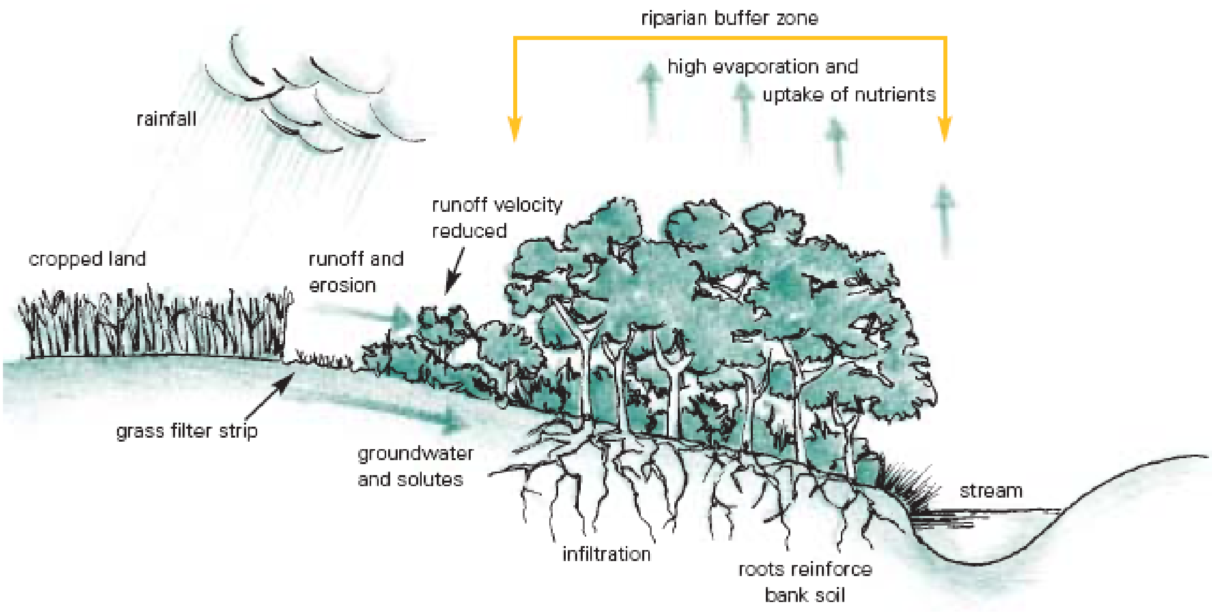

How a riparian vegetation buffer and grass filter strip combine to trap sediment, nutrient and other contaminants. Illustration The Idea to Here.

Figure 3: Conceptual model of the effect of riparian zones on runoff hydrology and filtering of sediment and nutrient (Source: Lovett and Price 2007)

Most of the empirical research on the use of buffer strips as mechanism for filtering overland flow has focused on the use of densely planted grass to reduce flow velocity from agricultural runoff, leading to the deposition of valuable topsoil and attached nutrients (See for example, Dillaha *et al.* 1989). Dense vegetated strips have been found to trap sediment efficiently provided that the flow height is less than the height of the vegetation (Barfield *et al.* 1979). In a study of grassed buffers, Hairsine (1996) found that whilst sediment removal efficiency was around 90%, trapping of phosphorous was only around 50% effective. The reason for this was that the grassed filter strips were less effective at trapping finer, clay-sized particles to which the phosphorous (and other nutrients) are attached. Similar results have been confirmed by other empirical studies, suggesting that grassed buffer strips were more effective at removing coarse sediment and aggregates than finer, clay-sized or organic particles and attached nutrients (Dillaha *et al.* 1989; Mayer *et al.* 2006).

In terms of riparian vegetation filtering sediments and nutrients in overland flow, McKergow *et al.* (2004) cited studies demonstrating that riparian vegetation in its natural condition can also trap between 40% and 95% of sediment loads; however noted that the variation in performance was large. The reason for this is that grassed filter strips tend to result in slower, more uniform flow than in natural riparian vegetation where understorey vegetation distribution is uneven (e.g. occurs in clumps) and often sparse, leading to distributed runoff along preferred pathways around tree trunks and roots (Prosser *et al.* 1999). As a result of this,

Prosser *et al.* (1999) suggested that the use of forested riparian zones buffers need to be wider that grassed buffers to achieve the same trapping efficiency.

Higher attenuation rates for sediment have been reported for buffers which combine grassed filters strips and native riparian vegetation (Hairsine 1996; McKergow *et al.* 2004), with Price *et al.* (2004) recommending a minimum riparian buffer of 10m from top of bank with additional grass filters based on catchment soil loss rates and filter slope. Prosser *et al.* (1999) suggested forested buffers of 10m from top of bank on low gradient lands (<5% slope) with an additional 5m dense grassed strip on steeper riparian land; noting that wider buffers are only necessary in areas where surface erosion rates are very high (e.g. Wet Tropics bioregion).

