WHITE PAPER

USDA Forest Service | Pacific Northwest Region | Umatilla National Forest

WHITE PAPER F14-SO-WP-SILV-34

Silvicultural Activities: Description and Terminology[1]

David C. Powell; Forest Silviculturist

Supervisor's Office; Pendleton, OR

Initial Version: **JUNE 1992**

Most Recent Revision: **FEBRUARY 2018**

[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 the USDA Forest Service.

INTRODUCTION

Silviculture is defined as the art and science of controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society on a sustainable basis (Helms 1998, USDA Forest Service 2004). This white paper defines many silvicultural terms, and it provides FACTS database codes for commonly prescribed cutting methods.

In the early 1990s, the advent of ecosystem management created some confusion about silvicultural terminology and how it should be applied. Whether it was appropriate or not, some land managers abandoned historical definitions and created new silvicultural terms, even when the new terms were being used to describe old (traditional) ways of managing the forest.

In some situations, new terms were being coined to avoid old ones tainted with a timber production bias, or because an old term was considered inflammatory (clearcutting). In other instances, new terms represented a conscious and deliberate effort to match the name of a term with predicted conditions or outcomes resulting from application of ecosystem management or adaptive management concepts.

As a result of uncertainty about proper application of silvicultural terminology in an era of ecosystem management, an objective of this white paper is to improve consistency on the Forest by providing examples of how silvicultural terms could be applied for a variety of situations.

SILVICULTURAL SYSTEMS

A silvicultural system is defined as “a planned series of treatments for tending, harvesting, and reestablishing a stand” (Helms 1998). Most of the management treatments being used in western forests can be assigned to one of three silvicultural systems (USDA Forest Service 2004; the coppice system is omitted due to its limited relevance in western North America):

1. **Even-aged silvicultural system**: a planned sequence of treatments designed to create or maintain a stand with predominantly one age class. The range of tree ages for an even-aged forest is generally assumed to be 20 percent or less of the rotation age (fig. 1).
2. **Two-aged silvicultural system**: a planned sequence of treatments designed to create or maintain a stand with two age classes (fig. 1).
3. **Uneven-aged silvicultural system**: a planned sequence of treatments designed to create or maintain a stand with three or more age classes (fig. 1).

These silvicultural systems include cutting methods designed to obtain regeneration (regeneration cutting methods), and a variety of cultural practices for modifying tree density and otherwise influencing development of an immature stand (intermediate cutting methods).

Age-Based Silvicultural Systems

Strictly defined, an even-aged stand has trees of the same age such as a plantation established in a single year. Uneven-aged stands theoretically contain trees of every age, ranging from seedlings that became established this year to mature veterans several centuries old. These arbitrary definitions mark the two end points of what is actually a continuum, and in nature, stands resembling either of the theoretical end points are seldom found.

In practical terms, even-aged stands are those where the trees comprising the main canopy layer have an age difference of no more than 20 percent of the rotation length (the age at which a mature stand is to be regenerated). Uneven-aged stands contain trees in at least three distinct age classes, and there are generally wide gaps in their age class distribution due to an intermingling of old trees, mid-age trees, and young regeneration (fig. 1).

Even-Aged Management

Even-aged management involves application of regeneration and intermediate cutting methods to create and maintain an even-aged stand. The even-aged regeneration cutting methods are clearcutting, seed-tree cutting, and shelterwood cutting. The even-aged silvicultural system also includes thinning, improvement cutting, release, and other intermediate cutting methods. Even-aged regeneration cutting methods are described below.

CLEARCUTTING

The Scientific Basis for Silvicultural and Management Decisions in the National Forest System (Burns 1989) defines clearcutting as “the harvesting in one operation of all trees with the expectation that a new, even-aged stand will be established.” Regeneration then occurs following natural seeding from adjacent stands, from seed contained in the timber harvest debris (slash) or forest floor, or from artificial regeneration treatments (planting or direct seeding).

There are many variants of clearcutting; two common variants are strip clearcutting, and continuous or patch clearcutting. Patch clearcutting is divided further into large-patch clearcuts, which are generally larger than two acres and would logically be managed as separate stands or polygons following treatment (Powell 2014), and small-patch clearcuts, which are often smaller than two acres and would seldom be managed as individual stands after harvest.

Figure 2 shows an example of large-patch clearcutting as it was traditionally practiced; clearcutting with leave trees, as clearcutting is currently implemented by leaving islands of residual live trees and standing dead wood as snags (Franklin et al. 2007); small-patch clearcutting; and strip clearcutting.

SEED-TREE CUTTING

Burns (1989) defines seed-tree cutting as a “clearcut except for a few seed-producing trees selected to naturally regenerate the harvested area.” This regeneration cutting method differs from shelterwood cutting in that the seed trees are usually too far apart to provide much site amelioration (shade or shelter). Seed-tree cutting involves two steps: a seed cut and a removal cut.

To be considered a seed-tree seed cutting, the prescribed treatment must have an expectation (objective) for establishment of even-aged regeneration and, on average, at least six desirable trees are retained on each treated acre. The residual trees must be capable of producing seed, regardless of whether or not they were retained for this purpose (fig. 3).

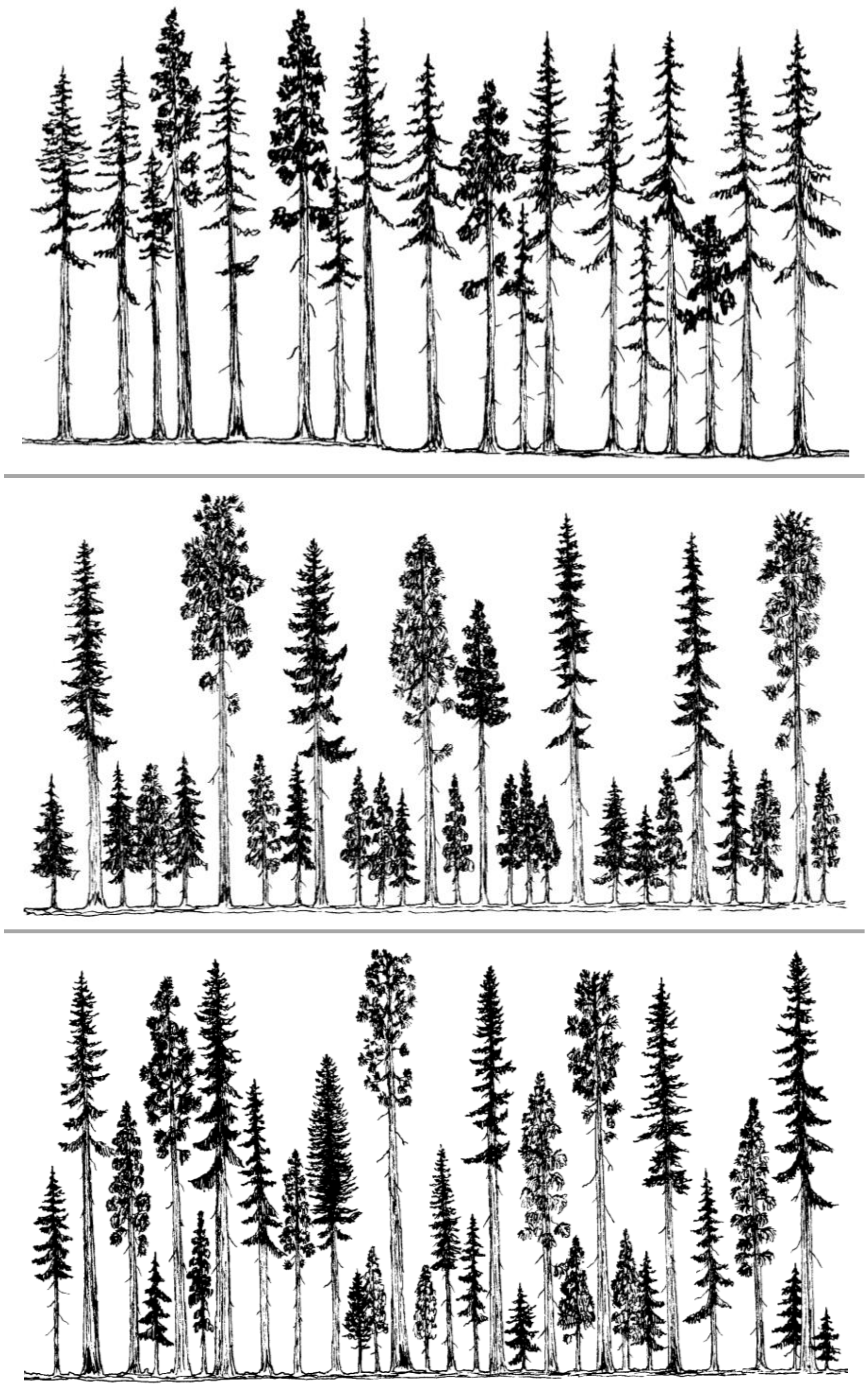

Figure 1 – Three common stand structures (from Powell 1994). Even-aged stands (top) are single-cohort because trees in subordinate canopy positions (these are referred to as overtopped, subcanopy, or suppressed trees) result from a forest development process called differentiation; smaller trees are not younger trees in even-aged forests (O'Hara and Oliver 1999). Two-aged stands (middle) and uneven-aged stands (lower) are multi-cohort because subcanopy trees became established at different times (Oliver and Larson 1996).

