RIPARIAN SILVICULTURAL STRATEGIES FOR FISH HABITAT EMPHASIS[1]

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ABSTRACT.--A computer simulation model was used to evaluate the effect of silvicultural practices on the potential recruitment of large organic material to streams. Western hemlock (Tsuga heterophylla), grand fir (Abies grandis), and subalpine fir (Abies lasiocarpa) habitat types were analyzed. Potential recruitment was assumed to be related to the density of greater than 12 inch DBH trees, and the number and size of trees affected by mortality. In western hemlock and grand fir habitat types, the number and mortality of greater than 12 inch DBH trees generally peaked between ages 90 and 130, but the average size of recruitable trees was greatest in stands older than 200. The potential recruitment from these stands was maximized by thinning the stands to greater than 889 trees per acre and harvesting the riparian vegetation with small openings (less than 600 feet along the stream) at a rate of 4 to 5 percent of the streambank length per decade. Both leave strips and standard timber rotations (100 years) resulted in much lower rates of potential tree recruitment. Salvaging and commercial thinning also reduced recruitment of large organic material. Alpine fir habitat types did not respond as positively to vegetative manipulation. In these stands, the density of greater than 12 inch DBH trees peaked between 110 to 150 years. Mortality was generally greatest between ages 120 and 130. The recruitment of large organic material from these sites was optimized by using leave strips or by limiting harvest of the riparian zone to 3 percent per decade. Thinning, which maintains at least 889 trees per acre, was optimum.

To implement the treatment guidelines, successful conifer regeneration and low erosion potentials must exist. Special considerations are needed to remove logging slash from the normal high water zone and to maintain a few trees in the unit for future recruitment. The harvest of timber and treatment of slash in adjacent, upslope units needs to be coordinated with the riparian treatments.

INTRODUCTION

Riparian vegetation directly influences the stream environment. Riparian vegetation moderates stream temperature profiles (Brown and Krygier 1970; Martin et al. 1981) and influences the magnitude of autotrophic and heterotrophic

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production (Meehan et al. 1977; Martin et al. 1981; Triska et al. 1982; Minshall 1978; Hawkins et al. 1982; Murphy et al. 1981). Riparian vegetation also plays an important role in stabilizing streambanks, and thereby contributes to the formation of undercut banks and channels with low width to depth ratios (Meehan et al. 1977; Pfankuch 1975; Swanson et al. 1982).

Riparian vegetation provides large organic material (LOM) to streams, and thereby significantly influences biological and physical conditions. Large organic material creates pools, reduces stream scour, and assists in stabilizing channels (Lisle 1983; Swanson and Lienkaemper 1978; Keller and Swanson 1979). Large organic material is responsible for in-channel storage of potentially massive amounts of sediment (Megahan 1982; Bilby 1984; Beschta 1979; Heede 1977). These storage sites are also important locations in biological processing of particulate organic material (Meehan et al. 1977; Sedell and Triska 1977; Triska et al. 1982). In addition to being the primary pool-forming agent in many small to intermediate size forested streams; large organic material also plays a role in accumulating gravel beds used for spawning and in providing instream cover. Significant reductions in habitat quality and fish densities have occurred where density of LOM has been reduced in streams (Martin et al. 1981; Toews and Moore 1982; Sedell et al. in press; Bryant 1981; Bisson and Sedell in press).

These study results need to be incorporated into riparian management activities if the hydrological integrity and fish habitat quality of forested streams are to be maintained. Unfortunately, translation into management has been difficult due to conflicting resource demands in riparian zones, and the shortage of information on effects of silvicultural management strategies on biological and physical dynamics of streams. Temperature models such as Brown's (1970) have been useful in estimating stream temperature increases resulting from canopy removal. However, in many cases, loss of tree recruitment from the riparian zone is of greater concern than potential increases in stream temperature. Bilby (1984) developed guidelines for management of LOM in stream channels with characteristics similar to his study stream, and several studies have noted reductions in stream habitat quality and fish populations in drainages where riparian zones have been clearcut (Newbold et al. 1980; Bisson and Sedell in press; Sedell et al. in press; Toews and Moore 1982; Martin et al. 1981). But, little work has been done on silviculture practices to enhance recruitment of LOM. Although, leave strips or salvage logging are often considered the only silvicultural treatments compatible with stream riparian zones, other options may exist. To more fully explore these options and the response of fish habitat to management alternatives, effects of successional changes and silvicultural practices on LOM recruitment need to be evaluated.

The objectives of this study are: (1) to evaluate effects of alternative silvicultural strategies on potential recruitment of LOM, and (2) to identify silvicultural practices which enhance potential recruitment of LOM in north Idaho's *Tsuga heterophylla/clintonia uniflora* (TSHE/CLUN), *Abies grandis/clintoria uniflora* (ABGR/CLUN), *Abies lasiocarpa/clintonia uniflora* (ABLA/CLUN), and *Abies lasiocarpa/menziesia ferruginea* (ABLA/MEFE) habitat types.

