8.1 Riparian margin establishment/protection

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State of knowledge of the "Riparian margin establishment/protection" attribute: Good / established but incomplete – general agreement, but limited data/studies

Part A—Attribute and method

A1. How does the attribute relate to ecological integrity or human health?

The establishment and protection of riparian margins by fencing and planting with a combination of trees, shrubs, sedges, and grasses can benefit the ecological integrity and human health of adjacent waterbodies in several ways:

- by reducing contaminant losses in surface runoff and shallow subsurface flows from land, including sediment, nitrogen, phosphorus (McKergow et al. 2022) and *E. coli* (Collins et al. 2004).
- by stabilising waterbody banks (Marden et al. 2005; Simon et al. 2023; Stantec, Auckland Council 2023) and improving bank condition (Hughes 2016);
- by shading waterbodies (Rutherford et al. 2021) to reduce water temperatures (Rutherford et al. 1997) and nuisance growths of aquatic plants and algae (Matheson et al. 2017);
- by providing physical habitat for aquatic (Parkyn et al. 2003, Jowett et al. 2009, Hickford and Schiel 2011), semi-aquatic and terrestrial biota.

The extent of benefit afforded by riparian margin establishment/protection on ecological integrity or human health is spatially and temporally variable and depends on landscape, climatic and biological factors that affect the riparian margin, the land surrounding it and adjacent waterbody. Factors that affect performance include upslope land use and associated contaminant loading rates, rainfall, temperature, geology, land slope, soil type, hydrological flow pathways, the extent, soil and vegetation characteristics of the riparian margin, and the physical, chemical, and biological characteristics of the adjacent waterbody.

In catchments where fencing and planting of riparian margins have been carried out, the ecological integrity and human health of adjacent and downstream waterbodies is expected to improve, especially where the establishment and protection activities have been extensive. However, catchment or reach-scale studies that have monitored indicators of ecological integrity and human health in adjacent waterbodies before and after, or upstream and downstream of, fencing and planting of riparian margins have often reported inconclusive results, especially for water quality variables (Parkyn et al. 2003, Davies-Colley and Hughes 2020) or findings of improvements are correlative only (Wrightstow and Wilcock 2017, Graham et al. 2018, Graham and Quinn 2020). Interpreting the results of catchment and reach scale investigations of riparian fencing and planting is difficult given the influence of the many factors listed above which can vary spatially and temporally over the course of a study. Therefore, the strongest evidence of improvements afforded by riparian margin establishment and protection is likely to come from:

- investigations that limit the influence of confounding factors and/or quantify them to allow their influence to be accounted for in the development of relationships (e.g., inflow-outflow water quality studies to determine contaminant attenuation by riparian buffers; McKergow et al. 2020a);
- investigations that use models with a sound physical basis to determine relationships (models of radiation and sunpath that can incorporate riparian and stream characteristics to determine stream shade; Rutherford et al. 2021).

The resultant relationships can be combined in data-driven catchment modelling approaches to generate catchment scale predictions of impact (e.g., Matheson et al. 2021).

A2. What is the evidence of impact on (a) ecological integrity or (b) human health? What is the spatial extent and magnitude of degradation?

Indigenous vegetation in New Zealand was removed as land was cleared for settlement and farming (Ewers et al. 2006). This included removal of indigenous vegetation from the riparian margins of waterbodies particularly in lowland areas (Miller 2002). Loss of vegetated riparian margins will have contributed to the degradation of freshwater and downstream receiving environments by:

- enabling greater quantities of contaminants to enter waterbodies;
- lessening stream bank stability;
- reducing shading of waterbodies; and
- removing habitat for aquatic, semi-aquatic and terrestrial biota.

Beginning in the 1970s efforts to set-aside, fence, and plant riparian margins in New Zealand (and elsewhere; Mohan et al. 2022) began in sensitive lake and river catchments (i.e., Taupō and Upper Kaituna; McKergow et al. 2016). Early this century, a partnership between organisations in the dairy sector introduced national requirements for riparian margins to be fenced to exclude dairy stock from entering streams wider than a stride (>1m) and deeper than a gumboot (>30cm) (Fonterra Co-operative Group, Regional Councils, Ministry for the Environment, and Ministry of Agriculture and Forestry 2003). Recently enacted national stock exclusion guidelines (New Zealand Government 2020) require stock (beef cattle, dairy cattle, dairy support cattle, deer, or pigs) to be kept at least 3m away from waterbodies (wetlands, lakes, and rivers) >1m wide.