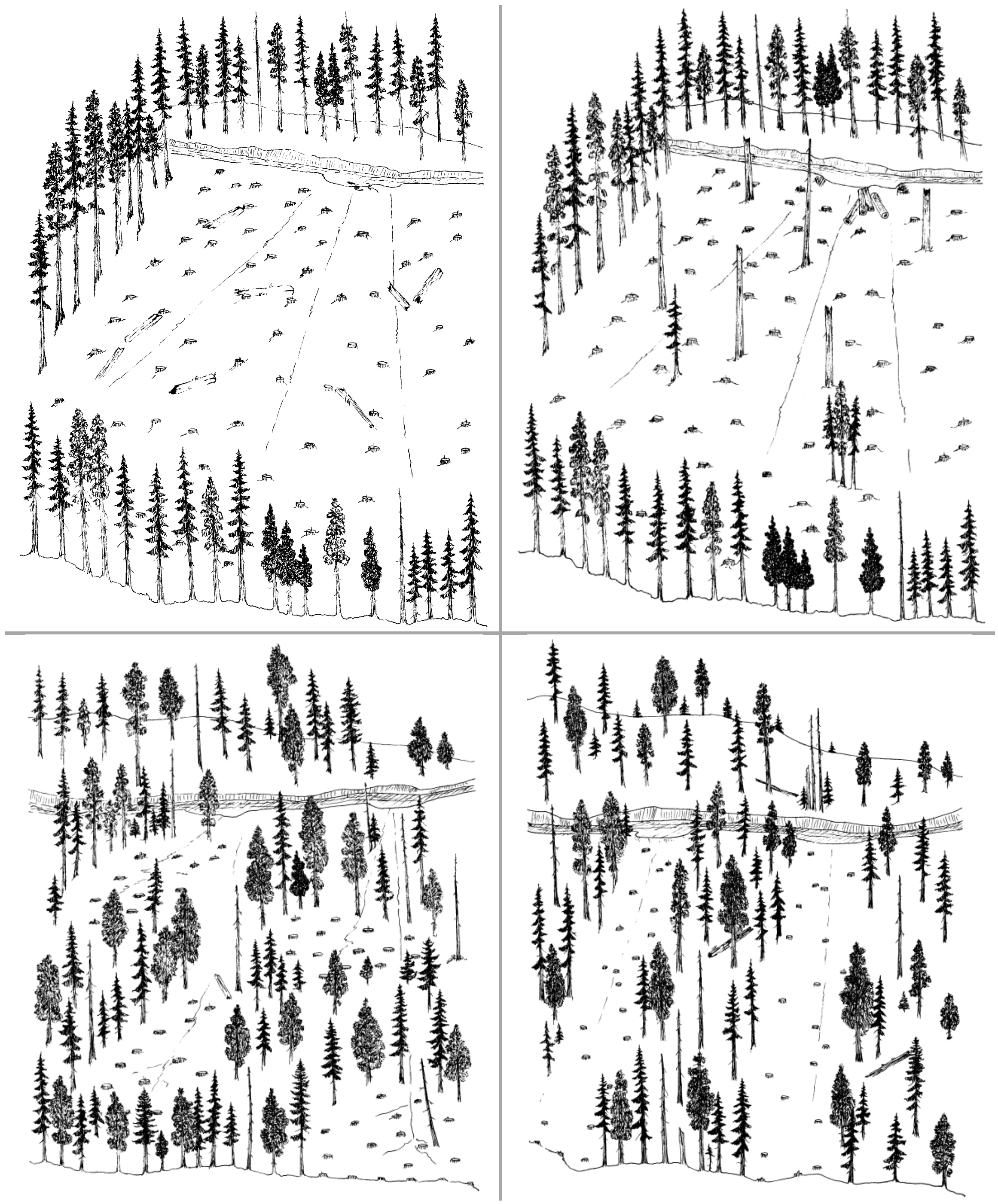

Figure 2 – Clearcutting. Traditional large-patch clearcutting (upper left) removed all live trees and most of the dead wood from an entire stand area. Clearcutting with leave trees (upper right) retains some live trees and dead wood. Small-patch clearcutting (lower left) removes trees from areas too small to be managed as separate stands. Strip clearcutting (lower right) creates a post-treatment condition resembling ski runs, and it is often used to redistribute the snowpack and augment water yields. <u>Note</u>: it is often assumed that any cutting creating openings smaller than 2 acres is group selection. However, either small-patch clearcutting or group selection can be used to create openings of 2 acres or less – what is important is an answer to this question: Will the stand be managed (and regulated) by using the even-aged (clearcutting) or uneven-aged (group selection) silvicultural system (see items 4 and 5 on page 16)?

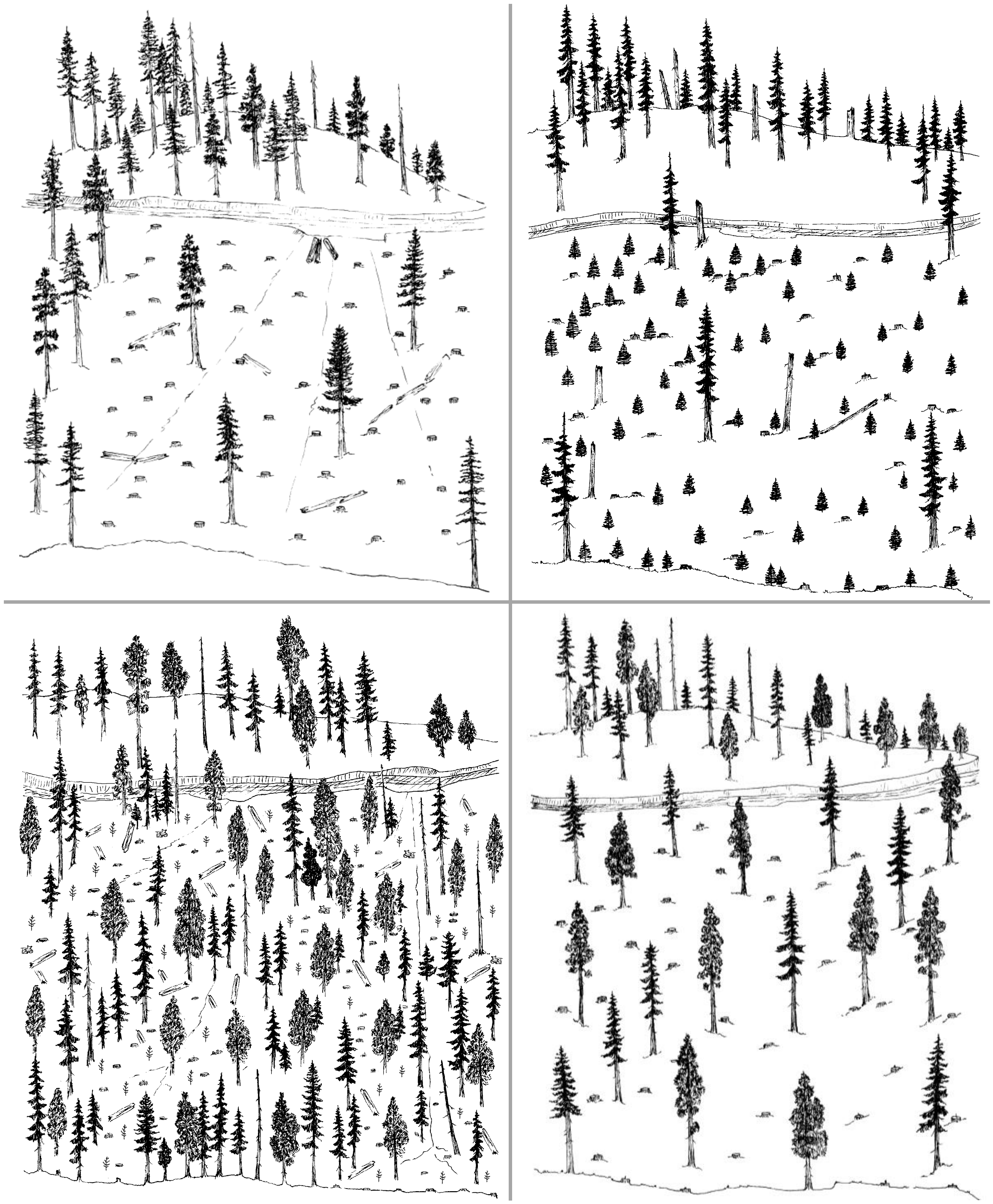

Figure 3 – Seed-tree and shelterwood cutting. Seed-tree seed cutting (upper left) leaves at least 6 residual trees per acre, and they must be distributed in such a way as to ensure adequate natural regeneration. Seed-tree cutting with leave trees (upper right) reserves all or some of the seed trees for non-regeneration objectives such as green-tree snag replacements. Shelterwood preparatory cutting (lower left) is the first cut in a 3-step shelterwood sequence; it is generally used with spruce-fir stands on cold-forest sites, or in other situations with high windthrow risk. Shelterwood seed cutting (lower right) is the first cut in a 2-step shelterwood sequence, or the second cut in a 3-step shelterwood sequence; it is often used with either dry-forest or moist-forest stands on montane sites. A shelterwood seed cut leaves at least 12 residual trees per acre distributed in such a way as to ensure adequate natural regeneration.

Note: This white paper contains many references to 'desirable' trees. Desirable trees are those whose characteristics contribute to meeting desired future conditions and other Forest Plan (FP) components; undesirable trees lack such characteristics. When FP components change from one management area to another, trees considered to be desirable could also change.

For particularly dense stands, retaining the largest trees in the seed cut may allow them to develop vigorous crowns and tapering (stable) stems. Retaining trees with enough disease or damage to limit their seed production would not qualify as a seed-tree seed cut, although reserving such trees for wildlife purposes and other resource objectives might be desirable.

SHELTERWOOD CUTTING

Shelterwood regeneration method involves a series of entries designed to improve vigor and seed production potential of residual trees, and to provide suitable conditions for seedling establishment. To be considered a shelterwood method, a silvicultural prescription must include an explicit regeneration objective (even for a preparatory cut). Shelterwood cutting involves either two or three steps (fig. 3). Generally, shelterwood cutting method is used to create an even-aged or two-aged stand over a period of 20 years or so.

A three-step shelterwood includes a preparatory cut, a seed (establishment) cut, and a removal cut. Three-step shelterwoods are traditionally used in special situations, such as areas with high susceptibility to windthrow caused by shallow soil depth, areas with a high water table, tree species with shallow roots, recreation sites or visual corridors, or for stands with spindly trees having height-to-diameter ratios of 80 or more.

A three-step shelterwood variant, for example, is often ideal for regenerating shallow-rooted species, such as Engelmann spruce, on areas with physical site factors contributing to high windthrow susceptibility. In the northern Blue Mountains, sites with high windthrow potential frequently have volcanic ash-cap or loess-dominated soils overlying residual materials of Columbia River basalt (fig. 4).

Typical application of the shelterwood regeneration method involves a two-step shelterwood, which has a seed (establishment) cut and a removal cut. Much of the time, a uniform shelterwood is used, which means that seed and removal cuts are applied to an entire stand area. An irregular shelterwood refers to variants such as strip or group shelterwoods, where openings of various shape and size are created (bottom two drawings in fig. 2 shows what group and strip shelterwoods could look like), and seed and shelter are provided from the side (e.g., from side shading) rather than from seed or shelter trees located directly overhead.

Shelterwood cutting differs from the seed-tree method in that sufficient residual trees are retained to influence environmental conditions for an entire stand, rather than just a small area around each reserve tree. Shelterwood seed (establishment) cuts retain twelve or more well-distributed trees on each acre.

An appropriate number of residual trees for shelterwood cutting will vary from one area to another because it depends on tree species, diameter, height, crown width, slope position, aspect, and other biotic or abiotic factors. As was true for seed-tree cutting, residual seed trees must be capable of producing acceptable quality and quantity of seed.

