ISSN 1170-2001

NEW ZEALAND FRESHWATER FISHERIES MISCELLANEOUS REPORT NO. 59

DEVELOPMENT OF GUIDELINES FOR THE MANAGEMENT OF STREAMSIDE RIPARIAN STRIPS

by

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A joint MAF-DSIR Report to the New Zealand Limnological Society on the workshop "Criteria for the establishment of riparian strips" held at Christchurch in May 1990.

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SEPTEMBER
1990

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This report is one of a series initiated in January 1989, and issued by the Freshwater Fisheries Centre, MAF Fisheries. The series was established to ensure that reports prepared for clients, tribunal hearings, internal use, etc., are collected together and available to future users. They are for limited circulation, and some may be confidential.

ISBN 0-477-08398-6

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Introduction

Management of riparian zones and their vegetation has been a long-standing concern of managers of water quality, fisheries, and wildlife. Interactions of streamside vegetation and streamflow can control water and sediment routing, fish and wildlife habitat, and aquatic production (for example, Mosley 1981, Mason and MacDonald 1982, Swanson et al. 1982, Beschta et al. 1987, Bisson et al. 1987, Wesche et al. 1987, Green et al. 1989, Dungey 1990, Gregory et al. in press, Hicks et al. in press). Observations of the influence of riparian vegetation on aquatic habitat are not new. In 1885, Van Cleef made the following observation:

> "....I have become satisfied that the destruction of trees bordering on these streams and the changed condition of the banks produced thereby, has resulted in the destruction of the natural harbors or hiding places of the trout......"

In this document, we intend to investigate the definition of riparian strips, to examine their functions, and to propose approaches to the problem of determining how large and where they should be.

Distinction between a riparian zone and a riparian strip

Confusion has arisen over what constitutes the riparian zone because people have viewed streamside areas in many different contexts. As physical environments are variable, so is the structure of riparian zone vegetation. Consequently, we find the most useful definition of the riparian zone is one based on function. Gregory et al. (in press) have defined riparian zones functionally as

> "...three-dimensional zones of direct interaction between terrestrial and aquatic ecosystems."

We draw a distinction between the riparian zone as a zone of influences of land upon water, and riparian strips as the area of streamside (or lakeside) vegetation actually involved in some management activity. For instance, in coniferous forest, functional relationships of the riparian zone are: 1) as a source of fine litter, 2) as a source of large woody debris, and 3) as a source of shade. Each function acts over different distances from the stream margin (Figure 1). The width of a riparian strip to be left to protect the stream environment during logging, for instance, would depend on the functions of the streamside vegetation and type of aquatic ecosystem to be preserved.

Functions of a riparian zone

Functions of a riparian zone can vary greatly, and can include biological and physical influences (Table 1). Two predominant influences are upon 1) the geomorphic processes of

