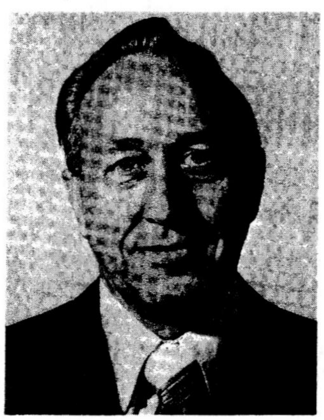
2509

Natural and Man-Caused Slash In Headwater Streams

by
HENRY A. FROEHLICH
School of Forestry
Oregon State University
Corvallis, Oregon

Figure 1
Natural debris accumulations such as shown here in study Channel M prior to logging were common in all of the headwater streams except those recently sluiced-out. A large quantity of sediment is trapped upstream from these barriers.

"LET'S MAKE ONE THING PERFECTLY CLEAR — WATER" reads a poster printed in 1970 by the Soil Conservation Service. This catchy slogan has been echoed by a large number of groups and concerned individuals. Federal agencies have been working under guidelines developed, in part, as a result of Executive Order 11507. In this Order President Nixon states that as a matter of policy, "It is the intent of this order that the Federal Government in the design, operation, and maintenance of its facilities shall provide leadership in the nationwide effort to protect and *enhance* the quality of our air and water resources" (emphasis mine). "Facilities" were later defined to include Federally managed forest and range lands.



Henry A. Froehlich

Governor McCall's staff in cooperation with Federal agencies has developed a program called: Goals For A Livable Oregon. Concerning Natural Resources, the program calls for the development, use and protection of Oregon's natural resources in a manner which will provide optimum benefits to present and future generations. This program would include developing and enforcing standards regarding logging practices, agricultural operations and gravel operations as they relate to water pollution. In addition, the program calls for studying the effects of timber production and recreation on watersheds and designing timber harvesting systems that are compatible with sound stream management including downstream needs.

OREGON FOREST PRACTICE RULES

In 1971 the Oregon State Legislature passed the Forest Practices Act and by July 1, 1972 a set of rules, provided for in the act, became effective and had the force of law. The Rules place considerable emphasis on stream protection. The Forest Practices Act specified that the Rules will be designed to assure the continuous growing and harvesting of forest tree species and to protect the soil, air and water resources, including but not limited to streams, lakes and estuaries. In order to allow for flexibility in applying the Rules the state was divided into three regions: Eastern, Northwest and Southwest with each of the latter two regions being further divided into two subregions. However, the rules relative to stream protection are quite similar over the state.

Stream Classification

Two classes of streams are defined in the Rules as follows: "Class I streams are those which are valuable for domestic use, are important for angling or other recreation and/or used by significant numbers of fish for spawning, rearing or migration routes. Stream flows may be either perennial or intermittent during parts of the year; Class II streams are headwater streams or minor drainages that generally have limited or no direct value for angling or other recreation. They are used by only a few, if any, fish for spawning or rearing. Their principal value lies in their influence on water quality or quantity downstream in Class I waters. Stream flow may be either perennial or intermittent." Since the basic criteria are most strongly related to the actual or potential use of the water by

Reprinted from 1973 Edition, Pacific Logging Congress "LOGGERS HANDBOOK", Vol. XXXIII

fish life, the stream classification has primarily been done by the staff of the state game commission, fish commission or fisheries biologists in Federal agencies.

Of course, there is no doubt as to the classification of the major streams, and there has been reasonable agreement concerning the upper limits of the State Class I streams. The actual classification or delineation of the upper limits of the Class II stream, however, is open to a much wider range of interpretation and classification. Some may wish to treat any defined channel no matter how small as a Class II stream while others would treat the small headwall channels as part of the watershed slope.

