Applying Forest Stand Improvement (CPS Code 666), using Specification for Ponderosa Pine/Jeffrey Pine/Sierra Nevada Mixed Conifer, in Mixed Conifer Stands of the Sierra Nevada

Supplemental Information for Planners, Land Owners, and Contractors

Refer to Practice Specification for Forest Stand Improvement-Ponderosa Pine/Jeffrey Pine/Sierra Nevada Mixed Conifer. Previously Specification code known as 666B.

Matthew McNicol, Area 3 Forester, 2011

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Historical data shows that pre-fire suppression forests of the Sierran Mixed Conifer type were dominated by groups of large trees interspersed with both open grass or shrub dominated areas and pockets of tree regeneration. Low and moderate intensity fires created a mosaic of mixed aged stands. As older, decadent trees died and fires opened canopy space, new seedlings established and existing trees in the understory grew into the openings. In essence, the forest was comprised of pockets of mixed species, with each pocket varying in age, as seen below.

The above illustration is taken from the Sierra Nevada Ecosystem Project and depicts a "late succession" stand which has been shaped by frequent, low and moderate intensity fires. More often than not, when applying Forest Stand Improvement using the specification for Ponderosa Pine/Jeffery Pine/Mixed Conifer in the state of California we are working in the dense pockets of 10 to 40 year old stands as depicted in the right and left edges. Where in the past (pre-fire suppression) these stands were thinned by fire and a relatively minor component of the forest as a whole, today they are much more common and contiguous. They create hazards of both fire and health because they carry more trees per acre than available water can support. Continuity of vegetation is high and drought effects are increased.

The Sierran mixed conifer forest type is one of the few forests where all of the species present in regenerating stands will be found in the "climax" or declining stands. Species specific information, most importantly shade tolerance, is crucial background information when determining how a stand will react to treatment. Please see species description at the end of this document. For more species specific info: http://www.fs.fed.us/database/feis/plants/index.html

Types of Stands:

Though there are many variations of the two forest structures discussed here, generally either an even-aged forest, or an uneven-aged forest will be encountered in the Sierra Nevada.

Even-aged means that there is one age class present in the forest. The best example of this is a plantation. For example, a high intensity fire completely burned 80 acres of forestland; it was replanted, and is now 30 years old. Another example would be a timber harvest used a clear cut to remove timber on 20 acres and the site was re-planted afterwards. Species are generally shade intolerant. Even though

trees have may have started to display height dominance (stratify) or there may be different types of trees, they are all one age class.

Uneven-aged means there are 3 or more age classes in the forest. This is what is typically encountered on private forest land in the Sierra Nevada. An example would be a moderate intensity fire creates canopy gaps of differing sizes where both new trees establish and existing trees are released from competition, gaining canopy dominance as a result. Another example would be a timber harvest removed trees individually or in series small groups (1/4 to 3 acres), creating variable canopy gaps which are utilized by different species. Species present are usually a mix of all types. Depending on the intensity of canopy disturbance, the effect, as mentioned above, can be small groups of similar-aged stands, of differing ages within the forest.

Pre-Commercial Thinning:

