WHITE PAPER

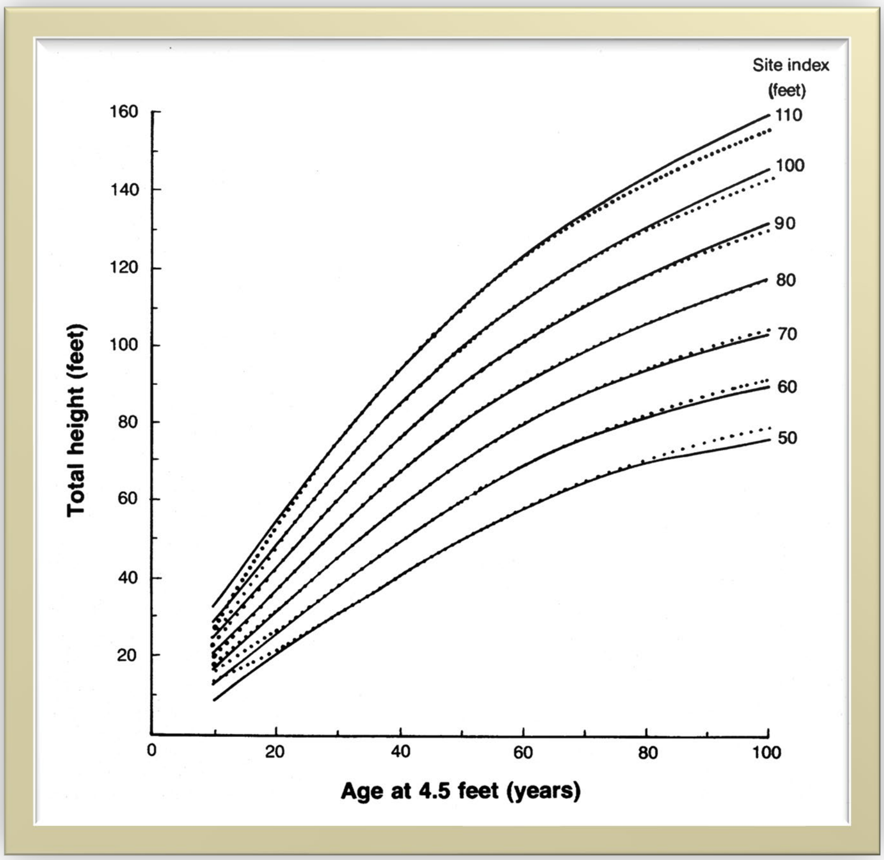
USDA Forest Service | Pacific Northwest Region | Umatilla National Forest

WHITE PAPER F14-SO-WP-SILV-5

Site Productivity Estimates for Upland Forest Plant Associations of Blue and Ochoco Mountains[1]

David C. Powell; Forest Silviculturist
Supervisor's Office; Pendleton, OR

Initial Version: **SEPTEMBER 2010**
Most Recent Revision: **DECEMBER 2018**



[1] White papers are internal reports and have received only limited review. Viewpoints expressed in this paper are those of the author – they do not necessarily represent positions of USDA Forest Service.

INTRODUCTION

Site productivity is an inherent characteristic of forest ecosystems. Not only does productivity affect how much timber volume an area can produce, but it can be thought of as an "ecological engine" powering vegetation change – it controls the speed at which shade-tolerant species get established beneath shade-intolerant trees, the rate at which forests produce and accumulate biomass, and the response of composition and structure to fire, insects, pathogens, and other disturbances.

This white paper provides site productivity estimates for seven tree species (ponderosa pine, interior Douglas-fir, western larch, lodgepole pine, grand fir, Engelmann spruce, and subalpine fir) and for 42 upland-forest plant associations described for the Blue and Ochoco Mountains of northeastern Oregon and southeastern Washington (Johnson and Clausnitzer 1992). The plant associations are organized further into potential vegetation groups (Powell et al. 2007).

Because site quality, site productivity, site index, and other terms are often used interchangeably (and sometimes incorrectly so), this paper begins with a summary of important terminology.

Terminology Notes (based on Helms 1998)

Site productivity is assumed to be a synonym for site quality. Site quality is defined as "the productive capacity of a site, usually expressed as volume production of a given species." Note that a site quality or site productivity class is usually determined by using site index. Productivity is defined in an ecological context as "the rate at which biomass is produced per unit area by any class of organisms."

Note that productivity refers to a ***rate*** of biomass production, so it reflects a site's intrinsic capability to grow trees. Production, however, refers to the amount of goods or services produced by an area – there is no connotation of the rate at which a good or service is produced (if a site has 10,000 board feet per acre, was it produced in 50 years or 250 years?). This means that productivity and production are not synonymous terms.

The ***rate*** aspect of productivity is an important consideration. If you were buying wheat land in northeastern Oregon outside of Pendleton, you would prefer to purchase the highest productivity or highest 'quality' land. Wheat land productivity is often expressed as bushels per acre – normal or average land in the areas you're considering might be referred to as "50 bushel per acre" ground, with exceptional sites perhaps being "100 bushel per acre" land. If you know prevailing values for wheat, in dollars per bushel, you can easily translate productivity rate differences between 50 bushels per acre, and 100 bushels per acre, into dollars and cents.

Site is defined as "the area in which a plant or stand grows, considered in terms of its environment, particularly as this determines the type and quality of the vegetation the area can carry."

CONCEPTS AND PRINCIPLES

Potential species composition, forest structure, and stand density of forest sites vary in response to changes in landform, topography, climate, soils, slope exposure, geology, and other physical site factors (Powell et al. 2007). Changes in these abiotic factors are a source of variation in site productivity. Since productivity is related to intrinsic factors such as landform and soil depth, these site-level characteristics are commonly referred to as 'ecological site potential' because they are perceived to be as permanent as the land itself (Daubenmire 1973).

A common system for estimating ecological site potential involves use of plant associations (habitat types). This classification unit of 'potential vegetation' has much in common with site productivity because the land area supporting a plant association is considered to integrate variation in elevation, soil, geology, and related factors in such a way that it will support the same climax overstory and understory vegetation (Davis et al. 2001). Because site productivity and potential vegetation are both controlled by abiotic factors (geology, soils, etc.), it is sometimes confusing as to how they differ.

Two primary factors affecting forest site productivity are soil characteristics (nutrient status, rooting depth, drainage, texture, etc.) and moisture availability within the tree rooting zone. It would certainly be possible, although difficult and time consuming, to estimate site productivity by measuring important soil and moisture characteristics directly. Generally, a direct measurement approach is only practical for research purposes.

Because of a strong linkage between soils and site productivity, many studies have attempted to correlate soil mapping units with site quality (Base and Fosberg 1971, Brown and Loewenstein 1978, Carlson and Nimlos 1966, Chen et al. 2002, Monserud et al. 1990, Sprackling 1973, and others). Unfortunately, correlation between soil mapping units and site index has often been poor.

For forest ecosystems, poor correlation between site productivity (e.g., site index) and soil types is thought to reflect the fact that soils are often not classified and interpreted by using factors with a direct influence on tree growth, such as drainage class, thickness of the surface horizon, and subsurface horizon depth (Davis et al. 2001). In northern Idaho, for example, it was found that the height of ponderosa pine trees for a given age corresponded to soil depth down to bedrock, or down to a closely packed, mottled soil horizon (Parker 1952).

But studies for other tree species, or for other geographical locations, have not necessarily identified soil depth as an important factor affecting site productivity in a forestry context: "Relatively little of the soil profile data available are included in this report. However, it is clear from what are presented that no useful correlation exists between vegetation types as defined herein and profile types distinguished on the basis of color, texture, structure, depth, sequence of horizons, etc. Closely similar stands of climax forest occur on soils with very different profile characteristics, and different climax forests may have similar profiles" (Daubenmire and Daubenmire 1968, p: 52).

Despite comments about a lack of correlation between site productivity and soil characteristics (Daubenmire and Daubenmire 1968, Davis et al. 2001), it is obvious that these two factors are related! Soils are the foundation supporting forest growth and productivity, so a lack of correlation between site productivity and soils most likely reflects disparities between how forests and soils are being mapped and described for an area. If mapping and interpretation scales for the two factors were congruent (and they seldom are), then I believe stronger relationships would be evident.

BACKGROUND: SITE INDEX AND YIELD CAPABILITY

Site index (SI) is defined as "a species-specific measure of actual or potential site quality, expressed in terms of the average height of trees included in a specified stand component" such as dominant and codominant trees (Helms 1998). SI is derived by measuring total height and age (either breast-height age, or total age) for 'top-height' trees defined as the dominant and codominant crown classes in a stand, and then using the height and age measurements to calculate an SI value.

By definition, SI provides the potential height of dominant and codominant trees, which are the tallest trees in an even-aged stand or the topmost layer in a multi-layered stand structure. This means that SI does not provide an estimate of average stand height because certain crown classes (intermediate and subordinate trees) are intentionally not sampled when selecting site trees.

If the site trees selected for measurement are chosen carefully, and if they meet the specifications of the published SI curves (such as lack of top damage from budworm or defoliating insects, little or no evidence of growth suppression in the increment core, etc.), then the SI values are assumed to provide an accurate assessment of inherent site quality.

SI values are expressed in feet – an SI value of 70 means that the total height for dominant and codominant trees at 50 years of age (if the site index curves use 50 years as a reference age) would average 70 feet. If the curves use 100 years as a reference age, then an SI value of 70 means that dominant and codominant trees would average 70 feet in total height at 100 years of age.

Site index values pertain to a reference age (such as 50 years or 100 years), and reference age varies from one set of published curves to another. Reference age functions as an 'indexing' mechanism because it scales all measurements to a common baseline, without which it would be difficult to know if top-height differences reflect site quality variation, or the fact that a sampled stand had more time to grow (it was older) than another sampled stand. Published sources of SI curves for the Blue Mountains are provided in table 1.

Table 1: Source of site index curves for major Blue Mountains tree species.

Tree Species	Species Code	Site Index Source	Reference Age (Years)	Age Limit (Years)
Engelmann spruce	PIEN	Brickell 1970	50 (total)	≤ 200
Grand fir	ABGR	Cochran 1979b	50 (BH)	≤ 100
Interior Douglas-fir	PSME	Cochran 1979a	50 (BH)	≤ 100
Lodgepole pine	PICO	Dahms 1975	90 (BH)	≤ 120
Mountain hemlock	TSME	Means et al. 1986	100 (BH)	≤ 240
Ponderosa pine	PIPO	Barrett 1978	100 (BH)	≤ 140
Subalpine fir	ABLA2	Brickell 1970	50 (total)	≤ 200
Western larch	LAOC	Cochran 1985	50 (BH)	≤ 100
Western white pine	PIMO	Brickell 1970	50 (total)	≤ 105
Whitebark pine	PIAL	Hegyi et al. 1981	100 (total)	≤ 300

Sources/Notes: Species code is an alphanumeric code used for species identification in a CVS database; "BH" in reference age column indicates that a reference age is at breast-height rather than total age; age limit is an age range of measured site trees for which a site index curve is applicable.

CVS PLOTS AS A SITE INDEX DATA SOURCE

During the 1990s, Blue Mountain national forests installed a grid-based inventory system called Current Vegetation Survey (CVS) (USDA Forest Service 1995). CVS plots were installed on a 1.7-mile grid (each plot was located 1.7 miles away from adjoining plots) except for designated Wilderness areas, where grid spacing was 3.4 miles between plots.

For Blue Mountains national forests of northeastern Oregon, southeastern Washington, and west-central Idaho, initial installation of forested CVS plots occurred in 1993 and 1994; nonforest CVS plots were established across all three national forests in 1995 and 1996. Plot information collected during this 1993-1996 period is referred to as occasion 1 data. Since their initial installation, every CVS plot has been remeasured once, and this subsequent information is referred to as occasion 2 data (Christensen et al. 2007).

When evaluating data sources providing measured values for a wide range of tree attributes, CVS information is generally acknowledged to be the best Blue Mountains dataset available because its grid-based approach prevents plot location bias, and its quality control/quality assurance emphasis was very high (Max et al. 1996). For this reason, it was decided to use CVS information when calculating site index and yield capability values for Blue Mountains.

ANALYSIS METHODOLOGY

I pooled occasion 1 CVS data for all three Blue Mountains national forests (e.g., Malheur, Umatilla, and Wallowa-Whitman), and a resulting database was queried to extract site tree records and their associated information, including CVS plot and point numbers they occurred on. Site trees are easily identified in the database because they have a unique vegetation (tree history) code: 13.

Potential vegetation is represented in a CVS database by using ecoclass codes (Hall 1998). Each CVS plot consists of a 5-point cluster, and an ecoclass code was recorded for each of five points. Site trees are coded to the point they occur on, or near, so an ecoclass code could be readily assigned to each site tree record by using a database query, and CVS plot and point identifiers as common fields to link ecoclass and site index tables.

After 6,664 site tree records were extracted from CVS occasion 1 database (e.g., all records with a vegetation code of 13 were extracted), data was filtered to remove problem records. Problem records generally had one of two issues:

(1) they are missing a measured height or age value, which means that a site index value could not be calculated for them, or

(2) recorded age value exceeds a site-index curve's age limit, which varies by tree species (final column in table 1 provides age limits for each site-index curve).

Certain site index curves, particularly Cochran's curve for western larch (Cochran 1985), are very sensitive to an age limit, and age values beyond the limit quickly produce nonsensical results.

A total of 155 problem records were removed from a site-tree dataset, resulting in 6,509 usable records for further site index analysis.

An analysis dataset was then transferred to Excel and stratified by potential vegetation type (plant association), based on ecoclass codes associated with all site-tree records. Site index and yield capability were calculated for each record by using equations referencing measured values of tree age and tree height as input variables (for site index) or calculated values of site index (for yield capability).

Source of calculation equations varied – some came from a published site index source document (see table 1), whereas others were taken from USDA Forest Service (1987) or Hanson et al. (2002).

RESULTS

Analysis methodology described in the previous section was used to calculate site index values for more than 6,500 observations, and results were stratified (sorted) for potential vegetation types of Blue and Ochoco Mountains (Johnson and Clausnitzer 1992, Powell et al. 2007).

It is seldom possible to directly compare site indexes from one tree species to another because reference ages vary, and some site curves use breast-height age whereas others use total age. Because it is useful to be able to compare site productivity between different tree species growing on an area with the same ecological site potential (e.g., potential vegetation type), a metric called 'yield capability' was calculated.

Yield capability is a potential growth rate, in cubic feet per acre per year, for fully stocked stands on an area with a given site index. Generally, yield capability equations were the same ones used in the Forest Service's stand examination program (USDA Forest Service 1987).

Site productivity estimates, expressed as yield capability, are provided in seven charts (Charts 1-7), one for each tree species, and they are presented on pages 17-23 (explanatory notes about the charts are provided on page 24).

At the base of each tree species chart, standard Forest Service productivity classes (3-7) are shown for reference.

IS SITE INDEX THE BEST PREDICTOR OF SITE PRODUCTIVITY?

Daniel et al. (1979) define site quality as the 'maximum timber crop' that forestland can produce in a given time. They go on to note that "since site quality is measured by the maximum timber crop (volume) produced within a given period, it can vary with tree species and the time element chosen." This means that "a particular area could have a different site quality depending on whether it supported Douglas-fir, western hemlock, or western redcedar" (Daniel et al. 1979, p. 236). A situation where site quality differs by tree species has also been noted for broadleaved species of the eastern U.S. (Gingrich 1964).

Concepts discussed here from the Daniel et al. (1979) text raise important questions about site quality (productivity) and its evaluation. If site quality is best evaluated in a timber production context (e.g., by determining the maximum timber crop), does this suggest that stand-level measures of site quality might be more appropriate than individual-tree measures such as site index? And if stand-level measures are considered superior to individual-tree measures, particularly for sites with low stocking capacity (MacLean and Bolsinger 1973), wouldn't some measure of inherent stockability (stocking capacity) be effective as an overall productivity indicator?

Note that a MacLean and Bolsinger 1973 research paper describes how it is possible to locate relatively high-performing individual trees on low-productivity plant associations such as ponderosa pine/bluebunch wheatgrass and ponderosa pine/Idaho fescue. Without exception, these high-performing trees do not represent typical or customary site conditions for these plant associations. As described by MacLean and Bolsinger (1973), high-performing trees on poor sites generally grow in favorable microsites – areas where more soil or water collects than is typical for a site as a whole.

If high-performing trees are selected as site trees for low-productivity plant associations, a common occurrence because stand examination crews are trained to select only the best trees as site trees, then resulting productivity calculations will overestimate site quality. (Because site trees generally don't need to be a growth-sample or a sample tree, it is okay for stand exam crews to find their site-tree samples anywhere in a stand, including from areas that don't occur on a sample plot.)

The bottom line is this: site trees can provide valuable information about site productivity, but only if they reflect predominant conditions of an area. Selecting site trees growing in atypical situations (microsites) is counterproductive because the objective of a stand exam is to characterize typical (average) conditions for a stand, *not to describe the microsites of an area*.

