Beyond Biology – Recruitment, Mobility/Stability, and Delivery of Large Wood in Streams

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Presentation Outline

- **Large Wood Recruitment Processes**
- **Large Wood Mobility**
- **Natural Types of Large Wood Accumulations**
- **Large Wood Longevity (Decay Rates)**

Large Wood Recruitment Processes

Channel Dependent Processes
- *Bank erosion*
- *Lateral Migration*
- *Floods*

Channel Independent Processes

Bank Erosion

George Washington and Jefferson NF, Virginia

Au Train River, Michigan

Large Wood Recruitment Processes

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Channel Independent Processes

Lateral Migration

From Abbe et al., National Large Wood Manual 2016

Large Wood Recruitment Processes

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Channel Independent Processes

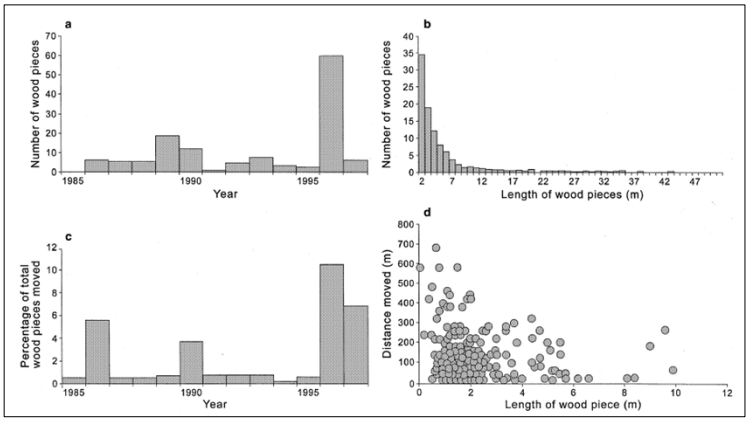
Floods

Large Wood Recruitment Processes

Channel Dependent Processes

Channel Independent Processes

Floods



Large Wood Recruitment Processes

Channel Dependent Processes

Channel Independent Processes
- *Landslides*
- *Debris flows*
- *Windthrow/ Blowdown*
- *Ice Storms*
- *Tornados*
- *Fire*
- *Insect kill*
- *Disease*

Landslides/Debris Flows

Large Wood Recruitment Processes

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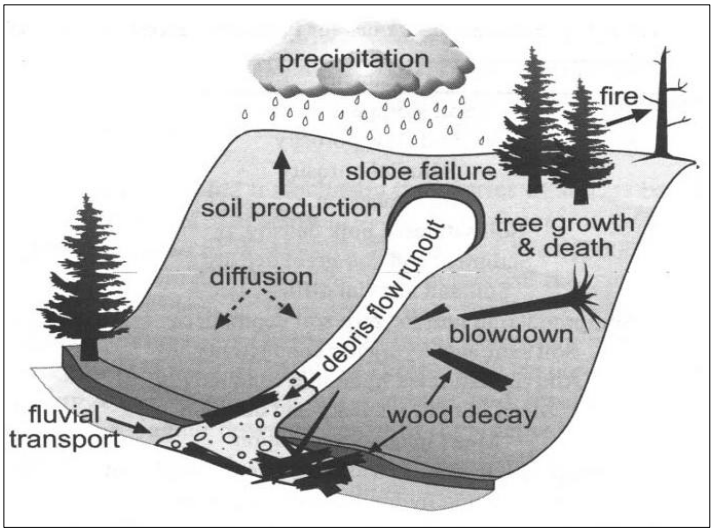
Landslides/Debris Flows



From Lancaster and others, 20000

Large Wood Recruitment Processes

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- *Fire*
- *Insect kill*
- *Disease*

Windthrow, Blowdown, Natural Mortality

Prince of Wales Island, Southeast Alaska

Large Wood Recruitment Processes

Channel Dependent Processes

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- *Ice Storms*
- *Tornados*
- *Fire*
- *Insect kill*
- *Disease*

Fire

Stillwater Creek, Arapaho Roosevelt NF, Colorado
Photos courtesy of Mark Weinhold

