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July 22, 2008

WOODLAND/FORESTRY TECHNICAL NOTE NO. NM 40

SUBJECT: ECS – WHAT IS SITE INDEX?

Effective Date: Effective when received.

Purpose: The attached document is intended to assist the planner in producing accurate site indices in forest inventory. The site index value can then be used with stocking guidelines in the Forest Stand Improvement (666) specifications and job sheet to calculate the recommended number of trees per acre and/or square feet of basal area per acre and/or D + X spacing.

Background: This technical note describes appropriate usage of site index in forest management planning. It also describes and diagrams the best ways to gather accurate height and age data in order to most closely approximate site index. The graphs at the end of the document are site index curves for the Southwest or Rocky Mountain region for ponderosa pine, aspen, douglas-fir, mixed conifer, Englemann spruce, piñon-juniper, and white fir.

GEORGE CHAVEZ
State Resource Conservationist

What is Site Index?

Site index (SI) is a measure of potential site productivity —the capacity of an area of land to grow trees of a given species (Figure 2.1). It is defined as the average height that free growing, undamaged top height trees of a given species can achieve in 50 years growth above breast height. Simply, SI is the height of doms at age 50 when they have been able to grow to their full potential. On sites where suppression, repression, or damage have reduced top height growth, SI is best thought of as the top height that would be attained at bh age 50 by unsuppressed, unrepressed, undamaged top height trees.

Top Height

Until very recently, top height trees were defined as the 100/ha largest DBH trees of a given species. Now this definition has been changed. The new definition of a top height tree is the "largest DBH tree of a given species in a 0.01 ha plot." This definition makes sure that all the top height trees cannot be located in a cluster in one corner of the hectare.

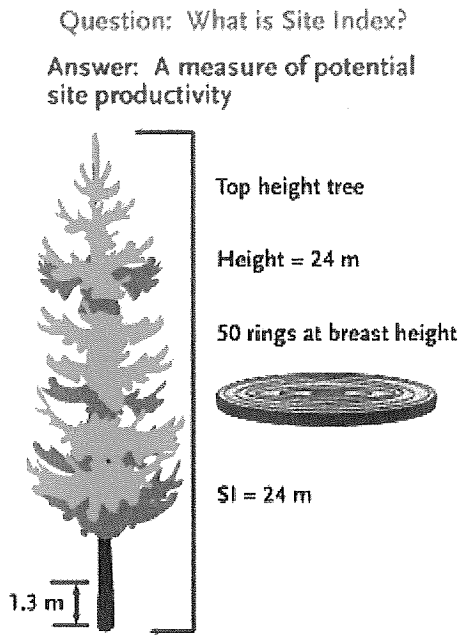


Figure 2.1. What is site index

Total age, breast height age, and years to breast height

The concept of SI is based on breast height age—not total age. Figure 2.2 illustrates the differences between total age, breast height age, and years to breast height. Total age is the number of years since seed germination. The number of years it took a tree to grow from seed to breast height is termed "years to breast height." The number of years growth above breast height is termed "breast height age."

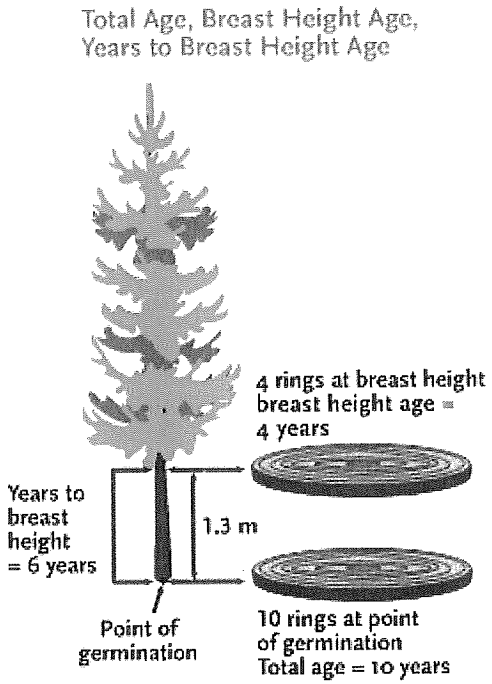
Breast height age is the number of annual growth rings at breast height. Total age is the number of rings at the point of germination.

Breast height is 1.3 m above ground measured from the high side.

This measure of productivity is based on stand height because stand height is:

- easy to measure
- closely related to stand volume
- relatively independent of stocking density.

SI allows standardized comparisons of productive potential between sites, across a broad range of existing stand conditions.



In the past, site productivity was recorded as a site class (i.e.,good, medium, poor).

Where is SI used?

Site index has many uses in:

- inventory
- silviculture
- timber supply analysis.

Inventory

In inventory, SI is used as a basic descriptor of site quality and used to grow the inventory to keep height and volume estimates current.

Silviculture

In silviculture, accurate estimates of SI are required to adequately describe site quality, formulate appropriate prescriptions, schedule and prioritize treatments and to predict stand growth and yield.

In many cases, site index is the single most important factor determining stand growth and yield. To illustrate how site index affects stand development, Figure 2.3 shows WinTIPSY (version 1.3) output for a coastal Fd stand planted at 1100 stems/ha on site index 25, 30, and 35 m.