Figure 4 – Windthrow in spruce-fir forest in the northern Blue Mountains. Engelmann spruce is a shallow-rooted species, which increases its susceptibility to windthrow for almost any site condition. But abiotic factors can also contribute to increased wind damage because this site has an ash or loess layer above residual soils derived from Columbia River basalt or lacustrine (lakebed) sediments. These soils (typically Andept soil types) have high water-holding capacity, an important aspect of Engelmann spruce habitat. Flat areas and north-facing slopes have well-developed vegetation inhibiting soil erosion, allowing the ash to be retained on site. However, a relatively thick mantle of loamy, fine-textured ash or loess may lack structural integrity, providing poor anchorage for tree roots. Silvicultural options could be limited for wind-susceptible sites: avoid tree harvest altogether; salvage windfall as storms continue to unravel the forest; or gradually open the canopy by using intermediate cutting methods, or the preparatory cut of a 3-step shelterwood method (Alexander 1987, Roe et al. 1970).

OVERSTORY REMOVAL CUTTING

Overstory removal cutting is used in multi-layered stands with a fully stocked understory of healthy and desirable advance regeneration (fig. 5). An objective of this cutting method is to mimic the removal cut of a 2-step shelterwood sequence, and for this reason, it is often referred to as a simulated shelterwood cutting method (Alexander 1987, Nyland 2007).[2]

In the Blue Mountains, overstory removal cutting was historically viewed as an ideal solution to the silvicultural problem presented by tens of thousands of acres of multi-cohort stands resulting from almost 100 hundred years of fire suppression. Overstory removal cutting seemed to represent an ideal response to this management issue for at least four reasons:

- It avoided the cost of tree planting, an expensive practice.
- It avoided the undesirable appearance associated with clearcutting.
- It maintained pleasing aesthetics associated with a green, forested setting.
- It captured accumulated growth of understory trees existing for 60 years or more.

---

[2] A 'simulated' shelterwood term is apropos because Nature, not man, initiated tree regeneration (i.e., if a shelterwood seed 'cut' occurred in the past, Nature did it). Note that human alteration of a keystone ecosystem process (suppressing surface fire for more than a century) also helped create multi-cohort stands often managed by using a simulated shelterwood approach.

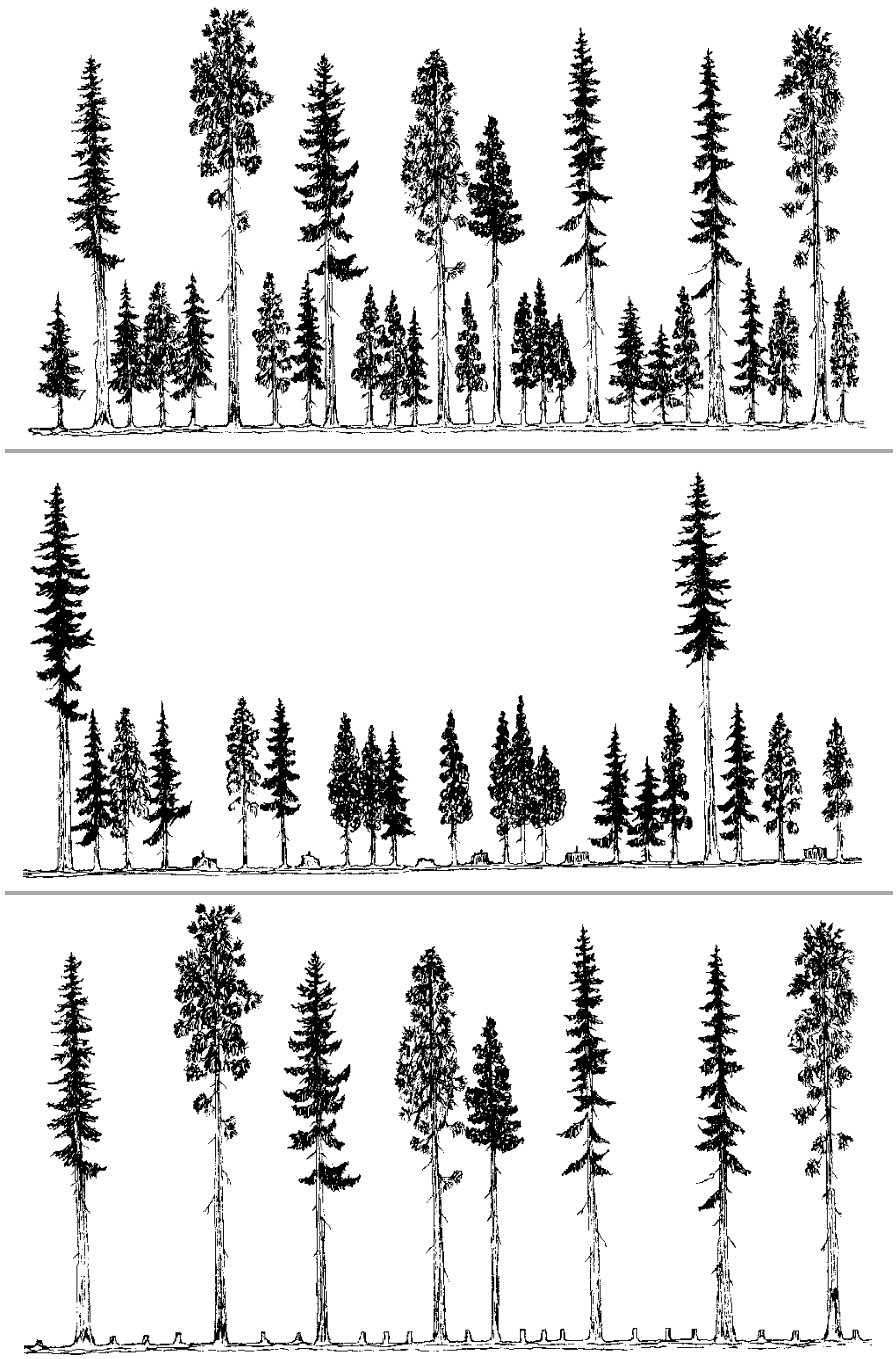

Figure 5 – Examples of overstory removal and understory removal cutting in a mixed-conifer forest. Either of these cutting methods is appropriate for two-aged (multi-cohort) stands (top, showing untreated stand). An overstory removal (middle) removes most or all the overstory trees to release a cohort of advanced regeneration. A few overstory trees may be retained depending upon land management objectives, but removing all the overstory could also be appropriate. An understory removal (lower) removes all or most of the understory cohort. It is typically prescribed to improve or maintain vigor of large-diameter trees such as older ponderosa pines or western larches, or to use harvest to mimic historical thinning effects of frequent, low-severity wildfire.

Potential advantages of overstory removals were not realized for Blue Mountains because this method is incompatible with many forest health issues: late-seral, shade-tolerant advance regeneration is highly susceptible to drought, defoliating insects (western spruce budworm and Douglas-fir tussock moth), root diseases, and stem decay caused by Indian paint fungus (Cochran 1998, Gast et al. 1991, Hayes et al. 2001, Torgersen 2001, Wickman 1992).

UNDERSTORY REMOVAL CUTTING

Understory removal cutting is also used in multi-cohort stands but it removes the advance regeneration cohort rather than the overstory cohort (fig. 5). The typical objective of understory removal cutting is to improve vigor and longevity of overstory trees (such as old ponderosa pines or western larches) by removing their major source of competition – understory trees, particularly the long-crowned, shade-tolerant species that function well as ladder fuel.

Understory removals could help restore the abundance of large-diameter trees across the interior Columbia River basin (Quigley et al. 1996) by improving growth rates for larger intermediate trees such as those in a 15- to 20-inch diameter class. Understory removals, including ladder-fuel reduction treatments to address crown fire susceptibility, are also implemented to improve physiological vigor of overstory trees, regardless of diameter or age (Graham et al. 1999, 2004).

Note that unlike overstory removal, there is no specific term and associated coding for understory removal. This means that an understory removal must be coded as an intermediate cutting method – commercial thinning, improvement cutting, or noncommercial thinning are obvious choices depending on silvicultural objectives and stand characteristics (see table 1).

Uneven-Aged Management

Uneven-aged management uses regeneration and intermediate cutting methods to create and maintain an uneven-aged stand. The uneven-aged regeneration methods are individual-tree and group selection cutting. Uneven-aged management also includes intermediate cutting methods, such as thinnings and improvement cuttings, to adjust stand density and accomplish other cultural objectives for treatment areas containing immature trees.

An important difference between even-aged and uneven-aged management involves the regulation of growing stock. In even-aged management, yields are regulated by controlling the area in each age class, and by how a rotation length is established, which is the time period required to grow trees to maturity as indicated by culmination of mean annual increment (Davis et al. 2001, Powell 2018). In uneven-aged management, growing stock is the primary factor used to regulate yields, rather than area (even-aged regulation uses the acreage in each age class).

Since uneven-aged management is applied to an entire stand area (although not every acre is treated in every cutting cycle), area objectives (treat 25% of the stand in small groups) are irrelevant. In fact, statements such as “we will treat 25% of the stand with group selection” are a sure tip-off that an even-aged concept is probably being used because regulation seems to be based on area (i.e., 25% of the stand’s acreage) instead of growing stock (Powell 2018).

Silvicultural prescriptions for uneven-aged regimes should provide quantified objectives about residual stocking, including specifications for these items (these items are related to what is referred to as the BDq method of uneven-aged regulation, as described in Fiedler 1995):

- Desired diameter distribution (expressed as a q factor (diminution quotient), or as developed by using stand density index as described in Cochran 1992, Long 1995, and other sources);
- Maximum tree diameter to be retained;
- Residual basal area; and
- Optimum cutting cycle.

Note: Further information about regulating an uneven-aged diameter distribution, and preparing a silvicultural prescription and marking guide for uneven-aged management, is provided in a white paper: "How to Prepare a Silvicultural Prescription for Uneven-aged Management" (Powell 2018).

INDIVIDUAL-TREE SELECTION

This regeneration cutting method involves removing selected trees from certain size or age classes over an entire stand area. Removing single trees creates small openings similar to those resulting from natural mortality, so this method favors the regeneration of species that can tolerate, and develop acceptably in, shade (fig. 6).

Individual-tree selection is used to create or maintain an uneven-aged stand. Periodically applying individual-tree selection, along with intermediate cutting methods, eventually results in a stand condition containing trees of many ages and sizes. This cutting method provides maximum flexibility in choosing trees to cut or leave, but it is most applicable to uniformly spaced stands with an irregular or uneven-aged structure. In mixed-species stands, it inevitably leads to an increase in the proportion of shade-tolerant tree species (Powell 2018).

GROUP SELECTION

This regeneration cutting method involves removing small groups of trees. The distance across an opening created by this method is usually no more than one to two times the surrounding tree height, up to a maximum size of two acres. These openings permit more sunlight to reach the forest floor than with individual-tree selection, and some regeneration of shade-intolerant species is possible (fig. 7).

Group selection is used to create or maintain an uneven-aged stand. Periodic application of regeneration and intermediate treatments results in small groups or clumps dispersed through a stand, with each group containing trees of similar ages and sizes. Group selection is an ideal alternative for uneven-aged stands whose existing structure is already groupy or clumpy. When groups approach maximum size (about 2 acres), the openings resemble small-patch clearcuts or the group shelterwood variant (Powell 2018, and see fig. 2).