The spirit of the Rules as they apply to Class I streams can be summarized as: Maintain stream beds and streamside vegetation in as near a natural state as possible in order to protect water quality and aquatic habitat. The Rules list a number of specific acts that will be done to achieve this. Relative to logging slash, the Rules require: "wherever possible trees shall be felled, bucked and limbed so the tree or any part thereof will fall away from any Class I stream. Remove all material that gets into such a stream as an ongoing process during harvesting operations. Place removed material above high water level." In general there is considerable flexibility allowed in the harvesting operations near or across the Class I streams. Probably the most significant criteria being used in judging whether a logging job meets the standards of the Rules lies in the *necessity* of affecting a stream. It may be acceptable to fall trees across a Class I stream when it appears that this is the only realistic alternative, and provided that cleanup is prompt and effective. However, when it appears that the timber falling could have been accomplished in some other manner the same degree of stream disturbance is likely to be considered unacceptable. The same is true for landing locations or number and location of stream crossings.

Because the upper limits of Class II streams are not clearly defined, considerable judgement is required in interpreting and applying the Rules. The basic principle behind the requirements concerning Class II streams is to take whatever precautions are necessary to maintain the quality of the Class I stream rather than the direct effect on the Class II stream. This obviously requires a judgement of any direct or potential damage to a stream some distance removed from the site of the logging. Debris accumulations within the head of a very small channel in an area frequently subject to slumps and "sluice-outs" might well be an unacceptable hazard. On the other hand, a similar accumulation in another more stable drainage might be of little concern.

Rule Enforcement

Streams have also drawn the most attention in the enforcement of the new Rules. In the first six months of operation under the new Oregon Forest Practice Rules 63 enforcement actions were taken. Of these, 64 percent had to do with streams affected by either road construction or logging, and 17 percent were related to road maintenance and erosion control measures. The remainder of the warnings or citations were for failure to notify the State before beginning a logging operation. About 60 percent of the water-related enforcement actions were for unacceptable impacts on Class I streams. It is also worth noting that there were no citations, only warnings, on violations concerning Class II streams. This no doubt reflects a degree of uncertainty concerning the actual impacts on Class II streams and represents a learning period for both the Rules inspectors and the forest industry. I expect that this will change with time and enforcement will become more stringent on Class II streams. Thankfully, there appears to be a willingness on the part of many groups and individuals who expressed strong concern initially on whether or not the Rules would be effective to give the State and Industry time to make adjustments and go through this learning process.

It is a fact of life then that stream protection and stream cleanup requirements are with us and are likely to increase. Many people are surprised to learn what small, apparently insignificant streams are actually used for spawning by anadromous fish or support resident trout. We are all becoming more aware of the interrelated nature of the stream systems and the role that the Class II streams play in maintaining the quality of the more important Class I segments. In spite of this, there should be no doubt that both economic logging and satisfactory fish habitat can be achieved over a wide range of conditions. There are a number of unanswered questions, however, concerning the condition in which Class II streams should be left when logging is completed. How much and what type of material should be removed? What are natural, undisturbed streams like? What is the probability of the material actually affecting downstream use. Answers to these and related questions are not easy to come by, and no doubt considerable judgement and opinion will always be required in dealing with the Class II stream.

RESEARCH ON ORGANIC DEBRIS

In an effort to answer some of these questions, stream measurements were made on a wide range of streams on the west side of the Cascades during the past two years. Undisturbed stream channels were selected that were included in planned logging operations so that the same section of stream channel could be observed before any disturbance, after timber falling, after yarding, and finally after stream cleanup or slash burning if any was done. Seventeen drainages were included in the initial sample, ranging in size from six to 7500 acres. All drainages supported old-growth Douglas-fir having an estimated stand defect of from 30 to 40 percent.

Sixteen of the sites were on the west side of the Cascades and one on the east side of the Coast range. With the exception of the two largest streams, the side slopes adjacent to the channel were very steep, averaging from 57 to 92 percent. After examining a large number of channels it appeared that in general

Table 1. Characteristics of sample streams and quantities of natural organic debris

