3.0 METHODS

3.1 Study Region

The study area was located within the west and south Gippsland dairy regions of southeastern Victoria. All sites were within the areas governed by the West Gippsland Catchment Management Authority (WGCMA). The WGCMA boundaries extend from the alpine areas below Mansfield in the north to Wilson's Promontory in the south and from Warragul in the west to Sale in the east (see Figure 1). West Gippsland is divided into 3 state-recognised river basins; the Latrobe and Thomson basins, which flow to Lake Wellington in the east, and the South Gippsland basin that flows to the southern coast and adjacent inlets.

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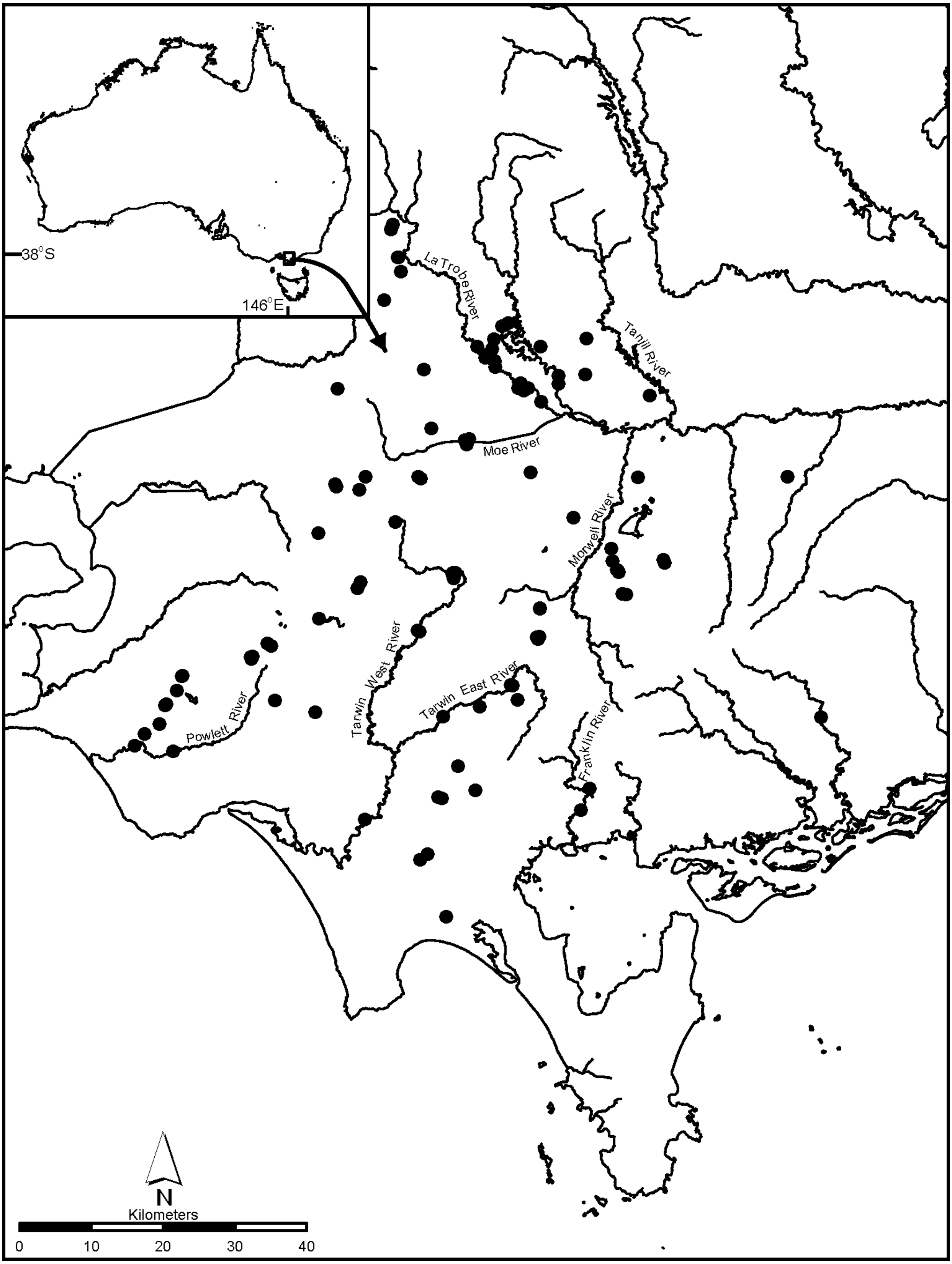

Figure 1. Map of the study area showing the south and west Gippsland dairy regions and the location of the survey sites and reference sites. Some dot points are indistinguishable as they are close together.

