Uneven-aged Silviculture

The Selection System in Acadian Mixed-Conifer Forests

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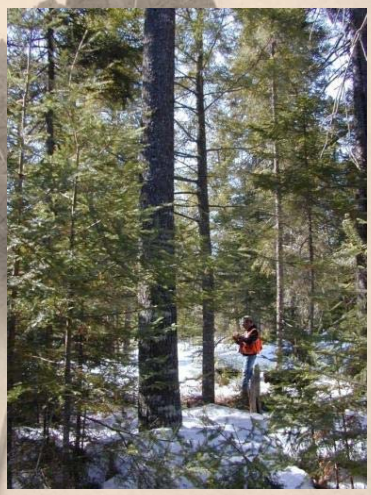
Uneven-aged Silviculture

- Uneven-aged silviculture
  - create and maintain stands with three or more distinct age classes
  - selection cuttings
- "Multi-aged" includes two-aged variants



Selection Cuttings

- Simultaneously
  - harvest
  - tend
  - regenerate
- Frequent, relatively equal harvest cuttings
  - Cutting cycle (no rotation)

Origins of Balanced Selection

- Normal yield tables
- Regulated forests
- Age classes occupy equal area
- Sustained yield

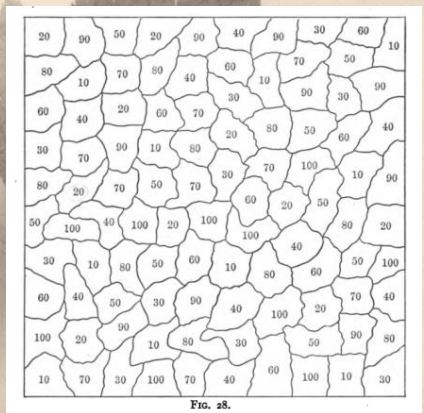


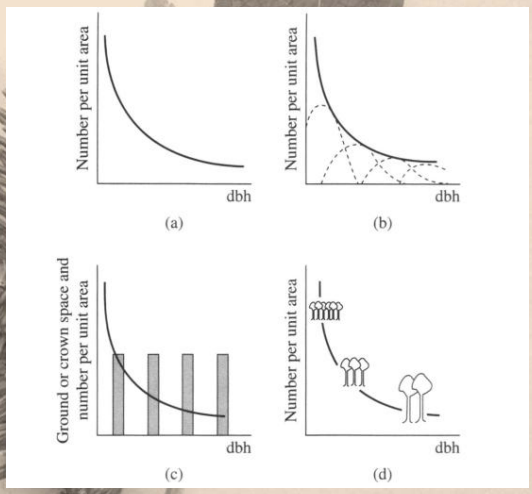
FIG. 28.

A portion (one acre) of an ideal single tree selection stand managed on a rotation of 100 years under a 10 year cutting cycle. Ten age classes are represented each occupying approximately one-tenth of the area. The numbers indicate the age of the trees.

Hawley 1921

Stand Structural Goal

- Balance
- Age – size correlation



Nyland 1987

Managing Selection Cuttings

- Target dbh distribution ("target structure")
- Compare actual to target; harvest accordingly

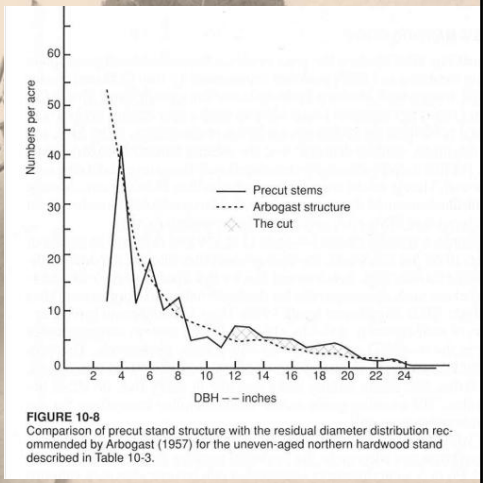
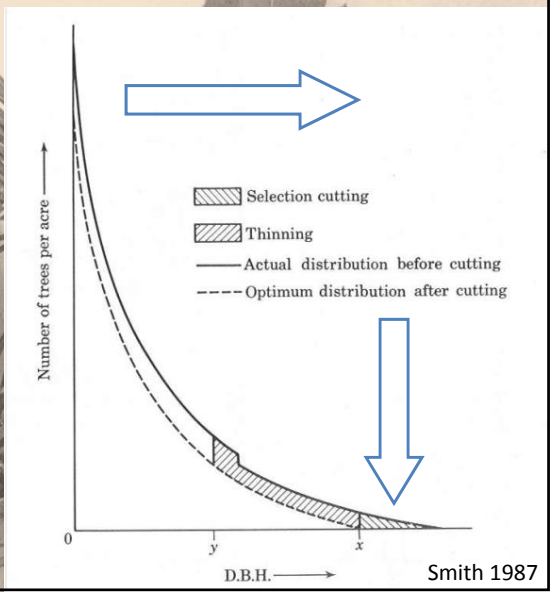


