WoodWorks™
WOOD PRODUCTS COUNCIL

# Introduction to Wood Species and Grading

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# Special Thanks to WEI

WoodWorks would like to recognize and thank the Wood Education Institute for the use of some of the graphics displayed in this presentation. In particular, we would like to thank:

Mikhail Gershfeld
Charles Chadwell
Rakesh Gupta
Kenny Martin


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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

# Course Description

This presentation will provide an introductory review of wood species and grades, and the impact of these factors on structural properties and durability. Grading rules, design properties and identification stamps will be discussed. Wood species common in different regions of the country will be highlighted, as will the varying degrees of natural decay resistance associated with certain species.

# Learning Objectives

1. Review the significance of wood grading rules and grading agencies to structural design properties of wood framing members.
2. Discuss available wood species as well as methods of grading and identification for common wood framing material.
3. Highlight the range of natural decay resistance inherent in common wood framing species.
4. Explore the impact that regional climatic conditions have on growing conditions and product availability.

# Wood Species & Grading: Necessity

Structural wood used in construction can vary in species and grade. This affects:

- Mechanical properties (strength)
- Decay resistance
- Visual appearance

Understanding species & grading provides framework for proper design & specification

Photo: Vanwoody.com

The Bullitt Center Photo: John Stamets

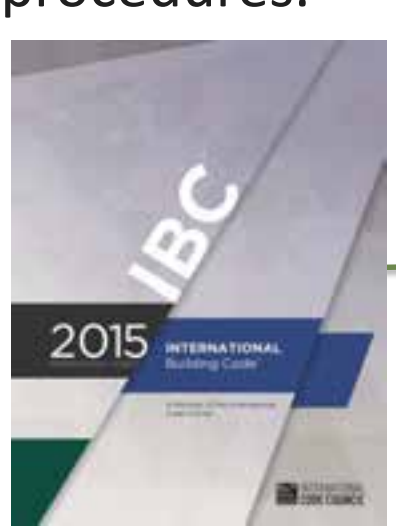
# Outline

- Codes & Standards
- Reference Design Values
  - Grading Methods
  - Species
  - Grade
  - Size
- Identification Stamps
- Specific Gravity
- Naturally Decay Resistant Species
- Treating Wood
- Exposed Architectural Species
- Hardwood vs. Softwood
- Geographic Impacts

# Wood Species & Grading: Building Code

## IBC **2303.1.1 Sawn Lumber**

Sawn lumber used for load-supporting purposes…shall be identified by the grade mark of a lumber grading or inspection agency that has been approved by an accreditation body that complies with DOC PS 20 or equivalent. Grading practices and identification shall comply with rules published by an agency approved in accordance with the procedures of DOC PS 20 or equivalent procedures.




# Referenced Standard & Grading Rules

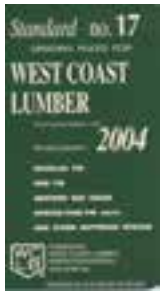
DOC PS 20: U.S. Department of Commerce Voluntary Product Standard PS 20-15 (American Softwood Lumber Standard)

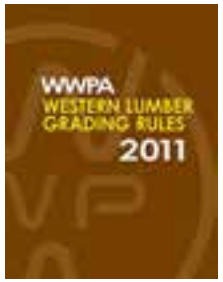
Grading rules established by 7 agencies:

- National Lumber Grades Authority (Canada)
- Northeastern Lumber Manufacturers Association
- Northern Softwood Lumber Bureau
- Redwood Inspection Service
- Southern Pine Inspection Bureau
- West Coast Lumber Inspection Bureau
- Western Wood Products Association





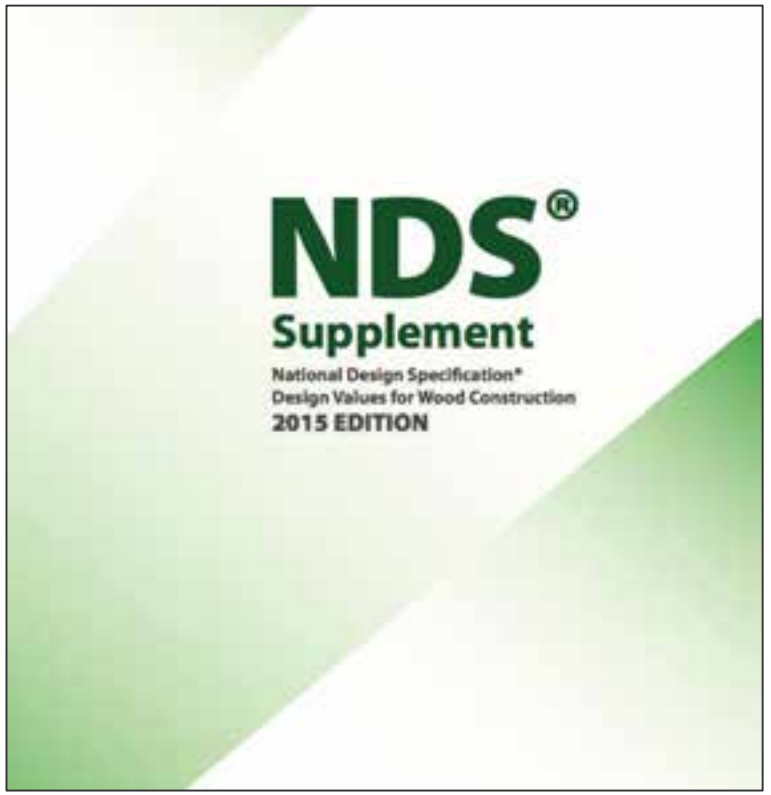


# Reference Design Values - NDS

Reference design values for lumber – given in Chapter 4 of AWC's NDS Supplement – are generated using the 7 sets of recognized grading rules as well as by using the provisions in one or more of the following:

- ASTM D1990: Standard Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens
- ASTM D245: Standard Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber
- ASTM D2555: Standard Practice for Establishing Clear Wood Strength Values



# Reference Design Values

**Reference Design Values**: The quantifiable mechanical properties that are associated with each identifiable commercial grade of wood


| Reference Design Values | |
|---|---|
| $F_b$ | Bending stress |
| $F_v$ | Shear stress |
| $F_t$ | Tension stress |
| $F_c$ | Compression stress |
| $F_{cT}$ | Compression stress perpendicular to grain |
| $E/E_{min}$ | Modulus of elasticity |