[And, these comments about microsites are conceptually like an earlier discussion about lack of correlation between site productivity and soils (see ***Concepts and Principles*** section). Much of the reason for a lack of productivity-soils correlation relates to scale, in much the same way as scale influences how uncommon conditions (microsites) should be evaluated when determining if site trees from microsites appropriately reflect a sampled stand.]

When considering an environment boundary-line concept (Sackville Hamilton et al. 1995), is there much qualitative difference between maximum stand density index (SDI), expressed by tree species and plant association, and traditional productivity measures such as site index? And, wouldn't we expect sites with high carrying capacity for stand density (i.e., they have high maximum SDI) to also have high timber volume productivity (assumed to be analogous to yield capability – potential cubic-foot volume production at culmination of mean annual increment)?

[Note: a boundary-line approach described by Sackville Hamilton et al. (1995) shows how self-thinning populations of plants, including trees, follow size-density trajectories with a slope of approximately -3/2. *For a given tree species*, their conceptually important work shows that a different size-density boundary line exists for each plant association, rather than one boundary line pertaining to an entire tree species, which was suggested by Reineke (1933) and others.]

I believe that maximum density is an effective indicator of site quality, and I also believe it offers advantages over traditional productivity indicators such as site index. Although we may not be able to identify all the influences involved, we know that different site factors control height growth potential (e.g., site index) than stockability (e.g., maximum SDI carrying capacity).

"In a conceptual sense, stockability can be regarded as the tolerance of a forest system to the presence of and/or competition from increasing numbers of trees. This tolerance may differ with environment and, in that regard, might be considered an aspect of site quality independent of that reflected in site index or potential height growth (cf Sterba 1987)" (DeBell et al. 1989).

Maximum density (SDI) reflects productivity in a carrying capacity context – sites with higher maximum SDI values are more productive than sites with lower maximum SDI values because they have more capacity to carry (produce) tree biomass. Or to express it in a different way, tree species with higher maximum SDI values (*for the same plant association*) are more productive than species with lower maximum values.

Why do variations in site quality, by tree species, occur? There may be several reasons, but an important one relates to light-water tradeoff theory (Smith and Huston 1989), which postulates that *plants cannot simultaneously have high tolerance for low levels of light and water*.

Tree species adapted to water-limited sites (e.g., dry forests) are governed by a specific suite of life history traits, with dominant conifers evolved to compete for water first and light second. Light-water tradeoff theory helps explain a common situation where tree species with low shade tolerance, which tend to be early-seral species with relatively high drought tolerance, are often the first trees to experience mortality in low-light environments associated with high stand density.

A primary disturbance process affecting dry-forest sites – recurring surface fire occurring at a frequency of 5-20 years for Blue Mountains – creates an uneven-aged stand dominated primarily by fire-resistant ponderosa pine (Powell 2014a). As long as fires continue, dry-forest stands are regularly thinned, and competition for water is maintained at relatively low levels.

Maximum density information suggests that certain life history traits favoring ponderosa pine's survival when exposed to frequent fire (high, sparse crowns to resist torching; thick bark to resist bole damage; etc.) most likely represent a productivity tradeoff when compared with life history traits for more productive species such as grand fir (which has low, dense crowns; thin bark; etc.) that are not adapted to a fire environment.

Under this light-water tradeoff concept, a low severity/high frequency fire regime favors tree species (ponderosa pine) that evolved traits to compete most effectively for water, and only secondarily for sunlight. Conversely, a high severity/low frequency fire regime promotes species (grand fir) that evolved traits to compete effectively for sunlight, and secondarily for water.

Note that light-water tradeoff does not imply species exclusion – dry sites supporting a low severity/high frequency fire regime have a predominance of tree species adapted to compete for water (shade intolerant species such as ponderosa pine, which historically comprised 50 to 80% of a dry site's species composition), but species adapted to compete for sunlight (shade tolerant species such as Douglas-fir and grand fir) also occur on dry sites. However, shade-tolerant tree species occur at low levels comprising less than 10%, individually, of the historical species composition for dry sites (Powell 2014a: table 9 on p. 88).

The fact that light-water relationships result in a productivity tradeoff is reflected in tree density levels associated with historical fire regimes. For dry biophysical environments (sites), 40 to 85% of an area historically supported low stocking levels (and lower levels of maximum potential density for ponderosa pine), whereas 5 to 15% historically supported high stocking levels (and higher levels of maximum potential density related specifically to occurrence of Douglas-fir and grand fir) (Powell 2014a: table 11 on p. 89).

With a properly functioning low severity/high frequency fire regime, dry-forest areas with lower stocking levels supported stands comprised primarily of species adapted to compete for water (ponderosa pine), whereas dry-forest areas with higher stocking levels supported species adapted to compete for sunlight (Douglas-fir and grand fir).

Species-level differences discussed in this section are reflected in tradeoffs of maximum potential density, whether expressed as stand density index or basal area (see Powell 2014a: table 7 on p. 73, which shows how much of a dry-forest landscape supported low stocking levels, and how much supported moderate or high stocking levels).

In my view, a bottom line from this discussion is that site index and maximum density (SDI) are not closely related. This is perhaps not surprising because site index is designed to reflect height growth rate of dominant and codominant trees (e.g., what is height of dominant/codominant trees at a specified reference point, expressed as a breast-height or total age?), whereas maximum density reflects stockability differences between tree species, and between sites of differing ecological site potential (as represented by plant associations or potential vegetation types).

Differences between site index and maximum density are illustrated in figures 1-7, which show site index and maximum SDI values for ponderosa pine, Douglas-fir, grand fir, western larch, lodgepole pine, Engelmann spruce, and subalpine fir. Each figure shows how maximum SDI and site index vary for a tree species when it occurs on a variety of potential vegetation types (PVTs).

PVTs are shown in figures 1-7 by using acronyms (codes), and the acronyms are translated into common names in appendix 1.

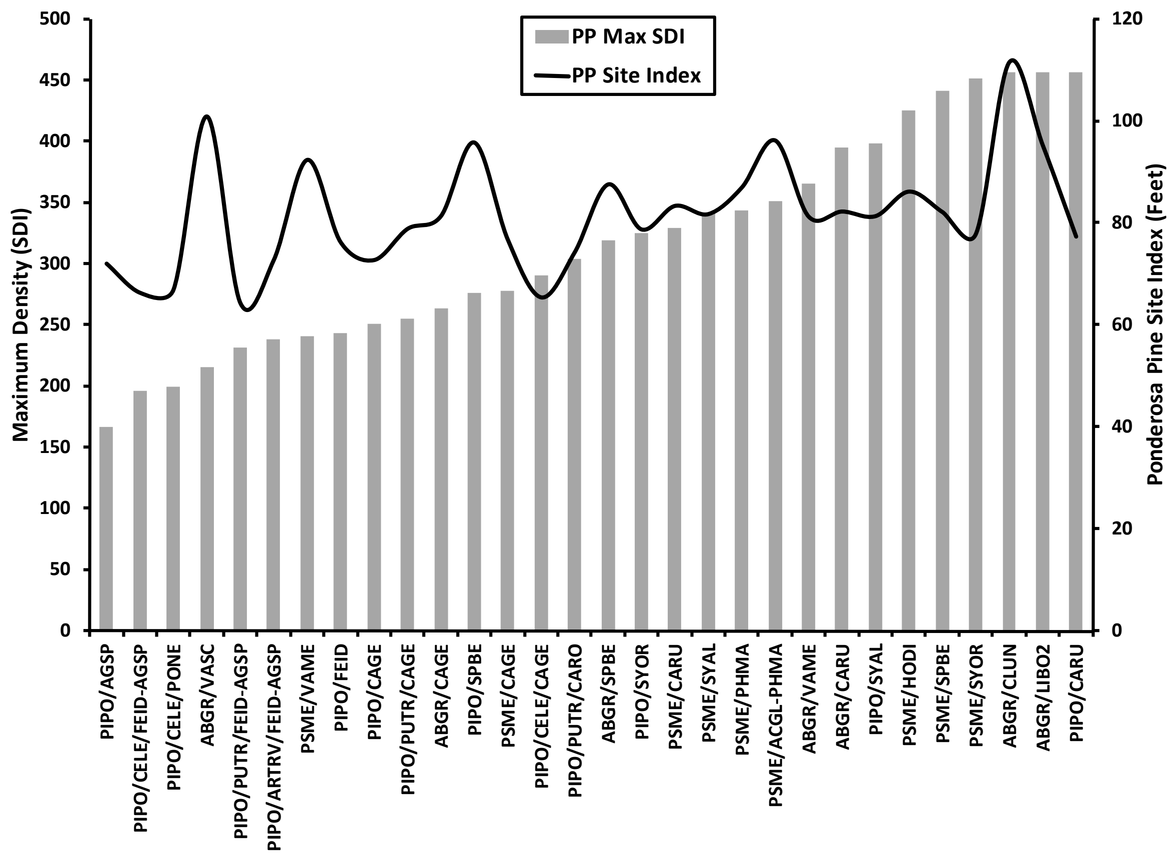


Figure 1 – Maximum density (stand density index, SDI) and site index values for ponderosa pine on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for ponderosa pine (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for ponderosa pine (such as ABGR/VASC and PSME/VAME) to have relatively high site index values, and for potential vegetation types with relatively high stockability for ponderosa pine (such as PSME/SPBE and PSME/SYOR) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

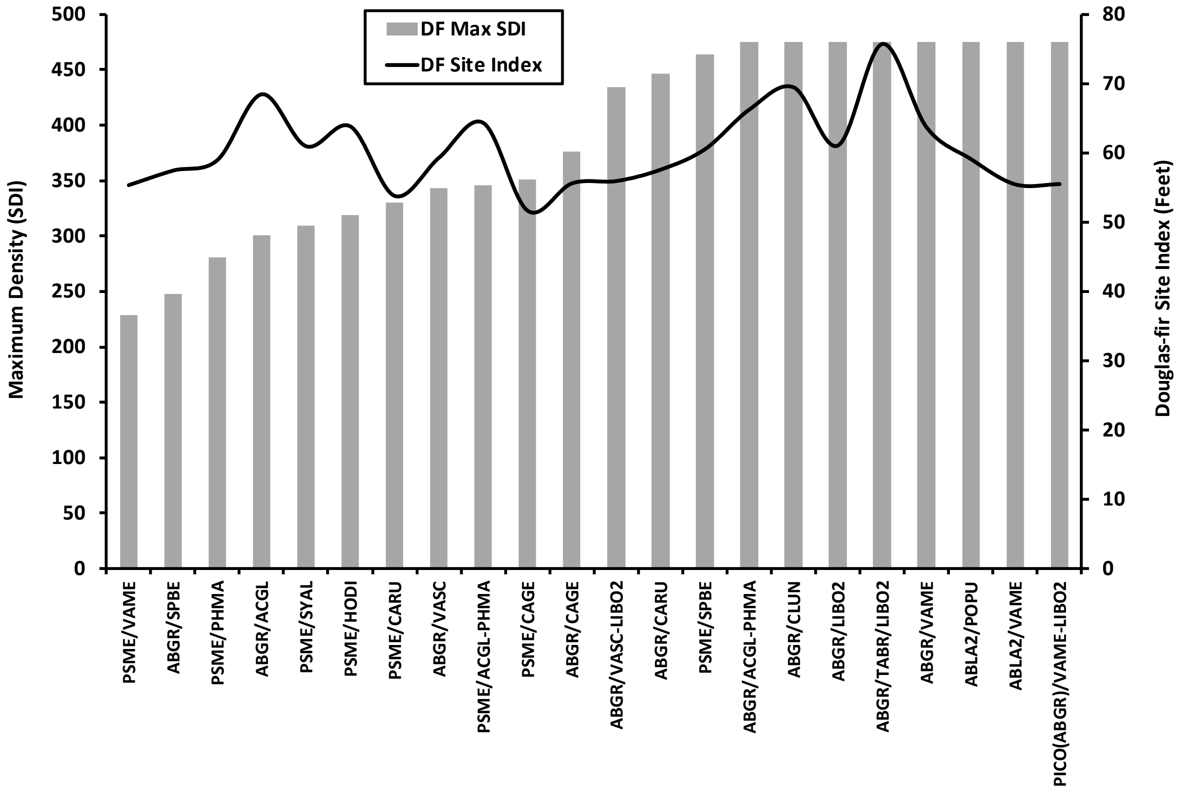


Figure 2 – Maximum density (stand density index, SDI) and site index values for Douglas-fir on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for Douglas-fir (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for Douglas-fir (such as ABGR/ACGL and PSME/ ACGL-PHMA) to have relatively high site index values, and for potential vegetation types with relatively high stockability for Douglas-fir (such as ABGR/LIBO2 and PICO(ABGR)/VAME-LIBO2) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

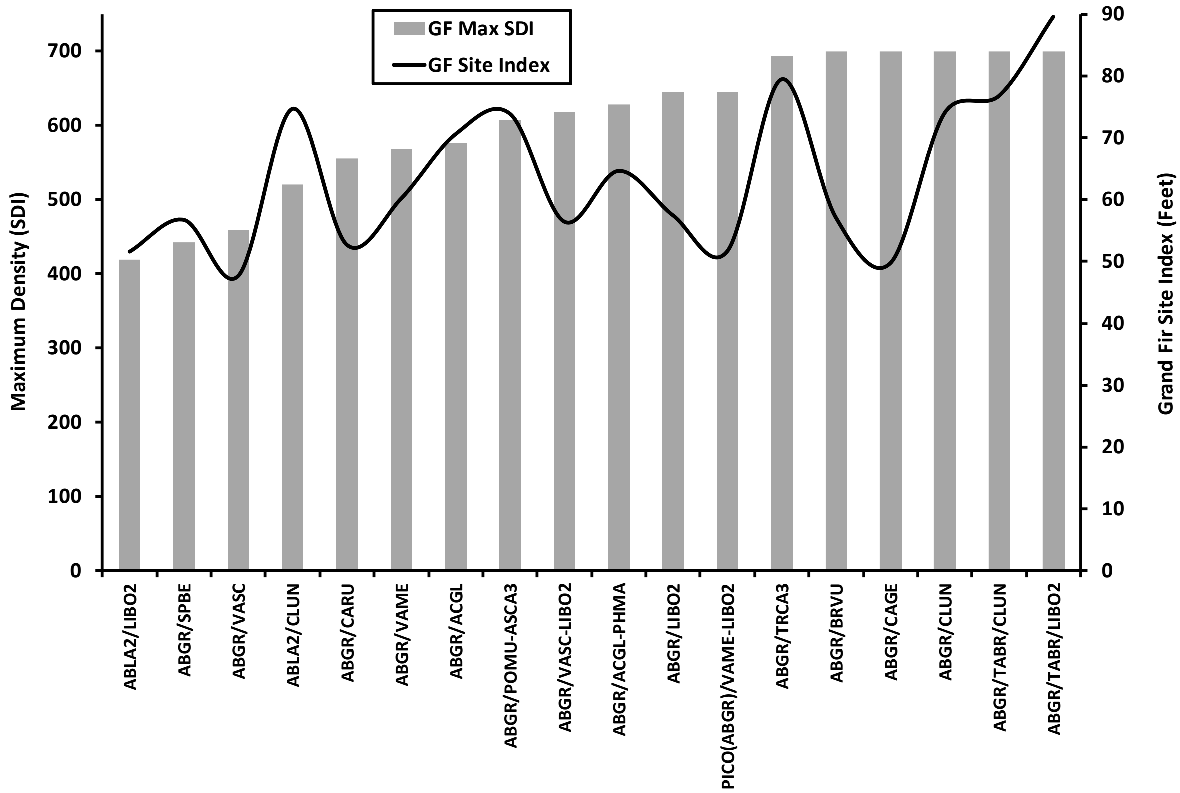


Figure 3 – Maximum density (stand density index, SDI) and site index values <u>for grand fir</u> on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for grand fir (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for grand fir (such as ABLA2/CLUN) to have relatively high site index values, and for potential vegetation types with relatively high stockability for grand fir (such as ABGR/CAGE) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