Problems with Incorrect Site Index Determinations

It is important to correctly estimate SI. Incorrect SI estimates can lead to a variety of problems, including:

- inappropriate silviculture prescriptions
- inability to accurately schedule and plan for future treatments (as required under SMPs – Stand Management Prescriptions)
- inability to prioritize treatment dollars to the best sites
- incorrect estimates of the growth potential of regenerated stands
- incorrect information in the silviculture and inventory databases
- inaccuracies in the timber supply analysis.

Biased Site Index and Stands Growing Below Potential

Site index is a measure of the site's potential to grow trees. However, the stand that is currently on the site may not express potential, and may not achieve potential, due to:

- overtopping by brush or trees
- excessive establishment density
- damage by insects, disease, snow, etc.
- treatment such as excessive pruning or thinning-out of top height trees.

When these factors have reduced the height growth of top height trees, and when site index is predicted from top height tree height and age, the resulting site index estimate is biased. It underestimates site potential. Some have called this value the "expressed site index" or "indicated site index." "Biased site index" is the term that will be used in this course.

Tree Growth Response to Improved Site Quality

Compared to a poor site, a site that is "better" for a given tree species provides the required resources (e.g., light, soil water, soil nutrients, CO2) and environmental conditions (e.g., temperature, soil aeration) at levels that are closer to optimum for more days of the year. Under these favourable conditions, trees achieve more growth; top height growth is greater and stands attain a greater top height at bh age 50 years. Thus, the site has a greater site index. The increased height growth of trees ***on better sites*** can be understood as a result of four factors (Figure 2.13):

1. **Resource availability**—a greater quantity of resources are available per day and there are more days in the growing season.
2. **Resource capture**—trees can support more foliage thus capturing more of the available light.
3. **Efficiency of resource use**—the resources that have been captured are used more efficiently. More photosynthate is produced per unit of resources captured. The efficiency of resource use is greater as:
    a. there are fewer days in the growing season where soil moisture deficit, frosts, air moisture vapour pressure deficits, and other environmental conditions limit photosynthesis; and
    b. improved nutrient levels in the leaves improves the yield of photosynthate per unit of captured light.
4. **Allocation to roots**—underground resources (e.g., soil moisture and nutrients) are acquired more easily. Thus, the tree needs to allocate less of its photosynthate to the roots, leaving a greater proportion to be allocated to stem growth. The increased top height growth on better sites is the result of the combined effect of these tree responses to improved site quality.

Site Index Curves

The site index curve method predicts SI from height and age measurements taken on carefully selected sample trees. Site index curves are available for the following species:

- Ponderosa pine, Englemann spruce, aspen, Douglas-fir, white fir, piñon-juniper, mixed conifer. (*note that the PJ curves are based on basal area, not height)

The site index curve method is best suited to even-aged, pure species, middle-aged stands that are healthy (Figure 7.1). Usually, a stand is not suited to the Site Index Curve method if:

- it is uneven aged
- the sample trees have been overtopped by trees or brush
- it has received partial cutting removing the larger trees
- many of the sample trees are seriously damaged or diseased
- the sample trees are old (age class 8 and 9)
- the sample trees are excessively large or rotten at DBH.

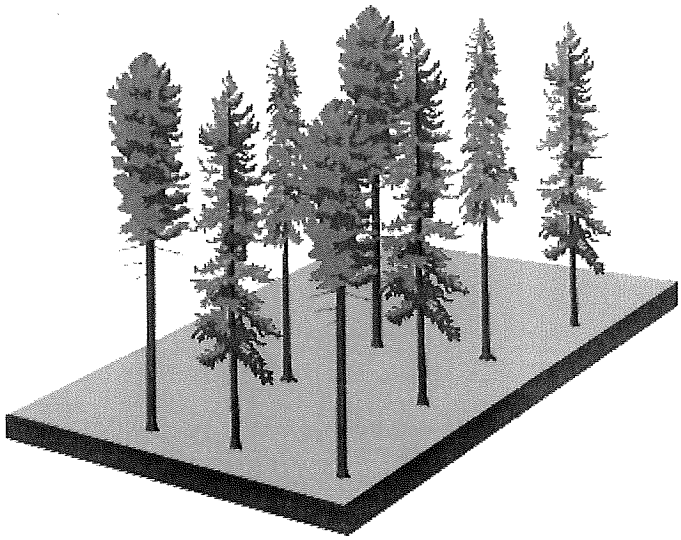


Figure 7.1. Stands suited to site index curves include many 30- to 140-year-old stands.

When correctly used, the site index curve method produces an accurate estimate of SI. However, the required heights and ages can be costly and difficult to accurately measure. Sampling is very similar to the growth intercept method. To use the site index curve method:

1. pre-stratify the opening
2. in each stratum,
    a. select a site index species
    b. collect height and age data on suitable top height sample trees
    c. compute the average SI.

Spread plots across the stratum. In a 5.64 m radius plot, identify the largest DBH tree of the SI species. Measure it for height and age if it meets the following criteria:

- undamaged stem with vigorous, uniform annual height growth above breast height
- dominant or codominant crown class and not overtopped by other trees or brush
- vigorous and uniform ring width from pith to bark.

Age is determined at breast height by counting rings on an increment core taken at 1.3 m above ground on the high side (see Appendix 2). Total tree height is usually determined with a suunto and distance tape (see Appendix 1).

For each sample tree, read the corresponding SI from the appropriate SI curve or table.

