THINKING ABOUT DEAD WOOD IN MANAGED LANDSCAPES.

Doug Heiken, Oregon Wild, 2012

Dead wood functions

	Nutrients	**Water**	**Sediment**	**Energy**	**Other**
Capture	Primary production, nutrient binding sites	Anchor snowpack, moderate hydrograph	Arrest debris flow; ravel barrier, stabilize soil	Microsite cooling (from convection, or radiation)	
Store	Buffer, spatial/ temporal diversity	Buffer, spatial/ temporal diversity	Buffer, spatial/ temporal diversity	Buffer, spatial/ temporal diversity	
Release	Respiration, fertilization	Increases humidity	Routes and delivers material to stream	Microsite warming	

Dead Wood and Wildlife

Dead wood is used by a wide variety of terrestrial, riparian, and aquatic species …
Spotted owls, woodpeckers, secondary cavity nesters, fish, reptiles, amphibians, bats, marten, fisher, prey species, plants, fungi, lichen, bryophytes, mollusks, insects, arthropods, etc...

Dead wood is used for a wide variety of life functions …
Nesting, roosting, foraging, burrowing, display, thermal regulation, hiding cover, display/calling/drumming, mobility, favorable microsites, spatial partitioning, substrate supporting growth of plants, fungi, lichen, (nitrogen fixation)

Dead wood abundance and distribution has **cascading effects through the trophic network.**

More dead wood functions:

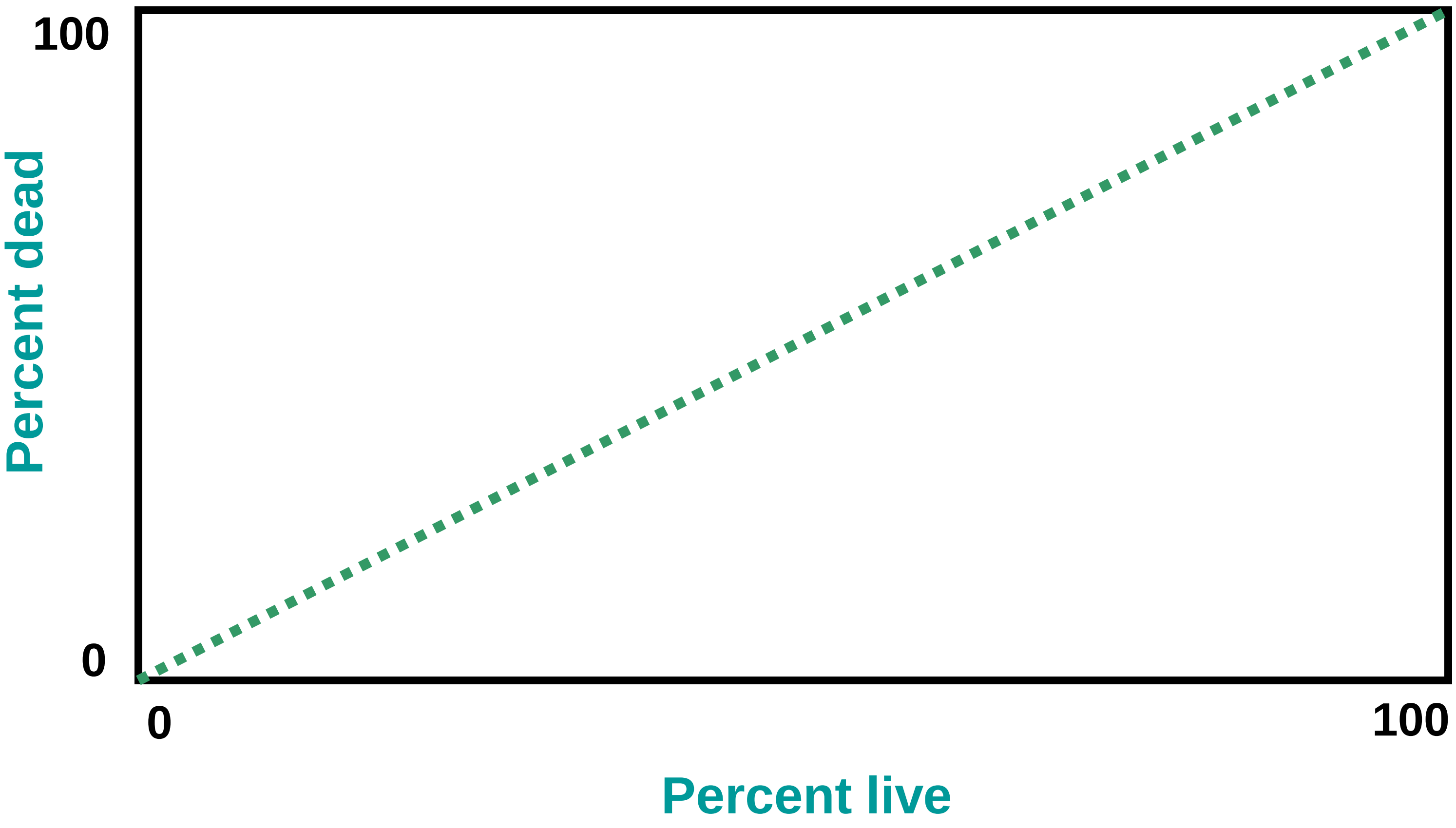
- Carbon storage, global carbon cycle, climate change;
- Mechanical damage, or protection *from* mechanical damage;
- Energy dissipation (heat, wind, and water);

Scale Considerations:

- Tree scale
- Stand scale
- Landscape scale

+ Temporal scales

What’s the optimum mix of live and dead wood at each scale?



Tree Scale

Trees are often considered to be alive or dead, but living trees can have decadence features like broken top, cavity, cat face, hollow, dead branch, loose bark, etc.

The natural life-cycle of a tree:

- Phase 1: germination and growth,
- Phase 2: death, decay, CO2.

People forget about the 2nd phase after the tree dies. Lots of interesting things happen here.

In a natural forest, a tree is born, grows, dies and is recycled *in situ*. Humans dramatically changed this equation by exporting large amounts of woody biomass .

Landscape Scale

A healthy landscape includes areas where dead wood is less abundant or more abundant, based largely on time-since-disturbance —

