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Stand Density Protocol for Mid-Scale Assessments[1]

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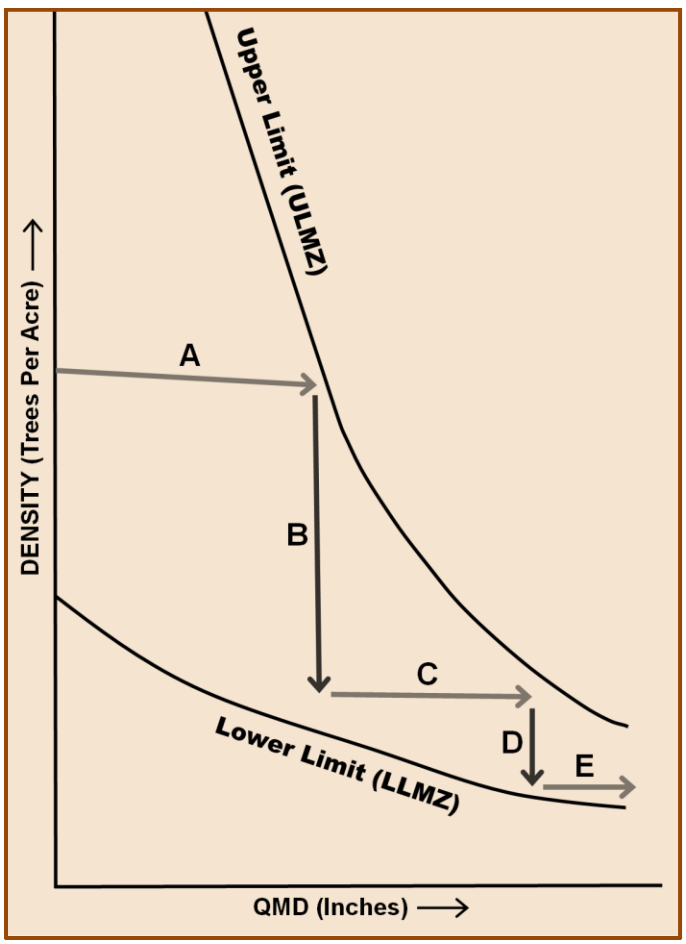

[1] White papers are internal reports; they receive only limited review. Viewpoints expressed in this paper are those of the author – they may not represent positions of USDA Forest Service.

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INTRODUCTION

Stand density needs to be determined before deciding if a forest polygon is overstocked. It can be characterized by using stand density index, leaf area index, or another relative density measure, or as trees per acre, basal area per acre, wood volume, canopy cover, or any number of similar absolute density measures (Curtis 1970, Ernst and Knapp 1985).

At a broad, conceptual scale, stand density is influenced by at least three primary factors.

1. Potential vegetation (PV) is an indicator of 'carrying capacity' for stand density (moist sites can support more density than dry sites). PV controls the rate at which forests produce and accumulate density – how fast existing trees grow and how quickly new trees get established. Consider two examples of how potential vegetation affects stand density (selected to represent both ends of a carrying capacity spectrum):
   a. On the ponderosa pine/bluebunch wheatgrass plant association, a fully-stocked ponderosa pine stand supports 133 trees per acre at a quadratic mean diameter of 10 inches;
   b. On the grand fir/twinflower plant association, a fully-stocked ponderosa pine stand supports 365 trees per acre at a quadratic mean diameter of 10 inches (Powell 1999).
   c. This means that for the same stocking level (full stocking), stand size (quadratic mean density of 10 inches), and tree species (ponderosa pine), carrying capacity of grand fir/twinflower sites is almost three times greater (365/133 = 275%) than carrying capacity of ponderosa pine/bluebunch wheatgrass sites.

2. Species composition has an important influence on stand density relationships because shade-tolerant trees can tolerate high density levels better than shade-intolerant tree species (Cochran et al. 1994).

3. Disturbance processes regulate stand density by periodically killing trees and maintaining stocking levels within a range of variation that differs for each combination of species and plant association (Cochran et al. 1994).

   Fire, insects, and other disturbance agents reduce tree density and modify stocking levels; Armillaria root disease, Douglas-fir beetle, Douglas-fir tussock moth, fir engraver, Indian paint fungus, mountain pine beetle, spruce beetle, western pine beetle, and western spruce budworm are insects and diseases that seem to respond positively to high tree density (Powell 1999).

   Range of variation information for insect and disease susceptibility is provided in this white paper: F14-SO-WP-Silv-22, *Range of variation recommendations for insect and disease susceptibility* (Schmitt and Powell 2012).

This protocol was designed to help users evaluate stand density and stocking levels when conducting mid-scale analyses, including watershed analysis (REO 1995), project-level planning for large analysis areas (NEPA), and landscape-level assessments such as Rainville et al. (2008).

Specifically, this mid-scale stand density protocol was prepared in response to two primary objectives:

1. Quantify four stocking thresholds (lower limit of a management zone, upper limit of a management zone, full stocking, maximum density) for two potential vegetation units (plant association groups, potential vegetation groups) and four traditional forestry metrics (stand density index, trees per acre, basal area per acre, canopy cover percentage).
2. Provide database queries for calculating three tree density ratings (high, moderate, low) for three stand size classes (seedlings/saplings, poles, small trees), two potential vegetation units (plant association groups, potential vegetation groups), and three traditional forestry metrics (trees per acre, basal area per acre, canopy cover percentage).

DEVELOPING AN ANALYSIS PROTOCOL

A protocol is valuable for producing long-term data sets of known quality; protocols help provide information to meet the Forest Service's business requirements and program objectives. This protocol provides data tables, queries, and other procedures relating to stand density and stocking assessments for mid-scale analysis areas.

Suggested Blue Mountains stocking levels were initially developed by Cochran et al. (1994), but they are provided in only one form – as stand density index (which equates to trees per acre, *but only at a quadratic mean diameter of 10 inches*).

A Cochran et al. (1994) research note accounts for potential vegetation because stocking levels differ by plant association, and it also accounts for tree species composition because stocking levels differ for each of seven conifer species.

Powell (1999) expanded the Cochran et al. (1994) stocking information by expressing it as trees per acre, basal area per acre, canopy cover, and equilateral tree spacing, and by calculating these metrics for a variety of tree sizes ranging from 1 to 30 inches of mean stand diameter at breast height (e.g., quadratic mean diameter).

For this mid-scale protocol, plant associations included in Cochran et al. (1994) and Powell (1999) were aggregated into two potential vegetation hierarchical units – plant association groups (PAGs) and potential vegetation groups (PVGs). A protocol for assigning potential vegetation types (plant associations, plant community types, plant communities) to PAGs and PVGs is described in Powell et al. (2007).

Any stocking analysis is species dependent. Some tree species are more sensitive to overcrowding than others, and this reality is clearly demonstrated when examining suggested stocking levels presented in Cochran et al. (1994) and Powell (1999).

For this mid-scale protocol, seven conifer species included in Cochran et al. (1994) and Powell (1999) were also included here when presenting stocking thresholds in tables 1-3 and tables 7-9. Those seven species are: ponderosa pine, interior Douglas-fir, western larch, lodgepole pine, Engelmann spruce, grand fir, and subalpine fir.

For some tables in this protocol, stocking levels are also provided for a 'mixed composition' consisting of three to five species; number of species included in mixed composition data varies by potential vegetation group or plant association group.

For database queries (tables 4-6 and 10-12), a 'limiting species' approach was used by assuming that tree species with low stocking levels have restrictive growing-space requirements, and that other species – those with higher stocking levels – have less exacting growing-space requirements and will develop acceptably under low stocking levels established for 'limiting species.'

Stand density index (SDI) is a relative density measure that does not vary by tree size. When converting from SDI to other traditional forestry metrics such as basal area, it was necessary to vary suggested stocking levels slightly by tree size. Note that Powell (1999) explains why this variation is necessary (see "basal area considerations" section on page 18 in Powell 1999).

To account for size-class variations, database queries (tables 4-6 and 10-12) were stratified by using three stand-size categories (seedlings/saplings, QMD < 5"; poles, QMD 5-8.9"; and 'small+' size class, QMD ≥ 9").

STAND DENSITY INDEX

Stand density index (SDI) expresses a relationship between number of trees per acre and quadratic mean diameter (QMD); SDI is indexed to a QMD of 10 inches (Daniel et al. 1979, Reineke 1933). This means that an SDI of 140 can be the same as 140 trees per acre, *but only when a stand's QMD is 10 inches*; at any other QMD, tree density associated with an SDI of 140 would be something other than 140 trees per acre.

SDI can be used in two ways – as a relative density measure, and as an 'absolute' stand density metric just like trees per acre or basal area per acre. When used in a relative density context, a calculated SDI value is compared against a stand density reference level – maximum density or full stocking are often used as a reference level.

For this mid-scale protocol, SDI values for each combination of plant association and tree species from Powell (1999) were entered into a spreadsheet, plant associations were grouped (in the spreadsheet) into plant association groups (PAGs) and potential vegetation groups (PVGs) by using information from Powell et al. (2007), and arithmetic average SDI stocking-level values were then computed for ten PAGs and three PVGs.

[Note that all calculations pertaining to PAGs and PVGs used arithmetic averaging, by which I mean the averages were not weighted to account for whether a potential vegetation type occupied a lot, or little, of the Umatilla NF's landbase. This means that stocking levels for ABBR/VAME and other common plant associations were given the same weight during averaging operations as stocking levels for ABGR/GYDR and other uncommon plant associations.]

Table 1 shows stand density index (SDI) values associated with four stocking thresholds, seven conifer species, and three potential vegetation groups. Table 7 provides the same information as table 1 except it includes plant association groups instead of potential vegetation groups.

TREES PER ACRE

This metric is an absolute measure of tree density per unit area. In a forestry context, tree density is generally more useful than canopy cover for characterizing species abundance because two tree species could have the same canopy cover percentage, but one occurs as many small individuals (high tree density) whereas the other has relatively few large individuals (low tree density).

Stem density is often considered to be an effective metric when comparing individuals in the same lifeform (trees with trees, tall shrubs with tall shrubs, etc.). Conversely, stem density is probably an inappropriate metric for comparing divergent lifeforms (for example, stem density is probably not an appropriate metric for comparing density of trees and forbs in the same plant community).

Powell (1999) describes how the stand density index values from Cochran et al. (1994) were converted into trees per acre (TPA).

For this mid-scale protocol, TPA values for each combination of plant association and tree species from Powell (1999) were entered into a spreadsheet, plant associations were grouped (in the spreadsheet) into plant association groups (PAGs) and potential vegetation groups (PVGs) by using information from Powell et al. (2007), and average TPA stocking-level values were then computed for ten PAGs and three PVGs.

Table 1 shows 'trees per acre' values associated with four stocking thresholds, seven conifer species, and three potential vegetation groups. Table 7 provides the same information as table 1 except it includes plant association groups instead of potential vegetation groups. **Note that TPA values in tables 1 and 7 are a 'trees per acre' stocking level for stands with a quadratic mean diameter of 10 inches only.**

Table 4 provides 'trees per acre' database queries for three tree density categories (low, moderate, high), three stand size categories (seedlings/saplings, poles, small trees), and three potential vegetation groups. Table 8 provides the same information as table 4 except it includes plant association groups instead of potential vegetation groups.

BASAL AREA PER ACRE

Basal area refers to cross-sectional area of a tree (in square inches) above a specified break-point diameter; a 'basal area per acre' stand density metric sums individual values for all trees on an acre and converts the resulting square inches value to square feet. Foresters use basal area when prescribing density management treatments, and it is sometimes used in ecological studies as a measure of species dominance.

Powell (1999) describes how stand density index values from Cochran et al. (1994) were converted into basal area per acre (BAA).

For this mid-scale protocol, BAA values for each combination of plant association and tree species from Powell (1999) were entered into a spreadsheet, plant associations were grouped (in the spreadsheet) into plant association groups (PAGs) and potential vegetation groups (PVGs) by using information from Powell et al. (2007), and average BAA stocking-level values were then computed for ten PAGs and three PVGs.

Table 2 shows basal area values associated with four stocking thresholds, seven conifer species, and three potential vegetation groups. Table 8 provides the same information as table 2 except it covers plant association groups instead of potential vegetation groups.

Table 5 provides ‘basal area per acre’ database queries for three tree density categories (low, moderate, high), three stand size categories (seedlings/saplings, poles, small trees), and three potential vegetation groups.

Table 9 provides the same information as table 5 except it includes plant association groups instead of potential vegetation groups.

CANOPY COVER PERCENTAGE

Canopy cover is a density metric used extensively in ecological studies. It is defined as vertical projection of vegetation foliage onto the ground surface when viewed from above. Canopy cover has certain limitations when compared with other forest density alternatives (see the ‘trees per acre’ section).

Powell (1999) describes how stand density index (SDI) values from Cochran et al. (1994) were converted into canopy cover (CC) percentages, primarily by converting SDI values to trees per acre, converting trees per acre values to basal area per acre, and then using equations developed by Ed Dealy (1985) to convert basal area per acre values to canopy cover percentages.

For this mid-scale protocol, CC percentages for each combination of plant association and tree species from Powell (1999) were entered into a spreadsheet, plant associations were grouped (in the spreadsheet) into plant association groups (PAGs) and potential vegetation groups (PVGs) by using information from Powell et al. (2007), and average CC stocking-level values were then computed for ten PAGs and three PVGs.

Table 3 shows canopy cover percentages associated with four stocking thresholds, seven conifer species, and three potential vegetation groups. Table 9 provides the same information as table 3 except it includes plant association groups instead of potential vegetation groups.

Table 6 provides ‘canopy cover percentage’ database queries for three tree density categories (low, moderate, high), three stand size categories (seedlings/saplings, poles, small trees), and three potential vegetation groups.

Table 10 provides the same information as table 6 except it includes plant association groups instead of potential vegetation groups.

Table 13 provides four forestry metrics (stand density index, trees per acre, basal area per acre, and canopy cover percentage), by plant association group, for two silviculturally relevant stocking thresholds – lower and upper limits of a management zone.

Table 14 provides the same information as table 13 except it includes potential vegetation groups instead of plant association groups.

Note: figures 4-12 (located at end of this document before the glossary) provide suggested stocking levels (trees per acre, basal area per acre, canopy cover percentage) for three potential vegetation groups, a range of quadratic mean diameters, a mixed species composition, and an irregular stand structure.

MAXIMUM DENSITY (FIGURES 1 AND 3)

When L.H. Reineke developed stand density index (Reineke 1933), he plotted tree densities for fully stocked, even-aged stands and then drew a freehand line skimming the outermost data values, such that most of the size-density points fell below the line (fig. 3).

Reineke's outermost boundary line represents maximum density for a species, and if his sample of fully-stocked stands was reasonably complete, then the maximum density line is a threshold that would seldom be breached – in a 'go/no-go' context, areas above the line (to the right of it) function as a 'no-go' area in terms of stand density.

Cochran et al. (1994) and Powell (1999) describe full stocking in great detail, but neither source quantifies maximum density. Powell (1999), however, refers to maximum density and notes that maximum density is easily calculated when full stocking is known (see table 3 on page 15 in Powell 1999).

This means that Cochran et al. (1994) and Powell (1999) provide information needed to calculate maximum density:

1. Powell (1999: table 3 on page 15) states that maximum density can be calculated as 125% of full stocking;
2. Cochran et al. (1994) provide species-wide values of full stocking for each of seven conifer species occurring in the Blue Mountains (see table 1 on page 3 in Cochran et al. 1994); and
3. Cochran et al. (1994) and Powell (1999) provide full stocking values for each combination of plant association and tree species occurring in the Blue-Ochoco and Wallowa-Snake physiographic provinces (see tables 3 and 4 in Cochran et al. 1994).

Maximum density is included in this mid-scale stocking-level protocol because it is a useful metric for forest dynamics modeling involving the Forest Vegetation Simulator (it is used with the SDIMAX keyword, for example).

[Note: White paper F14-SO-WP-Silv-39, "Updates of maximum stand density index and site index for Blue Mountains variant of Forest Vegetation Simulator," provides additional information about using maximum density stocking-level information with FVS.]

The table below provides Province-wide values of full stocking, and their corresponding values of maximum density, for seven tree species included in Cochran et al. (1994).