Industry in the area is dominated by those that draw directly from the region's natural resources (e.g. agriculture, electricity and forestry) with the region being the most densely settled area in the state outside metropolitan Melbourne (Waterwatch 2000). Agriculture is dominated by dryland pasture farming usually of dairy and beef cows. Dairy farming in the region began in the mid 1800's with extensive clearing throughout the catchment continuing well in to the 1950's (Anon. n.d.). The average herd size is 166 milking cows. This number is steadily increasing as smaller farms succumb to competition from larger farms and the difficulties of farming small acreage on steep land.

The area experiences warm dry summers (average maximum 24.0 ºC in January) and cold wet winters (average maximum 12.2 ºC in July). The study area takes in the designated bioregions of the Gippsland Plain and the Strezlecki Ranges. Mean annual rainfall ranges from approximately 900mm in the drier Gippsland Plain up to 2000mm in the much wetter Strezlecki Ranges (Bureau of Meteorology 2003). Topography varies significantly across the two bioregions. The Gippsland Plain includes lowland coastal and alluvial plains characterised by gently undulating terrain, while the Strezlecki Ranges consists of moderate to steep slopes with deeply dissected blocks of sandstone, siltstone and shales (DPI 2002). The rich soils support wet and damp forests as well as shrubby foothill forest.

Each bioregion has distinctly different vegetation communities and consist of different Ecological Vegetation Classes (EVC's). Each EVC represents one or more floristic communities that occur in similar types of environments and tend to show similar ecological responses to environmental disturbance (DPI 2002). Each bioregion has dominant known and expected (pre 1750's) EVC's.

The Gippsland Plain is dominated by the Lowland Forest EVC. The floristic community of this EVC is severely depleted due to intensive clearing for agriculture. Soils vary from damp sands to sandy topsoils over gravel or clay subsoils. Dominant overstorey vegetation includes White Stringybark *(Eucalyptus globoidea*), Narrow-leaf Peppermint (*Eucalyptus radiata*), Blackwood *(Acacia melanoxylon*) and Silver Wattle (*Acacia dealbata*). Austral Bracken *(Pteridium esculentum*), Kangaroo Grass

(*Themeda triandra*) and various Tussock species (*Poa* spp.) would have dominated the dense groundcover (RFA 1999). (See Appendix 1a for detailed species list and EVC description).

The Strezlecki bioregion supports three major EVC's being Wet Forest, Damp Forest and Shrubby Foothill Forest. The Wet and Damp Forest EVC's support similar floristic communities with Wet Forest more common on topographically protected high rainfall areas and headwaters of south flowing streams and Damp Forest (see Appendix 1b) extending to lower elevations and rainfall areas. Dominant eucalypts include Messmate (*Eucalyptus obliqua*), Mountain Grey Gum (*Eucalyptus cypellocarpa*) and Blackwood (*Acacia melanoxylon*) with Mountain Ash (*Eucalyptus regnans*) more dominant in Wet Forests (see Appendix 1c). Typical understoreys include a variety of moisture dependent fern species such as Rough Tree fern (*Cyathea australis*), Soft Tree fern (*Dicksonia antarctica*), Common Ground fern (*Calochlaena dubia*) and Mother Shield fern (*Polystichum proliferum*) (RFA 1999).

Shrubby Foothill Forest occurs in habitats at the drier end of Damp Forest on fertile well-drained soils. This EVC is dominated by overstorey species of Narrow-leaf Peppermint (*Eucalyptus radiata*), Messmate (*Eucalyptus obliqua*) and Mountain Grey Gum (*Eucalyptus cypellocarpa*). Ground cover is very species poor and includes Austral Bracken *(Pteridium esculentum*) and Tall Sword-sedge (*Lepidosperma elatius*) (RFA 1999) (see Appendix 1d).