FIGURE 10-8
Comparison of precut stand structure with the residual diameter distribution recommended by Arbogast (1957) for the uneven-aged northern hardwood stand described in Table 10-3.

Nyland 2016

Dynamics of Balanced DBH Distributions

- Growth pushes distribution to the right
- Cutting pulls it down



Smith 1987

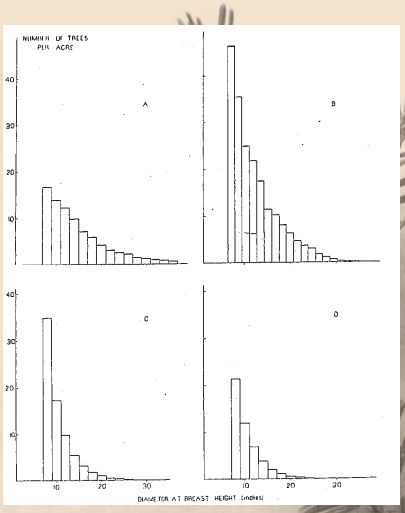
Why Practice Selection Cutting?

- Continuous forest cover
- Mature trees
- High vertical structural diversity
- Sustained yield from small parcels
- Emulates small-scale natural disturbance regimes

Challenges

- Prone to misapplication
  - Tendency to high-grade, diameter-limit cutting
  - Inattention to regeneration
- Potential for residual stand damage
- Windfirmness
- Cannot protect regeneration during spruce budworm outbreaks

q structure



Meyer 1952

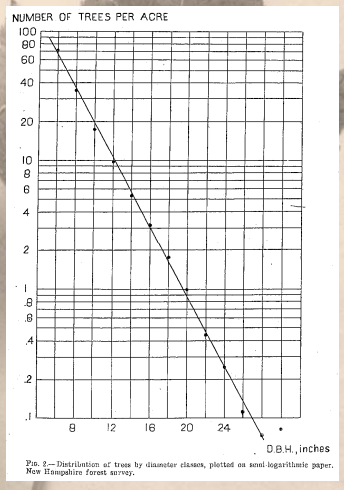


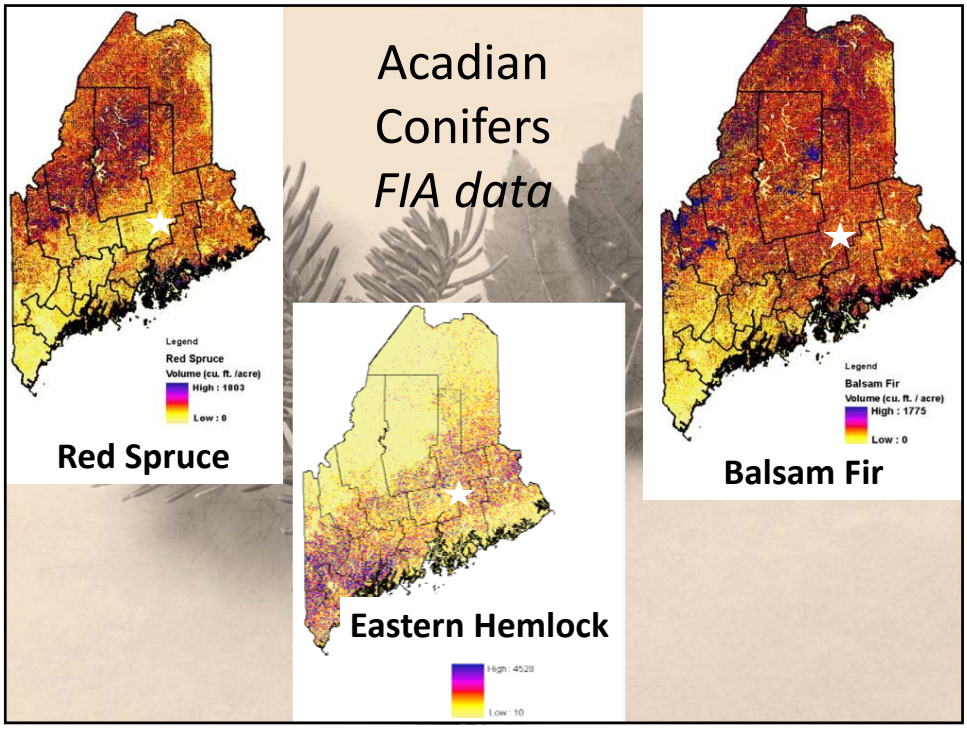
Fig. 2.—Distribution of trees by diameter classes, plotted on semi-logarithmic paper. New Hampshire forest survey.