Tree Species	Province-wide Full Stocking[1]	Maximum Density[2]
Ponderosa pine	365	456
Interior Douglas-fir	380	475
Western larch	410	512
Lodgepole pine	277	346

Tree Species	Province-wide Full Stocking[1]	Maximum Density[2]
Engelmann spruce	469	586
Grand fir	560	700
Subalpine fir	416	520

[1] Province-wide full stocking values for the Blue Mountains are the SDIn values from table 1 in Cochran et al. (1994). Because these full-stocking values are maximums pertaining to an entire Blue Mountains physiographic province, *they are not specific to any particular plant association*.

[2] Maximum density was calculated as 125% of maximum full stocking (see table 3 in Powell 1999).

Table 15 (page 40) provides maximum density values for combinations of tree species and plant association occurring on the Umatilla National Forest.

FULL STOCKING (FIGURES 2 AND 3)

This stocking threshold is also included in figure 1, but it is referred to as ‘normal density’ in that figure.

In stand-density literature, full stocking is often referred to as normal density because it represents stand density values published in normal yield tables (e.g., Barnes 1962, McArdle et al. 1961, Meyer 1961). “The term fully stocked stand has traditionally meant a stand that has the same density as given in the natural stand normal yield table for that site and age” (Davis et al. 2001, p. 167).

“It is unfortunate that the word ‘normal’ has become attached as a standard of comparison to the concept of stands fully stocked at a given age; there is nothing normal about them in the sense of being ‘usual’ or ‘regular’. When foresters wanted to determine the potential growth for natural stands on these sites, they did not use a random sample but rather selected only stands that appeared healthy, had an even distribution of trees on the ground, and were at the highest density levels observed; in short, they looked for nature’s best” (Davis et al. 2001, p. 188 and 190).

Full stocking is also called ‘average-maximum’ density because it is analogous to a least-squares regression line for scatter plot data collected from fully-stocked stands (fig. 3). In fact, a least-squares fit of normal-stand data used to construct Meyer’s normal yield tables for ponderosa pine (Meyer 1961) results in an SDI of 365 (Oliver and Uzoh 1997), and an SDI of 365 is used as a maximum (province-wide) full-stocking value for ponderosa pine in the Blue Mountains (see table at bottom of previous page).

Full stocking implies a high stand density condition when considering a site’s inherent capacity to support stocking (MacLean and Bolsinger 1973); trees in fully stocked stands compete vigorously with each other for water, sunlight, and nutrients. Full stocking or normal density is assumed to apply to single-cohort (even-aged) stands where intertree competition is causing a full range of crown classes to develop (e.g., crown-class differentiation) – dominant, codominant, intermediate, and subcanopy trees are present in differentiated stands.

If intense competition associated with full stocking persists, then density-dependent tree mortality eventually becomes substantial. And density-dependent tree mortality is selective – inevitably, it tends to have the most influence on smaller, subordinate trees (intermediate and subcanopy crown classes), and on shade-intolerant tree species.

Stands whose tree density is at, or close to, full stocking have trees that are dying from intertree competition – dying trees tend to be those that 'fell behind' during crown-class differentiation – these are trees in intermediate and subordinate (suppressed) crown classes. Since foresters want to maintain stand density at levels low enough to prevent this density-dependent tree mortality (shown as 'self-thinning zone' in fig. 2), they typically prescribe stocking levels that are well below the full-stocking threshold.

Cochran et al. (1994) provides full-stocking SDI values for combinations of tree species and plant association occurring in Blue-Ochoco and Wallowa-Snake geographical areas (see their tables 3 and 4) (Johnson and Clausnitzer 1992, Johnson and Simon 1987).

For five primary upland-forest tree species of the Blue Mountains, Cochran et al. (1994) full-stocking SDI values are used as a reference level when calculating upper and lower limits of a management zone – Douglas-fir, western larch, Engelmann spruce, grand fir, and subalpine fir.

As described below, upper and lower limits of a management zone were not calculated as a percentage of full stocking for ponderosa and lodgepole pines because of considerations relating to mountain pine beetle susceptibility.

Cochran et al. (1994) and Powell (1999) provide additional background information about a full stocking threshold.

UPPER LIMIT OF A MANAGEMENT ZONE (FIGURE 2)

This stocking threshold is also included in figure 1, but it is referred to as 'lower limit of self-thinning zone' in that figure.

Management zone is defined as an "area defined by the upper and lower bounds of acceptable relative densities in stands managed for a particular objective" (Ernst and Knapp 1985).

Cochran et al. (1994) followed this national policy regarding management zone by using full stocking as a relative-density reference level, and by basing upper and lower limits of a management zone on percentages of full stocking (for most species). Their 'particular objective' was to establish a management zone that avoids the self-thinning zone (fig. 2) by staying below it, thereby precluding density-dependent tree mortality for small trees.

Foresters generally prefer to manage stand density in ways that avoid the tree mortality typically experienced by small trees in subordinate canopy strata. One way to meet this objective is to establish an upper stocking threshold – an upper limit of a management zone (ULMZ) – that discourages a subcanopy crown class (intermediate and suppressed crown classes) from developing. This strategy avoids most competition-induced tree mortality associated with a self-thinning process (self-thinning zone in fig. 2).

Since the lower limit of a self-thinning zone is believed to be 60% of maximum density (fig. 1), which is equivalent to 75% of full stocking (fig. 2), Cochran et al. (1994) recommended that an upper limit of a management zone be set at this 75% level to avoid tree mortality caused by self-thinning (Cochran 1982).

Although Cochran et al. (1994) provides estimates of full stocking for combinations of tree species and plant association for Blue-Ochoco and Wallowa-Snake provinces (see tables 3 and 4 in Cochran et al. 1994), that source does not provide explicit SDI values for an upper limit of a management zone stocking level. However, Cochran et al. (1994) does describe a process for how to calculate a ULMZ level.

For five of seven major tree species occurring in upland-forest potential vegetation types of the Blue Mountains (Douglas-fir, western larch, Engelmann spruce, grand fir, and subalpine fir), an upper limit of a management zone was calculated directly as 75% of full stocking.

For two of seven major Blue Mountains tree species (e.g., ponderosa pine and lodgepole pine), ULMZ values were not calculated as a percentage of full stocking because Cochran and others (1994) used a special ULMZ calculation procedure to account for mountain pine beetle susceptibility. *This means that for ponderosa and lodgepole pines, ULMZ values cannot be calculated as a percentage of full stocking*.

Calculated values of ULMZ are provided in Powell (1999) for both lodgepole pine and ponderosa pine. Refer to that source for explicit ULMZ values, and for a detailed description of a ULMZ calculation methodology for ponderosa and lodgepole pines.

Cochran et al. (1994) and Powell (1999) provide additional background information about an upper limit of a management zone stocking threshold.

LOWER LIMIT OF A MANAGEMENT ZONE (FIGURE 2)

Cochran et al. (1994) recommended that lower limit of a management zone (LLMZ) be established in such a way as to "capture a significant portion of the site resources in tree growth." Since this objective is best met by selecting a stand development benchmark called 'lower limit of full site occupancy' (see fig. 1), it was used as an LLMZ.

A 'lower limit of full site occupancy' stand development benchmark is equivalent to 50% of full stocking (see fig. 2 and Cochran et al. 1994), so LLMZ stocking levels were generally calculated as 50% of full stocking.

For five of seven major Blue Mountains tree species (e.g., Douglas-fir, western larch, Engelmann spruce, grand fir, and subalpine fir), LLMZ was calculated directly as 50% of full stocking.

For two of seven major Blue Mountains tree species (e.g., ponderosa pine and lodgepole pine), ULMZ values were not calculated as a percentage of full stocking because Cochran and others (1994) used a special ULMZ calculation procedure to account for mountain pine beetle susceptibility. *This also means that for ponderosa and lodgepole pines, LLMZ values cannot be calculated as a percentage of full stocking*.

Since LLMZ represents 67% of ULMZ for five of seven major Blue Mountains tree species, the same concept was used for lodgepole pine and ponderosa pine – LLMZ values for these two species are 67% of ULMZ values.

Cochran et al. (1994) and Powell (1999) provide additional background information about a lower limit of a management zone stocking threshold.

CAUTIONS AND CAVEATS

No protocol can address every contingency. Please consider these potential limitations when using the protocol described in this paper.

1. Early-seral species were generally selected to represent a PVG or PAG for database query tables, perhaps implying that late-seral species (spruce, firs) do not exist or that they would be preferentially removed during a density management treatment such as thinning.
   Response: Selecting an early-seral species to represent a PAG or PVG, a simplifying assumption, was done because of the 'most-limiting species' concept discussed earlier in this white paper (see page 4). Note that the most-limiting tree species for a potential vegetation unit (plant association, PAG, or PVG), in a stocking-level or density-management context, is always an early-seral species.
2. Only one tree species was selected to represent a PVG or PAG for database query tables, perhaps implying that mixed-species stands do not exist or that a mixed composition would be discriminated against during a density management treatment.
   Response: Selecting a single species to represent a PVG or PAG, a simplifying assumption, is necessary for a mid-scale protocol; it is not implied that an operational treatment (such as a thinning) would be designed for just a single tree species.
3. The database query tables (4-6 and 10-12) use the management zone concept; the low category corresponds to the lower limit of the management zone, the moderate category refers to the management zone, and the high category corresponds to the upper limit of the management zone. Some users might find this range of stocking levels to be too conservative.

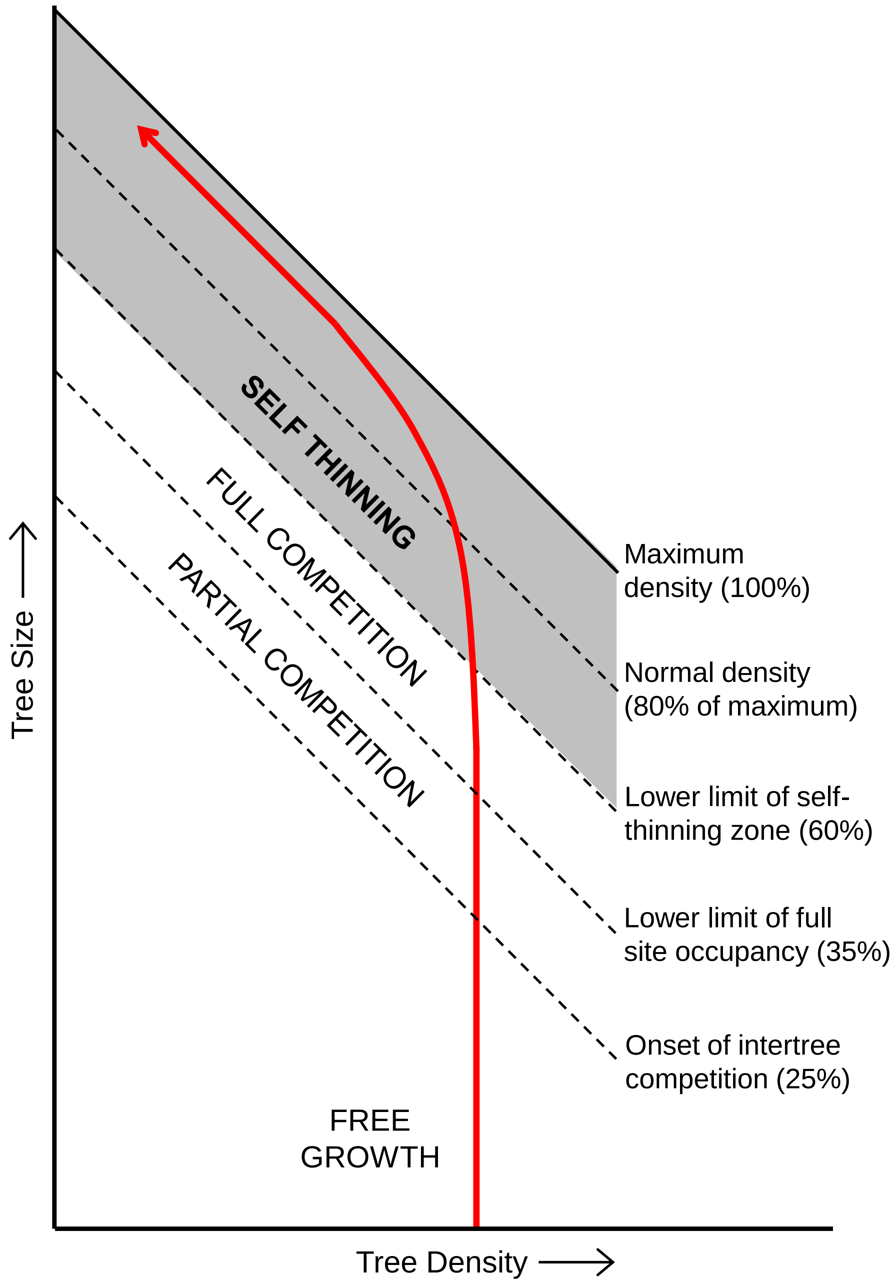

Figure 1 – Stand development as related to maximum density. Initially, trees do not use all a site's resources during a period of free growth (little or no intertree competition occurs then). When roots and crowns begin to interact, an *onset of intertree competition* threshold has been reached. As growth continues through a partial-competition zone, trees capture all growing space and a *lower limit of full site occupancy* threshold is breached. At this point, full competition is occurring between trees. As competition intensifies, stands enter a *self-thinning* zone (gray shading) by crossing a *lower limit of self-thinning zone* threshold. In a self-thinning zone, trees can only increase in size after one or more of their neighbors relinquish growing space by dying. Many small trees are dying as a stand passes the *normal density* threshold and approaches *maximum density*. Maximum density is shown as a solid line because it is an absolute threshold. Maximum density is a reference level for this stocking-level system.

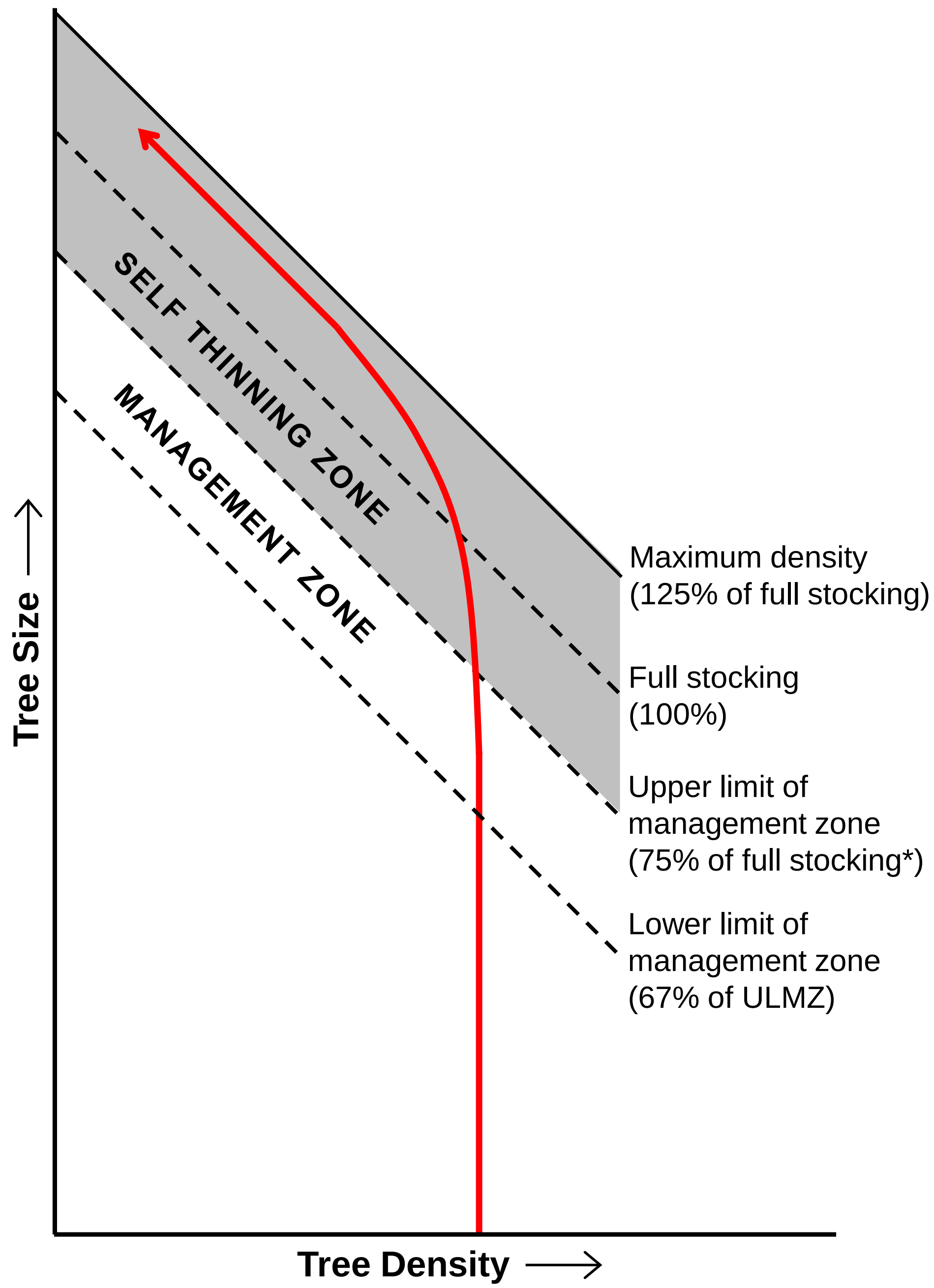

Figure 2 – Stand development as related to full stocking. When Cochran et al. (1994) published suggested stocking levels, they quantified *full stocking* for combinations of upland-forest plant association and tree species for Blue Mountains province (Johnson and Clausnitzer 1992, Johnson and Simon 1987). When comparing this figure and figure 1: (1) Cochran paper did not include *maximum density* (but I included here for reference); (2) *normal density* in fig. 1 is called *full stocking* here (the names vary, but this is the same stocking level); (3) *lower limit of self-thinning zone* in fig. 1 was used as an *upper limit of a management zone* in the Cochran paper; (4) *lower limit of full site occupancy* in fig. 1 was used as a *lower limit of a management zone* in Cochran paper; (5) Cochran paper did not use an *onset of intertree competition* threshold in figure 1 as a stocking level; and (6) Cochran paper used *full stocking* as a reference level for their stocking-level system, instead of *maximum density* as used in figure 1.

