SELECTION SYSTEM:
REGULATING GROWTH AND YIELD

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Background reading:


Sources cited:


Continued:


So what do we accomplish with selection system silviculture …
FUNCTIONS OF SILVICULTURE

CONTROL
- Establishment
- Composition
- Density / Growth

FACILITATE
- Management
- Harvest
- Use

PROTECT
- Trees
- Site

SALVAGE
- Dead & dying trees
- Potential mortality before it occurs

The matter of current concern

But pre-salvage ...

... before mortality and loss occurs

... one purpose for periodic tending
With selection system ... controlling density, structure, mortality, and growth

Ecological requirements for selection system ...

1. Must work with adapted species

   - Reasonably shade tolerant
   - Will grow well through fairly old ages
   - Reasonably long lived
   - Must readily regenerate at frequent intervals
      
      … prolific seeder
      
      … can develop as advance regeneration
Ecological requirements for selection system ...

2. Must control age class / diameter distribution to insure regular recruitment and upgrowth
   - To realize structural stability
   - To get regular regeneration across adequate area
   - To maintain desired conditions in the stand
   - To provide consistency of desired values
Financially mature

The tending

In this case for northern hardwoods using the Arbogast structure ...

... based on earlier research by Eyre and Zillgitt (1953)

For northern hardwoods we can use the Arbogast guide for planning and controlling selection system

Can you visualize the necessary treatment?

... cross-hatched means an excess of trees per size class
leading to this condition after two entries

This is the source ...

Only this one remained stable

From Eyre and Zillgitt 1953
Of the alternatives tried ....

... this one could be recreated through time

From Eyre and Zillgitt 1953

And has been …

… like this
Stability …

… ending with sufficient trees in each diameter class to allow another cutting back to the desired diameter distribution

After Adams and Ek 1974

Stability …

… consistency
With stability meaning we can recreate the target structure at the end of each cutting cycle.

In fact …

… note the structural stability through three cutting cycles.
And all that follows from deliberate control of the diameter distribution and stand density …

... like this

Remember ...

... a separate production function for each cohort
At any point in time ...

... at least in a balanced stand

... multiple age classes ...

... each at a different stage of development

But with control of the density and stocking in each age class by periodic selection system cutting ...

... to create and maintain a balanced structure
Like this ....

Arrows mark entries at end of each cutting cycle

Nyland 2002

Resulting in this ....

Arrows mark entries at end of each cutting cycle

Nyland 2002
With any one age class developing like this …

Now combine the separate age-class saw-toothed production functions into a composite one for an entire uneven-aged stand …

… all age classes together
… the production function for uneven-aged communities under silviculture

… due to good control over structure and density
And how about tree growth following a treatment …

Our expectations ...

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<table>
<thead>
<tr>
<th>Basal area</th>
<th>Ft²/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>69</td>
</tr>
<tr>
<td>B</td>
<td>?</td>
</tr>
<tr>
<td>C</td>
<td>92</td>
</tr>
<tr>
<td>D</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>134</td>
</tr>
</tbody>
</table>

... from cutting through the structure

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a. Average diameter growth on different cuttings over 20-year period. A, Heavy; B, Intermediate; C, Light; D, Group selection; E, Reserve

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... and note the effect on small trees from cutting to an appropriate density
Also favoring the most vigorous as residuals ...

**FIFTEEN-YEAR MOVEMENT PERCENTS FOR NORTHERN HARDWOODS UNDER SELECTION SYSTEM**

<table>
<thead>
<tr>
<th>AGE CLASSES</th>
<th>DIAMETER CLASS</th>
<th>UP 0</th>
<th>UP 1</th>
<th>UP 2</th>
<th>UP 3</th>
<th>UP 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5</td>
<td>10</td>
<td>45</td>
<td>40</td>
<td>5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>6-11</td>
<td>-</td>
<td>28</td>
<td>60</td>
<td>8</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>12-17</td>
<td>-</td>
<td>25</td>
<td>50</td>
<td>20</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>18-24</td>
<td>-</td>
<td>5</td>
<td>70</td>
<td>20</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>25+</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Keeping these as residuals
The best of each age class

... stability  ... consistency  ... quality  ... good growth
The overall outcome …

... a loss of structural stability through time

From Roach 1974

Commonly leading to a patchy residual stand ...

... with an unpredictable outcome
Check the stability of three different strategies...

... with different lines showing the diameter distribution before each of four separate entries to the stand

... and the structural stability of this strategy

Using the Arbogast structure


Check the stability of these three different strategies...