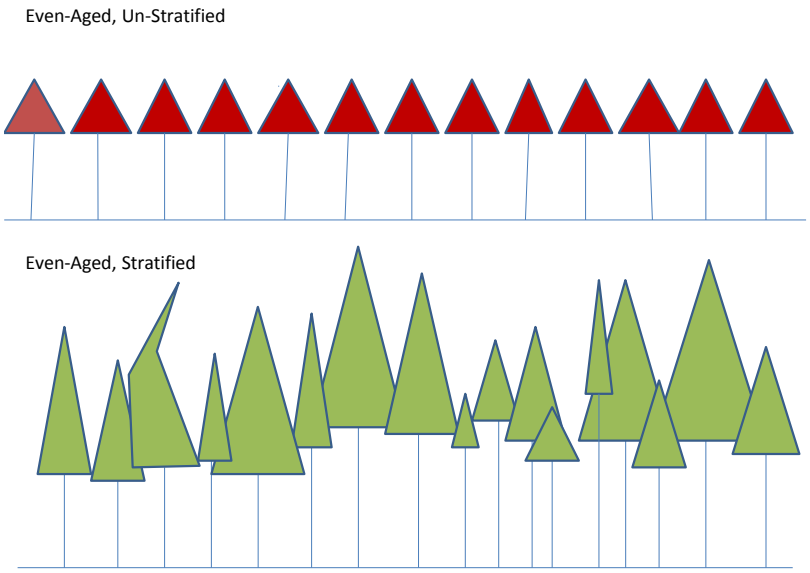
In the state of CA, treating forests using the specification for Ponderosa Pine/Jeffrey Pine/Sierra-Nevada Mixed Conifer is typically limited to removing trees of 2 to 12 inches diameter at breast height (dbh). This is partly due to regulation of timber harvests by the public resource code, which defines a saw log as being 10 inches dbh and over, and partly due to the intent of the practice, which is to treat pre-commercial size classes, since this has a profound effect on the health of the forest but presents a large financial obstacle to the land owner since no revenue is generated from the operation.

Forests, very generally, develop under natural processes by reproducing (trees) in large numbers which are then thinned by a combination of natural agents such as inter-tree competition, biotic agents (insect, fungal, bacterial), or a-biotic agents (fire, snow, wind). As mentioned earlier, fire played a large role in thinning mixed conifer forests and without it, trees tend to grow vigorously until they experience competition with each other. Then growth slows until competition induced mortality occurs (trees stratify and shaded trees die), which creates fuel conditions for damaging, high intensity fires when a fire event does occur. By thinning trees in the 15 to 40 year age class and reducing the number of trees per acre to levels the site can support, vigorous growth is maintained, fuel continuity is reduced, and the best trees are left to grow into the upper canopy and reproduce.

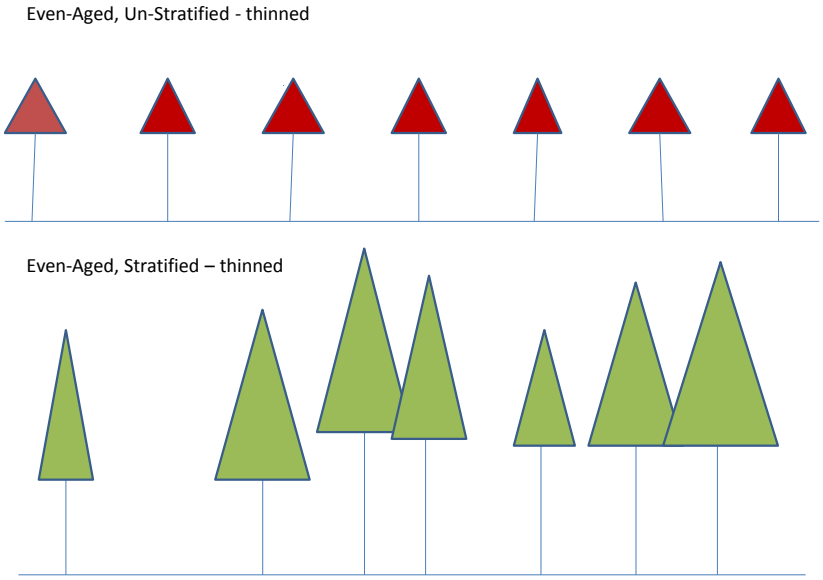
Applying Forest Stand Improvement (Code 666) with Specification: Ponderosa Pine/Jeffrey Pine/ Sierra Nevada Mixed Conifer (PJC):

To determine current Trees Per Acre (TPA) and desired TPA, NRCS commonly uses a 20 tree sample where average diameter and average distance are determined. These values are expressed as a D+X formula and give guidelines for average spacing between trees and ultimately, the number of trees per acre. A description of the D+X method is at the end of this document. It is generally a guide but can be literally applied in young stands which have not stratified. Otherwise, trees of the best form and vigor are retained while weaker, diseased, poorly formed, and dead trees are removed.