Regional councils have also provided advice and funding to assist landowners to set-aside, fence, and replant riparian margins and in some regions these activities have been extensive (e.g., Taranaki, Graham et al. 2018). Nevertheless, on a national scale, the available evidence suggests that the riparian margins of most waterbodies still lack protection, especially those of smaller streams (<1m wetted width). Where riparian margins have been fenced and planted, they typically have non-woody vegetation and narrow widths (<5m; Greenwood et al. 2012; Renouf and Harding 2015; Norris et al. 2020).

A3. What has been the pace and trajectory of change in this attribute, and what do we expect in the future 10 - 30 years under the status quo? Are impacts reversible or irreversible (within a generation)?

Removal of indigenous vegetation from riparian margins would have been a rapid process in those areas of New Zealand that were first and most extensively used for settlement and farming. As more of the country was settled, additional areas of vegetated riparian margin would have been removed, leaving only remnants, especially in lowland areas. Reports documenting extents of indigenous riparian forest loss and remnant extents remaining are limited (but see Miller 2002). Nevertheless, it seems reasonable to assume that the pace and trajectory of degradation for this attribute, would track similarly to degradation in extent of indigenous vegetation cover, generally.

Anecdotal evidence suggests that set-aside, fencing and planting riparian margins has taken place at many locations around New Zealand, but, in general, the pace and scale of change to reverse the degradation in this attribute has been slow and limited. This is expected to continue in the next 10-30 years under the status quo.

The degradation in national extent of riparian margin establishment and protection is mostly reversible, the main impediment is cost. It will be more costly (or even cost-prohibitive) to set-aside, fence, and plant riparian margins in some locations than in others due to variation in:

- lost opportunity costs associated with current use of the land;
- costs to remove existing built infrastructure (if applicable, i.e., in urban areas); and
- costs to fence, plant and maintain the margin areas.

A4-(i) What monitoring is currently done and how is it reported? (e.g., is there a standard, and how consistently is it used, who is monitoring for what purpose)? Is there a consensus on the most appropriate measurement method?

There is no national monitoring or reporting of riparian margin establishment/protection or consensus on the most appropriate measurement method. Some local authorities assess the condition of stream riparian margins as a component of stream habitat assessments for State of Environment monitoring (e.g., Collier and Kelly 2005) and a national habitat assessment protocol has been developed (Clapcott 2015). Other monitoring protocols with riparian components include the stream ecological valuation method (SEV, Rowe et al. 2006), the stream habitat assessment protocol (SHAP, Harding et al. 2009), the restoration indicators toolkit (Parkyn et al. 2010), and the stream health monitoring and assessment kit (SHMAK, NIWA 2019). Habitat assessments typically evaluate several aspects of riparian condition including canopy cover (over stream), the width of the fenced margin, and vegetation composition, bank protection and stability.

The riparian management classification (RMC; Quinn et al. 2001) was developed to assess stream riparian state and functions and it has been applied to streams in Canterbury, Waikato, and Nelson (Phillips and Marden 2004, Quinn 2009). The Jobs for Nature biodiversity monitoring protocols (Clapcott et al. 2021) which form the basis of the Department of Conservations' online Freshwater Biodiversity Guide (FBG) tool, has been designed for monitoring of stream riparian restoration projects. The FBG protocols cover a much broader set of riparian parameters than prior tools, including aspects of plant survival, canopy height, plant and animal pests, terrestrial invertebrates, herpetofauna, bats and birds. Both the RMC and FBG also include protocols for monitoring the state of many instream parameters.

To the authors knowledge, local authority State of Environment riparian margin monitoring data have not been used to report on national or regional scale state and trend in this attribute, except for the Waikato Region by Pingram et al. (2023). Graham et al. (2020) also analysed trends in several riparian indicators from the Waikato State of Environment ecological data specifically for the Waikato River catchment. The Waikato Region conducts a 5-yearly survey specifically focused on the riparian characteristics of pastoral waterways (Norris et al. 2020). The survey includes random stratified sampling site measurements of the proportion of bank length effectively fenced, bank length with woody vegetation, and bank length with erosion and has been used to track their state over time since 2002. Lake riparian margins have been less commonly assessed by local authorities (but see Wildland Consultants 2011).