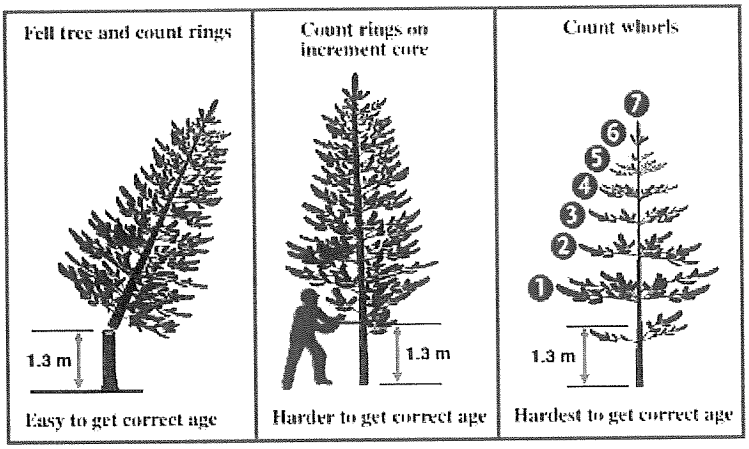
With the SI curve, the X axis shows the breast height age and the Y axis shows the top height for a given species (Figures 7.2A).

The tables have breast height age down the side, top height along the top, and site index in the body of the table (Figure 7.2B).

Average the SI determined for each sample tree to obtain the average SI for the stratum.

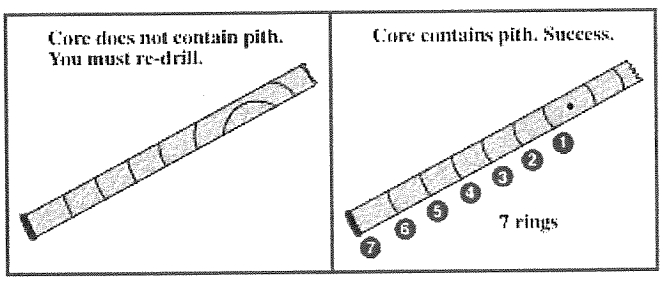
1. Use an Accurate Method to Determine Age

There are three methods that can be used to determine the age of a sample tree at breast height: fell the tree at breast height and count rings on the stem cross-section, count rings on an increment core taken at breast height, and count annual branch whorls above breast height. These three methods of determining age differ in accuracy. Generally, it is easiest to get an accurate age by felling the tree and counting rings on the cut face. The method of counting branch whorls is the most difficult method to use to get an accurate age. Counting rings on an increment core is intermediate in difficulty.



2. Take a Quality Increment Core

Rings are easiest to count on high quality cores. To obtain high quality cores, keep your increment borer sharp and clean. Hold the borer steady when you begin to drill. Re- the tree until you get an increment that contains the pith. Often you can improve your chances of hitting the by aligning the borer with tree center using the branch angles into the pith.

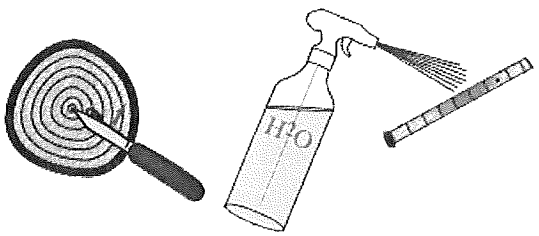


drill
core

pith

3. Prepare the Surface for Counting

On both an increment core and a cut face, wetting the surface may make rings more visible. Also, shaving a thin layer of wood the surface will often make rings more visible. you are felling the tree, use a sharp handsaw make sure the rings are clear.

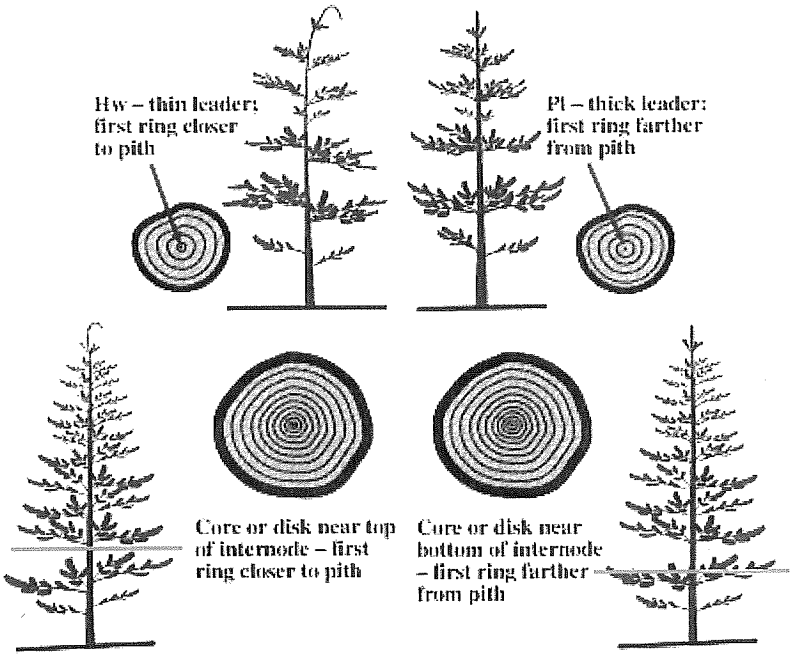


from
If
to

4. Accurately Locate the Pith and First Ring

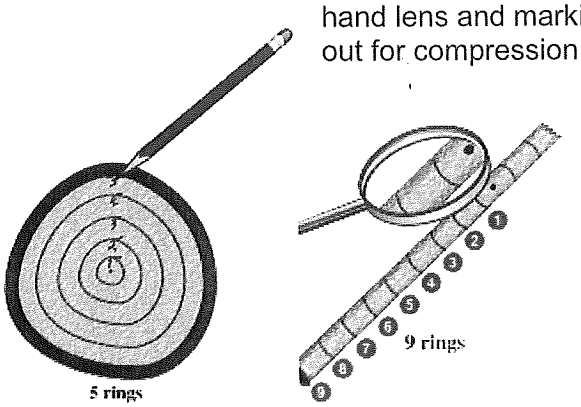
On the increment core (or stem cross-section), locate the pith. Generally, the pith is an oval-shaped area of darker, spongier material. Confirm that you've got the pith by making sure that the rings closest to it form concentric circles around the pith.

