DENSITY MANAGEMENT and CONVERSION TREATMENTS and ATTAINING RIPARIAN RESERVE FUNCTION

Management Direction Concerning Silvicultural Activities Inside the Riparian Reserves

Record of Decision -

Riparian reserves are areas along all streams, wetlands, ponds, lakes, and unstable or potentially unstable areas where the conservation of aquatic and riparian-dependent terrestrial resources receives primary emphasis. The main purpose of the reserves is to protect the health of the aquatic system and its dependent species; the reserves also provide incidental benefits to upland species. These reserves will help maintain and restore riparian structures and functions, benefit fish and riparian-dependent non-fish species, enhance habitat conservation for organisms dependent on the transition zone between upslope and riparian areas, improve travel and dispersal corridors for terrestrial animals and plants, and provide for greater connectivity of late-successional forest habitat (USDA; USDI 1994 pg. ROD 7).

Basis for Standards and Guidelines -

Component four of the Aquatic Conservation Strategy:

Watershed Restoration: A comprehensive, long-term program of watershed restoration to restore watershed health and aquatic ecosystems, including the habitats supporting fish and other aquatic and riparian-dependent organisms. (USDA; USDI 1994, pg. B-12)

Riparian Vegetation

Active silvicultural programs will be necessary to restore large conifers in Riparian Reserves. Appropriate practices may include planting unstable areas such as landslides along streams and flood terraces, thinning densely-stocked young stands to encourage development of large conifers, releasing young conifers from overtopping hardwoods, and reforesting shrub and hardwood-dominated stands with conifers. These practices can be implemented along with silvicultural treatments in uplands areas, although the practices will differ in objective and, consequently, design.

In-Stream Habitat Structures

In-stream restoration, based on the interpretation of physical and biological processes and deficiencies during watershed analysis, can be an important component of an overall program for restoring fish and riparian habitat. In-stream restoration measures are inherently short term and must be accompanied by riparian and upslope restoration to achieve long-term watershed restoration. Maintaining desired levels of channel habitat complexity, for example, may best be achieved in the short term by introducing structures. However, a riparian area with the complete array of functions and processes should provide coarse woody debris to the channel in the long term.

In-stream restoration will be accompanied by riparian and upslope restoration if watershed restoration is to be successful. In-stream restoration, including in-channel structures, will not be used to mitigate for management actions that degrade existing habitat, as a substitute for habitat protection, or to justify risky land management activities and practices. Priority must be given to protecting existing high quality habitat. (USDA; USDI 1994 pg. B-31, B-32)

Summary of Aquatic Conservation Strategy for Watershed Restoration: . . . Silvicultural treatments may be used to restore large conifers in Riparian Reserve . . . (USDA; USDI 1994 pg. B-32)

Standards and Guidelines

TM-1. Prohibit timber harvest, including fuelwood cutting, in Riparian Reserves, except as described below. Riparian Reserve acres shall not be included in calculations of the timber base.

a. Where catastrophic events such as fire, flooding, volcanic, wind, or insect damage result in degraded riparian conditions, allow salvage and fuelwood cutting if required to attain Aquatic Conservation Strategy objectives.

b. Salvage trees only when watershed analysis determines that present and future coarse woody debris needs are met and other Aquatic Conservation Strategy objectives are not adversely affected.
c. Apply silvicultural practices for Riparian Reserves to control stocking, reestablish and manage stands, and acquire desired vegetation characteristics needed to attain Aquatic Conservation Strategy objectives (USDA; USDI 1994 pg. C-31, C-32).

FM-4. Design prescribed burn projects and prescriptions to contribute to attainment of Aquatic Conservation Strategy objectives (USDA; USDI 1994 pg. C-36).

WR-1. Design and implement watershed restoration projects in a manner that promotes long-term ecological integrity of ecosystems, conserves the genetic integrity of native species, and attains Aquatic Conservation Strategy objectives (USDA; USDI 1994 pg. C-37).

FW-1. Design and implement fish and wildlife habitat restoration and enhancement activities in a manner that contributes to attainment of Aquatic Conservation Strategy objectives (USDA; USDI 1994 pg. C-37).

Assessment on how Density Management may affect Riparian Functions
Table DM-1 presents the riparian functions identified by FEMAT (1993), and how they may be affected by:

- no action,
- a conservative density management prescription,
- by a density management prescription designed to put a stand on a trajectory to develop into old-growth,
- by an alder/ brush field conversion.

These four scenarios do not cover all management options for managing inside the Riparian Reserve, but they are attempts to sample a full range of management intensities. The table includes an assessment of whether we can attain an objective to protect each riparian function, and lists function specific recommendations to insure attainment of function protection.

The stand exam data used to project stand development for the no treatment and the two density management scenarios in this assessment were collected at 2 sites on Burnt Ridge inside the South Fork Coos Watershed. Stand development was projected using The Stand Projection System (SPS) version 2.3a. A d/D ratio of 0.8 was used for all density management simulations. Two cutting intensities 120 crop trees/ acre, and 60 crop trees/ acre and a no treatment control were modeled. Additional description of the stands and modeled treatments are in the following chart:

Location	Sect. 10 & 15, T.27S., R.09W. Burnt Ridge by Nickols Drive (FOI # 240574 & pt. 243152)	Sect. 15, T.27S., R.09W. Burnt Ridge, Beyers Way area (FOI # 240592)
management history	1973: PCTed to 12X12 1990: Fertilized	1970: PCTed, spacing not recorded 1990: Fertilized
site index (based on King's 50-year index)	127	115
stand age at time of stand exam	31years (data collected July 1993)	32 years (data collected Aug. 1993)
first stand age modeled	35 years	35 years
initial stocking	259 trees/ acre	291 trees/ acre
natural mortality between time of stand exam and treatment year	mortality from age 35 to age 40 = 11 trees averaging 10.7 inch dbh	mortality from age 35 to age 40 = 10 trees averaging 9.7 inch dbh
stand age at time of density management entry	40 years	40 years
stand development projected to stand age:	200 years	200 years

<u>The reasoning for modeling a 60-tree/ acre density management treatment</u>: Tappeiner *et al.* (1997) observed old-growth trees often averaged 20-inches dbh at age 50 and 40 inches at age 100. This

individual growth rate is higher than observed in plantations today. By running stand development simulations, Tappeiner and co-authors (1997) found 31 to 46 trees/ acre, at age 20-years, resulted in the better fit to observations made in old growth stands with respect to the estimates of total densities and densities of the larger diameter classes. This suggests that the old-growth stands developed with low density, regenerated over time, and had little inter tree competition. This may explain why Spies *et al.* (1988) consistently found low amounts of coarse woody debris in Coast Range old growth stands. For this assessment, we modeled stand development based on leaving 60 trees/ acre after the density management entry assuming we will need about half those trees to become large snags or down logs. The stand management objective is to obtain an array of old-growth characteristics within 40-years after the density management entry. Forty years was picked because we consider 40-year old single cohort stands as suitable dispersal habitat for the Northern Spotted Owl. Where we are culturing for old-growth characteristic, one attribute we want to attain is an understory stand that is at least as permeable for the Northern spotted owl as is suitable dispersal habitat.

Treatments not modeled in the 60-trees/ acre SPS run but that we may want to do, depending on site specific conditions and projected post treatment mortality:

- Manage for snag and coarse woody debris levels consistent with recommendations in this document, and/or the current LSR Assessment as appropriate based on land use allocations, and based on the stand specific conditions.
- Site prep (if needed) and underplant, using primarily shade tolerate tree species, immediately following the initial density management treatment.
- Make additional density management entries to adjust the understory stand stocking levels when the understory trees are approximately age 10 to 15-years and again when they are approximately age 30 to 45-years.
- We may need additional noncommercial treatments, in the overstory, between ages 60 and 200 to recruit snags and down wood. The target overstory stocking level at age 200 is 30 to 35 green trees/ acre. No wood from the overstory exported from the site after the initial density management treatment is completed. Neither the effects of the added growing space obtained by creating snags nor the root competition from the understory stand were modeled.

Treatments not modeled in the 120-trees/ acre SPS run but that we may want to do, depending on site specific conditions and project post treatment mortality:

- Manage for snag and coarse woody debris levels consistent with recommendations in this document, and/or the current LSR Assessment as appropriate based on land use allocations, and based on the stand specific conditions.
- We may need additional snag creation entries for timely obtainment of large snags and down wood.

The above treatment regimens are conceptual. ID teams develop the management prescriptions based on project specific conditions, and experience gain from previous efforts. On sites where we use density management to obtain stocking levels comparable to 120-trees/ acre at age 40, we may need to deviate from the single entry treatment modeled in SPS if we desire to put the stand on a trajectory to develop late-successional characteristics. For example, an additional density management entry, after age 60-years, may be needed to provide additional growing space, or to recruit a multilayer/ multi-aged stand.

<u>Other considerations</u>: The recommendations in Table DM-1 are based on a watershed scale perspective. ID teams should consider recommendations when planning projects. However, ID Teams may find some recommendations are not suitable for some projects based on site specific conditions. Both the Watershed Analysis recommendations and LSR Assessment recommendations apply to project sites in those Riparian Reserves that are also inside the Late-Succession Reserve. Should ID teams find the Watershed Analysis recommendations in conflict with the LSR Assessment Recommendations, the ID

team should decide which recommendations are more appropriate based on project specific conditions. However, treatments that are not covered by LSR Assessment and which have not previously been reviewed and exempted by REO may need to be submitted for REO review.

Note to user: Table DM-1 is formatted to print on 11X17-inch paper and is 13 pages long. If you are viewing a word processor version of this document, you may need to adjust your work processing program's settings so you can view and scroll across 11X17 size pages. You will need a printer that can print 11X17 paper if you want to print a hard copy. If you are viewing a pdf. version of this document using Acrobat Reader then Table DM-1 will print out, at a reduced scale, on landscape oriented 8.5X11 paper.

Table DM-1: ACS Objectives, Riparian Processes and How They May Be Affected by Density Management and Alder/ Brush Field Conversion Treatments in Stands 15 to 80-years Old

Recommendations, statements of conditions under which the Riparian Reserve functions are attained are in the shaded blocks. The words "recommend" and "attain" and related terms are *italicized* to help the reader key into the recommendations and attainment statements.
Tree height, in this table, is the current height of dominant trees in the overstory canopy, excluding emergent trees or carryover legacy trees. Site potential tree height/ distances are specifically referred to as "site potential . . . "