watershed 10 HJA

	Watershed		Water Course				Debris		
Channel No.	drainage area (acres)	ave. side slope near stream %	depth (feet)	width (feet)	cross section area (sq. ft.)	gradient %	coarse (tons/100 feet)	fine (tons/100 feet)	total (tons/100 feet)
A	.6	71	.4	2.0	0.8	65	21.3	0.61	21.9
B	11	70	.5	3.0	1.5	57	22.4	1.01	23.4
C	20	85	.7	3.0	2.1	60	(14.0)*	0.94	14.9
D	23	85	.7	3.0	2.1	60	7.8	1.68	9.5
E	24	87	.6	6.0	3.6	29	10.4	0.60	11.0
F	70	60	1.0	7.5	7.5	7	7.1	0.50	7.6
G	83	90	1.0	11.0	11.0	28	24.8	1.01	25.8
H	90	92	1.2	9.0	11.0	29	12.1	0.78	12.9
I	96	66	1.3	9.0	12.0	15	7.2	0.76	8.0
J	122	73	1.7	9.0	15.0	15	11.2	0.77	12.0
K	141	88	1.7	11.0	18.0	22	0.8	0.14	0.9
L	282	57	1.2	28.0	34.0	10	12.6	0.94	13.5
M	288	62	1.6	19.0	31.0	11	5.7	0.73	6.4
N	403	73	2.5	16.0	40.0	17	14.2	0.72	14.9
O	1,323	76	2.5	30.0	75.0	10	11.7	0.42	12.1
P	1,593	38	5.0	15.0	75.0	6	7.5	0.62	8.1
Q	7,520	20	5.5	55.0	300.0	20	2.8	0.22	3.0
					Average		11.3	0.76	12.1

*Estimated from adjacent channel measurements

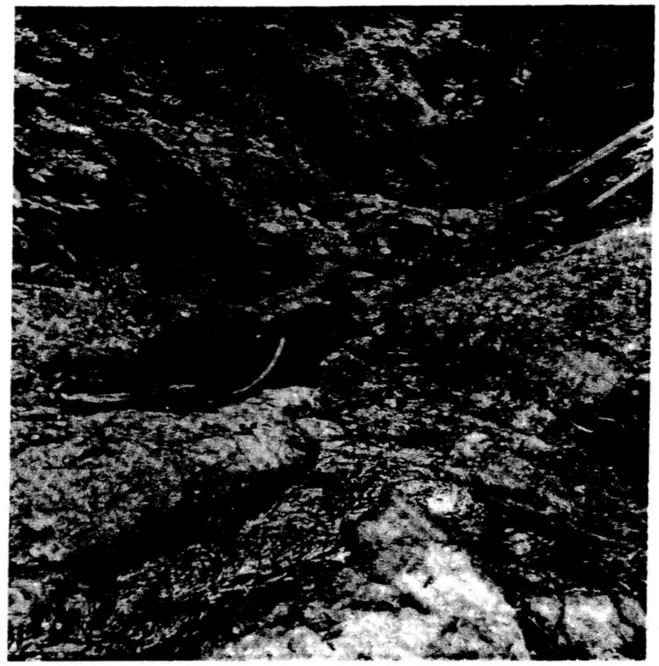


Figure 2

Portion of Channel K showing effects of sluice-out a few years prior to logging. Organic debris now averages 0.9 tons/100 feet of channel.

a 15-foot zone on each side of the stream centerline would include the normal zone of influence or source area of debris movement into the channel. This 30-foot strip would include most of the area scoured by "sluice-outs" or debris avalanches in the small channels. This zone would also include most of the area covered by average high flows on all but the largest channels observed. Throughout this paper "channel" refers to the actual water course plus whatever stream bank is within 15 feet of the centerline. Sample sections were 200 to 400 feet long and were chosen so as to fall within the setting to be logged.

Within this 30 x 400-foot strip (.28-acre) centered over the stream channel the volume of coarse and fine debris was estimated. Coarse debris included all organic material that was larger than 4 inches in diameter and over one foot long. Chunks of wood decayed to the point where they would crumble if moved downstream were not included. The diameter at both ends and length were recorded for each piece for later conversion to cubic volume and weight. Fine debris included small twigs from approximately 0.01 inch in diameter to branches and splintered wood up to 4 inches in diameter. This fine debris was sampled at four randomly located points along cross sections of the channel. Cross sections were taken at 25-foot intervals. A planar intercept method was used to estimate the volume of fine debris represented by this sample. Additional data on channel and slope characteristics were also taken to aid in observing the effect of logging on the stream. Some of the physical features of each of the 17 streams are given in Table 1.

The study was financed through McIntire-Stennis funds and is part of a program of Forest Engineering research at Oregon State. Graduate students Dick Lammel and Dale McGreer assisted in the field measurements. The cooperation of a large number of logging contractors, timber companies, the staff of the Willamette National Forest and the Eugene and Roseburg Districts of the BLM were all necessary to carry out this work.