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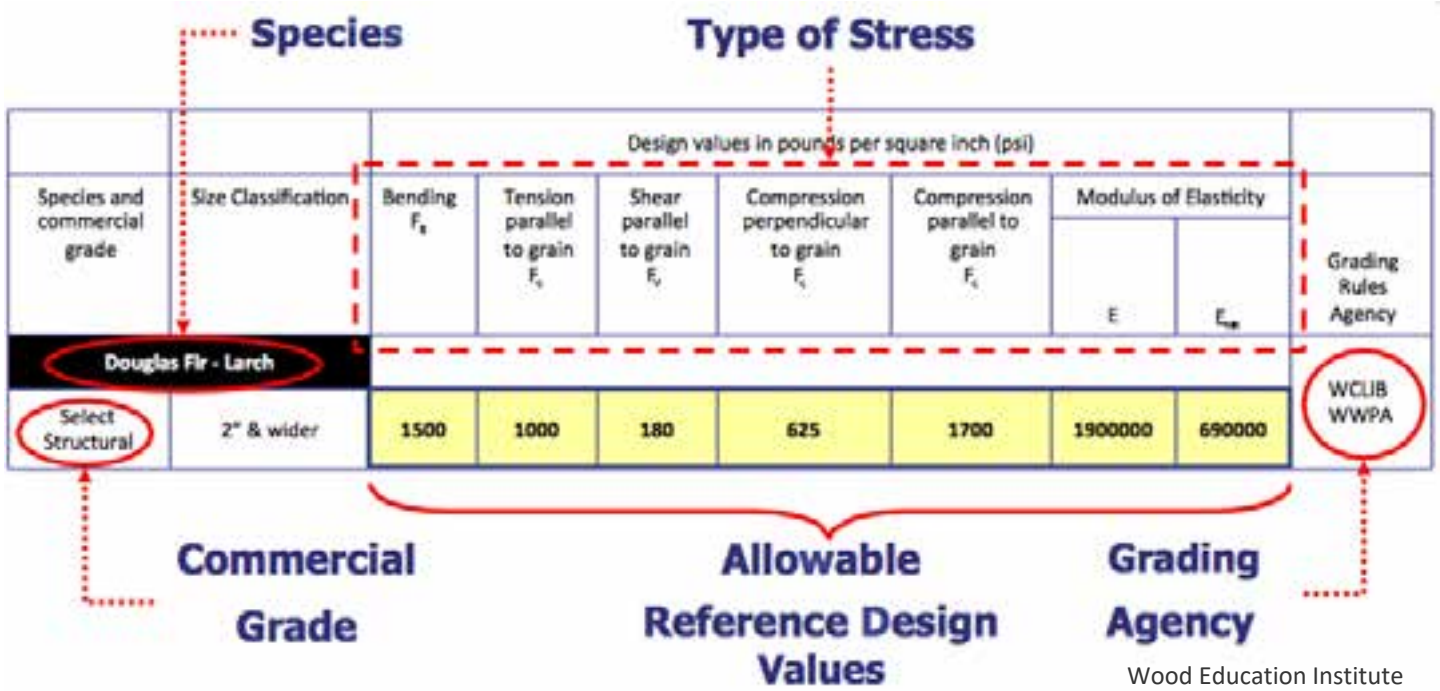
# Reference Design Values

Reference Design Values in NDS are given based on four main variables:

- Grading Method
- Species Group
- Commercial Grade
- Size Classification



# Reference Design Values: Grading Methods

**Grading**: The process of categorizing wood members into groups that have common material properties.

Grading methods:

- Visually Graded Lumber (VGL)
  - Grade is determined by visual inspection using the guidelines of the applicable grading rules
- Machine Stress Rated (MSR)
  - Automated, nondestructive method of grading in which the modulus of elasticity of a member is determined through an applied bending load
- Machine Evaluated Lumber (MEL)
  - Automated, nondestructive method of grading in which MSR lumber undergoes radiographic inspection to measure density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Notes:

NDS groups MSR & MEL into “Mechanically Graded Dimension Lumber”

MSR & MEL only apply to dimension lumber 2” thick

# Reference Design Values: Species

Over 100 sawn lumber species are available and in use as structural members in construction

These species are grouped into 50 species combinations in NDS Supplement, Chapter 2, based similarities in mechanical properties

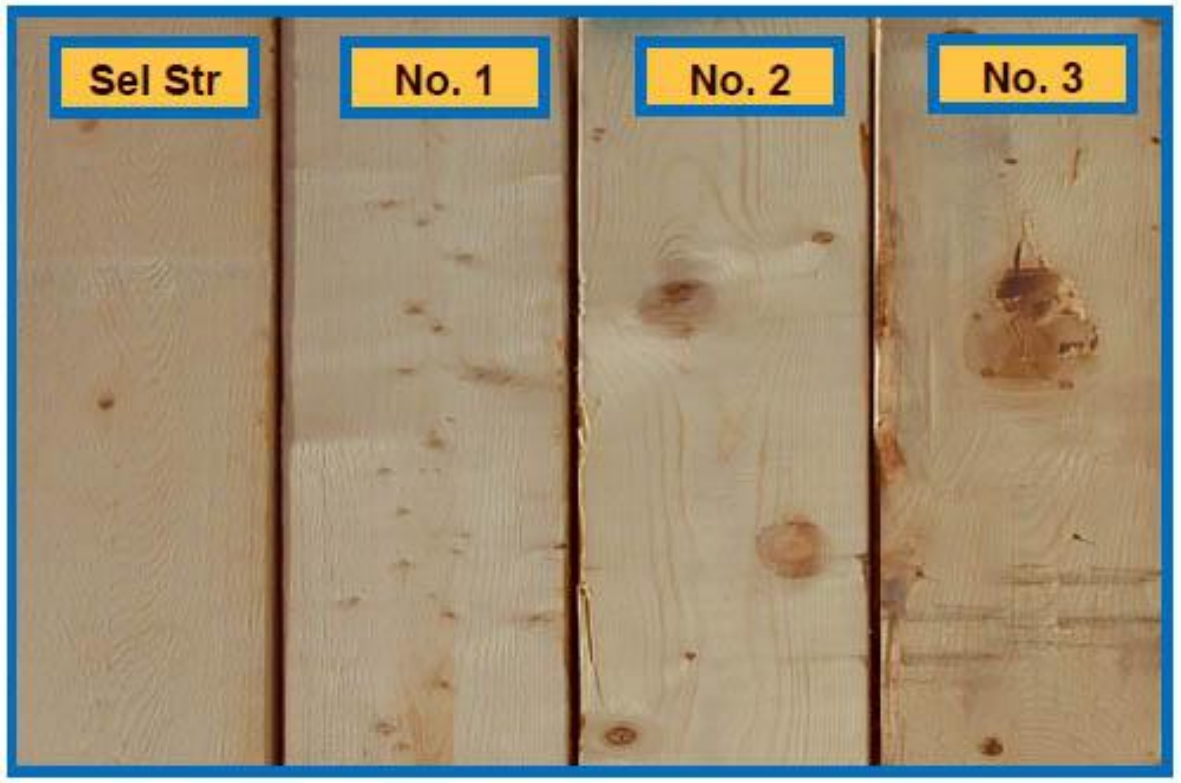
Note that Southern Pine reference design values are separate in Table 4B, all others are in Table 4A

| Species or Species Combination | Species That May Be Included in Combination | Grading Rules Agencies | Design Values Provided in Tables |
|---|---|---|---|
| Douglas Fir-Larch | Douglas Fir<br>Western Larch | WCLIB<br>WWPA | 4A, 4C, 4D, 4E |
| Douglas Fir-Larch (North) | Douglas Fir<br>Western Larch | NLGA | 4A, 4C, 4D, 4E |
| Douglas Fir-South | | WWPA | 4A, 4C, 4D, 4E |
| Eastern Hemlock | | NELMA<br>NSLB | 4D |
| Eastern Hemlock-Balsam Fir | Balsam Fir<br>Eastern Hemlock<br>Tamarack | NELMA | 4A |
| Eastern Hemlock-Tamarack | Eastern Hemlock<br>Tamarack | NELMA<br>NSLB | 4A, 4D, 4E |
| Eastern Hemlock-Tamarack (North) | Eastern Hemlock<br>Tamarack | NLGA | 4D, 4E |

# Reference Design Values: Commercial Grade

**Commercial Grade**: A function of the member's use and quality as defined in the Grading Rules

- Select Structural
- Dense No. 1
- No. 1
- No. 2
- No. 3
- Stud
- Construction
- Standard
- Utility



# Reference Design Values: Commercial Grade

Grading Rules define parameters for quality for various growth characteristics such as:

- Checks
- Knots
- Pitch & Pitch Streaks
- Pockets
- Shake
- Slope of Grain
- Stain
- Unsound Wood
- Wane
- Warp

**PITCH & PITCH STREAKS:** An accumulation of resinous material. If the material leaves well defined line, it is called a pitch streak.

**POCKET:** Well defined opening between the annual growth rings, usually contains pitch or bark.

**SHAKE:** Separation of grain between the growth rings, often extending along the board's face and sometimes below its surface.

