Decadence and Decay in Forest Ecosystems

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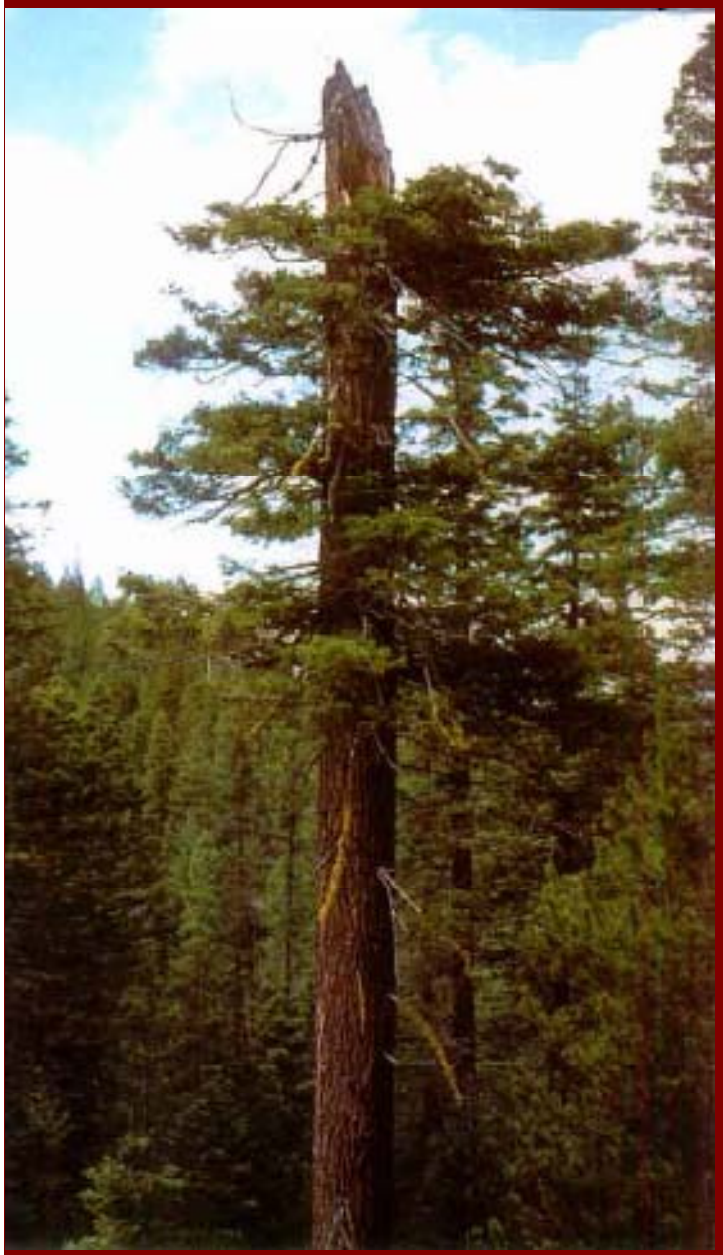
Big dead wood comes only from big live wood

Decay processes result in . . .

. . . and . . .



. . . and ultimately

Topics we'll cover

- Factors affecting coarse wood abundance
- Decay processes
- Roles of coarse woody debris and other decay elements
- How to incorporate decay processes in management

How does CWD enter the system?

- **Starts with a live tree that either**:
- Falls over, in whole or in part, OR
- Dies and stays standing, eventually falling over

How does dead wood leave the system?

- Decay
- Combustion
- Removal

What affects CWD inputs?

- Primary productivity
  - Tied to moisture and temperature
  - Decrease in productivity and CWD input moving from coast to east
  - Decrease in productivity and CWD input moving from low to high elevation

What affects CWD inputs?

- Primary productivity
- Succession
  - Produces pulses and lags in mortality
  - Competitive exclusion = lots of smaller wood that is transitional
  - Old growth = fewer pieces, but larger wood with longer residence time
  - No information on eastside patterns

What affects CWD inputs?

- Primary productivity
- Succession
- Fire
  - Fire regimes vary in effects on CWD input
  - Alters composition of dead wood (size, type, and species) and affects loss through combustion

What affects CWD inputs?

