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Mass Timber: Overview and Issues for Congress

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SUMMARY

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Mass Timber: Overview and Issues for Congress

Mass timber is a class of engineered wood products made into structural pieces of much larger sizes and more diverse shapes than can be made with lumber alone. Mass timber is a substitute for conventional mineral building materials (e.g., steel, concrete) due to its size and physical properties. Mass timber also sequesters carbon and may result in less greenhouse gas (GHG) production during manufacturing than mineral materials. These characteristics have raised the possibility that mass timber could replace conventional materials in the commercial building sector and could generate associated co-benefits, such as reducing the sector's carbon footprint—potentially on a large scale.

Development of mass timber products has the potential to change the role of wood in the U.S. construction industry. Traditionally, most structures built with wood have been in the residential sector using *light-frame wood construction*: walls, roofs, and other structural assemblies made of nailed dimensional lumber and engineered wood, epitomized by familiar single-family housing construction. Buildings built with mass timber products can be larger and more complex than buildings made using light-frame wood construction. Because mass timber can be used to build tall wood buildings—defined as buildings that are six stories or more in height—mass timber can penetrate the commercial building sector.

Mass timber and tall wood buildings may have some disadvantages over conventional construction methods or may face barriers to adoption. Because mass timber is an emerging technology with minimal market share, researchers identify high costs, unfamiliarity within the construction community, and unresolved questions about performance as potential disadvantages compared with conventional construction. In some cases, it is unclear whether these issues are intrinsic to mass timber itself or would change if mass timber were more widely used. Recent changes to model building codes may reduce barriers to increased construction of tall wood buildings. However, in general, mass timber and tall wood buildings comprise a small portion of the U.S. building economy. As of March 2023, 1,753 mass timber projects had been constructed or were in design in the United States; for context, 5.9 million commercial buildings were constructed in 2019 alone.

Mass timber's potential to replace mineral materials has generated interest from those seeking to reduce the building sector's environmental impacts. Mass timber products may improve on the GHG-related characteristics of mineral materials in two ways: mass timber sequesters carbon**,** and mass timber generates relatively lower GHG emissions in production compared with mineral materials. Proponents of mass timber also have forecast a number of possible "upstream" benefits of mass timber production and manufacturing, particularly if mass timber construction were adopted on a broad scale; these benefits stem from mass timber's potential to grow wood's role in the construction industry and, in turn, potentially drive increased demand for timber. Mass timber has therefore become part of a broader conversation about the role of timber markets in driving the extent, composition, health, and management of forests.

The federal government funds research and provides financial and technical assistance to facilitate wood product innovation, including development and deployment of mass timber and tall wood buildings. This is generally (but not exclusively) done through the Forest Service's (FS) State and Private Forestry (SPF) and Research and Development (R&D) mission areas, although some authorities also relate to management of FS and Bureau of Land Management (BLM) federal forests. Notable programs include the Wood Innovations Grants Program in the SPF mission area and the Forest Product Laboratory in the R&D mission area; however, numerous other programs and authorities may apply. Should Congress wish to further incentivize mass timber research, development, and use, it may consider several options, including expanding existing assistance and research programs within the FS; applying materials preferences to federally owned or funded building and infrastructure projects; and offering incentives as part of applicable federal timber harvesting projects.

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Introduction

Mass timber is a class of engineered wood products made into structural pieces of much larger sizes and more diverse shapes than can be made with lumber alone.[1] Due to its size and physical properties, mass timber is a substitute for conventional mineral building materials such as steel or concrete. Mass timber also sequesters carbon and may result in less greenhouse gas (GHG) production during manufacturing than mineral materials. These characteristics have raised the possibility that mass timber could replace conventional materials in the commercial building sector and could generate associated co-benefits, such as reducing the sector's carbon footprint or contributing to forest management goals—potentially on a large scale.

Recent changes to model building codes may reduce barriers to increased construction of tall wood buildings. At present, in general, mass timber and tall wood buildings comprise a small portion of the U.S. building economy. As of March 2023, 1,753 mass timber projects had been constructed or were in design in the United States; for context, 5.9 million commercial buildings were constructed in 2019 alone.

This report begins with an overview of the U.S. wood products industry and then discusses mass timber, including potential advantages and unresolved questions regarding the material. It then provides a summary of relevant programs administered by the Forest Service (FS) in the U.S. Department of Agriculture (USDA). The report concludes with a discussion of policy options, should Congress wish to support the use of mass timber.

Overview of Solid Wood in the U.S. Wood Products Industry

The *wood products* industry is a diverse commodity industry in which various products made from wood, such as lumber, flooring, paper, and many others, are manufactured from cut trees (*timber*).[2] The United States is both the largest producer and the largest single consumer of wood in the world.[3] In 2019, approximately 13.7 billion cubic feet of industrial roundwood were harvested in the United States.[4] The wood products industry primarily consists of solid wood products and of pulp and paper products, with other uses (e.g., woody biomass energy) playing

[1] When used colloquially, the term *mass timber* is sometimes used to include lumber-sized, beam-shaped products known as *structural composite lumber*. These products are similar in size and shape to lumber made of solid wood, although they have favorable mechanical characteristics. This means they are generally viewed as substitutes for other kinds of wood (i.e., solid wood lumber) as opposed to substitutes for non-wood materials. Therefore, for the purposes of this report, these products are not considered to be mass timber.

[2] The wood products industry does not include trees grown to provide crops for human consumption, such as orchards and vineyards. The wood products industry also may be referred to colloquially as the *forest products industry*. Some also may refer to the *timber industry*, which generally refers to the industry concerned with growing and harvesting trees but not with the later processing and manufacturing steps in the wood products supply chain.

[3] Delton Alderman, *United States Forest Products Annual Market Review and Prospects, 2015-2021*, Forest Service (FS), Forest Products Laboratory (FPL), October 2020.

[4] James Howard and Shaobo Liang, *U.S. Timber Production, Trade, Consumption, and Price Statistics*, FS, FPL-RP-701, 2019 (hereinafter referred to as Howard and Liang, *U.S. Timber Production*); and Food and Agriculture Organization (FAO), *FAOSTAT Forestry Database, Forest Product Consumption and Production*, 2020. *Industrial roundwood* is unprocessed logs harvested for commercial purposes as opposed to for personal or household use. Timber may be measured in cubic feet or in board feet (BF), a unit of wood equaling 1 inch by 12 inches by 12 inches. The BF in a log is not equal to the cubic feet in a log, as some wood is lost in the processing of a log to squared dimensions, and BF cannot be directly converted to cubic feet.

comparatively minor roles. Most wood products in the United States, including most lumber and engineered wood products, derive from *softwoods*—coniferous trees such as pine, spruce, and fir.

Solid wood products are the largest subset of products made from wood and wood pulp. Making solid wood products from timber may be a single- or multi-stage process, generally involving a first step of physically transforming logs into a primary product of varying sizes of solid wood (e.g., lumber, chips, strands, veneers), which then may enter the marketplace or undergo further processing. Broad classes of wood products can be described as follows:

- **Lumber** refers to solid wood products, such as beams and planks, sawn from logs. Lumber is either *rough-sawn* or *finished.* Finished lumber is smoothed on at least one side and is primarily produced for the construction industry in standardized sizes known as *dimensional lumber* (e.g., 2x4s, 2x2s). Rough-sawn lumber is not smoothed and is primarily produced for other industries, where it will undergo further processing (e.g., the furniture industry).
- **Engineered wood products** are products made by joining together pieces of wood—such as chips, strands, veneers (i.e., thin sheets), or other pieces—to form a composite product. Engineered wood products are manufactured to final specifications (i.e., size, shape, and physical characteristics) and therefore vary widely in their properties and uses. Examples of engineered wood products include plywood, particle board, oriented strand board, and medium-density fiberboard. Engineered wood products in the United States are primarily used in construction.
- **Other manufactured wood products** include diverse products made from solid pieces of wood, engineered wood, or both. Examples include poles, railroad ties, cabinetry, furniture, and flooring.

The construction industry is the largest source of demand for wood; consequently, lumber and engineered wood products are the largest category of wood product production. For example, in 2019, about 40% of industrial wood product production was lumber.[5]

Wood's Role in the U.S. Construction Industry

The construction industry is the largest source of demand for wood in the United States, and almost all of this demand derives from residential construction. This is because of a distinct split in building construction styles, methods, and purposes in the United States. One class of construction is *residential* construction—houses, duplexes, low-rise apartment buildings, and similar housing-related buildings—which are usually made of wood. The other class is *commercial* construction, comprising not only stores and offices but also public buildings such as schools, libraries, and hospitals; commercial buildings are generally made of concrete, steel, and similar mineral materials.

In the United States, building with wood in the modern era has typically been in the form of *light-frame construction*: walls, roofs, and other structural assemblies made of nailed dimensional lumber and engineered wood, epitomized by familiar single-family housing construction across the country. Light-frame construction dominates residential construction in the United States, and residential construction is consequently the most significant source of U.S. demand for lumber and engineered wood products. In 2021, 92% of new U.S. residential construction was timber-

[5] Consuelo Brandeis et al., *Status and Trends for the U.S. Forest Products Sector: A Technical Document Supporting the Forest Service 2020 RPA Assessment*, FS, GTR-SRS-258, January 2021.

framed.[6] In 2017, about 69% of U.S. softwood lumber was used for residential construction, including new construction and upkeep and remodeling.[7] In contrast, the U.S. commercial building sector is dominated by mineral materials. Commercial buildings in the United States are most commonly constructed of steel (46%), followed by concrete, with a minimal amount of wood used.[8]

These trends stem from a combination of engineering realities (i.e., the relatively low amount of weight that can be carried by light-frame construction), concerns regarding the fire risk of wood construction, cultural preferences, materials prices, and other factors.[9] Some of these factors may be formalized in *building codes*—laws adopted at the local or state level that describe building construction materials and methods, maintenance standards, and other criteria (see "Tall Wood Buildings" for more information).[10] For example, building codes generally limit light-frame structures to a few stories in height, generally because of fire safety considerations and the natural limitations on light-frame buildings' ability to carry weight.[11]

Mass Timber

What Is Mass Timber?