The following examples illustrate how applying 666 in accordance to these practice specifications and requirements can effectively improve forest health, reduce vertical and horizontal fuels continuity, and enhance the ecosystem services that forests provide.



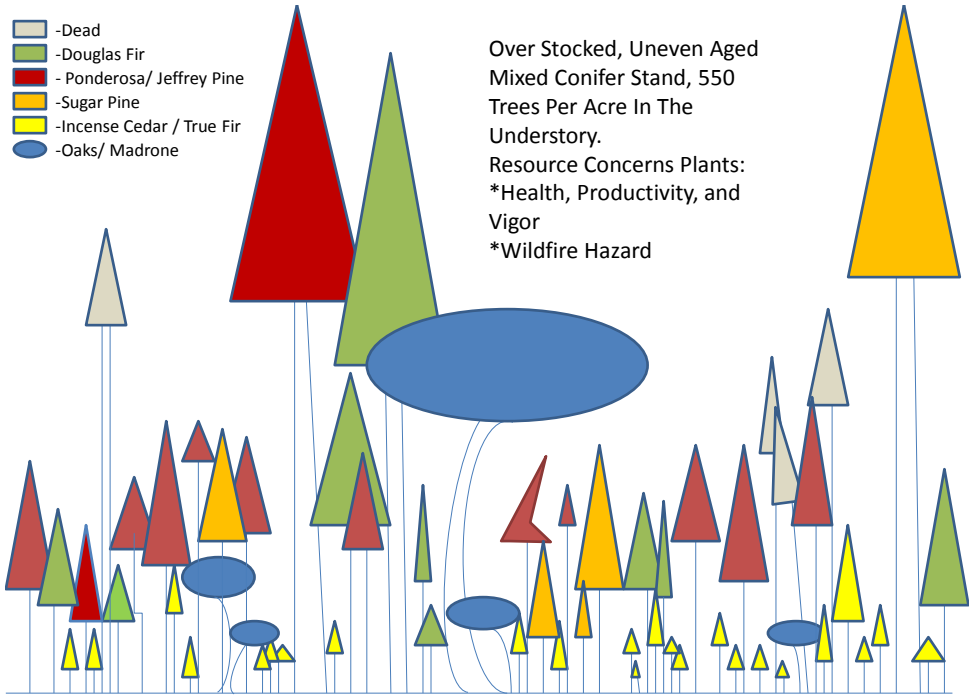
In this example we have 2 even-aged stands, one which has begun to stratify (show height dominance) and a younger stand which has not. Both stands have TPA counts which are too high for the soil productivity and will begin to show significant decreases in diameter growth, eventually resulting in competition induced mortality.



