Informal literature review of papers potentially relevant to riparian setback distance August 2019

The first part of the list is an assessment of all the papers supplied by Forest and Bird and Fish and Game with their submissions on the NES.
The second selection are from various forestry sources. Many can be found on the Eastland Wood Council's website http://eastlandwood.co.nz/reports-and-submissions/. The remainder I can provide the full reports as pdf.

MCI is a preferred parameter for measuring effects and the subject of some discussion at MfE/LAWF et al, re the water quality parameters for the NPS-FM, the NOF etc. A number of the papers below assess fish presence, absence and species composition.

Robin Black's electric fishing surveys of the forests that Hancock's manage in Northland, Waikato, Bay of Plenty, inland Wanganui, and Nelson/ Marlborough is the final table. Robin started his observations in these forests in the mid 1990s, so he has a reasonably long record.

Column 3 coded green = Relevance to woody debris in streams affecting native fish habitat
Column 1 coded brown = relevant to riparian distance and sediment discharge

Papers supplied by F&B and F&G in their submissions	**Place/date**	**Relevance to woody debris in streams affecting native fish habitat**
Paper title		
A review of the efficiency of buffer strips for the maintenance and enhancement of riparian ecosystems	Ontario 2004	Not. Agriculture
A review of the scientific literature on riparian buffer width extent and vegetation	Georgia 1999	Not particularly. Assessing buffer widths for temperature control, inputs of large woody veg (aquatic ecosystem), and providing ecosystem for diverse terrestrial riparian wildlife communities (north American mammalian)
Composition and flight periodicity of adult caddisflies in New Zealand hill-country catchments of contrasting land use	Waikato 2010	Not particularly. MCI. More about refining a collection technique for assessing presence and range of trichoptera. No clear conclusion on presence/abundance. Not clear what the dominant vegetation type is.
Composition and temporal changes in macro invertebrate communities of intermittent streams in Hawke's bay New Zealand	Hawkes Bay 2010	Not directly. MCI Comparing species richness for headwater intermittent and perennial streams. No mention of surrounding vegetation type.
Conserving macroinvertebrate	Victoria	Not.

diversity in headwater streams -The importance of knowing the relative contributions of alpha and beta diversity	2010	MCI. Assessment of species diversity, but not in relation to vegetation cover.
Defining macroinvertebrate assemblage types of headwater streams	Finland 2003	Not. MCI in boreal streams
Effects of riparian buffers on nitrate concentrations in watershed discharges	Croplands Chesapeake Bay 2011	Not.
Factors influencing the distribution of kokopu and koaro	Mid South island	Yes Native fish. Presence of kokopu and koaro linked to forests not pasture. (but native, not plantation?) From abstract: *Banded Kokopo maintain station in the gentle water of pools and backwaters, usually* ***where there is woody debris*** *or large streambed materials (large cobbles and boulders), which can provide cover. Woody debris and large streambed materials (cobbles and boulders) probably provide protection from the effects of flooding, during which banded kokopu are susceptible to being washed downstream and injured by abrasion. The availability of appropriate microhabitat was the most important factor influencing the distribution of banded kokopu identified in this study. Laboratory observations showed that trout are more aggressive than banded kokopu, and have the potential to influence the kokopu's distribution by competitive interference*
Land use effects on habitat water quality periphyton and benthic invertebrates in Waikato New Zealand hill-country streams	Waikato 2010	Yes. Land use effects on water Q and MCI From abstract: *Differences were greatest between the pasture and native forest streams. Only 1-3% of incident light reached native and pine forest streams whereas 30% reached pasture streams. Pasture streams had 2.2°C higher mean temperature than the native streams, and 5 fold higher nitrate, 30-fold higher algal biomass, and 11-fold higher gross photosynthesis. Native streams were 60% wider than pasture, with pine streams intermediate. Pine and pasture streams had 3-fold higher suspended solids and fine sediment stored in the streambed than native streams. Woody debris volume was 17-fold greater in pine than pasture streams, with native streams intermediate. Invertebrate taxa richness did not differ between land uses. Community composition differed most between pasture and native forest, with pine forest streams intermediate.*
Macroinvertebrate diversity in headwater streams - a review	Victoria 2008	Not. MCI. Assessment of species diversity, but not in relation to vegetation cover.
Managing riparian zones - A	1995	Not

contribution to protecting new Zealand's rivers and streams		A guide for dealing with pasture riparian
Measuring stream macroinvertebrate responses to gradients of vegetation cover When is enough enough?	NZ 2010	Sort of. MCI in various reaches of streams that go through both pasture and native cover From abstract: *Percentage of catchment vegetation in native forest had stronger relationships with measured diversity and condition metrics than segment or reach scale measures of riparian vegetation. Functional feeding group metrics were weakly associated with upstream catchment vegetation cover. Of the macroinvertebrate metrics tested, the RIVPAC O⁄E and an organic pollution tolerance metric based on species presence–absence (MCI) had the strongest relationships with percentage native riparian vegetation, followed by the quantitative MCI and measures of the richness and relative abundance of Ephemeroptera, Plecoptera and Trichoptera faunas. The O⁄E and MCI indicated that catchments with 80–90% in native forest or scrub (low-growing trees) were associated with faunas indicative of ''clean'' water quality.* *Of the biodiversity indices considered Fisher's α Index of species richness had the strongest relationship with percent native riparian vegetation in the upstream catchment. There are no established thresholds for measuring biodiversity loss in New Zealand streams, but this analysis indicates that on average streams draining catchments with 40– 60% upstream native vegetation cover retain 80% of the mean biodiversity present in pristine forest streams.*
Planted riparian buffer zones in New Zealand	Pasture NZ	Not. MCI
Quantitative review of riparian buffer width guidelines from canada and the united states	Canada and US 2003	Not really. Harvesting allowed within the buffer, not clearfell? Not over the stream? Looking at protecting terrestrial biodiversity in North American context. *Our primary objective is to review and analyse the structure and underlying riparian values embodied in forest management guidelines throughout jurisdictions in Canada and the United States. It is not an examination of the how effective these guidelines are in maintaining riparian values; this would require an examination of empirical data on water quality and aquatic and terrestrial habitat, and biota. Instead, this paper focuses on buffer width guidelines as one manifestation of resource management used to maintain riparian values*
Recovery of three New Zealand rural streams as they pass through native forest remnants	Kaipara 1997	Not. Use of native forest remnants along sections of streams to ameliorate effects of pasture use.
Relationships between riparian buffer widths and the effects of logging on	Tasmania 1994	Possibly. Although caveats = eucaluptus, groundbased, with pre-1994 Australian forestry management practices.

