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# A BIBLIOGRAPHY OF SOME NEW ZEALAND RIPARIAN LITERATURE

**Compiled by**

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# A BIBLIOGRAPHY OF SOME NEW ZEALAND RIPARIAN LITERATURE

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## ABSTRACT

A list of 61 New Zealand references dealing with riparian zones of freshwater habitats is presented alphabetically under eight subheadings; Water quality, Morphology, Invertebrates, Fish, Birds, Exotic forestry, Management and General. Abstracts, summaries, conclusions or recommendations are given where these were presented in the references. Additional relevant information (included in parentheses) and keywords have also been included. This bibliography is not comprehensive. Rather it is intended as an introductory resource for managers trying to come to grips with existing information on riparian zones in New Zealand.

## 1. WATER QUALITY

Cooke, J.G. (1988): Sources and sinks of nutrients in a New Zealand hill pasture catchment II. Phosphorus. *Hydrological Processes* 2: 123-133.

PHOSPHORUS, FERTILISER, SURFACE RUN-OFF, MANAGEMENT, SEDIMENT ENRICHMENT, EUTROPHICATION, DIFFUSE SOURCE POLLUTION, WAIKATO

The management of the riparian zone has been suggested as a technique controlling the amounts of phosphorus (P) entering watercourses draining pasture catchments. A study was therefore made of P entering a stream from various sources (rainfall, surface and subsurface derived runoff, direct fallout from aerial topdressing), with the object of providing a rational basis for the design of effective riparian management schemes. P entrained in surface runoff could account for virtually all of the P entering the stream during storms. Approximately 20% of the annual P export from the catchment could be accounted for by direct aerial input of P to the stream during autumn topdressing. More than 85% of the P was exported from the catchment as particulate P. Stream sediments had higher P sorption capacities, and were enriched with P relative to the soils from which they were derived. There was a pronounced seasonal variation in sediment enrichment which could be predicted ($r^2$=0.92) by the logarithm of the rainfall since fertiliser topdressing (LNFERT) and flood intensity. The amount of P lost in streamflow during any flood event was predicted ($r^2$=0.94) by peak flow, 7 day antecedent peak flow and LNFERT. Approximately 40% of the 1.3 kg $P.ha^{-1}$ exported during 1981 occurred in 4 storms with recurrence intervals of more than 3 months. From a P budget compiled from 9 events it was hypothesised that the stream acted as a net sink for P at baseflow and low-medium intensity floods but was a source of P at higher flood intensities. It was concluded that P losses from hill pasture catchments could be reduced by avoidance of direct application of P to the stream channel, and by fencing out stock from seasonally saturated areas during periods of saturation. The ultimate success of the latter technique would depend on whether buffer vegetation could retain accumulated P during extreme storm events.

Cooke, J.G.; Cooper, A.B. (1988): Sources and sinks of nutrients in a New Zealand hill pasture catchment. III Nitrogen. *Hydrological Processes 2:* 135-149.

NITROGEN, SURFACE RUNOFF, NITRATE, ORGANIC N, EUTROPHICATION, DIFFUSE SOURCE POLLUTION, SEEPAGE ZONES, DENITRIFICATION, WAIKATO

A study was made of the nitrogen (N) inputs to, and exports from, a stream draining a pasture catchment near Hamilton, New in order to plan measures for minimising N losses to natural waters. *An* estimated 7 kg was exported from the catchment during 1981 of which 86% was in reduced forms (Kjeldahl-N, TKN) and the remainder as nitrate-N ($NO_3$-N). Virtually all of the reduced N inputs came from saturated overland flow whereas $NO_3$-N inputs were dominantly subsurface derived. The TKN exported by individual storm events could be predicted ($r^2$=0.97) from peak flow and from the peak flow rate in the 7 days preceding the storm. A TKN balance for 8events showed that except for large floods (return period approximately a year) the stream system was a net sink for TKN. During large floods, scouring of the organic rich seepage areas resulted in the stream system itself being a net source of TKN. Microbial assays for nitrification and denitrification activity indicated that the main nitrate source was the well-aerated greywacke and ash soils and that the permanently saturated seepage zones were a significant nitrate sink. An in-stream nitrate addition experiment showed that up to 20 mg was removed from the stream. Simultaneous measurements of 20 mg $N.m^{-2}.h^{-1}$ denitrification activity demonstrated that only about 1% of this removal could be accounted for by denitrification. It was inferred that plant uptake was responsible for the remainder. Retention of near-stream seepage areas is suggested as a measure for minimising $NO_3$-N export, whilst removal of stock from seasonally saturated areas during periods of saturation should reduce soil loss and hence TKN inputs to the stream.

Cooke, J.G.; Dons, T. (1988): Sources and sinks of nutrients in a New hill pasture catchment I. Stormflow generation. *Hydrological Processes* 2: 109-122.

SATURATED AREAS, SURFACE RUNOFF, SUBSURFACE STORMFLOW, THROUGHFLOW, WATER QUALITY MANAGEMENT, PASTURE, WAIKATO

The processes of stormflow generation were studied in a hill pasture catchment near Hamilton, New Zealand. Although rainfall was relatively evenly distributed throughout the year, stormflow was highly seasonal and over 65% occurred during winter. Three main processes contributing to stormflow were identified which could be related to soil type and physiographic position. On gleyed soils derived from rhyolitic saturation overland flow was the dominant process. Hydrographs from "Whipkey" throughflow troughs also indicated there was a subsurface response (saturated wedge) from this soil type. On steeper convex slopes, more permeable soils were derived from weathered greywacke. The presence of ephemeral springs on the hillslopes and direct observation during storm events indicated that storm runoff was generated as return flow from this soil. It was noted that nitrate concentrations from subsurface sources were 5-10 times higher than surface runoff. This difference in concentration was in a chemical mixing equation which partitioned stormflow sources. This was compared with the stormflow predicted from rain falling onto saturated areas. There was good agreement between the 2 models for winter-spring events with respect to the volumes of surface runoff predicted, however the saturated areas model underestimated total stormflow. The results of the study are briefly discussed in terms of the potential for water quality management. (…The presence of an ungrazed grass buffer strip should act as a filter for nutrients entrained upslope, and also decrease net precipitation onto the soil surface).

Hearne, J.W.; Howard-Williams, C. (1988): Modelling nitrate removal by riparian vegetation in a springfed stream: the influence of land-use practices. *Ecological Monitoring* 42: 179-198.

LAND-USE, TONGARIRO/TAUPO

Downstream nutrient flux has been modelled in a second-order, springfed stream in New Zealand where the stream banks have been protected by the establishment of fenced riparian strips. This has allowed the development of an aquatic streambank vegetation which assists in the removal of dissolved nitrogen from the stream water. The model comprises a coupled system for first-order, non-linear partial differential equations to incorporate the feedback effects of nitrogen uptake and release as the water moves downstream. The most sensitive parameters in the model were shown to be the growth and mortality constants for the aquatic vegetation. Analysis of varied farming practices on nutrient uptake by the riparian vegetation shows that winter grazing of the system is disadvantageous to nutrient uptake but that grazing at rates 2-3 times the regional average can be sustained during summer months without adversely affecting uptake. Decreasing nutrient mass flows at the springs either by altering concentration or discharge would greatly reduce nutrient export when below defined threshold values, and increases in mass flows above these values would increase export proportionately. Nutrient uptake was found to be proportional to concentration only at low flows.

Howard-Williams, C.; Downes, M.T. (1984): Nutrient removal by streambank vegetation. In: *Land treatment of wastes: preceedings of a seminar.* (Ed: Wilcock, R.J.), Water and Soil Miscellaneous Publication, Water and Soil Directorate, Ministry of Works and Development for the National Water and Soil Conservation Authority, Wellington, 409-424.

TONGARIRO/TAUPO

A characteristic stream bank vegetation develops along watercourses which are protected from grazing. These plants generally have high growth rates (ca. 0.04 $g.g^{-1}.day^{-1}$) and some accumulate high nitrogen and phosphorus levels compared with terrestrial plants. Our work has shown that decrease in nitrate with distance downstream is due largely to uptake by this vegetation type. Denitrification is shown to be a less important process in direct nitrate removal. The significance of these processes in streams of the North Island is briefly reviewed.

Howard-Williams, C.; Pickmere, S. (1989): Nutrient removal by streambank vegetation. Taupo Research Laboratory Report 111. Division of Water Sciences, DSIR, Taupo.

