White-bellied and Orange-bellied Frogs (*Geocrinia alba* and *Geocrinia vitellina*) Recovery Plan

Geocrinia alba

Geocrinia vitellina

Western Australian Wildlife Management Program No. 59

Department of Parks and Wildlife

May 2015

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Locked Bag 104, Bentley Delivery Centre WA 6983

Foreword

Recovery Plans are developed within the framework laid down in Department of Parks and Wildlife Policy Statements Nos 44 and 50 (CALM 1992; CALM 1994), and the Australian Government Department of the Environment's Recovery Planning Compliance Checklist for Legislative and Process Requirements (DEWHA 2008). Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of threatened species and ecological communities. Recovery plans are a partnership between the Department of the Environment and the Department of Parks and Wildlife. The Department of Parks and Wildlife acknowledges the role of the *Environment Protection and Biodiversity Conservation Act 1999* and the Department of the Environment in guiding the implementation of this recovery plan. The attainment of objectives and the provision of funds necessary to implement actions are subject to budgetary and other constraints affecting the parties involved, as well as the need to address a range of priorities. Recovery Plans do not necessarily represent the views or the official position of individuals or organisations represented on the Recovery Team.

This Recovery Plan was approved by the Department of Parks and Wildlife, Western Australia. Approved Recovery Plans are subject to modification as dictated by new findings, changes in status of the taxon or ecological community and the completion of recovery actions. Information in this Recovery Plan was accurate as of May 2015.

Recovery Plan Preparation: This Recovery Plan was prepared by Kim Williams, Department of Parks and Wildlife, South West Region and Gary McMahon, Ecosystem Solutions (PO Box 685, Dunsborough WA 6281) on behalf of and with guidance from the *Geocrinia* Recovery Team.

Acknowledgements; The following groups or organisations have provided valuable support in the implementation of the previous recovery plan for this species and the development of this plan; the University of Western Australia, Augusta-Margaret River Shire, Lower Blackwood Land Conservation District Committee, National Threatened Species Network, South West Catchment Council and Perth Zoo. Manda Page, Holly Raudino, Mia Podesta, Amy Mutton and Abby Thomas (Department of Parks and Wildlife) reviewed and updated the plan and prepared figures.

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Contents

Summary

Geocrinia alba (Wardell-Johnson & Roberts 1989)

Family: Myobatrachidae

DPaW Region: South West Region

DPaW District: Blackwood District

IBRA Regions: Warren

Shire: Shire of Augusta – Margaret River

Current status of taxon:

- Endangered under Section 179 of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- Listed as Schedule 1 of the Specially Protected Fauna Notice under section 14(2)(ba) of the Western Australian *Wildlife Conservation Act 1950*. Ranked as Critically Endangered using the IUCN Red List criteria (IUCN 2004) by the Government of Western Australia.

Habitat critical to survival:

Geocrinia alba inhabit swampy flows along drainage depressions in an area of subdued topography (relief < 80m) near the junction of the Leeuwin-Naturaliste Ridge and Blackwood Plateau (Wardell-Johnson & Roberts 1993; Conroy 2001). Breeding sites are typically associated with sandy soils, dense overstorey vegetation dominated by *Homalospermum firmum*, *Agonis linearifolia*, *Astartea fascicularis*, and a dense ground layer of rhizomatous vegetation, usually composed of *Pseudoloxocarya* sp., *Loxocarya* sp. and *Tetrarrhena laevis* (Wardell-Johnson & Roberts 1993; Conroy 2001).

Geocrinia vitellina (Wardell-Johnson & Roberts 1989)

Family: Myobatrachidae

DPaW Region: South West Region

DPaW District: Blackwood District

IBRA Regions: Warren

Shire: Shire of Augusta – Margaret River

Current Status of Taxon:

- Vulnerable under Section 179 of the Commonwealth EPBC Act;
- Listed as Schedule 1 of the Specially Protected Fauna Notice under section 14(2)(ba) of the Western Australian Wildlife Conservation Act. Ranked as Vulnerable using the IUCN Red List criteria (IUCN 2004) by the Government of Western Australia.

Habitat critical to survival:

Geocrinia vitellina inhabit sites that are structurally, edaphically and floristically similar to those of *G. alba*, though the two species do not co-occur.

Threatening Processes

The main threatening processes that are limiting the recovery of these *Geocrinia* species that are addressed in this plan are:

- Physical habitat disturbance;
- Alterations in hydrology;
- Vegetation clearing;
- Inappropriate fire events;
- Decrease in water quality;
- Disease;
- Climate change; and
- Lack of knowledge.

Recovery Goal:

The overarching goal of the recovery program is to maintain or increase the current extent and viability of these species.

Recovery Objectives
• To protect and effectively manage populations and the habitat critical for their survival
• To increase species viability through population augmentation and establishment
• To achieve an evidence-based management approach
• To increase community awareness and understanding

Geocrinia alba criteria for success:

This Recovery Plan will be deemed successful if, within the initial 10 year period, all of the following are achieved:

- The rate of loss of subpopulations is reduced and the total number of extant subpopulations of *G. alba* does not decrease by more than 20 per cent (using 2012 data as a baseline).
- There is no permanent reduction (using a five year rolling average) in the number of calling *G. alba* males in the McCleod Creek core habitat populations that had greater than 10 calling males in 2009.
- At least two *G. alba* populations with a minimum 10 calling males are successfully established via translocation.
- An evidence-based management approach is applied to conserve and manage *G. alba*.

Geocrinia alba criteria for failure:

This Recovery Plan will be deemed to have failed if, within the initial 10 year period, any of the following are achieved:

- The total number of extant subpopulations of *G. alba* declines by more than 20 per cent (using 2012 data as a baseline).
- There is permanent reduction of 40 per cent or more (using a five year rolling average) in the number of calling *G. alba* males in the McCleod Creek habitat populations that had greater than 10 calling males in 2009.
- No *G. alba* populations (with a minimum 10 calling males) are successfully established via translocation.
- An evidence-based management approach cannot be applied to conserve and manage *G. alba*.

Geocrinia vitellina criteria for success:

This Recovery Plan will be deemed successful if, within the initial 10 year period, all of the following are achieved:

- The number, distribution and size of subpopulations of *G. vitellina* known in the wild remains stable or increases (based on a five year rolling average of male call counts).
- At least one *G. vitellina* population with a minimum of 10 calling males is successfully established via translocation.
- An evidence-based management approach is applied to conserve and manage *G. vitellina*.

Geocrinia vitellina criteria for failure:

This Recovery Plan will be deemed to have failed if, within the initial 10 year period, any of the following are achieved:

- Any naturally occurring (i.e. non-translocated) *G. vitellina* population becomes extinct as a result of controllable anthropogenic threats (e.g. fire, feral pigs, deliberate habitat destruction).
- No *G. vitellina* populations (with a minimum 10 calling males) are successfully established via translocation.
- An evidence-based management approach cannot be applied to conserve and manage *G. vitellina*.

1 Introduction

Recovery plans are important management documents that enable recovery activities related to threatened species and ecological communities to be progressed within a planned and logical framework.

