturing at rates comparable to the civilian workforce in general.

White workforce representation, on the other hand, is consistently higher across all forest industries when compared to the civilian workforce, with a representation exceeding 83 % in these sectors.

Race and ethnicity representation in selected occupational groups, as well as detailed forest sector-related occupations, in the years 2005 and 2021

In terms of diversity representation at the occupational level (across

Table 4

Workforce representation in the civilian workforce and across logging, forestry, wood products manufacturing and paper manufacturing industries for the years 2005 and 2021.

Industry	Group	Percent		Total (thousand)	
		2005	2021	2005	2021
Total, 16 years and over employed civilian labor force	Black or African American	10.8	12.3	15,306.8	18,767.5
	Asian	4.4	6.6	6236.1	10,070.4
	White	–	77.5	–	118,250.3
	Hispanic or Latino	13.1	18	18,566.6	27,464.6
Logging	Black or African American	9.7	5.2	10.3	4.4
	Asian	–	–	–	–
	White	–	93.9	–	78.1
	Hispanic or Latino	3.1	7.6	3.3	6.4
Forestry	Black or African American	2.8	–	1.8	–
	Asian	1.5	–	0.8	–
	White	–	–	–	–
	Hispanic or Latino	4.0	–	2.1	–
Wood products manufacturing industry	Black or African American	10.6	9.6	57.5	41.0
	Asian	2.1	0.7	11.4	3.0
	White	–	85.9	–	366.8
	Hispanic or Latino	14.6	19.7	79.1	84.1
Paper manufacturing industry	Black or African American	10.5	10.6	130.3	82.2
	Asian	2.4	3.7	29.8	28.7
	White	–	83.1	–	644.0
	Hispanic or Latino	12.1	13.3	150.2	103.1

No data available or reported. Data for White was not disclosed at the detailed industry level until 2017 (BLS 2023).

different industries), including gender, race (Black, Asian, White), and Hispanic or Latino ethnicity, some changes can be observed when comparing 2005 and 2021 numbers.

The natural resources occupations have not notably diversified, and the racial representation remains low (Table 5). The percentage of Black employees was 6 % and Asian 2 % in 2021, very similar to the representation in 2005. The Black workforce percentage was 10 % among forest and conservation workers (up by 4% from 2005), while among logging workers the share was 2 %. Asian representation in natural resources was so low that statistics do not exist. White and Hispanic and Latino representation have changed more notably. White workers constituted 56 % of the workforce (down from 67% in 2005), while Hispanic and Latino workers accounted for 33 % (up from 21 % in 2005) of the natural resource occupation workforce in 2021. Forest and conservation workers, logging workers, and first-line supervisors follow the same trends.

Management occupations have been diversifying in terms of race since 2005. In 2021, the percentage of management occupations for Blacks were 9 %. Asians were 9 % and Hispanic and Latinos were 10 % of management occupations. Our data shows that among conservation scientists and foresters, racial representation is limited. White racial identities constituted 95 % of the workforce in 2021, while Black and

Table 5

Proportions of Black, Asian, White, and Hispanic or Latino ethnicity workers in selected occupational groups (bolded), as well as detailed forest sector related occupations in the years 2005 and 2021 (% of employees).

Group	Occupation	2005	2021
Black	Natural resources occupations	7	6
	Forest and conservation workers	7	10
	Logging workers	9	2
	First-line supervisors	3	4
	Management occupations	8	9
	Conservation scientists and foresters	4	–
	Production occupations	12	13
	Sawing machine workers	11	12
	Woodworking machine workers	7	6
	Other woodworkers	0	0
	Paper machine workers	22	25
	Natural resources occupations	2	2
	Forest and conservation workers	–	–
	Logging workers	–	–
	First-line supervisors	–	–
Asian	Management occupations	6	9
	Conservation scientists and foresters	–	–
	Production occupations	5	5
	Sawing machine workers	2	–
	Woodworking machine workers	2	–
	Other woodworkers	–	–
	Paper machine workers	2	6
	Natural resources occupations	67	56
	Forest and conservation workers	64	57
	Logging workers	79	82
	First-line supervisors	67	57
	Management occupations	78	69
	Conservation scientists and foresters	93	95
	Production occupations	61	56
	Sawing machine workers	70	69
White	Woodworking machine workers	65	75
	Other woodworkers	89	91
	Paper machine workers	29	38
	Natural resources occupations	23	33
	Forest and conservation workers	21	33
	Logging workers	11	33
	First-line supervisors	28	33
	Management occupations	6	10
	Conservation scientists and foresters	0	5
	Production occupations	20	24
	Sawing machine workers	14	19
	Woodworking machine workers	24	25
	Other woodworkers	7	9
	Paper machine workers	12	19

- no data were available.