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# Reference Design Values: Commercial Grade

| Partial List of Grading Limitations | | | | |
|---|---|---|---|---|
| Structural Light Framing – 2" to 4" thick, 2" to 4" wide<br>Structural Joists and Plank – 2" to 4" thick, 5" and wider | | | | |
| | Lumber Grade | | | |
| ***Characteristic*** | **Select Structural** | **No. 1** | **No. 2** | **No. 3** |
| *Checks* | Not limited | Not limited | Not limited | Not limited |
| *Knots (largest allowed knot on the wide face edge)* | %"/2" nom<br>%"/4" nom | ½"/2" nom<br>1"/4" nom | %"/2" nom<br>1¼"/4" nom | ¾"/2" nom<br>1¾"/4" nom |
| *Manufacture* | E | E | F | F |
| *Shake* | 2 ft. long | 2 ft. long | 2 ft. long | 1/3 the length |
| *Slope of grain* | 1 in 12 | 1 in 10 | 1 in 8 | 1 in 4 |
| *Splits* | Width of piece | Width of piece | 1.5 x Width of piece | 1/6 the length of piece |

Standard 17 Grading Rules for West Coast Lumber 2004
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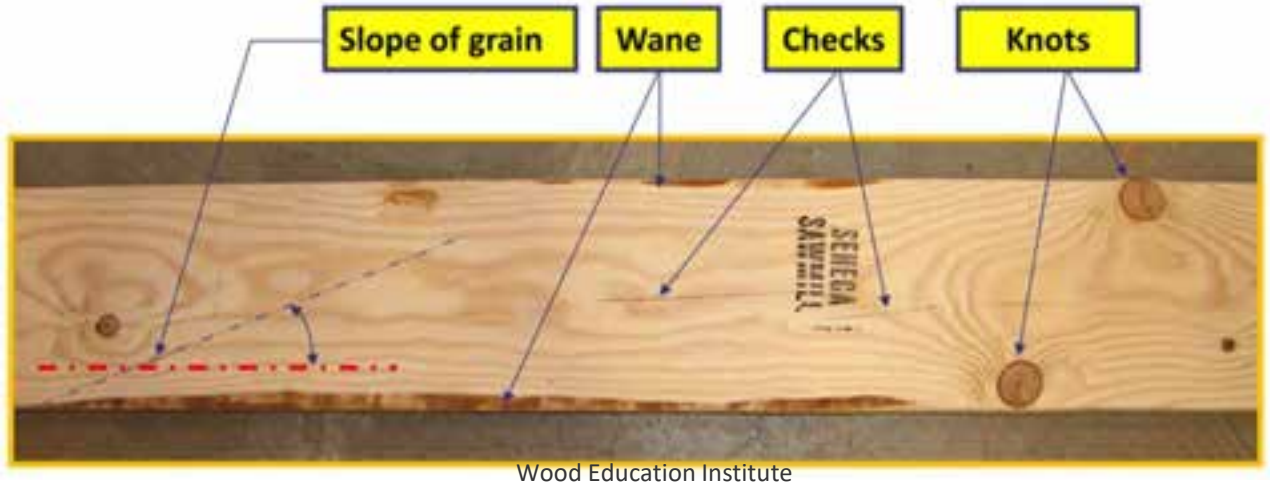


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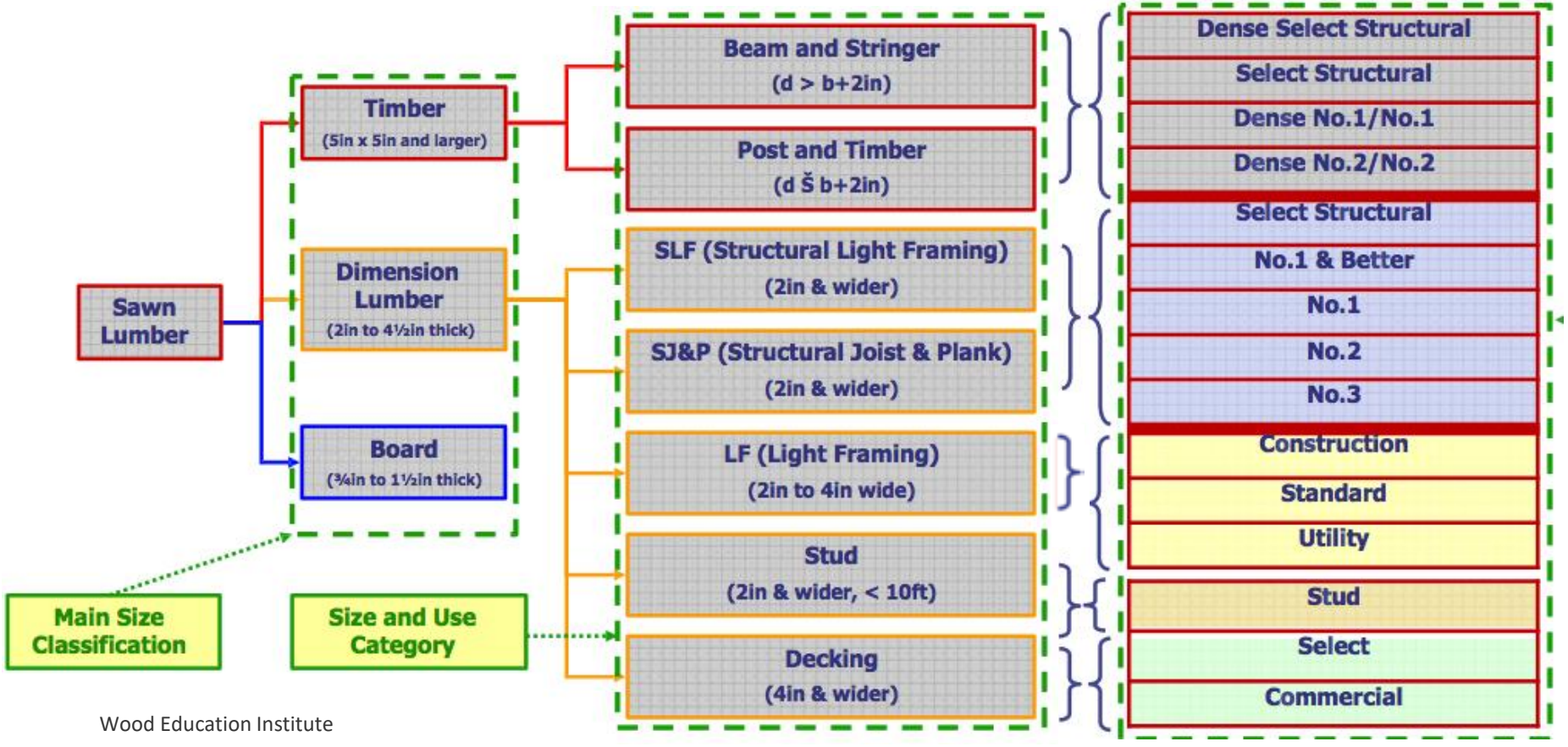
# Reference Design Values: Size Classification

Three size classifications: **Dimension**, **Timber**, & **Boards**

- **Dimension:** 2”-4” thick, 2” wide & wider
- **Timber:** 5”x5” & larger
- **Board:** 1” thick & thicker, 2” wide & wider