TONGARIRO/TAUPO

A distinct aquatic and semi-aquatic vegetation develops rapidly along the margins of pastoral streams and grows across the stream surfaces where streams are protected fmm stock grazing. This vegetation has the capacity to remove dissolved inorganic nitrogen and phosphorus compounds from stream waters thereby reducing nutrient loads downstream. Studies on this vegetation type and its effect on stream have been carried out on the Whangamata Stream, Lake Taupo. The rates of nutrient removal were found to depend on the seasonality of growth rates of the stream bank vegetation, vegetation biomass, stream discharge and stream length. In the long term, nutrients were either stored in stream bank sediments or returned to the stream, mostly in particulate In the case of nitrogen, losses to the atmosphere by denitrification occurred. Floods or increased discharge resulted in a net loss of particulate matter downstream. A quantitative assessment of the fate of nitrate in summer in 1980-81 showed that 42% was removed by stream bank vegetation. Of this, half was lost to the atmosphere as $N_2$ by denitrification and half was eventually returned to the stream following decomposition. The major proportion (90%) of this was as particulate nitrogen and dissolved organic nitrogen, both of these forms being available (in the short term) as downstream growth promoting nutrients. Simulation modelling of nitrate transformations in the Whangamata Stream has shown that winter removal of the streambank vegetation would be disadvantageous to nutrient uptake but that in summer streambank vegetation harvesting at rates equivalent to 2-3 times the local average grazing rate for pastures would not adversely affect nutrient uptake. Fencing of riparian zones removes land from productive farming, prevents stock access to water and prevents easy movement of stock across streams. In addition, continued development of streambank vegetation can cause problems with fish migrations (i.e. in trout spawning streams). It would therefore be advantageous to minimise the area removed for riparian strips and to consider a policy of active rather than passive management of these strips.

Howard-Williams, C.; Pickmere, S.; Davies, J. (1986): Nutrient retention and processing in New Zealand streams: the influence of riparian vegetation. *New Zealand Agricultural Science* 20(2): 110-114.

Nitrogen entering streams in diffuse form from pastoral catchments usually occurs as nitrate. Studies on New Zealand headwater streams have shown that nitrate is retained and transformed within streams by aquatic organisms and those associated with the riparian zone. Nitrate uptake in streams decreases with increasing discharge and increases with increasing plant biomass and with increasing stream width per unit of discharge. Macro-phytes are shown to be more important than bacteria in nitrate removal from these streams. The use of streams and associated riparian zones for retention of diffuse nutrient pollutants can be optimised by identification of critical riparian areas for protection.

McColl, R.H.S. (1978): Chemical runoff from pasture: the influence of fertiliser and riparian zones. *New Zealand Journal* of *Marine and Freshwater Research* 12(4): 371-380.

NORTHLAND

Runoff of phosphorus, nitrate, ammonium, calcium, magnesium, sodium, potassium, chloride and sulphate was measured in 15 and at low flows in 3 "nested" experimental catchments covered from scrub to pasture. Multiple regression analysis suggested that over 2.5 years, fertiliser application had a cumulative effect on the concentration of calcium, potassium and sulphate in storm waters leaving the experimental basin, but only in the flood waters from the small wholly-grassed sub-catchment (Pukeiti) was there an increase in phosphorus concentrations. A similar pattern was at baseflows. Reactive phosphorus losses of up to 1 $kg.ha^{-1}$ left Pukeiti in post-fertiliser storm events but mean losses from the whole basin were only about 0.004 $kg.ha^{-1}$ per storm and there was little evidence of any fertiliser effect. The stream below Pukeiti has well developed riparian vegetation with marsh and scrub. The phosphorus losses the basin seem of little significance agriculturally and environmentally. Although the losses from Pukeiti sub-catchment were of sufficient magnitude to a strong impact on water quality in waterways and lakes (mean total phosphorus concentration in post-fertiliser floods 1.91 $g.m^{-3}$) this subcatchment appeared to have little effect on the quality of water eventually leaving the whole basin. The results are discussed in relation to sub-catchment differences and it is suggested that they give support to the use of riparian zones along streams to reduce phosphorus runoff.

Smith, C.M. (1989): Riparian pasture retirement effects on sediment, phosphorus, and nitrogen in channelised surface runoff from pastures. *New Zealand Journal of Marine and Freshwater Research* 23: 139-146.

RIPARIAN MANAGEMENT, SURFACE RUN-OFF, NITROGEN, PHOSPHORUS, SEDIMENT LOADS, WAIKATO

Riparian pasture retirement effects on the chemistry of channelised surface run-off from 2 moderately steep hillslopes was examined in a 22 month study. Seventy-one surface run-off events occurred. They varied in size by about 2 orders of magnitude. Sediment, phosphorus, particulate-and nitrate-nitrogen concentrations in the run-off (in each event) at retired riparian pasture sites were significantly ($P<0.001$) and substantially lower than concentrations in run-off at grazed riparian pasture sites. Concentrations also varied less extensively at retired sites ($P<0.001$). Riparian pasture retirement impacts on total loads were examined by comparing the average concentrations in in 22 at retired and grazed sites. These event-flow-weighted total and volatile suspended solids, particulate P and N, dissolved P, and nitrate-nitrogen means were <87%, <84%, <55% and <67%, respectively, lower at the retired sites. It was concluded that riparian pasture retirement is an effective means of reducing surface run-off pollutant loads to waterways in the short term, but long-term impacts need to be examined.

Smith, C.M. (1990): Riparian afforestation and pasture retirement impacts on streamwater yields and quality. Internal Report No. 90/05. DSIR Water Quality Centre, Hamilton. 33 pages.

EXOTIC FORESTRY, HYDROLOGY, PASTURE, SEDIMENT, NITROGEN, PHOSPHORUS, NELSON/MARLBOROUGH

The objectives of this study were to determine how various riparian land uses influence pastoral catchment water yields and water quality (sediment, nitrogen and phosphorus). It involved a catchment comparison study using 4 of the Moutere experimental catchments, located 20 km southwest of Nelson. Analysis of 18 years flow records showed that riparian afforestation reduced water yields by 22-54% when the *Pinus radiata* stand was 8-10 years old. These reductions are larger than would be expected from the results of earlier complete-catchment afforestation studies, and indicate that the riparian zone is playing a disproportionately important role in influencing catchment hydrology. Riparian management effects on water quality were examined by comparing and stormflow water quality over a 2 year period. The interpretation of these data was complicated because of flaws in the experimental design. To be specific, the study was too short-termed, not sufficiently replicated and lacked an adequate calibration phase. Nevertheless, important findings emerged from the work. The 2 pastoral catchments with riparian afforestation generally produced run-off of poorer quality than the completely grassed, control catchment. Both concentrations and mass exports were higher; the latter in spite of the reductions in water yield caused by afforestation. Exports of sediment, total phosphorus, total nitrogen, and nitrate were 1.5-3.2 times, 1.4 times, 1.5-1.6 times, and 2.3-2.6 times larger from the riparian afforested catchments. These findings directly with popular expectations, but are probably not surprising when the catchment hydrological and riparian processes that are likely to control pollutant transfer and removal are considered. Extensive upland areas in the Moutere catchments may sometimes generate surface run-off. However, with riparian afforestation there is little close vegetative ground cover under the pine, or well developed in-stream macrophyte beds to filter and adsorb out pollutants carried in this run-off. Furthermore, may have reduced the extent of riparian wetlands thereby reducing denitrification rates. These represent deductive reasons for the observed effects, and specifically designed process studies are needed to provide confirmatory evidence. The effects of riparian pasture retirement on water quality could not be unequivocally determined from the results of this study because water quality varied between identically managed catchments in the 1 year calibration study, and because water quality varied extremely in the control catchment between calibration and treatment surveys. Furthermore, no firm conclusions could be reached regarding riparian pasture retirement effects on water yields. This study shows that designing riparian management schemes to effectively reduce diffuse source pollutant inputs to waterways requires a clear understanding of the stormflow generation processes within a specific catchment and knowledge of the important run-off sediment source areas, in addition to a thorough appreciation of how riparian processes can be managed to modify run-off pollutant load. We need to investigate the individual processes that regulate diffuse pollutant inputs to waterways rather than merely attempt to monitor the result of these processes at the catchment outlet. Finally this study emphasises yet once again the potential problems inherent in undertaking short-term, non replicated catchment comparison studies especially when either no, or an inadequate calibration study is undertaken.

Smith, C.M. (1992): Riparian afforestation effects on water yields and water quality in pasture catchments. *Journal of Environmental Quality* 21: 237-245.

AFFORESTATION, EXOTIC FORESTRY, PASTURE CATCHMENTS, HYDROLOGY, NELSON/MARLBOROUGH

The flow records for 2 pasture headwater catchments for 9 years before, and 9 years after riparian afforestation in 1 catchment were compared. Average rainfall 1021 $mm.yr^{-1}$.Riparian afforestation reduced water yields by 68 to 104 mm (21-55%) when the *Pinus radiata* stand was 8 to 10 years old. Delayed runoff declined by 52 to 93 $mm.yr^{-1}$ (27-63%). Afforestation reduced the quickflow yield in 1 year (22 mm or 40%). Peak flows declined in small events, were not affected in medium-sized events, and may have increased in large events. The large reductions in yield indicate that the riparian zone had a disproportionately important influence on catchment hydrology. They are attributed to high transpiration losses from the riparian pine in seasons with water deficits, and higher that usual forest interception losses because of the small-scale planting. Streamwater sediment, total and dissolved N and P concentrations in these 2 catchments and another riparian afforested catchment were monitored for 2 years. Concentrations were generally lower in the completely pastured catchment. Estimated annual sediment, total P, Kjeldahl N, and nitrate exports from the pasture catchment were 31-60%, 70%, 61-64%, and 58-74% of those from the riparian afforested catchments in spite of a higher water yield. Possible explanations for the poor water quality in riparian afforested catchments are described including the lack of riparian wetlands, in-stream vegetation, and close riparian ground cover. The consequences of riparian afforestation in pasture catchments may not be readily predicted from the impacts of complete catchment afforestation.