- Primary productivity
- Succession
- Fire
- Insects and pathogens
  - Operate at endemic or epidemic level
  - Create diverse habitat and stimulate nutrient cycling
  - Key to creating decay elements in live trees!

What affects CWD inputs?

- Primary productivity
- Succession
- Fire
- Insects and pathogens
- Other disturbances
  - Flooding, wind, volcanism, landslides
  - Differences in amount and condition of wood contributed to system

What affects CWD outputs?

- Decay
  - Highly sensitive to wood structure and chemistry
  - Limited by temperature, moisture, and oxygen
  - Thus, local climate affects decay rates, as influenced by season, geography, successional stage, aspect, etc.

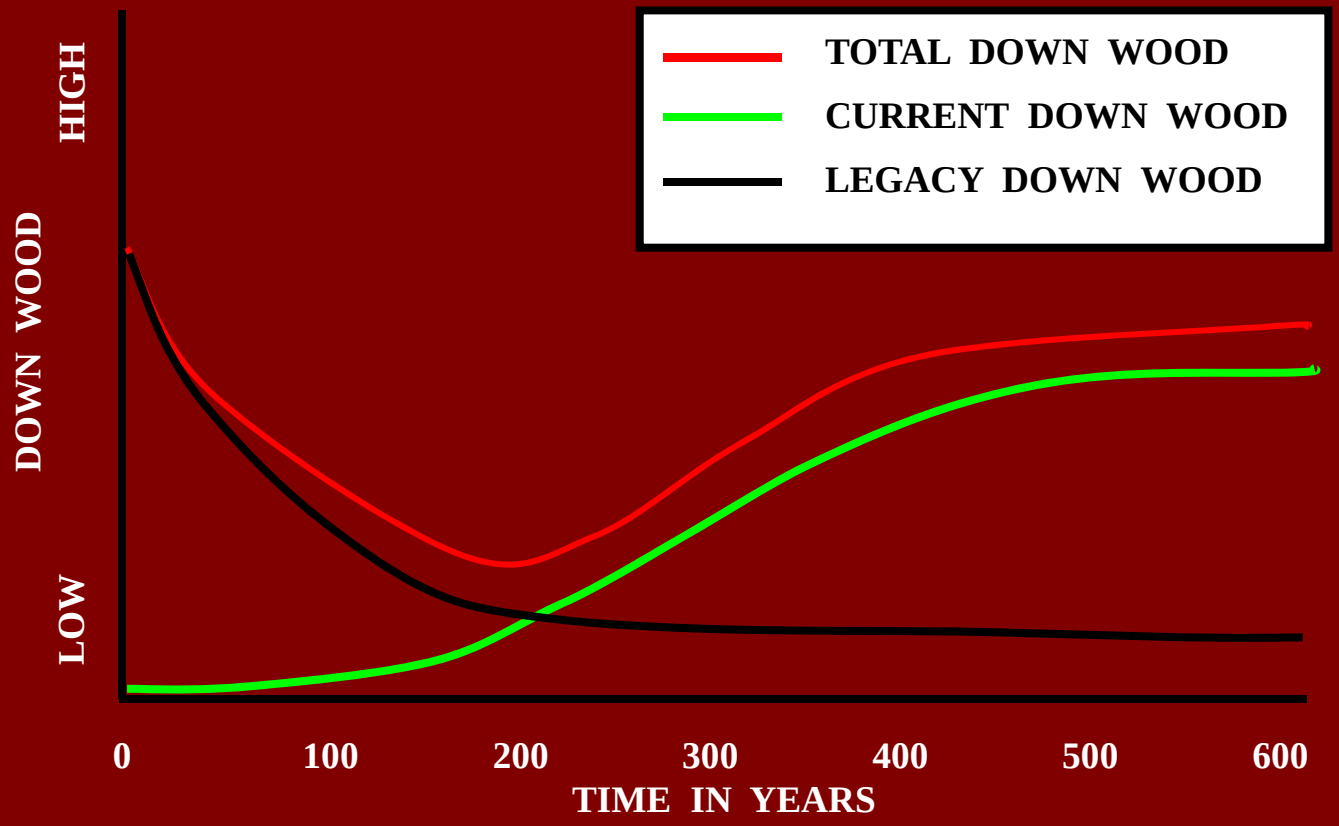
What affects CWD outputs?

