INTERIM RECOMMENDATION FOR THE USE OF BUFFER STRIPS FOR THE PROTECTION OF SMALL STREAMS IN THE MARITIMES

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ABSTRACT

Buffer strips for the protection of small headwater streams during and after clear cutting serve several purposes.

a) Protection against direct radiation and heating.
b) Protection from sediment emanating from the cut areas.
c) Protection from crossings by logging equipment.
d) Main source of food for animal life in the stream.

It is proposed that on fairly level terrain a buffer strip 15-20 m wide is sufficient to protect the stream if it extends to the origin of the stream and includes springs. On steeper terrain wider strips are required.

RESUME

Les bandes tampons protégeant les petits ruisseaux pendant et après une coupe à blanc sont utiles de plusieurs façons.

a) Elles protègent contre la radiation directe et la chaleur.
b) Elles protègent contre les sédiments émanant des aires coupées.
c) Elles protègent contre l'empiètement par les appareils de coupe.
d) C'est la principale source d'alimentation de la faune dans les ruisseaux.

L'auteur suggère une bande tampon de 15 à 20 m de largeur, en terrain assez horizontal, à condition que la bande soit établie jusqu'à la tête du ruisseau et ses sources. Un terrain plus incliné nécessitera des bandes tampons plus larges.

INTRODUCTION

"No cutting, excavation, or construction will be allowed on Crown Land within 300 feet of the center line of any public highway or resource access road or within 200 feet of the bank or shore of any lake or stream or the center line of any forest road as designated by the Minister without the approval of and under the direction of the District Forester. 68-46" Regulation under the Crown Lands Act (N.B. Reg. 67-52) in New Brunswick.

In 1977, no regulations governed the cutting along streambanks in Nova Scotia. The absence of regulations in Nova Scotia and the application of the above-mentioned regulation under present day interpretation in New Brunswick have left many small streams in a dismal state after clear-cutting operations. A survey of the literature, information from other sources, and local research indicate that present day interpretation of regulations governing the application of buffer strips[1] is outdated and should be modified.

This report briefly discusses the detrimental effects of clear cutting stream banks and other logging practices, and presents preliminary recommendations for the use of buffer strips to minimize these effects.

It is not the intention of this report to present recommendations for road construction, etc. as they have been adequately covered by other reports (e.g. Rothwell 1971).

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[1]A riparian buffer strip is a strip of undisturbed soil and vegetation (trees and otherwise) left along streambanks (1) to protect streams against erosion, sedimentation, and overheating, and (2) as a source of food for the organisms inhabiting the stream.

CHANGES IN A STREAM AFTER CLEAR CUTTING AND OTHER LOGGING PRACTICES IN THE ABSENCE OF A BUFFER STRIP

The stream bottom of many fast flowing headwater streams consists of a conglomeration of rock fragments, ranging from large boulders to fine sand but with little silt and clay. This conglomerate contains many small interstices through which flowing water brings oxygen and food to the inhabiting insect larvae and removes their metabolites. Trout and salmon deposit their eggs in such spaces.

Present logging practices in the absence of a buffer strip can affect the stream in the following ways.

1. *Suspended sediments*[2] *in stream water*

a) Causes. Logging and roadbuilding always result in increased suspended sediments (silt and clay) and high turbidity of the stream water. In most logging operations, erosion is usually of short duration (Hornbeck 1960). Poor planning and building of stream crossings, however, can cause continued erosion of ditches, resulting in a repeated input of sediment into the stream. This situation stabilizes only after many years.

b) Effects. Suspended fine sediment is much less detrimental to the aquatic habitat than coarse bedload sediment[3] (Platts 1970). Suspended

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[2] Suspended sediment is the silt and clay fraction of the disturbed streambed or eroded soil that stays in suspension in flowing water but settles out in still water.

[3] Bedload sediment is the coarser material such as fine sand and gravel that moves along the stream bottom when the current is strong. Under normal conditions this material does not move. Most bedload movement even in heavy current is restricted to fine and coarse sand. Most of the material moved is in the 1 and 2-mm size classes.

silt and clay affect some of the insects in a stream by clogging their food trapping mechanism, others cannot cling to the silt-covered stones (Hynes 1970).

Adult fish, apparently, are not directly affected by limited quantities of silt (Wallen 1951, Hynes[4] 1973). Phillips (1971) found that suspended concentrations had to exceed 200-300 ppm for several days before mortality occurred. This rarely happens. Cordone and Kelly (1961) found no conclusive evidence in the literature to support any general answer on whether suspended sediment is directly harmful to fish.