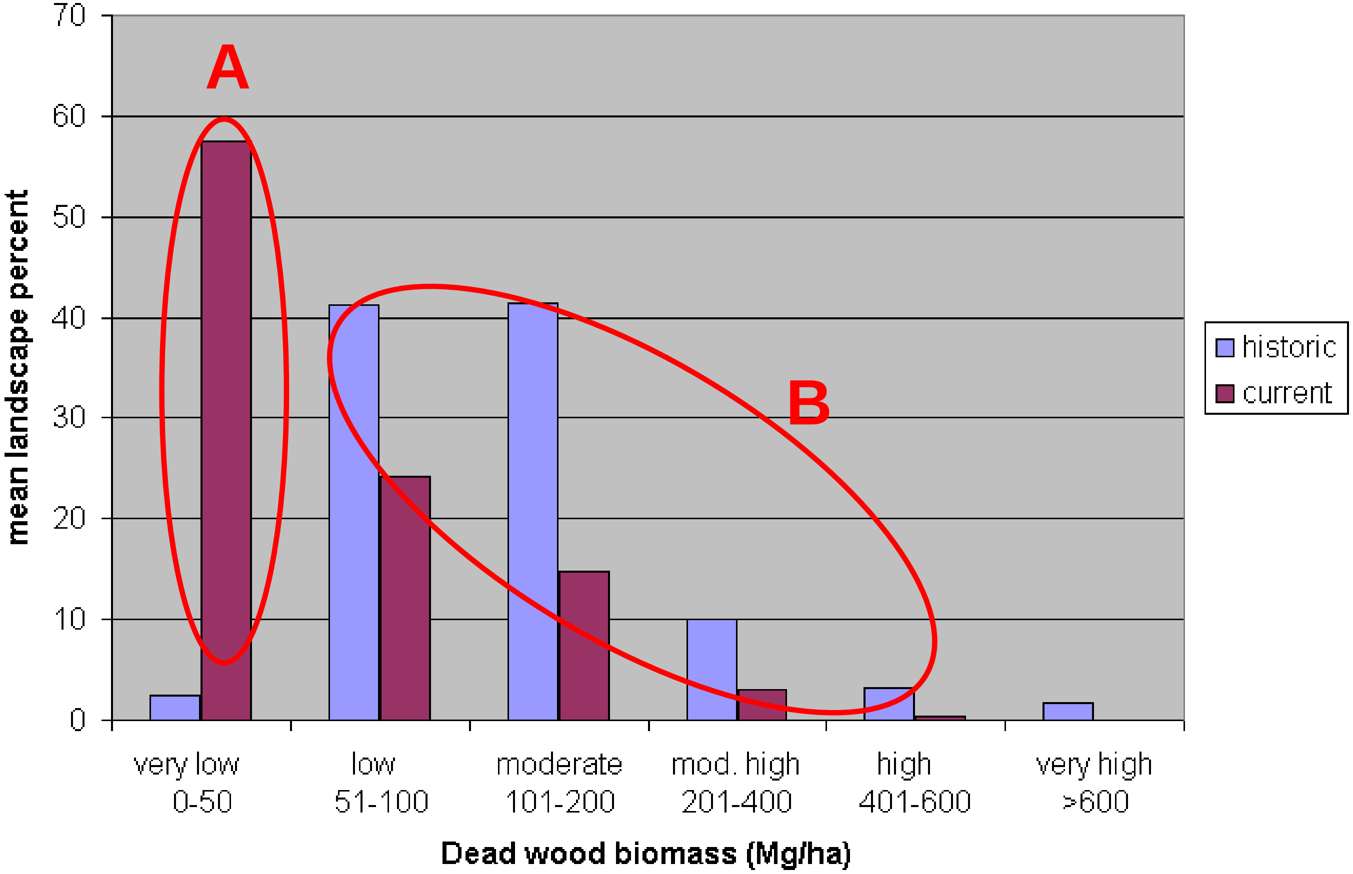
> fire, wind, insects, root rot, flood, ice-snow, landslides, etc.

Variable disturbance across the landscape, leads to variable dead wood across the landscape.

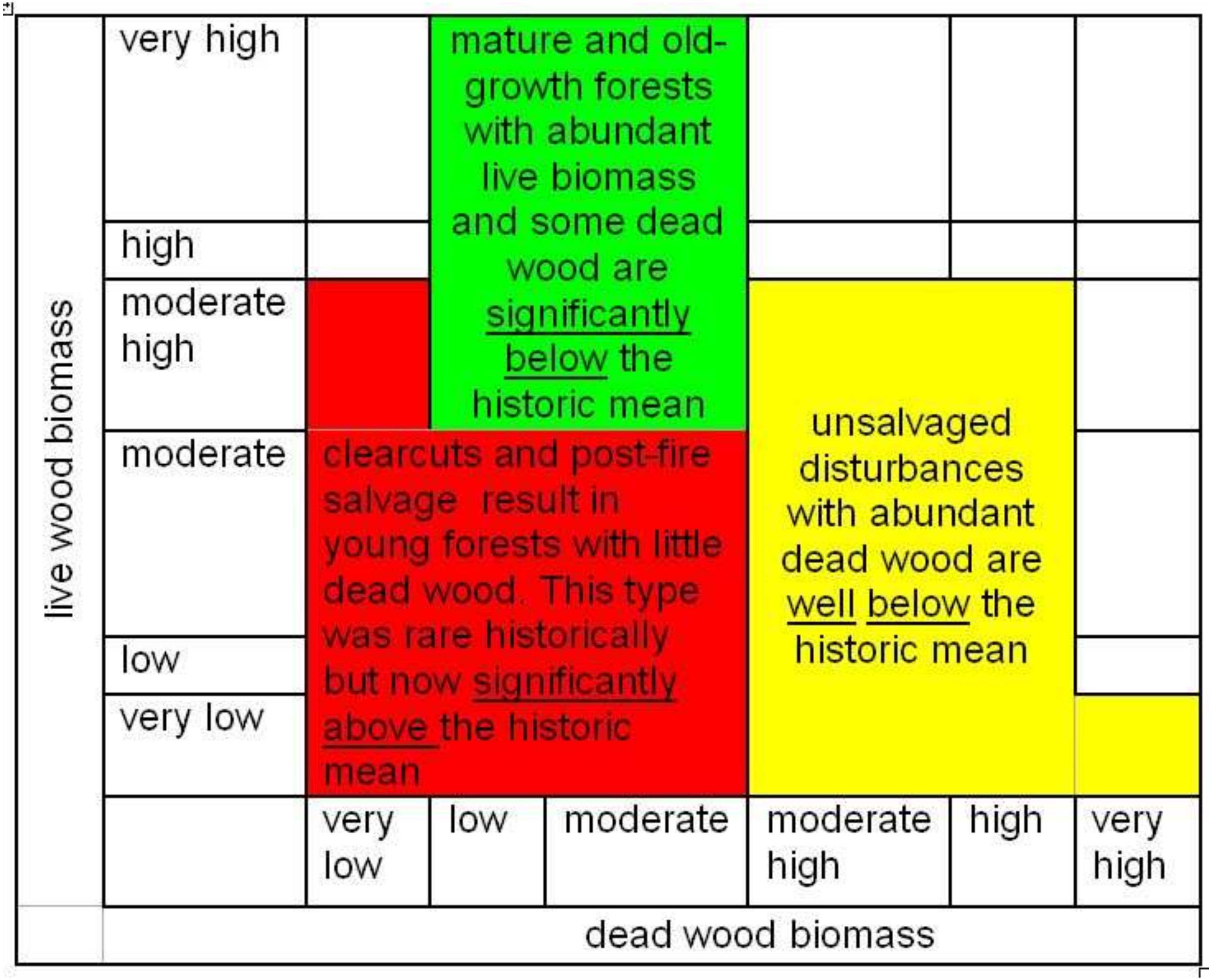
Where wood has been exported via logging, dead wood is almost always lacking.

Historic vs Current Dead Wood Biomass in the Oregon Coast Range

[data from Nonaka (2003) MS Thesis]



A. Areas with little or no dead wood are over-represented.
B. Areas with abundant dead wood are under-represented.
Will logging make this situation better or worse?



live wood biomass

very high

high

moderate high

moderate

low

very low

mature and old-growth forests with abundant live biomass and some dead wood are significantly below the historic mean

clearcuts and post-fire salvage result in young forests with little dead wood. This type was rare historically but now significantly above the historic mean

unsalvaged disturbances with abundant dead wood are well below the historic mean

very low

low

moderate

moderate high

high

very high

dead wood biomass

Abundance of forest types with various combinations of live and dead wood relative to historic mean values derived from multiple 1,000 year simulations. Based on Table 3.4 *in* Nonaka, E, Spies, TA, Wimberly, MC, and Ohmann, JL. Historical range of variability (HRV) in live and deadwood biomass: a simulation study in the Coast Range of Oregon, USA.

Stand Scale

“Forest health” is not the same as tree health.

A healthy forest has capacity for tree growth, as well as agents of mortality.

A healthy stand includes both live and dead trees. A stand lacking dead trees is missing something important.

Stand Structure:
Building and Breaking Carbon Chains

The structure of natural forests is largely determined by the long-term net effects of two competing natural processes:

- **Photosynthesis** which builds carbon chains (cellulose) and creates woody biomass (that fills 3D space);

- **Respiration** and **Combustion** which breakdown carbon chains and deplete biomass (that makes holes in 3D space).

These processes play out via forest **disturbance**, and the often long periods of **growth & development** between disturbances.

