RECOMMENDED SITE INDEX CURVES FOR IMMATURE COASTAL DOUGLAS FIR

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ABSTRACT

Site index curves for Douglas fir on the coast of British Columbia, Pacific Northwest States and other parts of the world are compared. Curves derived by King (1966) are recommended for use in immature stands of Douglas fir on the coast of B.C. until the B.C. Forest Service completes development of local curves.

INTRODUCTION

The Growth and Yield Subcommittee of the Regional Advisory Committee[1/] recommended that a study be undertaken to evaluate all available site index curves for Douglas fir and, if necessary, develop new ones for immature stands on the coast of B.C. The study reported here was undertaken by the Canadian Forestry Service (C.F.S.) in response to this recommendation.

The concept of site index is based on the assumption that stands having the same height at a particular index age (usually 50 or 100 years) also have identical height-growth patterns throughout the life of the stands, even though they may be growing in different areas. This assumption rarely applies in nature. Ideally, a separate set of site index curves should be derived for each area or group of growing conditions having a characteristic growth pattern. Unfortunately, it is usually impractical to develop more than one or two sets of curves because of inadequate knowledge or resources.

1/ Composed of representatives of industry, government and university interests.

As a consequence, trees with dissimilar growth habits are frequently combined in the derivation of site index curves. Curves 1 and 2 (Fig. 1) illustrate the cumulative height growth of 90-year-old dominant trees observed in two plots on Vancouver Island. Height growth is quite similar until age 40, after which there is considerable divergence. Height-age measurments of standing trees with these growth properties would lead to very different estimates of site quality, depending on the age of the trees when sampled. Top damage caused by ice and snow (e.g. Cowichan Valley) is another factor affecting the relationship between height and age. Curve 3 in Figure 1 illustrates the actual height growth of a dominant tree which had no external evidence of damage. Furthermore, there is no guarantee that growth patterns observed in the past will not be affected by changes in climate and management practices. These and other considerations have a bearing on the accuracy and utility of site index curves, and partly explain why a particular set of site index curves may be praised by one forest owner and condemmed by others. Unfortunately, it is all but impossible to define the average height-age relationship of a range of conditions even with an extensive and costly survey. Firstly, all sites do not support trees old enough to permit site index determination, and secondly, the average curves are likely to be outdated in a few years because harvesting and management practices change and the forest land base is not constant.

Harmonized Site Index Curves

Site index curves are most frequently constructed from temporary plot data by plotting the average height of dominant and codominant trees over the average age of the trees on each plot. An average curve is usually drawn free hand. If the anamorphic technique is used, other curves are spaced above or below the average curve in proportion to their height at the index age. The data must adequately sample the range in sites within each age class, and the effect of site differences on height growth must be relatively constant at all ages, i.e., the shapes of all curves must be similar. Polymorphic methods (Bruce and Schumacher 1950) avoid the last assumption.

It should be pointed out that harmonized curves depict the height-age relationship of stands rather than individual trees. Dominant trees at age 20, for example, are not the same trees as those at age 60, because some of the original dominants will have dropped into the lower-crown classes in the intervening 40 years.

Natural Site Index Curves

Height-age curves may be constructed by means of stem analysis of individual trees. The resulting set of natural site index curves is inherently polymorphic because each curve is obtained independently from data for a given site. The curves represent the growth of individual trees that remained in the dominant or codominant crown classes until the time when they were felled and measured. Only the tallest and most vigorous trees at age 20 will still be in the upper-crown classes at age 60. Consequently, natural height-age curves tend to overestimate the height of dominant and codominant trees in young stands. Since harmonized and natural site index curves for a particular site must give the same height at the index age, natural site index curves will usually underestimate the average height of dominant and codominant trees in stands older than the index age. This disadvantage can be overcome by employing analytical techniques that allow stem analysis data from trees of all ages to be combined in the derivation of curves. King (1966) used this approach in conjunction with a novel stem-analysis technique that can be used on standing trees. He measured the total height of each tree in addition to the distance of the whorls above the ground using an abney level. Whorls obscurred by the crown were omitted.