3.2 Study design

All sites were riparian areas on dairy farms with no major irrigation. Sites were divided into stream size categories; tributaries and small creeks (1^{st} - 2^{nd} order streams), and large creek and rivers ($\geq 3^{rd}$ order streams). In most cases small stream sizes occurred in the Strezlecki Ranges (hilly) bioregion and larger creeks and rivers occurred on the Gippsland Plain (flats). These two stream size categories were then each further spilt into two site categories: a) remnant or planted and b) grazed (see Figure 2).

Although the study involved a balanced design, site selection was random within each of the four final categories. Size of creeks and their current management were not known until arrival at the site.

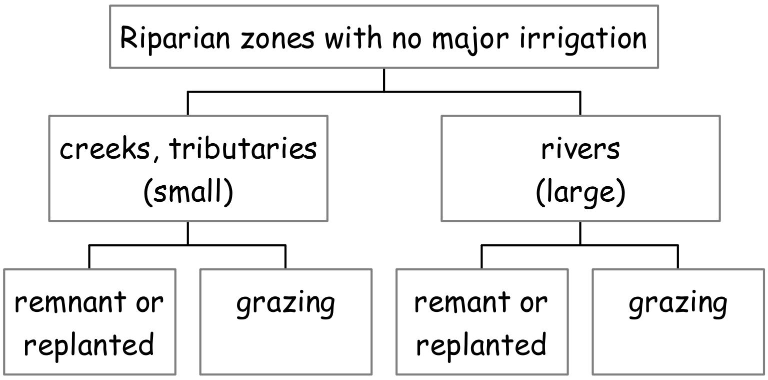

Figure 2. A summary of the study design. Each of the 4 bottom level groups contained 25-30 individual riparian sites (n=107).

Twenty-eight individual farmers were interviewed in relation to current and past on-farm management practices. Participants were chosen randomly with all farmers answering the same questions set prior to the interview being conducted. Although farmers were chosen randomly some declined to participate in the interview due to time constraints on the farm (interview time was approximately 1hour).

Surveys of riparian condition were conducted at 107 sites between June and November. Condition index measurements included measures of habitat, cover, debris, natives and species (see section 3.4 later). Of the 107 sites for which riparian condition was measured 38 were linked to farmer interview data as some of the interviewed farmers had more than one riparian area.

3.3 Landholder interviews

Interviews were conducted with 28 different landholders. Interview questions pertained to both past and present on-farm management practices and did not include any questions relating to social aspects of riparian management (e.g. farmer perceptions of riparian areas, why they are important, why restoration has or hasn't been attempted).

Questions were divided into 5 broad categories. 1) General questions that included questions about farm size, ownership and past land use. 2) Stocking rates and paddock sizes with questions about the break up of current stocking rates, past stocking rates, number and size of paddocks and rotational grazing practices employed. 3) Streambanks and watering points that included questions about flooding, numbers of riparian paddocks, total length of creek/river frontage, riparian restoration (if any) and weed management techniques. 4) Effluent, irrigation and stock loss that included methods and frequency of irrigation, types of effluent systems and management of effluent and loss of stock in creek/river associated areas. 5) Conservation and new management regimes, which included questions about any new management that has resulted in an improved farm environment, whether this new management was cost positive and if they were members of Landcare (see Appendix 2 for full interview).

3.4 Ecological condition and rapid appraisal

Owing to the spatial scales of human impacts on the landscape and the need for assessment of ecological change, there is an expanding field of research focused on rapid appraisal techniques to measure ecosystem condition or integrity (Fairweather 1999; Boulton 1999). Condition refers to the degree to which human-altered ecosystems diverge from local semi-natural ecosystems in their ability to support a community of organisms and perform ecological functions (Karr 1999).

In order to investigate the condition of riparian areas on private properties, we used rapid surveys of the ecological condition of riparian habitats (Appendix 3). During the surveys we obtained measures for a number of indicator variables that are linked to physical, biotic community and landscape functions of riparian habitats (Table 1).