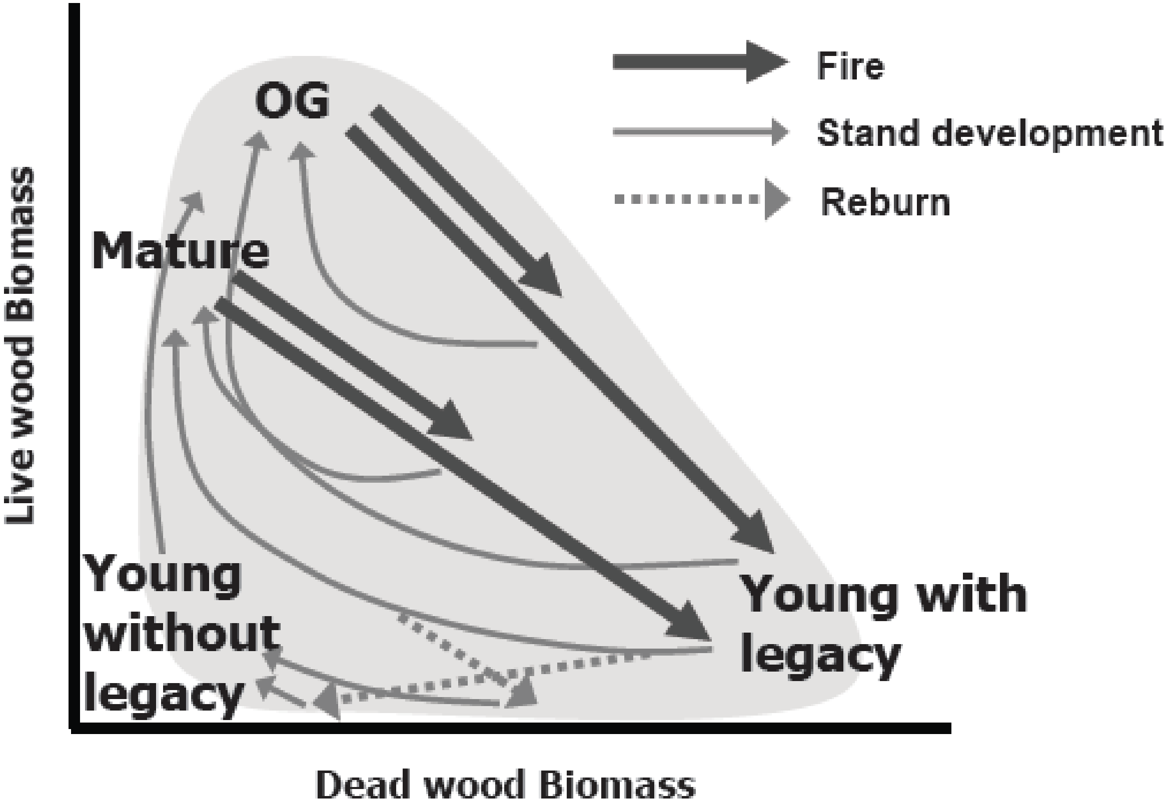


Figure 3.2: Dynamics of live and dead wood biomass in response to different fire severities and frequencies. The thick arrows are fire events, and the short ones are moderate-severity fires, which do not convert all live wood biomass into deadwood. The dotted arrows indicate repeated burns, which returned to the stand when live biomass has not been well developed. The thin arrows indicate stand development over time. “Young with legacy” refers to young stands (< 80 yrs) with high amounts of deadwood, and “young without legacy” refers to young stands with relatively small amounts of deadwood because of reburns. The shaded area conceptually indicates all possible range of pathways under the fire regime and forest growth. Under the historical fire regime, the shaded area can be considered as the HRV of biomass dynamics. Mature = mature forests (80-200 yrs). OG = old-growth forests (> 200 yrs). [from Etsuko Nonaka’s MS Thesis: CHAPTER 3: HISTORICAL RANGE OF VARIABILITY (HRV) IN LIVE AND DEAD WOOD BIOMASS: A SIMULATION STUDY IN THE COAST RANGE OF OREGON, USA]

Management Effects

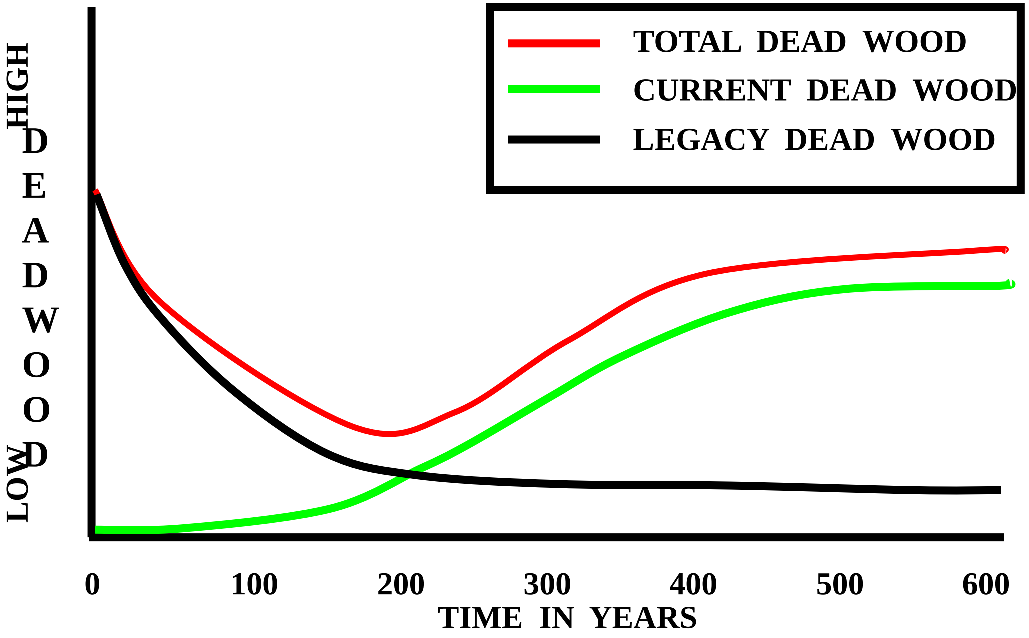
Management affects both growth and mortality processes, and adds a significant novel process which is biomass export via logging.

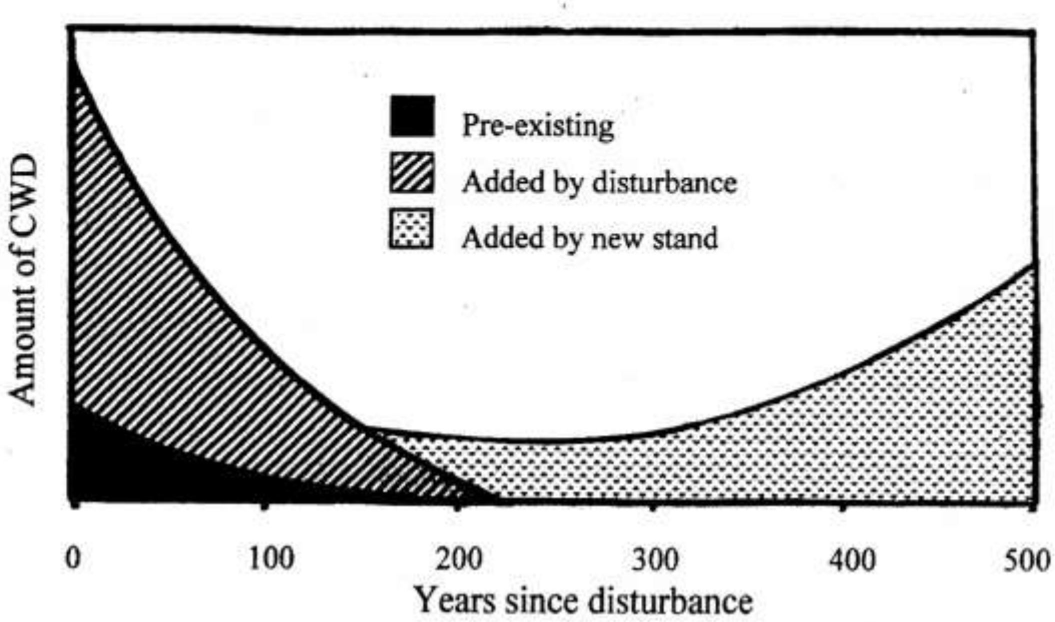
Foresters are typically trained to focus on the tree growth up to a point of controlled mortality, capture, and export. This truncates the natural process, affecting dead wood at all scales.