Smith, C.M.; Williamson, R.B.; Cooper, A.B. (1989): Riparian retirement - the effects on streambank stability and water quality. In: *Changing Times:* Proceedings of the New Zealand Association of Soil and Water Conservation annual conference. (17-19 May 1989), Nelson, 27-35.

In 1983 a suite of investigations began at the Water Quality Centre into managing riparian zones for improved water quality. Results from the initial studies in a pastoral catchment near Hamilton were very encouraging. Firstly, grassed buffer strips were shown to substantially reduce sediments, P (phosphorus), and N (nitrogen) concentrations in surface runoff (i.e. by 80-87%). Secondly, riparian wetlands were found to be very important in reducing groundwater nitrate concentrations (i.e. >90%). Substantial groundwater nitrate removal was also observed in the riparian wetlands of forested catchments at Rotorua. All these studies showed that large improvements in catchment runoff quality could be obtained from managing relatively small stretches along the Ongoing studies are examining existing retirement schemes. In a pastoral catchment comparison study at Moutere there were no short term water quality benefits from retiring riparian pasture, while catchments with pine in the riparian zone had the poorest water quality. In Southland, we focused on the physical and biological impacts of riparian management. Retirement was of little benefit because it did not influence the stream erosion mechanisms and grazing had only a minor impact on stream erosion and the biota. In contrast, the preliminary results of another study indicate that streambank erosion has declined in the Ngongotaha catchment near following riparian retirement. Riparian retirement does not invariably improve water quality or the stream environment. The effects depend on complex interactions between factors such a catchment hydrology and geology, nutrient processing, stream morphology and streambank vegetation. Clearly, we need to thoroughly understand the role of these factors in any specific catchment before an effective retirement scheme can be designed.

## 2. MORPHOLOGY

Williamson, R.B.; Smith, R.K.; Quinn, J.M. (1990): The effects of riparian grazing on channel form and stability of *6* grazed streams, Southland, New Zealand. Water Quality Centre Publication No. 19, 42 pages.

GRAZING, CHANNEL FORM, STABILITY, SOUTHLAND

The effects of grazing animals on stream margins and the benefits of riparian retirement to streambank erosion and aquatic habitat were assessed through the survey of *6* streams and rivers in Southland, New Effects and benefits were assessed by comparing morphological and vegetation data between grazed and retired reaches, and making inferences about channel erosion processes and the effect on those characteristics that benefit aquatic habitat. Grazing was found to have relatively little effect on channel morphology and bank stability of most streams. On the 2 larger streams, which had relatively active channels, grazing damage was slight and appeared to be playing little part in overall streambank erosion or characteristic morphology. Past effects, if they occurred, would have been obliterated by shifts in channel position. In the other small streams, the channel was far less active and damage to streambanks was highly variable ranging from 0-25% of the channel length. The worst damage seemed to be associated with a combination of factors: a relatively high stocking rate with cattle and an exceptionally wet streamside soil. The least damage was observed on the smallest stream surveyed, demonstrating that the large potential for damage to such small streams is only realised under the appropriate conditions. In most other streams, the damage was highly localised, in some cases leading to wider, shallower sections, but not significantly changing the average dimensions of the channel. Only in the most damaged situation had significant channel widening occurred. We attributed the relatively low degree of grazing damage in most streams compared with that overseas to the relatively dry streamside soils, moist temperate climate, high inaccessible banks and possibly better stock management. Benefits of retirement were thus limited to the retention of remnant native shrubs and tussock along stream margins, protection against man-made channel alterations and the prevention of localised, stock-induced streambank damage in small streams. In the larger actively migrating streams, retirement by itself would have little effect on the dominant erosion processes. The lack of recolonisation by native species, particularly large shrubs and trees that might stabilise banks and enhance habitat, leads us to suggest that greater benefits would accrue if the retired zones were planted in appropriate tree species. This would seem to be a particularly attractive option in larger streams where an improvement in trout fisheries and a reduction in erosion is required.

Williamson, R.B.; Smith, R.K.; Quinn, J.M. (1992): Effects of riparian grazing and channelisation on streams in Southland, New Zealand 1. Channel form and stability. *New Zealand Journal* of *Marine and Freshwater Research* 26: 241-258.

RIPARIAN PROTECTION, GRAZING, STREAM BANK EROSION, CHANNEL MORPHOLOGY, AGRICULTURE, AQUATIC HABITAT, SOUTHLAND

The effects of mixed sheep and cattle grazing of stream margins, channelisation, and the benefits of riparian retirement were assessed through a survey of 5 streams in Southland, New Zealand. Morphological and vegetation data affecting erosion processes and aquatic habitat were compared among grazed, channelised and retired reaches. There is no evidence that grazing streambanks in floodplain streams of northern will lead to rapid and severe deterioration channel form, except in small streams (< 2 m wide) under intensive grazing wet streamside soils. Generally, the dominant erosion mechanism - the undercutting of banks - is largely unaffected by grazing stream margins. In contrast, channelisation has led to severe streambank and streambed erosion in 2 of the 3 streams examined. The major factor in this degradation appears to be straightening and deepening the channel so that underlying uncohesive shingle is exposed to high flows. Riparian retirement had variable effects depending on the stability of the stream channel. On smaller, relatively inactive channels, it reduced localised bank erosion from livestock trampling, especially at cattle crossings. However, this damage (which sometimes can be quite visible) did not lead to significant change in average channel form or width in the 7-15 years since the land has been converted to intensive agriculture from extensively grazed tussock. Retirement also increased vegetation overhang. On the larger channels that were more actively meandering, retirement had comparatively little because retirement or grazing effects are rapidly by channel migration.

## 3. INVERTEBRATES

Collier, K.J.; Winterbourn, Jackson, R.J. (1989): Impacts of wetland afforestation on the distribution of benthic invertebrates in acid streams of Westland, New Zealand. *New Zealand Journal of Marine and Freshwater Research 23:* 479-490.

WETLANDS, PAKIHI, DRAINAGE, ACID STREAMS, EXOTIC FORESTRY, WESTLAND

> Inter-relationships between some physical and chemical parameters of streams, the degree of catchment development, and benthic invertebrate distributions were investigated on two dates at 26 running water sites in North Westland, New Zealand. Streams draining catchments recently developed for forestry had higher summer water temperatures, greater total reactive aluminium concentrations (up to 31°C and 911 $mg.m^{-3}$, respectively), and lower pH (down to 4.1) than most streams draining undeveloped wetland or native forested catchments. Apparent differences in water chemistry were attributed to the most recent development being at the heads of wetland catchments where leaching of organic acids into drainage waters was probably highest, rather than to any effects of development per se. Overall, streams that were very acidic (pH mostly <5.0 and often <4.5) and drained wetland catchments supported 1.3-3.3 fewer invertebrate taxa than sites that consistently had pH > 4.5 and drained native forested catchments. Invertebrate colonisation appears to be limited by the extreme acidity of brownwater streams on pakihi wetlands. (… in groups of streams where riparian vegetation had been removed, November water temperatures were, on average, 8-13°C higher than for groups of undeveloped sites. It is quite likely than elevated water temperatures limit the distributions and/or development of some invertebrate species…).

Lester, P. (1992): Shade and substrate: mechanisms of willow tree influence on a central Otago stream macroinvertebrate community (Abstract). *New Zealand Limnological Society Newsletter* 28: 26.

> WILLOWS, OTAGO
>
> Previous studies in Central Otago streams have indicated that high densities of willow trees reduce stream macroinvertebrate densities. In order to determine the relative importance of light and substrate in affecting this distribution, 2 riffles in a Central Otago stream were artificially shaded. Baskets containing substrate typical of willow and open sites were placed in artificially shaded, open, and willow-shaded riffles. Total invertebrate numbers were significantly higher in artificially shaded baskets than in those shaded by willow. Artificial shading resulted in similar numbers of invertebrates to the open sites, which indicates light was not important in controlling invertebrate densities. This is in agreement with data indicating similar levels of primary production at all sites. Hence there is an effect of willows that was not related to either shading or substrate. Rather, the presence of willow trees was found to significantly decrease invertebrate densities. This suggest some other factor, such as the effect of willows on water chemistry, may be important in influencing invertebrate distribution.

