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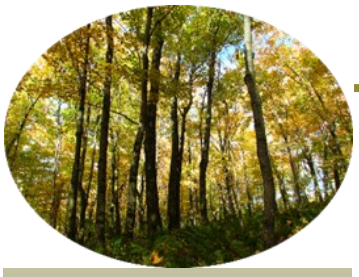
Institut de recherche sur les feuillus nordiques Inc.
Northern Hardwoods Research Institute Inc.

Stocking Guide: A Tool for Managing Young Even-Aged Hardwood Stands



November 2017

Technical Note

Silviculture

INTRODUCTION

Stocking guides, initially developed by Gingrich in 1967, are tools that help: (1) to assess current competitive status of a forest stand, and (2) suggest the timing and intensity of thinning required to increase growth and quality of the crop trees in the future. It is also useful for visualizing stand growth dynamics as a stand matures. The Gingrich (1967) stocking guide was calibrated for yellow birch dominated stratified mixture, in even-aged stands of northwest New Brunswick, to help foresters with silviculture decision making. Periodically measured data coming from a commercial thinning experiment located in northwest New Brunswick was used to calibrate the stocking guide. Elements, application and important considerations about the guide are discussed in the subsequent sections.

HIGHLIGHTS

- **Gingrich stocking guide was calibrated for yellow birch dominated stands with even-aged stratified mixture in New Brunswick to help forest practitioners with silviculture decision making.**
- **Elements and applicability of the guides are illustrated with examples in this technical note.**

ELEMENTS OF THE STOCKING GUIDE

This stocking guide is a four-dimensional graph with the number of trees (DBH≥10cm) per hectare (TPH) on the X-axis and tree basal area (BA) per hectare (m^2/ha) on the Y-axis. In addition, quadratic mean diameter (QMD) for the trees in the stand is represented by the inclined vertical lines, and the level of stocking (stocking %) is represented by the inclined horizontal lines (Figure 1). These four key stand attributes (TPH, BA, QMD, and stocking %) provide the basis for silviculture decision making. While quadratic mean diameter indicates

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the average tree size in the stand, stocking level is designed to compare absolute measure of stand density to a standard. This standard is based on an observed maximum density for undisturbed natural stands (control plot) at a given site and stage of stand development. Here, stocking % refers to the relative density to the standard which is used as a basis for silvicultural decisions making. The desired condition of the stand after treatment is also described by this measure. Broader categories of stocking levels are represented as “A” (Figure 1: green line), “B” (Figure 1: yellow line), and “C” (Figure 1: red line) lines. The “A” line represents the maximum stocking for undisturbed stands of average structure where the stand fully utilizes the site potential. The “B” line is the lower limit of stocking required for full occupancy of the site.

This is where trees face minimum competition (crowns are fully developed and are just touching each other). In general for tolerant hardwood stands with stratified mixture, the “B” line is approximately 50 % of the “A” line level. The “C” line refers to the stands that are currently understocked but are expected to reach the “B” line roughly within 10 years (Gingrich, 1967).

Stem quality is a prime concern while managing hardwood stands for timber production because hardwood timber prices range from a few hundred dollars per thousand board feet for a lower quality sawlog to several hundred dollars for a higher quality sawlog or veneer log. Defect free straight stems are always graded as higher quality sawlogs. Studies have shown that stand density management can help improving stem quality of the crop trees when pruning is not a silvicultural option. Therefore, the Q-line (quality line) is provided in the stocking guide to show the level of stand density required for natural pruning. At average stand diameter about 15 cm, most of the crop trees attain at least 5 m long clear bole. Thus, the line ends at 15 cm QMD as the stand can be thinned to B-line after 5 m long clear bole development.

