*Extension Note**

B.C. Journal of Ecosystems and Management

Making sense of site index estimates in British Columbia: A quick look at the big picture

Steve Stearns-Smith[1]

Abstract

Site index remains the primary estimate of forest site productivity used throughout British Columbia and around the world. Forest managers often need a better understanding of how various site index estimates are derived in order to effectively apply them in operational settings. Historically, most site index estimates in Canada were derived from the photo-interpreted estimates of stand height and age found in extensive inventories. However, a wider range of data sources and site index tools now make both direct and indirect estimation of site index possible. Consequently, several different site index estimates may exist for any given hectare. The most prominent example involves comparisons of site index estimates derived from natural stand (old-growth) inventories versus the higher estimates frequently observed in post-harvest second-growth stands. These differences can have positive implications for timber supply. An understanding of site tree selection is essential when choosing the best available site index estimate for a given application.

Contact Information

1 Manager, Southern Interior Growth and Yield Co-operative, c/o Interior Lumber Manufacturers' Association, 360–1855 Kirschner Road, Kelowna, BC V1Y 4N7. E-mail: steve.stearns-smith@shaw.ca

Southern Interior Forest Extension and Research Partnership

SOUTHERN INTERIOR SIGY CO-OPERATIVE GROWTH AND YIELD

* *This extension note is a co-publication of the Southern Interior Forest Extension and Research Partnership and the Southern Interior Growth and Yield Co-operative.*

Site Productivity and Site Index

Many decisions in forestry rely on estimates of the land's inherent ability to grow trees and yield timber. These ***site productivity*** estimates serve as a baseline for land-use decisions, land appraisals, silviculture investment analyses, and growth and yield predictions. To provide a consistent basis for these various comparisons and applications, site productivity estimates should be independent of current stand conditions and historic management practices.

For more than 100 years, ***site index*** has remained the world's most widely used measure of site productivity. For any given species, site index is simply defined as the average height at some fixed age (commonly 50 years at breast height) attained by dominant and co-dominant site trees selected to reflect ***site potential***. In practice, this means the height growth of site trees should be relatively free from past effects of suppression, repression, and damage from insects, disease, and weather. Unrestrained height growth makes a good index of site potential because, unlike diameter or volume growth, it is relatively stable and robust over a large range of managed stand densities.

Tree growth is limited by genetics and by the effects of environmental factors, such as temperature, moisture, nutrients, and light. Trees and other plants constantly compete with one another for these growth-limiting resources. Some sites are naturally more productive than others because they possess a more favourable supply or balance of these basic resources. A site's inherent ability to provide these resources is largely governed by ***site factors*** such as topography, soils, and climate. The basic concept of site productivity recognizes the link between potential timber productivity and these site factors.

The "site tree" concept is the central strength of site index, but also its main weakness. Theoretically, all sites capable of growing trees possess a unique site index for every species. Realistically, existing stand conditions rarely produce suitable site trees for every species. Logging, catastrophic natural disturbances, or brush dominance can temporarily eliminate trees altogether. Even when trees are present, several common stand histories reduce the likelihood of finding suitable site trees. Some examples include:

- overly dense, fire-origin pine exhibiting height growth repression across all crown classes;
- old-growth stands with years of accumulated damage and disease; and
- trees suppressed at one time or another by brush competition or an overstorey canopy.

Consequently, ***direct estimates*** of site index using site trees are sometimes impossible in recently disturbed areas, or in old-growth, uneven-aged, and mixed-species stands. Over the years, this situation has inspired many attempts to develop ***indirect estimates*** of site index using various site factors or their surrogates. In all cases, site tree selection still plays an important role in the development of indirect estimation tools (Figure 1).

The United States and eastern Canada have a long history of soil classification and mapping accompanied by soils-based predictions of site index. In similar fashion, British Columbia's biogeoclimatic ecosystem classification (BEC) system is being used to predict site index through various approaches, including the provincial ***SIBEC*** (Site Index–Biogeoclimatic Ecosystem Classification) program. Indirect site index estimates tend to be less accurate than direct site tree measurements. This is because soil and ecosystem classification schemes are imperfect substitutes for the individual site factors that we might otherwise have difficulty measuring or even identifying. However, these indirect methods can still provide useful information if the degree of uncertainty associated with them is recognized and tolerable. In fact, in the absence of suitable site trees, indirect tools often provide the best available estimates of site potential.

