Riparian buffers in New Zealand forestry

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ABSTRACT

This article discusses the concerns and ideas of regulators, forest owners, and researchers relating to riparian buffers in New Zealand forests, in order to further understand the current practices and questions regarding retirement of riparian zones following forest harvesting and planting. The riparian buffer issue is of increasing importance in New Zealand as the area of forests due to be harvested is rapidly increasing and many of the areas to be harvested are on more difficult terrain.

The perceived advantages and disadvantages of riparian buffers in New Zealand forestry were: water quality protection from sediment, the economic cost of riparian buffer retirement, riparian improvement of habitat, public image, maintenance of riparian areas once established, and the harbouring of pests (e.g. possums) and weeds in riparian buffers. We identified areas in which future research is required in order to answer questions that foresters and regulators posed.

INTRODUCTION

Riparian buffers are the strip of land which separates upland soils (e.g. forested and agricultural land) from streams, rivers, lakes, and wetlands. The utilisation of riparian buffer areas for stream protection has a long history in New Zealand. Many riparian areas were left unplanted when exotic species were planted in large forests several decades ago. All of the reasons for leaving these areas are not known but certainly protection of character of the streams was a consideration by the early foresters. Riparian protection of streams draining into Lake Taupo was mandated and implemented by government agencies in the 1970s. We believe that the riparian buffers created by this action were among the first required for water quality protection. Thus, it has long been known that vegetation adjacent to a stream tended to protect that stream from man's activities upslope.

This is an ideal time to be considering the utilisation of riparian buffers in forests as the new Resource Management Act has both forestry companies and regional councils evaluating their responsibilities for stream protection in areas where forests are to be harvested and/or planted. Both groups are seeking quantitative information on effects of utilisation of riparian buffer areas to guide their actions. The need for information is particularly urgent because of the dramatic increase in both the area under forestry and the more difficult locations in New Zealand becoming ready for harvest in the near future. Thus Regional Councils need to know immediately where replanting lines should be established.

Prior to the preparation of this article, we visited regional councils, forest owners, and riparian area researchers throughout New Zealand in order to obtain their views and concerns for riparian buffer management. Here we evaluate and summarise the pertinent scientific literature on this topic, and the concerns and knowledge present in the regional councils and forestry companies, and make recommendations for needed research.

STATUS OF PREVIOUS AND CURRENT RESEARCH

It is generally agreed that riparian zones serve a number of beneficial functions in the landscape; however, there is very little quantitative data on the processes known to occur.

Studies have shown that intact riparian buffers are capable of reducing the amount of sediment entering surface water in the US agricultural systems (Cooper *et al.* 1987; Lowrance *et al.* 1986) and New Zealand agricultural (Smith 1989; Smith 1992) and forested systems (Graynoth 1979). Phosphorus removal has been shown to occur in New Zealand agricultural riparian buffers (Cooke 1988), and has been shown to be related to sediment deposition (Cooper and Gilliam 1987) in US studies.

Similarly, US (Jacobs and Gilliam 1985; Lowrance *et al.* 1984; Peterjohn and Correll 1984) and New Zealand (Cooke and Cooper, 1988; Smith 1989; Cooper, 1990; Schipper *et al.*, in press) studies have shown that riparian buffers can remove nitrogen from groundwater prior to discharge into surface waters. Nitrogen removal is thought to be principally by denitrification and plant uptake.

In addition to the protection of water quality, riparian vegetation plays an essential role in the maintenance of stream water temperature in agricultural systems (Quinn *et al.* 1992; Hicks and Howard-Williams 1990) and forested systems (Beschta and Taylor 1988). Graynoth (1979) showed that the removal of riparian vegetation during harvesting can result in greater fluctuations in stream water temperatures than in a comparison catchment where riparian vegetation was retained.

Riparian vegetation also plays an important role in the provision of wildlife habitat for native and exotic fish. Hicks and Howard-Williams (1990) pointed out that native and exotic fish may have different habitat requirements in terms of the type of riparian vegetation present.