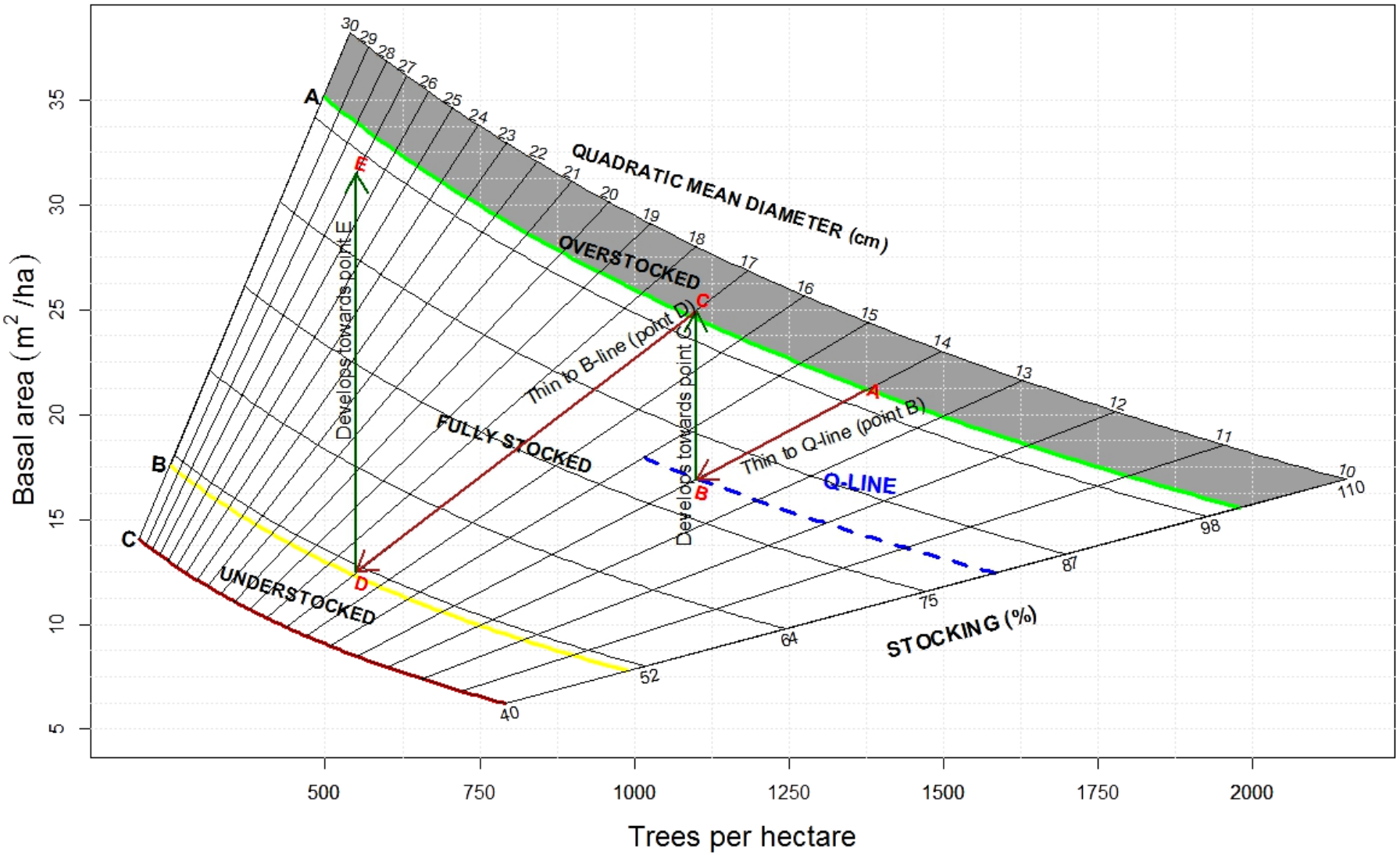


Figure 1: Assessing thinning requirement with stocking guide. Point A=initial stand condition that can be thinned to point B. With time, the stand will develop towards point C. When the stand reaches to Point C, then the stand can be thinned to point D. Once the stand is thinned to point D, it will develop towards point E. Stand values at different points are provided in the table.

APPLICATION OF THE STOCKING GUIDE

The stocking guide provides forestry practitioners with a valuable tool for making stand-level decisions on when to thin a stand based on stocking and average stand diameter. There are three important steps needed to be followed (Figure 2) to apply the stocking guide. At first, stand-level information is obtained through a pre-treatment forest inventory (Figure 2: Step 1). This will provide the necessary information to use the NHRI Silviculture Prescription System (SPS) for determining stand eligibility for commercial thinning (Figure 2: Step 2).

When the stand is eligible for commercial thinning, use of stocking guide is recommended to determine removal intensity and residual levels (Figure 2: Step 3). The two basic stand attributes that are required to use the stocking guide are: (1) the number of trees per hectare (TPH), and (2) the basal area per hectare (BA). This information is generally obtained from a pre-treatment forest inventory (Figure 2: Step 1). Once TPH and BA are known, stocking level and quadratic mean diameter of the stand are determined by plotting the stand position in a stocking guide, where: X-axis = TPH and Y-axis = BA of the stand. When a stand is close to A-line (green line), it represents that the stand is at the upper limit of fully stocked zone. In this condition, trees will start to die because of competition (the area above the line is also know as 'Zone of imminent competition and mortality'). At this point, diameter growth of crop trees will be minimum. Therefore, this is the right time to thin the stand. If the stand diameter is less than 15cm and at least 50% trees do not have 5m long clear bole, then thin the stand to Q-line (Figure 1: point B from Point A). Crop trees will naturally prune the lower branches at this level of stand density. In the future, stand will develop from point 'B' towards point 'C'. When the stand is at point 'C', the stand is again at the upper limit of the fully stocked zone. At this time, the QMD will be greater than 15cm and ≥ 50% of the trees will have 5m long clear bole. Thus, at this time, the stand can be thinned to B-line (Figure 1: from Point 'C' to Point 'D'). The stand will develop towards point 'E' in future. A decision tree, presented in Figure 3, can be used with stocking guide to assess thinning needs for a given stand.