METHODS

Eight stands in North Idaho representing four habitat types (Copper et al. 1985) were selected for the study. The habitat types included were TSHE/CLUN, ABGR/CLUN, ABLA/CLUN, and ABLA/MEFE. The attributes of the selected stands were similar to those generally found in riparian areas in North Idaho (Table 1).

TABLE 1.--Attributes of stands selected for evaluation in the study.

Habitat Type	Aspect	Elevation (feet)	Initial Stocking Trees/ Acre	Species Composition-% 1/ WL	WP	DF	GF	WRC	WH	ES	SAF
TSHE/CLUN	NE	3400	2872	3	19	8	56	1	13		
TSHE/CLUN	NE	3400	3263	5	19	6	50	10	10		
TSHE/CLUN	N	3600	2377		9		29	1	69		
TSHE/CLUN	NW	3500	1766		15	13	40	23			
TSHE/CLUN	NE	3600	1039		6	5	48	6	35		
ABGR/CLUN	SE	4400	4453	6	1	9	82		2		
ABLA/CLUN	E	5200	4686	4						26	70
ABLA/MEFE	SE	5000	1165		6					41	53

1/ WL - western larch (*Larix occidentalis*)
WP - western white pine (*Pinus monticola*)
DF - Douglas-fir (*Pseudotsuga menziesii*)
GF - grand fir (*Abies grandis*)
WRC - western redcedar (*Thuja plicata*)
WH - western hemlock (*Tsuga heterophylla*)
ES - engelmann spruce (*Picea engelmannii*)
SAF - subalpine fir (*Abies lasicarpa*)

A computerized stand model (Wykoff et al. 1985) was used to test the effects of different thinning treatments. The model was capable of projecting changes in stand composition and mortality through time. Each stand was projected to age 300. Average mortality per year ranged from 0.7 to 1.6 percent depending on thinning intensity. A maximum residual basal area was selected using upper limits suggested by Region One Preliminary Stocking Curves (USDA, Forest Service, 1984) for each habitat type.

Three treatment levels were applied to each stand. Thinning from below was accomplished where residual stocking was reduced to 889, 538, and 194 trees/acre.

Two thinnings were projected in a TSHE/CLUN stand. Within the simulation, a thinning from below was completed with a residual stocking level of 889 trees per acre followed by a thinning from below where basal area was reduced to 120 square feet per acre. Thinnings were done at age 25 and 75 years.

To calculate tree recruitment potential and to serve as a basis of comparison between treatments several assumptions were made. Tree recruitment was assumed to result from primarily two processes: bank undercutting and tree mortality. The active undercutting zone was estimated to extend 6 feet back from the banks. Stream encroachment and bank undercutting were considered responsible for live trees entering streams from this zone. Tree mortality was also considered as an important contributor to recruitment. Width of the mortality zone was dependent on tree size with larger trees estimated to have a wider effective distance from the stream (Table 2). Suitable recruitment was considered trees which extended into the channel at least eight feet with a minimum diameter of 10 inches.

TABLE 2.--The probability that a greater than 9.9 inch log will fall at least eight feet across a stream based upon tree size and distance from the stream.

DISTANCE FROM STREAM (feet)	DBH SIZE CLASS (inches) 12-14.9	15-17.9	18-20.9	21-23.9	24-25.9	>26.0
0-10	.24	.40	.43	.44	.45	.46
10-20		.32	.37	.38	.42	.42
20-30		.22	.31	.35	.38	.39
30-40			.23	.30	.34	.36
40-50			.14	.25	.30	.33
50-60				.18	.26	.28
60-70				.05	.20	.24
70-80					.13	.19
80-90						.12

The eight foot length is based upon the assumption that this is the average length needed to create a quality pool in second to fourth order streams with channel widths ranging from 8 to 24 feet. The 10 inch minimum diameter requirement is based upon a survey of pools which noted that 10 inches was the smallest size log responsible for pools on second through fourth order streams (Lloyd, 1985). Assuming normal taper, trees with a diameter at breast height (DBH) of 12 inches would be the smallest tree in riparian stands capable of producing a 10 inch diameter log eight feet into the channel.

