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Management Techniques for Conifer Plantations – Part III
Crop Planning - Predicting Future Harvests
By Mark Richardson

This is the last in a series of three articles introducing some of the concepts of using a Density Management Diagram (DMD) as a decision-making tool for managing conifer stands. In the first two articles, it was shown that stand growth can be optimized through a series of well-timed thinnings. Thinning a stand at the right time provides tangible benefits to both forest and landowner. Proper harvesting keeps the forest healthy and growing at its maximum rate. The benefit to the landowner from this optimal growth rate comes in the form of a higher return on investment over the life of the woodlot; harvested trees are worth more because they are larger in size and better in quality.

By knowing the density and average diameter of a stand, a landowner can easily use the DMD to determine first if thinning is recommended, and if so, how many trees need to come out in order to keep the stand growing at its optimal rate. In the example provided in Article II, a typical stand of red pine, with an initial density of 2,400 trees per hectare and an average diameter of 14.1 cm, should be thinned by 1,000 trees (40 percent) per hectare. In Figure 1, Point A shows the initial density. To calculate the recommended harvest, follow along the upwardly curving trend of the height line to where it intersects the Thin-to Line at Point B, then drop a vertical line down to where it intersects the x-axis (Point C). The recommended harvest is the initial density minus the value of the Point C. In this case it is 2,400-1,400 or 1,000 trees per hectare.

Although the ability to determine harvest levels using easily collected forest inventory information is the DMD's forte, it is not the only use for the DMD. The correct use of the DMD allows landowners to make informed estimates of harvest volumes and predictions about when the next harvest will occur.

Predicting Harvest Volumes

Most harvests are sold on a total volume basis, not by the individual stem. As a result, it makes sense to calculate the estimated harvest

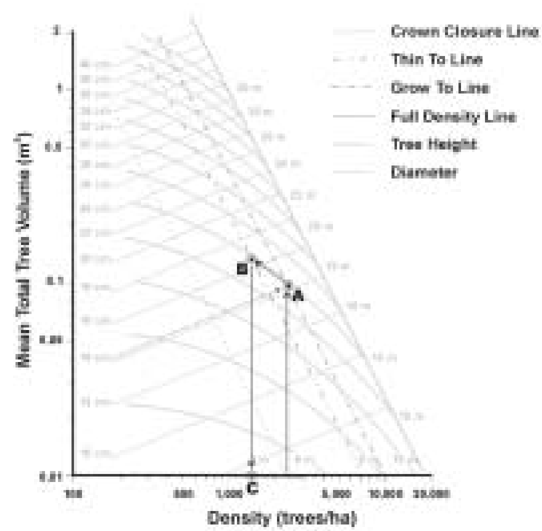

Figure 1: Determining the recommended

volume which has a direct impact on the overall price paid to the landowner – obviously more volume (and better quality) means more money in the landowner's pocket. Estimating volumes, therefore, is critical for determining selling price and ensuring that the landowner is getting a fair value for the product. This concept is fundamental to good, fiscally responsible forest management – selling timber without knowing all the facts is a big mistake. It is the responsibility of the landowner, not the logger or the buyer, to ensure that the best deal has been reached.

The y-axis on the DMD provides a quick method of estimating harvest volumes. Other techniques including the use of Standard Volume Tables may be more appropriate, depending on the forest. It is always a good idea to use more then one system of calculating volumes. In the example given in Figure 1, 1,000 trees per hectare were harvested. This represents a total harvest of 10,000 trees from the 10 ha total forest area. Figure 2 shows how to estimate the average tree volume; simply project a horizontal line from Point A, left to where it intersects the y-axis (Point D). By taking the value of the intersection point (0.10 m^3/tree) and multiplying by the number of trees harvested, the landowner can quickly determine what the estimated volume per hectare and total volume is (1,000 m^3/ha).