The white-bellied frog (*Geocrinia alba*) and orange-bellied frog (*Geocrinia vitellina*) were discovered in 1983 and described in 1989 (Wardell-Johnson & Roberts 1989) with an extended description provided in 1990 (Roberts *et al.* 1990). A Recovery Plan was prepared in 1995 (Wardell-Johnson *et al.* 1995) and this plan constitutes a review of the recovery actions from that plan and an update and development of new recovery actions for the next 10 years, based on updated knowledge and information.

This document constitutes a formal recovery plan for these two *Geocrinia* species and includes distribution, salient aspects of ecology and biology, threatening processes and decline, and presents the actions, and associated costs, necessary to recover these species.

1.1 Description

Geocrinia alba is a small frog (~20-25mm) with a light brown to grey dorsal surface and a white or very faint yellow wash ventral surface. Ventral skin is smooth and the dorsal surface has two parallel rows of brown "wart-like" spots that extend along the body from the eyes to cloaca. Its toes are short and unwebbed. The males mating call is a series of 11-18 pulses repeated irregularly (Roberts *et al.* 1990).

Geocrinia vitellina is similar except it has a yellow/orange ventral surface and its mating call is a series of 9-15 pulses (Roberts *et al.* 1990).

1.2 Conservation status

Geocrinia alba is listed as Endangered under Section 179 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). It is listed as 'rare or likely to become extinct' under Section 14(2) of the Western Australian *Wildlife Conservation Act 1950,* and is ranked as Critically Endangered by the Western Australian Government using the IUCN Red List criteria (IUCN 2004), under criterion B 2a, b (ii, iii, iv, v):

Area of occupancy estimated to be less than 10km^2, and:

a. Severely fragmented or known to exist at only a single location.

b. Continuing decline, observed, inferred or projected, in the following;

(ii) area of occupancy,

(iii) area, extent and/or quality of habitat,

(iv) number of locations or subpopulations,

(v) number of mature individuals.

The conservation status for *G. alba* in 1995 was Endangered (under the *Endangered Species Protection Act 1992* (ESPA)). In 2000, the status was transferred as Endangered under the EPBC Act. Note the ESPA did not include the category of Critically Endangered, and the classification of the species under that Act was transferred to the EPBC Act.

Data obtained from monitoring *G. alba* over the last 10 years indicate that the species is likely to meet the criteria of Critically Endangered under the EPBC Act, consistent with the State classification under the Wildlife Conservation Act.

Geocrinia vitellina is listed as Vulnerable under Section 179 of the Commonwealth EPBC Act. It is listed as rare or likely to become extinct under Section 14(2) of the Western Australian Wildlife Conservation Act, and is ranked as Vulnerable under IUCN criteria (IUCN 2004) by the Western Australian Government, under criterion VU D2:

> Population with a very restricted area of occupancy (typically less than 20km^2) or number of locations (typically five or fewer) such that it is prone to the effects of human activities or stochastic events within a very short time period in an uncertain future, and is thus capable of becoming Critically Endangered or even Extinct in a very short time period.

The conservation status for *G. vitellina* in 1995 was Vulnerable under the ESPA. In 2005, the conservation status was considered unchanged and classified as Vulnerable under the EPBC Act.

1.3 Taxonomy

The white-bellied frog (*Geocrinia alba*, Wardell-Johnson & Roberts 1989) and orange-bellied frog (*Geocrinia vitellina*, Wardell-Johnson & Roberts 1989) are members of the *Geocrinia rosea* frog complex (Anura: Myobatrachidae). This group includes four allopatric species restricted to the lower south west of WA. All species lay eggs that undergo direct development, a derived character not found in other *Geocrinia* species, or related genera such as *Crinia*. The current distribution of these four species is consistent with an allopatric speciation model where subtle geographic barriers have led to their differentiation (Wardell-Johnson *et al.* 1995).

Classification of these taxa as distinct species within *Geocrinia* is justified on the grounds of distinct differences in ventral colouration, less obvious differences in the male call and significant level of genetic divergence (Wardell-Johnson *et al.* 1995).

1.4 Biology and ecology

Reproduction and Development

Both species share a fully terrestrial breeding biology. Males form choruses throughout spring (September to November) and call from small flask-shaped burrows in soil, usually under litter, moss, or other vegetation (Driscoll 1996; Conroy 2001). Amplexus and oviposition occur within the burrow and the eggs are left unattended. The clutch sizes are small with studies showing the average numbers of eggs being 10-12 (Conroy 2001). The eggs hatch and larvae develop and metamorphose within the burrow in the jelly associated with the egg mass, with no free swimming or feeding stage – a reproductive strategy known as direct development (Driscoll 1996; Conroy 2001). At metamorphosis, juveniles leave the nest. The juvenile stage is prolonged and recruitment into the breeding cohort occurs at 2 or 3 years of age (Conroy 2001). Both species can live for up to six years, however as adult mortality is high (the adult survival rates are among the lowest observed for anurans) the majority only breed for a single season (Driscoll 1996; Conroy 2001). In summary, both species have low fecundity, extended juvenile period and highly variable adult survival. As such, both species are susceptible to demographic catastrophes, both environmental and stochastic.

The breeding season ranges between late August and early-to-mid December. Clutch size, offspring size at metamorphosis and development time, all decrease significantly during the season for both species. Therefore those females that lay earlier produce more and larger offspring, than those that lay later in the season (Conroy 2001).

Population Studies

Genetic studies and mark-recapture studies confirm that there is very little migration amongst and between populations. The genetic differences between the populations of *G. alba* and *G. vitellina* are very large, particularly given the small distances between populations (maximum of 18km and 4km respectively; Driscoll 1996). These large genetic differences suggest that current levels of gene flow are approaching zero. The conclusion that both species are very sedentary is consistent with a mark-recapture study which showed that movement of 95 per cent of adult male frogs, within the study was less than five metres between seasons within a year, and less than 20m between years (Driscoll 1996; Driscoll 1997; Conroy 2001). Although, an extinct site was apparently recolonised by *G. alba* after six years, indicating that while rare, some movement may be possible between sites. This restricted mobility has important implications with regard to the potential for dispersal, gene flow and the capacity for locally extinct populations to re-establish by natural means.

Both isolation in continuous populations and genuine isolation of disjunct breeding sites have probably resulted in the large genetic differences amongst populations of both species (Driscoll 1996). A low capacity to disperse may reduce the likelihood of recolonisation following local extinctions, and as such any local extinction may be permanent.

Conroy (2001) states that recruitment is the main driver of population size, with recruits forming the largest age-class in every year studied. Annual fluctuations in the number of breeding males are predominately driven by variations in the level of recruitment to the breeding cohort. In turn, fluctuations in recruitment appear to be influenced by local, rather than regional phenomena (Conroy 2001; Conroy & Brook 2003).

The male to female ratio is approximately 1:1, based on an analysis of the sex ratio of eggs per clutch and field studies where the number of egg clutches equalled the number of males marked (Driscoll 1996; Driscoll 1999). For both species it is possible to obtain an accurate estimate of the number of calling males from aural counts and given the known male to female ratio these data can be extrapolated to give an estimate of abundance (Driscoll 1998b).