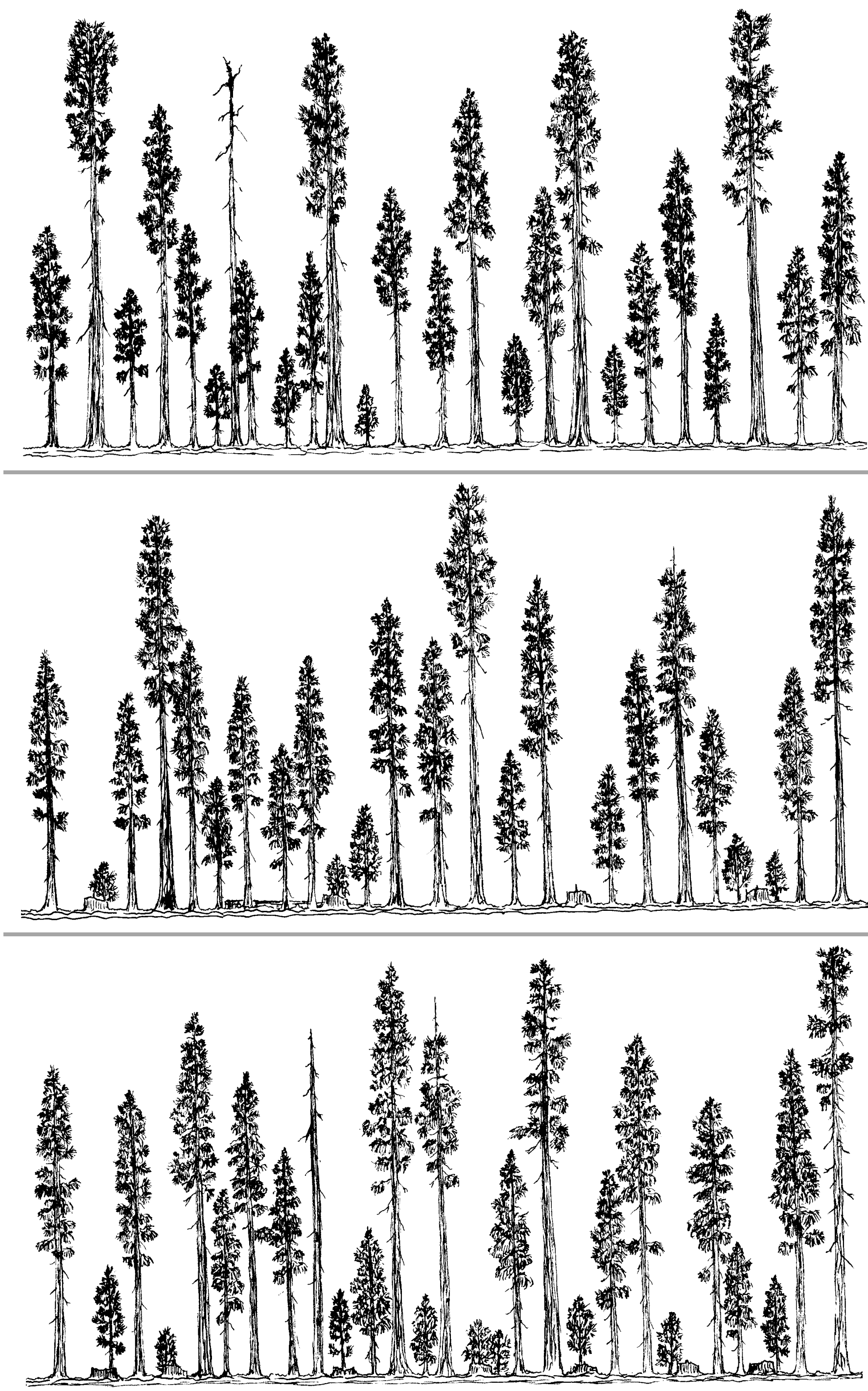

Figure 6 – Examples of individual-tree selection cutting in ponderosa pine. Uneven-aged management is best suited for stands with a high proportion of climax species. Because of their shade intolerance, early-seral stands of lodgepole pine or western larch are generally incompatible with individual-tree selection. In the Blue Mountains, individual-tree selection is most compatible with forests at either end of the ecological spectrum – climax ponderosa pine stands on dry-forest sites, and climax spruce-fir stands on cold-forest sites. For ponderosa pine, uneven-aged management is easier when it is climax than when it is a successional species.

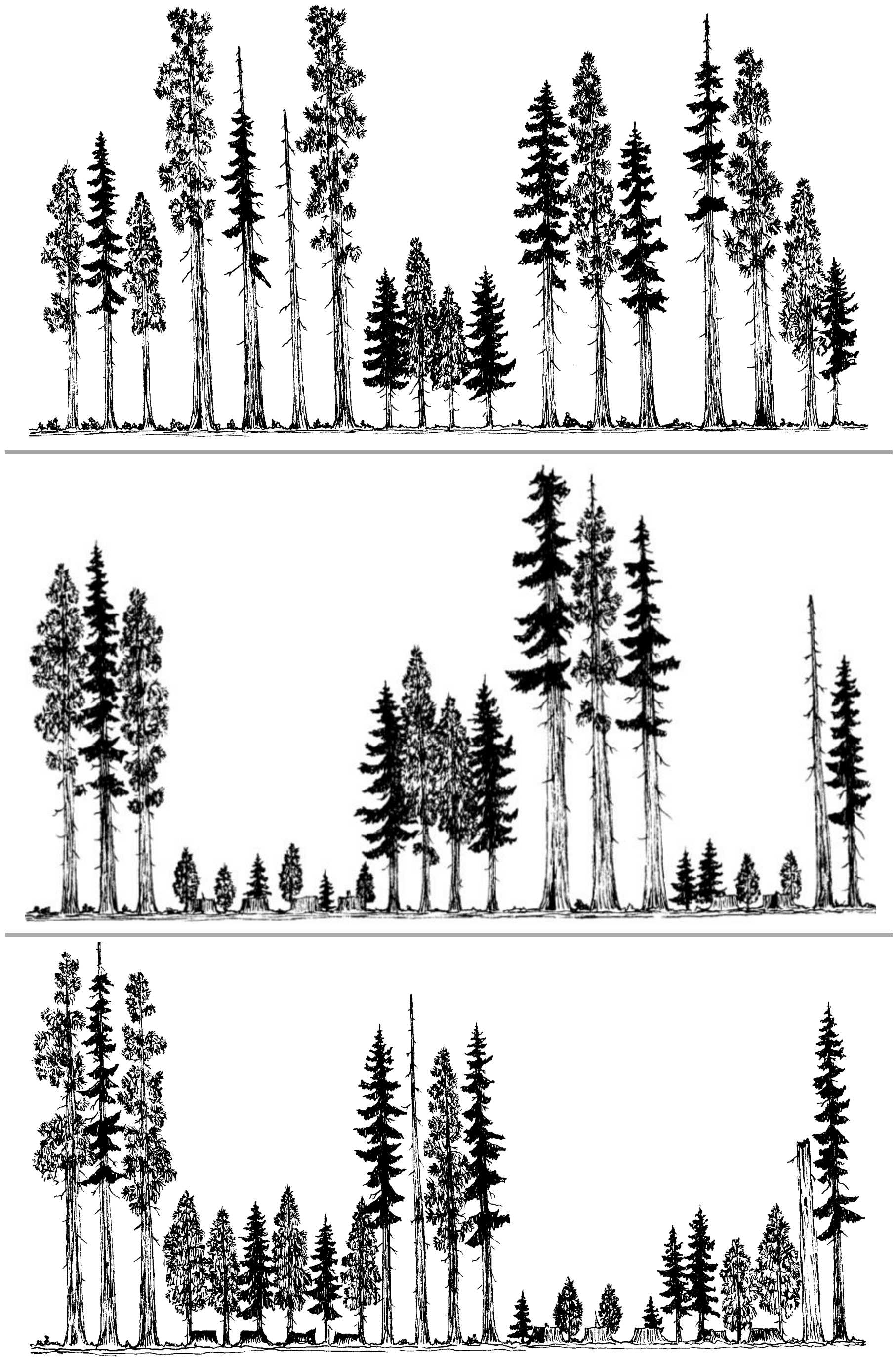

Figure 7 – Examples of group selection cutting in a mixed-conifer forest. Group selection cutting is often used in situations where it is desirable to maintain shade-intolerant species in mixed stands. Group selection cutting provides operational advantages because timber harvest damage can be managed by concentrating equipment movement in the openings. If not implemented carefully, group selection can result in removing groups of mature trees, but foregoing cultural treatments (noncommercial thinning, weeding, release, etc.) in immature portions of a stand. Also, if group size is too large or not controlled, there may be a tendency to compromise some of the benefits of uneven-aged management, such as site protection and amelioration (Powell 2018).

Intermediate Cutting Methods

Intermediate cutting methods are used to modify the growth, quality, vigor, composition, or structure of a forest stand after its establishment, and prior to its final harvest (USDA Forest Service 2004). This means there is no objective for obtaining regeneration in association with an intermediate cutting method (but it might occur anyway).

A little preaching by a terminology wonk: please don't prescribe commercial thinning, improvement cutting, or any other intermediate cutting method, and then state in a prescription or NEPA specialist report that you want regeneration, or expect to obtain it, <u>as a result of the treatment</u> – *if you prescribe a silvicultural treatment with a stated objective or expectation of regeneration, then please select a regeneration cutting method for your treatment*!
[<u>Note</u>: This caution does not relate to existing (advanced) regeneration, or to future regeneration occurring as 'volunteer' ingrowth, because either situation generally results from natural processes functioning independently of active forest management (e.g., silviculture).]

People frequently think of forests as tranquil and never changing. But change does occur, although it can be so slow for old forest as to be referred to as an "invisible present" (Magnuson 1990). Unlike old forests, young forests are dynamic, and they change rapidly (Oliver and Larson 1996). Intermediate cutting can influence the speed and direction of young forest dynamics to accelerate development of desired forest structure, reduce fire risk and, at the same time, produce some of the utilitarian goods and services desired by society.

In USDA Forest Service, two intermediate cutting methods are traditionally implemented as part of the timber stand improvement program – noncommercial thinning and release (fig. 8).

<u>IMPORTANT USAGE NOTE</u>: Sometimes, it is erroneously assumed that intermediate cutting is associated solely with even-aged management; this is incorrect – intermediate methods are also used with the two-aged and uneven-aged silvicultural systems (see page 2).