- Decay
- Combustion
  - Eliminates as well as produces CWD
  - Post-fire environment will affect decay rates through changes in:
    - Temperature
    - Moisture
    - Nutrient availability

What affects CWD outputs?

- Decay
- Combustion
- Physical removal
  - Nothing left to decay

DOWN WOOD ACCUMULATION



Decay processes

- Log decay on forest floor
- Log decay in streams
- Snag decay
- Other decay features

Changes in down wood as it decays

- As wood decays, it undergoes changes in:
  - Structural attributes
  - Decomposition rates
  - Water holding capacity
  - Density and internal surface area
  - Chemical composition
  - Nutrient composition
- As these components change, organism niches within the wood change

Down wood decay classes

- Class I
  - Freshly fallen live tree
  - Looks much as it did as a standing tree
  - Least time spent in this class

Down wood decay classes

- Class II
  - Beginning to soften
  - All but largest branches are gone
  - Where elevated, some sagging may occur

Down wood decay classes

- Class III
  - Bark all or mostly gone
  - Breaking into large, hard pieces
  - Original color starting to fade
  - Tree roots invading sapwood

Down wood decay classes

- Class IV
  - All of tree in contact with ground
  - Sapwood lost and heartwood in cubes
  - Texture is small, soft pieces
  - Shape may be oval
  - Tree roots invading heartwood
  - 50% volume lost

Down wood decay classes

- Class V
  - Completely oval shape
  - Texture is soft and powdery
  - Wood held together solely by plant roots
  - Often just a mound of soil
  - Only 10% of original tree volume remains

Decay stage varies

- Within same tree
  - Mainly due to taper
  - As tree approaches Class V, variability declines

Tissue substrate as niches

- Four major tree tissues
- Outer bark (5-20%)
- Inner bark (phloem) (<5%)
- Sapwood (living part of xylem) (5-20%)
- Heartwood (dead part of xylem) (60-80%)

Wood tissue characteristics

	OB	IB	SW	HW
% of bole	5-20%	<5%	5-20%	60-80%
Phys. activity	Inactive	Active	Active	Inactive
Function	Barrier	Growing cells	Store H_2O & minerals	Support; store wastes
Decay rate	Gone by Class IV	First to decay	Gone by Class IV	Last to decay

Decay – who's doing it and how?

- Class I wood available to only a few invaders.
  - Bark beetles, wood boring insects, some fungi, some bacteria
- These invaders bring in their own associated predators and parasites, and transport additional bacteria and fungi
- These organisms are KEY to opening up the log and making it available to other organisms

Decay – who's doing it and how?

- At Class II, sapwood begins to soften and moisture content has increased.
  - Bark provides shelter and is ideal habitat for different suite of invertebrates and microorganisms
- Vascular plants may start to root in sapwood if accessible via bark openings. Mycorrhizal associations soon follow.

Decay – who's doing it and how?

- Major changes at Class III due to bark sloughing and sapwood exposure
- Insect galleries forming in sapwood

Decay – who's doing it and how?

- Class IV may be most diverse stage. A microcosm of organisms
- Fungi abound and animals distribute fungal spores
- Wood boring insects make their way into heartwood
- Optimal stage for plant succession due to high moisture, minerals, and N.

Decay – who's doing it and how?

- In Class V, interstitial spaces in heartwood collapse to a mulch-like mound.
- Excellent rooting material, but no longer good animal habitat.
- Ultimately reverts back to soil

Wood decay in streams

- Oxygen limits decay rates
  - Decay is slower (microbes and fungi decomposers on land highly aerobic)
  - Decay can only happen near the surface of the wood
- Higher levels of fragmentation than on land due to abrasion

Wood decay in streams

- Algae and microbes colonize surface, softening wood.
- Decomposed surface is grazed by invertebrates or abraded by water flow, while other organisms feed on algae and microbes.
- As wood softens, available to shredders that increase wood surface area & provides more O2 penetration
- Generally, waterlogged areas decompose in thin surface layers (about ¼ inch)

Snag decay

- Similar process as for logs except:
  - Break apart faster than logs due to abrasion and lack of support
  - Slower mineralization due to temperature extremes and less moisture

Decay in live trees

- Need an entrance point in bark for fungi to enter
- Live sapwood is generally decay resistant
- Heartwood not decay resistant, but must be exposed to fungal spores

Hollow trees and logs

- Advanced heartwood decay leaves a hollow core
- Heartwood infections only occur in live trees
- Hollow logs can only come from hollow live trees!

