FOREST RESEARCH REPORT

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Land Capability and Site Index Curves for Nova Scotia Hardwoods

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Contents

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Introduction

Site Index (SI) curves and Land Capability (LC) ratings are important tools used to estimate productivity of forest stands in Nova Scotia. Land Capability ratings are used to define sustainable levels of harvest and appropriate management prescriptions (among other uses). In 1987 (NSDLF), SI curves were produced for Nova Scotia hardwoods based on stem analysis data. Preliminary combined SI and LC curves were then produced for the Forestry Field Handbook (NSDNR, 1993). The LC portion of these curves was based on an earlier version of the Hardwood Growth and Yield Model (HWGNY) whose methods are described in NSDLF (1990). An updated version of the HWGNY was published in 2006 (O'Keefe and McGrath). This model was used to create updated combined SI and LC curves for this report. Separate curves were produced for Intolerant Hardwoods, Tolerant Hardwoods and Aspens.

Methods

The development of hardwood SI curves with LC ratings started with the development of SI equations in 1987 (NSDLF). These original equations were formed using stem analysis data where height and age of free growing, dominant trees could be derived. For a more detailed discussion of SI, refer to Hush *et al.* (2003: 195-200). In these original equations, age was expressed as years at stump height (15 cm, 6 inches) and height in metres with an index age of 50 years at stump height used. These equations were subsequently converted to breast height age constrained[*] versions by Kerr (1990). The converted equations (Appendix I) form the basis for the SI curves shown in this report (Figures 1-3).

Nova Scotia's Hardwood Growth and Yield Model (HWGNY, O'Keefe and McGrath, 2006) was then used to assign LC ratings to given SI. This relationship was made by running HWGNY at full stocking for various SI and examining the model output for Peak Mean Annual Increment (PMAI[†]). Land Capability is the PMAI as generated by HWGNY for a given Site Index. Model output was examined to determine what value of SI resulted in 0.5 $m^3ha^{-1}yr^{-1}$ increments of LC. Site Index values that resulted in PMAI values associated with the upper limits of the 0.5 $m^3ha^{-1}yr^{-1}$ classes were then used to plot height over age to form the LC/SI curves shown in Figures 1-3. For example, SI values that resulted in LCs of 2.75 $m^3ha^{-1}yr^{-1}$ and 2.25 $m^3ha^{-1}yr^{-1}$ for tolerant hardwoods (14.20 m and 16.19 m respectively) were used in the SI equations to create the height verses age curves in Figure 2 that form the upper and lower limits of the 2.5 $m^3ha^{-1}yr^{-1}$ LC class. Site Index values resulting in upper limit LC curves for all species groups are shown in Appendix I. In summary, LC values in these curves represent the expected PMAI of fully stocked stands for a given SI, if harvested at the time[‡] of PMAI. Stands that are density controlled, by either pre-commercial thinning or planting treatments for example, would expect to yield a higher PMAI than the LC would indicate in these curves (NSDNR, 1993). On the other hand, stands that encounter early suppression or lower than full stocking would result in lower PMAI's than indicated.

Results

Figures 1-3 show the Hardwood Land Capability/Site index curves produced for Nova Scotia. Enough data were available to produce separate curves for Intolerant Hardwoods, Tolerant Hardwoods and

[*] Equations were mathematically constrained so that the curves would pass through the index height at age 50.

[†] Peak Mean Annual Increment is the maximum gross merchantable volume per hectare per year, where this includes trees exceeding 9.1 cm (3.6 in) in diameter at breast height outside bark, excluding tops smaller than 7.6 cm (3 in) in diameter inside bark and stumps 15 cm (6 in) tall. Internal rot is not deducted. It is expressed as solid cubic metres. Age is calculated based on stump height measurements.

[‡] The age at which PMAI occurs, can be determined from Nova Scotia's Growth and Yield Model (MacPhee and McGrath, 2007).

Aspens[§]. Additional data are required to produce Site Index curves for white ash, balsam poplar and American beech[**].

