Intermediate Stand Management Options for Pines & Hardwoods

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What are Intermediate Operations or Treatments?

- From the Dictionary of Forestry: Any treatment or tending designed to enhance growth, quality, vigor, and composition of a stand after establishment, a regeneration event and prior to harvest
- Examples of intermediate treatments: woody release (cleaning and liberation cuts), herbaceous weed control, fertilization, timber stand improvement, pruning, commercial and precommercial thinning, crop tree release, and prescribed fire
- We will cover the last three

Thinning: An Intermediate Stand Management Tool

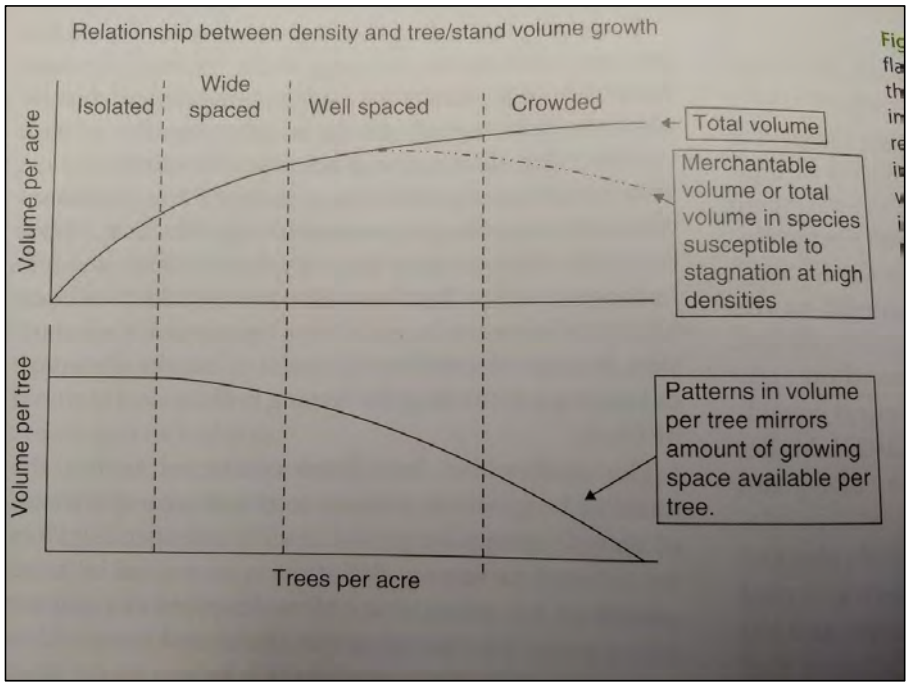
Commercial vs. Precommercial Thinning

- Commercial Thinning-produce a net income from cut trees
  - Usually 5” minimum dbh up to a ≈3” top diameter
- Precommercial Thinning-carried out as an investment
  - Costs of operation exceeds income from the cut
  - Done to improve stand growth, improve individual tree health, and stand structure
  - Not common-Usually only conducted in dense, naturally regenerated pine stands
  - >5,000 stems/acre or when live crown ratios are expected to dip below 35% by the first commercial thinning

Example of a precommercially thinned pine stand in South Carolina. Photo: Stephen Peairs

Thinning Introduction

- Thinning involves removal of individual or groups of trees to create growing space and favor growth and development of better formed trees
- Captures mortality that would occur naturally
- Decreases chances of stand growth stagnating
- Conducted in pine stands more commonly than hardwood stands



Adapted from Ashton and Kelty (2018)

Thinning Introduction

- Used to meet landowner objectives where the goal is to favor development of large diameter trees harvested for higher value products
- Thinning usually not used if biomass or pulpwood only are objectives
  - Use short rotations to maximize yields
- From a timber management perspective, thinning is used to either:

1. Maximize total wood yield from a stand OR
2. Increase growth rates of individual crop trees by considering spacing among stems

Thinning Introduction

- Loblolly pine stand example--may reduce the risk of catastrophic insect outbreaks (e.g. southern pine beetle) and/or reduce wildfire risk by reducing stand density

Basal area (ft^2 per acre)	Age (years)	SPB Hazard Rating
<70	<10	Very low
70 - 90	10 – 13	Low
90 - 120	14 – 17	Medium
120 – 145	18 – 21	High
>145	>21	Very high

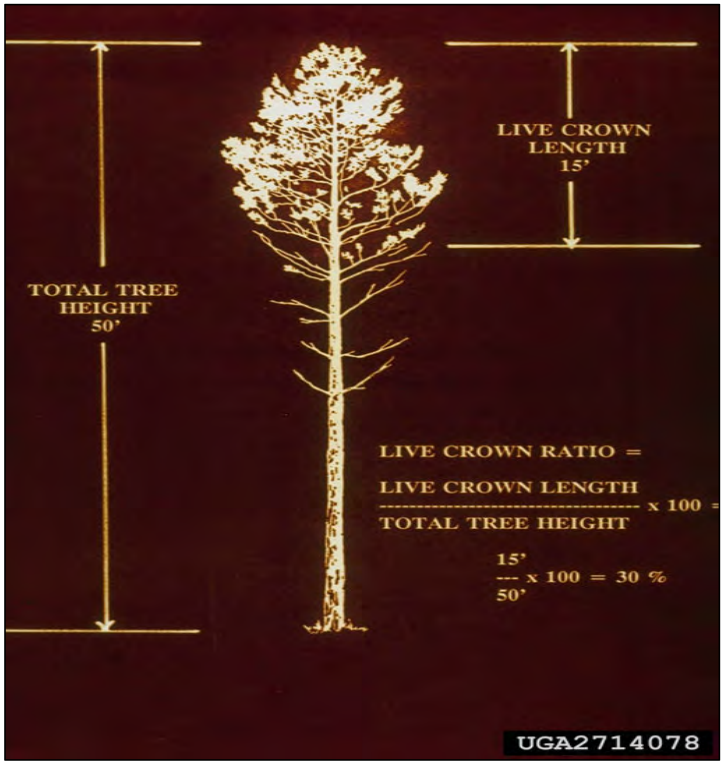
Tenets of Thinning

- Thinning removes designated trees to allocate resources and growing space to specific trees
- Removals with thinning should be light enough so that growth of undesirable woody vegetation does not become a problem before the next regeneration harvest
- Canopy gaps created by thinning are usually small enough so that understory tree growth is limited
- Regeneration is NOT a goal of thinning

How Do You Know When Thinning is Needed?

- Operations should occur before stand growth stagnates and begins to self-thin (natural mortality)
- But, thinning should provide enough volume to be operational
- A balance is required

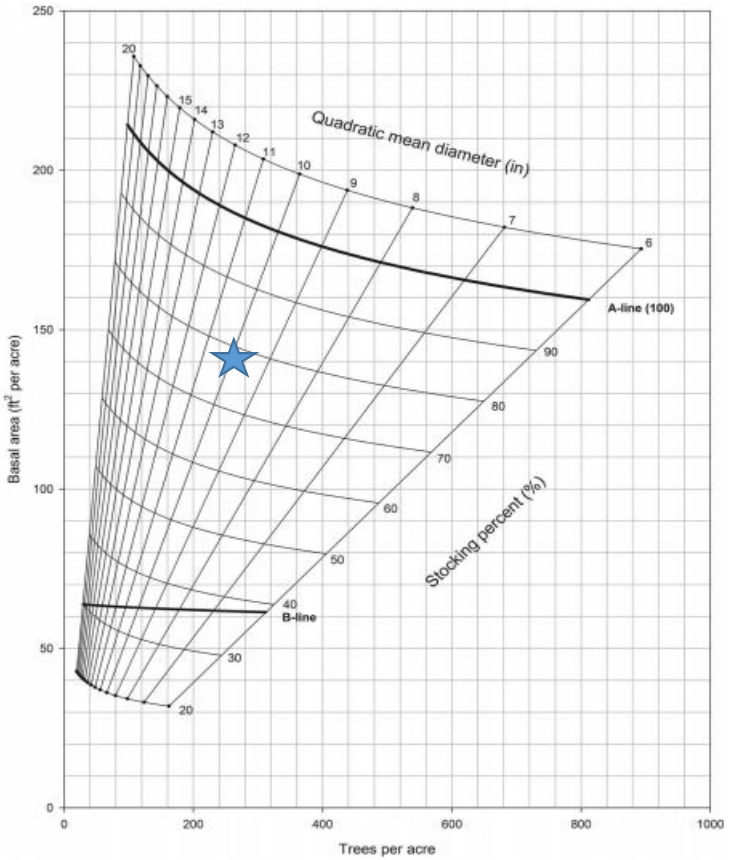
How Do You Know When Thinning is Needed?



- Live crown ratio and stand density (trees/ac and/or basal area/ac) are the two easiest methods
- When basal area reaches 100-120 ft^2/ac, biologically the stand is in need of thinning
  - Higher values possible with loblolly
- Live crown ratio > 35-40% -- < 25-34% growth reductions occur

How Do You Know When Thinning is Needed?

- More advanced techniques are available
- Stocking charts and stand density index (SDI) charts
- Stocking gives an idea of available growing space
- BA/ac, trees/ac, and quadratic mean diameter
- Overstocked (above A-line), fully-stocked, and understocked (below B-line)



Longleaf Pine Stocking Chart—Adapted from Kara et al. (2018)

140 ft^2 BA
11” average diameter
Stocking=77%

How Do You Know When Thinning is Needed?