SILVICULTURE TERMINOLOGY AND ECOSYSTEM MANAGEMENT

Silvicultural terms have traditionally focused on the practices, methods, and activities used to manage vegetation, not on the future outcomes or conditions created by applying the treatments. A good example is clearcutting – the objective is not to clear an area and maintain it in a bare condition as long as possible, as if we were managing for parking lots. Clearcutting is just a means to an end (objective). It can be thought of as an activity (practice, method) suitable for reaching our ultimate destination and, in many cases, we could have gotten there just as easily by selecting another activity (such as seed-tree or shelterwood cutting).

In an era of ecosystem management, where we are striving to produce desired future conditions as described in Land and Resource Management Plans, there is a pressing need for a modern, outcome-based terminology. The new terms should focus on results and outcomes (the ends), rather than the methods and practices used to achieve them (the means).

Since we lack a terminology focused on outcomes, I will provide some examples of how current terms can be used (and coded) in an ecosystem management context.

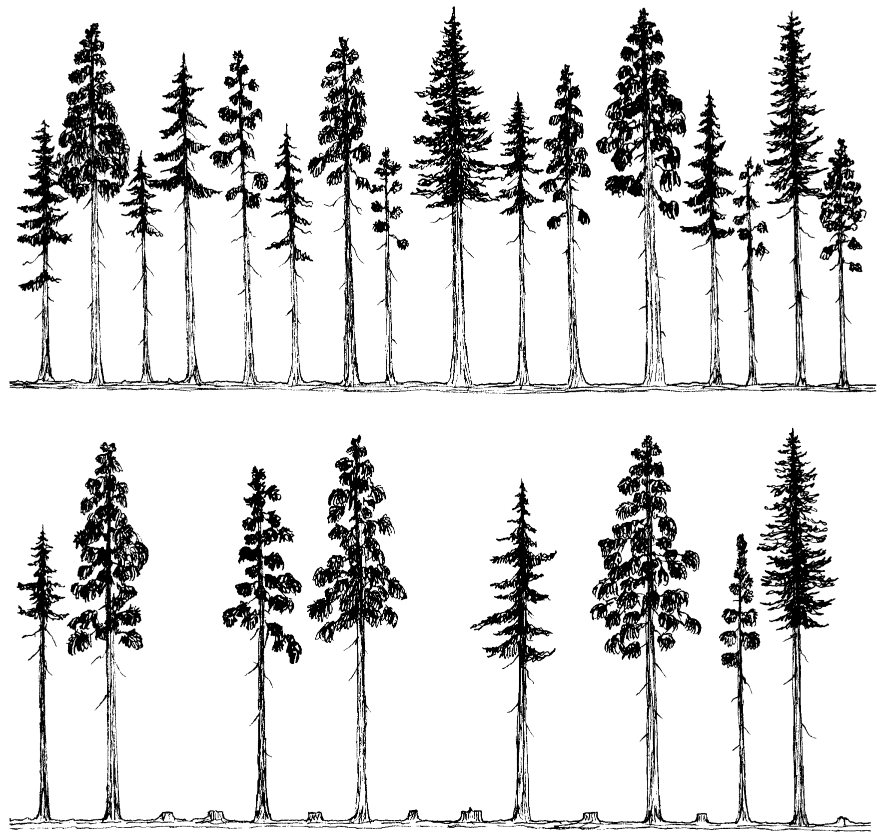

Figure 8 – Example of low thinning in a mixed-conifer forest (from Powell 1999). Low thinning is defined as the removal of trees from lower crown classes or canopy layers in order to favor those in upper crown classes or layers. Low thinning is also referred to as 'thinning from below.' Note how smaller trees were removed in every instance but one: the western larch in the center of the top panel was infected with dwarf mistletoe to an extent that threatened its continued survival. Because of its canopy position, the larch would not have been removed in a low thinning except for insect or disease reasons.

1. Smith et al. (1997) state, "the true clear cutting method lays bare the area treated and leads to the establishment of an even-aged high forest." They also admit that there are many circumstances where the term has been loosely applied, and that most of these situations should not be called clearcuts because they represent something other than "laying an area bare."

2. Many of the regeneration treatments referred to as sloppy or fuzzy clearcuts result in an on-the-ground appearance far different than application of true clearcutting.

   If enough reserve trees are left in an even-aged regeneration cutting unit to significantly influence its ecological condition, then it should be coded as clearcut with reserves, seed-tree with reserves, or shelterwood with reserves to better reflect post-harvest environmental conditions. The point is: If enough residual trees are retained to create a two-age stand with more than 10% full stocking, then they are reserve trees. *Once again, it is assumed that residual trees are retained for purposes other than regeneration*.

3. Although traditional application of both seed-tree and shelterwood cutting involves removing the residual trees after they successfully provide seed and shelter, the definitions do not preclude their long-term retention for other purposes.

   Therefore, retaining live overstory trees for biodiversity purposes, as legacy trees, or for green-tree snag replacements, would best be coded as seed-tree or shelterwood cutting with leave trees (single-age stands where residual trees are less than 10% of full stocking).

4. 'Crop-tree management' and other light partial cutting schemes do not qualify as individual-tree selection unless prescribed by using uneven-aged management objectives (such as the BDq method; see Fiedler 1995).

   Similarly, regeneration cutting that creates small openings does not automatically qualify as group selection, even when the openings are less than two acres in size, unless the stand structure is regulated using uneven-aged methods (Fiedler 1995, Long 1995).

5. Small openings created in an even-aged stand (openings smaller than 2 acres in size and with no intent to track them as separate stands or polygons in FSVeg or your vegetation database) should be termed small-patch clearcuts and managed as such if the objective is not to create or maintain an uneven-aged stand.

A Need for Consistency

Terms and definitions we use for silvicultural practices are fundamentally important, particularly regarding regeneration harvest. One hallmark of a professional silviculturist is that he or she has a deep understanding of silvicultural terminology and can use it carefully and consistently to effectively communicate within and outside the silviculture community (Thomas 1992). Consistent use of silvicultural terminology is essential, for these and other reasons:

- Without consistent application of definitions and codes, it will be impossible to use automated database systems such as FACTS to compile meaningful reports. One of the most important functions of a system like FACTS is to provide historical information about the silvicultural treatments occurring in the past. This function leaves 'tracks' for the next generation of silviculturists, but it is only valuable if terminology is applied consistently – what is coded as a clearcut on one unit (Ranger District) or in one year (2000) should be the same as what is coded as a clearcut on another unit or in another year.
- Without consistent application of definitions and codes, it will be difficult to meet the monitoring requirements of our Land and Resource Management Plan (USDA Forest Service 1990) – a particular cutting method coded on one Ranger District might not mean the same thing when coded on another District. [And, see appendix 1, Why We Do It, in WP #33.]
- Without consistent definitions and codes, we cannot communicate effectively when describing silvicultural treatments in environmental assessments, environmental impact statements, specialist reports, and other NEPA documents. Once again, we need to be sure that what is termed a shelterwood seed cut in Heppner's environmental documentation is reasonably similar to a shelterwood seed cut in Walla Walla's documentation.

Table 1 is designed to provide a consistent set of codes and definitions for many of the silvicultural activities and practices we use when managing forested ecosystems.

Table 1: Codes and definitions for selected regeneration and intermediate cutting methods.

CODE	NAME AND DEFINITION OF CUTTING METHOD
	REGENERATION CUTTING METHODS
	NOTES: National Forest Management Act regulations require that harvested areas be adequately restocked within 5 years of final harvest (36 CFR 219.27). For a regeneration cutting method involving a series of cuts, the 5-year requirement begins when a removal cut is made. Tree density present immediately after a removal cut must meet or exceed minimum stocking standards from the Forest Plan, or it must be attained within 5 years of a removal cut.
4111	**Patch clearcut (EA/RH/FH):** a variant of stand clearcutting where patches or strips are removed from within an individual stand boundary to incrementally create a new even-aged stand. This method normally requires two or more entries before all the original 'parent' stand has been treated (e.g., included in a patch or strip).
4115	**Patch clearcut with leave trees (EA/RH/FH):** same as patch clearcut except that minor numbers of leave trees are retained (less than 10% of full stocking; see note at end of table) to achieve objectives other than regeneration.
4113	**Stand clearcut (EA/RH/FH):** even-aged regeneration cutting method that removes essentially all live trees from an entire stand, and does so in one entry (e.g., the whole stand is treated at one time).
4117	**Stand clearcut with leave trees (EA/RH/FH):** same as stand clearcut except that minor numbers of leave trees are retained (less than 10% of full stocking) to achieve objectives other than regeneration.
4121	**Shelterwood preparatory cut (EA/NRH/NFH):** removing trees near the end of a rotation to gradually open the canopy and thereby build crown, develop windfirmness, and otherwise improve a stand's capability to produce seed. Seed production or regeneration establishment is not an objective of preparatory cutting.
4192	**Two-aged preparatory cut with reserves (2A/NRH/NFH):** same as shelterwood preparatory cut except that substantial numbers of reserve trees are retained (at least 10% or more of full stocking) to achieve objectives other than regeneration.
4122	**Seed-tree preparatory cut (EA/NRH/NFH):** same as for shelterwood preparatory cut except it is being used with the seed-tree regeneration cutting method.
4131	**Shelterwood establishment cut, with or without leave trees (EA/RH/NFH):** removing a significant proportion of the overstory canopy to promote seed production and create conditions conducive for establishment and survival of natural or planted regeneration. This cut must leave at least 12 acceptable, well-distributed seed trees per acre (not applicable when using a strip shelterwood because shelter and seed are provided by uncut areas). Minor numbers of leave trees can be retained (less than 10% of full stocking), to ensure that a live component will be present after a removal cut is eventually made, to achieve objectives other than regeneration.

CODE	NAME AND DEFINITION OF CUTTING METHOD
4194	**Two-aged shelterwood establishment cut with reserves (2A/RH/NFH):** same as shelterwood establishment cut except that substantial numbers of reserve trees are retained (at least 10% or more of full stocking) so that a two-aged stand will be present after a removal cut has been completed.
4132	**Seed-tree seed cut, with or without leave trees (EA/RH/NFH):** same as for shelterwood establishment cut except it is being used with the seed-tree regeneration method. This cut must leave at least 6 acceptable, well-distributed seed trees per acre (not applicable when using a strip seed cut because shelter and seed are then provided by uncut areas).
4183	**Two-aged seed-tree seed and removal cut with reserves (2A/RH/NFH):** this is a final removal cut that removes all trees except those needed for regeneration, along with sufficient reserve trees (at least 10% or more of full stocking), to create a two-aged stand and satisfy objectives other than regeneration. This is both a seed cut and removal cut because seed trees and reserves are both retained to create a two-aged stand (e.g., seed trees are not removed).
4141	**Shelterwood removal cut (EA/NRH/FH):** removing trees that were left in a shelterwood establishment cut; leave trees designated during an establishment cut, if any, should also remain after this entry.
4196	**Shelterwood removal cut with reserves (2A/NRH/FH):** same as shelterwood removal cut except that substantial numbers of reserve trees are retained (at least 10% or more of full stocking) to achieve objectives other than regeneration, and to create a two-aged stand.
4145	**Shelterwood removal cut with leave trees (EA/NRH/FH):** final removal cut except that minor numbers of leave trees are retained (less than 10% of full stocking) to achieve objectives other than regeneration.
4142	**Seed-tree final cut (EA/NRH/FH):** removing trees that were retained in a seed-tree seed cut (note: this code assumes that leave trees were not retained by the seed cut and are therefore not present for this entry).
4146	**Seed-tree removal cut with leave trees (EA/NRH/FH):** same as seed-tree final cut except that minor numbers of leave trees are retained (less than 10% of full stocking) to achieve objectives other than regeneration.
4151	**Single-tree selection cut (UA/RH/NFH):** uneven-aged cutting method where individual trees are removed uniformly throughout a stand to maintain an uneven-aged stand structure.
4152	**Group selection cut (UA/RH/FH):** uneven-aged cutting method where groups of trees are removed from areas less than 2 acres in size to maintain an uneven-aged stand structure.