Large Wood Recruitment Processes

Channel Dependent Processes

Channel Independent Processes

- *Landslides*
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- *Tornados*
- *Fire*
- *Insect kill*
- *Disease*

Effects of Logging on Large Wood Recruitment

- **Bilby and Ward 1991**
  - **Logging interrupts the input of debris**
  - **Primary and Second-growth forests losses exceed inputs**
- **Andrus et al. 1988**
  - **Natural replacement = decades or centuries depending on the tree species**
- **Murphy and Koski 1989**
  - **In-stream LWD depletion rates at 1-3% per year**
  - **After clearcutting, steady decline of pre-logging LWD over 250 yr**
  - **Post-logging recovery >150 years**
- **Spetich et al. (1999)**
  - **LWD density proportional to land productivity/stand age**
  - **Only stands >80 yr showed LWD input**
- **Natural treefall (vs. logging) accounted for 80% of step formation in mountain channels (Marston 1982)**

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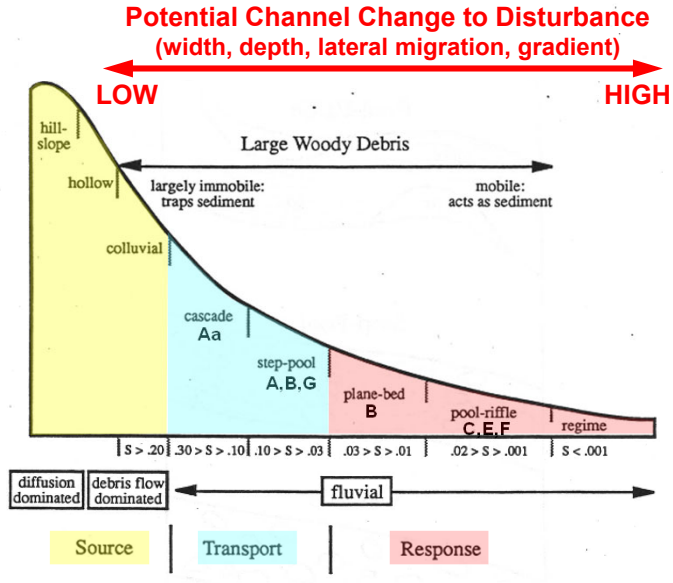
Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors



From Montgomery & Buffington, 1993

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors

Small Channels
median wood piece length greater than channel width (STABLE/NOT MOBILE)

Medium Channels
upper quartile wood piece length greater than channel width (MODERATELY STABLE/LIMITED MOBILITY)

Large Channels
wood piece length less than channel width (NOT STABLE/MOBILE)

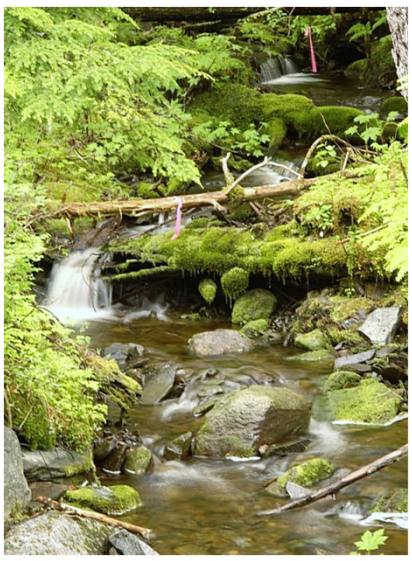
Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors

Small Channels
median wood piece length greater than channel width (STABLE/NOT MOBILE)



Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors

Medium Channels

upper quartile wood piece length greater than channel width
(MODERATELY STABLE/LIMITED MOBILITY)

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors

Large Channels

wood piece length less than channel width
(NOT STABLE/MOBILE)

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors

- *Snags*
- *Wood density*
- *Embedment*
- *Rootwads*
- *Waterlogging*
- *Wood length ratio to channel width*
- *Wood orientation*
- *Wood diameter ratio to flow depth*

Prichard Creek, ID
Photo courtesy of Marty Melchior

Large Wood Mobility

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Ratio of Channel Width to Wood Length

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- **Mass matters**
- **Sediment deposition and embedment = ballast**
- **Roots = ballast**
- **Waterlogging = reduction in buoyancy**