Based on de Liocourt 1898

Penobscot Experimental Forest

- 3800-acre forest
- Located in central Maine
- U.S. Forest Service
  - Long-term silviculture experiment
  - 65+ years of research

Acadian Forest



Selection System (1950-present)

- Single-tree selection
- BD*q* structural goal
- 19 stands
- 5-, 10-, 15-, 20-year cycles
- 100+ selection cuts

M. Westveld, A. Hart, W. Kidd, T. McLintock

Marking Guidelines

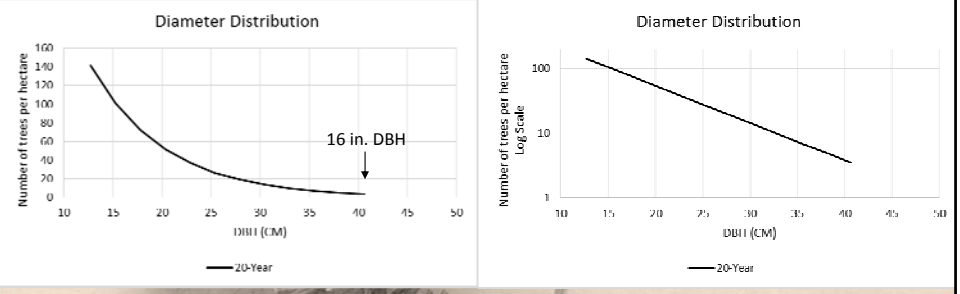
- BD*q* structural goal
- Control quality and vigor
  - Remove cull and high risk trees, undesirables species
- Control composition
  - Increase spruce, decrease hemlock and fir

Composition Goal (1950)

		Observed 1950
Spruce spp.	35 – 55%	16%
Balsam fir	15 – 25%	20%
E. hemlock	15 – 25%	30%
N. white-cedar	5 – 10%	12%
Pine spp.	5 – 10 %	4%
Birch spp.	5 – 10 %	4%
Other	5 – 10%	14%

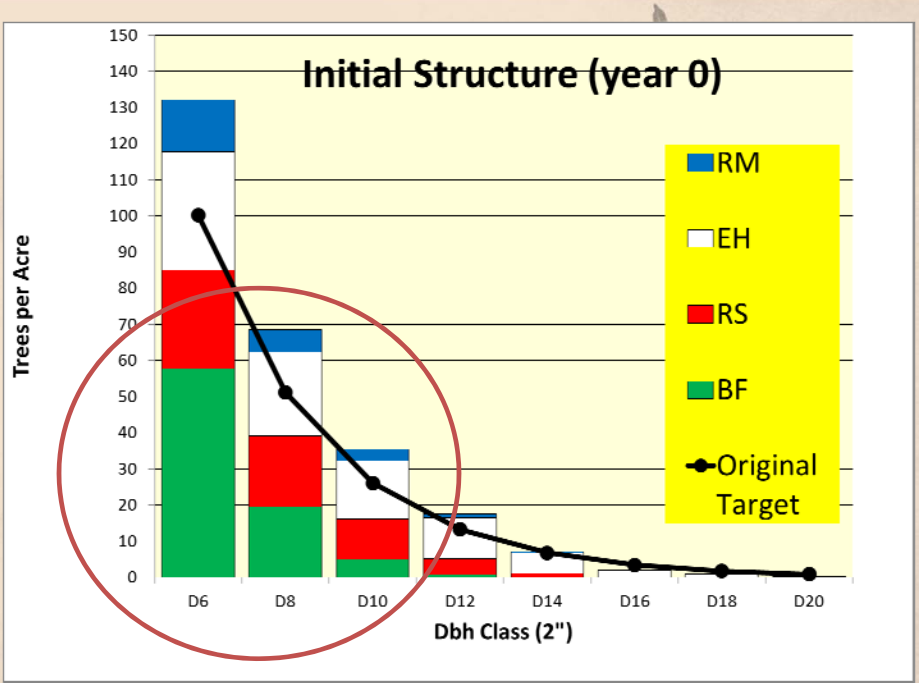
Structural Goal

- Example: 20-year cycle



Note: metric units

- *q* factor = 1.96 on 2-inch DBH classes
- Merchantable-size BA = 60 to 90 ft^2/ac