2. *Streambed quality deterioration*

(a) Causes. Clear cutting almost always results in increased runoff and erosion. Anything that disturbs and compacts the soil affects the rate of runoff, and erosion increases the quantity of sediment that is washed into the stream. The practice of crossing streams with logging equipment, the construction of culverts and bridges, and the improper construction of logging roads contribute most to siltation. On the Nashwaak River watershed in New Brunswick, a single crossing of Manzer Brook by logging equipment caused 50 kg of suspended material (silt and clay) to drift down the stream.

From data on the soil texture, it was concluded that at least 100 kg of other non-suspendable soil material (fine sand, etc.) dislodged and moved downstream. This is the material that plugs the interstitial spaces in the gravel bed and causes most of the damage.

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[4] Hynes. H.B.N. 1973. The effect of sediment on the biota of running water. Mimeo. Copy.

Haupt and Kidd (1965) found that in Idaho, skid trail crossings through streams produced large amounts of sediment. Megahan and Kidd (1972), also in Idaho, determined that erosion from roads increased sediment deposition by an average of 750 times that of similar undisturbed watersheds for a period of six years after construction.

Data on the effects of improper culvert construction in Howard Brook indicate that tons of soil material (1064 m^2, 37,6000 cu ft or approx. 1,300 tonnes) (Hansen 1974) moved down the streambed, filling interstices for many kilometers. No data are available to indicate how long it takes for a stream to rid itself of these sediments but answers should be forthcoming from research now in progress.

(b) Effects of changes in streambed quality. Sediment deposition and the filling of the interstices in gravel-bottomed streams cause drastic changes in the flora and fauna living in the streambed. Fish living in this type of stream feed mostly on large insect larvae and nymphs of caddisflies, stoneflies, and mayflies (Phillips 1971, Eustis and Hillen 1954, Sprules 1947, McCrimmon 1954). Most of these larvae do not burrow in mud and sand as do some of the smaller larvae. If the interstices in the gravel beds fill with fine sediment, there is a drastic decrease in the presence of the larger larvae.

The Aquatic Life Advisory Committee of the Ohio River Valley Water Sanitation Commission (1956) observed that comparatively small amounts of sand and silt moving along a stream bottom will eliminate most of the habitats suitable for aquatic insects and thus greatly reduce the productivity of these forms. Several other studies draw the same conclusions (Ellis 1931, Tebo 1955, Bachmann 1958, Wustenburg 1954).

Sedimentation and the filling of the interstices with sand and silt also interfere with the reproduction of some fish such as salmon and trout. They normally bury their eggs deep in the gravel where they are safe from predators and washout. The eggs are, however, very dependent on the intergravel flow of water for their oxygen supply and the removal of metabolites. Fine sediment in the interstices cuts off the flow of water and these types of fish will not lay their eggs in such places. If eggs are already present, the lack of oxygen will kill them.

Koski (1966) found that even where dissolved oxygen was high and metabolite concentration low, sediment formed a physical barrier trapping the emerging fry which later starved to death.

Sedimentation and the filling of the interstices also prevent plant detritus, the main food source of the insect larvae, from being trapped. The detritus is washed quickly downstream and the productivity of a stream is thus lowered. The fact that coarse rubble supports more animals than sand is almost certainly correlated with the amount of living space available (Scott and Rushforth 1959).

3. *Elevated stream water temperatures*

(a) Causes. There is an extensive literature on the effects of clear cutting stream banks and the removal of shade-producing vegetation on the temperature of the streamwater. Removal of the shading overstory allows direct solar radiation into the streams resulting in higher water temperatures and greater fluctuations of water temperatures. Much information was summarized by Brown and Krygier (1967, 1970) and Brown (1972). Brown (1969) noted a six-fold increase in net all-wave radiation at the surface of streams in clear cuts as compared to those in forest. In the Maritimes, we can expect a twenty-fold increase with a comparable increase in water temperatures. Brown and Krygier (1970) reported a 15.5°C (28°F) increase in maximum temperatures of a small stream after clear cutting.

In New Brunswick, much of the water in small streams is supplied by cold springs. Nevertheless, considerable increases in water temperature can be expected after clear cutting.