Mass timber, as described above, is a class of engineered wood products made from solid wood pieces (i.e., dimensional lumber) into large structural pieces under controlled conditions. Various kinds of mass timber can be used to create common load-bearing structural pieces used in construction, including panels for walls, floors, ceilings, and roofs; straight and curved beams; joists; and rafters. Types of mass timber include (but are not limited to) the following:[12]

- **Cross-Laminated Timber (CLT)**: Layers of dimensional lumber stacked with the grain running perpendicular at 90-degree angles and joined with adhesive. CLT is usually constructed as panels, generally 2-10 feet wide and up to 60 feet in length. CLT also can be constructed in custom sizes, with the possible dimensions and shapes scaling to standard dimensional lumber's sizes. (See **Figure 1** and **Figure 2**.)
- **Glue-Laminated Timber (glulam)**: Layered dimensional lumber where pieces are first joined end-to-end in a single layer, then the layers are stacked with the grain running parallel and joined with adhesive. Glulam's grain pattern promotes strength across long spans, such as columns or beams. Glulam is produced in beams with standard widths and lengths of over 100 feet and can be produced as custom-sized beams or in custom shapes, including curves. (See **Figure 1** and **Figure 3**.)

[6] Jing Fu, "The Share of Wood-Framed Homes Increased in 2021," National Association of Home Builders, July 22, 2022.

[7] Howard and Liang, *U.S. Timber Production.*

[8] University of Michigan Center for Sustainable Systems, "Fact Sheet: Built Environment," September 2022.

[9] Britt Faulstick, "Why Wood Construction Is Making a Comeback," Drexel University College of Engineering, January 17, 2019. Hereinafter referred to as Faulstick, Wood's Comeback.

[10] For more information, see CRS Report R47665, *Building Codes, Standards, and Regulations: Frequently Asked Questions*.

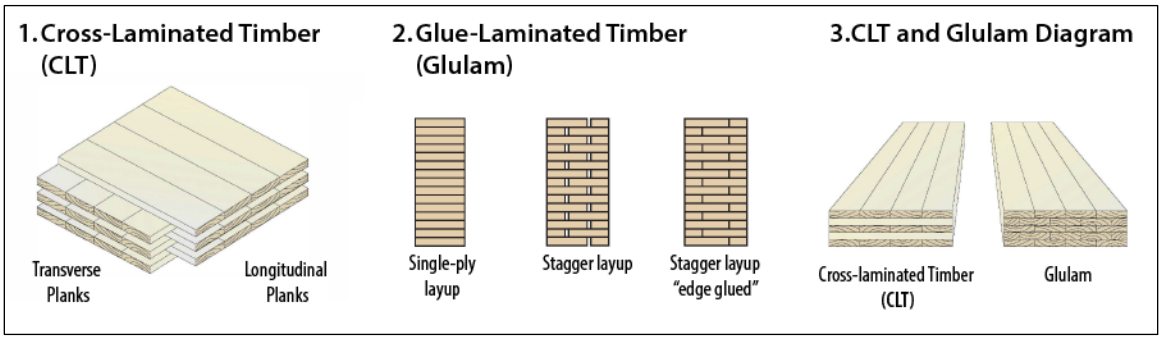
[11] Ibid.

[12] For more information on mass timber types, see APA-The Engineered Wood Association, "Products," at https://www.apawood.org; and ThinkWood, "Timber Products," at https://www.thinkwood.com/mass-timber.

- **Nail-Laminated Timber** and **Dowel-Laminated Timber:** These products consist of layered dimensional lumber joined together mechanically with nails or dowels, respectively. They are usually constructed as panels.
- **Mass Plywood Panels (MPP)**: Layered veneers joined with adhesive. MPP pieces can be constructed as panels or beams, with great flexibility in their size and shape and a maximum size of 12 feet wide by 48 feet long.

Of these types of mass timber, CLT and glulam are generally the most commonly used.

Figure 1. Diagrams of Cross-Laminated Timber and Glue-Laminated Timber



Sources: Images 1 and 3: *CLT Handbook*, Erol Karacabeyli, Brad Douglas ed. (Co-published by FPInnovations and U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, Binational Softwood Lumber Council, 2013). Image 2: James Wacker and Matthew Smith, *Standard Plans for Glue-Laminated Timber Bridge Superstructures: Longitudinal Glulam Decks, Glulam Stringer Bridges, and Transverse Glulam Decks*, U.S. Department of Agriculture, Forest Service, Forest Products Laboratory, FPL-GTR-260, Madison, WI, 2019.

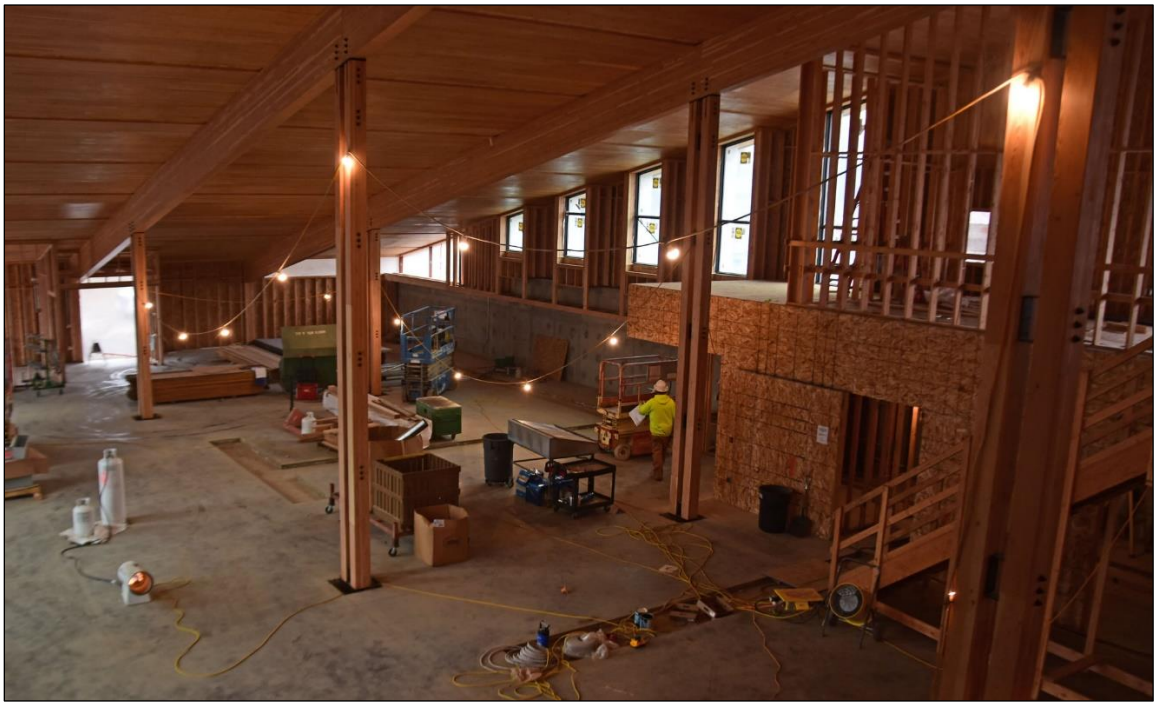
Notes: Image 1 shows a common *layup* (configuration) for CLT. Dimensional lumber is joined into a single layer with the grain going in the same direction, known as a *lamella* or *lam*. Then, odd numbers of lams are layered together with the grain alternating to make the final panel. CLT's alternating grain pattern promotes stability and strength across every dimension in the final material. Image 2 shows several possible layups for glulam when viewed head-on; different layups are chosen to promote different properties of strength in the final material. Image 3 depicts a comparison of glulam and CLT, particularly showing that CLT is configured with alternating grain and glulam is configured with each lam's grain going the same direction. Glulam's grain pattern promotes strength across long spans, such as columns or beams.

As an engineered wood product, mass timber is made to meet a final specification, including the choice of size and shape and the necessary physical properties (e.g., weight, ability to carry loads and resist stresses, acoustic and aesthetic properties). Manufacturers achieve this in the final product by considering the manufacturing method, the mechanical limitations of the wood and the way it is joined together, and the piece's size and shape. In addition, during the mass timber manufacturing process, the manufacturer inspects and grades the smaller component parts and identifies their defects; this allows manufacturers to distribute each component part throughout a final piece to ameliorate flaws and maximize the product's strength and load-bearing properties. By specifically placing component timber, manufacturers can optimize the final piece's strength and control its acoustic properties, appearance, and other characteristics desirable in architectural applications. The result of this process is a material that can equal or exceed the properties of concrete and steel—for example, glulam has 1/6 the weight of concrete for pieces of similar size—with otherwise comparable properties of strength and stiffness.[13]

[13] F. Asdrubali et al., "A Review of Structural, Thermo-physical, Acoustical, and Environmental Properties of Wooden Materials for Building Applications," *Building and Environment*, vol. 114 (2017), pp. 307-332. Hereinafter referred to as Asdrubali, "Properties of Wooden Materials."