# Reference Design Values: Examples

Grading Method

**Table 4A Reference Design Values for Visually Graded Dimension Lumber (2" – 4" thick)[1,2,3]**

| Species and commercial grade | Size classification | Design values in pounds per square inch (psi) | | | | | | | Specific Gravity[4] | Grading Rules Agency |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Bending | Tension parallel to grain | Shear parallel to grain | Compression perpendicular to grain | Compression parallel to grain | Modulus of Elasticity | | | |
| | | $F_b$ | $F_t$ | $F_v$ | $F_{c\perp}$ | $F_c$ | E | $E_{min}$ | G | |
| **DOUGLAS FIR-LARCH** | | | | | | | | | | |
| Select Structural | 2" & wider | 1,500 | 1,000 | 180 | 625 | 1,700 | 1,900,000 | 690,000 | 0.50 | WCLIB WWPA |
| No. 1 & Btr | | 1,200 | 800 | 180 | 625 | 1,550 | 1,800,000 | 660,000 | | |
| No. 1 | | 1,000 | 675 | 180 | 625 | 1,500 | 1,700,000 | 620,000 | | |
| No. 2 | | 900 | 575 | 180 | 625 | 1,350 | 1,600,000 | 580,000 | | |
| No. 3 | | 525 | 325 | 180 | 625 | 775 | 1,400,000 | 510,000 | | |
| Stud | 2" & wider | 700 | 450 | 180 | 625 | 850 | 1,400,000 | 510,000 | | |
| Construction | 2" - 4" wide | 1,000 | 650 | 180 | 625 | 1,650 | 1,500,000 | 550,000 | | |
| Standard | | 575 | 375 | 180 | 625 | 1,400 | 1,400,000 | 510,000 | | |
| Utility | | 275 | 175 | 180 | 625 | 900 | 1,300,000 | 470,000 | | |

Commercial Grade

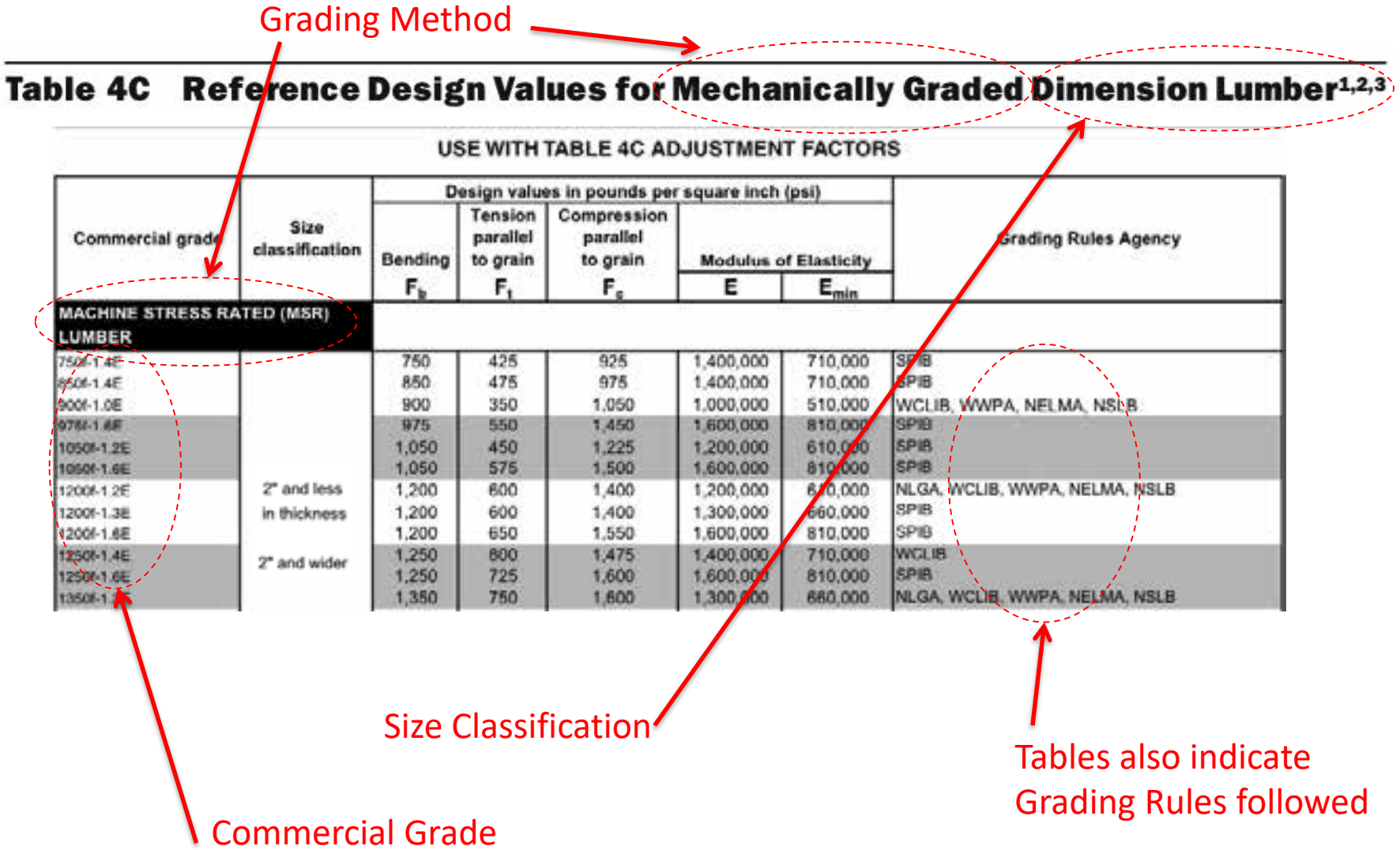
Species

Size Classification

Note: NDS splits Dimension & Timber into separate Reference Design Tables, no structural properties given to Boards

