Livestock access: 101

Technical guidance for DOC input to collaborative processes for regional freshwater plan development

The purpose of this guidance document is to provide DOC staff with information about the current government position on stock exclusion, and an introduction to the adverse effects of livestock access to freshwater and estuarine ecosystems. It sets out why, when and where livestock access to freshwater and estuarine ecosystems are of concern to DOC, and how the effects of livestock access can be avoided or managed.

The summary on page 2 summarises the key impacts of livestock on freshwater ecosystems and outlines key points to advocate for. Companion documents about the impacts of nutrients, sediment, and removal of riparian vegetation, on water quality, ecosystem health and associated values have also been prepared. Contact the Freshwater Team for more information if needed.

Contents

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Summary

The current policy and regulations around stock exclusion are as follows:

- The Government (through the Clean Water 2017 package[1]) has developed regulations (believed to come into effect in May 2018) to exclude stock from waterways on land used for dairy and dairy support, beef cattle, pigs and deer by July 2022.
- The stock exclusion regulations propose to exclude dairy cattle and pigs from most lakes, rivers and streams from 1st July 2017[2], with compulsory stock exclusion to follow on a staggered basis until 2030, extending to include beef and deer. The rules vary depending on the slope of the land, with stock (dairy and beef cattle, pigs and deer) to eventually be excluded from all waterways, lakes and wetlands on flat land (0–3°), and waterways over 1 metre wide, lakes and wetlands on rolling (>3–15°) and steeper (<15°) land. Specific details of the regulations are set out in section 1.1.
- Sheep and goats are not covered by the proposed stock exclusion regulations.
- Councils will have the ability to apply more stringent stock exclusion rules where they see this as necessary or desirable.
- A number of councils already have stock exclusion rules that generally relate to intensively farmed stock or are targeted to priority water bodies.
- DOC processes grazing licences on Public Conservation Land (PCL). These approvals are governed by the General Policy and local Conservation Management Strategies. Standard conditions are attached to grazing licences that prohibit stock access to waterways. However, improving compliance with these conditions is a work in progress.

The key adverse effects of livestock access to freshwater ecosystems are:

- Consumption of plant matter.
- Trampling of riparian plants and fish habitat, and subsequent compaction of soil (pugging).
- Nutrient inputs and microbial contamination from urine and faeces.
- Stream bank erosion from vegetation removal and trampling.

DOC staff should advocate for councils to be more stringent than the national regulations in the following ways:

- Excluding stock from all waterways, including small permanently flowing rivers and streams, on rolling and steep land. Small streams (<1 m) are currently excluded from the regulations, yet small headwater streams have important biodiversity and hydrological values.
    - Where exclusion from all waterways regardless of size is deemed practically impossible, stock should at least be excluded from waterways that are significant for threatened fish species. GIS tools and databases can be used to help identify which catchments are most significant for threatened fish species.
    - Another compromise option that may be more stringent than the national regulations and provide greater protection for significant freshwater values, would be to seek that stock are excluded from certain places at certain times of the year (if not possible year-round). This is particularly important for protecting spawning habitat.
- Sheep and goats are not included in the national regulations on the basis that they are generally not attracted to waterways. However, there may be situations when excluding these species is important to safeguard habitat.
- Councils should be encouraged to exclude all stock from outstanding waterbodies.
- The national regulations will require stock exclusion, without dictating how stock are going to be excluded (e.g., no requirement for permanent fencing). They also do not stipulate any setback distance, or have a requirement to include any riparian management. Vegetated buffers, even containing only grass, will perform valuable riparian functions such as filtering overland flow of

[1] http://www.mfe.govt.nz/publications/fresh-water/clean-water-90-of-rivers-and-lakes-swimmable-2040

[2] Note that as these initial dates set in the consultation document have passed, new dates will likely be set when the regulations come into effect.

sediment and nutrients. Many councils already have a programme for encouraging riparian planting, but recognising this through their statutory plans may ultimately lead to achievement of improved riparian restoration.

1. Government policies relating to stock exclusion

1.1 Proposed national regulations for stock exclusion

The Government is proposing to exclude cattle, pigs and deer from waterbodies by 2030. A draft national regulation has been developed, and is believed to come into effect around May 2018. It would exclude dairy cattle (on milking platforms[3]) and pigs from lakes, wetlands and waterways over 1 metre wide by 1 July 2017[4], and other stock types at later dates.

The waterbodies included will be:

- Permanently flowing waterways (rivers, streams and drains) of any size on the 'plains' (land with a slope of 0–3°).
- Permanently flowing waterways (rivers, streams and drains) with an active channel that is over 1 metre wide at any point on land greater than 3° in slope.
- Lakes, as per the Resource Management Act 1991 definition (bodies of fresh water which are entirely or nearly surrounded by land).
- Natural wetlands, as per the Resource Management Act definition (permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions), but not including wet pasture, or places where water temporarily ponds after rain or pasture containing patches of rushes.

The stock exclusion proposal was set out in the Clean Water 2017 discussion document (MfE 2017), and is summarised in Table 1 below. Submissions were called for, and summarised in recommendations to Government, however, as yet there have been no changes proposed to the stock exclusion regulations from those that were consulted on.

The 2017 amendments to the Resource Management Act included new sections[5]—360(1)(hn) that will enable these regulations to be made; 360(1)(ho) that provides for related infringement offences; and 360(1)(bb) that allows the regulations to set infringement fees of up to $100 per animal (up to a maximum of $2000), rather than the maximum $1000 that applies to other infringement notices under the RMA.

Any district or regional plan rules that are more stringent than requirements set in section 360(hn) will prevail over the regulations. The regulations may require a council to withdraw or amend plan rules that are inconsistent without using an RMA Schedule 1 process.

Table 1: The Clean Water Package proposes the following national stock exclusion rules:

	Pigs	Dairy cows (on milking platforms)	Dairy support	Deer	Beef Cattle

[3] 'Milking platforms' is the term used to describe the farms where cows are being milked, compared to 'dairy support' farms which graze cows when they have been dried off for winter. The proposed regulations would apply equally to all dairy cattle, but over different timeframes.

[4] Note that as these initial dates set in the consultation document have passed, new dates will likely be set when the regulations come into effect.

[5] http://www.legislation.govt.nz/act/public/1991/0069/latest/DLM239372.html?search=ts_act%40bill%40regulation%40deemedreg_resource_resel_25_a&p=1

Steeper land (>15°)	By 1 July 2017 Pigs must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2017 Dairy cattle on milking platforms must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2022 Dairy support cattle that are break feeding[6] must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2022 Deer that are break feeding must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2022 Beef cattle that are break feeding must be excluded from waterways over 1 metre wide, lakes and wetlands.
Rolling land (>3-15°)	By 1 July 2017 Pigs must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2017 Dairy cattle on milking platforms must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2022 Dairy support cattle must be excluded from waterways over 1 metre wide, lakes and wetlands.	By 1 July 2022 Deer that are break feeding must be excluded from waterways over 1 metre wide, lakes and wetlands. 1 July 2030 This then applies to all deer.	By 1 July 2022 Beef cattle that are break feeding must be excluded from waterways over 1 metre wide, lakes and wetlands. 1 July 2030 This then applies to all beef cattle.
Plains (0-3°)	By 1 July 2017 Pigs must be excluded from waterways over 1 metre wide, lakes and wetlands. 1 July 2020 This then applies to all waterways.	By 1 July 2017 Dairy cattle on milking platforms must be excluded from waterways over 1 metre wide, lakes and wetlands. 1 July 2020 This then applies to all waterways.	By 1 July 2022 Dairy support cattle must be excluded from all waterways, lakes and wetlands.	By 1 July 2022 Deer that are break feeding must be excluded from all waterways, lakes and wetlands. 1 July 2025 This then applies to all deer.	By 1 July 2022 Beef cattle that are break feeding must be excluded from all waterways, lakes and wetlands. 1 July 2025 This then applies to all beef cattle.