Taken together, these properties mean that mass timber can be made into large, load-bearing, structural pieces that equal or exceed the physical capabilities of—and therefore, can replace—concrete and steel in building applications. Mass timber can be used to construct buildings that otherwise are not, or cannot be, made of wood, such as primarily commercial buildings commonly made of mineral materials (for examples of buildings made with mass timber, see **Figure 2** and **Figure 3**).[14] On a broad scale, mass timber technology has generated excitement in some academic and media circles about the possibility of substantially transforming the commercial building sector, leading to a conversation about "timber cities."[15] Mass timber's potential to expand the uses of wood has similarly generated excitement about potential co-benefits, such as "greening" the building sector, expanding wood products markets, and others. The following sections discuss the use of mass timber for certain buildings and the possible co-benefits.

Figure 2. Example of a Modern Mass Timber Forest Service Building



Source: Nez Perce-Clearwater National Forest Facebook page, photo posted January 29, 2021, accessed by CRS on June 14, 2023. Supporting information is from Forest Service, Nez Perce-Clearwater National Forest website, "Construction Completed on New Forest Supervisor's Office in Kamiah," undated, accessed June 14, 2023; and Forest Service, Wood Innovations Success Stories, "Mass Timber Is Showcased in New Forest Supervisor's Office," FS-1161(j), July 2021.

Notes: This image shows an interior construction photo of the Nez Perce-Clearwater National Forest supervisor's office in Kamiah, ID, a Forest Service mass timber building. The building is constructed of cross-laminated timber (CLT), glue-laminated timber (glulam), and other wood products and mineral materials. The building's features include a structural CLT roof system, a CLT elevator shaft, and exposed glulam beams and columns throughout the structure. The photo shows visible CLT panels in the roof structure and glulam columns and beams supporting the roof. Although it is not specified in Forest Service supporting materials, the other

[14] Ibid.

[15] For example, see Arthur Neslen, "Timber Cities 'Could Cut 100bn Tons of CO2 Emissions by 2100,'" *Guardian*, August 30, 2022; and Harry Cockburn, "'Timber Cities' Could Save a Billion Tonnes of Emissions by 2100," *Independent*, August 30, 2022.

wood products in the image (for example, framing the room on the right side) likely are other engineered wood products, such as oriented strand board or plywood.

Figure 3. Example of a Historical Forest Service Mass Timber Building

Source: Forest Service Forest Products Laboratory Flickr page, uploaded December 18, 2013. Supporting information is from James Spartz, "Historic Glued-Laminated Arches Evaluated for Structural Quality," Forest Service, Forest Products Laboratory Lab Notes, January 13, 2013; Douglas Rammer and Jorge de Melo Moura, *Structural Evaluation of the Second-Oldest Glued-Laminated Structure in the United States*, Forest Service, Forest Products Laboratory, General Technical Report, FPL-GTR-226, 2013, pp. 269-276; Eben Lehman, "October 15, 1934: Glued Laminated Timber Comes to America," Forest History Society, October 15, 2018; and James Spartz, "Soy Proteins as Wood Adhesives," Forest Service, Forest Products Laboratory Lab Notes, May 6, 2014.

Notes: This image shows the Forest Service's Forest Product Laboratory's "Building Two," which was constructed in 1934 of glue-laminated timber (glulam) arches and plywood panels to demonstrate the performance of wooden arch buildings. At the time of its construction, Building Two was the second glulam building in the United States. The building stood until 2010, when it was decommissioned. Its performance was tested at various points in its life, including testing of the glulam arches after decommissioning. The building's construction exemplifies glulam's common use as beams, columns, and similar structural pieces and glulam's potential for curved, cantilevered, and other creative shapes. The glue for the glulam arches was based on casein proteins from cow's milk.

Tall Wood Buildings

Development of mass timber products, particularly CLT, has allowed for buildings of increasing size and complexity to be built with mass timber, expanding the use of wood in building beyond light-frame construction.[16] Mass timber has the potential to penetrate the commercial building sector because it can be used for buildings—such as many commercial buildings—that are taller and bigger than light-frame construction would allow (see **Figure 4**). These *tall wood* or *tall mass timber buildings*, which are six stories or more in height and primarily made of mass timber, are

[16] I. Kuzmanovska et al., "Tall Timber Buildings: Emerging Trends and Typologies," conference paper presented at the 2018 World Conference on Timber Engineering, 2018.

becoming allowable forms of construction in most of the United States. Recent changes to model building codes may reduce barriers to increased construction of tall wood buildings.

Figure 4. Example of a Tall Wood Building

Source: Forest Service, "World's Tallest Timber Building Opens," July 29, 2022, at https://www.fs.usda.gov/inside-fs/delivering-mission/apply/worlds-tallest-timber-building-opens. Additional information: ThinkWood, "Ascent," accessed June 15, 2023, at https://www.thinkwood.com/construction-projects/ascent; TimberLab, "Ascent," accessed June 15, 2023, at https://timberlab.com/projects/ascent.

Notes: The image shows the construction of Ascent MKE, the tallest wood building in the world at 25 stories. It is located in Milwaukee, WI, and was constructed in 2022. Ascent MKE is a hybrid mass timber and concrete building, consisting of 19 mass timber stories on a concrete podium. The mass timber stories are constructed of CLT panels and glulam beams and columns, with 50% of the mass timber exposed in the final design. CLT floor panels and glulam framing columns are visible in the image above. To demonstrate that a building with this amount of exposed wood could comply with applicable fire safety regulations, the Forest Service's Forest Products Laboratory conducted the world's first three-hour fire test on the building's glue-laminated (glulam) timber beams, which the beams met or exceeded. The Forest Service also provided support for Ascent through a Wood Innovations grant for engineering and design.

Historically, most building codes in the United States have primarily allowed wood construction in the form of light-frame construction of a few stories in height. Some building codes also include so-called *heavy timber* or *post-and-beam* buildings, a style of construction using large,

solid timbers that is used relatively little today and that building codes limit in size.[17] These limits are based on a combination of engineering realities regarding wood as a material and historical concerns about fire risk in wood buildings, particularly in urban environments. These building codes have limited the markets and carbon sequestration potential of wood as a building material.[18]

Building codes are codified at state or local levels but may be based on model codes produced by nongovernmental standard-developing organizations. In particular, the International Code Council (ICC) is the foremost body that develops model building codes for new construction in the United States, referred to as the International Building Code (IBC). In some jurisdictions, building codes refer to the IBC in its entirety. Other building codes may refer to the IBC with modifications, use other models, or be entirely locally developed. Prior to 2019, the IBC did not include tall mass timber construction. At the time, some such projects had been initiated or completed in the United States, but most of those projects were within the size limits of the applicable building code; the remainder used processes described in local law to gain approval.[19] In January 2019, the ICC approved a set of proposals to allow tall wood buildings as part of the 2021 IBC.[20] The 2021 IBC included three new construction types allowing the use of mass timber in buildings of between 9 and 18 stories, depending on various factors, including fire risk.

A major factor that has limited the use of tall wood buildings is negative perceptions surrounding the fire safety of wood. These fire concerns largely stem from a conflation of light-frame construction and mass timber construction. In light-frame construction, the building's structure is made of small wood pieces with gaps or air voids between them; this configuration can ignite quickly and allows fire to spread rapidly. By contrast, mass timber construction is made of large, solid wood pieces with minimal voids or gaps between them. These pieces tend to char rather than ignite, creating a protective outer layer that resists ignition. Significant bodies of research have established the behavior of mass timber pieces in fires, including the use of different protective designs, such as encapsulating mass timber in fire-resistant materials or designing mass timber pieces to be structurally sound even after charring (i.e., with a *sacrifice layer*).[21] Researchers have fire-tested mass timber assemblies (i.e., a wall or a floor) and full-scale *compartments*—enclosed buildings or building portions such as a room, story, or entire structure. These studies have helped the industry develop an understanding of the behavior of different mass timber structures in fire, and this understanding is used to design mass timber buildings, including in the context of building codes. For example, the 2021 IBC's construction types limit the number of stories in mass timber buildings based on the buildings' design and the associated fire risks.

According to the industry association WoodWorks, as of December 2022, 19 states had adopted the tall wood building provisions of the 2021 IBC, some with local amendments.[22] The organization also noted that 12 cities and counties had adopted the 2021 IBC tall mass timber

[17] For further discussion, see Jesse Heitz, "Heavy Timber 101, Part 1: History and Design," *International Fire Fighter*, November 12, 2015, and Faulstick, Wood's Comeback.

[18] Stephen S. Kelly and Richard Bergman, "Potential for Tall Wood Buildings to Sequester Carbon, Support Forest Communities, and Create New Options for Forest Management," FS, FPL, RIP-4851-018, 2017.

[19] Lindsey Leardi, "Mass Timber: Shattering the Myth of Code Exceptions," *ArchDaily*, May 12, 2021.

[20] Scott Breneman, Matt Timmers, and Dennis Richardson, *Tall Wood Buildings in the 2021 IBC*, WoodWorks, 2022.

[21] Joseph Abed et al., "A Review of the Performance and Benefits of Mass Timber as an Alternative to Concrete and Steel for Improving the Sustainability of Structures," *Sustainability*, vol. 14, no. 9 (May 5, 2022). Hereinafter referred to as Abed et al., "Performance and Benefits of Mass Timber."

[22] Woodworks.org, "Status of Building Code Allowances for Tall Mass Timber in the IBC," updated December 2022.

provisions. These changes mean the allowable size of tall mass timber buildings has increased by as much as 10 stories in these states and localities.