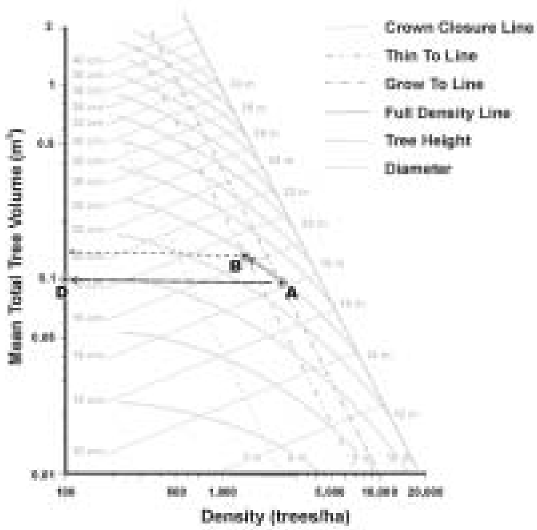

Figure 2: Estimated average volume per

The pre-harvest tree volume in this example is 0.10 cubic metres. The estimated post-harvest tree volume could be found by drawing a horizontal line across from Point B. Note how the post-harvest tree volume would be slightly higher then the pre-harvest volume; this occurs because during a thinning harvest, smaller lower-value trees are selected to be harvested. The removal of these smaller trees increases the average stand diameter (as discussed in Article II) and the average tree volume of the remaining trees.

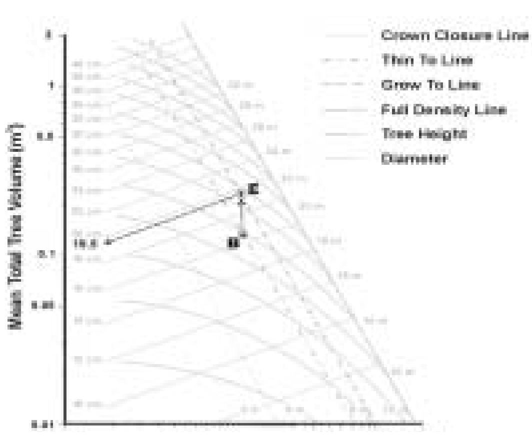

Figure 3: Average diameter of the next harvest.

Predicting Average Diameter of the Next Harvest

After thinning, the stand plots at the Thin-to Line (Figure 2, Point B) with a density of 1,400 trees per hectare. This opens up the stand, providing additional resources to the remaining trees, which keeps them growing at their optimum rate. The density of the stand should not change again until the next thinning when the average diameter reaches the Grow-to Line (Figure 3, Point E) – at this point the landowner is managing the stand, not Mother Nature.

The estimated future average diameter of this stand at the point where thinning is recommended can then be interpreted off the graph; in this example it would be approximately 19.5 cm average at breast height.

Predicting the Future Harvest Information

The question of how many trees will be harvested during the future thinning operations can be answered using the same methods described in Article II. Figure 4 shows the stand trajectory over time. As can be seen from the graph, the objective of all future harvests is to keep the stand situated between the Thin-to and Grow-to Lines as the trees increase in average diameter (volume) and decrease in density.

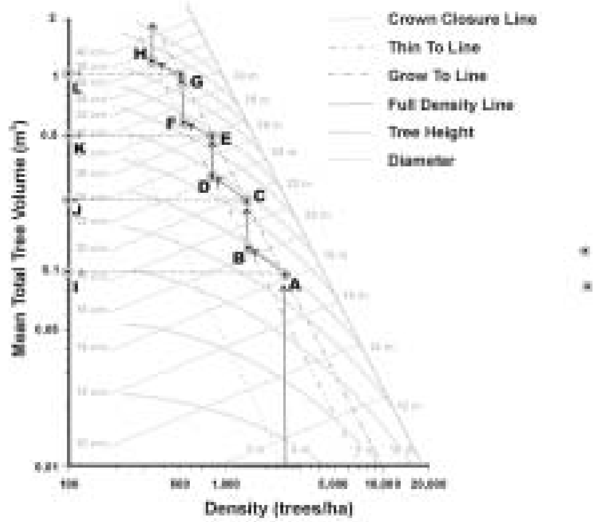

Figure 4: Stand projection through time.

Table 1 provides a summary of the expected harvests, listing densities before and after thinnings, along with the expected average diameter, tree volume predicted from the y-axis, and finally, the calculated volumes per hectare and for the entire 10-ha stand.

Table 1: Stand projection over time for a 1 hectare compartment of red pine.

