National Recovery Plan for the

Giant Gippsland Earthworm

Megascolides australis

Beverley D. Van Praagh and Alan L. Yen

Australian Government

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Prepared by Beverley Van Praagh (INVERT-ECO) and Alan Yen (Department of Primary Industries Victoria)

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This Recovery Plan has been developed with the involvement and cooperation of a range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

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Cover photograph: Giant Gippsland Earthworm by Beverley Van Praagh

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Summary

The Giant Gippsland Earthworm (*Megascolides australis)* is endemic to an area of approximately 40,000 ha in the western Strzelecki Ranges of south and west Gippsland, Victoria. It has a fragmented distribution and occurs predominantly in permanent pasture used for dairying. Populations are generally restricted to small patches of suitable moist habitat including creek banks, soaks, and wet south-facing hillslopes. The life history of the species, including long life span, low reproductive and recruitment rates, and low dispersal ability, make the fragmented populations susceptible to environmental disturbances and catastrophic events. Anecdotal information regarding historical distribution patterns suggests that numbers have declined and the range of the species has contracted, probably due to farming activities and infrastructure development, although precise factors responsible for this decline are unclear. Major threats to the species include actions which cause changes to the local hydrology and both physical and chemical disturbances.

The Giant Gippsland Earthworm is listed as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and as Threatened under the Victorian *Flora and Fauna Guarantee Act 1988*. About 90 hectares of its habitat has also been listed on the register of the National Estate (Coy 1991). This national Recovery Plan for the Giant Gippsland Earthworm is the first recovery plan prepared for the species. The Plan details the species' distribution, habitat, threats, and recovery objectives and actions necessary to ensure the long-term survival of the Giant Gippsland Earthworm. More detailed information on the ecology, conservation status, and implementation and costs of recovery can be found in Appendices 1 and 2 appended to this plan.

Species Information

Description

The Giant Gippsland Earthworm (*Megascolides australis)* belongs to the family Megascolecidae. The species is elongate and cylindrical with 300-500 segments. The anterior third of the body is deep purple/ while the remainder of the body is a pale pink-grey, fleshy colour. *M. australis* can reach lengths up to 150 cm with an average size and diameter of around 80 cm and 2 cm respectively. Weights up to 400 g have been recorded, although the average is closer to 200 g (Van Praagh 1992, 1994). Newly hatched earthworms are around 18 cm long. While there have been old reports in the literature of worms reaching lengths of over three metres, no specimens of this size have been recorded during the past 15 years. McCoy (1878) provides a full description of the species, while Spencer (1888) described its morphology, and Jamieson (1971) elaborates on the systematics of the species.

Distribution

M. australis is restricted to a relatively small region of south and west Gippsland, Victoria (Figure 1), in an area roughly bound in the north by Warragul, and in the south by Loch and Korumburra. Mt Worth represents the most easterly point of distribution. The most southerly confirmed record occurs around Kernot and Almurta. There is little information regarding the historical distribution of the species. The extant distribution of *M. australis* was initially determined by questionnaires completed by local residents in the late 1970s (Smith & Peterson 1982). The Atlas of Victorian Wildlife contains records of the *M. australis* as far south as Archies Creek. However this record and several others around Blackwood Forest and Glen Forbes are unsubstantiated. The species does not occur in sandy soils found west of Kernot, although there is a specimen in the Museum Victoria collection with label information indicating that it was collected at Queensferry in 1877.

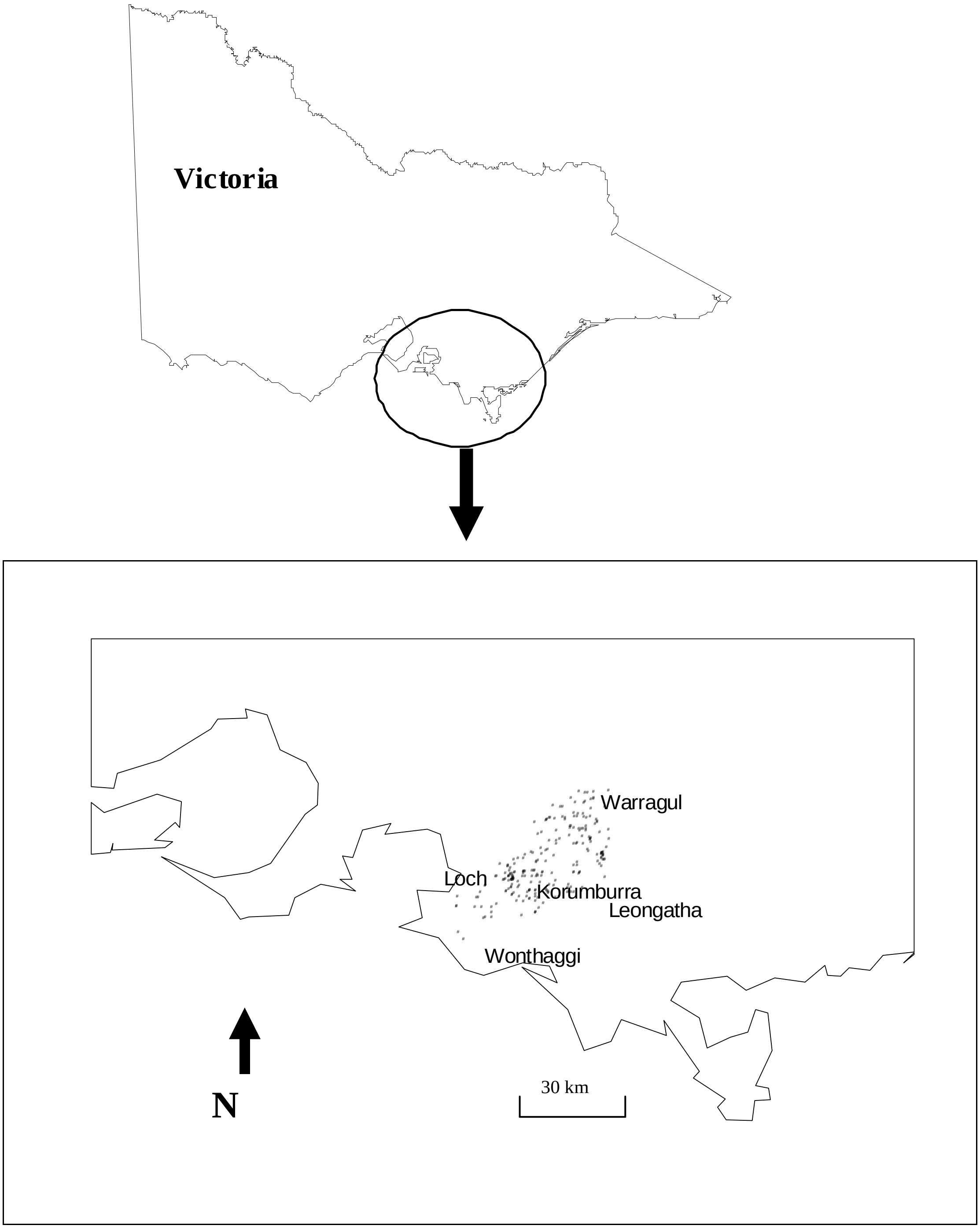

Figure 1. Distribution of the Giant Gippsland Earthworm

The extent of this range is approximately 40,000 ha but the area of occupancy of most sites can be very small and can comprise areas of less than 10 square meters. Most known populations occur on privately-owned land. Mount Worth State Park, located about 20 km south-east of Warragul on the western edge of the Strzelecki Ranges, is the only public land conservation reserve with a known population and the species appears to be restricted to an area of approximately 2 km^2 in the south-eastern section of the reserve.