Mass Timber and the Environmental Impact of Structures

Mass timber's potential to replace mineral materials has generated interest from those seeking to reduce the building sector's environmental impacts. Although estimates vary, data suggest the carbon emissions from construction and materials manufacturing in the global building sector may account for 10% or more of the world's carbon dioxide (CO_2) emissions.[23] A recent study concluded that if the global population increases to 9.3 billion by 2050, as projected by the United Nations Population Division, then the cumulative GHG emissions from primary materials production for the development of new infrastructure by 2050 will be about 350 gigatons (Gt) of CO_2. That would be approximately 35%-60% of the maximum global total of carbon that could be emitted without increasing the average global temperature by more than 2°C.[24] Other studies conclude that reductions in the GHGs associated with the manufacture of mineral-based construction materials—referred to as *embodied GHG emissions*—will be challenging for various reasons, such as the lack of potential to increase manufacturing efficiency or to increase the use of recycled materials.[25] Researchers suggest that one potential strategy for mitigating the building sector's emissions includes substituting conventional mineral-based materials with products that have lower embodied GHG emissions, such as mass timber.

Mass timber products may have lower embodied carbon emissions compared with mineral materials in two ways: mass timber sequesters carbon, and mass timber generates relatively lower GHG emissions in production than mineral materials. Although the results of analyses on this topic vary, mass timber may sequester a mean of approximately 0.48 tons of carbon (tC) per 1 ton of mass timber material, with a mean of approximately 0.12 tC emitted in production, or a net sequestration of about 0.36 tC per ton.[26] In contrast, steel and concrete materials sequester little to no measurable carbon but result in larger emissions per unit—much more, in the case of steel (a mean of approximately 0.54 tC per ton of material). Production of cement, the bonding material in concrete, releases a median of approximately 0.78 tC per ton of material produced.[27]

On the building scale, several recent meta-analyses found significant reductions in carbon-related measures of mass timber buildings compared with conventional construction. A 2022 review of life-cycle analyses of CLT multistory buildings found an average 40% reduction in "carbon

[23] United Nations Environment Programme (2020). 2020 *Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector*, Nairobi. This statistic excludes emissions associated with the use of buildings (i.e., for electricity, heating, and cooling).

[24] Daniel Muller et al., "Carbon Emissions of Infrastructure Development," *Environmental Science and Technology*, vol. 47 (2013), pp. 11739-11746 (hereinafter referred to as Muller et al., "Carbon Emissions of Infrastructure"); and Galina Churkina et al., "Buildings as a Global Carbon Sink," *Nature Sustainability*, vol. 3 (April 2020), pp. 269-276 (hereinafter referred to as Churkina et al., "Buildings as a Global Carbon Sink"). Population projections from U.N. Population Division, *World Population Prospects: The 2010 Revision, Comprehensive Tables*, vol. 1, United Nations: New York, 2012. The total greenhouse gas emissions level that would limit climate change to an average global temperature increase of 2°C derive from Malte Meinshausen et al., "Greenhouse-Gas Emission Targets for Limiting Global Warming to 2°C," *Nature*, vol. 458 (2009), pp. 1158-1162.

[25] Churkina et al., "Buildings as a Global Carbon Sink," and Muller et al., "Carbon Emissions of Infrastructure."

[26] Carbon sequestration is the process by which atmospheric carbon dioxide is taken up by plants (including trees) and stored in biomass and soils. This storage of carbon helps offset sources of carbon dioxide to the atmosphere. See CRS Report R46312, *Forest Carbon Primer*, by Katie Hoover and Anne A. Riddle.

[27] U.S. Environmental Protection Agency, "U.S. Cement Industry Carbon Intensities (2019)", EPA 430-F-21-004, October 2021.

footprint" when using CLT compared with "conventional construction materials."[28] A separate 2022 review also found a 43% reduction in average embodied GHG emissions in mass timber buildings compared with reinforced concrete.[29] Both reviews found variability in the environmental impacts of CLT buildings, which the reviews attributed to the diversity of the buildings assessed (including their size, design, and location, as well as the type of building used for comparison and other factors) and inconsistent methods in the underlying studies.

In general, it remains unclear what overall impacts mass timber adoption would have on emissions from the building sector on a broad scale. The issue has not yet been widely studied, and existing studies' results are sensitive to research assumptions, such as the scale of wood building adoption and the time horizon of analysis, among others. A 2020 article found that, in a "90% timber" scenario where most new construction worldwide by 2050 was mass timber, the total carbon stored by 2050 would be 2-20 Gt of carbon, equivalent to approximately 7-73 Gt of CO_2.[30] In addition, the study found that the 90% timber scenario would avoid 36 Gt of CO_2 emissions.[31] A 2022 study found that housing 90% of the world's new urban population by 2050 in new wood buildings would avoid approximately 106 Gt of additional CO_2 emissions by 2050, or about 10% of the maximum cumulative carbon emissions needed to limit global average temperature increases to 2°C.[32] Both studies found a range of possible outcomes, with less adoption of mass timber technology resulting in proportionally smaller impacts (i.e., less net carbon sequestration or fewer avoided emissions). Both studies also noted that the assumption of near-total adoption of mass timber technology is unlikely, meaning the reported impacts in the upper range of potential effects are also unlikely.

Mass Timber, Forest Management, and the Timber Industry

Proponents of mass timber also have forecast a number of possible "upstream" benefits of mass timber production and manufacturing, particularly if mass timber construction were adopted on a broad scale. These benefits could occur if increased use of mass timber were to grow wood's role in the construction industry, which, in turn, could drive increased demand for timber, impacting forest management outcomes and the rural economy. In this regard, mass timber has become part of a broader conversation about the role of wood product markets in driving the extent, composition, health, and management of forests.

Growth in the timber industry could expand opportunities for forest management. *Forest management* is the process of intervening in forest processes and composition to promote desired

[28] Adel Younis and Ambrose Dodoo, "Cross-Laminated Timber for Building Construction: A Life-Cycle-Assessment Overview," *Journal of Building Engineering*, vol. 52 (2022), p. 104482. This article is a meta-analysis of 27 life-cycle assessments of CLT buildings compared with buildings of a variety of "conventional" materials, such as reinforced concrete, steel, and others. As such, the 40% reduction should likely be viewed as a highly general average with substantial variation for individual cases.

[29] Zhuocheng Duan, Qiong Huang, and Qi Zhang, "Life Cycle Assessment of Mass Timber Construction: A Review," *Building and Environment*, vol. 221 (2022), p. 109320.

[30] Churkina et al., "Buildings as a Global Carbon Sink." The authors describe the "90% timber" scenario as being "in which countries with current low industrialization levels also make the transition to timber in urban construction through the evolution of the construction and material manufacturing sector." It is unclear whether 90% refers to countries, overall worldwide population, overall worldwide numbers of buildings, or some other measure; it is also unclear whether "total carbon stored" includes all construction over the scenario period or only construction with wood. Conversion to CO_2 equivalents by CRS.

[31] CRS calculation from Churkina et al., "Buildings as a Global Carbon Sink," supplementary information, Table 9, using the 90% timber scenario and business-as-usual scenarios, "Primary Structure + Enclosure" data.

[32] Abhijeet Mishra et al., "Land Use Change and Carbon Emissions of a Transformation to Timber Cities," *Nature Communications*, vol. 13 (August 30, 2022), p. 4889.

objectives, such as restoring wildlife habitat, reducing *hazardous fuels* (built-up organic material that increases the risk of wildfire), or others.[33] Commercial timber harvesting is a common method for managing forests by removing certain trees to promote desired forest conditions. It also can serve as a mechanism to finance forest management through timber revenues, including in the federal forests of the National Forest System (NFS), managed by the FS, and the public domain lands managed by the Bureau of Land Management (BLM). Although these forests are federally owned, timber harvesting on them—including timber harvesting for various forest management purposes—is generally conducted by private contractors, who purchase the right to harvest and sell specified federal timber.[34] Such federal forest management activities are often contingent on offering federal timber that is profitable to potential industry partners.

Some researchers and stakeholders posit that mass timber manufacturing could incentivize certain forest management activities by expanding markets for certain kinds of harvested timber.[35] In particular, some forest management activities may involve harvesting trees that are too small to be used as lumber (*small-diameter materials*); however, harvesting these trees may be unprofitable due to low market prices or lack of downstream demand, potentially creating barriers to certain forest management projects if commercial timber harvesting is not financially feasible. Small-diameter materials are suitable for some forms of mass timber, such as CLT, and thus could support associated forest management projects by generating demand for harvested trees.[36] In addition to the specific issue of small-diameter materials, stakeholders assert that increased mass timber demand could result in various positive land management-related outcomes. For example, some posit that mass timber (as well as forest products markets generally) can help support rural economic development and prevent forestland conversion.[37]

In general, mass timber's potential effects on the timber industry, forests, or forest management are unclear. This is especially true with regard to any specific location or particular land ownership situation (e.g., federal forests). Such effects are sensitive to assumptions about the scale of mass timber adoption, which is speculative. Given this limitation, the small body of research on mass timber's impact on forest-related metrics in the United States has examined possible impacts across a range of future demand scenarios. This research generally shows that the impact of mass timber production on forest management would depend on the scale of mass timber manufacturing in the United States and its geographic distribution. For example, a study commissioned by the Softwood Lumber Board (SLB), an industry group, found that in its most optimistic scenario, lumber consumption in 2035 may be 17% higher than current consumption due to mass timber adoption. At the same time, the SLB study estimated a range of possible

[33] For more information, see CRS Report R46976, *U.S. Forest Ownership and Management: Background and Issues for Congress*, by Katie Hoover and Anne A. Riddle.

[34] CRS Report R45688, *Timber Harvesting on Federal Lands*, by Anne A. Riddle.

[35] For example, see Asdrubali, "Properties of Wooden Materials," and Melissa Kroskey, "Mass Timber: Providing Value in a Differentiated Product While Contributing to Sustainability and Resiliency Goals," Urban Land Institute, October 25, 2021.