- SDI relates quadratic mean diameter to trees/ac and is not affected by site quality or past management practices
- Determination of tree volumes is not necessary
- Index scores are specific to individual species and can be used to make thinning decisions quickly after a standard inventory

<u>Loblolly pine example</u>

- Greatest theoretical SDI value a stand could reach is 450
- Stands begin to self thin at 50-55% (225-247) of 450
- Thinning is usually conducted when the stand reaches 45% of 450 (≈200-205)
- Thinning should reduce SDI to 30% (135) of 450

Basal area (ft^2 per acre)	Trees per acre									
	100	200	300	400	500	600	700	800	900	1000
40	78	90	97	103	108	112	115	118	121	124
50	93	107	116	123	129	133	138	141	145	148
60	108	124	134	142	149	154	159	164	167	171
70	122	140	152	161	168	175	180	185	189	194
80	136	156	169	179	187	194	200	206	211	215
90	149	171	186	197	206	214	220	226	232	237
100	162	187	202	214	224	232	240	246	252	257
110	175	201	218	231	242	251	259	266	272	278
120	188	216	234	248	259	269	277	285	292	298
130	200	230	250	264	276	287	296	304	311	318
140	213	244	265	280	293	304	314	322	330	337
150	225	258	280	296	310	321	332	340	349	356
160	237	272	295	312	326	338	349	359	367	375
170	248	285	309	328	343	355	366	376	385	394
180	260	299	324	343	359	372	384	394	403	412
190	271	312	338	358	374	388	401	411	421	430
200	283	325	352	373	390	405	417	429	439	448

Target Area

Pre- and post-thinning targets

Longleaf Pine SDI Diagram

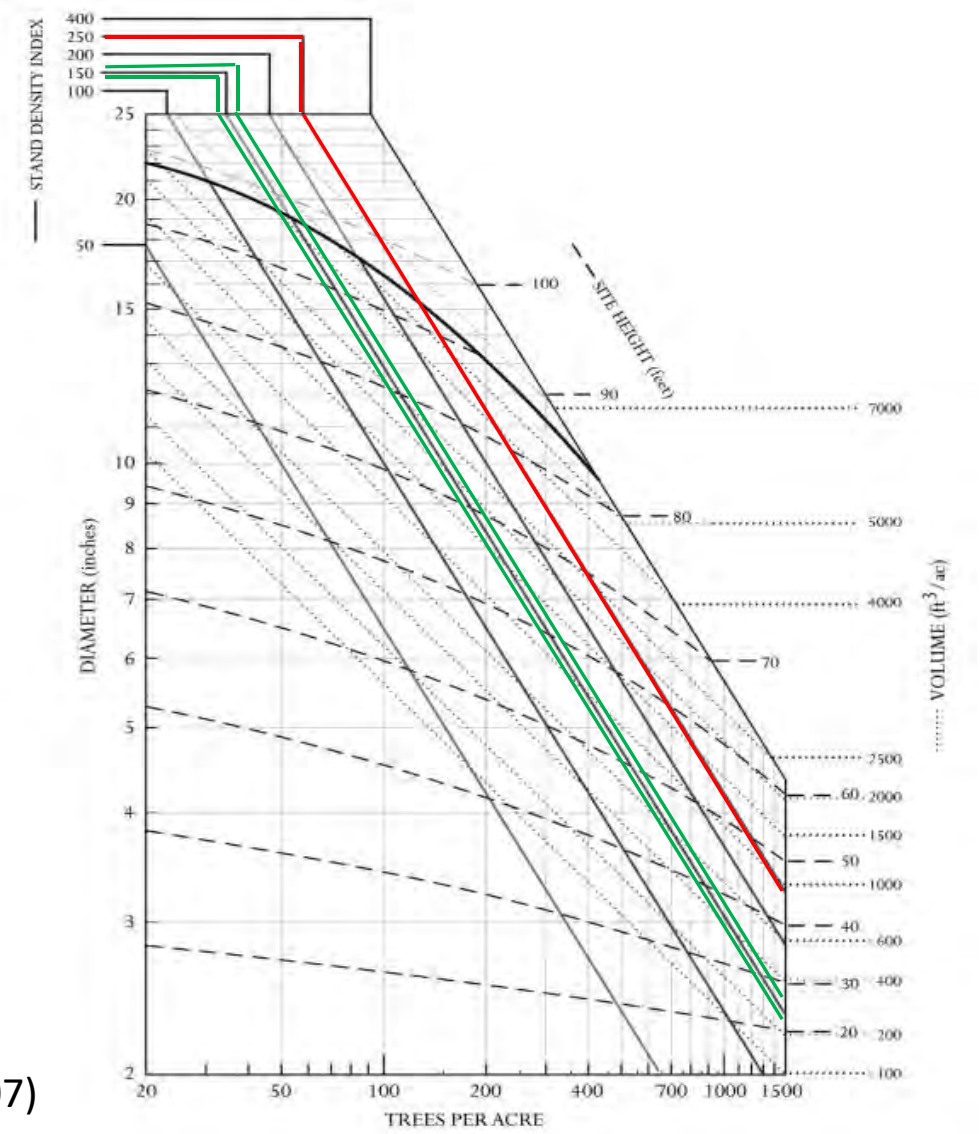


Figure 2. A density management diagram for even-aged longleaf pine stands.

From Shaw and Long (2007)

Maximum SDI=400

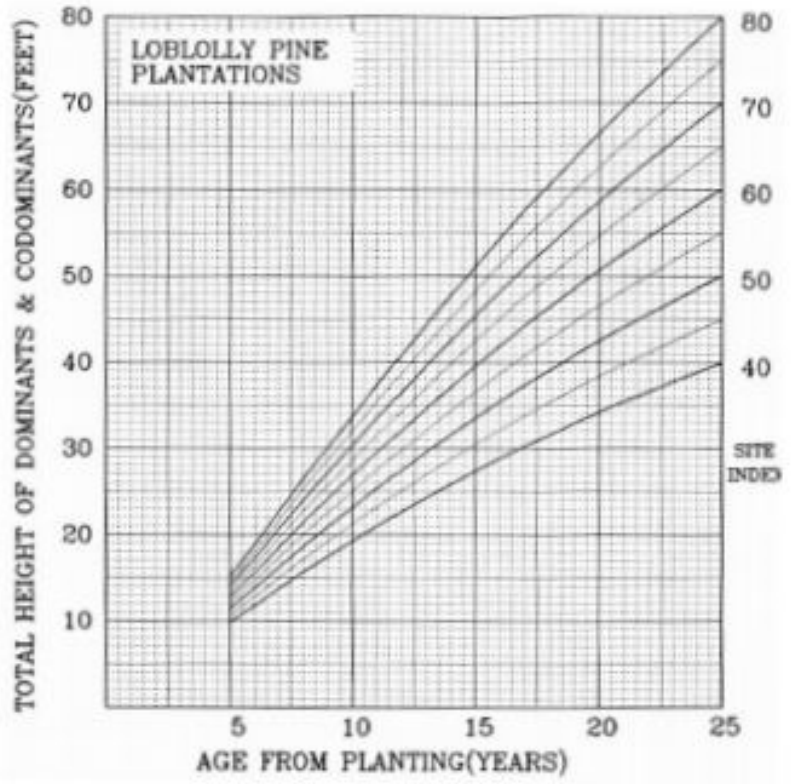
Mortality occurs at ≈ 250 (red line)

Intraspecific Competition @ 100

Thinning should occur between 140 and 160 (green lines)

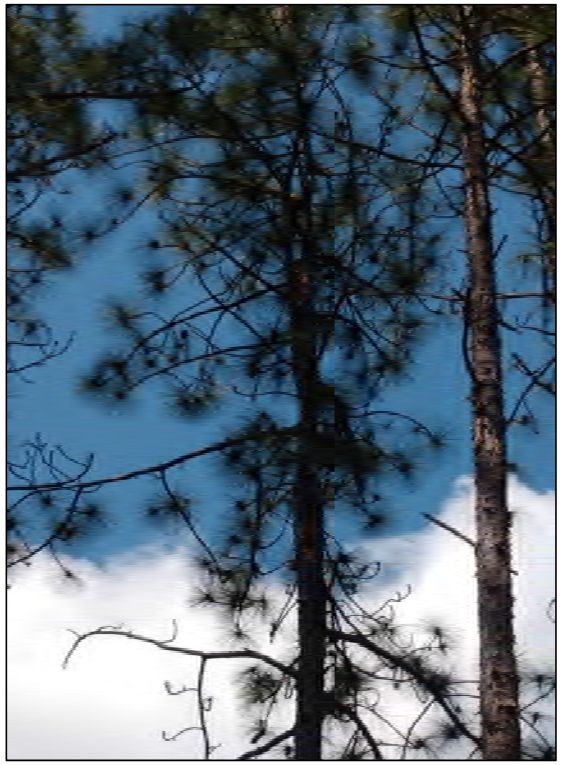
Thinning Rules of Thumb

- Thin to a basal area equal to the site index of the stand if unsure of basal area to thin to
- If a stand is thinned late, do not thin as heavily (do not thin to the site index level)
  - Rate of production slower-higher BA needed to maintain yields
- It is important to have good and thorough inventory data to be able to properly thin a pine stand
- Stands that are thinned more than once--each thin should keep better residual stems