How to Use LC/SI Curves (Figures 1-3)

LC/SI curves were derived from, and are meant to apply, to even-aged stands. To use these curves, the total height in metres and breast height age in years of dominant trees in a stand must be measured. It is important that the trees measured are free growing (no periods of suppression), with no insect, disease or other damage. Overmature "wolf trees" must not be used. Five trees of the same species, distributed throughout the stand, should be measured. The average height and age of these trees is then located on the appropriate curve to obtain Site Index and Land Capability. For example, if the average height of the dominant trees in a sugar maple stand is 14.1 m and the average age 40 years at breast height, then the SI (at age 50) would be 16.2 m and the LC would be 2.75 $m^3ha^{-1}yr^{-1}$, as it falls on the upper limit line for LC class 2.5. First, the point where 16.2 m and 40 years falls on the plot is found (Figure 2). The point is then projected forward to cross the index age (50) line, parallel to the nearest height age curve. In this case this would be at a height of 16.2 m at 50 years of age at breast height. The LC associated with this SI is determined by following parallel to the closest height age curve to the right hand border of the graph. In this case the LC associated is 2.75 $m^3ha^{-1}yr^{-1}$ since the height and age fall directly on one of the LC upper limit lines. If the point falls between two upper limit height age lines the LC would fall within that 0.5 $m^3ha^{-1}yr^{-1}$ LC class. For example, when the average height and age for sugar maple is 60 years of age and 17 m tall, the LC would fall between the 2.25 and 2.75 $m^3ha^{-1}yr^{-1}$ lines and be within the 2.5 $m^3ha^{-1}yr^{-1}$ class

[§] Intolerant Hardwoods = red maple (*Acer rubrum* L.) and white birch (*Betula papyrifera* Marsh.). Tolerant Hardwoods = sugar maple (*Acer Saccharum* Marsh.), yellow birch (*Betula alleghaniensis* Britton), and red oak (*Quercus rubra* L.). Aspens include trembling aspen (*Populus tremuloides* Michx.) and largetooth aspen (*Populus grandidentata* Michx.).

[**] white ash (*Fraxinus americana* L.), balsam poplar (*Populus balsamifera* L.), American beech (*Fagus grandifolia* EHer.)