The Selection System of Silviculture in Spruce-Fir Stands—Procedures, Early Results, and Comparisons with Unmanaged Stands

by Robert M. Frank and Barton M. Blum

q= 1.96 on 2" classes

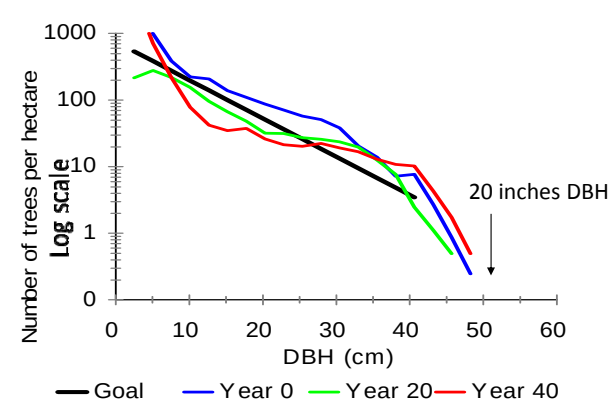
Table 1.—Balanced diameter-class distributions ("q" = 1.4): theoretical stand stocking goals at the start of 5-, 10-, and 20-year operating intervals (expressed as number of trees per acre and square feet of basal area per acre).

Dbh Class	5-year Operating interval		10-year Operating interval		20-year Operating interval	
	Trees	Basal area	Trees	Basal area	Trees	Basal area
in.	*no.*	*ft²*	*no.*		*no.*	*ft²*
5	78	10.6	68		57	7.7
6	56	10.9			40	8.0
7	40	10.6			29	7.7
8	28	9.9		7.7	21	7.2
9	20	9.0		7.9	15	6.5
10	15	7.9		7.0	11	5.8
11	10	6.8		6.0	7	5.0
12	7	5.8		5.1	5	4.2
13	5	4.9		4.1	4	3.6
14	4	4.0			3	2.9
15	3	3.3	2		2	2.4
16	2	2.7	2		1	2.0
17	1		1	1.5	—	—
18	1		1	1.5	—	—
19	1		—	—	—	—
Total	271	92.7	237	79.6	195	63.0
1-4	774	23.3	683	20.5	565	17.0
Grand total	1045	115.0	920	100.0	760	80.0

Forest Service Research Paper NE-425 Frank and Blum (1978)

