Stand Density and Spatial Pattern in Coast Redwood
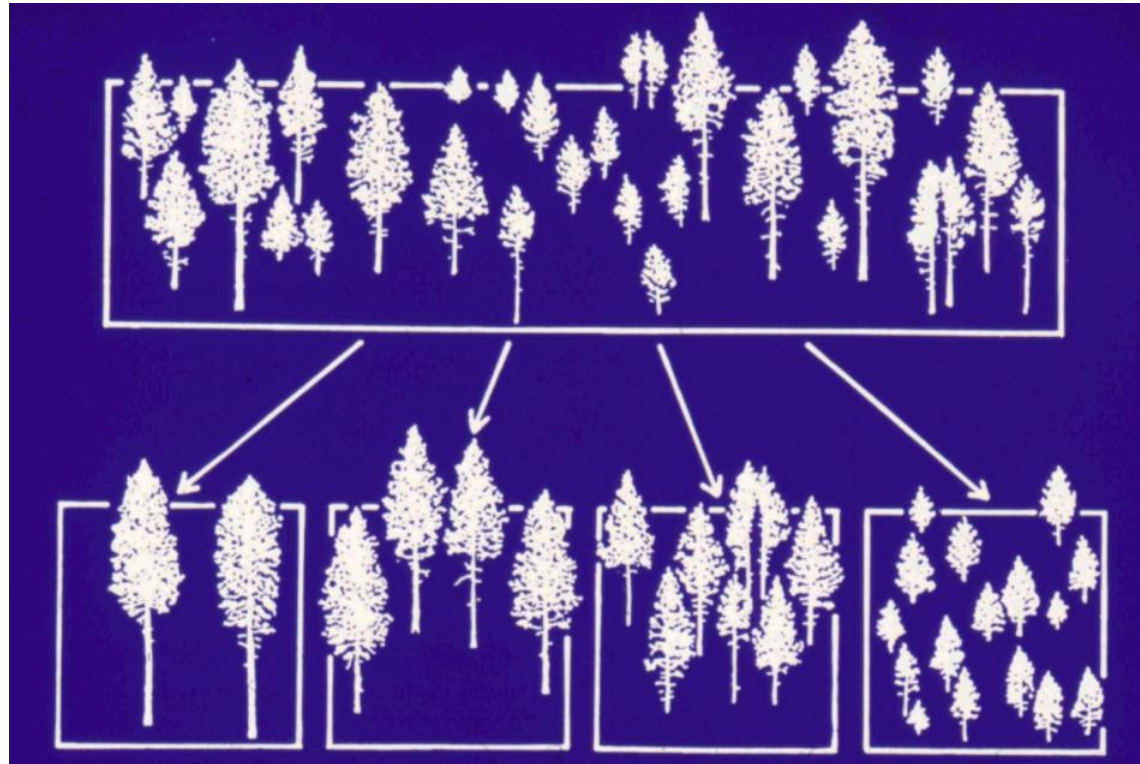## Implications for Management and Carbon Sequestration

John-Pascal Berrill
Humboldt State University
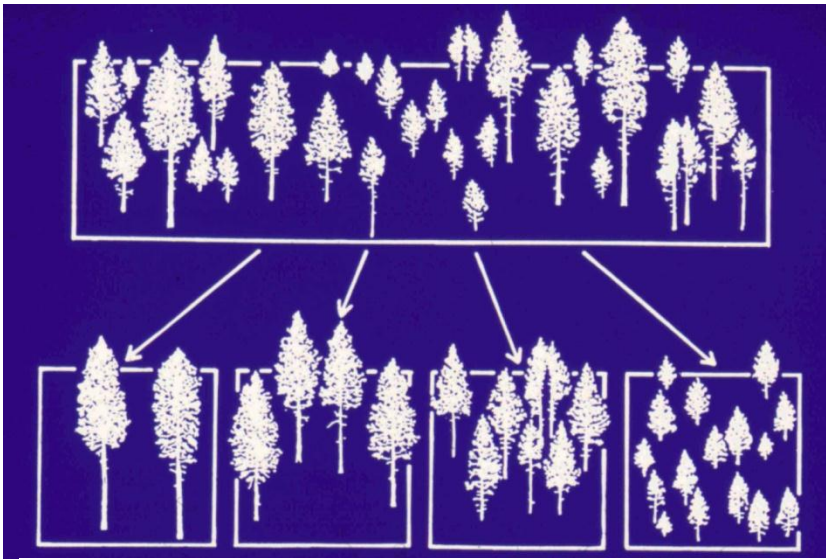
Kevin L. O'Hara
University of California, Berkeley