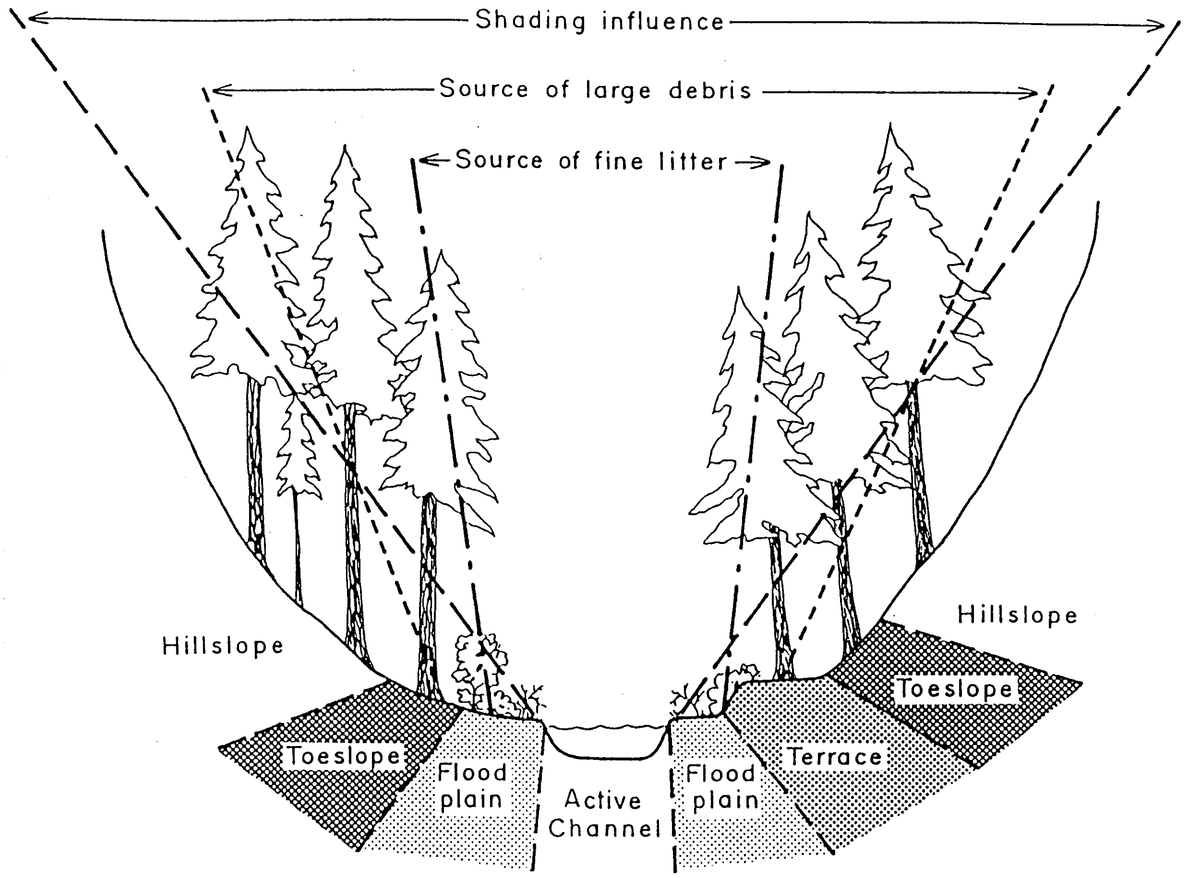

Figure 1. Zones of influence of streamside vegetation in coniferous forest on the stream channel in relation to geomorphic surfaces (from Gregory et al. in press).

Table 1. Function of riparian vegetation with respect to aquatic ecosystems (modified from Swanson et al. 1982).

Site of riparian vegetation	Component	Function
Above ground or above channel	Canopy and stems	1. Shade, controls temperature and instream primary production. 2. Provides source of large and fine plant detritus. 3. Provides source of terrestrial invertebrates. 4. Provides wildlife habitat.
In channel	Large woody debris derived from riparian vegetation	1. Controls channel gradient, and movement of water and sediment. 2. Shapes habitat - pools, riffles, cover for fish. 3. Provides substrate for biological activity.
On streambanks	Roots	1. Increases streambank stability. 2. Creates overhanging banks that provide fish cover. 3. Takes up nutrients and water from ground and stream water. 4. Retards movement of sediment.
On floodplains	Stems and low-lying canopy	1. Retards movement of sediment, water, and floated organic debris in flood flows. 2. Creates overhanging banks that provide fish cover. 3. Acts as a spawning ground for indigenous fish, e.g., *Galaxias* species.

channel structure and flood plain formation, and 2) stream productivity through allochthonous inputs (litter), and inputs of radiant energy (controlling light and temperature). The functional links between the riparian vegetation and aquatic biota can be conveniently expressed in a flow diagram (Figure 2).

Channel structure has a particularly important role to play. A complex channel structure, to which large woody debris contributes, retains organic matter allowing processing to occur. Channel structure also controls geomorphic processes such as movement and storage of water and sediment, stream gradient, and energy dissipation.

The control that the riparian zone exerts on geomorphic processes cannot be over-emphasised. It is a major key to understanding how riparian vegetation affects the stream itself. Evolution of the stream channel and stability of terraces and floodplains (Figure 1) depends to a large extent on the nature and structure of vegetation colonising new surfaces. Plant succession takes place on these surfaces, and may be periodically disturbed by floods, "resetting" the channel and its margins to earlier successional stages, or to bare surfaces (Osterkamp and Hupp 1984).