Broomed trees

- Caused by dwarf mistletoe, broom rust fungi, or needle cast fungus
- Mistletoe seeds spread by projectile dispersal or carried by animals.
- Broom rusts require an alternate host
- Needle cast fungi infect needles and spread into twigs and buds

Roles of CWD and Decay Elements

- Animal habitat
- Plant habitat
- Nutrient cycling and organic material
- Geomorphic processes

Snags as animal habitat

- Many species are obligate snag users (e.g. black-backed woodpecker)
- Use includes nesting, foraging, roosting, resting, denning
- Snag use by a particular animal depends on size, species, abundance, density, distribution and decay characteristics of the snag


black-backed woodpecker cavity

Down wood as animal habitat

- Many species require down wood (e.g. California red-backed vole)
- Use includes foraging, denning, nesting, travel corridors, hiding and thermal cover

Hollow trees and logs as habitat

- A very specific feature required by some wildlife species (e.g. Vaux's swifts, denning fisher)
- Tree diameter needs to be large enough to accommodate larger animals (e.g. bears, fisher)
- Limited to tree species that can maintain bole integrity when hollow.

Decayed live trees as habitat

- Live trees stand longer than snags
- Decaying heartwood desirable for some cavity excavators, while weaker excavators use decaying sapwood.

•Localized decay in tree wounds provides insect habitat that in turn are prey for vertebrates.

Broomed trees as habitat

- Broom platforms used for nesting, roosting and resting.
- Mistletoe shoots and fruits are forage
- Tree may remain alive for decades

CWD as fish habitat

- Log jams store sediment
- Provides cover
- Creates hydrologic features like pools and backwaters
- Abundance of fish in streams strongly associated with CWD abundance

CWD as aquatic invertebrate habitat

- Abundance directly linked to CWD. Over 50 taxa closely associated with CWD
- Used has shelter, food, attachment sites, oviposition, pupation, refugia from predation or environment
- CWD a transition from water to land when partially or occasionally submerged

CWD as terrestrial invertebrate habitat

- Habitat for many inverts
- Some host specific to species (e.g. bark beetles), others to decay stage (e.g. millipede)
- Many trophic levels within a dead tree

Down wood as plant habitat

- Provides for non-vascular as well as vascular plants. Rooting in logs extracts water and nutrients
- On disturbed sites, large wood shelters plants and provides shade, shelter and moisture
- On steep slopes, protects seedlings from erosive forces
- May be important seedbed in some ecosystems

CWD role in nutrient cycle

- As decay advances, nutrient level in wood increases (N, Ca, Mg, P?)
- K tends to leach out of wood
- Obtains nutrients from:
  - N fixers living in wood
  - Throughfall and litterfall landing on wood
  - Uptake from plants living on wood
  - Interactions with soil when in contact