Linklater, W. (1991): The riparian vegetation -stream macroinvertebrate relationship in small forest streams, Canterbury, New Zealand. M.Sc. Thesis, University of Canterbury.

BENTHICINVERTEBRATES, LITTER PROCESSING, CANTERBURY

The influence of riparian vegetation, conferred by its litter and shading, on the macroinvertebrate community was investigated in 4 small, first order, forest streams in Canterbury, New Zealand. The 4 streams had different riparian forests with different seasonal litterfall and shading regimes. The in-stream distribution of the detritivorous fauna was examined by Surber sampling in 5 microhabitats common to each stream. The principal shredders found were *Oeconesus maori, Zelandopsyche ingens, Pycnocentria forcipata, Austroperla cyrene,* and *Zelandobius confusus,* and most large fine particle collectors were mayfly or Scirtidae beetle larvae. The highest densities of detritivores were associated with coarse detritus in pools, but correlations with detrital biomass were weak probably because of the "super-abundance" of coarse leaf litter. I examined the strength of the riparian vegetation-stream association by testing the Litter-link and Shredder Response models of Cummins (1986) and Cummins *et al* (1989) that describe the faunal feeding response to leaf litter inputs. By introducing leaves into streams in baskets at the time of peak litterfall, bimonthly Surber sampling each stream, and recording monthly using buckets anchored to the banks for a year (November 1989 -November 1990), spatial and temporal aspects of the response models were investigated. My results indicate that Cummin's models are not applicable in the streams studied despite their highly seasonal leaf inputs, relative stability, high retentive capacity, large detrital standing stocks, and large shredder faunas. Thus, life history patterns of the most abundant were similar in a11 despite differences in leaf fall patterns which in turn were poor stream detrital biomass. Effective bank retention of leaves allowed blow-in, wash-in and spates to dictate leaf input regimes which were therefore unpredict-able. Perhaps as a consequence of this, shredder life cycle-riparian litterfall synchrony has not evolved. Finally, I devised an analogue of Cummins (1986) Litter-Link Model, the Light-Link to test possible temporal relationships between the abundance of the grazer and collector-browser faunas and the seasonal shading regime associated with leaf fall. Measurements of light intensity, the standing stock of periphyton, and grazer and collector-browser biomass were made regularly between November 1989 and November 1990. Results indicate that the in-stream periphyton biomass was not influenced by changes in seasonal regimes due riparian leal and browser and collector-scraper taxa were not temporally with annual periphyton biomass peaks. In summary, strong spatial and temporal links between stream macroinvertebrate communities and dominant riparian tree species were not Sound in the forest streams studied, and this provides suppon previously expressed views that such associations are weakly developed in New Zealand.

Linklater, W.; Winterbourn, M.J. (1993): Life histories and production of two trichopteran shredders in New Zealand streams with different riparian vegetation. *New Journal of Marine and Freshwater Research* 27: 61-70.

TRICHOPTERA, SHREDDERS, STREAMS, LIFE HISTORIES, RIPARIAN VEGETATION, AQUATIC INSECTS, PRODUCTION, DETRITUS, CANTERBURY

The life histories, microdistributions, and annual production of two shredders *Oeconesus maori* (Oeconesidae) and *Pycnocentria forcipata* (Conoesucidae) were investigated in three small streams at Hinewai, Banks Peninsula, New Zealand. The riparian forest at the three sites was dominated by different tree species: mahoe, *Melicytus ramiflorus,* tree fuschsia, *Fuchsia excorticata;* and red beech, *Nothofagus fusca* – each of which had a a distinctive litterfall pattern. Mean annual biomass of detritus (>0.5mm) on the stream bed was high (777-1982 g DW $m^{-2}$) but temporal changes in biomass did not reflect litterfall patterns. *O. maori* was most abundant in pools. Small larvae appeared in late spring and most were in instar 4 and 5 in late autumn and winter. Mean larval densities in the three streams ranged from 90 to 1126 $m^{-2}$. Annual production was greatest in the mahoe-dominated stream. Larvae of *P. forcipata* were most abundant on small falls and among root mats. Its life history was difficult to interpret. Mean larval densities ranged from 59 to 332 $m^{-2}$ and annual production was again highest in the mahoe-dominated stream. We found little evidence for a shredder response in these three streams (i.e. the maximisation of shredder biomass at the time of litter conditioning). A general lack of predictably pulsed litter inputs to streams, and a species-poor shredder fauna make it unlikely that such a response will be found in many New Zealand running waters.

Quinn, J.M.; Williamson, R.B.; Smith, R.K.; Vickers, M.L. (1992): Effects of riparian grazing and channelisation on streams in Southland, New Zealand. 2. Benthic invertebrates. *New Zealand Journal of Marine and Freshwater Research* 26:259-273.

AGRICULTURE, RIPARIAN PROTECTION, GRAZING, CHANNELISATION, STREAM TEMPERATURE, SOUTHLAND

A survey of benthic invertebrate faunas in riparian-protected, riparian-grazed, and channelised reaches of 5 Southland streams with catchment sizes of 3-37 $km^2$ was carried out. It was part of a wider investigation to assess the effects of riparian grazing and channelisation on stream habitat and biota. In small streams (catchment areas 3-10 $km^2$; width 14 m), channelisation or intensive grazing by cattle greatly reduced shading by riparian vegetation, resulting in substantial increases in daily maximum temperatures during summer. Channelisation also caused gross changes in channel morphology and intensive grazing of a reach with moist streamside soils was associated with increased bed sediment and bank damage. Marked changes in invertebrate communities were associated with these habitat modifications. In general, taxa favoured by cool water and low periphyton abundance (e.g. Plecoptera, *Palaleptamphopus caeruleus, Deleatidium* sp. and *Heliopsyche* albescens) decreased in density, whereas densities of taxa favoured by an abundance of periphyton (e.g. Chironomidae and *Oxyethira albiceps)* increased. In contrast, differences in physical habitat and invertebrate commun-ities were minor between paired grazed and riparian-protected reaches of the larger streams (catchment areas 10-33 $km^2$; median widths 6-16 m) where grazing had little or no effect on stream shading. These results indicate that in small streams, with median natural channel widths below c. 6 m, the effects on benthic invertebrates decrease in the following order: channelisation > intensive grazing by cattle > extensive grazing by cattle and/or sheep. Shade provided by riparian vegetation appears to play a vital role in maintaining cool, headwater, stream habitats for benthic invertebrate communities in these streams.

Rounick, J.S.; Winterbourn, M.J. (1982): Benthic faunas of forested streams and suggestions for their management. *New Zealand Journal of Ecology 5: 140-149.*

MANAGEMENT

The influence of physical factors and forest type on the distribution of benthic invertebrates in 43 New Zealand streams was investigated using a systematic survey technique. A small nucleus of common taxa was numerically dominant at most sites regardless of forest type. The mayfly *Deleatidium* was found at 42 of the sites and was the most abundant taxon at 27. Other widely distributed genera were *Nesameletus, Coloburiscus* (Ephemeroptera), *Stenoperla, Zelandoperla, Zelandobius* (Plecoptera), *Olinga,* and *Hydrobiosis* (Trichoptera). Numbers of invertebrate taxa and relative abundance of shredders (large particle detritivores) were not correlated with stream gradient but were correlated significantly with stream stability. Implications of these findings for stream management are discussed, and it is suggested that combined physical-faunal surveys of the kind used in this study have the potential to identify streams which may require particular protection. (…In New Zealand where direct forest vegetation stream invertebrate linkages appear to be weak, it is probable that buffer strips are primarily of value as "policemen" limiting direct sediment introduction and protecting stream banks from logging-induced erosion.)

## 4. FISH

Glova, G.; Sagar, P. (1990): Riparian willows - are they important to fish? *Freshwater Catch* 42: 8.

WILLOWS

(... In respect to the distribution of fish in relation to willows, brown trout biomass was almost certainly highest in moderately-willowed and lowest in non-willowed sections . . . Small native fish (blue-gilled bully, common bully, inanga) were relatively abundant in non-willowed sections of Shag River, but relatively scarce in sections . . . The non-willowed sections contained mostly small eels (<300 mm total length), whereas the sections supported eels of all sizes.)

Main, M.R.; Lyon, G.L. (1987): Diet and feeding of koaro (*Galaxias brevipennis*) in forested, South Westland streams. *Mauri Ora* 14: 77-86.

GALAXIIDAE, KOARO, DIET, WESTLAND

The diet of koaro (*Galaxias brevipennis* Gunther) from 11 streams in South Westland was investigated. The most abundant prey in guts of summer-feeding fish were larvae of Trichoptera (34.6%), aquatic Diptera (24.6%) and Ephemeroptera (13.8%) whereas in winter, fish consumed ephemeropteran (24.2%) and trichopteran (23.1%) larvae. Prey were taken approximately in proportion to their abundance in the drift and benthos. Terrestrial prey items were present in low numbers in koaro guts, but they dominated gut contents gravimetrically, because of their greater individual weights. Stable carbon isotope analyses of fish tissue ($^{13}$C - 25.0 to -25.5%) confirmed that terrestrial prey were a major source of dietary carbon utilised by koaro in forested streams. In laboratory experiments, koaro selected aquatic prey when in still water, but they fed almost equally on terrestrial and aquatic prey when in running water. This suggests that terrestrial prey may be taken primarily when drift feeding in riffles. (. . . Nevertheless, koaro are less dependent on riparian vegetation to provide a source of food than are banded kokopu, and perhaps as a consequence their habitat requirements and distribution are more diverse).

