4. DISCUSSION

4.1 GGE distribution in relation to past and present land–use

Active GGEs were found at 6 sites in the 148 ha farm, in 4 distinct habitat types including minor creek lines, flat to gentle sloping alluvial terraces above present flood levels steep south facing hillslopes with terracettes and a small colluvial footslope without terracettes.

The current distribution and abundance of the GGE would have been determined by (1) pre-European landscape factors; (2) immediate changes associated with European settlement; and (3) past and present agricultural activities.

(1) Pre-European landscape factors

The pattern of GGE distribution pre-European settlement is not known. It is most likely to have been influenced by large scale landscape processes that determined availability and suitability of GGE habitat although suitable habitat need not have been occupied by GGE. The main factors are topography, soil dynamics, catchment size, hydrological processes, vegetation cover, and fire. It is unlikely that the GGE was evenly distributed even pre-European settlement, and its distribution was influenced by smaller scale local factors that were influenced by large scale factors; for example, openness of vegetation cover.

(2) Land form changes associated with European settlement

Since the mid 1800's, extensive forest clearing, introduction of grazing animals and the maintenance of a more-or-less continuous ground cover of sown pasture has greatly altered the surface and sub-surface hydrology of the Strzelecki Ranges. A major consequence has been to increase the rate of run-off, particularly during storms by removing the rainfall interception once provided by the forest canopy. This has increased the quick-flow of streams and provided more energy for streams to incise channels and to scour the bed and banks of alluvial material. This process has affected the Foster Creek and tributaries, causing deepening and widening of the main channels and exposing bedrock on the channel floor. A further consequence of this would be an increase in the rate of surface and groundwater drainage and probable lowering of the water table. However, this would in part be offset by the lowered transpiration demand as a result of removing the forest canopy and suppressing tree regeneration. Overall, surface and groundwater movements are now probably more volatile than prior to European settlement. The rate of soil loss by surface wash and soil creep would also have increased with exposure of the soil surface and removal of the retraining factor provided by tree roots. Soil loss would have increased in the immediate post-clearing time but then stabilised as sown pasture has been maintained.

In summary, the landform changes resulting from settlement are most likely to have been an increase in the occurrence of rapid and extreme events, such as flooding, sediment movement from stream bed and banks and large slope failures. There has been soil loss from upper and steeper slopes and accumulation on the lower slopes, terraces and floodplain. Weathering rates, although relatively rapid, are still too slow to have compensated for soil loss on upper slopes. Although this means the soil profile on these upper slopes is thinner, there is clear soil profile differentiation as new topsoil soil horizons have formed from the biomass provided by crop and pasture plants over the past 100 years or more. Similarly, as the soil material washed onto the lower slopes and terraces was originally topsoil from upslope, the impact on the residual soil has been less severe than if this transported debris was stony or from subsoils. The direct impact of these changes on GGE's is not known. It is possible that some of the subsurface hydrological changes, for example, increased soil moisture in some areas may have been beneficial to the species.

(3) Past and present agricultural activities

The reduction in GGE range has often been attributed to post European settlement tree clearing and subsequent agriculture practices. Effects of initial vegetation clearance on soil habitat would have been pronounced in the upper soil horizon where increased exposure after tree removal would have resulted in decrease moisture levels. However, the deeper soil horizon primarily occupied by GGE would have been buffered from the initial changes in soil micro-climate and probably experienced an increase in available moisture due to the absence of large trees transpiring and removing soil moisture (see above). The GGE's are non-selective, geophagous feeders, relying on organic matter, bacteria and fungi digested from soil passed through the gut. This generalised diet and their depth in the soil profile may allow them to cope with the change from forest to permanent pasture.

The relationship between current GGE distribution and abundance to most agricultural practices is speculative. Most of the information regarding effects of agricultural practices on earthworm populations is derived from observations of European earthworms, primarily because native megascolecids usually do not survive vegetation clearance. Therefore, we have very little direct knowledge of the effects of these activities where indigenous species such as the GGE persist under pastoral systems.