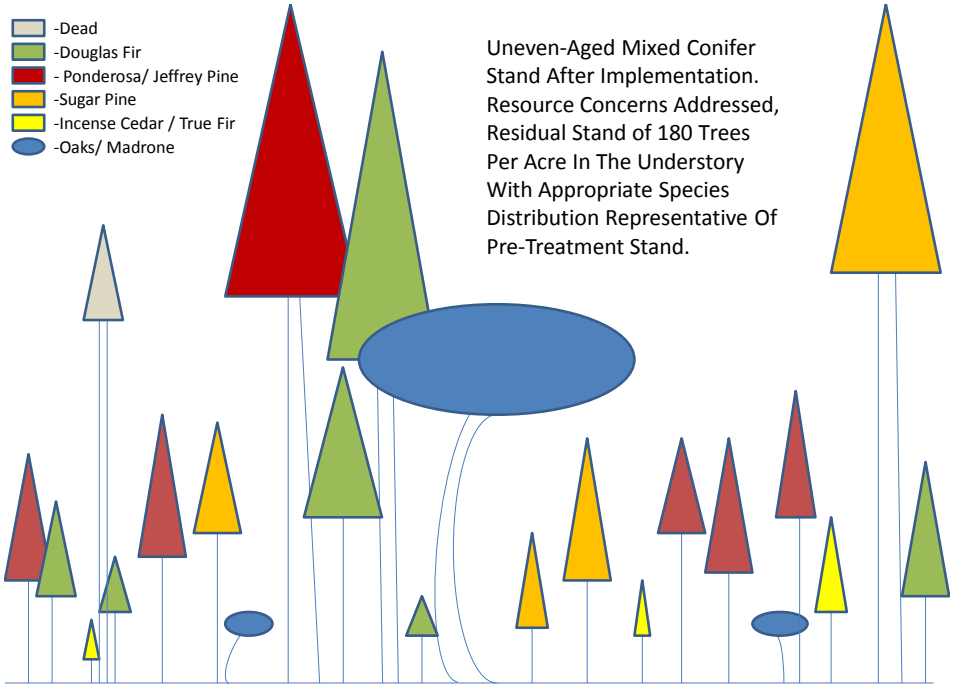
By applying 666 at this point, water, light, and nutrient resources are re-allocated to the trees of best form and vigor. Over topped shade intolerant trees, trees with small crowns, broken tops, deformed stems, and diseased or infested trees are all removed, leaving the best specimens to grow. This maintains the vigorous growth typical of early stand development, increasing resilience to drought, insect, and fire occurrence. As shown in the illustration, stratified stands will almost always be variable and grouped after thinning is applied.

Above is an example of an even aged stand, reforested after a stand replacing fire with ponderosa pine, showing some stratification. D+X inventory results showed a D+0 spacing (8” avg diameter, 8 ft avg spacing) with 650 TPA, where the desired TPA for the site was 190 to 225 which would be a D+7 (8 avg diameter , 15 foot average spacing).

After installing 666, this photograph shows a mix of grouped and evenly spaced trees as selected for qualities listed above.



Above is an example of the more common conditions encountered in the Sierra Nevada; small canopy gap succession creates more complex structural and species diversity in the forest. Below is the stand after 666 has been installed. As illustrated, this thinning leaves the trees of best form with dominant canopy positions for their level of shade tolerance. Also, we can see how this practice breaks up the continuity of vegetation both vertically and horizontally while maintaining a multi-layered stand.



Above is an example of a highly overstocked, un-even aged mix conifer stand. Below is the stand after treatment, showing multiple age classes and species in the residual stand.

As shown by illustrations and photos, there are commonly two or more strata, or layers, in uneven – aged stands. Densities and species distribution are highly variable but some general things to consider for most sites as illustrated:

*Thinning should not focus on removing one stratum of trees, such as indiscriminately removing all lower canopy trees.

*If the species is shade-intolerant it should have open canopy above to grow into. The exception is for stands regenerating under black oak.

*Crowns should be approximately 1/3rd or more of the height of the tree with pointed tops to be able to respond to release from competition.

*Species less represented should be favored for release where applicable. For example, sugar pine will commonly be the least represented in upper and lower canopies and responds well to release in lower strata. When feasible, release sugar pine rather than more common species in the stand.

*Though under historic fire intervals shade tolerant species would mostly be removed in 15 to 40 year stands, small numbers would escape being burned, such as those in rock outcrops. While releasing the shade intolerants is more desirable, incense cedar and/ or white fir of good form and position should be retained in small numbers (up to 10%).

*Broad leaf trees, such as the oaks, pacific madrone, big leaf maple, and alder are essential habitat features for wildlife. Post treatment stands should maintain volumes of broadleaf trees necessary to meet wildlife needs.

*The goal of thinning is not to make the forest fire proof but to create conditions where the forest can burn and continue to thrive afterward, with minimal loss in overstory canopy cover.

Snags:

Snags (standing dead trees) are an immensely important structural feature of forests, particularly managed forests where some later stages of succession are not present or in limited areas. A wide variety of species depend wholly or partly on snags for certain stages of their lifecycle. In the mixed conifer forest type, snags in the 1 to 10 inch size classes do not provide much habitat benefit; they are typically short lived, being broken down by wind and snow fairly rapidly. Under historic fire return interval they would be consumed by fires quickly as well. In the forest of today, snags in this size class present a higher hazard in the form of fuel loading and continuity than they do a habitat benefit and for that reason, should be removed in 666 installations.