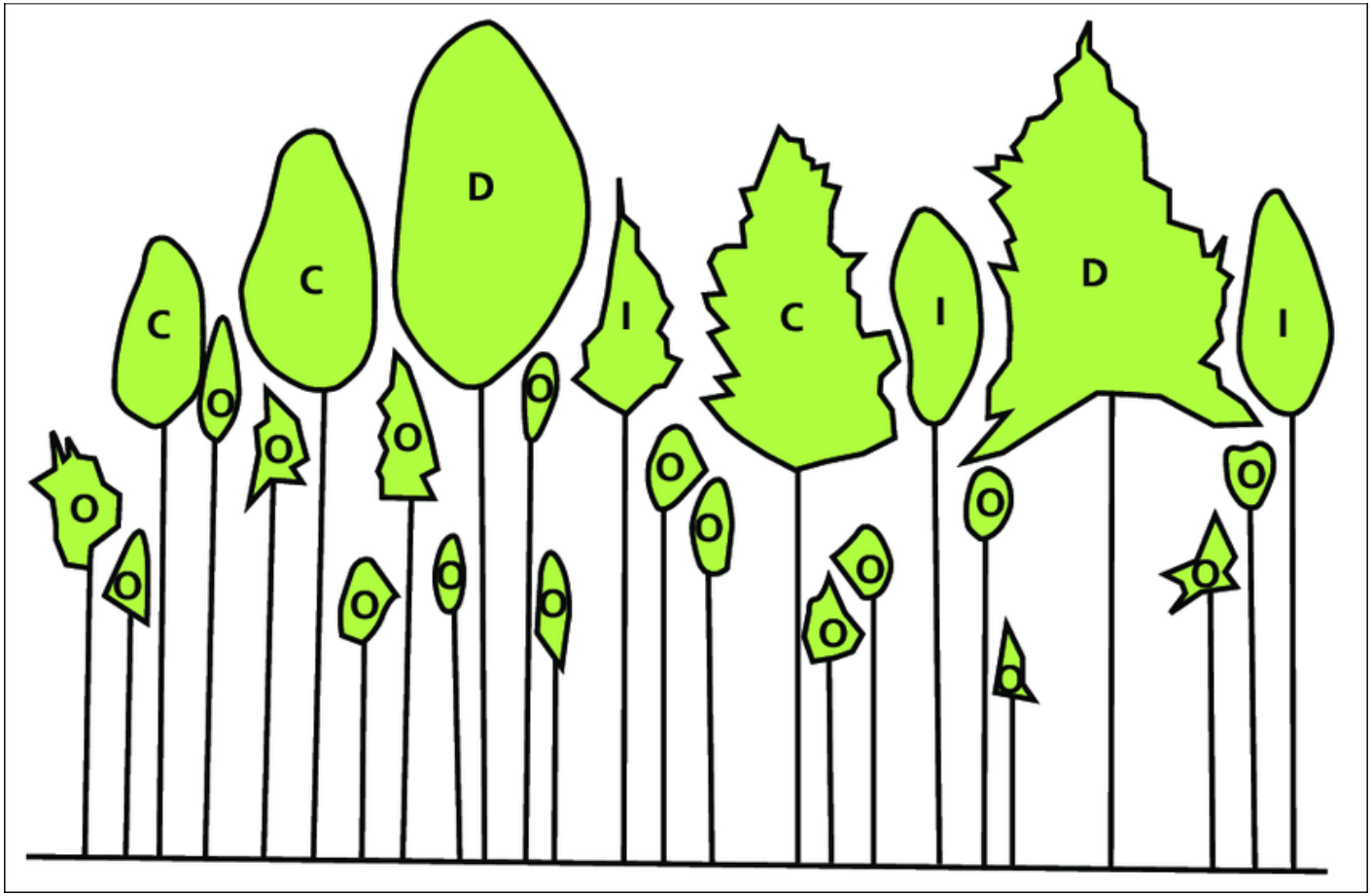


Target Trees for Removal

- Several factors should be considered when removing individual trees
- Diseased and damaged trees
- Deformed trees—forks, ramicorn branches, and heavy branch whorls
- Size—crown class (D, CD, I, S), height, live crown ratio, and dbh



Crown classes can be very important for choosing trees to cut during a thinning



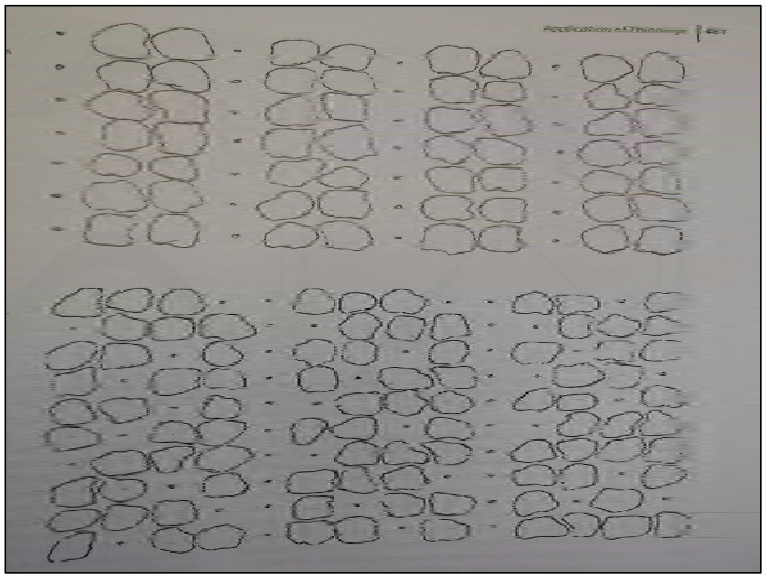
Thinning Timing

- Timing is critical during certain years
- Scattered bark beetle infestations in same and adjoining counties—thinning postponed to winter months (access dependent)
- Widespread bark beetle infestations in same and adjoining counties—thinning postponed until activity subsides
- Stands with high annosus root rot hazard (greater than 65% sand in first 12” of the soil profile on droughty upland sites) should be thinned during the summer

Thinning Methods

- Selective and systematic methods—more selective methods (e.g. crown or high, low, and free thinnings)
- Selective—removes trees of lower growth potential such as small, diseased, or overtopped or suppressed/poorly formed trees
- Systematic—removes a fixed proportion of trees
  - Removals are oriented along planting rows or corridors
- May be used exclusively of one another or together (more common in pine plantations)

Thinning Methods



Adapted from Ashton and Kelty (2018)

- Combination thinning—3rd, 4th, 5th, or occasionally 6th or 7th row removal-operator choice along rows
- Strip + mark thinning done in natural stands—a predetermined width of trees are removed and trees may be removed in leave strips
- Free thinning-trees with issues removed first then considerations for spacing and position are made

Thinning Methods-Precommercial Thinning

- May be needed in naturally regenerated loblolly and occasionally shortleaf pine stands following good seed years
- Strip thinning-cutting or crushing trees in parallel strips-improve growing space for trees on edge of leave strips
  - Allows for faster crown differentiation
  - Drum chopper, bulldozer, brush cutter, etc.

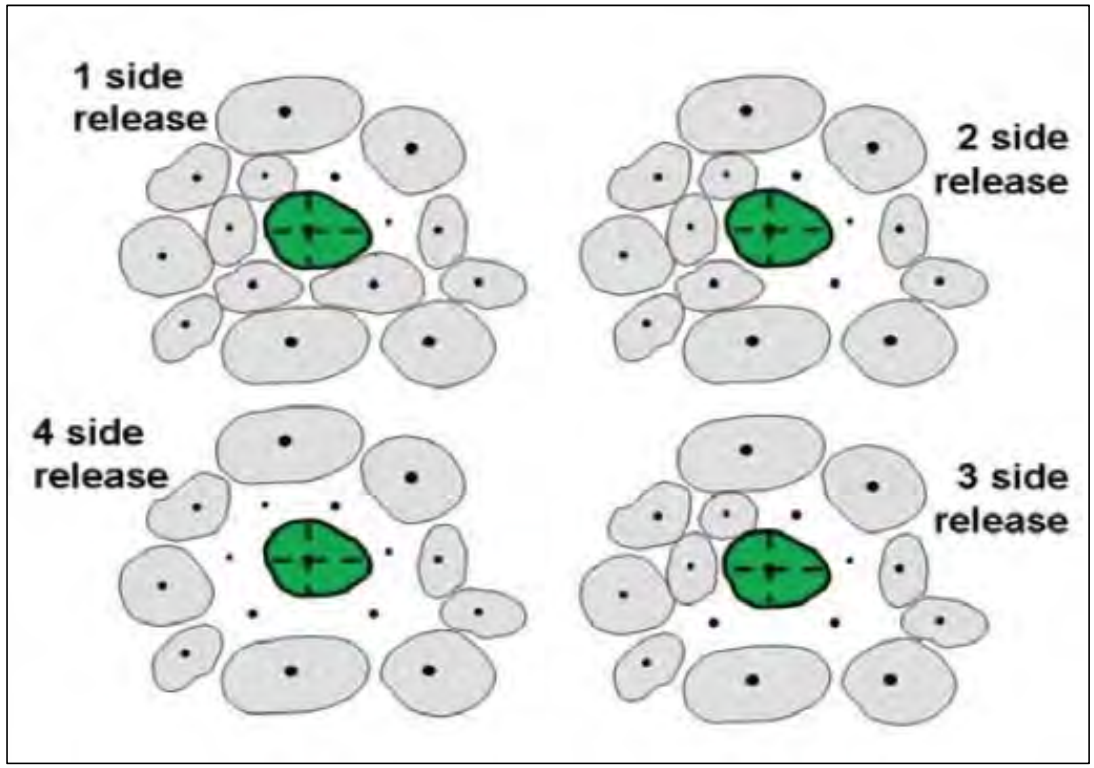
Note the cut trees left in place. Photo: Stephen Peairs

Thinning Methods-Precommercial Thinning

Precommercial thinning using a drum chopper

Precommercial thinning by a Seppi or mulch mower

Crop Tree Release



Miller et al. 2007

Crop Tree Release Introduction

- *Crop tree release* is the selection and release of desirable trees by removing adjacent competing trees in immature stands
- Purpose --- increase growing space, increase growth rate, increase proportion of highly-valued species in the stand (MUST have high value species—work with consulting forester to determine local markets)
- Pine or hardwood stands?
  - Performed more often in hardwood stands with potential for high value trees (stave logs, veneer logs, etc.) more so than pine stands—economic considerations