Potential tree recruitment from undercutting and mortality zones was added. Recruitment from the undercutting zone was calculated by determining the total number of live trees with diameters greater than 11.9 inches and assuming a 20 percent recruitment rate each decade from the zone. Recruitment from mortality was estimated by interpolating the volume of mortality occurring each decade in the following diameter classes (in inches): 12 to 14.9; 15 to 17.9; 18 to 20.9; 21 to 23.9; 24 to 25.9; 26 and greater. Mortality volume was then converted to trees/acre using the USDA Forest Service Region 1 Volume Tables (USDA, Forest Service, 1980) based on dominant tree height projections. Probability of recruitment from each size class was calculated by determining the average length of a 10 inch diameter tree bole, assuming 4 inch taper over the first 32 feet and 3 inches of taper for each additional 16 foot length. One hundred feet was considered the maximum height of a 10 inch diameter bole. The riparian zone subject to mortality was then divided into 10 foot segments from the streambanks. Probability of recruitment of each size class from each 10 foot segment was estimated by determining the maximum angle within which a 10 inch diameter bole would extend at least 8 feet beyond the streambank. This angle was divided by 360° assuming an equal probability of falling in all directions. Probablities listed in Table 2 resulted from this assessment.

To determine tree recruitment potential per mile of stream based on these probabilities, the following relationships were used:

1. $R_M = \sum T_d \sum 2.42 P_i$

   where:

   R_M = probable number of trees recruited per mile of stream due to mortality each decade.

   T_d = number of trees per acre within a particular size class removed due to mortality each decade.

   2.42 = number of acres in each 10 foot segment of riparian zone per mile of stream.

   P_i = probability that a tree of a particular size class and within a particular riparian segment will be recruited to the stream.

2. $R_u = 0.291\ T$

   R_u = probable number of suitable size live trees recruited per mile of stream due to undercutting each decade.

   0.291 = 1.45 acres per mile of stream assumed to be vulnerable to undercutting and 0.2 probability that a suitable size tree will be recruited each decade.

   T = number of suitable size live trees available each decade that are greater than 11.9 inches DBH.

3. $R_T = R_M + R_u$

R_T = probable total number of trees recruited each decade that extend 8 feet into the stream with minimum 10 inch diameter log.

To estimate effects of timber harvest, alternative harvesting intensities were evaluated. Harvest intensities differed based on length of the streambank vegetation harvested each decade. A harvest intensity of 10 percent, for example, would open 10 percent of the streambank length each decade and would equate to a 100 year timber rotation. Because there are two streambanks along the channel, total length of streambank vegetation is twice the stream channel length.

Effects of different harvest intensities was estimated based on the following equation:

$$4. \quad R_I = \Sigma \frac{R_{Ti}}{N_i}$$

R_I = average probable number of trees recruited per mile each decade that would extend 8 feet into the channel with minimum 10 inch diameter resulting from a timber rotation (harvest intensity) of I.

R_{Ti} = probable number of trees recruited per mile of stream in decades 1 through i.

N_i = number of decades in a timber rotation (harvest intensity) of I.

RESULTS

Results of this study show that the density and mortality of greater than 11.9 inch DBH trees change with stand age. These changes influenced levels of potential log recruitment. Thinning intensity, harvest intensity and the number of thinnings also affected the log recruitment potential of stands.

Stand Density

Recruitment of trees due to stream undercutting was assumed to be related to the density of greater than 11.9 DBH trees present on the bank during each decade. The density of greater than 11.9 inch DBH trees in the TSHE/CLUN habitat type peaked when stand age reached 100 and 120 years (Fig. 1). A sharp rise in density of suitable trees occurred in stands between the ages of 50 and 100 years, but a steady decline was noted after age 120. The ABGR/CLUN habitat type exhibited a peak similar to that observed in TSHE/CLUN habitat type (Fig. 1). This peak did not occur until the stand approached 160 years old. The ABLA/CLUN and ABLA/MEFE habitat types had peaks which occurred when stands approached ages between 130 and 150 years old (Fig. 1). As in the ABGR/CLUN habitat type, a sharp decline occurred when stands exceeded 160 years of age.

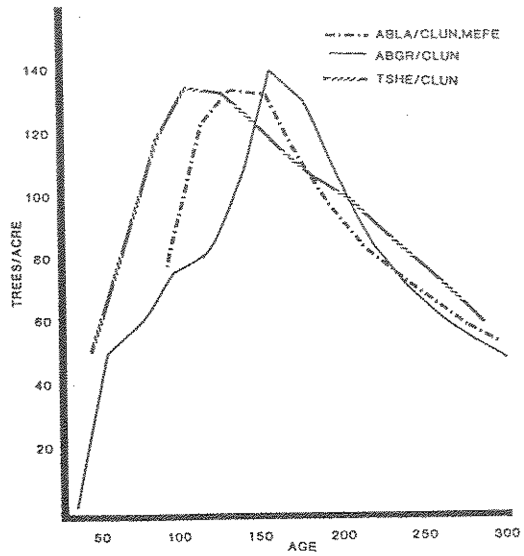

FIGURE 1.--Trees per acre greater than 11.9 inches DBH by stand age in ABLA/CLUN, ABLA/MEFE, ABGR/CLUN, and TSHE/CLUN habitat types thinned to 889 trees per acre.