To locate the first ring, consider where the core or cut was taken within the internode. At the top of the internode, little wood has formed so the first ring is very close to the pith. At the bottom of the internode, more wood has formed so the first ring is farther away from the pith. Also, consider the thickness of wood on the leaders of the sample trees. A species with a thick woody leader (such as Pl) will have the first ring well away from the pith.



5. Carefully Count Rings

To help resolve questions while counting, roll the increment core over to look at all sides. On a cut face, look at rings around the complete surface to help resolve ring counting questions. You may improve your accuracy by using a hand lens and marking rings with a pencil while counting. Watch out for compression wood 1/2 rings.

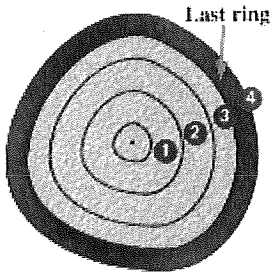


6. Correctly Account for the Last Ring

Make sure your method of counting rings takes account of the last ring that is pressed against the inner bark. The method of ring counting that is shown in the diagrams in this document is as follows:

a. Do not count the pith

b. Count the first ring around the pith as ring 1

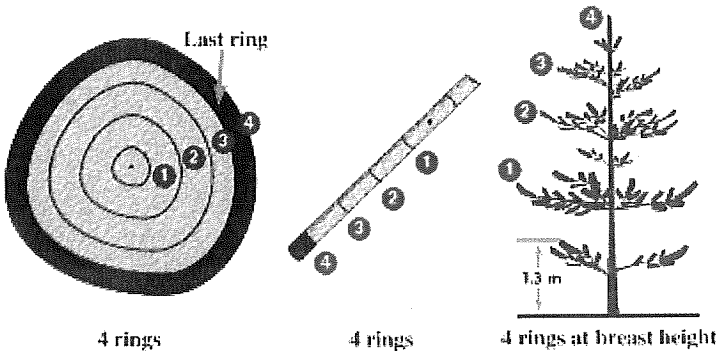


c. Count each ring out to the bark

d. Count the last ring pressed against the inner bark.

7. Double Check

It is useful to double check your age determination every now and again. On small trees it is relatively quick and easy to compare the age determined by counting whorls to the age determined by felling or drilling the tree.



4 rings 4 rings 4 rings at breast height

8. Office Counting

In some cases, you may want to take a disk cut from breast height or the increment core back to the office to count rings under improved light and magnification. To transport cores, place core in a plastic drinking straw and seal the ends of the straw.

For more information about the this course, please contact:
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Victoria, British Columbia
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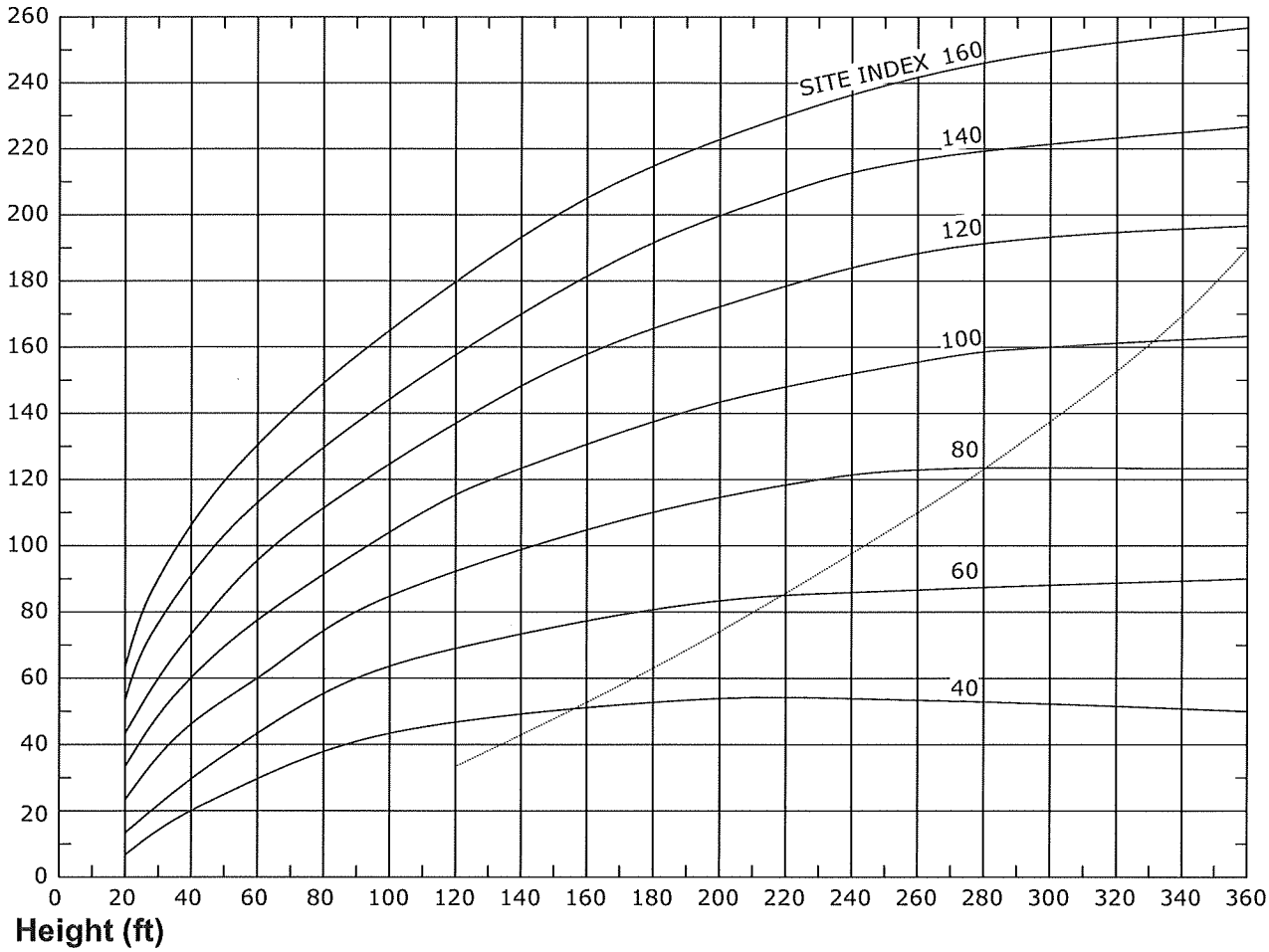
Site Index Curves