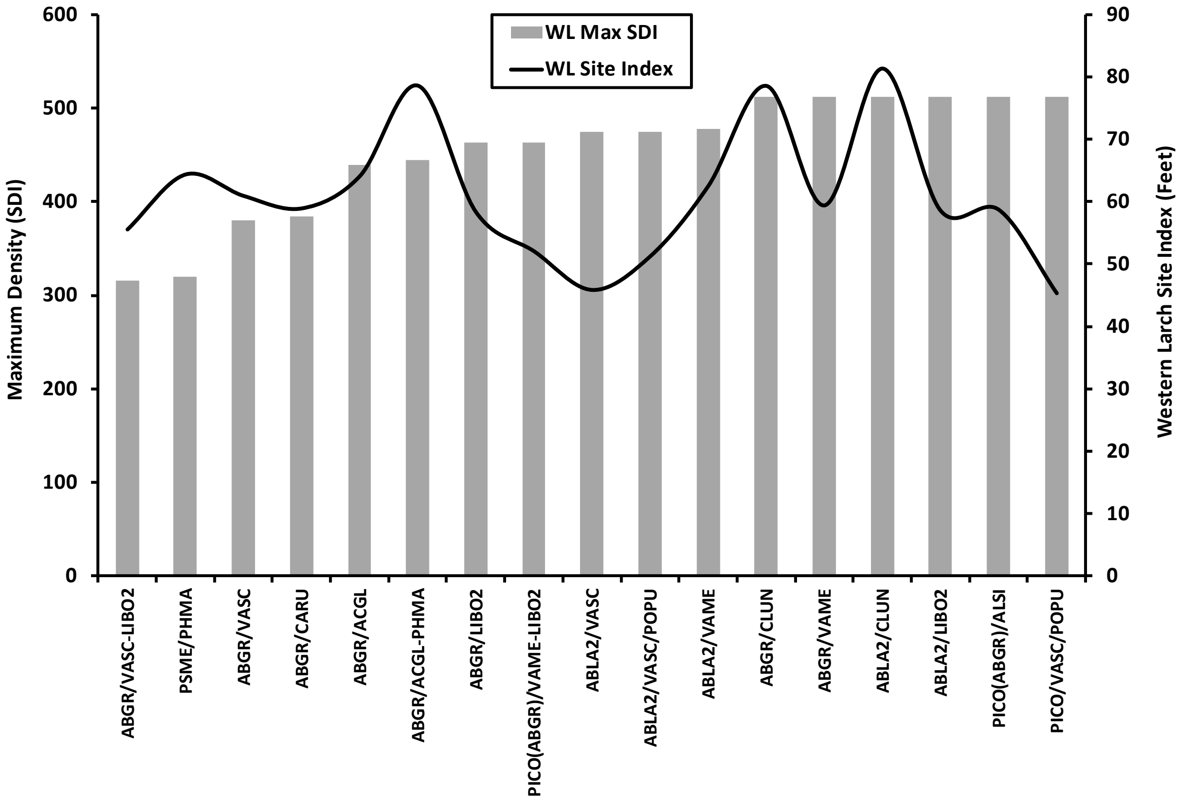


Figure 4 – Maximum density (stand density index, SDI) and site index values for western larch on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for western larch (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for western larch (such as PSME/PHMA) to have relatively high site index values, and for potential vegetation types with relatively high stockability for western larch (such as PICO/VASC/POPU) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

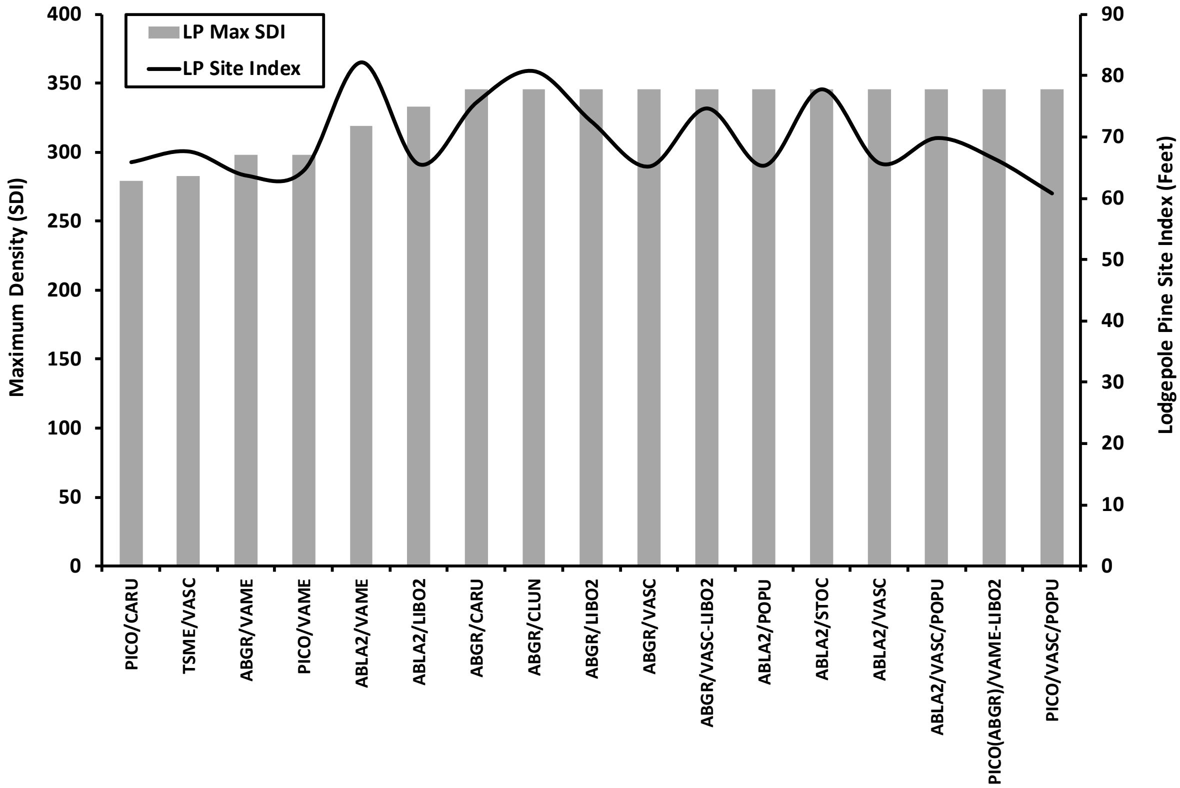


Figure 5 – Maximum density (stand density index, SDI) and site index values for lodgepole pine on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for lodgepole pine (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for lodgepole pine (such as ABLA2/VAME) to have relatively high site index values, and for potential vegetation types with relatively high stockability for lodgepole pine (such as PICO/VASC/POPU) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

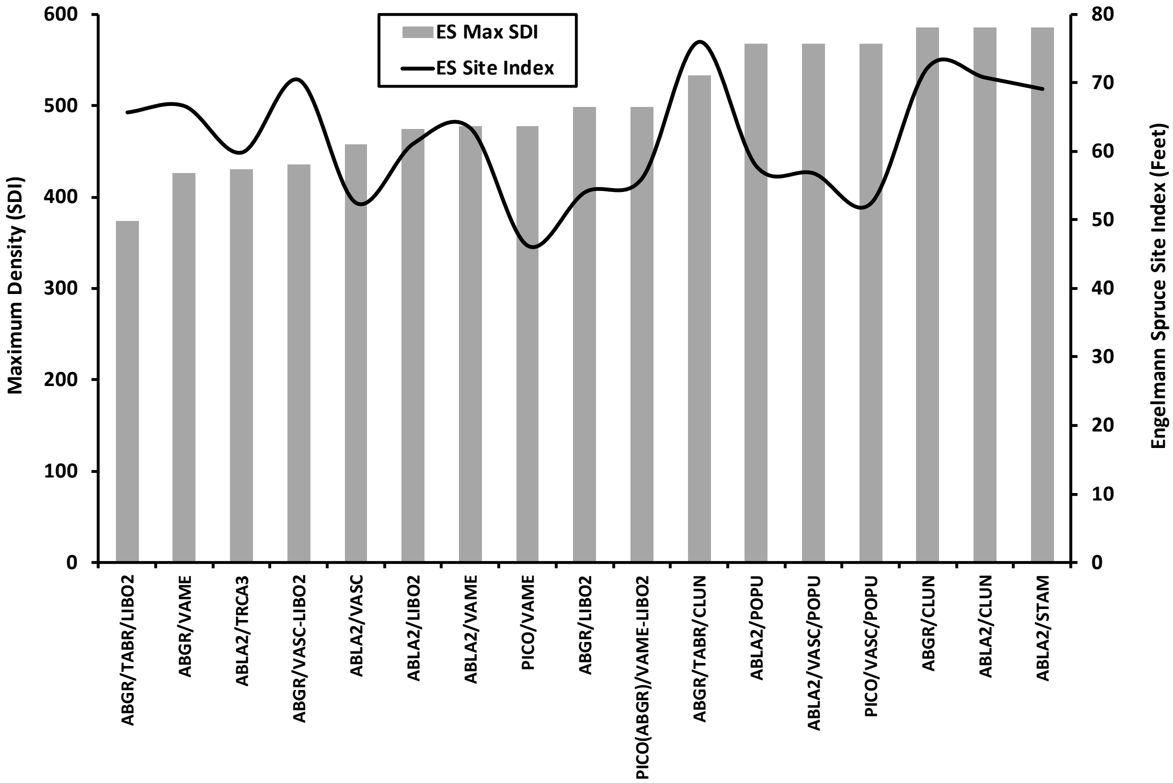


Figure 6 – Maximum density (stand density index, SDI) and site index values for Engelmann spruce on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for Engelmann spruce (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for Engelmann spruce (such as ABGR/TABR/LIBO2) to have relatively high site index values, and for potential vegetation types with relatively high stockability for Engelmann spruce (such as PICO/VASC/POPU) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

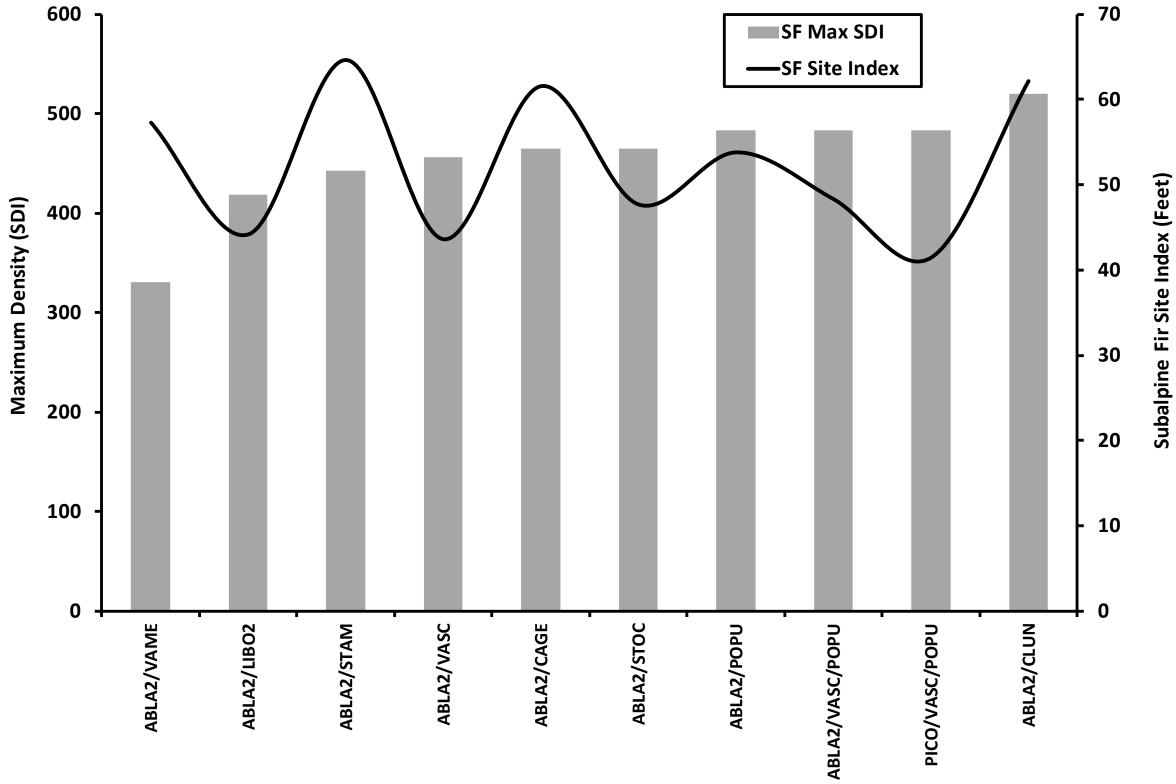


Figure 7 – Maximum density (stand density index, SDI) and site index values for subalpine fir on a range of potential vegetation types for Blue Mountains of northeastern Oregon and southeastern Washington. Potential vegetation types are ordered from those with lowest maximum density for subalpine fir (left) to those with highest maximum density (right).

Note that it is possible for potential vegetation types with relatively low stockability for subalpine fir (such as ABLA2/VAME) to have relatively high site index values, and for potential vegetation types with relatively high stockability for subalpine fir (such as PICO/VASC/POPU) to have relatively low site index values.

Potential vegetation types are shown by using their acronyms (codes); appendix 1 translates acronyms into common plant names.

YIELD CAPABILITY CHARTS

The next seven pages present **yield capability** charts produced during site productivity analyses described in this white paper (Charts 1-7).

Note that yield capability is defined as a potential growth rate, in cubic feet per acre per year, for fully stocked stands on an area with a given site index. In some stand examination and forest survey sources, yield capability is referred to as 'survey yield.'

Yield capability is assumed to reflect potential stand growth rates, expressed as cubic foot volume production, at a point where a stand's growth is at culmination of mean annual increment (i.e., a point where graphical lines depicting trends in periodic annual increment and mean annual increment intersect or cross).

Yield capability is often calculated from site index measurements because it is not possible to directly compare site index values, between tree species, because site index curves are species-specific, and because they can differ dramatically from one species to another (some use a 50-year base age, others a 100-year base; some use breast-height tree age, others use total age; etc.).

For this white paper, yield capability data were used to derive estimates of potential productivity, by tree species and potential vegetation type, by using a simple, multi-step process.

1. Site tree information was obtained for each species of interest. For this white paper, I used site tree data collected by forest inventory crews when installing Current Vegetation Survey (CVS) plots across Blue Mountains national forests, resulting in more than 6,500 site-tree records for a variety of species. Earlier sections in this white paper describe the source of site-tree data, and how it was processed for these analyses.
2. As described in an Analysis Methodology section of this white paper, mathematical equations were used to calculate a site index value for each site-tree observation.
3. After calculating site index, other equations were used to calculate a yield capability estimate, in cubic feet per acre per year, for each site-index value. Earlier sections in this white paper define yield capability, and describe its concepts and principles.
4. By using CVS plot and point identifiers, it was possible to associate a potential vegetation type with each database record. After completing site index and yield capability calculations, database records were sorted by tree species and potential vegetation type.
5. Yield capability charts were then prepared to portray productivity estimates hierarchically by tree species (first sort), potential vegetation type (second sort), and then indirectly by potential vegetation group (analysis data was not sorted explicitly into PVGs, but each chart was organized into dry upland forest, moist upland forest, and cold upland forest PVG sections).
6. For cross-referencing purposes, standard US Forest Service productivity classes are shown on the bottom of each chart so that users can see where a productivity estimate for any species/potential vegetation type combination occurs.

Page 24 provides explanatory notes about much of the productivity information presented in these yield capability charts.