Based upon the assumptions used in the analysis, the relative contribution of undercutting of live trees to potential tree recruitment became less with increasing stand age. In stands 100 years old or younger, undercutting accounted for over 40 percent of the projected levels of log recruitment. Between stand ages 100 to 200 years, potential recruitment from undercutting ranged from 25 to 50 percent. In stands older than 200 years, trees recruited by undercutting comprised approximately 25 percent of the total.

Stand Mortality

Tree mortality was also assumed to contribute to potential tree recruitment. For TSHE/CLUN, ABLA/CLUN, and ABLA/MEFE habitat types, recruitment due to tree mortality peaked between 120 to 140 years of age. The ABGR/CLUN habitat type differed slightly, peaking at 160 years of age.

Peaks in tree mortality were dominated by 12-14.9" and 15-17.9" DBH size classes for all habitat types (Figs. 2,3,4). At older ages, larger diameter, taller trees dominated mortality. However, the enlarged zone of influence (of individual trees) did not compensate for the overall lower tree densities.

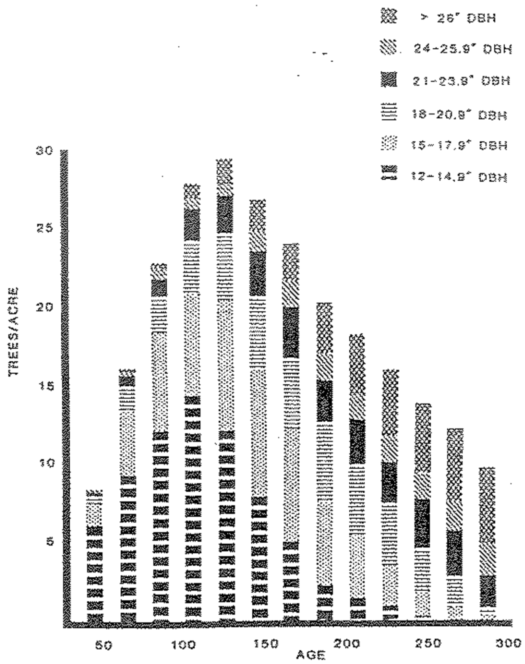

FIGURE 2.--Tree mortality by diameter class in TSHE/CLUN stands thinned to 889 trees per acre.

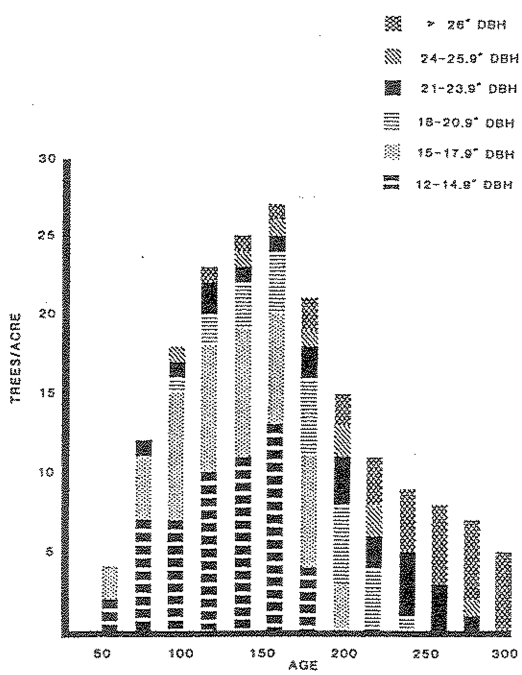

FIGURE 3.--Tree mortality by diameter class in an ABGR/CLUN stand thinned to 889 trees per acre.

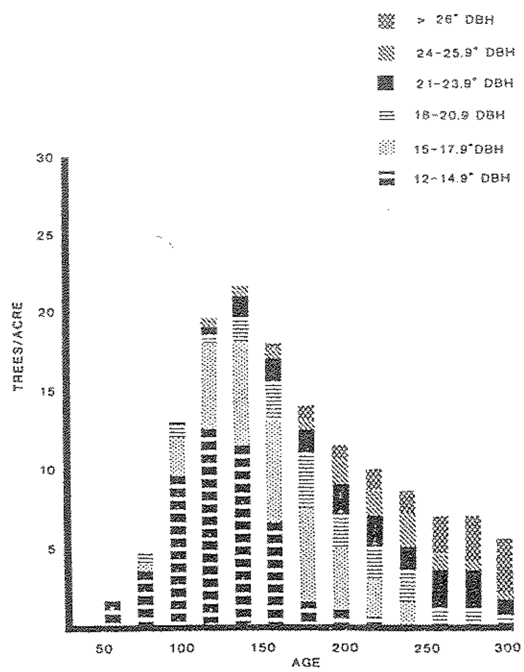

FIGURE 4.--Tree mortality by diameter class in ABLA/CLUN and ABLA/MEFE stands thinned to 889 trees per acre.