Stand Structure: DBH Distribution

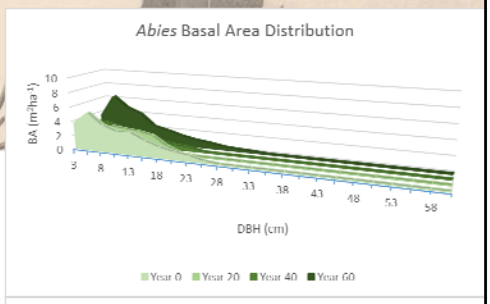
Example: 20-year cycle

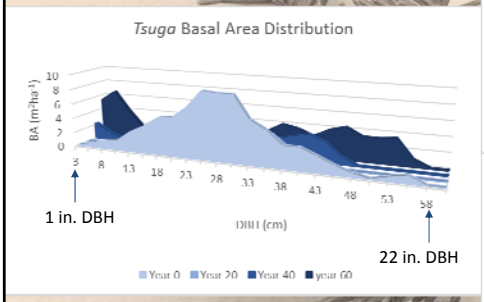


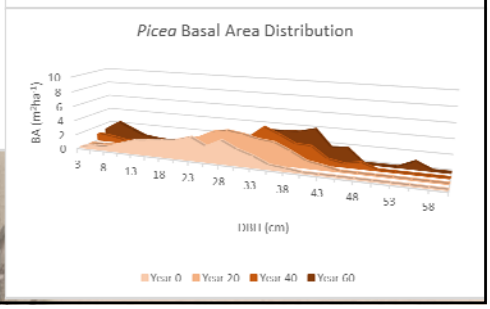
Note: metric units

Species Composition

Example: 20-year cycle



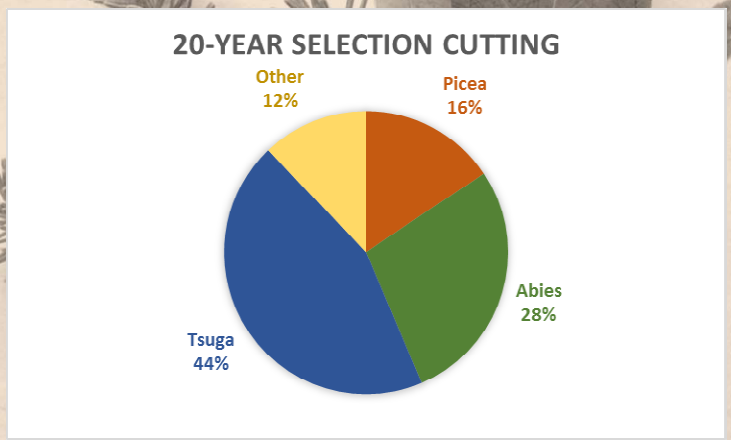




Note: metric units

Regeneration

Seedlings, year 60



~ 5,500 stems/ac

What Worked?

- Stands well stocked with vigorous trees
- Increased spruce basal area
- Continuous production of sawtimber
- Abundant regeneration

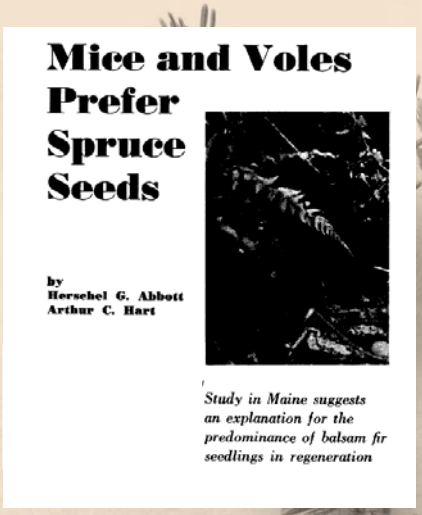

What didn't work

- Reverse-J diameter distribution
  - Bimodal structure

- Species composition
  - Little to no spruce recruitment


Why?

Seed Predation


Mice and Voles Prefer Spruce Seeds

by
Herschel G. Abbott
Arthur C. Hart

Study in Maine suggests an explanation for the predominance of balsam fir seedlings in regeneration

Red squirrel midden

Courtesy of Alessio Mortelliti, University of Maine

Regeneration Substrate

- Density of spruce and hemlock seedlings higher on decayed wood than adjacent forest floor, and lower on hardwood litter
- Density of fir and red maple do not differ between substrates

Weaver et al. 2009

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Herbivory

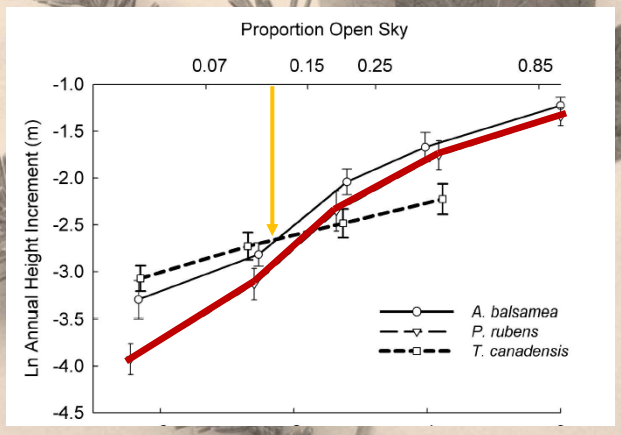
Species	Number of seedlings	Number browsed	Percent browsed
Balsam fir	1916	89	**5%**
Eastern hemlock	834	62	**7%**
Northern white-cedar	188	46	**25%**
Red spruce	388	145	**37%**
Red maple	2168	137	**6%**

Data shown for species with n>100 seedlings (216 plots)