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors
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- *Wood orientation*
- *Wood diameter ratio to flow depth*

- **The larger the ratio of wood length to channel width will typically reduce wood mobility**

Large Wood Mobility

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Ratio of Channel Width to Wood Length

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- *Rootwads*
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Prichard Creek, ID; Photo Courtesy of Marty Melchior

- **Rootwads and branches provide resistance to drag forces**

Large Wood Mobility

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Ratio of Channel Width to Wood Length

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Little Manistee River, MI*; Photo Courtesy of Marty Melchior*

Large Rivers
- **Wood parallel to flow**
- **Root wads face upstream (not always)**
- **Drag force dependent on surface area (tree diameter)**
- **Bed resistance – scour versus wood movement**

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

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- *Snags*
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- *Wood diameter ratio to flow depth*

Whittlesey Creek, WI: *Photo Courtesy of Interfluve*

- **Resistant bed material = bank scour**
- **Mobile bed material combined with resistant banks will cause scour beneath the wood structure**

Large Wood Mobility

Channel Type

Ratio of Channel Width to Wood Length

Other Factors
- *Snags*
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- *Embedment*
- *Rootwads*
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- *Wood length ratio to channel width*
- *Wood orientation*
- *Wood diameter ratio to flow depth*

Photo L. Swan (*InterFluve*)

- **Increased mobility of LW in harvested basins indicates instability of both the channel and habitat formed by LW (Ralph et al 1994)**
- **LW distribution varies inversely with stream size (Bilby 1979, Keller and Tally 1979, Leinkamper and Swanson 1987, Keller and Swanson 1979)**
- **Debris counts similar, but LW volume (size of pieces) was greater in unlogged versus logged streams (Ralph et al. 1994)**
- **Size and position are key to LW stability and retention (Bilby 1984, Grette 1985, Bisson et al. 1987, Murphy and Koski 1989)**

Presentation Outline

- Large Wood Recruitment Processes
- Large Wood Mobility
- Natural Types of Large Wood Accumulations
- Large Wood Longevity (Decay Rates)

Natural Types of Large Wood Accumulations

Old Growth Large Wood Reference Conditions

Types of Large Wood Accumulations
- *Step jams*
- *Valley jams*
- *Flow Deflection jams*
- *Bench jams*
- *Bar Apex jams*
- *Meander jams*
- *Floodplain wood*

Harris River, Tongass NF, Alaska

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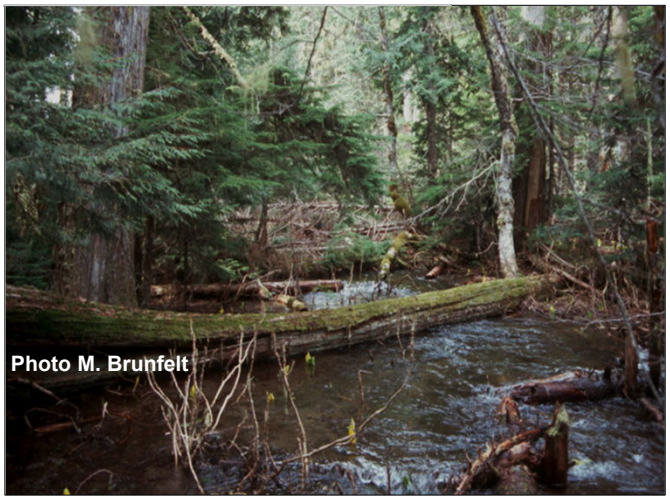
Clearbranch Creek, Oregon



Large Wood Densities
- **Primary growth, <10 pieces per 100ft**
- **2nd Growth forest, 10-30 pieces per 100 ft**
- **Old growth forest, > 30 pieces per 100 ft**

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Old Growth Reference Conditions; Olympic Peninsula, Washington