PERCEIVED ADVANTAGES AND DISADVANTAGES OF RIPARIAN BUFFERS IN EXOTIC FORESTS

It was obvious from our meetings with forestry industry representatives, regional councils, and with water quality specialists that all believed that riparian buffer areas have some utility in exotic forests and that most, within these groups, are reasonably close to agreement.

The most often mentioned values of riparian buffers were:

(1) Protection of water quality
(2) Aesthetic beauty of native vegetation adjacent to streams.
(3) Better habitat for fish and wildlife, in that they
   (a) allow greater biodiversity
   (b) provide better organic inputs (food source) to streams for organisms.

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(4) Delineation of the area where heavy machinery should not be operated during harvesting and preparation for planting, and where trees should not be felled during logging.
(5) Better public image for the forest industry.

The most often mentioned disadvantages of riparian buffers in exotic forests were:

(1) Increased costs of logging if these buffers are treated as total exclusion areas and if the riparian vegetation cannot be damaged during harvest.
(2) Loss of productive land.
(3) Ideal place for growth of weeds and animal pests.
(4) Maintenance is a problem – particularly with regard to regeneration of pines. Who is responsible for maintenance?
(5) Problem when replanting if areas cannot be sprayed with herbicides or burned.

DISCUSSION OF ADVANTAGES OF RIPARIAN BUFFERS IN EXOTIC FORESTS

Water quality

The most obvious potential benefit of riparian buffers in exotic forests is maintenance of water quality. We believe that in exotic forests, in contrast to agricultural areas, water quality protection is largely limited to reduction of sediment entering the streams during harvest and in the two to three year period following harvest. By two to three years following harvest, new growth on the site will usually stabilise the soil, whether or not a riparian buffer is present. There is such a small amount of nutrients entering streams from forested sites at any time during the rotation that any reduction by riparian areas is not likely to result in a biologically significant effect, except possibly in unusually sensitive areas. A special case exists where nutrient-rich wastewaters are applied to forests for treatment purposes. In this situation, riparian buffers will likely be very important for reducing the amount of nutrients entering streams.

Another water quality benefit sometimes cited for riparian buffer areas is stream temperature regulation. However, temperature is not a clearly identified problem in streams draining from NZ forests, possibly due to the lack of relevant studies. Provided logging practices are designed to cut only a small percentage of major catchments in any one year, streams from harvested areas usually enter unharvested stream reaches fairly quickly, so we do not believe stream temperature to be a major problem. Hence, this report focuses on sediment reduction as being the dominant water quality benefit of riparian buffers in exotic forests.

No researcher who has worked in the area questions whether riparian buffers left intact during harvest and forest re-establishment can reduce sediment entry into streams. There is also general agreement that leaving exotics that are now planted immediately adjacent to streams would cause more problems because of wind throw, etc., than careful harvesting. If one accepts the premise that riparian buffers are needed in some areas to reduce the sediment getting into streams by increasing bank stability after harvest and trapping sediment generated upslope, then a large suite of questions without definitive answers arises. Among the first is: "Which streams need additional protection and does the benefit justify the cost?" This depends upon the character of the stream, downstream usage, and the relative cost/benefit of providing protection.

One question upon which there is lack of agreement between some Regional Council personnel and the forestry industry is: "What is a stream as opposed to a gully, and for what size 'stream' should riparian areas be required?" We believe that this should vary between regions and soil types, but that there should be a general guideline based on the flow being perennial with a certain minimal flow rate except in areas of documented unusual sensitivity (e.g. protection of an endangered species).

Native riparian vegetation retained with minimal damage during skyline harvesting of a radiata pine catchment.

One of the most controversial issues with regard to riparian buffers is required width. An exact answer cannot be obtained from existing scientific data because of insufficient information. A frequently mentioned width is 20 metres but this is not a scientifically-based figure. It appears to us that, in essentially all situations where forest owners and regional council representatives meet on site, a mutually satisfactory and reasonable agreement on appropriate boundaries is reached. However, neither the owners nor the councils can afford to go to every site to discuss planting lines. Thus reasonable guidelines must be developed; so it is imperative that more research on width requirements be undertaken!