Snags 15 to 16 inches in diameter and larger dramatically increase in wildlife habitat value, being large enough to provide denning and nesting structures for cavity excavators and cavity users. For the mixed conifer type, ideally an average of one large diameter snag every 2 acres would exist, all in different levels of height and decay. For this reason, larger snags should not be treated for fuels reduction purposes unless they fall within a strategic suppression zone, a fuel break, fire break, or pose a road side hazard. In stands where there aren't existing snags, look for trees 15 to 18 inches which are defective,

poor form, or diseased which can be recruited as snags by chainsaw or hatchet girdling. Recruiting snags in this manner can often accomplish 666 objectives and create habitat simultaneously.

Species Descriptions

Ponderosa Pine (Pinus ponderosa) – Ponderosa pine is the least shade tolerant of the species in this forest type. It becomes the dominant regeneration component in larger canopy gaps (1/4 acre and larger) and under natural fire intervals was the major tree species of the mix due to its rapid growth and fire resistance with increases in size. Ponderosa pine responds well to thinning into the 100 to 125 year classes depending on the quality of the site. Once a ponderosa pine is over-topped by surrounding trees and loses its dominant position in the canopy, it is not likely to release well (respond to thinning by increasing growth) and should be removed in thinning operations.

Douglas Fir (Pseudotsuga menzesii) – Douglas fir is relatively shade intolerant but will assume a co-dominant to intermediate roles in stand succession. It will be found in larger canopy gaps but can also utilize smaller disturbances to regenerate. Douglas fir is often out grown by ponderosa pine in the early stages of succession but will capitalize on any decline of ponderosa and gain dominant canopy positions, where it will remain into the latest stages of succession. Douglas fir of good form will respond well to thinning of surrounding canopies and is often the species to assume canopy gaps left by the removal of defective ponderosa pine.

Sugar Pine (Pinus lambertiana) - Sugar pine is the tallest and largest of the conifer mix, yet often assumes a less dominant position in the canopy than both Ponderosa pine and Douglas fir. It is almost always found in far fewer numbers than the all other species as well, comprising 10 to 15 percent of the species mix, typically. Considered “moderately shade tolerant” this species has a wide range of regenerative capabilities. It will be found in upper canopies of regenerating stands after large canopy gap creation, or in lower understory strata after very small disturbances in the canopy. When in lower canopy positions it has shown the ability to very effectively utilize available light and increase height growth into later stages of succession. Sugar pine responds well to competition release and like Doug fir, often fills canopy gaps created by removing defective ponderosa pine. Interestingly, though thin barked, sugar pine has evolved with fire by tolerating high levels of girdling (cambium kill) and can maintain normal growth rates after losing up to 50% of the cambium following a fire.

Incense Cedar (Libocedrus decurrens) – Incense cedar is very shade tolerant and at lower elevations (generally 2000 to 4000 feet) is the major understory tree component of the mixed conifer forest. Incense cedar is not dependant on disturbance to regenerate as the species listed above are, though will typically be found regenerating in shady edges of large canopy gaps. It produces large numbers of seed each year which germinate through thick duff layers in shaded conditions, slowly growing towards the upper canopy layers until it gains a foot hold and grows large enough to resist fire. Under natural fire interval this species was heavily thinned due to its thin bark and slow growth. Lack of natural fire interval has resulted in a proliferance of incense cedar in the understory which comprises much of the

“dog hair” stands we associate with high fire hazard in the tree canopies. Incense cedar responds well to thinning and after established will grow well in full sunlight.

White Fir (Abies concolor) – White fir is very similar to incense cedar in regeneration and growth habits but of all the conifers is the least resistant to fire. Becoming more prolific above 4000 feet elevation it is again, associated with high fire hazard as incense cedar is in lower elevations, creating high fuels continuity. White fir responds well to thinning and release.