Population information

There are no data on which to base population estimates or trends. This is mainly the result of the difficulties inherent in studying a subterranean species. There are currently 254 records of *M. australis* in the Atlas of Victorian Wildlife distributed in south and west Gippsland. Within this range, populations are fragmented and appear to be discrete with little opportunity for genetic exchange. Recently, mitochondrial COI analyses of Giant Gippsland Earthworm populations at Loch Hill and Bena, approximately 5 km apart, indicated that the two populations were significantly differentiated in their genetic structure and represented distinct phylogenetic lineages (Woods 2006). Given the poor dispersal abilities of the species and limited geographic range and connectivity of suitable habitat, it is likely that present-day populations have been isolated for significantly long periods of evolutionary time, evolving as distinct genetic entities.

The number of individuals within a population varies but is usually quite small, possibly due to the limited availability of contiguous habitat. In some instances, only one or two individuals per site have been observed. However, where suitable conditions are more extensive, larger populations have been found. The largest population to date was uncovered at Loch Hill during the translocation of a population of *M. australis* threatened by road construction, where over 800 individuals were recovered from an area of approximately 2500 m^2 (Van Praagh *et. al*. 2002, AVS 2006).

Anecdotal information supplied in questionnaires by Smith and Peterson (1982) suggests that the populations have become extinct. More recently, during surveys by Van Praagh in 2008 and 2009, landowners have expressed concern that populations have not been recorded over recent years due to the current drought.

The current state of knowledge about the distribution of *M. australis*, population sizes, and genetic variability of the populations precludes identification of important populations. However, 10 populations have been identified as potentially important based on their significance as (1) research populations (Loch Hill translocation site, private properties at Loch and Jumbunna, and DPI Ellinbank Centre); (2) populations on public land (Mt Worth State Park, and eight sites along Railway Reserve Victoria Rail Track South Gippsland Highway between Bena and Korumburra); and (3) populations located within remnant vegetation on private properties in Poowong North (Cochrane's Road and Weaver's Road), Poowong (Drouin-Korumburra Road), and Drouin South Invermay Road). This list is not complete but is based on the limited information available at present. Future investigation and improved knowledge may lead to a change in understanding of what constitutes an important population and will most likely reveal many more populations that can be targeted for specific protection mechanisms.

Habitat

Megascolides australis is found predominantly in exotic pastures used for dairying. It is generally found in the deep blue-grey clayey soils formed mainly from cretaceous rocks in the Western Strzelecki Ranges and in the alluvial areas derived from this soil to the north and south west (Smith & Peterson 1982). The primary habitat of this species is generally found along creek banks, adjacent to soaks and on wet south-facing hillslopes, often with terracettes. Mt Worth State Park supports remnant stands of Mountain Ash and Wet Forest, once widespread over the Strzelecki Ranges and representative of much of the vegetation that would have occurred throughout the species' range (Gippsland CRA 1999). This vegetation has now almost entirely been removed with only small pockets of remnant vegetation remaining. Unlike the habitat critical for survival of many endangered species, survival of *M. australis* does not appear to be dependent on the presence of remnant vegetation. It is likely that clearing of the original forested earthworm habitat resulted in local extinction of the species in parts of its range. However, the species may be able to adapt to the development of pastures given maintenance of appropriate hydrological conditions and protection from particular disturbances. Studies of *M. australis* distribution at Mt Worth found that it occurred mainly in the open, pastured areas surrounded by remnant vegetation and was absent from under the remnant vegetation (Van Praagh & Hinkley 2000a). Similar findings have been observed recently along revegetated stream banks and areas of remnant bush where the species was confined to the more open, disturbed areas (Van Praagh *et al*. 2004, 2005; Van Praagh 2008). It is possible that the species occupied similar types of open, wetter areas under the original vegetation.

The area of habitat suitable for *M. australis* within its known range is small and extremely patchy. Populations are fragmented and can be very localised, sometimes restricted to an area of several square metres of suitable habitat. However, in some instances, the species can be found over larger areas. For example, on a steep south-facing hillslope, just east of the township of Loch, *M. australis* occurred over an area of approximately 2500 m^2.

While precise habitat factors governing the distribution of *M. australis* are unknown, there are certain landscape features that can be used to predict the distribution of the species. In particular, these include local soil hydrological conditions, slope and micro-topography and the nature and depth of the soil. However, there are many landscape features governing local soil conditions, including overall catchment size, vegetation cover, and soil sub-surface, all of which may play a role in influencing the habitat suitability. A proposed recovery action is to determine the habitat critical to the survival of *M. australis*.

Local site hydrology and ground water levels appear important habitat features *for M. australis*. Streamsides provide one of the most important habitats. Populations are usually found within close proximity to streams or drainage channels, usually within 40 m but are often restricted to within 5 to 10 m of the banks. They are associated with streams but not channels and active streambanks and are almost always found above the active flood plain. Flooding and siltation of the larger river-banks may explain the absence of the species from these sites.

Sites supporting populations of *M. australis* generally have a high soil moisture content that is retained almost all year round. This includes soaks, roadsides and gullies and, on some occasions, even clay vehicle tracks. In addition, the species may be found on steep wet slopes with a southerly or westerly aspect.

The specific soil and hydrological factors that provide suitable habitat for *M. australis* have not been identified. Water balance within burrows is important for worm movement and respiration, and burrows occupied by the species are very wet with some free flow of water. Therefore, a certain amount of sub-soil water flow is likely to be critical.

The species is generally found in the deep blue-grey clayey soils formed mainly from cretaceous sediments (sandstone, siltstones and mudstones) in the rolling to steep hills of the western Strzelecki Ranges, and in the alluvial areas derived from this soil to the north and south west (Smith & Peterson 1982). *M. australis* prefer deep soils (>1m) with a predominantly clay structure, and are absent from sites with high silt content, from sandy soils and from floodplains.

A feature of steep hill-slopes occupied by *M. australis* sites is the well defined terracettes extending across the slope, usually at right angles to the direction of maximum slope. Recent investigations on a hill slope at Loch found the species to be restricted to a specific area of the hill characterised by pronounced terracettes (Van Praagh *et al.* 2002). The terracettes present an irregular surface that provides temporary pondage during run-off, allowing retention and recharge of soil moisture (N. Rosengren pers. com. 2004). This may be important in sustaining conditions required for *M. australis* survival on these slopes. The size (breadth and depth) of these terracettes may prove to be important indicators of potential habitat suitability for *M. australis*.