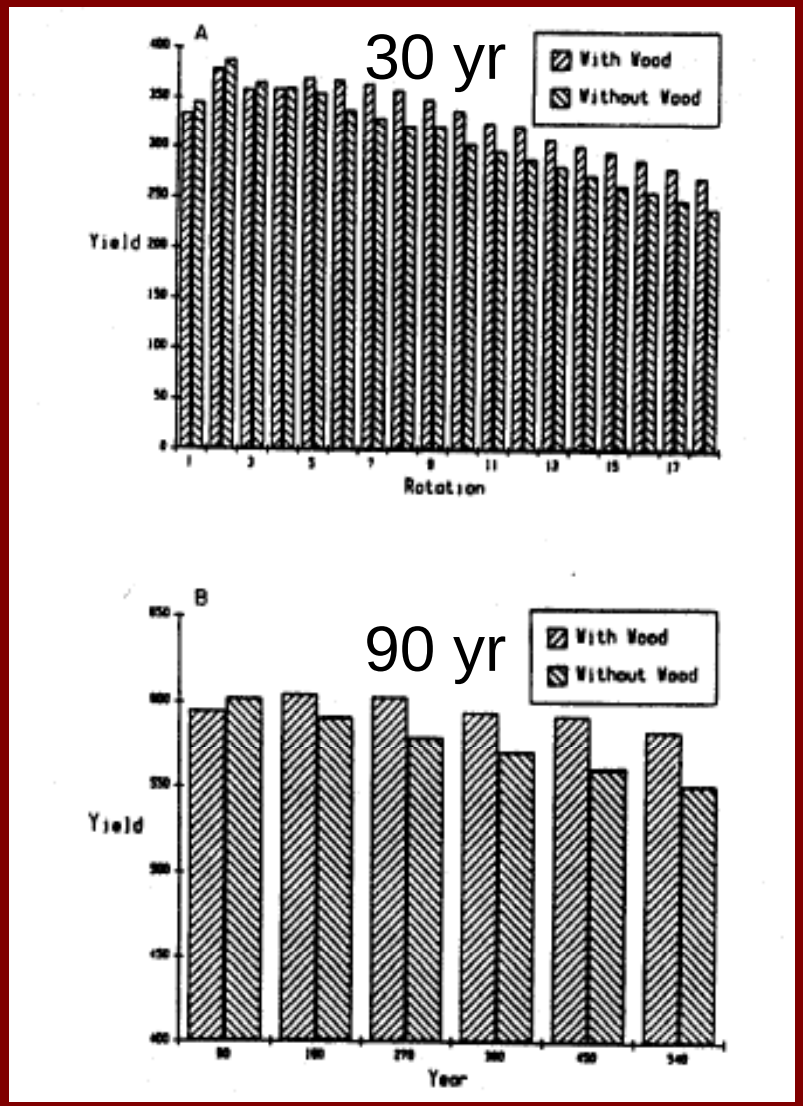
Nutrient concentrations (%) in old-growth Douglas-fir forest

Component	N	P	K	Ca	Mg	Na
Total forest floor	0.50	0.098	0.11	0.87	0.26	0.014
Fallen tree stems.	0.10	0.0031	0.0111	0.076	0.0076	0.0024

Mass (pounds/acre) and nutrient content in old-growth Douglas-fir forest

Component	Organic Matter	N	P	K	Ca	Mg	Na
Total forest floor	45,568	228	44.7	50.1	396.4	118.5	6.4
Fallen tree stems.	191,350	191	6.0	21.3	145.4	14.5	4.7

CWD effects on site productivity



- Modeled Western hemlock stand on OR coast w/residual Sitka spruce CWD.
- Clearcut and compare removing CWD with no removal
- Yield decreases in all scenarios, but more so with CWD removal and with shorter rotation

Harmon et al 1986. Fig. 18

CWD role in organic matter input

- CWD provides substantial proportion of total organic matter returning to forest floor
- 24-29% of total organic matter in several forest ecosystems, and as high as 60-74% in Douglas-fir stands
- CWD a savings account of soil organic matter and nutrients

Geomorphic function of CWD

- Control downslope movement of water, soil and litter.
  - Interrupted surface and subflow of water at Mt. St. Helens
  - Erosion rates in areas of down forest lower than areas clearcut before eruption
- Uprooted trees create microtopographic features and important in soil mixing and heterogeneity

Geomorphic function of CWD

- Channel morphology
- Creates step profile. Ability of influence decreases with increasing stream order
- Can be acute or chronic
- Deflects flow or causes divergence
- Transport by flood and mass movement events dramatically alters channel geometry

Geomorphic function of CWD

- Sediment and organic matter storage
- Temporary storage in stream channels
  - Removal of CWD jam from 3rd order stream in Coast Range released 5,250 m^3 of stored sediment
- Stream reaches with CWD retain leaves ~10 times more efficiently than reaches without accumulations. Holds material long enough to provide food for microbes and invertebrates

Geomorphic function of CWD

- CWD movement in channels influenced by
  - Piece size relative to stream width
  - Degree of burial
  - Degree of lodging
  - Decay stage
  - Position and orientation