Natural Debris in Streams

Natural debris accumulations of surprisingly large volumes were common in all but the largest channel. The average debris accumulation of all samples was 12 tons of organic debris per 100 feet of stream channel. About 94 percent of this was in large material and six percent was fine debris. On channels A, B, C and G there was a fairly visible age sequence of material. The bottom layer of material was in an advanced state of decay and this was topped with material showing less and less decay. Most channels had some sound, merchantable wood in the upper layer. In Channel G, a few hemlock growing on top of some of the logs in the channel were found to be about 25 years old. Thus, in spite of the fact that the channel gradient was 26 percent and drained an area of 83 acres, the organic material had probably accumulated over at least a 50-year period. Channel G likely carried flows of 15-20 cubic feet per second a few times during this period. In contrast Channel H, which is quite similar to Channel G, contained only half as much natural debris. There was strong evidence of past scouring of this channel in the oversteepened channel walls plus the absence of almost any material in an advanced stage of decay.

Slash in Headwater Streams

The Function of Natural Debris

The coarse and fine organic debris is as much a natural part of the stream system as is silt, sand, gravel and boulders. The organic debris is also cycled through the stream system in somewhat the same way as the inorganic material. Some of the coarse debris has a relatively long period of residence in or near the channel awaiting slow decay and weathering (Figure 1). In many channels this slow process is interrupted by catastropic events such as sluice-outs or extreme floods (Figure 2). Some of the fine debris moves much more readily although some of it is also incorporated in the beds and banks of the channels. There the material either decays or is flushed when high flows shift the gravel deposits.

The role that this debris plays in the overall stream system is not well known. Meehan (1969) observed on some salmon streams in Alaska that log-sized debris had the effect of aiding in the self cleaning of the stream. He noted that the increased water velocity around the obstacles caused gravel to shift and silty material to be flushed out. Eventually the obstacle itself would be shifted downstream and thus bring about changing current patterns. This feature would probably only hold true for streams as large as O, P, or Q of our study. On the smaller channels one of the major roles of the debris is as an energy dissipator. Heede (1972) observed that stream velocities of high mountain streams were markedly reduced by the natural debris barriers. Energy is consumed at each barrier and the erosive force of the water greatly reduced in these steep headwater drainages. The debris obviously serves as sediment traps for the large load of naturally occuring sediment moving in these channels. Gravel bars form behind the debris jams and are slowly released as the barriers decay, erode away, or are displaced by undercutting (Figure 3). New barriers are continually formed in a random fashion along the stream system. Unless a catastrophic event takes place it appears that some sort of equilibrium is established. Natural organic debris also serves as a food energy source and habitat for a wide variety of aquatic and riparian organisms. Dr. James Sedell, Research Associate in Fisheries, is studying this function in detail under the International Biologcal Program for the Coniferous Biome. Channels A, B, O and Q are included in the IBP study streams.

CHANGES PRODUCED BY LOGGING

Logging near and across drainages can change the amount and condition of the debris. To better understand what changes take place with clearcut logging in these old-growth stands we remeasured the debris on ten of the channels after each stage of logging. The same sections of stream were used in each successive measurement. Three settings were clearcut harvested by conventional free-falling and cable yarding, four units were logged by cable-assist directional falling and cable yarding, and three were conventional falling-yarding but with a buffer strip between the clearcut and the channel. The results of these measurements are shown in Tables 2 and 3. The small number of channels studied under each logging system is not sufficient to allow a statistical analysis of the results. However, it is expected that the data will provide some insight to the trend of the effect of certain cutting practices and some useful observations can be made.

Figure 3

The mixture of coarse and fine organic debris plus silts, sand and gravel making up this stream bed is exposed by channel cutting during recent peak flows. This deposition took place prior to logging, possibly during the 1964-65 peak flow.

Figure 4

Measuring logs and slash in Channel K after timber falling. New material added during falling averaged 42 tons/100 feet. After yarding, 22 tons/100 feet remained in the channel. Cleanup reduced this to 3.3 tons/100 feet.