During the submission phase for the regulations, the NZ Freshwater Sciences Society and the Land and Water Forum) raised the following issues that are useful to keep in mind when considering the regulations or seeking that councils include more stringent measures (discussed further in section 3).

Issues raised by the NZ Freshwater Sciences Society:

- Excluding break feeding stock from waterways is particularly important since this practice has significant deleterious effects on water quality and stream and bank habitat. Given this, and the fact that break feeding is usually practiced with temporary fencing, the deadline for stock to be excluded during break feeding could be brought forward considerably.
- The exclusion of pigs and dairy cattle from all waterways on flat land should be immediate rather than by 2020.
- Provisions excluding break feeding or general exclusions from waterways <1 metre wide should be tightened up. Smaller waterways and headwater streams serve important ecological functions and deserve protection from stock trampling of habitat. In addition, contamination of headwaters from sediment and stock defecation should be avoided.
- Small streams and wetlands provide important biodiversity and ecosystem services, so stock should be excluded from waterways of any size [more of this later in this guidance].

[6] Break feeding is where stock are kept behind a temporary fence which is moved regularly to allow access to sections of the paddock at a time.

- Stock should be excluded from gravel margins and beaches of larger rivers—i.e., this is not clear in the current regulations, so councils may need to clarify the extent of the edge of a river for rules they create under these regulations.
- Setback distances from waterways are needed to ensure ecosystem health/habitat aspects of waterways are protected from stock trampling and water quality benefits are maximised. Setbacks should take account of slope and soil type. Setbacks also protect farmers from loss of fencing materials from regular flooding.
- Dairy support cattle should be treated in the same manner as milking dairy cattle. Although they have lower nutrient outputs than milking cattle, non-milking dairy cows have the same trampling impacts on habitats as milking dairy cattle.

Issues raised by the Land and Water Forum:

- Stock exclusion rules need to avoid impractical requirements like short intermittent stretches of fencing (e.g., five metres of fencing here, no fencing here, five metres of fencing here, etc.) on land with variable slopes.
- The use of 'exceptions' or 'alternative option' should be strictly limited. LAWF's fourth report recommended that: 'Exceptions from national and regional stock exclusion requirements should be provided in limited situations where large costs and significant impracticalities relative to the environmental benefits can be demonstrated…'

1.2 Regional council approaches to livestock access

Table 2 sets out the current state of stock exclusion rules in different regions. This highlights that there is a variable approach to stock exclusion. Monitoring and enforcement efforts are also variable. This table is included so that DOC staff can see what approach neighbouring regions have adopted; however, it was copied from the MfE draft regulatory impact statement prepared at the end of 2016 (MfE 2016), so please check the current plan provisions for any regions you may be interested in.

Table 2: Summary of current stock exclusion rules in regions as at December 2016. Source: MfE draft regulatory impact statement (MfE 2016).

Council	Summary of where and when stock exclusion rules apply	Status
Councils WITH current, proposed or draft region-wide stock exclusion rules		
Waikato	Priority waterbodies (in force)	Current
Bay of Plenty	Priority waterbodies (in force)	Current
Canterbury	Intensively farmed stock and priority areas (in force)	Current
Horizons	New intensive farming or existing intensive farming in priority areas (in force)	Current
Southland	Current rules: winter intensive grazing and priority waterbodies (in force) Proposed rules: where slope is less than 16 degrees; deer by 2020, other stock (except sheep) by 2018	Current Proposed
Marlborough	Intensively farmed stock, by 2022	Proposed
Gisborne	Winter intensive grazing by 2017 (riparian setbacks also required)	Proposed
Auckland	Intensive stock to be excluded by 2021 for lakes, wetlands and permanently flowing rivers/streams, and 2026 for intermittent rivers/streams	Proposed
Wellington	Similar to proposed national rules[7]	Proposed

[7] DOC submitted, and presented evidence on the stock exclusion rules of Greater Wellington Regional Council's proposed Natural Resources Plan. Refer to freshwater technical evidence, water quality evidence, and legal submissions.

Northland	Similar to proposed national rules[8]	Draft
Taranaki	Intensively farmed stock by 2020 (riparian planting also required)	Draft
Councils WITHOUT region-side stock exclusion rules		
West Coast	Stock access is a permitted activity (except for Lake Brunner catchment)	Current
Hawke's Bay	Stock access is a permitted activity (except for Tukituki catchment)	Current
Tasman	Stock access is a permitted activity (except at Te Waikoropupu Springs)	Current
Nelson	Stock access is a permitted activity	Current
Otago	Stock access is a permitted activity	Current

1.3 Stock exclusion on grazing concessions on public conservation land.

DOC currently authorises grazing to take place on public conservation lands within proximity of waterways, including marginal strips (via vegetation management agreements). Guidance regarding this activity is principally found within DOC's Conservation General Policy, as well as the General Policy for National Parks (and within the context of various Conservation Management Strategies and Conservation Management Plans). While the Conservation General Policy does not specifically call for reductions in grazing on PCL, it does note that criteria are to be considered before the granting of a grazing concession—these include existing use, adverse effects on waterways, erosion, and ensuring continued public access (Conservation General Policy, section 11.2). Conversely, many Conservation Management Strategies and national park management plans discuss proactively retiring grazing land. Nothing within current DOC policies limit internal decision makers from retiring expiring grazing concessions.

There are currently 672 active grazing concessions and 45 vegetation management agreements[9] registered within the permissions database. Overall, the number of active grazing concessions on PCL has declined since 2006 (Table 3). Reductions may be explained by 'phasing out' decisions derived from relevant policies, as well as treaty settlements, land transfers and disposals.

Table 3: Grazing licenses on public conservation land. Source: DOC website for information for financial years 2006–2014; Permissions database for calendar year 2017. Data currently unavailable for 2015–16.

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2017
Active grazing concessions	754	774	761	769	766	757	718	708	672

Permissions has developed an application process to meet the legal requirements of the Conservation Act (including requiring the completion of an impact statement where effects of the concession are unknown). DOC's standard grazing agreements contain specific guidance concerning fencing requirements to exclude livestock from waterways, and a requirement that an adequate ungrazed vegetation strip is to be maintained along all watercourses. Other conditions include:

- the use of electric fencing at a designated distance from waterways,
- low stock rates,
- adherence to regional water plans, and
- replanting of riparian areas.

There is nothing limiting decision makers from including *additional* restrictions and/or contractual requirements on grazing permissions holders on a case-by-case basis.