A4-(ii) Are there any implementation issues such as accessing privately owned land to collect repeat samples for regulatory informing purposes?

Current riparian margin monitoring approaches use survey sites that are often on privately owned land requiring staff conducting the survey to contact landowners to gain access permissions (Collier and Kelly 2005, Norris et al. 2020). Iwi/hapū/rūnanga should also be kept informed of any survey work being conducted in their rohe. In future, increased availability of remotely-sensed products (e.g., aerial and satellite imagery, LiDAR) may allow survey data to be collected without the need for physical site visits (for example see Pattle Delamore Partners (PDP) 2023), provided there are no legal barriers to obtaining data on privately owned land in this way.

A4-(iii) What are the costs associated with monitoring the attribute? This includes up-front costs to set up for monitoring (e.g., purchase of equipment) and on-going operational costs (e.g., analysis of samples).

Current riparian margin monitoring approaches rely primarily on visual assessments. They incur the following costs:

- Initial set up costs including staff time to design the monitoring programme, purchase of equipment, training staff to undertake the survey;
- Staff time and travel expenses to carry out the field surveys;
- Staff time to enter and analyse the data gathered;
- Staff time to report the results;
- Staff time and expenses involved in maintaining survey equipment.

These costs will vary by region depending on the number of sites to be monitored and the set of riparian margin indicators to be measured.

A5. Are there examples of this being monitored by Iwi/Māori? If so, by who and how?

There are several examples of riparian margin establishment and protection being monitored by iwi/hapū/rūnanga. For example, in the Waitao catchment, Bay of Plenty, riparian vegetation, and its functions, were assessed in 2010, seven years after a programme of stream fencing and riparian planting was initiated by Ngā Pāpaka O Rangataua and other partners in the Te Awa O Waitao Restoration Project (Cooper et al. 2007, Blackett et al. 2011). In another example, riparian margin use, vegetation extent and composition, and riverbank condition were assessed as part of the development of a Cultural Heath Index (CHI) for streams and waterways, which gathered monitoring data on the Kakaunui, Taieri, Hakatere, and Tukituki rivers (Tipa & Tierney 2003). The CHI has since been adapted by many other iwi/hapū/rūnanga around New Zealand across a range of habitats (streams, rivers, lakes, wetlands, marine environs)[1]. More recently, bank vegetation and protection have been assessed as part of the development of Ngāti Maniapoto indicators and methodologies to support watercress assessment in streams and rivers and tested in the Turitea stream (Herangi and Ratana 2021). Further, in a summary of Kaupapa Māori Freshwater Assessments (Rainforth and Harmsworth 2019) most of the 13 tools identified appear to have a riparian habitat component. This suggests that one or more riparian parameters are being monitored by iwi/hapū/rūnanga using a variety of tools and approaches. Waterway access to stock (proxy for riparian protection) is also a component of many assessment methods being used by iwi/hapū/rūnanga.

A6. Are there known correlations or relationships between this attribute and other attribute(s), and what are the nature of these relationships?

Riparian margin establishment/protection conceivably influences all other attributes listed under the Freshwater Domain in this project, i.e., trace metals in water and sediment, groundwater nitrate, surface water flow alteration, groundwater depletion, and catchment permeability.

Riparian margin establishment/protection is likely to result in the interception of trace metals transported to waterbodies in surface runoff and shallow subsurface flows. Trace metals adsorbed to sediment can be deposited with sediment in vegetated riparian margins (Tang et al. 2014), especially those with plantings that encourage sediment deposition (e.g., with a dense, uniform grass filter, McKergow et al. 2022). Trace metals dissolved in water are likely to be assimilated into riparian vegetation biomass via root uptake as surface runoff water infiltrates into riparian soil, or as shallow subsurface flows pass through the vegetation root zone. Groundwater nitrate, transported in shallow subsurface flows through the vegetation root zone is also likely to be assimilated by vegetation. Groundwater nitrate may also be denitrified to nitrogen gases (i.e., N_2 or N_2O) in the vegetation root zone which typically has organic-carbon-rich soils that support this process. However, groundwater nitrate and trace metals in deeper aquifers, below the plant root zone will not be subject to plant uptake (and, in the case of nitrate, less likely to be denitrified).