Decline and threats

The Giant Gippsland Earthworm is of conservation concern because of its limited distribution, probable decline and life history characteristics. Particular aspects of the biology and ecology of *M. australis*, such as long lifespan, low reproductive and recruitment rates, and poor dispersal ability, render the fragmented populations vulnerable to threatening processes (Van Praagh 1992; McCarthy *et al*. 1994).

There are no historical records of *M. australis* distribution before vegetation clearance by European settlers, and the overall effects of this clearance on *M. australis* are not known. Broad-scale development of the region for agriculture clearly has had some affect on the species, evident from the many anecdotal reports suggesting 'thousands' of *M. australis* were killed during ploughing, leaving the fields 'red with blood' (Barrett 1931, 1935; Smith & Peterson 1982).

The relationship between current *M. australis* 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 do not survive vegetation clearance. Therefore, we have very little direct knowledge of the effects of these activities in situations where indigenous species such as *M. australis* persist under pastoral systems.

M. australis appears to have some tolerance to disturbance as demonstrated by its presence in pastures, under vehicle tracks and within open areas of pine plantations (Van Praagh & Hinkley 1999). However, while *M. australis* co-exists with the current agricultural systems of South Gippsland, the relationship may be very fragile because of the species fragmented distribution and life history characteristics. The high proportion of adults found in most studies and their apparent longevity may indicate that some populations may not be sustainable in the long term; it is possible that these populations will take many years (even decades) to become extinct unless recruitment is increased.

Whilst not all threatening processes operating on *M. australis* are known or understood, some key threats can be identified. The two major threats to the species are physical disturbances to the soil and altered hydrology such as changes in water table level, flooding and drainage patterns. Chemical soil disturbances represent potential threats but the impacts are unknown. Many of the actions responsible for threatening processes are interrelated and are associated with infrastructure development and agriculture and include:

1. Alteration to water table or drainage patterns; (e.g. flooding, drainage of creeks, dam building and dense revegetation of habitat)
2. Destruction of soil habitat (e.g. intensive farming such as cultivation, pugging by cattle or compaction by heavy machinery, road and dam making, urbanisation);
3. Chemical soils disturbances (e.g. fungicides, weedicides, insecticides and fertilizers).

Altered hydrology

Alteration of the water table and natural drainage patterns is probably one of the most serious threats to *M. australis* populations. For example, construction of drains is thought to have resulted in local extinction of the Giant Gippsland Earthworm from a section of roadside habitat west of Loch that was widened in the mid-1990s. The Giant Gippsland Earthworm was found at this site in 1990 (Van Praagh 1994), and again in 1993 when an overtaking lane was constructed (the late F. Dent, pers. comm. 2004). This section of road was widened and table drains constructed in 1995, causing lowering of the water table. A survey five years later failed to locate any Giant Gippsland Earthworms in the area (Van Praagh & Hinkley 2000b).

The effects of other, more distant disturbances such as reducing or increasing water flow upstream may influence populations downstream. Although *M. australis* is often found on stream banks, it is usually found on the smaller tributaries of the major river systems and is often absent from the larger streams and rivers. The reason for this is unknown but may be related to frequent flooding and silt deposition.

Establishment of plantations and dense revegetation of *M. australis* habitat is thought to result in localised alteration of hydrological conditions that may be detrimental to the species. While *M. australis* habitat pre-European settlement is thought to be tall, wet forest, there is no information available to determine the historical distribution of the species within this forested landscape. However, newly established plantations or regenerating eucalypt forests are known to significantly alter hydrological regimes (catchment water yields) in the first two decades of growth due to interception and the high transpiration rates of growing trees (e.g. Clarke 1994; Keenan *et al*. 2004). Due to the sensitivity of *M. australis* to changing soil moisture conditions, establishment of timber plantations or revegetation in the vicinity of *M. australis* colonies may potentially be detrimental to the species due to lowering of the water table leading to drying of soils. Whilst the short term impacts of plantation establishment and revegetation are thought to be detrimental to *M. australis* populations, the long-term effects (positive or negative) are unknown. There is also some concern that plantation establishment and revegetation may impact on the sub-surface area available for the species by filling potential occupation space with tree roots and woody debris. The physical disturbance of ripping and/or digging large holes for plantation or revegetation purposes may also kill earthworms (Van Praagh *et. al*. 2007).

Soil disturbances

Mechanical earthworks such as excavation, dam building and cultivation directly impact on *M. australis* survival by physically damaging individual earthworms and egg cocoons. *M. australis* generally occurs within the top 1.5 m of soil at an average depth of 0.5 m (Van Praagh 1994), while egg cocoons are found within 40 cm of the soil surface at an average depth of around 23 cm (Van Praagh 1992). However, they can be found just under the soil surface, particularly during the wetter months when the soil is very moist. Individuals have no regenerative capacity, and consequently die if injured. Those that are incidentally exposed during earthworks are subject to damage from ultraviolet radiation, desiccation and predation.

These soil disturbances also indirectly affect the earthworm by destroying and altering its habitat. Compaction caused by heavy machinery and pugging affects burrow structure and the worm's ability to make new burrows. Any changes to the soil microclimate can also be detrimental to *M. australis* survival.

Chemical disturbances

There is no information available on the effects of herbicides and pesticides on *M. australis*. However there is a body of literature on the effects on other earthworm species. Effects of agricultural pesticides on earthworms depend on the nature of the chemicals used. Herbicides tend to have low toxicity for earthworms (when used at prescribed rates) whereas fungicides and fumigants tend to be very toxic (Lee 1985). A number of horticultural sprays are considered highly toxic to earthworms (Lee 1985) and have been shown to kill native and introduced earthworms. Fumigants and many insecticides (e.g. organochlorines and carbamates) are known to kill earthworms. The effects of these chemicals on earthworm populations may persist, even when chemical residues are no longer detectable in the soil. Lee (1985) provides an extensive list of the known effects on earthworms of over 80 different biocides. Organochlorides, until they were banned, were used to combat cockchafers in South Gippsland. The main current biocide threats are insecticides used to spray insect pests of summer crops (John Bowman, pers. comm. 2004).

In general, applications of fertilisers in the form of superphosphates and nitrogen are considered to have a beneficial effect on other species of earthworms, by increasing plant production, and organic matter inputs (in the form of decaying roots, litter and crop residues) (Edwards & Lofty 1977; Lee 1985). However, specific responses to fertilisers may vary, depending on the earthworm species involved. Responses may depend on the soil pH preference of the species. In general, earthworms favour alkaline soils with a pH of around 7. Continued use of ammonium-containing or -forming fertilisers is potentially damaging to earthworm populations, as the soils may become too acidic, whereas the addition of lime, creating more alkaline environments, is often favourable to earthworms. Heavy applications of inorganic fertilisers (in particular ammonia-based fertilisers) may cause immediate reductions in earthworm abundance due to the short term changes in soil pH (Edwards 1983). The effects of fertilisers on *M. australis* are not known. The effects of pH on *M. australis* distribution are unknown, but preliminary studies indicate that it can tolerate acidic soils with a pH of 4.0 - 6.0 (Van Praagh 1994).