Riparian Reserve function	**Untreated stands**	**Density management based on conventional commercial thinning spacings**	**Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory**	**Alder/ Brush field Conversions**
General affects and considerations: Unless otherwise indicated by the citation, the entries in this column are taken from FEMAT (1993, pages V-26 to 29). See FEMAT for the primary references. Critical distances noted in FEMAT are in **bold type**. Tables DM-5& DM-6 show the heights of riparian trees and critical distances for a range of stand ages, and site indexes.	Analysis based on a SPS run projecting stand development assuming no treatment:	Analysis based on a SPS run projecting stand response to density management at age 40. The post-treatment stocking level was 120 trees/ ac.	Analysis based on a SPS run projecting stand response to density management & understory regeneration at age 40. The post-treatment stocking level was 60 overstory trees/ ac. Additional noncommercial entries are expected (but not modeled) between ages 60 and 200 to recruit snags and down wood leaving 30 to 35 green overstory trees at age 200.	Red alder stand conversion to conifer or mixed stand would begin with a clearcut or a regeneration cut approaching the severity of a conventional clearcut. Brush field conversion to conifer or mixed stand would begin with a site preparation treatment to control the brush.
Root strength [Affected ACS objectives: 3, 4, 5, 6, 8] Half a tree crown diameter is an estimate of extent to which root systems of trees next to a slide scar margin affect soil stability. The contribution of root strength to maintaining streambank integrity also declines at a distance of **one-half crown diameter** (FEMAT 1993) Andrus and Froehlich (1992) in a study of blowbown in buffer strips, on Coast Range sites, found that even when catastrophic blowdown occurred, few trees became sources of sediment entering a stream. Only 7 sites out of 30 had sediment yield increases greater than 1%, and only 2 greater than 6% compared to rough estimates of pre-blowdown sediment yields. This increased sediment yield was almost always associated with upturned rootwads in or at the edge of a stream. The sediment was released when high flows scoured the exposed surface of the rootwad hole and washed soil out of the root mass. Andrus and Froehlich also observed that rootwads, even on very steep ground, rarely slid down hill more than 20 feet (McGreer; Andrus 1992). Ravel from upslope rootwad holes was rarely a source of sediment because the rootwad blocked downward movement of that material. Rootwad scars on steep ground did not appear to expand with time, and the disturbed slopes did not become sites for landslides. Where tree boles entered the stream, they found no cases where a net increase in sedimentation occurred. Releases of streambank sediments caused by flow diversions from the new trees in the stream were compensated for by the extra sediment storage capacity of the new large woody debris.	Closely spaced trees have small crowns and a correspondingly small root mass. Stands in the stem exclusion stage have little understory vegetation that can provide additional root strength. The small individual tree root mass makes trees in dense stands vulnerable to blowdown around where gaps form in those stands, and on the lee side of sharp ridges and stand edges.	Depending on site conditions and pretreatment root mass of the leave trees, thinning may result in a short term increased risk of blowdown. As the crown size increases, with the corresponding increase in root mass and bole thickness, the risk of blowdown or snap out decreases. This results in a greater resistance to blowdown for the stand as a whole compared with its pretreatment condition. The root systems of some severed trees will be sufficiently connected to green trees through root grafts to allow them to live and provide soil stability. The roots of green trees will expand along with the tree crowns replacing those roots that died because of cutting. Understory shrub and herbs will increase in both number and vigor following thinning, thereby providing additionally root mass supplementing the tree roots. Activities more than half a crown width inland from the edge of the stream bank are unlikely to reduce the effectiveness of root strength on maintenance of stream bank stability.	The same as for density management based on conventional commercial thinning spacings. The roots of the overstory trees may not fully colonize the gaps between trees for some years following the density management treatment. Shrub roots and roots of the understory tree that regenerate following the treatment will provide soil stabilization in the wider gaps in the interim. Activities more than half a crown width inland from the edge of the stream bank are unlikely to reduce the effectiveness of root strength on maintenance of stream bank stability.	Activities more than half a crown width inland from the edge of the stream bank are unlikely to reduce the effectiveness of root strength on maintenance of stream bank stability.
Assessment of, and recommendations for attainment of the root strength function:	Stream bank stability, as conferred by root strength, is *attained* with an unthinned stream side stand. The root masses of trees within one-half crown width of the stream bank edge provide protection from stream bank erosion. Trees farther back provide little to no additional benefit for stream bank stability. Even on steep ground, sediment delivery as a result of blowdown, is largely confined to trees within 20 feet of the stream edge and that risk posed by sediment originating from rootwads and rootwad holes are considered minor. Protection of water quality with respect to mitigating the sediment delivery following blowdown of stream side trees *will be attained* when those trees that fall into the stream are retained allowing that woody material to trap sediments.	The following *recommendations are to assure attainment* of stream bank stability as provided by root strength: - On ground with slopes less than 68%, leave all trees with crowns that reach to or over any part of a stream bank. - On ground with slopes equal or steeper than 68%, leave all trees with crowns that reach to or over any part of a stream bank, or within 20 feet of the edge of the stream bank, whichever results in the wider buffer. On slide scarps: Apply the *recommended treatments* for stream banks to those scarps that otherwise are likely to contribute sediment to a stream. Thinning immediately inland from the no thin buffer *will not prevent attainment* of stream bank stability as conferred by root strength. Thinning may benefit those trees just inside the buffer strip by providing them additional growing space resulting in larger crowns and correspondingly increased root masses.	The following *recommendations are to assure attainment* of stream bank stability as provided by root strength: - On ground with slopes less than 68%, leave all trees with crowns that reach to or over any part of a stream bank. - On ground with slopes equal or steeper than 68%, leave all trees with crowns that reach to or over any part of a stream bank, or within 20 feet of the edge of the stream bank, whichever results in the wider buffer. On slide scarps: Apply the *recommended treatments* for stream banks to those scarps that otherwise are likely to contribute sediment to a stream. Thinning immediately inland from the no thin buffer *will not prevent attainment* of stream bank stability as conferred by root strength. Thinning may benefit those trees just inside the buffer strip by providing them additional growing space resulting in larger crowns and correspondingly increased root masses.	The following *recommendations are to insure attainment* of stream bank stability as provided by root strength: Alder conversions: - Where there are no releasable conifers, leave all trees with crowns that reach to or over any part of a stream bank, or within 20 feet of the edge of the stream bank, whichever results in the wider buffer. - Where there are releasable conifers on the stream bank edge do a project by project evaluation considering the risks and benefits of releasing individual trees on the stream banks and tailor the prescription to fit site specific conditions. Brush field Conversions: Leave a 10 to 20-foot no treatment buffer next to stream banks. On slide scarps: Apply the *recommended treatments* for stream banks to those scarps that otherwise are likely to contribute sediment to a stream.

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Large wood delivery to the stream [Affected ACS objectives: 1, 2, 3, 4, 5, 6, 7, 8] The probability that a falling tree will enter the stream is a function of slope distance from the channel in relation to tree height. The effectiveness of stream side forests to deliver large wood to the channel is low at distances greater than approx. **one tree height away from the channel** (FEMAT 1993). McDade *et al.* (1990) found more than 70% of wood debris in streams originated within 66 feet, and found 11% of debris pieces in the channel came from within 1-meter of the stream. All observed hardwood pieces in the stream came from within 82 feet whereas 13 % of all conifer pieces were from a source more than 82 feet from the stream. The maximum observed source was 198.5 feet in an old-growth stand. The distance of origin for in channel debris was significantly greater for streams in old-growth forests, for 3rd order streams, and for conifers as opposed to hardwood debris. There was no significant differences in distance from origin to channel for steep and gentle areas. For this analysis, we define large wood as having a diameter equal or greater than 20 inches. The stand age when the opportunity to use active management to recruit large wood is based on when the average stand diameter is equal or greater than the minimum diameter suitable for a particular type of snag or down wood habitat or riparian function. Optimal attainment of all riparian functions is most likely when trees selected to become down wood and snags are recruited from the middle third and lower third size classes represented in the stand. The alternative of killing the largest fastest growing trees in the stand: -will delay attainment of large green trees [Minimum standards for old-growth Douglas-fir on hemlock sites include ≥8 Douglas-fir/ ac. > 32-in. dbh or 200-yr old. (Old-growth Definition Task Group 1986)] - will almost always select against the trees with the deepest crowns, and thus retard attainment of stands with a deep canopy condition. Deep canopies are a standard used to define old-growth (Old-growth Definition Task Group 1986). - constitutes a form "selection pressure" against the segment of the tree population that is genetically best adapted to the site (Smith 1962). See discussion on tree mortality at the end of this section.	Untreated stands will produce the highest numbers of dead trees. Competition mortality in young stands is from the lower crown classes and/or areas of dense stocking. Both factors result in snag/ down log recruitment from among the smaller diameter trees (Peet; Christensen 1987). This will result in large contributions of organic matter. However, little of this organic matter produced during the first 120 to 180-years of the stands' existence will be suitable for long-lasting large structure. On the SI 127 site, 20 in.+ average size dead trees attained by age 120. On the SI 115 site, 20 in.+ average size dead trees attained by age 180. On the SI 127 site, 20 in.+ ave. live trees attained by age 70. On the SI 115 site, 20 in.+ ave. live trees attained by age 110.	Conventional thinning practices and spacings remove mainly trees that would have died in the coming 5 to 20 years from competition mortality had there been no thinning. As the stand grows, recaptures the site and competition mortality begins again, the trees that die will be larger following a thinning treatment than had there been no thinning. Although, the dead trees will be larger than those recruited from unthinned stands, few of those dead trees will be large enough to provide long-lasting large structure during the first 80-years of the stands' existence. On the SI 127 site, 20 in.+ ave. size dead trees attained by age 80. On the SI 115 site, 20 in.+ ave. size dead trees attained by age 90. On the SI 127 site, 20 in.+ ave. live trees attained by age 60. On the SI 115 site, 20 in.+ ave. live trees attained by age 70.	The wide spacing employed in this treatment will produce 20+ inch trees in a shorter period than will conventional commercial thinning or by leaving the site not treated. Most natural recruitment of large wood will be from forms of mortality other than competition mortality. During the first 100-years, fewer trees will fall into the stream or the riparian zone compared with an untreated stand but a higher percent of those trees will be larger than 20 inches. By actively managing the understory stand stocking levels, we can also obtain 20+ inch dbh trees from the understory in approximately 70 years after the overstory density management treatment was completed. If the understory stand regenerates at a high density, and there is no subsequent disturbance/ management then there may be few 20+ inch trees produced in the understory for 200 years. On the SI 127 site, 20 in.+ ave. size dead trees attained by age 50. On the SI 115 site, 20 in.+ ave. size dead trees attained by age 60. On the SI 127 site, 20 in.+ ave. live trees attained by age50. On the SI 115 site, 20 in.+ ave. live trees attained by age 60.	Alder stands become candidates for conversion, in part, because they are unable to provide large durable wood to the streams or riparian zone. The conversion process reduces short term wood contributions to the stream or riparian zone, with a long term benefit of attaining conifers that can contribute large durable wood in the future. In the absence of disturbance, the alder stands with a salmonberry understory, will become salmonberry brush fields when the alders die. Salmonberry bush fields are a "climax communities" that are unable to contribute wood to the streams. Trees cannot establish in a salmonberry brush field without a disturbance that frees growing space (Emmingham; Hibbs 1997; Hemstrom; Logan 1986). **Estimated Time Required for Planted Seedlings or Saplings to Be Released From Overtopping Vegetation or Hdwd-Dominated Canopy, and to Reach 18- or 24-ins**. Table from Emmingham and Hibbs (1997) **Management approach** / **Age (years) to attain:** conifers free to grow* / 18-in dbh conifers / 24-in. dbh conifers **Clearcut & plant conifers** With intensive thinning: 3 / 40 / 55 No thin (McArdle et al. 1961): 10 / 80 / 120 **Thin hdwd-dominated stand** Release 15-ft tall suppressed conifers w/ aggressive thinning: 60 / 80 / 105 Release 15-ft tall suppressed conifers w/ minimal thinning: 125 / 150 / 180 Planting conifers w/ aggressive thinning: 75 / 95 / 120 Planting conifers w/ minimal thinning: 140 / 165 / 195 * Free to grow in the clearcut defined as growing freely above competing shrubs or herbs. Free to grow in the hdwd-dominated stands defined as conifers growing to 100-ft tall, which is a common height of alder canopies.
Assessment of, and recommendations for attainment of large wood delivery to the stream function: Assessment/ recommendation applicable to all treatments: Obtaining down wood or snags by killing or cutting conifer trees that rank among the largest third in the stand *will allow more rapid attainment of large down wood and snags but will retard attainment of other LS/OG attributes.*	Attainment of large wood (20 in.+ dbh) delivery to the stream/ riparian zone via natural mortality from an untreated stand is unlikely before the stand reaches 120 to180-years old. Earlier attainment of large wood delivery from an unthinned stand, through active management, is practical after the stand reached 70 to 110-years old (time when the average tree diameter ≥20 inches dbh).	Attainment of large wood (20 in.+ dbh) delivery to the stream/ riparian zone via natural mortality from a treated stand likely when the stand is 80 to 90-years old. Earlier attainment of large wood delivery, through active management, is practical after the stand is 60 to 70-years old. A no-treatment buffer would assure attainment of small wood entering the stream. A wide no-treatment buffer would delay attainment of large diameter trees that would likely to fall into the stream. Retaining a half tree height no-treatment buffer to meet other passive restoration objectives *would delay attainment* of large wood delivery to the stream. *Recommend*: Depending on site specific conditions, a density management treatment of this intensity (a conventional commercial thinning spacing) within a half tree height of the stream, combined with a buffer designed to protect stream bank stability (width = half a tree crown diameter) *will shorten the delay in attainment of large diameter trees and still allow for attainment of other riparian reserve functions.* If stand & site conditions allow, consider cutting and leaving some of the surplus conifer stems at the time of the density management treatment to provide small and medium size wood in the streams and riparian zone for the interim until the stand can contribute large wood on its own.	Attainment of large wood (20 in.+ dbh) delivery to the stream/ riparian zone via either natural mortality or active management from a treated stand likely when the stand is 50 to 60-years old. A no-treatment buffer would assure attainment of small wood entering the stream. A wide no-treatment buffer would delay attainment of large diameter trees that would likely to fall into the stream. Retaining a half tree height no-treatment buffer to meet other passive restoration objectives *would delay attainment* of large wood delivery to the stream. *Recommend:* Depending on site specific conditions, a density management treatment of an intensity similar to a conventional commercial thinning spacing, within a half tree height of the stream, combined with a buffer designed to protect stream bank stability (width = half a tree crown diameter) *will shorten the delay in attainment of large diameter trees within the half tree height distance of streams and still allow for attainment of other riparian reserve functions. Thinning to a wide spacing farther back from the stream will allow rapid attainment of large diameter trees that can contribute large wood to the stream and riparian zone in the future.* If stand & site conditions allow, consider cutting and leaving some of the surplus conifer stems at the time of the density management treatment to provide small and medium size wood in the streams and riparian zone for the interim until the stand can contribute large wood on its own.	Attainment of large wood delivery to streams/ riparian zone from a converted site depends on initial stocking levels, timeliness of maintenance treatments, and density management treatment(s) applied to the new stands. *Recommend:* Cut and leave some level of red alder stems at the time of the conversion to provide nondurable small and medium size wood in the streams and riparian zone for the interim before the subsequent conifer stand is ready to supply down wood. Retain a level of wood consistent with the objective of attaining sufficient plantable ground for establishing a conifer or mixed stand. To the extent practical, the wood retained on the riparian zone should also be within the range observed by Ursitti (1990). The amount of wood retained on upland sites, within the Riparian Reserve, should be within the range observed by Spies *et al.* (1988).