Overall, riparian vegetation has been shown to act as an effective means of trapping sediment, particularly coarse sediment and to a lesser extent nutrient, in overland flow. The effectiveness of riparian vegetation as a physical filter has been shown to be enhanced by combining with an additional grassed buffer. Evidence from the scientific literature supports the conjecture that the establishment and maintenance of riparian zones of at least 10m, when combined with additional grassed buffers of 5m or more, could contribute to the maintenance of water quality via the filtering of sediments and attached nutrients in runoff.

The next section reviews the role of riparian vegetation in the biological transformation of nutrients.

3.2.2 BIOLOGICAL TRANSFORMATION

Biological transformation is the second of the two main mechanisms whereby riparian zones act as filters for sediment and nutrients in runoff (Prosser *et al.* 1999). Biological or biologically-facilitated processes which take place in riparian zones to reduce nutrient delivery to waterways include:

- Uptake of physically deposited (and transformed) nutrients (nitrogen and phosphorous) by riparian vegetation (e.g. soluble phosphorous being absorbed by plants).
- Biological transformation of dissolved nutrients into forms which can be taken up by riparian vegetation (e.g. nitrification[2] or absorption of dissolved nitrate, NO_3^-), and,
- Reactions in organic riparian soil and stream-bed sediments which convert nitrate to nitrogen gas which is liberate to the atmosphere (denitrification).

These transformations are facilitated by organic, moist soils which are characteristic of forested riparian zones which, together with high plant density and biomass, promote the biological transformation and storage of nutrients transported in shallow groundwater in the riparian zone (hyporheic zone).

One of the main nutrients which enter streams from shallow groundwater (subsurface) flow is nitrate (Hill 1996; Prosser *et al.* 1999; Mayer *et al.* 2006). Nitrogen has been shown to be a limiting factor in regulating the growth of nuisance algae which contribute to poor water quality in freshwater streams in south east Queensland (Abal *et al.* 2005). Total nitrogen, oxides of nitrogen (including nitrate) and isotopes of nitrogen ($\delta^{15}N$) have been adopted as water quality indicators in south east Queensland (Queensland Environmental Protection Agency 2007). Riparian denitrification, a microbial process whereby soluble nitrate in the hyporheic zone is converted to nitrogen gas, has been shown to important in the reducing nitrogen delivery to streams (Mayer *et al.* 2006). Denitrification is an important nutrient removal mechanism in ecosystems because; unlike other transformations such as uptake by plants, the liberated nitrogen gas is completely removed from the system. Denitrification in riparian zones of perennial streams primarily occurs via two mechanisms: firstly, as base flow passes though the riparian zone and secondly, as stream water is stored in banks when a flood wave passes (Hunter *et al.* 2006) (Refer to Figures 4 & 5). In ephemeral streams, denitrification occurs via the interaction between surface water and the hyporheic zone in areas where a localised perched shallow groundwater table can form (Hunter *et al.* 2006) (Refer to Figure 6).

[2] Creation of nitrate from biological oxidation of ammonia

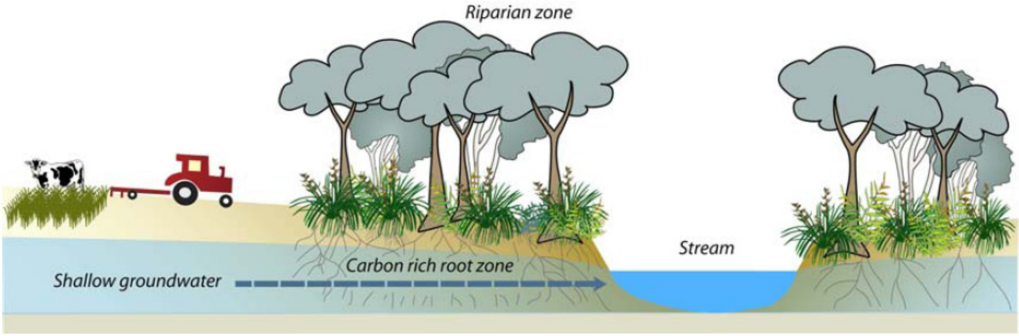

Figure 4: Groundwater interaction with riparian buffers in perennial streams: baseflow component (Source: Hunter et al. 2006)