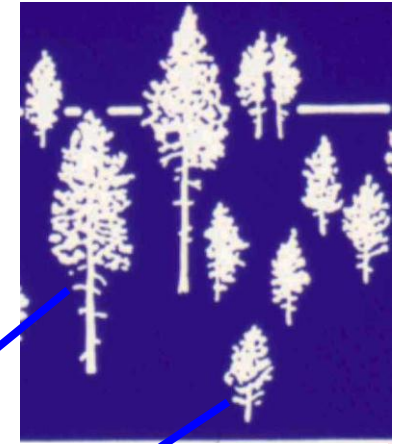# Redwood Multiaged Stocking Assessment Model (RW-MASAM)

- Model 'grows' each cohort separately

- Data collected on Jackson DSF, Mendocino Co.

Redwood MASAM

Example:
2-aged
stand

| Maximum Stand LAI ECC (m^2/m^2)	7.2		60% of max. LAI 12		
	Overstory		**Understory**		
	Emergents	B-stratum	C-stratum	D-stratum	Total
Percent Growing Space (LAI)		40	60		100%
Trees/ha by Component		90	150		240
Leaf Area Index/Component BCC	0.0	2.6	0.0	0.0	2.6
Leaf Area Index/Component ECC	0.0	2.9	4.3	0.0	7.2
Volume Increment/Tree (dm^3/yr) ECC	0.0	98	63	0.0	
Component Increment (m^3/ha/yr) CC	**0.0**	**7.2**	**4.7**	**0.0**	**12.0**
Tree Vigor (dm^3/m^2/yr) ECC	0.0	305	219	0.0	
Q. Mean DBH/Component (cm) ECC	**0.0**	**70**	50	**0.0**	
Basal Area/Component (m^2/ha) BCC	0.0	17	0.0		17.5
Basal Area/Component (m^2/ha) ECC	**0.0**	**34**	**29**	**0.0**	**63.5**
Stand Density Index (in/ac) ECC	0.0	183	178	0.0	361