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Large wood delivery to the riparian area [Affected ACS objectives: 1, 2, 8, 9] Large down wood is recruited into the riparian areas from riparian forests and from upslope forests. The effectiveness of upland forest to deliver large wood to the riparian area is naturally expected to decline at distances greater than approximately **one tree height from the edge of the riparian area** (FEMAT 1993). Minimum standards for old-growth Douglas-fir on hemlock sites include CWM ≥15 tons/acre including 4 pieces ≥ 24 inch dbh and > 50 ft long (Old-growth Definition task Group 1986). See discussion on tree mortality at the end of this section. The discussion on the timing of active management to recruit "large wood delivery to the stream" section of this table also applies to obtaining large wood delivery to the riparian zone through active management.	The same discussion as for "large wood delivery to the stream." The average newly dead tree dbh will not equal or exceed 24-inches before the stand is 200-years old on the SI 115 site, and will be attained by age 190-years on the SI 127 site. Opportunity to recruit 24-inch wood from among the average size green trees using active management begins at stand age 120-years on the SI 127 site and 170-years on the SI 115 site.	The same discussion as for "large wood delivery to the stream." The average newly dead tree dbh will equal or exceed 24-inches at stand age 160-years on the SI 127 site, and will be attained by age 200-years on the SI 115 site. Opportunity to recruit 24-inch wood from among the average size green trees using active management begins at stand age 90-years on the SI 127 site and at age 120 on the SI 115 site.	The same discussion as for "large wood delivery to the stream." The average newly dead tree dbh will equal or exceed 24-inches at stand age 70-years on the SI 127 site. Opportunity to recruit 24-inch wood from among the average size green trees using active management also begins at stand age 70-years on both the SI 127 site and the SI 115 site. The SPS model shows 24+ inch morality occurring sometime after age 80 on the SI 115 sites. The SPS model reports the average dbh of the trees that have died in the 5 years before each report date, but only when the mortality averages one or more trees/ acre for that 5-year period. After age 80, the SPS model predicted a mortality rate of less than 1 tree dying/ acre per 10-year report period.	The same discussion as for "large wood delivery to the stream." The timing for recruiting large wood to the riparian zone is the same as for "large wood delivery to the stream."
Assessment of, and recommendations for attainment of large wood delivery to the riparian zone function: Assessment/ recommendation applicable to all treatments: Obtaining down wood or snag by killing or cutting conifer trees that rank among the largest third in the stand *will allow more rapid attainment of large down wood and snags but will retard attainment of other LS/OG attributes.*	Attainment of 24 in.+ dbh wood delivery to the riparian zone via natural mortality from an untreated stand is unlikely before the stand reaches 190-years on the SI 127 site. On the SI 115 site, regular mortality among 24inch+ trees occurs after stand age 200-years. Earlier attainment of 24 inch+ diameter wood delivery from an unthinned stand, through active management, is practical after the stand reached 120 to 160-years old.	Attainment of 24-inch+ dbh wood delivery to the riparian zone via natural mortality from a treated stand is likely when the stand is 160-years old on the SI 127 site, and 200-years old on the SI 115 site. Earlier attainment of 24-inch+ diameter wood delivery from a conventionally thinned stand, by actively killing trees from among the average-size trees on the site, is practical after the stand reaches 90-years old on the SI 127 site and 120-years on the SI 115 site.	Attainment of 24-inch+ dbh wood delivery to the riparian zone via natural mortality from a treated stand is likely when the stand is 70-years old on the SI 127 site. Additional 24-inch diameter wood may be actively recruited by killing average-size trees on the site when the stand is at least 70-years old on both the SI 127 and SI 115 sites.	The same as for "large wood delivery to the stream"

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Leaf & other particulate organic matter input to stream [Affected ACS objectives: 2, 6, 9] The distance away from a stream from which leaf litter input originates depends on site-specific conditions. Thus, the effectiveness of flood plain riparian forests to deliver leaf and other particulate organic matter decreases at distances greater than approximately **half a tree height away from the channel**. The FEMAT scientists were unaware of studies examining litter fall from riparian zones as a function of distance of litter source to the channel. However, a study on the composition of benthos invertebrate communities in streams with riparian buffers greater than 100 feet wide found those communities indistinguishable from those in streams flowing through unlogged watersheds (FEMAT 1993). Conifer litter enters the stream through the year whereas litter from deciduous trees shrubs enter in a fall season pulse. Hardwood litter input is most likely along: - 3rd order and larger streams below 1,800-feet elevation, particularly those with a flood plain. - Steep unstable/ slide prone 1st & 2nd order draws and headwalls. Hardwood litter input also comes from alders that occupy disturbed sites. These include road cuts and fills, compacted soils and sites where harvest activities unintentionally converted conifer stands to alder stands. For background information, see Bilby's (1997) article "Aquatic-Terrestrial interactions in Pacific Northwest" in the Cope Report 10(1&2): 9-13, for a summary discussion on disturbance, diversity and productivity of aquatic communities.	Leaf litter input to a small stream from a stand in the stem exclusion stage may be limited to litter from one to a few tree species. In many stands, above 1,800 feet elevation, the litter input is primarily from conifers and predominantly from Douglas-firs. The main exceptions are red alder-dominated slide prone draws. Leaf litter input to larger streams, where the stand is unable to form a closed canopy over the stream, will include litter from stream side shrub and herb vegetation that can survive on the side light reaching the forest floor from the canopy gap over the stream.	In many stands, above 1,800 feet elevation, the litter input is primarily from conifers and predominantly from Douglas-firs. The main exceptions are red alder-dominated slide prone draws. Litter input from hardwoods can be reduced if hardwoods are preferentially selected as cut trees. Conversely, preferentially retaining hardwoods may increase litter input to streams from hardwoods and provide those hardwoods additional growing space by removing competing conifers. Thinning levels that increase light levels received by stream side vegetation will result in greater understory vegetation vigor and growth in those locations. That, in turn, will increase the litter contributed by the stream side vegetation to the stream. Increased understory growth and vigor away from the stream edge will have little impact on litter entering the stream. Thinning treatments that lead to greater stand complexity next to a stream will increase the array of niches for insects and other arthropods, and for epiphytes. This in turn leads to a greater variety in types of organic matter that can fall into the stream.	Same discussion as for density management based on conventional thinning spacings. Broadleaf trees as a group respond to wide thinning spacing by producing abundant adventitious sprouts, all along the tree bole changing the appearance of the tree.	When compared with conifer litter, red alder litter decomposes more rapidly, and provides a more nutritious but less consistent food source for shredding macroinvertebrates (Bilby 1997). A successful red alder stand conversion to conifer can greatly reduce or eliminate the source of alder leaf litter from the converted site. Establishing a dense conifer stand that completely overtops a narrow stream will greatly reduce litter input from stream side herbs and shrubs during the period the stand is in the stem exclusion stage. Total removal of all canopy shading would reduce litter input, and increase light received by a stream. This will cause an increase in algal productivity thus favoring grazing macroinvertebrates (Bilby 1997).
Assessment of, and recommendations for attainment of the leaf & other particulate organic matter input to stream function:	Forgoing stand treatment *will not prevent attainment* of leaf litter in the stream. Depending on the species composition of the stand, and the canopy closure directly above the stream, forgoing stand treatment *may retard attainment* of a diverse range of litter entering the stream in the near term compared with stands actively managed to attain multiple canopy layers and diverse plant species composition. Small streams flowing through stands that are in the stem exclusion stage do not receive enough light to allow for primary production and thus limits aquatic grazing insects.	Density management *will not prevent attainment* of leaf litter in the stream. *Attainment of a diverse range litter entering a stream may be assured or retarded depending on the density management prescription:* - Wide no treatment buffers next to streams *may retard attainment* of herb and shrub litter input in the near term if the part of the stand adjacent to and directly over the top of the stream is in the stem exclusion stage. - Retention of and providing growing space for a diverse range of trees species within a distance of the stream equal to half a tree height *will assure attainment* of a diverse range litter entering the stream. This greater streamside stand diversity may also allow for a greater diversity of epiphytes and insects that could potentially fall into the stream.	The *attainment and recommendations for this intensity of treatment are the same as for "density management based on conventional commercial thinning spacing."* In addition: Activities, within a distance of the stream equal to half a tree height, to obtain an understory stand composed of trees unrepresented or poorly represented in the overstory *will assure attainment* of a diverse range of litter entering a stream.	Brush field conversion prescriptions, which include streamside buffers intended to protect stream bank stability *will not prevent attainment* of leaf litter into the stream. Alder conversion prescriptions, with a stream side buffer width that is only intended to protect stream bank stability may result in a short term reduction of litter input, but *will not prevent long term attainment* of leaf litter into the stream. ID teams may identify sites where a short term reduction of litter input may be acceptable in order to gain long term benefits for other Riparian Reserve functions. Alder conversion prescriptions, which include stream side buffers on both sides of the channel intended to provide shade for the stream, *will assure attainment* of leaf litter into the stream but *may retard attainment* of other Riparian Reserve functions on some sites. The *long term attainment* of a diverse range litter entering a stream is contingent on subsequent density management treatments.