CHART 1: YIELD CAPABILITY FOR PONDEROSA PINE

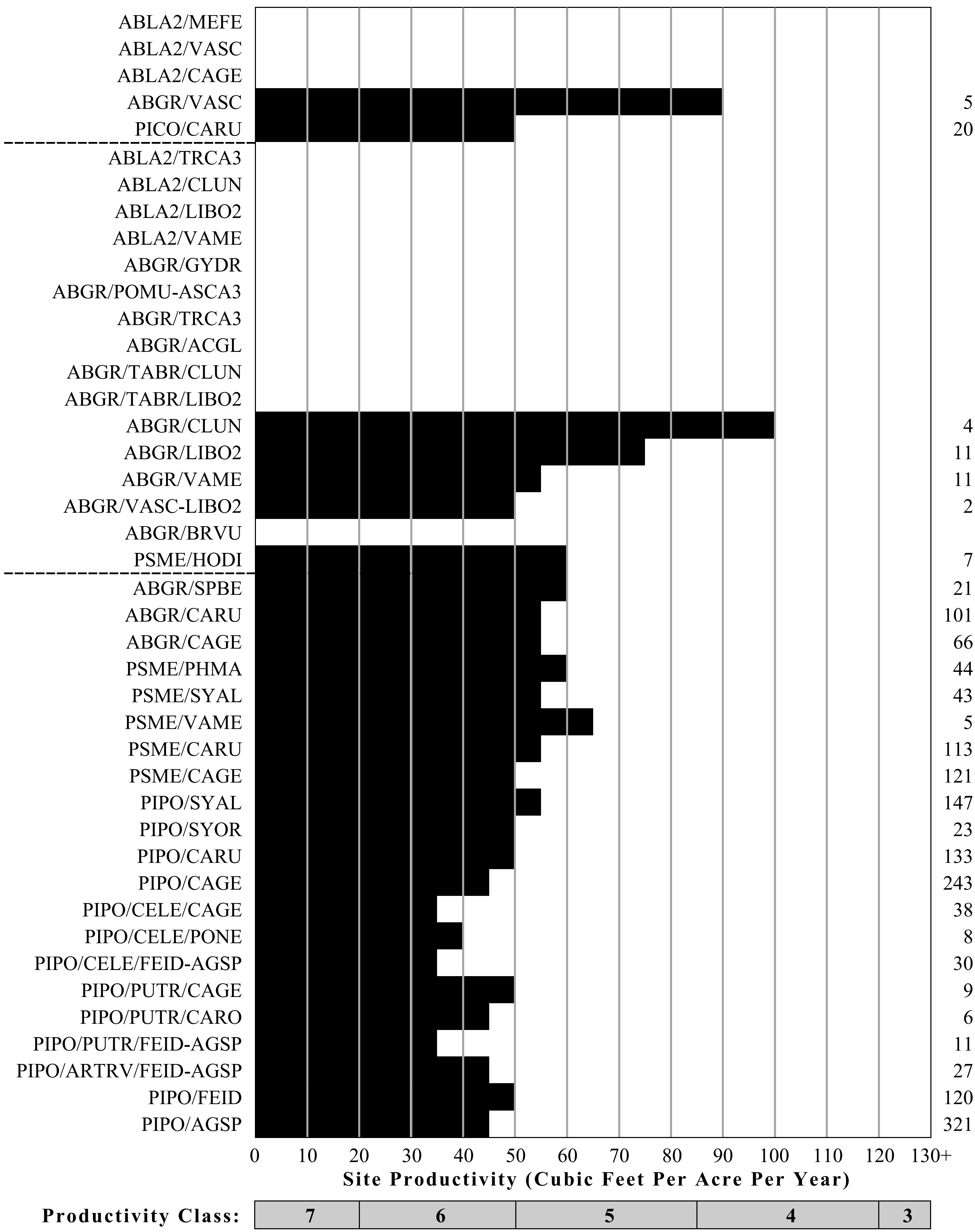


CHART 2: YIELD CAPABILITY FOR DOUGLAS-FIR

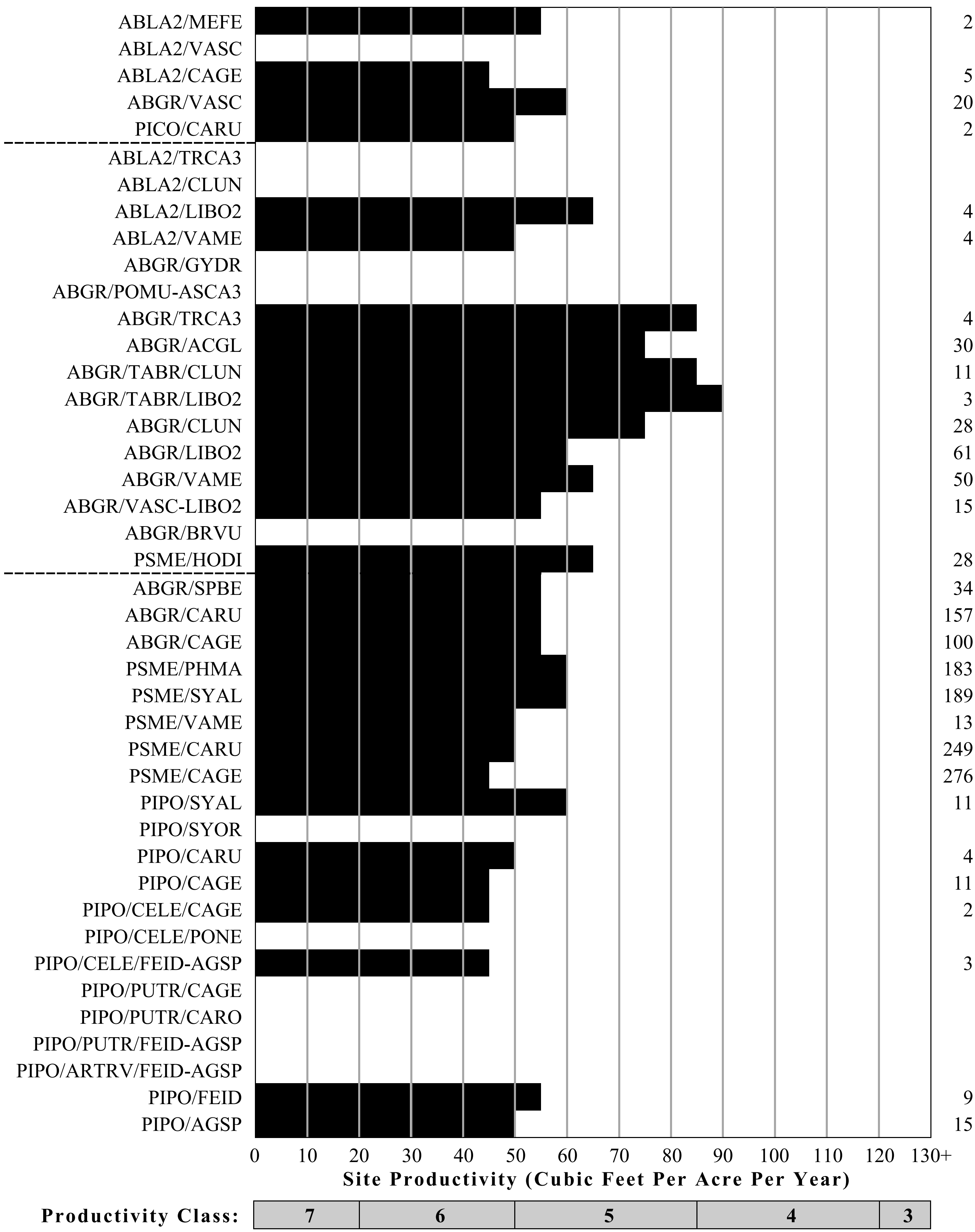


CHART 3: YIELD CAPABILITY FOR WESTERN LARCH

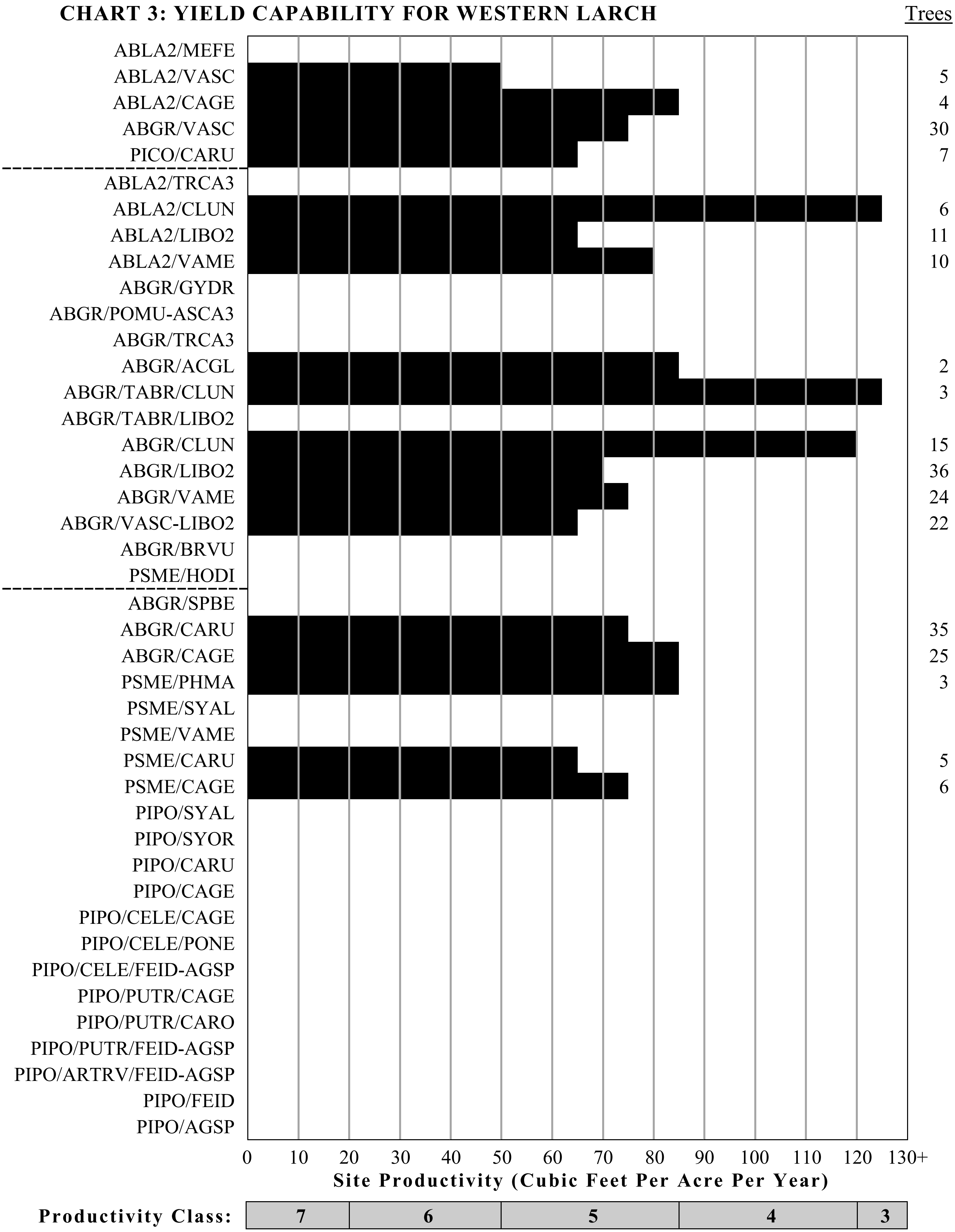


CHART 4: YIELD CAPABILITY FOR LODGEPOLE PINE

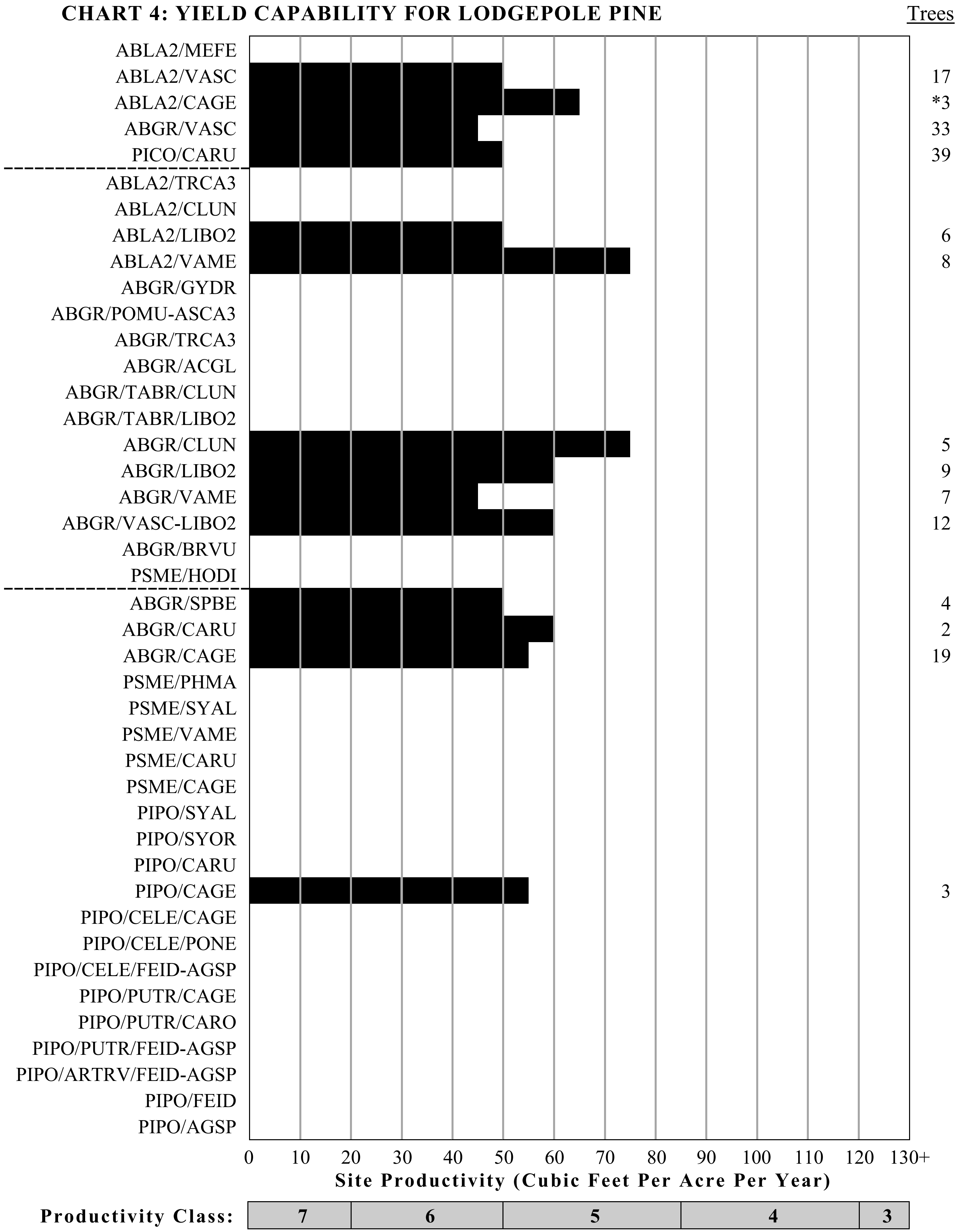


CHART 5: YIELD CAPABILITY FOR GRAND FIR

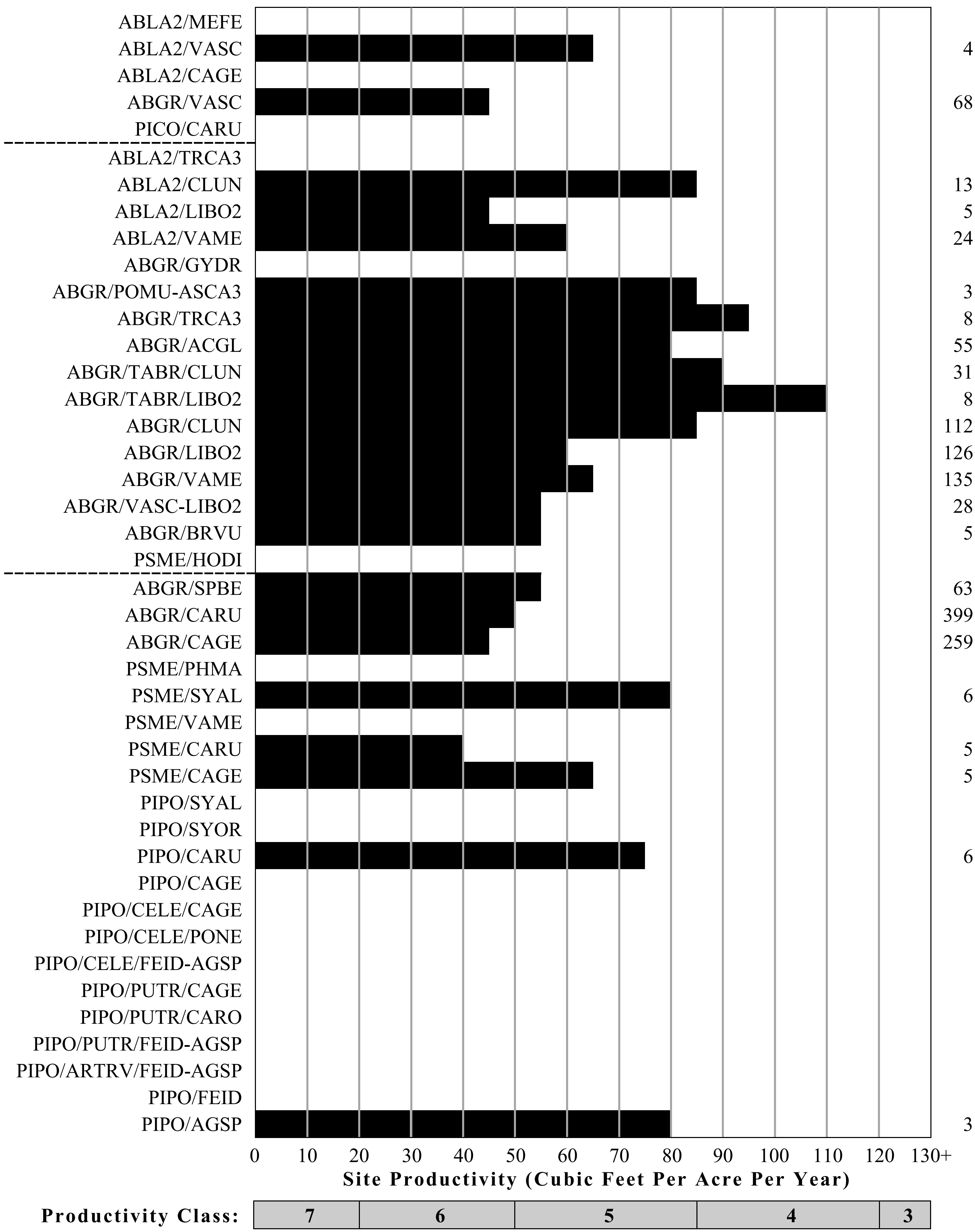


CHART 6: YIELD CAPABILITY FOR ENGELMANN SPRUCE

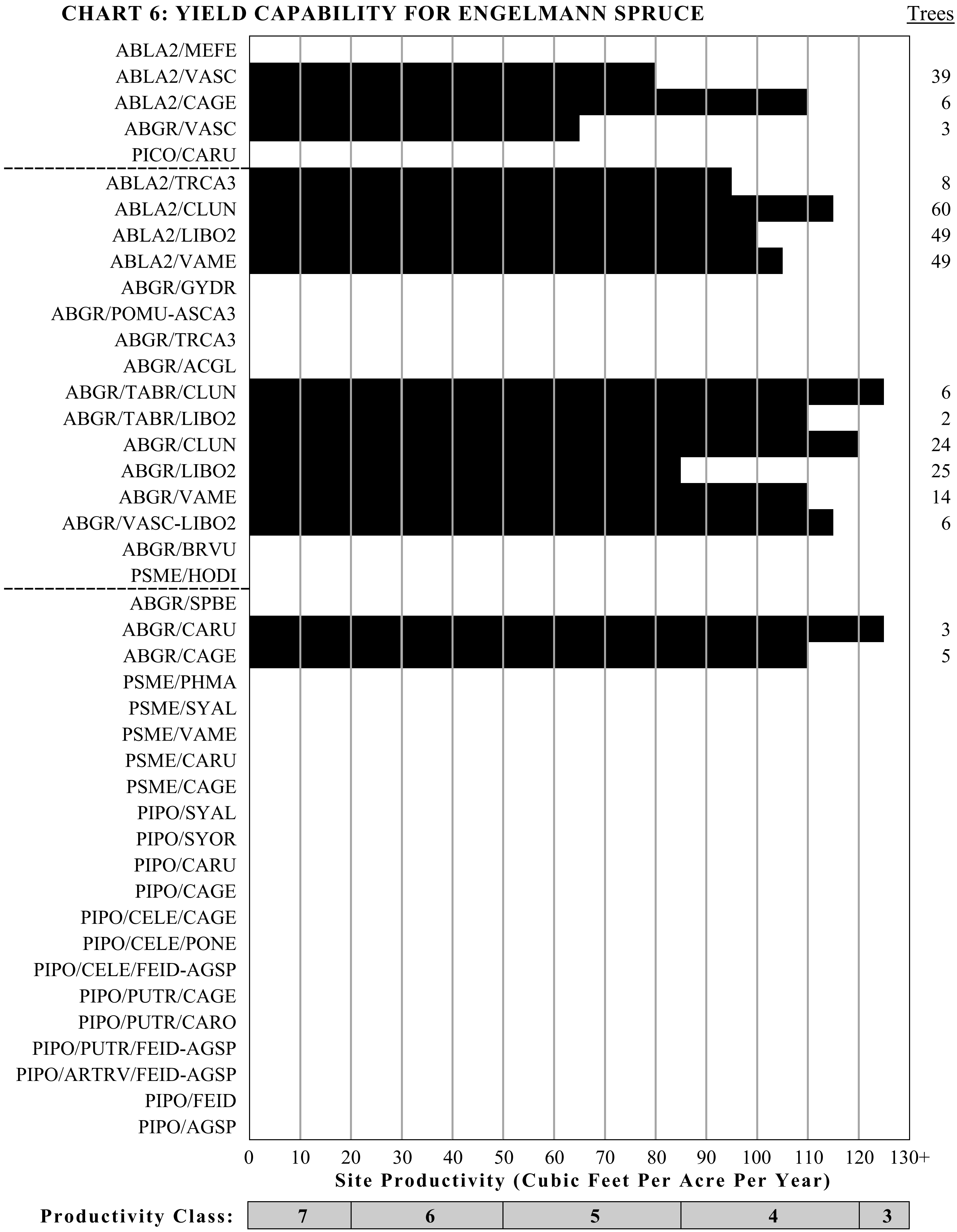
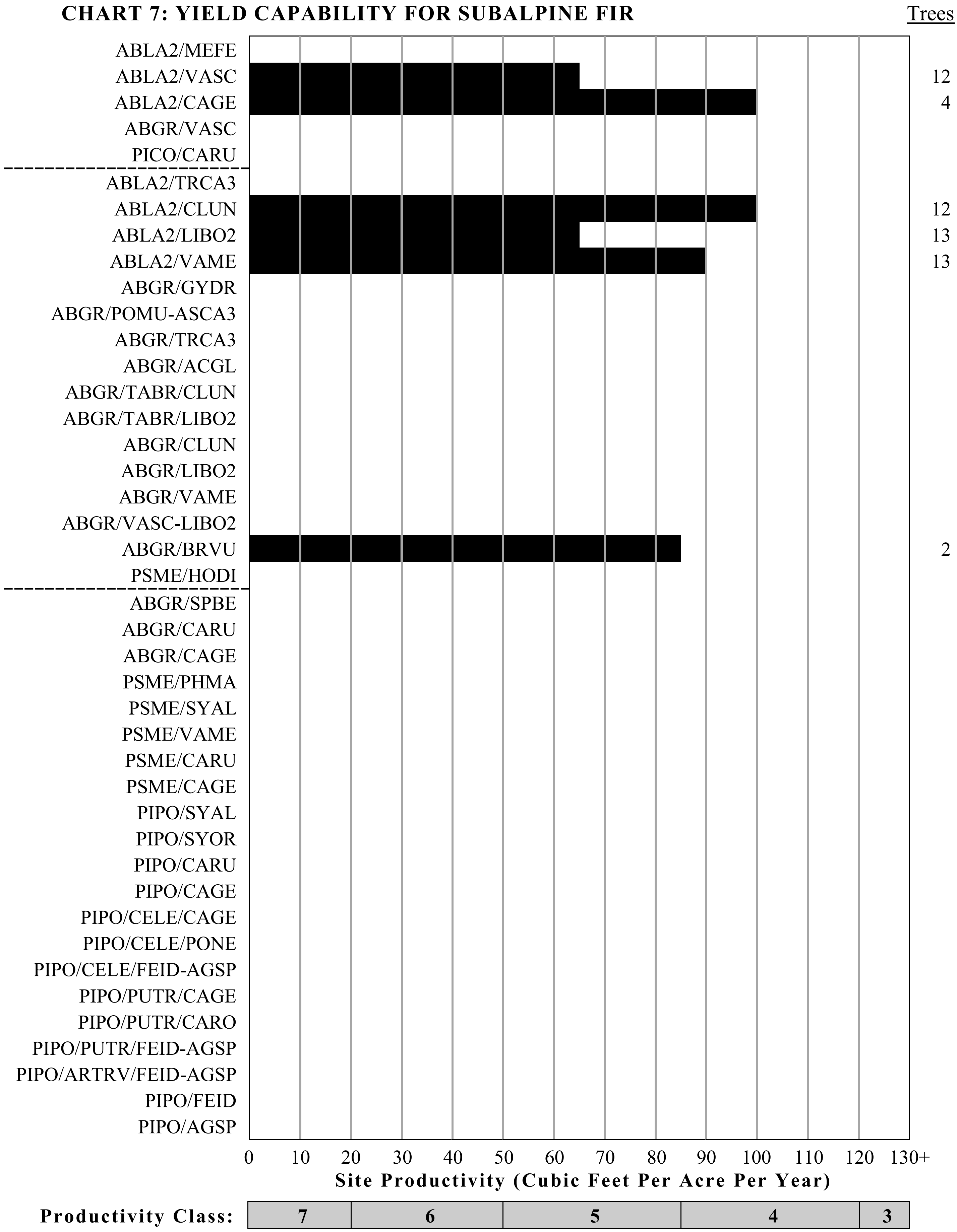


CHART 7: YIELD CAPABILITY FOR SUBALPINE FIR



SOURCES AND NOTES FOR SITE PRODUCTIVITY CHARTS

1. Seven productivity charts are provided (pages 17-23), one for each of seven primary conifers of Blue Mountains: ponderosa pine, interior Douglas-fir, western larch, lodgepole pine, grand fir, Engelmann spruce, and subalpine fir (organized from driest to wettest).
2. Leftmost column shows alphanumeric acronyms (such as PIPO/CARU) for plant associations of Blue and Ochoco Mountains. Acronyms are derived from scientific names for a plant association. Plant associations and their acronyms are described in "Plant Associations of the Blue and Ochoco Mountains" (R6-ERW-TP-036-92) by Johnson and Clausnitzer (1992).
3. Within each chart, plant associations are organized by potential vegetation group (PVG), as based on Powell et al. (2007); dashed lines delineate breaks between Dry Upland Forest PVG (bottom of each chart), Moist Upland Forest PVG (middle), and Cold Upland Forest PVG (top). Within a PVG, plant associations are organized from warm and dry (bottom of list in a PVG section) to cold and moist (top of list in a PVG section).
4. Site productivity was derived from trees measured to estimate site index, which provides an estimate of potential height of dominant and codominant trees as a measure of inherent site quality. Site index estimates were used to calculate a metric called yield capability (sometimes termed survey yield), which is a potential growth rate, in cubic feet per acre per year, for fully stocked stands on an area with a given site index.
5. "Trees" column located right of productivity bars provides number of site index trees used to calculate yield capability. If an asterisk precedes a number-of-trees value, it means that a site productivity estimate was derived from a plant community or plant community type for a plant association (these are seral or successional stages of a plant association).

REFERENCES

Barrett, J.W. 1978. Height growth and site index curves for managed even-aged stands of ponderosa pine in the Pacific Northwest. Res. Pap. PNW-232. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 41 p. https://www.treesearch.fs.fed.us/pubs/37176

Base, S.R.; Fosberg, M.A. 1971. Soil-woodland correlation in northern Idaho. Northwest Science. 45(1): 1-6.

Bates, C.G. 1918. Concerning site. Journal of Forestry. 16(4): 383-388. doi:10.1093/jof/16.4.383

Brickell, J.E. 1970. Equations and computer subroutines for estimating site quality of eight Rocky Mountain species. Res. Pap. INT-75. Ogden, UT: USDA Forest Service, Intermountain Forest and Range Experiment Station. 22 p. https://www.archive.org/download/equationscompute75bric/equationscompute75bric.pdf

Brown, H.G.; Loewenstein, H. 1978. Predicting site productivity of mixed conifer stands in northern Idaho from soil and topographic variables. Soil Science Society of America Journal. 42(6): 967-971. doi:10.2136/sssaj1978.03615995004200060029x

Carlson, T.C.; Nimlos, T.J. 1966. Using soil series to predict site index and wood specific gravity in western Montana. Northwest Science. 40(2): 56-67.

Carmean, W.H. 1975. Forest site quality evaluation in the United States. Advances in Agronomy. 27: 209-269. doi:10.1016/S0065-2113(08)70011-7

Chen, H.Y.H.; Krestov, P.V.; Klinka, K. 2002. Trembling aspen site index in relation to environmental measures of site quality at two spatial scales. Canadian Journal of Forest Research. 32(1): 112-119. doi:10.1139/x01-179

Christensen, G.A.; Dunham, P.; Powell, D.C.; Hiserote, B. 2007. Forest resources of the Umatilla National Forest. Res. Bull. PNW-RB-253. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 38 p. http://www.treesearch.fs.fed.us/pubs/27656

Cochran, P.H. 1979a. Site index and height growth curves for managed, even-aged stands of Douglas-fir east of the Cascades in Oregon and Washington. Res. Pap. PNW-251. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 16 p. https://www.treesearch.fs.fed.us/pubs/37177

Cochran, P.H. 1979b. Site index and height growth curves for managed, even-aged stands of white or grand fir east of the Cascades in Oregon and Washington. Res. Pap. PNW-252. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 13 p. https://www.treesearch.fs.fed.us/pubs/37178

Cochran, P.H. 1985. Site index, height growth, normal yields, and stocking levels for larch in Oregon and Washington. Res. Note PNW-424. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 24 p. https://www.treesearch.fs.fed.us/pubs/26835

Coile, T.S. 1938. Forest classification: classification of forest sites with special reference to ground vegetation. Journal of Forestry. 36(10): 1062-1066. doi:10.1093/jof/36.10.1062

Comeau, P.G.; Comeau, M.A.; Utzig, G.F. 1982. A guide to plant indicators of moisture for southeastern British Columbia, with engineering interpretations. Land Management Handbook No.

5. Victoria, BC: Province of British Columbia, Ministry of Forests, Information Services Branch. 119 p. https://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh05.pdf

Corns, I.G.W. 1983. Forest community types of west-central Alberta in relation to selected environmental factors. Canadian Journal of Forest Research. 13(5): 995-1010. doi:10.1139/x83-132