Berrill & O'Hara 2007 CJFR

Stand BA Development after Partial Harvesting
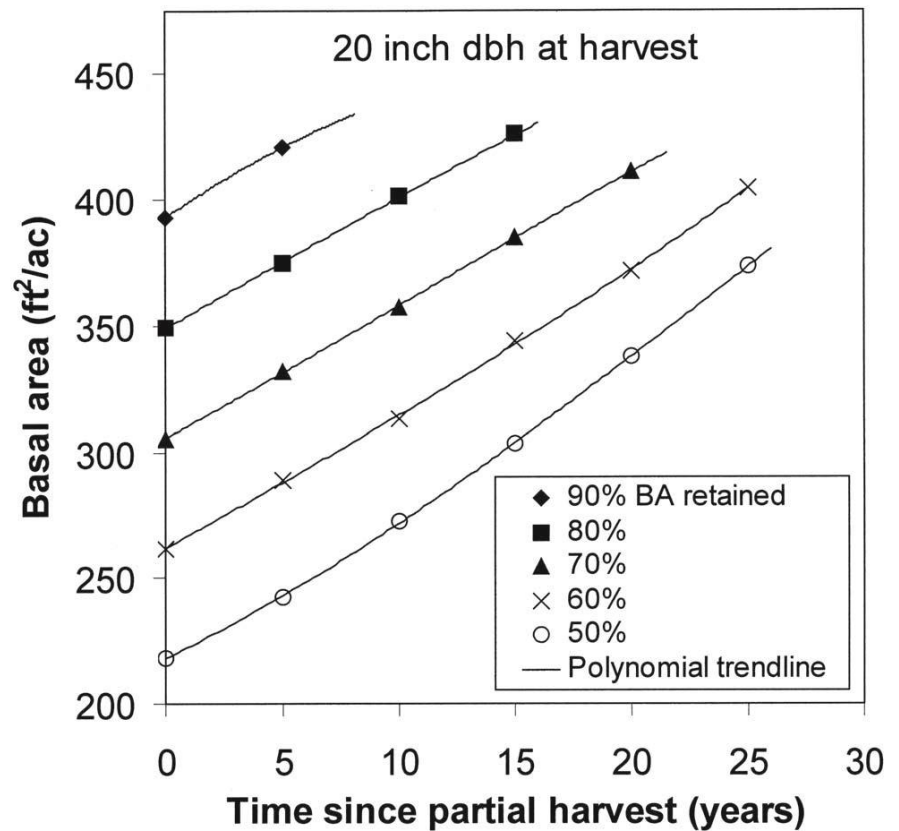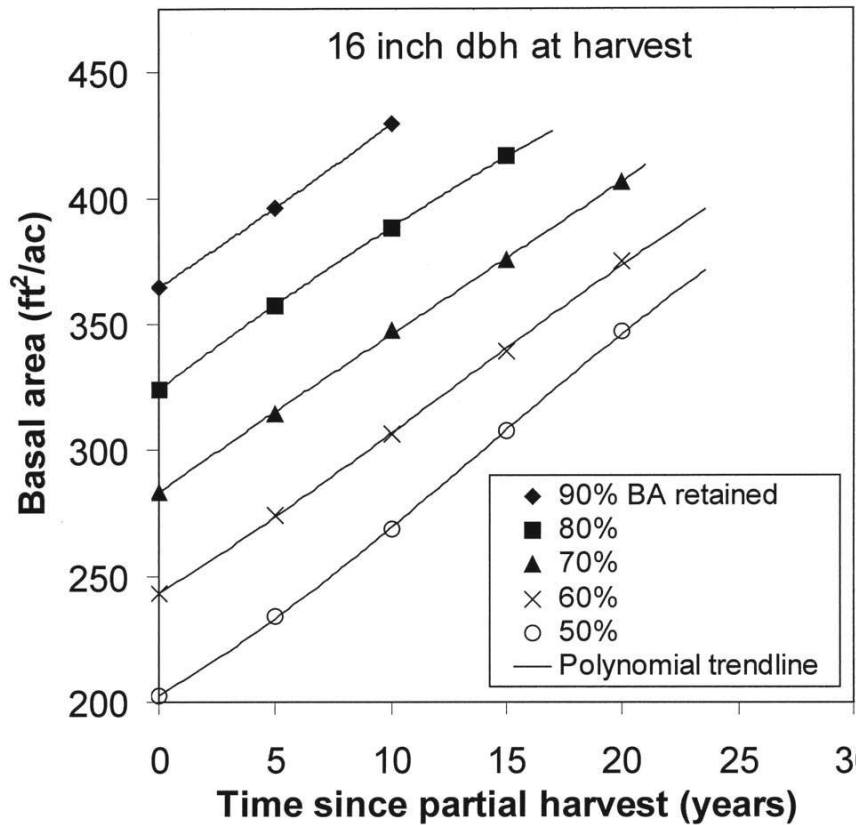
- Preharvest: 290 tpa 16" dbh (left) or 200 tpa 20" dbh (right) = crowded

- Retain 50, 60, 70, 80, or 90% BA

- Stand BA = trees retained + new sprouts (PCT: 2 sprouts per stump)

- Trendlines extend to time when <u>Stand BA</u> returned to preharvest stocking (crowded)