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Water quality: temperature as affected by shade [Affected ACS objectives: 1, 4, 9] Effectiveness of streamside forest to provide shade varies with topography, channel orientation, extent of canopy opening above the channel, and forest structure, particularly extent of both under- and overstory. In the Oregon Coast Range, riparian buffers of 100 feet or more have been reported to provide as much shade as undisturbed late-successional/ old growth forests (FEMAT 1993). A 100-foot distance is approximately equal to **half a tree height** for a late-successional/ old growth tree. Brazier and Brown (1973) found angular canopy density correlated well with stream temperature control. The angular canopy density is measured for the solar angle during the minimum flow period. For streams in their study, the maximum angular canopy density (maximum shading ability) was reached within an 80-foot width, with 90% of maximum reached in within 55-feet. Brazier and Brown observed the efficiency of heat blocking increased rapidly with increasing buffer strip width, up to 30-feet, before leveling off at a maximum, at around 40-feet. Along small streams, understory species can provide shade as effectively as merchantable trees (Brown *et al.* 1971.) On Coast Range sites, where no buffers were left following logging, riparian vegetation regrowth along small streams (about 10 feet wide) will provide shade levels equivalent to mature stands in 10 years (Summers 1982 cited in Skaugset 1992). Another study showed 50% of a Coast Range stream shaded within 5 years of harvesting and burning (Beschta *et al.* 1987). Our knowledge on the effect of shade on water temperature is based on comparing stream temperatures under forested conditions to a denuded state. It is also based on research to establish how wide a buffer has to be to negate the affect of an adjacent clearcut on stream temperature. We know of no peer reviewed publications on the affect of filtered light (as influenced by different levels of stand density/ crown closure) on stream temperature in the Douglas-fir region.	Stands in the stem exclusion stage allow little light to penetrate to the forest floor. The amount of light reaching the forest floor is less than at any other stage of stand development, as indicated by the relative amounts of understory vegetation. (Both overstory stands and later understory stands can go through a stem exclusion stage exerting similar affects on understory vegetation). Intuitively, solar heating of streams flowing through a stand in the stem exclusion stage is less than experienced by a stream flowing through an old growth stand that has sufficient light penetration to support a herb and shrub layer. Eventually the stand will come out of the stem exclusion stage. There after, wind caused crown to crown contact and abrasion will result in light gaps around all of the tree crowns. This will then allow sufficient skylight to reach the forest floor to support a herb and shrub layer.	Intuitively, solar heating of streams flowing through a stand thinned to a target density designed to maximize wood production may be comparable to that experienced by many streams flowing through a mature forest. This is based on observing that both commercially thinned stands and mature stands having enough light penetration to the forest floor to support a shrub/ herb layer but not enough light to sustain long term survival and growth of understory trees (barring a stand disturbance that further opens the overstory). SPS predicted the crown ratios 10 years after treatment to be 57% on the SI 127 site and 61% on the SI 115 site. This is compared with 50% and 49%, respectively at stand age 40 before treatment. These deeper crowns, which combined with 20-feet of height growth on the better site and 17-feet on the poorer site during that 10-year period, results in a deeper crown. The deeper crowns increase the crowns' ability to intercept the direct sunlight that enters the stand at an angle. The gaps between the crowns, resulting from thinning, allow the indirect skylight to penetrate the thinned stand in the same way that crown gaps created by wind abrasion eventually allow light to enter an unmanaged stand that is coming out of the stem exclusion stage. Stand treatments on the north side of streams that flow in either a westerly or easterly direction will not affect stream shading and therefore do not affect stream temperatures. Treatments next to streams that are dry in the late summers will not affect down stream temperatures. Narrow streams that are fully shaded due to intrenchment, or a dense overtopping shrub layer may be little affected by treatments to adjacent overstory stands, with respect to stream temperature as affected by shade. On other sites, leaving an untreated or lightly treated buffer next to the stream may avoid short term impacts.	Opening the stand to 60-trees/ ac. along the stream edge will increase the solar radiation reaching the water surface. The amount of increase cannot be predicted based on stem count (crown depth and tree height are also factors controlling the amount of light entering a stand). However in the short term, the retained canopy will still provide partial shade for the stream. Since treatment objective is to establish an understory stand of trees, a minimum light penetration of 30% is needed to get the understory trees established. Considering that the overstory crowns will expand to reoccupy the canopy gaps, the optimal initial target for light penetration to the forest floor may be closer to 60% of full sun light to allow for long term growth. (Chen & Hibbs 1999). Where this density management approach is used next to a small stream, the understory regeneration may provide approximately 50% of full shade 5 years after treatment. The new understory stand will provide shade levels equivalent to mature stands in 10 years. This suggests the combined shade from both the overstory and the understory will approach the equivalent of that provided by old growth in less that 10 years, and potentially as short as 5 years. SPS predicted the crown ratios 10 years after treatment to be 61% on the SI 127 site and 63% on the SI 115 site. This is compared with 50% and 49%, respectively at stand age 40 before treatment. SPS predicts the overstory stands on both the higher and the lower site stands used in this analysis will retain crown ratios of 56% or deeper until at least age 200-years. Stand treatments on the north side of streams that flow in either a westerly or easterly direction will not affect stream shading and therefore do not affect stream temperatures. Treatments next to streams that are dry in the late summers will not affect down stream temperatures. Narrow streams that are fully shaded due to intrenchment, or a dense overtopping shrub layer may be little affected by treatments to adjacent overstory stands, with respect to stream temperature as affected by shade. On other sites, leaving an untreated or lightly treated buffer next to the stream may avoid short term impacts.	An alder conversion next to a stream, where no streamside buffer is retained, may result in solar radiation levels approaching 100% reaching the stream surface. Site conditions can cause the actual solar radiation levels, and subsequent water warming, to be less. Stream side shrubs and woody debris in or over the stream will provide shade. Topographic shading and shading from stands to the immediate south and west of the stream can be very valuable for maintaining cool temperatures. Retaining scattered alders on the conversion site next to a stream can provide some benefitting shade with respect to water temperatures. However, for a conversion treatment to succeed, the retained overstory must be open enough to allow light levels on the forest floor to exceed 60% of full sunlight. Retaining higher overstory canopy closures wold slow growth of the underplanted conifers and require frequent retreatments to maintain light penetration to the forest floor. Along small streams, regenerating trees can provide approximately 50% of full shade 5-years after treatment, and will provide shade levels equivalent to mature stands in 10 years. Stand treatments on the north side of streams that flow in either a westerly or easterly direction will not affect stream shading and therefore do not affect stream temperatures. Treatments next to streams that are dry in the late summers will not affect down stream temperatures. On other sites, leaving an untreated or lightly treated buffer next to the stream may avoid short term impacts.

Riparian Reserve function	**Untreated stands**	**Density management based on conventional commercial thinning spacings**	**Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory**	**Alder/ Brush field Conversions**
Assessment of, and recommendations for attainment of the water quality: temperature, as affected by shade function of the Riparian Reserve: *Assessment/ recommendation applicable to all treatments*: Should blowdown occur next to a stream, retaining those trees that fall across or into the stream to the extent consistent with protecting habitat and down stream values. Retention of blowdown material in the streams will allow that material to provide dead shade and by that partially mitigate the loss of shade from standing trees.	Protection of water quality, with respect to temperature as conferred by shading, *is attained* with an unthinned stream side stand.	Density management treatments of this intensity *will not prevent attainment* of stream temperature protection through shading: - on sites next to streams that are dry in the late summer. - in stands on the north side of streams that flow either in an easterly or westerly direction. These sites are best identified at the project scale. Treating certain other sites may not prevent attainment of stream temperature protection through shading because of topographic shading, deeply incised channels, or heavy understory vegetation. Those sites are identifiably only through site specific evaluation. On all other sites, a no treatment buffer with a slope distance width equal to half the average height of the trees inside the buffer will *assure attainment* of stream temperature protection through shading. Given a half tree width no-treatment buffer concept is based on the width needed to protect stream temperatures from the full sunlight conditions in an adjacent clearcut, a buffer of this width provides a measure of protection beyond what is necessary for a project where a partial canopy is retained in the treated area. In the case where a conservative to moderate thinning is done down to the stream edge, the amount of light reaching the stream surface may be in the range on natural variability for mature wild stands. Therefore, project ID teams have some flexibility to prescribe treatments for land within half a tree height of a stream to *assure attainment of the CWD and late-successional habitat Riparian Reserve functions without preventing attainment of the stream shading function in the long term*. Proposals to treat within this zone should be based on a project specific evaluation. Possible projects may include recruiting large wood to the stream, snag creation, individual tree release or applying a spacing prescription within the range commonly used for commercial thinning See the note in the "density management with the objectives of rapid diameter growth for overstory treess and regenerating an understory" column to the left for the distinction between conservative and moderate thinning.	Density management treatments of this intensity *will not prevent attainment* of stream temperature protection through shading: - on sites next to streams that are dry in the late summer. - in stands on the north side of streams that flow either in an easterly or westerly direction. These sites are best identified at the project scale. Treating certain other sites may not prevent attainment of stream temperature protection through shading because of topographic shading, deeply incised channels, or heavy understory vegetation. Those sites are identifiably only through site specific evaluation. On all other sites, a no treatment buffer with a slope distance width equal to half the average height of the trees inside the buffer will *assure attainment* of stream temperature protection through shading. Given the half tree width no-treatment buffer concept is based on the width needed to protect stream temperatures from the full sunlight conditions in an adjacent clearcut, a no treatment buffer of this width provides a measure of shade protection beyond what is necessary for a project where there is partial canopy retention. Therefore, project ID teams have the flexibility to prescribe treatments for land within half a tree height of a stream to *assure attainment of other Riparian Reserve functions without preventing attainment of the stream shading function in the long term*. Proposals to treat within this zone should be based on a project specific evaluation. Possible projects may include recruiting large wood to the stream, snag creation, individual tree release or density management using a conventional commercial thinning spacing. See the note below for a discussion on what spacings fall within the range of conventional commercial thinning spacing. Note: Densities of 80 to 120 trees/ acre are within the range commonly prescribed for conventional commercial thinnings. Thinning 40-year old stands, which had been previously precommercial thinned, down to 80 trees/ acre is within the range of conventional commercial thinning practice where the objective is to manage for a combination of high stand volumes, full stocking levels and large piece size. Thinning 40-year old stands, which have had no previous thinning treatment, to 120 trees/ acre is also within the range of conventional practice where there is a risk of blowdown. Depending on the average leave tree size, crown depth, and site quality, a prescription to leave 100 to 120 trees/ acre is considered a conservative spacing and a prescription to leave 80 to 90 stems is moderate intensity thinning when treating 40-year old stands. Thinning 80-year old stands to 80 trees/ acre is considered a middle of the road to conservative treatment.	Alder/ brush field conversion to conifer *will not prevent attainment* of stream temperature protection through shading: - on sites next to streams that are dry in the late summer. - in stands on the north side of streams that flow either in an easterly or westerly direction. These sites are best identified at the project scale. Treating certain other sites may not prevent attainment of stream temperature protection through shading because of topographic shading, deeply incised channels, or heavy understory vegetation. Those sites are identifiably only through site specific evaluation. On all other alder conversion sites, a no-treatment buffer with a slope distance width equal to half the average height of the trees inside the buffer *will assure this management activity will not prevent near term attainment* of stream temperature protection through shading. Protection buffers of this width may retard attainment of other Riparian Reserve functions on some sites. Therefore, ID teams may prescribe different buffer widths or some level of active management within on the ground within a half tree height distance from the stream based on site specific conditions. Individual tree release inside the streamside buffer is expected to help attain other Riparian Reserve functions, and may either result in a short term reduction, or have no affect on shading. Individual tree release *will not prevent attainment* of stream temperature protection in the long term. On all other brush field conversion sites, the 10 to 20-foot no treatment buffer intended to provide stream bank root strength protection will also *assure attainment* of stream temperature protection on small streams and avoid a short term additional decline in shading next to treated sites. Promptly reestablishing forest cover on land within a slope-distance of the stream equal to half the height of a site potential tree *will assure long term attainment* of stream temperature protection through shading.

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Riparian microclimate [Affected ACS objectives: 1, 8, 9] Microclimate is likely influenced by widths of both the riparian area and the stream channel. Riparian zones along larger streams consist of 2 distinct parallel bands of vegetation separated by the stream channel. By contrast, channels of lower order streams are so narrow that a functionally continuous canopy usually exists above the stream. The FEMAT authors are unaware of reported microclimate observations in riparian zones but Chen (1991) documented microclimate changes in old-growth stands as a function of distance from a clearcut edge. These patterns vary substantially with season, time of day, edge aspect, and extent of tree removal in harvested stand (FEMAT 1993). Chen used stands on uniform ground that did not exceed 10 degree slopes. The reader should exercise caution in extrapolating Chen's findings to lower slopes and riparian sites that are partially protected from winds and direct sun by deeply incised complex topography. A clearcut next to old-growth can result in a change in humidity and wind speed at distances into the forest interior equal up to 3 tree heights (Chen 1991). This represents the extreme. Edge orientation plays a critical role for all microclimate variables. Gradients generally are longest and steepest on partially clear warm dry days on southwest-facing edges. Wind penetration is highly related to stand density and understory structure. Wind may reach deep into a stand where tree branches are high and the understory sparse, and may penetrate only a short distance where the canopy is continuous and understory dense (Chen *et al.* 1995). Chen (1991) found edge influence into old-growth stands on biological variables varied dramatically from essentially none to up to 450 feet for small (0-10 cm) hemlock seedlings. See discussion edge effect at the end of this section.	Untreated stands remain in the stem exclusion stage longer than thinned stands. The high competition and low light penetration into these stands will result in low crown ratios and an exclusion of an understory stand. Therefore, a clearcut edge next to an untreated stand may result in a deeper penetration of wind and light into the stand from the edge compared with a thinned stand with deep crowns, or a stand with a well-developed understory component. The low light levels under a stand in the stem exclusion stage do not allow for establishment and growth of an understory stand. Successful understory stand recruitment is contingent on a stand disturbance that favorably alters the under canopy microclimate resulting in higher light levels reaching the forest floor (Oliver; Larson 1990). The light availability on the forest floor for the no thin treatment in a study of two 30-year old Coast Range stands was <2% to 6% of full sun light(Chan *et al.* 1996a).	Thinned stands will develop a higher crown ratio compared with unthinned stands. The deeper crowns in the thinned stands result in a narrower gap between the ground and the base of the crown, which reduces light and wind penetration into the stands from exposed edges. Thinning at this intensity will not alter the microclimate enough to allow a complex multi-canopy understory to develop. Thinning at this intensity may alter the microclimate within the treated stand so that it is more like the microclimate under a mature stand and less like that under a stand in the stem exclusion stage. The light availability on the forest floor for the thin to 100 trees/ acre treatment in a study of two 30-year old Coast Range stands was 20% to 39% of full sun light (Chan *et al.* 1996a).	Understory tree establishment is contingent on sufficient light penetrating into a stand to support tree survival and growth (Oliver & Larson 1990). Treated stands will develop a higher crown ratio compared with unthinned stands. A treatment of this intensity will allow an understory stand to establish. In the short term the stand is more permeable to light and wind. In the long term, the treated stand will have deeper crowns and an understory, which will limit light and wind penetration into the stand from an exposed edge. Applying a treatment of this intensity will result in an edge between the newly treated stand and a mature or old-growth stand. However, from a microclimate and habitat perspective, this "edge" will not be as sharp nor will the edge effect zone be as deep as that between a mature/ old-growth stand and a new clearcut (Harris 1984; Chen *et al* 1995). The light availability on the forest floor for the thin to 60 trees/ acre treatment in a study of two 30-year old Coast Range stands was 38% to 65% of full sun light, and 63% to 82% of full sunlight where the stands were thinned to 30 trees/ acre. (Chan *et al.* 1996a).	Since a sharp edge already exists between a brush field and an adjacent stand of trees, a brush field conversion will unlikely alter the microclimate conditions in adjacent stands in the short term. In the long term, replacing a bush field with a new stand of trees will decrease the microclimatic and habitat contrasts between the treated site and the adjacent stands. An alder conversion treatment will result in an edge between the treated area and the adjacent stands. The sharpness and gradient of the edge effect will depend on: - How similar/ different the treated area is compared with the adjacent stand (Harris 1984). For example, if the adjacent stands are young plantations (10 yrs. or less) the contrast will be slight. - How much space there is between the base of the crowns and the ground in the adjacent stands. For example, stands with deep crowned trees and a dense understory will experience less edge effect than stands with and open understory and short crowns (Chen *et al.* 1995). - The edge location will also affect the sharpness and gradient of the edge effect. A stand with an edge facing north or east will experience less edge affect than if the edge faced southwest (Chen *et al.* 1995).
Assessment of, and recommendations for attainment of the Riparian microclimate function: *Assessment/ recommendation applicable to all treatments*: Edge effect can be minimized by keeping the contrast between the treated stand and the adjacent LS/OG stand low. This is done by feathering edges, protecting/ cultivating understory trees, concentrating retention trees along edges, and rapid regeneration of the cut areas (Harris 1984; Chen *et al*. 1995; Oliver & Larson 1990).	No treatment in similar stands will *not prevent attainment of interior microclimate conditions in adjacent LS/OG stands*. No treatment in similar stands *will retard attainment of microclimate conditions within the stand needed for establishing an understory stand and retard attainment of deep crown conditions associated with old growth.*	Density management treatments of this intensity *will not prevent long term attainment of interior microclimate conditions in adjacent stands*. The retention of a continuous forest cover in the treated area is expected to reduce the area of edge influence into adjacent untreated stands (Chen 1991). Density management treatments of this intensity *may attain microclimate conditions within the treated stand favorable for developing a shrub/ herb layer, but may not attain microclimate conditions favorable to long term understory tree growth*.	Density management treatments of this intensity *will not prevent long term attainment of interior microclimate conditions in adjacent stands*. The retention of a continuous forest cover in the treated area is expected to reduce the area of edge influence into adjacent untreated stands (Chen 1991). At the latest, interior microclimate conditions will be fully attained when the height of understory trees in the treated stand are equal to the height of the base of the crowns in the adjacent stand, or when the overstory canopy in the treated stand closes. See Table DM-2 and associated discussion, for estimated time to until full attainment of interior microclimate conditions. Density management treatments of this intensity *may attain microclimate conditions within the treated stand (and in adjacent stands along the shared stand boundary) favorable for developing a shrub/ herb layer, and for long term understory tree growth*.	Brush field conversions *will not affect existing interior microclimate conditions in adjacent stands in the near term and will assure attainment of restored interior microclimate conditions in the adjacent stand in the long term*. Alder conversions may reduce interior microclimate conditions in the adjacent stands in the near term but *will not prevent attainment of interior microclimate conditions in the long term*. Adjacent stand interior microclimate conditions will be fully attained when the height of the trees regenerated on the conversion site are equal to the height of the base of the crowns in the adjacent stand (Harris 1984, pg. 111). See Table DM-2 and associated discussion, for estimated time to until full attainment of interior microclimate conditions.