(b) Effects of high water temperatures. Temperature is a very important factor in stream ecology. It is closely related to the capacity of the water to dissolve oxygen. Many invertebrate species need specific temperature ranges to live and reproduce. Any changes in temperature will result in changes in the species composition.

Sprules (1947) showed that the ratio between several insect orders changed as the temperature changed. At the species level, the effect would be more pronounced. The significant rise in temperature in the summer in New Brunswick's streams after clear cutting would result in drastic changes in the invertebrate fauna in these streams, even if sedimentation, etc., did not occur. For stream fishes, water temperature is also an important factor. Brook trout can withstand temperatures from 0-25.3°C but they cannot tolerate sudden changes. The highest normal summer water temperature of small trout streams in New Brunswick runs from 13-20°C. In many instances, exposure to sunlight will raise the water temperatures over the absolute limit of 25.3°C, and will result in the death of the brook trout in the stream.

4. *High biological oxygen demand in streams*

(a) Causes. In careless logging operations, excessive organic debris is deposited in the stream (Fig. 1) (Narver 1971). The decomposition of this material exerts a high demand on the oxygen dissolved in the stream water. Also, large quanties of algae will colonize the debris deposited in the stream (Hansmann and Phinney 1973). The algae produce a higher oxygen content in the water in the summer while photosynthesis is occurring but after the algae die in the winter, decomposition of the algal biomass causes a great oxygen deficit.

(b) Effects. The oxygen demands of invertebrates are intricately interwoven with water temperature and water movement. Less oxygen dissolves in warm water than in cold. In turbulent water, oxygen is usually at a satisfactory level for animal and plant life.

In general, it can be said that many fast-water animals are more stenothermic than their still-water relatives (Hynes 1970). They are restricted to a narrower temperature range, in this instance cold temperature, and thus are accustomed to higher dissolved oxygen levels.

At the higher water temperatures, saturation with air is necessary for trout. Less than 75% saturation, however, reduces activity even at low temperatures (Hynes 1970). At low dissolved oxygen concentrations, many species of fish attempt to find sections of the watercourse with higher concentrations.

5. *Low food supply*

(a) Causes. In many of our woodland streams, 95% of all food consumed by the invertebrate fauna is derived from leaves, branches,

Fig. 1. Frenchman Brook (N.B.) one year after logging in 1976.

etc., that fall into the stream from trees and shrubs (Fisher and Likens 1973, Minshall 1967, Sedell *et al.* 1973). Removal of these trees and shrubs also removes this food source. Early in the vegetational succession, the tree and shrub species are replaced by other species of fast-growing herbs and shrubs, resulting in a totally different food source.

Also, the increase in sunlight reaching the stream results in an increase in primary productivity by totally different organisms, such as algae and mosses.

(b) Effects. Since many of the invertebrates and fish are food specific, the removal of the usual terrestrial food source and its replacement by other terrestral species coupled with a change in species composition and an increase in the total algal biomass cause great changes in the invertebrate and fish populations.

PREVENTION OF THE DETERIORATION OF SMALL HEADWATER STREAMS

Properly designed buffer strips can prevent, or at least ameliorate, the deleterious effects of logging as follows:

(1) No slash will be deposited in the stream, thus preventing an unnecessary strain on the oxygen supply.

(2) Stream bank erosion is kept at a minimum.

(3) Unnecessary traffic across the stream is prevented.

(4) Increased exposure to direct sunlight and its resulting heating of the water does not occur.

(5) The buffer strip acts as a filter against sediment entering the stream from upslope logged-over areas.

(6) The terrestrial food source for aquatic life is not disrupted.

To obtain the best results, with the least loss of merchantable trees to the logging operation, both the width and extent of the buffer strip have to be considered.

Width of the buffer strip.

Minimizing the detrimental effects of clear cutting on the stream, during and after logging, depends on the different functions of the buffer strip.

(a) The buffer strip acts as a filter and barrier against overland flows of sediment that originate on the clearcut, or from nearby skidding trails and road construction. To protect the stream, a narrow strip will suffice on flat terrain but a wider strip will be necessary along steep slopes. The width of the required buffer strip thus depends on the slope, the rate of precipitation or melt, the type of vegetative cover, and the texture and structure of the soil. Trimble and Sartz (1957) suggest a basic strip of 65 m that increases 60 cm (2 ft) in width with every 1% increase in slope. In New Brunswick, it has been observed that mud, generated from road construction in an area with springs, flowed across a 100-m (330-ft)-wide buffer strip with a 3% slope. However if areas with springs are protected, a 65-m (200-ft) buffer strip should be sufficient on most slopes. But it is obvious that each case will have to be judged separately.