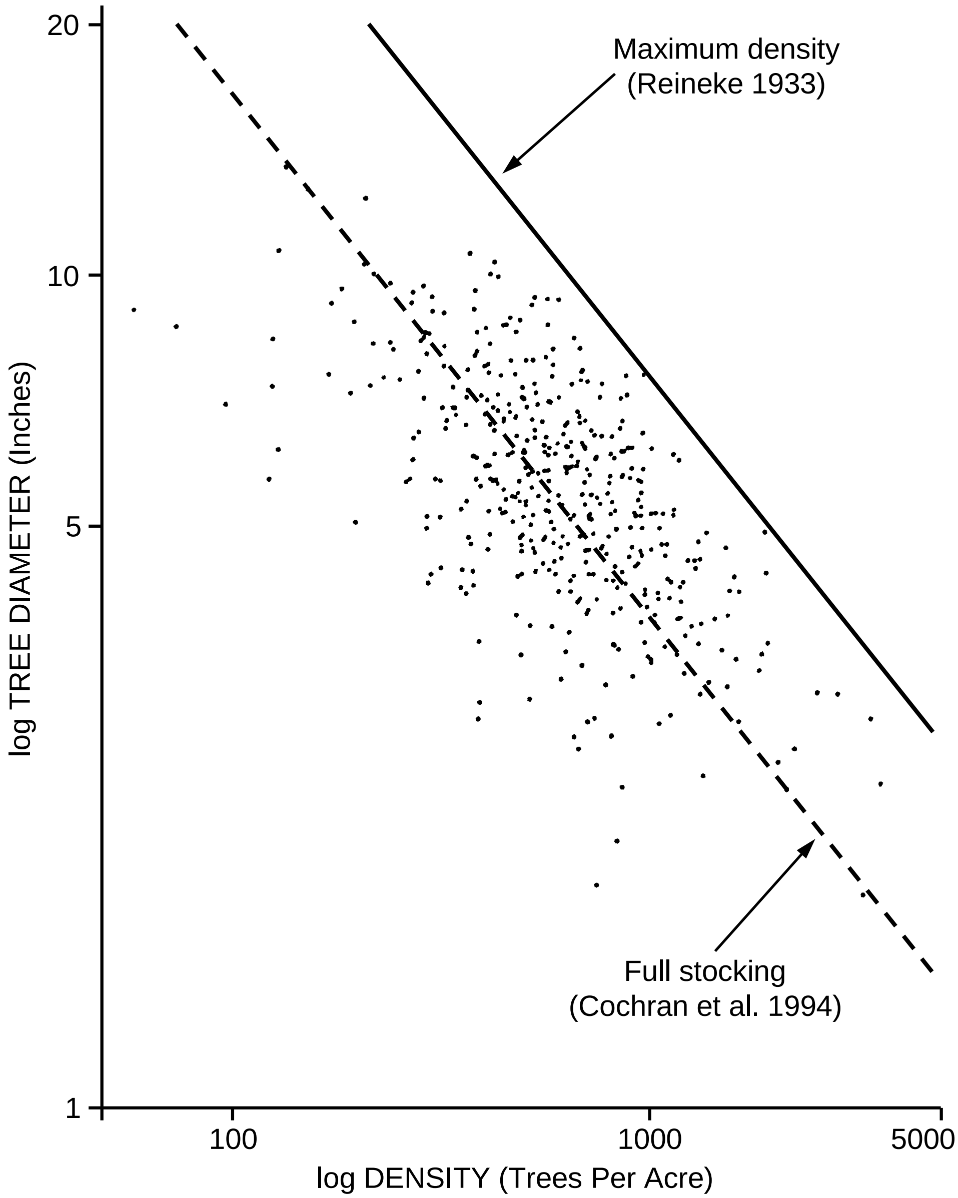

Figure 3 – Relationship between maximum density and full stocking. L.H. Reineke, creator of stand density index, plotted tree diameter and density for well-stocked, even-aged stands, by individual tree species, on logarithmic scales (Reineke 1933). This resulted in a scatter plot where each dot represents one stand's data for mean diameter and trees per acre. Instead of following regular statistical methods (minimizing squared deviations), Reineke drew a straight line above the cloud of points (not through them) – this is a solid **maximum density** line in this figure.

But, when a least-squares regression approach is used with this scatter-plot data, the result depicts average density for fully stocked stands – this is a dashed **full stocking** line in this figure. This average line is referred to as normal density or full stocking (Meyer 1961, McArdle et al. 1961). Cochran et al. (1994) use full stocking as a relative density reference level, and their upper and lower limits of a management zone are referenced to full stocking (fig. 2).

The Cochran et al. (1994) process differs from Reineke's approach because Reineke used maximum density as a relative density reference level.

Table 1: Tree density, expressed by using *stand density index*, for four stocking thresholds and three potential vegetation groups.

Potential Vegetation Groups[2]	Tree Species	TREE DENSITY (SDI[1]) LLMZ	ULMZ	FS	Max[3]
Dry Upland Forest	Ponderosa pine	57	85	201	251
	Interior Douglas-fir	127	191	254	318
	Western larch	121	181	241	301
	Lodgepole pine	114	170	277	346
	Engelmann spruce				
	Grand fir	213	319	425	532
	Subalpine fir				
	Mixed composition[4]	81	121	218	272
Moist Upland Forest	Ponderosa pine	115	172	296	370
	Interior Douglas-fir	148	223	297	372
	Western larch	171	256	342	428
	Lodgepole pine	114	170	267	334
	Engelmann spruce	185	278	371	463
	Grand fir	246	369	492	615
	Subalpine fir	158	238	317	396
	Mixed composition[4]	163	244	333	417
Cold Upland Forest	Ponderosa pine	63	93	159	199
	Interior Douglas-fir	158	237	317	396
	Western larch	167	250	334	418
	Lodgepole pine	113	169	250	313
	Engelmann spruce	172	257	343	429
	Grand fir	173	259	346	433
	Subalpine fir	184	276	367	459
	Mixed composition[4]	132	197	275	344

[1] SDI refers to stand density index; all SDI values pertain to an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure. Values in this table also represent a trees per acre (TPA) stocking level, *but only when quadratic mean diameter is 10 inches*; at any QMD other than 10 inches, these values do not represent a TPA stocking level. If tree-density cells in this table are empty (all entries for Engelmann spruce and subalpine fir for Dry Upland Forest, for example), it means that the species does not occur in that PVG.

[2] Potential vegetation groups are a mid-scale unit in a potential vegetation hierarchy (Powell et al. 2007).

[3] LLMZ is lower limit of a management zone; ULMZ is upper limit of a management zone; FS is full stocking; and Max is maximum density (all four levels are shown in fig. 2).

[4] Mixed composition is a weighted average based on these species mixes:

Dry upland forest: 70% ponderosa pine, 20% Douglas-fir, and 10% grand fir.

Moist upland forest: 30% Douglas-fir, 20% western larch, 20% lodgepole pine, and 30% grand fir.

Cold upland forest: 10% Douglas-fir, 10% western larch, 50% lodgepole pine, 20% Engelmann spruce, and 10% subalpine fir.

Table 2: Tree density, expressed by using *basal area per acre*, for four stocking thresholds and three potential vegetation groups.

Potential Vegetation Groups[2]	Tree Species	TREE DENSITY (BAA[1])			
		LLMZ	ULMZ	FS	Max[3]
Dry Upland Forest	Ponderosa pine	31	46	110	137
	Interior Douglas-fir	69	104	139	173
	Western larch	66	99	131	164
	Lodgepole pine	62	93	151	189
	Engelmann spruce Grand fir Subalpine fir	116	174	232	290
	Mixed composition[4]	44	66	119	148
Moist Upland Forest	Ponderosa pine	63	94	162	202
	Interior Douglas-fir	81	122	162	203
	Western larch	93	140	187	233
	Lodgepole pine	62	93	146	182
	Engelmann spruce	101	151	202	252
	Grand fir	134	201	268	335
	Subalpine fir	86	130	173	216
	Mixed composition[4]	89	133	182	227
Cold Upland Forest	Ponderosa pine	34	51	87	108
	Interior Douglas-fir	86	129	173	216
	Western larch	91	137	182	228
	Lodgepole pine	62	92	137	171
	Engelmann spruce	94	140	187	234
	Grand fir	94	141	189	236
	Subalpine fir	100	151	201	251
	Mixed composition[4]	72	108	150	187

[1] BAA refers to basal area per acre, in square feet; all BAA values pertain to a quadratic mean diameter of 10 inches and an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure.

Footnotes 2-4 are the same as for table 1.

Table 3: Tree density, expressed by using canopy cover percentages, for four stocking thresholds and three potential vegetation groups.

Potential Vegetation Groups[2]	Tree Species	TREE DENSITY (CC%[1]) LLMZ	ULMZ	FS	Max[3]
Dry Upland Forest	Ponderosa pine	34	41	59	63
	Interior Douglas-fir	67	74	78	82
	Western larch	56	63	68	72
	Lodgepole pine	55	62	71	75
	Engelmann spruce Grand fir Subalpine fir	80	87	93	97
	Mixed composition[4]	43	50	61	65
Moist Upland Forest	Ponderosa pine	49	57	67	72
	Interior Douglas-fir	70	76	81	85
	Western larch	62	69	74	78
	Lodgepole pine	55	62	70	74
	Engelmann spruce	76	83	88	92
	Grand fir	83	91	96	99
	Subalpine fir	73	80	85	89
	Mixed composition[4]	76	83	89	93
Cold Upland Forest	Ponderosa pine	38	46	55	60
	Interior Douglas-fir	71	78	82	86
	Western larch	62	69	74	78
	Lodgepole pine	55	62	69	73
	Engelmann spruce	75	82	87	91
	Grand fir	77	84	89	93
	Subalpine fir	76	83	88	92
	Mixed composition[4]	58	65	71	75

[1] CC% refers to canopy cover percentage (for trees only); all CC% values pertain to a quadratic mean diameter of 10 inches and an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure.

Footnotes 2-4 are the same as for table 1.

Table 4: Database queries utilizing *trees per acre* information to calculate a tree density rating for mid-scale assessments involving potential vegetation groups.

Potential Vegetation Groups[1]	Diameter Class Categories[2]	Size Class Codes[3]	TREE DENSITY (TPA[4])		
			Low	Moderate	High[5]
Dry Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 478	479-713	≥ 714
	Poles (7" QMD)	5 or 6	≤ 107	108-159	≥ 160
	Small+ (12" QMD)	> 6	≤ 41	42-60	≥ 61
Moist Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 1,372	1,373-2,057	≥ 2,058
	Poles (7" QMD)	5 or 6	≤ 317	318-474	≥ 475
	Small+ (12" QMD)	> 6	≤ 125	126-186	≥ 187
Cold Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 915	916-1,368	≥ 1,369
	Poles (7" QMD)	5 or 6	≤ 210	211-313	≥ 314
	Small+ (12" QMD)	> 6	≤ 82	83-122	≥ 123

[1] Potential vegetation groups are a mid-scale unit in a potential vegetation hierarchy (Powell et al. 2007).
Tree species selected to represent each potential vegetation group are ponderosa pine for dry upland forest; western larch for moist upland forest; and lodgepole pine for cold upland forest.

[2] Some vegetation databases provide a size-class code characterizing average tree size for a forest polygon. If an average size class is available, then queries should use it rather than layer-based size classes.

[3] Size class codes are described in Powell (2013); values in this table summarize stocking levels (TPA) for three size class categories established by using quadratic mean tree diameter.

[4] TPA refers to trees per acre; all TPA values pertain to an irregular stand structure except for Cold Upland Forest potential vegetation group, where TPA values pertain to an even-aged structure.

[5] Low tree density corresponds to lower limit of a management zone stocking threshold; moderate refers to the management zone (stocking zone located between lower and upper limits); high corresponds to upper limit of a management zone.

Table 5: Database queries utilizing *basal area per acre* information to calculate a tree density rating for mid-scale assessments involving potential vegetation groups.

Potential Vegetation Groups[1]	Diameter Class Categories[2]	Size Class Codes[3]	TREE DENSITY (BAA[4]) Low	Moderate	High[5]
Dry Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 23	24-34	≥ 35
	Poles (7" QMD)	5 or 6	≤ 29	30-42	≥ 43
	Small+ (12" QMD)	> 6	≤ 32	33-47	≥ 48
Moist Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 67	68-100	≥ 101
	Poles (7" QMD)	5 or 6	≤ 85	86-126	≥ 127
	Small+ (12" QMD)	> 6	≤ 98	99-146	≥ 147
Cold Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 45	46-66	≥ 67
	Poles (7" QMD)	5 or 6	≤ 56	57-83	≥ 84
	Small+ (12" QMD)	> 6	≤ 64	65-96	≥ 97

Footnotes 1-3 and 5 are the same as for table 4.

[4] BAA refers to basal area per acre, in square feet; BAA values pertain to an irregular structure except for Cold Upland Forest, where BAA values pertain to an even-aged structure.

Table 6: Database queries utilizing *canopy cover* information to calculate a tree density rating for mid-scale assessments involving potential vegetation groups.

Potential Vegetation Groups[1]	Diameter Class Categories[2]	Size Class Codes[3]	TREE DENSITY (CC%[4]) Low	Moderate	High[5]
Dry Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 29%	30-36	≥ 37%
	Poles (7" QMD)	5 or 6	≤ 33%	34-39	≥ 40%
	Small+ (12" QMD)	> 6	≤ 35%	36-42	≥ 43%
Moist Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 56%	57-63	≥ 64%
	Poles (7" QMD)	5 or 6	≤ 60%	61-67	≥ 68%
	Small+ (12" QMD)	> 6	≤ 63%	64-69	≥ 70%
Cold Upland Forest	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 49%	50-56	≥ 57%
	Poles (7" QMD)	5 or 6	≤ 53%	54-59	≥ 60%
	Small+ (12" QMD)	> 6	≤ 56%	57-62	≥ 63%

Footnotes 1-3 and 5 are the same as for table 4.

[4] CC% refers to canopy cover percentage (for trees only); all values pertain to an irregular stand structure except for Cold Upland Forest, where CC% values pertain to an even-aged structure.

Table 7: Tree density, expressed by using *stand density index*, for four stocking thresholds and ten plant association groups.