[8] http://www.nrc.govt.nz/contentassets/2fbd03768d21478cae1d87527806e172/regional-plan-fact-sheet---livestock-access-to-water-bodies---version-2.pdf

[9] Additional vegetation management agreements may exist that have not been captured in the Permissions Database—see DOC-2797686.

However, compliance is the most challenged, and challenging aspect of DOC's management of grazing adjacent to waterways. Collaborative work between compliance and permissions is currently underway (including revamped reporting and notification protocols). Enforcement improvements should remain a key focus for DOC in relation to this issue.

In summary, DOC's approach to stock exclusion on grazed public conservation land is through the following components:

1. Sound licensing agreements with permissions holders which includes restrictive covenants, conditions and indemnification clauses (current).
2. An on-going, robust compliance strategy to include development of forms, training, systematic enforcement and cataloguing of compliance (ongoing).
3. Re-evaluation of DOC policies as necessary to ensure that DOC's grazing positions are correct in light of Conservation Management Strategies, national park management plans and the proposed national stock exclusion rules (recommended, yet to be implemented).
4. Work to improve the capture of compliance data within the Permissions Database (recommended).
5. Coordinated communication with the public and permissions holders to redress concerns about grazing on PCL (on-going).
6. A willingness by DOC to retire or restrict current grazing activities on PCL as necessary (recommended).

2. What are the impacts of livestock access on freshwater and estuarine ecosystems?

2.1 What are the direct effects of livestock access to water?

Livestock access to stream beds and riparian margins can have significant adverse effects on freshwater fish habitat. Effects include: disturbance to the stream bed and banks (e.g., compaction and pugging of soil), collapse of stream banks, grazing and trampling of riparian vegetation, destruction of fish spawning habitat, and increased sediment and nutrient inputs to the waterway (e.g., Hickford & Schiel 2014, Williamson et al. 1992).

Compaction and pugging of soil

Livestock can affect soil structure in two ways: compaction and pugging. Pugging occurs when soils are very wet, usually close to saturation level, and the animals' hooves penetrate the surface soil—this squashes and buries plants and prevents water draining through the soil surface layer. Compaction occurs when soils are moist, but not saturated. The soil surface generally stays intact, so while animal hooves don't penetrate the soil, compaction still decreases the water storage capacity of the soil. Both of these effects increase surface water runoff (pugging more so than compaction) and can have long lasting effects on the soil if pastures do not recover sufficiently before being re-grazed.

Destruction of fish spawning habitat

Mitchell (1991, in Reeves & Champion 2004) investigated the effects of cattle grazing on whitebait spawning grounds in a riparian wetland next to the Kaituna River in the Bay of Plenty. He found that inanga (*Galaxias maculatus*) preferred to lay their eggs within the area that stock were excluded from, and also that survival rates were significantly higher where cattle had been excluded. It is likely that poor survival of eggs in grazed pasture is due to the direct effects of trampling and consumption, and indirectly as the result of plant removal, leading to desiccation and greater temperature fluctuations. The common practice of intense rotational grazing of cattle on riverbanks has been noted as having a greater impact than most other forms of grazing (Reeves & Champion 2004).

Other species of fish (e.g., a number of the non-migratory galaxias species) spawn on emergent instream vegetation which could be trampled on or grazed by stock in the stream.

Nutrient leaching

The main sources of nutrients to waterways in grazed pasture are animal dung and urine, industrial fertilisers, and soil particles suspended in water. Urine, which contains high nitrogen (N) in the form of ammonia (NH_3), is an easily leachable source due to its chemical properties in the soil (Monaghan et al. 2007), while dung contains a range of pathogens (e.g., *E. coli*) and organic material, including N, phosphorus (P) and potassium (K).

Sediment loss

Sediment particles carry a number of associated nutrients, but particularly phosphorus, which binds to soil, and contributes to increased algae growth. Sediment runoff occurs when soil particles are suspended in surface waters that drain into waterways. Sediment tends to settle on the bottom substrate and can smother aquatic life. Sediment can enter waterbodies from pugging and trampling of the steam banks which causes erosion, vegetation loss and soil loss. Sediment released from trampled beds and banks can clog the sensitive gill structures of macroinvertebrates and fish and reduce sight feeding opportunities for fish and bird species (McArthur 2017).

Sheep farming usually has a higher rate of sediment loss to waterways than dairy farming, but still lower than mixed stock and deer (McDowell & Wilcock 2008).

In summary, the key direct effects of livestock grazing adjacent to waterways are:

- Consumption of plant matter and consequent loss of shade.
- Trampling of riparian plants and fish habitat, and subsequent compaction of soil (pugging).
- Nutrient inputs.
- Microbial contamination from urine and faeces.
- Stream bank erosion from vegetation removal and trampling.

2.2 What are the indirect effects of livestock access to water?

A number of indirect effects also result from livestock access. These include smothering of fish and aquatic life through sedimentation (see the sediment guidance, DOC-2767706, for further information on the effects of sediment), nutrient toxicity from runoff (see the nutrients guidance, DOC-1556048, for further information), and the likely loss of marginal vegetation that provides shade (causing increased water temperatures, light penetration and aquatic plant and algal growth).

The indirect effects are summarised well by Hickford & Schiel (2014):

> 'Intense livestock grazing can impact growth of riparian vegetation through compacting soil and increasing run-off, removing foliage, and damaging vegetation through trampling and browsing. This, in turn, modifies the riparian microclimate by increasing ground-level temperatures and evaporation. Cattle and sheep preferentially graze riparian vegetation because of the better quality and variety of forage, shorter distance to water, and microclimatic features.'

2.3 How do different types of livestock affect waterways?

Dairy farming is the most intensive and high impact type of livestock grazing because pastures are more often irrigated, the animals are heavier, and they require a more varied diet than sheep or deer. Sheep typically have less impact on soil structure, hydrology and water nutrient inputs (the main factors affecting waterway health) than dairy, beef and deer.

Sheep tend to compact soils to a lesser extent than dairy cattle, as they weigh less, do not penetrate the soil so readily, and are mostly grazed on non-irrigated land (which is less likely to be highly saturated and compactable). Sheep are also generally less likely to enter waterways. Sheep produce smaller urine patches than cattle (and probably deer), but these can still be a problematic source of nutrients in areas of high runoff, such as steep hill country and water saturated soils (this is highly dependent on the porosity of the soil, stocking rates and local rainfall). Similarly, sheep farming typically requires lower and less frequent doses of industrial fertilisers so is usually less prone to nutrient leaching. The average nitrogen lost from the soil on NZ dairy farms, between 2006 and 2007, was 39 kilograms per hectare per year, compared with 12 kilograms for deer farms and 8 kilograms for sheep and beef farms (MAF 2008).

There may be some need for excluding sheep from waterways during winter crop grazing, as this practice typically causes greater surface runoff than usual pasture gazing (McDowell & Houlbrooke 2009). This would be particularly relevant during high rainfall events when soils are water saturated; although cattle still have a greater impact than sheep in this respect. Similarly, all livestock should be restricted from grazing newly cultivated or recently sown or tilled paddocks, as they easily absorb water and become more unstable and less resilient to treading by livestock. This may be addressed by the requirements in the proposed regulations to exclude stock from waterways during break feeding.

Deer are large animals capable of damaging water bodies. Some species of deer wallow, and these wallows can be major sources of sediment and pathogens when connected to other water bodies (MfE 2016).