Conroy and Brook (2003) showed that for these two species the population dynamics are most sensitive to changes in juvenile survival, then to fecundity, and thirdly to adult survival. In practical terms, this suggests that management interventions which attempt to mitigate threats causing juvenile mortality are likely to be most successful in arresting metapopulation declines.

1.5 Distribution

These frogs have restricted and patchy distributions. Both species have naturally fragmented distributions due to their dependence on specific breeding habitat provided in broad drainage lines with riparian vegetation (Wardell-Johnson & Roberts 1993). It is difficult to estimate the area of occupancy as the creek lines vary in width from a few centimetres to tens of metres and accurate mapping of the habitat is not available. *Geocrinia alba* extent of occurrence is calculated as 130km^2 (Roberts *et al.* 1999) (Figure 1). However, the area of occupancy is expected to be 1.9km^2 (Wardell-Johnson & Roberts 1993). The discrepancy is due to the species not utilising all available suitable habitat (Wardell-Johnson & Roberts 1993). Approximately 77 per cent of the actual area of occupancy of *G. alba* is within privately managed land. Much of this land has been cleared of native vegetation and is now used for agricultural activities (Figure 1). Wardell-Johnson and Roberts (1991) estimate that 70 per cent of potentially suitable riparian vegetation has been cleared within the range of *G. alba* while an analysis of 2004 aerial imagery has calculated this figure as 65.6 per cent of the extent of occurrence. Clearing activity, albeit small in scale, continues in the region.

Geocrinia vitellina extent of occurrence is calculated to be 6km^2 with an area of occupancy based on suitable habitat estimated at 0.08km^2 (Conroy 2001) (Figure 1). The entire range of *G. vitellina* lies within the Blackwood River National Park, an area managed by Department of Parks and Wildlife and relatively free from major modification.

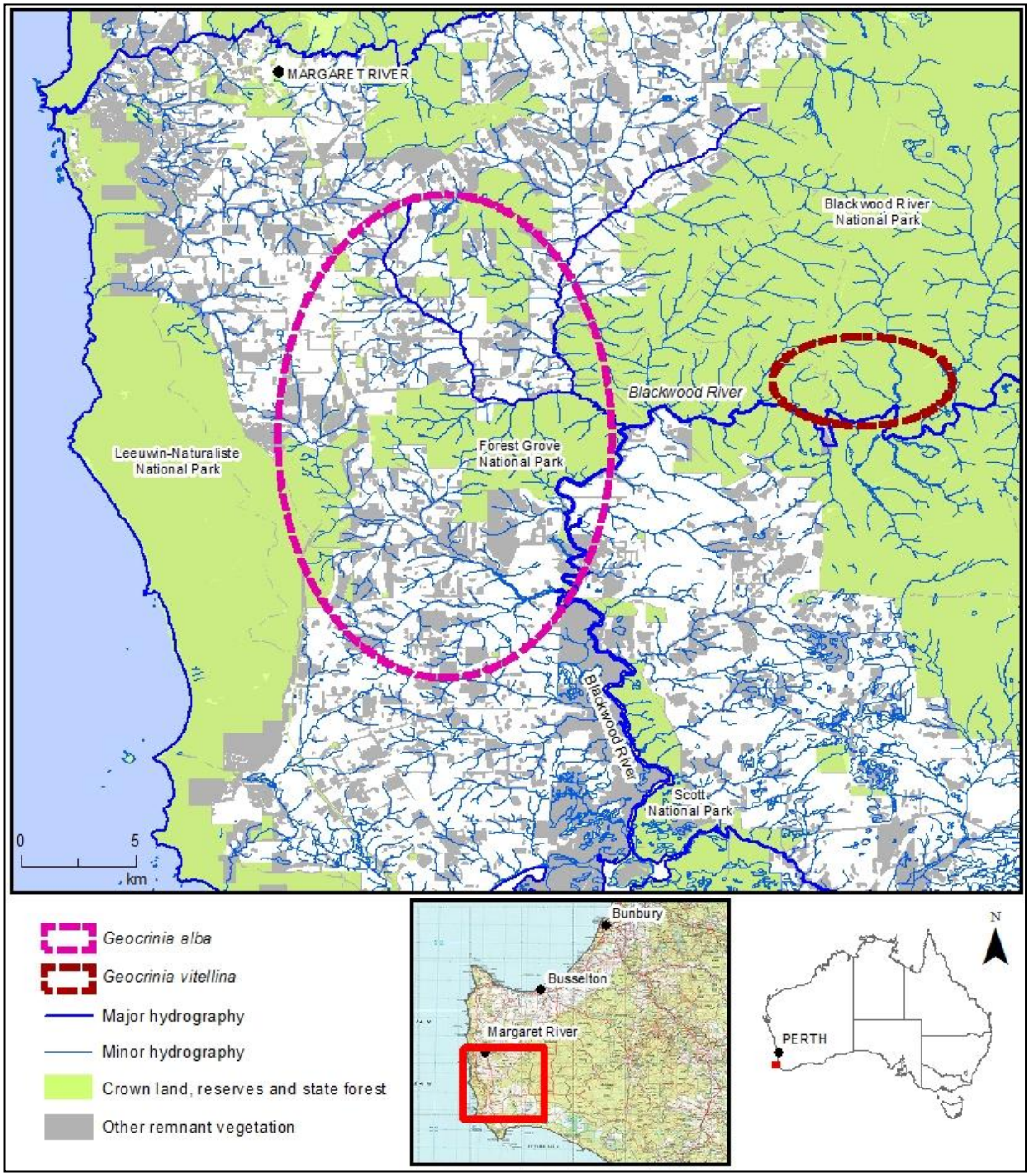

Figure 1: Extent of occurrence for *Geocrinia alba* (left) and *Geocrinia vitellina* (right).

2 Status of populations

All known populations of both species are considered important.

The recognition of discrete populations is however difficult because the scale of isolation is small and there is an implied consecutiveness along drainage systems (Wardell-Johnson *et al*. 1995). For the purpose of this plan the following definitions apply:

- **Discrete populations** represent discrete management units – defined cautiously given the high probability of limited dispersal and the low likelihood of natural dispersal. Discrete populations often occur on separate creek systems, but can also occur on the same creek line (or connecting tributaries) if any one of three factors exist:
    1. A physical barrier, such as a road. Given the low dispersal ability of both species, roads may be an effective barrier to population connection.
    2. A change in land use. If the land use adjacent to an area of occupancy changes along the creek line this may have a local impact on immediately adjacent frog populations (e.g. water use by adjacent blue gum plantations; spray drift from vineyards).
    3. A lack of survey in intervening areas. If calling frogs have been recorded at two places but surveys have not been undertaken in the intervening area, then they are considered discrete populations (also refer to Appendix 1 in Wardell-Johnson *et al*. 1995 for more details). The uncertainty about presence/absence in the unsurveyed gap is a cautious approach to population definition.
- A **subpopulation** is delineated within a population by a distance of 50m along the same creek line but not separated by a physical barrier, change of land use or lack of survey.