Thinning Number	Before Thinning Density	Average DBH at Thinning	After Thinning Density	Harvest Density	Estimated Tree Volume	Estimated Volume Per Ha	Estimated Total Volume (10 ha)
1	(A) 2,400	14.1	(B) 1,400	1,000	(I) 0.1	100	1,000 m^3
2	(C) 1,400	19.2	(D) 850	550	(J) .225	123.8	1,238 m^3
3	(E) 850	25.5	(F) 550	300	(K) .47	141	1,410 m^3
4	(G) 550	33.9	(H) 325	225	(L) 1.1	247.5	2,475 m^3
Final	325	>38	0	325	NA	NA	3,250 poles

The letters in the columns correspond to the derived values on the DMD (Figure 4). Note the bottom row of the table. After the fourth thinning, the stand density is 325 trees/ha, which plots close to the top of the DMD. At this time, all that is left are the best trees, which should (hopefully!) qualify as poles when harvested. Poles are the desired end crop for red pine plantations because they are worth considerably more then sawlogs. Currently selling for greater than $45.00 per tree, this price could also increase substantially depending on quality, size, markets and location. For the landowner managing this 10-ha plantation, the final sale of 3,250 poles could represent a considerable amount of money. This sum does not include the revenue earned from selling the 6,100 cubic metres harvested during the previous thinning operations. Although this is just an example, it can easily be demonstrated that properly managed conifer stands have the potential to pay significant dividends to the landowner. In addition to the generated revenue, thinning opens the stand up, allowing hardwoods to regenerate underneath – these hardwoods become the next forest after the final harvest.

Predicting When Future Harvests Will Occur

Figure 4 and Table 1 demonstrate that it is relatively easy to use a DMD to predict future densities, sizes and volumes. Although this information allows the landowner to compare (model) different management scenarios, it does not reveal when future harvests should occur – will it be in five years, or 15? Knowing when to harvest next is important for the landowner trying to predict future revenues and allocate necessary resources.

The DMD, along with another graph called a site index (SI) curve, (Figure 5), can be used to estimate when harvests should occur. Figure 5 shows a typical Site Index Curve. Like the DMD, there are different curves for different tree species as well as for planted and natural stands. Site index is a measure of how "well" trees grow on different sites; the better the site, the taller the trees. Site index is simply a way of quantifying this relationship by looking at how tall trees would be at age 50 on different sites. For example, a tree that is 20 m tall (y-axis) at age 50 (x-axis) would have a site index of 20 (right side). On a poorer site, a tree would have a lower site index because at age 50, the overall stand height would be less (refer to Article II). The opposite applies for better quality sites; at age 50, they would have taller trees and therefore higher site indexes. It is this strong age to height relationship that is independent of density (as discussed in Articles I and II) that makes the site index curve so useful.

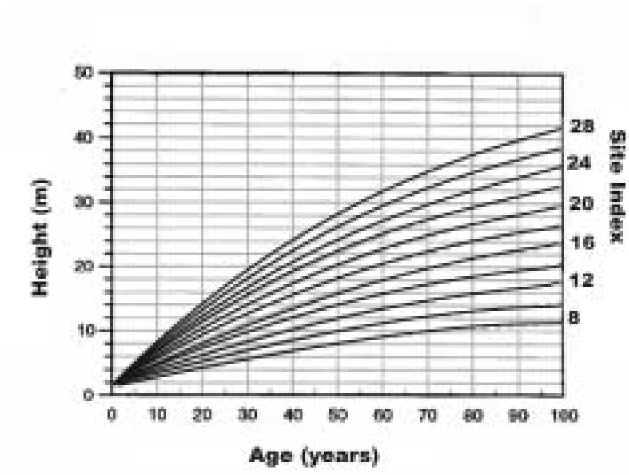

Figure 5: Site index curve for red pine

To predict when future harvests should occur, it is necessary to first determine site index. In the example inventory given in Article II, age (30 years) and height (15 m) can be plotted on the graph (Figure 6, Point A) and projected along the curved line to the right axis. In this case the site index is 22.

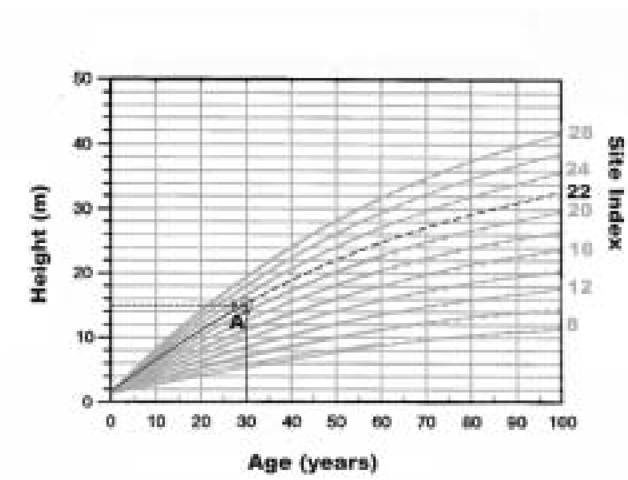

Figure 6: Determining site index (SI).