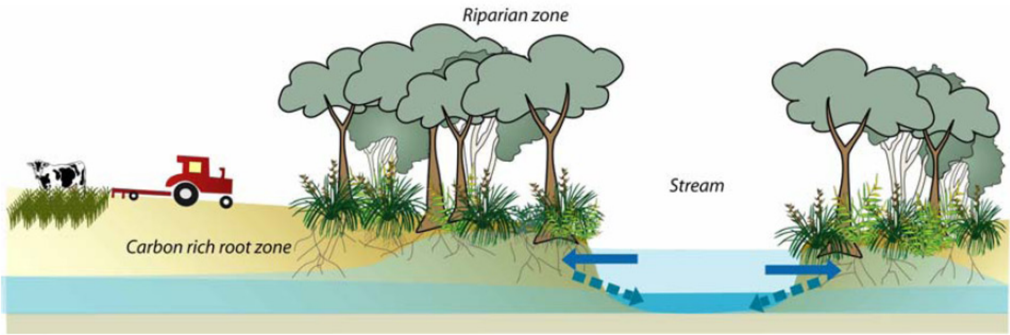

Figure 5: Surface water interaction with riparian buffers in perennial streams: bank storage during flood events (Source: Hunter et al. 2006)

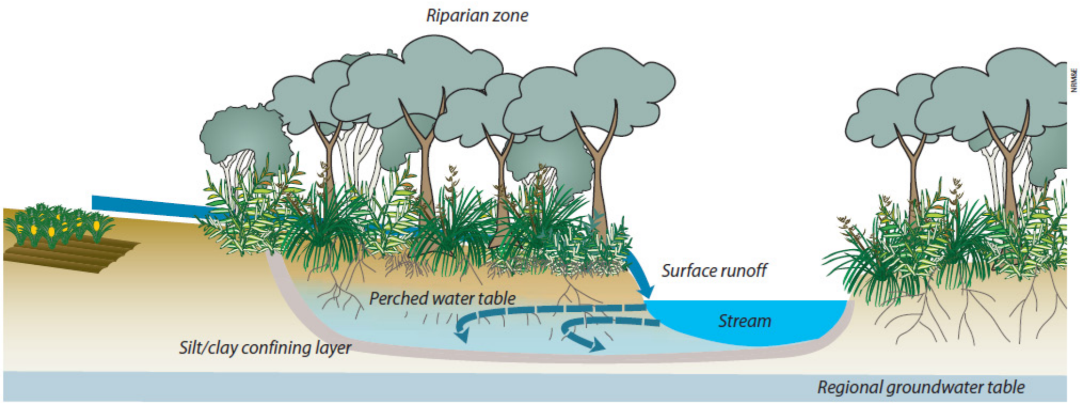

Figure 6: Surface water interaction with riparian buffers in ephemeral streams (Source: Hunter et al. 2006)

In overseas research, Hefting and de Klein (1998) measured the difference in nitrate concentrations in shallow groundwater at the boundary of an agricultural field and the edge of an adjacent waterway. They found that nitrate concentrations rates were greater at the edge of the field (greater than 40mg/L) than at the edge of the waterway (0.1–2 mg/L). Results suggest that nitrate concentrations in groundwater decreased by 95% when it flowed through the riparian buffer zone (Hefting and de Klein 1998). Hefting and de Klein (1998) also noted that forested riparian buffers were more effective at denitrification than grass buffers.

Australian research into the role of riparian denitrification has been limited; however a recent empirical study by Hunter *et al.* (2006) using riparian soils from Coochin Creek, south east Queensland, found that riparian denitrification was significant in reducing nitrate delivery to streams. Hunter *et al.* (2006) found that rates of denitrification were shown to increase with increasing soil carbon content and rates generally increased substantially with the addition of bio-available carbon. Riparian vegetation is also the primary source of carbon in the hyporheic zone and forest soils typically contain higher soil carbon content than soils under cleared/pasture conditions (Hunter *et al.* 2006). Thus, the presence of riparian vegetation is a limiting factor in the rate of riparian denitrification.

Hunter *et al.* (2006) noted that riparian denitrification effectiveness was likely to vary spatially according to soil types and topography. Riparian denitrification was likely to be more effective in riparian vegetation which had the following characteristics:

- low in the landscape (alluvial soils),
- flat (i.e. slopes less than 3%),
- relatively shallow stream banks, and,
- soils with moderate hydraulic conductivity to allow for denitrification to occur.

Similarly, Mayer *et al.* (2006) concluded that riparian buffers will be most effective at controlling nitrogen through denitrification when the following conditions are met:

- water flow (overland and subsurface) is uniform
- soil infiltration rates are high
- anaerobic (saturated) conditions persist in the subsurface, and,
- sufficient organic carbon is present[3].

These characteristics can be mapped and interpreted with the aid of geographical information systems and a digital elevation model (DEM). Such techniques could be used to identify riparian areas in the Moreton Bay Regional Council catchment area which are likely to contribute to riparian denitrification.

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[3] Riparian vegetation roots and associated mychorizae are the primary source of organic carbon in the hyporheic zone.