The known and predicted range of *G. alba* was surveyed in the early 1990s. This resulted in the number of known populations increasing from 26 recorded in 1991 to 54 in 1993. The definition of a population was devised (Wardell-Johnson *et al*. 1995) and applied to *G. alba* in 1996 and the number of known subpopulations was 72 (*Geocrinia* Recovery Team 1996). In December 2007, using the same definitions, the cumulative total number of recognised subpopulations was 102. There have been no new subpopulations found since 2007. Of the 102 subpopulations, 26 (25.5 per cent) are now considered locally extinct (a site is described as extinct if calling males are absent over four consecutive years) (Figures 2 & 3). Recently, a site considered extinct has been recolonised by a few individuals after six years (K. Williams, Department of Parks and Wildlife, *pers. comm*.). Figure 4 shows the number of *G. alba* subpopulations in different size classes over three time periods (1995-1999, 2000-2004, 2004-2010). This indicates that there is a trend towards smaller populations and increased extinctions (Figure 4).

Geocrinia alba inhabit swampy flows in drainage depressions in an area of subdued topography (relief < 80m) near the junction of the Leeuwin-Naturaliste Ridge and Blackwood Plateau (Wardell-Johnson & Roberts 1993; Conroy 2001). Breeding sites are typically associated with sandy soils, dense overstorey vegetation dominated by *Homalospermum firmum*, *Taxandria linearifolia*, and *Astartea fascicularis*, and a dense ground layer of rhizomatous vegetation, usually composed of *Pseudoloxocarya* sp., *Loxocarya* sp. and *Tetrarrhena laevis* (Wardell-Johnson & Roberts 1993; Conroy 2001).

Fifteen *G. vitellina* subpopulations (including three at sites where frogs have been translocated/introduced) are found on six tributaries along the northern side of the Blackwood River (Figures 5 & 6). There have been two extinctions of subpopulations of this species recorded to date, one naturally occurring subpopulation and one translocated population. Figure 7 shows the number of *G. vitellina* subpopulations in different size classes over three time periods (1995-1999, 2000-2004, 2004-2010). This demonstrates a greatly reduced number of extinctions compared to *G. alba*, and an increase in the number of populations with a larger population size (Figure 7).

These occurrences characteristically have a moderate relief of at least 120m elevation (Wardell-Johnson & Roberts 1993) in contrast to the surrounding areas (Wardell-Johnson & Roberts 1991). *Geocrinia vitellina* inhabit sites that are structurally, edaphically and floristically similar to those of *G. alba*, however the two species do not co-occur.

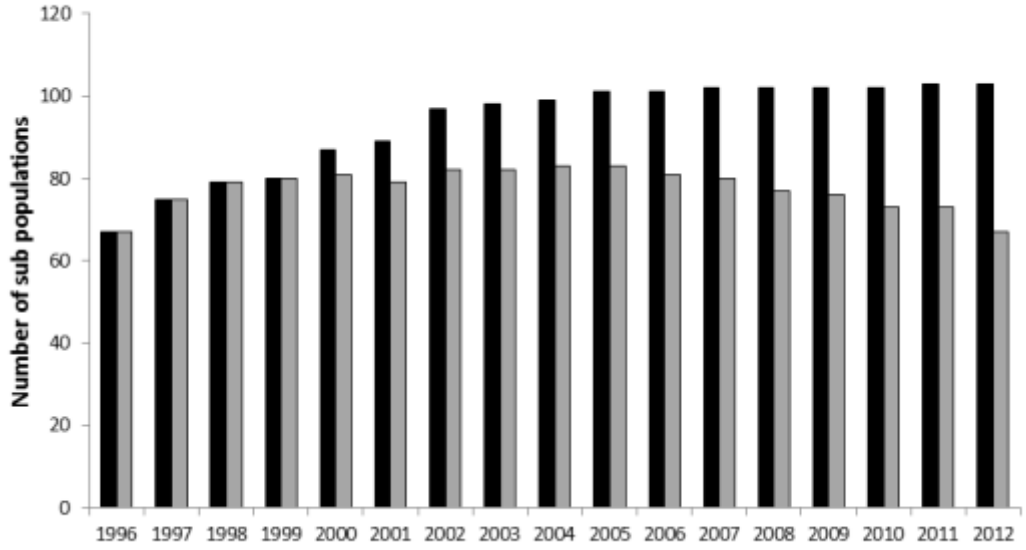

Figure 2: Relative abundance of *G. alba* 1996 - 2012. Cumulative Total (black bars) represents the total number of subpopulations ever known to have existed since 1996. Net Total (grey bars) represents the actual number of extant subpopulations recorded per year.

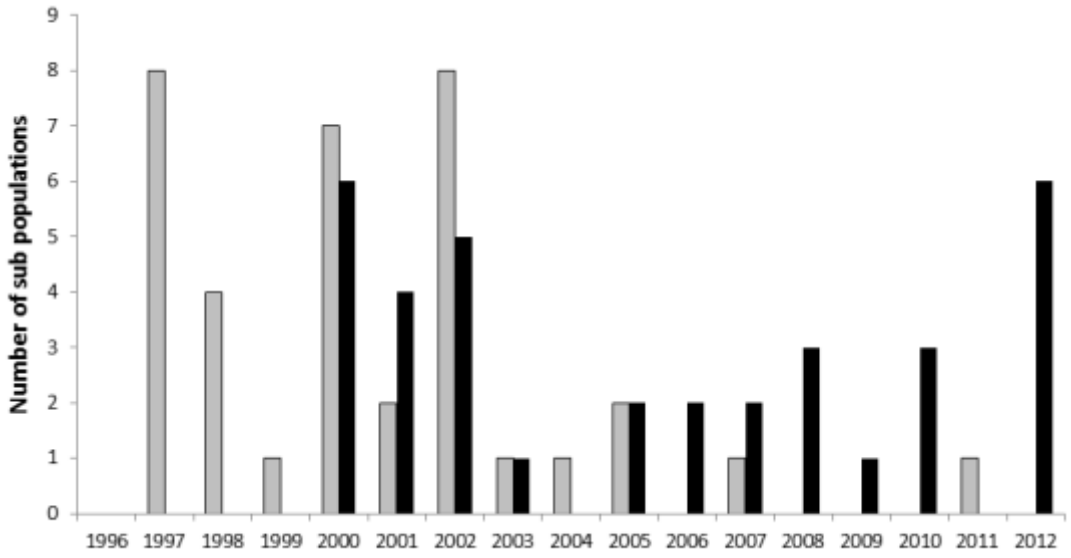

Figure 3: *Geocrinia alba* subpopulation discoveries (grey bars) and extinctions (black bars) between 1996 and 2012.