Recovery Information

Strategy for Recovery

The strategy for recovery of the Giant Gippsland Earthworm will be to immediately develop and implement strategies to improve our knowledge of the species distribution and habitat requirements. A priority in achieving this is to obtain fine-scale mapping of the species without relying on current, time-consuming and destructive surveying methods. This will result in the further identification of important populations that will be targeted for protection.

As the range of *M. australis* encompasses large areas of privately owned agricultural land, the strategy will also involve entering into conservation covenants with private landowners to fence off populations and ensure their long-term protection from identified threatening processes (e.g changes in land use, hydrology and soil disturbances). Landowners will be encouraged to consider the species and its habitat on their land, and to adopt sympathetic land management practises. It is also found in areas subject to development, particularly around the urban town centres of Warragul, Drouin and Korumburra. The success of this Recovery Plan will rely to a large degree on the education and involvement of the local community and the formulation of practical management prescriptions that are accessible to land holders and land managers. Management prescriptions for conservation of *M. australis* will be refined as research outcomes are available.

Program Implementation

The Recovery Plan will run for five years from the start of implementation. The Giant Gippsland Earthworm Recovery Team comprises stakeholder representatives including, DSE, South Gippsland Catchment Management Authority, South Gippsland Shire, and scientists. This group will coordinate implementation of the recovery plan. Implementation of individual actions will remain the responsibility of the relevant agencies and organisations identified in the Recovery Plan (subject to available resources), who will be responsible for preparing work plans and monitoring progress toward recovery within their own jurisdiction.

Program Evaluation

The Recovery Team will be responsible for informal evaluation annually. Towards the termination of the Recovery Plan, an external reviewer will be appointed to undertake a formal review and evaluation of the recovery program.

Recovery Objectives
Within the life span of this Recovery Plan, the **specific shorter-term objectives** are to:

Objective 1. Model the extant distribution of suitable habitat of *M. australis* using edaphic, geomorphic and hydrological data.

Current knowledge of the distribution and habitat requirements of *M. australis* populations is incomplete. For subterranean species like *M. australis*, modelling is an important adjunct to records acquired through the expensive and destructive sampling that is necessary in order to confirm the presence of the species in the field. A number of apparently important physiographic, edaphic and hydrological factors have been identified as indicators of potential earthworm habitat. Specifically, creek banks, soaks, blue-grey clayey soil, southern aspects, and slopes with terracing. However, the complete range of site scale and landscape scale environmental features and interactions have not been evaluated for their capacity to predict suitable and or occupied habitat. In particular, the interplay of solar radiation, regolith and surface and subsurface drainage variables are considered worthy of further analysis. Species distribution models (SDMs) are used to predict the geographic range of a species from occurrence (presence; or presence/absence) records and relevant environmental data. The basic method for developing spatially explicit SDMs (i.e. maps) involves collating the co-ordinates of reliable (and preferably systematically acquired) occurrence records and extracting the values for range of available and potentially useful spatial data from the same locations within a Geographic Information System. Useful data layers will include satellite imagery, airborne geophysics, digital elevation models and data derived from these (such as terrain models, climate models, solar radiation models, and wetness indices). The sites and their attributes will then be used to train and develop a model.

Objective 2. Develop non-destructive methodologies for locating and monitoring populations.

There is no method available for survey, research or monitoring *M. australis* without destroying habitat and damaging or killing individual worms. The development of non-destructive or low impact monitoring techniques would be an invaluable tool to further our understanding of the biology and ecology of this species without the threat of destroying individuals. There are many technologies that are used to monitor subterranean biotic and abiotic components, and there is potential to test and adapt some of these to use with *M. australis*. These include techniques such as ground penetrating radar (to monitor burrows) and sound and vibration sensors.

Objective 3. Examine the impacts of the following land uses on populations: (a) dairy and meat production; (b) vegetable growing; (c) transport and infrastructure corridors; (d) urbanisation; (e) agroforestry and plantation forestry; and (f) revegetation of degraded streams and slopes.

While there are some changes to the environment that are common to a broad range of different land uses, we still do not understand how these operate and impact upon *M. australis*. Furthermore, individual land uses may have unique impacts. Consequently, a medium term monitoring programme across different land uses would provide important information to develop threat abatement strategies to be used by both private and public land managers (Objectives 6 and 7).

Objective 4. Determine the influence of hydrological processes on *M. australis* populations.

Soil hydrological processes appear to be critical in influencing the distribution of *M. australis*. However the nature of this relationship remains undetermined. Past advice to landholders has been to revegetate *M. australis* habitat (Van Praagh 1991, Taylor *et al.* 1997). This is now being questioned because of the concerns about the impact of replanting on local hydrological conditions. Dense replanting may lower the water-table and alter local soil moisture conditions leading to drying of the soils (Van Praagh *et al*. 2007). There is also some concern that dense plantings may reduce the sub-surface area available for worm-habitat by filling potential occupation space with tree roots and woody debris. Given the scale of revegetation in the region and, in particular, the often very dense planting of riparian habitat (prime *M. australis* habitat), revegetation may represent an important potential threat to the species. This may also have implications for forestry activities within the species' range. Information on the effects of revegetation on *M. australis* populations is required so that more accurate guidelines for landowners and managers can be developed. Pre- and post-revegetation experiments may take many years of monitoring and are dependent on the development of better monitoring techniques than are currently available. In the short term, priority should be given to investigate the more specific hydrological requirements of this species and the changes produced by revegetating *M. australis* habitat. The effects of plants on underground hydrology processes and the subsequent effects on *M. australis* can be modelled to determine appropriate revegetation strategies that will minimize harm to *M. australis.*

Objective 5. Develop criteria for determining the most important populations for conservation.

Currently the important populations identified are those that have been studied or presumed to be important because of their geographical location or land tenure, and there is no guarantee that these are the most important populations for the long term survival of the species. There is a need to develop criteria to define important populations necessary for the species' long-term survival and recovery to be applied to data obtained from distribution modelling (Objective 1). This information will also feed into conservation management through agreements with private landowners and/or possible reservation establishment (Objectives 6, 7 and 8).

Objective 6. Establish a regional forum with municipal authorities to examine use of planning schemes mechanisms to protect habitat of *M. australis*.

The escalation of urban development and associated infrastructure encroaching on *M. australis* habitat constitutes one of the most serious threats to this species. This is compounded by the fact that *M. australis* is often overlooked during environmental assessments associated with planning procedures. This is probably because *M. australis* is predominantly found in pastured sites and is not normally associated with native vegetation, therefore, there is no overlay to trigger a referral to DSE. This has been partially addressed by the production of a Guide for Planners and the development of an *M. australis* Biosite layer. Education and involvement of land managers in issues relating to *M. australis* conservation is crucial for successful conservation of this species.

Objective 7. Liaise with local community land management agencies, including Trust for Nature, Landcare, the West Gippsland CMA and Greening Australia Victoria to develop a consistent set of guidelines for managing habitat of *M. australis*. *M. australis* primarily occurs on privately owned agricultural land.