At each scale, how is the natural mix of live and dead wood changed as a result of past and ongoing management?

How can those effects be mitigated?

Stand Scale: Dead wood curve over time





Stand Scale: Dead Wood "Gap"

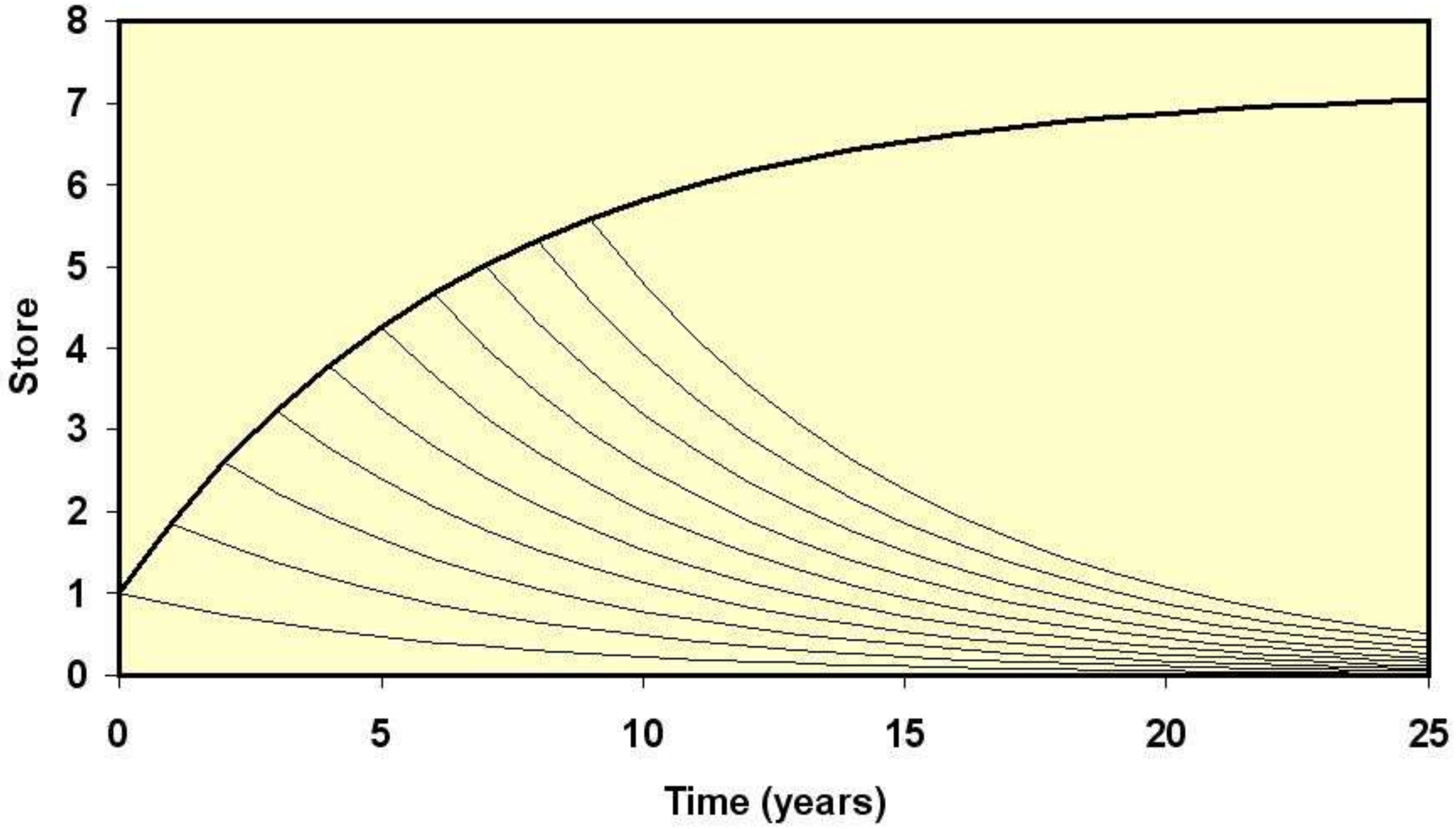
The "U-shaped curve" reveals a natural "gap" in the temporal distribution of dead wood.

What might enlarge that natural gap, making it uncharacteristically wide or deep?

Regen harvest and salvage logging eliminate the recruitment of legacies from one stand to the next, thus enlarging the gap on the front end.

Thinning captures mortality and enlarge the gap on the back end.

Stand Scale: Dead Wood Accumulation Requires Continuous Recruitment



Continuous input of dead trees builds up over time even though the individual trees are decaying. If the rate of decay is constant and the rate of input is reduced the cumulative build-up is also reduced.

Image from Harmon 2008 “five points” powerpoint.

Possible Mitigation

- Conduct non-commercial prescriptions that retain dead wood, e.g., fall-and-leave, snag creation. This mimics natural processes that create episodic pulses of dead wood while reducing competition for resources within the stand.
- Leave areas untreated at many scales to allow unencumbered processes of growth and mortality. Find the right mix of treated and untreated. Identify objectives based on the quantity and quality of dead wood necessary to meet habitat needs and ecological functions.
- Maybe put three practices in the mix: (i) no treatment, (ii) commercial treatment, (iii) non-commercial treatment.

Examples from modeling

- “All models are wrong; some are useful.”
- All guesses about the future rely on models of some sort.
- Though mathematical models are incomplete; mental models are also fallible.
- Some results counter to prevailing views.
- The math is compelling: $X – n < X$.
- It’s difficult to “add” dead wood by “subtracting” trees.

Bottleneck LSR Enhancement Project EA, Salem BLM, Oregon

http://www.blm.gov/or/districts/salem/plans/files/sdo_080-07-16_eafonsi.pdf

98 year old stand thinned to 44-66 trees per acre

Table 9 clearly shows that thinning will adversely affect mortality processes. **Note the major difference in the number of stems recruited and the relatively minor difference in live and dead tree diameters between thinned and unthinned stands.** Strangely, in spite of this evidence, the EA claims that thinning would be beneficial. (e.g., “Long-term increase in quality CWD recruitment” and “Long-term increase in quality instream large woody debris (LWD) recruitment” The analysis fails to recognize any trade-off between dead wood size and quantity.