The vegetation planted in riparian margins may affect surface water and groundwater availability, by altering water losses due to evaporation and plant evapo-transpiration processes. The extent of alteration to rates of plant evapo-transpiration rates will depend on the species planted, and what existing species they replace (e.g., pasture grasses). It will also depend on how much the new vegetation alters evaporative losses. Vegetation is generally expected to decrease evaporative losses

[1] For some examples, see https://www.stats.govt.nz/indicators/cultural-health-index-for-freshwater-bodies

via enhanced rainfall interception, build-up of organic soils which retain water, root biomass increasing soil permeability and shading of land and water surfaces.

The set-aside, fencing and planting of riparian margins is also likely to improve the permeability of soils in these areas, especially in grazed areas, as soil compaction from livestock treading will be eliminated (Cooper et al. 1995). Increased root biomass and organic matter is also likely to improve soil permeability.

Part B—Current state and allocation options

B1. What is the current state of the attribute?

At national scale, anecdotal evidence suggests that the riparian margins of most waterbodies still lack protection, especially those of smaller streams (i.e., streams <1m wetted width). Where riparian plantings have been established it seems that the width of plantings is typically narrow. It is expected that most regional councils and unitary authorities include some form of riparian assessment in their State of Environment monitoring programmes. Therefore, it may be possible to bring these data together in a national state assessment. It might also be possible for riparian datasets from other sources, such as iwi/hapū/rūnanga cultural assessments and community-based projects (e.g., funded by Jobs for Nature) to be included in a national scale assessment.

B2. Are there known natural reference states described for New Zealand that could inform management or allocation options?

Areas of riparian margin located within remnant tracts of indigenous vegetation could possibly serve as natural reference states. However, even these remnant margin areas are likely to have suffered some degree of modification, especially where surrounding land use is highly modified. It may be possible to predict natural reference state using multiple lines of evidence and modelling approaches like those applied for groundwater nitrate (Daughney et al. 2023) and catchment nitrogen and phosphorus loads (Snelder et al. 2018).

B3. Are there any existing numeric or narrative bands described for this attribute? Are there any levels used in other jurisdictions that could inform bands? (e.g., US EPA, Biodiversity Convention, ANZECC, Regional Council set limit)

Many of the visual assessment protocols used to assess riparian margin condition use narrative descriptions to assign a score for specific parameters. These narratives and scores are amenable to conversion to narrative bands (i.e., A-D bands as used in the National Policy Statement for Freshwater Management (NPS-FM) attributes). Protocols used to assess riparian margin condition that generate quantitative data for specific parameters could be converted to numeric bands but the maximum and minimum values possible for these parameters need to be determined as well as a justifiable process applied to identify the points of transition between A-B, B-C and C-D bands. Examples of how narrative and numeric bands can be developed for stream and lake riparian condition parameters are illustrated in the pilot Waikato River Report Card (Williamson et al. 2016),

funded by the Waikato River Authority (WRA)[1] and guided by a Waikato River Iwi Advisory Group, where the following numeric and narrative parameters were scored A-D:

- Stream fencing state
- Stream shade state
- Lake riparian condition

B4. Are there any known thresholds or tipping points that relate to specific effects on ecological integrity or human health?

There are known thresholds for riparian canopy cover (over stream) which creates sufficient shading to regulate growths of nuisance periphyton and macrophytes to levels recommended to protect stream ecological values. An analysis of data from Waikato Regional Councils' Regional Ecological Monitoring of Streams Programme showed that with ≥65-70% canopy cover of riparian vegetation the weighted composite cover (WCC) of periphyton was always <30% and channel clogginess by macrophytes (MCC) was always <50% (Matheson et al. 2017). These findings have also been supported by research in Canterbury streams (Collins et al. 2018). The <30% periphyton WCC and <50% MCC thresholds are provisional stream ecological integrity guidelines identified by Matheson et al. (2012).