Conservation covenants are required to ensure the long-term protection of populations. Any conservation efforts must rely on the co-operation of landholders, as well as land managers (Shires, private and government organisations). An increased awareness and understanding of the identification of *M. australis* and its habitat and conservation requirements is required in order for land-holders to implement any management recommendations. The general consensus amongst landowners is that worms are good for the soil and therefore good for farming. The dissemination of interpretive material for landholders that is easily accessible and gives clear summaries of current knowledge of *M. australis* conservation and management is essential in promoting sympathetic land management practices. Whilst some critical information regarding the conservation requirements of this species is unknown, interim conservation guidelines have been developed and presented in the most recent Land for Wildlife Note

Objective 8. Develop and implement a strategy for the role of conservation reserves and management networks in the protection of habitat of *M. australis*.

The majority of known Giant Gippsland Earthworm populations are located on private land, and the few instances where they are found on public land, they are either small populations in railway or roadside reserves or at the extreme of the range (Mt Worth). Based on results on distribution modelling (Objective 1), a strategy will be developed to assess future options on the use of reserves and management networks to conserve the species.

Objective 9. Develop and implement protocols for dealing with inadvertent exposure of *M. australis*.

Given the subterranean and cryptic nature of *M. australis*, even when appropriate survey, assessment and planning have been undertaken at a site, it is still possible to uncover *M. australis* during earthworks. Clear recommendations on how to proceed in this situation are required. At present, it is recommended that contractors that expose *M. australis* during earthworks dig a hole close to the site but away from the immediate threat and bury the worms under loose soil. The immediate or long term survival of these earthworms is unknown although trials conducted during the translocation project indicated that some of these earthworms do survive and move away from the plot they were buried in. While ‘rescuing’ and relocating individual earthworms may not aid in the overall recovery of the species, it helps promote a sympathetic attitude amongst contractors and others regarding the conservation of the species. It also increases awareness and the likelihood of reporting *M. australis* sightings. Inadvertent exposure of *M. australis* often results in damaged specimens that will not recover. As the range of genetic variability of the species across its range is not known and important for future conservation strategies, a strategy to collect and store salvage tissue for research on the conservation genetics of *M. australis* needs to be developed and implemented.

Objective 10. Develop and implement agreed protocols for translocation of *M. australis*

Periodically, development decisions may cause sites or parts of sites supporting populations of *M. australis* to be destroyed. With the expansion of urbanisation and development of areas within the range of *M. australis*, populations of the earthworm will continue to be threatened by such disturbances. If such developments proceed, then contingencies must be made to minimise effects on the overall conservation of the species. In many instances, with appropriate survey and planning, populations can be detected *prior* to development so that options of removing the threat can be considered (e.g. cable re-alignment). However, such mitigating practises are not always possible, and translocation of the population may be considered. Protocols on whether translocation should be undertaken need to be developed.

Recovery Objectives, Performance Criteria and Actions - Summary

Objective	Performance Criteria	1. Actions
1. Model the extant distribution of suitable habitat of *M. australis* using edaphic, geomorphic and hydrological and other relevant data.	Species distribution model (SDM) produced for *M. australis*.	1.1 Collate all existing known records from the Atlas of Victorian 1.2 Wildlife and/or from other data sources/bases. 1.2 Collate all existing data pertaining to “absences” in the landscape from Atlas of Victorian Wildlife and/or other sources. 1.3 Identify potential existing known records from which an accurate GPS co-ordinate could be obtained in the field. 1.4 Identify potential data/records on “absences” from which an accurate GPS co-ordinate could be obtained in the field. 1.5 Obtain accurate GPS locality data for selected existing known records and for selected localities containing data on absences. 1.6 Develop a high resolution DEM. 1.7 Identify relevant suite of environmental data and develop into a set of geospatial data layers. 1.8 Develop, validate and calibrate a GIS-based, spatially explicit model of potential habitat. The model will attempt to identify the relationships between observations of the Giant Gippsland Earthworm and edaphic, geomorphological, and hydrological variables influencing distribution. 1.9 Produce a detailed map identifying likely *M. australis* habitat and apparently suitable unoccupied habitat. 1.10 Use map to identify additional important populations to target for conservation (see Objective 5) 1.11 Ensure appropriate land managers have access to distribution map to help ensure land management and mitigation occurs in the most appropriate areas.

2. Develop non – destructive methodologies for locating and monitoring populations	Ecologically sustainable method for locating and monitoring *M. australis* populations for conservation management.	2.1 Conduct a workshop of relevant experts to determine feasibility of different methodologies as non destructive monitoring techniques. 2.2 Investigate and trial sampling techniques based on outcomes of workshop.
3. Examine the impacts of the following land uses on populations: dairy and meat production; vegetable growing; transport and infrastructure corridors; urbanisation; agroforestry and plantation forestry; revegetation of degraded streams and slopes.	Information on threatening processes resulting from common land uses obtained and used for conservation management.	3.1 Establish demographic monitoring program of selected populations in relation to major land uses occurring within habitat range. 3.2 Report on monitoring program and use results to inform development of guidelines for habitat management.
4. Determine the influence of hydrological processes on *M. australis* populations	Increased knowledge of the hydrological requirements of this species and impacts of revegetation on *M. australis* populations and development of appropriate guidelines.	4.1 Draft interim guidelines for revegetation of *M. australis* habitat based on existing knowledge and presumed limiting factors, to be modified or revised as information improves. 4.2 Encourage landowners not to revegetate known *M. australis* habitat until such time as more specific guidelines are available. 4.3 Initiate research to develop a model to determine the hydrological and other soil parameters required by this species. Investigate the impacts of different densities of revegetation on factors such as hydrological patterns and water table levels and how these may impact upon *M. australis* populations. 4.4 Undertake surveys of *M. australis* populations in revegetated sites of different age classes and densities.

		4.5 Develop guidelines for revegetation of *M. australis* habitat and ensure distribution to appropriate Land Care groups.
5. Develop criteria for determining the most important populations for conservation.	Identification of important populations for conservation management.	5.1 Convene multidisciplinary panel to determine criteria for determining populations critical for conservation. 5.2 Apply criteria to known populations.
6. Establish a regional forum with municipal authorities to examine use of planning schemes mechanisms to protect habitat of *M. australis.*	Strategic directions in planning schemes for conservation management.	6.1 Establish steering group of relevant municipal and wildlife authorities to define and oversee implementation of project to identify relevant mechanisms within Local Planning Provision Framework (LPPF). 6.2 Conduct facilitated workshop with stakeholders to scope issues regarding recognition of earthworm conservation in municipal planning schemes. 6.3 Collate workshop results and produce options paper on planning scheme mechanisms to improve protection of earthworm habitat. 6.4 Disseminate of interpretive material for PV, land managers and that is easily accessible and gives clear summaries of current knowledge of *M. australis* conservation and management is essential in promoting sympathetic land management practices. 6.5 Promote and distribute information regarding *M. australis* assessments to all relevant agencies (Shire Councils and key Stakeholders) likely to encounter *M. australis* during land management activities. 6.6 Establish in-service training workshops for local council planners and other relevant bodies to facilitate the implementation of the Planning Guide and use of Biosite layer. 6.7 Provide information on *M. australis* conservation to key land managers (Shires, DPI, PV and CMA) to allow dissemination of updated information on *M. australis* conservation to their stakeholders.
7. Liaise with local community land management agencies, including TfN,	Improved understanding between management and advisory agencies on consistent approach to managing habitat in relation to surrounding land uses.	7.1 Establish steering group of relevant stakeholders to scope and manage project to develop industry and land use specific guidelines to mitigate for threatening processes. 7.2 Conduct workshops with relevant stakeholders and industry advisors