<table>
<tr>
<th>Riparian Reserve function</th>
<th>Untreated stands</th>
<th>Density management based on conventional commercial thinning spacings</th>
<th>Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory</th>
<th>Alder/ Brush field Conversions</th>
</tr>
<tr>
<td>Water quality: sediment
[Affected ACS objectives: 3, 4, 5, 6, 8]

The authors of a thorough literature review of widths of riparian areas required to protect water quality found the required width to protect water quality ranged from 12 to 869 feet. A western Washington study found that 200 foot buffers, about one site potential tree, would be effective to remove sediment in most situations if the buffer were measured from the edge of the flood plain (FEMAT 1993).

The width of protection areas needed to provide for ecological protection needs on intermittent streams, which includes protection from surface erosion input, varies with slope class and geologic parent material. The width ranges from 200 feet slope distance where there are granitic soils on > 70% slopes down to about 30 feet where there is resistant sedimentary parent material with < 30% slopes (FEMAT 1993, pg. V-38).

See the water quality discussion at the end of this section.</td>
<td>Not treating the stand will result in no management related sedimentation.</td>
<td>Density management at this intensity will retain most of the live tree roots, and will not involve site preparation.

Failure to follow BMPs may pose a road related sediment delivery risk in those locations where roads are close to or cross streams.

Yarding practices inconsistent with BMPs may also pose a sediment delivery risk.</td>
<td>Density management at this intensity will retain most of the live tree roots.

Failure to follow BMPs may pose a road related sediment delivery risk in those locations where roads are close to or cross streams.

Yarding practices inconsistent with BMPs may pose a sediment delivery risk.

Site prep practices inconsistent with BMPs may pose a sediment delivery risk.</td>
<td>Failure to follow BMPs with respect to roads, yarding and site prep may pose a sediment delivery risk.

Risks of management related sediment delivery are associated with substandard & poorly located roads, potentially with site prep on the more fragile sites, and are influenced by the physical features of the site and proximity of activity to a stream.

Sediment delivery potential increases following loss of roots on extremely fragile sites.

The Forest Plan allows for silvicultural activities on unstable ground to restore conifers (USDA; USDI 1994 pg. B-31, B-32). However, conversion of sites inside the Riparian Reserve with a TPC classification of FGNW may increase the risk of sediment delivery by mass movement during the 3 to 10 years following treatment (Gresswell et al. 1976). This corresponds to the time needed for new tree roots to fully occupy the soil. Risks associated with the loss of root strength can be reduced by controlling competitive vegetation with techniques that set back the aerial part of the target plants without killing the roots. Sediment from surface erosion is controlled by maintaining the organic layer or by maintaining or restoring vegetation cover. On Coast Range sites, the herb layer will recover site full occupancy in the first growing season following disturbance.</td>
</tr>
<tr>
<td>Assessment of, and recommendations for attainment of water quality: sediment function:</td>
<td>Protection of water quality, with respect to sedimentation, is attained with an unthinned stream side stand.</td>
<td>Density management treatments of this intensity will not prevent attainment of water quality protection with respect to sedimentation provided BMPs (USDI 1995 Appendix D) are followed.</td>
<td>Density management treatments of this intensity will not prevent attainment of water quality protection with respect to sedimentation provided BMPs (USDI 1995 Appendix D) are followed.

To assure attainment of water quality protection with respect to sedimentation, design site preparation treatments to avoid exposing bare mineral soil to the extent practical based on existing knowledge and technology when regenerating trees within the distances of a stream shown in the table to the right under the alder/ brush field column:</td>
<td>Alder or brush field conversions will not prevent the attainment of water quality protection with respect to sedimentation provided BMPs (USDI 1995 Appendix D) are followed.

Promptly reestablishing ground cover will assure attainment of water quality protection with respect to sediment in the short term. Promptly reestablishing forest cover will assure attainment of water quality protection with respect to sediment in the long term.

To assure attainment water quality protection with respect to sedimentation, design site preparation treatments to avoid exposing bare mineral soil to the extent practical based on existing knowledge and technology when regenerating trees within the distances of a stream shown in the table below:

Zone of Greatest Concern for Protecting Soil From Surface Erosion When Planning Site Preparation as Determined by Slope Class and Rock Type. From Fig V-14 in FEMAT (1993)

<table>
<tr><th>Rock Type</th><th>Slope Distance Widths by Slope Class (distance measured from the stream edge)</th><th></th><th></th><th></th></tr>
<tr><td></td><td><30%</td><td>30-50%</td><td>50-70%</td><td>>70%</td></tr>
<tr><td>Resistant sediment</td><td>25 ft.</td><td>50 ft.</td><td>75 ft.</td><td>100 ft.</td></tr>
<tr><td>Intermediate sediment</td><td>50 ft.</td><td>50 ft.</td><td>100 ft.</td><td>125 ft.</td></tr>
<tr><td>Other resistant</td><td>50 ft.</td><td>75 ft.</td><td>100 ft.</td><td>125 ft.</td></tr>
<tr><td>Unconsolidated</td><td>75 ft.</td><td>100 ft.</td><td>150 ft.</td><td>175 ft.</td></tr>
</table>
Resistant sediment includes sandstone (ex: Tyee sandstone)
Intermediate sediment includes siltstones, mudstones (ex: Elkton siltstone)
Other resistant includes marine basalt
Unconsolidated includes landslide debris and alluvial soils