(b) The buffer strip acts as a barrier against stream crossings by skidders and other equipment. The width of the buffer strip for this purpose, is difficult to designate. If it is too narrow it may tempt a skidder operator to take a shortcut through the stream. This could be prevented by incorporating monetary penalties into the regulations for violation of buffer strips.

(c) The buffer strip protects the stream from full direct sunlight. Research has shown that the presently prescribed 65-m (200-ft) wide buffer strip is not required for shade in New Brunswick. The percentage of sunlight reaching a stream was determined for buffer strips of varying widths in both hardwood and softwood stands. The relationships found were the same for both stands. (Fig. 2). The research showed that as the width increased beyond 7.5 m (25 ft) the percentage of sunlight reaching a stream slowly decreased from 12% to about 4%. A buffer strip over 15 m (50 ft) wide is thus sufficient to protect the stream water

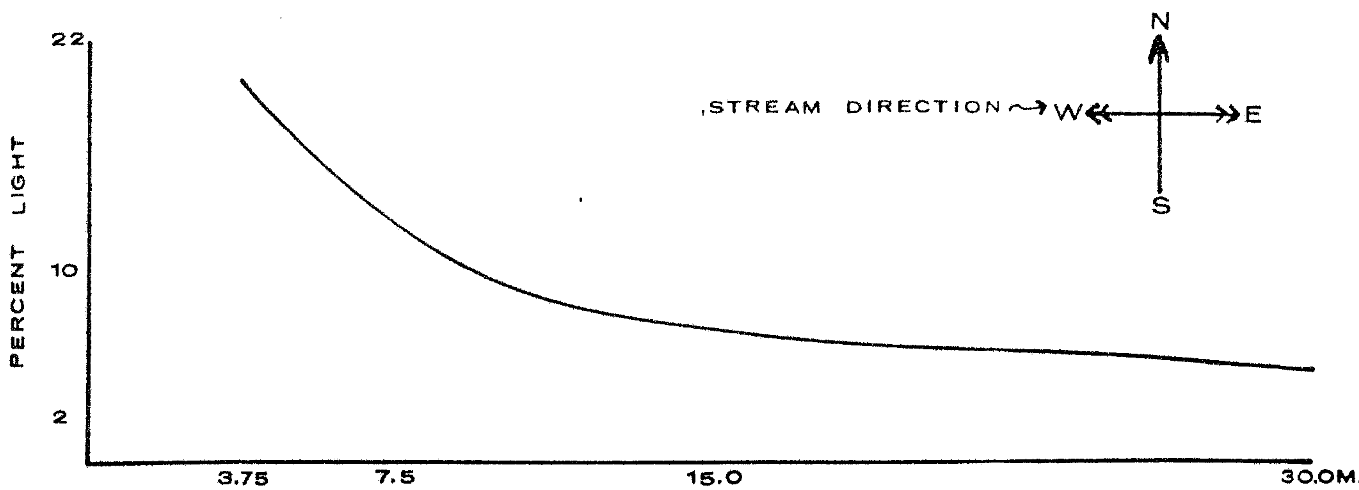

Fig.2a Percent sunlight transmitted through buffer strips of varying widths in a softwood stand.