CODE	NAME AND DEFINITION OF CUTTING METHOD
	INTERMEDIATE CUTTING METHODS
	NOTES: After intermediate cutting, density of acceptable, undamaged trees must meet or exceed FP minimum stocking standards, generally specified by forest type or working group. "If salvage or sanitation cutting is heavy enough to require regeneration, it is considered a regeneration harvest rather than intermediate cutting, and steps should be taken to adequately restock the stand within five years of final harvest" (FSM 2471.41 – Consideration).
4210	**Improvement cut:** intermediate cutting, but only in stands past the sapling stage, to improve composition and quality. Trees of undesirable species, form, or condition are removed from the upper canopy, often with an understory thinning.
4211	**Liberation cut:** release treatment, but only in stands not past the sapling stage, to free favored trees from competition with older, overtopping trees.
4220	**Commercial thinning:** intermediate cutting to reduce stand density and improve stand or tree growth, enhance forest health, and meet other resource objectives. This treatment can be used to recover potential mortality, while also producing merchantable wood products.
4231	**Salvage cut:** intermediate cutting to remove trees that are dead or dying because of injurious agents other than competition. The primary goal is to remove dead and dying trees before their economic value is lost. Note that there is a distinction between salvage cutting and salvage timber harvest, even though the terms are often used interchangeably (see Glossary). Note: If salvage harvest will be heavy enough to create a nonstocked opening (see "horizontal diversity" section in Forest-wide standards and guidelines, Umatilla NF Land and Resource Management Plan, page 4-73), then the treatment should be coded as a regeneration cutting method.
4232	**Sanitation cut:** intermediate cutting to improve stand health by stopping or reducing the actual or anticipated spread of insects and disease. The sanitation and salvage terms are often used interchangeably, but this usage is incorrect. For example, removing dying trees from a root-disease center is a sanitation treatment if harvest helps slow the spread or intensification of root disease. The same treatment would be coded as salvage if harvest has little or no effect on root disease.
4242	**Harvest without restocking:** an intermediate entry where trees are harvested from lands where restocking of trees is not desired to meet desired vegetative conditions (reference FSH 1909.12, 64.2.). Sometimes, Forest Plan direction may allow timber removals without desiring, or requiring, post-harvest regeneration. This usually occurs for management areas where forested lands are 'unsuitable.'

Sources/Notes: Definitions were taken from FSM 2400 – Forest Management, chapter 2470 – Silvicultural Practices, amendment 2400-2014-1 (USDA Forest Service 2014), or from the FACTS user guide (June 2016 version). Codes were taken from the FACTS user guide.

Note: Leave-tree and reserve-tree definitions refer to "10% of full stocking." For the Blue Mountains, full-stocking values are provided, by plant association and tree species, in Cochran et al. (1994) and Powell (1999).

Abbreviations used in conjunction with the regeneration cutting method names are:

2A = Two ages (two-aged silvicultural system)

EA = Even aged (even-aged silvicultural system)

UA = Uneven aged (uneven-aged silvicultural system)

FH = Final harvest

RH = Regeneration harvest

NFH = Not final harvest

NRH = Not regeneration harvest

ACKNOWLEDGMENTS

Wayne Long, retired fire management officer for the Walla Walla Ranger District of the Umatilla National Forest, prepared the excellent cutting method and stand structure line drawings used throughout this document.

GLOSSARY

This glossary includes terms that are not defined in the text or table 1.

Active management. Planned, intentional actions in an area that are specifically designed to obtain a desired objective or result (Boise Cascade Corporation 1996).

Adaptive management. A dynamic approach to land management in which the effects of treatments are continually monitored and used, along with research results, to modify management on a continuing basis to ensure that objectives are being met (Helms 1998).

Advanced regeneration. Trees that have become established naturally under a mature forest canopy, and are capable of developing normally if the overstory is removed or killed.

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, the cross-sectional area of all stems in a stand and expressed per unit of land area (e.g., basal area per acre).

Climax. The culminating seral stage in plant succession for any given site where, in the absence of catastrophic disturbance, the vegetation has reached a highly stable condition and undergoes change very slowly (Dunster and Dunster 1996). A self-replacing community that is relatively stable over several generations of the dominant plant species, or very persistent in comparison to other seral stages (Kimmins 1997).

Cohort. A group of trees developing after a single disturbance, commonly consisting of trees of similar age, although one cohort can include a considerable span of ages ranging from seedlings or sprouts to trees that predated the disturbance (Helms 1998). Stands are often characterized as single-cohort or multicohort depending on whether they contain one or several cohorts (Oliver and Larson 1996).

Crown class. A categorization or classification of trees based on their crown position relative to adjacent trees within the same canopy stratum; four primary crown classes are recognized:

> **Dominant** – a tree whose crown extends above the general level of the main canopy, receiving full light from above and partial light from the sides.
>
> **Codominant** – a tree whose crown helps to form the general level of the main canopy, receiving full light from above and limited light from the sides.
>
> **Intermediate** – a tree whose crown extends into the lower portion of the main canopy but is shorter than the codominants, receiving little direct light from above and virtually none from the sides.
>
> **Subcanopy** (overtopped) – a tree whose crown is completely overtopped by the crowns of one or more neighboring trees, occurring in a subordinate or submerged position relative to the main canopy.

Cutting cycle. The planned interval between partial harvests in an uneven-aged stand (Helms 1998).

Cutting method. Intentional application of silvicultural practices (commercial or noncommercial activities in a tree stand) designed to obtain regeneration or otherwise establish a new stand or tree cohort (regeneration cutting methods), or to tend (culture) an existing stand by modifying its species composition, stand density, or vertical structure (intermediate cutting methods such as release, thinning, weeding, etc.) (Smith et al. 1997). Regeneration and intermediate cutting method definitions are provided in table 1.

Ecosystem management. Management driven by explicit goals, executed by policies, protocols and practices, and made adaptable by monitoring and research based on our best understanding of the ecological interactions and processes necessary to sustain ecosystem composition, structure, and function (Christensen et al. 1996).

Forest. An ecosystem characterized by a more or less dense and extensive tree cover, often consisting of stands varying in characteristics such as species composition, structure, age class, and associated processes, and commonly including meadows, streams, fish, and wildlife (Helms 1998).

Forest density management. Cutting or killing trees to increase intertree spacing and to accelerate growth of remaining trees; manipulation and control of forest (tree) density to achieve one or more resource objectives. Forest density management is often used to improve forest health, to open the canopy for selected trees, to maintain understory vegetation, or to promote late-successional characteristics for biological diversity (Helms 1998).

Forest health. Perceived condition of a forest based on concerns about such factors as its age, structure, composition, function, vigor, presence of unusual levels of insects or disease, and resilience to disturbance. Note that perception and interpretation of forest health is influenced by individual and cultural viewpoints, land management objectives, spatial and temporal scales, relative health of stands comprising the forest, and appearance of the forest at a particular point in time (Helms 1998).

Forest management. Generally, the branch of forestry concerned with its overall administrative, economic, legal, and social aspects, and with application and coordination of its essentially scientific and technical aspects such as silviculture, protection, and regulation (Doliner and Borden 1984).

Forest stand. A contiguous group of trees sufficiently uniform in age-class distribution, composition, and structure, and growing on a site of sufficiently uniform quality, to be a distinguishable unit (Helms 1998).

Growing space. An intangible measure of a site's total resources (sunlight, moisture, nutrients, etc.) that are available to a plant (Helms 1998). Growing space refers to the availability of all resources needed by a plant to exist on a given site (O'Hara 1996).

Leave tree. A tree retained after even-aged regeneration cutting – leave tree characteristics are the same as for reserve trees (and see that glossary term), but fewer leave trees are retained per acre than when prescribing reserve trees. As described for reserve trees, leave trees are retained for purposes other than regeneration, and they comprise a minor portion of the stand, which is defined as less than 10% of full stocking. For the Blue Mountains, full-stocking values are provided, by plant association and tree species, in Cochran et al. (1994) and Powell (1999).

Low thinning. Removal of trees from lower crown classes, layers, or strata to favor those in upper crown classes, layers or strata; also referred to as "thinning from below."

Marking guide. Marking guides are written direction, generally prepared by a certified or qualified silviculturist, to provide silvicultural guidelines or specifications for selecting trees to retain, or optionally trees to remove, in order to accomplish specific stand management objectives. Marking guides provide operational direction and guidelines to implement a detailed silvicultural prescription. They are written in such a way as to convey detailed specifications, and to clarify concepts and silvicultural terminology, related to why and how trees are selected and marked to implement a cutting method in a designated stand or treatment unit.

Natural regeneration. Renewal of a forest community by natural (as compared to human) means, such as tree seedling establishment from seed produced on-site or from adjacent areas, or from seed brought in by wind currents, birds, or animals.

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

Overstory. In a forest with more than one story (layer), overstory includes trees forming the uppermost canopy layer; in a two-storied forest (stands with two clearly defined canopy layers), taller trees form the overstory and shorter trees the understory (Helms 1998).

Partial cutting. Harvest operation in which only certain trees are removed from a stand of merchantable trees.

Reforestation. The natural or artificial renewal of a forest ecosystem by establishing trees. Also called regeneration.

Reserve tree. Live trees, pole-sized or larger, retained in either a dispersed or aggregated manner after a regeneration period under clearcutting with reserves, seed-tree with reserves, shelterwood with reserves, group selection with reserves, or coppice with reserves regeneration method. Reserve trees are retained for objectives other than regeneration, such as provision of future snags (e.g., green-tree replacement trees). It is assumed that reserve trees occupy at least 10% of a stand's growing space, and this is further defined as 10% or more of the full-stocking density management level. For the Blue Mountains province, full-stocking values are provided, by plant association and tree species, in Cochran et al. (1994) and Powell (1999).

Residual trees. Trees remaining in an area following tree harvest, thinning, or other disturbance events such as insect or disease outbreaks and wildfire.