Plant Association Groups[2]	Tree Species	TREE DENSITY (SDI[1])			
		LLMZ	ULMZ	FS	Max[3]
Cold Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine				
	Engelmann spruce				
	Grand fir				
	Subalpine fir	195	293	390	488
Cold Dry Upland Forest	Ponderosa pine	63	93	159	199
	Interior Douglas-fir	158	237	317	396
	Western larch	167	250	334	418
	Lodgepole pine	114	170	277	346
	Engelmann spruce	172	257	343	429
	Grand fir	173	259	346	433
	Subalpine fir	172	259	344	430
Cool Dry Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine	112	167	223	279
	Engelmann spruce				
	Grand fir				
	Subalpine fir				
Cool Wet Upland Forest	Ponderosa pine				
	Interior Douglas-fir	179	269	359	449
	Western larch	142	213	284	355
	Lodgepole pine				
	Engelmann spruce	170	255	340	424
	Grand fir	263	395	526	658
	Subalpine fir				
Cool Very Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch	176	264	353	441
	Lodgepole pine				
	Engelmann spruce	201	302	402	503
	Grand fir	249	375	499	624
	Subalpine fir				

Table 7: Tree density, expressed by using *stand density index*, for four stocking thresholds and ten plant association groups.

Plant Association Groups[2]	Tree Species	TREE DENSITY (SDI[1]) LLMZ	ULMZ	FS	Max[3]
Cool Moist Upland Forest	Ponderosa pine	93	140	304	380
	Interior Douglas-fir	175	263	351	439
	Western larch	178	267	356	445
	Lodgepole pine	114	170	267	334
	Engelmann spruce	184	276	367	459
	Grand fir	238	357	476	595
	Subalpine fir	158	238	317	396
Warm Very Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir	114	171	228	285
	Western larch	165	248	331	414
	Lodgepole pine				
	Engelmann spruce	152	228	304	380
	Grand fir	217	325	433	541
	Subalpine fir				
Warm Moist Upland Forest	Ponderosa pine	137	204	287	359
	Interior Douglas-fir	126	189	252	314
	Western larch	193	290	386	483
	Lodgepole pine				
	Engelmann spruce	220	330	440	550
	Grand fir	263	395	526	658
	Subalpine fir				
Warm Dry Upland Forest	Ponderosa pine	83	124	247	309
	Interior Douglas-fir	127	191	254	318
	Western larch	121	181	241	301
	Lodgepole pine	114	170	277	346
	Engelmann spruce				
	Grand fir	213	319	425	532
	Subalpine fir				
Hot Dry Upland Forest	Ponderosa pine	31	46	155	193
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine				
	Engelmann spruce				
	Grand fir				
	Subalpine fir				

[1] Same as for table 1.

[2] Plant association groups are a mid-scale unit in a potential vegetation hierarchy (Powell et al. 2007).

[3] Same as for table 1.

Table 8: Tree density, expressed by using *basal area per acre*, for four stocking thresholds and ten plant association groups.

Plant Association Groups[2]	Tree Species	TREE DENSITY (BAA[1]) LLMZ	ULMZ	FS	Max[3]
Cold Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine				
	Engelmann spruce				
	Grand fir				
	Subalpine fir	106	160	213	266
Cold Dry Upland Forest	Ponderosa pine	34	51	87	108
	Interior Douglas-fir	86	129	173	216
	Western larch	91	137	182	228
	Lodgepole pine	62	93	151	189
	Engelmann spruce	94	140	187	234
	Grand fir	94	141	189	236
	Subalpine fir	94	141	188	235
Cool Dry Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine	61	91	122	152
	Engelmann spruce				
	Grand fir				
	Subalpine fir				
Cool Wet Upland Forest	Ponderosa pine				
	Interior Douglas-fir	98	147	196	245
	Western larch	77	116	155	194
	Lodgepole pine				
	Engelmann spruce	93	139	185	231
	Grand fir	143	215	287	359
	Subalpine fir				
Cool Very Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch	96	144	192	240
	Lodgepole pine				
	Engelmann spruce	110	164	219	274
	Grand fir	136	204	272	340
	Subalpine fir				

Table 8: Tree density, expressed by using *basal area per acre*, for four stocking thresholds and ten plant association groups.

Plant Association Groups[2]	Tree Species	TREE DENSITY (BAA[1]) LLMZ	ULMZ	FS	Max[3]
Cool Moist Upland Forest	Ponderosa pine	51	76	166	207
	Interior Douglas-fir	96	144	192	239
	Western larch	97	146	194	243
	Lodgepole pine	62	93	146	182
	Engelmann spruce	100	150	200	250
	Grand fir	130	195	259	324
	Subalpine fir	86	130	173	216
Warm Very Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir	62	93	124	155
	Western larch	90	135	181	226
	Lodgepole pine				
	Engelmann spruce	83	124	166	207
	Grand fir	118	177	236	295
	Subalpine fir				
Warm Moist Upland Forest	Ponderosa pine	74	111	157	196
	Interior Douglas-fir	68	103	137	171
	Western larch	105	158	211	263
	Lodgepole pine				
	Engelmann spruce	120	180	240	300
	Grand fir	143	215	287	359
	Subalpine fir				
Warm Dry Upland Forest	Ponderosa pine	45	67	135	169
	Interior Douglas-fir	69	104	139	173
	Western larch	66	99	131	164
	Lodgepole pine	62	93	151	189
	Engelmann spruce				
	Grand fir	116	174	232	290
	Subalpine fir				
Hot Dry Upland Forest	Ponderosa pine	17	25	84	105
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine				
	Engelmann spruce				
	Grand fir				
	Subalpine fir				

[1] BAA refers to basal area, in square feet per acre; all BAA values pertain to a quadratic mean diameter of 10 inches and an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure.

Footnotes 2-3 are the same as for table 7.

Table 9: Tree density, expressed by using *canopy cover percentages*, for four stocking thresholds and ten plant association groups.

Plant Association Groups[2]	Tree Species	TREE DENSITY (CC%[1]) LLMZ	ULMZ	FS	Max[3]
Cold Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine				
	Engelmann spruce				
	Grand fir				
	Subalpine fir	77	84	89	93
Cold Dry Upland Forest	Ponderosa pine	38	46	55	60
	Interior Douglas-fir	71	78	82	86
	Western larch	62	69	74	78
	Lodgepole pine	55	62	71	75
	Engelmann spruce	75	82	87	91
	Grand fir	77	84	89	93
	Subalpine fir	75	82	87	91
Cool Dry Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine	55	62	67	71
	Engelmann spruce				
	Grand fir				
	Subalpine fir				
Cool Wet Upland Forest	Ponderosa pine				
	Interior Douglas-fir	73	80	84	88
	Western larch	59	66	71	75
	Lodgepole pine				
	Engelmann spruce	74	82	87	90
	Grand fir	84	92	97	100
	Subalpine fir				
Cool Very Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir				
	Western larch	63	70	75	79
	Lodgepole pine				
	Engelmann spruce	78	85	90	94
	Grand fir	83	91	96	100
	Subalpine fir				

Table 9: Tree density, expressed by using *canopy cover percentages*, for four stocking thresholds and ten plant association groups.

Plant Association Groups[2]	Tree Species	TREE DENSITY (CC%[1]) LLMZ	ULMZ	FS	Max[3]
Cool Moist Upland Forest	Ponderosa pine	45	53	67	72
	Interior Douglas-fir	73	79	84	88
	Western larch	63	70	75	79
	Lodgepole pine	55	62	70	74
	Engelmann spruce	76	83	88	92
	Grand fir	82	90	95	99
	Subalpine fir	73	80	85	89
Warm Very Moist Upland Forest	Ponderosa pine				
	Interior Douglas-fir	66	72	77	81
	Western larch	62	69	74	78
	Lodgepole pine				
	Engelmann spruce	73	80	85	89
	Grand fir	81	88	93	97
	Subalpine fir				
Warm Moist Upland Forest	Ponderosa pine	52	60	66	71
	Interior Douglas-fir	67	74	79	82
	Western larch	64	72	77	81
	Lodgepole pine				
	Engelmann spruce	79	86	91	95
	Grand fir	84	92	97	100
	Subalpine fir				
Warm Dry Upland Forest	Ponderosa pine	42	50	63	67
	Interior Douglas-fir	67	74	78	82
	Western larch	56	63	68	72
	Lodgepole pine	55	62	71	75
	Engelmann spruce				
	Grand fir	80	87	93	97
	Subalpine fir				
Hot Dry Upland Forest	Ponderosa pine	25	32	55	59
	Interior Douglas-fir				
	Western larch				
	Lodgepole pine				
	Engelmann spruce				
	Grand fir				
	Subalpine fir				

[1] CC% refers to canopy cover percentages (for trees only); all CC% values pertain to a quadratic mean diameter of 10 inches and an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure.

Footnotes 2-3 are the same as for table 7.

Table 10: Database queries utilizing *trees per acre* information to calculate a tree density rating for mid-scale assessments involving plant association groups.

Plant Association Groups[1]	Diameter Class Categories[2]	Size Class Codes[3]	TREE DENSITY (TPA[4]) Low	Moderate	High[5]
Cold Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 1,566	1,567-2,347	≥ 2,348
	Poles (7" QMD)	5 or 6	≤ 361	362-541	≥ 542
	Small+ (12" QMD)	> 6	≤ 142	143-212	≥ 213
Cold Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 925	926-1,379	≥ 1,380
	Poles (7" QMD)	5 or 6	≤ 212	213-315	≥ 316
	Small+ (12" QMD)	> 6	≤ 83	84-123	≥ 124
Cool Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 905	906-1,357	≥ 1,358
	Poles (7" QMD)	5 or 6	≤ 207	208-310	≥ 311
	Small+ (12" QMD)	> 6	≤ 81	82-121	≥ 122
Cool Wet UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 1,142	1,143-1,712	≥ 1,713
	Poles (7" QMD)	5 or 6	≤ 264	265-394	≥ 395
	Small+ (12" QMD)	> 6	≤ 104	105-155	≥ 156
Cool Very Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 1,414	1,415-2,120	≥ 2,121
	Poles (7" QMD)	5 or 6	≤ 327	328-489	≥ 490
	Small+ (12" QMD)	> 6	≤ 129	130-192	≥ 193
Cool Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 1,428	1,429-2,142	≥ 2,143
	Poles (7" QMD)	5 or 6	≤ 330	331-494	≥ 495
	Small+ (12" QMD)	> 6	≤ 130	131-194	≥ 195
Warm Very Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 701	702-1,050	≥ 1,051
	Poles (7" QMD)	5 or 6	≤ 195	196-291	≥ 292
	Small+ (12" QMD)	> 6	≤ 86	87-129	≥ 130
Warm Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 1,151	1,152-1,717	≥ 1,718
	Poles (7" QMD)	5 or 6	≤ 257	258-383	≥ 384
	Small+ (12" QMD)	> 6	≤ 99	100-147	≥ 148
Warm Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 697	698-1,039	≥ 1,040
	Poles (7" QMD)	5 or 6	≤ 156	157-231	≥ 232
	Small+ (12" QMD)	> 6	≤ 60	61-88	≥ 89
Hot Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 260	261-387	≥ 388
	Poles (7" QMD)	5 or 6	≤ 58	59-86	≥ 87
	Small+ (12" QMD)	> 6	≤ 22	23-32	≥ 33

[1] Plant association groups are a mid-scale unit in a potential vegetation hierarchy (Powell et al. 2007). UF refers to upland forest. Tree species selected to represent each plant association group are as follows: subalpine fir for cold moist UF; lodgepole pine for cold dry UF; lodgepole pine for cool dry UF; western larch for cool wet UF; western larch for cool very moist UF; western larch for cool moist UF; interior Douglas-fir for warm very moist UF; ponderosa pine for warm moist UF; ponderosa pine for warm dry UF; ponderosa pine for hot dry UF.

Footnotes 2-3 and 5 are the same as for table 4.

[4] TPA refers to trees per acre; all TPA values pertain to an irregular stand structure except for Cold Dry UF and Cool Dry UF plant association groups, for which TPA values pertain to an even-aged structure.

Table 11: Database queries utilizing *basal area per acre* information to calculate a tree density rating for mid-scale assessments involving plant association groups.

Plant Association Groups[1]	Diameter Class Categories[2]	Size Class Codes[3]	TREE DENSITY (BAA[4]) Low	Moderate	High[5]
Cold Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 77	78-114	≥ 115
	Poles (7" QMD)	5 or 6	≤ 96	97-144	≥ 145
	Small+ (12" QMD)	> 6	≤ 112	113-166	≥ 167
Cold Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 45	46-67	≥ 68
	Poles (7" QMD)	5 or 6	≤ 57	58-83	≥ 84
	Small+ (12" QMD)	> 6	≤ 65	66-96	≥ 97
Cool Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 44	45-66	≥ 67
	Poles (7" QMD)	5 or 6	≤ 55	56-82	≥ 83
	Small+ (12" QMD)	> 6	≤ 64	65-95	≥ 96
Cool Wet UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 56	57-83	≥ 84
	Poles (7" QMD)	5 or 6	≤ 71	72-105	≥ 106
	Small+ (12" QMD)	> 6	≤ 82	83-122	≥ 123
Cool Very Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 69	70-103	≥ 104
	Poles (7" QMD)	5 or 6	≤ 87	88-130	≥ 131
	Small+ (12" QMD)	> 6	≤ 101	102-150	≥ 151
Cool Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 70	71-104	≥ 105
	Poles (7" QMD)	5 or 6	≤ 88	89-131	≥ 132
	Small+ (12" QMD)	> 6	≤ 102	103-152	≥ 153
Warm Very Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 34	35-51	≥ 52
	Poles (7" QMD)	5 or 6	≤ 52	53-77	≥ 78
	Small+ (12" QMD)	> 6	≤ 68	69-101	≥ 102
Warm Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 56	57-83	≥ 84
	Poles (7" QMD)	5 or 6	≤ 69	70-101	≥ 102
	Small+ (12" QMD)	> 6	≤ 78	79-115	≥ 116
Warm Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 34	35-50	≥ 51
	Poles (7" QMD)	5 or 6	≤ 42	43-61	≥ 62
	Small+ (12" QMD)	> 6	≤ 47	48-69	≥ 70
Hot Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 13	14-18	≥ 19
	Poles (7" QMD)	5 or 6	≤ 15	16-22	≥ 23
	Small+ (12" QMD)	> 6	≤ 17	18-25	≥ 26

Footnotes 1-3 and 5 are the same as for table 10.

[4] BAA refers to basal area per acre, in square feet; all BAA values pertain to an irregular stand structure except for Cold Dry UF and Cool Dry UF plant association groups, for which BAA values pertain to an even-aged structure.

Table 12: Database queries utilizing *canopy cover* information to calculate a tree density rating for mid-scale assessments involving plant association groups.

Plant Association Groups[1]	Diameter Class Categories[2]	Size Class Codes[3]	TREE DENSITY (CC%[4]) Low	Moderate	High[5]
Cold Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 72%	73-78	≥ 79%
	Poles (7" QMD)	5 or 6	≤ 75%	76-82	≥ 83%
	Small+ (12" QMD)	> 6	≤ 78%	79-84	≥ 85%
Cold Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 49%	50-56	≥ 57%
	Poles (7" QMD)	5 or 6	≤ 53%	54-59	≥ 60%
	Small+ (12" QMD)	> 6	≤ 56%	57-62	≥ 63%
Cool Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 49%	50-55	≥ 56%
	Poles (7" QMD)	5 or 6	≤ 53%	54-59	≥ 60%
	Small+ (12" QMD)	> 6	≤ 55%	56-62	≥ 63%
Cool Wet UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 53%	54-59	≥ 60%
	Poles (7" QMD)	5 or 6	≤ 57%	58-63	≥ 64%
	Small+ (12" QMD)	> 6	≤ 60%	61-66	≥ 67%
Cool Very Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 57%	58-63	≥ 64%
	Poles (7" QMD)	5 or 6	≤ 61%	62-67	≥ 68%
	Small+ (12" QMD)	> 6	≤ 64%	65-70	≥ 71%
Cool Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 57%	58-63	≥ 64%
	Poles (7" QMD)	5 or 6	≤ 61%	62-68	≥ 69%
	Small+ (12" QMD)	> 6	≤ 64%	65-70	≥ 71%
Warm Very Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 57%	58-62	≥ 63%
	Poles (7" QMD)	5 or 6	≤ 63%	64-69	≥ 70%
	Small+ (12" QMD)	> 6	≤ 67%	68-73	≥ 74%
Warm Moist UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 48%	49-54	≥ 55%
	Poles (7" QMD)	5 or 6	≤ 51%	52-58	≥ 59%
	Small+ (12" QMD)	> 6	≤ 53%	54-60	≥ 61%
Warm Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 38%	39-45	≥ 46%
	Poles (7" QMD)	5 or 6	≤ 42%	43-48	≥ 49%
	Small+ (12" QMD)	> 6	≤ 44%	45-51	≥ 52%
Hot Dry UF	Seed-Sap (3" QMD)	≥ 1, < 5	≤ 21%	22-27	≥ 28%
	Poles (7" QMD)	5 or 6	≤ 24%	25-30	≥ 31%
	Small+ (12" QMD)	> 6	≤ 26%	27-32	≥ 33%

Footnotes 1-3 and 5 are the same as for table 10.