Tables also indicate Grading Rules followed

# Reference Design Values: Examples



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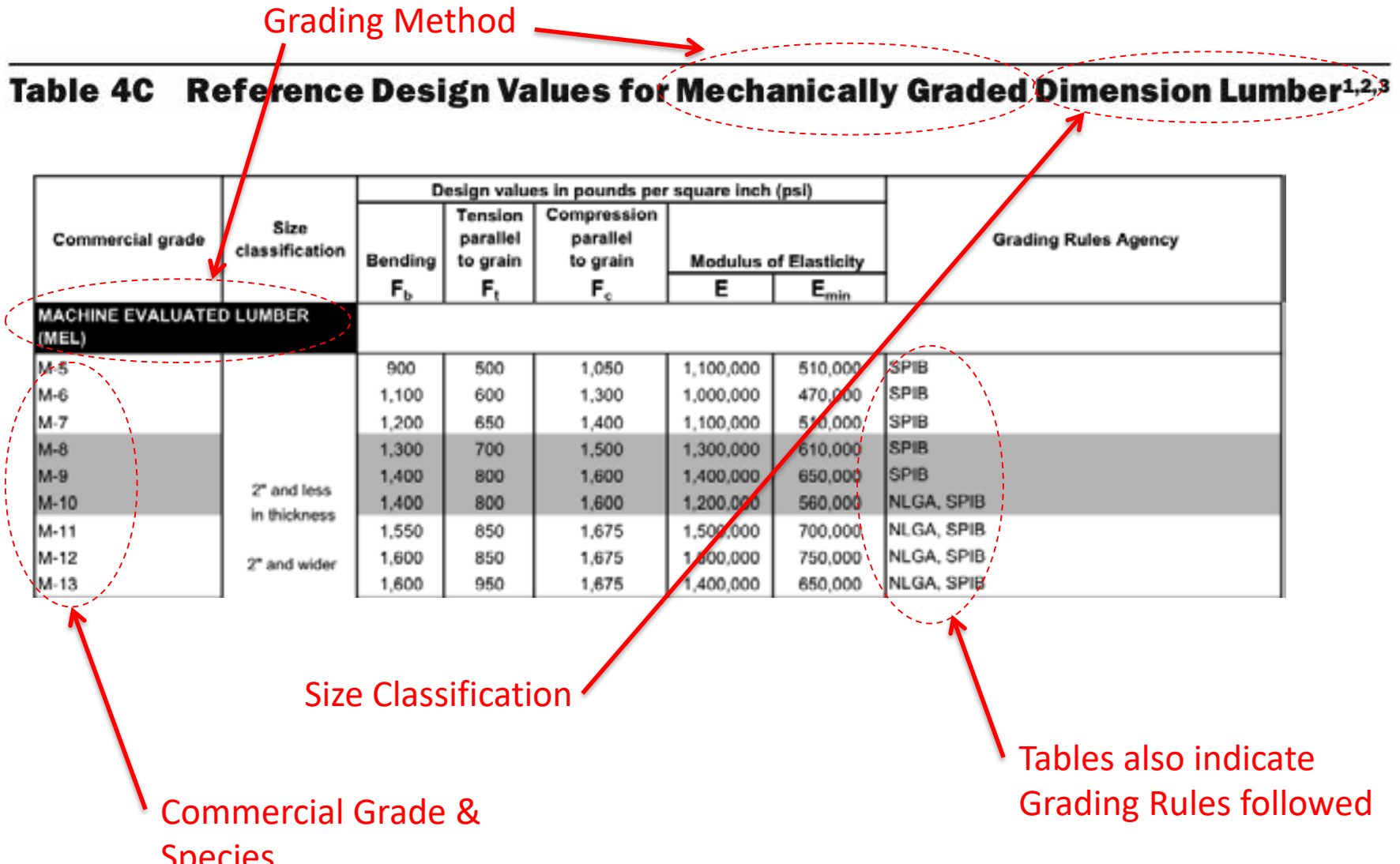
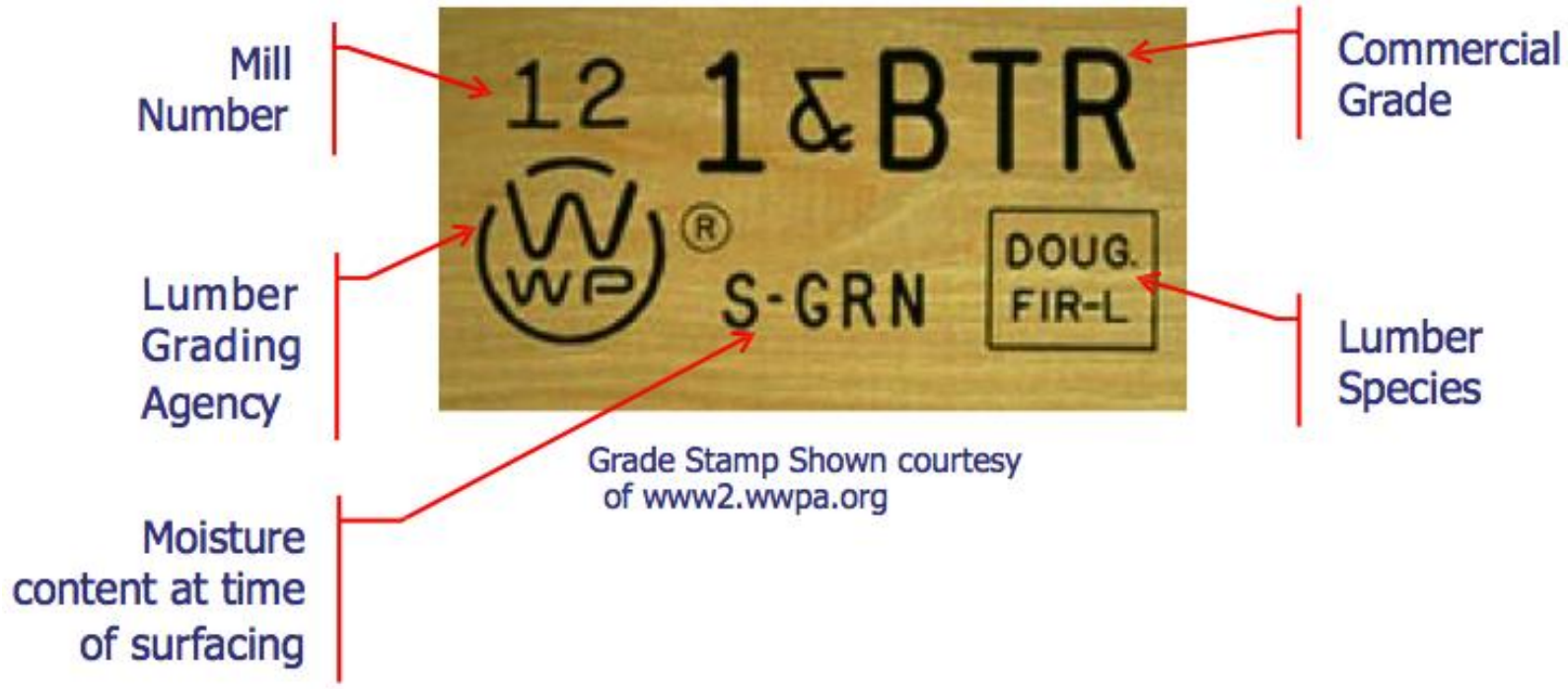


# Identification Stamps

Stamp applied directly to a member that includes pertinent information (e.g. Lumber grading agency, species, grade, etc.)

Required per IBC 2303.1.1




Example VGL Stamp

# Identification Stamps

Examples of Identification Stamps for Mechanically Graded Lumber


Example MSR Stamp

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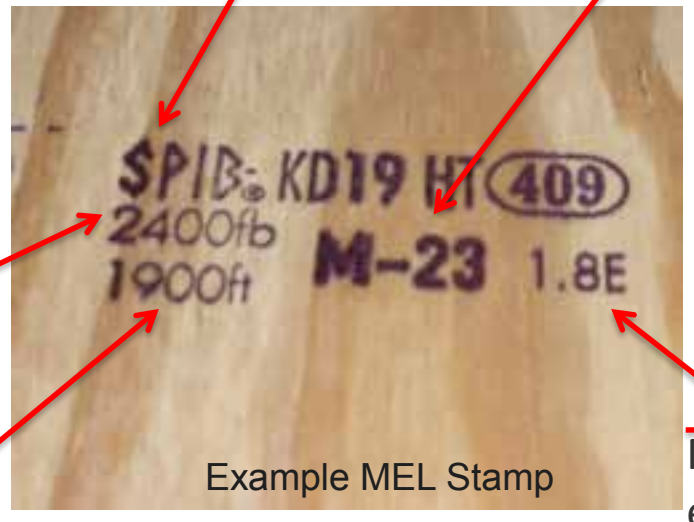


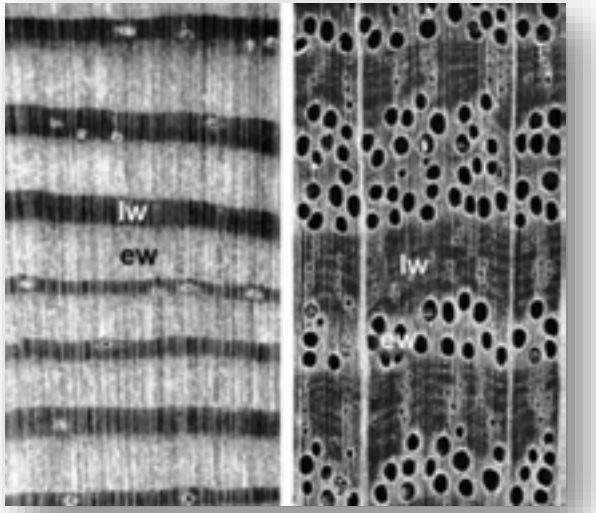

Example MEL Stamp

# Specific Gravity

Specific Gravity (SG), or density, is the weight or mass of wood divided by the volume of the specimen at a given moisture content

- Density generally expressed in lbs/ft$^3$; SG generally expressed as a decimal (0.50) which is a comparison to the SG of water (SG = 1.0)
- Function of cell wall thickness, growth rate
- Generally, higher SG translates to higher structural properties
- Given in NDS Chapter 11

Density comparison: earlywood (ew) to latewood (lw)