Asian representation was undocumented in 2021. Hispanic and Latino workforce representation increased from 0 to 5 %.

In production occupations (Table 5), the share of workforce that is Black was 13 %, and Asian were 5 % in 2021, which is similar to the representation in 2005. The share of White representation was 56 % in 2021, which is 5 percentage points less than in 2005. Hispanic and Latino representation in the workforce increased from 20 % in 2005 to 24 % in 2021, which compares to the general civilian workforce representation of 13.1 and 18 %, respectively. In the detailed forest sector related occupations, Black workforce particularly presented as paper machine workers with a 25 % share 2021. Asian representation is low in the production occupations, while White representation is relatively high. However, representation is decreasing and relative to the civilian workforce White racial identities are less represented in production occupations than other races. Hispanic and Latino workforce representation is in the forest sector specific production occupations.

Ownership demographics in paper manufacturing, wood manufacturing, logging, and forestry industries by gender, race, Hispanic ethnicity and in the year 2020

The total number of businesses in the forest sector, whose ownership is categorized by race, gender and race, and Hispanic ethnicity and gender is presented in Table 6. These data enable us to highlight some intersectionality (Bolton et al., 2023), although they are only available for certain demographic groups.

In 2020, the U.S. had over 23,000 firms engaged in paper manufacturing, wood product manufacturing, and forestry and logging. Wood product manufacturing had the highest number of firms, with 11,620, followed by forestry and logging with 8896 firms, and paper manufacturing with 2374 firms.

The majority of the firms had White owners. In forestry and logging, 97 % of businesses were White-owned. In wood product manufacturing and paper product manufacturing, White ownership stood at 95 % and 84 %, respectively.

Racial, ethnic and gender representation was limited, as was the data. For forestry and logging, and paper product manufacturing, we are unable to present any numbers. In Wood product manufacturing, American Indian and Alaska Natives and Asians owned less than 1 % of the businesses, while Hispanics owned 4.6 % of the firms. 0.9 % of firms were owned by Black, and 0.1 % was owned by Black women. In the same industry, Asian women owned 0.2 % of the firms, and White women owned 6 %. Despite that Native Hawaiians and other Pacific

Table 6

Distribution of business ownership by race, ethnicity and gender in 2020 (% of firms, forestry and logging $n = 8896$, wood product manufacturing $n = 11,620$, Paper product manufacturing $n = 2516$).

Racial and Hispanic business ownership in 2020 (% of Firms)		Forestry and Logging	Wood product manufacturing	Paper product manufacturing
Race				
American Indian and Alaska native	**		0.9	**
Asian	**		0.9	**
Black or African American	**		0.6	**
White	97.1		94.6	84.1
Unknown/not reported	2.9*		3*	15.9*
Hispanic/non-Hispanic ethnicity				
Hispanic	0.02		4.6	4.1
• Hispanic, White			4	5
Non-Hispanic	99.5		91.9	82.6
• Non-Hispanic, White	96.9		90.2	79
• Non-Hispanic, Black or African American	**		0.6	**
• Non-Hispanic, Asian	**		0.9	**

*Calculated by subtracting information on other categories from 100 %, ** values missing or withheld due to data quality concerns.

Islanders own wood product manufacturing firms, data were not available due to the uncertainties and limitations, and thus their share falls under “unknown”.

Additionally, some co-ownership arrangements between men and women existed in wood product manufacturing and paper product manufacturing with the largest share being 12.6 % in the wood product manufacturing industry and 6.4 % in the paper product manufacturing industry (Table 6).

Women ownership in wood product and paper product manufacturing industries in 2020 (% of firms).