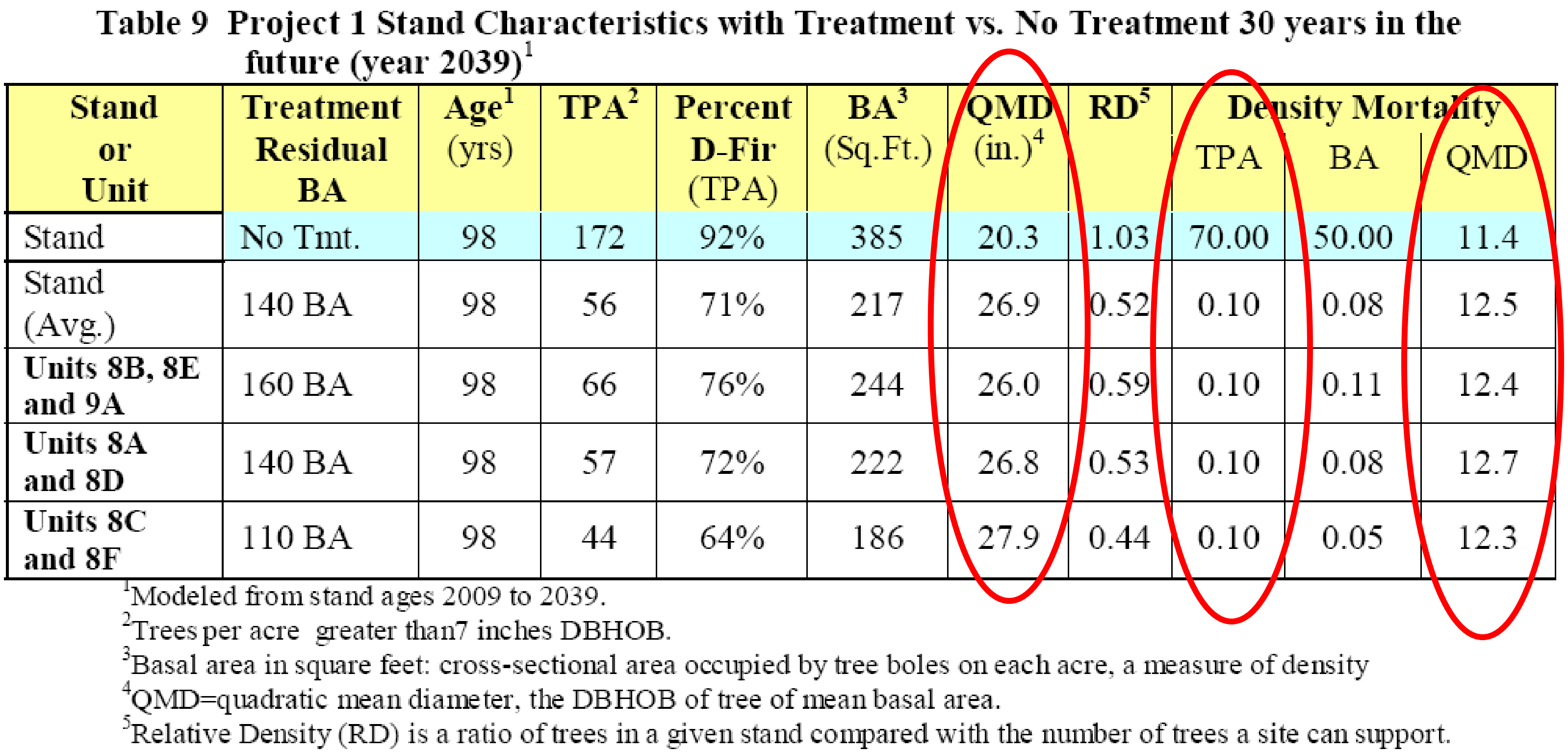


Table 9 Project 1 Stand Characteristics with Treatment vs. No Treatment 30 years in the future (year 2039)[1]

Stand or Unit	**Treatment Residual BA**	**Age[1]** (yrs)	**TPA[2]**	**Percent D-Fir** (TPA)	**BA[3]** (Sq.Ft.)	**QMD** (in.)[4]	**RD[5]**	**Density Mortality**		
								TPA	BA	QMD
Stand	No Tmt.	98	172	92%	385	20.3	1.03	70.00	50.00	11.4
Stand (Avg.)	140 BA	98	56	71%	217	26.9	0.52	0.10	0.08	12.5
Units 8B, 8E and 9A	160 BA	98	66	76%	244	26.0	0.59	0.10	0.11	12.4
Units 8A and 8D	140 BA	98	57	72%	222	26.8	0.53	0.10	0.08	12.7
Units 8C and 8F	110 BA	98	44	64%	186	27.9	0.44	0.10	0.05	12.3

[1] Modeled from stand ages 2009 to 2039.

[2] Trees per acre greater than7 inches DBHOB.

[3] Basal area in square feet: cross-sectional area occupied by tree boles on each acre, a measure of density

[4] QMD=quadratic mean diameter, the DBHOB of tree of mean basal area.

[5] Relative Density (RD) is a ratio of trees in a given stand compared with the number of trees a site can support.

Rickreall EA, Salem BLM, 2012

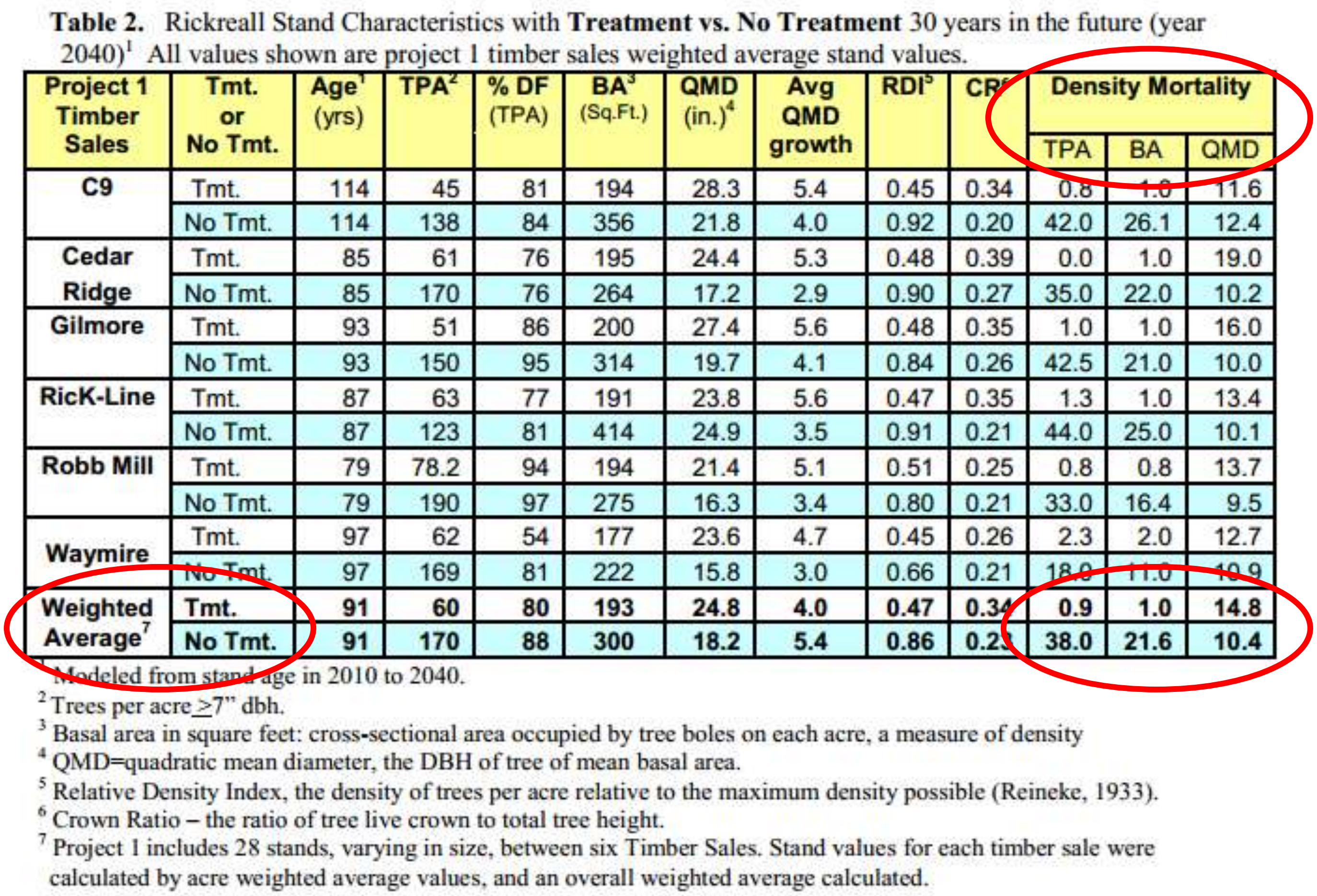


Table 2. Rickreall Stand Characteristics with **Treatment vs. No Treatment** 30 years in the future (year 2040)[1] All values shown are project 1 timber sales weighted average stand values.