Source: Wood Handbook, USDA Forest Service

**Table 11.3.3A Assigned Specific Gravities**

| Species Combination | Specific[1] Gravity, G |
|---|---|
| Alaska Cedar | 0.47 |
| Alaska Hemlock | 0.46 |
| Alaska Spruce | 0.41 |
| Alaska Yellow Cedar | 0.46 |
| Aspen | 0.39 |
| Balsam Fir | 0.36 |
| Beech-Birch-Hickory | 0.71 |
| Coast Sitka Spruce | 0.39 |
| Cottonwood | 0.41 |
| Douglas Fir-Larch | 0.50 |
| Douglas Fir-Larch (North) | 0.49 |
| Douglas Fir-South | 0.46 |
| Eastern Hemlock | 0.41 |
| Eastern Hemlock-Balsam Fir | 0.36 |
| Eastern Hemlock-Tamarack | 0.41 |
| Eastern Hemlock-Tamarack (North) | 0.47 |
| Eastern Softwoods | 0.36 |
| Eastern Spruce | 0.41 |

| Species Combinations of MSR and MEL Lumber | Specific[1] Gravity, G |
|---|---|
| Douglas Fir-Larch | |
| E=1,900,000 psi and lower grades of MSR | 0.50 |
| E=2,000,000 psi grades of MSR | 0.51 |
| E=2,100,000 psi grades of MSR | 0.52 |
| E=2,200,000 psi grades of MSR | 0.53 |
| E=2,300,000 psi grades of MSR | 0.54 |
| E=2,400,000 psi grades of MSR | 0.55 |
| Douglas Fir-Larch (North) | |
| E=1,900,000 psi and lower grades of MSR and MEL | 0.49 |
| E=2,000,000 psi to 2,200,000 psi grades of MSR and MEL | 0.53 |
| E=2,300,000 psi and higher grades of MSR and MEL | 0.57 |
| Douglas Fir-Larch (South) | |
| E=1,000,000 psi and higher grades of MSR | 0.46 |
| Engelmann Spruce-Lodgepole Pine | |
| E=1,400,000 psi and lower grades of MSR | 0.38 |
| E=1,500,000 psi and higher grades of MSR | 0.46 |
| Hem-Fir | |
| E=1,500,000 psi and lower grades of MSR | 0.43 |

# Naturally Durable Species

Some wood species, due to their composition and cell structure, are naturally resistant to insect damage and moisture or decay

- IBC 2304.12 provides requirements

Douglas-Fir

Western Red Cedar

Jwlumber.com

# Naturally Decay Resistant Species

| Natural Durability of North American Softwoods | | |
|---|---|---|
| **Species** | **Predominant in the Tree** | **Heartwood Durability** |
| Western Red Cedar | Heartwood | Durable |
| Eastern White Cedar | Heartwood | Durable |
| Yellow Cedar | Heartwood | Durable |
| Redwood | Heartwood | Durable |
| Douglas Fir | Heartwood | Moderately Durable |
| Southern Pine | Sapwood | Moderately Durable |
| Western Larch | Heartwood | Moderately Durable |
| Tamarack (E. Larch) | Heartwood | Moderately Durable |
| Western Hemlock | Heartwood | Slightly Durable |
| Eastern Hemlock | Heartwood | Slightly Durable |
| White Spruce | Heartwood | Slightly Durable |

Source: Canadian Wood Council

# Species: Treating Wood

Some wood species are easier to treat than others. The cell structure determines how permeable the wood is to chemicals

Pressure-treated Douglas-fir

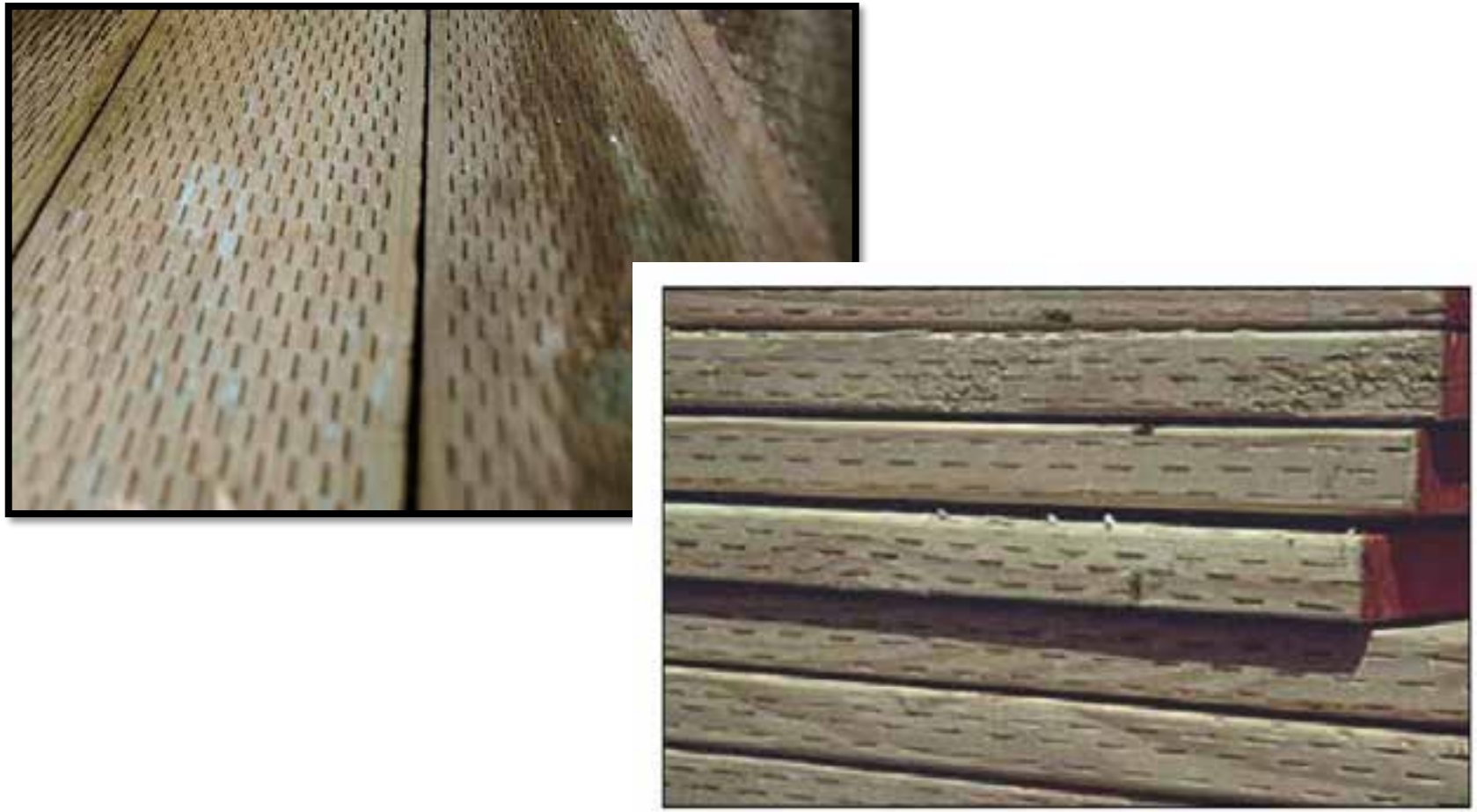
Pressure-treated Southern Pine

Photo from University of Tennessee Forest Products Extension

Fire retardant-treated wood

# Species: Treating Wood

Incising is a method to increase chemical penetration



*Incising is an aid in securing deeper and more uniform penetration of preservatives in western softwood species such as Douglas-fir, Hem-Fir and Spruce-Pine-Fir.*