The width of the riparian zone susceptible to frequent disturbance by floods depends on the channel shape, and this has a clear relationship to rock type (Hupp 1982). Resistant rock types create a higher channel gradient than softer rocks, increasing channel width, but decreasing depth. Flood damage to streamside vegetation in reaches with hard rock compared to

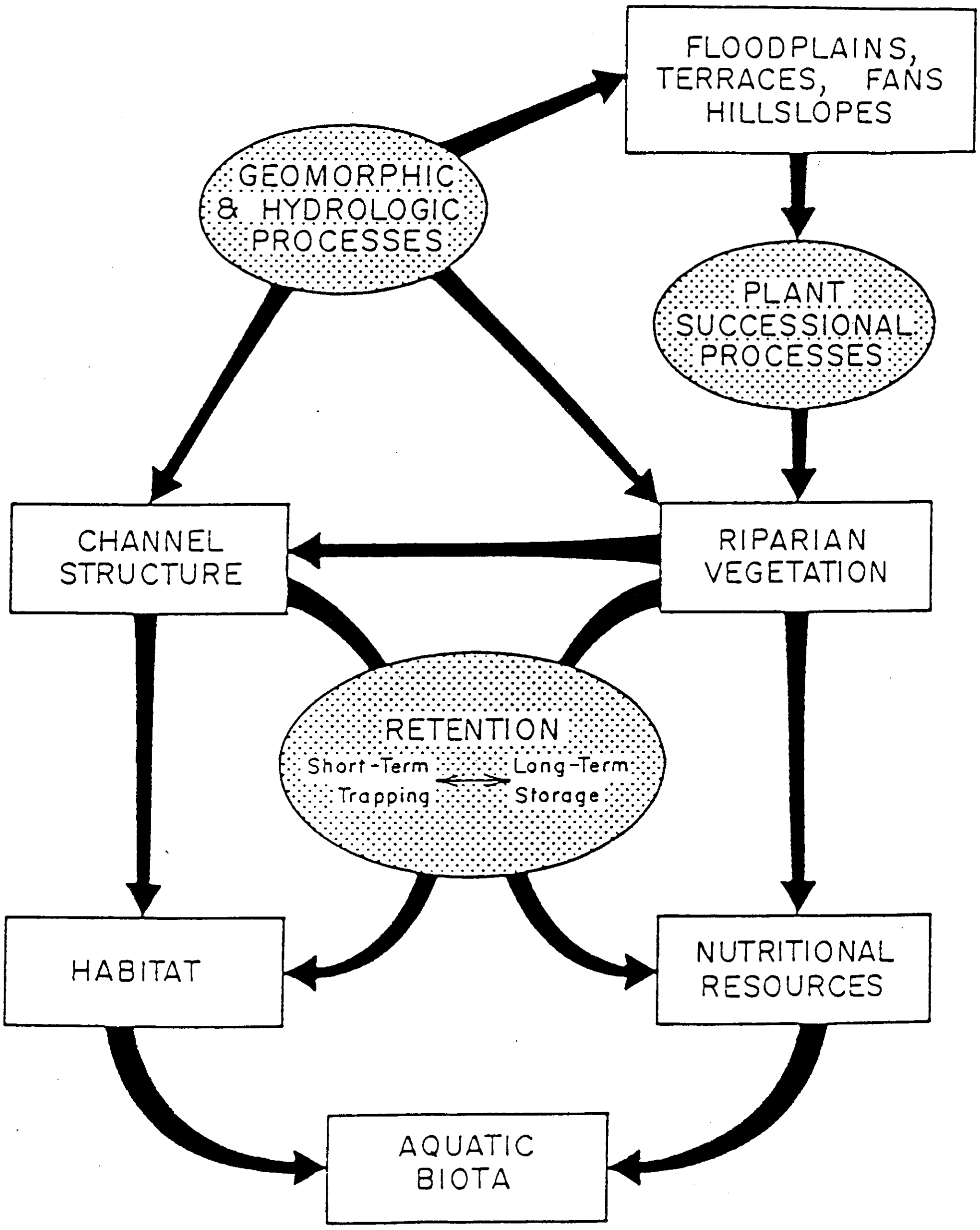

Figure 2. Functional relationships between riparian vegetation, geomorphic and hydrologic processes, and aquatic biota (from Gregory et al. in press).

soft rock (Hupp 1982). Locally, width of riparian zones can be controlled by soil type. For instance, riparian zones in the Lake Taupo catchment vary in width depending on the susceptibility to erosion of soils on either side of the stream.

Riparian zone functions change with stream width. Changes in width with increasing stream order have been generally summarised as the stream continuum concept (Figure 3). Though this concept has been challenged (e.g., Winterbourn et al. 1981), it still provides a useful framework for considering the function of riparian zones. Stream width and stream order increase in a predictable manner with increasing basin area (Hack 1957, Chorley et al. 1984, p318). As streams widen progressively down a basin, the role of riparian vegetation in shading and aquatic productivity through breakdown of allochthonous material (respiration - R) diminishes, and primary production (P) increases. Similarly, as discharge increases, the impact of streambank vegetation on sediment transport and water quality becomes less important. The relationship of other functions of riparian vegetation, such as creating bank stability and channel complexity, remain.