PONDEROSA PINE SITE CLASSES



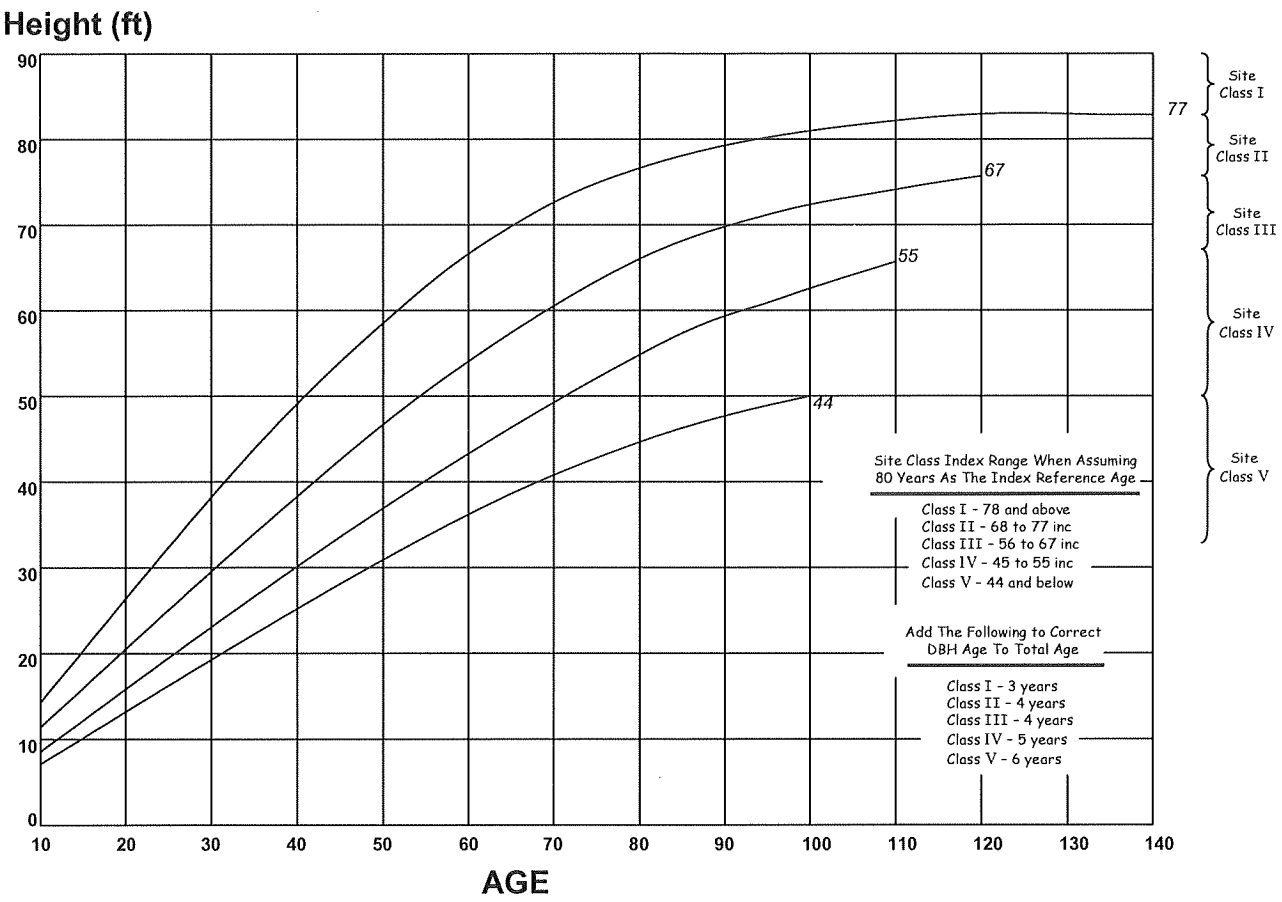
AGE (at breast height or requires adding?)