Project 1 Timber Sales	Tmt. or No Tmt.	Age[1] (yrs)	TPA[2]	% DF (TPA)	BA[3] (Sq.Ft.)	QMD (in.)[4]	Avg QMD growth	RDI[5]	CR[6]	Density Mortality		
										TPA	BA	QMD
C9	Tmt.	114	45	81	194	28.3	5.4	0.45	0.34	0.8	1.0	11.6
	No Tmt.	114	138	84	356	21.8	4.0	0.92	0.20	42.0	26.1	12.4
Cedar Ridge	Tmt.	85	61	76	195	24.4	5.3	0.48	0.39	0.0	1.0	19.0
	No Tmt.	85	170	76	264	17.2	2.9	0.90	0.27	35.0	22.0	10.2
Gilmore	Tmt.	93	51	86	200	27.4	5.6	0.48	0.35	1.0	1.0	16.0
	No Tmt.	93	150	95	314	19.7	4.1	0.84	0.26	42.5	21.0	10.0
RicK-Line	Tmt.	87	63	77	191	23.8	5.6	0.47	0.35	1.3	1.0	13.4
	No Tmt.	87	123	81	414	24.9	3.5	0.91	0.21	44.0	25.0	10.1
Robb Mill	Tmt.	79	78.2	94	194	21.4	5.1	0.51	0.25	0.8	0.8	13.7
	No Tmt.	79	190	97	275	16.3	3.4	0.80	0.21	33.0	16.4	9.5
Waymire	Tmt.	97	62	54	177	23.6	4.7	0.45	0.26	2.3	2.0	12.7
	No Tmt.	97	169	81	222	15.8	3.0	0.66	0.21	18.0	11.0	10.9
Weighted Average[7]	**Tmt.**	**91**	**60**	**80**	**193**	**24.8**	**4.0**	**0.47**	**0.34**	**0.9**	**1.0**	**14.8**
	No Tmt.	**91**	**170**	**88**	**300**	**18.2**	**5.4**	**0.86**	**0.2[illegible]**	**38.0**	**21.6**	**10.4**

[1] Modeled from stand age in 2010 to 2040.

[2] Trees per acre ≥7" dbh.

[3] Basal area in square feet: cross-sectional area occupied by tree boles on each acre, a measure of density

[4] QMD=quadratic mean diameter, the DBH of tree of mean basal area.

[5] Relative Density Index, the density of trees per acre relative to the maximum density possible (Reineke, 1933).

[6] Crown Ratio – the ratio of tree live crown to total tree height.

[7] Project 1 includes 28 stands, varying in size, between six Timber Sales. Stand values for each timber sale were calculated by acre weighted average values, and an overall weighted average calculated.

The EA says "Proposed thinning in the riparian treatment areas is anticipated to increase the average growth of the remaining trees between 18 to 166 percent over 30 years compared to not treating the stands (Snook 2011 and Roux 2011). In the long-term the increase in the size of trees in riparian areas could benefit LWD recruitment to the stream channel."

While the EA is quick to say that the thinning alternatives will increase the "size" of remaining trees. The analysis and description in the EA fail to mention that thinned stands will recruit 97% fewer stems and 95% less basal area from "density mortality" compared to no action.

Holland Moonsalt EA
Cottage Grove RD
Umpqua NF, Oregon

- 40-50 year old stands thinned to 40-90 trees per acre
- 400+ acres treated in riparian reserves
- 50-60 ft buffers on perennial streams
- No buffer on “stable” intermittent Streams
- Thinning reduces recruit of small snags, large snags, and dead wood.

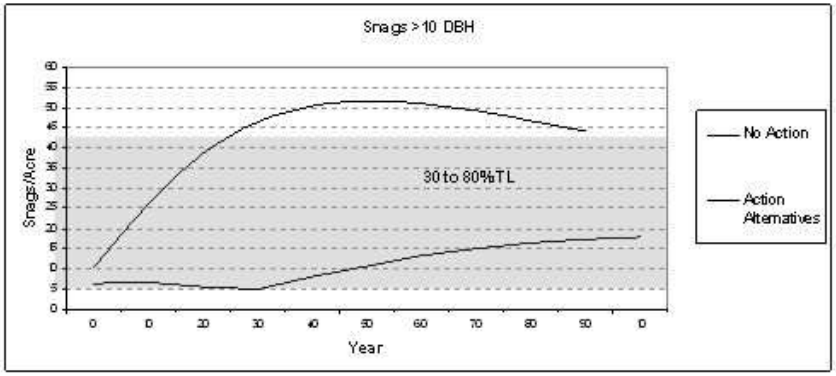


Figure 18. Short and Long Term Changes to ≥10" Snags (Snags/Acre by Year)

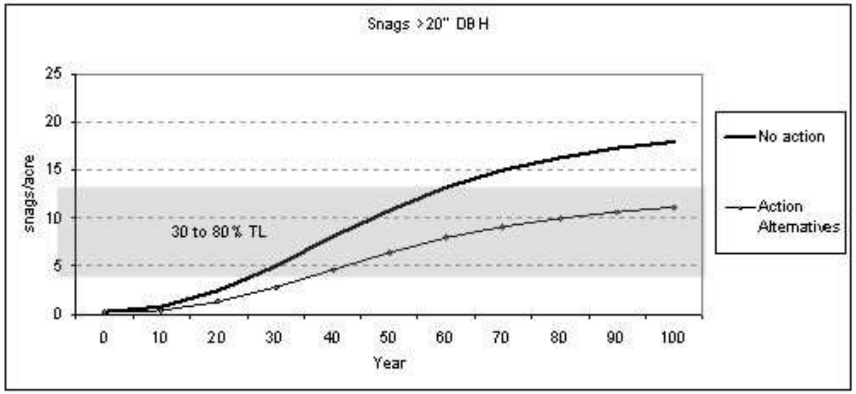


Figure 19. Short and Long Term Changes to ≥20" dbh Snags (Snags/Acre by Year)

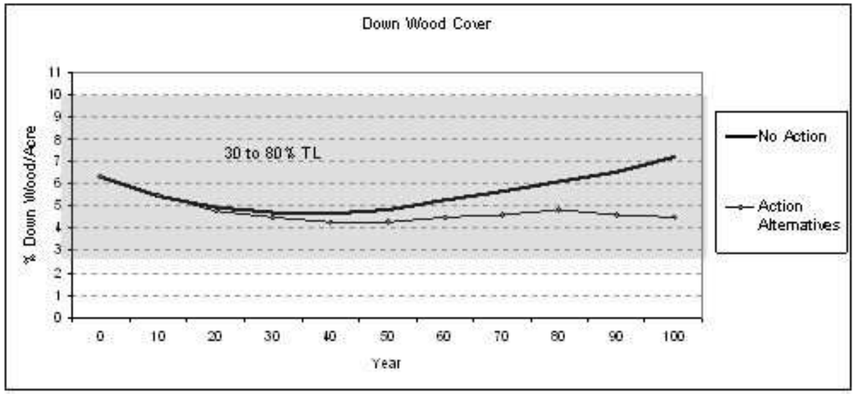


Figure 20. Short and Long Term Changes to ≥ 6" Diameter Down Wood

Curran-Junetta, Cottage Grove RD

Umpqua NF, Oregon

40-60 year old stands thinned to 40-60 tpa

Heavy thinning delays by more than 60 years the attainment of habitat objectives for large snags (i.e. mid-point of the gray band representing 30-80% tolerance level).