Natural site index curves are generally preferred to curves of an harmonized origin because they require fewer sample trees, every site in each age class does not have to be sampled, and the curves represent the actual pattern of height growth based on individual trees. Consequently, they are less subject to error. Ideally, site curves should be based on permanent sample plots but adequate data are rarely available.

METHODS

An index age of 50 years is selected for this study because of the trend toward shorter rotations and the need to check site index of stands at an early age.

Direct determination of age at breast height is used because it is more accurate and convenient than estimation of the total age of the stand dating back to its origin. Douglas fir has passed the initial period of establishment and site adjustment by the time breast height is reached. The leaders are generally beyond the reach of deer, and the inhibiting effects of bracken and brush are minimal. Breast-height age, for the most part, eliminates the necessity of deriving correction factors to allow for the number of years required to reach one-foot or breast height. In practice, plantations cannot be considered to be successfully established until 300 to 400 trees per acre are above breast height, especially in areas where animals and competing vegetation pose problems.

An index age of 50 years based on breast-height measurement of age is a convenient common denominator for comparing site curves because some sets do not reach the age of 100 years and others are already based on breast-height age and can not easily be converted to total age. Consequently, all sets of site index curves were converted graphically to age at breast height with 50 years as the index age. The procedure enabled direct visual comparison of curves by means of transparent overlays. Subjective judgment was necessary in a few cases to determine the number of years some authors had allowed for trees to reach breast height. The 10 families of curves compared are described in Table 1. The eighth set of curves was derived for this study. The data were provided by MacMillan Bloedel Co., Pacific Logging Co. and the Canadian Forestry Service, and comprise stem-analysis data for Douglas fir not already incorporated into site index curves.

RESULTS

Site curves from Great Britain (Bradley, Christie and Johnston 1966) and New Zealand (Duff 1956), although similar to one another (Fig. 2), are limited in scope and do not conform with the general growth patterns observed in B.C. and the Pacific Northwest States. The curves developed by Barnes (1947) (Fig. 3) depart even further from the trend of the remaining seven sets. Heger's curves (Heger 1958) shown in the same figure are aberrant in the lower-site classes (too steep) and also the lower-age classes (too low). McArdle, Meyer and Bruce (1949) present site curves (Fig. 4) high in the lower-age classes and low in the upper ages. Those developed by Spurr (1952) (Fig. 4) are a little steep in the upper-site classes and do not cover the lower sites adequately. The remaining sets

TABLE 1. DESCRIPTION OF SITE INDEX CURVES

	CURVE	YEAR	LOCATION	METHOD	FORM
1.	Bradley	1966	Great Britain	Unknown	Polymorphic
2.	Duff	1956	New Zealand	Subjective	Polymorphic
3.	Barnes	1947	B.C.	Harmonized	Anamorphic
4.	Heger	1958	U.B.C. Forest	Stem Analysis	Polymorphic
5.	McArdle	1949	Pacific N.W.	Harmonized	Anamorphic
6.	Spurr	1952	Pacific N.W.	Permanent Sample Plots	Polymorphic
7.	Warrack	1959	Lake Cowichan	Natural & Harmonized	Polymorphic
8.	C.F.S.	1970	Vancouver Is.	Stem Analysis	Polymorphic
9.	B.C.F.S.	N/A	B.C. Coast	Harmonized	Anamorphic
10.	King	1966	Washington	Stem Analysis	Polymorphic

(Warrack 1959; C.F.S.[1]; B.C.F.S.[2]; King 1966) are reasonably homogeneous and represent trees sampled on the coast of B.C. or Washington. Curves prepared by the C.F.S. and Warrack (Fig. 5) are too limited with regard to the range of ages or sites to be of general use. The difference between the B.C.F.S. and King's curves (Fig. 6) in the 0-to 20-age classes can be attributed to the shortage of data collected in this range by the B.C.F.S. Measurement of additional trees to strengthen the data in the lower-age classes is planned. The previous two sets of curves (Warrack and C.F.S.) support the height-growth trends shown by King in the lower-age class. This is especially true if the actual height-age curves of plots in the C.F.S. study are superimposed over King's curves. The departure of King's and B.C.F.S. curves beyond 80 years is small and well within the range of expected variation, considering that the older age classes were not sampled as intensively as the others.