Density Management Zone
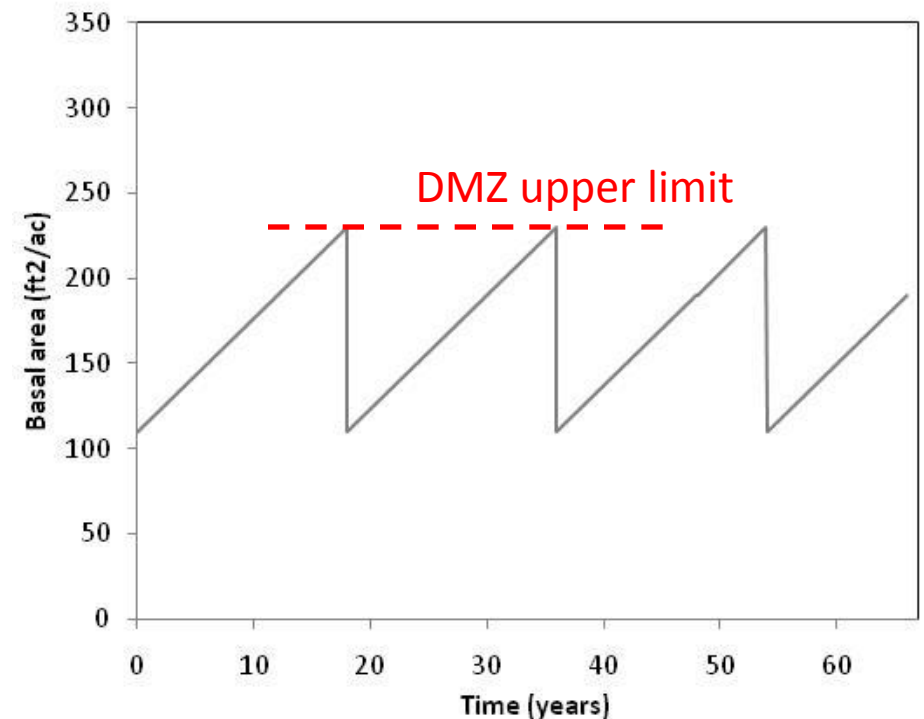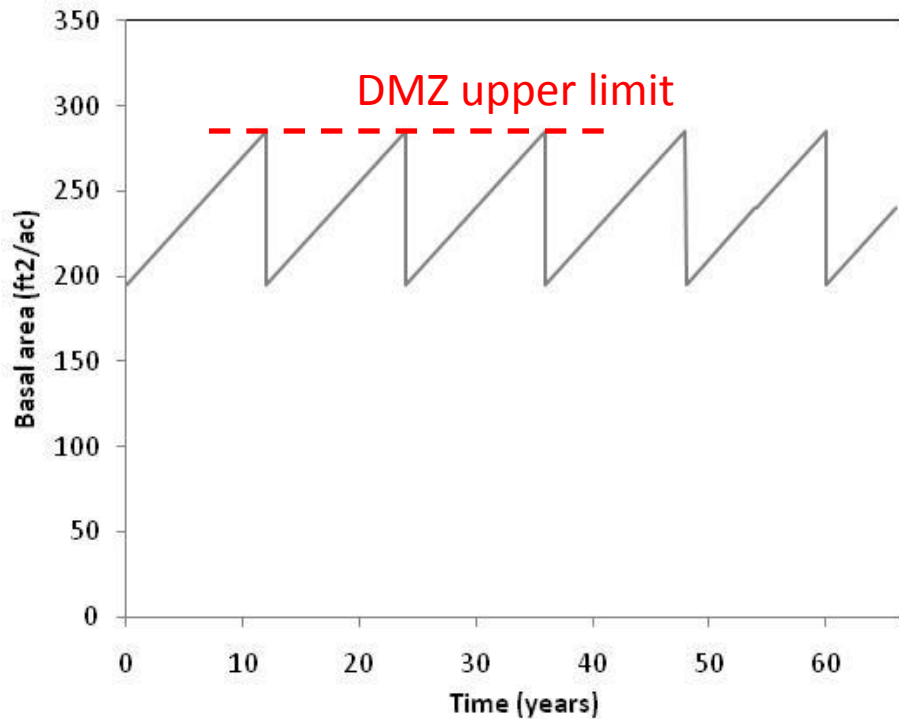
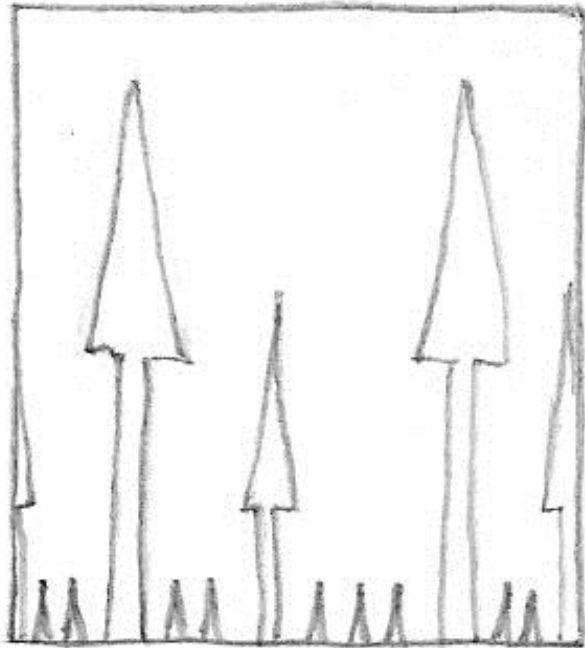

Harvest: light & frequent   v. heavy & infrequent
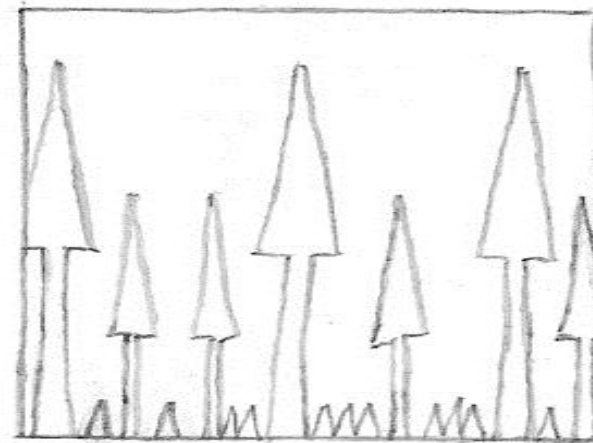
Stocking: higher   v. lower