Landcare, WGCMA and GAV to develop a consistent set of guidelines for managing habitat of *M. australis*.		to canvas known threatening processes and options for mitigation. 7.3 Collate results and prepare guidelines for avoiding, minimising and mitigating habitat loss and degradation. 7.4 Encourage landholders to participate in the conservation of *M. australis*. Include field days to help land-owners identify populations on their properties and increase awareness of ways in which landowners can protect these populations. This may require the appointment of an extension officer to facilitate this process. 7.5 Develop and send a questionnaire to landholders requesting information on *M. australis* distribution and habitat (e.g. Smith & Peterson 1982). This information could be linked into a Website (see Action 3.4) and Action 1.1. The data collected will increase awareness of *M. australis* and contribute to the knowledge of species distribution, the effects of recent drought on populations and aid in selection of properties for Actions relating to effects of native vegetation on distribution. It may also yield valuable information regarding changes in the status of *M. australis* populations over the past 28 years. 7.6 Ensure interpretive material such as the updated Land for Wildlife Note is readily available to the public through offices of land management agencies, Landcare networks and local festivals. Interim guidelines for conservation of *M. australis* can be found in the Land For Wildlife Note.
8. Develop a strategy on the role of conservation reserves and management networks in the protection of habitat of *M. australis*.	Strategic directions for reserve establishment are developed.	8.1 Establish steering group of relevant land and wildlife managers to define and oversee implementation of project to identify options for reserve management in the protection of earthworm habitat. 8.2 Conduct facilitated workshop with relevant stakeholders to scope issues regarding feasible approaches to reserve establishment. 8.3 Collate workshop results and produce options paper on proposals for a reserve network.

9. Develop protocols to deal with *M. australis* exposed/damaged in the field. Collect and store salvage tissue for research on the conservation genetics of *M. australis.*	An emergency response for when *M. australis* are accidentally uncovered during soil disturbance activities is available to relevant agencies to ensure successful release/recovery of earthworms injured during excavation	9.1 Develop a contingency plan with agreed protocols by relevant authorities should *M. australis* be accidentally uncovered during soil disturbance activities. 9.2 Distribute agreed protocols to relevant agencies (attached to permits provided by Council?) and provide in-service training to support this process (linked to Action 8).
	Material collected for investigations into conservation genetics.	9.3 Determine feasibility of accessing a storage system for injured *M. australis* for future genetic analysis 9.4 Set up protocols for collection and storage of *M. australis* genetic material of individuals damaged during surveys or soil disturbances for future analyses.
10. Develop and implement agreed protocols for *M. australis* translocations.	Protocols for *M. australis* translocation are developed.	10.1 Determine the circumstances under which Giant Gippsland Earthworms may be translocated and develop agreed protocols in line with IUCN framework.

Implementation Costs

The estimated cost of implementing the Recovery Plan is $1.675 million over five years.

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Total cost	760,000	470,000	195,000	105,000	145,000	1,675,000

Role and Interests of Indigenous People

Indigenous communities on whose traditional lands the Giant Gippsland Earthworm occurs have been advised, through the relevant DSE Regional Indigenous Facilitator, of this Recovery Plan and invited to comment and be involved in the implementation of the Recovery Plan.

Biodiversity Benefits

Implementation of this Recovery Plan includes a number of potential benefits for other species throughout the range of the Giant Gippsland Earthworm. Principally, this will be through the protection and management of habitat. Protection of the soil habitat in which *M. australis* lives may have beneficial consequences for soil health, sustainable agriculture and water quality and waterway health where *M. australis* occur on streamside embankments. The Narracan Burrowing Crayfish (*Engaeus phyllocercus)* is listed as threatened under Victoria's FFG Act (1988). This species and *M. australis* overlap in range and may be found in similar habitats. Both are known to occur close together at Mt Worth State Park (Van Praagh & Hinkley 1999). Several indigenous species of earthworm occur together with *M. australis*. At present they are unidentified and may represent new species, also with limited distributions. The distributions of the threatened Strzelecki Gum (*Eucalyptus strzeleckii*) and *M. australis* overlap in parts of their ranges, and the management actions for both species need to be checked to ensure that they are compatible. The Recovery Plan will also play an important educational role as the Giant Gippsland Earthworm has the potential to act as a flagship species for highlighting broader conservation issues on farmland.

Social and Economic Impacts

Implementing some of *M. australis* conservation actions may have an impact on landowners. As the majority of *M. australis* habitat occurs on private land, implementation could conflict with current agricultural activities (primarily dairy farming) or future agricultural activities and other developments on private land such as sub-division for residential development (as well as the associated infrastructure such as roads and rail). It is important to identify and resolve potential conflicts early, and this will involve discussions between landowners, developers, and planning authorities. As *M. australis* has a very patchy distribution, the areas on individual properties in which it occurs are generally very small. In the past this has resulted in rapid and easy resolution of land management issues as most landowners are proud to have *M. australis* on their property. Protection of known *M. australis* habitat has been an important activity of the Landcare groups in South Gippsland.

M. australis has a high profile in South Gippsland, and is generally regarded as an important part of the environment by the local community. As one of the few iconic species surviving in the region the giant earthworm has become part of the local folklore and in the past was celebrated during the Karmai festival in Korumburra. The beneficial effects of earthworms for soil health are well known. Conservation of *M. australis* is expected to have positive consequences for sustainable land-use in the region. Involving the community and private landowners in recovery efforts foster a sense of pride in contributing to conservation programs.

Management Practices

The range of the Giant Gippsland Earthworm encompasses large areas of agricultural land. It is also found in areas subject to infrastructure development including road construction, housing and industry. The success of this Recovery Plan will rely to a large degree on formulating practical management prescriptions that are accessible to land holders and land managers. Efforts will be made to educate the community and landowners about the plight of *M. australis* and involve them in conservation efforts. Landowners will be encouraged to consider the species and its habitat on their land, and to adopt sympathetic land management practises.

The Recovery Plan also advocates strategies to improve our knowledge of the species and its ecology. A priority in achieving this is to obtain fine-scale mapping of the species without relying on current, time-consuming and destructive methods.
As the effects of specific agricultural activities on *M. australis* populations are currently unknown, specific management prescriptions cannot yet be determined. However, certain land management activities present clear threats to the species. These include any practices that disturb the soil habitat of the worm, and/or alter drainage or water levels. Activities such as road construction, changing hydrology, urban development, dam construction, ploughing/cultivation, urbanisation and possibly compaction all have the potential to detrimentally affect earthworm populations. Where possible these activities should be avoided in areas supporting *M. australis*. Management prescriptions for conservation of *M. australis* will be refined as research outcomes are available.