Corns, I.G.W.; Annas, R.M. 1986. Field guide to forest ecosystems of west-central Alberta. Vancouver, BC: UBC Publication. 251 p. isbn:0-662-14644-1

Cox, G.S.; McConnell, R.C.; Matthew, L.M. 1960. Ponderosa pine productivity in relation to soil and landform in western Montana. Soil Science Society of America Proceedings. 24(2): 139-142. doi:10.2136/sssaj1960.03615995002400020021x

Dahms, W.G. 1975. Gross yield of central Oregon lodgepole pine. In: Baumgartner, D.M., ed. Management of lodgepole pine ecosystems: symposium proceedings. Pullman, WA: Washington State University, Cooperative Extension Service: 208-232.

Daniel, T.W.; Helms, J.A.; Baker, F.S. 1979. Principles of silviculture. 2nd ed. New York: McGraw-Hill Book Co. 500 p. isbn:0-07-015297-7

Daubenmire, R. 1973. A comparison of approaches to the mapping of forest land for intensive management. Forestry Chronicle. 49(2): 87-91. doi:10.5558/tfc49087-2

Daubenmire, R.; Daubenmire, J.B. 1968. Forest vegetation of eastern Washington and northern Idaho. Tech. Bull. 60. Pullman, WA: Washington State University, College of Agriculture, Agricultural Experiment Station. 104 p. https://www.fs.usda.gov/treesearch/pubs/50665

Davis, L.S.; Johnson, K.N.; Bettinger, P.S.; Howard, T.E. 2001. Forest management: to sustain ecological, economic, and social values. 4th ed. New York: McGraw-Hill. 804 p. isbn:0-07-032694-0

DeBell, D.S.; Harms, W.R.; Whitesell, C.D. 1989. Stockability: A major factor in productivity differences between *Pinus taeda* plantations in Hawaii and the southeastern United States. Forest Science. 35(3): 708-719. doi:10.1093/forestscience/35.3.708

Frothingham, E.H. 1918. Height growth as a key to site. Journal of Forestry. 16(7): 754-760. doi:10.1093/jof/16.7.754

Frothingham, E.H. 1921. Classifying forest sites by height growth. Journal of Forestry. 19(4): 374-381. doi:10.1093/jof/19.4.374

Gingrich, S.F. 1964. Criteria for measuring stocking in forest stands. In: Proceedings, Society of American Foresters. Denver, CO: 198-201.

Green, R.N.; Marshall, P.L.; Klinka, K. 1989. Estimating site index of Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) from ecological variables in southwestern British Columbia. Forest Science. 35(1): 50-63. doi:10.1093/forestscience/35.1.50

Hall, F.C. 1998. Pacific Northwest ecoclass codes for seral and potential natural communities. Gen. Tech. Rep. PNW-GTR-418. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 290 p. https://www.treesearch.fs.fed.us/pubs/5567

Hanson, E.J.; Azuma, D.L.; Hiserote, B.A. 2002. Site index equations and mean annual increment equations for Pacific Northwest Research Station forest inventory and analysis inventories, 1985-2001. Res. Note PNW-RN-533. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 24 p. https://www.treesearch.fs.fed.us/pubs/5146

Heger, L. 1971. Confidence interval for site index using curves based on stem analyses. Canadian Journal of Forest Research. 1(4): 241-245. doi:10.1139/x71-033

Heger, L. 1973. Effect of index age on the precision of site index. Canadian Journal of Forest Research. 3(1): 1-6. doi:10.1139/x73-001

Hegyi, F.; Jelinek, J.J.; Viszlai, J.; Carpenter, D.B.; Britneff, A.A. 1981. Site index equations and curves for the major tree species in British Columbia. Forest Inventory Report No. 1. Victoria, BC: Ministry of Forests, Inventory Branch. 54 p. https://www.for.gov.bc.ca/hfd/library/documents/bib24877.pdf

Heiberg, S.O. 1939. Forest soil in relation to silviculture. Journal of Forestry. 37(1): 42-46. doi:10.1093/jof/37.1.42

Helms, J.A., editor. 1998. The dictionary of forestry. Bethesda, MD: The Society of American Foresters. 210 p. isbn:0-939970-73-2

Holmes, J.R.B.; Tackle, D. 1962. Height growth of lodgepole pine in Montana related to soil and stand factors. Bull. No. 21. Missoula, MT: Montana State University, Montana Forest and Conservation Experiment Station, School of Forestry. 12 p.

Johnson, C.G., Jr.; Clausnitzer, R.R. 1992. Plant associations of the Blue and Ochoco Mountains. Tech. Pub. R6-ERW-TP-036-92. Portland, OR: USDA Forest Service, Pacific Northwest Region, Wallowa-Whitman National Forest. 164 p. Plant-Associations-of-the-Blue-and-Ochoco-Mountains

La Roi, G.H.; Strong, W.L.; Pluth, D.J. 1988. Understory plant community classifications as predictors of forest site quality for lodgepole pine and white spruce in west-central Alberta. Canadian Journal of Forest Research. 18(7): 875-887. doi:10.1139/x88-135

MacFarlane, D.W.; Green, E.J.; Burkhart, H.E. 2000. Population density influences assessment and application of site index. Canadian Journal of Forest Research. 30(9): 1472-1475. doi:10.1139/cjfr-30-9-1472

MacLean, C.D.; Bolsinger, C.L. 1973. Estimating productivity on sites with a low stocking capacity. Res. Pap. PNW-152. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station. 18 p. https://www.archive.org/download/CAT92273128/CAT92273128.pdf

Max, T.A.; Schreuder, H.T.; Hazard, J.W.; Oswald, D.D.; Teply, J.; Alegria, J. 1996. The Pacific Northwest Region vegetation and inventory monitoring system. Res. Pap. PNW-RP-493. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 22 p. https://www.treesearch.fs.fed.us/pubs/2875

McQuilkin, R.A.; Rogers, R. 1978. A method for determining the precision of site index estimates made from site index prediction functions. Forest Science. 24(2): 289-296. doi:10.1093/forestscience/24.2.289

Means, J.E.; Campbell, M.H.; Johnson, G.P. 1986. Height growth and site index curves for mountain hemlock in the Oregon and southern Washington Cascades. Unpub. Rep. Portland, OR: USDA Forest Service, Pacific Northwest Forest and Range Experiment Station. 31 p.