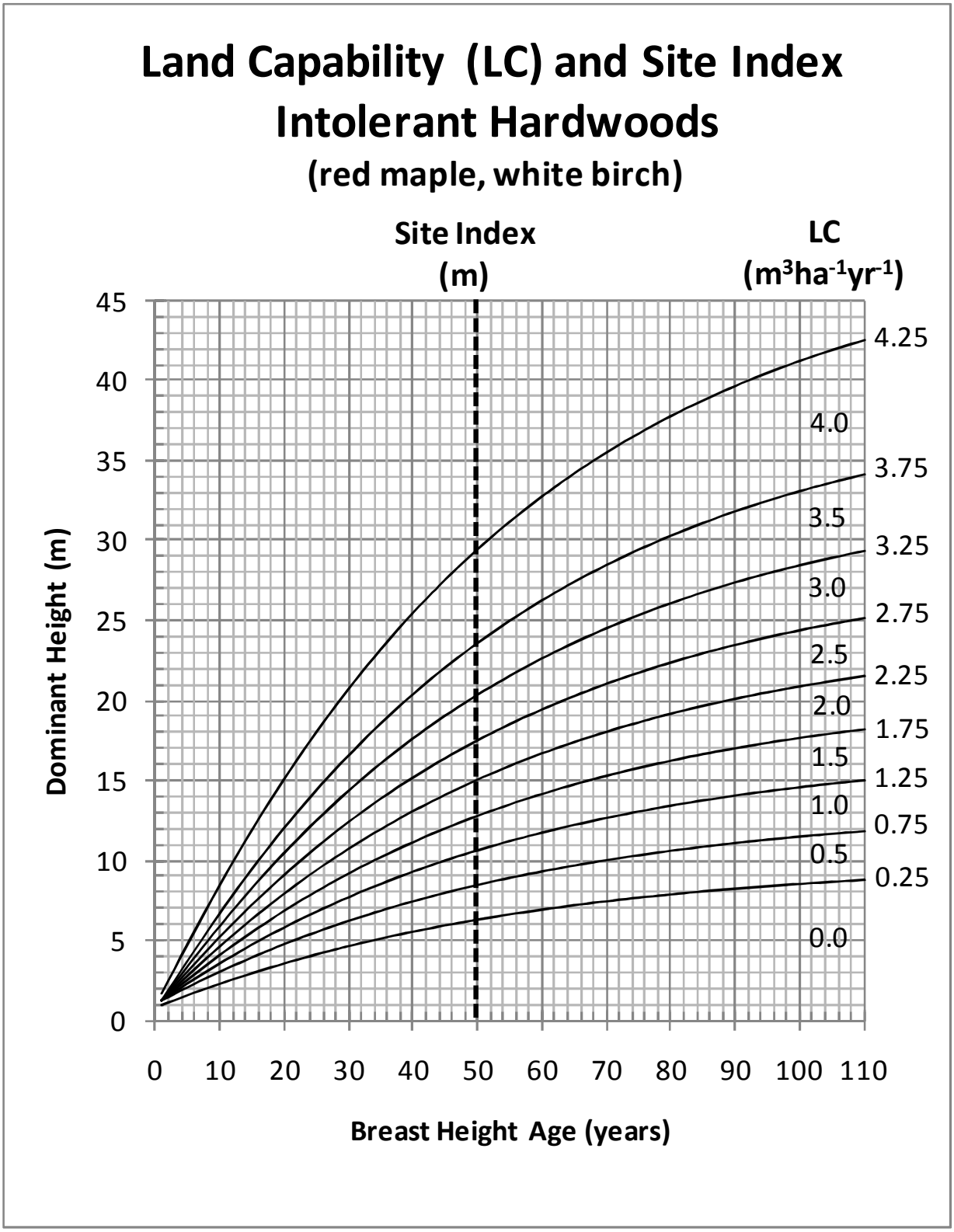

Figure 1. Land Capability/Site Index Curves for Nova Scotia Intolerant Hardwoods.