RECOMMENDATIONS

Site index curves developed by King (1966) should be used for immature Douglas fir on the coat until other curves are demonstrated to be superior. When using these curves, site trees should be selected from the dominant crown class and preferably according to the method outlined by King in which the 10 trees of largest diameter in a 50-tree plot are measured for height and age. King has tabulated heights for one-year age classes and two-foot site classes.

1/ Curves developed by the Canadian Forestry Service and reported in this publication.

2/ Forest Surveys and Inventory Division, B.C. Forest Service, unpublished.

Further study by the Canadian Forestry Service is unwarranted in view of the progress being made in this respect by the Forest Surveys and Inventory Division of the B.C.F.S.

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Fig. 1. Height-age curves showing the effects of soil depth and top breakage.

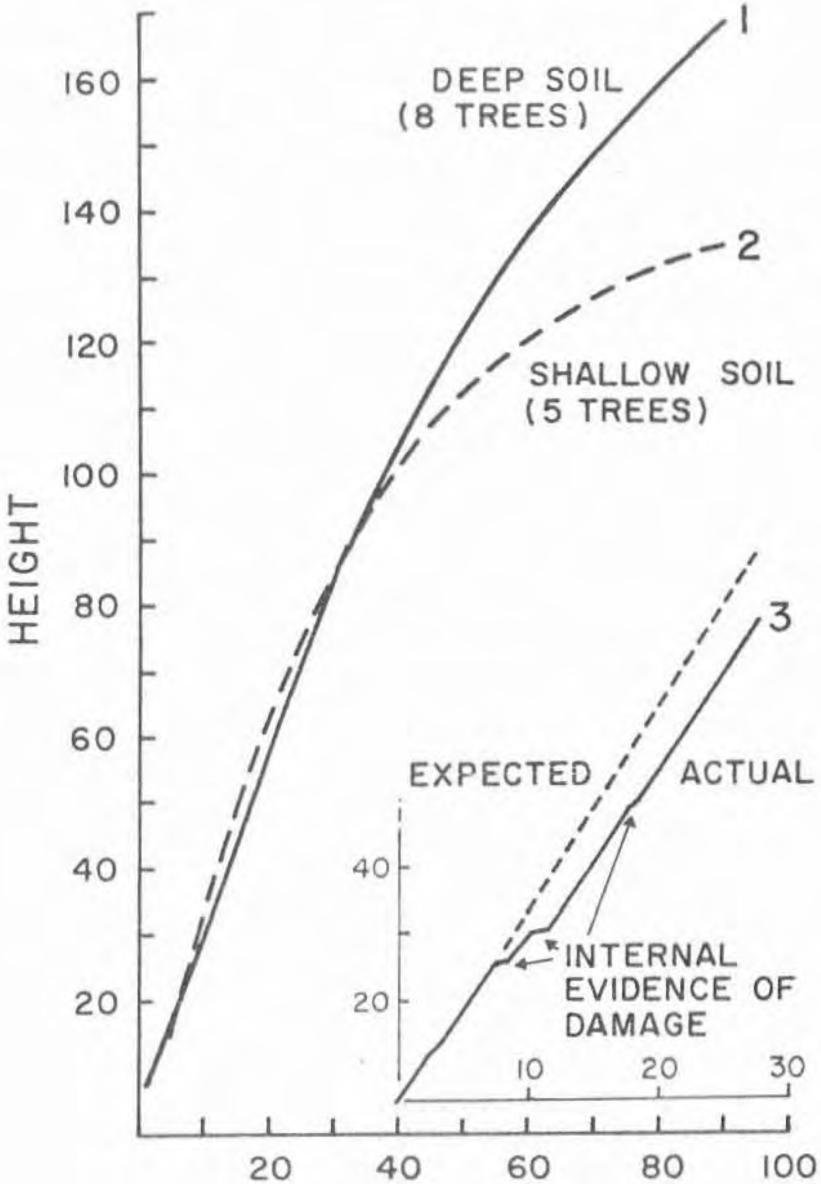
Fig. 2. Comparison of site index curves developed by Duff and Bradley.

