RELATIVE DENSITY AND ITS USE IN THINNING

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Nyland - 2010

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Background reading:

Sources cited:
WHY THIN …

- Improve sawtimber production
  ... get larger trees in less time
  ... increase board-foot yields
  ... enhance stand-wide quality and value
  ... influence species composition
- Promote stand development
  ... enhance habitat for plants and animals
  ... alter visual qualities
  ... facilitate other non-market uses
  ... move toward “old-growth” conditions
- Influence hydrologic characteristics (water quality and yields)
- Promote tree vigor and stand health (growth and resiliency)
- Stimulate seed production (like preparatory cutting)
- Promote litter decomposition (release nutrients)
To influence stand development in favor of a landowner’s objectives ...

How to measure success ...

**Timber values**
- volume and value realized
- tree growth rates and sizes
- tree vigor and health
- stand structural features
- diameter and height distributions

**Ecologic factors**
- number and sizes of understory plants
- amount of coarse woody debris
- homogeneity of structural features (orderliness or “neatness”)
- thickness and composition of soil organic layers

**Social interests**
- light levels near the ground
- ease of movement through a stand
- degree and distance of visibility (fewer stems and brighter understory)
… depending on the objectives for management

Remember this critical concept …
Developed primarily for timber objectives …

Expected development of unthinned oak stands

A Maximum stocking

... the curve shows the maximum basal area for stands with a specified number/acre

Roach and Gingrich 1968
ALSO, we need some minimum stocking for full site utilization ...

… with full net production at about 60% relative density

Suggesting a minimum stocking AFTER thinning ...

For FULL site utilization

Roach and Gingrich 1968
But with mortality increasing with REL DEN >80% ... 

Roich and Gingrich 1968

Giving us a zone for rational action ... 

Nyland 2002
B-level relative density gives you ...

- full net cubic-foot production
  ... per acre per year

- enhanced individual tree growth
  ... commensurate with full net cubic volume production per acre per year

To realize full net production ...

Keep stands in the GREEN zone

... with the associated ecologic conditions that follow

Roach and Gingrich 1968
... altering stand conditions to serve the objectives

So we can use the stocking guide as an aid in planning thinning ...

FOR OAK STANDS

Reach and Gingrich 1968
But Roach tried it with Allegheny hardwoods ... 

... with poor results

Until he accounted for species composition ...

... separating

CAPS (bc, wa, and tulip-poplar)

OTHERS (all other species)

... demonstrating that species composition made a difference
With a separate line for each species group ...

... each A line to represent a different proportion of basal area in CAPs

Roach 1977

And then adding a family of B lines ...

... one for each species group (set at 60% of each A line)
... and this worked well in most cases

... to 60% relative density
But experience suggested that this guide needed enhancement ...

... particularly to account for stands with lots of red maple

So Stout asked ...

... *WHAT IF* I add additional species groups

She approached it using the tree-area ratio (TAR) ...

**TREE-AREA RATIO (TAR)**

- a mathematical device for apportioning ground area using stem diameters

- where the area of a stand is expressed as a function of $\Sigma D \& \Sigma D^2$

- $\Sigma$ (TAR) of all trees present = 1.00
**RELATIVE DENSITY = \( \Sigma (TAR) \)**

- expressed in CENTACRES

- the TAR'S for different species can be compared to determine how to best account for species composition in assessing competition within forest stands

- TAR differed between CAPS & two other species groups

See Stout and Nyland 1986

**Stand relative density = \( \Sigma \) (Tree relative density)**

**Tree relative density = \( f \) (Tree diameter and species)**
So three groups for Allegheny hardwoods ...

CAPS – bc, wa, & tulip-poplar

HM-BE – hm, be, stm, oaks except ro

OTHER – all other species

... we use these for other northern hardwoods as well

This defines the contribution of individual trees to stand relative density (by species) ...

... e.g., for 16-inch tree

Stout and Nyland 1986
But Stout found that even this improvement needed refinement ... 

The number, shape, and position of the lines depends upon the species mix and regional conditions ... 

So we use this set for hardwood stands in NYS ...
Try this field tally sheet ...

<table>
<thead>
<tr>
<th>Stand Number</th>
<th>Cherry Group</th>
<th>Red Maple Group</th>
<th>Beech-Maple Group</th>
<th>All Species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BA5</td>
<td>BA5</td>
<td>BA5</td>
<td>BA5</td>
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<tr>
<td></td>
<td>143</td>
<td>127</td>
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</tbody>
</table>

RD factors included

Marquis et al. 1984
Quality considered ...

Acceptable Growing Stock

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<tr>
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<th>All Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>A6S</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>A65</td>
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<tr>
<td>U6S</td>
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<td>U65</td>
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BA Conv. Factor = 10 - 100, 28 - 3

Poor trees as well ...

Unacceptable Growing Stock

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BA Conv. Factor = 10 - 100, 28 - 3
And species group

Also by diameter class within each group
An example ...

Here we calculate relative density rather than getting it from a chart...

See instruction sheet for guidance in making these calculations ...

... a typical field tally
And based on the findings, we can prepare a marking guide to control the thinning ...

**NOTE:** Remove up to 35% RD ...

... but don’t reduce the stand below 60%
And how much to cut from each size class ....

From the distribution of cut chart ....

For a crown thinning ....

... taking a trial distribution of cut from this chart

... in this case for

$DM = 14$ inches

Marquis et al. 1984
And how much to cut from each size class ….

From the distribution of cut chart …

32.16 * 0.63 = 20.26

BUT check the UGS …

... to see how a cut of this kind would match actual conditions in the stand
The proposed cut would NOT reduce the ST UGS adequately so we make an adjustment to fit the real situation.
... expressed as a % of what we have

... and finally expressed as a marking guide
Then we go back and convert it to basal area removed ...

Our prescription ...

Our guide
Insuring full site utilization …

... and a full level of production

... at about 60% relative density we get full gross cubic-foot volume growth

After Mar:Möller 1954

And control of mortality as well ...

The B line on stocking charts set at the best estimate of a stand density where net P.A.I. peaks for stands at different ages.
Examine some real responses from thinning trials ...

... for a stand

... for a tree

Helms, Daniel, and Baker 1979

Marquis 1986
Stand-level cubic-foot volume production like this ...

In older managed stands bd ft production seems to peak at a somewhat higher residual relative density ...

... but this still needs better definition

Marquis 1986
With stocking below 80% ...

... mostly the smaller trees of poor crown positions die

With stocking above 60% ...

... FEW epicormics in stands with at least 60% relative density
Giving us a model for management ...

... keep stands in the green zone

Primarily ...

Keep stands in the GREEN zone

Nyland 2002

Roach and Gingrich 1968
The same basic idea ...

For the stages of development portrayed, the optimum residual basal area should be increased from about 62 to 80 ft²/ac ...

... if periodically thinned to 60% RD

And note this for northern hardwoods ...

Residual BASAL AREA increased with each thinning ...

Reukema and Bruce 1977

... for Douglas-fir
To give you this ...
... but we must have one somewhere near here