Relating function of riparian strips to use

Specific uses of a stream and its environment change the functions of that might be emphasised in riparian zone management. Functions vary with different climates, successional stage of vegetation, and existing land uses.

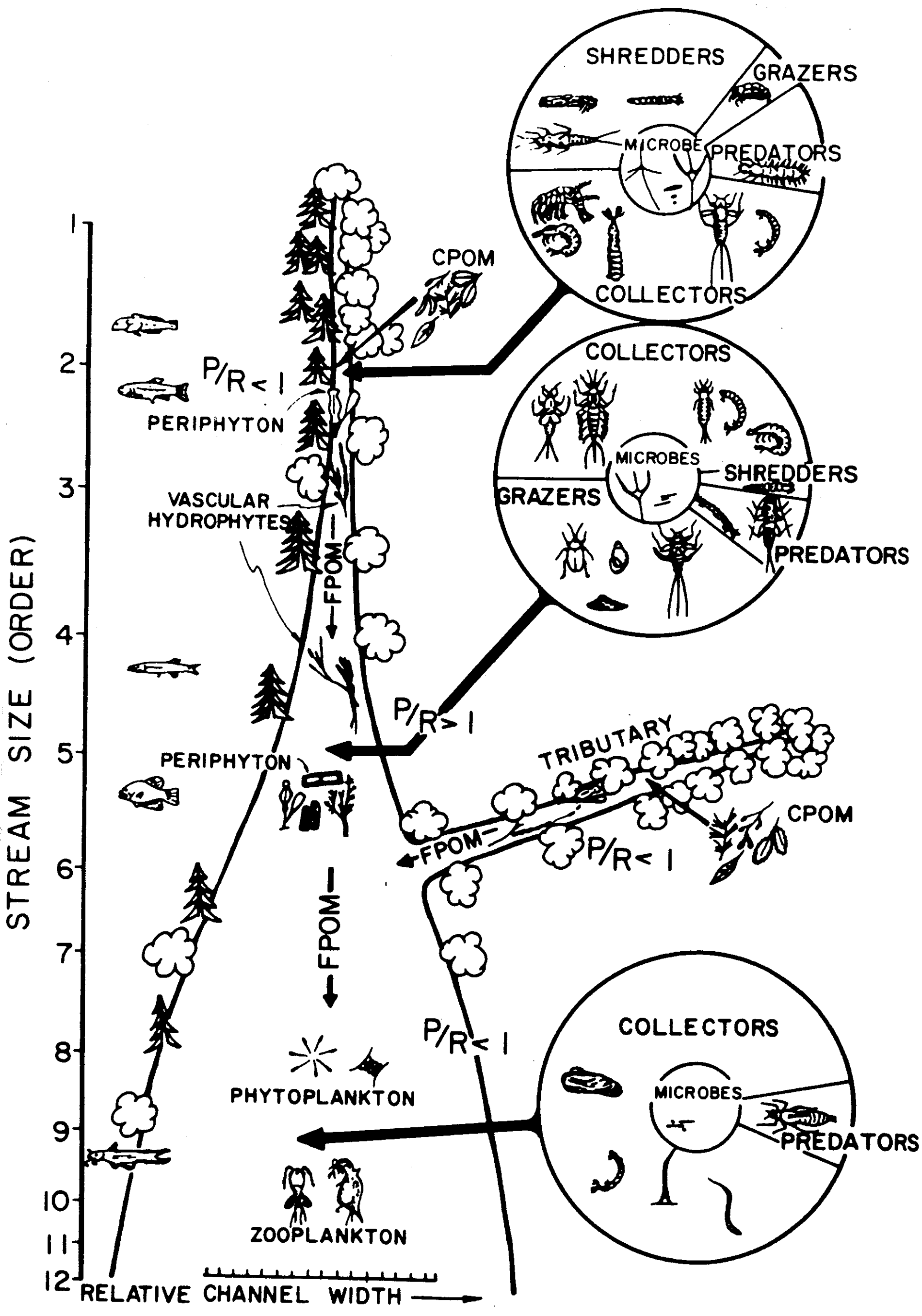

Figure 3. Hypothetical relationships between stream size and the progressive shift in structural and functional attributes of stream communities (P=primary production, R=respiration) (from Vannote et al. 1980).