Rotation. In even-aged systems, the period (in years) between regeneration establishment and final cutting (Helms 1998). The National Forest Management Act requires that rotation age must be the same as, or greater than, 'culmination of mean annual increment' age.

Salvage cutting. An intermediate cutting method designed to remove dead or dying trees resulting from disturbance agents other than intertree competition, primarily to recover economic value that would otherwise be lost (see table 1).

Salvage timber harvest (salvage harvest). Tree harvest activities (felling, bucking, skidding, etc.) completed to implement a salvage cutting treatment.

Selective cutting. A system in which groups of trees, or individual trees, are periodically removed from a forest, as based on economic criteria aimed at maximizing commodity revenues rather than trying to meet silvicultural objectives such as regeneration (Dunster and Dunster 1996). Compare with: selection cutting definitions provided in table 1 (page 18).

Seral stage. The identifiable stages in the development of a sere, from an initial pioneer stage, through various early and mid-seral stages, to late seral, subclimax, and climax stages. The stages are identified by different plant communities, different ages of the dominant vegetation, and by different microclimatic, soil, and forest conditions (Kimmins 1997). Four seral stages are recognized (Hall et al. 1995):

> **Early Seral**: clear dominance of seral species (western larch, ponderosa pine, lodgepole pine, etc.); PNC species are absent or present in very low numbers.
>
> **Mid Seral**: PNC species are increasing in the forest composition as they actively colonize the site; PNC species are approaching equal proportions with seral species.
>
> **Late Seral**: PNC species are now dominant, although long-lived seral species (ponderosa pine, western larch, etc.) may still persist in the plant community.
>
> **Potential Natural Community (PNC)**: the biotic community that one presumes would be established and maintained over time under present environmental conditions; seral species are scarce or absent in the plant composition.

Shade tolerance. The capacity of trees to grow satisfactorily in the shade of, and in competition with, other trees (Helms 1998). Also see: tolerance.

Silvicultural prescription. A planned series of treatments designed to change current forest structure to one meeting the goals and objectives established for an area (Helms 1998). A prescription is a written statement or document defining the outcomes to be attained from silvicultural treatments. The outcomes are generally expressed as acceptable ranges of the various indices being used to characterize forest development (Dunster and Dunster 1996).

Silvicultural system. A planned series of treatments for tending, harvesting, and reestablishing a stand of trees. Note that the series of treatments typically involves both regeneration cutting methods and intermediate cutting methods (see the cutting method definitions provided in table 1). Three silvicultural systems are recognized: even-aged, two-aged, and uneven-aged.

Silvicultural treatment. A process or action that can be applied in a controlled manner, according to the specifications of a silvicultural prescription or forest plan, to provide actual or potential benefits (Hoffman et al. 1999).

Silviculture. Applying techniques or practices to manipulate forest vegetation by directing stand and tree development, and creating or maintaining desired conditions. Silviculture is based on an ecosystem concept emphasizing a need to evaluate the many abiotic and biotic factors influencing the choice and outcome of silvicultural treatments and their sequence over time, and the long-term consequences and sustainability of management regimes. [Definition derived from multiple sources.]

Stocking. The amount of anything on a given area, particularly in relation to what is considered optimum; in silviculture, an indication of growing-space occupancy relative to a pre-established standard.

Thinning. A silvicultural treatment in immature forests designed to reduce tree density and improve growth of residual trees, enhance forest health, or recover potential mortality resulting from intertree competition (Helms 1998). Two types of thinning are recognized (Powell et al. 2001):

Commercial thinning: a thinning where trees being removed have characteristics imparting economic value (sufficiently large size, etc.), which then allows them to be sold to a business enterprise.

Noncommercial (precommercial) thinning: a thinning where trees being removed are too small to be sold for conventional wood products such as lumber; the excess trees are typically left on site after being cut, or are concentrated into piles and then burned.

Timber stand improvement. Treatments in immature forests to improve the composition, structure, condition, health, and growth of tree stands. The goal of timber stand improvement activities is to improve forest health, or to accomplish other objectives by regulating stand density, removing competing vegetation and fuel ladders, and maintaining soil productivity.

Tolerance. A forestry term expressing the relative ability of a plant (tree) to complete its life history, from seedling to adult, under the cover of a forest canopy and while experiencing competition with other plants (Harlow et al. 1996). In general ecology usage, tolerance refers to the capacity of an organism or biological process to subsist under a given set of environmental conditions. Note that the range of conditions under which an organism can subsist, representing its limits of tolerance, is termed its ecological amplitude (Helms 1998).

Tree harvest. The felling, bucking, skidding, on-site processing, and loading of trees onto trucks for transport to a market or to an off-site facility for further processing (Helms 1998).

Understory. All of the vegetation growing under a forest overstory. In some instances, understory is only considered to be small trees (e.g., in a forest comprised of multiple canopy layers, the taller trees form the overstory, the shorter trees the understory); in other instances, understory is assumed to include herbaceous and shrubby plants in addition to trees. When understory refers to trees only, other plants (herbs and shrubs) are often called an undergrowth to differentiate between the two components (Helms 1998).

REFERENCES

Alexander, R.R. 1987. Ecology, silviculture, and management of the Engelmann spruce-subalpine fir type in the central and southern Rocky Mountains. Agric. Handb. No. 659. Fort Collins, CO: USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. 144 p. http://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=1144&context=barkbeetles

Arno, S.F.; Harrington, M.G.; Fiedler, C.E.; Carlson, C.E. 1996. Using silviculture and prescribed fire to reduce fire hazard and improve health in ponderosa pine forests. In: Proceedings of the 17th annual forest vegetation management conference; 1996 January 16-18; Redding, CA: 114-118. http://www.fvmc.org/PDF/FVMCProc17th(1996).pdf

Barrett, J.W. 1980. Regional silviculture of the United States. 2nd ed. New York: John Wiley & Sons, Inc. 551 p. isbn:0-471-05645-6

Bates, C.G. 1926. Some relations of plant ecology to silvicultural practice. Ecology. 7(4): 469-480. doi:10.2307/1931172

Benecke, U. 1996. Ecological silviculture: the application of age-old methods. New Zealand Forestry. 41(2): 27-33. http://www.nzjf.org.nz/free_issues/NZJF41_2_1996/3C9B76A8-5725-4ADF-B6DB-56562EBC2BBB.pdf

Boise Cascade Corporation. 1996. Forest ecosystem management: a graphic overview. La Grande, OR: Boise Cascade Corporation, Timber and Wood Products Division. 52 p.

Burns, R.M., tech. comp. 1983. Silvicultural systems for the major forest types of the United States. Washington, DC: U.S. Department of Agriculture, Forest Service. 191 p. https://www.fs.usda.gov/treesearch/pubs/32974

Burns, R.M., comp. 1989. The scientific basis for silvicultural and management decisions in the national forest system. Gen. Tech. Rep. WO-55. Washington, DC: USDA Forest Service. 180 p. https://archive.org/download/CAT31125176/CAT31125176.pdf

Burton, P.J.; Sutherland, D.C.; Daintith, N.M.; Waterhouse, M.J.; Newsome, T.A. 2000. Factors influencing the density of natural regeneration in uniform shelterwoods dominated by Douglas-fir in the sub-boreal spruce zone. Victoria, BC: B.C. Ministry of Forests, Research Branch. 65 p. https://www.for.gov.bc.ca/hfd/pubs/docs/wp/WP47.pdf

Christensen, N.L.; Bartuska, A.M.; Brown, J.H.; Carpenter, S.; D'Antonio, C.; Francis, R.; Franklin, J.F.; MacMahon, J.A.; Noss, R.F.; Parsons, D.J.; Peterson, C.H.; Turner, M.G.; Woodmansee, R.G. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications. 6(3): 665-691. doi:10.2307/2269460

Cochran, P.H. 1992. Stocking levels and underlying assumptions for uneven-aged ponderosa pine stands. Res. Note PNW-RN-509. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 10 p. http://www.treesearch.fs.fed.us/pubs/25110

Cochran, P.H. 1998. Examples of mortality and reduced annual increments of white fir induced by drought, insects, and disease at different stand densities. Res. Note PNW-RN-525. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 19 p. http://www.treesearch.fs.fed.us/pubs/3036

Cochran, P.H.; Geist, J.M.; Clemens, D.L.; Clausnitzer, R.R.; Powell, D.C. 1994. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington. Res.

Note PNW-RN-513. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 21 p. http://www.treesearch.fs.fed.us/pubs/25113

D'Amato, A.W.; Jokela, E.J.; O'Hara, K.L.; Long, J.N. 2018. Silviculture in the United States: An amazing period of change over the past 30 years. Journal of Forestry. 116(1): 55-67. doi:10.5849/JOF-2016-035

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

Daubenmire, R.F. 1943. Vegetational zonation in the Rocky Mountains. Botanical Review. 9(6): 325-393. doi:10.1007/BF02872481

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

Day, K.; Koot, C.; Wiensczyk, A. 2011a. The shelterwood silvicultural system in British Columbia – A practitioner's guide. Part 1: Implementation considerations. BC Journal of Ecosystems and Management. 12(2): 74-86. https://jem-online.org/index.php/jem/article/download/139/85

Day, K.; Koot, C.; Wiensczyk, A. 2011b. The shelterwood silvicultural system in British Columbia – A practitioner's guide. Part 2: The interplay of stand dynamics, disturbance, and regeneration. BC Journal of Ecosystems and Management. 12(2): 87-94. https://jem-online.org/index.php/jem/article/download/140/86

Day, K.; Koot, C.; Wiensczyk, A. 2011c. The shelterwood silvicultural system in British Columbia – A practitioner's guide. Part 3: Operational implementation. BC Journal of Ecosystems and Management. 12(2): 95-106. https://jem-online.org/index.php/jem/article/download/141/88

Doliner, L.H.; Borden, J.H. 1984. Pesterms: a glossary of forest pest management terms. Pest Management Rep. No. 3. Victoria, BC: British Columbia Ministry of Forests. 34 p.

Dunster, J.; Dunster, K. 1996. Dictionary of natural resource management. Vancouver, BC: UBC Press. 363 p. isbn:0-7748-0503-X

Emmingham, W.H.; Oester, P.T.; Fitzgerald, S.A.; Filip, G.M.; Edge, W.D. 2005. Ecology and management of eastern Oregon forests: a comprehensive manual for forest managers. Manual 12. Corvallis, OR: Oregon State University, Extension Service. 208 p. Ecology of eastern OR forests weblink

Fiedler, C.E. 1995. The basal area-maximum diameter-q (BDq) approach to regulating uneven-aged stands. In: O'Hara, K.L., ed. Uneven-aged management: opportunities, constraints and methodologies. MFCES Misc. Pub. No. 56. Missoula, MT: University of Montana, School of Forestry: 94-109.