	Wood product manufacturing	Paper product manufacturing
Race		
Asian women	0.1	**
Black or African American women	0.1	**
White women	6.4	11.2
Hispanic/non-Hispanic ethnicity		
Hispanic women	**	0.1
Non-Hispanic women	6.2	12.4

** values missing or withheld due to data quality concerns.

Equal women/men ownership in wood product and paper product manufacturing industries in 2020 (% of firms)

	Wood product manufacturing	Paper product manufacturing
Race		
American Indian and Alaska native	0.03	**
Asian	0.1	**
Black or African American		**
White	13.1	6.2
Hispanic ethnicity		
Hispanic	0.6	6.4
Non-Hispanic	12.6	**

** values missing or withheld due to data quality concerns.

Foreign-born workforce in selected occupational groups, as well as detailed forest sector-related occupations, for the years 2005 and 2021

The share of foreign-born workers was about 17 % of the civilian workforce in 2021, which is up by 2 % from 2005. During the same period, the share of foreign-born workers increased across all the occupation groups and detailed forest sector occupations, except for sawing and woodworking machine workers (Table 7).

In 2021, 27 % of the natural resources workforce were foreign-born on average. The foreign-born share was higher in forest conservation workers (29 %) and first-line supervisors (29 %). Management occupations had 14 % foreign-born share in the workforce, but there was no data for the share for conservation scientists and foresters. Production occupations had a total of 23 % foreign workforce in 2021, while all the detailed forest-sector related production occupations had less than 20 %.

Men represented 61 % of the foreign-born workforce in 2005 and 58 % in 2021 (Table 8). In natural resources occupations, the share of women was 5 and 6 % on average in 2005 and 2021, respectively.

The representation of foreign-born women in forest related occupations was lower than men. Only in forest and conservation workers was the representation close to equal in 2021.

Employment of foreign-born workers in large private sector companies 2015–2021: a geographical perspective

Through the H-1B visa program U.S. companies and employers temporarily employ foreign workers in specialized occupations that require a high level of knowledge, typically accompanied by a bachelor's degree or higher in the relevant field or its equivalent. In 2021, the sampled 30 companies applied for a total of 147 H-1B visas, representing

Table 7

Foreign-born workforce in occupation groups and specific forest sector -related occupations for years 2005 and 2021 (% of employees).

Occupation	2005	2021
Total, 16 years and over employed civilian labor force	15	17
Natural resources occupations	22	27
Logging workers	12	14
Forest and conservation workers	21	29
First-line supervisors	18	29
Management occupations	11	14
Conservation scientists and foresters	–	–
Production occupations	22	23
Sawing machine workers	14	12
Woodworking machine workers	20	19
Other woodworkers	4	9
Paper machine workers	14	19

– indicates no data available or value rounds to zero.

an 8 % decrease from the previous year (2020) (Fig. 5). Since 2015, there has been an overall increase in the number of H-1B visa applications within the U.S. forest sector, with 2018 recording the highest number of applications.

The data reveals a notable concentration of roles for foreign-born experts in the southern states of the United States. Georgia emerges as a prominent destination for foreign-born employees within the forest sector. In 2021, the state hosted 38 applications, which represented approximately 25 % of the total applications received (Fig. 6).

Discussion

Presently, the private forest sector workforce in the U.S. has low but varying levels of diversity and representation across forest industries and occupations, and in business ownership, aligning with prior research in the public sector (Westphal et al., 2022; Sachdeva et al.,

2023; Locke et al., 2023). Our findings also corroborate arguments from the broader economics literature, highlighting the persistent and consistent nature of gender segregation in employment. This segregation was found to be more pronounced in economically developed countries than in less developed countries (Bertay et al., 2020; Lippa et al., 2014). While gender has garnered significant attention in academic research on the forest sector workforce (Sjölöe et al., 2023; Crandall et al., 2020; Baublyte et al., 2019; Larasatie et al., 2019; Johansson et al., 2018; McGown 2015), there is a comparative lack of understanding regarding workforce dynamics along various racial, ethnic, and immigration status cross-sections, as well as intersectionalities.

The contribution of this study is twofold. Firstly, it examined the state of representation in the U.S. forest sector simultaneously from multiple demographic perspectives. Secondly, leveraging insights from this study, we can highlight the absence of specific groups in the data and discuss the implications of these gaps (Bolton et al., 2023). While there are risks associated with quantitative indicators for tracking progress (such as the risk of merely improving metrics without addressing power dynamics, as discussed by Ville et al., 2023), quantitative data can facilitate discussions on workforce needs and identify gaps in the data monitoring system. It also helps identify the necessary data improvements to align with principles like those outlined in the Inclusive Data Charter (IDC) (Bolton et al., 2023).