Black oak (Quercus kelogii) – The major broad leaved tree of the mixed conifer type, it becomes mixed with other oaks (interior live, canyon live, tanoak) and Pacific madrone, depending on latitudinal and elevation location. Generally, these species have a wide range of shade tolerance. They are found in all type and size disturbances and are persistent into the latest stages of succession. The growth habit of broad leaf trees is phototropic, meaning they grow towards available light (horizontally) as opposed to geotropic form of conifers, where growth is always perpendicular to the earth, or vertical. This ultimately means that conifer will always overtop broad leaved trees and canopy position in reference to thinning is not necessarily important. Conifers can grow up through oak canopies and stands naturally grow this way. Broad leaf trees play a crucial role in providing wildlife habitat elements (food and shelter) and should always be perpetuated when present.

D+X Spacing:

D+X spacing is an economical way to thin pre commercial size classes without extensive inventory and marking. Trees to be retained are selected on a crop tree retention basis where dominant and co-dominant trees of good form and health are selected. Then, based on site productivity, trees around it for a certain distance are cut to reduce competition to the residual stand and leave the appropriate number of trees for the site. The following example shows D+X spacing formulation:

The understory strata of an uneven-aged forest is sampled by measuring and recording the species, diameter, and distance of 20 trees. Trees are selected by running a transect in one general bearing and choosing the closest tree within 45 degrees to either side of that bearing. The above information is recorded, starting at sampled tree the bearing is followed to the next closest tree, and repeated until 20 samples are recorded. Take the arithmetic mean of these values. For this stand let’s assume we have an average diameter of 9 inches dbh and the average spacing between trees was 12 feet. To determine the existing D+X we need to solve for X. 9+X=12. X=3, so D+3 is the current spacing.

From the soil survey we determine the Site Index for soil in the unit is 95. Now looking at the tables in "PP/JP/SNMC" specification, we see that the recommended D+X spacing for site index 95 is D+6. For our sampled stand, at D+3, this means the average spacing should be increased by 3 feet. So: 9+6=15, for the recommended D+X spacing.

To determine the change in number of trees per acre this increase in spacing will mean, divide the square footage in an acre by the average spacing squared:

- 43560/ 12 * 12 = 43560/144 = 302 trees per acre
- 43560/ 15 * 15 = 43560/225 = 193 trees per acre

From this we can determine there are approximately 110 trees per acre which should be removed to maintain growth rates the soil is capable of.

Other inventory methods are acceptable to determine stocking in addition. For more details and direction refer to References and Resource Assessment Tools in Section 1 of the eFOTG (https://efotg.sc.egov.usda.gov/).

This is not intended to create perfect spacing between trees in a stand. For example, if two dominant trees, 10 inches in diameter are 11 feet away from each other where D + 6 spacing is required, the two trees should be retained. This spacing constant is a guide to ultimately retain the appropriate amount of trees per acre, which can vary up to 20% + or - per acre and still meet management objectives for health and productivity.

In uneven-aged stands the D+X constant will change with each small, even-aged pocket or will treat distinct understory strata as a separate stand (e.g., advanced Douglas Fir or Incense cedar regeneration under Ponderosa pine overstory). Treating canopy strata differently is important in mixed conifer zones to maintain proper species distribution.

In summation, to apply the 666 specification for Ponderosa Pine/Jeffrey Pine/Sierra Nevada Mixed Conifer, take the following steps:

1. Perform a zig zag transect inventory/ other suitable inventory
2. Determine average spacing and average diameter
3. Determine existing D+X spacing
4. Determine Site Index for the dominant soil(s) in the planning unit in soil survey/ web soil survey/soil data mart
5. Reference tables at the end of specification for Ponderosa Pine/Jeffrey Pine/Sierra Nevada Mixed Conifer.
6. Match Site index of soils in planning unit to site index range in tables to determine the desired D+X spacing
7. Determine excess trees per acre from existing D+X
8. Use data to formulate practice requirements, installation criteria, and cost share rates
9. Consult NRCS forester for assistance