Pigs can wallow in streams and wetlands in a similar way to deer, and are included in the proposed stock exclusion regulations. MfE's regulatory impact statement notes, however, that pigs are generally housed and therefore don't generally have access to waterways.

2.4 How are the effects of stock in waterways cumulative?

There are cumulative effects from stock accessing waterways. The inputs from grazing and access to waterways on one small lifestyle block may seem negligible on its own, but many small lifestyle blocks within one catchment can have concentrated effects further downstream, particularly if there are sensitive receiving environments, such as lakes or estuaries, downstream.

Increased winter flows can reduce the residence time of nutrients and sediment close to the source, but may be just transferring the impact to downstream ecosystems, such as lakes, wetlands and estuaries. Likewise, there can be cumulative effects of different types of stressors on waterways. For example, if there is a sheep farm with low nitrogen but moderate sediment (and therefore phosphorus, which binds readily to sediment) inputs upstream of a dairy farm, then the high nitrogen inputs from the dairy farm, additional to sediment/phosphorus inputs from the sheep farm, may cause the waterway to reach a tipping point.

2.5 How does land slope alter the effects of livestock access?

Slope is a key factor affecting the severity of impacts on waterways, primarily through increased rates of nutrient runoff and increased erodibility. These effects are also amplified by heavy rainfall and/or frequency of heavy rain fall events.

2.6 What are the impacts of livestock grazing in wetlands?

In addition to the general effects of livestock grazing on freshwater ecosystems discussed above, Reeves & Champion (2004) summarised the impacts of stock on wetlands as follows:

- Livestock grazing on plants in wetlands have been found to ultimately affect the structure and function of wetland vegetation. While the impacts of grazing do vary, and some plants seem to do well (even increasing their biomass and reproduction) when grazed, overall effects can greatly alter a wetland. Grazing can open up patches to invasion by weedy species, or favour species that do well under grazing over those that don't, changing the composition of vegetation in the wetland. When combined with other stressors, grazing can have significant adverse effects on some wetland plants.

The effects of grazing also differ between different types of stock—all stock do impact wetlands to some degree, but the scale of the impacts is variable and dependent on the type of stock.

- Grazing in wetlands can affect wetland fauna as well, including birds (e.g., fernbird, crake, bittern), invertebrates (e.g., dragonflies) and fish (e.g., mudfish). Effects range from damage to nests, burrows, spawning sites, mating perches, etc. and loss of suitable sites for reproduction, to a reduction in available habitat (resulting from decreased diversity of wetland vegetation and/or increase of weedy species, meaning on overall lower diversity of habitat).
- There is limited information on the effects that livestock grazing has on water and soil quality in wetlands, however, studies have found that: nitrate-nitrogen increased in heavily grazed fens; water quality is poorer in grazed wetlands (particularly those with higher intensity grazing); and trampling can alter soil structure and stability (especially when grazed during 'drier' times), reducing the ability for water to filter through the soil.

Managing grazing in wetlands

The effects of grazing are variable across different wetland types, and in some instances grazing has been found to have negligible effects, raising a question about whether some wetland types might be more resilient to livestock grazing, or whether there are some cases where conservation values could be managed through specific grazing regimes. For example, in some cases low densities of grazing sheep or cattle have been found to reduce woody, weedy species, and maintain a short turf, increasing the diversity of native vegetation. However, any potential benefits would only occur under low stocking rates, and should be assessed on a site-specific basis, taking into account the conservation objectives of each site and factors such as palatability, growth form and vigour of the native wetland species, as well as the general level of disturbance likely to result from stock type and stocking rate, to determine whether any level of grazing is appropriate.

Further investigation into the effects of grazing on wetlands should be conducted before grazing is considered as a potential management tool, as there are many associated detrimental effects that result from grazing. As grazing can also frequently result in an increase in weedy vegetation, rather than desired species, and wetlands where positive benefits from grazing have been found are those that have been grazed for a long period of time, it is questionable whether the grazing actually provides any long-term benefit. Other control options, such as targeted use of herbicides (which control weedy species without affecting native vegetation), are likely to result in better outcomes.

2.7 What are the impact of livestock grazing in estuaries?

Livestock trampling in estuaries has been found to have similar effects to those listed above for wetlands. Studies have found grazing causing impacts, although not always detrimental, to vegetation composition—e.g., some grazing opened up space for threatened species (Reeves & Champion 2004 and references therein). One NZ study found grazing resulted in a change to mangrove substrate, with macroinvertebrate densities in the aerobic mud layer appearing to be lower, and surface algae and seagrass absent in trampled areas (Bellingham & Davis 2008).

2.8 What are the effects of livestock access on recreational, aesthetic and cultural values?

From a recreational, aesthetic and cultural perspective, the biggest benefit of excluding stock from waterways is the removal of the direct contamination from faeces and urine. Disease causing organisms and sediment are two types of contaminants that can enter waterbodies from stock access, and that impact on recreational, aesthetic and cultural values.

3. When and where should council rules be more stringent than the regulations?

The exclusion of all stock from waterways is recognised as best practice. The national regulations recognise this, but also recognise the need to phase in the requirement for stock exclusion for certain land types to enable landowners to plan for the resourcing of this change in their land management. The regulations exclude certain types of waterways on the basis that the cost:benefit analysis does not warrant their inclusion. Councils have the ability to be more stringent than the national regulations, and this may provide DOC with an opportunity to advocate for more stringent provisions, particularly around the application of rules to more waterways in order to protect conservation values

3.1 Small streams on rolling and steep land

The proposed stock exclusion regulations apply only to permanently flowing rivers and streams over one metre wide on rolling and steep land, and all permanently flowing rivers and streams, regardless of size, on flat land with a slope of 0–3°. Streams smaller than one metre wide form the headwaters of larger rivers and can often have very high biodiversity values, often greater than those in larger streams. As they form the headwaters of all larger waterways, they have an impact on water quality in the rest of the catchment—what happens in these smaller waterways can have impacts further down the catchment.

However, the costs of including small streams has been deemed potentially high for some farms, and with practical difficulties in terms of farm management. Therefore, small streams on rolling or steep land have been excluded from the proposed national regulations.

Small streams less than one metre in width (e.g., headwater and tributary streams) provide important habitat for many species, often containing more variable, and greater amounts of the habitat preferred by native fish species than larger streams or mainstem rivers. For example, small streams can be more easily shaded by riparian vegetation, and (depending on the quality of the riparian vegetation) can have vegetation overhanging into the water, providing instream cover. Larger streams have higher flows and so cannot readily retain habitat features such as instream debris, shading, and steep, stable banks (e.g., Jowett et al. 2009; Meyer et al. 2007). Effects on stream habitat are also often more significant on small streams than large ones—for example, riparian vegetation may provide shading over the entire width of a small stream, but only a portion of a large one, so removal of riparian vegetation from a small stream results in a sudden change to habitat (e.g., Meyer et al. 2007).

Small streams, or headwater streams have the following hydrological and biodiversity values (TRC 2010):

- They provide natural flood control.
- They have the greatest surface area:soil ratio, so contribute the most to recharging groundwater and downstream systems.
- They are the most varied of running water ecosystems, providing a wide variety of different types of habitat.
- They support diverse, and often unique, invertebrate, fish and bird biodiversity.
- They provide crucial links between aquatic and terrestrial ecosystems.
- The hyporheic zone (the area below the surface of the stream) is where stream cleansing and nutrient processing occurs, and across the whole small stream network is proportionally greater than the area below larger streams.