[36] For example, see Magnus Fredriksson et al., "Using Small-Diameter Logs for Cross-Laminated Timber Production," *BioResources*, vol. 10, no. 1 (January 20, 2015), pp. 1477-1486; and Lauren Redmore et al., *Mass Timber and Other Innovative Wood Products in California: A Study of Barriers and Potential Solutions to Grow the State's Sustainable Wood Products Sector*, Sierra Institute for Community and Environment, 2021.

[37] For example, see U.S. Congress, House Committee on Transportation and Infrastructure, *The Business Case for Climate Solutions*, 117th Cong., 1st sess., March 17, 2021; and Office of Senator Ron Wyden, "Wyden, Salinas, Duarte, Gluesenkamp Perez Introduce Bill to Restore Forests, Boost Rural Economies by Supporting Wood Product Innovation," press release, July 28, 2023.

outcomes.[38] Another U.S.-specific study found that projected growth in existing forests would exceed even the highest possible U.S. demand for mass timber.[39] Outcomes likely would be geographically dependent, as well. The SLB study predicted most mass timber lumber supply would originate from the eastern United States, in which case there may be relatively few benefits to the federal forests, which are located mostly in the West.[40] Similarly, impacts to rural economies could depend on where mass timber manufacturers are located. Other forest management outcomes also would depend on the scale, location, and nature of timber harvesting for mass timber.

Studies on worldwide impacts of mass timber adoption, also using various scenarios of potential future mass timber demand, found wide ranges of potential impacts to forestland area, timber demand, and other metrics.[41] For example, some worldwide studies estimate increased demand for wood to produce mass timber would lead to increased land conversion to plantation forests worldwide and to increased harvesting of protected forests.[42]

Mass Timber and Tall Wood Building Market Penetration

Mass timber and tall wood buildings are a small percentage of total U.S. built environment. As of March 2023, 1,753 mass timber projects had been constructed or were in design in the United States; for context, approximately 5.9 million commercial buildings were constructed in 2019 alone.[43] These mass timber projects include multifamily residential buildings, commercial buildings, and various institutional buildings (e.g., schools, museums, theaters). They also include nonbuilding structures, such as bridges. Some 24 mass timber structures are over 7 stories in height, and the tallest, Ascent MKE (**Figure 4**), is a hybrid concrete-mass timber residential building with 25 stories that was completed in 2022.[44]

According to industry advisory group Mass Timber Strategy, as of May 2023, there were 7 companies making CLT panels at locations in 5 U.S. states and 20 glulam manufacturers in 11 states.[45] Most manufacturers are located in or near the Pacific Northwest (i.e., Oregon, Washington, and nearby states) or the Southeast (i.e., Arkansas, Alabama, and other states in the

[38] FPInnovations and Ben Romanchych Consulting, "Mass Timber Outlook," presentation to Softwood Lumber Board, October 2020; and Jeff Conmick, Luke Rogers, and Kent Wheiler, "Increasing Mass Timber Consumption in the U.S. and Sustainable Timber Supply," *Sustainability*, vol. 14 (December 30, 2021), p. 381 (hereinafter referred to as Conmick, Rogers, and Wheiler, "Increasing Mass Timber Consumption").

[39] Conmick, Rogers, and Wheiler, "Increasing Mass Timber Consumption."

[40] FPInnovations and Ben Romanchych Consulting, "Mass Timber Outlook," presentation to Softwood Lumber Board, October 2020.

[41] For example, see Prakash Nepal, Craig Johnson, and Indroneil Ganguly, "Effects on Global Forests and Wood Product Markets of Increased Demand for Mass Timber," *Sustainability*, vol. 13 (December 17, 2021), p. 13943; and Abhijeet Mishra et al., "Land Use Change and Carbon Emissions of a Transformation to Timber Cities," *Nature Communications*, vol. 13 (August 30, 2022), p. 4889.

[42] For example, see Prakash Nepal, Craig Johnson, and Indroneil Ganguly, "Effects on Global Forests and Wood Product Markets of Increased Demand for Mass Timber," *Sustainability*, vol. 13 (December 17, 2021), p. 13943; and Abhijeet Mishra et al., "Land Use Change and Carbon Emissions of a Transformation to Timber Cities," *Nature Communications*, vol. 13 (August 30, 2022), p. 4889.

[43] Woodworks.org, "Mass Timber Projects in Design and Constructed in the United States (March 2023)," March 2023; and U.S. Energy Information Administration, "2018 Commercial Buildings Energy Consumption Survey," 2020.

[44] For more information, see Woodworks Innovation Network, "Ascent," at https://www.woodworksinnovationnetwork.org/projects/ascent.

[45] Mass Timber Strategy, "Mass Timber Marketplace," at https://www.masstimberstrategy.com/marketplace, accessed May 22, 2023.

region). Builders in the United States also can access mass timber components made worldwide, such as from Canadian and European manufacturers.

Barriers to Adoption and Potential Disadvantages of Mass Timber and Tall Wood Buildings

Mass timber and tall wood buildings may have some disadvantages over conventional construction methods or face barriers to adoption. Because mass timber is an emerging technology with minimal market share, researchers identify high costs, unfamiliarity within the construction community, or unresolved questions about performance as potential disadvantages compared with conventional construction. In some cases, it is unclear whether these issues are intrinsic to mass timber itself or would change if mass timber were more widely used. These issues are discussed below.

Mass timber is widely perceived as being more costly than comparable steel and concrete building materials; however, the body of research on the costs of mass timber is small, and conclusions are mixed. A 2022 review article specified that concern about high project costs is a significant reason for slow adoption of mass timber construction.[46] For example, the review's authors cited two studies that showed the use of mass timber could increase materials costs by between 16% and 30% compared with mineral materials. Yet, the same review also cited other studies that concluded mass timber use would result in materials costs savings or in which results were unclear or dependent on other factors (e.g., where the mass timber was produced). Some features of mass timber may reduce other building costs. For example, building with mass timber can involve lower labor costs and shorter times to completion than building with mineral materials, as mass timber components are typically prefabricated offsite and assembled on-site. Ultimately, however, the construction industry's perception of mass timber construction is that it is more costly than comparable concrete and steel construction—which industry professionals consistently cite as one of the most significant barriers to widespread adoption.[47]

Studies have identified other potential barriers to mass timber and tall wood building adoption. Some have cited limitations in building codes (though it is unclear how the changes to the 2021 IBC may have affected these limitations, as most such issues were identified prior to the update of the IBC). Some have identified unfamiliarity with mass timber in the architectural community; for example, a 2022 survey of architects and structural engineers found that a lack of experience, training, and tools among the construction industry was a key barrier to adoption of CLT. [48] In addition, some have acknowledged a lack of demand for mass timber buildings or even resistance on the part of potential clients. For example, some studies claim that clients may associate mass timber with light-frame buildings' relatively weaker structures and higher fire risk.[49] Also at issue are unresolved questions regarding tall mass timber buildings' performance under certain hazardous conditions, such as earthquakes and tornadoes (see "Questions Regarding Mass Timber and Tall Wood Buildings"). The performance of conventional buildings in such conditions has been established over decades of research and real-world observation, whereas most knowledge

[46] Joseph Abed et al., "Performance and Benefits of Mass Timber."

[47] Ibid.

[48] Patrick Penfield et al., "Assessing the Adoption of Cross Laminated Timber by Architects and Structural Engineers Within the United States," *Journal of Green Building*, vol. 17, no. 1 (March 25, 2022), pp. 127-147.

[49] For example, see Clay Risen, "Cross-Laminated Timber Is the Most Advanced Building Material," *Popular Science*, February 26, 2014.

about mass timber buildings' performance in such situations is based on a relatively small body of research.

Questions Regarding Mass Timber and Tall Wood Buildings

Mass timber and tall wood buildings are relatively new building technologies. Thus, questions about their performance and marketability remain. According to a 2023 research needs assessment of the mass timber industry conducted by FS, some issues requiring further investigation regarding mass timber and tall wood building construction and design can be summarized as follows:[50]

- **Performance issues**, such as managing moisture and insect pests, including in varying climates.
- **Safety issues**, such as expanded investigations of fire performance (e.g., in larger spaces or with more exposed wood surfaces) and performance of larger buildings under hazardous conditions (e.g., earthquakes, tornadoes, hurricanes).
- **Design and architectural issues**, such as developing and testing certain kinds of assemblies, repair methods, construction method standardization, and design methods for certain weather hazards (e.g., hurricanes, tornadoes).
- **Materials and manufacturing processes**, such as developing and standardizing quality assurance and grading methods and use of alternative woods (i.e., hardwoods, mixed species, and reclaimed woods).
- **Infrastructure/nonbuilding applications**, such as bridges and highway sound barriers.

Forest Service Programs and Authorities to Support Mass Timber

The federal government funds research and provides financial and technical assistance to facilitate wood product innovation, including development and deployment of mass timber and tall wood buildings. This is generally (but not exclusively) done through the FS's State and Private Forestry (SPF) and Research and Development (R&D) mission areas, although some authorities also relate to management of FS and BLM federal forests.

Through SPF, FS provides forest-related technical and financial assistance, outreach, and education opportunities to various stakeholders, including the wood products community (e.g., nonprofits, businesses, educational institutions, forest landowners). FS SPF provides this assistance for several purposes, such as promoting forest retention, forest health, and community wildfire preparedness and improving, expanding, and marketing uses of wood and wood products. FS SPF generally provides this assistance to the partners through grants, cooperative agreements, or other instruments. FS has the general authority to provide such assistance;[51] Congress also has authorized specific assistance programs, such as those to encourage wood innovation, as listed in **Table 1**.[52]

[50] Marco LoRicco et al., "Research Needs Assessment for the Mass Timber Industry," Proceedings of the 3rd North American Mass Timber Research Needs Workshop, FS, FPL, FPL-GTR-297, March 2023.

[51] 16 U.S.C. §2101.