Note: A paper on sediment delivery in the Coast Range, which is now in review, suggests this recommendation and table may be overly conservative. ID teams may choose to base sediment reduction prescriptions on new data when such information is published.</td>
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Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Wildlife habitat [Affected ACS objectives: 1, 2, 4, 8, 9] The Riparian Reserves confer benefits to riparian-dependent and associated species other than fish, enhance habitat conservation for organisms that are dependent on the transition zone between upslope and riparian areas, and provide for greater connectivity of the watershed. The Riparian Reserves will also serve as connectivity corridors among the Late-Successional Reserves (USDA; USDI 1994, pg. B-13) The continued viability of several late-successional J-2 species is dependent on applying the "Riparian Reserve Scenario 1" [described on Table III-4, pg. III-9 FEMAT 1993] along those intermittent streams where the species are found (Holthausen *et al*. 1994).	Unthinned stands that are in the stem exclusion stage support the lowest species richness of all the stand development stages.	"Creative prescriptions" favorably influence the species richness and the numbers of late-successional stand associated species occupying thinned sites. These prescriptions include varying spacing to create gaps and clumps, retaining of some level of hardwoods, and retaining or recruiting snags, down wood and shrubs. Logging systems, which avoid or cause only minimum soil and duff layer disturbance, reduce impacts on amphibians. (Taken from the notes for the Cooperative Forest Ecosystem Research 9/16/98 Young Stand Biodiversity field tour - copy in Density Management Appendix)	Little competition mortality among the overstory trees is expected following a density management treatment that leaves 60 trees/ acre. This is consistent with observations in wild stands. Competition mortality kills the smaller trees in the stand. Few large trees die because of competition (Peet; Christensen 1987). Instead, insect, disease, mechanical, or weather related injury or disturbance cause most mortality among large trees. To keep a 40-yr. old stand, which is thinned to 60 trees/ acre, on a trajectory to develop into old growth, at least 25 to 30 more trees have to be killed to provide growing space for the remaining trees. This second entry is also desired to recruit additional LS/OG habitat attributes like large snags and down logs. The SPS runs suggest the second entry is best accomplished when the stand is 60-yrs. old or older.	Alder conversion projects change the cover type on the site from alders, which depend on severe (stand replacing) disturbances occurring on cycles of less than 80-years to maintain its occupation of the site, to a conifer or mixed stand cover type that can potentially attain old-growth conditions.
Based on Tappeiner *et al.* (1997), a stand is likely on a trajectory to become old-growth if its average dbh is approximately 20-inches at age 50-yrs.	SPS projects the stand average green tree dbh to be: 19.9 inches at stand age 100-years on the SI 115 site. 20.1 inches at stand age 70-years on the SI 127 site.	SPS projects the stand average green tree dbh to be: 20.5 inches at stand age 70-years on the SI 115 site. 21.0 inches at stand age 60-years on the SI 127 site.	SPS projects the overstory stand average green tree dbh to be: 19.7 inches at stand age 50-years on the SI 115 site. 21.6 inches at stand age 50-years on the SI 127 site.	Depends on initial stocking level and density management treatment(s) applied to the new stands.
Minimum standards for old-growth Douglas-fir on hemlock sites includes ≥8 Douglas-fir/ ac. > 32-in. dbh or 200-yr old. (Old-growth Definition Task Group 1986)	32 in. ave. dbh not attained by stand age 200-years on either the SI 115 or the SI127 site. (Ave. stand dbh at age 200-years = 26.1 inches on the SI 115 site and 29.0 inches on the SI 127 site. The largest trees in both stands, at age 200, are likely > 32 in. dbh)	32 in. ave. dbh not attained by stand age 200-years on either the SI 115 or the SI127 site. (Ave. stand dbh at age 200-years = 28.6 inches on the SI 115 site and 30.6 inches on the SI 127 site. The largest trees in the stand, at age 200, are likely > 32 in. dbh)	32 inch ave. dbh attained by stand age: 170-years on the SI 115 site (32.2 inch ave dbh) 150-years on the SI 127 site (32.4 inch ave dbh) Eight DF >32 in, dbh/ acre likely attained earlier.	Depends on initial stocking level and density management treatment(s) applied to the new stands.
Total natural mortality from when the annual mortality is ≥ 20 in. dbh to when the stand is 100-years old:	0 trees/ acre on both SI 115 and SI 127 sites	2 trees/ acre on the SI 115 site 4 trees/ acre on the SI 127 site	3 trees/ acre on the SI 115 site 4 trees/ acre on the SI 127 site (Under this approach, we will make 25 to 30 additional trees into snags or down wood through active management).	Depends on initial stocking level and density management treatment(s) applied to the new stands.
Total natural mortality from when the annual mortality is ≥ 20 in. dbh to when the stand is 200-years old: [Minimum standards for old-growth Douglas-fir on hemlock sites include ≥4 conifer snags/ ac. > 20-in. dbh & > 15 ft tall. (Old-growth Definition Task Group 1986)]	20 trees/ acre on the SI 115 site 48 trees/ acre on the SI 127 site	22 trees/ acre on the SI 115 site 30 trees/ acre on the SI 127 site	6 trees/ acre on the SI 115 site 7 trees/ acre on the SI 127 site	Depends on initial stocking level and density management treatment(s) applied to the new stands.
Total natural mortality, all diameter classes, from age 35 to age 200-years:	SI 115 - 200 trees die/ acre SI 127 - 174 trees die/ acre	SI 115 - 48 trees die/ acre SI 127 - 56 trees die/ acre	SI 115 - 20 trees die/ acre SI 127 - 20 trees die/ acre (Under this approach, we will make 25 to 30 additional trees into snags or down wood through active management).	Depends on initial stocking level and density management treatment(s) applied to the new stands.
Snag nesting habitat, from natural mortality, assured when the average newly dead tree dbh equals or exceeds the following size thresholds: 11+ in. (Downy woodpecker) 15+ in. (Red-breasted sapsucker & Hairy woodpecker) 17+ in. (Red-breasted nuthatch & Northern flicker) 25+ in. (Pileated woodpecker) based on the Marcot (1992) Snag Recruitment Simulator. Lundquist and Mariani (1991)observed that cavity-nesting birds show a disproportional preference for large (>20-inch dbh) snags. Lundquist and Mariani concur with several authors cited in their paper that argue for snag management based on mean nest-tree diameters instead of minimum diameter guidelines. Based on their study, Lundquist and Mariani recommend managing for snags of at least at 30-inches. Lundquist and Mariani also observed cavity-nesting species had a strong preference for decay class II and III snags, and in western Washington, preferred Douglas-fir, western hemlock and western white pine snags to snags of other tree species.	Snags equal or greater to the threshold diameter class regularly recruited starting by stand age: target size / age & actual size: SI 115 / SI 127 11+ in. / 60-yr (11.6 in.) / 40-yr (11.2 in.) 15+ in. / 100-yr (15.3 in.) / 70-yr. (16.3 in.) 17+ in. / 120-yr (17.4 in.) / 80-yr. (17.6 in.) 25+ in. / >200-yr. / 200-yr. (25.0 in.)	snags equal or greater to the threshold diameter class regularly recruited starting by stand age: target size / age & actual size: SI 115 / SI 127 11+ in. / 50-yr. (14.8 in.) / 40-yr. (11.2 in.) 15+ in. / 60-yr. (16.8 in.) / 50-yr. (17.3 in.) 17+ in. / 70-yr. (18.0 in) / 50-yr. (17.3 in.) 25+ in. / >200-yr. / 170-yr. (25.4 in.)	snags equal or greater to the threshold diameter class regularly recruited starting by stand age: target size / age & actual size: SI 115 / SI 127 11+ in. / 50-yr. (18.0 in.) / 40-yr. (11.2 in.) 15+ in. / 50-yr. (18.0 in.) / 50-yr. (20.6 in.) 17+ in. / 50-yr. (18.0 in.) / 50-yr. (20.6 in.) 25+ in. / * / 90-yr. (25.8 in.) * Mortality rate too low for SPS to report ave. dead tree dbh by decade. Last report: age 80 when ave. newly dead tree = 21.5".	depends on initial stocking level and density management treatment(s) applied to the new stands

Riparian Reserve function	**Untreated stands**	**Density management based on conventional commercial thinning spacings**	**Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory**	**Alder/ Brush field Conversions**
Understory herb and shrub layer Species richness is high before stands enter the stem exclusion stage and consists of disturbance resistant species surviving the stand initiating event and early seral species. Species richness is at its lowest during the mid seral period when the stand is in the stem exclusion stage. Species richness returns to high levels as low to moderate severity disturbances create and maintain gaps in the overstory mature/ old growth conditions.	Stands in the stem exclusion stage have little or no herb or shrub layer. The stem exclusion stage lasts from about stand age 15 to age 70, sometimes longer. The length of time when the understory vegetation is minimal to absent depends on initial tree stocking levels and site quality.	If not already present, the understory herb and shrub layer rapidly establishes following opening of the overstory canopy. Increased light to the forest floor will increase the vigor and colony size of plant species that reproduce by layering or expand via rhizomes. These clonal species include salal, salmonberry, and vine maple. In the absence of ground disturbance, these shrub species can limit understory tree regeneration.	Similar development as in stands treated using the commercial thinning model. Primary difference is the lower leave tree count in the wide spacing scenario will result in higher light levels reaching the forest floor, and in turn, greater shrub and herb layer growth and vigor. Depending on the density of the understory stand, the understory trees will go through a stem exclusion stage just like the overstory had. The length of time the understory stand is in the stem exclusion stage will depend on initial stand density, site quality, and the timing and intensity of density management applied to the understory stand. At one extreme, the understory can enter the stem exclusion stage when the understory trees are around 10 to 15-years old and remain there until at least age 70. With very low initial densities or with aggressive density management treatment(s), the understory stem exclusion stage could be avoided all together.	Stand conversion resets the site back to the stand initiation stage (before the stem exclusion stage). On sites with a well established salmonberry shrub layer, salmonberry can form a closed canopy shading out all herbs and shorter shrub species. Maintenance treatments, intended to set back salmonberry growth and insure conifer survival, will also allow the shorter stature plants to survive on the site for as long as the maintenance treatments are repeatedly applied. Broadcast burning, combined with forage seeding, can delay salmonberry reestablishment and provide forage for ungulates for 5 or 6 years following treatment. Once conifers establish on the site, the condition of the herb and shrub layer over time will depend on initial stocking levels and subsequent density management treatments.
Foraging substrate for insectivore birds - Abundance of invertebrates on tree bark increases with increasing tree diameters and deeper bark furrows. - Trees with many dead branches may support more arthropods than trees with few dead branches. - Multilayered canopies (both tree and shrub layer) provide greater range of habitats resulting in greater richness of invertebrate species. - Red alders support an abundance of defoliating insects (Weikel, Hayes 1997) Huff and Raley (1991) observed bird communities of old-growth showed great overlap with those of unmanaged naturally regenerated 35 to 79-year old stands and 80 to 190-year old stands. The vegetation in the old-growth stands was distinguished from the younger forest by only a small set of structural attributes, such as tree density, mean stand diameter, and basal area (Spies; Franklin 1991). Huff and Raley (1991) detected significant age-class differences for bark and aerial foragers. Seven of 8 hole or bark nesters, 6 of which were bark foragers, reached their highest abundance in mature and old-growth stands. The strong association between bark-forager abundance and stand age may be a function of the increase in large (>20-inch dbh) as the stands age (Spies; Franklin 1991).	Stand condition with respect providing foraging substrates: - Diameter growth slow. This in turn means slow development of bark furrows limiting numbers of insects that use bark. Also small tree diameters means insectivores have to visit more trees (and expend more energy) than in stands where the trees have larger diameters just to cover the same amount of tree trunk surface area. - Many dead branches that are small to very fine. This condition can support more arthropods than trees with few dead branches. - Little herb/ shrub layer. Tree canopy depths decreasing. Shallow tree crowns and little herb or shrub cover means there is less foraging substrate in the closed canopy unthinned stand than in more open thinned stands. - Suppression mortality recruits small dead wood. This limits the arthropod populations to only those species that can small diameter dead wood. Also for a given surface area of foraging substrate, an insectivore has to expend more energy foraging for food when the individual pieces of substrate are small than when the material has a large diameter.	Stand condition with respect providing foraging substrates: - Diameter growth rate increased following density management. This in turn means more rapid development of bark furrows, which provides more habitat for insects that use bark. Also larger tree diameters means insectivores can then visit fewer trees (and expend less energy) to forage a given amount of trunk surface area compared to unthinned stands. - Leave trees have small to very fine dead branches, which died before the density management treatment. Larger dead branches will be recruited as the canopy closes and deepens, thereby shading lower branches. That will provide a range of arthropod habitats. Stand will continue to provide dead small and very fine branches which are productive arthropod habitats. - Increased light levels allow understory plants to establish increasing the variety of substrates for insects resulting in a greater total number of insects and a greater diversity of insect species available for insectivores. -Tree crown depth increases. This also increases the amount and diversity of habitats used by tree crown dwelling insects. - In the short term, logging slash supplies new small dead wood on the ground. - In the long term, Suppression mortality supplies medium sized dead wood in addition to small sized wood. Random mortality, caused by insects, disease, physical injury and weather related stress supplies the large dead wood. This greater range in dead wood size means there is a greater diversity of habitats allowing for a greater insect diversity. The larger surface area on the larger pieces of dead wood allow more efficient foraging by insectivores.	Stand condition with respect providing foraging substrates: Same as those listed in the Density management based on conventional thinning spacing column with the following additions: - Understory trees will establish, however, the herb and shrubs remain until understory tree canopy closes. Low initial understory stocking or precommercial thinning of the understory trees to a wide spacing can delay understory tree canopy closure. - Small diameter dead branches and small diameter down wood are produced as understory tree canopy closes. This can begin as early as 10 to 15 years after the density management treatment. - Overstory tree crown depth increases. Large diameter dead branches produced as overstory crowns expand and become deeper. - Depending on the initial understory tree stocking level, the understory stand will begin supplying small diameter down wood and snags approximately 10 to 15 years after the understory trees established.	On landslide/ debris torrent prone sites, periodic severe disturbances will maintain red alders on the site. On sites where stand replacing disturbances are typically spaced more than 80 years apart, alder stands with only a salmonberry understory will become brush fields when the alders die of old age. Two story stands with an alder overstory and an established hemlock or cedar understory will eventually become a single story hemlock or cedar stand. When a site, which has a low probability of experiencing a stand replacing event during the next 80 to 200+ years, is converted to conifers, then that conifer stand can be set on a trajectory to develop late-successional/ old growth characteristics. In the near term, the types and abundance of foraging substrates will depend on the prescription. Following conversion, there will be a short term loss of those habitat attributes that are size and volume depended. For example, alders with some measure of diameter and crown mass are replaced by small conifer seedlings. However in the long term, size and volume potential of the conifers greatly exceeds that of the alders. Habitat characteristics will change resulting in a shift in the species using the site. For example the insects that specialize in feeding on alder leaves will be replaced by insects that specialize in feeding on conifer needles.
Northern Spotted Owl Dispersal Habitat: Stand age 40-years+, or when the stand's average green tree is $\geq$ 11 inch dbh & canopy cover is $\geq$ 40% Northern Spotted Owl Suitable Habitat: Stand age 80-years+.	The SI 115 site meets the average stand dbh and crown closure requirements for dispersal habitat at age 35-yrs. The SI 127 site meets the average stand dbh and crown closure requirements for dispersal habitat before age 31-yrs.	The example stands have $\geq$ 11 in. dbh with canopy closure $\geq$ 40% before the density management treatment. A treatment of this intensity will not drop the canopy closure below 40% or reduce average stand dbh for either the SI 115 or the SI 127 site.	Stand dbh $\geq$11 in. with canopy closure $\geq$ 40% are met before the density management treatment. Canopy closure is <40% immediately following density management treatment. The canopy closure is projected to again be $\geq$40% about 5 years after treatment (Tucker *et al.* 1993).	Dispersal habitat, as defined by age, is attained 40-yrs. following conversion and planting. Dispersal habitat, as defined by tree diameter and crown closure, may be attained in 25 to 35-years with timely stand maintenance and early stocking control.