An understanding of site tree selection is essential to evaluate potential height-age data, select tools, and assess the usefulness of the resulting site index estimates.

A Source of Confusion

Before the 1990s, most Canadian foresters encountered site index only in the context of provincial forest inventories. Site index still appears in some inventories as ***site class*** (e.g., good, medium, poor, and low).

Forest inventories in Canada evolved to meet the logistical and financial challenges presented by a vast,

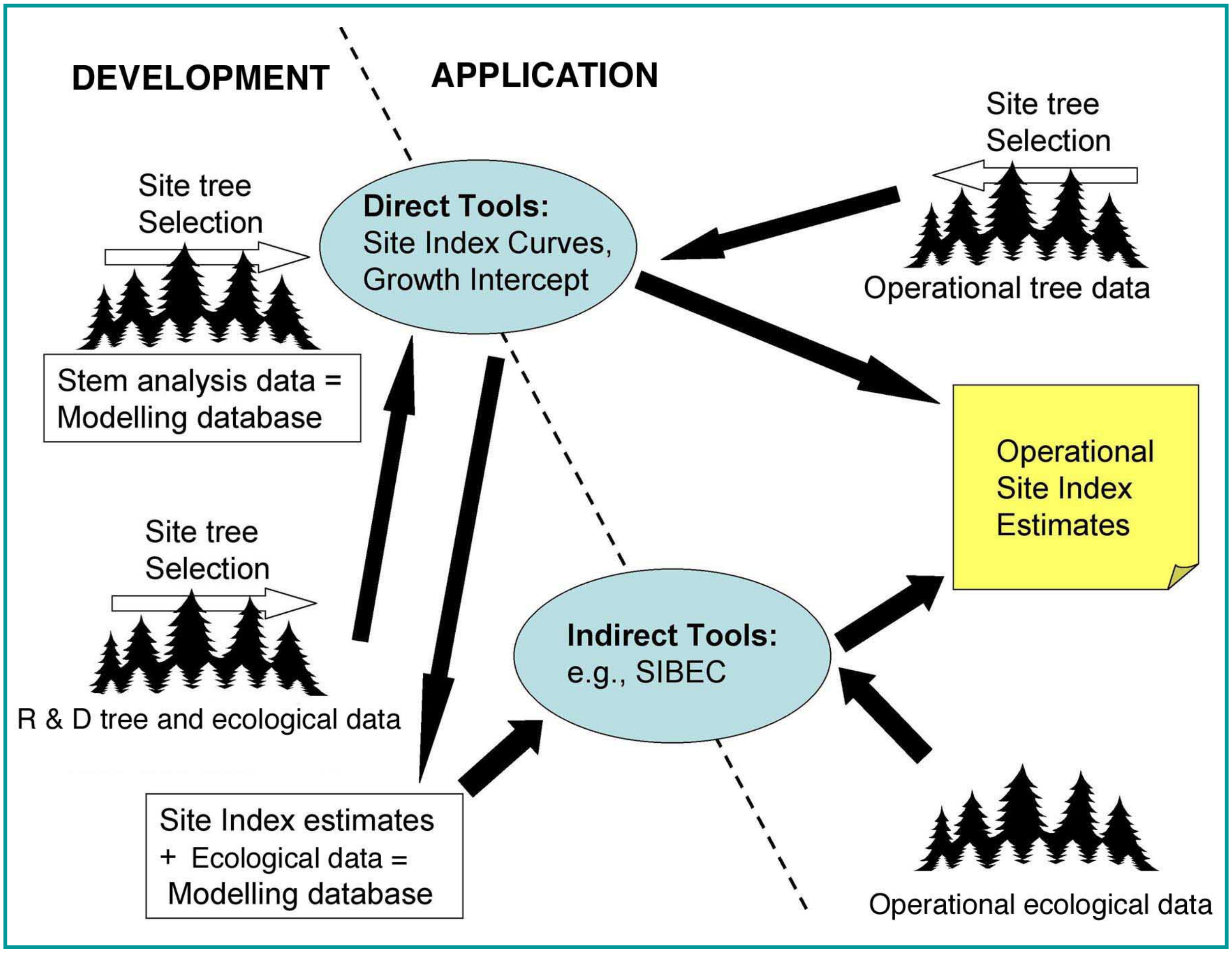

FIGURE 1. The central role of site tree selection in the development and application of direct and indirect site index estimation tools.