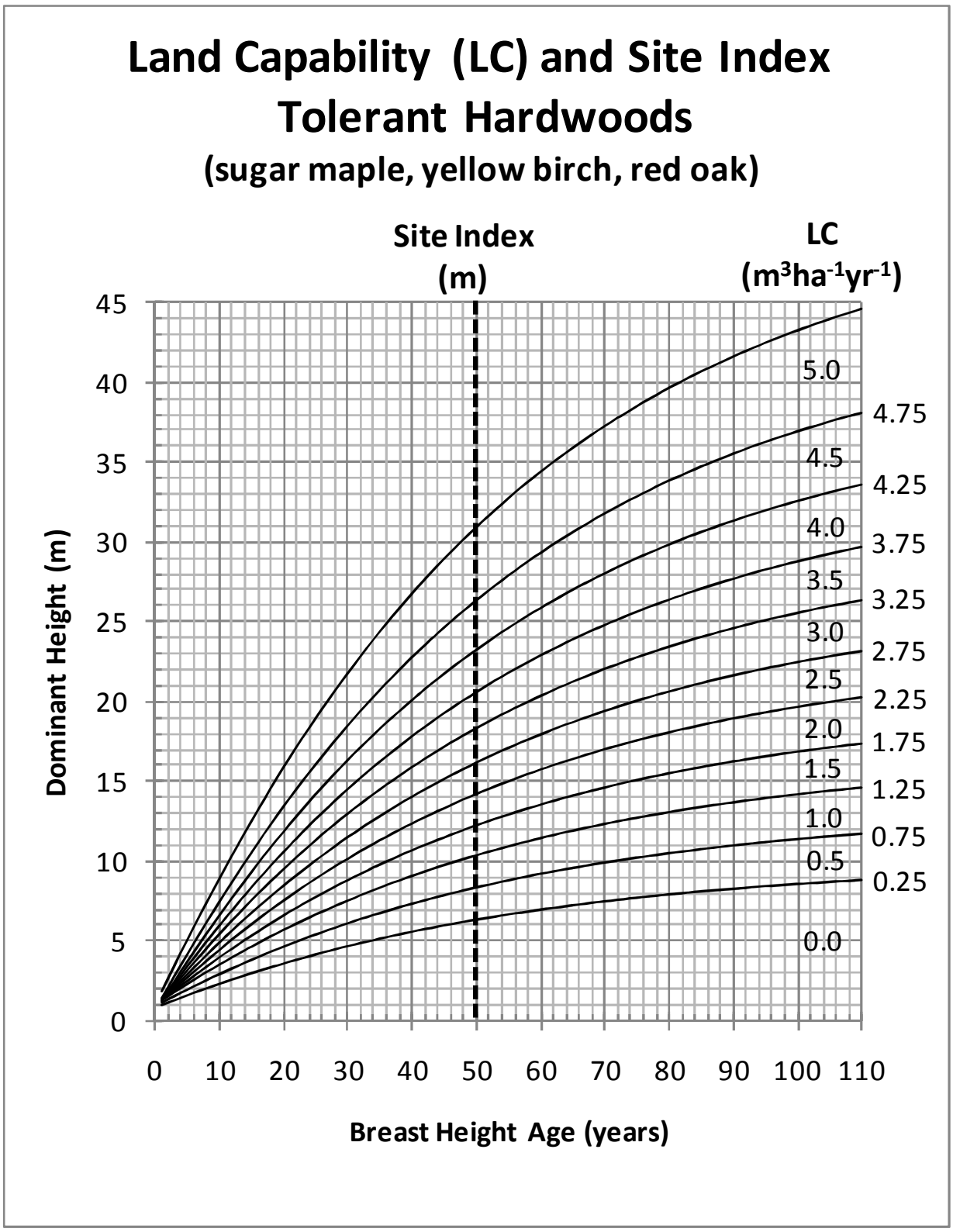

Figure 2. Land Capability/Site Index Curves for Nova Scotia Tolerant Hardwoods.