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Vertical structural diversity among the trees in the stand Minimum standards for old-growth Douglas-fir on hemlock sites include a deep, multilayered canopy (Old-growth Definition task Group 1986).	These stands typically are composed of trees from the same cohort. Vertical diversity is a product of crown position (dominant, codominant, intermediate and suppressed) within a single canopy layer.	Preferential retention of the larger trees and cutting the small trees can reduce structural diversity within the overstory. Over time after the thinning, the overstory trees differentiate again into crown classes where there is nonuniform spacing. Tree wounding/ snap-out, which reduces the vigor of the affected trees compared with adjacent healthy trees, and microsite conditions that give some trees a competitive advantage also foster crown differentiation. We may obtain a naturally seeded second age class following a density management entry, depending on the amount of ground disturbance and vegetation competition. However, understory tree regeneration may be precluded if there is little ground disturbance combined with well-established understory shrubs. The understory tree regeneration following the thinning will temporarily increase both size and species diversity (overhead shade favors tolerant hemlocks, true firs and cedars over the shade intolerant Douglas-fir). However, a typical commercial thinning designed to maximize wood production does not provide enough light for vigorous understory tree regeneration and growth (Chan *et al*. 1996). Long term survival and growth of the understory trees are contingent on whether additional disturbance retards overstory canopy closure.	Understory regeneration is assured by underplanting in this management scenario. This ultimately results in a multilayered canopy. In the short term, we expect the stand development at this spacing to be similar to that stands treated using the commercial thinning model. In the long term, the wider spacing of the overstory trees means more light for a longer period of years will reach the forest floor, which favors long term survival and growth of the understory trees. The COPE scientists, in their experiments with establishing understory stands, targeted 60% light levels to the forest floor as the amount needed for successful underplanting (Chan *et al* 1993). Additional active management (snag/ down log creation) may be needed in the overstory to maintain understory tree vigor if overstory stocking approaches 0.55 relative density index. That stocking level equals 55 DF/ ac averaging 30 inches dbh, or 35 DF/ ac averaging 40 inches dbh. See assumptions used when predicting tree mortality.	Converting a red alder stand to conifer typically means replacing a single story - single cohort alder stand with a single story - single cohort conifer stand. Where there are established and/or releasable conifers on the site, the replacing conifer stand will be a two-cohort stand. The older carry over conifers will provide vertical diversity. A density management treatment, with an objective to regenerate an understory, potentially could be applied to the replacement conifer stand 30 or more years after a successful conversion treatment. Where there is full sunlight, vertical diversification can be obtained by planting a mix of Douglas-fir and hemlock. Douglas-firs grow faster than hemlocks under full sunlight conditions resulting in a natural stratification of the Douglas-firs into the upper part of the canopy and hemlock into the lower part of the canopy (Wierman; Oliver 1979). Similar stand stratification will likely occur where Douglas-firs and redcedars are grown together. If Douglas-fir and hemlock regenerate simultaneously, subsequent recruitment of additional cohorts may be limited because of dense hemlock canopies. Canopy openings suitable for establishing understory trees may not form for 300-400 years (Stewart 1986) unless there is active management to obtain the light level on the forest floor necessary for tree seedling survival and long term growth.
Tree species diversity Minimum standards for old-growth Douglas-fir on hemlock sites include: - 2 or more species with wide range of ages and tree sizes. - Tolerant associates (wh, wrc, gf, bl-maple) ≥12/ ac. & >16-in. dbh (Old-growth Definition task Group 1986).	Most of the trees are Douglas-fir where stands regenerated after clearcutting or after a stand initiating burn. A few stands have a high percent of hemlock where timber harvest was in effect an overstory removal and/or there was minimal site preparation. All trees are the same cohort. Successful understory regeneration will require a disturbance.	Partial shade favors regeneration of shade tolerant tree species. Long term survival of those understory trees depends on additional disturbance maintaining favorable light conditions in the understory necessary for survival and growth.	Partial shade favors regeneration of shade tolerant tree species. The wider spacing among the overstory trees, following density management, assures the long term survival of the understory trees. In addition to the shade tolerant understory trees, some shade intolerant trees may survive and grow on the north side of the larger gaps in the stand. Understory tree growth was not modeled. However, attainment of 12 understory trees >16-in dbh is likely in 60-years based on observations in natural stands. Additional active management (snag/ down log creation) may be needed in the overstory to maintain understory tree vigor if overstory stocking approaches 0.55 relative density. See assumptions used when predicting tree mortality.	With few exceptions converting a red alder stand to conifers will consist of replacing the alder on the site with one or more species of conifer. Alders may be perpetuated on some sites following cutting and site prep: - In no-treat/ lightly treated stream side buffers. - Where the conversion project design includes partial retention of red alder trees on the site. - When red alders reestablish on the project site in areas where they do not threaten project success. Potentially, we may cut gaps in stands dominated by hardwood species other than red alder. In those situations we are adding conifers to increase species diversity and not attempting to change the dominant species on the site. We may also treat individual hardwoods, other than alder, that have a stump sprout clump form as the result of past harvesting. We can treat these stump clumps by cutting all but 1 to 3 stems on each stump to transform those clumps back into a single stem tree form.

Riparian Reserve function	Untreated stands	Density management based on conventional commercial thinning spacings	Density management with the objectives of rapid diameter growth for overstory trees and regenerating an understory	Alder/ Brush field Conversions
Assessment of and recommendations for attainment of wildlife habitat function:	Untreated stands, with similar site quality and stocking levels to the example used in this assessment have a *low probability of attaining all conditions that define old-growth much before stand age 200*. High stocking levels *retard attainment* of large green and dead attributes, and detain development of the multi-canopy, multi-age conditions that, in part, define old-growth. A low to moderate severity disturbance (fire or wind storm) may change that prognosis. *These stands are not on the growth trajectory to develop into old-growth stands typical for the Coast Range.* Killing trees that rank among the largest third of the trees in the stand to attain large snags and down wood *will retard attainment* of other characteristics used to define old-growth. Also an aggressive and consistently applied practice of intentionally killing the largest trees on the site is, in effect, a selection pressure against the best adapted trees on the site. This may be inconsistent with Riparian Reserve Standard and Guide WR-1intention of conserving genetic integrity of native species. Leaving the stands untreated, retains conditions favorable to species that benefit from mid-seral conditions (small to medium diameter trees growing in well stocked, single story stands that are in the stem exclusion stage of stand development.) A decision to not apply density management lowers the risk of damaging the legacy structures that provide refuges for species benefitting those late-successional habitat elements. This carries the cost of forgoing treatments that set the stand on a trajectory to once again produce late-successional habitat elements that can replace the old legacy elements as those older elements are lost through natural decomposition processes.	Stands, with similar site quality and stocking levels to those used in this assessment, and subject to a similar treatment intensity, *will attain many attributes used to define old-growth by stand age 160*. A low to moderate severity disturbance (fire or wind storm or additional treatments) may have to occur before these stands attain the multi-canopy, multi-age conditions that, in part, define old-growth. *These stands are not on the growth trajectory to develop into old-growth stands typical for the Coast Range.* Killing trees that rank among the largest third of the trees in the stand to attain large snags and down wood *will retard attainment* of other characteristics used to define old-growth. Also a regular practice of intentionally killing the largest trees on the site is, in effect, a selection pressure against the best adapted trees on the site. This may be inconsistent with Riparian Reserve Standard and Guide WR-1intention of conserving genetic integrity of native species. Density management project prescriptions need to include treatments to recruit new late-successional forest elements and/or incorporate design features that protect late-successional forest elements already on the sites. Otherwise, implementing these projects carry a risk of decreasing the amounts of late-successional characteristics in the short term.	Based on work by Tappeiner *et al.* (1997), most Coast Range old-growth trees averaged 20-inches dbh by age 50-years, and averaged 40-inches dbh by the time they were 100-years old. Thinning stands to 60 trees/ acre, which are similar to those stands used in this assessment, will produce stands that average 20-inch dbh age 50-years. However, without killing additional trees, those stands will average 27 to 29-inches dbh at age 100. Stands, with similar site quality and stocking levels to those used in this assessment, and subject to a similar density management treatment intensity plus a subsequent snag creation treatment about age 60, *will attain many attributes used to define old-growth by stand age 100 to 150*. Initial density management treatment and underplanting will assure attainment of tree size, species diversity and canopy characteristics used to define old-growth. These stands, *at age 50-years, will be on the growth trajectory to develop into old-growth stands typical for the Coast Range*. A low severity disturbance (or tree killing/ snag creation treatment) is likely needed when the stands are 60-years old or older to keep the stands on trajectory. Otherwise, *these stands, at age-100 years, may track on a growth trajectory that is on the lower end of the range of average stand diameters/ higher end of the range of stem densities for typical Coast Range old-growth*, and the stands may fall short of the levels of snags and down wood used to define old-growth. Additional disturbances are likely necessary if the understory stand is to attain rapid growth rate, complex age structure, and become a source of large snags and down logs. Density management project prescriptions need to include treatments to recruit new late-successional forest elements and/or incorporate design features that protect late-successional forest elements already on the sites. Otherwise, implementing these projects carry a risk of decreasing the amounts of late-successional characteristics in the short term.	*Conversion projects on sites subject to frequent severe disturbance may not attain desired LS/OG habitat*. Those sites are best managed for alder, thereby *assuring attainment of an array of riparian habitats*. Alder or brush field *conversion to conifer (or mixed stand condition) on conifer sites will promote attainment of LS/OG habitat* on upland sites within the Riparian Reserve and *assure attainment of an array of riparian habitats* on sites within the riparian zone. Retaining alder on frequently disturbed sites within the riparian zone (or the transition zone between the riparian zone and upland sites) *will assure attainment* of an array of riparian habitats. *Recommend* retaining alder on sites, and stream banks that are subject to frequent severe disturbance (for example sites with a high landslide frequency or subject to frequent stream bank scouring recurring on cycles of 80-years or less). *Recommend* converting alder stands and brush fields to conifer on those Riparian Reserve sites that are not subject to frequent severe disturbance (an example of a frequent severe disturbance are debris torrents occurring on cycles of 80-years or less). The ultimate *attainment of LS/OG conditions is contingent* on stocking management and timely stand maintenance treatments. Candidate sites for converting to conifer are those sites that previously supported conifer. *To assure attainment* of tree species diversity, vertical structural diversity, and potentially other Riparian Reserve functions, retain all free-to-grow and releasable conifers, and all hardwood trees, other than red alder to the extent that regenerating conifer remains practical.

Additional information supplementing Table DM-1

Microclimate: Table DM-2 below shows the theoretical maximum number of years that will pass from the time a sharp clearcut edge is created until the interior microclimate is fully recovered. This period assumes the worst case conditions: abrupt southwest facing edges, sparse understory in the older stand, no topographic sheltering. Feathered edges, dense understory vegetation, topographic sheltering, and edge orientation can lessen the depth of the cut edge's effect on the interior microclimate and reduce the time until the interior microclimate conditions are fully recovered (Harris 1984; Chen *et al.* 1995; Oliver & Larson 1990).

Table DM-2: Years from the Time a Sharp Clearcut Edge Is Created until the Interior Microclimate Is Fully Recovered for a Range of Stand Heights and Crown Depths on Kings SI_{50} 126 Land

Percent crown:		40%		50%		60%		70%	
Percent exposed bole:		60%		50%		40%		30%	
The affected stand's age, in yrs, when cutting the adjacent stand created the edge.	The ht. of tallest trees, in ft., in the affected stand at time cutting created the edge.	Ht. of the gap between ground and base of the crown, in ft., on the edge of the affected stand.	Yrs. of growth required for before the new stand blocks gap created clearcutting.	Ht. of the gap between ground and base of the crown, in ft., on the edge of the affected stand.	Yrs. of growth required for before the new stand blocks gap created clearcutting.	Ht. of the gap between ground and base of the crown, in ft., on the edge of the affected stand.	Yrs. of growth required for before the new stand blocks gap created clearcutting.	Ht. of the gap between ground and base of the crown, in ft., on the edge of the affected stand.	Yrs. of growth required for before the new stand blocks gap created clearcutting.
20	47	28	**13**	23	**11**	19	**10**	14	**9**
40	98	59	**23**	49	**20**	39	**17**	29	**13**
60	134	80	**31**	67	**26**	53	**21**	40	**17**
80	157	94	**38**	78	**30**	63	**24**	47	**19**
100	177	106	**39**	89	**35**	71	**27**	53	**21**
120	192	115	**47**	96	**38**	77	**30**	58	**23**

Note: The height age relations from Kings site index tables (King 1966). Stand ages are assumed to be age at breast height, from the Kings Tables, plus 4 years. The site index used is 126.

Chen (1991) reported the area of edge influence, into old-growth stands, for the biological variables given in Table DM-3.