Height of dominant and codominant trees of average breast high diameter.

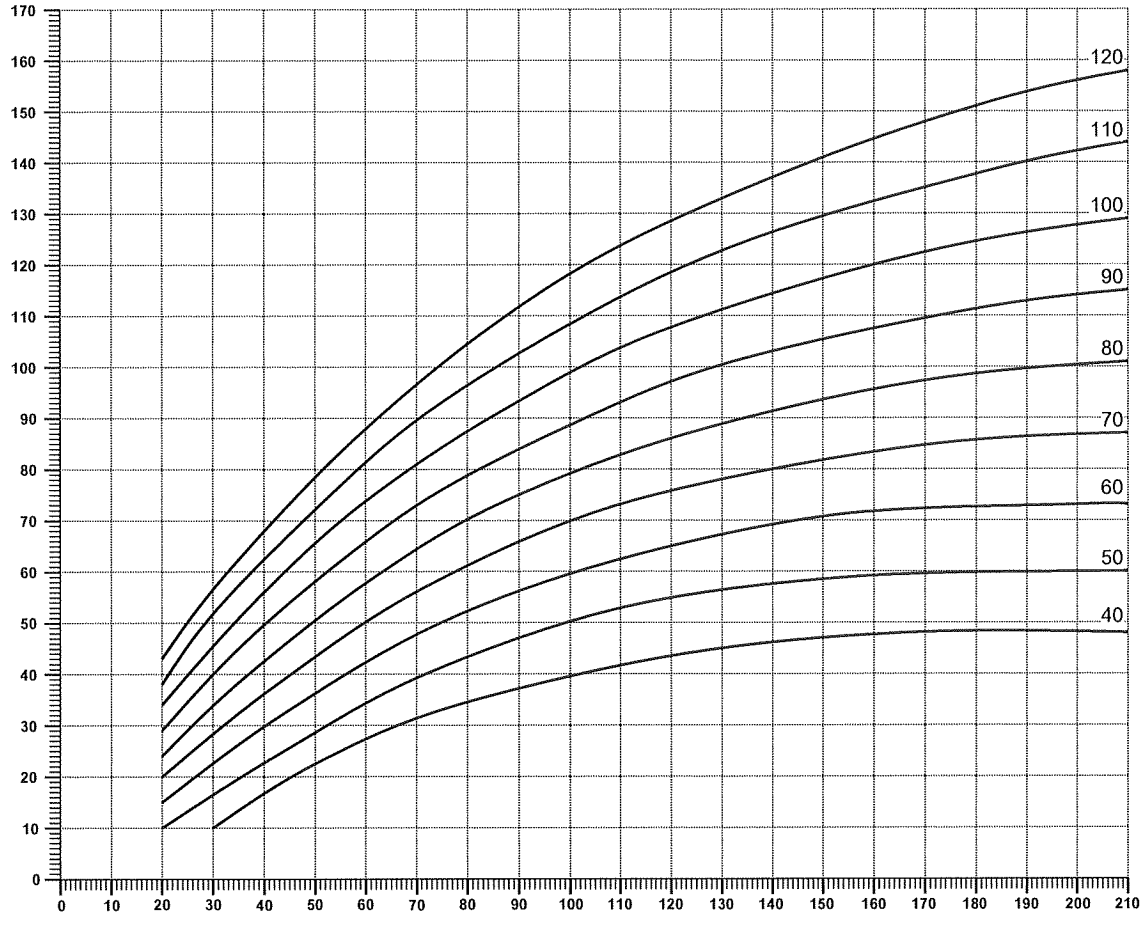
From Figure 2, U.S.D.A., Technical Bulletin 630

The broken curve has been added to indicate approximate age at which trees reach their ultimate height for any site. One may estimate site quality from this chart by using average total height alone for all instances falling to the right of the broken curve.