General economic research has concluded that women are more inclined towards roles involving human interaction rather than "inanimate things and mechanical systems" (Lippa et al., 2014), a pattern reflected in the forest sector data. Our data reveals an overall upward trend in employment within roles such as first-line supervisors, conservation and forestry workers, and forest and conservation scientists. The shift in employment from wood production positions toward ecosystem-focused roles, emphasizing human interaction and innovation (Economic Commission for Europe (ECE) 2018; Stangel-Meseke 2017), appears to be intricately linked to the increasing diversity within the sector, influencing not only gender representation but also, in certain instances, the

Table 8

Gender, race and ethnicity distribution among foreign workforce for the years 2005 and 2021 (% of employees).

	2005						2021					
	Men	Women	Black	Asian	White	Hispanic or Latino	Men	Women	Black	Asian	White	Hispanic or Latino
Total, 16 years and over employed civilian workforce	61	39	8	22	20	49	58	42	10	25	16	47
Natural resources occupations	95	5	4	6	13	77	94	6	4	5	8	83
Forest and conservation workers	100	–	–	–	–	100	50	50	–	–	–	100
Logging workers	90	–	–	–	10	90	86	14	–	–	–	100
First-line supervisors	100	–	–	–	–	100	100	–	–	–	7	100
Management occupations	55	45	8	40	31	19	54	46	11	42	24	22
Conservation scientists and foresters	–	–	–	–	–	–	–	–	–	–	–	–
Production occupations	63	37	4	19	13	64	61	39	8	19	10	62
Sawing machine workers	88	13	–	13	–	75	67	–	–	–	–	100
Woodworking machine workers	89	11	–	11	–	89	100	–	–	–	–	100
Other woodworkers	100	–	–	–	–	100	100	–	–	–	50	50
Paper machine workers	63	38	–	13	13	63	67	33	–	33	33	67

– indicates no data available or value rounds to zero.

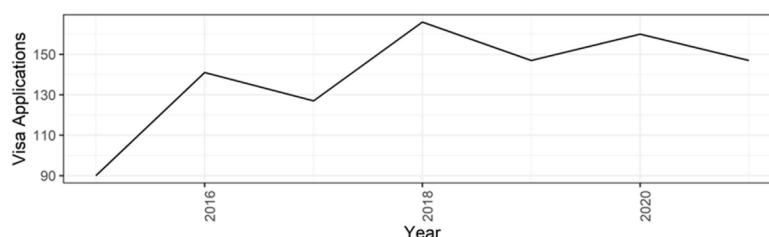


Fig. 5. Number of H-1B Visa Applications by a sample of forest product industry companies from 2015 to 2021.

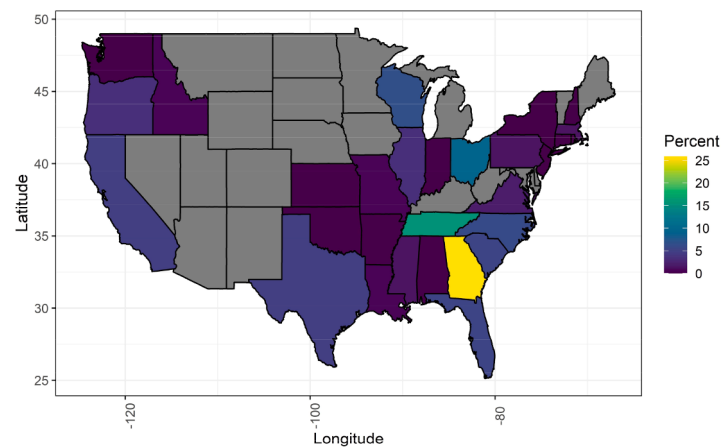


Fig. 6. Geographical distribution of H1B visas in the year 2021 (% of applied visas).

representation of various racial and ethnic groups.

Our results show notable increases in shares of women as forest and conservation workers and as conservation scientists and foresters, although they still remain underrepresented. Similar trends have been recently reported in undergraduate programs, which also highlight persistently low racial and ethnic representation in forestry (Bullard et al., 2023). According to our findings and previous literature (Deak et al., 2023; Blinn et al., 2021), the representation of Hispanic and Latino workers, as well as foreign-born workers, is rapidly increasing, particularly in natural resources and production occupations. Conversely, our data reveals that the representation of Black and Asian employees has either stalled or decreased, except in specific occupations such as forest and conservation workers, where the share of Black employees increased from 7 % to 10 % between 2005 and 2010.