In summarising the changes of function with specific uses, we have distinguished between riparian strips with short or tall vegetation, corresponding loosely to pasture or forest (Table 2). We recognise that short vegetation includes ungrazed lands that have natural or induced tussock grass cover. Forest cover includes indigenous or introduced tree species, and may or may not be actively managed. In addition, for short or tall vegetation, we need to consider the functional relationships of the riparian strip with salmonid production, indigenous fish production, water quality, erosion control, wildlife values, and cultural, aesthetic, and recreational values.

Salmonid production. The structure of both short and tall riparian vegetation needs to be maintained to protect salmonid spawning, rearing, and adult habitat. Shading is important for stream temperature regulation, especially in low latitudes. Riparian vegetation can also control channel stability and create channel complexity and cover. Streambank vegetation reduces channel width and increases channel depth. Herbaceous vegetation prevents bank erosion in unshaded reaches, while trees strengthen banks and allow undercutting. Undercut banks can be important salmonid cover.

Table 2. Positive and negative influences of forest and low riparian zone vegetation on salmonid production, indigenous fish production, water quality, erosion control, wildlife values, and cultural, aesthetic, and recreational values.

Riparian vegetation type	Stream size	Values to be protected					
		Salmonid production	Indigenous fish	Water quality	Erosion control	Wildlife values	Cultural, aesthetic and recreational values
Forest	small	+/-	++	+	++	++	+/-
	large	+	++	+	++	++	+/-
Ungrazed grassland and low vegetation	small	++	+	++	++	+	++
	large	+	+	?	+	+	++

++ = highly positive influence
+ = positive influence
+/- = neutral influence, or both positive and negative influences
? = unknown

Animal type and grazing intensity are important considerations in whether riparian strips need to be fenced. For instance, salmonid habitat values may be maintained with low-intensity sheep grazing, but not generally with cattle grazing. Because of their larger size compared to sheep, cattle tend to compact streamside soils more, and to accelerate bank erosion. Thus exclusion of cattle is likely to be required to maintain riparian functions, but this may depend on stream size. Small streams have been shown to be more susceptible to grazing damage than large streams (Smith et al. 1989). For instance, in large Southland streams there were only minor differences in channel width and invertebrate populations between stream reaches with and without riparian zone protection (Quinn et al. in prep.).

Not all effects of riparian vegetation enhance salmonid production. Heavy shading can reduce instream primary production, which may be an important food base for aquatic invertebrates. The negative effects of shading in reducing food production may outweigh the benefits of low temperatures and habitat complexity. Thus a consequence of increasing shade and lower temperature may be reduced salmonid productivity. Short species such as tussock may be preferable to trees in the riparian strip for salmonid streams.

Indigenous fish. In general, levels of temperature, oxygen, and turbidity acceptable for indigenous fish for rearing and adult habitat are similar to those acceptable for salmonids. Indigenous fish do, however, show differences from salmonids in some habitat requirements. Some indigenous fish, for instance, banded kokopu (*Galaxias fasciatus*) and giant kokopu (*G. argenteus*) seem to require shade and complex habitat frequently associated with indigenous forest (Hanchet 1990), although these requirements are by no means absolute. Native forest over streams is a source of terrestrial invertebrates in the diet of some *Galaxias* species (Winterbourn 1987).

Salmonids are largely visual feeders, and low light has been shown to restrict their feeding (Wilzbach and Hall 1985). Indigenous fish, some of which are nocturnal, e.g., *G. brevipinnis* (Glova and Sagar 1989), and are therefore not reliant on light to feed, may have a competitive advantage over salmonids in heavily shaded streams. In contrast to salmonids, the negative effects of shading in reducing instream food production for indigenous fish may be outweighed by the benefits of low light intensity, low temperatures, habitat complexity, and inputs of terrrestial invertebrates.

The habitat requirements of indigenous fish as a group are more diverse that those of salmonids, and it is probably more effective to consider guilds of species that occupy similar habitats (Gorman 1987). Some examples of habitat guilds of indigenous fish in New Zealand are common bullies (*Gobiomorphus cotidianus*), blue-gilled bullies (*G. hubbsi*), and torrentfish (*Cheimarrichthys fosteri*). These fish tend to occupy lowland mainstem habitats, where riparian vegetation does not exert such an influence on the stream environment as it does in smaller, lower-order streams. Banded kokopu, longfinned eels (*Anguilla dieffenbachii*), and short-jawed kokopu (*Galaxias postvectis*) frequently occupy tributaries or habitats upstream, where the effect of riparian vegetation is more important than in larger rivers.