[4] CC% refers to canopy cover percentages (for trees only); all CC% values pertain to an irregular stand structure except for Cold Dry UF and Cool Dry UF plant association groups, for which CC% values pertain to an even-aged structure.

Table 13: Suggested stocking levels, summarized by plant association group, for upland forest sites.

Plant Association Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5]				UPPER LIMIT OF THE MANAGEMENT ZONE[5]			
				SDI	TPA	BAA	CC%	SDI	TPA	BAA	CC%
Cold Moist UF	**ABLA**	Seed-Sap (< 5")	3" QMD	195	1,566	77	72	293	2,348	115	79
		Poles (5-9")	7" QMD	195	361	96	75	293	542	145	83
		Small+ (> 9")	12" QMD	195	142	112	78	293	213	167	85
Cold Dry UF	**PIPO**	Seed-Sap (< 5")	3" QMD	63	527	26	33	93	787	39	41
		Poles (5-9")	7" QMD	63	118	32	37	93	176	47	44
		Small+ (> 9")	12" QMD	63	45	35	39	93	68	53	46
	PSME	Seed-Sap (< 5")	3" QMD	158	975	48	62	237	1,463	72	68
		Poles (5-9")	7" QMD	158	271	73	68	237	407	109	75
		Small+ (> 9")	12" QMD	158	120	94	73	237	180	142	79
	LAOC	Seed-Sap (< 5")	3" QMD	167	1,340	66	56	250	2,011	99	63
		Poles (5-9")	7" QMD	167	310	83	60	250	464	124	67
		Small+ (> 9")	12" QMD	167	122	96	63	250	183	144	70
	PICO	Seed-Sap (< 5")	3" QMD	114	925	45	49	170	1,380	68	57
		Poles (5-9")	7" QMD	114	212	57	53	170	316	84	60
		Small+ (> 9")	12" QMD	114	83	65	56	170	124	97	63
	PIEN	Seed-Sap (< 5")	3" QMD	172	1,377	68	69	257	2,066	101	76
		Poles (5-9")	7" QMD	172	318	85	73	257	477	127	80
		Small+ (> 9")	12" QMD	172	125	98	76	257	188	148	83
	ABGR	Seed-Sap (< 5")	3" QMD	173	1,389	68	71	259	2,083	102	78
		Poles (5-9")	7" QMD	173	321	86	75	259	481	129	82
		Small+ (> 9")	12" QMD	173	126	99	78	259	189	148	85

Plant Association Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%	UPPER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%
Cold Dry UF (cont.)	ABLA	Seed-Sap (< 5")	3" QMD	172	1,383	68	69	259	2,073	102	76
		Poles (5-9")	7" QMD	172	319	85	73	259	479	128	80
		Small+ (> 9")	12" QMD	172	126	99	76	259	188	148	83
Cool Dry UF	PICO	Seed-Sap (< 5")	3" QMD	112	905	44	49	167	1,358	67	56
		Poles (5-9")	7" QMD	112	207	55	53	167	311	83	60
		Small+ (> 9")	12" QMD	112	81	64	55	167	122	96	63
Cool Wet UF	PSME	Seed-Sap (< 5")	3" QMD	179	1,105	54	64	269	1,658	81	70
		Poles (5-9")	7" QMD	179	307	82	70	269	461	123	77
		Small+ (> 9")	12" QMD	179	136	107	75	269	204	160	81
	LAOC	Seed-Sap (< 5")	3" QMD	142	1,142	56	53	213	1,713	84	60
		Poles (5-9")	7" QMD	142	264	71	57	213	395	106	64
		Small+ (> 9")	12" QMD	142	104	82	60	213	156	123	67
	PIEN	Seed-Sap (< 5")	3" QMD	170	1,364	67	69	255	2,047	100	76
		Poles (5-9")	7" QMD	170	315	84	73	255	473	126	80
		Small+ (> 9")	12" QMD	170	124	97	76	255	186	146	83
	ABGR	Seed-Sap (< 5")	3" QMD	263	2,113	104	78	395	3,170	156	86
		Poles (5-9")	7" QMD	263	488	130	83	395	732	196	90
		Small+ (> 9")	12" QMD	263	192	151	85	395	288	226	92
Cool Very Moist UF	LAOC	Seed-Sap (< 5")	3" QMD	176	1,414	69	57	264	2,121	104	64
		Poles (5-9")	7" QMD	176	327	87	61	264	490	131	68
		Small+ (> 9")	12" QMD	176	129	101	64	264	193	151	71

Plant Association Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%	UPPER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%
Cool Very Moist UF (cont.)	PIEN	Seed-Sap (< 5")	3" QMD	201	1,613	79	72	302	2,419	119	79
		Poles (5-9")	7" QMD	201	373	100	76	302	559	149	83
		Small+ (> 9")	12" QMD	201	147	115	79	302	220	173	86
	ABGR	Seed-Sap (< 5")	3" QMD	249	2,004	98	78	375	3,006	148	85
		Poles (5-9")	7" QMD	249	463	124	82	375	694	185	89
		Small+ (> 9")	12" QMD	249	182	143	84	375	273	214	91
Cool Moist UF	PIPO	Seed-Sap (< 5")	3" QMD	93	786	39	41	140	1,173	58	48
		Poles (5-9")	7" QMD	93	176	47	44	140	262	70	51
		Small+ (> 9")	12" QMD	93	68	53	46	140	101	79	54
	PSME	Seed-Sap (< 5")	3" QMD	175	1,081	53	63	263	1,622	80	70
		Poles (5-9")	7" QMD	175	301	80	70	263	451	121	77
		Small+ (> 9")	12" QMD	175	133	104	74	263	200	157	81
	LAOC	Seed-Sap (< 5")	3" QMD	178	1,428	70	57	267	2,143	105	64
		Poles (5-9")	7" QMD	178	330	88	61	267	495	132	69
		Small+ (> 9")	12" QMD	178	130	102	64	267	195	153	71
	PICO	Seed-Sap (< 5")	3" QMD	114	925	45	49	170	1,380	68	57
		Poles (5-9")	7" QMD	114	212	57	53	170	316	84	60
		Small+ (> 9")	12" QMD	114	83	65	56	170	124	97	63
	PIEN	Seed-Sap (< 5")	3" QMD	184	1,473	72	70	276	2,210	108	78
		Poles (5-9")	7" QMD	184	340	91	74	276	510	136	81
		Small+ (> 9")	12" QMD	184	134	105	77	276	201	158	84

Plant Association Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%	UPPER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%
Cool Moist UF (cont.)	**ABGR**	Seed-Sap (< 5")	3" QMD	238	1,910	94	77	357	2,866	141	84
		Poles (5-9")	7" QMD	238	441	118	81	357	662	177	88
		Small+ (> 9")	12" QMD	238	174	136	83	357	260	204	91
	ABLA	Seed-Sap (< 5")	3" QMD	158	1,273	62	68	238	1,909	94	75
		Poles (5-9")	7" QMD	158	294	78	72	238	441	118	79
		Small+ (> 9")	12" QMD	158	116	91	74	238	173	136	81
Warm Very Moist UF	**PSME**	Seed-Sap (< 5")	3" QMD	114	701	34	57	171	1,051	52	63
		Poles (5-9")	7" QMD	114	195	52	63	171	292	78	70
		Small+ (> 9")	12" QMD	114	86	68	67	171	130	102	74
	LAOC	Seed-Sap (< 5")	3" QMD	165	1,327	65	56	248	1,990	98	63
		Poles (5-9")	7" QMD	165	306	82	60	248	460	123	67
		Small+ (> 9")	12" QMD	165	121	95	63	248	181	142	70
	PIEN	Seed-Sap (< 5")	3" QMD	152	1,219	60	67	228	1,829	90	74
		Poles (5-9")	7" QMD	152	282	75	71	228	422	113	78
		Small+ (> 9")	12" QMD	152	111	87	74	228	166	130	81
	ABGR	Seed-Sap (< 5")	3" QMD	217	1,740	85	75	325	2,609	128	82
		Poles (5-9")	7" QMD	217	402	107	79	325	602	161	86
		Small+ (> 9")	12" QMD	217	158	124	82	325	237	186	89
Warm Moist UF	**PIPO**	Seed-Sap (< 5")	3" QMD	137	1,151	56	48	204	1,718	84	55
		Poles (5-9")	7" QMD	137	257	69	51	204	384	102	59
		Small+ (> 9")	12" QMD	137	99	78	53	204	148	116	61

Plant Association Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5]				UPPER LIMIT OF THE MANAGEMENT ZONE[5]			
				SDI	TPA	BAA	CC%	SDI	TPA	BAA	CC%
Warm Moist UF (cont.)	PSME	Seed-Sap (< 5")	3" QMD	126	774	38	58	189	1,160	57	65
		Poles (5-9")	7" QMD	126	215	57	65	189	323	86	71
		Small+ (> 9")	12" QMD	126	95	75	69	189	143	112	75
	LAOC	Seed-Sap (< 5")	3" QMD	193	1,550	76	59	290	2,325	114	66
		Poles (5-9")	7" QMD	193	358	96	63	290	537	144	70
		Small+ (> 9")	12" QMD	193	141	111	65	290	211	166	73
	PIEN	Seed-Sap (< 5")	3" QMD	220	1,765	87	74	330	2,648	130	81
		Poles (5-9")	7" QMD	220	408	109	78	330	611	163	85
		Small+ (> 9")	12" QMD	220	160	126	80	330	241	189	87
	ABGR	Seed-Sap (< 5")	3" QMD	263	2,113	104	78	395	3,170	156	86
		Poles (5-9")	7" QMD	263	488	130	83	395	732	196	90
		Small+ (> 9")	12" QMD	263	192	151	85	395	288	226	92
Warm Dry UF	PIPO	Seed-Sap (< 5")	3" QMD	83	697	34	38	124	1,040	51	46
		Poles (5-9")	7" QMD	83	156	42	42	124	232	62	49
		Small+ (> 9")	12" QMD	83	60	47	44	124	89	70	52
	PSME	Seed-Sap (< 5")	3" QMD	127	784	38	58	191	1,176	58	65
		Poles (5-9")	7" QMD	127	218	58	65	191	327	87	71
		Small+ (> 9")	12" QMD	127	97	76	69	191	145	114	76
	LAOC	Seed-Sap (< 5")	3" QMD	121	968	48	50	181	1,452	71	57
		Poles (5-9")	7" QMD	121	223	60	54	181	335	90	62
		Small+ (> 9")	12" QMD	121	88	69	57	181	132	104	64

Plant Association Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5]				UPPER LIMIT OF THE MANAGEMENT ZONE[5]			
				SDI	TPA	BAA	CC%	SDI	TPA	BAA	CC%
Warm Dry UF (cont.)	**PICO**	Seed-Sap (< 5")	3" QMD	114	925	45	49	170	1,380	68	57
		Poles (5-9")	7" QMD	114	212	57	53	170	316	84	60
		Small+ (> 9")	12" QMD	114	83	65	56	170	124	97	63
	ABGR	Seed-Sap (< 5")	3" QMD	213	1,708	84	75	319	2,562	126	82
		Poles (5-9")	7" QMD	213	394	105	79	319	592	158	86
		Small+ (> 9")	12" QMD	213	155	122	81	319	233	183	89
Hot Dry UF	**PIPO**	Seed-Sap (< 5")	3" QMD	31	260	13	21	46	388	19	28
		Poles (5-9")	7" QMD	31	58	15	24	46	87	23	31
		Small+ (> 9")	12" QMD	31	22	17	26	46	33	26	33

Sources: Based on Powell (1999).

1 Plant association groups are a mid-scale unit in a potential vegetation hierarchy (Powell et al. 2007). UF refers to upland forest.

2 Tree species acronyms are: ABGR: grand fir; ABLA: subalpine fir; LAOC: western larch; PICO: lodgepole pine; PIEN: Engelmann spruce; PIPO: ponderosa pine; PSME: interior Douglas-fir.

3 Some vegetation databases contain a size-class code representing average tree size for an entire polygon; values in this table summarize stocking levels (SDI, TPA, BAA, CC%) for three size-class categories (based on tree diameter).

4 QMD is quadratic mean diameter at breast height, a measurement point assumed to be 4½ feet above average ground level. These QMD values represent a mid-point for a diameter class specified in the previous table column.

5 SDI refers to stand density index; TPA refers to trees per acre; BAA refers to basal area per acre; CC% refers to canopy cover percentages (for trees only); all values in this table (SDI, TPA, BAA, CC%) pertain to an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure.

Table 14: Suggested stocking levels, summarized by potential vegetation group, for upland forest sites.

Potential Vegetation Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%	UPPER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%
Cold Upland Forest	PIPO	Seed-Sap (< 5")	3" QMD	63	527	26	33	93	787	39	41
		Poles (5-9")	7" QMD	63	118	32	37	93	176	47	44
		Small+ (> 9")	12" QMD	63	45	35	39	93	68	53	46
	PSME	Seed-Sap (< 5")	3" QMD	158	975	48	62	237	1,463	72	68
		Poles (5-9")	7" QMD	158	271	73	68	237	407	109	75
		Small+ (> 9")	12" QMD	158	120	94	73	237	180	142	79
	LAOC	Seed-Sap (< 5")	3" QMD	167	1,340	66	56	250	2,011	99	63
		Poles (5-9")	7" QMD	167	310	83	60	250	464	124	67
		Small+ (> 9")	12" QMD	167	122	96	63	250	183	144	70
	PICO	Seed-Sap (< 5")	3" QMD	113	915	45	49	169	1,369	67	57
		Poles (5-9")	7" QMD	113	210	56	53	169	314	84	60
		Small+ (> 9")	12" QMD	113	82	64	56	169	123	97	63
	PIEN	Seed-Sap (< 5")	3" QMD	172	1,377	68	69	257	2,066	101	76
		Poles (5-9")	7" QMD	172	318	85	73	257	477	127	80
		Small+ (> 9")	12" QMD	172	125	98	76	257	188	148	83
	ABGR	Seed-Sap (< 5")	3" QMD	173	1,389	68	71	259	2,083	102	78
		Poles (5-9")	7" QMD	173	321	86	75	259	481	129	82
		Small+ (> 9")	12" QMD	173	126	99	78	259	189	148	85
	ABLA	Seed-Sap (< 5")	3" QMD	184	1,474	72	70	276	2,211	109	77
		Poles (5-9")	7" QMD	184	340	91	74	276	511	136	82
		Small+ (> 9")	12" QMD	184	134	105	77	276	201	158	84