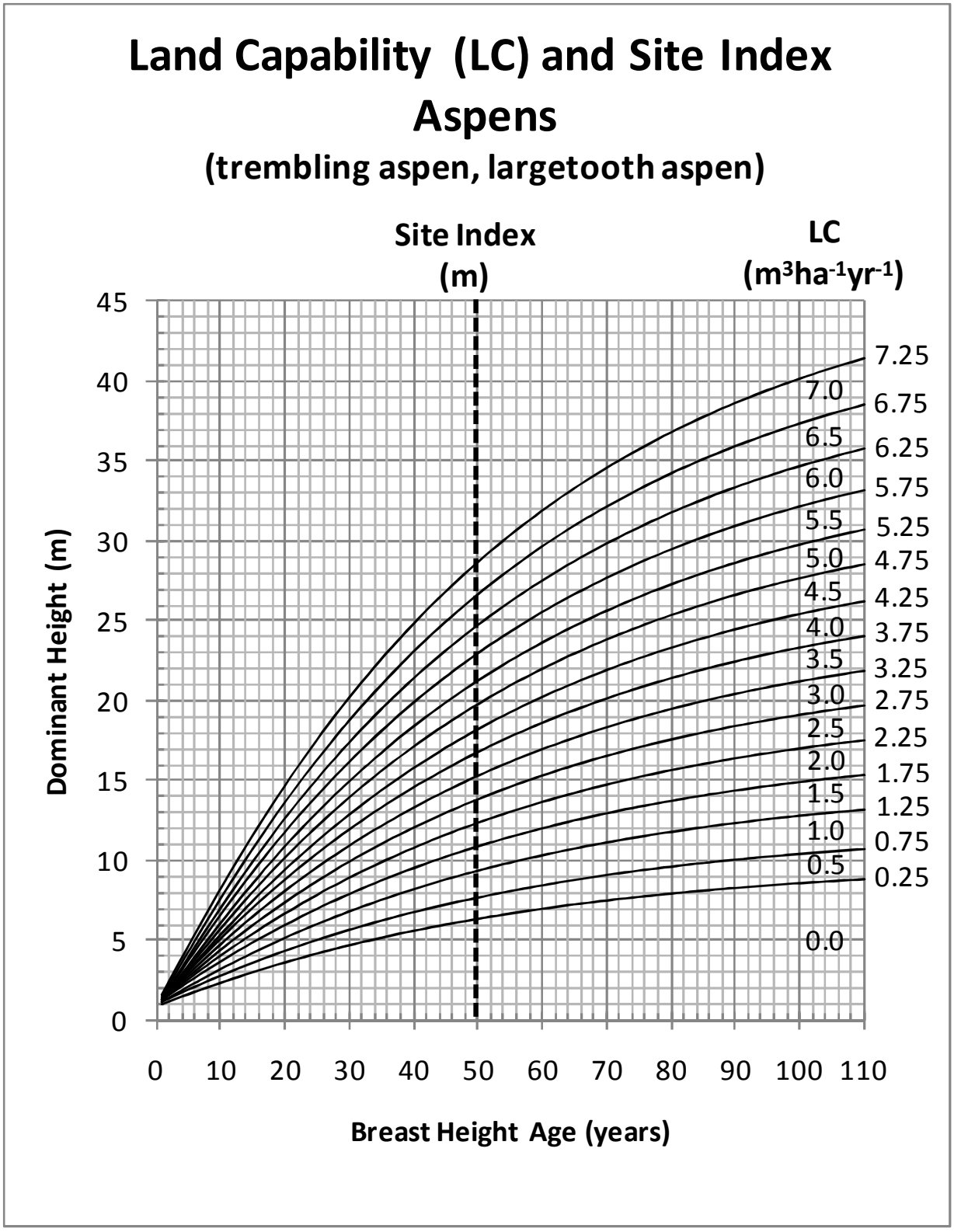

Figure 3. Land Capability/Site Index Curves for Nova Scotia Aspens.

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Appendix I. Site Index Equations and Table of Upper Limit Values

The following equations were utilized to produce the Land Capability/Site Index Curves shown in this report:

$$DHT = Z * Y^{b5}$$

$$Z = SI * Y50^{-b5}$$

$$Y = 1.0 - e^{-b4*X}$$

$$Y50 = 1.0 - e^{-b4*X50}$$

$$X = BHAGE + 10.5513 - 0.7565 * \mathrm{SI} + 0.03390 * \mathrm{SI}^{1.7826} - 1$$

$$X50 = 50 + 10.5513 - 0.7565 * \mathrm{SI} + 0.03390 * \mathrm{SI}^{1.7826} - 1$$

$$b4 = 0.0192$$

$$b5 = 1.076$$

Where **DHT** = Dominant Height in metres; **SI** = Site Index in metres at an index age of 50 years at breast height; **BHAGE** = Age in years at breast height; **e**= Naperian constant = *2.7182818284, **Z, Y, Y50, X, X50** =* interim calculations.

To produce graphs as shown in Figures 1-3, the Site Index (SI) associated with the upper limits for each Land Capability (LC) class specific to a species group must be entered in the equations above, where SI appears. These equations are then run for different ages to produce height over age curves for that LC.

The Site Index (SI) associated with the upper limits of half metre Land Capability (LC) classes Intolerant Hardwoods, Tolerant Hardwoods and Aspens.			
LC $(m^3 ha^{-1} yr^{-1})$	**SI (m @ 50 years breast height age)**		
	Intolerant	**Tolerant**	**Aspens**
0.25	6.323	6.325	6.323
0.75	8.470	8.340	7.700
1.25	10.590	10.320	9.370
1.75	12.770	12.260	10.900
2.25	15.050	14.200	12.370
2.75	17.470	16.190	13.850
3.25	20.310	18.340	15.300
3.75	23.650	20.600	16.750
4.25	29.450	23.220	18.250
4.75	-	26.350	19.790
5.25	-	30.980	21.300
5.75	-	-	22.950
6.25	-	-	24.730
6.75	-	-	26.650
7.25	-	-	28.700