[52] See FS, "Grants, Cooperative Agreements, and Other Agreements," *Forest Service Manual 1580*, for a list and discussion of statutory authorities.

Through R&D, FS conducts research and extension on various forest-related topics, including wood products. FS has a general mission to conduct, support, and cooperate in forest- and rangeland-related research, including use of renewable resources such as wood products.[53] FS also may support or cooperate with other research organizations, including by offering competitive research grants.[54] FS organizes its research program using the FS National Research Plan, which identifies five research emphasis areas, including forest products innovation.[55] Research on wood products, potentially including innovative wood products, occurs throughout FS R&D's units, such as in the Southern, Pacific Northwest, Northern, and Rocky Mountain research stations.[56] In addition, FS R&D has a research unit focused specifically on wood products, the Forest Products Laboratory (FPL).

The FS has collaborated with and/or supported various organizations to research, develop, and deploy mass timber and tall wood building technology.[57] For example, the FS partners with WoodWorks, Thinkwood, and other industry groups and nonprofit organizations that provide education and technical assistance to architects and developers to design and build mass timber structures. The FS also has directly supported construction of tall wood buildings, such as Ascent MKE. In addition, FS research on the fire, seismic, and other structural performance of tall wood buildings supported changes to the 2021 IBC. It is not always clear what specific FS mission area or authority has supported each of these—and other—activities. In general, the FS may conduct such activities through its general SPF or R&D authorities, through specific programs (see **Table 1**), or through coordinated efforts across mission areas.

Table 1. Forest Service Programs and Authorities That May Support Innovative Wood Products

Program	Authorized Activity	Program Authorization	Funding Authorization	FS Office
Community Wood Energy and Wood Innovations (Community Wood)	Financial assistance	7 U.S.C. §8113	Up to $25 million annually, through FY2023	SPF
Forest Products Laboratory	Research, extension	Authorized under general FS research authorities, 16 U.S.C. §1642	No authorized funding level	R&D
Research and Development Program for Wood Building Construction	Research, technical assistance, extension	7 U.S.C. §7655c	No authorized funding level	R&D

[53] 16 U.S.C. §1642.

[54] 16 U.S.C. §1642(a).

[55] FS, *FY2020 Budget Justification*, 2019.

[56] FS, "Forest Products," at https://www.fs.usda.gov/research/forestproducts.

[57] For example, see Brian Brashaw and Kevin Naranjo, *Mass Timber Momentum Expands Forest Product Markets*, FS, October 21, 2020.

Program	Authorized Activity	Program Authorization	Funding Authorization	FS Office
Rural Revitalization Technologies	Financial assistance, technical assistance, extension	7 U.S.C. §6601(d)	$5 million annually, through FY2023	R&D
Wood Innovation Grant Program	Financial assistance	7 U.S.C. §7655d	No authorized funding level	SPF

Source: CRS.

Notes: FS = Forest Service; R&D = Research and Development mission area; SPF = State and Private Forestry mission area. Programs and authorities are listed in alphabetical order. For more information on FS's financial and technical assistance programs, see CRS Report R45219, *Forest Service Assistance Programs*, by Anne A. Riddle.

In addition to supporting activities related to mass timber, these programs may support other activities related to wood utilization, such as specified wood energy projects or other innovative wood products. These projects are described under the relevant headings below (e.g., see "Community Wood Energy and Wood Innovation Program" and "Wood Innovation Grant Program").

Forest Service State and Private Forestry Programs

Community Wood Energy and Wood Innovation Program (Community Wood)

The Community Wood Energy and Wood Innovation Program (Community Wood program) provides cost-share grants to support innovative wood product facilities (including those that produce mass timber) and community wood energy systems. Although the program can support mass timber-related projects, most of the program's funding has been used to support community wood energy systems. Congress authorized the Community Wood program in the 2018 farm bill by expanding the purposes and uses of an existing grant program focused on community wood energy that had never received appropriations.[58]

The 2018 farm bill authorization provides cost-share grants for two project types: construction of innovative wood product facilities and installation of community wood energy systems. *Innovative wood product facilities* include facilities that produce mass timber, as well as other products made of wood.[59] *Community wood energy systems* are defined as energy systems for public or private facilities that produce energy using unprocessed woody biomass, including residuals.[60]

Cost-share grants made under the Community Wood program may cover up to 35% of the capital cost for installing a community wood energy system or building an innovative wood product

[58] P.L. 115-334. The Community Wood Energy and Wood Innovation Program amended the Community Wood Energy Program, established in the 2008 farm bill (P.L. 110-234 §9013; 7 U.S.C. §8113).

[59] The definition of *innovative wood product facilities* also includes "wood products derived from nanotechnology or other new technology processes, as determined by the Secretary; or other innovative wood products that use low-value, low-quality wood, as determined by the Secretary."

[60] 7 U.S.C. §8113(a)(1). For the purposes of the program, community wood energy systems must specifically produce thermal energy or combined thermal energy and electricity, where thermal energy is the primary output, and must use unprocessed woody biomass that does not cause the conversion of forests to non-forest use.

facility, capped at a total of $1 million.[61] A maximum of 25% of the annual grant funds may go to projects proposing to build innovative wood products facilities. The Secretary is to consider these criteria for awarding both categories of grants:

- energy efficiency;
- cost effectiveness;
- whether the project represents the best available commercial technology;
- likelihood of success, as demonstrated by detailed project specifications (e.g., engineering and design work) in advance of the grant application; and
- other "technical, economic, conservation, and environmental" criteria established by the Secretary.

Additional criteria apply to community wood energy system grants.[62] According to the FS, the program emphasizes "assisting sawmills in economically challenged areas to retool or add advanced technology."[63]

The FS awarded the first grants under the Community Wood program in FY2020 (see **Table 2** for information on funded projects by year). Although project purposes under the program are not always clear, most projects appear to relate to wood energy, with few projects directly related to mass timber.

Table 2. Community Wood Energy and Wood Innovation Program (Community Wood) Funded Projects

Fiscal Year	Number of Projects	Funding (in millions of $)
2020	6	1.5
2021	7	2.1
2022	21	16.4[a]

Source: CRS, using information from Forest Service (FS), "Wood Innovations Data," at https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovations-data; and FS, "2022 Community Wood Grant Program Awards," at https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation-2022-community-wood-grant-program-awards.

Notes: The Community Wood program is funded through the National Forest System Hazardous Fuels budget line item.

a. Congress appropriated $15.0 million for the Community Wood program through regular appropriations for FY2022 (P.L. 117-103, Division G Joint Explanatory Statement). The FS FY2024 budget justification specifies that additional funding for Community Wood grants comes from the Infrastructure Investment and Jobs Act (P.L. 117-58) and the budget reconciliation measure known as the Inflation Reduction Act (P.L. 117-169).

[61] If special circumstances, as determined by the Secretary of Agriculture, apply, then the Community Wood program may cover up to 50% of the capital cost for installing a community wood energy system or building an innovative wood product facility, capped at a total of $1.5 million. Special circumstances may include situations such as if a project involves a school or hospital in a low-income community.

[62] Specifically, the Secretary of Agriculture must consider whether the proposed system will displace conventional fossil fuel generation, minimize increases in emissions, increase delivered thermal efficiency, and use the most stringent control technology possible.

[63] FS, "Wood Innovations," at https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation.

Wood Innovation Grant Program

The Wood Innovation Grant Program provides cost-share grants and cooperative agreements to support expansion of wood product and wood energy markets. The program has been used to support both wood product and wood energy projects, though it has supported relatively more wood product-related projects, including mass timber projects. Congress authorized the program in the 2018 farm bill by formalizing in law an existing request for proposals (RFP) for grants under another authority.[64]

The Wood Innovation Grant Program supports two categories of competitive grants and cooperative agreements:

- Expanding and accelerating wood product markets (WPM), with preference given to projects that support commercial building markets or other markets that use innovative wood products, including (but not limited to) conducting training and outreach on use of innovative wood building materials, facilitating establishment of new building codes that incorporate innovative wood products, developing regional or national market strategies and capacity, and completing commercial construction projects using innovative wood materials.
- Expanding and accelerating wood energy markets (WE) that use wood residues for heating, cooling, or electricity, including (but not limited to) feasibility assessments and evaluations of wood energy potential across sectors or geographies, developing "clusters" of wood energy projects, and completing late-stage wood energy project development tasks (i.e., permitting, engineering designs, cost analyses).

Although the 2018 farm bill referred to the RFP in codifying the Wood Innovation Grant Program in law, certain program criteria and goals are defined in statute rather than in the RFP. The 2018 farm bill defined eligible entities and specified a 50% cost share for the funding.[65] In addition, the 2018 farm bill specified that the Secretary of Agriculture shall give priority to proposals that include retrofitting or use of existing sawmill facilities located in counties in which the average annual unemployment rate exceeded the national average unemployment rate by more than 1% in the previous calendar year.

Although the Wood Innovation Grant Program was not codified in law until the passage of the 2018 farm bill, the FS made grants and cooperative agreements in the WE and WPM categories prior to 2018, under the previous authority. Thus, FS information on the Wood Innovation Grant Program includes funding awarded prior to 2018.

[64] Prior to the 2018 farm bill, the FS had established a Wood Innovation Grant Program based on the broad Rural Revitalization Technologies authority (see "Rural Revitalization Technologies"). Congress directed the FS to award one or more grants to specified eligible entities according to the program, as described in the *Federal Register* notice for the FY2016 request for proposals (RFP) at 80 *Federal Register* 63498, October 2015. The RFP's purpose was to "substantially expand and accelerate wood energy and wood products markets throughout the United States to support forest management needs on National Forest System and other forest lands."

[65] P.L. 115-334 §8643; 7 U.S.C. §7655d.