Main, M.R.; Lyon, G.L. (1988): Contribution of terrestrial prey to the diet of banded kokopu (*Galaxias fasciatus* Gray) (Pisces: Galaxiidae) in South Westland, New Zealand. *Verhandlungen der Internationale Vereinigung fur Theoretische und Angewandte Limnologie* 23: 1785 – 1789.

GALAXIIDAE, BANDED KOKOPU, WESTLAND

The banded kokopu (*Galaxias fasciatus* Gray) is the most abundant of a group of 3 rather similar, large galaxiids endemic to New Zealand. The others are the giant kokopu *(G. argenteus* Gmelin) and the short-jawed kokopu (G. Clarke). Ecology of all species is poorly known. The banded kokopu is quite widely distributed, but it appears to have specialised habitat requirements, resulting in a patchy distribution. Thus, it is absent from some large areas including most of the east coast of the South Island. Banded kokopu appear to be most abundant in native forested streams, where riparian vegetation may provide an important source of prey as it does for the Australian galaxiid *G. olidus.*

McDowall, R.M. (1980): Forest cover over streams is vital to some native freshwater fishes. *Forest & Bird* 215(13:5): 22-24.

GALAXIIDAE

(…Whatever causes it, populations of the banded kokopu the short-jawed kokopu (*Galaxias postvectis*) and the koaro (*Galaxias brevipennis*) are always sparse in streams that do not have a good canopy of forest. It need be only a forest of secondary regrowth – wineberry, five-finger, and the like -but it seems that these species prefer forested streams.)

Mitchell, C.P. (1990): Whitebait spawning grounds in the Bay of Plenty. New Zealand Freshwater Fisheries Miscellaneous Report No. 40, Freshwater Fisheries Centre, MAF Fisheries, Rotorua.

GALAXIIDAE, WHITEBAIT, SPAWNING, BAY OF PLENTY

Known whitebait spawning grounds should he fenced off from grazing stock, or retired from grazing during the main whitebait spawning period. Research should be undertaken into methods for optimising whitebait egg survival by management and manipulation of riparian vegetation. To pursue these concepts, the spawning ground on the left bank of the Kaituna River has been selected as an experimental area. It was fenced off in autumn 1989, and the density and survival of eggs inside and outside the enclosure is being monitored. Long-term monitoring will be required to follow changes in spawning site selection as the vegetation alters, now that it is no longer grazed. At present, the fish have shown a strong preference for spawning within the fenced off area.

Mitchell, C.P. (1990): Whitebait spawning grounds in the lower Waikato River. New Zealand Freshwater Fisheries Miscellaneous Report No. 42, Freshwater Fisheries Centre, MAF Fisheries, Rotorua.

GALAXIIDAE, WHITEBAIT, SPAWNING, WAIKATO

Immediate steps should be taken to protect known whitebait spawning grounds from further grazing, by fencing and agreement with the adjacent landowner. Former spawning grounds should be restored. These areas should be fenced and replanted with appropriate vegetation. Further investigations into spawning areas are required. In particular, the area from the Elbow up to Mercer should be explored. The Aka Aka system should be resurveyed to identify spawning grounds.

Mitchell, C.P (1991): Whitebait spawning ground management: interim report. New Freshwater Fisheries Report No. 131, Freshwater Fisheries Centre, MAF Fisheries, Rotorua.

GALAXIIDAE, WHITEBAIT, SPAWNING, BAY OF PLENTY

A whitebait spawning ground on the Kaituna River, Bay of Plenty, was fenced off from livestock in April 1989. A year was allowed for vegetation regrowth the preference of spawning inanga (*Galaxias maculatus*) was assessed. One year after fencing, the survival of 3 cohorts of eggs, laid at monthly intervals, was followed through development until hatching. Survival of eggs, within and outside the enclosure, was compared. No major changes in plant composition had occurred after a year, but the vegetation was denser and the abundance of some native plants had increased within the enclosure. It was found that inanga preferred to lay their eggs within the enclosure: in these areas, eggs were found within centimetres of previous month's and year's spawnings. Survival of inanga eggs was greatest inside the enclosure. From spawning until hatching there was no significant change in egg density for the March, April or May 1990 cohorts. Implants of artificially-spawned eggs were used to compare survival within and outside the enclosure. Egg survival outside the enclosure was low. Poor survival of eggs in grazed pasture could be due to desiccation, greater temperature fluctuations, or to predation. The use of 1 $mm^2$ mesh nylon netting coven increased survival over 1 month from 0.7% to 54%. These interim results suggest that fencing whitebait spawning grounds is needed to define: (i) the effects of plant succession on spawning preference and egg survival, after cessation of grazing; (ii) the role of predators and other factors in egg mortality.

Taylor, M.J.; Buckland, A.R.; Kelly, G.R. (1992): South Island inanga spawning surveys 1988-90. New Zealand Freshwater Fisheries Report No. 133, Freshwater Fisheries, MAF Fisheries, Christchurch.

GALAXIIDAE, WHITEBAIT, INANGA

Surveys for inanga (*Galaxias maculatus*) spawning sites in South Island waterways commenced in 1988. Spawning sites were found in 19 catchments, 10 in Wetland, 6 in Canterbury, and 3 in Nelson. Most surveys by MAF Fisheries ceased in 1990, although further surveys have been carried out by the Department of Conservation. This collates data available up to the end of the 1991 spawning season. Spawning zones normally were located in dense bankside vegetation along watercourses, near the upstream limit of the spring tide saltwater intrusion. In modified catchments, inanga eggs usually were found amongst the mass of roots, stems, leaves, and root runners at the bases of introduced grasses. Eggs found in relatively unmodified native vegetation were located in moist leaf litter, trapped and shaded by flaxes, native tussocks, and the bush subcanopy. Spawning usually commenced approximately 40 minutes after high water, on ebbing spring tides, and persisted for nearly 40 minutes. In this study, inanga spawned about 3 days after the full moon, although spawning on full moon tides also has been recorded in other studies. Spawning site habitats were found to be vulnerable to damage by stock, channelisation, pollution, and a reduction in bank vegetation. It is also suspected, proven, that the operation of flood control gates may be detrimental to egg survival. Most spawning areas were already suffering from the adverse effects of some of these impacts, to various degrees, and immediate conservation measures had to be, and were taken to minimise their effect. Unfortunately, many sites are still vulnerable, and at least one has been totally destroyed by draglining activities. Recommendations are made on how these impacts can be reduced or eliminated, and the spawning habitat restored.

## 5. BIRDS

Collier, K.J.; Moralee, S.J.; Wakelin, M.D. (1993): Factors affecting the distribution of blue duck *Hymenolaimus malacorhynchos* on New Zealand rivers. *Biological Conservation* 63: 119-126.

BLUE DUCK, STABILITY, BENTHIC INVERTEBRATES, CONSERVATION

Benthic invertebrates and/or physical habitat data were collected along 37 sections of river to help develop criteria for selecting sites for the establishment of new populations of blue duck *Hymenolaimus malacorhynchos*. Sections of river where blue duck pairs were present had significantly greater stability (range of Pfankuch scores = 61-103), channel gradient (>12 $m.km^{-1}$) and elevation (82-1050 m a.s.l.), narrower widths (8-60 m), coarser bed substrata (particularly more boulders), and more native riparian forest (>50% of vegetation on average) than where blue duck were absent. Abundance and taxonomic richness of the invertebrate faunas (major foods of blue duck) were not significantly different between sections with and without birds, but invertebrate faunas of sections where blue duck pairs were present had significantly greater proportions of stoneflies, more stonefly taxa and lower proportions of dipteran larvae. Density of blue duck at the time of the survey was significantly correlated with physical stability of the river such that more stable sections had more pairs per kilometre. Physical stability, channel gradient, and the composition of riparian vegetation and substrata are recommended as useful criteria for selecting sections of river for the establishment of new populations of blue duck in the future.

## 6. EXOTIC FORESTRY

Bawden, R.; Wood, T. (1992): Riparian strips: the forestry perspective. Riparian Zone Workshop (12 March 1992), 7.

Collier, K.J. (1989): Downstream impacts of pakihi development. Science and Research Internal Report No. 42, Department of Conservation, Wellington, 17 pages.