Table 2. Changes in the total coarse and fine debris with stage of logging and with cutting practice. Tons per hundred feet of channel.

Channel	Natural debris	Material added in tree falling	Percent increase	Excess material after yarding	Total material after yarding
Conventional, free-falling—cable yarding					
I	8.0	82	1025	21	29
K	(10.0)[1]	42	420	12	22
M	6.5	17	265	1.9	8
Average	8.1	47	570	11.6	20
Cable-assist directional falling—cable yarding					
C	15	9.5	63		
D	9.5	20	210	10	20
G	26	11	42	-6.9	19
J	12	16	133	-0.7	11
Average	16	14	112	-0.8	17
Conventional, free-falling—cable yarding—buffer strip[2]					
F	7.6	2.1	28	-3.0	4.5
L	14	1.8	13	1.2	15
N	15	0.01	0	0.01	15
Average	12	1.3	14	-1.8	11.5

[1] Estimated normal loading.
[2] Buffer strips were: F—20-50' alder, maple and small hemlock; L—30-50' hardwood, large Douglas fir, cedar; N—100-130' lange Douglas fir, cedar and hemlock.

Table 3. Changes in the fine debris (0.1-4.0 inches) with stage of logging and with cutting practice. Tons per hundred feet of channel.

Channel	Natural debris	Material added in tree falling	Percent increase	Excess material after yarding	Total material after yarding
Conventional, free-falling—cable yarding					
I	0.76	3.32	436	4.27	5.04
K	0.76	3.39	446	4.53	5.28
M	0.73	0.69	95	0.44	1.17
Average	0.75	2.47	325	3.08	3.38
Cable-assist directional falling—cable yarding					
C	0.94	0.22	23		
D	1.68	0.94	56	3.47	5.15
G	1.06	0.99	93	2.34	3.40
J	0.77	0.28	36	1.20	1.97
Average	1.11	0.61	69	2.34	3.51
Conventional, free-falling—cable yarding—buffer strip[1]					
F	0.50	0.36	72	0.51	1.01
L	0.94	0.09	10	0.17	1.11
N	0.72	0.00	0	0.00	0.72
Average	0.72	0.15	27	0.22	0.95

[1] Buffer strips were: F—20-50' alder, maple and small hemlock; L—30-50' hardwood, large Douglas fir, cedar; N—100-130' large Douglas fir, cedar and hemlock.

Conventional Free-falling

The actual quantity of material added to the channels during timber falling varied from 17 tons per 100 feet added to Channel M to 82 tons added to Channel I. Channel K had 42 tons of material added (Figure 4). The drainage with the largest amount added appeared to be the easiest terrain in which to work.

Figure 5

This view of Channel I after tree falling shows the large amount of material added by this falling job. Considerable breakage is also evident.

Channels M and I were somewhat similar in topography to Channel K which had the most broken ground and steepest sideslopes. Breakage was not measured, but could be compared by observation. The timber felled around Channel I had the greatest visible breakage of any unit in the study (Figure 5).

The attitude of the various cutting crews toward stream protection requirements differed markedly. I believe that this difference in attitude on the part of the falling crew played the biggest part in determining the amount of debris added during timber falling. Of course, Channel I draining only 96 acres is not very impressive, and while the stream runs year around, it does get very low in summer. However, each of these settings had a stream cleanup requirement in the logging contract and any addition of debris to the channels that was not absolutely necessary would appear to only add to the total logging cost. Channel M is an example of what a reasonable degree of care can accomplish in conventional timber falling along a stream. Breakage on this setting appeared to be the lowest of any of these three units. Much of the 17 tons of new material that was added to Channel M was in log-sized pieces and was later yarded. Several sound wind-thrown trees were salvaged from the stream zone to be replaced with a slightly greater volume of new material.

Yarding reduced the quantity of excess material in the channels from 82 down to 21 tons per 100 feet in Channel I, from 42 to 12 tons in K and from 17 to 2 tons in Channel M. It is not usually possible to identify new material added during yarding. Some root

Figure 6
A small section of Channel I during low summer flow. The sampling frame and leveling rod were used in measuring the 5 tons/100 feet of fine debris remaining after yarding.