Recent research has found that smaller streams contribute 77% of the national contaminant load (total N and dissolved reactive P) (McDowall et al, 2017).

Because of this, it is recommended that DOC advocate for the exclusion of stock from streams smaller than one metre on rolling or steep land, though being mindful that a targeted approach to prioritise catchments is more likely to be successful than a blanket regional approach. Sections 3.2 and 3.3 provide more detail on ways that exclusion of stock from small waterways, or of livestock other than cattle, pigs and deer, can be targeted to protect significant habitats, where seeking to exclude stock from all waterways across a region is deemed impractical.

3.2 Habitat for threatened species

Given that there are often practical difficulties in fencing all waterways, then, as a minimum, DOC should advocate to protect indigenous freshwater biodiversity and habitat for threatened fish species:

- Threatened species—stock should specifically be excluded from waterways containing populations of 'Threatened' and 'At Risk'[10] indigenous fish species. Some councils may identify these within regional plans, and these can also be checked or a list relatively easily compiled based on the New Zealand Freshwater Fish Database (NZFFD) records of threatened and at risk species. These waterways would ideally be updated as new survey records are found.
- Species Management Units (SMUs) identify DOC's sites for species management to achieve species persistence. SMUs for non-migratory fish species have been confirmed, and can be found in the Business Plan or in NATIS (if you use ArcGIS), or ask the Freshwater Team. Polygons for migratory fish species have been identified by the Freshwater Team, but have not yet been confirmed as SMUs, but could be provided by the Freshwater Team. While they do not identify the locations of all threatened species populations, SMUs and species polygons could be used to identify priority catchments for threatened species.
- Spawning habitats of the five migratory *Galaxias* species—inanga, kōaro, giant kōkopu, shortjaw kōkopu and banded kōkopu (i.e., the 'whitebait' species) all spawn in riparian habitats (e.g., Figure 1) during times of elevated flows, or during spring tides. The survival of eggs, and their spawning success, relies on the riparian vegetation providing a humid environment, shading from the sun, and regulating temperature. This means that their spawning habitats are particularly vulnerable to stock trampling and grazing. The juveniles of these five species also make up the whitebait catch, so are of recreational, as well as conservation, importance.
    - Inanga—the spawning habitats of inanga can be relatively easily identified, as spawning occurs in tidally-influenced reaches of lowland waterways, near the salt wedge (the interface between saltwater and freshwater). Eggs are spawned within understorey riparian vegetation that is only inundated during spring tides. The proposed national stock exclusion regulations should see the exclusion of stock from lowland rivers, however, some smaller streams (less than one metre in width) that provide spawning habitats for inanga may not be captured if they are not on land classified as flat (0–3° slope), or if affected by livestock other than cattle, deer or pigs. Depending on the type of livestock, exclusion rules may not come into effect for several years (up to 2025), which means that critical habitat for inanga may continue to be impacted for an extended period of time, unless more stringent rules are applied. Spawning habitat can be degraded relatively quickly (e.g., stock damaging riparian vegetation and collapsing banks through grazing and trampling of soil), however, restoration of degraded habitats can take many years. Inanga spawning habitats could be protected in all streams by excluding stock from the discrete sections of waterway around the salt wedge where spawning occurs, and the timing of exclusion rules brought forward for these areas.

Figure 1: Exposed inanga eggs in amongst moss and blades of tall fescue grass and herb plants. Photo: Pete Ravenscroft.

    - Giant kōkopu, shortjaw kōkopu, kōaro and banded kōkopu—there is only limited research regarding the location of spawning habitats for these species, which means that, unlike inanga, pin-pointing precise sections of waterways to target for stock exclusion would have some inaccuracy. Therefore, stock should ideally be excluded from the entire waterway where each of

[10] As per the New Zealand Threat Classification lists, and including species that are Threatened—Nationally Critical, Nationally Endangered and Nationally Vulnerable, or At Risk—Declining, Recovering, Relict and Naturally Uncommon. Goodman et al. (2014) contains the current conservation statuses for freshwater fish.

these species are present. However, where impractical to exclude stock from the entire waterway, GIS could be used to predict where spawning is likely to occur in waterways that contain these species, based on what is known about their spawning habitats, NZFFD records, and predicted fish distributions. Appendix II provides an illustrative example of how this method could be applied, however, it would involve a large amount of time and effort, and would only be a very coarse estimation with a high level of uncertainty (e.g., places where it was indicated spawning may occur may have no spawning, etc.).

3.3 At certain critical times of the year

Year-round stock exclusion from waterways is the ideal situation (a lot of damage to habitat can be caused outside of key times, such as spawning season—pugging of banks, destruction of habitat, increased sediment and nutrient inputs to the waterway, etc.), however, if this is deemed not possible, then excluding stock from waterways and riparian areas during spawning and migration times may at least result in better spawning success, egg survival and recruitment.

- During spawning—as noted above, the migratory *Galaxias* species (i.e., whitebait species) spawn in the riparian area during times of high flows or spring tides. Eggs are deposited amongst vegetation or detritus while it is temporarily inundated with water, then develop out of water (protected by the damp and humid conditions provided by the vegetation or detritus). Larvae hatch and are carried to the sea when the eggs are re-submerged on a following high flow or spring tide. Spawning success is very dependent on the nature and composition of available riparian vegetation and substrate, and survival of eggs after spawning is dependent on factors associated with the height and density of vegetation, especially ground-level temperature and humidity.

  To be effective, stock would need to be excluded for at least two months prior to the start of peak spawning season, to allow for vegetation to recover and re-establish spawning habitat. However, studies have found that it can take several years for vegetation to recover fully (i.e., not only increasing in height, but also the density of tillers, depth of aerial root wad and reduction in bare space—factors that are all critical for reducing temperature and increasing relative humidity, which are key to egg survival), improving the microclimate amongst the vegetation and resulting in greatly increased egg deposition and survival. Excluding stock from whitebait spawning habitats during only part of the year would therefore provide some protection for these species, but would not be as effective as year-round exclusion. Figure 2 shows the main spawning season, including peak spawning months, for the five whitebait species—though note that spawning can occur year-round.

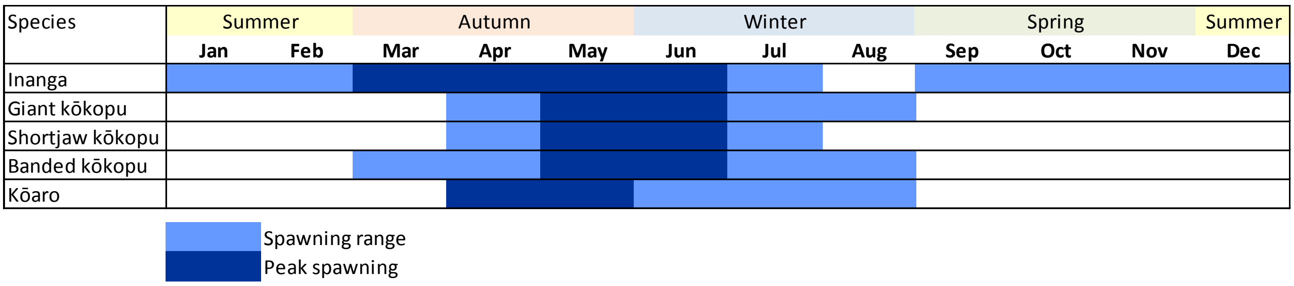

Figure 2: Spawning timing for the five migratory *Galaxias* species. Source for spawning times: Smith (2014).