The width of riparian buffer needed depends on many factors. Probably the most important factor is what is expected of the riparian area or the number of functions to fulfil (e.g. bank stabilisation, stopping of sediment from upslope, diversity of vegetation, etc.). Other factors influencing width needed for water quality protection include slope per cent and length, soil type, and quality of water needed. It appears unnecessary to require ultra pure water in streams that drain from forest sites into agricultural areas with no riparian strips to help in maintaining stream quality.

Marking of area which should remain intact during forest operations

Having a clear boundary for forest operations was a benefit of riparian buffers mentioned by all of the regional councils visited. We believe that this is a very valid reason for having riparian buffers. We have seen several examples where logging

crews were very careful with native vegetation in riparian areas and obviously took pride in doing minimal damage to the vegetation present. There is no question that equipment working immediately adjacent to streams will increase the amount of sediment entering the stream. The same is true for trees cut on the edge of the stream, even when great care is taken to ensure that the tree is not felled across the stream. It might be argued, and perhaps with some validity, that the amount of sediment getting into streams as a result of careful harvesting adjacent to streams is small. However, it is also true that there is extra expense required for logging within a few metres of the stream and leaving these areas might have a small effect on profit of logging. It is possible that a 5 to 10 m buffer would be effective for this purpose, although this width is highly dependent on adjacent topography.

Aesthetics, better habitat, and better public image

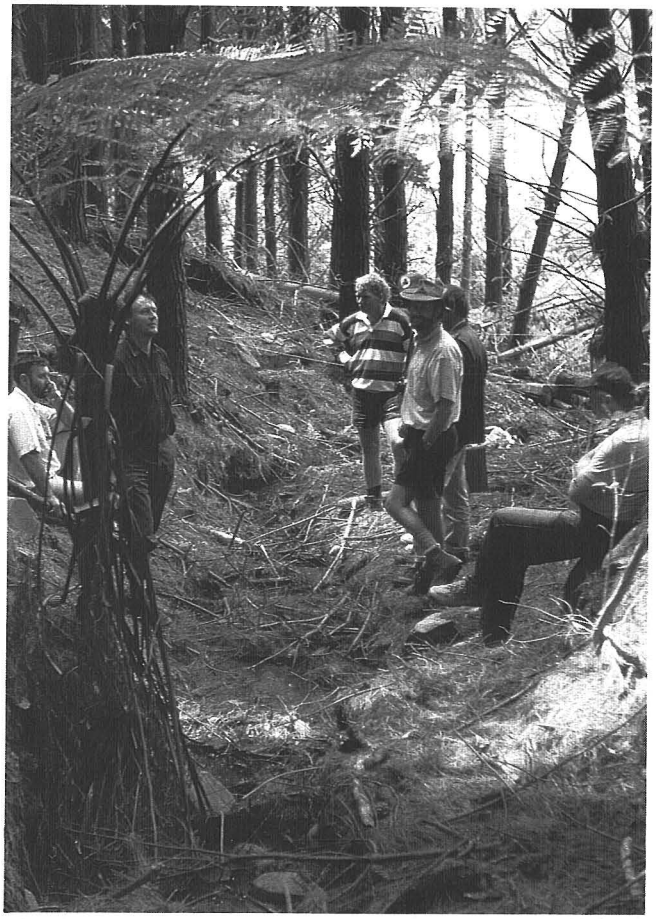
The value of riparian buffers in exotic forests for each of these factors is very difficult to measure and/or evaluate. Even foresters charged with the responsibility of growing trees enjoy having "native bush" beside the streams. A diversity of organic materials getting into the water from a variety of plant materials may be better for the stream biota than pine needles, although we have not seen data to support this. There is also a tendency for riparian buffers to provide a more constant light and temperature regime for the stream biota. The long-term value of this in an exotic forest rotation is unknown, but any effect would likely be positive.