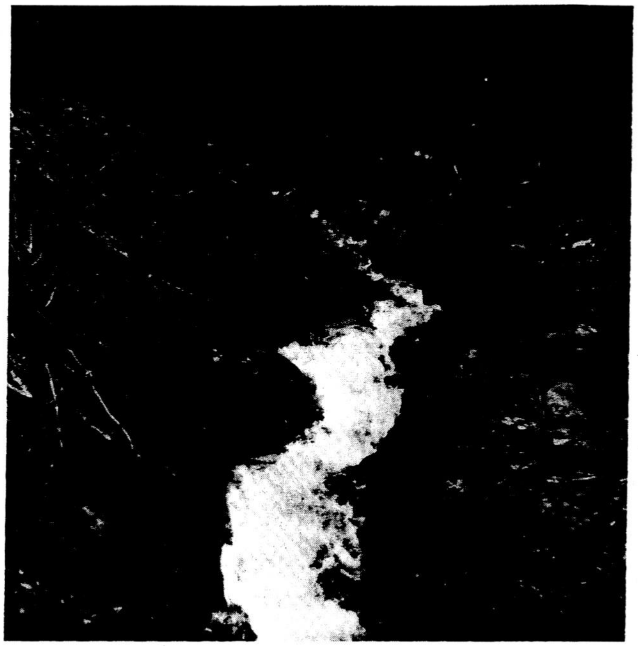


Figure 7
Channel K after stream cleanup reduced the total loading to an average of 3.3 tons/100 feet of channel.

wads rolled from the steep slopes into Channel K during yarding, but for the most part it appears that with any reasonable logging chance the quantity of material added during yarding is not as important as that added during falling.

Each of these channels is a Class I stream and the next problem is to decide what material, if any, should be removed in a cleanup operation. Channel I now contains 29 tons of material per hundred feet and cleanup will probably be done before this winter. It is more heavily loaded than any of the heaviest natural loadings we found and from 10 to 20 tons/hundred feet will likely be removed. Slash burning may be an effective way to reduce the loading and might actually produce less bank disturbance than yarding the debris (Figure 6).

Channel M has a net increase of about 1.5 tons/100 feet and it appears that further cleanup would not benefit the stream system. No clear hazard can be seen as a result of the 29 percent increase in debris on this channel. A portion of Channel K was cleaned,

Figure 8
Pattern of falling on slope above Channel J. Most trees were pulled directly away from stream by cable-assist falling.

including some hand piling, which reduced the debris loading to 3.3 tons/hundred feet (Figure 7). This may be an excessive amount of cleaning and probably could only be justified where the material is either very close to a Class I stream or poses a threat to culverts a short distance below the cutting unit. I believe it is quite important to clean the channel of new slash upstream from culverts as the material tends to move downstream a short distance with even moderately high flows before it becomes stabilized. Cleaning the channel upstream from culverts from ten to twenty times the culvert diameter would greatly reduce the danger of culvert plugging.

Cable-assist Directional Falling

The effect of "tree pulling" and cable yarding on the amount of slash entering channels was observed on two very small drainages (20-23 acres) and two larger drainages (80-120 acres). The quantity of logs and debris added to each of these channels was remarkably similar. The new material added ranged from 9.5 to 20 tons per 100 feet and averaged only 14 tons. These cutting units were in the roughest terrain of any we studied and included slopes of over 100 percent gradient. The two small channels were treated much like the remainder of the watershed slopes rather than as distinct channels, and trees were pulled away from the two draws more to reduce breakage than as a stream protection measure. The steepness of the slopes and condition of the timber is reflected in the fact that these channels had accumulated from 9.5 to 26 tons of material under natural conditions.

The limited breakage that occurred on these cable-assist falling units meant that most of the 14 tons of material that was added to the channel could be readily yarded (Figures 8, 9). Since there was a chip-log market, utilization was quite complete. The net effect of the logging was to reduce the debris in Channels G and J from a before cutting average of 19 tons to an average of 15 tons per hundred feet. Channel G was included in slash burning but there was no measurable decrease in the debris.

A very important feature of this type of timber falling practice is that relatively little fine debris and branchwood enters the channel. Under free-falling up to 3½ tons of fine debris entered the channel while under the tree-pulling method the maximum added was under one ton of fine debris per 100 feet with an average of 0.61 tons. Approximately half as much new fine debris remained in the channel after yarding the cable-assist felled units as was found with conventional felling.