Table 3. Wood Innovation Projects and Funding

Fiscal Year	Federal Funding (in millions of $)			Number of Projects		
	WE	WPM	Total	WE	WPM	Total
2015	3.7	4.7	8.3	20	23	43
2016	3.5	5.2	8.7	17	25	42
2017	2.5	5.9	8.4	12	26	38
2018	1.2	6.7	7.9	6	28	34
2019	2.2	6.6	8.8	11	29	40
2020	1.6	6.0	7.6	7	27	34
2021	2.4	6.1	8.4	12	29	41
2022[a]	—	—	16.4	—	—	78

Source: CRS, using information from https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovations-data and https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation-2022-grant-recipients.

Notes: WE = wood energy markets; WPM = wood product markets. The Wood Innovation Grant Program is funded through the National Forest System Hazardous Fuels budget line item. Figures may not sum due to rounding.

a. FY2022 awards were not differentiated by grant type.

From FY2015 to FY2022, the FS awarded grants and cooperative agreements to 350 projects for a total of approximately $74.5 million in federal funding.[66] From FY2015 to FY2021, the FS awarded funding to 187 projects in the WPM area, comprising approximately $41.1 million, about 70% of the total awarded amount (FY2022 is excluded because grant awards were not differentiated by type in that year).

Funded projects related to mass timber include various activities, such as the following:

- developing mass timber manufacturing processes and supply chains;
- developing and testing mass timber products, such as testing mass timber products' blast resistance, fire performance, seismic performance, and acoustic characteristics;
- building mass timber structures and developing mass timber building techniques, such as for various low- and mid-rise applications (e.g., townhouses, modular dwellings, mid-rise commercial structures, temporary military structures, schools), tall wood buildings, and other infrastructure (e.g., bridges);
- analyzing mass timber markets, the economics of mass timber manufacturing and construction, and the lifecycle of mass timber products; and
- conducting outreach and education on construction methods for tall wood buildings and mass timber.

[66] FS uses funding provided through language in annual appropriations bills allocating between $5 million and $15 million annually for grants to encourage wood or biomass utilization. This language has been provided in various forms since about FY2005, and sometimes Congress has further specified that the grants should incentivize the use of biomass from national forests. For example, in the Consolidated Appropriations Act, FY2021 (P.L. 116-260), Congress allocated approximately $12.5 million from the National Forest System account for grants "using any authorities available to the Forest Service under the 'State and Private Forestry' appropriation, for the purpose of creating incentives for increased use of biomass from NFS lands."

Funding for Wood Product Manufacturing in the Infrastructure Investment and Jobs Act (P.L. 117-58)

The Infrastructure Investment and Jobs Act (P.L. 117-58) established a grant program to open or improve wood product manufacturing facilities in close proximity to federal or Indian lands. Such facilities must be located near federal or Indian forestland in need of restoration, particularly areas at high risk of wildfire or insect and disease infestations, as determined by the Secretaries of Agriculture and the Interior. Facilities are eligible for funding if they purchase and process woody materials (e.g., small-diameter materials) from projects on these lands. The first awards were made under this program in April 2023. The nature of the facilities funded through the program is not specified, so it is unclear whether any—and, if so, how many—relate to mass timber. Given that mass timber manufacturing occurs after primary wood processing, it is also unclear whether mass timber facilities would be broadly eligible for the grants.

In April 2023, the FS awarded $29.0 million to 42 projects in 15 states, primarily in the western United States. In most states, the FS funded one or two projects, with by far the most (14) in California. The FS specified that "more than two thirds" of the funded facilities would use byproducts from forest restoration on landscapes identified in the FS's Wildfire Crisis Strategy, the agency's 10-year strategy to reduce hazardous fuels.[67] The FS also specified that two-thirds of all funded facilities were in "disadvantaged communities," as identified by the Climate and Economic Justice Screening Tool.[68]

Forest Service Research and Development Programs

Forest Products Laboratory

FPL, established in 1910, is a research facility within the FS's R&D mission area. FPL focuses specifically on "identifying and conducting innovative wood and fiber utilization research."[69] FPL's research emphasizes areas such as advanced composites, advanced structures, nanotechnology, woody biomass utilization, and forest biorefinery (developing and using fuels and chemicals from wood).[70] Much of FPL's work directly relates to innovative wood products, such as researching, developing, and testing mass timber products and structures. FPL cooperates with industry, academia, and nonprofits to conduct research, outreach, education, and technology transfer.[71] FPL also patents technologies developed at FPL or other FS research units and makes patented technologies available for licensing or cooperative research opportunities.[72]

The 2018 farm bill directed the Secretary of Agriculture to conduct research and development, education, and technical assistance to facilitate the use of innovative wood products in building construction.[73] These activities can take place at the FPL or through the SPF mission area, or they

[67] FS, "Wood Products Infrastructure Assistance Grants," at https://www.fs.usda.gov/science-technology/energy-forest-products/wood-innovation/wood-products-infrastructure-assistance-grants.

[68] FS, "Biden-Harris Administration Invests Nearly $34M to Strengthen Wood Products Economy, Forest Sector Jobs, Sustainable Forest Management," press release, April 6, 2023.

[69] FS, FPL, "FPL Mission and Strategic Plan," at https://www.fpl.fs.fed.us/research/research_emphasis_areas/index.php.

[70] Ibid.

[71] FS, FPL, "Partnerships," at https://www.fpl.fs.fed.us/partners/index.shtml.

[72] FS, FPL, "Patents and Licensing," at https://www.fpl.fs.fed.us/partners/patents/index.shtml.

[73] P.L. 115-334 §8642; 16 U.S.C. §7655c.

can occur through competitive grants to institutions of higher learning. These activities are to prioritize the following:

- improved commercialization of innovative wood products;
- safety and life-cycle analyses of tall wood building materials, manufacturing, and construction;
- impacts of innovative wood products on wildlife; and
- other areas identified by the Secretary of Agriculture in collaboration with stakeholders.

The law specified that the research program is to focus on measurable performance goals, which "shall be achievable within a 5-year timeframe."[74] It is unclear what, if any, specific projects have been conducted or funded under this program, as many FS R&D activities related to innovative wood products predate the enactment of this provision.

Rural Revitalization Technologies

Congress has directed the Secretary of Agriculture to establish and carry out programs relating to rural economic development (known as Forestry Rural Revitalization).[75] These programs are implemented through different USDA agencies, including the FS. In particular, the Rural Revitalization Technologies (RRT) section of this authority authorizes the FS, acting through the FPL, to carry out a program to accelerate adoption of technologies and establish small business enterprises that use biomass and small-diameter wood materials.[76] The RRT also authorizes the FS to create community-based wood-related enterprises through marketing activities and demonstration projects. The authority afforded by RRT is broad, and the FS has undertaken a number of activities under it (for example, see "Wood Innovations Grant Program"). The other sections of the Forestry Rural Revitalization program are administered through the National Institute for Food and Agriculture.

Other Authorities

In the past, Congress has sometimes sought to incentivize or encourage timber harvesting on federal land that supported or provided feedstock for specified forestry industries. For example, in the 115th Congress, Congress authorized the FS and BLM to give a procurement preference under the stewardship contracting authority to contractors that would promote an innovative use of harvested forest products, including CLT. The stewardship contracting authority is generally viewed as a tool for streamlining and incentivizing restoration of federal forests through several mechanisms, such as by allowing contracts that combine multiple forest management activities at once and offsetting the costs of restoration activities with revenues from timber harvesting. It is unclear to what extent this provision of the stewardship contracting authority has been used, if at all.

The FS also has used general FS and federal authorities to acquire and construct buildings using mass timber. For example, the FS recently constructed the new supervisor's office of the Nez Perce-Clearwater National Forest of mass timber (see **Figure 2**). The FS, and other federal agencies, may be able to undertake similar projects in the future for various administrative,

[74] 7 U.S.C. §7655c(d).

[75] 7 U.S.C. §6601.

[76] 7 U.S.C. §6601(d).

recreational, and other buildings and structures (see "Materials Preferences in Federally Owned or Assisted Buildings").

Options for Congress

Some in Congress have expressed interest in increasing the adoption of mass timber and tall wood buildings.[77] Should Congress wish to provide support for this policy in addition to the programs and funding previously described, options for consideration could include the following:

Expanding Mass Timber Assistance and Research and Development Programs

In general, Congress has primarily supported mass timber and tall wood buildings through the FS assistance and research programs described above (see "Forest Service Programs and Authorities to Support Mass Timber"). Options for further action could include increasing appropriations to these programs to increase the number or size of funded projects and providing additional congressional direction for existing programs or amendments to underlying statutes. In weighing such options, for example, Congress could consider whether additional eligible uses of grant funding should be specified under the Wood Innovations and Community Wood programs or whether to limit the programs' eligible projects to eliminate competing project categories. Other options include reducing the nonfederal cost-share or match requirement for existing grant funds or establishing new grant programs related to mass timber; both of these options are included in H.R. 5044 and S. 2662 of the 118th Congress.

Other options could include clarifying or adding to the purposes of other assistance and research programs to ensure mass timber is included across a variety of federal agencies. For example, Congress could consider whether to provide explicit direction regarding mass timber and the funding for wood product facilities in the Infrastructure Investment and Jobs Act, either by amending the act or through other legislation (see "Funding for Wood Product Manufacturing in the Infrastructure Investment and Jobs Act"). As another example, Congress could require that ongoing federal research related to building sustainability and safety, such as that conducted by the National Institute of Standards and Technology, incorporate mass timber.[78]

Authorization of new assistance or research programs to address specific mass timber-related issues of interest could also be an option—for example, programs specific to tall wood buildings or non-building wood structures. In general, approaches relating to expanding federal programs or funding may require competition for scarce federal resources (e.g., funding, program staff), whereas approaches relating to eliminating competing project types may face opposition from those issues' stakeholders.