One Thinning

Within the TSHE/CLUN habitat type, thinning intensity affected potential tree recruitment. Stands thinned to 889 and 538 trees per acre exhibited similar upwards trends during the first 150 years (Fig. 5), with tree recruitment peaking at over 100 trees per mile of stream. However, in stands thinned to 889 trees per acre, recruitment rates of over 100 trees per mile of stream were maintained for the next 70 years. In stands thinned to 538 trees per acre a decline to less than 100 trees per mile of stream was observed during the same period. Stands thinned to 194 trees per acre displayed a reduction in potential recruitment as compared to other thinning intensities. Mean values in stands thinned to 194 trees per acre never exceeded 70 trees per mile of stream. Effects of this heavier thinning were noted within the first 100 years of the stands growth and continued throughout the projection.

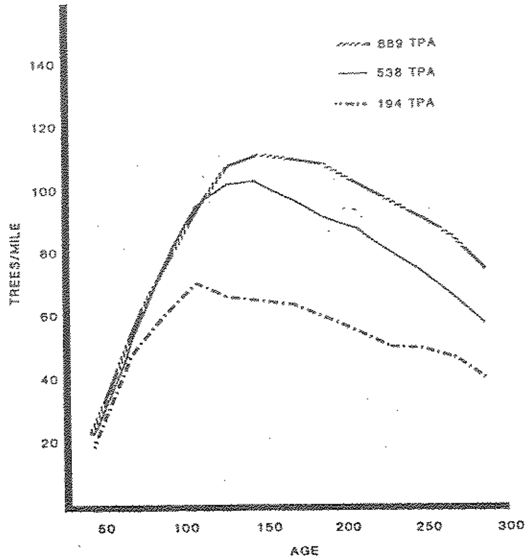

FIGURE 5.--Effect of stand age and thinning intensity on potential tree recruitment in TSHE/CLUN stands.

Effects of one thinning on the ABGR/CLUN habitat type were similar to the TSHE/CLUN habitat type. Maximum tree recruitment occurred when the stand was thinned to 889 trees per acre, peaking at over 100 trees per mile of stream (Fig. 6). This peak was not seen when the stand was thinned to 538 trees per acre where trees recruited approached 90 trees per mile. Recruitment was further reduced when the stand was thinned to 194 trees per acre.

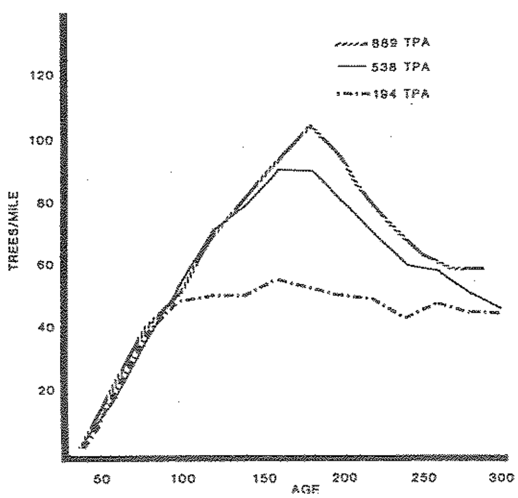

FIGURE 6.--Effect of stand age and thinning intensity on potential tree recruitment in an ABGR/CLUN stand.

The ABIA/CLUN and ABIA/MEFE habitat types exhibited the largest differences in potential tree recruitment with various intensities of thinning. Stands thinned to 889 trees per acre had the highest numbers of trees recruited per mile of stream (Fig. 7). This peak occurred at 160 years. Stands thinned to 538 trees per acre exhibited similar levels of potential tree recruitment as the 889 thinning during the first 140 years, but were lower thereafter. Effects of a heavier thinning 194 trees per acre, reduced tree recruitment by about 50 percent, as compared to the other two thinning intensities.

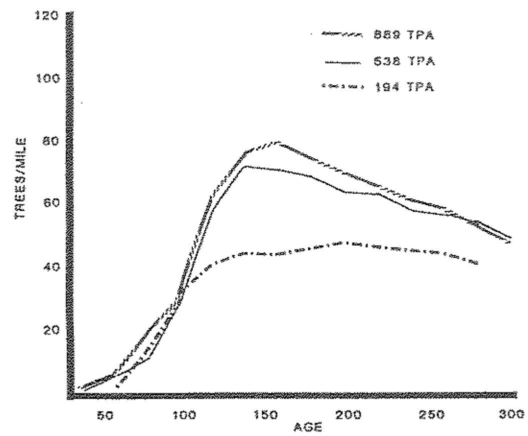

FIGURE 7.--Effect of stand age and thinning intensity on potential tree recruitment in ABLA/CLUN and ABLA/MEFE stands.