Studies are under way to measure the difference in breakage between the two falling systems as well as to determine the costs of manpower and machinery associated with tree pulling.

Buffer Strip Protection

Three distinctly different units were studied for the effect of buffer strips on reducing debris in stream channels. The three units were felled by conventional methods and cable yarded. The terrain on Channels F and N were nearly as rugged as the other units in the study. but Channel L was significantly better ground and was comparable to the conventionally cut unit on Channel M.

On Channel F a 20-50 foot strip of hardwoods (alder and maple) and a few small hemlock were marked to be left for a buffer. A number of leaners were felled through this buffer but only 2.1 tons of debris per 100 feet were added to the stream. Yarding removed most of this plus some merchantable material from the existing debris. Some cleaning that was with or closely followed yarding further reduced the debris from its original volume of 7.6 tons per hundred feet to 4.5 tons. The thin buffer did act to some degree as a physical barrier to material moving downslope and even though it was broken in a number of places it served a useful purpose.

The buffer strip on Channel L was about 50 feet wide and consisted almost entirely of large old-growth. A very few leaners fell through this buffer and the net effect of the logging was virtually no change. Only 1.8 tons per hundred feet were added and a part of this was yarded. The total debris change was from 14 tons per hundred feet under natural conditions to about 15 tons after logging (Figure 10). The terrain on this unit was such that the trees, including the buffer strip, could have been "pulled" without allowing any new material to enter the channel. As the buffer is on the north side of the stream, this could have been done without seriously affecting the stream.

The unit on Channel N was designed to leave a buffer strip from 100-130 feet wide. The buffer consisted of large Douglas-fir, cedar and hemlock. The ground above this strip was extremely steep and considerable material collected at the upper edge of the buffer during falling. Practically no debris penetrated this wide strip. One of the reasons for the width of buffer here was that a sharp break in slope was used for the buffer boundary. This buffer does represent a big investment in wood fibre and growing space and hopefully will be managed some day to recover at least that part that is not effective in shading the stream.

The Forest Practice Rules call for providing shading, soil stabilizing and water filtering effects of vegetation along Class I streams where possible. The buffer should provide at least 75 percent of the original shade. There is flexibility in the requirements on width and density of the buffer and mature timber may be logged from the strip. In the Northwest Oregon Region staggered settings may be used along a stream provided stream temperatures are not increased significantly. A problem we observed with a number of buffer strips was the amount of windthrow. In spite of being in a relatively sheltered situation, tall Douglas-fir along a water course are often not very windfirm (Figure 11). We will be observing a number of buffer strips over time to aid in developing guidelines for the selection of safe boundaries.

The Rules also require leaving stabilization strips of undergrowth vegetation along Class II streams to prevent sediment washing into streams. Under the heavy stands of old-growth we studied, there was

Figure 9

After cable-assist falling on Channel G. Debris loading was increased by 42% or 11 tons/100 feet. After yarding, channel loading was 7 tons/100 feet less than the original accumulation.

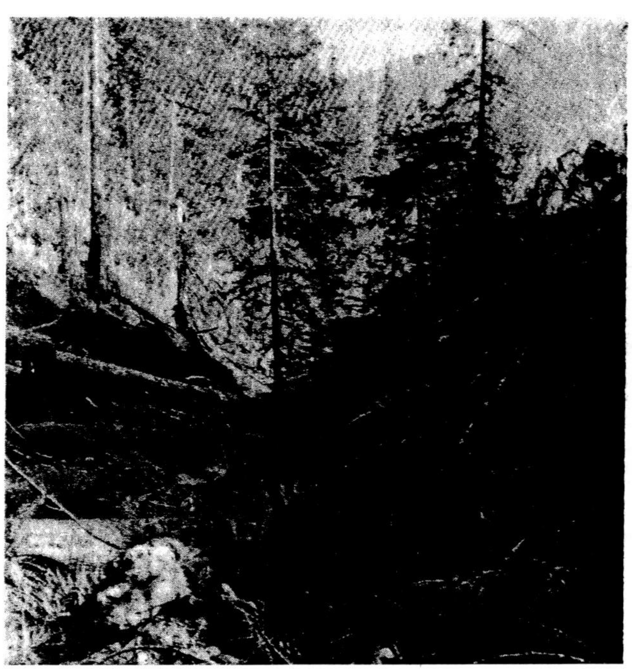


Figure 10

Channel L had a 50-foot buffer strip of scattered old-growth. The new material added during logging about equalled the amount removed. There was a net increase of one ton/100 feet of channel.