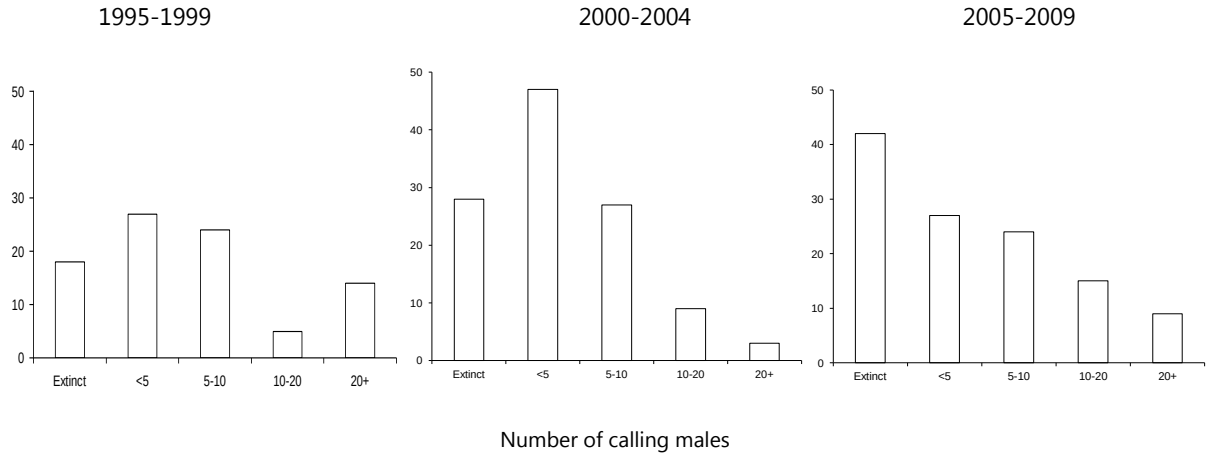

Figure 4: Distribution of *Geocrinia alba* subpopulations across size classes for three time periods (1995-1999, 2000-2004 and 2005-2009), based on annual monitoring of the number of calling males.

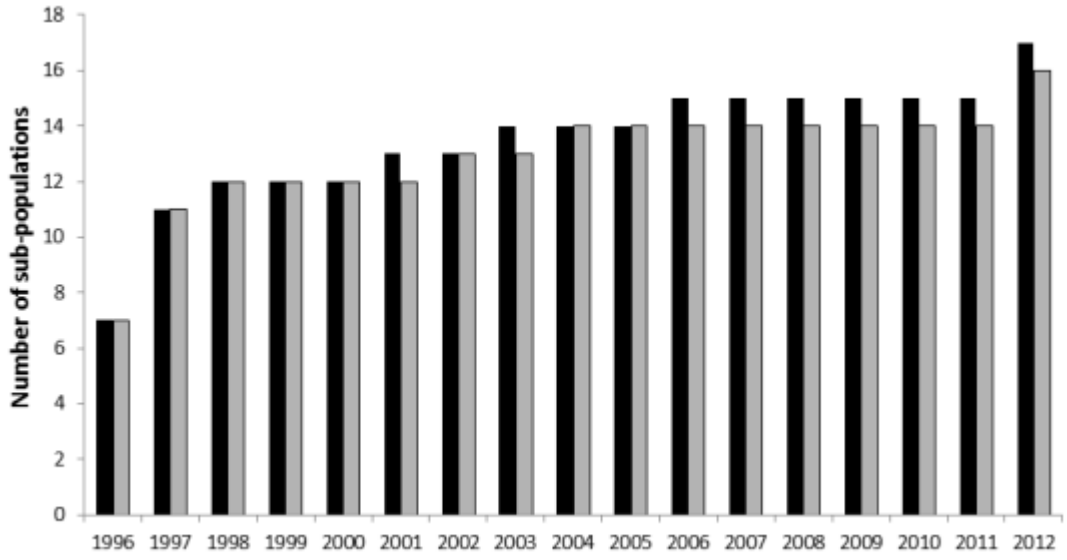

Figure 5: Relative abundance of *Geocrinia vitellina* 1996 - 2012. Cumulative Total (black bars) represents the total number of subpopulations ever known to have existed since 1996. Net Total (grey bars) represents the actual number of extant subpopulations recorded per year (including translocations/introductions).

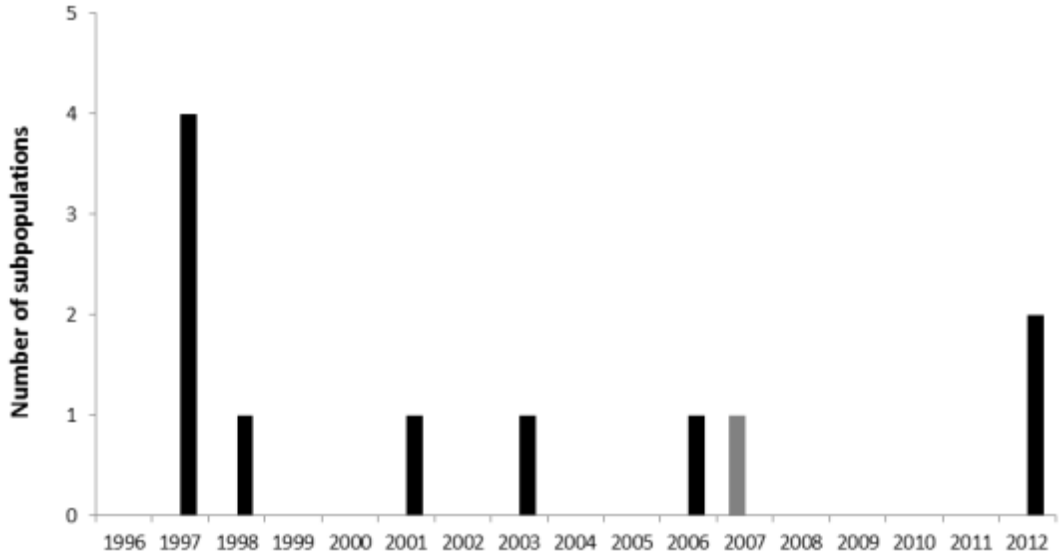

Figure 6: *Geocrinia vitellina* subpopulation discoveries (grey bars) and translocation failures (black bars) between 1996 and 2012. Note there have been no extinctions recorded during the monitoring period.

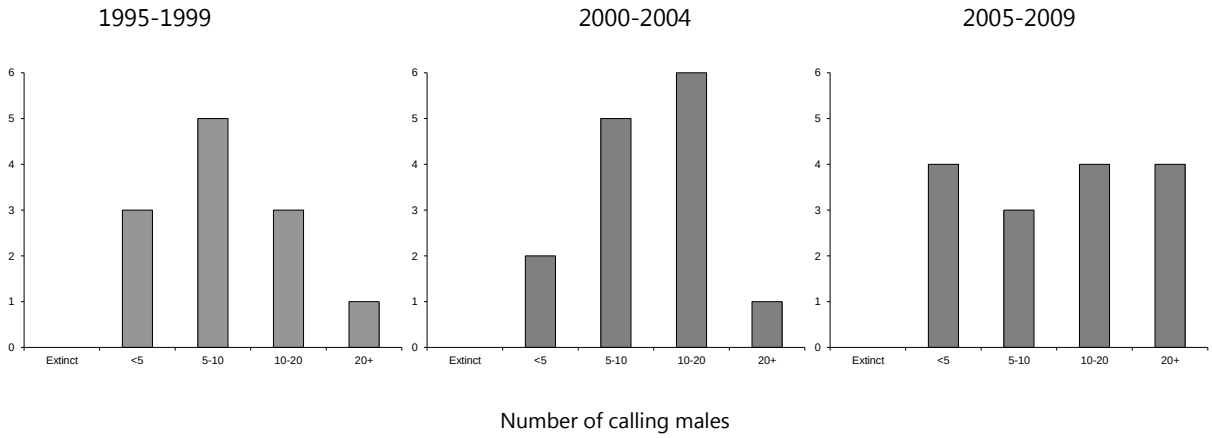

Figure 7: Distribution of *Geocrinia vitellina* subpopulations across size classes for three time periods (1995-1999, 2000-2004 and 2005-2009), based on annual monitoring of the number of calling males.