stream habitat invertebrate community composition and fish abundance		Logging effects on MCI From abstract: *Logging significantly increased riffle sediment, length of open stream, periphytic algal cover, water temperature and snag volume. Logging also significantly decreased riffle macroinvertebrate abundance, particularly of stoneflies and leptophlebiid mayflies, and brown trout abundance. All effects of logging were dependent on buffer strip width and were not significantly affected by coupe slope, soil erodibility or time (over one to five years) since logging. All impacts of logging were significant only at buffer widths of <30 m. Minimum buffer widths for eliminating logging impacts on stream habitats and biota are discussed.* From conclusion *Finally, width is not the only factor that determines the efficacy of buffers to protect streams from land-use activities. Interception of surface runoff and the degree of impact on the light climate and temperature of a stream are also dictated by buffer vegetation characteristics. This is also a factor in the interception of pesticide drift from forestry spraying operations (Barton and Davies 1993). Care must be taken to preserve the integrity of the buffer as well as its extent and width (Clinnick 1985). Penetration of the buffer during logging operations or inappropriate enhancement of slope drainage may significantly increase the potential for surface water to drain through the buffer unimpeded, thereby increasing the opportunity for sediment input to streams. These factors need more detailed evaluation. Certainly, buffer width and quality are interrelated, but at the coarse scale of the present study, width appears to be a dominant factor.*
Responses of periphyton and insects to experimental manipulation of riparian buffer width along forest streams	Canada 2003	Yes. Caveat = north America, and indicator species = salamanders. *We have shown that a gradient of riparian buffer widths created a gradient in light and temperature that led to non-linear increases in periphyton biomass and insect abundance.* *There is a need for replicated experiments to infer causation in different riparian management approaches and to separate site-specific differences from treatment effects*
Review of information on riparian buffer widths necessary to support sustainable vegetation and meet aquatic functions (002)	Auckland 2000	*The literature review revealed that there was a paucity of research in this area* Mainly aimed at pasture situation Forestry p27 *The amount of sediment lost from a catchment depends on site factors such as slope, soil type, and harvesting operations, but in general, road and landing-area construction are believed to be the major sources of sediments from forests (Boothroyd & Langer 1999). Research with vegetated filter strips and simulated rainfall indicates that buffer widths of less than 10 m are effective at trapping sediment as most of the sediment is trapped in the first 2 m (Fransen 2000).*
Review of riparian buffer zone effectiveness	NZ 2004/5	Mainly about pasture, although: P16 *Quinn et al. (2004) studied the effect of native forest buffers within plantation forestry on stream invertebrate communities in the Coromandel Peninsula, New Zealand. Clearcut reaches had the lowest*

		diversity and taxon richness of 28 stream sites, while sites that had been logged leaving continuous buffers did not differ from those in intact native or mature plantation forest, indicating that buffers greatly reduced disturbance associated with logging. Logging impacts were strongly related to increases in periphyton biomass, water temperature, fine sediment, and channel instability. P17 *The buffer widths of Coromandel forestry sites studied by Quinn et al. 2004) ranged from 8-27m and supported stream invertebrate communities similar to those in native or mature plantation forest* *P25 The key to improving biodiversity in streams and riparian zones is habitat diversity and connectivity. The greatest improvements in habitat diversity are likely to occur when riparian management involves planted trees or remnant forest. Riparian planting effects on stream habitat for aquatic biota include:* *• provision of woody debris as trees fall into streams over the long term, providing habitat diversity and cover for aquatic invertebrates and fish;* *• increased shade and provision of terrestrial food sources (fallen leaves etc.) as riparian plants grow so that levels of instream productivity and trophic pathways resemble the natural state;* *• reduced erosion and inputs of fine sediment from (1) exclusion of livestock, leading to an improvement in streambed and bank habitat and (2) interception of hillslope sediment over the long term, and (3) tree roots that stabilise the stream banks and provide habitat;* *• reduced water temperatures if sufficient lengths of upstream shade exist, and lower air temperatures and humidities, and less wind exposure, in the riparian zone where the adult stages of some aquatic insects spend part of their lives and some native fish lay their eggs (banded kokopu, short-jawed kokopu). The buffer width required to achieve improvements in aquatic biodiversity is uncertain and variable between studies. Few studies have the luxury of experimentally testing mature buffer widths (i.e., with replication and under similar physical conditions), rather it is a case of looking at whatever existing buffers are available.*
Riparian vegetated buffer strips in water-quality restoration and stream management	USA 1993	No. Agriculture
Role of buffer strips in management of waterway pollution - A review	Australia 1994	No. agriculture
Setbacks Castelle Wetland and stream buffer size	USA 1994	Broad bush conceptual. Identifies that variable width is better, but needs more skill to implement.
The need to ground truth 30.5m buffers	Utah 2007	Not really. Indicator species is toad