Crop Tree Release Introduction

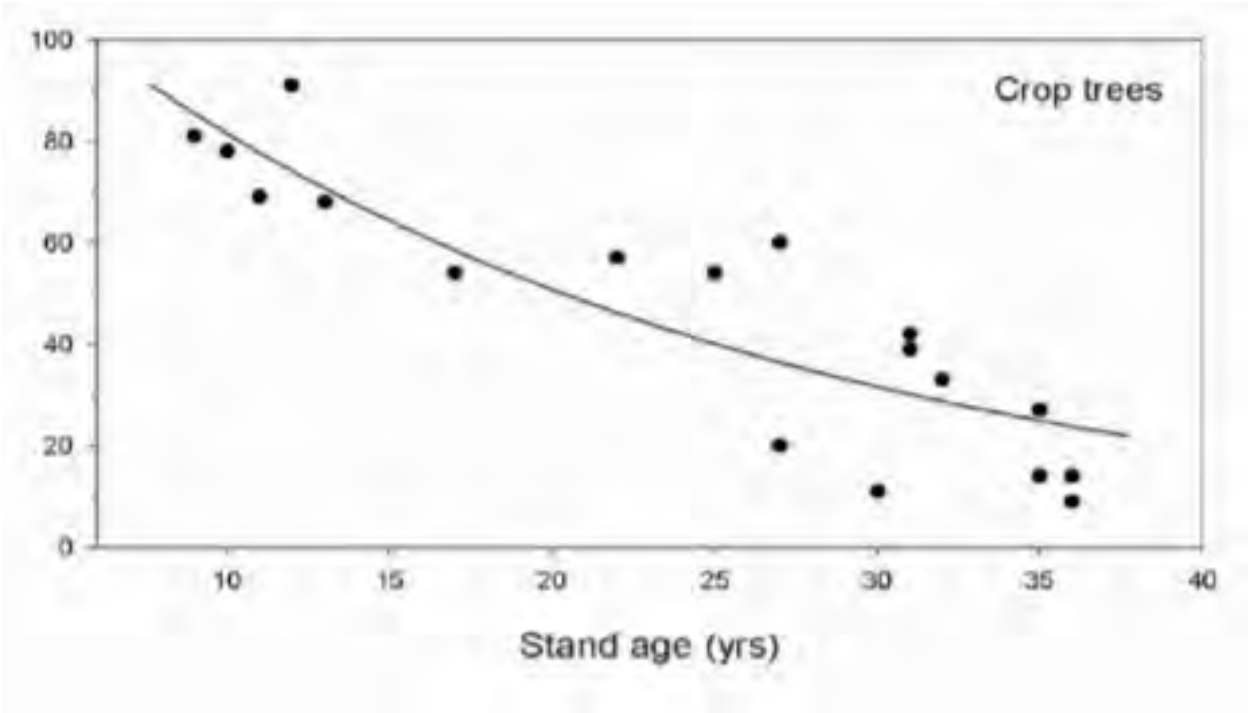
In application

1. Target 30-50 crop trees per acre—will vary by stand age when release is conducted (next slide)

2. Use crown touching technique, release on at least 2 and preferably 3 or 4 sides --- judge differences in cost of treatment

3. Remove only trees interfering with horizontal crown expansion

Crop Tree Release Introduction



Miller et al. 2007

Crop tree density per acre varies by age

Crop Tree Release Introduction

In application

4. Apply in overstocked, young stands where form and/or butt log has been established after crown closure
   - Usually hardwoods that are 15-40 years old
   - Consider longevity of crop tree species (e.g. white oaks usually live longer than red oaks)
5. Competing trees may be mechanically cut or girdled, and/or chemically (herbicide) removed
   - Mechanical felling cheaper than herbicide release BUT more labor intensive—herbicides more efficient on larger acreages and in younger stands

Crop Tree Release Introduction

Avoid Trees with

- Live crown ratios < 33%
- Most intermediate & and all suppressed crown classes
- Flat-topped crowns

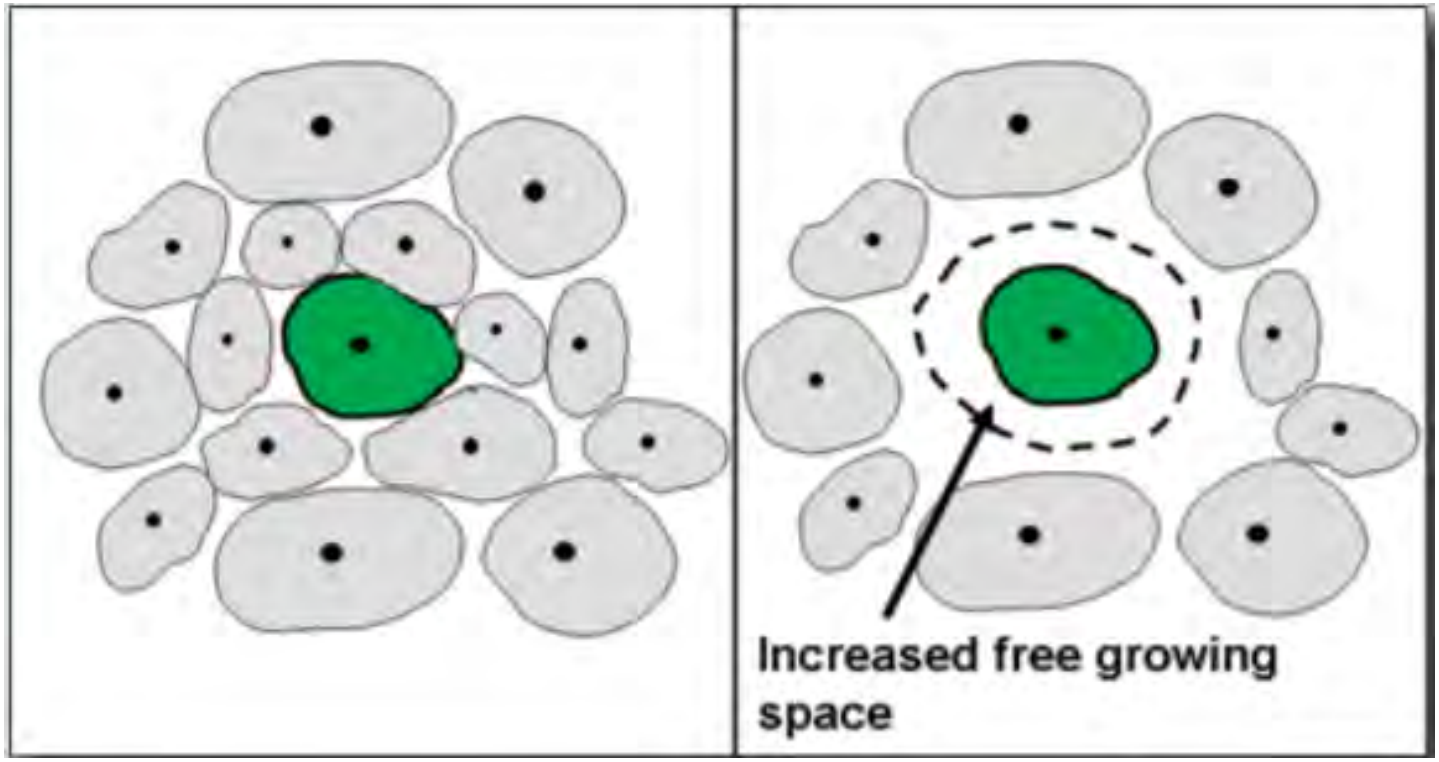
Usually these indicate low-vigor, non-responsive trees

- Also avoid trees with defects (e.g. forks and plentiful knots) and diseased (e.g. butt rot) or insect damaged trees

Crop Tree Release Benefits

- Growth rate is enhanced, rotation is shortened
- Better trees, improved form & grade
- Better sites
- Primary Factor ---- Adjusts species composition. Greater proportion of higher-valued species in the stand!

Crop Tree Release Operations



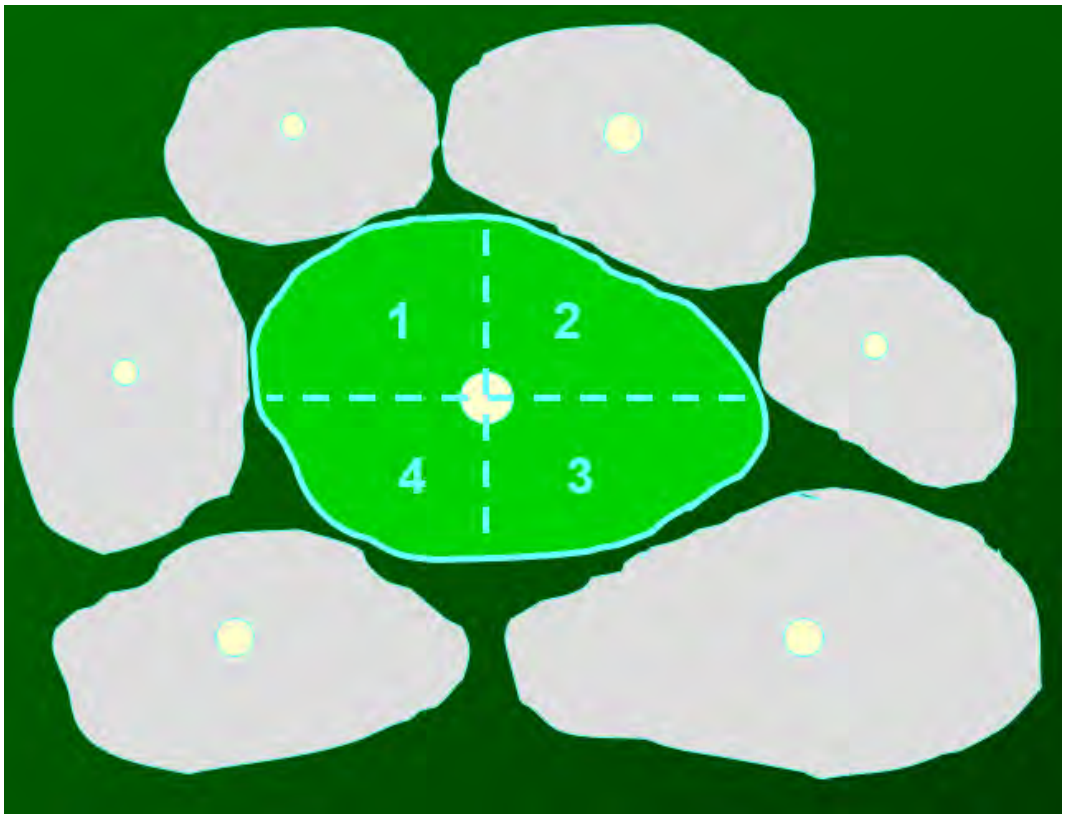
Miller et al. 2007

Improve horizontal growing space for crop tree (green) crown

Crop Tree Release Operations

Divide crown into four sides

Extent of release is based on number of sides where all touching trees at similar level are cut