Potential Vegetation Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5]				UPPER LIMIT OF THE MANAGEMENT ZONE[5]			
				SDI	TPA	BAA	CC%	SDI	TPA	BAA	CC%
Moist Upland Forest	PIPO	Seed-Sap (< 5")	3" QMD	115	969	48	44	172	1,445	71	51
		Poles (5-9")	7" QMD	115	216	58	48	172	323	86	55
		Small+ (> 9")	12" QMD	115	83	65	50	172	125	98	58
	PSME	Seed-Sap (< 5")	3" QMD	148	915	45	60	223	1,373	67	67
		Poles (5-9")	7" QMD	148	254	68	67	223	382	102	74
		Small+ (> 9")	12" QMD	148	113	88	71	223	169	133	78
	LAOC	Seed-Sap (< 5")	3" QMD	171	1,372	67	56	256	2,058	101	64
		Poles (5-9")	7" QMD	171	317	85	60	256	475	127	68
		Small+ (> 9")	12" QMD	171	125	98	63	256	187	147	70
	PICO	Seed-Sap (< 5")	3" QMD	114	925	45	49	170	1,380	68	57
		Poles (5-9")	7" QMD	114	212	57	53	170	316	84	60
		Small+ (> 9")	12" QMD	114	83	65	56	170	124	97	63
	PIEN	Seed-Sap (< 5")	3" QMD	185	1,487	73	70	278	2,231	109	78
		Poles (5-9")	7" QMD	185	344	92	74	278	515	138	81
		Small+ (> 9")	12" QMD	185	135	106	77	278	203	159	84
	ABGR	Seed-Sap (< 5")	3" QMD	246	1,976	97	77	369	2,964	145	84
		Poles (5-9")	7" QMD	246	456	122	82	369	684	183	89
		Small+ (> 9")	12" QMD	246	180	141	84	369	269	211	91
	ABLA	Seed-Sap (< 5")	3" QMD	158	1,273	62	68	238	1,909	94	75
		Poles (5-9")	7" QMD	158	294	78	72	238	441	118	79
		Small+ (> 9")	12" QMD	158	116	91	74	238	173	136	81

Potential Vegetation Groups[1]	Tree Species[2]	Diameter Class Categories[3]	Diameter Class Midpoint[4]	LOWER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%	UPPER LIMIT OF THE MANAGEMENT ZONE[5] SDI	TPA	BAA	CC%
Dry Upland Forest	**PIPO**	Seed-Sap (< 5")	3" QMD	57	478	23	29	85	714	35	37
		Poles (5-9")	7" QMD	57	107	29	33	85	160	43	40
		Small+ (> 9")	12" QMD	57	41	32	35	85	61	48	43
	PSME	Seed-Sap (< 5")	3" QMD	127	784	38	58	191	1,176	58	65
		Poles (5-9")	7" QMD	127	218	58	65	191	327	87	71
		Small+ (> 9")	12" QMD	127	97	76	69	191	145	114	76
	LAOC	Seed-Sap (< 5")	3" QMD	121	968	48	50	181	1,452	71	57
		Poles (5-9")	7" QMD	121	223	60	54	181	335	90	62
		Small+ (> 9")	12" QMD	121	88	69	57	181	132	104	64
	PICO	Seed-Sap (< 5")	3" QMD	114	925	45	49	170	1,380	68	57
		Poles (5-9")	7" QMD	114	212	57	53	170	316	84	60
		Small+ (> 9")	12" QMD	114	83	65	56	170	124	97	63
	ABGR	Seed-Sap (< 5")	3" QMD	213	1,708	84	75	319	2,562	126	82
		Poles (5-9")	7" QMD	213	394	105	79	319	592	158	86
		Small+ (> 9")	12" QMD	213	155	122	81	319	233	183	89

Sources: Based on Powell (1999).

1 Potential vegetation groups are a mid-scale unit in a potential vegetation hierarchy (Powell et al. 2007).

2 Tree species acronyms are: ABGR: grand fir; ABLA: subalpine fir; LAOC: western larch; PICO: lodgepole pine; PIEN: Engelmann spruce; PIPO: ponderosa pine; PSME: interior Douglas-fir.

3 Some vegetation databases contain a size-class code representing average tree size for an entire polygon; values in this table summarize stocking levels (SDI, TPA, BAA, CC%) for three size-class categories (based on tree diameter).

4 QMD is quadratic mean diameter at breast height, a measurement point assumed to be 4½ feet above average ground level. These QMD values represent a mid-point for a diameter class specified in the previous table column.

5 SDI refers to stand density index; TPA refers to trees per acre; BAA refers to basal area per acre; CC% refers to canopy cover percentages (for trees only); table values (SDI, TPA, BAA, CC%) pertain to an irregular stand structure except for lodgepole pine, which pertains to an even-aged structure.

Table 15: Maximum stand density index values by tree species and plant association.

PLANT ASSOCIATION	ECOCLASS	PIPO	PSME	LAOC	PICO	PIEN	ABGR	ABLA2
ABLA2/TRCA3	CEF331				346	430		478
ABLA2/CLUN	CES131			513		586		520
ABLA2/LIBO2	CES414			513		474		419
ABLA2/MEFE	CES221							520
ABLA2/VAME	CES311			478	319	478		331
ABLA2/VASC	CES411		458	475	346	458		456
ABLA2/VASC/POPU	CES415		458	475	346	458		456
ABLA2/CAGE	CAG111				346			465
ABGR/GYDR	CWF611						691	
ABGR/POMU-ASCA3	CWF612			438		586	608	
ABGR/TRCA3	CWF512			498		485	693	
ABGR/ACGL	CWS912		301	439		405	576	
ABGR/TABR/CLUN	CWC811					533	700	
ABGR/TABR/LIBO2	CWC812		475	378		374	700	
ABGR/CLUN	CWF421		475	513	346	586	700	
ABGR/LIBO2	CWF311	456	475	463	346	499	645	466
ABGR/VAME	CWS211	365	475	513	298	426	569	515
ABGR/VASC-LIBO2	CWS812		434	316	346	436	618	230
ABGR/VASC	CWS811	215	343	380	346		460	
ABGR/SPBE	CWS321	319	248				443	
ABGR/CARU	CWG112	395	446	384	346		555	
ABGR/CAGE	CWG111	263	376				700	
ABGR/BRVU	CWG211			513		586	700	
PICO/CARU	CLS416				279			
PSME/ACGL-PHMA	CDS722	351	346					
PSME/PHMA	CDS711	343	281	320				
PSME/HODI	CDS611	425	319					
PSME/SPBE	CDS634	441	464					
PSME/SYAL	CDS622	341	309	256				
PSME/SYOR	CDS625	451						
PSME/VAME	CDS812	241	229					
PSME/CARU	CDG121	329	330					
PSME/CAGE	CDG111	278	351					
PIPO/SYAL	CPS522	398						
PIPO/SYOR	CPS525	325						
PIPO/CARU	CPG221	456						
PIPO/CAGE	CPG222	251						
PIPO/CELE/CAGE	CPS232	290						
PIPO/CELE/PONE	CPS233	199						
PIPO/CELE/FEID-AGSP	CPS234	196						
PIPO/PUTR/CAGE	CPS222	255						
PIPO/PUTR/CARO	CPS221	304						
PIPO/PUTR/FEID-AGSP	CPS226	231						
PIPO/ARTRV/FEID-AGSP	CPS131	238						
PIPO/FEID	CPG112	243						
PIPO/AGSP	CPG111	166						

Sources/Notes: Plant associations included here are those known to occur on upland sites of Umatilla National Forest (see Powell 1999). Plant association acronyms (ABLA2/TRCA3) and ecoclass codes (CEF331), used to record plant associations on field forms and in computer databases, are described in Hall (1998, as supplemented). Maximum SDI values provided in species columns were calculated as 125% of full stocking (see table 3 in Powell 1999 and fig. 2 in this white paper), and those values are provided by Cochran et al. (1994) and Powell (1999). Tree species acronyms used as column headings are described in footnotes to tables 13 and 14.

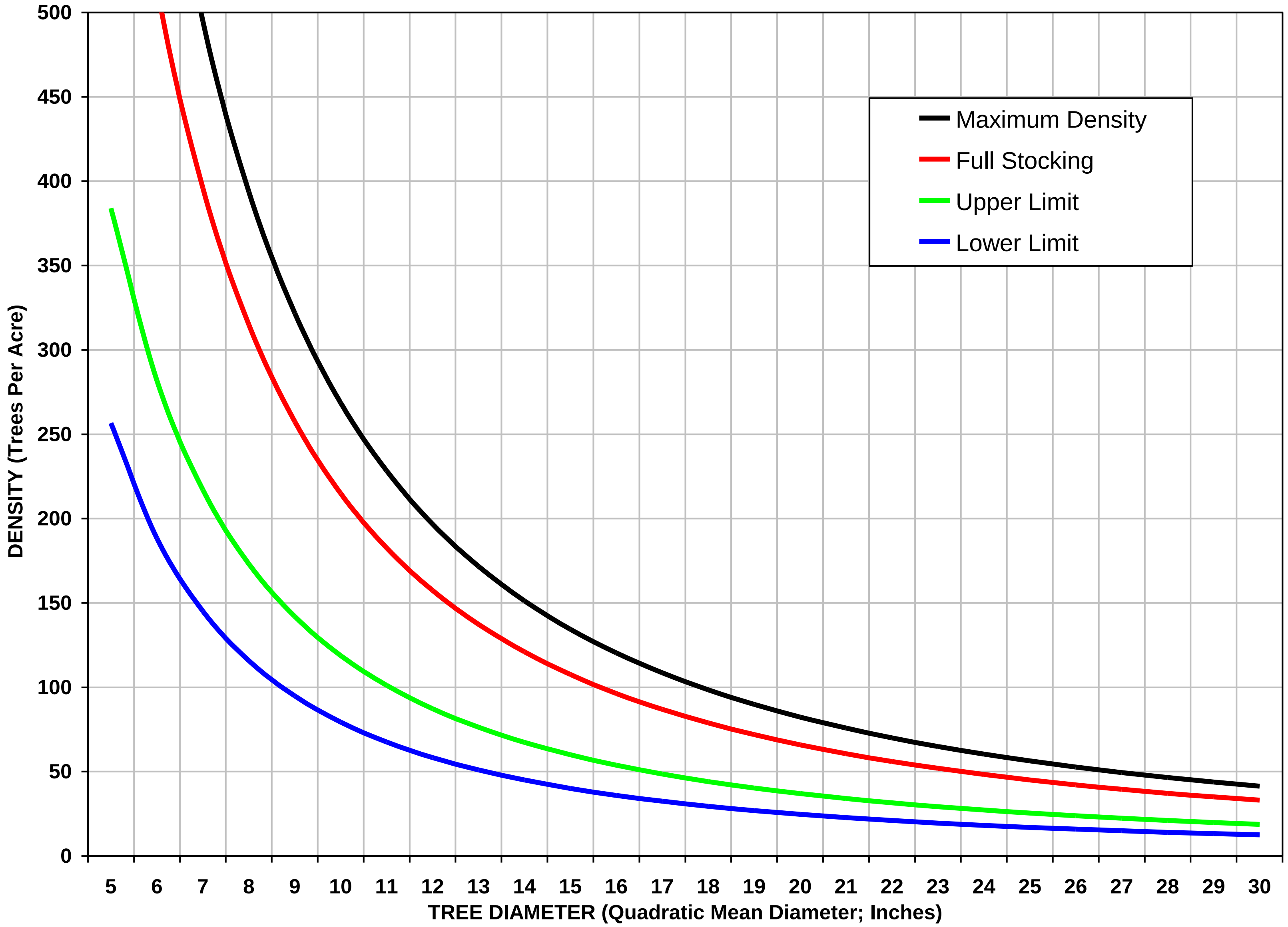

Figure 4 – Suggested stocking levels (trees per acre) for Dry Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (70% ponderosa pine, 20% Douglas-fir, 10% grand fir), and an irregular stand structure.

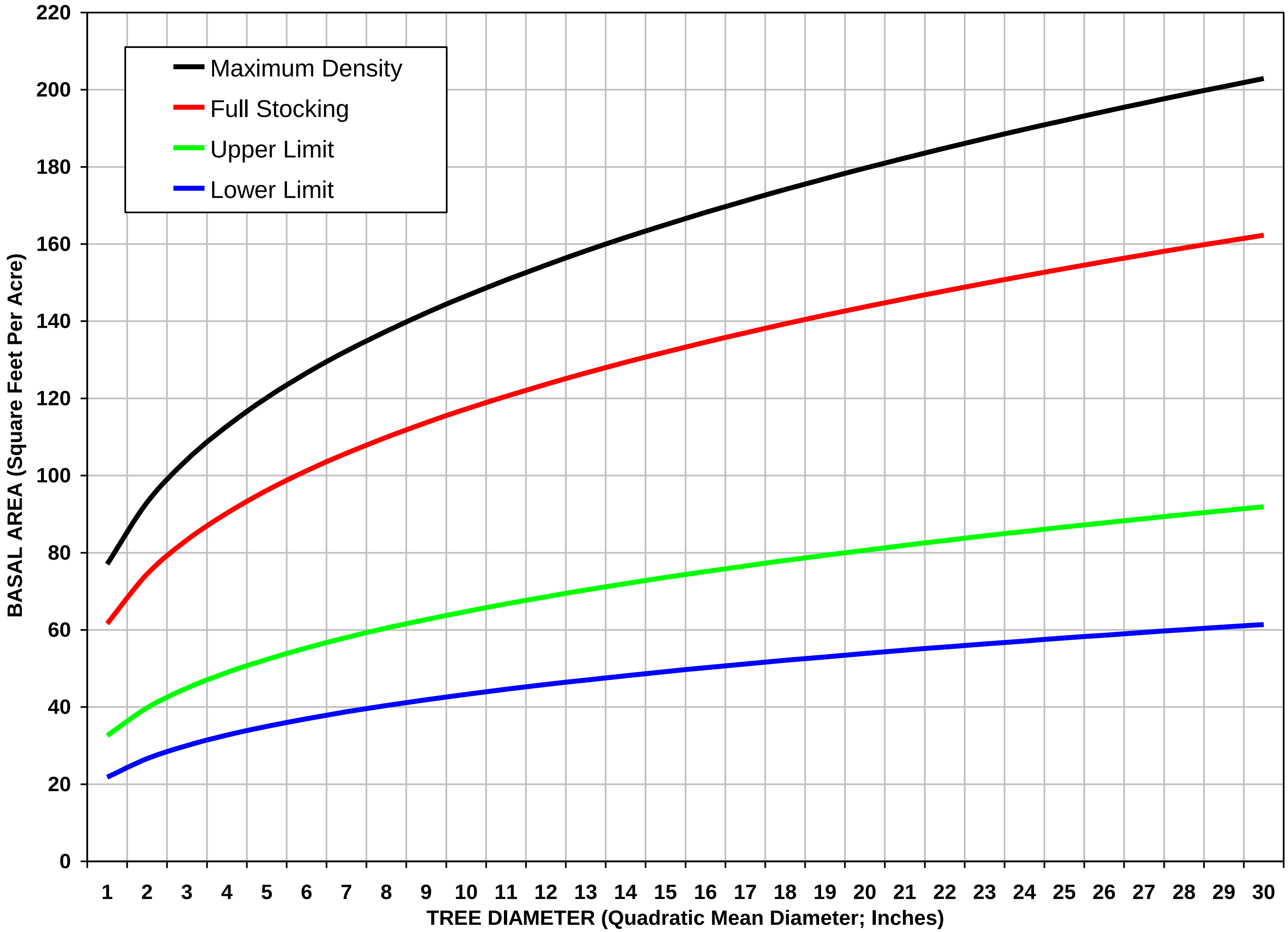

Figure 5 – Suggested stocking levels (basal area, ft^2/acre) for Dry Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (70% ponderosa pine, 20% Douglas-fir, 10% grand fir), and an irregular stand structure.