Tolerances to diurnally varying temperature for three species of adult aquatic insects from New Zealand	NZ 2005	By inference, greater temp variation in unbuffered streams? No direct link
Transition from pasture to native forest land-use along stream continua	NZ 1999	No. Use of native forest remnants along sections of streams to ameliorate effects of pasture use.
Using stream macroinvertebrates to compare riparian land use practices on cattle farms in southwestern wisconsin	USA Pasture 2000	No agriculture
Water quality impact of a dairy cow herd crossing a stream	NZ 2004	No agriculture
Forestry sourced papers		
Stream size influences stream temperature impacts and recovery rates after clearfell logging Quinn	Coromandel NZ 2008	Yes *Our small study streams (<200 ha, <6 m wide channel) tended to have a lag of only 2–3 years after logging was completed before reductions in temperature were observed (Figs. 3–5). Clearcut riparian areas at Whangapoua are most often initially recolonised by adventive weed species that form dense cover but are low growing (<3 m height) (e.g., Fig. 2 sites 49 and W) (Langer et al., 2008). However, where native shrub species in the riparian vegetation had been crushed during harvesting operations, but some stem and root systems remained, it was common for coppice regrowth to be abundant and this often resulted in rapid restoration of native cover (e.g., Fig. 2 sites 29 and OP) (Langer et al., 2008). The species most commonly observed with this regeneration strategy were mahoe, rangiora, karamu and the tree ferns (Langer et al., 2008).*
Pine afforestation and stream health: a comparison of land-use in two soft rock catchments, East Cape, New Zealand	East Coast 2007	Yes *Stream stability had a dominant influence on epilithon biomass and benthic invertebrate communities in our study. There was evidence that these pine plantation streams have greater stability and lower water temperature than the pastoral streams, resulting in improved stream ecological health. However, in large streams, bed instability may occur even under pine afforestation affecting invertebrate communities, and high sediment yields and turbidity are likely to persist where deep-seated geological disturbance has occurred. Furthermore, if pine trees are harvested up to the stream edge we would expect to find increases in water temperature and destabilisation of stream banks, with consequent impacts on water quality and stream health.*
Monitoring water quality in catchments dominated by plantation	2013	Short of data. More representative sites needed.

forestry		*Based on our representativeness analyses (Section 3.2.2, Table 7), up to 11 new monitoring sites are potentially required in five climate/source-of-flow classes which currently lack any sites in forested catchments. A further 10 are required in two classes (CW/H, WW/L) which are currently under-represented. Five classes (most notably CW/L), which are overrepresented by the current network, are not considered further in this report.*
Effects of logging with and without riparian strips on fish species abundance, mean size, and the structure of native fish assemblages in Coromandel, New Zealand, streams	Coromandel NZ 2002	Yes From abstract: *Fish abundance at the logged sites was compared with reference sites in both unlogged pine and native forest. The abundance of Anguilla dieffenbachii (Gray) and Anguilla australis (Richardson) was not significantly affected by logging. However, the abundance of Galaxias fasciatus (Gray) and Gobiomorphus huttoni (Ogilby) was. There were fewer Ga. fasciatus at the logged sites without buffers than at the reference sites, but more at the logged sites with buffers. The abundance of Go. huttoni was higher at the logged sites than at the reference sites, and was highest at the logged sites with riparian buffers. Overall, the different species specific responses to logging maximised total fish numbers at the logged sites. As total fish numbers, the abundance of Ga. fasciatus, and species equitability, a measure of fish assemblage structure, were all highest at the logged sites with riparian buffer strips, we concluded that riparian strips enhanced the native fish community of streams within these logged catchments.* *The size of the riparian zone is also important. Riparian zone continuity for the entire watershed may be more important for fish communities than riparian strips alongside localised stream reaches (Roth et al. 1996). Also, riparian zone length may be more important than width for increasing fish abundance (Jones et al. 1999).*
Impacts of Forest Harvesting on Giant Kokopu, Ngakaroa Stream, Omataroa Forest, Bay of Plenty	NZ 2005	Yes *Although there was no statistically significant difference in the abundance of giant kokopu in the Ngakaroa Stream before or after logging, the study suggested that deliberate planting of riparian zones with pine trees (!!) can encourage regeneration of shade-tolerant, native scrub-hardwood species, thereby providing acceptable conditions for a range of native fish, including giant kokopu. This contrasts with reserving unplanted riparian buffer strips which led to invasion by light-demanding exotic weed species. This pragmatic approach could lead to cost-effective and comparatively rapid restoration of habitat for native forest-dwelling fish such as giant kokopu. Appropriate planting and harvesting regimes are described.*
Characteristics and Geomorphic Effect of Wood in New Zealand's Native Forest Streams	NZ 2005	Yes. Importance of wood in streams Conclusion: *Wood is relatively abundant in New Zealand forested streams, with volumes (ranging from 85–470 m3 ha–1) well within the reported ranges for the USA (excluding the Pacific Northwest),*