Mogren, E.W.; Dolph, K.P. 1972. Prediction of site index of lodgepole pine from selected environmental factors. Forest Science. 18(4): 314-316. doi:10.1093/forestscience/18.4.314

Monserud, R.A.; Moody, U.; Breuer, D.W. 1990. A soil-site study for inland Douglas-fir. Canadian Journal of Forest Research. 20(6): 686-695. doi:10.1139/x90-092

Mueller-Dombois, D. 1964. The forest habitat types of southeastern Manitoba and their application to forest management. Canadian Journal of Botany. 42(10): 1417-1444. doi:10.1139/b64-138

Nigh, G.D.; Krestov, P.V.; Klinka, K. 2002. Trembling aspen height-age models for British Columbia. Northwest Science. 76(3): 202-212. http://hdl.handle.net/2376/928

Nigh, G.D.; Love, B.A. 1999. How well can we select undamaged site trees for estimating site index? Canadian Journal of Forest Research. 29(12): 1989-1992. doi:10.1139/x99-163

Parker, J. 1952. Environment and forest distribution of the Palouse Range in northern Idaho. Ecology. 33(4): 451-461. doi:10.2307/1931520

Peterson, W.C.; Hibbs, D.E. 1989. Adjusting stand density management guides for sites with low stocking potential. Western Journal of Applied Forestry. 4(2): 62-65. doi:10.1093/wjaf/4.2.62

Powell, D.C. 2014a. Active management of Blue Mountains dry forests: Silvicultural considerations. White Paper F14-SO-WP-Silv-4. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 238 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd491870.pdf

Powell, D.C. 2014b. Updates of maximum stand density index and site index for Blue Mountains variant of Forest Vegetation Simulator. White Paper F14-SO-WP-Silv-39. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 43 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3794788.pdf

Powell, D.C.; Johnson, C.G., Jr.; Crowe, E.A.; Wells, A.; Swanson, D.K. 2007. Potential vegetation hierarchy for the Blue Mountains section of northeastern Oregon, southeastern Washington, and west-central Idaho. Gen. Tech. Rep. PNW-GTR-709. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 87 p. http://www.treesearch.fs.fed.us/pubs/27598

Pregitzer, K.S.; Barnes, B.V. 1982. The use of ground flora to indicate edaphic factors in upland ecosystems of the McCormack Experimental Forest, upper Michigan. Canadian Journal of Forest Research. 12(3): 661-672. doi:10.1139/x82-100

Reineke, L.H. 1933. Perfecting a stand-density index for even-aged forests. Journal of Agricultural Research. 46(7): 627-638. https://naldc-legacy.nal.usda.gov/naldc/download.xhtml?id=IND43968212&content=PDF

Roth, F. 1916. Concerning site. Journal of Forestry. 14(1): 3-12. doi:10.1093/jof/14.1.3

Roth, F. 1918. Another word on site. Journal of Forestry. 16(7): 749-753. doi:10.1093/jof/16.7.749

Rowe, J.S. 1956. Uses of undergrowth plant species in forestry. Ecology. 37(3): 461-473. doi:10.2307/1930168

Rowe, J.S. 1992. The ecosystem approach to forestland management. Forestry Chronicle. 68(2): 222-224. doi:10.5558/tfc68222-2

Sackville Hamilton, N.R.; Matthew, C.; Lemaire, G. 1995. In defence of the -3/2 boundary rule: a re-evaluation of self-thinning concepts and status. Annals of Botany. 76(6): 569-577. doi:10.1006/anbo.1995.1134

Shirley, H.L. 1936. The utilization of solar radiation by forests. Bulletin of the American Meteorological Society. 17(3): 64c-67. doi:10.1175/1520-0477-17.3.64c

Smith, T.; Huston, M. 1989. A theory of the spatial and temporal dynamics of plant communities. Vegetatio. 83(1/2): 49-69. doi:10.1007/BF00031680

Sprackling, J.A. 1973. Soil-topographic site index for Engelmann spruce on granitic soils in northern Colorado and southern Wyoming. Research Note RM-239. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p. https://archive.org/download/CAT73403031/CAT73403031.pdf

Sterba, H. 1987. Estimating potential density from thinning experiments and inventory data. Forest Science. 33(4): 1022-1034. doi:10.1093/forestscience/33.4.1022

Strong, W.L.; Pluth, D.J.; La Roi, G.H.; Corns, I.G.W. 1991. Forest understory plants as predictors of lodgepole pine and white spruce site quality in west-central Alberta. Canadian Journal of Forest Research. 21(11): 1675-1683. doi:10.1139/x91-231

Swanson, D.K.; Grigal, D.F. 1989. Vegetation indicators of organic soil properties in Minnesota. Soil Science Society of America Journal. 53(2): 491-495. doi:10.2136/sssaj1989.03615995005300020031x

USDA Forest Service. 1987. Calculations and formulas used to derive R6TSE output tables. Program User's Guide Appendix II, R6TSE Program User's Guide. Portland, OR: USDA Forest Service, Pacific Northwest Region. 16 p.

USDA Forest Service. 1995. Current vegetation survey. Version 1.5. Portland, OR: USDA Forest Service, Pacific Northwest Region, Natural Resource Inventory. 79 p.

Verbyla, D.L.; Fisher, R.F. 1989. Ponderosa pine habitat types as an indicator of site quality in the Dixie National Forest, Utah. Western Journal of Applied Forestry. 4(2): 52-54. doi:10.1093/wjaf/4.2.52

Watt, R.F. 1953. Site index changes in western white pine forests. Res. Note No. 132. Missoula, MT: USDA Forest Service, Northern Rocky Mountain Forest and Range Experiment Station. 2 p. https://archive.org/download/CAT31015452/CAT31015452.pdf

APPENDIX 1

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
ABGR/ACGL	grand fir/Rocky Mountain maple	PA	CWS912	Warm Very Moist UF	Moist UF
ABGR/ACGL (FLOODPLAIN)	grand fir/Rocky Mountain maple (floodplain)	PA	CWS543	Warm Moderate SM RF	Moderate SM RF
ABGR/ACGL-PHMA	grand fir/Rocky Mountain maple-ninebark	PCT	CWS412	Warm Moist UF	Moist UF
ABGR/ARCO	grand fir/heartleaf arnica	PCT	CWF444	Cold Dry UF	Cold UF
ABGR/ATFI	grand fir/ladyfern	PA	CWF613	Warm High SM RF	High SM RF
ABGR/BRVU	grand fir/Columbia brome	PA	CWG211	Warm Moist UF	Moist UF
ABGR/CAGE	grand fir/elk sedge	PA	CWG111	Warm Dry UF	Dry UF
ABGR/CALA3	grand fir/woolly sedge	PC	CWM311	Warm High SM RF	High SM RF
ABGR/CARU	grand fir/pinegrass	PA	CWG112	Warm Dry UF	Dry UF
ABGR/CLUN	grand fir/queencup beadlily	PA	CWF421	Cool Moist UF	Moist UF
ABGR/COOC2	grand fir/goldthread	PA	CWF511	Cool Dry UF	Cold UF
ABGR/GYDR	grand fir/oakfern	PA	CWF611	Cool Very Moist UF	Moist UF
ABGR/LIBO2	grand fir/twinflower	PA	CWF311	Cool Moist UF	Moist UF
ABGR/POMU-ASCA3	grand fir/sword fern-ginger	PA	CWF612	Cool Very Moist UF	Moist UF
ABGR/SPBE	grand fir/birchleaf spiraea	PA	CWS321	Warm Dry UF	Dry UF
ABGR/SYAL (FLOODPLAIN)	grand fir/common snowberry (floodplain)	PCT	CWS314	Warm Low SM RF	Low SM RF
ABGR/TABR/CLUN	grand fir/Pacific yew/queencup beadlily	PA	CWC811	Cool Wet UF	Moist UF
ABGR/TABR/LIBO2	grand fir/Pacific yew/twinflower	PA	CWC812	Cool Wet UF	Moist UF
ABGR/TRCA3	grand fir/false bugbane	PA	CWF512	Cool Very Moist UF	Moist UF
ABGR/VAME	grand fir/big huckleberry	PA	CWS211	Cool Moist UF	Moist UF
ABGR/VASC	grand fir/grouse huckleberry	PA	CWS811	Cold Dry UF	Cold UF
ABGR/VASC-LIBO2	grand fir/grouse huckleberry-twinflower	PA	CWS812	Cool Moist UF	Moist UF
ABGR-CHNO/VAME	grand fir-Alaska yellow cedar/big huckleberry	PCT	CWS232	Cool Moist UF	Moist UF
ABLA2/ARCO	subalpine fir/heartleaf arnica	PCT	CEF412	Cool Moist UF	Moist UF
ABLA2/ATFI	subalpine fir/ladyfern	PA	CEF332	Cold High SM RF	High SM RF
ABLA2/CAAQ	subalpine fir/aquatic sedge	PCT	CEM123	Cold High SM RF	High SM RF
ABLA2/CACA	subalpine fir/bluejoint reedgrass	PA	CEM124	Cold Moderate SM RF	Moderate SM RF
ABLA2/CADI	subalpine fir/softleaved sedge	PCT	CEM122	Cold High SM RF	High SM RF
ABLA2/CAGE	subalpine fir/elk sedge	PA	CAG111	Cold Dry UF	Cold UF
ABLA2/CARU	subalpine fir/pinegrass	PCT	CEG312	Cool Dry UF	Cold UF
ABLA2/CLUN	subalpine fir/queencup beadlily	PA	CES131	Cool Moist UF	Moist UF
ABLA2/LIBO2	subalpine fir/twinflower	PA	CES414	Cool Moist UF	Moist UF
ABLA2/MEFE	subalpine fir/fool's huckleberry	PA	CES221	Cold Moist UF	Cold UF
ABLA2/POPU	subalpine fir/skunkleaved polemonium	PCT	CEF411	Cold Dry UF	Cold UF
ABLA2/RHAL	subalpine fir/white rhododendron	PCT	CES214	Cold Moist UF	Cold UF
ABLA2/SETR	subalpine fir/arrowleaf groundsel	PA	CEF333	Cold High SM RF	High SM RF
ABLA2/STAM	subalpine fir/twisted stalk	PCT	CEF311	Cool Wet UF	Moist UF
ABLA2/STOC	subalpine fir/western needlegrass	PCT	CAG4	Cold Dry UF	Cold UF

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
ABLA2/TRCA3	subalpine fir/false bugbane	PA	CEF331	Cool Moist UF	Moist UF
ABLA2/VAME	subalpine fir/big huckleberry	PA	CES311	Cool Moist UF	Moist UF
ABLA2/VASC	subalpine fir/grouse huckleberry	PA	CES411	Cold Dry UF	Cold UF
ABLA2/VASC/POPU	subalpine fir/grouse huckleberry/skunkleaved polemonium	PA	CES415	Cold Dry UF	Cold UF
ABLA2/VAUL/CASC5	subalpine fir/bog blueberry/Holm's sedge	PCT	CEM313	Cold High SM RF	High SM RF
ABLA2-PIAL/JUDR	subalpine fir-whitebark pine/Drummond's rush	PCT	CAG3	Cold Dry UF	Cold UF
ABLA2-PIAL/POPH	subalpine fir-whitebark pine/fleeceflower	PCT	CAF2	Cold Dry UF	Cold UF
ABLA2-PIAL/POPU	subalpine fir-whitebark pine/skunkleaved polemonium	PCT	CAF0	Cold Dry UF	Cold UF
ADPE	maidenhair fern	PCT	FW4213	Warm High SM RH	High SM RH
AGDI	thin bentgrass	PCT	MD4111	Warm Low SM RH	Low SM RH
AGSP	bluebunch wheatgrass	PA	GB41	Hot Dry UH	Dry UH
AGSP-ERHE	bluebunch wheatgrass-Wyeth's buckwheat	PA	GB4111	Hot Dry UH	Dry UH
AGSP-POSA3	bluebunch wheatgrass-Sandberg's bluegrass	PA	GB4121	Hot Dry UH	Dry UH
AGSP-POSA3-ASCU4	bluebunch wheatgrass-Sandberg's bluegrass-Cusick's milkvetch	PA	GB4114	Hot Dry UH	Dry UH
AGSP-POSA3 (BASALT)	bluebunch wheatgrass-Sandberg's bluegrass (basalt)	PA	GB4113	Hot Dry UH	Dry UH
AGSP-POSA3-DAUN	bluebunch wheatgrass-Sandberg's bluegrass-onespike oatgrass	PA	GB4911	Hot Dry UH	Dry UH
AGSP-POSA3-ERPU	bluebunch wheatgrass-Sandberg's bluegrass-shaggy fleabane	PA	GB4115	Hot Dry UH	Dry UH
AGSP-POSA3 (GRANITE)	bluebunch wheatgrass-Sandberg's bluegrass (granite)	PA	GB4116	Hot Dry UH	Dry UH
AGSP-POSA3-OPPO	bluebunch wheatgrass-Sandberg's bluegrass-pricklypear	PA	GB4118	Hot Dry UH	Dry UH
AGSP-POSA3-PHCO2	bluebunch wheatgrass-Sandberg's bluegrass-Snake River phlox	PA	GB4117	Hot Dry UH	Dry UH
AGSP-POSA3-SCAN	bluebunch wheatgrass-Sandberg's bluegrass-narrowleaf skullcap	PA	GB4112	Hot Dry UH	Dry UH
AGSP-SPCR-ARLO3	bluebunch wheatgrass-sand dropseed-red threeawn	PCT	GB1911	Hot Dry UH	Dry UH
ALIN/ATFI	mountain alder/ladyfern	PA	SW2116	Warm High SM RS	High SM RS
ALIN/CAAM	mountain alder/bigleaved sedge	PA	SW2114	Warm High SM RS	High SM RS
ALIN/CAAQ	mountain alder/aquatic sedge	PC	SW2126	Warm High SM RS	High SM RS
ALIN/CACA	mountain alder/bluejoint reedgrass	PA	SW2121	Warm Moderate SM RS	Moderate SM RS
ALIN/CADE	mountain alder/Dewey's sedge	PCT	SW2118	Warm Moderate SM RS	Moderate SM RS
ALIN/CALA3	mountain alder/woolly sedge	PA	SW2123	Warm Moderate SM RS	Moderate SM RS
ALIN/CALEL2	mountain alder/densely tufted sedge	PC	SW2127	Warm Moderate SM RS	Moderate SM RS
ALIN/CALU	mountain alder/woodrush sedge	PC	SW2128	Warm Low SM RS	Low SM RS
ALIN/CAUT	mountain alder/bladder sedge	PA	SW2115	Warm High SM RS	High SM RS
ALIN/EQAR	mountain alder/common horsetail	PA	SW2117	Warm Moderate SM RS	Moderate SM RS
ALIN/GLEL	mountain alder/tall mannagrass	PA	SW2215	Warm High SM RS	High SM RS
ALIN/GYDR	mountain alder/oakfern	PCT	SW2125	Warm Moderate SM RS	Moderate SM RS
ALIN/HELA	mountain alder/common cowparsnip	PCT	SW2124	Warm Moderate SM RS	Moderate SM RS
ALIN/POPR	mountain alder/Kentucky bluegrass	PCT	SW2120	Warm Low SM RS	Low SM RS
ALIN/SCMI	mountain alder/smallfruit bulrush	PCT	SW2122	Warm High SM RS	High SM RS
ALIN-COST/MESIC FORB	mountain alder-redosier dogwood/mesic forb	PA	SW2216	Warm Moderate SM RS	Moderate SM RS
ALIN-RIBES/MESIC FORB	mountain alder-currants/mesic forb	PA	SW2217	Warm Moderate SM RS	Moderate SM RS
ALIN-SYAL	mountain alder-common snowberry	PA	SW2211	Warm Low SM RS	Low SM RS