PAKIHI, WESTLAND,

Pakihi are isolated areas of mostly flat or gently sloping land where saturated and infertile soils support predominantly sedges, ferns, rushes, mosses and sometimes manuka. Recently, about half the exotic tree plantings in have been on pakihi which has been drained by v-blading. In recently v-bladed catchments, peak stream flows (>10 $l.s^{-1}.ha^{-1}$) can be 3 times more frequent and sediment transport almost 2 orders of magnitude higher than in undeveloped pakihi catchments. These can cause downstream sedimentation and channel erosion whereas vegetation clearance typically results in substantial increases in water temperature which may detrimentally affect aquatic life. Where undisturbed native forest is present immediately downstream, the effects of v-blading are likely to be most severe in the first kilometre of stream channel and for the first two years following development. Areas of undisturbed pakihi vegetation alongside the main drainage channel and at the heads of catchments could reduce the scale of impacts by detaining accelerated runoff and sediments, keeping water temperatures down and providing habitat for aquatic life.

Collier, K.; Simons, M.; Simpson, P.; Waugh, J. (1992): Riparian zones and production forestry - a DOC perspective. Riparian Zone Workshop (12 March 1992), 34-41.

RIPARIAN ZONES, CONSERVATION VALUES

The importance of riparian zones as the interface between land and water has long been overlooked and undervalued even though it has been recognised in the legislation throughout New Zealand land management history. DOC has statutory responsibility to manage and advocate for the conservation of natural and historic resources, and we see management of riparian strips as a key element in carrying out DOC's mission. The Department is concerned over potential effects of forestry production on terrestrial and aquatic values including loss of archaeological sites, reduction in recreational and Maori values, and damage to the habitat of native plants and animals. We are concerned also with the generally low quality of riparian zones in agricultural areas. Wise riparian management offers great potential for habitat protection and restoration (e.g., linking forest remnants and establishing new forests), and for the enhancement of both terrestrial and aquatic conservation values in a common zone.

Cooper, A.B. (1992): Riparian zone management -applying the scientific method. Riparian Zone Workshop (12 March 1992), 46-48.

Cowie, B. (1983): The impacts of forestry upon stream fauna. In: *Biological monitoring in freshwaters:* proceedings of a seminar. Water and Soil miscellaneous Publication 83. (Eds: Pridmore, R.D.; Cooper, A.B.) Water and Soil Directorate, Ministry of Works and Development for the National Water and Soil Conservation Authority, Wellington, 217-223.

Forestry operations such as roading, logging and burning can have major impacts upon stream environments. These impacts include changes in the hydrological regime (higher base flows, "flashier" flood peaks), changes in water temperatures, changes from an allochthonous to an autochthonous energy b e, an increase in debris in the stream, and, perhaps most significantly, sedimentation. Excess sediment fills the interstitial spaces between stones and in doing so changes both the abundance and specific composition of the invertebrate community as well as smothering fish redds and eggs. There is some evidence that in New Zealand these changes are relatively greater in stable than in unstable streams. In any given catchment the logging practices adopted are a major factor in determining impacts upon the stream environment. Leaving riparian strips alongside streams is a simple means of helping to limit such impacts. In New Zealand most catchments are logged using tracked bulldozers; this requires roads to be built around catchment contours and unless these are carefully they can lead to excess sediment entering streams. Other practices such as root raking and burning can also affect the stream biota. One critical factor that cannot be controlled is the occurrence of storm events; most sediment enters streams following large storms and no matter how carefully logging is carried out, such events are still likely to have major impacts upon streams.

Evans, D. (1992): Riparian zones - a company perspective. Riparian Zone Workshop (12 March 1992), 24-25.

Gilliam, J.W.; Schipper, L.A.; Beets, P.N.; McConchie, M. (1992): Riparian buffers in New Zealand forestry. *New Zealand Forestry* August 1992, 21-25.

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 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 research is required in order to answer questions that foresters and regulators posed.

Hardie, E. (1992): Catching the bullet with a fishing net. Riparian Zone Workshop (12 March 1992), 8-11.

McNeil, J. (1992): Planning for effects in the absence of complete information: an approach for riparian strips. Riparian Zone Workshop (12 March 1992), 26-28.

Murphy, G.; Murphy, G.E. (1992): The impacts of riparian zone management on forest harvesting. Riparian Zone Workshop (12 March 1992), 42-45.

Olsen, P.F. (1992): Riparian zones. Riparian Zone Workshop (12 March 1992), 12-17.

As forest managers, we would not support the removal of all controls on land clearing for afforestation. We therefore give qualified support to the principal of riparian strips, especially on steep land. We do not agree with having to keep 20 metres back from waterways which gentle pasture land. Control of felling is relatively easy to practice under these conditions and there can be minimal effects caused to waterways by logging. There is justification to vary strip width under certain circumstances. We are concerned that riparian strips and their larger reserve extension could come to be regarded as total protection areas and harvesting to the point where it becomes uneconomic. Foresters must retain options to make use of land contained within the strips, if necessary. We are aware that forestry has a high visual impact and for this reason, it attracts more than its deserved share of attention from the public and officialdom. Constraints placed on forestry operations, including requirements for reserves and riparian strips, are not commensurate with those applied to other land uses. This is probably because forestry is a much easier target for regional authorities and conservationists than, say, farming. However, these views do not necessarily imply that more controls should be applied to the way land is used for farming. Reasons behind the requirement for each strip should be well defined. It should not be sufficient to merely continue with practices just because they have happened for years or because they are required by law. What functions are served by riparian strips? At the commencement of second and subsequent rotations, existing riparian strips should be examined to determine whether their retention is necessary, desirable or convenient.

Sutton, G.; Ngapo, N. (1992): Riparian protection areas. Riparian Zone Workshop (12 March 1992), 29-33.

We are able to minimise adverse impacts of forestry in three main ways: control earthmoving operations so that their impact is minimal/negligible; use riparian protection areas to lessen the risk of potential problems; control the amount of clearfell logging in critical catchments within any 5 year period. The use of riparian protection areas is a vital management practice within the Bay of Plenty.

Tozer, C. (1992): Exotic plantation forestry – Nelson/Marlborough. Riparian Zone Workshop (12 March 1992), 18-23.

NELSON/MARLBOROUGH

Council requires the most up to date information on riparian zone management and protection in order to fulfil its statutory functions. Its

Transitional Regional Plan is currently under review with input from the forestry industry and other interest groups. Any new research data will be helpful in assessing resource issues and formulating policy options. A schedule of Council staff and questions concerning riparian zone protection is attached. It is hoped this will indicate what information gaps may exist. A series of slides portraying special aspects of riparian zone management in the Nelson/Marlborough are shown.

Winterbourn, M.J. (1986): Forestry practices and stream communities with particular reference to New Zealand. In: *Stream protection: The management* of *rivers for instream uses.* (Ed: Campbell, I.C.) Water Studies Centre, Chisholm Institute of Technology, 249.

BENTHIC INVERTEBRATES, WESTLAND

The effects forestry operations can have on the environment and biota of streams are outlined briefly and their relative importance in New Zealand are discussed. In particular, ongoing research in the Maimai experimental area, north Westland, is described. Species composition of the benthos in streams draining small Maimai catchments has been little affected by clearfelling, burning or replanting with exotics whether a riparian strip of forest vegetation has been retained or not. Standing crops of benthic algae in the 6-9 years since logging generally were not elevated in streams which were opened up by the removal of riparian vegetation. However, a shift towards greater use of autochthonous (cf. allochthonous) carbon by benthic invertebrates was detected in these streams. Evidence available to date indicates that in New where rivers generally are short, fast-flowing and subject to frequent floods, increases in algal and secondary production and sedimentation problems are likely to he localised, short-term phenomena. Nevertheless, buffer strips should be left whenever possible so as to maintain the integrity of the stream environment.

## 7. MANAGEMENT

Ackroyd, P. (1989): Marginal strips and riparian land management. (Unpublished report for the Ministry for the Environment). Centre for Resource Management, Lincoln University, Christchurch. 12 pages.

> The history of marginal strips makes it difficult to accept the view that marginal strips are sacrosanct and that the rights of the public and the Crown should be protected at all costs. Marginal strips were designed to deal with historical circumstances that are of no relevance today. Current management objectives for riparian land will be difficult to achieve given that marginal strips are to be used for purposes for which they were not intended, and that there may well be merit in alternative arrangements to Crown ownership of riparian land. Mechanisms exist within the existing legislation to overcome these difficulties. The Minister of Conservation has the discretion to decide whether the objectives of reasonable and practical public access to the adjacent water and the desirability of conservation objectives, necessitate the retention of marginal strips in public (i.e. Crown) ownership. Exercise of this discretion can allow riparian land to be made available for management under alternative arrangements and any revenue so raised could address better the legislative objectives of public access, public amenity, protection for the environment, and conservation advocacy. A mixture of private and communal ownership of marginal strips should be encouraged because this would provide a measure of the value placed by the public on such land and would thereby assist in determining the extent to taxpayers and ratepayers should contribute to such reserves. Providing for a greater degree of protection for areas adjacent to water may well require a different mix of state ownership, communal ownership, and private ownership than at present.