Affected Interests

M. australis occurs predominantly on freehold land, with small areas found on public land. The protection of *M. australis* has implications for regional planning, land management, agriculture and tourism in Gippsland. All recovery actions will be undertaken in collaboration with affected stakeholders through involvement in the Recovery Team, workshops, community awareness campaigns and production of educational material. This includes private landowners, planners (Shires and Catchment Management Authorities), infrastructure development agencies, tourism interests, and commercial forestry interests.

- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Victoria
- Parks Victoria
- West Gippsland CMA

- Port Phillip and Western Port CMA
- Baw Baw and South Coast Shires

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Personal Communications

John Bowman DPI, Leongatha
The late Fred Dent, Vic Roads
Dr Neville. Rosengren, La Trobe University Bendigo
Susan Taylor Flora and Fauna Officer, DSE Yarram

Recovery Action Implementation Timetable

Obj	*Description*	*Priority*	*Responsibility*	*Cost estimate*					
				Year 1	Year 2	Year 3	Year 4	Year 5	Total
1	Distribution, habitat	1	DSE, research institutions	$200,000	$100,000	$50,000	$20,000	$20,000	$390,000
2	Survey, monitoring	1	DSE, research institutions	$200,000	$200,000	$50,000	$20,000	$20,000	$490,000
3	Land use impacts	1	DSE, local govt	$150,000	$100,000	$50,000	$25,000	$25,000	$350,000
4	Hydrological processes	1	DSE, research institutions	$150,000	$50,000	$25,000	$20,000	$20,000	$265,000
5	Important populations	1	DSE	$0	$0	$0	$0	$10,000	$10,000
6	Planning schemes	1	DSE, local govt	$30,000	$10,000	$10,000	$10,000	$10,000	$70,000
7	Liaison	2	DSE, CMAs, local govt	$30,000	$10,000	$10,000	$10,000	$10,000	$70,000
8	Reserves	3	DSE, PV	$0	$0	$0	$0	$10,000	$10,000
9	Exposure/damage	2	DSE	$0	$0	$0	$0	$10,000	$10,000
10	Translocation	2	DSE	$0	$0	$0	$0	$10,000	$10,000
			TOTALS	$760,000	$470,000	$195,000	$105,000	$145,000	$1,675,000

Abbreviations: CMAs=Catchment Management Authority; DSE=Department of Sustainability and Environment; PV=Parks Victoria

Appendix 1: Background Information for the Giant Gippsland Earthworm

Species Information

Description

The Giant Gippsland Earthworm (*Megascolides australis)* belongs to the family Megascolecidae, a mainly Southern Hemisphere group, which occurs in Australia, South and Central America, Africa and south-east Asia (Jamieson 1971). The species is elongate and cylindrical with 300-500 segments. The anterior third of the body is deep purple/black while the remainder of the body is a pale pink-grey, fleshy colour. *M. australis* has eight longitudinal rows of setae forming four series of pairs with the outer pairs of each segment further apart than those of the inner pairs. The clitellum begins approximately half way along segment xiii and extends to segment xxi. Adults have three prominent light coloured bands on the ventral surface of the clitellar region, the first positioned partly on segment xvii and xviii, the second on segment xviii and xix, and the third band on segments xix and xx. Additional bands may sometimes be present. The vas deferens or male genital openings are found within the second band on segment xviii, positioned on two raised papillae. The female openings occur on segment xiv.

M. australis can reach lengths up to 1.5 m with an average size and diameter of around 80 cm and 2 cm respectively. Weights up to 400 g have been recorded, although the average is closer to 200 g (Van Praagh 1992, 1994). Newly hatched earthworms are around 18 cm long. While there have been old reports in the literature of worms reaching lengths of over three metres, no specimens of this size have been recorded during the past 15 years.

Life history and population structure

Much of the biology of Giant Gippsland Earthworm remains unknown, reflecting the difficulty in sampling a subterranean animal with a very fragile body. Collection of data requires a destructive sampling technique during which many individual earthworms are injured and killed. Attempts at keeping this species in captivity have met with limited success. The only information available on the biology and age structure is from a study by Van Praagh in the late 1980s where a relatively small population was studied over three years at a streamside at Loch (Van Praagh 1994). More recently, a translocation study on a hillslope at Loch, provided an opportunity to examine a much larger number of *M. australis* over a two month period (AVS 2006).

Several differences between the hillslope and streamside population were found. The hillslope population had a lower adult mean weight (140g cf 208g) and a lower mean weight of clitellate adults (255 g cf 158 g). The maximum adult weight at the stream side site was almost 400g whereas at Loch hill, the maximum recorded was 260g with the majority of adults found under 200g. The population in the first study was located on the banks of a tributary of the Bass River. This habitat may be more optimal than that found on a hillslope leading to larger earthworms with a greater threshold weight for breeding. The Loch Hill collection site was a steeply sloping convex hillside with south to southeast aspect near a change in contour direction around a small spur. There are three factors potentially reducing the quality of potential worm habitat at this site compared with stream bank sites or terraced lower hillslope sites: (i) although deeply weathered and with soils 1.5 metres thick, the regolith profile included a higher fraction of stones and larger blocks of decomposing sandstone thus reducing the sub-surface volume of habitat and available moisture, (ii) although slow-draining internally, there is probably more rapid sub-soil removal of decomposing lithic and organic materials and (iii) steeper slopes and the weak development of terracettes allow more rapid surface runoff and lower infiltration rate leading to occasional drying of the soil profile. This indicates that population characteristics may differ according to local habitat conditions.

Three age classes of worms have been identified based on the number and position of clitella banding (Van Praagh 1994). These are juveniles, sub adult and adults. These small, light coloured bands occur on the ventral surface (underneath) of the worm between segments xvii and xix. Juvenile worms have no external banding, subadults have one or two, and adults have three bands on segments xvii, xviii and xix.

The *M. australis* population at Loch Hill was dominated by adult worms where they comprised 58% of the population collected with subadults and juveniles being in similar proportions (21 and 20.6% respectively). This is consistent with the streamside study at Loch and supports that suggestion that this species is long-lived and spends most of its life in the adult phase.

Breeding

The Giant Gippsland Earthworm is a hermaphroditic species (Van Praagh 1996; Woods 2006). Breeding occurs predominantly in spring and summer (September to February). Large amber-coloured egg cocoons ranging in size from 5 to 9 cm are laid in chambers branching from the adult burrow at an average depth of 22 cm. Only one embryo is found in each egg cocoon, which is thought to take over 12 months to incubate. Egg production appears to be very low and may not occur every year, depending on seasonal conditions. Factors determining breeding cycles are not known but possibly related to soil moisture and temperature conditions. Weekly investigation of a population of *M. australis* during the breeding season indicated that clitellate adults (e.g. breeding and egg laying) were found throughout the field period from October to December. Smaller numbers were found initially with clitellate adults reaching a peak after the second week of November where over 50% of adults found had swollen clitellar.

Although the life span of the species is unknown, field and limited laboratory studies suggest that it is long lived, possibly taking up to 5 years to reach sexual maturity. Field studies examining the age structure of several adjacent *M. australis* populations at a site in Loch (Van Praagh 1992) found the populations to consist predominantly of adults at all times of the year. This suggests a slow growth rate and population turnover, with a low rate of recruitment. Individuals are fragile, and even slight bruising or damage may result in death. Populations of *M. australis* appear isolated from others, and the opportunities for genetic exchange are limited.