Riparian buffers are popular with the public and if the forestry industry can get a better public image by providing riparian buffers at a minimal cost it may be in its economic best interests to do so. For example, in areas where no riparian buffers exist, streams will become somewhat cloudy with even normal rainfall events during and immediately after harvesting. This quantity of sediment may not be sufficiently great to cause biological damage but it will certainly be visually apparent downstream. If riparian buffers largely prevent the small losses of sediment, the public may be more accepting of the large problem with sediment that will occur if a very large rainfall event (15 to 20 year storm) occurs soon after logging.

DISCUSSION OF DISADVANTAGES OF RIPARIAN BUFFERS IN EXOTIC FORESTS

Increased costs of logging

The increased costs of logging appeared to be the greatest reservation of forest owners with regard to leaving riparian buffers in planted forests. It is in this area where "good faith" between forest owners and the regional councils is most needed. Riparian areas should be treated as areas where every attempt is made to keep disturbance to a minimum but they should not be treated as "sacred" areas that are not to be disturbed for any reason. If riparian zones are deemed "sacred", then the number and length of skid sites and roads will increase, resulting in increased costs and increased number of potential sites for sediment loss (Vaughan 1984). There is no reason why riparian zones cannot perform their intended functions for water quality and stream habitat if tops of vegetation are broken by skyline systems, or if some trees are cut and left on the ground. It is even possible that activities such as this would increase the effectiveness for trapping sediment because of the increased resistance to surface water flow through them. Thus regulators should be prepared to allow "reasonable" activity to occur in the riparian buffers during logging. However, it is incumbent upon the owners to ensure that activities which disturb riparian buffers are necessary and not just convenient.



Representatives of regional councils, forest owners and researchers meet in the field to discuss the roles of riparian buffers in plantation forestry.

Loss of productive land

Forest owners must compete for business on a world market and, as such, must be able to produce a product as economically as possible. Thus, anything which might cause a loss of productivity in a forest is of economic importance. There is considerable variation in the estimates of the cost of maintaining riparian buffers in exotic forests by representatives of the forestry industry. There are some who believe that the costs are great and others believe that they are minimal. A source of some of this variance in opinions may be a result of large differences between various terrains and soil types, but this does not totally explain the lack of agreement between individuals consulted. There is no question that logging adjacent to streams is more expensive because of the need to keep logs and sediment out of streams. Some believe that the increased costs of both planting and harvesting in potential riparian buffers and the poorer growth sometimes observed in these areas may minimise the economic loss of incorporating riparian buffers. This appears to be easily researchable and answers to this question could be generated fairly quickly, so it is a high priority for future research.

Increased problems with weeds and animal pests

There seems to be no argument that presence of native vegetation adjacent to streams will tend to increase the population of possums. The size of this increase is unknown, as is the economic costs to the forest producer. Some foresters felt that the damage done to young forests by possums was very large and others seemed to think it was insignificant. This is another area where there apparently are little or no scientific data to support any claim.

The costs of maintaining weed control during forest establishment is a concern of all forest operations. There is a fear that the presence of riparian buffers would increase weed pressure and thus increase costs of establishment. Whether this is a fact or unfounded fear is unknown. The natural succession of native plants which occurred in the Lake Taupo farming area when riparian buffers were established there many years ago suggests that the problem may not be as large as many fear, but more definitive information on this topic is needed.

Management of riparian buffers

The amount and cost of required management in riparian buffers is of great concern to forest owners. Noxious weeds, wild pines, etc. are viewed as possible large problems by some. If wild pines are allowed to take over riparian areas, there could be a bigger problem than having the area planted. Estimates of the cost of removing wild pines from the riparian areas vary widely. Some have said that the costs would be minimal if the trees were cut at the time of first thinning but others do not agree. The size of the problem could vary tremendously between regions. Where there is a good native vegetation seed source, the plant cover may limit pines getting started. Again there are no data to support any contention, although it is certainly known that pines will regenerate in any area left unplanted and owners will incur some cost to remove them. However, once mature native vegetation is established, it is unlikely that large numbers of pines will move in. Thus, it is not likely that wild pines will cause problems beyond the first rotation when riparian zones are established.