Franklin, J.F.; Mitchell, R.J.; Palik, B.J. 2007. Natural disturbance and stand development principles for ecological forestry. Gen. Tech. Rep. NRS-19. Newtown Square, PA: USDA Forest Service, Northern Research Station. 44 p. http://www.treesearch.fs.fed.us/pubs/13293

Gast, W.R., Jr.; Scott, D.W.; Schmitt, C.; Clemens, D.; Howes, S.; Johnson, C.G., Jr.; Mason, R.; Mohr, F.; Clapp, R.A. 1991. Blue Mountains forest health report: "new perspectives in forest health." Portland, OR: USDA Forest Service, Pacific Northwest Region, Malheur, Umatilla, and Wallowa-Whitman National Forests. Irregular pagination. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev7_015666.pdf

Graham, R.T.; Harvey, A.E.; Jain, T.B.; Tonn, J.R. 1999. The effects of thinning and similar stand treatments on fire behavior in western forests. Gen. Tech. Rep. PNW-GTR-463. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 27 p. http://www.treesearch.fs.fed.us/pubs/2979

Graham, R.T.; McCaffrey, S.; Jain, T.B., technical editors. 2004. Science basis for changing forest structure to modify wildfire behavior and severity. Gen. Tech. Rep. RMRS-GTR-120. Fort Collins, CO: USDA Forest Service, Rocky Mountain Research Station. 43 p. http://www.treesearch.fs.fed.us/pubs/6279

Hall, F.C.; Bryant, L.; Clausnitzer, R.; Keane, R.; Geier-Hayes, K.; Kertis, J.; Shlisky, A.; Steele, R. 1995. Definitions and codes for seral status and structure of vegetation. Gen. Tech. Rep. PNW-GTR-363. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 39 p. http://www.treesearch.fs.fed.us/pubs/5619

Harlow, W.M.; Harrar, E.S.; Hardin, J.W.; White, F.M. 1996. Textbook of dendrology. 8th edition. New York: McGraw-Hill. 534 p. isbn:0-07-026572-0

Hayes, J.L.; Quigley, T.M.; Starr, L., eds. 2001. Forest health and productivity in eastern Oregon and Washington. Northwest Science. 75(special issue): 1-251. issn:0029-344X

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

Hoffman, R.E.; Twery, M.J.; Alban, L.M.; Nyland, R.D. 1999. Forests and people. NE-INF-138-99. Burlington, VT: USDA Forest Service, Northeastern Research Station, Aiken Forestry Sciences Laboratory. 24 p. https://www.fs.usda.gov/treesearch/pubs/4032

Johnson, M.C.; Peterson, D.L. 2005. Forest fuel treatments in western North America: Merging silviculture and fire management. Forestry Chronicle. 81(3): 365-368. doi:10.5558/tfc81365-3

Kimmins, J.P. 1997. Forest ecology; a foundation for sustainable management. 2nd edition. Upper Saddle River, NJ: Prentice Hall. 596 p. isbn:0-02-364071-5

Long, J.N. 1995. Using stand density index to regulate stocking in uneven-aged stands. In: O'Hara, K.L., ed. Uneven-aged management: opportunities, constraints and methodologies. MFCES Misc. Pub. No. 56. Missoula, MT: University of Montana, School of Forestry: 110-122.

Magnuson, J.J. 1990. Long-term ecological research and the invisible present. BioScience. 40(7): 495-501. doi:10.2307/1311317

Matthews, J.D. 1992. Silvicultural systems. New York: Oxford University Press. 284 p. isbn:0-19-854670-X

Mitchell, R.J.; Palik, B.J.; Hunter, M.L., Jr. 2002. Natural disturbance as a guide to silviculture. Forest Ecology and Management. 155(1-3): 315-317. doi:10.1016/S0378-1127(01)00568-0

Natural Resources Canada. 1995. Silvicultural terms in Canada. Hull, QB: Natural Resources Canada, Canadian Forest Service, Policy, Economics and International Affairs Directorate. 109 p. http://cfs.nrcan.gc.ca/pubwarehouse/pdfs/24216.pdf

Nyland, R.D. 2007. Silviculture: concepts and applications. 2nd edition. Long Grove, IL: Waveland Press, Inc. 682 p. isbn:978-1-57766-527-4

O'Hara, K.L., ed. 1995. Uneven-aged management: opportunities, constraints, and methodologies. MFCES Misc. Pub. No. 56. Missoula, MT: University of Montana, School of Forestry. 166 p.

O'Hara, K.L. 1996. Dynamics and stocking-level relationships of multi-aged ponderosa pine stands. Forest Science. 42(Supplement 2): 1-34. doi:10.1093/forestscience/42.s2.a0001

O'Hara, K.L. 2014. Multiaged silviculture: Managing for complex forest stand structures. 1st ed. New York: Oxford University Press. 213 p. isbn:9780198703068

O'Hara, K.L. 2016. What is close-to-nature silviculture in a changing world? Forestry. 89(1): 1-6. doi:10.1093/forestry/cpv043

Oliver, C.D.; Larson, B.C. 1996. Forest stand dynamics. Update edition. New York: John Wiley. 520 p. isbn:0-471-13833-9

Powell, D.C. 1994. Effects of the 1980s western spruce budworm outbreak on the Malheur National Forest in northeastern Oregon. Tech. Pub. R6-FI&D-TP-12-94. Portland, OR: USDA Forest Service, Pacific Northwest Region, Forest Insects and Diseases Group. 176 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5358589.pdf

Powell, D.C. 1999. Suggested stocking levels for forest stands in northeastern Oregon and southeastern Washington: an implementation guide for the Umatilla National Forest. Tech. Pub. F14-SO-TP-03-99. Pendleton, OR: USDA Forest Service, Pacific Northwest Region, Umatilla National Forest. 300 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5405482.pdf

Powell, D.C., comp. 2014. Vegetation polygon mapping and classification standards: Malheur, Umatilla and Wallowa-Whitman National Forests. White Paper F14-SO-WP-Silv-56. Pendleton, OR: USDA Forest Service, Umatilla National Forest, Supervisor's Office. 16 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3794798.pdf

Powell, D.C. 2018. How to prepare a silvicultural prescription for uneven-aged management. White Paper F14-SO-WP-Silv-49. Pendleton, OR: USDA Forest Service, Umatilla National Forest, Supervisor's Office. 105 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3794793.pdf

Powell, D.C.; Rockwell, V.A.; Townsley, J.J.; Booser, J.; Bulkin, S.P.; Martin, T.H.; Obedzinski, B.; Zensen, F. 2001. Forest density management: recent history and trends for the Pacific Northwest Region. Tech. Pub. R6-NR-TM-TP-05-01. Portland, OR: USDA Forest Service, Pacific Northwest Region. 21 p. https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3798353.pdf

Puettmann, K.J.; Coates, K.D.; Messier, C. 2009. A critique of silviculture: managing for complexity. Washington, DC: Island Press. 189 p. isbn:978-1-59726-146-3

Quigley, T.M.; Haynes, R.W.; Graham, R.T. 1996. Integrated scientific assessment for ecosystem management in the interior Columbia basin. Gen. Tech. Rep. PNW-GTR-382. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 303 p. http://www.treesearch.fs.fed.us/pubs/25384

Rist, L.; Moen, J. 2013. Sustainability in forest management and a new role for resilience thinking. Forest Ecology and Management. 310: 416-427. doi:10.1016/j.foreco.2013.08.033

Roe, A.L.; Alexander, R.R.; Andrews, M.D. 1970. Engelmann spruce regeneration practices in the Rocky Mountains. Prod. Res. Rep. No. 115. Washington, DC: USDA Forest Service. 32 p. https://archive.org/details/CAT87210675

Smith, D.M.; Larson, B.C.; Kelty, M.J.; Ashton, P.M.S. 1997. The practice of silviculture: applied forest ecology. 9th edition. New York: John Wiley & Sons, Inc. 537 p. isbn:0-471-10941-X

Society of American Foresters. 1981. Choices in silviculture for American forests. Washington, DC: Society of American Foresters. 80 p. isbn:0-939970-09-0

Tappeiner, J.C., II; Maguire, D.A.; Harrington, T.B. 2007. Silviculture and ecology of western U.S. forests. Corvallis, OR: Oregon State University Press. 440 p. isbn:978-0-87071-187-9

Thomas, J.W. 1992. On being professional. Journal of Forestry. 90(2): 12-16. doi:10.1093/jof/90.2.12

Torgersen, T.R. 2001. Defoliators in eastern Oregon and Washington. Northwest Science. 75(Special Issue): 11-20. http://hdl.handle.net/2376/976

USDA Forest Service. 1990. Land and resource management plan; Umatilla National Forest. Portland, OR: USDA Forest Service, Pacific Northwest Region. Irregular pagination. http://www.fs.usda.gov/main/umatilla/landmanagement/planning

USDA Forest Service. 2014. FSM 2400 – forest management; chapter 2470 – silvicultural practices. Amendment no. 2400-2014-1 (March 6, 2014). Washington, DC: USDA Forest Service, National Headquarters (WO). 58 p.

Wickman, B.E. 1992. Forest health in the Blue Mountains: the influence of insects and disease. Gen. Tech. Rep. PNW-GTR-295. Portland, OR: USDA Forest Service, Pacific Northwest Research Station. 15 p. http://www.treesearch.fs.fed.us/pubs/9032

Winthers, E.; Fallon, D.; Haglund, J.; DeMeo, T; Nowacki, G.; Tart, D.; Ferwerda, M.; Robertson, G.; Gallegos, A.; Rorick, A.; Cleland, D.T.; Robbie, W. 2005. Terrestrial ecological unit inventory technical guide. Gen. Tech. Report WO-68. Washington, DC: USDA Forest Service, Washington Office, Ecosystem Management Coordination Staff. 254 p. https://www.fs.usda.gov/treesearch/pubs/53335

Zenner, E.K. 2014. The ongoing story of silviculture on our natural public forestlands. Journal of Forestry. 112(6): 611-616. doi: 10.5849/jof.14-059

APPENDIX: 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 more than 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, and they continuously evolve as an issue matures, experiencing many iterations (versions) 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 perception 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. Ex-

amples 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).

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

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

Paper #	Title
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 on Malheur, Umatilla, and Wallowa-Whitman National Forests
58	Seral status for tree species of Blue and Ochoco Mountains

REVISION HISTORY

April 2012: Since its inception in June of 1992, this white paper has been revised at least a dozen times, but no specific revision history was maintained because a 'revision history' convention was not instituted until the Umatilla National Forest developed a new white-paper format in late 2011. For the April 2012 version, formatting and editing changes were made, and activity coding was adjusted to agree with Appendix B of the FACTS User Guide.

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

February 2018: Minor editing and formatting changes were made. Leave trees was added as a glossary entry, and the coding and descriptions in Table 1 were modified substantially to agree with comtemporary usage in Forest Service Manual 2470, and the FACTS user guide.