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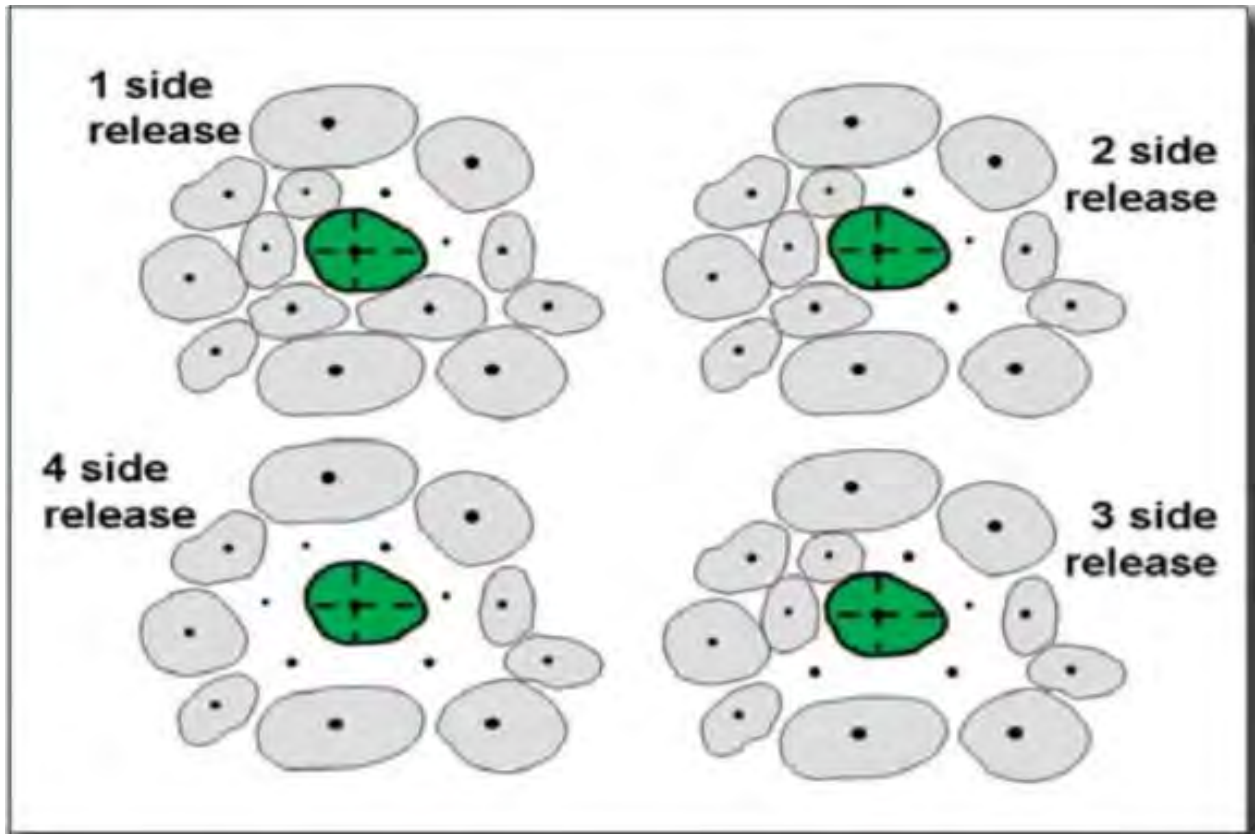
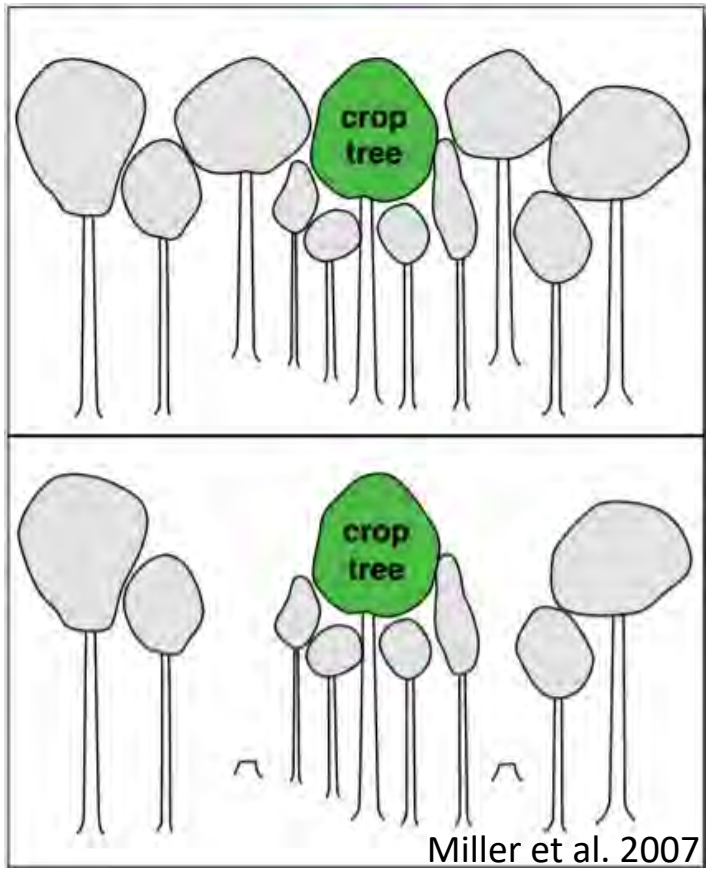


Miller et al. 2007

Crop Tree Release Operations



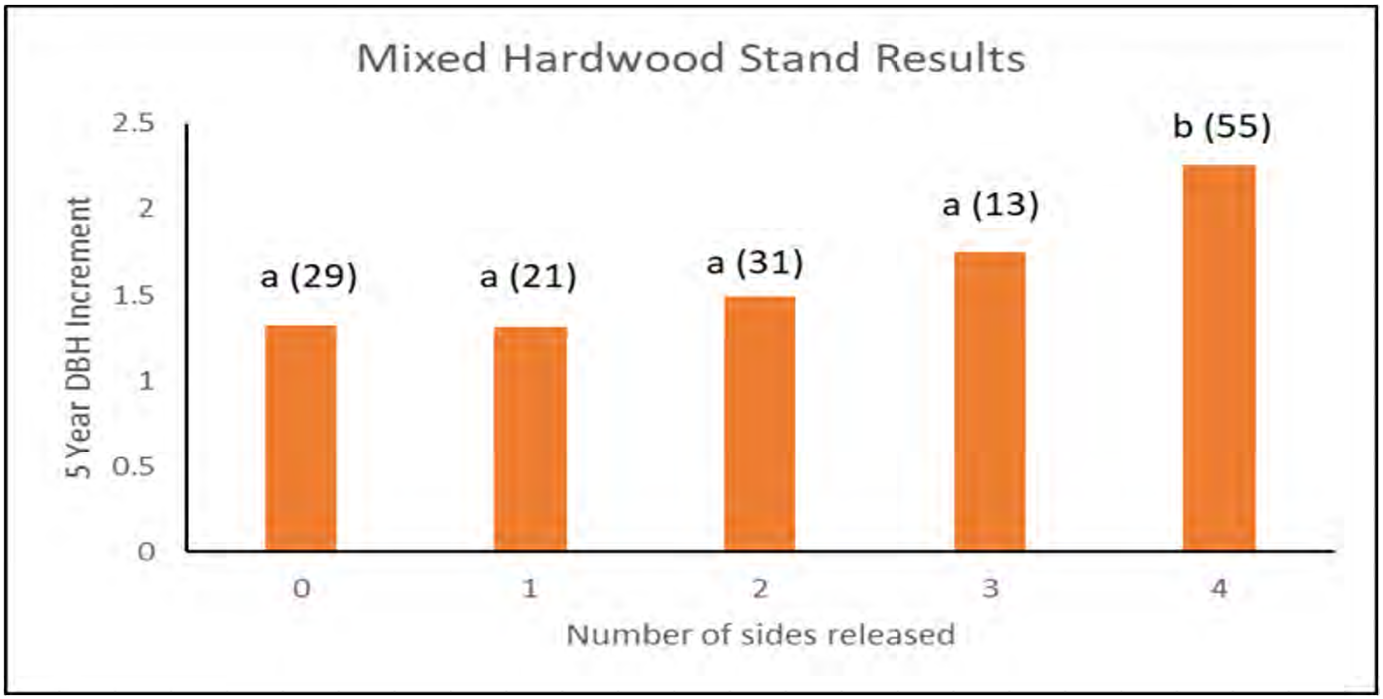
Miller et al. 2007

- Subordinate trees in weak intermediate or suppressed/overtopped crown positions below the main crown of the crop tree do not need to be removed
- Over time these trees may improve wood quality of the crop tree's lower bole by acting as 'trainer trees'

Crop Tree Release Results

Results from 12-year-old mixed hardwood study in West Virginia Lamson et al. (1990)

Number of trees in parentheses



Columns with the same letter are not statistically different at the P=0.05 level.

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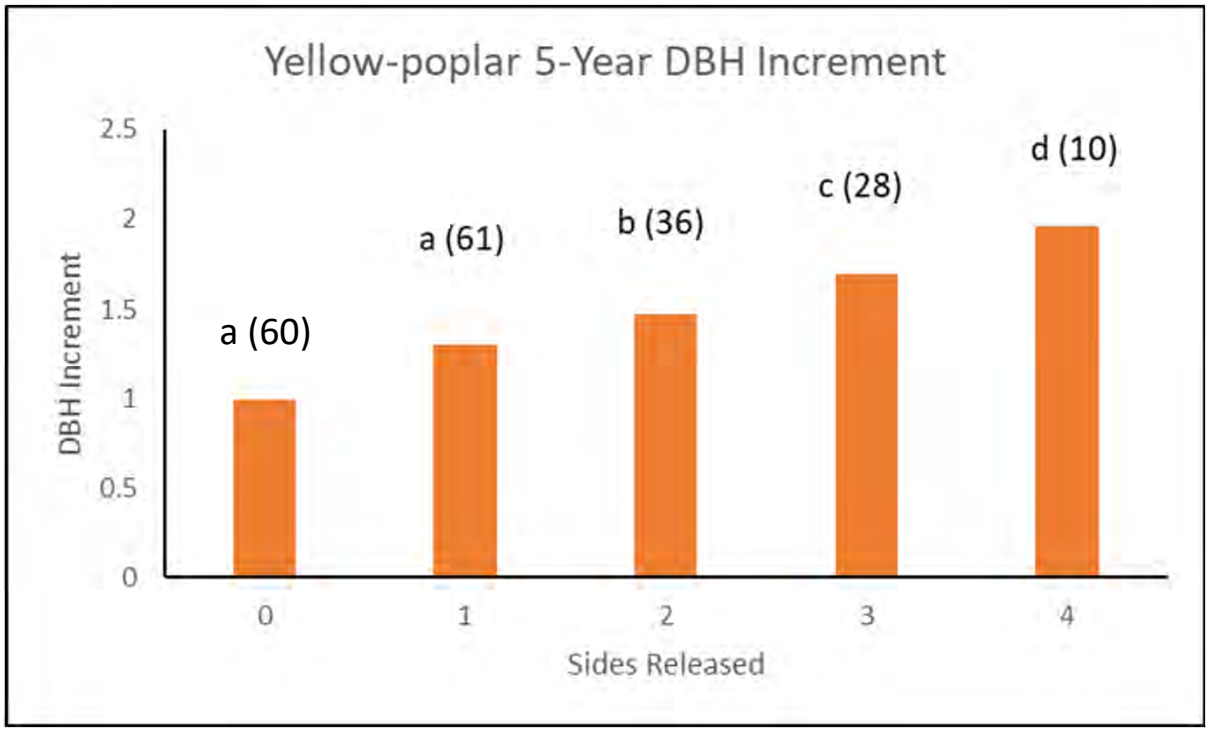