It should also be recognised that riparian buffers cannot replace the generally recommended logging practices with regard to roads, landings, etc., for reducing sediment. Because roads and landings are the major source of sediment even when the best practices are followed, it should be recognised that some crossing of riparian buffers by equipment may be the preferred logging plan. If absolutely no activity is allowed in the riparian areas, increased roading may be more detrimental than allowing some activity in the riparian areas.

USE OF TREE CROPS FOR RIPARIAN VEGETATION IN AGRICULTURAL AREAS

This article has focused upon use of riparian buffers in exotic forests and essentially ignored use of riparian buffers in agricultural areas. However, all riparian area researchers and regional council personnel agree that the greatest potential improvement in water quality through the use of riparian vegetation in NZ is in agricultural areas. Agricultural areas cover a much larger area than exotic forests and the loss of both sediments and nutrients from agricultural areas is larger per unit area than losses from exotic forests over the rotational cycle of the forests. It has been suggested that high-value, long-rotation tree crops could be planted in riparian buffers in agricultural areas to serve both the water quality functions and to help offset the loss in income and their cost of establishment and harvesting.

RESEARCH NEEDS

New Zealand researchers were among the first to conduct work on the water quality benefits of riparian buffers. The quality of their work has achieved worldwide recognition.

Re-establishment of radiata pine in a catchment where wide riparian buffers are being left to protect surface water quality of a stream feeding a valuable estuary.

However, this effort was relatively small in relation to the needs for information, and recent funding restrictions have decreased the level of active research in this area. Also, there has been essentially no research done to measure effectiveness of riparian buffers in exotic forests.

To achieve maximum benefits, multidisciplinary research will be required. The highest research priority we saw was the investigation of the cost/benefits of establishment and management of riparian buffers in exotic forests and in agricultural areas. It was clear that the requirement for riparian zones in New Zealand forests was dependent on the specific nature and importance of each site in terms of water quality and habitat. Research is required to classify areas in New Zealand which require different levels of riparian zone protection.

The most obvious need for research on riparian buffers in exotic forests is for information on the effectiveness of buffers in reducing sediment entry into streams under a variety of conditions. Although nutrients entering streams from most exotic forests are not considered a problem by the authors of this report, the effect on nutrients such as nitrogen and phosphorus should be determined concurrently with measurements on sediment. Sediment and nutrient information must be obtained for other data on this topic to have any value. Another more easily researchable question involves a quantitative assessment of loss of forest productivity associated with establishment of riparian buffers of various dimensions on the major soil types. This information should be combined with estimates of increased costs of planting and harvesting of exotic trees in riparian areas to make an initial assessment of cost to forest owners for establishing riparian buffers. An evaluation of in-stream biotic improvement such as better food source, more desirable temperature regime, etc., must be made for a complete evaluation of the need for riparian buffers. Finally the cost and appropriate management of buffers for potential problems such as weeds, animal pests, and wild trees must be determined.

Many of the same questions listed above for riparian buffers in exotic forests must be answered for the use of planted high-value tree crops as riparian buffers in agricultural areas. One difference is that nutrient removal by riparian zones is likely to be of greater importance in agricultural than in forest ecosystems. The change in stream biota is likely to be more dramatic because of larger changes in temperature, light input, and nutrient contents, and this should be evaluated. Other questions such as what are the best trees to plant, how close should they be planted to the stream, etc., must also be answered.

The existing Rotorua Wastewater Purification Project in Whakarewarewa Forest assumes that significant losses of nitrogen will occur in riparian zones through denitrification. The existing experiment provides a unique opportunity for researchers at the Forest Research Institute to fill some of the many scientific gaps in our information about this process. These data would be valuable for understanding and predicting the loss of nitrogen in riparian zones in agricultural land.

SHORT-TERM RECOMMENDATION

There are many unanswered questions with regard to use of riparian buffers in exotic forests, and research to obtain these answers should be started as soon as possible. However, policy decisions must be made before new research data become available. A national committee should be appointed to develop guidelines for implementation of riparian buffers in exotic forests. This committee should have representatives from the forest owners, regional councils, Department of Conservation, and researchers from the Water Quality Centre and Forest Research Institute.

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