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
ALPR	meadow foxtail	PCT	MD2111	Warm Low SM RH	Low SM RH
ALRU (ALLUVIAL BAR)	red alder (alluvial bar)	PCT	HAF226	Warm Moderate SM RF	Moderate SM RF
ALRU/ATFI	red alder/ladyfern	PCT	HAF227	Warm High SM RF	High SM RF
ALRU/COST	red alder/redosier dogwood	PC	HAS511	Warm Moderate SM RF	Moderate SM RF
ALRU/PEFRP	red alder/sweet coltsfoot	PCT	HAF211	Warm Moderate SM RF	Moderate SM RF
ALRU/PHCA3	red alder/Pacific ninebark	PA	HAS211	Warm Moderate SM RF	Moderate SM RF
ALRU/SYAL	red alder/common snowberry	PCT	HAS312	Warm Moderate SM RF	Moderate SM RF
ALSI	Sitka alder snow slides	PCT	SM20	Cold Very Moist US	Cold US
ALSI/ATFI	Sitka alder/ladyfern	PA	SW2111	Warm High SM RS	High SM RS
ALSI/CILA2	Sitka alder/drooping woodreed	PA	SW2112	Warm High SM RS	High SM RS
ALSI/MESIC FORB	Sitka alder/mesic forb	PCT	SW2113	Warm Moderate SM RS	Moderate SM RS
ALVA	swamp onion	PCT	FW7111	Cold High SM RH	High SM RH
AMAL	western serviceberry	PCT	SW3114	Hot Low SM RS	Low SM RS
ARAR/FEID-AGSP	low sagebrush/Idaho fescue-bluebunch wheatgrass	PA	SD1911	Warm Moist US	Moist US
ARAR/POSA3	low sagebrush/Sandberg's bluegrass	PA	SD9221	Hot Dry US	Dry US
ARCA/DECE	silver sagebrush/tufted hairgrass	PA	SW6111	Hot Moderate SM RS	Moderate SM RS
ARCA/POCU	silver sagebrush/Cusick's bluegrass	PCT	SW6114	Hot Low SM RS	Low SM RS
ARCA/POPR	silver sagebrush/Kentucky bluegrass	PCT	SW6112	Hot Low SM RS	Low SM RS
ARRI/POSA3	stiff sagebrush/Sandberg's bluegrass	PCT	SD9111	Hot Dry US	Dry US
ARTRV/BRCA	mountain big sagebrush/mountain brome	PCT	SS4914	Warm Moist US	Moist US
ARTRV/CAGE	mountain big sagebrush/elk sedge	PA	SS4911	Cold Moist US	Cold US
ARTRV/FEID-AGSP	mountain big sagebrush/Idaho fescue-bluebunch wheatgrass	PA	SD2911	Warm Moist US	Moist US
ARTRV/POCU	mountain big sagebrush/Cusick's bluegrass	PA	SW6113	Hot Low SM RS	Low SM RS
ARTRV/STOC	mountain big sagebrush/western needlegrass	PCT	SS4915	Cool Dry US	Cold US
ARTRV-PUTR/FEID	mountain big sagebrush-bitterbrush/Idaho fescue	PCT	SD2916	Hot Moist US	Moist US
ARTRV-SYOR/BRCA	mountain big sagebrush-mountain snowberry/mountain brome	PCT	SD2917	Warm Moist US	Moist US
BEOC/MESIC FORB	water birch/mesic forb	PCT	SW3112	Warm Moderate SM RS	Moderate SM RS
BEOC/WET SEDGE	water birch/wet sedge	PCT	SW3113	Warm High SM RS	High SM RS
CAAM	bigleaved sedge	PA	MM2921	Warm High SM RH	High SM RH
CAAQ	aquatic sedge	PA	MM2914	Warm High SM RH	High SM RH
CACA	bluejoint reedgrass	PA	GM4111	Warm Moderate SM RH	Moderate SM RH
CACA4	silvery sedge	PCT	MS3113	Warm Moderate SM RH	Moderate SM RH
CACU (SEEP)	Cusick's camas (seep)	PCT	FW3911	Warm Very Moist UH	Moist UH
CACU2	Cusick's sedge	PA	MM2918	Warm High SM RH	High SM RH
CAGE (ALPINE)	elk sedge (alpine)	PCT	GS3911	Cold Dry UH	Cold UH
CAGE (UPLAND)	elk sedge (upland)	PCT	GS39	Cool Dry UH	Cold UH
CAHO	Hood's sedge	PCT	GS3912	Cool Moist UH	Cold UH
CALA	smoothstemmed sedge	PC	MW2913	Cold High SM RH	High SM RH
CALA3	woolly sedge	PA	MM2911	Warm Moderate SM RH	Moderate SM RH
CALA4	slender sedge	PC	MM2920	Warm High SM RH	High SM RH

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
CALEL2	densely tufted sedge	PA	MM2919	Warm Moderate SM RH	Moderate SM RH
CALU	woodrush sedge	PA	MM2916	Cold High SM RH	High SM RH
CAMU2	star sedge	PCT	MS3112	Warm Moderate SM RH	Moderate SM RH
CANE	Nebraska sedge	PCT	MM2912	Hot Moderate SM RH	Moderate SM RH
CANU4	torrent sedge	PCT	MM2922	Hot High SM RH	High SM RH
CAPR5	clustered field sedge	PCT	MW2912	Cold High SM RH	High SM RH
CASC5	Holm's sedge	PA	MS3111	Cold High SM RH	High SM RH
CASH	Sheldon's sedge	PCT	MM2932	Hot Moderate SM RH	Moderate SM RH
CASI2	shortbeaked sedge	PCT	MM2915	Warm High SM RH	High SM RH
CAST	sawbeak sedge	PCT	MW1926	Warm High SM RH	High SM RH
CAUT	bladder sedge	PA	MM2917	Warm High SM RH	High SM RH
CAVEV	inflated sedge	PA	MW1923	Warm High SM RH	High SM RH
CELE/CAGE	mountain mahogany/elk sedge	PCT	SD40	Hot Moist US	Moist US
CELE/FEID-AGSP	mountain mahogany/Idaho fescue-bluebunch wheatgrass	PA	SD4111	Hot Moist US	Moist US
CERE2/AGSP	netleaf hackberry/bluebunch wheatgrass	PA	SD5611	Hot Moist US	Moist US
CEVE	snowbrush ceanothus	PCT	SM33	Warm Moist US	Moist US
CILA2	drooping woodreed	PC	MW2927	Cold High SM RH	High SM RH
COST	redosier dogwood	PA	SW5112	Hot Moderate SM RS	Moderate SM RS
COST/SAAR4	redosier dogwood/brook saxifrage	PCT	SW5118	Warm High SM RS	High SM RS
CRDO	Douglas hawthorne	PCT	SW3111	Hot Low SM RS	Low SM RS
DECE	tufted hairgrass	PA	MM1912	Warm Moderate SM RH	Moderate SM RH
ELBE	delicate spikerush	PC	MS4111	Cold High SM RH	High SM RH
ELCI	basin wildrye	PA	GB7111	Hot Very Moist UH	Moist UH
ELPA	creeping spikerush	PA	MW4912	Hot High SM RH	High SM RH
ELPA2	fewflowered spikerush	PCT	MW4911	Cold High SM RH	High SM RH
EQAR	common horsetail	PA	FW4212	Warm Moderate SM RH	Moderate SM RH
ERDO-POSA3	Douglas buckwheat/Sandberg's bluegrass	PCT	FM9111	Hot Dry UH	Dry UH
ERIOG/PHOR	buckwheat/Oregon bladderpod	PA	SD9322	Hot Dry UH	Dry UH
ERST2-POSA3	strict buckwheat/Sandberg's bluegrass	PCT	FM9112	Hot Dry UH	Dry UH
ERUM (RIDGE)	sulphurflower (ridge)	PCT	FM9113	Hot Dry UH	Dry UH
FEID (ALPINE)	Idaho fescue (alpine)	PCT	GS12	Cold Moist UH	Cold UH
FEID-AGSP	Idaho fescue-bluebunch wheatgrass	PA	GB59	Warm Moist UH	Moist UH
FEID-AGSP (RIDGE)	Idaho fescue-bluebunch wheatgrass (ridge)	PCT	GB5915	Warm Moist UH	Moist UH
FEID-AGSP-BASA	Idaho fescue-bluebunch wheatgrass-balsamroot	PA	GB5917	Warm Moist UH	Moist UH
FEID-AGSP-LUSE	Idaho fescue-bluebunch wheatgrass-silky lupine	PA	GB5916	Warm Moist UH	Moist UH
FEID-AGSP-PHCO2	Idaho fescue-bluebunch wheatgrass-Snake River phlox	PA	GB5918	Warm Moist UH	Moist UH
FEID-CAGE	Idaho fescue-elk sedge	PCT	GB5922	Warm Moist UH	Moist UH
FEID-CAHO	Idaho fescue-Hood's sedge	PA	GB5921	Warm Moist UH	Moist UH
FEID-DAIN-CAREX	Idaho fescue-timber oatgrass-sedge	PA	GB5920	Warm Very Moist UH	Moist UH
FEID-KOCR (HIGH)	Idaho fescue-prairie junegrass (high)	PA	GB5913	Cool Moist UH	Cold UH

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
FEID-KOCR (LOW)	Idaho fescue-prairie junegrass (low)	PA	GB5914	Warm Moist UH	Moist UH
FEID-KOCR (MOUND)	Idaho fescue-prairie junegrass (mound)	PA	GB5912	Cool Moist UH	Cold UH
FEID-KOCR (RIDGE)	Idaho fescue-prairie junegrass (ridge)	PA	GB5911	Cool Moist UH	Cold UH
FEVI	green fescue	PCT	GS11	Cold Moist UH	Cold UH
FEVI-CAHO	green fescue-Hood's sedge	PCT	GS1111	Cold Moist UH	Cold UH
FEVI-LULA2	green fescue-spurred lupine	PA	GS1112	Cold Moist UH	Cold UH
GLEL	tall mannagrass	PA	MM2925	Warm High SM RH	High SM RH
GLNE/AGSP	spiny greenbush/bluebunch wheatgrass	PA	SD65	Hot Dry US	Dry US
JUBA	Baltic rush	PCT	MW3912	Hot Moderate SM RH	Moderate SM RH
JUOC/ARAR	western juniper/low sagebrush	PCT	CJS1	Hot Dry UW	Dry UW
JUOC/ARRI	western juniper/stiff sagebrush	PCT	CJS8	Hot Dry UW	Dry UW
JUOC/ARTRV	western juniper/mountain big sagebrush	PCT	CJS2	Hot Moist UW	Moist UW
JUOC/ARTRV/FEID-AGSP	western juniper/mountain big sagebrush/fescue-wheatgrass	PA	CJS211	Hot Moist UW	Moist UW
JUOC/CELE/CAGE	western juniper/mountain mahogany/elk sedge	PCT	CJS42	Hot Moist UW	Moist UW
JUOC/CELE/FEID-AGSP	western juniper/mountain mahogany/fescue-wheatgrass	PCT	CJS41	Hot Moist UW	Moist UW
JUOC/FEID-AGSP	western juniper/Idaho fescue-bluebunch wheatgrass	PA	CJG111	Hot Moist UW	Moist UW
JUOC/PUTR/FEID-AGSP	western juniper/bitterbrush/Idaho fescue-bluebunch wheatgrass	PA	CJS321	Hot Moist UW	Moist UW
LECOW	Wallowa Lewisia	PCT	FX4111	Hot Dry UH	Dry UH
METR	buckbean	PC	FW6111	Warm High SM RH	High SM RH
PERA3-SYOR	squaw apple-mountain snowberry	PCT	SD30	Hot Moist US	Moist US
PHLE2 (TALUS)	syringa bordered strips (talus)	PCT	NTS111	Hot Very Moist US	Moist US
PHMA-SYAL	ninebark-common snowberry	PA	SM1111	Warm Moist US	Moist US
PICO(ABGR)/ALSI	lodgepole pine(grand fir)/Sitka alder	PCT	CLS58	Cool Very Moist UF	Moist UF
PICO(ABGR)/ARNE	lodgepole pine(grand fir)/pinemat manzanita	PCT	CLS57	Cool Dry UF	Cold UF
PICO(ABGR)/CARU	lodgepole pine(grand fir)/pinegrass	PCT	CLG21	Cool Dry UF	Cold UF
PICO(ABGR)/LIBO2	lodgepole pine(grand fir)/twinflower	PCT	CLF211	Cool Moist UF	Moist UF
PICO(ABGR)/VAME	lodgepole pine(grand fir)/big huckleberry	PCT	CLS513	Cool Moist UF	Moist UF
PICO(ABGR)/VAME/CARU	lodgepole pine(grand fir)/big huckleberry/pinegrass	PCT	CLS512	Cool Moist UF	Moist UF
PICO(ABGR)/VAME/PTAQ	lodgepole pine(grand fir)/big huckleberry/bracken	PCT	CLS519	Cool Moist UF	Moist UF
PICO(ABGR)/VASC/CARU	lodgepole pine(grand fir)/grouse huckleberry/pinegrass	PCT	CLS417	Cold Dry UF	Cold UF
PICO(ABLA2)/CAGE	lodgepole pine(subalpine fir)/elk sedge	PCT	CLG322	Cold Dry UF	Cold UF
PICO(ABLA2)/STOC	lodgepole pine(subalpine fir)/western needlegrass	PCT	CLG11	Cold Dry UF	Cold UF
PICO(ABLA2)/VAME	lodgepole pine(subalpine fir)/big huckleberry	PCT	CLS514	Cool Moist UF	Moist UF
PICO(ABLA2)/VAME/CARU	lodgepole pine(subalpine fir)/big huckleberry/pinegrass	PCT	CLS516	Cool Moist UF	Moist UF
PICO(ABLA2)/VASC	lodgepole pine(subalpine fir)/grouse huckleberry	PCT	CLS418	Cold Dry UF	Cold UF
PICO(ABLA2)/VASC/POPU	lodgepole pine(subalpine fir)/grouse huckleberry/polemonium	PCT	CLS415	Cold Dry UF	Cold UF
PICO/ALIN/MESIC FORB	lodgepole pine/mountain alder/mesic forb	PC	CLM511	Cold Moderate SM RF	Moderate SM RF
PICO/CAAQ	lodgepole pine/aquatic sedge	PA	CLM114	Cold High SM RF	High SM RF
PICO/CACA	lodgepole pine/bluejoint reedgrass	PC	CLM117	Cold Moderate SM RF	Moderate SM RF
PICO/CALA3	lodgepole pine/woolly sedge	PC	CLM116	Cold Moderate SM RF	Moderate RF

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
PICO/CARU	lodgepole pine/pinegrass	PA	CLS416	Cool Dry UF	Cold UF
PICO/DECE	lodgepole pine/tufted hairgrass	PA	CLM115	Cold Moderate SM RF	Moderate SM RF
PICO/POPR	lodgepole pine/Kentucky bluegrass	PCT	CLM112	Cold Low SM RF	Low SM RF
PIEN/ATFI	Engelmann spruce/ladyfern	PCT	CEF334	Cold High SM RF	High SM RF
PIEN/BRVU	Engelmann spruce/Columbia brome	PCT	CEM125	Cold Low SM RF	Low SM RF
PIEN/CADI	Engelmann spruce/softleaved sedge	PA	CEM121	Cold High SM RF	High SM RF
PIEN/CILA2	Engelmann spruce/drooping woodreed	PC	CEM126	Cold Moderate SM RF	Moderate SM RF
PIEN/COST	Engelmann spruce/redosier dogwood	PA	CES511	Cold Moderate SM RF	Moderate SM RF
PIEN/EQAR	Engelmann spruce/common horsetail	PA	CEM211	Cold Moderate SM RF	Moderate SM RF
PIEN/SETR	Engelmann spruce/arrowleaf groundsel	PCT	CEF335	Cold High SM RF	High SM RF
PIMO/DECE	western white pine/tufted hairgrass	PCT	CQM111	Warm Moderate SM RF	Moderate SM RF
PIPO/AGSP	ponderosa pine/bluebunch wheatgrass	PA	CPG111	Hot Dry UF	Dry UF
PIPO/ARAR	ponderosa pine/low sagebrush	PCT	CPS61	Hot Moist UF	Dry UF
PIPO/ARTRV/CAGE	ponderosa pine/mountain big sagebrush/elk sedge	PCT	CPS132	Hot Dry UF	Dry UF
PIPO/ARTRV/FEID-AGSP	ponderosa pine/mountain big sagebrush/fescue-wheatgrass	PA	CPS131	Hot Dry UF	Dry UF
PIPO/CAGE	ponderosa pine/elk sedge	PA	CPG222	Warm Dry UF	Dry UF
PIPO/CARU	ponderosa pine/pinegrass	PA	CPG221	Warm Dry UF	Dry UF
PIPO/CELE/CAGE	ponderosa pine/mountain mahogany/elk sedge	PA	CPS232	Warm Dry UF	Dry UF
PIPO/CELE/FEID-AGSP	ponderosa pine/mountain mahogany/fescue-wheatgrass	PA	CPS234	Hot Dry UF	Dry UF
PIPO/CELE/PONE	ponderosa pine/mountain mahogany/Wheeler’s bluegrass	PA	CPS233	Hot Dry UF	Dry UF
PIPO/ELGL	ponderosa pine/blue wildrye	PA	CPM111	Warm Dry UF	Dry UF
PIPO/FEID	ponderosa pine/Idaho fescue	PA	CPG112	Hot Dry UF	Dry UF
PIPO/PERA3	ponderosa pine/squaw apple	PCT	CPS8	Hot Dry UF	Dry UF
PIPO/POPR	ponderosa pine/Kentucky bluegrass	PCT	CPM112	Hot Low SM RF	Low SM RF
PIPO/PUTR/AGSP	ponderosa pine/bitterbrush/bluebunch wheatgrass	PCT	CPS231	Hot Dry UF	Dry UF
PIPO/PUTR/CAGE	ponderosa pine/bitterbrush/elk sedge	PA	CPS222	Warm Dry UF	Dry UF
PIPO/PUTR/CARO	ponderosa pine/bitterbrush/Ross sedge	PA	CPS221	Warm Dry UF	Dry UF
PIPO/PUTR/FEID-AGSP	ponderosa pine/bitterbrush/Idaho fescue-bluebunch wheatgrass	PA	CPS226	Hot Dry UF	Dry UF
PIPO/RHGL	ponderosa pine/sumac	PCT	CPS9	Hot Dry UF	Dry UF
PIPO/SPBE	ponderosa pine/birchleaf spiraea	PCT	CPS523	Warm Dry UF	Dry UF
PIPO/SYAL	ponderosa pine/common snowberry	PA	CPS522	Warm Dry UF	Dry UF
PIPO/SYAL (FLOODPLAIN)	ponderosa pine/common snowberry (floodplain)	PA	CPS511	Hot Low SM RF	Low SM RF
PIPO/SYOR	ponderosa pine/mountain snowberry	PA	CPS525	Warm Dry UF	Dry UF
POFR/DECE	shrubby cinquefoil/tufted hairgrass	PA	SW5113	Warm Moderate SM RS	Moderate SM RS
POFR/POPR	shrubby cinquefoil/Kentucky bluegrass	PCT	SW5114	Warm Low SM RS	Low SM RS
POPR (DEGEN BENCH)	Kentucky bluegrass (degenerated bench)	PCT	MD3112	Cool Moist UH	Cold UH
POPR (MEADOW)	Kentucky bluegrass (meadow)	PCT	MD3111	Warm Low SM RH	Low SM RH
POSA3-DAUN	Sandberg’s bluegrass-onespike oatgrass	PA	GB9111	Hot Dry UH	Dry UH
POTR/ALIN-COST	quaking aspen/mountain alder-redosier dogwood	PCT	HQS222	Warm Moderate SM RF	Moderate SM RF
POTR/ALIN-SYAL	quaking aspen/mountain alder-common snowberry	PCT	HQS223	Warm Moderate SM RF	Moderate SM RF