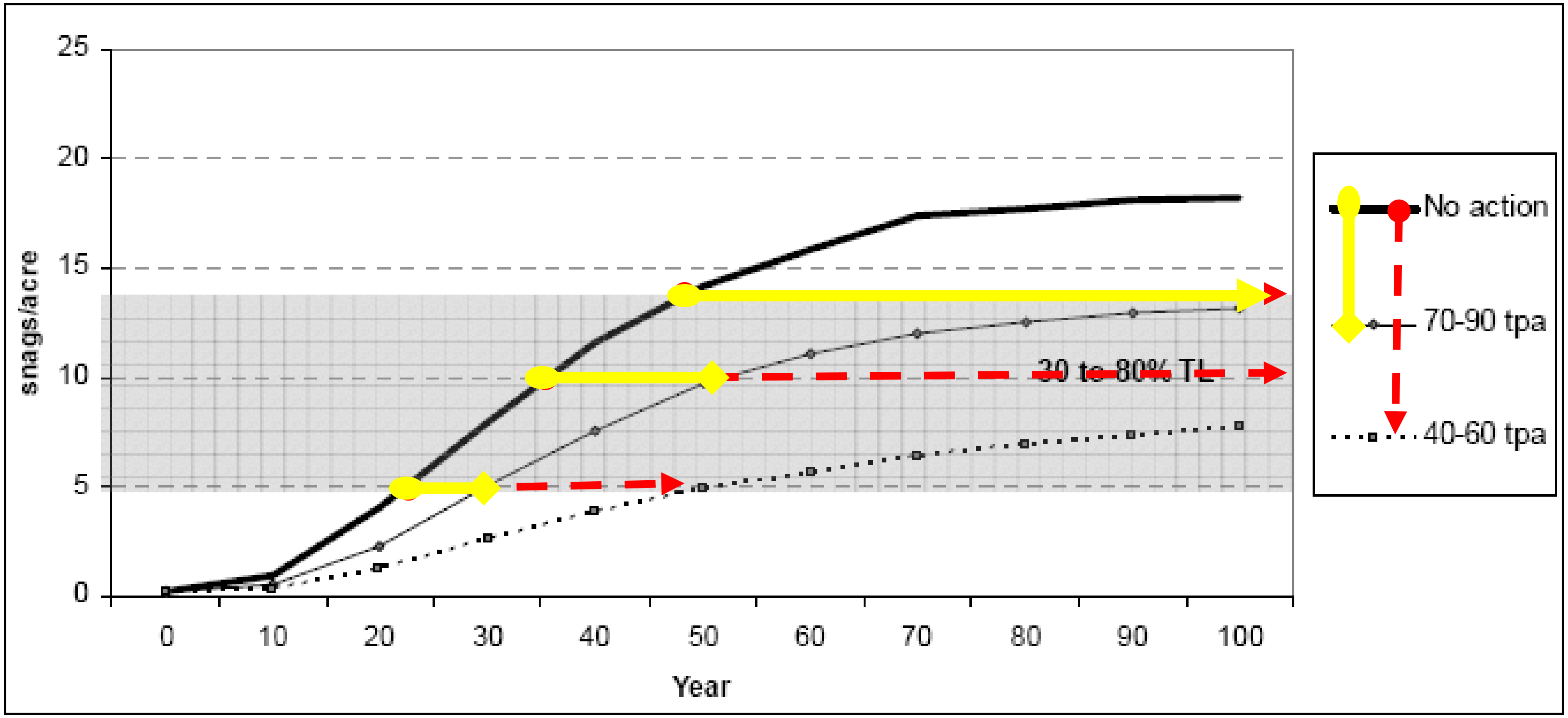
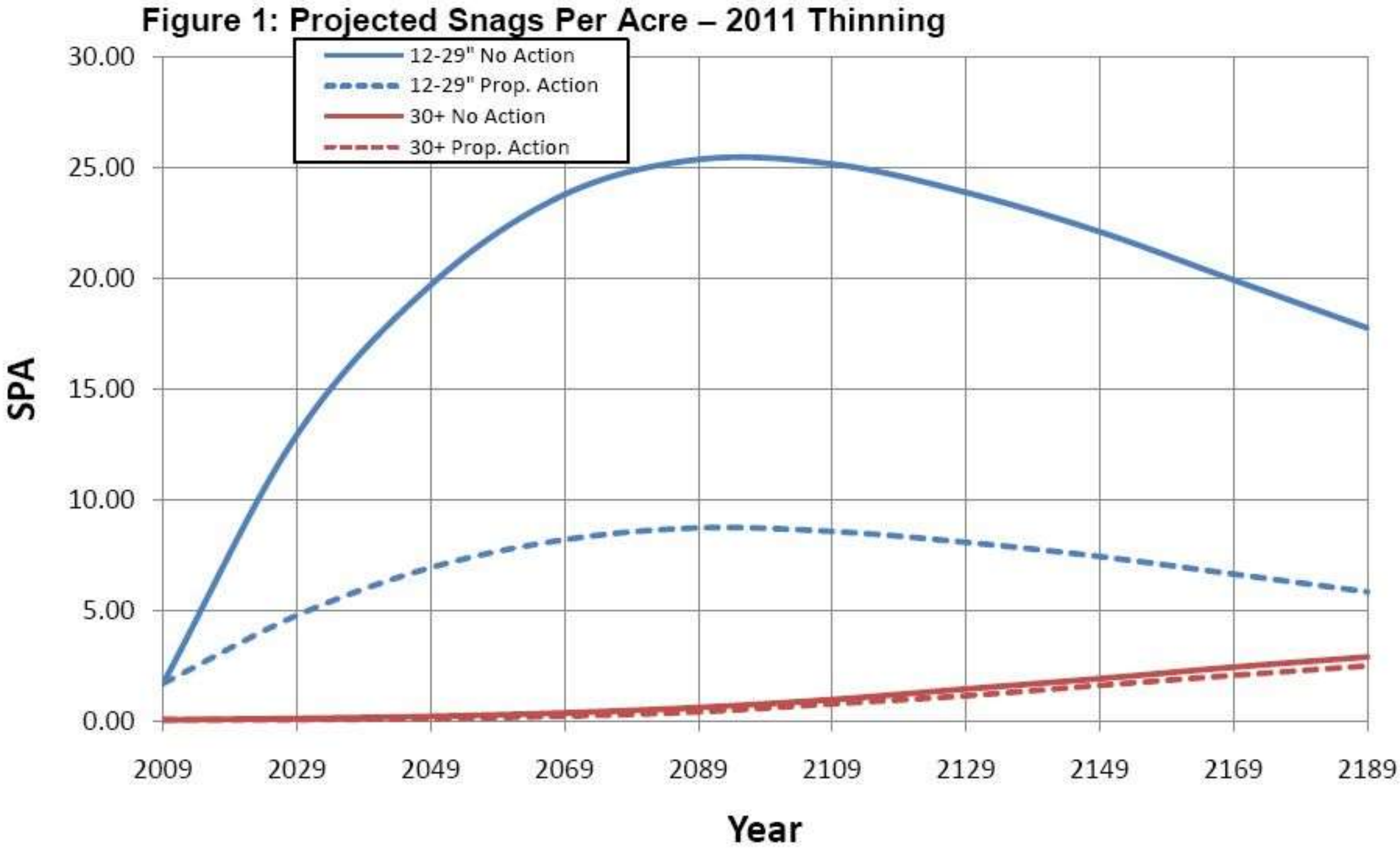


Figure 15. Short and long-term changes to ≥20" dbh snags.

2011 Thinning EA, Eugene BLM, Oregon

- Stands 30-70 years old
- Thinned to 60 to 120 trees per acre, and
- 120 to 160 square feet of basal area per acre
- 400 acres located in riparian reserves



Upper Cavitt EA, North Umpqua RD

Umpqua NF, Oregon

- Stands 44-62 years old thinned to 55-85 trees per acre
- Stream buffers $\geq$25 ft

Chapter 3 – Affected Environment/Environmental Effects *Upper Cavitt Timber Sale EA*