B5. Are there lag times and legacy effects? What are the nature of these and how do they impact state and trend assessment? Furthermore, are there any naturally occurring processes, including long-term cycles, that may influence the state and trend assessments?

It will take time for tree, shrub and sedge vegetation planted on riparian margins to mature and reach their full potential for reducing contaminant losses from land, stabilising banks, improving bank condition, and providing shade and physical habitat. It is likely to be necessary, therefore, for any state and trend assessment of riparian margin establishment/protection to consider the development stage of the vegetation and how close it is to maturity.

Some vegetation types will mature and reach their maximum height and density more quickly (e.g., grasses). In contrast, it will take many years for larger tree species to mature, and for their root structures to reach their full below-ground biomass and extent. Enrichment of riparian soils with leaf litter and plant organic exudates is also likely to be a longer-term process, even in areas planted with fast-maturing and/or annual species.

The state of the riparian margins prior to fencing and planting is also likely to influence the pace and trajectory of recovery. As noted under A1, the extent of benefit afforded by riparian margin establishment/protection on ecological integrity or human health is spatially and temporally variable and depends on various landscape, climatic and biological factors which includes the state of the riparian margins at the time that recovery was initiated.

[1] The Waikato River Authority was set up on 25 November 2010 under section 22(1) of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 (the Act) and section 23(1) of the Ngāti Tuwharetoa, Raukawa, and Te Arawa River Iwi Waikato River Act 2010.

B6. What tikanga Māori and mātauranga Māori could inform bands or allocation options? How? For example, by contributing to defining minimally disturbed conditions, or unacceptable degradation.

In addition to the WRA report card example explained in B3, cultural health assessment protocols (e.g.,Tipa and Tierney 2003, Herangi and Ratana 2021) could help to inform narrative bands. For example, the CHI suggests the following metrics which are scored between 1 (unhealthy) and 5 (healthy):

- river bank condition,
- vegetation – banks & margins,
- indigenous species – margins & adjacent land,
- use of the river banks + margins.

In the watercress assessment (Herangi and Ratana 2021) users of the methodology are asked to give the following metrics scores between 1 (unsatisfied) to 5 (satisfied):

- if they are satisfied that bank vegetation is healthy and that it is the right vegetation to support tuna/swimming/drinking water,
- if they are satisfied that the banks are protected to support tuna/swimming/drinking water,
- if they are satisfied that the effects of pest plants and invasive species are minimised at this site.

Part C—Management levers and context

C1. What is the relationship between the state of the environment and stresses on that state? Can this relationship be quantified?

The state of riparian margin establishment/protection is driven by the need for land to be used for rural and urban purposes. Evidence from regional surveys suggests that in rural locations, riparian margins are often in pasture and used for livestock grazing (Norris et al. 2020). They may also be planted in crops. In urban locations, riparian margins are likely to be mown or rank grass areas, have footpaths or even built structures. Where land is set aside from these uses, riparian margin establishment and protection is expected to benefit the ecological integrity and human health of adjacent waterbodies in the ways described in A1.

C2. Are there interventions/mechanisms being used to affect this attribute? What evidence is there to show that they are/are not being implemented and being effective?

There have been several interventions/mechanisms employed to affect riparian margin establishment and protection in New Zealand as follows:

C2-(i). Local government driven

These include council staff providing advice to landowners and financial subsidies to support riparian fencing and planting activities. Analysis of council data in the Taranaki region indicates that where significant tracts of fenced and/or planted margins have been re-established there is a correlation with improving trends for *E. coli* and macroinvertebrates (Graham et al. 2018).

C2-(ii). Central government driven

These include investments to fund riparian fencing and planting through the One Billion Trees Fund and the Provincial Growth Fund, and for Ministry for Primary Industries to provide extension services to support these initiatives through the Productive and Sustainable Land use package (Wetlands and waterways gain from 1BT funding | Beehive.govt.nz). These are recent initiatives that are in the process of being evaluated. Projects are often only required to report on simple indicators of effort such as kilometres of stream bank fenced and/or hectares of riparian margin planted but see Clapcott et al. (2021) for a broader range of recommended riparian protocols.