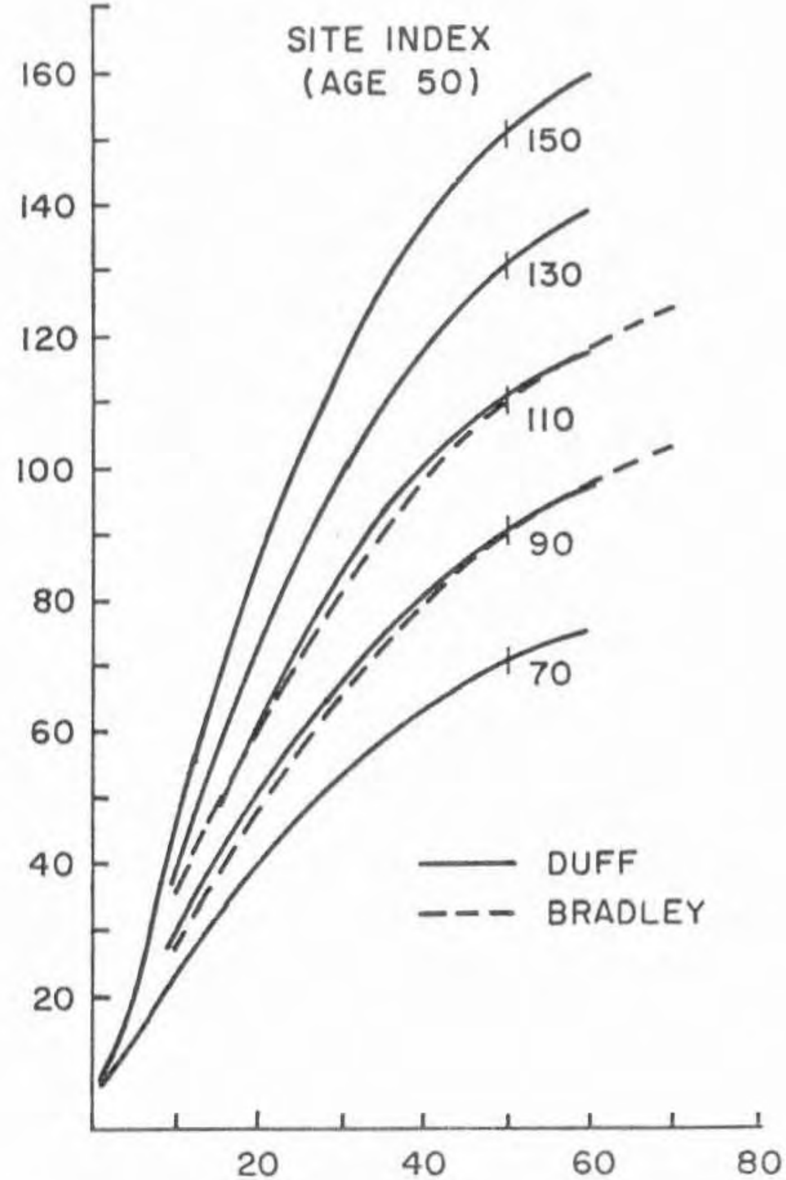
Fig. 3. Comparison of site index curves constructed by Barnes and Heger.

Fig. 4. Comparison of site index curves developed by McArdle and Spurr.

Fig. 5. Comparison of site index curves constructed by Warrack and the Canadian Forestry Service.

Fig. 6. Comparison of site index curves derived by the B.C. Forest Service and King.