Commercial Thin

Effects of two thinning treatments on potential tree recruitment in a TSHE/CLUN habitat type were evaluated (Fig. 8). Thinning from below at age 25, leaving 889 trees per acre, followed by another thinning from below at age 75 to a residual basal area of 120 reduced potential tree recruitment. This reduction was noted immediately after the second thinning occurred. When two thinnings were projected, tree recruitment never exceeded 60 trees per mile of stream, while the stand approached 120 trees per mile with only one thinning, 889 trees per acre, (Fig. 8). In general, potential tree recruitment was reduced by 50% in the stand with two thinnings.

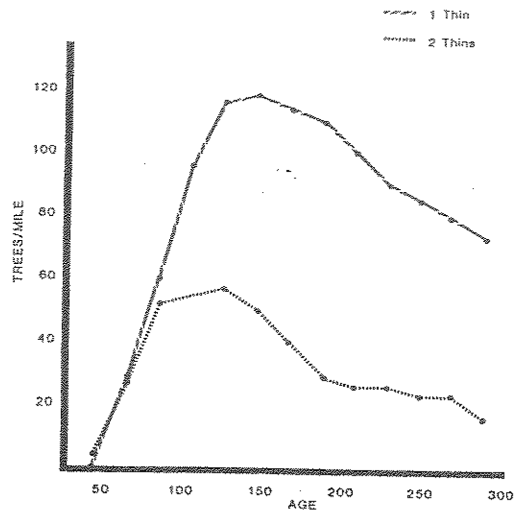

FIGURE 8.--Effect of one and two thinnings on potential tree recruitment in a TSHE/CLUN habitat type.

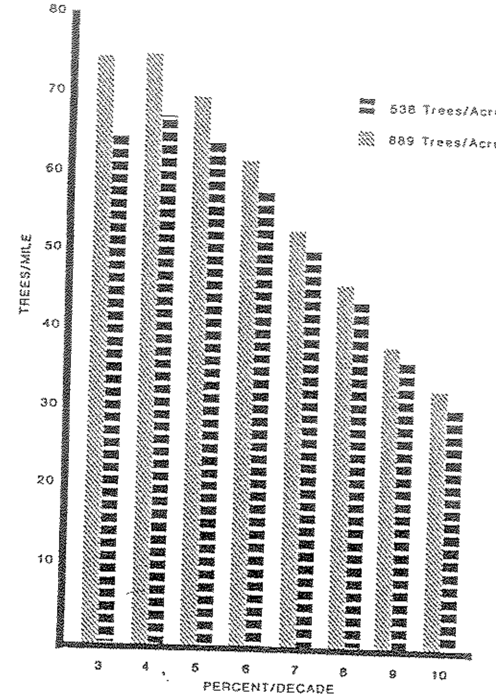

FIGURE 9.--Effect of harvest rate and thinning intensity on potential tree recruitment for TSHE/CLUN stands.

Harvesting Intensity

The effect of even-aged silvicultural systems (clearcut, seedtree, or shelterwood methods) in riparian zones for the three habitat types was evaluated. For all habitat types and thinning treatments, a negative effect on tree recruitment per mile of stream was observed as the percent of streamside zone harvested/decade was increased (Figs. 9,10,11). The TSHE/CLUN habitat type yielded the highest levels of potential recruitment at a harvest intensity of 4 percent/decade for both thinning treatments (Fig. 9). A slight reduction in trees recruited per mile of stream was noted at harvest intensity of 3 percent. Harvesting of ABGR/CLUN, ABLA/CLUN, and ABLA/MEFE habitat types resulted in similar peaks, but the number of recruited trees was generally less than the maximum recruited in the TSHE/CLUN habitat type (Figs. 9,10,11).

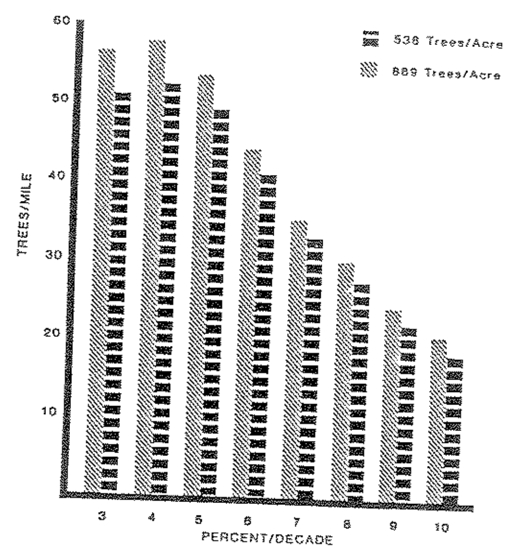

FIGURE 10.--Effect of harvest rate and thinning intensity on potential tree recruitment in an ABGR/CLUN stand.