		Australasia, and Europe (GURNELL, 2003). Wood in New Zealand's native forest streams was found to be geomorphically important in terms of retaining sediment and finer organic matter and increasing channel complexity – as has been reported in numerous studies of forested streams elsewhere. We expect that the influence of wood on geomorphology will prove to be closely related to ecological function in New Zealand streams (as has been reported elsewhere), and research is ongoing to investigate use of wood-related microhabitat by New Zealand native stream fauna
Influence of large woody debris on channel morphology in native forest and pine plantation streams in the Nelson region, New Zealand	NZ 2013	Yes. Summary: *pine plantation streams in the Nelson region contained higher volumes of LWD, larger proportions of LWD not influencing channel morphology, and lower pool numbers than native forest streams. Much of the wood not influencing channel morphology was suspended across the stream channel, particularly in the pine plantation streams. LWD volumes in forested streams of Nelson tended to be lower than in temperate forest streams in the Pacific north-west, but were similar to volumes reported from streams in subalpine old growth forests in Colorado. LWD in the Nelson streams had less influence on channel morphology, particularly pool formation and storage of sediment than in comparable Pacific north-west and Colorado streams. However, similarities exist in the spatial arrangement of LWD pieces influencing channel morphology (particularly pool formation) between forested streams in Nelson, the Pacific north-west, and Colorado.*
Distribution and abundance of coarse woody debris in some southern New Zealand streams from contrasting forest catchments	NZ 1993	Yes. From discussion – but lots more in discussion. Worth reading whole paper *Coarse woody debris is often an important determinant of structure and complexity of stream channels and may sometimes override the influence of geomorphic processes (Swanson & Lienkaemper 1978). Hanchet (1990) found that pools in forested tributaries of the Waikato river in the North Island of New Zealand had on average seven times more cover in the form of CWD than those in unforested streams. In the present study, pools in streams from the older native forests contained 70 to 100 times more wood than pools from the 10-year-old native and pine forest streams.*
Effects of forest harvesting and woody debris removal on two Northland streams, New Zealand	NZ 2013	Yes. Conclusion. Worth reading whole paper *The percentage of stream edge harvested is more likely to be a better indicator of harvesting impacts on factors such as light levels, temperature, DO, and aquatic invertebrate composition, than percentage catchment harvested. However, intact forested headwaters are a potential source of aquatic invertebrates for downstream stream re-colonisation and may enhance recovery rates of sensitive taxa once stream habitat and water quality become suitable. There has been no significant recovery of these streams toward preharvest conditions, 1-2 years after harvest. Shallow, low-order streams such as these, fed mainly by overland flow, are susceptible to temperature and DO changes when riparian vegetation is removed. Harvesting and stream-cleaning have less pronounced effects on streams with more stable,*

		cooler flow regimes, such as those in the central North Island fed by spring flows (e.g., Collier & Bowman 2003). It has been suggested that retention of moderate amounts of woody debris in small, spring-fed streams can moderate harvesting impacts (Collier & Smith 2003), but in these Northland streams retention time of woody debris is likely to be low and this would pose a risk to the downstream environment, given the frequency of high flow events observed during the trial period. The retention of riparian areas along the stream edge would assist in mitigating most of the adverse impacts observed in this study (Graynoth 1979; Thompson 2001). This comparison highlights the importance of considering the hydrological and landscape context when developing management plans for mitigating harvesting impacts on stream ecosystems.
Colonization and use of pine wood versus native wood in New Zealand plantation forest streams: implications for riparian management	NZ 2004	Yes. Worth reading whole paper *Although considerable information exists on the effects of forest harvesting on streams and the role of riparian vegetation in agricultural settings, few studies have investigated riparian management effects on exotic production forest streams. In the present short-term analysis of various woods potentially recruited from trees establishing in riparian planting set-backs, wood type (native versus pine) did not have an overriding effect on microfloral and macroinvertebrate colonization and utilization patterns. However, in 194 K. J. COLLIER ET AL. Aquatic Conserv: Mar. Freshw. Ecosyst. 14: 179–199 (2004) addition to habitat, wood also provides longer term functions in stream ecosystems, including provision of shade and structural control of channel morphology (Hilderbrand et al., 1997; Davies-Colley and Quinn, 1998), and these must also be considered when assessing the suitability of trees for riparian management. Pine logs decay rapidly (ca 25–30 yr: Collier and Baillie, 1999), whereas many native tree logs can take more than 100 yr to decay under water. However, the managed silvicultural regime of pine forest plantations ensures that wood inputs to streams occur on a regular basis when riparian areas are harvested (every 25–30 yr), and in this situation pine trees appear to provide a suitable in-stream substrate for microfloral and macroinvertebrate colonization. Where riparian buffers are implemented, residual pine wood may decay and leave the stream starved of wood until native species develop to the stage that they can contribute wood to streams. These considerations highlight the need to consider appropriate time scales when making decisions regarding the suitability of various riparian tree species in terms of providing wood to streams.* *Boothroyd and Langer (1999) concluded that riparian guidelines developed overseas have limited application to New Zealand, as they operate under different legislative frameworks, are often heavily prescriptive, and deal mainly with the harvesting of native forests compared with exotic forest in New Zealand.* *Macroinvertebrate faunas in mature pine forest streams are generally very similar to those in native*