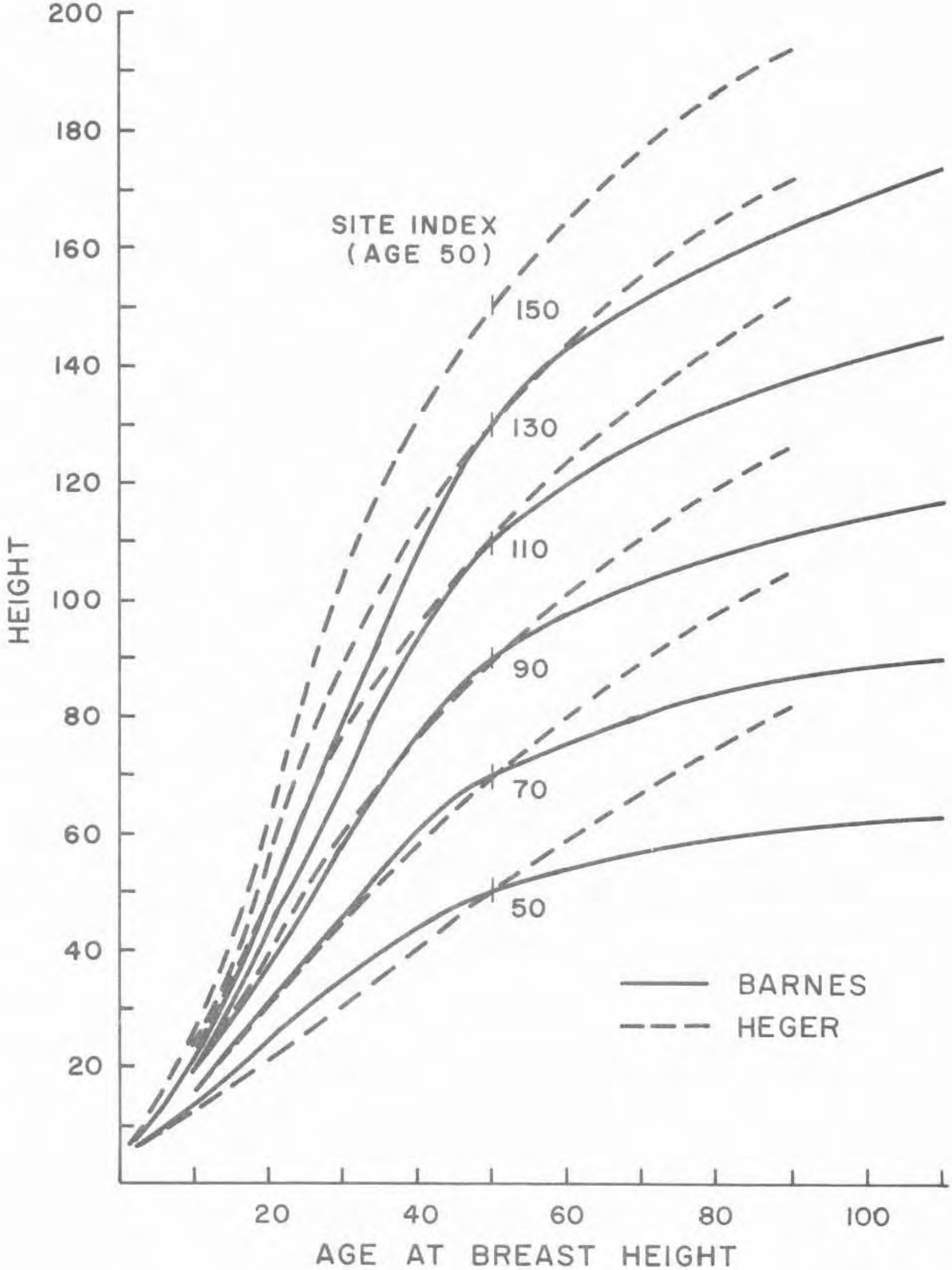




AGE AT BREAST HEIGHT