Image: Western Wood Preservers Institute

# Species: Treating Wood

| Treatability of North American Softwoods | | | |
|---|---|---|---|
| Tree | Permeability | Permeability | Predominant in the Tree |
| | Sapwood | Heartwood | |
| Douglas Fir | 2 | 4 | Heartwood |
| Western Hemlock | 2 | 3 | Heartwood |
| Eastern Hemlock | 2 | 4 | Heartwood |
| White Spruce | 2 | 3-4 | Heartwood |
| Southern Pine | 1 | 3 | Sapwood |

Source: Canadian Wood Council

1 – Permeable
2 – Moderately Impermeable
3 – Impermeable
4 – Extremely Impermeable

Sapwood generally more permeable for accepting treatment

Common species used for FRT:

| | |
|---|---|
| Douglas-fir | Spruce-pine-fir |
| Redwood | Spruce |
| White pine | Ponderosa Pine |
| Hem-fir | Western red cedar |
| Southern pine | White fir |
| Red pine | Western hemlock |

# Architecturally Exposed Species & Grades

Some structural wood framing components are left exposed and integrated with the architectural features of the building. These applications often require a unique criteria for allowable visible wood characteristics. The species and grade selection are key

- Common species include: Douglas-Fir, Hemlock
- Common grades: No. 1 & Better, Select Structural
- Glulam has options for “Architectural Grade”

Jackson Hole Airport
Photo: Matthew Millman Photography/Tim Griffith Photography

Indian Mountain Student Arts & Innovation Center
Photo: Robert Benson Photography

# Softwood vs. Hardwood

- Almost all structural wood used in construction is softwood
- Names do not refer to mechanical properties or density. Some softwoods (e.g. Douglas-Fir) are harder (denser) than hardwoods (e.g. balsa)

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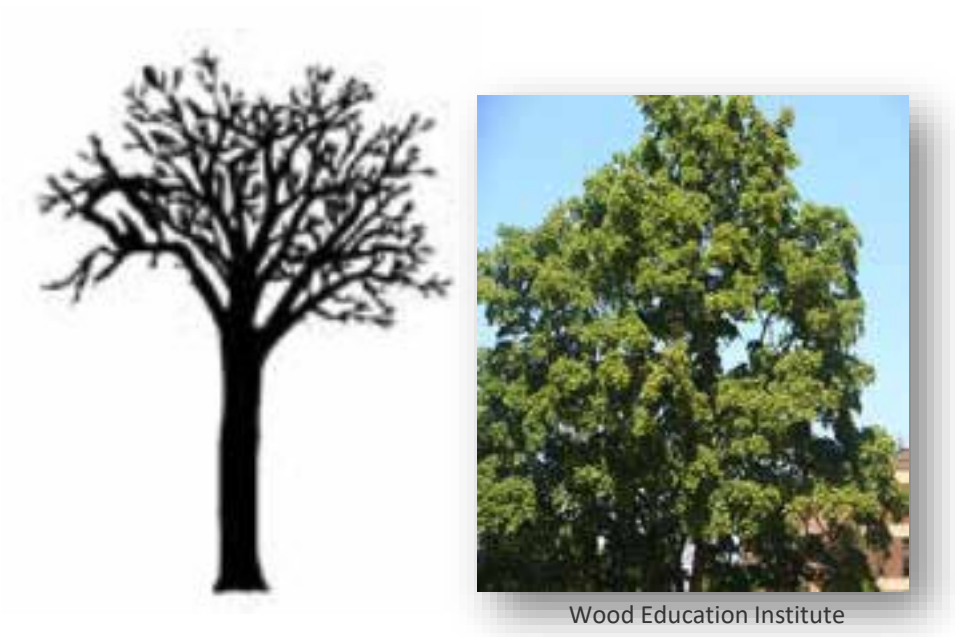
Softwood Trees



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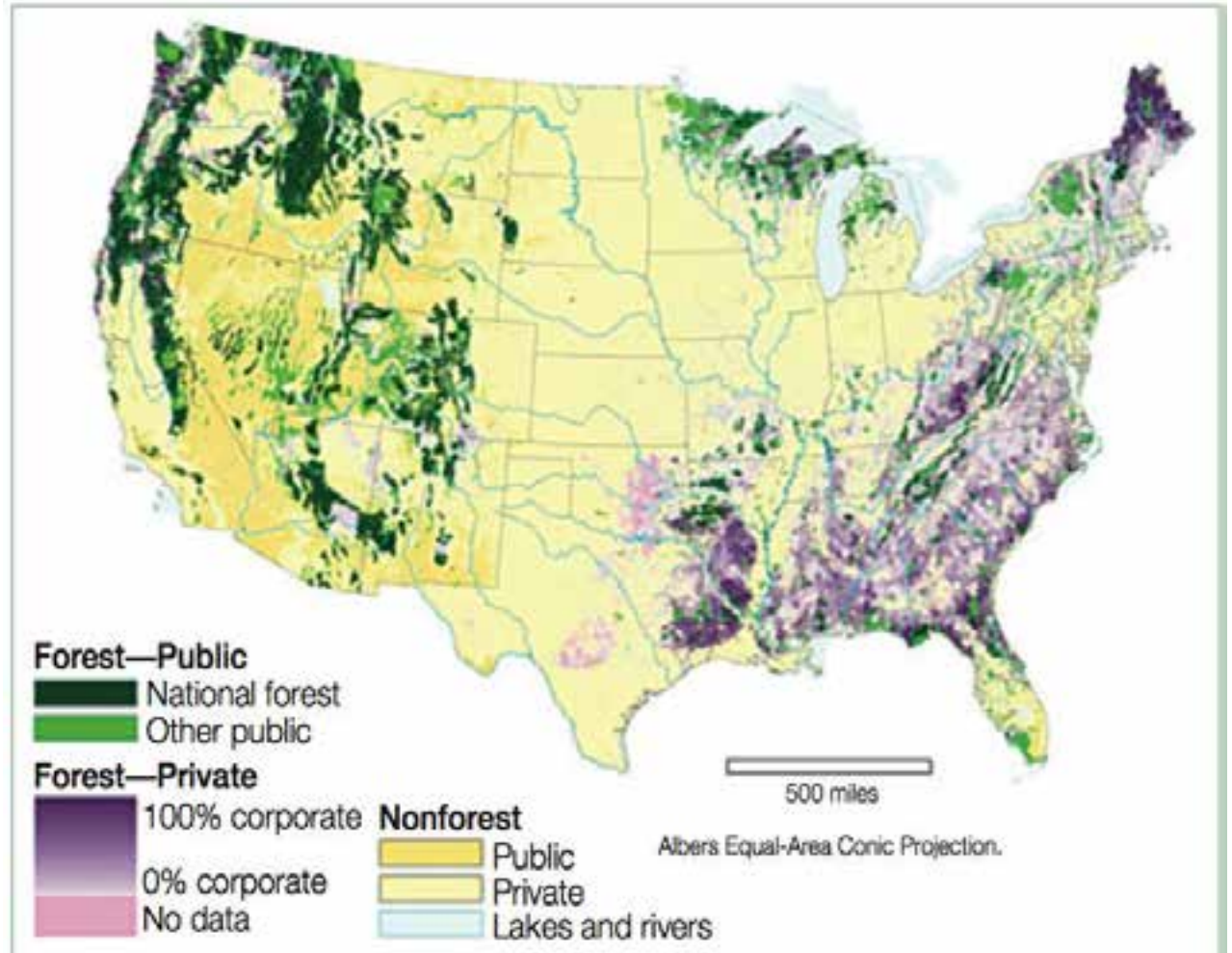
Hardwood Trees