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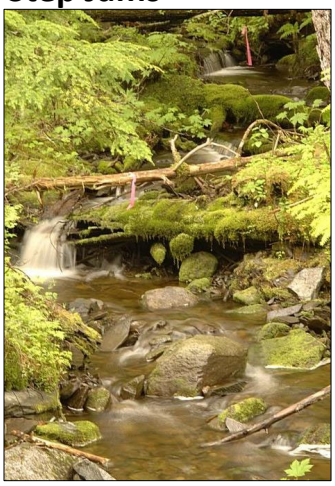
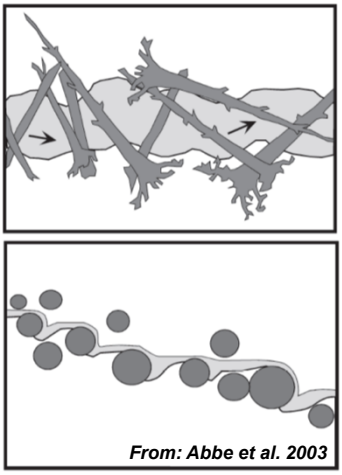
Step Jams





- **Location: Small to medium streams typically in transport reaches**
- **Geomorphic Effect: Vertical stability/control, pool scour, flow energy dissipation**

Natural Types of Large Wood Accumulations

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Step Jams

Spearfish Canyon Creek,South Dokota; Photo Courtesy M.Melchior

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Step Jams

Dundaff Creek, PA; Photo Courtesy of Marty Melchior

- **Thompson (1995) – Wood accounts for only 4% of the drop in profile, but is responsible for 70% of the sediment stored in the channel**

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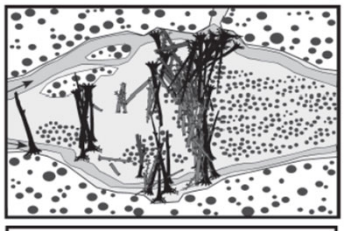
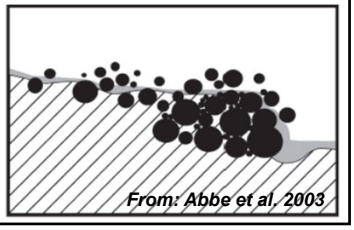
Valley Jams

Location:
- **Small to sarge streams in transport and Response reaches**

Geomorphic Effects:
- **Vertical stability/control**
- **Force lateral migration**
- **Change channel type (step pool and plane bed into pool riffle)**
- **Create complex channel planform across valley bottoms**
- **Flood refugia**





From: Abbe et al. 2003

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Valley Jams

Prichard Creek, ID
Photo Courtesy of M. Melchior

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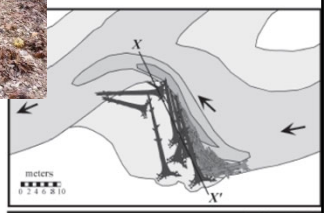
Deflection Jams



Location:
- **Small to large streams.**

Geomorphic effects:
- **Deflects flow eventually and becomes integrated into bank and protects bank.**

From: Abbe et al. 2003

Natural Types of Large Wood Accumulations

Old Growth Large Wood Reference Conditions

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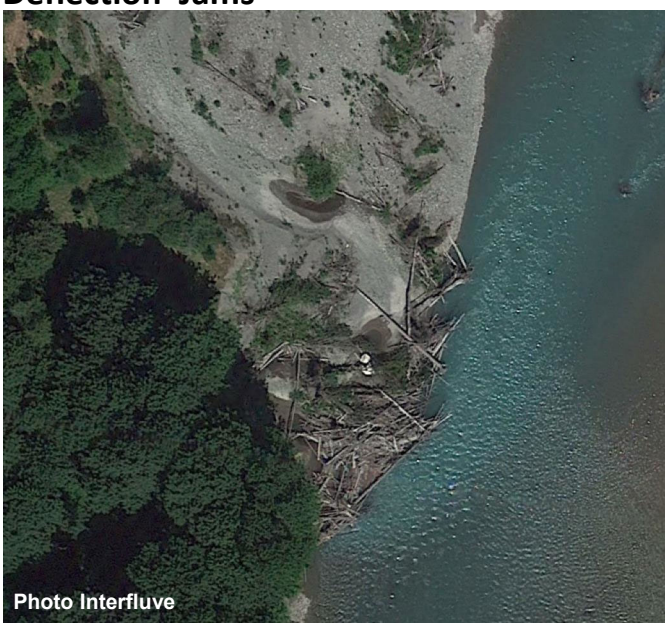