Table DM-3: Depth of Edge Effect (Area of Influence), into an Old-Growth Stand Caused by a Newly Created Clearcut as Indicated by Biological Responses

Biological variable		area of influence		Biological variable (cont.)		area of influence	
		in meters	in feet			in meters	in feet
Canopy cover		44	144	Regeneration of	DF overall	41	135
number of stems/ ha	overall	59	194		DF 0-10 cm tall	52	171
	6-30 cm DBH	57	187		DF 11-30 cm tall	39	128
	31-100 cm DBH	43	141		DF 31-100 cm tall	16	52
	WH	85	279	Regeneration of	WH overall	92	302
Basal area		68	223		WH 0-10 cm tall	137	449
Growth	DF	53	174		WH 11-30 cm tall	54	177
	WH	26	85		WH 31-100 cm tall	79	259
Mortality overall		125	410	Logs		56	184

Tree mortality: An individual tree's risk of mortality increases with proximity and size of neighboring trees (Peet and Christensen 1987). In comparison to wild stands where big trees get bigger by suppressing and killing the smaller trees, there is a lower rate of suppression mortality in conventional uniformly-spaced plantations. The crown depth, and therefore photosynthate producing surface decreases, at essentially the same rate for all trees in a plantation as the trees occupy the growing space. This uniformly distributed growth, and lower mortality rate results in a more efficient use of the site and higher yields in plantations compared with natural stands of the same age on similar sites. It does not supply the size diversity, variations in crown depth, nor the variation in health and vigor of trees associated with wild stands. In wild stands, mortality due to competition, and in fact most post-establishment mortality, occurs during the time between crown closure and the point when the gaps created by tree mortality can no longer be reoccupied by lateral growth of adjacent trees (Peet and Christensen 1987). Snags produced through competition mortality in young stands are from the lower crown classes and/or areas of dense stocking. Both factors result in snag recruitment from among the smaller diameters, short crown depth trees. Some snags recruited toward the end of the stem exclusion phase may be large enough to serve as roosting and nesting habitat for the small to medium size cavity dwellers. However, Carey *et al.* (1999) observed that suppression mortality in conifers does not contribute significantly to the function of standing decadent trees in either provision of cavities or gap formation. Small snags usually do not have top rot (or cavities) and do not stand very long. They do contribute to the course woody debris on the forest floor for a relatively short time before decaying. Large snags are recruited by factors other than suppression mortality (Peet and Christensen 1987). During the self thinning phase, clumpyness will decrease and the stand will acquire a relatively uniform spacing pattern (though not as uniform as a plantation laid out in a grid pattern). After the self thinning phase, most mortality will be due to factors other than growing space, like windthrow, lightening, disease, and fire (Peet and Christensen 1987).

<u>Assumptions used when predicting tree mortality</u>: The stand age used in the Table DM-1 for when natural mortality will result in snags/ down wood of a given size is the age the SPS model predicts the average diameter of the trees that die that year will be equal or greater than the desired diameter. The stand age used in the Table DM-1 for when recruitment of snags/ down logs is practical through active management is the age when the SPS model predicts the average tree in the stand will equal the desired diameter. The stands will have both green trees and mortality equaling the target diameter before those dates. However, before that date, creating snags/ down wood by active management comes at the cost of retarding stand development, retarding attainment of large green trees, and retarding attainment of natural mortality that can satisfy the minimum size requirements for the target habitat.

The maximum stand density index (SDI) for Douglas fir is 595 trees/ acre. The maximum SDI is the theoretical maximum number of trees/ acre in a stand for a given species when those trees average 10 inches dbh. SDI can also be expressed as a decimal fraction called relative density index (RDI). SDI is species specific, for example the maximum SDI for redwood is 800. RDI is an expression of stocking level relative maximum potential density and is not species specific therefore the maximum RDI for either Douglas-fir or redwood or any other species is 1.0. Table DM-4 shows the stocking level - average stand diameter relationship. Competition mortality (snag recruitment) is probable when the relative density index is greater than 0.55. Within stand variations in diameters and stocking levels can result in patches where the RDI is greater than 0.55 resulting in patch scale competition mortality before the stand as a whole exceeds a 0.55 RDI.

Table DM-4: Douglas Fir Stocking - Average DBH Relationship Determined from a Reineke Diagram

Relative density index	DF stand density index	DF trees/ acre when ave. stand dbh equals:				stand condition
		10 in.	20 in.	30 in.	40 in.	
1.00	595	595	160	100	64	Maximum size-density relationship
0.55	327	327	110	55	35	Lower limit of the zone of imminent competition mortality
0.15	89	89	24	15	10	Approximate point of crown closure

Water quality overview: Most research on how forest management affects water resources is from observations of practices that were in common use in the 1960s and 1970s (Adams; Ringer 1994). These practices include sidecast road construction on unstable sites, hot broadcast burning that consumed all duff on the site, logging down to the stream edge, and removing or burning woody debris found in the streams. Our technology, practices and standards have changed much since then, in no small part because of that research. In fact, several aspects of Federal land management under the Northwest Forest Plan, with its emphases on large reserves, and confinement of many practices to ridge top locations, are a direct outcome of that research. In addition, using best management practices (BMP) can largely avoid serious degradation of water quality by forest practices (Binkley; Brown 1993). BMPs are incorporated into the Coos Bay District ROD/RMP (USDI 1995: pg. 13, 25, 31, 70, 81 & Appendix D). Therefore, the reader is cautioned to consider the cited research in context of the time the data was collected and in light of current practices.

Water quality: stream temperature as affected by shade: For a given amount of exposure to sunlight, the increase in stream temperature is inversely proportional to stream volume (Brown; Krygier 1970). One study showed the relation between the timber volume left per foot of stream and the amount of heat blocked by that buffer is poor. Angular canopy density correlated well with stream temperature control. The angular canopy density is measured for the solar angle during the minimum flow period. For streams in that study, the maximum angular canopy density (maximum shading ability) was reached within an 80-foot width, with 90% of maximum reached in within 55-feet (Brazier; Brown 1973).

A study on Steamboat Creek in the Cascades showed stream temperatures did not increase where buffer strips were used between the stream and the clearcut. Cooling was not observed in the shaded segments of streams that had been clearcut in alternate blocks. The largest temperature increase occurred on a south-flowing reach where the stream was too wide to be shaded by the stream side vegetation from the midday sun (Brown *et al.* 1971). In another Cascade study conducted on the H. J. Andrews Experimental Forest, logging on a northwest facing slope increased maximum water temperature only after 55% of the drainage was logged and timber cut along major streams. On south-facing slopes, an increase occurred with a smaller percentage of cutting (Levno; Rothacher 1967). This suggests that aspect/ topographic shading play a role in protecting streams from solar radiation. Levno and Rothacher (1967) concluded that under a pattern of patch clearcuts, little or no increase in maximum stream temperatures would be expected unless a large portion of the stream bed was directly exposed to solar radiation.

Surviving understory vegetation and logging debris next to a stream may provide shade, which will reduce the effects of clearcut logging down to the stream edge. In a study on the H. J. Andrews, Levno and Rothacher (1969 cited in Adams; Ringer 1994) found clearcut logging increased maximum water temperature by 4°F. Subsequent slash burning and stream cleaning increased the maximum water temperature an additional 8-10°F.

Water quality: the effect of streamside and upland forest cover on sediment delivery to streams: Site conditions (soil type, slope, and geology), road location and construction standards, and site prep intensity have more affect in sediment delivery than soil disturbance caused by logging. The use of BMPs generally minimizes suspended sediment concentrations, though often at a substantial cost (Brazier; Brown 1973). Sources of sediment from surface erosion are soils exposed by broadcast burning, and along roads and landings (Beschta 1978). Beschta also noted in the Alsea Study that high-lead cable logging, light broadcast burning (in contrast to extremely hot burns) had little affect on sedimentation, and the retention of stream side buffers protected stream beds and banks from damage by yarding activities.

Sediment from road failure was considered the greatest water quality problem, according to a study by

Brown (1972b cited in Adams; Ringer 1994). In that same study, erosion of soils exposed by severe slash burning on steep slopes was often the principle cause of surface erosion. The former problem is avoided by confining roads to stable soils and ridge top locations, locating roads away from streams, timely road and culvert maintenance, using specially designed cable logging systems in place of building mid-slope roads, and by using construction techniques like end-hauling and full bench construction when building on fragile land is unavoidable. High-lead logging alone did not produce significant amounts of sediment where it was studied on Coast Range sites (Brown; Krygier 1971). In another study involving both Cascade and Coast Range sites, landsliding from forest roads was the most important source of increased stream sedimentation, whereas soil disturbance caused by logging operations resulted in no detectable increase in stream sedimentation (Fredriksen *et al.* 1973 cited in Adams; Ringer 1994). Surface erosion associated with burning is minimized by using burning under conditions that allow retention of the duff layer or by employing alternative site prep treatments that do not involve exposing bare mineral soils on steep sites (Brown 1972a&b cited in Adams; Ringer 1994; USDI 1995 Appendix D).

Soils on slopes that are less than the angle of repose are not at risk for landsliding. The angle of repose for most local soils is around 68%. Soils on surfaces steeper than the angle of repose are held on the hill side by plant roots. The roughness of the underlying bedrock is also a slope stability factor. Plant roots, act as an underground network that binds the soils together and anchors the soils into bedrock on steep slopes (Swanston; Dyrness 1973). When trees are cut, their roots die and lose strength. Rate of root strength loss after an alder is cut is unknown. However, Douglas-fir roots lose 50% of their strength 30 months after they are cut (Burroughs; Thomas 1977). The period of increased risk for landsliding is from 1 to 15 years after clearcutting. The greatest risk is around the 5th year after cutting. Landslide occurrence is strongly correlated with heavy precipitation events. If no intense rainstorms occur during the period of increased risk then landsliding may be avoided. New root growth reduces the risk of sliding to preharvest levels after about 15 years.

<u>Dominant tree height and stand age relationships and their effect on possible buffer widths</u> - Generally, above average Douglas-fir sites are also above average alder sites. However, the relationship is not strong enough that one can predict red alder site classes based on Douglas-fir site indexes. For example, the best alder sites are on flood plains classified as unsuitable for Douglas-fir. Conversely, Douglas-fir is better able to use excessively well drained sites and sites subject to unseasonable frosts compared with alders (Harrington; Courtin 1994). Based on the differences between Douglas-fir and red alder growth patterns, and taking into account the above cautionary statements, a stream side alder stand's influence on shading litter input and other functions will be wider at age 15 and narrower at age 50 than for similar aged Douglas-fir stands on similar sites. Tables DM-5 and DM-6 show the dominate tree heights by site class and age for Douglas-fir and red alder.

Table DM-5 Distances from Stream Edge Where a Douglas-fir Dominated Riparian Stand Is Most Likely to Contribute Wood to the Channel, Affect Stream Temperature, and Provide Litter and Fine Organic Debris Contributions to the Stream

stand age (calculated as dbh age plus 4 yrs.)	Kings SI_{50} 116 (Site index age 50-yrs. at dbh)		Kings SI_{50} 126 (Site index age 50-yrs. at dbh)		Kings SI_{50} 136 (Site index age 50-yrs. at dbh)	
	Ht. of the tallest trees in ft. (Dist. from the stream edge where most instream wood is recruited).	½ the ht. of the tallest trees in ft. (Dist. from stream where stand affects stream temp. & litter input).	Ht. of the tallest trees in ft. (Dist. from the stream edge where most instream wood is recruited).	½ the ht of the tallest trees in ft. (Dist. from stream where stand affects stream temp. & litter input).	Ht. of the tallest trees in ft. (Dist. from the stream edge where most instream wood is recruited).	½ the ht. of the tallest trees in ft. (Dist. from stream where stand affects stream temp. & litter input).
20	46	23	50	25	50	25
40	93	46	100	50	108	54
60	124	62	138	69	146	73
80	147	73	157	78	173	86

Table DM-6: Distances from Stream Edge Where a Red Alder Dominated Riparian Stand Is Most Likely to Contribute Wood to the Channel, Affect Stream Temperature, and Provide Litter and Fine Organic Debris Contributions to the Steam*

stand age	Harrington & Curtis SI_{20} 35 (Site index age 20-yrs.)		Harrington & Curtis SI_{20} 55		Harrington & Curtis SI_{20} 75	
	Ht. of the tallest trees in ft. (Dist from the stream edge where most instream wood is recruited).	½ the ht. of the tallest trees in ft. (Dist. from stream where stand affects stream temp. & litter input).	Ht. of the tallest trees in ft. (Dist. from the stream edge where most instream wood is recruited).	½ the ht. of the tallest trees in ft. (Dist. from stream where stand affects stream temp. & litter input).	Ht. of the tallest trees in ft. (Dist. from the stream edge where most instream wood is recruited).	½ the ht. of the tallest trees in ft. (Dist. from stream where stand affects stream temp. & litter input).
20	35	18	55	28	75	38
40	55	28	80	40	100	50
50	60	30	85	43	105	53

* Height/ age relationship is based on Harrington and Curtis (1986) as presented in fig. 1 printed in Puettmann (1994).

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