largely inaccessible, land base. As a result, aerial-photo interpretation remains the foundation of Canadian forest inventories. However, some compromises were necessary to produce estimates of site index in this way. In the absence of ground-based site tree selection, stand heights and ages estimated from photographs served as the ***best available estimates***. Each inventory polygon could then be assigned a site class (and later a site index), which represented the best available estimate of site productivity. This inventory perspective has prevailed for so long that site index still tends to be viewed as just another attribute of the existing stand, rather than as an attribute of the land base itself. Again, this is not the fault of inventory designs, since they were—and still are—professionally defensible given the situation. Nevertheless, the forestry community assumed traditional inventory-based site index estimates adequately represented the land's productive potential—that is, until higher growth rates began to be observed in post-harvest second-growth stands.

Second-growth Site Index

The relative importance of second-growth forests within long-range timber supply forecasts steadily increases as more second-growth is regenerated after old-growth harvest. Likewise, greater consideration is given to silviculture investments in these second-growth forests. As expected, the growth and yield estimates used within timber supply and silviculture investment analyses are very sensitive to site index.

An increasing number of well-documented studies show that second-growth stands may often exhibit a higher site index than the inventory site index derived from the previous old-growth stand. The potential for error in estimating height and age from small-scale aerial photographs accounts for only part of this phenomenon. Primarily, it is due to the lack of site tree selection inherent in traditional photo-based inventory techniques. Even so, we would expect to find more site trees in young, fast-growing second-growth stands than in old-growth stands with long, unknown height growth histories. Second-growth also tends to have better ground access, enabling us to practice site tree selection and obtain better site index estimates.

Choosing the Best Available Site Index Estimate

The recent emphasis on site productivity has resulted in an escalation of research activities. Consequently, several new site index tools have been developed. In addition to the familiar inventory-based estimates of site index, several other sources of site index estimates are now available. Given the potential for multiple site index estimates on the same site, the most appropriate one must be chosen for a particular situation. For example, an inventory-based site index estimate may still be the best for projecting height growth of existing old-growth stands; however, it may not be the best available estimate of site productivity for second-growth stands under different management regimes. Determining the utility of various site index estimates requires a well-grounded understanding of site index itself and the available tools.

Foresters in British Columbia now have several types of site index tools from which to choose.

- ***Height-age models***, also known as site index curves, show tree height as a function of breast height age. Height-age curves depict a series of height growth trajectories for site trees of a single species on different sites. The mathematical derivation of these curves creates some estimation uncertainty in very young stands.
- ***Growth intercept models*** are simply different mathematical derivations, often using the same data, which work slightly better for very young stands.
- ***Conversion equations*** provide site index estimates for a species based on a known site index for some other species.
- The provincial ***old-growth site index adjustment project*** (OGSI) and the Bulkley Forest District's operational adjustments to site index study (OASIS) were conceived to temporarily provide second-growth estimates for timber supply analyses until more comprehensive solutions, such as SIBEC models, attained operational status.
- Soils- and ecosystem-based indirect tools, such as ***SIBEC***, require some form of mapping to spatially link their site index predictions to the inventory for timber supply analysis purposes. Either terrestrial ecosystem mapping (TEM), or predictive ecosystem mapping (PEM), can provide that linkage, in addition to serving as an important tool for ecosystem-based forest management.

When selecting tools, foresters need to consider the powerful effect that site tree selection has on both the quality and utility of the resulting site index estimates. An understanding of site tree selection is essential to evaluate potential height-age data, select tools, and assess the usefulness of the resulting site index estimates (Figure 1). Because foresters constantly work with imperfect information, they must routinely appraise risk and uncertainty based on their technical understanding of the information sources. This applies to site index estimates as well.

With this basic understanding of site index, the reader is now encouraged to explore the current suite of site index tools and initiatives. A good place to start is the Site Productivity Working Group's Web site at:

http://www.for.gov.bc.ca/research/spwg/