Recently, Jansen and Robertson (2001a) developed and tested an index for the rapid appraisal of the ecological condition of riparian and floodplain habitats on the Murrumbidgee River using a sub-set of the indicators proposed by Ladson *et al.* (1999). The index was made up of six sub-indices, each with a number of indicator variables. In this study, we used an amended version of the Jansen and Robertson (2001a) index with five sub-indices as shown in Appendix 4. The five sub-indices included in the rapid assessment were: (1) width and longitudinal continuity of vegetation, (2) vegetation cover and structural complexity, (3) standing and fallen debris, (4) dominance of natives *vs* exotics, and (5) a series of special features including regeneration of canopy species, presence or absence of reeds and tree ferns and weed species declared noxious for the region.

In order to choose appropriate indicator variables for each of the sub-indices and to set appropriate scores for indicators we used seven reference sites across the west and south Gippsland regions (Table 2). The two major criteria used for choosing reference sites were: (1) that riparian vegetation structure was similar to that expected for the pre 1750 Ecological Vegetation Classes (see RFA 1999 and Appendix 1a-d) in the two bioregions of west and south Gippsland (Gippsland Plain, Strezlecki Ranges), and (2) where domestic livestock had been excluded from the site for more than 15 years.

On the basis of the observed vegetation structure at the reference sites, where there were four distinct layers (upper canopy, sub-canopy, understorey and ground cover) we increased the number of variables in the sub-index vegetation cover from three in the original index (Jansen & Robertson 2001a) to four for the Gippsland surveys. In addition, owing to the shading provided by the well-developed canopies and sub-canopies in the riparian habitats in the Strezlecki bioregion, (RFA 1999) we adjusted the scoring for the groundcover layer for all HILLY sites to 0=absent or 1=present. Scores for both HILLY and FLAT sites were scaled to scores out of 50 so that comparisons could be made across the region (see Appendix 4).

Note that choice as a reference site did not mean that the vegetation species composition was equivalent to the Ecological Vegetation Classes (see RFA 1999; DPI 2002) expected for these sites. This was because most sites had significant numbers of exotic plant species and some had significant understories of noxious weeds. Thus while they allowed us to establish indicators and scores for the rapid appraisal index based on structural attributes of the vegetation they did not score the maximum value for condition using the rapid appraisal index (see later).

Table 1. Functions of the riparian zone at different levels of organisation, the components of the riparian ecosystem which perform those functions, and the indicators of the function used in this study.

Functions	Components	Indicators
Physical:		
Reduction of erosion of banks	Roots	Tree cover
Sediment trapping	Roots	Tree cover
Controlling stream microclimate/ discharge/ water temperatures	Riparian forest	Tree cover
Filtering of nutrients	Vegetation, leaf litter	Ground cover vegetation Leaf litter cover
Community:		
Provision of organic matter to aquatic food chains	Vegetation	Vegetation cover Leaf litter cover
Retention of plant propagules	Terrestrial coarse woody debris, leaf litter	Terrestrial coarse woody debris Leaf litter cover
Maintenance of plant diversity	Regeneration of dominant species, presence of important species, dominance of natives vs exotics	Amount of regeneration Damage to regeneration Presence of reeds Dominance of native vs exotic vegetation
Provision of habitat for fauna	Terrestrial coarse woody debris, leaf litter, standing dead trees/hollows, riparian forest, habitat complexity	Terrestrial coarse woody debris Leaf litter cover Standing dead trees Vegetation cover Number of vegetation layers
Landscape:		
Provision of biological connections in the landscape	Riparian forest (cover, width, connectedness)	Vegetation cover Width of riparian forest Longitudinal continuity of riparian forest
Provision of refuge in droughts	Riparian forest	Tree cover

Table 2. Classification of the seven reference sites according to bioregions and locations, with brief descriptions of the vegetation structure at each site.

Gippsland bioregions[1] and reference sites	Map reference (Longitude, Latitude)	Description
Gippsland Plain		Alluvial, flat to undulating terrain. Dominant vegetation types (before agriculture) were lowland forest, grasslands, and grassy woodlands.
• Moondara State Park	146.30455 38.10278	
• Tyres State Park	146.40676 38.12935	
• Private property 1	145.59525 38.54847	
Strezlecki Ranges		Moderate to steep slopes. Dominant vegetation types are wet and damp forests with shrubby foothill forests
• Mt Worth State Park	146.41175 38.57626	
• Tarra Bulga National Park	146.62552 38.47721	
• Bull Beef Creek	146.23348 38.06656	
• Private property 2	146.38751 38.23259	

1. Based on DPI 2002.

Each site survey, to assess condition, was a 150-metre section of the riparian zone. At sites where stock could readily cross the creek both sides of the river/creek were assessed. At sites were stock could not access the opposite bank, one side of the river/creek was assessed. The same, trained observer conducted all surveys. At each site, the following parameters were scored:

- Longitudinal continuity of vegetation along the riverbank was assessed to determine the length and number of any discontinuities (gaps of at least 10 m) in canopy cover.