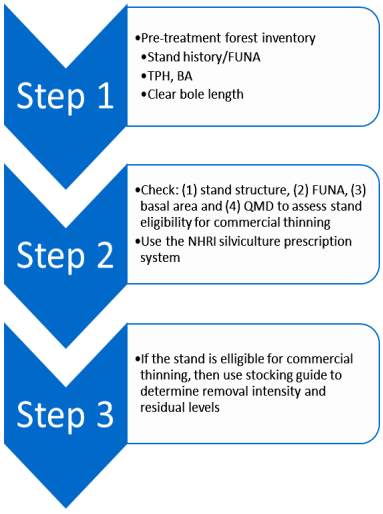


Figure 2: Steps to follow when considering

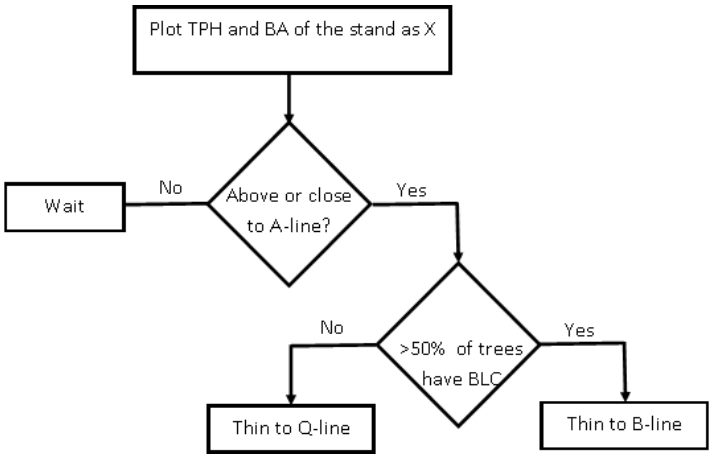
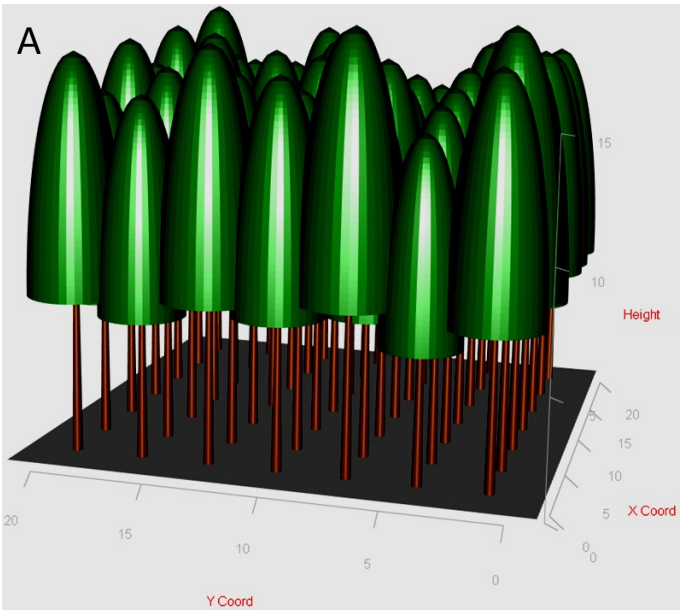
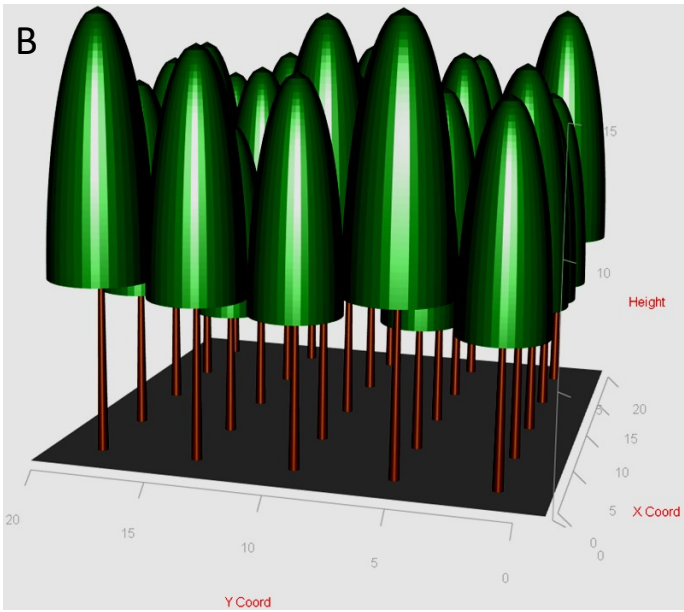