Dungey, R. (1990): Management of riparian margins with particular reference to the lower Clutha. *Freshwater Catch* 42: 3-5.

> OTAGO

Green, W.R.; McPherson, B.R.; Scott, D. (n.d.): Vegetation and aspects of river management. N.W.P.C. Technical Publication No. 7 (Compiled for the National Water Protection Committee of New Zealand Acclimatisation Societies).

Hicks, B.J.; Howard-Williams, C. (1990): Development of guidelines for the manage-ment of streamside riparian strips. New Zealand Freshwater Fisheries Miscellaneous Report No. 59, Freshwater Fisheries Centre, Rotorua. 22 pages.

> 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, p.41-49). 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 width and 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 optimum function of stream ecosystems. However, it would he 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 he 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.

Maturin, S. (1985): The impact of grazing in riparian strips. *The Landscape* Autumn 1985, 27-29.

GRAZING, SOUTHLAND

The science of agriculture is directed to achieving increased production and attention has been paid to developing appropriate management systems for riparian areas. Indeed, land managers, planners and users have not identified riparian strips as areas requiring specialised management. That grazing in riparian strips can cause severe damage to the ecosystem should not by disputed. Obviously, not all streams and rivers require protected riparian strips. However, there is an urgent need to identify those that do and to design suitable protection systems. Crying for more research while lamenting the continued degradation of wetlands is hypocritical.

Moody, T.J. (1980): The significance of the riparian zone in forest land management. Diploma in Natural Resources Thesis, Lincoln College. 32 p.

Selective management of the riparian zone in forested catchments is meaningless where manipulation of water yield and peak flows from upper catchments is being considered. Forest vegetation adjacent to a channel does play a major role in stream dynamics and sediment movement, regulating the removal of sediment supplied to the stream and contributing to channel and bank stability. The ability of riparian vegetation to regulate sediment movement is greatest for small mountain streams, but its role in maintaining bank stability remains important in downstream areas. Selective management of the riparian zone is, in this situation, a viable proposition, but will be significant where downstream bank instability and erosion is threatening productive land. In production forestry, buffer strips reduce markedly the disturbance to the stream environment by excluding the stream from logging. They can also be useful in minimising sediment and nutrient inputs into the stream, although for the latter, the magnitude of the difference may be negligible. But, accepting that provision of a buffer strip will reduce disruption of the stream and may reduce sediment inputs, the situations in New Zealand when they will have significant effects are largely unknown. More research must be done into the long-term effects of logging on freshwater fisheries, both in the upper catchment and downstream, and into situations in which buffer strips ere effective in minimising the introduction of sediments. Identification of some indicators by which foresters can estimate the benefits of strips is necessary before the Soil and Water Management Guidelines can be applied in any meaningful sense.

Murphy, G. (1992): Riparian zone management: a review of the literature. (Prepared for the Bay of Plenty Regional Council).

At the request of the Bay of Plenty Regional Council, a review of the post 1970, English-language literature relating to riparian zone management in temperate countries was carried out. The results of the review are collated in 3 parts: Part A summarises the literature, Pan B provides an annotated bibliography, Part C contains copies of some of the key references. The review identified that the main objectives for managing riparian zones were to protect the natural values of clean water for Maori, to provide a recreation resource, to provide an aesthetic resource, to provide habitat for terrestrial wildlife, to maintain site productivity, to maintain biodiversity of represent-tative vegetation types, to improve or maintain water quality, and to maintain aquatic wildlife and freshwater fisheries habitat. The characteristics of riparian zones to be managed were noted to be width of the zone, length either side of the stream, vegetation required, and activities permitted in the zone. Many of the costs of managing riparian zones would occur within the zones whereas benefits would occur in-stream (adjacent to the riparian zone, upstream and downstream), within the riparian zone itself, on land adjacent to the zone, and elsewhere. Benefits were also expected to span a large timeframe. Some benefits would occur immediately and only last for a few days. Others would take years before the benefits could be realised. Some benefits would accrue to future generations of New Zealanders. The responsibility for managing riparian zones will depend on the particular phase of management being carried out -planning, resourcing, implement-tation or monitoring. In general, local authorities would be likely to be involved in the planning and monitoring stages, land-owners, ratepayers and central government in the resourcing stage, and predominantly land-owners in the implementation stage. The steps to go through for managing riparian zones include identifying management objectives, identifying critical areas to meet objectives, developing best management practices, developing a know-ledge base, preparing guidelines, implementing actions to meet the objectives, and monitoring the on-going results. Throughout the text a number of areas where knowledge is thin and future research is required were noted.

Otago Acclimatisation Society; Otago Catchment Board (n.d.). Riparian management - a brief guide to streamside management and revegetation (Pamphlet).

Rich, J.W. (1991): Management strategies for the riparian zones of the Manganuiateo River. Master of Applied Science Thesis, Lincoln University. 132 p.

WANGANUI

The Manganuiateao River is the last unmodified river in the central North Island, and is protected against development by a Water Conservation Order. As a result of the Department of Conservation's concern for the apparent deterioration of Manganuiateao River riparian zone vegetation, this thesis presents a basis for riparian zone manage-ment. The research is composed of two studies; a riparian zone grazing exclusion study and an examination of the meanings managers ascribe to Manganuiateao River. The grazing exclusion study has two objectives. The first objective is to illustrate the change to native vegetation once stock is excluded. The second objective is to predict a 10 year scenario for indigenous riparian zone vegetation once stock is excluded. Results illustrate that after months of stock exclusion many new tree seedlings appear in the ground cover, and many existing species increase in number. It is predicted that a longer period of stock exclusion from riparian grazing will benefit both mature and re-establish-ing native riparian zone vegetation. The second study uses a naturalistic research to focus on the managers themselves, exploring the meaning ascribed to the Manganuiateao River. Meanings are determined by the ways in which managers interact with the river. Results indicate that conservation is a common management theme for both the formal managers (Department of Conservation, Ruapehu District Council) and the informal managers (e.g. adjacent landowners, Rotary Club). Interaction between management groups is also important for the continuing conservation of the Manga-nuiateao River. The management strategies presented focus on determining a suitable agricultural and recreational capacity for riparian zone vegetation. The grazing exclusion experiment illustrates that agriculture has caused considerable damage to indigenous riparian vegetation. Agricultural activity on riparian zones, therefore, needs to he curtailed, particularly on riparian zones clothed in native forest, unmodified except for changes caused through domestic stock grazing. It is possible, however, to continue grazing on the more heavily modified riparian zones. More information will be required on the user needs and wants to successfully determine recreational carrying capacity. To allow for an increase in the number of visitors to the river, while at the same time providing a "wilderness experience", management should increase the river's physical carrying capacity. This can be expanded by providing more interpretation and guiding the visitor to areas where carrying capacity is greater. Visitors' perceptions of crowding should also he evaluated by the managers as an aid to maintaining the wilderness environment.

Smith, C.M. (1993): Perceived riverine problems in New Zealand: impediments to environmentally sound riparian zone management, and the information needs of managers. Water Quality Centre Publication No. 24, Water Quality Centre, N.I.W.A.R., Hamilton. 44 pages.

The Resource Management Act 1991 explicitly addresses land-water ecotones. Their intrinsic values are a matter of national importance (section 6). Also, the Act recognises that land-water ecotones affect and may protect aquatic ecosystems from adverse effects of land activities (section 229) but requires that riparian management controls be directed toward meeting specified objectives, be justified and defensible (section 32). Given this legal framework, ready access to technical information on land-water ecotones is important for resource managers. Where gaps exist, research is necessary. In June 1992, the opinions of staff within Local Authorities, the Department of Conservation, and Fish and Game Councils were sought on the extent and severity of riverine problems in New Zealand the effect of present land use activities on our rivers, the performance of regulatory authorities, and their information needs to better manage riverine riparian zones for the protection of our rivers. Qualitative information sought by the questionnaire will assist in focusing and future research initiatives, and is seen by Ecosystems Division, NIWAR, and DOC a prerequisite to the development of riparian guidelines. Responses will influence the scope and contents of riparian management documents that the Division and/or DOC prepare (possibly in collaboration with other organisations). One hundred and ten questionnaires were sent out. The replies from 46 respondents are summarised in this report. An additional questionnaire soliciting information from each Local Authority and Department of Conservation Conservancy Office on existing riparian retirement and management schemes elicited replies from 3 Regional Councils. A summary of this information is also presented. In the opinion of respondents, there are diverse and extensive riverine problems. Present rural land uses have caused or contributed to many of these problems. Pastoral farming has the most damaging effects on our waterways. Our estuarine, lake and wetland margins have also been extensively modified by human activities. It is recognised that land-water ecotones fulfil a vital function within the landscape and that, if protected or managed correctly, they can moderate the effects of intensive land use on our freshwaters. Whilst acknowledging that riparian ecotones have intrinsic values, many respondents did not demonstrate a thorough understanding of riparian attributes essential for native flora and fauna. Such an appreciation is necessary amongst resource managers if habitats for valued species are to be preserved or enhanced. Technical, legal, political and social impediments to the adoption of ecologically sound riparian management practices exist. There is a perceived inability to scientifically substantiate the need for and benefits that will accrue from specific riparian land use controls. To some measure, this impediment can be dealt with by the provision of management documents. The majority of respondents requested that of an applied nature be made more available (e.g. design criteria for riparian schemes to meet specific purposes). A sizeable group also expressed a need for information of a fundamental nature on the structure of ecotones, and of the underlying linkages and dependencies between riverine ecotones and their terrestrial and aquatic ecosystems. This would ensure that management decisions and schemes are well founded. There is a need to develop, and advocate for the adoption of a holistic management approach for New Zealand's riverine riparian zones. Non-technical impediments to the adoption of best riparian options need to be addressed by the regulatory authorities. The resolution of many of these issues requires a change in public attitudes.