Four transects (30 m x 5 m) (perpendicular to the direction of river flow) were evenly spaced along the river or creek bank to record:

- channel width and width of the riparian vegetation (on the side(s) of the river being assessed),
- vegetation cover within four layers (ground cover - grasses, herbs, reeds and sedges to 1 m tall; understorey - herbs, reeds, shrubs and saplings 1-5 m tall; sub-canopy - trees >5 m tall and canopy >20m tall), and the percentage which was native

- the number of vegetation layers,
- leaf litter cover on the ground and the percentage which was native species,
- the presence or absence of standing dead trees (snags),
- the abundance of coarse woody debris (>10 cm in diameter) and the percentage which was native species,
- abundance of canopy species seedlings (<1 m tall),
- grazing damage to canopy species seedlings,
- the presence or absence of reeds and tree ferns, and
- the number of species of declared noxious weeds for the region.

Because livestock concentrate their activities at land-water interfaces, stocking rates may not be the best estimate of livestock impact on riparian areas (Robertson 1997). In this study, cowpat counts were used as an index of cattle activity at each site. Cowpats were counted within the four 30 metre transects and within 1 metre of the line on each transect.

At each site estimates for each indicator were averaged, scored and weighted, then summed to give a total score (see Appendix 4). Potential scores for the total condition index ranged from 0 (worst condition) to 50 (best condition). In order to summarise some of our results, we grouped total condition scores for surveyed sites into five categories, as follows: very poor condition <25, poor condition ≥25<30, average condition ≥30<35, good condition ≥35<40, and excellent condition ≥40. Correlations between variables were tested using Pearson's correlation coefficient (r).

As part of the study we wanted to determine whether a condition index score based on assessment of riverbank vegetation and litter provided a proxy assessment of in-stream condition. Measures of in-stream metabolism (daily rates of primary production (P) and respiration (R) for stream sediments and resultant P:R ratios to assess net autotrophy or heterotrophy) have been found to provide excellent indicators of in-stream "health" (Bunn *et al.* 1999). At a sub-set of 20 riparian sites in Gippsland where we had information to calculate the index of riparian condition we measured in-stream metabolism using the methods and equipment described in Bunn *et al.* 1999. The sites were chosen to represent a range of condition scores, stream sizes and spread evenly over the two bioregions. Regressions of in-stream metabolism on condition index scores (and sub-index scores) showed many significant relationships (see Appendix 5).

Another aspect of the study was determining the relationship between the riparian condition index scores, grazing impacts and riparian bird communities. There were two reasons for this: (1) A significant impact of grazing on riparian bird communities, and a significant relationship between riparian condition and bird communities would suggest that grazing, and associated decline in riparian health, is having far-reaching impacts on native bird populations in the region; and (2) A relationship between riparian condition and bird communities suggests the possibility that some bird species might be used as indicators of the success of altered land management practices to restore riparian areas. We recorded all birds seen and heard in the riparian zone during surveys to assess riparian condition scores. Each survey was completed in approximately thirty minutes, and covered an area of approximately 150x50m. For this preliminary study, only one survey was conducted at each site.

To examine the effects of grazing and riparian condition on the bird communities recorded at each site, we used Distance-based Multivariate Analysis for a Linear Model (Anderson 2001), and to illustrate how bird communities varied according to riparian condition, we used Non-metric Multi-dimensional Scaling in PRIMER (Clarke 1993). All analyses were done on presence-absence data, and similarities between sites were calculated using the Bray-Curtis metric. A Similarity Percentages Analysis was conducted in PRIMER (Clarke & Warwick 1994) to determine those bird species characteristic of riparian sites in poor and good condition. The results of these analyses are presented in Appendix 6.