		forest streams (Quinn et al., 1997; Quinn, 2000), and there is no evidence to suggest that the pool of potential colonists in the present study would have been limited by forest type. In parts of the country where little native forest remains, pine forest plantations provide an important regional reservoir for aquatic invertebrate biodiversity, and appropriate riparian management can sustain this role through the harvesting cycle (Harding et al., 2000). Where streams with unstable mobile pumice-beds predominate, inputs of wood to streams provide important habitat and resources for macroinvertebrate populations, and selection of appropriate tree species to fulfil this role is an important consideration of riparian management. The present study indicates that wood type is not an important factor affecting microfloral and macroinvertebrate colonization over the short term, but other roles of instream wood and longer time frames also need to be considered when developing riparian buffer management strategies for production forest streams.
New Zealand's exotic plantation forests as habitats for threatened indigenous species	NZ 2010	Maybe. Can't see any reference to fish though. Conclusion *Exotic plantation forests have become an integral and large-scale component of the New Zealand landscape. Plantations provide substantial areas of lowland habitat suitable for many forest-adapted species. However, large areas of these exotic forests have recently been converted to agricultural pasture, which does not support most forest-dwelling species. We recorded 118 threatened species within plantations but the total is undoubtedly much greater, due to the lack of survey effort and the difficulty in accessing data (e.g. finding old file notes and contract reports). A better reporting system to collate biodiversity records from plantations is urgently needed to facilitate information access and to enable opportunities for threatened species management. There has been some progress in our understanding of the contribution of plantation forests to the conservation of diverse assemblages of indigenous species and habitats. Nevertheless, it is clear that research is urgently required to quantify the full suite of benefits to threatened species and other elements of our native biodiversity within these plantations, before more are converted to non-forest land uses and to maximise conservation benefits, as new carbon forest plantations are likely to be created on marginal land.*
Stream channels are narrower in pasture than in forest	NZ 2010	Yes Worth reading whole paper *Exclusion of grazing animals and conservation plantings along stream channels in pasture landscapes are often promoted for their perceived benefits to streams and down-stream waters, including particularly, provision of shade, food in the form of leaf litter, woody debris which provides habitat diversity, and improved water quality (reduced sediment, nutrient, and faecal bacterial concentrations) (Collier et al. 1995). Some New Zealand studies (Dons 1987; Williamson et al. 1996) have reported the expected reduction in sediment yield following riparian retirement and planting in pumice lands. However, the results of the present study suggest that, more generally, promotion of shading vegetation*

		in the riparian zone may increase sediment yields for a period of years to decades as the stream channel attempts to reestablish a forest morphology. For example, Smith's (1992) study of small pasture streams at Moutere, Nelson, 9 years after riparian plantings of pines, revealed poorer water quality (higher suspended solids and nutrients) in the riparian-planted catchment than in the control (pasture) catchments—despite lower water yields. The lower water quality was attributed (mainly) to loss of ground cover vegetation under the shading pine canopy. I reiterate Smith's conclusion that "water quality managers need to be cautious about advocating widespread afforestation in pastoral areas".
Monitoring water quality in catchments dominated by plantation forestry	NZ 2013	Yes. Identifies that there is incomplete coverage in the water monitoring network of all climate types for assessing forestry effects, making it difficult to assess effects compared to other land uses. *Plantation forest catchments were under-represented in the existing water quality monitoring site network, with a mean area of 462 km2 per site (for 35 sites) compared to the national average of 334 km2 per site. The distribution of sites in environmental space is uneven. All 35 sites are in REC climate classes cold-wet, warm-wet, or warm-extremely wet, with neither dry climates nor cold extremely wet climates represented by any sites. A further 13 sites in forested catchments would be required to achieve parity with the national average, primarily in classes CD/H, CD/L, WD/L, and WW/L.* *Water quality data for sites in plantation forest catchments are highly variable in terms of data availability for specific variables, sampling frequency, and longevity of record. Dissolved oxygen is measured at all sites, and clarity, turbidity, E. coli, oxidised nitrogen, and dissolved reactive phosphorus recorded at 28-33 sites. Other nutrients (ammoniacal nitrogen, total nitrogen, total phosphorus) are widely monitored, but national comparisons are confounded by regional variation in laboratory procedures.* *The existing site network has very limited statistical power to discriminate between contrasting pairs of REC classes. Of 49 pairwise comparisons considered in this study, site numbers were sufficient to establish statistically significant differences for five variable x class combinations. Power for 21 pairwise comparisons was limited by a lack of data for sites in plantation forest catchments, but a further 23 comparisons were limited by a lack of data in both classes. Statistical power for a few comparisons would be significantly improved by increasing the number of sites in plantation forest catchments so as to achieve parity with the national average, but for many comparisons the number of additional sites required (tens, and sometimes hundreds) is unreasonably large. Thus, designing a site configuration*

		which will achieve representativeness is a much more tractable goal than achieving a specified level of statistical power.
Review of recent rural catchment based research in New Zealand	NZ 2009	Sort of. *Environmental management* • *Homogenization of stream structure and habitat (e.g. water temperature), leading to reduced aquatic faunal diversity across catchments, is a key degradation process which must be reversed to restore environmental values.* • *Variable or critical source areas – sites with impacts disproportionate to their size – can either contribute differentially to contaminant loads (e.g. livestock crossings, flood irrigation) or have key roles in mitigating losses (e.g. headwater and riparian wetlands). Such sites are priorities for cost-effective protection/remedial action.* • *Contaminants can take various flow paths (e.g. surface vs. groundwater) which need to be identified to understand and mitigate the associated lag effects on receiving water bodies.* • *Stock exclusion from waterways is highly effective at reducing direct inputs of pollutants and thus effecting large proportional reductions in contamination.* • *The continuity of riparian vegetation in time and space, interacting with stream order, is critical for mitigating land use effects on habitats and contaminant loads (where they pass through the zone of influence of the plants).* • *Extreme weather events have disproportionate effects on soil and water quality in the context of long time scales, and interact with different land cover patterns to produce variable recovery rates.* • *Land use has far-reaching effects on downstream and offshore ecosystems.* • *The use of information generated by land-use comparisons and associated modelling (as opposed to that derived from actual land use change) for planning land use change has limitations in terms of unanticipated transition effects and their interactions with other dynamic drivers (e.g. climate and economic cycles).* • *Variable time lags in environmental responses to management are a feature of catchment-scale processes and must be considered in planning.* • *There are a number of factors that drive additional time lags in the on-ground application of environmental management practises by land managers.*
J Quinn Whangapoua evidence		Yes. *4.7 deposition of slash in ephemeral stream channels may enhance their ability to filter sediment from stormflow by increasing the channel roughness so that flows are slowed and the contact between litter and sediment particles is increased. It is unclear what the net effect of slash deposition is in headwater*