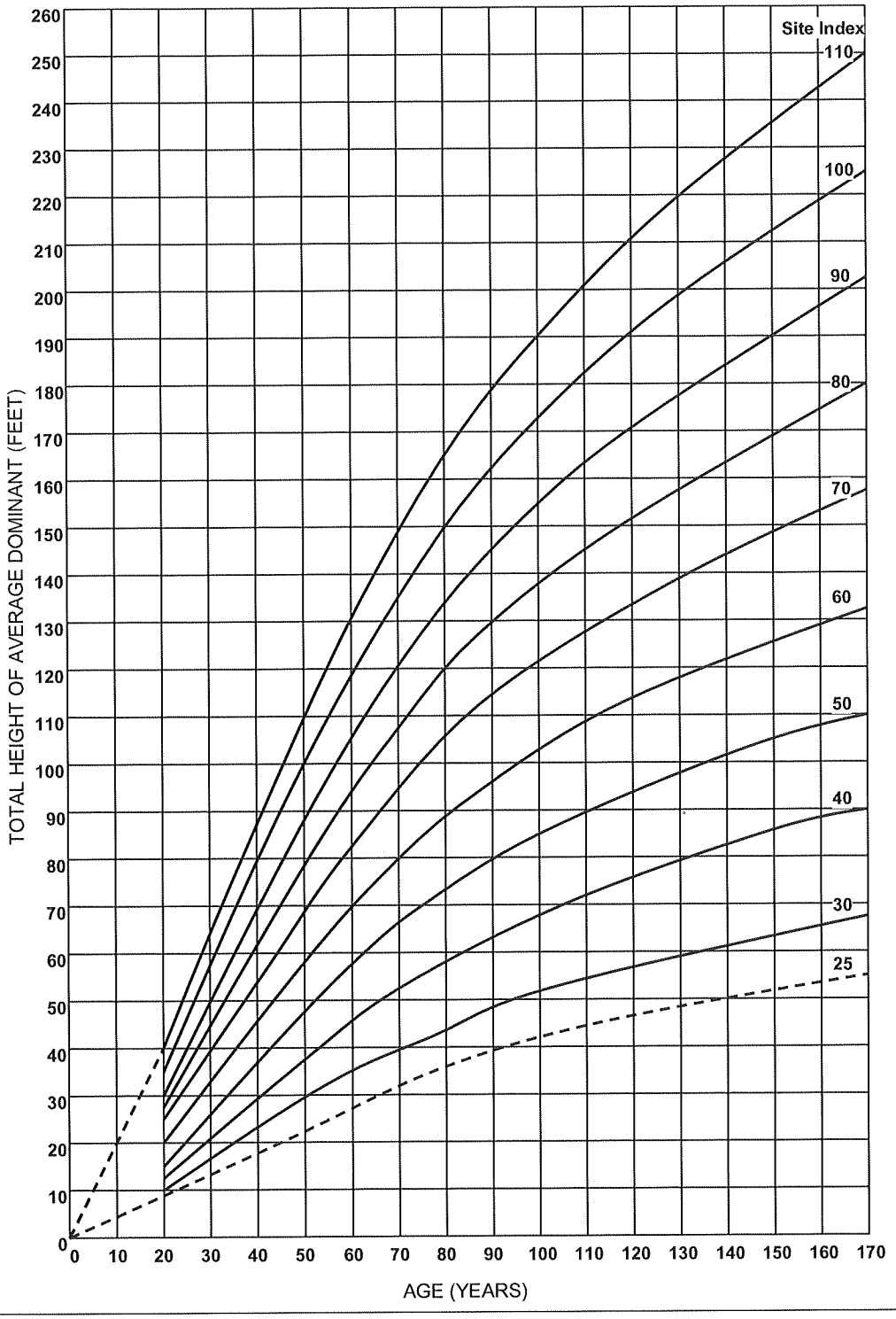
ASPEN SITE INDEX CURVES
IN THE CENTRAL ROCKY MOUNTAIN REGION



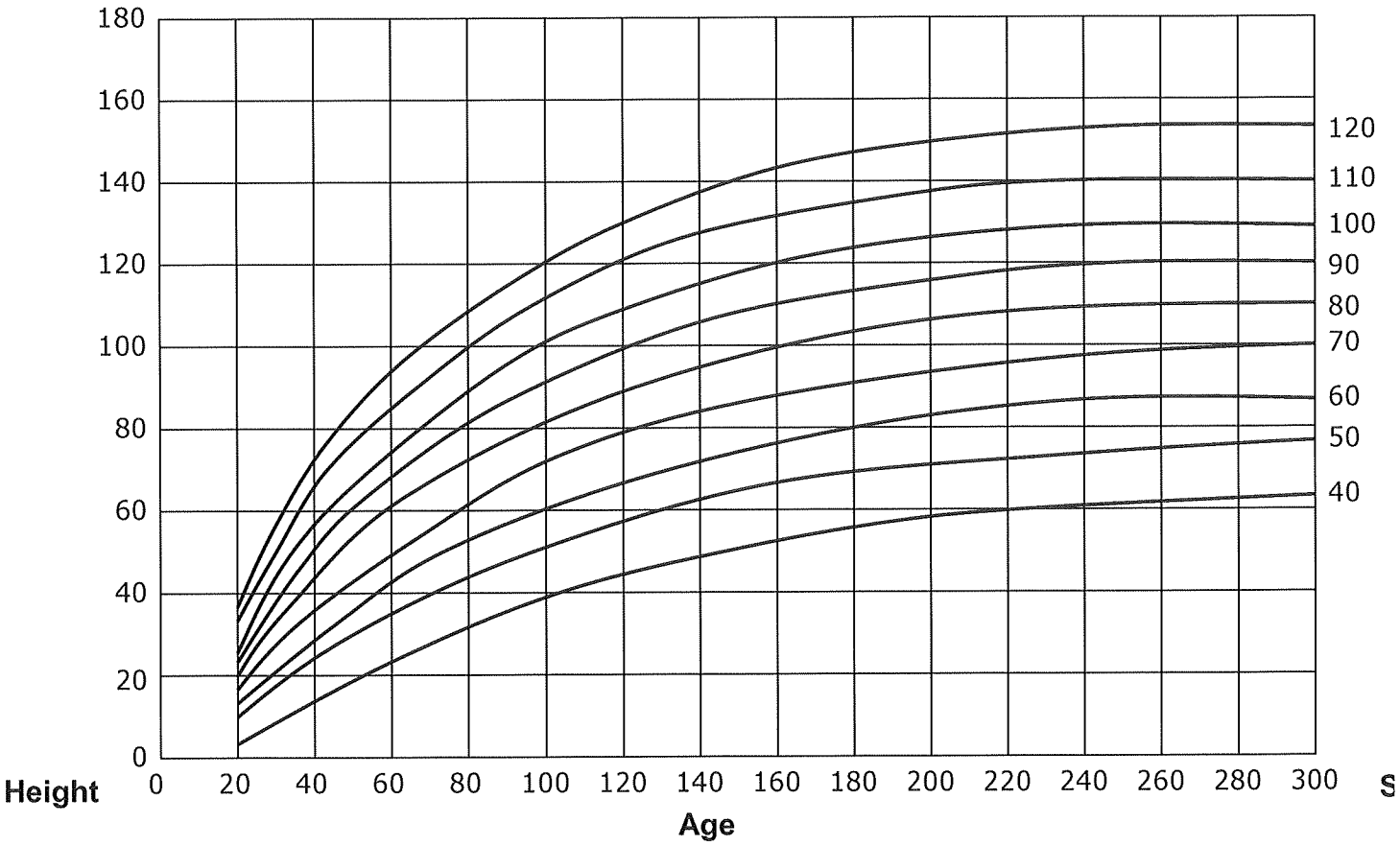
DOUGLAS-FIR SITE INDEX CURVES IN ARIZONA, NEW MEXICO, & SOUTHWESTERN COLORADO (reference age 100 years, breast height)