  Exclusion of stock from spawning habitats also relies on accurate identification of spawning locations for each species—providing suitable habitat in the wrong place will not increase or improve spawning success. For inanga, spawning sites are well defined, occurring in tidally-influenced reaches of lowland waterways, near the salt wedge (the interface between saltwater and freshwater), and peak spawning usually occurs immediately after autumn spring tides. The other four species tend to spawn in flooded riparian vegetation or amongst detritus alongside adult habitat, however, spawning habitat requirements are less documented, and these species may live throughout a waterway (not just in defined reaches, or where recorded).

- During peak migration—exclusion of livestock from waterways during peak migration times is another important consideration, especially in waterways with high value or diverse native fish communities, as pugging etc. caused by stock in streams and on banks can cause large amounts of sediment (increasing turbidity in water which may impact fish ability to migrate) and/or destroying resting habitats utilised by these juvenile fish on their way upstream.
- Further information on critical habitats for threatened freshwater fish, timings of migration and spawning and regional timings identified in regional plans, can be found in DOCDM-1240041.

3.4 Riparian management or a setback buffer

The stock exclusion regulations do not mention the need for fences to be set back sufficiently from a waterbody in order to enable the establishment of a vegetated riparian buffer. This is another area where councils could apply more stringency than the regulations, and an area that DOC should advocate for. At a minimum, simply allowing the establishment of a thick sward of grass can be beneficial in terms of filtering sediment and nutrients. Native riparian planting is also desirable to stabilise banks and provide habitat for fish (e.g., shading, input of wood and detritus). Ideally, riparian margins should consist of continuous vegetation strips, rather than patchy areas of vegetation, as this provides greater bank stability and consistent stream shade, and excludes stock from directly defecating in waterways or tramping fish habitat.

There are a number of well recognised benefits in having a setback buffer zone, in addition to excluding stock from direct access to the waterway. Further detail on the importance of riparian margins is outlined in Appendix I. Benefits include:

- Filtration of overland flows, reducing inputs of sediment and contaminants (dense grass growth can achieve this).
- Uptake of excess nutrients from surface and sub-surface flows.
- Additional protection of stream banks compared to fencing alone, reducing erosion.
- Prevention of trampling and pugging near the river, thus further reducing soil loss and sediment inputs compared to fencing alone.
- Fences are less likely to be damaged by flooding.
- Increased organic matter to streams that provides food and habitat for aquatic life.
- Vegetation in a planted riparian buffer provides shade, keeping water temperatures more stable, and providing a more suitable environment for aquatic species including fish and invertebrates.
- Shade reduces the grown of algae in waterbodies.
- Stable vegetated banks provide a greater range and quantity of habitats for aquatic life.

However, despite these benefits, the requirement to set fences back sufficiently from the waterbody has not been included in the national regulations—largely because of regional variation and costs of riparian planting and maintenance—although this was the subject of some submissions. From a conservation perspective, excluding stock from waterbodies is only the start of addressing restoring ecological health, an appropriate riparian buffer, ideally planted, is also essential.

It is telling to note that the Land and Water Forum submitted on the proposed stock exclusion regulations highlighting that they were concerned about the lack of reference to riparian management. Recommendations 31 and 39 and 41 of the Forum's fourth report[11] stated that:

> 'The national stock exclusion regulation should include a requirement that when permanent fences are erected to exclude stock, they should be placed the appropriate distance back from the waterway. The appropriate setback distance will vary at different points along the waterway and will be determined by an on-farm assessment required as part of GMP, as per recommendation 39 of this report.'

and

[11] http://www.landandwater.org.nz/

> 'Riparian setbacks and management strategies should be included in GMP requirements, either as part of industry GMP schemes or council GMP rules, where they are an appropriate mitigation…'

and

> 'Councils should impose riparian setback and management rules over and above GMP requirements in catchments with specific water quality issues, where this is an effective way of managing a particular issue. Councils should also consider catchment-specific riparian management rules for critical source areas and areas of specific ecological, social or cultural value.'

Given that the Forum's reports were the product of consensus amongst a wide range of stakeholders, it would be helpful to draw attention to this if subsequent discussions mean those same stakeholders start to withdraw their support from the consensus developed through the forum.

3.5 Outstanding waterbodies and regionally significant wetlands

The proposed regulations are anticipated to apply to wetlands, lakes and large permanently flowing rivers and streams over one metre on rolling and steep land, and all permanently flowing rivers and streams, regardless of size (MfE 2016). Regionally significant wetlands should therefore be captured. However, an issue remains regarding the date at which stock are required to be excluded from these waterbodies.

Therefore, DOC should advocate for bringing forward the dates for which stock are excluded from regionally significant wetlands. These wetlands should be under active management with respect to stock access, fencing and management of pests. Allowing sheep into regionally significant wetlands should be determined on a case by case basis, rather than permitted, in order to provide for the significant values of the wetland in question (McArthur 2017).

As the proposed regulations currently stand, smaller streams on rolling and steep country that feed into outstanding waterbodies will not be included. As outlined in section 3.1, DOC should also advocate for the exclusion of stock from streams less than one metre in width in rolling and steep country, particularly those that flow into outstanding waterbodies.

3.6 Additional stock

Sheep and goats are not mentioned in the proposed national regulations on the basis that they are smaller and prefer not to enter waterbodies. As noted above, the impact of sheep grazing adjacent to waterways are less than cattle. Therefore, they do not necessarily need to be permanently excluded from waterways, however, DOC should advocate that temporary fencing at the least is desirable when grazed on steep hill country that receives high rainfall (frequently and/or intensely), and also when grazing winter forage crops.

Further Reading

Agricultural Good Management Practice GMPs and mitigation strategies:

- Assessment of strategies to mitigate the impact or loss of contaminants from agricultural land to fresh waters. R.W. McDowell, B. Wilcock, D.P. Hamilton, 2013. Report prepared for MfE. https://www.mfe.govt.nz/sites/default/files/assessment-strategies-mitigate-impact-loss-contaminants-agricultural-land-freshwater_0.pdf
- Industry-agreed Good Management Practices relating to water quality. FAR, NZ Pork, DairyNZ, Beef and Lamb, HorticultureNZ, Deer Industry New Zealand, 2015. Prepared for Environment Canterbury. http://www.ecan.govt.nz/publications/General/Industry_Agreed_GMPs_A5_Version2_Sept2015_FINAL.pdf
- Practices to improve water quality for dairy, cropping, and drystock farms. http://www.waikatoregion.govt.nz/menus/