Burrow systems

M. australis live in complex, permanent burrows that extend to around 1 to 1.5 m in depth. One worm appears to occupy one discrete burrow system. Worms remain underground, feeding on the root material and organic matter ingested in the soil. On rare occasions earthworms have been seen above ground after being flooded out of their burrows by heavy rains or “dug up” by cattle in heavily pugged soil. Occupied burrows are always wet, even in summer, probably aiding the worm in movement and gas exchange. *M. australis* can be locally abundant with a mean density of 2 per m^3 with up to 10 worms per m^3 recorded (Van Praagh 1994).

M. australis leave their waste products (cast material) below the ground within their burrows, unlike most introduced earthworms that leave their casts above ground. Burrowing crayfish leave large, chimney mounds surrounding the entrance to their burrows. These mounds are often mistaken for *M. australis* casts but are in fact made by the common burrowing crayfish (*Engaeus hemicirratulus)*. These crayfish and the *M. australis* are often found together because they both prefer wetter habitats.

Recovery Information

Existing conservation actions

The Giant Gippsland Earthworm has been of interest to prominent naturalists since the 1930s (e.g. Barrett 1938, 1954), and articles about the species have appeared in many magazines and newspapers. It has also been included in several television documentaries. However, *M. australis* did not receive any significant conservation concern until the early 1980s (Smith & Peterson 1982; Yen *et al.* 1990). Conservation efforts to protect *M. australis* habitat began shortly after completion of the WWF (Australia) *M. australis* project, beginning with the production of a Land For Wildlife Note in 1991 (Van Praagh 1991). However, efforts increased after production of the *Flora and Fauna Guarantee* Action Statement (Taylor *et al*. 1997). Various activities for *M. australis* conservation have been implemented by local Landcare groups, including habitat rehabilitation by eradicating weeds and restoring native vegetation of *M. australis* habitat on crown land along the Bass River and its tributaries. DSE has also helped landowners to fence and revegetate known habitat areas on private property.

Major conservation activities include:

Biology and ecology

The following research into the biology and distribution of *M. australis* has been undertaken since the early 1980s. Much of this work has involved investigating the life history and biology of individual populations.

- Circulation of *M. australis* has been studied (Weber & Baldwin 1985).
- Crnov (1990) made preliminary attempts to identify potential genetic markers to study populations of *M. australis*. DNA extraction and digestion methods, as well as allozyme studies, were used to assess genetic variation between individuals. Due to the small number of *M. australis* examined, as well as technical difficulties, it was not possible to come to any definitive conclusions about genetic variation in *M. australis* populations.
- McCarthy *et al*. (1994) performed a preliminary population viability analysis to investigate the impact of collecting on the species. Based on the best available parameter estimates (survival rate, hatching rate and fecundity), simulations using RAMAS/stage were conducted to consider the effect of harvesting a single *M. australis* population. It was found that death or removal of three earthworms

from a population would result in the extinction of that local population within 50 years.

- Research on the distribution, biology and conservation of *M. australis* was undertaken by Van Praagh from 1987-1992 as part of a PhD study funded by WWF (Australia) (Van Praagh 1994).
- The histology of *M. australis* reproduction has been investigated (Van Praagh 1996).
- Studies of the distribution, biology and soil habitat of a population of *M. australis* at Loch Hill were undertaken during 2001 for Vic Roads (Van Praagh *et al.* 2002). This population occurs in the vicinity of proposed roadworks for the South Gippsland Highway between Loch and Bena.

Management of farm habitats for *M. australis* conservation in South Gippsland has been the subject of investigation as part of the Ecologically Sustainable Agriculture Initiative (ESAI) “Protection of Threatened Species in Agricultural landscapes” (2004–2005).

In October 2000, a population of *M. australis* was threatened by the re-alignment of the Loch bypass and would be severely impacted by its construction. Translocation was considered the only feasible option for conserving the population. A total of 901 *M. australis* were extracted from Loch Hill between October and December 2005 (AVS 2006). Of these, 611 were successfully translocated, in addition to 18 egg cocoons. Monitoring over the past two years has detected breeding adults as well as cocoons. This study provided a rare opportunity to gain access to and examine large numbers of Giant Gippsland Earthworms and is the first ever attempt at translocation of an earthworm species.

The Loch translocation study provided an opportunity to examine the levels of genetic diversity identified by analyses of mitochondrial and nuclear DNA of two populations at Loch and Bena (5km apart) (Woods 2006; AVS 2006). Methods were developed to analyse two separate regions of the mitochondrial genome and DNA sequences from these regions were determined.

Distribution surveys

Early information regarding the distribution of *M. australis* was obtained from questionnaires sent to approximately 2000 properties within the apparent range of the species in the early 1980s (Smith & Peterson 1982). Questionnaire responses also included information on *M. australis* sightings from the 1930s onwards. Van Praagh (1994) and Yen and Van Praagh (1993) added to this data set during distribution studies in the 1980s. While there are no records of the historical distribution of the species, there are records from specimens in Museum collections dating as far back as 1870.

Surveys for *M. australis* have also been conducted to determine the occurrence of the species in state forest under the Gippsland Regional Forest Agreement (Van Praagh & Hinkley 1999). Extensive surveys at Mt Worth determined the distribution of *M. australis* within the Park, including the extent of the species’ distribution under native vegetation (Van Praagh & Hinkley 2000a). Ongoing surveys for companies such as Vic Roads, Telstra, Bass Gas, Gippsland Water, Melbourne Water and Vic Track have also added to the information on distribution.

Planning and management

In 2002, an identification guide was developed in response to requests from Shire Planners in the Gippsland region for information on ways to identify *M. australis* and their habitat. This Guide, which is not yet published, is intended to help planners and land managers to identify potential *M. australis* habitat, detect the presence of the species within an area and identify specimens if necessary. This, in conjunction with information regarding threatening processes, will help planners, land managers and land owners to assess whether development within *M. australis* habitat represents a potential threat to the species.

Recently, the DSE, has developed a BioSite for *M. australis* using data derived from the DSE Land For Wildlife Atlas and personal observations by Van Praagh. The aim of this is to alert land managers of the possibility of where *M. australis* may occur. While this map gives an overall view of the distribution of the species, it can be used in conjunction with the identification of particular habitat factors to narrow down the probability of locating the species within a particular area.

Private land with habitat of *M. australis* has been listed on the Register of the National Estate (Coy 1991).

Information and awareness

Several community programs have formed specifically to conserve the species. Similarly, some works undertaken by individual farmers, including fencing and restoration of earthworm habitat, are intended solely as conservation measures for *M. australis* (Susan Taylor, pers. comm. 2004). Numerous newspaper and magazine articles, radio interviews and television segments regarding *M. australis*, as well as talks to Landcare groups, have contributed to the community's interest and involvement with this species. *M. australis* is the subject of several public displays in the region, including the Coal Creek Historical Park at Korumburra, Bass Giant Worm tourist display, and are the subject of interpretative panels displayed in the underpass at Loch. The species is the central theme of the Karmai festival, once held annually in Korumburra.

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