[77] For example, see U.S. Congress, Senate Committee on Energy and Natural Resources, *Full Committee Hearing On Forest Management, Forest Products, and Carbon*, 117th Cong., 2nd sess., May 20, 2021.

[78] National Institute of Standards and Technology (NIST) programs of interest may include the agency's Sustainable and Energy-Efficient Manufacturing, Materials, and Infrastructure Program, which focuses on improvements in measurement science and data relating to sustainable buildings, and NIST's National Fire Research Laboratory, a facility dedicated to understanding fire behavior and buildings' response to fire. For more information, see CRS Report R43908, *The National Institute of Standards and Technology: An Appropriations Overview*, by John F. Sargent Jr. Other federal agencies also may have programs related to building sustainability, safety, and other related topics.

Materials Preferences in Federally Owned or Assisted Buildings and Structures

Another option for Congress could be to express a preference or create a requirement that federally owned, rented, or assisted structures be made in whole or in part of mass timber. In the case of federally owned structures, options could include applying a price or procurement preference for mass timber structures, either across the federal government or for certain agencies (e.g., the Department of Defense). In the case of federally funded projects, selection preferences or other project-selection incentives for projects that include mass timber components could be established, such as higher funding or reduced matching requirements. These could apply either across the federal government or for certain agencies or project types (e.g., projects funded by the Department of Transportation or the Department of Housing and Urban Development). For example, in the 118th Congress, S. 2991 would direct the Secretaries of Agriculture and the Interior to procure specified structures made using domestic mass timber, subject to certain requirements.[79]

Requirements or incentives to use mass timber in federal structures may dovetail with a number of existing laws. In particular, they may complement laws addressing federal *green buildings* requirements—requirements that federally owned structures have reduced environmental footprints compared with standard practices. For example, federal law requires all federal agencies to implement green building practices, including reducing the environmental impacts of materials used in building construction, enhancing the quality of the indoor environment, and meeting many other criteria, many of which may be met by mass timber buildings.[80] Similarly, federal policies have previously provided incentives for federally funded buildings to adopt green building elements. In a specific example of both options in recent legislation, the Inflation Reduction Act provided $2.15 billion in funding for the General Services Administration to build or alter federally owned buildings using materials with reduced embodied carbon emissions and authorized the Federal Emergency Management Agency to provide certain forms of financial assistance to promote low-carbon or net-zero energy projects.[81]

For those seeking to provide additional support for mass timber, potential advantages of policy approaches related to federal procurement are that they may drive demand for mass timber materials and construction, help develop expertise among the construction industry, and provide practical "showcases" for mass timber construction and design. The extent of these benefits may be driven in part by which policy option is chosen. In aggregate, there are more federally funded than federally owned buildings and structures, meaning approaches related to federally funded projects may present a larger opportunity than those related to federally owned buildings. However, the greater degree of federal control in federal procurement processes versus stakeholder-driven projects may lead to more certainty in the amount of mass timber projects supported—for example, if no stakeholders take advantage of mass timber-related federal funding opportunities.

Because of the relatively low market penetration of mass timber structures so far, the federal government under this option likely would face increased costs, such as materials costs or the costs to hire from a small, specialized pool of contractors. In the case of federally owned structures, these costs would be reflected in increased procurement costs. In the case of federally

[79] S. 2991 would direct the Secretaries of Agriculture and the Interior to procure "facilities, buildings, or structures" made using domestically produced mass timber, including not fewer than 100 single-occupancy restrooms.

[80] For more information, see CRS Report R46719, *Green Building Overview and Issues*, by Corrie E. Clark.

[81] P.L. 117-169 §60503 and §70003.

funded projects, these costs could be reflected more subtly. For example, higher costs per project may mean fewer projects could be funded under the same program, or requirements to include mass timber could prevent partners from pursuing projects at all if they could not locate skilled contractors. Such issues may potentially be overcome by providing increased resources for mass-timber related programs, such as through increased appropriations, although this approach would be contingent on those increased appropriations successfully competing against other budget priorities.

Federal Timber Harvesting Authorities and Mass Timber

As described above (see "Other Authorities"), Congress has sometimes sought to incentivize or encourage timber harvesting on federal land that supported or provided feedstock for specified forestry industries, such as the procurement preference for mass timber under the stewardship contracting authority. Congress may wish to consider other means of incentivizing mass timber production through activities in federal forests, such as federal timber harvesting. This approach may be of particular interest for legislators who hope to realize land management-related benefits from the mass timber industry.

One option for Congress could be to apply a procurement preference to prospective timber purchasers when offering or awarding federal timber sales or other mechanisms involving timber harvesting—for example, through the Good Neighbor authority.[82] Other options could include reducing the costs of timber to purchasers who would use the timber for mass timber manufacturing, such as reducing per-unit or total sales prices after bidding. Another option could be making available certain timber sales specifically and only for mass timber production.

Approaches that facilitate access to federal timber (such as the options described in the preceding paragraph) could provide reduced materials costs for mass timber manufacturers, incentives for mass timber manufacturers to locate near federal forests, or incentives for certain forest management activities. A potential issue with this approach could be limitations on the ability to oversee whether timber is ultimately used for mass timber production (e.g., if timber purchasers are not the processors of the wood). Some stakeholders also may have concerns about favoring certain forestry industries over others or procurement practices that result in reduced revenues to the federal government, which may affect the funding available for certain land management activities.[83] Previous legislative efforts to secure federal timber supplies for specific sectors of the forest economy have sometimes collapsed due to economic conditions, allegations of anticompetitive behavior, or both.[84]

Other Options

Various other instruments exist to influence mass timber's patterns of use, production, and trade. Such tools include tariffs and other trade restrictions, tax incentives, preferential access to credit, and industry-specific business and manufacturing development support (e.g., loans, loan guarantees, and similar programs). The use of these instruments in the modern era to support

[82] For more information, see CRS In Focus IF11658, *The Good Neighbor Authority on Federal Lands*, by Anne A. Riddle.

[83] For information on FS and Bureau of Land Management uses of revenues from timber harvesting, see CRS Report R45688, *Timber Harvesting on Federal Lands*, by Anne A. Riddle; and CRS Report R43872, *National Forest System Management: Overview and Issues for Congress*, by Katie Hoover and Anne A. Riddle.

[84] For example, see David Clary, "What Price Sustained Yield? The Forest Service, Community Stability, and Timber Monopoly Under the 1944 Sustained Yield Act," *Journal of Forestry*, vol. 13, no. 1 (January 1, 1987).

individual industries has been mixed and often specific to a particular situation. As such, it is unclear whether these instruments are pertinent or politically viable in the context of mass timber.

For example, past presidential Administrations have used trade policy to protect other sectors of the timber industry, particularly the lumber industry.[85] However, it is unclear whether such a strategy would be viable for mass timber. U.S. trade policy generally has focused on liberalizing markets by reducing trade barriers through trade agreements and negotiations and relieving companies and workers facing unfair competition from imports.[86] It is currently unclear whether competition from foreign mass timber producers would be considered injurious, and so it is unclear how historically "typical" levers of U.S. trade policy might support the growing U.S. mass timber industry. However, some policymakers have questioned the rationale behind historical U.S. trade policy and have called for suspending (or reversing) efforts to liberalize trade and increasing trade barriers to protect domestic industries—a model that could be tried for mass timber but would represent in a departure from historical norms.[87]

As another example, federal support for business development in broad sectors (i.e., for businesses in rural areas, small businesses, and businesses owned by certain demographic groups) is a central role of agencies and programs such as the Small Business Administration, the USDA's Rural Development mission area, and the Department of Commerce.[88] However, business development and support programs specific to individual industries are comparatively rare and generally have been authorized in response to critical economic, political, national security, and other concerns.[89] In addition, some aspects of federal business development policy have been incorporated in existing assistance programs, such as the eligibility of businesses for FS SPF grant programs.

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[85] For more information, see CRS Report R42789, *Softwood Lumber Imports from Canada: Current Issues*, by Katie Hoover; and CRS Insight IN11364, *Forest Service Announces Timber Sale Contract Relief*, by Anne A. Riddle.

[86] For more information on U.S. trade policy, see CRS Report R45148, *U.S. Trade Policy Primer: Frequently Asked Questions*, coordinated by Cathleen D. Cimino-Isaacs; and CRS In Focus IF10156, *U.S. Trade Policy: Background and Current Issues*, by Shayerah I. Akhtar, Cathleen D. Cimino-Isaacs, and Karen M. Sutter.

[87] For more information on debates in U.S. trade policy, see CRS In Focus IF12327, *U.S. Trade Policy: Future Direction and Key Economic Debates*, by Andres B. Schwarzenberg.

[88] For more information, see CRS Report RL31837, *An Overview of USDA Rural Development Programs*, by Tadlock Cowan (congressional clients may contact the author for further information); CRS Report RL33243, *Small Business Administration: A Primer on Programs and Funding*, by Robert Jay Dilger, R. Corinne Blackford, and Anthony A. Cilluffo; and CRS Report R46816, *The Minority Business Development Agency: An Overview of Its History and Programs*, by Julie M. Lawhorn.

[89] For example, in the 117th Congress, the CHIPS Act of 2022 (Division A of P.L. 117-167) included provisions to support domestic semiconductor manufacturing, a critical "enabling technology" for a wide array of U.S. industries, due to concerns related to international competitiveness and national security. For more information, see CRS Report R47523, *Frequently Asked Questions: CHIPS Act of 2022 Provisions and Implementation*, by John F. Sargent Jr., Manpreet Singh, and Karen M. Sutter.

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