3 Habitat critical for survival

Geocrinia alba and *G. vitellina* have very restricted and fragmented distributions, due to their dependence on specific breeding habitats which are provided in broad drainage lines within riparian vegetation. The protection of this habitat is essential for the viability of these species. Given there is limited information on the specific physical, ecological and hydrological requirements for these species, generally low numbers within populations, and significant genetic variation between populations, the habitat currently occupied is considered critical to the survival of both species. Other habitat that can be identified as providing suitable hydrology, vegetation structure and protection from threats such as livestock, should also be acknowledged as critical, even if the species is no longer present within it. These sites may be the only sites available to release captive bred frogs in translocation efforts. Equally, unoccupied habitat that potentially facilitates movement/dispersal between populations and sub-populations, or to other unoccupied suitable habitat, is also considered necessary for the survival of these species and to maintain genetic exchange and their evolutionary development. The specific characteristics of suitable breeding habitat and habitat that facilitates movement/dispersal are considered a critical gap in our knowledge. This recovery plan includes actions to develop a better understanding of all habitat critical to survival.

4 Threats

The following potential threats are likely to impact on the survival of both *G. alba* and G. *vitellina*:

- physical habitat disturbance by feral and domestic fauna (e.g. pigs and cows), and humans;
- alterations in hydrology of surface or subsurface flows caused either naturally (i.e. drought) or due to anthropogenic change (i.e. dams, drainage, water extraction);
- vegetation clearing of habitat and surrounding areas;
- inappropriate fire events in and adjacent to habitat;
- changes in water chemistry and/or quality of either surface or ground water (i.e. contamination from herbicides, pesticides, fertilisers etc.);
- disease (i.e. chytrid fungus);
- climate change; and
- lack of knowledge especially related to habitat, species maintenance requirements and ecological thresholds.

4.1 Physical habitat disturbance

Both species occur in very specific habitats over a restricted area. Protection of this habitat is essential for their viability. *G. vitellina* are totally contained within the Blackwood River National Park. The majority of *G. alba* range (77%) is on private properties. Regardless of tenure, the habitats of both species are subject to physical disturbances. Traditionally, dairy and beef cattle have been the predominant land use on private property. Cattle have the potential to cause severe soil disturbance, especially as they obtain water from the creek habitats. Feral pigs (*Sus scrofa*) occur throughout the south-west of WA. They are capable of causing significant disturbance, particularly during summer, when they concentrate their activity within riparian zones in their attempts to source water. The Department of Parks and Wildlife traps for feral pigs in the area of both frog species on a regular basis, with 10-35 pigs removed per annum; however total eradication of feral pigs is not feasible because the methods used such as poisoning, trapping and shooting are not highly effective, and on occasion pigs are reintroduced by hunters.

Geocrinia vitellina, being located within a National Park, may be subject to increased human visitations, and strategies to minimise impacts (e.g. track closures, compliance and enforcement activities) will be required.

4.2 Alterations in hydrology

The breeding biology of *G. alba* and *G. vitellina* make them particularly vulnerable to changes in hydrology. Altering surface and/or sub-surface water flow may lead to desiccation or flooding of habitat. Clearing of vegetation (discussed below), establishment and harvesting of plantations, and construction of dams can all have impacts on surface and sub-surface streamflows. Although a previous study (Sutton 1990) indicated that only six per cent of landowners intended to dam creeks, the significant increase in viticulture operations and intensive horticulture that have emerged in the area over the past 10 years indicates this may be an increased threat. The establishment of vines usually requires the construction of dams as a water source. Another element of the viticulture industry is the need to ensure that any excess water is rapidly removed from areas under vines. Many larger vineyards establish sub-surface drainage systems to remove water quickly. These can vary from elaborate containment ponds to basic (and more common) buried agricultural drainage pipes to divert water.

4.3 Vegetation clearing

Geocrinia vitellina has a very limited extent of occurrence of less than 6km^2 and an extremely small area of occupancy (~0.08km^2) consisting of the habitat in six creek systems to the north of the Blackwood River. This area is entirely within the Blackwood River National Park, consequently vegetation clearing and logging are now of minimal threat to this species.

Geocrinia alba has an extent of occurrence of 130km^2 (Roberts *et al.* 1999), but within this it is confined to an area of occupancy of riparian vegetation of approximately 1.9km^2 (Wardell-Johnson & Roberts 1993). Most of the range has been cleared for agriculture. Clearing began in the 1920s and rapidly escalated between 1971 and 1981 (Pauli 1999). It has been estimated that 70 per cent of potentially suitable riparian vegetation has been cleared within the range of *G. alba* (Wardell-Johnson & Roberts 1991). *Geocrinia alba* appear to be able to persist within this modified environment, at least in the short term, providing the remaining riparian vegetation cover stays intact. Individuals of this species have not been found to persist at any sites where the riparian vegetation has been cleared or severely degraded. The majority of *G. alba* occur on private land where they are subject to the impacts of the owner's management regime. Most of the current populations have few individuals irrespective of tenure (27 populations have less than 5 calling males; 24 populations have between 5-10 calling males) (Figure 8). *Geocrinia alba* is highly susceptible to the impacts of vegetation clearing, and although vegetation clearing is regulated and the rate of broad scale clearing has declined over the last 20 years, vegetation is still cleared for fire break construction, maintenance of utility services and the creation of illegal drug crops. Therefore, vegetation clearing remains a significant threat to *G. alba,* and the protection of this habitat must be taken into account when applications to clear native vegetation are assessed.