Berven 2011

Competition

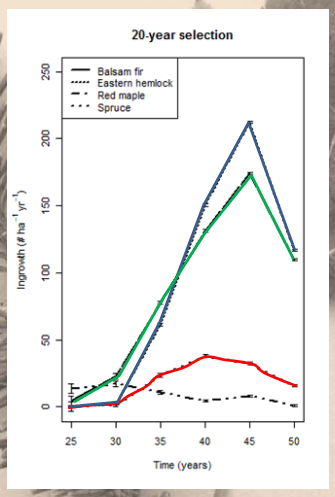
- Trees 1.5 to 20 feet tall



Note: metric units

Moores et al. 2007

Sapling Recruitment



100/ac/yr

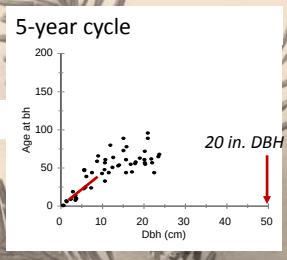
50/ac/yr

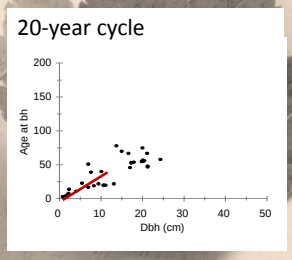
0/ac/yr

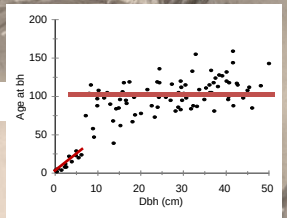
Tree Age – Size Relationships

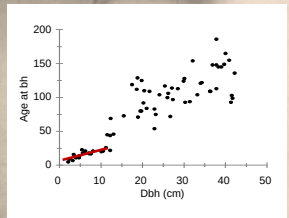
Balsam fir

Red spruce





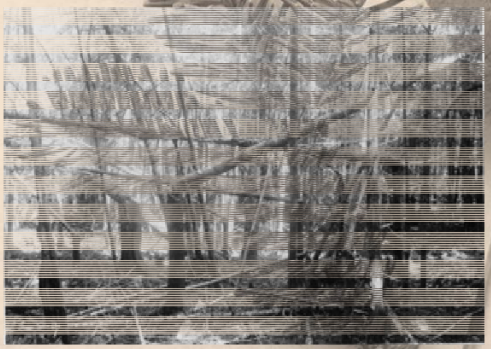




Note: metric units

Complexities of Mixed Species

- Balsam fir pathological longevity



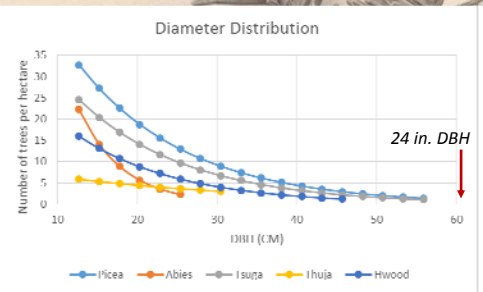
Alternative: Species-specific Goals

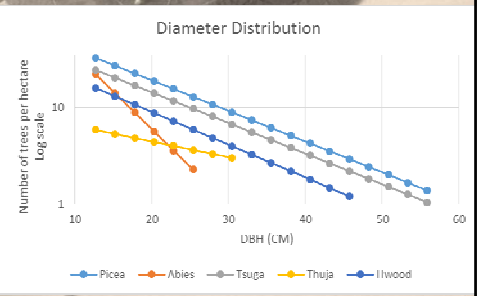
Example: 5-year cutting cycle treatment

5-year	EH		Spruce		BF		NWC		Hwoods		All species	
2 in q	1.45		1.45		2.50		1.20		1.50			
1 in q	1.20		1.20		1.58		1.10		1.22			
DBH		BA		BA		BA		BA		BA		BA
in	TPA	squft/ac	TPA	squft/ac	TPA	squft/ac	TPA	squft/ac	TPA	squft/ac	TPA	squft/ac
1	20.93	0.11	27.90	0.15	56.17	0.31	3.47	0.02	14.33	0.08	122.81	0.67
2	17.38	0.38	23.17	0.51	35.55	0.78	3.16	0.07	11.75	0.26	91.01	1.99
3	14.43	0.71	19.24	0.94	22.50	1.10	2.87	0.14	9.63	0.47	68.68	3.37
4	11.99	1.05	15.98	1.39	14.24	1.24	2.61	0.23	7.89	0.69	52.71	4.60
5	9.95	1.36	13.27	1.81	9.01	1.23	2.37	0.32	6.47	0.88	41.08	5.60
6	8.27	1.62	11.02	2.16	5.70	1.12	2.16	0.42	5.30	1.04	32.45	6.37
7	6.86	1.83	9.15	2.45	3.61	0.96	1.96	0.52	4.35	1.16	25.93	6.93
8	5.70	1.99	7.60	2.65	2.29	0.80	1.78	0.62	3.56	1.24	20.93	7.31
9	4.73	2.09	6.31	2.79	1.45	0.64	1.62	0.72	2.92	1.29	17.03	7.52
10	3.93	2.14	5.24	2.86	0.92	0.50	1.47	0.80	2.39	1.31	13.96	7.61
11	3.27	2.15	4.35	2.87			1.34	0.88	1.96	1.29	10.92	7.21
12	2.71	2.13	3.62	2.84			1.22	0.96	1.61	1.26	9.15	7.19
13	2.25	2.08	3.00	2.77					1.32	1.21	6.57	6.06
14	1.87	2.00	2.49	2.67					1.08	1.15	5.44	5.82
15	1.55	1.91	2.07	2.54					0.89	1.09	4.51	5.53
16	1.29	1.80	1.72	2.40					0.73	1.01	3.74	5.21
17	1.07	1.69	1.43	2.25					0.59	0.94	3.09	4.88
18	0.89	1.57	1.19	2.10					0.49	0.86	2.56	4.53
19	0.74	1.45	0.98	1.94							1.72	3.39
20	0.61	1.34	0.82	1.78							1.43	3.12
21	0.51	1.23	0.68	1.63							1.19	2.86
22	0.42	1.12	0.56	1.49							0.99	2.61
Sum >4.5		31.50		42.00		5.25		5.25		15.75		99.75
											WP	5.25
											Sum > 4.5	105
											Sum > 0.5	115