Figure 11
Windthrown trees from a 75-foot buffer strip of old-growth Douglas fir and hemlock one winter after logging.

Figure 12
A strip of understory vegetation that survives the falling and yarding will trap considerable debris as shown here a few feet above Channel M.

usually very little undergrowth especially on the smaller channels. Thus we had little opportunity to observe the survival of a strip of undergrowth. An example of the effect of this small understory in trapping logging slash above a stream is shown in Figure 12 taken at the edge of Channel M. It seems that the key to channel protection lies in keeping the number of trees dropped into the channel to a minimum. It was evident that the greater the volume that was put in and then yarded from the channel the greater the bed and bank disturbance. The rate of recovery of the stream side vegetation after the disturbance varies greatly, but in the Northwest Oregon Region only a few years is needed for a significant recovery. Where the buffer strip is subject to windthrow it may be better stream protection to carefully log the streamside zone, or at least the trees most susceptible to windthrow, than to leave a solid strip of old-growth along these small streams.

SUMMARY

Stream protection requirements in our timber producing areas are very much a part of the new "environmental awareness". Demands to maintain or even enhance conditions in the stream systems are likely to continue and will possibly become even stronger. Overcleaning channels may not be in the best interest of stream protection. We must recognize what the stream systems are like in their original condition and also to understand the role of the organic debris in these channels.

In the steep, headwater drainages under stands of old-growth Douglas-fir we found that the natural, undisturbed channels commonly contain around 12 tons of organic material within a 30-foot wide zone centered on the water course. Normally about seven percent of this is in fine debris under four inches in diameter. Maximum accumulations of natural debris in the drainages studied were 25.8 tons per 100 feet of channel. Recently "sluiced-out" channels contained about 0.9 tons of debris. Many of the channels observed appeared to have sustained debris avalanches or sluice-outs at varying times in the past. New debris accumulates as snags, windfalls and annual yields of litter collect in and near the water course. In most channels this debris holds back large quantities of sediment delivered to the stream from naturally occurring erosion.

Logging, especially at the tree falling stage, can produce large changes in the debris loads. However, under good conditions and with the falling crews having a concern for stream protection the net effect may be quite small. Directional falling with the tree-pulling system can reduce the quantity of material reaching the channel to a very small amount. The steeper and more broken the ground the greater is the advantage in using a tree-pulling system. The debris added during the falling stage on extremely steep ground by the cable-assist falling was about equal to that produced by very careful conventional falling on relatively good terrain.

Buffer strips were found to be effective debris barriers even when they were not continuous or of large widths. Possibly part of their effectiveness lies in the fact that the existance of the uncut strip forces the faller to take considerable precaution not to fall into the standing trees. The buffer strips, at times, represent a considerable investment in growing space and usable wood. Unless the buffer is necessary as a shade for stream protection, it appears that tree-pulling could accomplish a nearly equal degree of stream protection.

Research is underway by Dale McGreer, masters degree candidate, and myself to obtain detailed figures on savings in breakage by the tree pulling system as well as to record costs in man and machine hours. Actual costs of stream cleanup are also being gathered by Dennis Dykstra, Instructor in the Forest Engineering Department. Further study is planned to learn more about the conditions under which debris moves, including natural sluice-outs. Also, conditions are being observed to learn when logging debris actually poses some hazard to downstream uses. Buffer strips are being observed to obtain an understanding of their survival and long term effectiveness. ■

References

Heede, Burchard H. 1972. Flow and channel characteristics of two high mountain streams. USDA For. Serv. Res. Pap. RM-96. 12 p.

Meehan, W. R., W. A. Farr, D. M. Bishop, and J. H. Patric. 1969. Some effects of clearcutting on salmon habitat of two southeast Alaska streams USDA For. Serv. Res. Pap. PNW-82. 45 p.