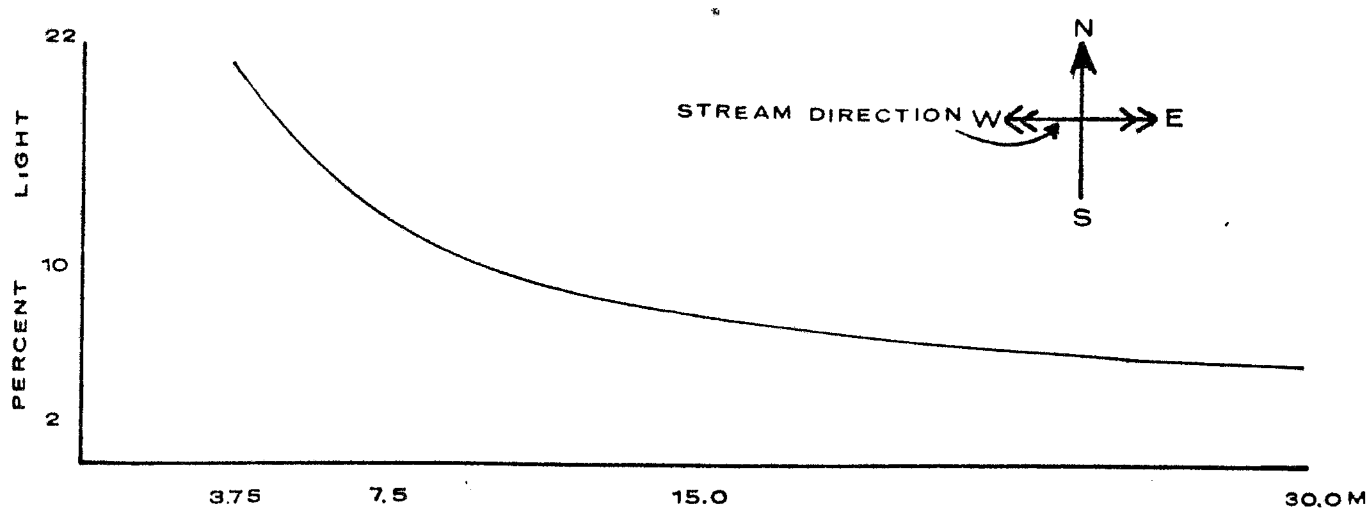

Fig.2b Percent sunlight transmitted through buffer strips of varying widths in a hardwood stand.

from reaching temperatures detrimental to aquatic life. If a stream runs east-west the north side of the stream does not need the protection from sunlight by a protective strip. The south side, protected by an average structured stand, would need a strip with a width approximately the height of the trees.

(d) The buffer strip acts as protection against (1) slash in the brook and (2) streambank erosion. It is obvious that a buffer strip as wide as 65 m (200 ft), is not necessary to protect against slash and streambank erosion. If penalties against violation of the buffer strip are included in the regulations a 15-m (50-ft) buffer strip is sufficient to protect the brook.

(e) The buffer strip acts as a food source. Only trees whose foliage can drop into the stream are contributors to the food source. Few trees farther than 15 m (50 ft) from the stream will be major contributors.

The extent of the buffer strip.

In New Brunswick, regulations governing the use of the buffer strip and the decision of what size of stream is to be protected are left to the judgment of the regional resource manager (New Brunswick Crown Lands Act, 1967). As a result, the smaller feeder streams are not protected and their banks are completely clear cut. Skidder operators drive and skid across these streams and in many instances completely obliterate the stream channels. This results in extensive erosion and causes the streams to search for new channels. The washed-out sediments are carried downstream into the protected sections of the stream, plugging productive gravel beds and causing considerable damage. This defeats the purpose of the buffer strip along the lower stretches of the streams.

Small streams are biologically important feeders of the main stream (Hynes 1970), and many originate in areas with many springs. These springs deliver cold water in summer and relatively warm water in winter to the stream. As a result, feeder streams are highly productive and exert a moderating effect on temperature fluctuations in the main stem. When they are disturbed they cease to be the source for repopulation of the lower stream reaches.

If the areas of these feeder streams are clear cut and obliterated by skidding, the water in the streams becomes highly susceptible to heating. Where shading is absent, water temperatures can rise rapidly depending on the speed of water movement, depth, and surface area, etc. In a clear-cut area, the temperature of the water in one spring was 3.5°C, but as the water flowed over the ground (the streambed was obliterated) the temperature increased to 23°C within a distance of 30 m (90 ft). This relatively warm water moves into those parts of the stream that are protected by a buffer strip and negates its effect.

CONCLUSIONS AND RECOMMENDATIONS

(1) A 65-m (200-ft) wide buffer strip is not always necessary for protection against heating of the stream water.

(2) On relatively flat terrain, a buffer strip as narrow as 15 m (50 ft) will provide adequate protection against both heating and sediments. On moderately sloping terrain a 65-m (200-ft) strip is adequate if reasonable

care is taken in the laying out of skid trails and haulroads.

(3) The buffer strip should extend the full length of the stream and also protect the major springs.

(4) Logging equipment should not be allowed to cross the buffer strip except where adequate protective measures have been taken.

(5) Windfalls occurring in the buffer strip after the logging operation, although objectionable aesthetically and a nuisance for fisherman, do not appreciably lessen the effectiveness of the buffer strip.

(6) In boggy areas bordering streams, hauling equipment should not be allowed. Cutting by chain saw and hauling by cable, however, should be allowed up to 15 m from the stream.

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