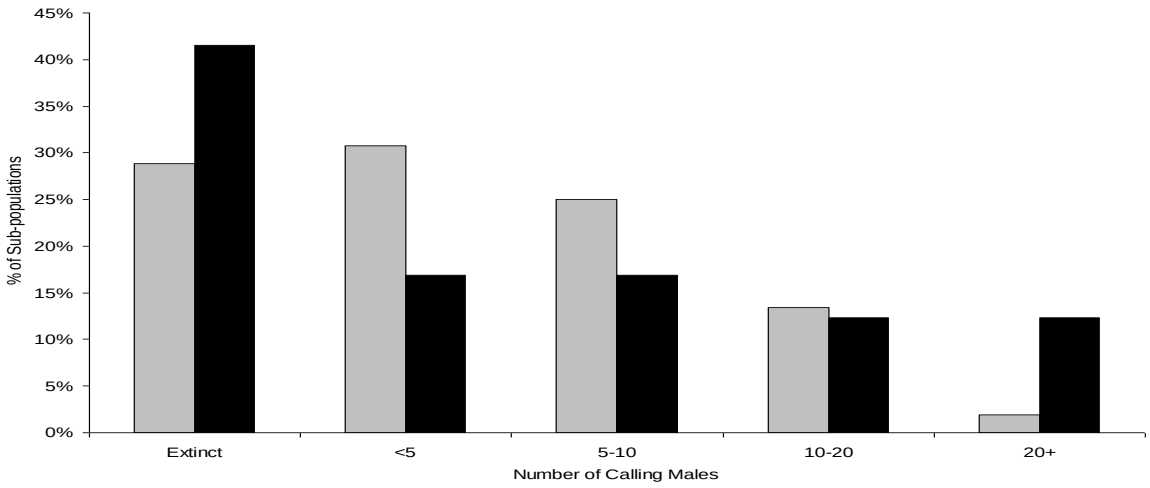

Figure 8: Number of *Geocrinia alba* on different land tenures (grey bars on conservation land, black bars on private property) as at December 2009.

4.4 Inappropriate fire events

Fire is an important component in the dynamics of Australian ecosystems as an agent for disturbance (Gill *et al.* 1981) and a natural factor in rejuvenating and maintaining age structures of floristic communities (Catling & Newsome 1981). Fire succession cycles generate spatial and temporal heterogeneity in habitats and microhabitats. At landscape levels fire stimulates and maintains local diversity (Catling & Newsome 1981; Pianka 1992). Fire is also an important management tool to reduce fuel loads resulting in lower intensity wildfires should they occur (Shea *et al.* 1981).

The effect of fire on many faunal groups is not well understood and this applies to *G. alba* and *G. vitellina*. Although information is incomplete, inferences regarding the effects of fire on these species can be made from limited data on *G. vitellina* following a wildfire in 1997, information about the breeding biology and habits of these two species, and evidence from the congeners *Geocrinia lutea* and *Geocrinia rosea* (Driscoll 1996; Driscoll & Roberts 1997; Bamford & Roberts 2003). These studies showed that for both wildfire and cooler season fuel reduction burns, these species may decline initially but, depending on a number of parameters (e.g. hydrological characteristics of the habitat and proximity to unburnt occupied areas); tend to recover within 5-7 years post fire. The fact that frequent, and often extensive fires occur in the area of their occurrence suggest that inappropriate fire events may be a major threat and as such fire management will be required for their conservation. Inappropriate fire events are not limited to wildfire but include the risks associated with escaped planned burns.

A number of sites with *G. vitellina* that are monitored annually have had at least 23 years between fire events and many of the *G. alba* on private lands are unlikely to have experienced fire since the 1960s. Annual monitoring of populations since the mid 1990s suggests that a population's abundance appears to fluctuate in response to variations in seasonal rainfall and summer drought conditions. *Geocrinia vitellina* and *G. alba* occur in permanently waterlogged conditions with seasonal inundation. This type of habitat was more common in the past when fire was not prevalent in the south-west of WA. Its current habitat comprises of remnants that preserve these (now unusual) conditions. In this respect *G. alba* and *G. vitellina* stand out from other fauna species that have adapted to the onset of aridity in the Pleistocene. As such, there appears to be no ecological requirement to apply fire within the habitat of these species to create a disturbance regime, rejuvenate the vegetation or to maintain species productivity, as is undertaken for other frog and mammal species. In addition, there is an increased risk of weed invasion and decline in habitat quality following fire in small remnants (Wardell-Johnson *et al.* 1995).

Where possible, fire should be excluded from swamp habitat, while surrounding land should be managed to include a variety of fire regimes.

4.5 Decrease in water quality

The breeding biology of *G. alba* and *G. vitellina* make them susceptible to changes in water quality within their habitat. These threats include:

- herbicide (and associated wetting agents), pesticide, fertiliser and other agricultural chemicals that may infiltrate the sites from adjoining agricultural lands;
- increased salinity levels associated with higher water tables resulting from vegetation clearing;
- acidification as a result of disturbance to acid sulphate soils; and
- siltation/sedimentation that can occur from disturbances within catchments.

The greatest of these threats is likely to be from the application of agricultural chemicals to lands in close proximity to frog populations. The application of fungicides, fertilisers, herbicides and pesticides to land adjoining known populations poses the risk of these entering and contaminating habitat areas or causing direct harm to the individual animals. The level of knowledge on the response of *Geocrinia* frog species to the range of agricultural chemicals is poor. However there is established international literature that highlights the sensitivity of frog species to commonly used agricultural chemicals (i.e. Mann *et al.* 2009).

4.6 Disease

The amphibian disease chytridiomycosis (*Bactrachochytrium dendrobatidis*) has been detected for both *G. vitellina* (Aplin & Kirkpatrick 2000) and *G. alba* (H. Robertson, Perth Zoo, pers. comm.). Despite detection there is no evidence to indicate that it has had, or is having any significant impact on the species to date. However based on the impact this disease has had on other frog species both in Australia and internationally, vigilance regarding hygiene practices is highly recommended until the risks are fully understood.

4.7 Climate change

The south-west of WA has been assessed as being particularly vulnerable to the effects of climate change (Pouliquen-Young & Newman 2000; Howden *et al.* 2003). There has been an observed rainfall decrease of 10-20 per cent in the south-west since the 1970s and an approximate increase in temperature of 0.7°C since the 1950s, with warming greater in winter (CSIRO 2002). The future predicted trend is continued warming and a decreased winter rainfall, with CSIRO suggesting an approximate temperature rise of 1°C and a 70mm reduction in annual rainfall by 2030, for the south-west (CSIRO 2002; Timbal 2004). Reduced rainfall is expected to impose additional pressures on the biodiversity of the South West Region, including *G. alba* and *G. vitellina* (Pouliquen-Young & Newman 2000). Climate change can exert biological, ecological and physical pressures resulting in changes such as a loss of canopy continuity and increased fire frequency. The impact of reduced rainfall may be less or delayed if it is found that the main source of water into a habitat is from aquifer outflow rather than surface run-off. Understanding the hydrology of occupied habitats and surrounding areas will assist in determining specific risk levels.

4.8 Lack of knowledge

There is a lack of knowledge on these two species, especially in relation to habitat and species maintenance requirements and ecological thresholds. More work is required to better understand the limits of acceptable change in terms of habitat parameters for both of these species. A greater understanding of their ecology and habitat requirements will allow more specific management actions to be developed.

5 International obligations

The plan is fully consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in June 1993. This plan will assist in meeting Australia's obligations under this convention.

6 Affected interests

All known *G. vitellina* occur on land which is managed by Department of Parks and Wildlife and *G. alba* occur on lands managed by Department of Parks and Wildlife, private owners and the Shire of Augusta Margaret River. Therefore these are the main parties to be affected by this Recovery Plan. Other parties with affected interests may include: Department of Agriculture and Food Western Australia; Water Corporation; Department of Water Western Australia; mineral exploration and extraction companies; Forest Products Commission Western Australia; private timber companies; Conservation Commission of Western Australia; Department of Planning Western Australia; Perth Zoo and private landholders.