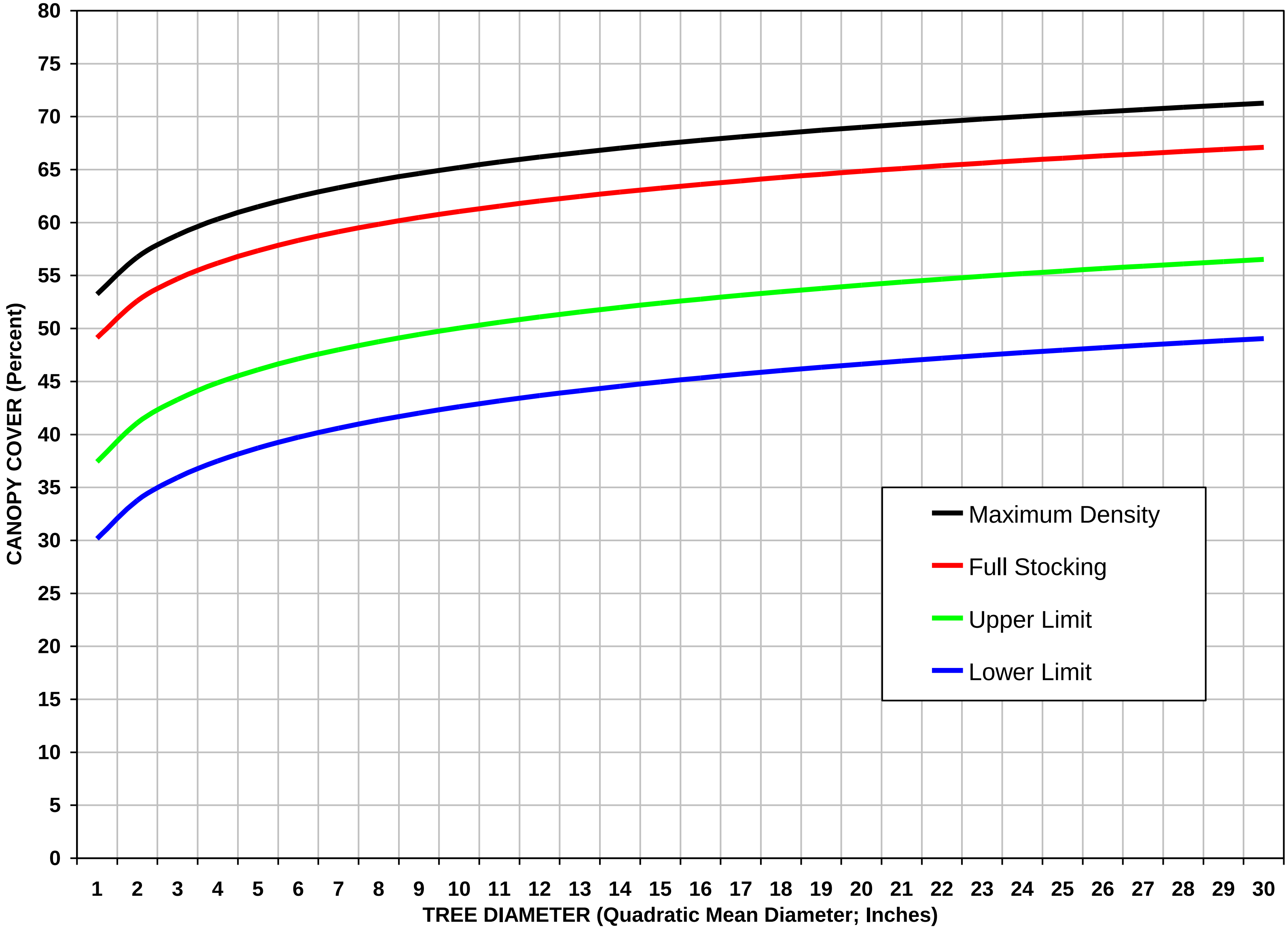

Figure 6 – Suggested stocking levels (canopy cover, percent) for Dry Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (70% ponderosa pine, 20% Douglas-fir, 10% grand fir), and an irregular stand structure.

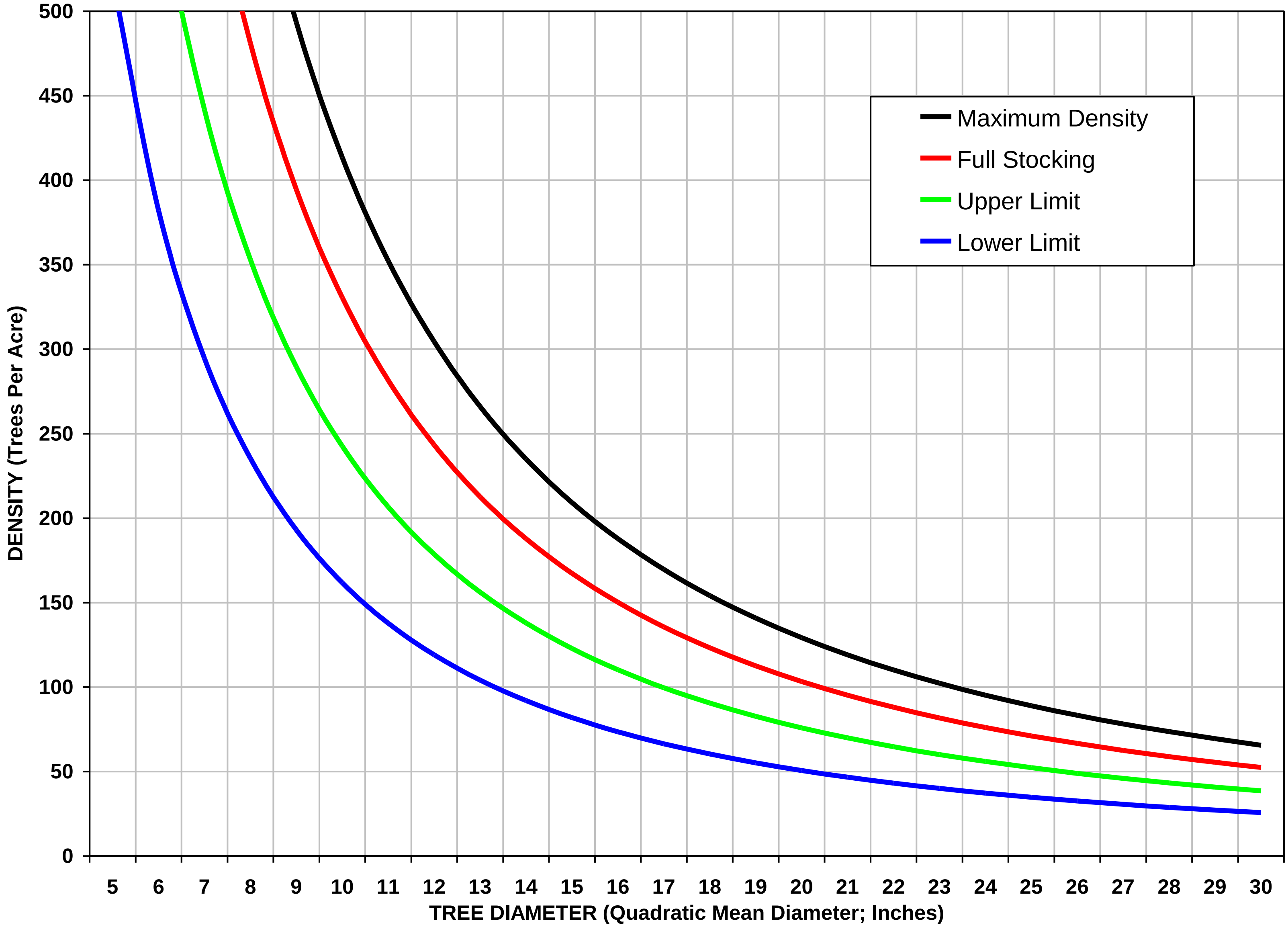

Figure 7 – Suggested stocking levels (trees per acre) for Moist Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (30% Douglas-fir, 20% western larch, 20% lodgepole pine, 30% grand fir), and an irregular stand structure.

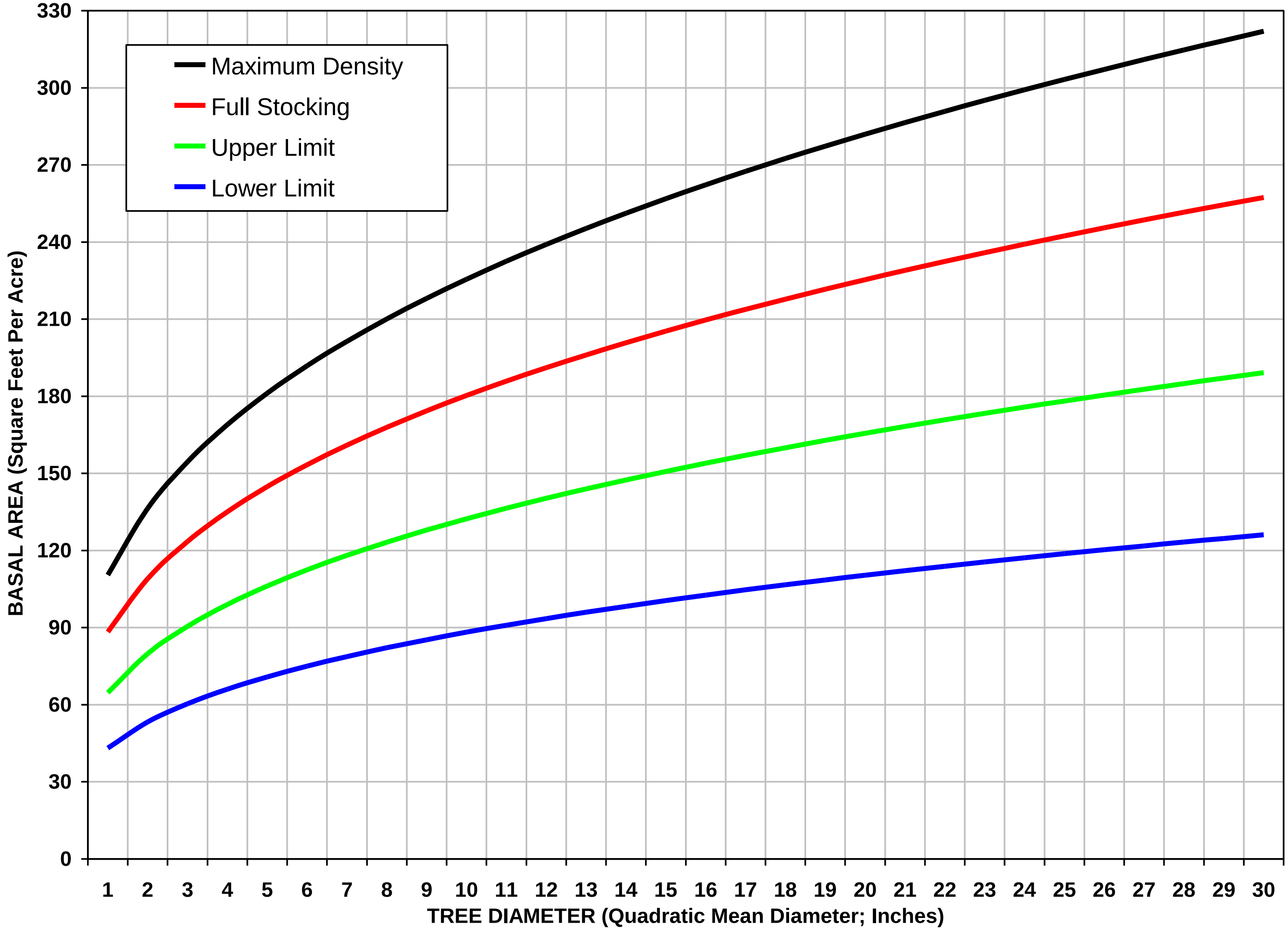

Figure 8 – Suggested stocking levels (basal area, ft^2/acre) for Moist Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (30% Douglas-fir, 20% western larch, 20% lodgepole pine, 30% grand fir), and an irregular stand structure.

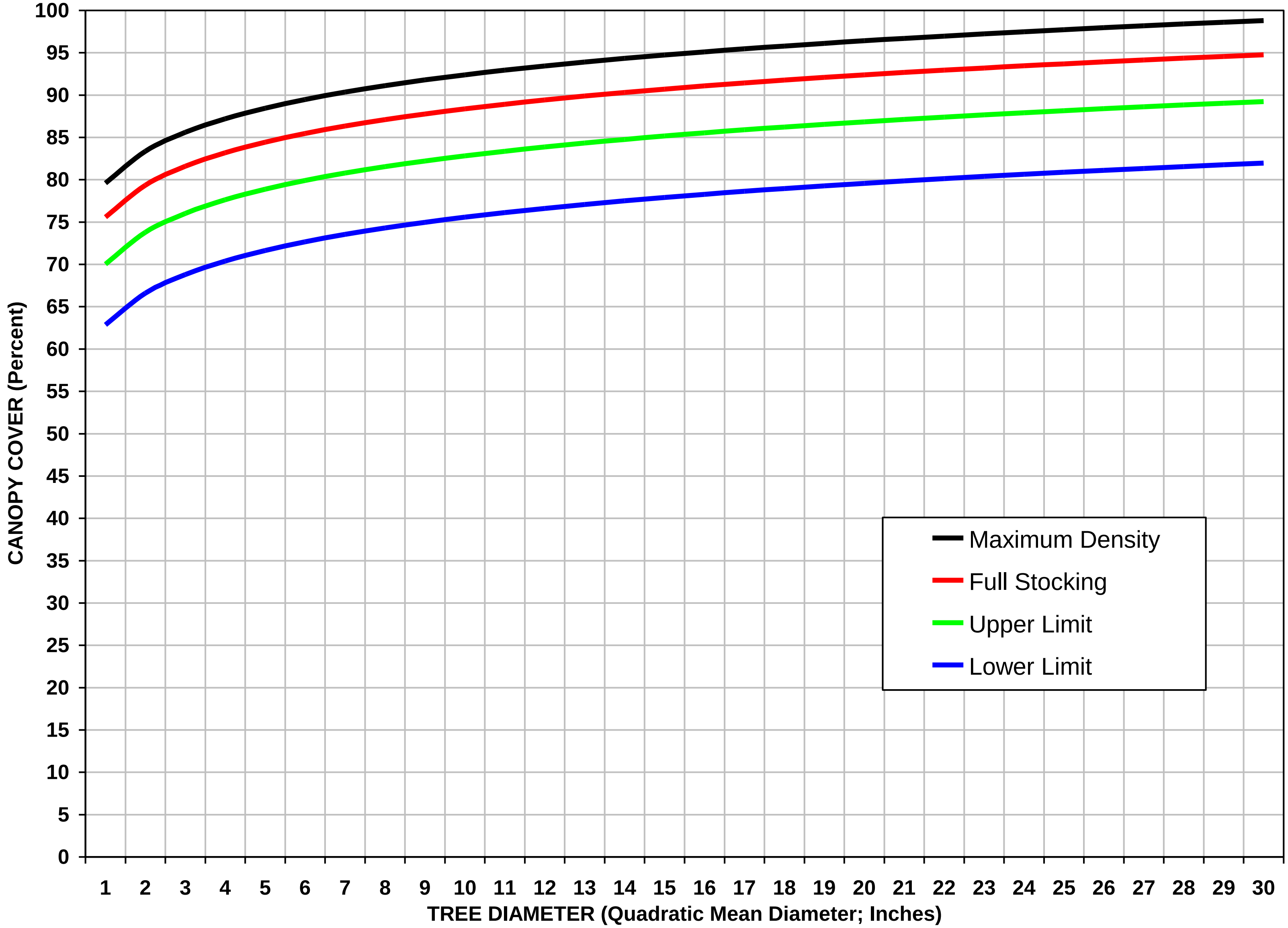

Figure 9 – Suggested stocking levels (canopy cover, percent) for Moist Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (30% Douglas-fir, 20% western larch, 20% lodgepole pine, 30% grand fir), and an irregular stand structure.