Figure 3: Decision tree to assess thinning need using stocking guides



Spacing: 3 m X 3 m

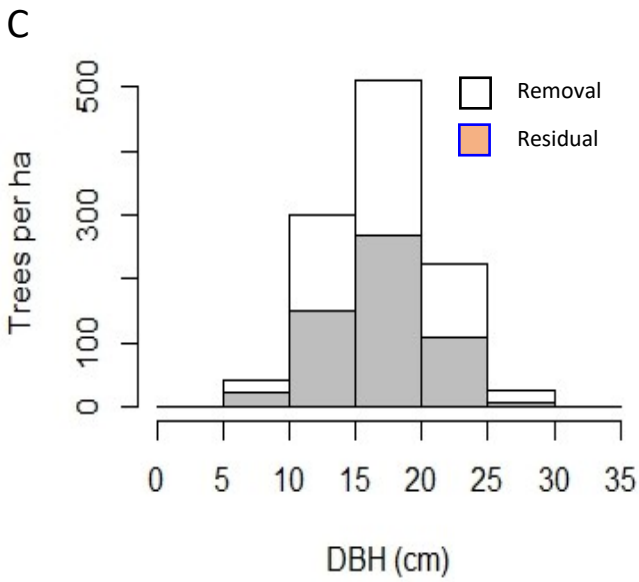
Density=1110 stems/ha, BA=25.5 m^2/ha and QMD=17 cm



Spacing: 4.25 m X 4.25 m

Density=560 stems/ha, BA=12.7 m^2/ha and QMD=17 cm

Figure 4: Visual representation of stand density (within a 20 m X 20 m plot) before and after thinning (Figure 1: C & D). A= at point 'C', B= at point 'D', C= tree size distribution before (at point 'C') and after free thinning treatment (at point 'D')



For example: if a stand is at point C as shown in Figure 1 with more than 50% of trees having BLC ≥5 m, then the stocking guide suggests to thin the stand to the B-line. Initially, at point C, the stand looks like Figure 4A. Free thinning maintains the before-thinning QMD in residual stand. So, go to B-line from point C, staying parallel to the nearest QMD isoline as shown in Figure 1. Point D is determined when the line coming from point C meets the B-line. Once the stand is thinned to B-line (at point D, Figure 1), the stand will look like Figure 4B. Removal and residual tree size distribution will be similar to Figure 4C.

TREATMENT REGULATION

1. Determining harvest level using stocking guide (Figure 1):

A) Stand values at point C (stand values before the treatment) are known from the inventory.

B) Stand values at point D:

(a) read down from point D to the X-axis to determine post harvest tree density,

(b) read across to the Y-axis to get post harvest stand basal area and,

(c) substract the values at point D from the values at point C to get harvest level estimates (basal area per ha or number of trees removed.).

2. Crop tree selection and spacing:

- Select good form and high vigour sugar maple and yellow birch trees from dominant and co-dominant crown position (e.g. in Figure 4C: select YB from DBH between 15 and 25 cm).
- Good form and high vigour sugar maple can also be selected as crop trees from intermediate crown position (e.g. in Figure 4C: SM from DBH between 10 and 15 cm).
- Make sure that three of more sides of all the crop trees are released.
- Make sure that crops trees are evenly distributed in the stand. Spacing (in meter) between crop trees in leave strips can be calculated as follows:

$$Spacing = \sqrt{\frac{10000}{Number\ of\ residual\ trees}}$$

3. Pecking order:

1. All unacceptable growing stock (detail: NHRI tree classification system).
2. Intolerant hardwood and softwood species from dominant and co-dominant crown class.
3. Hardwood species other than sugar maple and yellow birch.
4. Yellow birch from intermediate crown position.

CONCLUDING NOTE

1. Species and site factors may influence the maximum stand density standard. Thus, this guide is recommended for yellow birch dominated stratified mixture, even-aged stands in northwest New Brunswick only.
2. This guide focuses on high quality sawlog production. Recommended residual density and timing of treatment may vary for other objectives.
3. Feasibility or operability of the treatment should be decided based on professional judgement.
4. Improvements to this guide are required and the NHRI welcomes suggestions and opportunities to test further.

REFERENCES

Gingrich, S. F. 1967. Measuring and evaluating stocking and stand density in upland hardwood forests in the central states. Forest Science. 13: 38-53.

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