The U.S. federal government has policies in place to prioritize minority-owned businesses in contracting through, for example, Historically Underutilized Business (HUB) Zone program (Deak et al., 2023). Our results suggest that a compliance perspective alone is insufficient to foster diverse forest business ownership. In the field of forest sciences or in natural resources in general, studies predicting entrepreneurial intention, entrepreneurs' motivations, or performance remain scarce, despite the significant role entrepreneurs have in creating household income and in impacting natural resource management decisions, as well as community behaviors and values (Allen and Malin 2008). While the general business literature has focused on entrepreneurs, considering aspects such as personality (Brandstätter 2011) and socioeconomic characteristics of entrepreneurs (Giacomin et al., 2023), and the availability and attendance of entrepreneurial education (Bauman and Lucy 2021; Regele and Neck 2012), these studies could be expanded to encompass forestry and other natural resources fields.

The intersection of employee health, safety, and workforce characteristics in field-intensive positions with chronic labor force shortages presents a knowledge gap. Previous research across the U.S. shows field-intensive tasks like forestry and logging exhibit high job-related injury, illness, and fatality rates, with a relatively high dependency on temporary foreign-born contract workers filling these roles (Wilmsen et al., 2019; Vaughan et al., 2022; Blinn et al., 2021; de Castro et al. 2023; Deak et al., 2023; Russell 2023). There is also very little research or statistics on linguistic diversity, which is directly linked with effectiveness of safety training (O'Neal, 2006). Furthermore, spatially explicit data are largely absent, hindering our understanding of how well the private sector workforce reflects their surrounding community across different geographical contexts, as was analyzed for the public sector by Locke et al. (2023).

Numerous gaps persist in the data monitoring system in the private U.S. forest sector, necessitating improvements to generate data that meet the needs of various stakeholders who require accurate and user-

friendly workforce data in policy planning and effective supply chain management (Bolton et al., 2023; Economic Commission for Europe (ECE) 2018; Lippe et al., 2022). These limitations include aggregation levels, data coverage, and underrepresentation of different racial and multiracial, ethnic, and gender identities. There is a chronic lack of intersectional data, combining race and gender, for instance. Concerns about data quality or privacy hinder the publication of numbers for specific communities, such as American Indian and Alaska Natives, and addressing these gaps and understanding reasons behind variation in representation in different industries and occupations calls for interdisciplinary efforts combining social and data science.

Limitations

This report concentrates on diversity attributes for which data are available, acknowledging the existence of missing values and data limitations. The presented numbers for different employee groups do not add up to 100 % or total employees due to several reasons. Data for all races or ethnicities are either not reported or not available. Therefore, we chose not to estimate the "White" category at the industry level by subtracting percentages of other races from 100 %. Some values are missing because of data confidentiality measures or because the estimates did not meet publication standards, primarily due to sampling variability or concerns about response quality. When data are withheld to protect individual company confidentiality, they are aggregated into higher-level totals. Maintaining data integrity and sensitivity is a priority for the Census Bureau, which withholds data in the case of high sampling variability or poor response quality.

Additionally, some of our data are reported at irregular intervals in this paper. This is partly due to data availability and the desire to report the most recent information. The nature of changing jobs and required skills further complicates the categorization of jobs, over time. In this article, we adhere to the NAICS and SOC classification of occupations based on the 2018 categorization, and we focus on describing recent developments. Therefore, historical data at the occupational level are limited, and our assessment centers on the period from 2005 to 2021, encompassing multiple economic cycles. While we do not primarily focus on the impacts of the COVID-19 pandemic, it is noteworthy that the effects on employment were disproportionate among different occupations (Hayes and Lee 2023; Montenegro et al., 2022).

Regarding international experts, our analysis is limited to H-1B visas, while forest sector experts may also use O-type visas, which are common among university staff and other professionals with "extraordinary ability" in various fields (USCIS, 2023). However, our analysis focuses on private forest sector data and excludes universities and other educational institutions. We also encourage referring to the topical work by Blinn et al. (2021) and Russell et al. (2023) for H-2B visas, which is

nonimmigrant program that permits employers to temporarily hire nonimmigrants to perform nonagricultural labor or services in the United States.