Cohort Density

- DMZ & TPA define tree size at harvest

Example: same DMZ upper limit

Lower TPA = larger trees at harvest

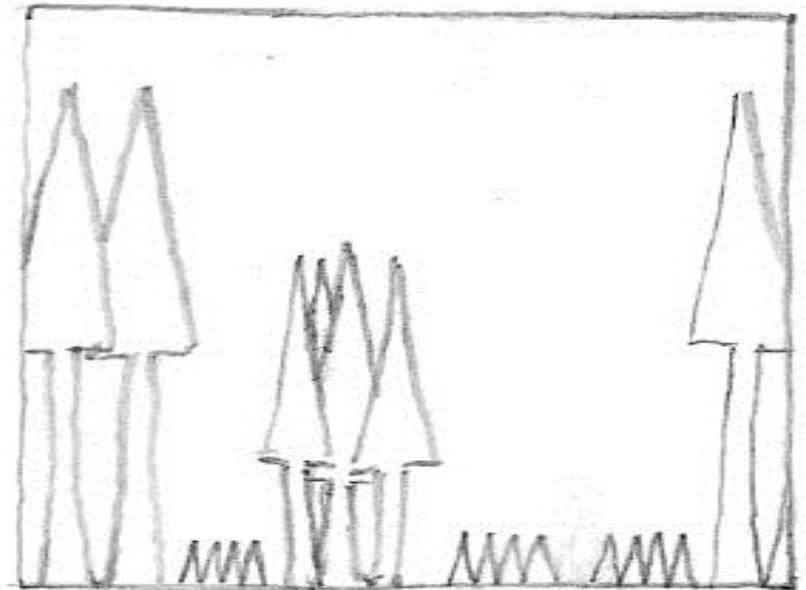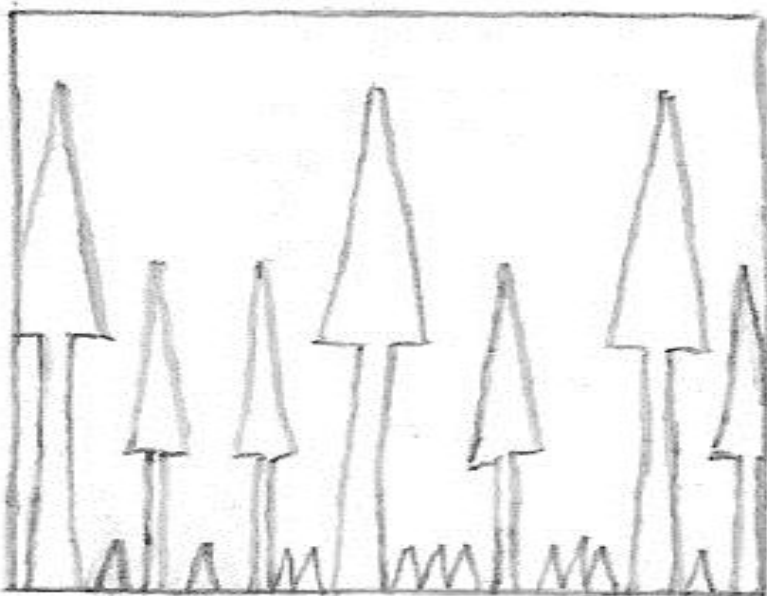Higher TPA = smaller trees at harvest

Dispersed v. Aggregated Retention

Dispersed retention:

- **Partial cutting within clumps**
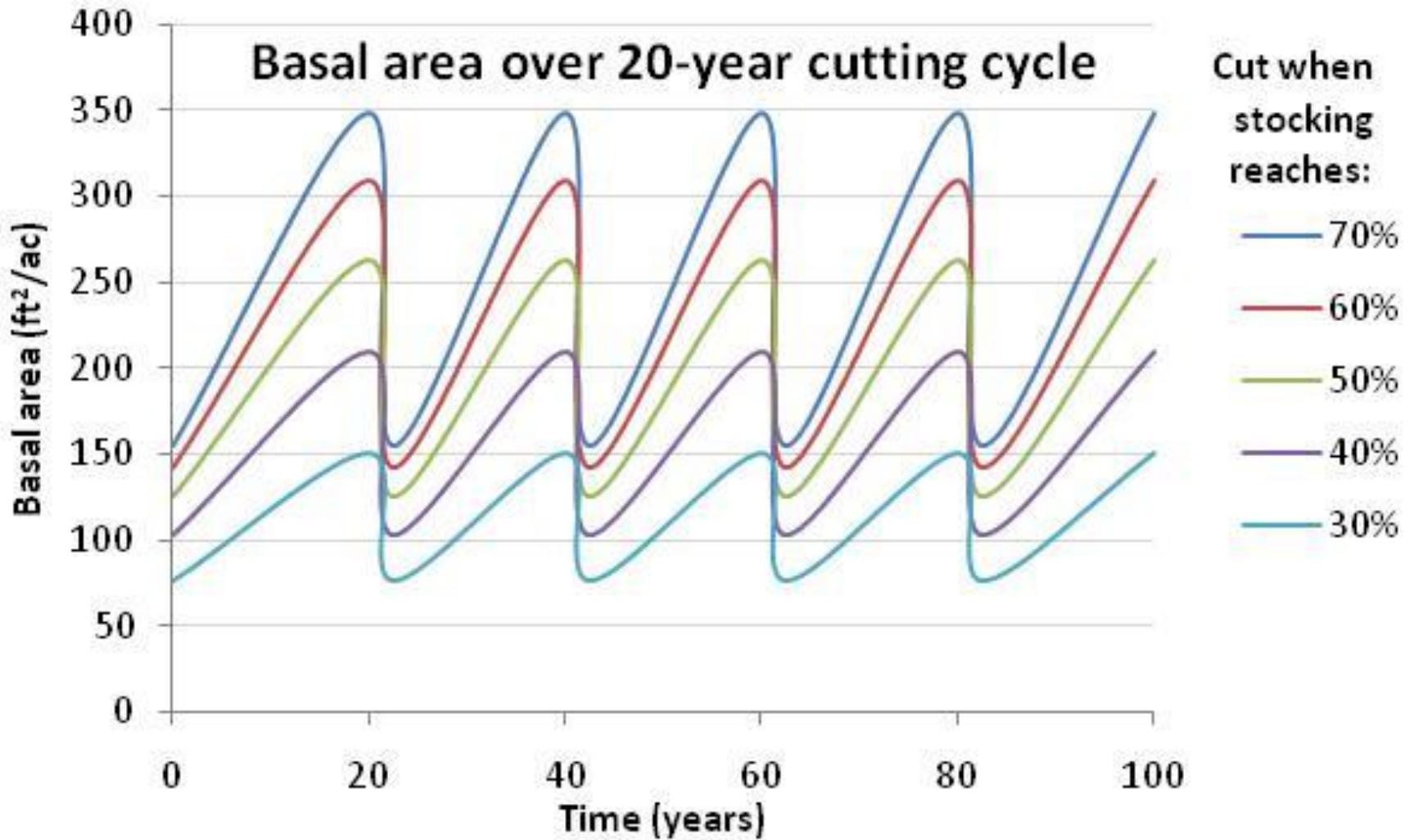
- Vigorous leave trees

- Can suppress new age class

Aggregated retention:

- **Cut entire clumps**

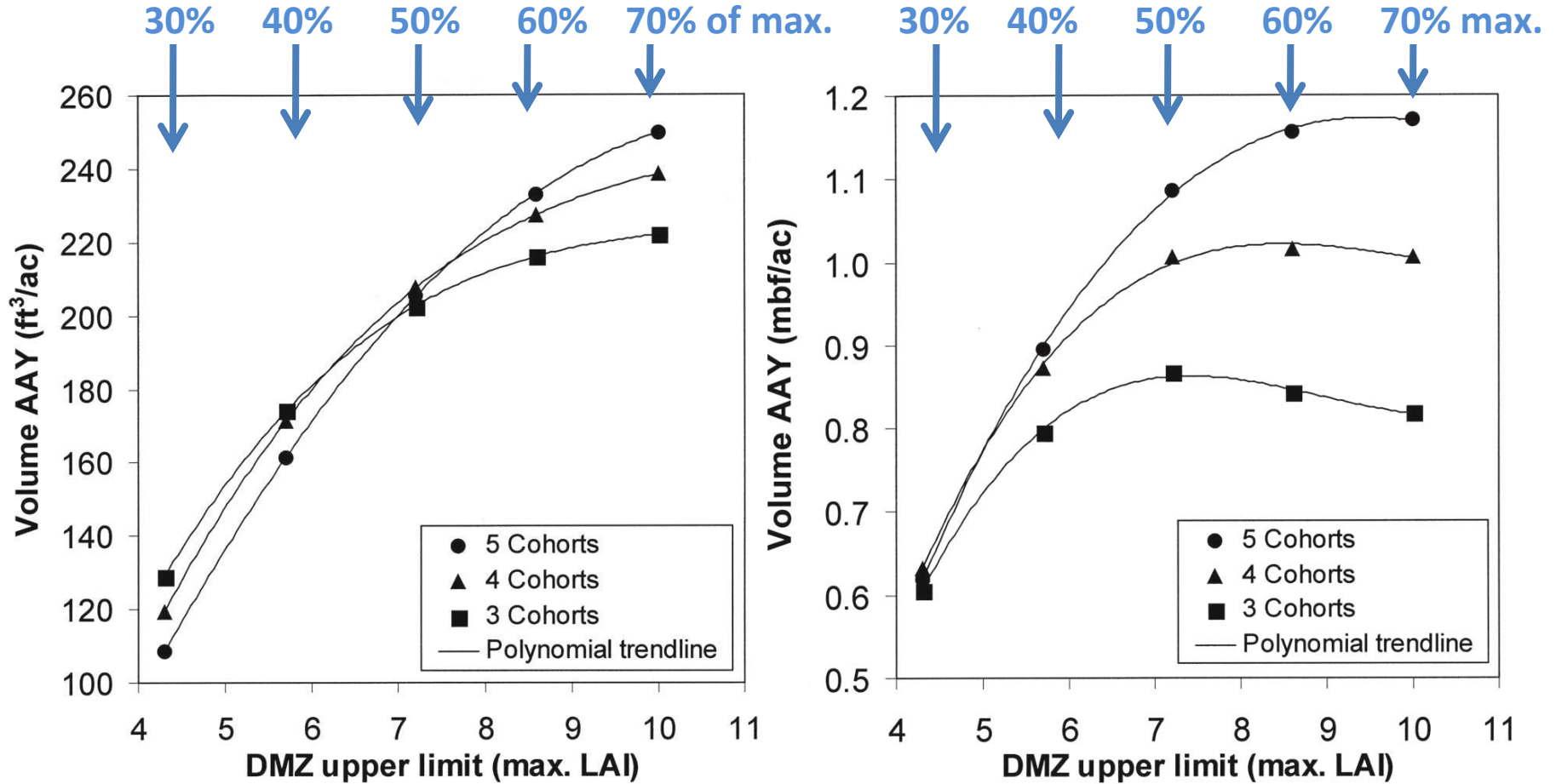- Leave trees are crowded

- Favors new age class

Density Management Zone

Basal area over 20-year cutting cycle

Cut when stocking reaches:
- 70%
- 60%
- 50%
- 40%
- 30%

(4 cohorts)

DMZ upper limit - "cut when stocking reaches..."

30% 40% 50% 60% 70% of max.   30% 40% 50% 60% 70% max.

- Board foot volume yield 'plateau' at high stockings, due to smaller tree sizes

Figure: Effect of DMZ on stand volume production in multiaged stands with 3-5 cohorts managed on a 20-year cutting cycle. *Berrill & O'Hara 2009 WJAF*
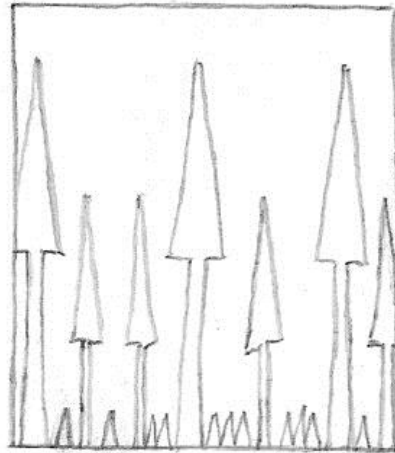
Redwood Field Experiment
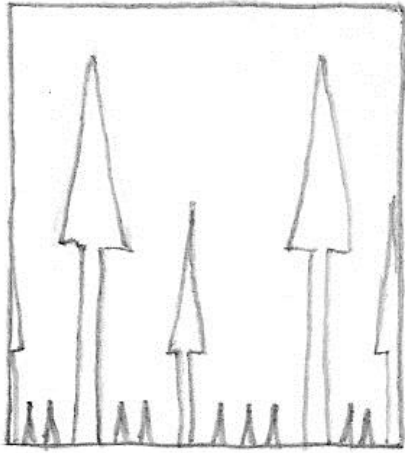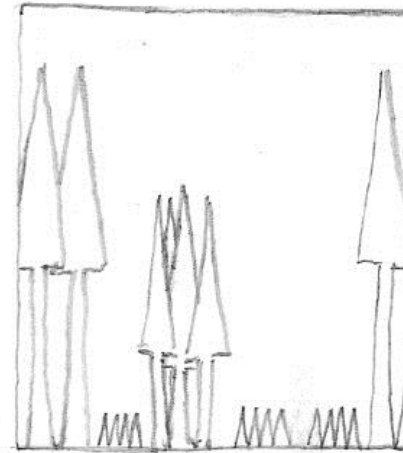