Managing waterways on farms

- Managing waterways on farms: A guide to sustainable water and riparian management in rural New Zealand. http://www.mfe.govt.nz/publications/fresh-water-land/managing-waterways-farms-guide-sustainable-water-and-riparian
- Stocktake of diffuse pollution attenuation tools for New Zealand pastoral farming systems. L.A. McKergow, C. Tanner, R.M. Monaghan, G. Anderson, 2007. NIWA client report HAM2007-161, prepared for Pastoral 21 Research Consortium. https://www.niwa.co.nz/sites/niwa.co.nz/files/import/attachments/stocktake-v10.pdf

Factsheets for farmers on fencing:

- Dairy NZ guide on fencing waterways: https://www.dairynz.co.nz/media/2071976/fencing-waterway-technote.pdf and https://www.dairynz.co.nz/environment/waterways/fencing-waterways/
- A guide to managing stock access to waterways in the Wellington Region http://www.gw.govt.nz/assets/Our-Environment/Land%20and%20soil/WGNDOCS-962755-v1-ManagingStockAccesstoWaterwaysintheWellingtonregion-FINAL.PDF

Review of impacts of agriculture on freshwaters:

- Review of the environmental effects of agriculture on freshwaters. S. Parkyn, F. Matheson, J. Cooke, J. Quinn, 2002. NIWA client report FGC02206, prepared for Fish and Game NZ. http://docs.niwa.co.nz/library/public/FGC02206.pdf

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McArthur, K. 2017: Statement of Evidence on behalf of the Minister of Conservation—Hearing 2 of the Greater Wellington Proposed Natural Resources Plan. LINK

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Appendix I: Benefits and principles around riparian restoration

Extract from information gathered by Philippe Gerbeaux for the Living Water Project.

Why riparian restoration?

Riparian restoration has been occurring in New Zealand for over 30 years, with the main objective being to buffer the aquatic systems from surrounding land use (Quinn et al. 1993).

The riparian zone is identified as the vegetated strip of land extending along the banks of rivers, streams, lakes and wetlands (Parkyn et al. 2000). It is the link between the stream environment and the terrestrial catchment, with a disproportionately large influence on community structure and water quality relative to its proportion of catchment area (Harding et al. 2009; Kauffman & Krueger 1984; Osborne & Kovacic 1993).

Functions performed by the riparian zone include bank stabilisation, flood control, reductions in peak flow during floods, stream temperature regulation, stock exclusion (reducing bank trampling, defaecation in-stream, stock losses and waterborne illness), filtration of surface runoff reducing in-stream sedimentation and nutrification, provision of organic matter in-stream as a food source, and provision of habitat for fish spawning and adult phases of aquatic invertebrates (Collier et al. 1995; Fennessy & Cronk 1997; Jorgensen et al. 2000; Kauffman & Krueger 1984; Lowrance et al. 1984; Osborne & Kovacic 1993; Parkyn et al. 2000, 2003).

Riparian zones planted with native species add to indigenous biodiversity. They can also play an important role as ecological corridors or linkages between other areas of established native planting. These corridors are ecologically important in providing links for dispersal, migration and genetic exchange, nutrient transport and energy flow (Davis & Meurk 2001). The effectiveness of fenced and planted riparian areas in fulfilling these functions is now widely accepted (Wood & Howard-Williams 2004).

Riparian management and restoration principles

The close relationship of the riparian zone with the in-stream system makes it a particularly important area for mitigation strategy focus (Quinn et al. 1993). Because of the functions listed above, stream restoration efforts in New Zealand (as well as around the world, including Australia, Japan, Europe and the United States), are focussing on riparian management to buffer the impact of land use on the aquatic environment (Harding et al. 2009; Parkyn et al. 2000; Quinn 2009).

The width, plant composition and plant density are important factors that should be considered when establishing a vegetated buffer (Parkyn et al. 2000). The width of riparian zone that is required to sustain terrestrial and in-stream habitat depends on a number of factors. Between projects, the aims of the planting, channel width, bank slope, vegetation type, position in the stream continuum and hydrological type will vary (Collier et al. 1995; Quinn et al. 2001; Reeves et al. 2004). These variations mean that a 'one size fits all' approach to planting rarely exists, and sites should be considered on a case by case basis (Quinn et al. 2001).

Indigenous plants initially may not be as vigorous as poplars or willows in stabilising stream banks, however they are better for long term stability and sustainability, because exotic species frequently require ongoing management (Parkyn et al. 2000). Ideally, a planted buffer strip would be self-sustaining and of minimal maintenance; protecting water quality and aquatic habitats, suppressing weed growth and forming a seed bank to allow natural regeneration (Parkyn et al. 2000).

Studies comparing multiple widths of planted buffers at the same location have showed that increasing buffer width results in increasing sediment and phosphate removal (Parkyn 2005).

A width of more than 10 metres on either side of the waterway has been recommended as the minimum necessary width for terrestrial biodiversity outcomes and to achieve a self-sustaining strip. Riparian zones with a width of less than five metres on each side of the waterway are unlikely to support self-sustaining vegetation, and weed growth can be a problem (Parkyn et al. 2000). Davis and Meurk (2001) suggest that a buffer between 15 and 20 metres wide on either side of the waterway is most likely to support self-sustaining plant populations with minimal maintenance while meeting most aquatic functions.

There is little known about the minimum length of buffer required for stream recovery, however, this will greatly depend on the size of the stream and the variable targeted for reduction (Scarsbrook & Halliday 1998). In spite of the benefits, restoration from the headwaters through to the river mouth is often unrealistic due to the significant cost and private land ownership. Discontinuous restoration is the next best thing, and is likely to mitigate some impacts of land use (Scarsbrook & Halliday 1998).

Establishing a closed canopy is also recognised as being important, though this will not happen immediately after planting occurs (Parkyn et al. 2000; Wood & Howard-Williams 2004). Canopy closure is important because it provides shading to the channel, thus moderating water temperature and reducing light levels, minimising water weed establishment and growth (Davis & Meurk 2001). To help achieve a closed canopy in a reasonably short time frame, and provide ground shading to reduce competition from weed species it is generally recommended that seedlings are planted at a distance of 0.75–1.1 metres apart (Parkyn et al. 2000).

In-stream conditions observed at a site are reflective of land use and management practices occurring upstream (Collier et al. 1995; Parkyn & Wilcock 2004). When attempting to influence a river through planting in the riparian zone, consideration needs to be given to conditions and management practices upstream. Riparian planting should be considered as a secondary restorative measure after controlling the addition of pollutants at their sources (Barling & Moore 1994).

Timescales are another important consideration in riparian planting (Collier et al. 1995). Riparian management is a long-term task, which requires ongoing maintenance and investment. The beneficial results provided by a riparian zone are not immediate, and may take many years to become apparent. Some studies have indicated that stream conditions may worsen before improvements are seen. This is particularly the case where channel widening occurs following shading (Davies-Colley 1997). Because of this, there is a need to keep expectations realistic to avoid disappointment (Davies-Colley 1997). It is also important that realistic targets are set, as it is probably impossible to restore the riparian area and water quality to conditions before land modifications began (Collier et al. 1995).

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For further information about riparian restoration:

The Waikato River Care website contains a link to a useful 'how to' guide on riparian restoration best practice in the lower Waikato River. While some of the information, and the suggested plant species listed, are relevant only for the Waikato, the principles in this guide are useful and applicable for all riparian restoration works. LINK

Environment Canterbury Regional Council. 2011. Riparian zones – a guide to the protection of Canterbury's rivers, streams and wetlands. Pamphlet E04/70. 7p.