		ephemeral and temporary streams. However, slash deposited in these channels may enhance the function of these systems for protecting downstream waterways through sediment retention. Logging slash in temporary and perennial headwater streams is likely to cause reductions in dissolved oxygen (as slash degrades) for 6 months after logging, Logging impacts on shade (and flow-on effects on water temperature/biota) are likely to be short-lived (a couple of years until low vegetation grows) or to not occur, due to shading by slash over these channels. *5.4 Logging impacts on fish: FRST funded research has shown that the fish fauna (total of eight species) was dominated by four species: Galaxias fasciatus (banded kokopu), gobiomorphus huttoni (redfin bully): and Anguilla australis and a. dieffenbachia (short and longfin eels). Total fish numbers were higher at harvested than unharvested sites, but densities of redfin bully were higher at harvested sites with buffers (similar for continuous and patch buffers) than clearcut sites whereas banded kokopu, that are relatively intolerant of high temperatures were leas abundant at clearcut sites (appendix 9). Density of the highly tolerant short-fin eel tended to be higher at harvested sites, particularly clearcuts, although the difference was not statistically significant. Densities of the endemic longfin eel were similar amongst the reach types, but the mean size and proportion of large fish of both eel species ended to decline from forested to logged/buffered to clearcut sites. These findings suggest that one of the top predators (shortfin eels) in these streams benefit form clear-cut logging effects. Loss of banded kokopu from clearcut reaches may reduce the recreationally and culturally important whitebait fishery, which is based on harvesting their juveniles as they return to streams from their marine larval phase. However ongoing research has shown banded kokopu abundance was maintained clear cutting without buffers at two sites where moderate amounts of slash were retained in the channel (providing cover for the fish) and the temperature during summer was below a daily maximum of 24C. Impacts on banded kokopu from clear-felling with slash removal are likely to persist until vegetation regrowth restores cover over the stream channel, which is likely to occur after 4-7 years in the favoured small stream habitats. These findings indicate that of the dominant fish at Whangapoua, only banded kokopu is sensitive to logging impacts and this species can be unaffected if the logging leaves a moderate level of slash in the stream channel as cover and high temperatures are not produced. The vegetation immediately adjacent to the channel has the creates influence on the stream habitat and biota because it provides the most effective reduction in near-stream soil disturbance, stream bank protection, shading, and input of leaf litter. Our research shows that 5m and 30m wide buffers of native forest provide very similar reduction of daily maximum air temperature in the middle of the buffer relative to a clearcut site (median reductions of 3.2C and 3.4 C for 5m and 30m buffers respectively). Research on adult insect use of riparian areas on 3 NZ stream streams (Collier and smith Hydrobiologia 361; 53-65) indicates that abundance of adult*

		caddisflies declines rapidly away from the stream, with total abundances at 5m and 20m being <40% and <21 % of that at the stream edge respectively. In the light of this finding, tougher with effective air temperature moderation provided by a narrow forested buffer at Whangapoua and the temporary nature of the reduction in riparian forest area/conditions in the plantation forest situation I doubt whether buffers wider than 10m are warranted to prevent significant adverse effects on stream invertebrates through impacts on adult habitat in this context. Thus 5 to 10m buffers of well-established native forest vegetation provide an area of suitable cool air temperature for adult aquatic insects in the streamside area where highest abundance of adults occurs.
Effects of progressive harvesting on stream invertebrates in two contrasting regions of NZs north island	NZ 2005	Yes *Essence is that landscape context can obscure stream-specific factors. Study overall showed subsidy, stress and neutral responses to progressive harvesting with respect to intra and inter-annual MCI variability.*
Temporal and land-cover trends in fresh water fish communities in New Zealand's rivers: an analysis of data from the New Zealand Freshwater Fish Database–1970–2007	NZ 2007	1. Over the past 30 years there has been a big increase in sites entered into the New Zealand Freshwater Fish Database (NZFFD). Most of this increase has been at pasture and indigenous forest sites. In the last decade (2000–2007) the number of pasture sites sampled was more than the number of sites for all other land-cove classes combined. 2. Thirty-seven years of fresh water fish and crustacean presence/absence data were obtained from the NZFFD; that was all entries on flowing water dating from January 1970 to June 2007 and consisted of 22,546 sites. 3. To enable between site comparisons an Index of Biotic Integrity(IBI) was used as it takes into account natural elevational and distance from coast variation in fish communities caused by the largely migratory New Zealand fish fauna. 4. Clear differences in IBI scores were found in relation to land cover. Sites in native vegetation catchments had significantly higher scores and more species than sites in pasture and urban catchments, while those in tussock land cover had the lowest scores. 5. Analysis of IBI scores over time revealed a significant reduction in average IBI scores for the past 37 years, especially over the last decade. 6. Investigation of the temporal trends by land-cover type showed the biggest declines were at pasture, tussock, and urban sites, while exotic forest sites showed no significant change and there was a significant improvement at native forest and scrub sites. 7. Where data was available for the same reaches sampled repeatedly over time these were analysed for changes. These showed more declines than improvements, although the differences were small. This