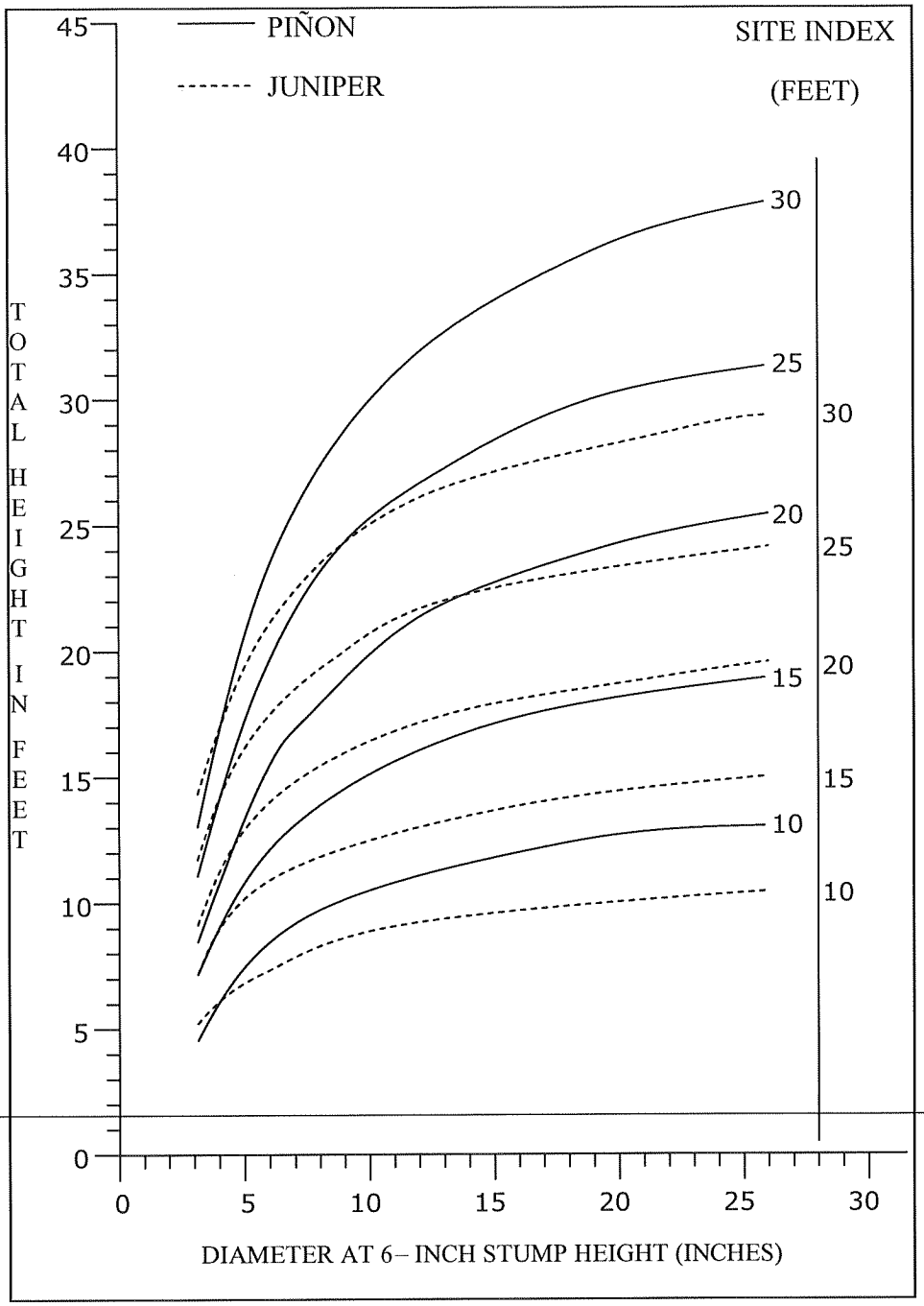
SITE INDEX VALUES OF DOMINANT TREES IN MIXED CONIFER STANDS IN CALIFORNIA OF AVERAGE BASAL AREA



ENGELMANN SPRUCE SITE INDEX CURVES
IN THE CENTRAL AND SOUTHERN ROCKY MOUNTAINS



PIÑON PINE AND JUNIPER SITE CLASSES



White fir site index curves