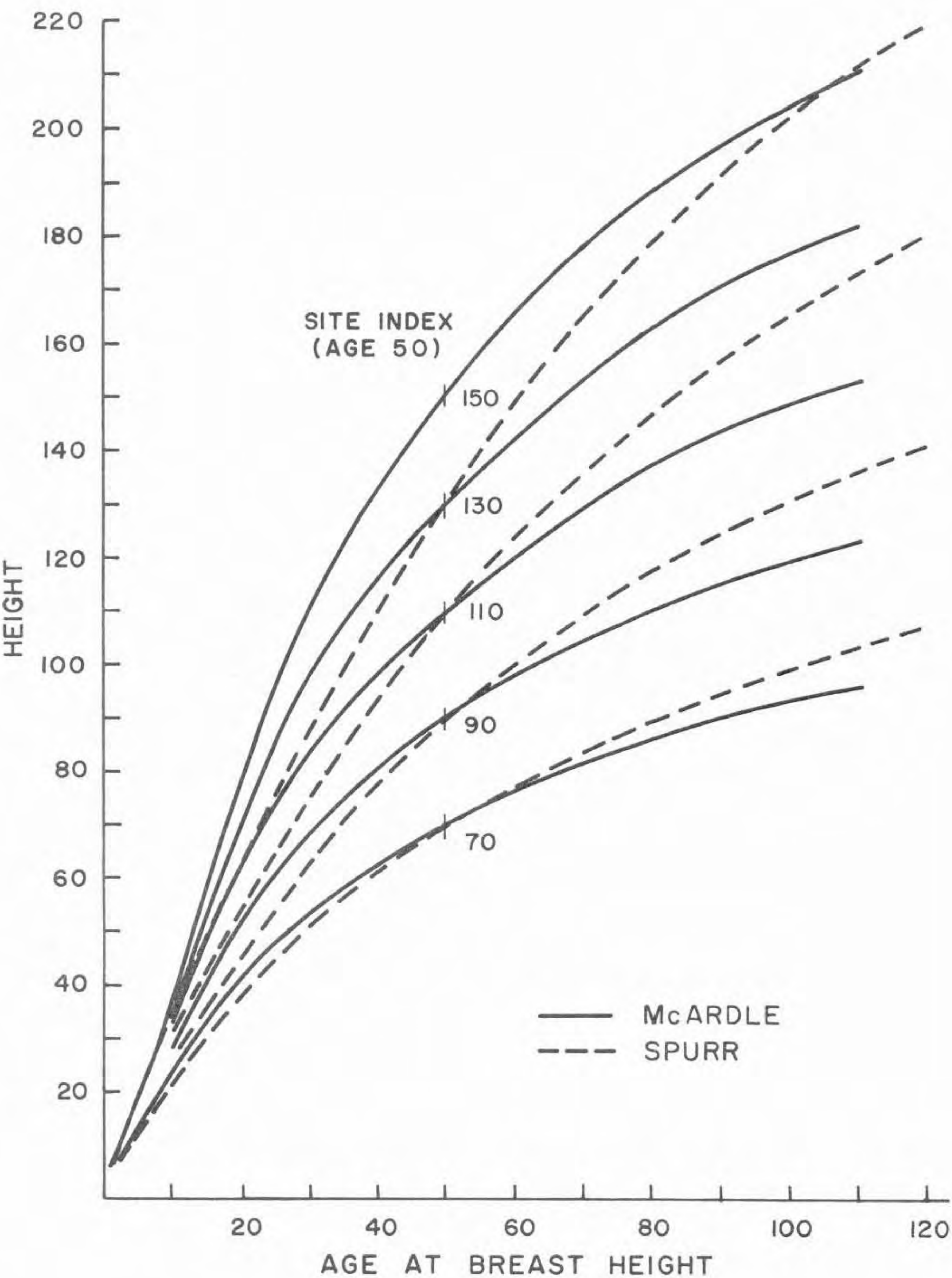
(1)

(2)