		study identified a shortage of repeatedly sampled sites. 8. The measures used in this study are only based on presence/absence data, thus the results are inherently conservative because fish species will show reduced abundance long before they become locally extinct. 9. This analysis highlighted the necessity for a set of long term repeatedly sampled monitoring sites for the whole country and the need to have a consistent sampling protocol.
Riparian buffers mitigate effects of pine plantation logging on New Zealand streams 2. Invertebrate communities	NZ 2004	Conclusion *This study indicates that late-rotation, exotic pine plantations on the Coromandel Peninsula have similar stream invertebrate community structure and associated biodiversity values to native forest. However, logging disturbance can degrade these biodiversity values severely unless buffers of undisturbed riparian forest are retained. Buffers that are continuous along the stream length provided more protection from the effects of logging than patch buffers that start some distance from the source of flow. Without these buffers, this press disturbance of clearcutting is likely to continue until riparian vegetation develops to a level where normal litter input occurs, shade controls periphyton blooms, stressful water temperature fluctuations and extremes fall within the tolerances of sensitive invertebrates, streambanks are stabilised, and sensitive stream biota can recolonise from less disturbed areas. The time for the shade related effects to occur will increase with stream width, but we expect disturbed conditions to persist for a substantial portion of the 25–30 years pine forest rotation unless riparian buffers are provided. A current study is addressing factors influencing the duration of clearfelling impacts. Our findings provide strong support for the environmental benefits for streams of retaining forested riparian buffers during logging of pine plantations on the Coromandel Peninsula. We expect the findings to be directly applicable to other north-eastern regions of New Zealand with similar topography and climate.*
Water quality in low-elevation streams and rivers of New Zealand: recent state and trends in contrasting land-cover classes	NZ 2004	Yes. From abstract: *Water quality state varied widely within land-cover classes: E. coli and dissolved nitrogen and phosphorus concentrations in the pastoral and urban classes were 2–7 times higher than in the native and plantation forest classes, and median water clarity in the pastoral and urban classes was 40–70% lower than in the native and plantation forest classes. Water quality state in the pastoral class was not statistically different from that of the urban class, and water quality state in the plantation forest class was not statistically different from that of the native forest class. Significant trends in low-elevation rivers were limited to four parameters: flow (trending down in all instances), and temperature, clarity, and conductivity (trending up in all instances). The trends in flow, temperature, and clarity were apparent at the national scale, and within the pastoral class. The magnitudes of these trends were very low, corresponding to changes of <0.5%/ year in parameter medians.*

		From discussion: *Inconsistent results from paired plantation-native forest comparisons may be partly because of variability in stand age and management practices. Elevated nutrient and sediment input to streams is typical of pine plantations for several years after road construction, site preparation, planting, and clear-felling (Fahey & Coker 1992; Oyarzun & Peña 1995). [Bridget Robson note: forest engineering and harvesting practices have changed markedly since the 1990s, with much emphasis on reducing circumstances that will create sediment]* *As stands mature, interception and nutrient uptake rates increase, peak flows decline, and sediment and nutrient losses decline (Fahey & Rowe 1992). With regard to water quality, decades-old pine plantations appear to function like native forests, with low rates of sediment and nutrient loss compared with pastoral land (Friberg et al. 1997). In addition to stand age-related effects, fertilisation affects DIN and DRP losses from plantation forests to streams (Neary & Leonard 1978; Binkley et al. 1999). [Bridget Robson note: it is currently uncommon for fertiliser/minerals to be applied to trees, other than a small amount of N to eucalyptus at planting, or to correct deficiencies e.g. Boron] Stand history and management information is rarely included in water quality studies of plantation forests. If these details were made available, the precision of water quality assessments could be increased.*
Wood in streams how much is good for fish? Dave Rowe Joshua Smith Brenda Baillie Mark Meleason	NZ 2004	Our observations have shown that small debris dams can greatly increase the abundance of both juvenile and adult banded kokopu. Dams increase water depth and may increase foods for banded kokopu (such as insect larvae and other aquatic invertebrates) and feeding habitat. They can also provide a place for the fish to hide from bird predators. In these small catchments, floods would rarely be big enough to dislodge the dams. So the high densities of banded kokopu supported by such debris-dam pools could well compensate for any loss of banded kokopu from the stream that occurs soon after logging. However, there are still many questions to be answered. What size of pool is required? How far apart should the dams be? How many are needed? The issue of how much wood is good for fish in streams presents some interesting challenges and potentially useful management outcomes for the forest industry. Trees are clearly vital components of stream ecosystems, whether they grow along the water's edge or lie fallen in the water. Our research is helping ensure that trees are managed to enhance rather than detract from stream health and native fish biodiversity
BOPRC MCI on plantation forests in the BoP 2016 ? author = Alistair Suren?		Table below and using QMCI (which is considered more accurate) the results are: Excellent 3 Good 8 Fair 2 Poor 3

		Some interesting points: • Waikawa (wide native riparians in NES-PF Orange zone) is entirely unharvested– water quality is good but not excellent. • The two "fair" catchments were both in a forest severely hit during cyclone Wilma and where, in many cases, there had been establishment right to the water's edge in steep and erodible country. Two of the poor results also reflects a similar circumstance. The other probably more a reflection of less well executed harvesting is on very broken terrain. • Most to the other sites had or were 'active harvesting' and were delivering good QMCI on yellow and orange terrains and with a first rotation history of no setbacks. • What this tends to reinforce is that landsliding is the biggest problem (whether in a pine forest, cutover or native forest). If that happens water quality will suffer. If it doesn't, good harvesting and earthworks practice can maintain good water quality. • In another forest where PF Olsens did their own monitoring for many years, one landslide in the native control block dropped clarity levels for an extended period. In the other control, we ultimately found that the consistently poor clarity, relative to the operationally affected streams, could be put down to road wash from the adjacent county (gravel) road.