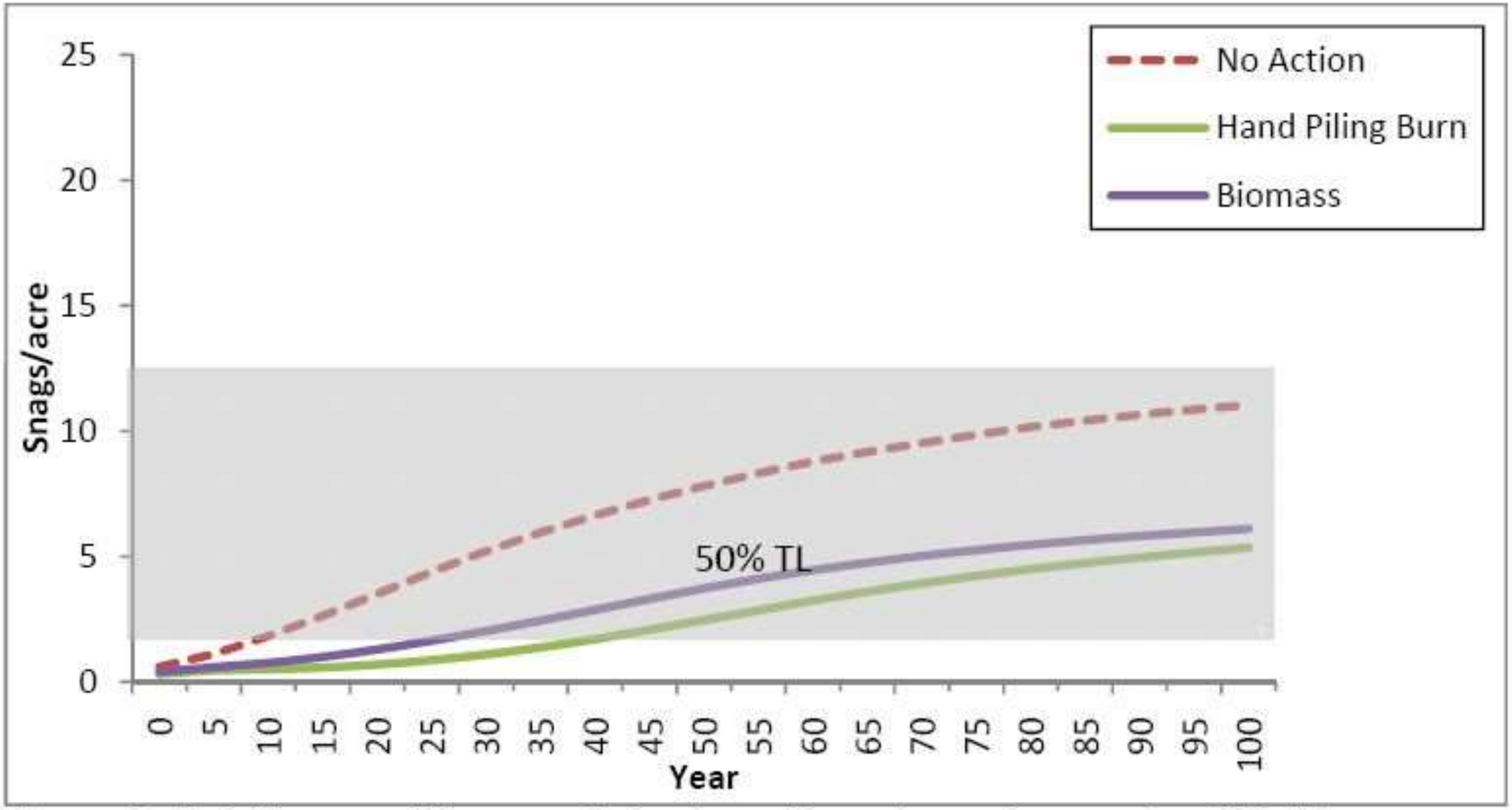
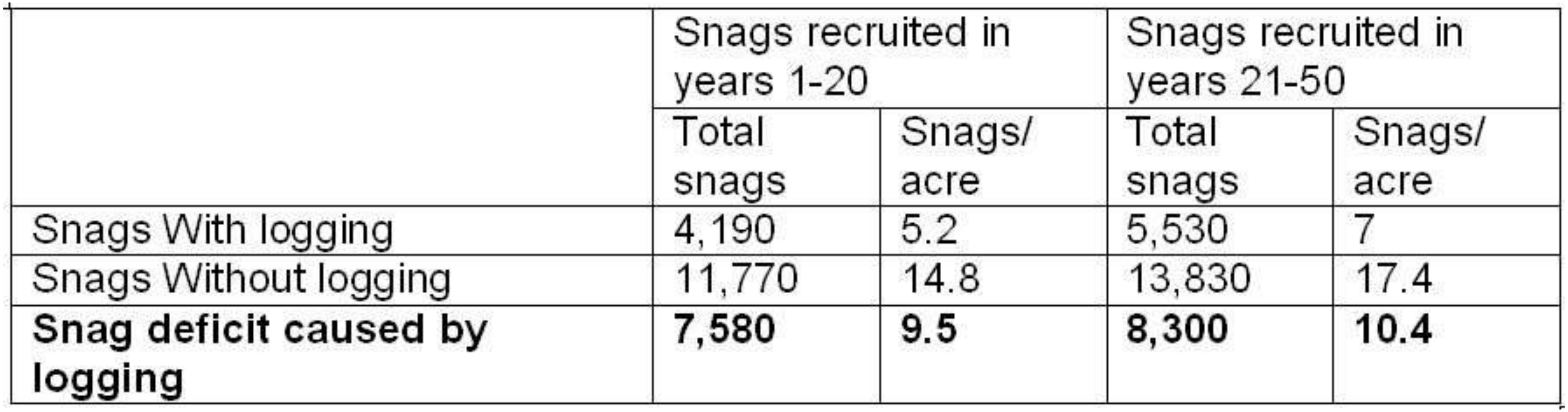


Figure 9. Existing conditions and short- and long-term changes to 20" dbh snags. The gray area represents the 50% tolerance level ranges (TL) from DecAID. There would be a slight delay in the attainment of large snags at the 50% TL under the action alternatives.

Third Elk Commercial Thinning EA, Roseburg BLM, Oregon

- 34-57 years old stands thinned to 80-120 ft^2 basal area per acre
- 35-60 ft stream buffers



	Snags recruited in years 1-20		Snags recruited in years 21-50	
	Total snags	Snags/ acre	Total snags	Snags/ acre
Snags With logging	4,190	5.2	5,530	7
Snags Without logging	11,770	14.8	13,830	17.4
Snag deficit caused by logging	**7,580**	**9.5**	**8,300**	**10.4**

(snag size not specified)

Garman, Steven L.; Cissel, John H.; Mayo, James H. 2003. Accelerating development of late-successional conditions in young managed Douglas-fir stands: a simulation study. Gen. Tech. Rep. PNW-GTR-557. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 57 p.

http://www.essa.com/documents/WWETAC/VegetationModelsClimateChangeWorkshop/Gap/Garman%20et%20al%202003.pdf

“Sixty-four thinning treatments were simulated for four rotation intervals (260, 180, 100, and 80 years) starting with a 40-year-old managed Douglas-fir stand. … In general, heavy thinning of existing stands at ages 40 and 60 years promoted rapid development of large boles, vertical diversity, and tree-species diversity, but provided the least amount of extracted volume and required artificial creation of dead wood. … Natural recruitment of snags was related to thinning densities (fig. 3A). In general, the amount of time to satisfy the snag criterion decreased with decreasing thinning densities in the first entry. This was due to faster development of large boles at lower stem densities and thus a greater potential for recruitment of large snags. Also, the amount of time to satisfy this criterion decreased with increasing thinning densities in both the second and third entry. This simply reflected the tendency for more stems to die with increasing stem densities. … Snag density at stand age 260 generally increased with increasing thinning density in the first entry and somewhat with increasing thinning density in the subsequent two thinning entries. This reflected the greater source of potential snags with increasing stem density. … Developmental trends for log mass (fig. 4) were similar to those for snag density. Leaving fewer stems in the first entry but more subcanopy stems in the second and third entries generally resulted in faster accumulation of log mass. … Artificial snag recruitment was important for maintaining snag densities when thinning to 62 TPH in the last entry or 99 TPH in the second entry (fig. 7A). These thinning treatments resulted in lower rates of natural mortality of large boles and required the artificial creation of two to four snags per hectare (figs. 7B through 7D) to satisfy the snag criterion at about the same time as live criteria (fig. 6G). … Treatments providing the most rapid attainment of live, late-successional conditions (i.e., all-≤297-≥186) required artificial creation of up to six snags per hectare to satisfy the snag criterion at about the same time as the live criteria (figs. 13A through 13D). Thinning to 99 TPH at stand age 60 or to 62 TPH at age 80 tended to delay the development of large snags … Log mass tended to be limiting (fig. 17A). Even with the addition of 15 Mg/ha of logs, the log-mass threshold level could not be satisfied by age 100 in the heavy thinning regimes … The stand age when the log-mass criterion was satisfied also differed among initial stand conditions. Starting with fewer but larger canopy stems delayed satisfying the log-mass criterion by up to two decades …

Management Implications

Results of this study illustrated two important relations between rapid development of late-successional attributes and long-term stand conditions. First, treatments that promote rapid development of an attribute will not necessarily produce the highest levels of the attribute over the course of a rotation. In this study, treatments providing rapid development of live, late-successional attributes generally produced relatively lower densities of shade-tolerant stems, lower amounts of Douglas-fir basal area, and fewer snags and logs over a rotation compared to other treatments.”