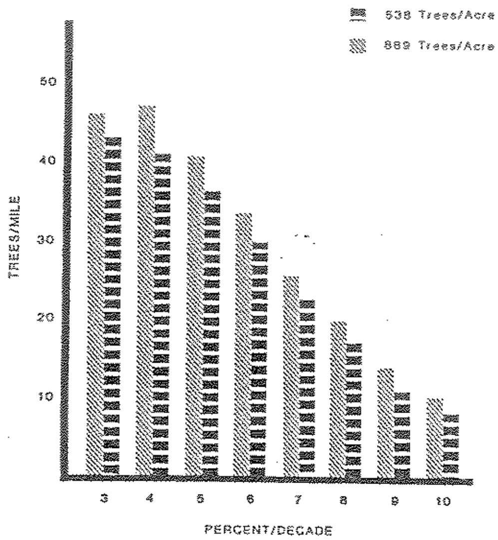

FIGURE 11.--Effect of harvest rate and thinning intensity on potential tree recruitment for ABLA/CLUN and ABLA/MEFE stands.

DISCUSSION

Potential recruitment of LOM was affected by stand age and management. In TSHE/CLUN and ABGR/CLUN habitat types, potential log recruitment peaked in 140 to 180 year old stands. Age of peak recruitment was dependent upon species composition and intensity of thinning. In the ABLA/CLUN and ABLA/MEFE habitat types, potential recruitment was also greatest during this period, but the peak was not as pronounced.

Changes in potential recruitment from TSHE/CLUN and ABGR/CLUN habitat types were associated with growth and mortality of seral species. Western larch, western white pine, and Douglas-fir were the most important seral species in stands evaluated. In stands less than 40 to 45 years old, trees of sufficient size to provide stable channel obstruction (greater than 10.9 inches DBH) were essentially absent. By 70 years of age, seral species began to reach a size suitable for log recruitment, and peaked in number between 110 and 160 years. Maximum recruitment occurred in 140 to 180 year old stands when mortality of seral species was greatest. As climax species replaced seral components, the average size of trees available for recruitment increased, but the number of suitable trees decreased. These changes resulted in an overall reduction in recruitment potential in stands older than 220 years. The gradual reduction would likely continue until the stand becomes sufficiently opened to allow regeneration to grow into adequate size trees. At this time, an equilibrium may become established between potential log recruitment and regeneration. This equilibrium could remain in effect until altered by a major event such as fire, blowdown, or harvesting. These results are similar to projections made by Likens and Bilby (1982), who indicated that a peak in organic debris dam development may occur as seral components are replaced by climax species in hardwood stands. However, they noted the effect would probably only be experienced in first and second order streams due to the small size of the channel obstructions resulting from seral species such as pin cherry (Prunus pensylvania). In our stands, seral species attain a much larger size before they are recruited, and therefore, are capable of influencing larger channels.

The ABLA/CLUN and ABLA/MEFE habitat types displayed similar trends during successional development, but effects on potential log recruitment were not as pronounced. Differences may be attributed to slower growth rates and a 20 to 30 year delay in maximum rates of mortality. Also, stand density as indicated by the crown competition factor was lower in these habitat types. Lower stand densities may permit continued replacement of suitable size trees even in mature stands. As a result, peaks in potential recruitment occurred later and were lower than observed in TSHE/CLUN and ABGR/CLUN habitat types. Also, reductions in potential recruitment from stands older than 220 years was not as severe.

Silviculture treatments affected potential log recruitment from these stands. Western larch and western white pine growing on the TSHE/CLUN habitat type and western larch on the ABLA/CLUN and ABLA/MEFE habitat types provided the highest levels of recruitment. Thinning to less than 889 trees per acre on all four habitat types reduced potential tree recruitment in stands older than 120 years.

Two thinnings reduced potential tree recruitment. An approximate 50 percent reduction in recruitment was noted in a TSHE/CLUN habitat type treated with two thinnings. Increases in individual tree growth resulting from this practice did not compensate for the reduction in suitable tree density. Salvaging of dead and dying trees would have a similar negative effect by removing trees which would otherwise be available for near term recruitment.

Timber harvest also affected recruitment of LOM. Harvesting TSHE/CLUN and ABGR/CLUN habitat types at a rate of 3 to 5 percent of streambank length (twice the measured stream length) per decade resulted in maximum levels of potential tree recruitment. Normal timber rotations (100 year, 10 percent per decade) resulted in a 55 to 80 percent reduction from these levels. These data also indicate that in these habitat types, some harvest is beneficial. After reaching a peak between the ages of 140 and 180 years, potential recruitment diminished. After 280 years, 40 to 50 percent reductions in recruitment from potential levels were noted. If a leave strip were used, this drop would likely continue until the stand was sufficiently opened to permit development of suitable size trees for recruitment in the understory. Assuming regenerated trees will not reach this size until the crown competition factor is less than 150 percent and the basal area is less than 200 square feet per acre, the projections model indicate that maximum rates of potential recruitment would be about 45 trees per mile of stream per decade. Harvesting the same stands at a rate of 4 or 5 percent per decade resulted in 60 to 75 trees per mile of stream per decade. By maximizing the presence of age classes most conducive to recruitment, these light harvesting schedules compensated for the low recruitment rates of stands less than 70 years old and actually exceeded projections for leave strips of climax vegetation. The primary benefit of unmanaged leave strips to recruitment is in providing a greater number of trees larger than 26.0 inches DBH. These larger trees may be important in higher order streams.