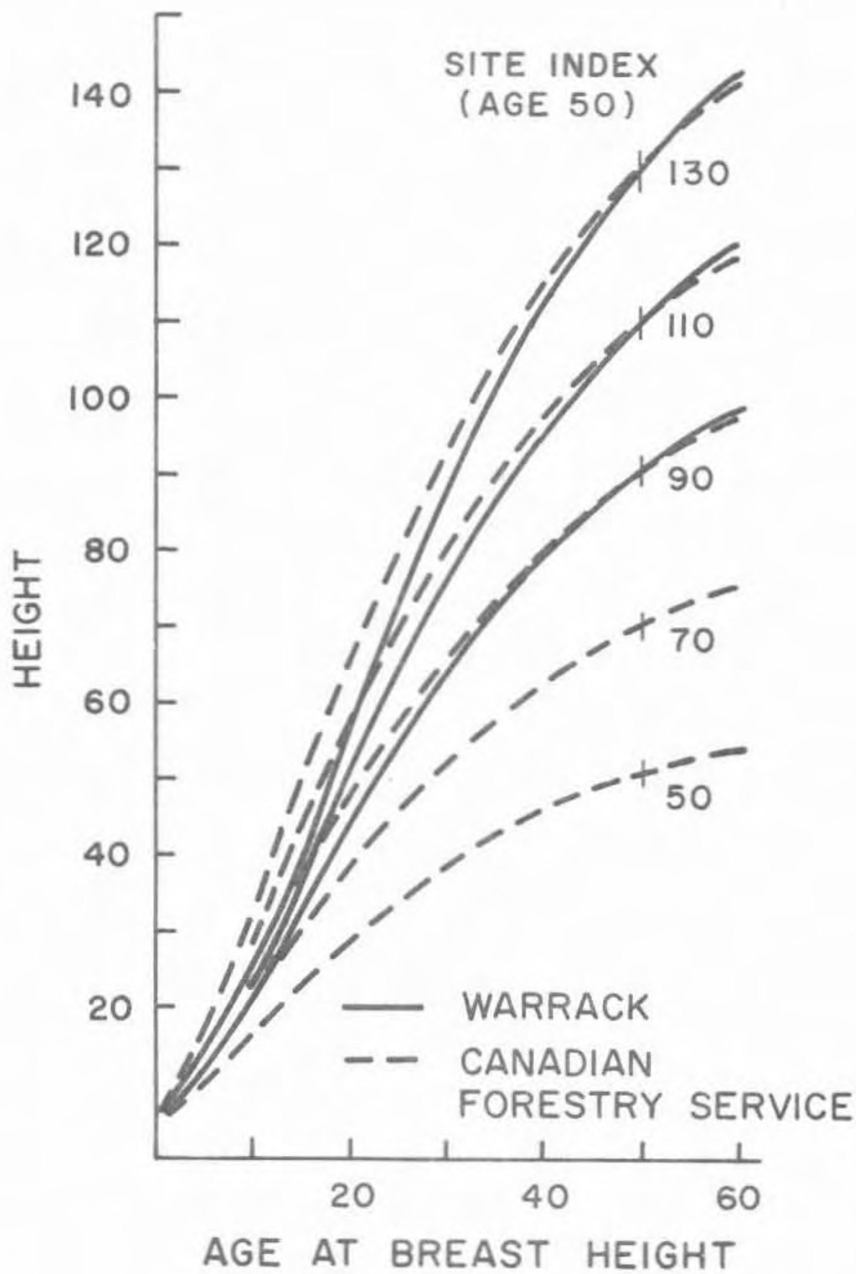
SITE INDEX
(AGE 50)
150
130
110
90
70
50
200
180
160
140
120
100
80
60
40
20
HEIGHT
20
40
60
80
100
AGE AT BREAST HEIGHT
BARNES
HEGER