Trees that count – guides for restoration in different regions.
https://www.treesthatcount.co.nz/resources/regional-guides-for-planting-natives/

Appendix II: Illustrative example of targeting sensitive waterways for threatened species

The following maps and method provide an illustrative example of how sensitive habitats for threatened species could be identified, based on identification of possible spawning locations for four of the migratory *Galaxias* species—giant kōkopu, kōaro, banded kōkopu and shortjaw kōkopu. The maps have been developed for one catchment only (Waitohu Stream in Wellington Region), and only aim to provide an example of how it might be possible to target only parts of the waterway for full livestock exclusion. They do not represent DOC's views on specific locations that livestock should be excluded from in that catchment.

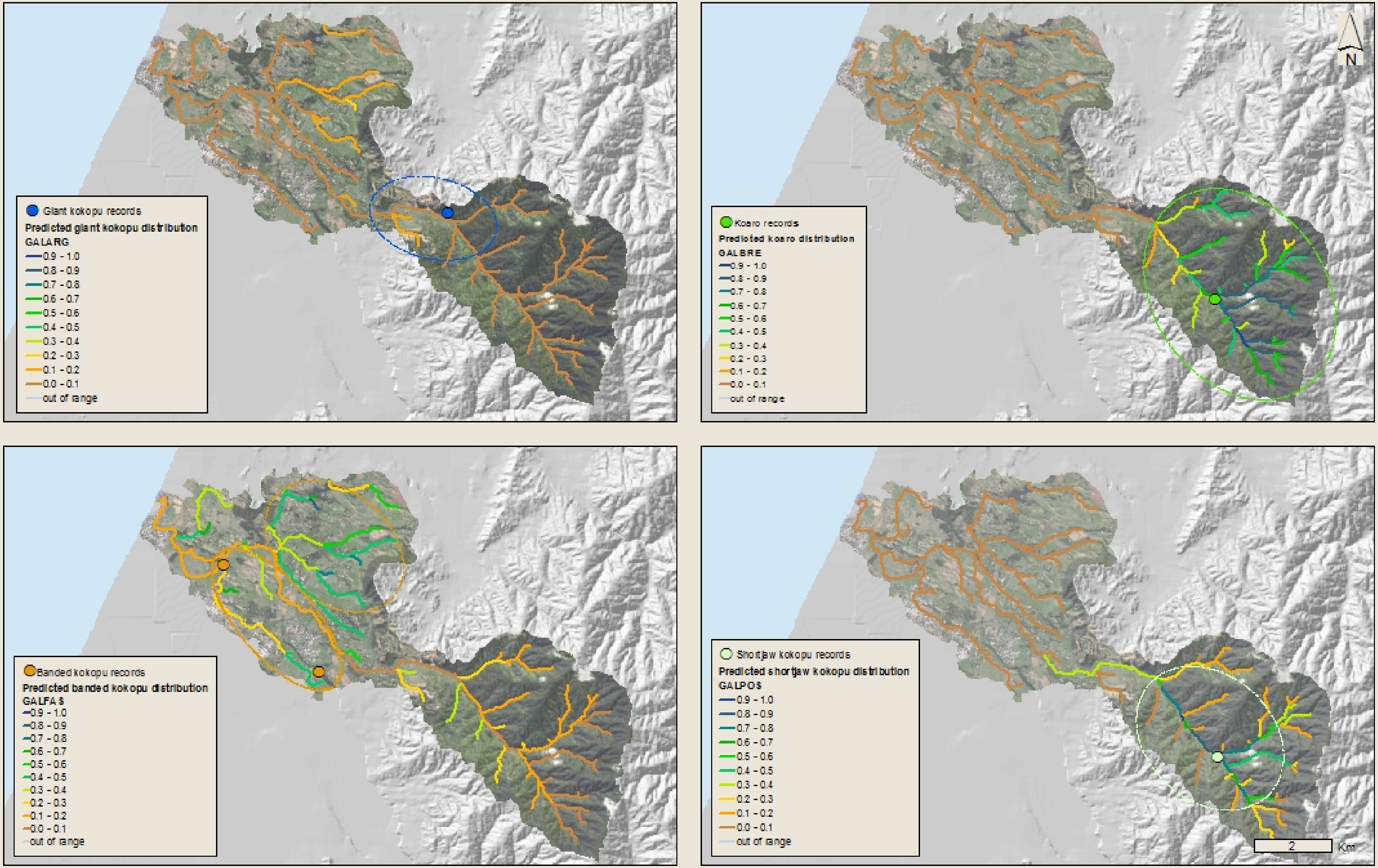
All five *Galaxias* species (including inanga) are present in this catchment, so for this particular example, it would be ideal if stock were excluded from much of the catchment, if not all—as if fish are present in the places shown, then they're likely to be throughout the rest of the catchment as well. An interesting picture might be shown in larger catchments, or those with only one or two galaxiid species in them.

Estimates of likely sensitive habitats for spawning are based on what is known about the spawning habits and habitat requirements of each species, records of where fish have been found (from New Zealand Freshwater Fish Database (NZFFD) records), and predictive models of fish distribution (note that predictive models have only been used to complement actual survey records, especially as only a few records exist for each species; actual presence of fish from survey records takes precedence over low predictions for a species). This is, however, only a very coarse representation, with inherent inaccuracy due to:

- Inaccuracies of the fish predictive model (while good in certain areas, no predictive model can be correct 100% of the time).
- The limited amount of knowledge about spawning habitats and locations for kōaro, giant kōkopu, shortjaw kōkopu and banded kōkopu.
- Survey records from the NZFFD that are old/not recently surveyed, so may not accurately represent what is present in the waterway now.
- Gaps in survey records—absence of fish records from a site is not necessarily a reflection of absence of fish from that site or stream, but usually a result of bias of where sampling has been undertaken.
- If records show a species to be present in one part of the catchment, then there is a likelihood that they are distributed throughout the catchment (particularly true for catchments that only have a small number of survey records).

Notes to help with interpretation of the maps:

- **Giant kōkopu**—predictive models all have very low predictions of giant kōkopu within the catchment, so aren't much use for predicting where spawning might occur; however, there is one NZFFD record for giant kōkopu in the catchment, so they are obviously present (despite low predictions). So, given that giant kōkopu spawn alongside reaches where the adults live, likely spawning habitat could be expected to be in the area around the survey record.
- **Kōaro**—the NZFFD contains a record for kōaro in this catchment, and fish prediction models also indicate that kōaro are likely to be present in habitat in the upper reaches of the catchment. Although in this instance this area appears to be in forest cover, if there was farming here, this would be the area that livestock should ideally be excluded from.
- **Banded kōkopu**—there are two records for banded kōkopu, both in the same tributary of the lower Waitohu Stream. Spawning habitat could therefore be expected to be along this entire reach (even though predictions are low in the middle of the reach); as well as in parts of the northern tributaries, where banded kōkopu predictions are high.
- **Shortjaw kōkopu**—as with kōaro, predictions for shortjaw kōkopu are reasonably high in the upper reaches of the catchment, and there is also a shortjaw kōkopu record in these upper reaches, so spawning would be expected here.



NZGD 2000 New Zealand Transverse Mercator
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Map of likely spawning locations for giant kokopu,

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