Species-specific Goals

Example: 5-year cutting cycle treatment

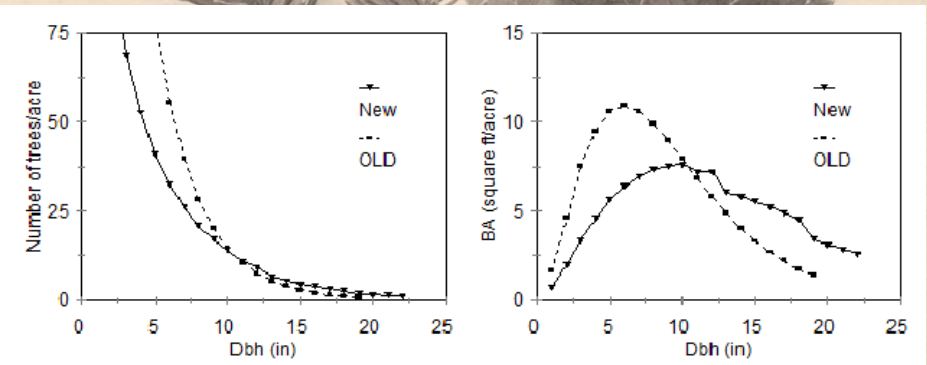




Note: metric units

Species-specific Goals

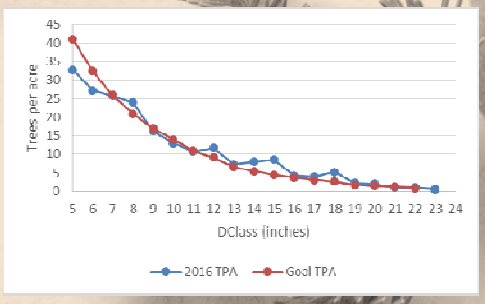
- Example: 5-year cutting cycle treatment