Once SI is known, it is necessary to look at what the difference in stand height will be between harvests. This can be determined using the height lines on the DMD. For this example, the stand will be growing from Point B to Point C in Figure 4. The change in height can be estimated by interpreting the differences in the height lines (the downwardly sloping curved lines). Keep in mind that it is this trend that is important and not the actual numbers attached to it – please review Article I and II. In this example, the change in height will be about 3 m between harvests (Figure 7).

With the SI and the change in height information, it now is possible to estimate time between harvests (Figure 8). The future height (15m + 3m = 18m, Point B) of the stand is projected left on the SI curve until it intersects the SI line (Point C) for that stand. A vertical line is then drawn down to the age axis (Point D). This number (38) represents the estimated stand age at which the next harvest will be recommended; with a current age of 30 years the landowner could expect to be thinning the stand in about eight years.

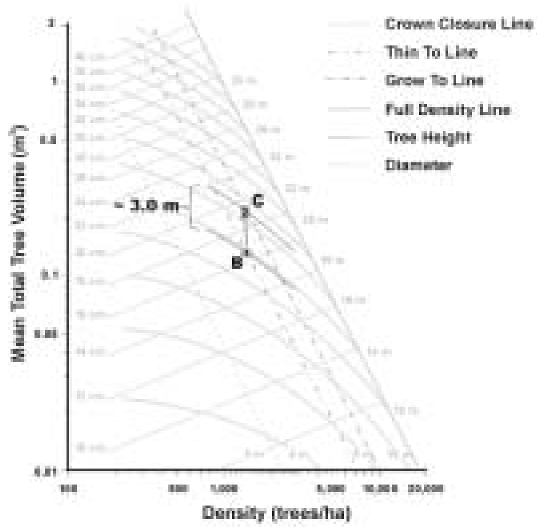

Figure 7: Estimating change in height between harvests (3 metres).

Final Comments

The density management diagram is a relatively new and powerful tool for managing even-aged conifer stands that are either planted or natural in origin. With basic forest inventory information, landowners have a quick method assessing stocking, determining harvest numbers, predicting yields and estimating years between harvests.

The purpose of this series of articles was to introduce the landowner to some of the aspects of using a DMD to manage conifer stands. These articles were not meant to be a management guide; there are other implications, especially when it comes to predicting volumes that are not discussed here. Landowners are encouraged to use a DMD and to hire a knowledgeable forest professional to assist them with managing their conifer stands. The Eastern Ontario Model Forest also has a comprehensive course on management techniques for conifers that provides more in-depth information. For additional information or to comment on the series, please contact the author. Mark Richardson is a forester working for the EOMF in Kemptville – he can be contacted at <mrichardson@eomf.on.ca> or (613) 258-8416.

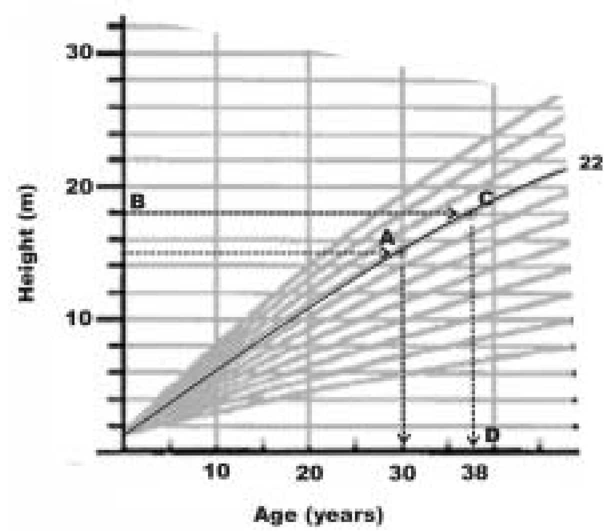

Figure 8: Estimating the years between harvests (8 years).