When management on this property over the last 50 years is considered, there is only one instance where a known GGE population has become extinct through agricultural activity. This involved concentrating movement of cattle to use one crossing point over a stream. This property has been subject to fairly low level stocking rates and very low levels of cultivation. At least one population of the GGE known to the landowner has survived for over 50 years. Old GGE burrows were also found at a site subject to a landslip some 5 years previously. However, no signs of earthworm activity were visible and the earthworm appeared to no longer be present at the site.

Whilst we do not have a clear understanding of the effects of the processes associated with agricultural activities (positive or negative) on GGE populations, several threats can be identified. These include physical and chemical disturbances to the soil, and altered soil hydrology. Many of the actions responsible for these processes are interrelated and associated with infrastructure development and agriculture. The nature of the agricultural activities, farm infrastructure associated with these activities and ongoing management is known to include some threatening processes. More recently, biodiversity enhancement through tree planting of stream banks and gullies has become an important part of farm management.

It is known that physical damage to GGE's or to GGE habitat can result from over- stocking (high stocking rates that cause pugging and changes to micro-topography), and cultivation (ploughing). The establishment and management of fodder cropping and commercial cropping could affect GGE habitat. Stocking rates may be particularly important on the steeper hillslopes supporting GGE populations. Farm infrastructure development (outlined below) may also result in physical impacts on earthworm habitat.

There are many activities associated with agriculture that may affect the hydrological processes of GGE sites. These include;

- Farm infrastructure -farm roadways introduce impenetrable surfaces (e.g. hard rock/fill) that may present a barrier for worm movement, increase run-off effects.
- Ponding for effluent treatment.
- Construction of dams (locally increase water table upstream).
- Dairy sheds (change movement patterns of animals, run-off, effluent, chemicals).

Chemical inputs may affect soil moisture availability and chemistry, changing of soil pH from acidic to more alkaline (e.g. addition of fertilisers, pesticides, weedicides, animal drenches). However there is no information regarding the impact of these chemical inputs on GGE survival.

One of the key recommendations for conserving GGE's has been to replant known sites with indigenous vegetation. This was based on the assumption that most native species would benefit from restoration to their original habitat. However, the precise areas occupied by the GGE within their original forested habitat are not known. It is possible that they were found in the more open areas of the forest or in areas of natural disturbance. Distribution of GGE along the more open sections of the revegetated creek and similar findings in other studies at Mt Worth State Park where the species was found in the open pastured areas and clay service tracks adjacent to native vegetation (Van Praagh and Hinkley 1999) tends to support this. Spacing of the large mature trees in the original forest may present a quite different environment than that created when stream banks and gullies are more densely replanted with shrubs, trees and grasses. It is thought that pre-European settlement, the area was covered by wet forest – continuous canopy cover, but old forests probably dominated by fewer larger trees with more open understorey. The ground layer was more grassy and with more logs and coarse woody debris. The thick regrowth often associated with this type of wet forest was due to fires, but the area did not experience many fires, and most of the forest was thought to be mature. The lower slopes were dominated by *Eucalyptus strzeleckii* and higher slopes probably *Eucalyptus regnans* (David Cameron and Josh Dorrough, pers comm 2004). The GGE may not be dependent on the presence of native vegetation for survival. However, whether revegetation of earthworm habitat is actually detrimental to the species is unknown at this stage.

4.2 Geomorphology and GGE distribution

Examination of the GGE distribution in relation to geomorphology of the farm site identified various landscape features that may play a role in influencing GGE distribution.

- The nature and depth of the soil (GGE prefer deep alluvial soils of a silty clay nature, absent from sandy soils and floodplains).
- The aspect of steep slopes (south).
- Slope and micro-topography of the steep hillslopes (presence of terracettes providing increased soil moisture through temporary pondage during run-off).
- Site hydrology- ground water levels and seasonal changes.
- Density of re-vegetation may also impact upon GGE populations with earthworms found in the more open sections of re-planted stream bank.
- Association with streams but not channels and active stream banks.