Tanner, C.C. (1992): A review of cattle grazing effects on lake margin vegetation with observations from dune lakes in Northland, New Zealand. *New Zealand Natural Sciences* 19:1-14.

GRAZING EFFECTS, AQUATIC PLANTS, NATIVE VEGETATION, ENDANGERED PLANTS, *HYDATELLA INCONSPICUA,* LAKE MANAGEMENT, WILDLIFE MANAGEMENT, DUNE LAKES, NORTHLAND

Lake margin vegetation has become increasingly valued as a habitat for wildlife and as a moderator of sediment and nutrient inputs from surrounding catchments. This has encouraged action to exclude livestock from lake shorelines. Cattle grazing effects arc reviewed in relation lo natural grazing of lake margin vegetation. Direct consumption and trampling of plant biomass by livestock affects the structure, diversity, productivity, succession and nutrient dynamics of plant communities. In addition, livestock grazing may affect lake marginal vegetation and water quality by pugging and erosion of lakeshores, nutrient addition, bacterial contamination and promotion of weed invasion. Agricultural modification of surrounding catchments also causes many indirect effects such as nutrient runoff and changed hydrological regimes. However, low levels of grazing can result in beneficial changes in lake margin vegetation by reducing domination by tall rank species and increasing plant and habitat diversity. Observations of cattle grazing impacts on the lake margin vegetation of Northland dune lakes showed a graded range of effects dependent largely on grazing pressure. Ungrazed, agriculturally undeveloped shorelines were characterised by *Leptospermum scoparium* growing to the wetted margin, grading into an inshore zone of mixed sedges (*Baumea juncea, B. huttonii, Leptocarpus similis,* and *Eleocharis acuta)* to 0.3-0.8 m depth, an outer sedge zone of *Eleocharis sphacelata* to 1-2 m depth, then a sharp boundary into fully submerged communities of charophytes and *Potamogeton* spp. in deeper water. At sites subject to heavy grazing pressure inshore sedge communities were absent, leaving only a remnant outer zone of emergent *E. sphacelata* in water too deep to graze. Sites with light to moderate grazing pressure were associated with more open inshore sedge zones showing an increased diversity and abundance of short shallow-water species including *Myriophyllum, Potamogeton, Lilaeopsis, Juncus* and *Triglochin* spp., and in some areas the endangered species *Hydatella inconspicua.* It is concluded that although heavy grazing of lakeshores is clearly detrimental to marginal vegetation, low levels of grazing may be an appropriate management tool in areas of some lakes to promote more diverse inshore habitats for plants and wildlife.

Taranaki Regional Council (1992): Management of riparian margins in Taranaki - a discussion document. Taranaki Regional Council, Stratford.

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The potential benefits of riparian management are multiple, and include a) potential water quality benefits via control of the entry of diffuse contaminants from overland run-off; b) real water quality benefits via provision of shade to the waterway which reduces peak water temperature and water temperature fluctuations (this is a particular problem in the Taranaki ring plain area); c) minimisation of streambank erosion and the sub-sequent release of sediment to the waterway; d) reduction of the impact of flooding; e) enhancement and maintenance of suitable habitat for aquatic and terrestrial flora and fauna; f) improvements to aesthetic values of river environments for recreational users; g) potential financial benefits in the form of shelter and timber; and h) improvements to farm management. These outcomes are consistent with the objectives of sustainable management of physical and natural resources, which the Taranaki Regional Council is required by legislation to promote. Council believes that the numerous benefits to the community that riparian management can offer justifies the adoption of a pro-active approach to the matter. The key questions are what level of urgency should be afforded to the programme, what is expected of the Regional Council in carrying out riparian management, and how should the council fund the costs of the programme. The Council believes that it is appropriate to adopt a relatively long timeframe (in the order of 20-25 years) for implementation of riparian management. This is similar to the timeframe that has been involved in the promotion of control of point sources of pollution in Taranaki. Council also believes that the project will have the greatest chance of success if it is promoted in an environment of co-operation and

voluntary acceptance rather than enforcement and regulation. The preferred strategy for implementation is a mix of a) education and advocacy; and b) establishment of joint venture agreements between landowners and interested community groups to target specific catchments and coastal strips. The most appropriate roles for the Council is considered to be as structure, direction and support to the project. This will be achieved in the initial 2 years of the project by allocating staff resources of one person for half-time to the tasks of producing educational and promotional material, and to establishment of 2 or 3 pilot catchment riparian joint venture schemes. The need for additional resources will be reviewed as demand for Council's services to assist with riparian management grows over time.

Taranaki Regional Council (1992): Discussion document - riparian management is key to water quality. *Recount* (September).

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Ward, J.C. (1986): The impact of land development on lakes. *New Zealand Agricultural Science* 20(2): 119-122.

LAKES

The effect of land development on the physical and biological processes in lakes is reviewed and related to water quality. Catchment development contributes to conflicts between multiple uses of land and water, and priority of use needs to be explicitly designated to resolve these conflicts. Examples show the need for consideration of both the catchment and the lake body in development planning. The importance of under-standing the catchment hydrology for lake management is emphasised. (…Most lakes do not receive nutrients uniformly around their margins. Certain areas are more hydrologically active than others and therefore carry more nutrients into the lake through surface and subsurface flows and groundwater. It is important that the hydrology of the lake is understood, so that those areas important for the management of nutrient and sediment inflow can be determined. Management of a 20 m riparian strip around a lake may not be the most efficient way to control nutrient additions to the lake water if, for example, the main movement occurs in only 15% of the land area in one part of the catchment.)

Williams, P.W.; Brickell, D. (1983): Guideline -Riparian Zone Management (Upper Waitemata Harbour Catchment study). Auckland Regional Authority, Auckland.

## 8. GENERAL

Howard-Williams, C. (1991): Dynamic processes in New Zealand land-water ecotones. *New Zealand Journal of Ecology* 15(1): 87-98.

AQUATIC VEGETATION, BENTHIC INVERTEBRATES, FISH, AVIFAUNA, CYCLIC CHANGE, SUCCESSION, INTERACTIONS, WATER MOVEMENT, SEDIMENT MOVEMENT, GROUND-WATER, NITROGEN, PHOSPHORUS, OXYGEN, REDOX

This paper reviews current knowledge of dynamic processes in New Zealand land-water ecotones drawing on published quantitative data wherever possible. Basic ecosystem processes in forested and natural unforested land-water ecotones are compared, and dynamic processes are discussed under the following headings: time scales of change; water movement; sediment trapping and transport; dissolved nutrient dynamics; dissolved oxygen; trophic interactions. Environmental "resetting" agents such as floods, fires and storms have been shown to be important regulators of change at the land-water interface. However, an element of stability is imparted by continuous allochthonous input from evergreen vegetation into the water at the interface, as well as an important contribution from terrestrial insects. Stable isotope studies have shown that such inputs are translated as a carbon source through aquatic food chains in some New Zealand streams. Dynamics of sediment movement and nutrients are governed by the complex patterns of water movement along the ecotone. Patterns of water movement at this interface are controlled by obstructions to flow providing eddies and "dead zones". Manning's coefficient of drag is a convenient measure of the degree of obstruction by aquatic vegetation, fallen branches etc. Nutrient dynamics along the land-water interface of lakes and streams are affected not only in moving surface water, but also in groundwater. New Zealand studies have, in recent years, concentrated on nitrogen pathways in ground waters at the interface where denitrification is shown to be an important N sink. This is controlled by dissolved oxygen and prevailing redox conditions. Implications for management of New Zealand land-water ecotones where ecosystem dynamics are governed by periodic physical disruptions such as floods, fires or dry-wet cycles are discussed.

Latta, I.K. (1974): Some effects of willows (*Salix fragilis*) on New Zealand streams and their faunas. M.Sc Thesis, University of Otago.

WILLOWS

Nicholls, M. (1989): Riparian protection, enhancement and restoration in New Zealand: the New Zealand experience. Paper presented to "River Landscapes" conference, 17 September 1989.