... this giving structural stability only where cutting controlled the number per dbh

Using the Arbogast structure

Structure only the sawtimber classes

Check the stability of these three different strategies ... 

... and no control

Using the Arbogast structure  
Structure only the sawtimber classes  
12-inch diameter-limit cutting

... through six diameter-limit cuttings

A  
R  
B  
O  
G  
A  
S  
T  
D  
L  
I  
M  
I  
T

Stable ...  
... and not
With diameter-limit cutting leading to

*a lack of structural stability through time* ...

... and *NO control over quality*

... oh my
D-limit cutting

Selection system

So would you dare do it …

After Nissen 2010
Now consider the cutting cycle length …

... for selection system

To set the cutting interval …

... the cutting cycle

Peak basal area growth by having

80 to 100 ft$^2$/ac at the **MIDPOINT** of a cutting cycle

... for northern hardwoods
Effective outcomes by matching residual density and the interval between cutting ...

Maximizing sawtimber yields ....

... with a range of strategies

Allow regrowth to the proper level to insure maximum production between entries ...

Volume removed equals volume grown

To insure this consistent pattern of regrowth and development ....
Aside from empirical structures ...
(e.g., like that by Arbogast)

... have foresters used other approaches to control partial cutting in uneven-aged stands
Remember \( Q \) ...

... of the geometric form

\[ m, mq, mq^2, \ldots mq^n \]

... a distribution that plots out as a straight line on semi-log paper

See Chapter 10, Nyland 2002

\( Q \) structures ...

... for an old-growth northern hardwood forest

... one way to represent an age class distribution

Meyer et al. 1961
Simple ...

Convenient...

Pertinent to old-growth stands ...

But is that relevant and useful for balancing the structure under selection system ...

Some studies question its general relevance ...

... implying an age progression

After Goff and West 1975
Goff and West found the rotated-S form more common ...

... becomes modified by silviculture where we periodically remove the financially mature trees (the repro method)

... simplified to a reverse-J distribution
But look at a simulation experiment to test the stability of single-Q structures …

... you set B, D, and Q
But …

… what actually happens if we cut to a Q structure, rather than use a truncated rotated-S distribution

An experiment with single-Q structures …

<table>
<thead>
<tr>
<th>SIZE CLASS DEFICIENCIES DEVELOPING OVER A 30-YEAR PERIOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q=1.2</td>
</tr>
<tr>
<td>FT²/AC</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>44</td>
</tr>
<tr>
<td>65</td>
</tr>
<tr>
<td>87</td>
</tr>
<tr>
<td>109</td>
</tr>
</tbody>
</table>

= Size class where deficiency develops over a 30-year period.
These single-Q structures did **NOT** remain stable.

So what minimal condition would remain stable ...

... *another test*

In northern hardwoods ...

... you need at least two Q values to adequately define the structure

... and many times three Q’s
Minimum condition in northern hardwoods ...

\[ q = 1.8 \text{ for saps} \]
\[ q = 1.5 \text{ for poles} \]
\[ q = 1.2 \text{ for sawtimber} \]

... resembling an Arbogast structure

Like Arbogast ...

For northern hardwoods we can use the Arbogast guide for planning and controlling selection system

... it also has a multiple-Q structure
Arbogast structure …

…it swings up to the left

… described by multiple q’s

… with q increasing for the smaller diameters

Our experiment …

… verified the Arbogast structure for northern hardwoods
These multiple-Q structures remained stable ...

**TABLE 10-2**

<table>
<thead>
<tr>
<th>dhb</th>
<th>15 yrs.</th>
<th>20 yrs.</th>
<th>25 yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(in)</td>
<td>(ft²/ac)</td>
<td></td>
</tr>
<tr>
<td>2-5</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
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<td>30</td>
<td>25</td>
</tr>
<tr>
<td>17+</td>
<td>15</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>70</td>
<td>65</td>
</tr>
</tbody>
</table>

… and also optimized production for the proposed cutting interval

They look like this ...
60-65 ft²/ac ... for a 25-year cutting cycle

~ 80 ft²/ac ... for a 15-year cutting cycle
The diameter distribution and the way that we control it give us a means to:

*Balance* the space among different age classes

*Control* density and inter-tree competition among the immature residuals

*Reduce* crowding to control mortality

*Concentrate* the growth onto the best trees

*Leave* appropriate numbers of residuals for full site utilization

So we have some choices to make …