Collecting data on more diverse professions could be explored through nationwide and regional associations that track their members, although more comprehensive data collection strategies were beyond the scope of this research. Additionally, the evaluation of salaries, type and duration of employment, community impacts and pay gaps across different occupations is left for future studies (Wyatt et al., 2021; Deak et al., 2023; Blinn et al., 2021).

The occupations related to the forest sector are more diverse than we are able to cover, and the socioeconomic contribution of all the occupations is diluted by the lack of data. Our inability to include roles such as urban foresters, arborists, restoration workers, landscape architects, and nature-based solution professionals from banking and finance, among others, creates a knowledge gap. Furthermore, industries with a high share of intermediate products are influenced by the ability of the end-user sector to maintain a sustainable workforce. For example, the wood products (especially lumber) manufacturing is linked with the construction sector.

Our analysis represents an initial step in comprehending diversity representation in the private sector from various demographic perspectives across different industries, occupational levels, and business ownership structures. We utilized all available data sources at our disposal with the aim of adhering to the IDC (2023) principles. In summary, we conclude there are significant gaps in diversity representation and inadequate data limiting the understanding of forest management and related business opportunities, as well as workforce concerns. While our analysis gives an overview on the workforce trends and employee representation in the private forest sector, based on our data, we are unable to identify underlying factors in this study. Further

work is needed to establish causal connections between the identified barriers and opportunities, and the monitored outcomes of workforce representation at local, regional, and global levels within the evolving private and public forest sectors.

CRediT authorship contribution statement

Jaana Korhonen: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review & editing. **Rajat Panwar:** Conceptualization, Writing – original draft, Writing – review & editing. **Jesse Henderson:** Conceptualization, Visualization, Writing – review & editing. **Kathryn Fernholz:** Writing – original draft, Writing – review & editing. **Zakiya Leggett:** Writing – review & editing. **Eliza Meyer:** Writing – review & editing. **Arvind A.R. Bhuta:** Writing – review & editing.

Declaration of Competing Interest

We declare no conflicts of interest, except it is pertinent to mention that Mrs. Fehrnholz is a founding member of the Women Forest Congress and the Forest and Wood Product Inclusions Council, and I currently serve as an advisory board member of the Women Forest Congress. These organizations are cited as examples of initiatives supporting inclusion within the U.S. Forest sector and beyond.

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Data availability

Data will be made available on request.

Appendix A. Description of occupational groups and detailed forest sector occupations including The Standard Occupational Classification (SOC) Codes (Source: U.S. Bureau Labor Statistics)

Natural resources occupations	
First-line supervisors (SOC 45–1011)	Directly supervise and coordinate the activities of agricultural, forestry, aquacultural, and related workers.
Forest and conservation workers (SOC 45–4011)	Under supervision, perform manual labor necessary to develop, maintain, or protect areas such as forests, forested areas, woodlands, wetlands, and rangelands through such activities as raising and transporting seedlings; combating insects, pests, and diseases harmful to plant life; and building structures to control water, erosion, and leaching of soil. Includes forester aides, seedling pullers, tree planters, and gatherers of nontimber forestry products such as pine straw.
Logging workers (SOC 45–4020)	Logging workers harvest forests to provide the raw material for many consumer goods and industrial products.
Management occupations	
Conservation Scientists and Foresters (SOC 19–1030)	Conservation scientists and foresters manage the land quality of forests, parks, rangelands, and other natural resources.
Production occupations	
Paper machine workers (SOC 51–9196)	Set up, operate, or tend paper goods machines that perform a variety of functions, such as converting, sawing, corrugating, banding, wrapping, boxing, stitching, forming, or sealing paper or paperboard sheets into products.
Woodworking machine workers (SOC 51–7042)	Set up, operate, or tend woodworking machines, such as drill presses, lathes, shapers, routers, sanders, planers, and wood nailing machines. May operate computer numerically controlled (CNC) equipment.
Sawing machine workers (SOC 51–7041)	Set up, operate, or tend wood sawing machines. May operate computer numerically controlled (CNC) equipment. Includes lead sawyers
Other Woodworkers (SOC 51–7099)	Titles represent occupations with a wide range of characteristics which do not fit into one of the detailed

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