New Treatments

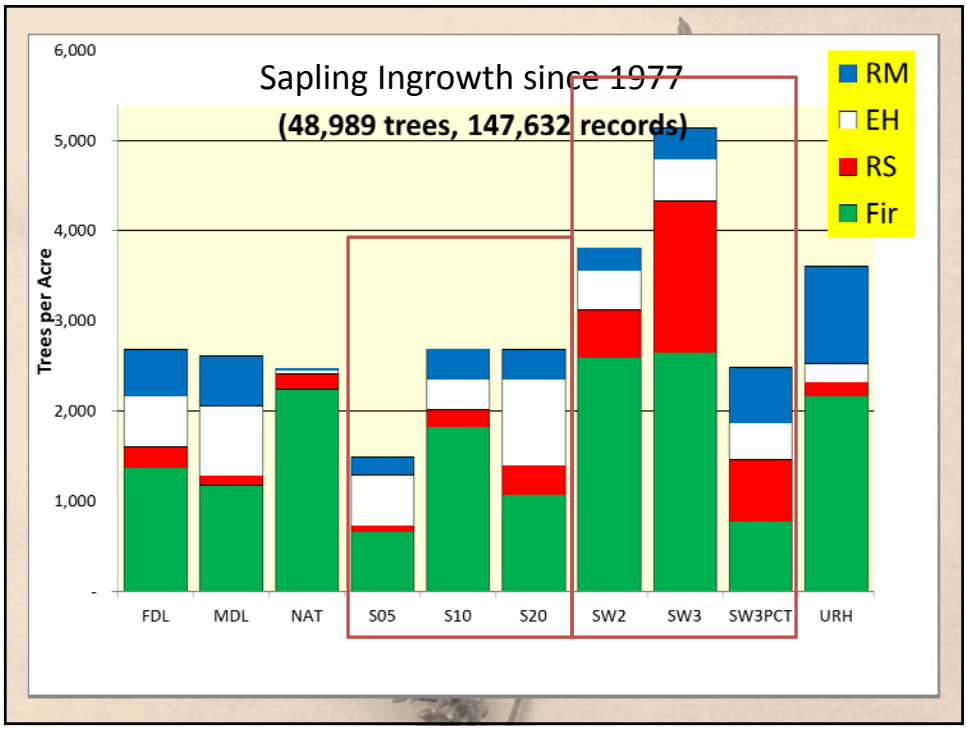
- Manage submerchantable trees

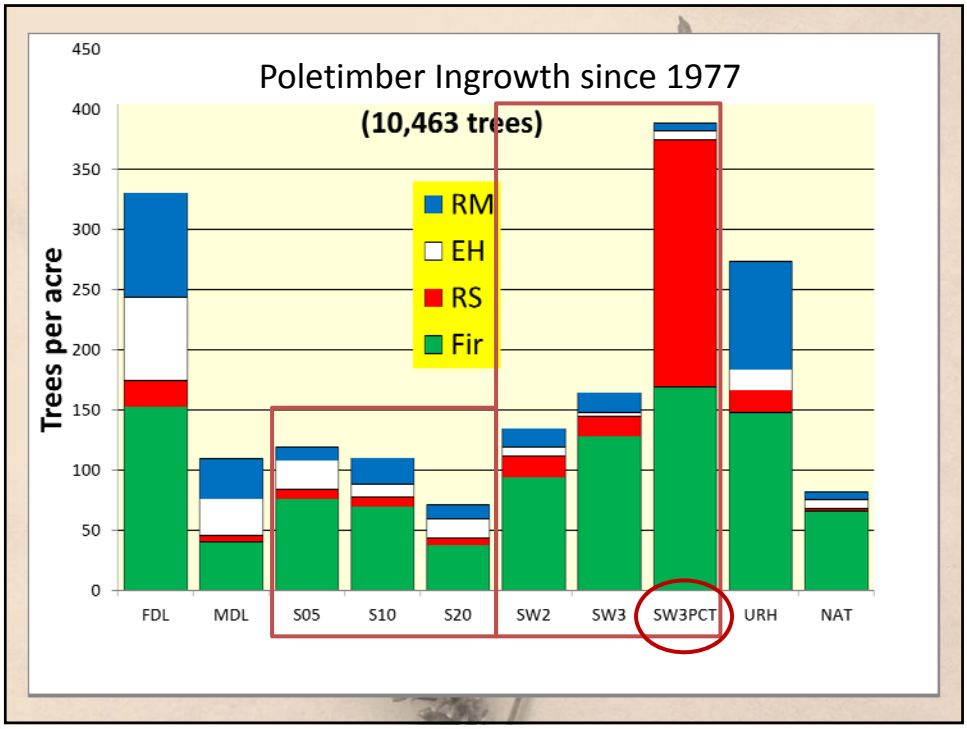
Outcomes



5-yr Selection, 2016

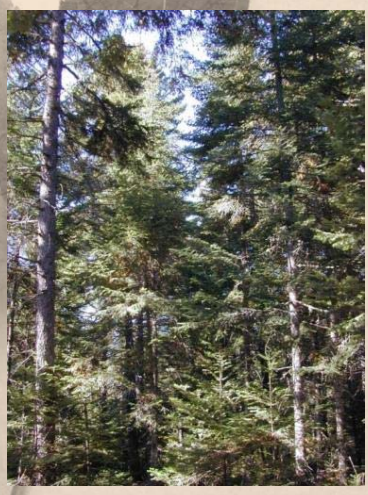
Sapling crop tree release





Review

- Why didn't we achieve our goals?
  - Poor age-size relationships
  - Slow sapling and pole ingrowth
  - Failure to account for species-specific dynamics
  - Problems were not evident
  - *Goals weren't realistic*



In Summary

- Single-tree selection maintains well-stocked, uneven-aged northern conifer stands
  - does not favor spruce; sapling growth rates are slow
- Reverse J structure difficult to achieve and maintain
  - attention to individual species and submerchantable trees needed to attain desired structure and composition


Alternatives for Uneven-aged Stands

- Area-based methods
  - Group selection
  - Irregular shelterwood


Acknowledgments

Robert Seymour and Aaron Weiskittel, University of Maine

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