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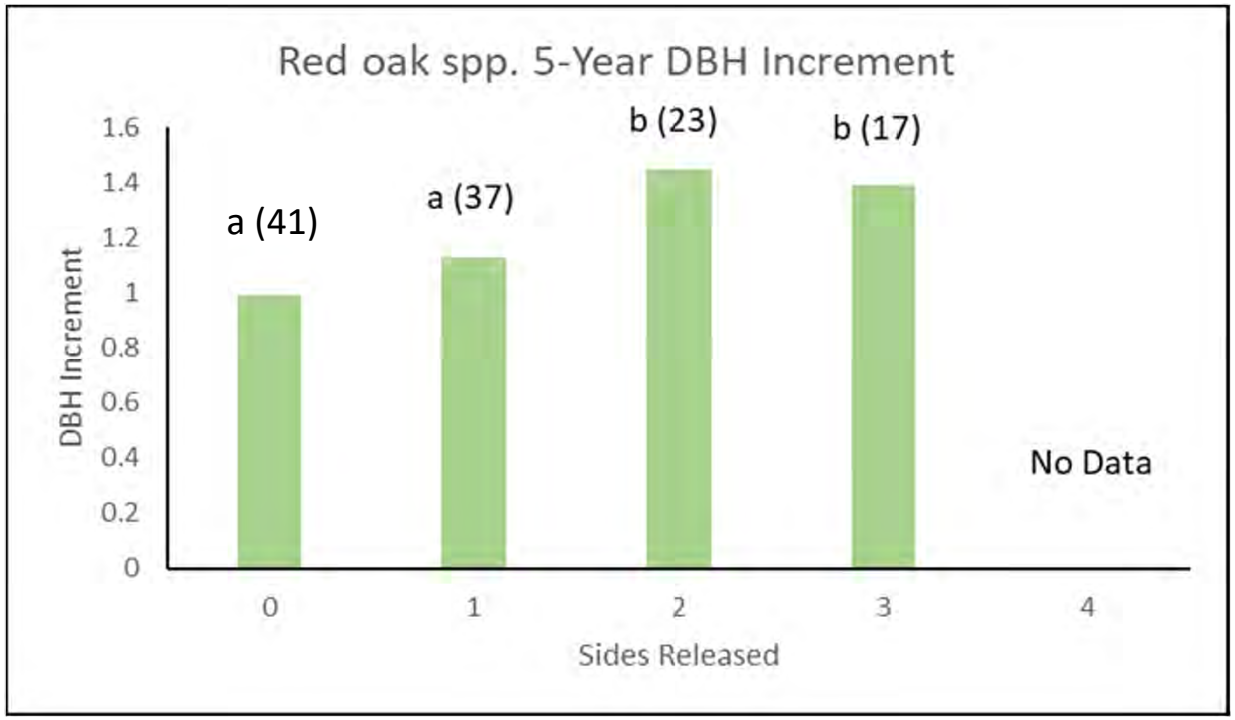

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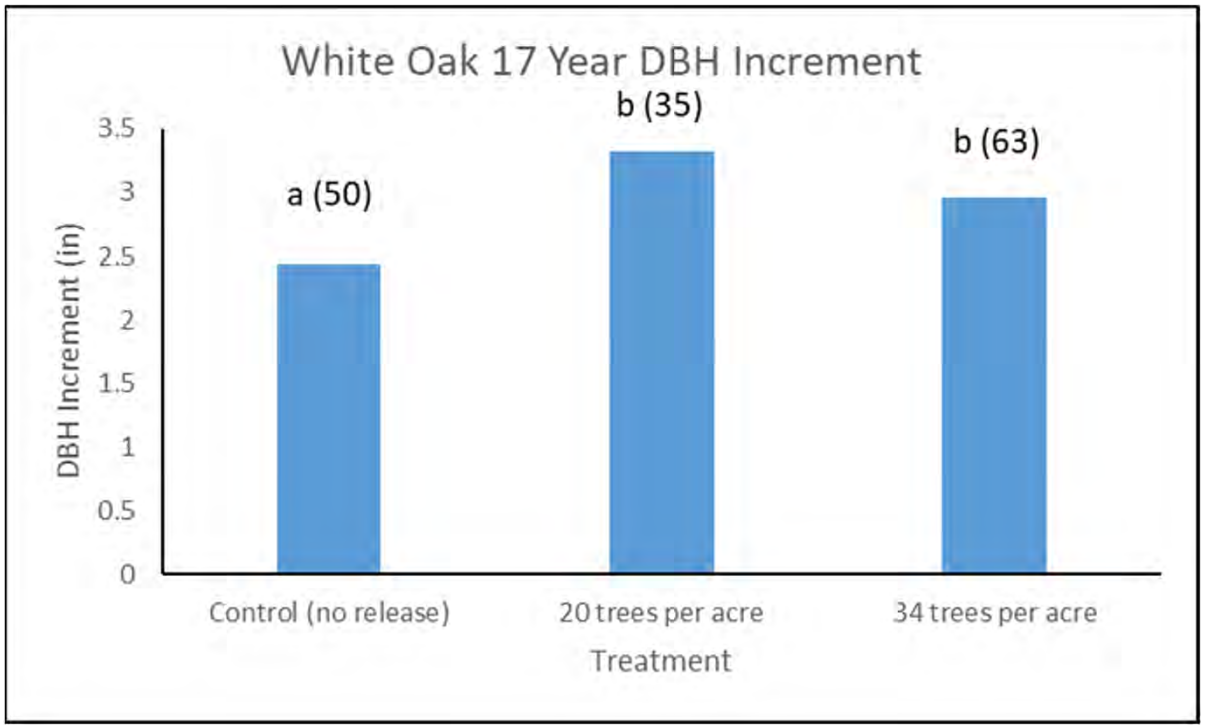
Crop Tree Release Results

Results from a white oak crop tree release study in Kentucky-Miller and Stringer (2004)

Number of trees in parentheses



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Crop Tree Release Summary

- Be sure markets exist for high value hardwoods in your area-select high value species
- Should be conducted in immature stands in stand exclusion stage of development
- Avoid trees with poor stem form
- Three and four side releases tend to perform best; do not remove suppressed stems near crop trees as they can act as trainer trees


Prescribed Fire

Prescribed Fire Introduction

- Prescribed fire (especially multiple burns conducted during a desired range of conditions) in pine systems has many benefits including:
  - Wildfire risk reduction—hazard fuel reduction
  - Habitat improvement for some wildlife species
  - Improved stand appearance
  - Increased stand accessibility
  - Reduce competing vegetation


Hazard Fuel Reduction
UGA0908003


Improved wildlife habitat for some species
Photo Courtesy: John Kush


Photo Courtesy of Jo
Improved stand appearance and accessibility

Reduction in competing vegetation

Photo: Holly Campbell

The Issue

- Pine dominated stands are not climax forest types
  - Transitional in terms of forest succession
- In the absence of disturbance, pine stands transition into pine-hardwood mixtures and eventually mixed hardwood stands
  - Successional rate faster on better productivity sites
- Hardwoods hamper growth of pines and reduce habitat and forage opportunities to many wildlife species
  - Herbaceous vegetation development