The ABLA/CLUN and ABLA/MEFE habitat types did not respond as positively to timber harvest. In these stands, recruitment from leave strips was estimated to be approximately 45 trees per mile of stream per decade. Harvesting riparian vegetation at a rate of 3 or 4 percent of streambank length per decade maintained this rate, but all other harvest schedules resulted in reductions.

Effects of these potential recruitment rates on stream habitats will be dependent on factors such as the longevity of resulting LOM in the stream and the channel type of the stream receiving the material. For example, assuming that the average life span of pools created by LOM is about 30 years in third order streams, and about half of the trees recruited actually form pools, pool habitat projections could be made. By harvesting 5 percent per decade in a TSHE/CLUN habitat type, 105 pools per mile of stream occupying about 30 percent of the stream area would result. If the same stand were managed as a leave strip, number of pools and pool area would be estimated to be 65 and 20 percent respectively. If a normal timber management rotation were used (100 years and 10 percent of the streambank length per decade), a reduction to 45 pools per mile of stream and 12 percent pool area would be projected. By adjusting assumptions used in this analysis (size of suitable LOM creating pools, stream size, channel type, and slope angle of the riparian zone), effects of alternative management approaches on habitat quality of specific reaches could be estimated.

Results of this study should be of value in selecting management strategies where fish and timber resources are concerns. The following general guidelines were developed based upon study results and experiences encountered when managing in riparian stands. It should be stressed, however, that these guidelines are based upon habitat types located in north Idaho. Their application to habitat types outside this area needs to be evaluated. In addition, these guides should only be considered as general considerations which will need to be modified based upon site specific environmental conditions and resource management concerns.

1. To optimize the recruitment of LOM, riparian stands on TSHE/CLUN and ABGR/CLUN habitat types should be harvested at a rate of about 4 percent of the streambank length per decade. Five percent per decade would be preferred if a timber stand being managed at a 100 year rotation is located between the riparian stand and road. A 5 percent entry rate (200 year rotation) would permit management of both stands while minimizing tradeoffs (Fig. 12). This approach would require coordinating timber harvest in the intervening timber management stand with riparian needs and leaving alternative riparian strips with each entry.

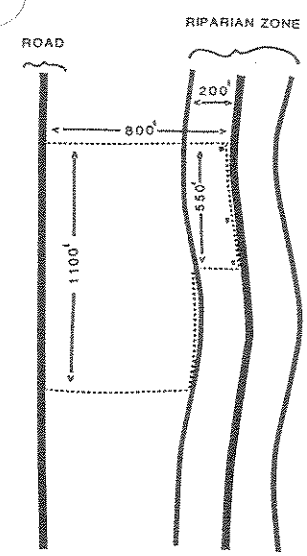

FIGURE 12.--A possible approach to integrate riparian management with adjacent timber management.

Standard timber rotations and leave strips are generally not recommended for these habitat types. However, leave strips may be preferred in larger streams (fifth order) where large trees are needed to create stable pools.

In the ABLA/CLUN and ABLA/MEFE habitat types, either leave strips, or 3 to 4 percent harvest rates would be preferred.

2. Harvesting of riparian stands should not be pursued at the recommended rates where conifer regeneration would be inhibited or where unstable soils exist. Regeneration could be inhibited where openings will raise the water table, stimulate brush development, or create frost pockets. Where these conditions are anticipated, an alternative management approach will be needed.

3. Harvested riparian zones should be treated to optimize conifer regeneration. Western larch and western white pine regeneration would be desirable in the habitat types evaluated.

4. Logging debris resulting from harvest should be moved out of the normal high water area. Dozer-piling of slash is generally not recommended due to the potential for sedimentation.

5. The four habitat types studied should not be thinned to less than 889 trees per acre. Two thinnings should not be pursued. If sanitation/salvage treatments are to be used, the following guides are recommended based upon tree size and their distance back from the stream:

Distance to Streambank (feet)	Leave Trees Greater than (DBH)
0 to 30	12"
30 to 60	18"
60 to 90	24"

Riparian zones directly influence stream habitats through the recruitment of LOM to the stream. Silvicultural treatments may directly influence this role by modifying the condition of riparian stands.

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