③

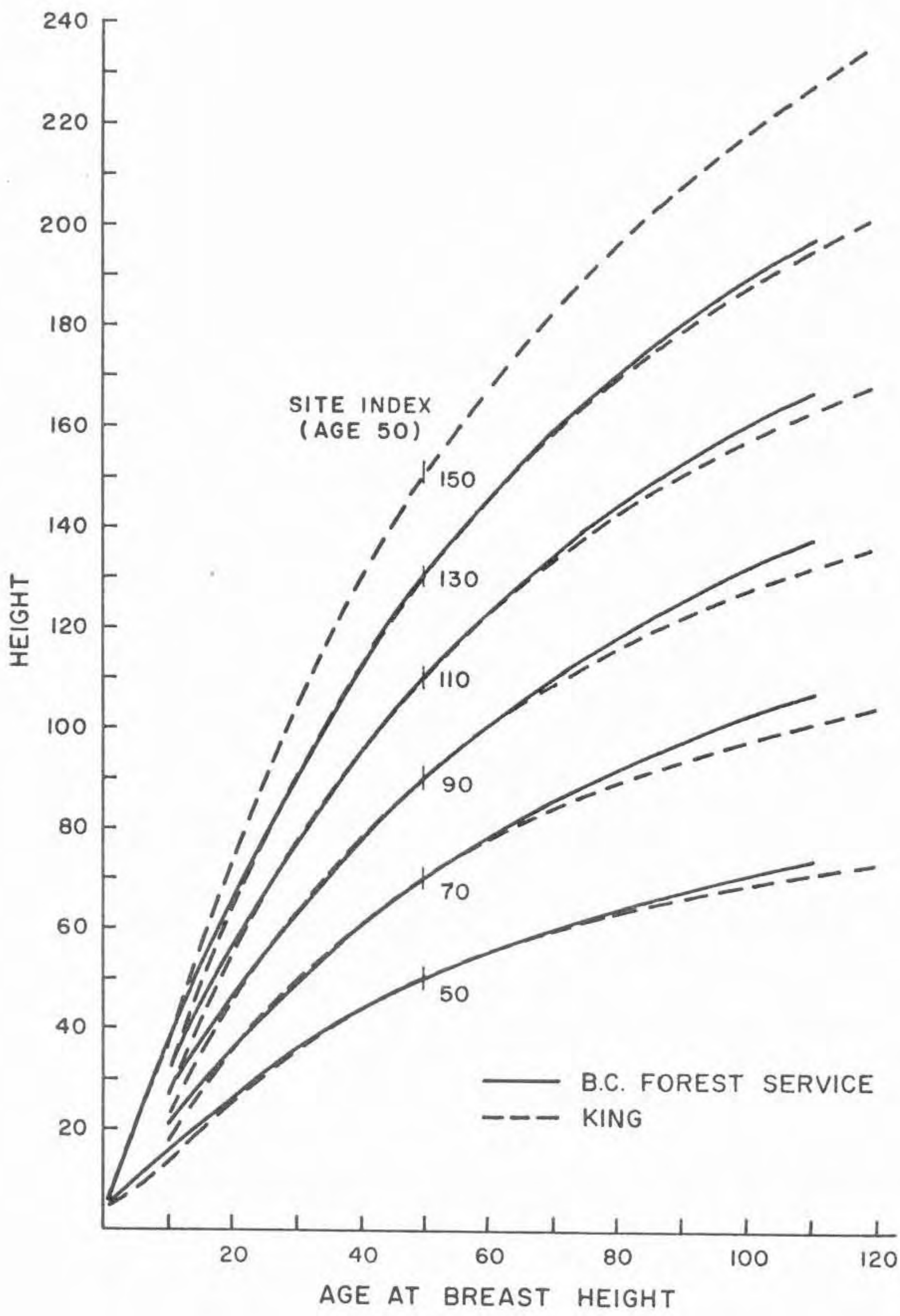


220
200
180
160
140
120
100
80
60
40
20
HEIGHT
SITE INDEX
(AGE 50)
150
130
110
90
70
McARDLE
SPURR
20
40
60
80
100
120
AGE AT BREAST HEIGHT

4


SITE INDEX
(AGE 50)
140
120
100
80
60
40
20
HEIGHT
130
110
90
70
50
WARRACK
CANADIAN
FORESTRY SERVICE
20
40
60
AGE AT BREAST HEIGHT

(5)


240
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HEIGHT
SITE INDEX
(AGE 50)
150
130
110
90
70
50
B.C. FOREST SERVICE
KING
20
40
60
80
100
120
AGE AT BREAST HEIGHT