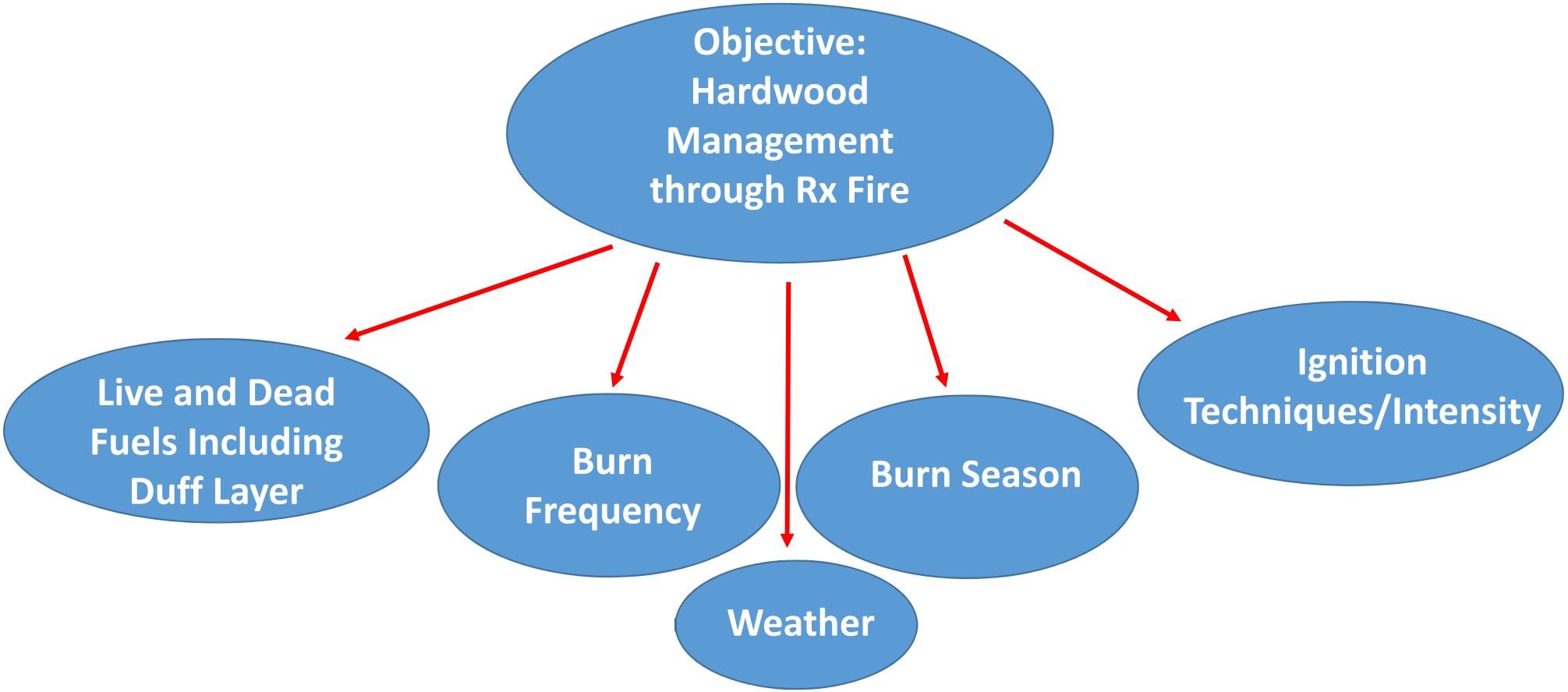
The Issue

- Most SE hardwoods resprout, burns only top-kill the stem below specific dbh thresholds
  - Some species such as oaks and hickories more resilient to repeated burning than mesic species such as maples and yellow-poplar
- Burning one time can eliminate seedling and sapling pine species that do not resprout-volunteer pines

What can you do to maintain growth of your pine stands?

- Several management options exist--mechanical, chemical, Rx fire, and combinations--consider them all
- Rx fire is the most economical and can be most conducive method to promote herbaceous vegetation development in the understory
- Underburning pine stands to control invading hardwoods has been recognized as a sound management tool for decades by federal, state and private forestry professionals
- Surveys have shown vegetation management through Rx fire as the 3rd most cited reason to burn on state and private lands (Haines et al. 2001)

Prescribed Fire Considerations



Fuel Characteristics of Southeast Pine Forest Types

- Dead fine fuels (<0.25”) or pine needles are primary carrier of fire in pine stands
- Dead hardwood leaves do not spread fire as effectively as pine needles
- Dead fine fuel moisture should range from about 8-15+% for most understory burns—dead 10 hr fuels (0.25-1”) will be usually be consumed below about 15% fuel moisture; charring and smoldering below 20% but greater than 15%
- Beware of pine stands that have not burned in more than five years-high fuel loads and/or duff layer
  - Piedmont and Coastal Plain pine stands that have not burned in 40+ years can have forest floor fuel loads of 13+ tons/acre
  - Comparatively, dormant season annually burned pine stands average about 1.5 tons/acre
- Dormant Season-Pine stands tend to have greater dead fuel loading and fewer live fuels
- Growing Season-understory vegetation living, greater live fuel moisture, warmer air temps and higher humidity

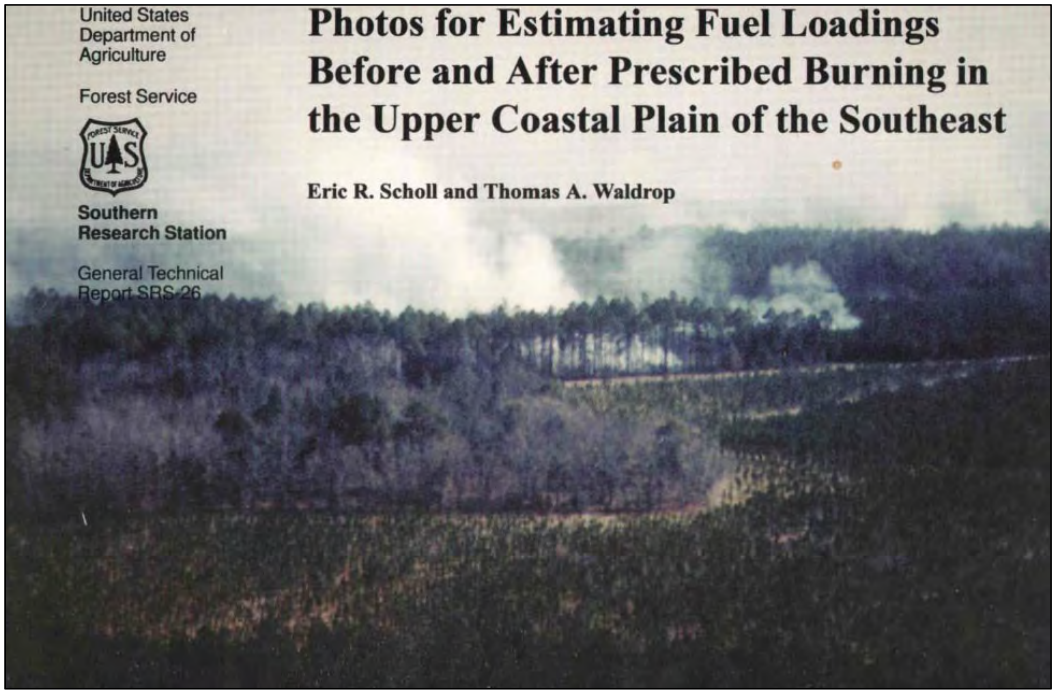
Pine/Hardwood Litter
Medium Fuel Loading
Slash Pine
5.5 tons/acre

Pine/Hardwood Litter
Medium Fuel Loading
Natural
Loblolly Pine
5.8 tons/acre

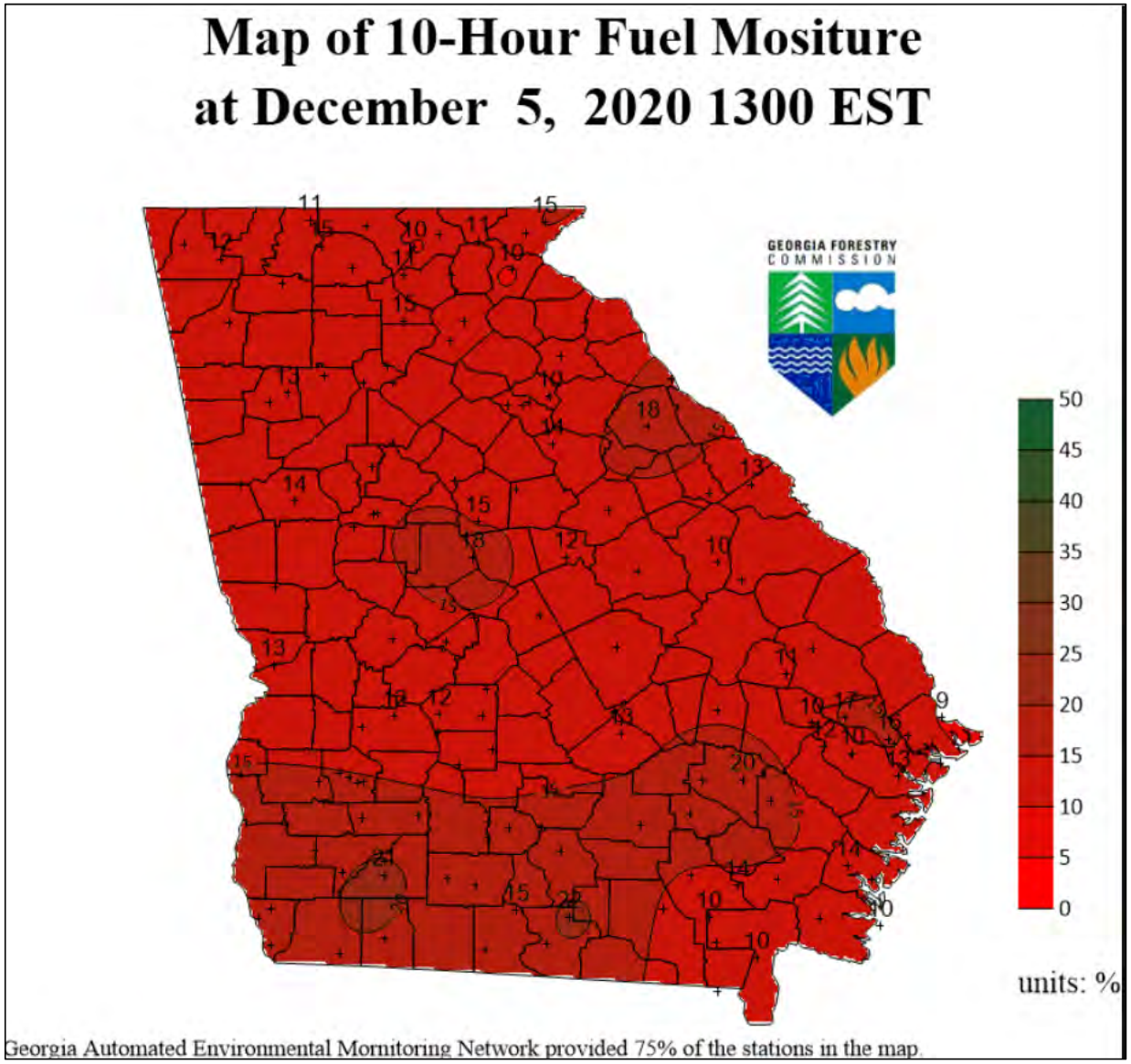
Pine/Hardwood Litter
Medium Fuel Loading
Loblolly Pine
Sawtimber
6.0 tons/acre