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
POTR/CAAQ	quaking aspen/aquatic sedge	PCT	HQM212	Warm High SM RF	High SM RF
POTR/CACA	quaking aspen/bluejoint reedgrass	PCT	HQM123	Warm Moderate SM RF	Moderate SM RF
POTR/CALA3	quaking aspen/woolly sedge	PA	HQM211	Warm Moderate SM RF	Moderate SM RF
POTR/MESIC FORB	quaking aspen/mesic forb	PCT	HQM511	Warm Moderate SM RF	Moderate SM RF
POTR/POPR	quaking aspen/Kentucky bluegrass	PCT	HQM122	Hot Low SM RF	Low SM RF
POTR/SYAL	quaking aspen/common snowberry	PCT	HQS221	Hot Moderate SM RF	Moderate SM RF
POTR2/ACGL	black cottonwood/Rocky Mountain maple	PCT	HCS114	Warm Moderate SM RF	Moderate SM RF
POTR2/ALIN-COST	black cottonwood/mountain alder-redosier dogwood	PA	HCS113	Warm Moderate SM RF	Moderate SM RF
POTR2/SALA2	black cottonwood/Pacific willow	PA	HCS112	Hot Moderate SM RF	Moderate SM RF
POTR2/SYAL	black cottonwood/common snowberry	PCT	HCS311	Hot Moderate SM RF	Moderate SM RF
PSME/ACGL-PHMA	Douglas-fir/Rocky Mountain maple-mallow ninebark	PA	CDS722	Warm Moist UF	Moist UF
PSME/ACGL-PHMA (FLOODPLAIN)	Douglas-fir/Rocky Mountain maple-mallow ninebark (floodplain)	PA	CDS724	Warm Moderate SM RF	Moderate SM RF
PSME/CAGE	Douglas-fir/elk sedge	PA	CDG111	Warm Dry UF	Dry UF
PSME/CARU	Douglas-fir/pinegrass	PA	CDG121	Warm Dry UF	Dry UF
PSME/CELE/CAGE	Douglas-fir/mountain mahogany/elk sedge	PCT	CDSD	Warm Dry UF	Dry UF
PSME/HODI	Douglas-fir/oceanspray	PA	CDS611	Warm Moist UF	Moist UF
PSME/PHMA	Douglas-fir/ninebark	PA	CDS711	Warm Dry UF	Dry UF
PSME/SPBE	Douglas-fir/birchleaf spiraea	PA	CDS634	Warm Dry UF	Dry UF
PSME/SYAL	Douglas-fir/common snowberry	PA	CDS622	Warm Dry UF	Dry UF
PSME/SYAL (FLOODPLAIN)	Douglas-fir/common snowberry (floodplain)	PA	CDS628	Warm Low SM RF	Low SM RF
PSME/SYOR	Douglas-fir/mountain snowberry	PA	CDS625	Warm Dry UF	Dry UF
PSME/TRCA3	Douglas-fir/false bugbane	PCT	CDF313	Warm Moderate SM RF	Moderate SM RF
PSME/VAME	Douglas-fir/big huckleberry	PA	CDS812	Warm Dry UF	Dry UF
PUPA	weak alkaligrass	PA	MM2926	Warm High SM RH	High SM RH
PUTR/AGSP	bitterbrush/bluebunch wheatgrass	PA	SD3112	Hot Moist US	Moist US
PUTR/FEID-AGSP	bitterbrush/Idaho fescue-bluebunch wheatgrass	PA	SD3111	Warm Moist US	Moist US
RHAL2/MESIC FORB	alderleaved buckthorn/mesic forb	PCT	SW5117	Warm Moderate SM RS	Moderate SM RS
RHGL/AGSP	smooth sumac/bluebunch wheatgrass	PA	SD6121	Hot Dry US	Dry US
RIBES/CILA2	currants/drooping woodreed	PCT	SW5111	Warm High SM RS	High SM RS
RIBES/GLEL	currants/tall mannagrass	PCT	SW5116	Warm High SM RS	High SM RS
RIBES/MESIC FORB	currants/mesic forb	PCT	SW5115	Warm Moderate SM RS	Moderate SM RS
SAAR4	brook saxifrage	PCT	FW6113	Warm High SM RH	High SM RH
SACO2/CAPR5	undergreen willow/clustered field sedge	PC	SW1128	Cold High SM RS	High SM RS
SACO2/CASC5	undergreen willow/Holm’s sedge	PA	SW1121	Cold High SM RS	High SM RS
SACO2/CAUT	undergreen willow/bladder sedge	PCT	SW1127	Cold High SM RS	High SM RS
SAEA-SATW/CAAQ	Eastwood willow-Tweedy willow/aquatic sedge	PC	SW1129	Warm High SM RS	High SM RS
SAEX	coyote willow	PA	SW1117	Hot Moderate SM RS	Moderate SM RS
SALIX/CAAQ	willow/aquatic sedge	PA	SW1114	Warm High SM RS	High SM RS
SALIX/CACA	willow/bluejoint reedgrass	PC	SW1124	Warm Moderate SM RS	Moderate SM RS
SALIX/CALA3	willow/woolly sedge	PA	SW1112	Warm Moderate SM RS	Moderate SM RS

Table 2: Potential vegetation types (PVT) for Blue Mountains section (from Powell et al. 2007)[1]

PVT CODE	PVT COMMON NAME	STATUS	ECOCLASS	PAG	PVG
SALIX/CAUT	willow/bladder sedge	PA	SW1123	Warm High SM RS	High SM RS
SALIX/MESIC FORB	willow/mesic forb	PCT	SW1125	Warm Moderate SM RS	Moderate SM RS
SALIX/POPR	willow/Kentucky bluegrass	PCT	SW1111	Warm Low SM RS	Low SM RS
SARI	rigid willow	PCT	SW1126	Hot Moderate SM RS	Moderate SM RS
SASC/ELGL	Scouler willow/blue wildrye	PC	SW1130	Cool Moist US	Cold US
SCMI	smallfruit bulrush	PA	MM2924	Warm High SM RH	High SM RH
SETR	arrowleaf groundsel	PA	FW4211	Warm High SM RH	High SM RH
SPCR (RIVER TERRACE)	sand dropseed (river terrace)	PA	GB1211	Hot Dry UH	Dry UH
STOC	western needlegrass	PCT	GS10	Cool Moist UH	Cold UH
SYAL/FEID-AGSP-LUSE	common snowberry/fescue-wheatgrass-silky lupine	PCT	GB5121	Warm Moist US	Moist US
SYAL/FEID-KOCR	common snowberry/Idaho fescue-prairie junegrass	PCT	GB5919	Warm Moist US	Moist US
SYAL-ROSA	common snowberry-rose	PCT	SM3111	Warm Moist US	Moist US
SYOR	mountain snowberry	PCT	SM32	Warm Moist US	Moist US
TSME/VAME	mountain hemlock/big huckleberry	PA	CMS231	Cold Dry UF	Cold UF
TSME/VASC	mountain hemlock/grouse huckleberry	PA	CMS131	Cold Dry UF	Cold UF
TYLA	common cattail	PCT	MT8121	Hot High SM RH	High SM RH
VEAM	American speedwell	PA	FW6112	Warm High SM RH	High SM RH
VERAT	false hellebore	PC	FW5121	Warm Moderate SM RH	Moderate SM RH

[1] This appendix is organized alphabetically by PVT code. Column descriptions are:

PVT CODE provides an alphanumeric code for each of 296 potential vegetation types described for Blue Mountains section.

PVT COMMON NAME provides a common name for each potential vegetation type.

STATUS provides classification status for each potential vegetation type: PA is Plant Association; PCT is Plant Community Type; PC is Plant Community.

ECOCLASS codes are used to record potential vegetation type determinations.

PAG (Plant Association Group) and PVG (Potential Vegetation Group) are two levels of a mid-scale potential vegetation hierarchy; PAG and PVG codes use the following abbreviations: SM is Soil Moisture, UF is Upland Forest physiognomic class, UW is Upland Woodland physiognomic class, US is Upland Shrubland physiognomic class, UH is Upland Herbland physiognomic class, RF is Riparian Forest physiognomic class, RS is Riparian Shrubland physiognomic class, and RH is Riparian Herbland physiognomic class.

APPENDIX 2: SILVICULTURE WHITE PAPERS

White papers are internal reports, and they are produced with a consistent formatting and numbering scheme – all papers dealing with Silviculture, for example, are placed in a silviculture series (Silv) and numbered sequentially. Generally, white papers receive only limited review and, in some instances pertaining to highly technical or narrowly focused topics, the papers may receive no technical peer review at all. For papers that receive no review, the viewpoints and perspectives expressed in the paper are those of the author only, and do not necessarily represent agency positions of the Umatilla National Forest or the USDA Forest Service.

Large or important papers, such as two papers discussing active management considerations for dry and moist forests (white papers Silv-4 and Silv-7, respectively), receive extensive review comparable to what would occur for a research station general technical report (but they don't receive blind peer review, a process often used for journal articles).

White papers are designed to address a variety of objectives:

(1) They guide how a methodology, model, or procedure is used by practitioners on the Umatilla National Forest (to ensure consistency from one unit, or project, to another).
(2) Papers are often prepared to address ongoing and recurring needs; some papers have existed for more than 20 years and still receive high use, indicating that the need (or issue) has long standing – an example is white paper #1 describing the Forest's big-tree program, which has operated continuously for 25 years.
(3) Papers are sometimes prepared to address emerging or controversial issues, such as management of moist forests, elk thermal cover, or aspen forest in the Blue Mountains. These papers help establish a foundation of relevant literature, concepts, and principles that continuously evolve as an issue matures, and hence they may experience many iterations through time. [But also note that some papers have not changed since their initial development, in which case they reflect historical concepts or procedures.]
(4) Papers synthesize science viewed as particularly relevant to geographical and management contexts for the Umatilla National Forest. This is considered to be the Forest's self-selected 'best available science' (BAS), realizing that non-agency commenters would generally have a different conception of what constitutes BAS – like beauty, BAS is in the eye of the beholder.
(5) The objective of some papers is to locate and summarize the science germane to a particular topic or issue, including obscure sources such as master's theses or Ph.D. dissertations. In other instances, a paper may be designed to wade through an overwhelming amount of published science (dry-forest management), and then synthesize sources viewed as being most relevant to a local context.
(6) White papers function as a citable literature source for methodologies, models, and procedures used during environmental analysis – by citing a white paper, specialist reports can include less verbiage describing analytical databases, techniques, and so forth, some of which change little (if at all) from one planning effort to another.
(7) White papers are often used to describe how a map, database, or other product was developed. In this situation, the white paper functions as a 'user's guide' for the new product. Examples include papers dealing with historical products: (a) historical fire extents for the Tucannon watershed (WP Silv-21); (b) an 1880s map developed from General Land Office survey

notes (WP Silv-41); and (c) a description of historical mapping sources (24 separate items) available from the Forest's history website (WP Silv-23).

The following papers are available from the Forest's website: Silviculture White Papers

Paper #	Title
1	Big tree program
2	Description of composite vegetation database
3	Range of variation recommendations for dry, moist, and cold forests
4	Active management of Blue Mountains dry forests: Silvicultural considerations
5	Site productivity estimates for upland forest plant associations of Blue and Ochoco Mountains
6	Blue Mountains fire regimes
7	Active management of Blue Mountains moist forests: Silvicultural considerations
8	Keys for identifying forest series and plant associations of Blue and Ochoco Mountains
9	Is elk thermal cover ecologically sustainable?
10	A stage is a stage is a stage…or is it? Successional stages, structural stages, seral stages
11	Blue Mountains vegetation chronology
12	Calculated values of basal area and board-foot timber volume for existing (known) values of canopy cover
13	Created opening, minimum stocking, and reforestation standards from Umatilla National Forest Land and Resource Management Plan
14	Description of EVG-PI database
15	Determining green-tree replacements for snags: A process paper
16	Douglas-fir tussock moth: A briefing paper
17	Fact sheet: Forest Service trust funds
18	Fire regime condition class queries
19	Forest health notes for an Interior Columbia Basin Ecosystem Management Project field trip on July 30, 1998 (handout)
20	Height-diameter equations for tree species of Blue and Wallowa Mountains
21	Historical fires in headwaters portion of Tucannon River watershed
22	Range of variation recommendations for insect and disease susceptibility
23	Historical vegetation mapping
24	How to measure a big tree
25	Important Blue Mountains insects and diseases
26	Is this stand overstocked? An environmental education activity
27	Mechanized timber harvest: Some ecosystem management considerations
28	Common plants of south-central Blue Mountains (Malheur National Forest)
29	Potential natural vegetation of Umatilla National Forest
30	Potential vegetation mapping chronology
31	Probability of tree mortality as related to fire-caused crown scorch
32	Review of "Integrated scientific assessment for ecosystem management in the interior Columbia basin, and portions of the Klamath and Great basins" – Forest vegetation

Paper #	Title
33	Silviculture facts
34	Silvicultural activities: Description and terminology
35	Site potential tree height estimates for Pomeroy and Walla Walla Ranger Districts
36	Stand density protocol for mid-scale assessments
37	Stand density thresholds as related to crown-fire susceptibility
38	Umatilla National Forest Land and Resource Management Plan: Forestry direction
39	Updates of maximum stand density index and site index for Blue Mountains variant of Forest Vegetation Simulator
40	Competing vegetation analysis for southern portion of Tower Fire area
41	Using General Land Office survey notes to characterize historical vegetation conditions for Umatilla National Forest
42	Life history traits for common Blue Mountains conifer trees
43	Timber volume reductions associated with green-tree snag replacements
44	Density management field exercise
45	Climate change and carbon sequestration: Vegetation management considerations
46	Knutson-Vandenberg (K-V) program
47	Active management of quaking aspen plant communities in northern Blue Mountains: Regeneration ecology and silvicultural considerations
48	Tower Fire…then and now. Using camera points to monitor postfire recovery
49	How to prepare a silvicultural prescription for uneven-aged management
50	Stand density conditions for Umatilla National Forest: A range of variation analysis
51	Restoration opportunities for upland forest environments of Umatilla National Forest
52	New perspectives in riparian management: Why might we want to consider active management for certain portions of riparian habitat conservation areas?
53	Eastside Screens chronology
54	Using mathematics in forestry: An environmental education activity
55	Silviculture certification: Tips, tools, and trip-ups
56	Vegetation polygon mapping and classification standards: Malheur, Umatilla, and Wallowa-Whitman National Forests
57	State of vegetation databases for Malheur, Umatilla, and Wallowa-Whitman National Forests
58	Seral status for tree species of Blue and Ochoco Mountains

REVISION HISTORY

November 2010: minor formatting and editing changes were made; an appendix was added describing the white paper system, including a list of available white papers.

December 2014: minor formatting and editing changes were made; a new section called "Is site index the best predictor of site productivity?" was added, including figures 1-7 and additional references.

December 2018: Numerous edits and revisions were made, based primarily on a technical peer review provided by Craig Busskohl, soil scientist (Craig served as Forest Soil Scientist for the Umatilla National Forest for several decades).