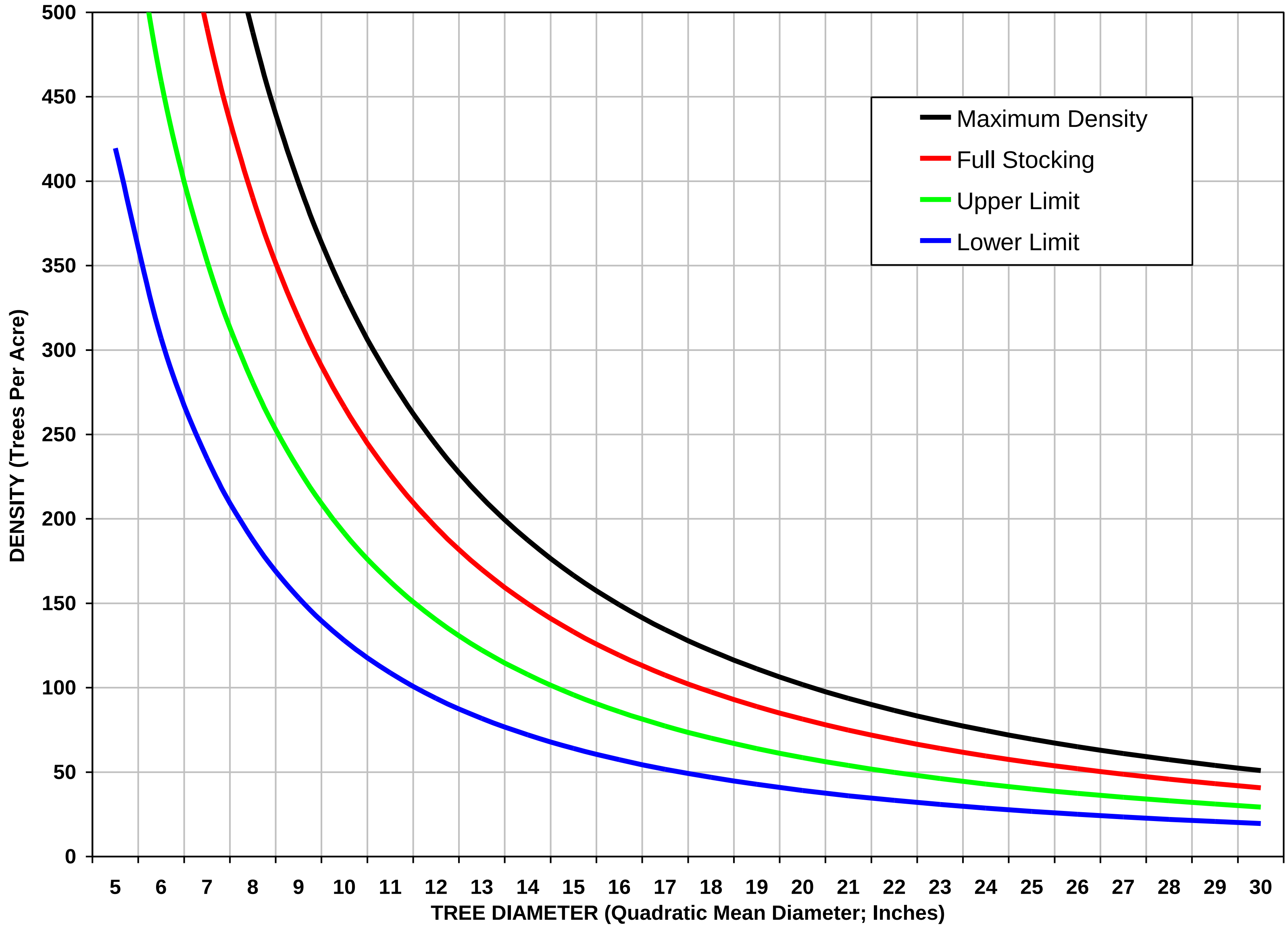

Figure 10 – Suggested stocking levels (trees/acre) for Cold Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (10% Douglas-fir, 10% larch, 50% lodgepole pine, 10% subalpine fir, 20% spruce), and an irregular stand structure.

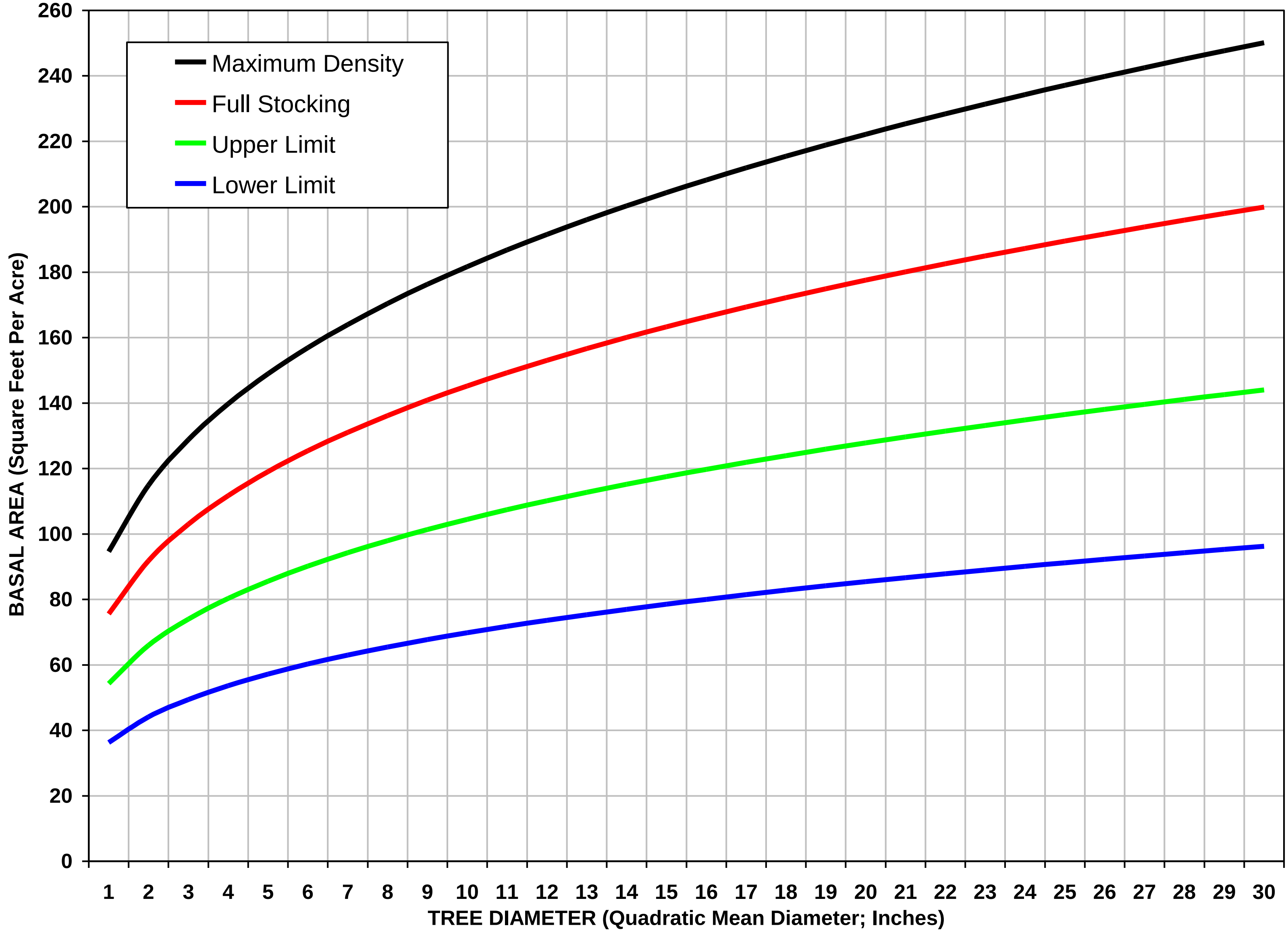

Figure 11 – Suggested stocking levels (basal area, ft^2/acre) for Cold Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (10% Douglas-fir, 10% larch, 50% lodgepole, 10% subalpine fir, 20% spruce), and an irregular structure.

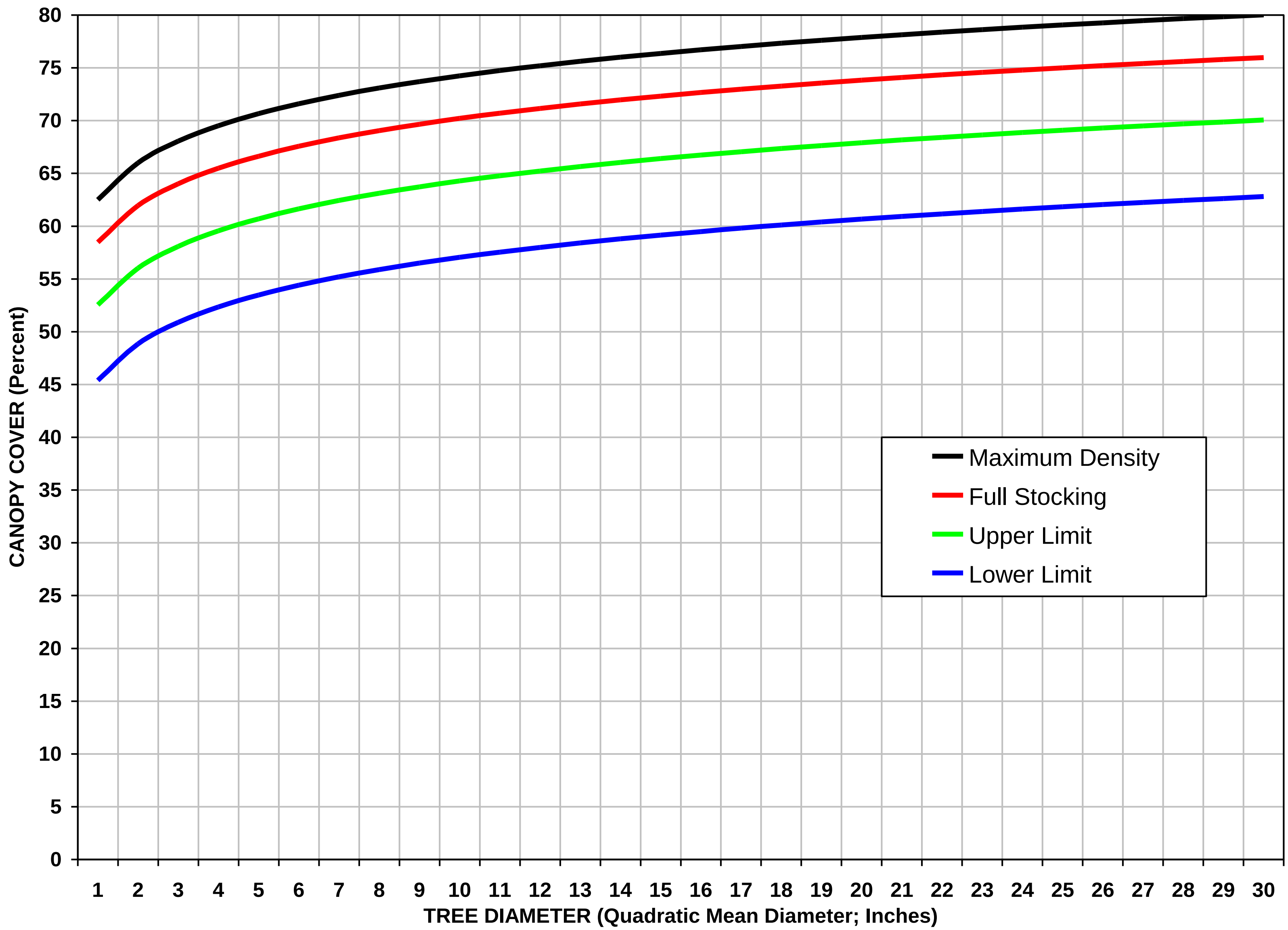

Figure 12 – Suggested stocking levels (canopy cover, percent) for Cold Upland Forest PVG, and for a range of quadratic mean diameters, a mixed composition (10% Douglas-fir, 10% larch, 50% lodgepole, 10% subalpine fir, 20% spruce), and an irregular structure.

GLOSSARY

Basal area. Cross-sectional area of a single tree stem, including bark, measured at breast height (4½ feet above ground surface on upper side of the tree); also, cross-sectional area of all stems in a stand and expressed per unit of land area (e.g., basal area per acre).

Canopy cover. Proportion of ground or water surface covered by a vertical projection of the outermost perimeter of natural spread of foliage or plants, including small openings within a canopy. In some applications of this concept, total canopy cover can exceed 100 percent because proportional cover of different vegetative strata is counted individually, resulting in canopy covering the ground more than once (i.e., in a multi-layered forest, ground is covered once by a low stratum or layer, and again by a higher stratum or layer). In other applications of a canopy cover concept, ground surface can only be obscured by foliage once, and canopy cover can never exceed 100 percent.

Full stocking. A point in development of even-aged stands in which differentiation has resulted in crown classes (Cochran et al. 1994); at full stocking, high stand density levels are causing intertree competition and resultant mortality of weaker, less-vigorous trees (e.g., self-thinning is occurring). Full stocking is analogous to normal density.

Irregular stand structure. A stand of trees characterized by variation in age structure or in spatial arrangement of trees; stands without a uniform age or size structure.

Lower limit of full site occupancy. This stand density threshold maintains sufficient stocking to allow a significant portion of a site's resources to be captured as tree growth. For stocking information presented in this white paper, this threshold is also referred to as lower limit of a management zone (Cochran et al. 1994, Powell 1999).

Lower limit of a management zone (LLMZ). A stocking level objective selected to coincide with a 'lower limit of full site occupancy' stand density threshold. For stocking information presented in this white paper, LLMZ values were always calculated as 67 percent of upper limit of a management zone values for all combinations of tree species and plant association (Cochran et al. 1994).

Lower limit of self-thinning zone. This stand density threshold refers to a stand development period where density is high enough to be causing competition-induced (density-dependent) tree mortality; this development period is called self-thinning. For stocking information presented in this white paper, this threshold is also referred to as an upper limit of a management zone (Cochran et al. 1994, Powell 1999).

Management zone. A management zone is a stocking-level zone established by setting upper and lower limits. For stocking information presented in this document, an upper limit of a management zone is based on a 'lower limit of self-thinning zone' stand density threshold (fig. 1), and a lower limit of a management zone is based on a 'lower limit of full site occupancy' stand density threshold (fig. 1).

Maximum density. Maximum density refers to the highest tree (stand) density that can exist for a tree species for a given mean size in self-thinning populations (Long 1996). For stocking information presented in this document, maximum density is assumed to be equivalent to 125% of full stocking (normal density) (Powell 1999).

Normal density. Stand density level assumed to reflect full site occupancy, but which allows room for development of crop trees; normal density is assumed to reflect 'average-maximum' competition, or average density of natural, undisturbed, fully-stocked stands. For stocking information presented in this white paper, normal density is assumed to be 80% of maximum density (Powell 1999). Normal density is analogous to full stocking.

Overstocked. Forestland stocked with more trees than normal, or with more trees than full stocking would require (Dunster and Dunster 1996). In an overstocked stand, tree density is high enough that intertree competition is occurring, and large trees are capturing growing space from small trees in a process called self-thinning.

Quadratic mean diameter. Diameter corresponding to mean basal area; *diameter of a tree of average basal area in a stand*.

Reference level. Absolute stand density that would normally be expected in a stand of given characteristics under some standard condition such as average-maximum competition (Ernst and Knapp 1985). For suggested stocking levels described in this document, full stocking (normal density or an 'average-maximum' level of competition) was used as a reference level (so, this means that upper and lower limits of a management zone were based on some proportion of full stocking as a reference level, not by using maximum density as a reference level, as is sometimes done with other stocking systems).

Relative density. A ratio, proportion, or percent of absolute (existing) stand density to a reference level defined by some standard level of competition. LLMZ is an application of the relative density concept because it is calculated as 67% of ULMZ stand density levels.

Self-thinning. Plant mortality caused by intraspecific (inter-plant) competition in crowded, even-aged stands. For self-thinning populations, increasing average size is associated with a progressive diminution in tree density (Long and Smith 1984). Self-thinning is also known as the $-{}^{3}/_{2}$ power rule, since self-thinning zones for many plant species have a slope of $-{}^{3}/_{2}$ when plotted on logarithmic axes (Westoby 1984).

Size class. Characterization of a vegetation layer's predominant tree-size situation when based on diameter at breast height; a layer with a pole size-class has a predominance of trees whose diameter is between 5 and 8.9 inches at breast height (breast height is defined as 4½ feet above ground surface on a tree's upper side).

Stand density. A quantitative measure of stocking expressed absolutely in terms of number of trees, basal area, or volume per unit area.

Stand density index. A widely used stand density measure developed by Lester Henry Reineke (1933) expressing relative density as a relationship between number of trees per acre and a stand's quadratic mean diameter or QMD (SDI indexes stand density to a QMD of 10 inches).

Stocking. Amount of anything on a given area, particularly in relation to what is considered optimum; in forestry usage, an indication of growing-space occupancy (by trees) relative to a pre-established standard.

Stocking levels. Stand density objectives expressed as constant or uniform amounts of stocking (Cochran et al. 1994).

Upper limit of a management zone (ULMZ). A stocking level objective selected to coincide with a 'lower limit of self-thinning zone' threshold. For stocking information presented in this white paper, ULMZ was set at 75 percent of full stocking (normal density) for all tree species except ponderosa and lodgepole pines, whose ULMZ values were established in such a way as to incorporate mountain pine beetle susceptibility (Cochran et al. 1994).

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APPENDIX 1: 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

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

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

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

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

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

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

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

Paper #	Title
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
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

Paper #	Title
58	Seral status for tree species of Blue and Ochoco Mountains

REVISION HISTORY

February 2013: minor formatting and editing changes were made; an appendix was added describing the white paper system, including a list of available white papers.