Fore	RC_SID	River_Name	Easting_TM	Northing_T	NZ_Rea	Routine_Sampl	BoP Ref	PF Ols	Forest	2016 QMC	Comment
2	BOP_NERM_021	Mangapapa	1933624.8	5754074.2	4018783	Y		y	Mangapapa	excellent	Totally harvested hill country over 2-3 years - trees to stream margin, hauled across, Orange Zone
10	BOP_NERM_102	Moetahanga Stream	1936938	5772671.9	4013026	Started_2014	BOP_RES_001	y	Tuararangaia	excellent	Totally harvested over several years, tall native riparian SNA - pulled away from with skyline slung across. Yellow zone. Note SNA partially destroyed from neighbours out of control fire- TA informed - no acknowledgement.
14	BOP_NERM_106	Otangimoana Stream	1896624.7	5706077.1	4013300	Started_2014	BOP_RES_032	y	Raingataiki Stn		Results not provided
15	BOP_NERM_107	Ruakaka	1967093	5776743	4011536	Started_2014		y	Wiotahi	Good	Totally harvested over several years - subject to major skid failure and debris deposition in 2008. Stream cleaned out and setbacks established. Orange zone
16	BOP_NERM_108	Orumanganui Stream	1966681	5774945	4012220	Started_2014		y	Wiotahi	Poor	Area subject to complete harvest 2007-09. Previous owner didn't replant nor maintain - major debris flood in storm about 2010. New owner subsequently replanted and setbacks established. Stream still settling. Orange zone
17	BOP_NERM_109	Panuiahine Stream	1967040	5772780	4012902	Started_2014		y	Wiotahi	Good	Under mature pine - Yellow Orange zones
18	BOP_NERM_110	Oteakona Stream _ Pine	1988103	5781735	4009810	Start_in_2015		y	Vexala	good	Mature pine +some native buffering. Yellow zone
21	BOP_NERM_113	Trib into Haraparapa River on	2010839	5805864	4003962	Start_in_2015		y	Omaio	good	Mature pine upper headwaters harvested with pull across. Highly erodible land minimal riparian in upper reaches. Orange zone
22	BOP_NERM_114	Trib into Haraparapa River_1 k	2012042	5805766	4004002	Start_in_2015		y	Omaio	excellent	Mature pine - lower reaches, upper reaches harvested and replanted in 2014 - middle reaches awaiting replanting. Orange zone
23	BOP_NERM_115	Waewaetukuku Stream (acces	2010287	5803244	4004413	Start_in_2015		y	Omaio	poor	Completely harvested - no real riparians initially and hit by cyclone Wilma 2011 with heavy slope erosion in upper Orange zone catchment. Replanted 2009-13 with setbacks established. Yellow zone
24	BOP_NERM_116	Kopua Stream	2016856	5817573	4001899	Start_in_2015		y	Waikawa	good	Mature pine + large native riparian unharvested. Orange zone
25	BOP_NERM_117	Nghunahu Stream	2018937	5819388	4001627	Start_in_2015		y	Waikawa	good	Ditto above
26	BOP_NERM_118	Trib into Onaia Stream	1892175	5796095	4005683	Start_in_2015		y	Pinnicles MR	poor	Completely harvested & little riparian some years back, replanted with setbacks but stream site effectively a gully infill and almost a developing wetland due to historic and probably harvest activity. Very steep broken and erodible. Red zone
27	BOP_NERM_119	Tributary into Kaituna River_N	1894836	5800167	4004928	Start_in_2015		y	Pinnicles MR	good	Catchment totally harvested approx 6- 8 years ago. Replanted with much improved setbacks, very steep broken and erodible. Red and Orange zone
28	BOP_NERM_120	Opurena Stream	1948365	5766633	4014688	Start_in_2015		y	Tuhoe	good	Substantially under harvest at present, minimal riparian previously, lowere reaches yellow zone, upper reaches Orange. Headwaters pull across.
29	BOP_NERM_121	Paekoau Stream	1947641	5767982	4014503	Start_in_2015		y	Tuhoe	fair	Harvesting around full catchment over 8 years, just completed, much replanted some to be replanted, lower reaches Yellow zone, upper reaches orange zone. Hit by cyclone Wilma in 2011 1:80-1:100 year event major landsliding in upper reaches thus high sediment deposition at time. Setbacks already leading to visible natural vegetation regrowth.
30	BOP_NERM_122	Owhaktoro Stream	1944555	5770317	4013642	Start_in_2015		y	Tuhoe		results not provided
31	BOP_NERM_123	Kotorenui Stream	1942318	5771081	4013525	Start_in_2015		y	Tuhoe	fair	Very recently harvested, incomplete preexisting riparian - will have been hauled across in its entirety but probably also cyclone wilma impacted - Landslips and earth flows occurred under standing trees in this storm. Originates across boundary in DoC land a short distance away so a bit surprising unless its preharvest condition was similar to the pinnicles one described above. Yellow zone