Pine/Hardwood Litter
Medium Fuel Loading
Planted
Loblolly Pine
7.2 tons/acre

https://www.state.sc.us/forest/fuelloads.pdf



Photographic fuel guides can help with burning decisions related to fuels—determine fuel loads



http://weather.gfc.state.ga.us/Maps.aspx

Woody Vegetation Reduction Requires Multiple Burns—Burn Frequency

- Regular intervals of Rx fire are needed to suppress hardwood tree and shrub species

- Multiple studies have shown that one Rx fire may reduce stem densities of susceptible species, but many undesirable species such as maples and gums become more plentiful

	Pre-burn 2000		Post 2001		Post 2002	
	Burn	Control	Burn	Control	Burn	Control
Density						
Seedlings (woody stems < 0.5 m height)						
All seedlings	68,480 b (4234)	48,480 a (2480)	138,120 **b** (18742)	58,120 **a** (600)	113,740 **b** (14190)	54,080 **a** (5760)
V. vacillans	34,840 a (5764)	19,360 a (13760)	83,040 **b** (17515)	21,120 **a** (11099)	71,560 **b** (24913)	25,770 **a** (13929)
Other species	33,640 a (6908)	29,120 a (7600)	55,080 a (5929)	37,000 a (6919)	42,180 a (4324)	32,280 a (4199)
Saplings (< 5.0 cm dbh, ≥ 0.5 m height)						
	9100 a (1122)	12,320 a (4480)	5900 **a** (369)	11,840 **b** (4160)	9525 a (1344)	9,480 a (4360)
Total density (seedlings + saplings)	77,580 a (4665)	60,800 a (2000)	144,020 **b** (18971)	69,960 **a** (3560)	122,660 **b** (14932)	63,560 **a** (1400)
Saplings only						
Basal area	2.85 a (0.92)	2.88 a (1.49)	1.23 **a** (1.06)	2.91 **b** (1.16)	1.44 **a** 0.73)	2.44 **b** 1.61)
$H'_{density}$	1.54 a (0.14)	1.52 a (0.23)	1.43 a (0.12)	1.62 a 0.18)	1.46 a 0.10)	1.49 a (0.24)
$H'_{basal\ area}$	1.17 a (0.16)	0.98 a (0.09)	1.22 a (0.07)	1.01 a (0.09)	1.27 a (0.14)	1.13 a (0.08)
S/plot	11.6 a (1.6)	11.1 a (1.9)	12.4 a (1.0)	12.1 a (2.1)	12.8 a (1.5)	11.1 a (1.7)
S/site	26.8 a (2.4)	25.5 a (0.5)	27.8 a (2.3)	27.5 a (0.5)	29.8 a (3.2)	27.0 a (1.0)

Elliott and Vose (2005)

Frequency of Burning

- Georgia Piedmont Rx fire studies with as many as 11 annual burns and seven biennial burns only controlled 85% and 59% of midstory and understory hardwood stems
- Annual burns are impractical for most landowners and managers
  - Most research suggests 2-4 year return intervals to suppress hardwoods in loblolly pine stands
- Understory burns do not usually kill hardwood stems greater than 3-4” dbh (dependent on flame heights and residence time); trees may decline with time especially with drought or other stressors

Frequency of Burning

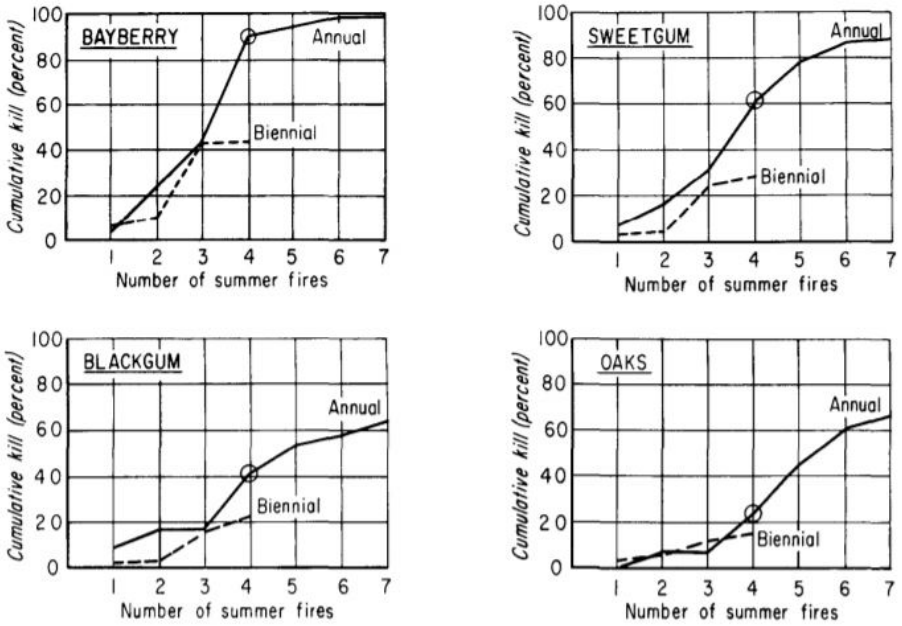


Figure 5. --Cumulative kill of certain understory species in even-aged 40- to 50-year old stands of loblolly pine prescribed burned with a series of summer fires.

Number of burns	Oak		Gum		Others	
	Top-killed	Killed[1] and not sprouting	Top-killed	Killed[1] and not sprouting	Top-killed	Killed[1] and not sprouting
	Percent					
	ANNUAL BURNS					
1	91.2	6.2	97.6	**10.0**	36.0	6.2
2	92.6	21.2	98.8	26.0	90.8	27.6
3	97.6	48.8	100.0	48.2	93.8	47.6
23	98.8	43.8	100.0	47.6	96.0	68.8
4	98.3	46.0	100.0	48.8	96.3	61.2
6	98.3	48.8	100.0	62.6	97.6	63.8
6	98.8	63.8	100.0	60.0	97.6	62.6
7	98.3	66.0	100.0	63.8	97.6	61.2
8	98.8	60.0	100.0	**76.2**	97.6	66.0
9	93.8	62.6	100.0	**77.5**	97.6	73.8
10	98.8	63.8	100.0	81.2	97.6	72.6
11	98.8	71.2	100.0	88.8	97.6	82.6
12	98.8	76.0	100.0	96.0	97.6	86.0
	BIENNIAL BURNS					
1	96.0	6.2	100.0	13.8	96.0	16.0
2	96.0	22.6	100.0	26.2	97.6	51.2
3	96.0	32.6	100.0	27.6	98.8	27.6
4	96.0	43.8	100.0	27.6	98.8	36.0
6	96.0	62.6	100.0	37.6	98.8	40.0
6	96.2	65.0	100.0	41.2	98.8	42.6
7	96.2	72.6	100.0	66.2	98.8	48.8

Lotti et al (1960) and Grano (1970)


Shortleaf pine stand burned every 3 years

When to Conduct the First Burn?

1-2” duff present under freshly fallen needles

- Stands with high dead fuel loads and/or stands not burned in 5-10+ years should receive one or more winter fuel reduction burns
- Conducted soon before and/or after rain to avoid duff consumption
- These burns can have good hardwood top-kill in some instances

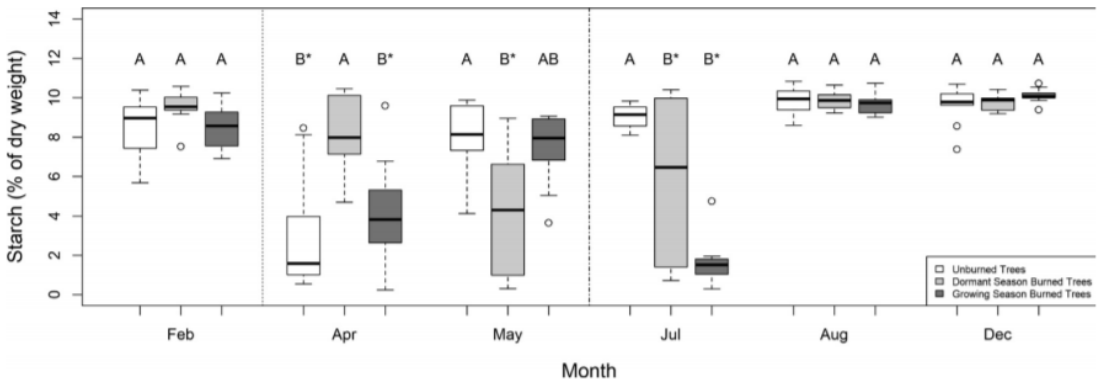
Season of Burning Implications

- Optimal season of burn to control under and midstory hardwoods less agreed upon in the literature
- Most older literature reports that growing season burns conducted soon after leaf out results in greater mortality
  - Dormant season burn results in more sprouts per stump
- New research may change thinking on this
- Study with 2-year-old sweetgum reports greater mortality with dormant season burns—no difference in root carbon reserves throughout the year (Ruswick et al. 2021)--results may vary by species
  - Recommend burning anytime weather and fuel conditions will result in top-kill

DC1

Season of Burning Implications

Sweetgum root starch percent concentration by burn season and month



Ruswick et al. (2021)

Maple and oak root starch percent concentration by season of burn

Species	Month	Starch concentration (% dry weight)	Total root dry weight (g)
Acer rubrum		3.21 ß	7.061 α
	April	5.00 b	1.677 d,e
	May	0.82 c	1.207 e
	October	12.28 a	18.311 a
Quercus rubra		10.28 α	6.495 α
	April	13.29 a	4.710 c,d
	May	4.45 b	2.989 d,e
	October	13.09 a	10.993 c
Quercus alba		9.00 α	3.850 ß
	April	11.49 a	3.289 d
	May	4.86 b	3.119 d,e
	October	10.66 a	5.587 c
All species			
	April	9.93 A	3.294 A
	May	3.38 B	2.294 A
	October	12.19 A	11.819 A

Huddle and Pallardy (1999)

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Summary

- Intermediate treatments are useful to maintain stand health, increase or maintain pine or hardwood growth rates, and reduce competing vegetation
- Stands must be in a condition where a positive growth response will occur—offset financial costs
- Tailor the intermediate treatment(s) to stand type and conditions
- Work with a professional forester when considering intermediate management options


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