Water quality. Riparian vegetation can reduce inputs of fine sediment from both bank erosion and overland flow. Ungrazed grasses and wetlands with emergent plants are particularly effective in trapping sediment produced by overland flow (Smith 1989). However, most grasslands are likely to be used for grazing, and this may cause sediment inputs to streams because of (1) trampling and destruction of streamside vegetation by cattle, and (2) reduced stability of hillslopes leading to slumping and earthflows. Leaf litter mats on the forest floor may, however, trap sediment as effectively as grasses, and sediment inputs from the forested land will be much less than from grazed grasslands.

Streamside wetlands may retard the entry of water to streams, allowing increased contact with vegetation and time for processing and removal of nutrients (McColl 1978, Smith et al. 1989), and toxic runoff. For example, nutrients may be effectively removed by instream and streambank vegetation (Cooper and Cooke 1984, Howard-Williams et al. 1986), but shading caused by trees can reduce growth of instream vegetation, inhibiting this process. Streambank vegetation is very susceptible to grazing, and benefits to water quality from streambank vegetation can be significantly reduced by grazing pressure, particularly in winter (Hearne and Howard-Williams 1988). The effect of riparian and instream vegetation on nutrients may be largely restricted to small streams, but wetlands associated with streams of any order can be effective areas of nutrient processing.

Erosion control. Riparian vegetation controls bank erosion, channel widening, and entry of fine and coarse sediment to streams. This is generally very desirable in maintaining aquatic habitat and water quality. Longitudinal transport of fine and coarse sediment can also be controlled by instream vegetation in unshaded areas. Large woody debris from riparian zones and living streamside trees has also been shown to retard coarse sediment transport (Mosley 1981). Grasses and short vegetation may be less effective. Areas high in the watershed, such as gullies above first order streams, also need protection, as these are often source areas for coarse and fine sediment. Partial source areas for run-off in the catchments of low-order streams should also be considered as high priority for protection, particularly in pasture catchments (Howard-Williams et al. 1986, Cooke 1988).

Grazing of sheep in riparian zones can increase erosion through destruction of vegetation. However, cattle may be more damaging than sheep because they also destroy vegetation by trampling (Dungey 1990).

Wildlife values. Riparian zones can provide corridors for wildlife such as birds and deer, providing access to water and routes for migrations. For instance, riparian corridors are particularly important for local movement of blue duck, (Science Faction/Fiction No. 9, 1989, Department of Conservation, Wellington).

Riparian zones can also be important habitats for many species of resident animals. Adult stages of aquatic invertebrates, for instance, may use riparian vegetation for habitat.

Cultural, aesthetic, and recreational values. The presence of riparian vegetation, and its nature and structure can affect cultural, aesthetic, and recreational values. Trees in riparian strips can restrict angling and access, but improve aesthetic and visual appreciation of the landscape. Dense growth of gorse or blackberry can also restrict access to streams and angling opportunities. Low vegetation in the riparian zone, such as grasses and tussock, are most useful to anglers.

Riparian zones can harbour pest animals such as opossums and rabbits. Farmers may be particularly concerned about the role of riparian trees in maintaining opossum populations. Opossums carry tuberculosis, and may infect cattle with this disease.

Guidelines for management of riparian strips

It is clear that some uses and values associated with riparian strips conflict. However, the value of riparian land is enshrined in law (Conservation Law Reform Act 1990, p41-49). Thus in thinking about guidelines for management of riparian strips, we need to consider:

1) where management is needed;
2) how large the strips should be in a) width and b) longitudinal extent;
3) what their vegetative structure should be, especially in relation to climate, existing geomorphic features such as floodplains and river terraces, and cultural, aesthetic, and recreational values, and in relation to function of the riparian strip, e.g., encouragement of streambank and wetland vegetation for water quality goals, and indigenous tree cover for native fish management.

We hope we have shown that protection of riparian zones is important for the optimal function of stream ecosystems. However, it would impossible and not advisable to provide a single set of prescriptions for size, location, and vegetative structure of riparian strips that would be appropriate for all climates, size of stream, and uses. We believe there may be classes of climates, stream sizes, and uses for which a suite of suggestions for riparian strips can be developed. This report should stimulate that process.

Acknowledgements

We would like to thank participants at the workshop "Criteria for the establishment of riparian strips", held at the 1990 annual conference of the New Zealand Limnological Society in Christchurch, for their input. Charles Mitchell and David Rowe of MAF Fisheries, Rotorua, and Jonet Ward of the Centre for Resource Management, Lincoln University, also made helpful suggestions that improved this report.

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