(1) low density 'dispersed' retention (3 cohort)

(2) high density 'dispersed'

(3) high density 'aggregated' retention

(4) group selection

Hypothesis:
- All trees vigorous
- Long live crowns
- Lower carbon seq.

Hypothesis:
- Shaded regen.
- High carbon seq.

Hypothesis:
- Vigorous regen.
- High carbon seq.

Hypothesis:
- Most vigorous regen.
- Unused space early
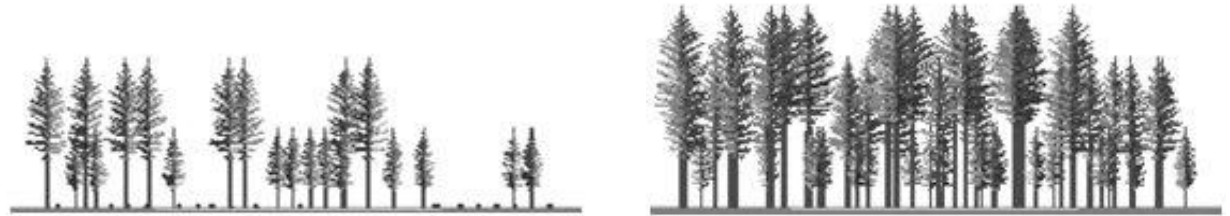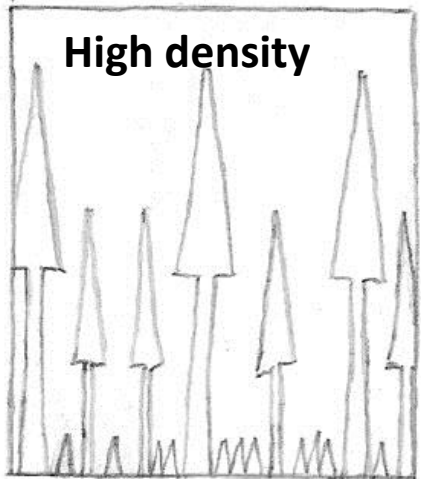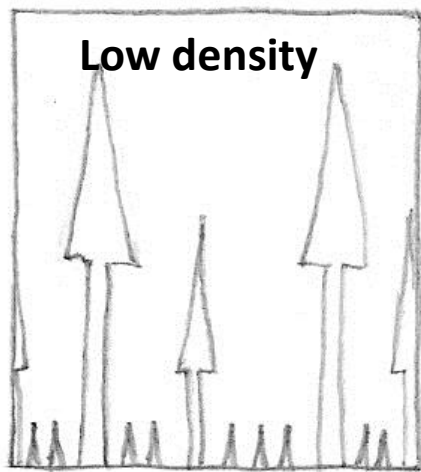- Suppressed trees in matrix

Modified selection system: schematic diagrams of multiaged stands with two to four cohorts, immediately before (left) and after (right) partial harvest, producing the same overstory tree at harvest. Diagrams were produced using Stand Visualization System (McGaughey 1997).

Berrill & O'Hara 2009 WJAF

Low density

High density

Schematic diagrams of 3-cohort multiaged stand structure to be implemented under single-tree selection treatments. Partial harvesting is used to install the treatment (shown on left). Over time the stand develops, until stocking reaches the prescribed upper limit (shown on right), signaling the end of one cutting cycle or "return interval", when partial harvesting re-creates structure on left and a second cutting cycle begins. Diagram adapted from Berrill and O'Hara (2009).

The density management zone (DMZ) defines the range between the upper and lower limits of stand density (i.e., stand density at the beginning and end of the cutting cycle; or said another way, stand density immediately before and after partial harvesting), where stand density is defined in terms of stand density index (SDI) or another measure of occupied growing space: leaf area index (LAI). It is hypothesized that the low density regime will have greater individual tree growth and vigor throughout the entire cutting cycle, but will produce less volume per acre than equivalent high density regimes.