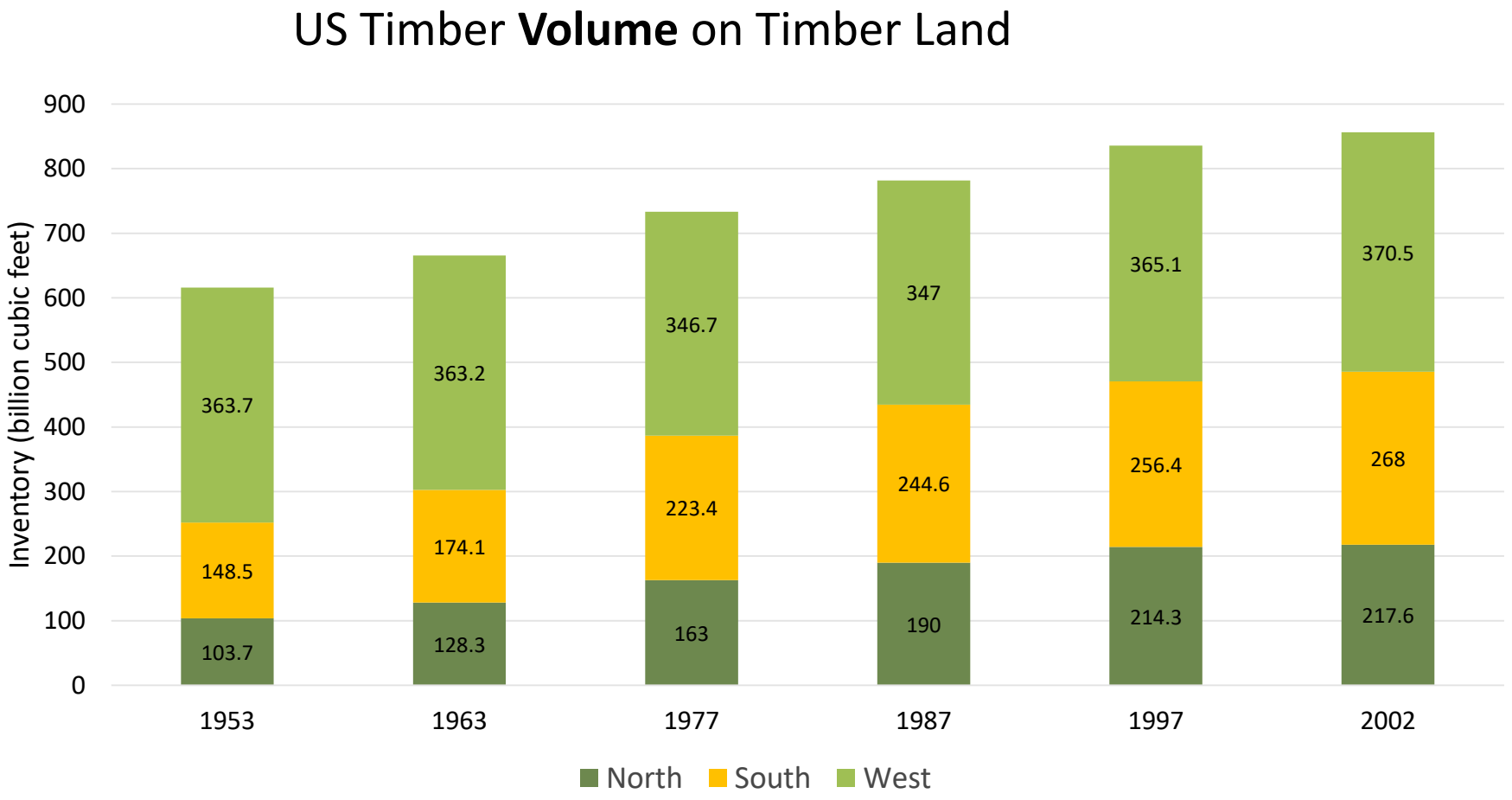
Source: Wood Handbook, USDA Forest Service

# Geographic Impacts: Growing Regions



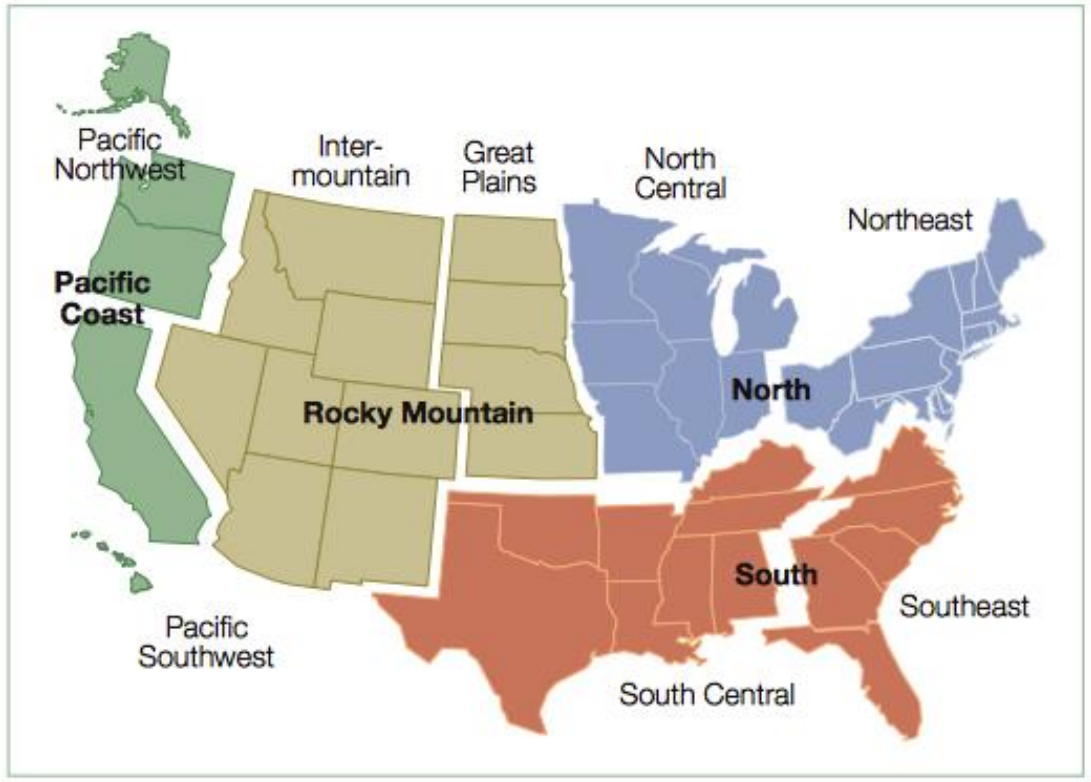

*Source: USDA-Forest Service, Future of America's Forests and Rangelands: Forest Service 2010 Resources Planning Act Assessment*

# Geographic Impacts: Growing Regions




*Source: USDA-Forest Service, US Forest Resource Facts and Historical Trends FS-801. (2004).*

# Geographic Impacts: Growing Regions




*Source: USDA-Forest Service, Future of America's Forests and Rangelands: Forest Service 2010 Resources Planning Act Assessment*

Predominant Softwood Species by Region

South:

- Southern Pine

North:

- Mixed pine
- Spruce-fir

Rocky Mountain:

- Juniper
- Fir-spruce-hemlock Douglas-fir

Pacific Coast:

- Douglas-fir
- Ponderosa Pine

# Geographic Impacts: Use & Availability

Growing Regions have a large impact on the available species of framing lumber in an area

Common framing lumber species by region

- **West**: Douglas-fir, hem-fir, redwood
- **Northeast**: Spruce-pine-fir, hemlock
- **South**: Spruce-pine-fir

Some species are available in areas beyond their growing region for certain characteristics (e.g. douglas-fir for its aesthetics, southern pine for its treatability)

Local availability, transportation costs, structural requirements, and aesthetic properties all play a role

Douglas-Fir Growing Regions


Eastern White Pine Growing Regions


*Source: USGS, Digital Representations of Tree Species Range Maps*

# Questions?

This concludes The American Institute of Architects Continuing Education Systems Course

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