C2-(iii). Iwi/hapū driven

There are many examples of iwi/hapū/rūnanga-driven interventions/mechanisms affecting this attribute around New Zealand. Examples include investments in riparian fencing and planting projects through the Waikato River Authority to deliver Te Ture Whaimana – the Vision & Strategy for the Waikato River (Waikato River Authority Projects (morphumdata.com)) and projects funded or partially funded by other central and local government initiatives. As for (ii) funded projects are often only required to report on simple indicators of effort such as kilometres of stream bank fenced and/or hectares of riparian margin planted. The CHI allows iwi/hapū/rūnanga users to assess whether they are satisfied that the riparian vegetation is healthy/protected and that it is the right vegetation to support their cultural values (e.g., mahinga kai).

C2-(iv). NGO, community driven

These include direction and/or guidance for riparian fencing and planting projects through NZ's primary sector organisations including DairyNZ, Beef&LambNZ and Fonterra. As noted under A2, industry guidelines have required riparian margins to be fenced to exclude dairy stock from entering streams wider than a stride (>1m) and deeper than a gumboot (>30cm) (Fonterra, Ministries for Agriculture and Environment, Local Government NZ 2003). The Dairy Best Practice Catchment study (Wrightstow and Wilcock 2017) found that improved stream fencing and effluent disposal was associated with improving trends in suspended sediment in all catchments and improving trends in other water quality parameters and certain macroinvertebrate metrics in some catchments. Other organisations that provide guidance and support for riparian planting include the New Zealand Landcare Trust, New Zealand Farm Forestry Association, Tane's Tree Trust and Tirohanga Ngahere Canopy and Rural Design.

C2-(v). Internationally driven

Restoring the vitality of degraded systems including riparian ecosystems is crucial for fulfilling the UN-Sustainable Development Goals in a timely manner and essential for attaining the targets of the UN-Decade (2021-2030) on Ecosystem Restoration (UN-DER) (Mohan et al. 2022). The Nature Conservancy is an international agency that is active in New Zealand (see Our Work in New Zealand | The Nature Conservancy) and provides support for conservation initiatives and nature-based solutions which can include riparian fencing and planting.

Part D—Impact analysis

D1. What would be the environmental/human health impacts of not managing this attribute?

Changes in the state of the riparian margin establishment and protection attribute affects ecological integrity and human health. If this attribute were not managed there are likely to be the following impacts:

- increased contamination of water that will detrimentally affect human water uses including drinking water, crop and stock water supplies and use of waterbodies for recreational activities;
- increased contamination of water that will detrimentally affect survival of aquatic life including taonga species important to iwi/hapū/rūnanga;
- continued loss of native aquatic, semi-aquatic and terrestrial biodiversity as physical habitat availability declines, and they are exposed to higher air and water temperatures;
- decreased water availability as less water is retained in the landscape through recharge of aquifers, retention in organic soils, and reduced evaporative losses.
- loss of cultural values, practices and mātauranga associated with (the appropriate) riparian vegetation (e.g., rongoā, raranga).

Not managing this attribute represents a missed opportunity to improve many aspects of ecological integrity and human health through riparian margin establishment and protection.

D2. Where and on who would the economic impacts likely be felt? (e.g., Horticulture in Hawke's Bay, Electricity generation, Housing availability and supply in Auckland)

Economic impacts from not managing this attribute will affect both urban and rural sectors in New Zealand. Impacts are likely to include:

- increased costs of removing contaminants from water extracted from degraded waterbodies for various uses, especially for human drinking water and crop and livestock water supplies;
- increased costs associated with development of water retention infrastructure to ensure sufficient water supplies for urban and rural uses during times of drought;
- increased costs associated with repairing flood damage resulting from higher rates of flow and contaminant mobilisation during storm events.

D3. How will this attribute be affected by climate change? What will that require in terms of management response to mitigate this?

Managing this attribute will increase landscape resilience to the anticipated effects of climate change. Riparian margin establishment and protection should lead to the following:

- Reducing flood and drought risk and associated damage as these events become more frequent and extreme by retaining water on the land, through recharge of soil and groundwater aquifers;
- Reducing the mobilisation of contaminants from land as storm events become more frequent and intense;
- Protecting native terrestrial, semi-aquatic and aquatic life that inhabit riparian margins and adjacent waterbodies including taonga species from increased air and water temperatures.

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