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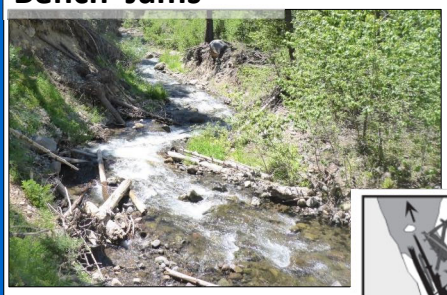
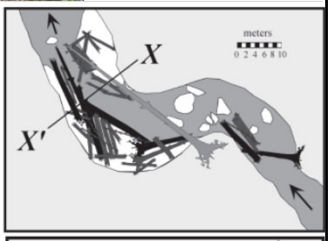
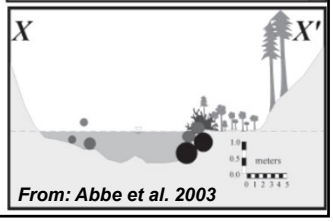
Bench Jams





Location:
- Small streams, steep channels > 2%

Geomorphic Effects:
- Limits lateral migration and local bank erosion
- Protects vegetation and floodplain deposits



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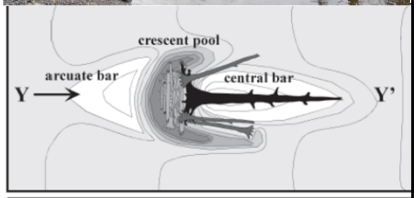
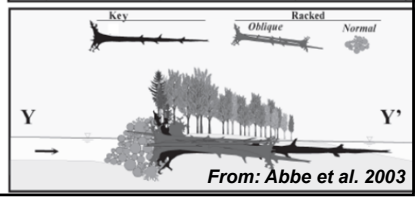
Bar Apex Jams

Location:
- Medium to Large streams

Geomorphic Effects:
- Bi-directional flow diversion
- Create refugia in dynamic channel migration zones
- Principal mechanism to form anastomosing channels





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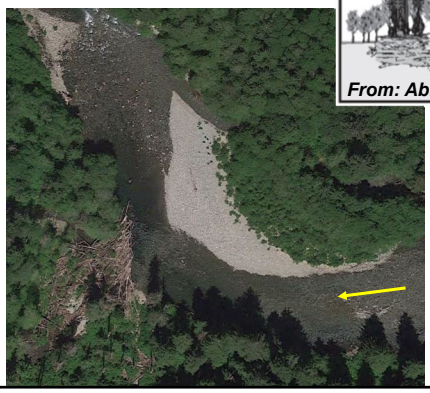
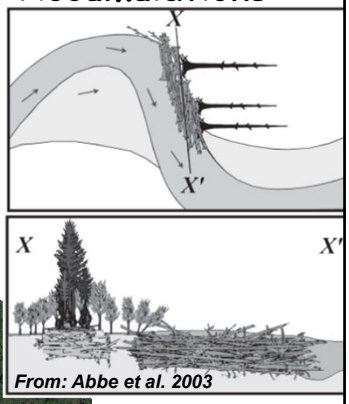
Meander Jams

Location:
- **Moderate to Large streams**

Geomrophic Effects:
- **Limit lateral migration**
- **Protect banks**
- **Cause channel avulsions**
- **Create aquatic habitat**





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Meander Jams

Prichard Creek, ID
Photo M. Melchior

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Floodplain Wood

Floodplain roughness
- **Avulsion protection**
- **Flood storage**
- **Sediment transport**

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Floodplain Wood

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Presentation Outline

- Large Wood Recruitment Processes
- Large Wood Mobility
- Natural Types of Large Wood Accumulations
- Large Wood Longevity (Decay Rates)

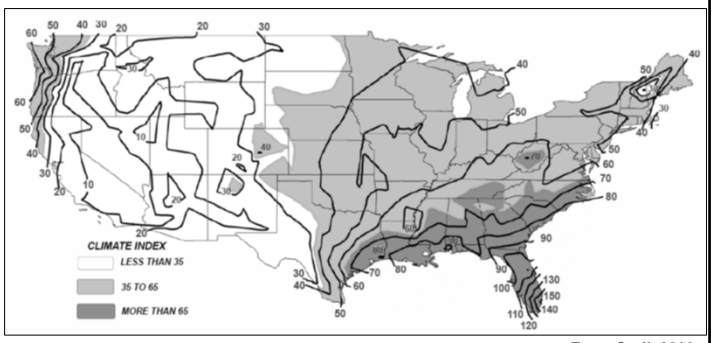
Large Wood Longevity (Decay Rates)

Climate

Wood Type

HydroGeomorphic Factors

Microbiral Activity and Insects



From Caril, 2009

Climate Index for Wood Decay Hazard (Scheffer Index)

- A function of rainfall and temperature
- Higher values indicate greater wood decay hazard
- Warmer temperatures and wetter conditions increase wood decay rates

Large Wood Longevity (Decay Rates)

Climate

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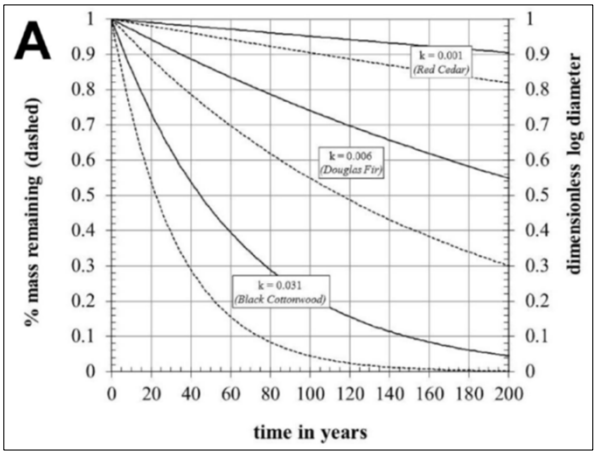

From Abbe et al., National Large Wood Manual 2016

Wood Properties that Influence Decay Rates

- Log diameter
- Density
- Lignin content
- Tannic acid
- Resins

Large Wood Longevity (Decay Rates)

Climate

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Microbiral Activity and Insects

Tree Type	Longevity of 1 ft diameter logs, wet dry conditions
Cedar	>20 yrs
Douglas fir	>20 yrs
Sitka spruce	>20 yrs
Black locust	>20 yrs
Osage orange	15 yrs
Oaks	15 yrs
White pine	15 yrs
Norway spruce	10 yrs
Catalpa	10 yrs
Black cherry/walnut	10 yrs
Alder/birch/ash	7 yrs
Basswood/Ponderosa/red pine	4 yrs
Aspen/Cottonwood	2 yrs
Sycamore	2-3 yrs
Poplar	1 yr

Wood longevity from different regions; mostly for climate index values greater than 40

Large Wood Longevity (Decay Rates)

Climate

Wood Type

HydroGeomorphic Factors

Microbiral Activity and Insects

Hydrology Influences

- Inundation frequency and duration
- Groundwater to surface water ratio
- Elevation of perennial inundation

Geomorphology Influences

- Abrasion during transport
- Impact from particles, trees, ice
- Burial

Large Wood Longevity (Decay Rates)

Climate

Wood Type

HydroGeomorphic Factors

Microbiral Activity and Insects

Ambient Moisture

- **Rainforest conditions can inhibit rot**
- **Dry conditions inhibit rot**
- **Cold inhibits rot**
- **Frequent wet-dry cycles increase decomposition**

Large Wood Longevity (Decay Rates)

Climate

Wood Type

HydroGeomorphic Factors

Microbiral Activity and Insects

White rot on Engelman's spruce

Microbial Degradation

- Saprophytic Fungal growth
- Digest cellulose and lignin
- Many species:
  - White rot (Basidomycota)
  - Brown rot (Basidomycota)
  - Soft rot (Ascomycota)

Insect Damage

- Many species:
  - Fir Engraver, Spruce beetle, Mountain pine beetle, Western pine beetle, Southern pine beetle, Emerald ash borer, etc.

Thank You!
QUESTIONS?