7 Role and interests of Aboriginal groups

The Aboriginal name for *Geocrinia* spp. is not known..

Department of Parks and Wildlife will consult with the South West Land and Sea Council as the regional representatives for native title and indigenous engagement in the south west of Western Australia. Implementation of recovery actions under this plan will include consideration of the role and interests of Aboriginal communities in the region. Input will be sought from any Aboriginal groups that have an active interest in areas where *Geocrinia* frogs are found. The Aboriginal Heritage Sites Register, maintained by the Department of Aboriginal Affairs, has been used to identify significant sites in the vicinity of areas occupied by these species. However, it is noted that not all significant sites are listed on the Register.

8 Social and economic interests

Geocrinia alba

Sixty five per cent of *G. alba* populations are on privately managed lands. Physical removal and the degradation of riparian vegetation are major threatening processes for the survival of this species, as are the impact of altered water regimes and potential chemical contamination from agricultural activities. Given the land use changes to viticulture and tree plantations that have occurred in the region over the past 10 years, a major issue exists in protecting known populations from the impacts of these activities on privately managed lands. Determination of appropriate buffers and minimal impact chemicals may require changes to land use planning and agricultural practices at locations adjacent to occupied frog habitat. Quantification of the level of environmental water flows required to sustain frog populations downstream of private dams may require changes to local water resource management. More prescriptive regulations defining the width and placement of firebreaks through environmentally sensitive areas such as riparian areas and associated swamps, are required and may result in impacts to land management activities and operations.

Geocrinia vitellina

All *G. vitellina* populations are on public lands managed by Department of Parks and Wildlife, consequently the implementation of this recovery plan is unlikely to cause any adverse social or economic impacts. Small scale inconveniences as a consequence of restricting recreational access to three creek systems containing occurrences are not expected to cause any adverse social impacts.

9 Broader biodiversity benefits

Successful conservation actions that assist in the survival and recovery of *G. alba* and *G. vitellina* have broader benefits for other species that require similar habitats. The maintenance, protection and restoration of the specialised riparian habitats of the frogs also assists the conservation of a number of nationally and State listed threatened fauna species such as *Engaewa* spp. (land burrowing crayfish), quokka (*Setonix brachyurus*), western ringtail possum (*Pseudocheirus occidentalis*), chuditch (*Dasyurus geoffroii*), white-tailed black cockatoos (*Calyptorhynchus baudinii* and *C. latirostris*), forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*), and state listed priority fauna species such as southern brown bandicoot (*Isoodon obesulus fusciventer*), and all other local frog species that require the maintenance and integrity of the vegetation and riparian zone. The State and nationally listed flora species *Reedia spathacea*, and the State listed Priority Ecological Community *Reedia spathacea, Empodisma gracillimum, Sporadanthus rivularis* dominated floodplains of the Blackwood Plateau will also benefit.

10 Recovery history

10.1 Recovery actions to date

The 1995 Orange-bellied and White-bellied Frog Recovery Plan (Wardell-Johnson *et al.* 1995) outlined six recovery strategies:

- survey habitat;
- habitat protection;
- community participation;
- population monitoring;
- population biology; and
- population genetic studies and translocations.

From these strategies, eight specific recovery actions were outlined:

- survey of riparian habitat;
- land tenure and management;
- fire management and research;
- habitat protection;
- wider community participation;
- population monitoring;
- genetic studies; and
- translocations.

A short summary of what has been achieved to date is presented below for each of the recovery actions.

Survey of Riparian Habitat

At the inception of the plan there were areas within the range of the species that had not been surveyed, especially those areas within private property and distant from access roads. An intensive survey of the creek systems to the east of the main area occupied by *G. vitellina* in the Spearwood Creek Complex and south of the Blackwood River has been conducted. This replicated a survey undertaken in 1992-1994. Being 4-6 years between surveys, any sub-adult populations of which may have been present, but not calling in the original survey would have matured into reproductive adults. However, no calling was observed and therefore no new populations were discovered (Williams 1998).

Land Tenure and Management

The majority of *G. alba* occur on private land along narrow corridors of riparian vegetation among extensive areas of cleared farmland (Wardell-Johnson *et al.* 1995). In 2000, 1570ha of *G. alba* habitat was acquired for addition to the Blackwood River National Park. This area contained approximately 30 per cent of the total number of known calling males (Williams 2000). Some other crown lands where *G. alba* occurred is now incorporated in Blackwood River and Forest Grove National Parks.

At the commencement of the plan, all records of the *G. vitellina* were in State forest, under management of Department of Parks and Wildlife. In 2004, this tenure was changed to National Park and currently all known *G. vitellina* are within the Blackwood River National Park.

Fire Management and Research

Figure 9 presents data on the variation in the number of *G. vitellina* calling males recorded from three sites burnt in a wildfire in September 1997 versus three unburnt sites in the same creek system. Over a 10 year post-fire period burnt and unburnt sites appear to have performed similarly with all but one of the unburnt sites showing an increasing trend in the number of males recorded on standardised transects. Research has been conducted on the impacts of burning activities on *G. lutea* (Driscoll & Roberts 1997), a congener frog that has similar breeding biology and population structure, but is more abundant and widespread. Findings from this research and observations have identified a set of parameters that are required to maximise post-fire survival of a *Geocrinia* frog occurrence. These are:

- large population of more than 50 pairs;
- extensive area of habitat (i.e. large swamp systems);
- riparian systems where surface water flows all year; and
- in close proximity (~200m) to other populations.

These observations have been distilled into four fire management practice determinations that are to be observed and further tested during the life of this plan:

- High intensity bushfires in riparian habitat should be avoided, particularly in late summer and autumn.
- Deliberate application of fire to occupied *Geocrinia* riparian habitat should only be considered/undertaken at inter-fire periods of 30-50 years.
- To maximise the possibility of recovery, protection burns within the occupied habitat should be undertaken in a manner and time of year (early spring) to minimise the intensity and area of the burn, to achieve a fine scale mosaic and have limited or no requirements for mineral earth firebreaks to be established.

- The non riparian vegetation abutting the *Geocrinia* habitat should be burnt on a minimum frequency of eight years to maintain a low fuel buffer surrounding *Geocrinia* habitat in a manner and time of year to reduce risk of escape into occupied habitat. Should fire escape from the protection burn and enter occupied habitat, this frequency should be modified to allow for a minimum of two generations of frogs to be bred for population recovery following fire events (*Geocrinia* Recovery Team 1996).

In addition, it is possible that these frogs move into upland areas at the end of the breeding season and this has implications for fire management also. Specifically:

- Burn only the minimum area needed to reduce the risk that all swamps will burn in a single fire.
- Burn as far away from swamps as possible to achieve the reduced risk goal. (generally agreed to be a minimum of 50m from swamps)
- Burn when frogs are most likely to be inhabiting swamps and not upland areas.
- Increase the capacity for rapid response suppression of unplanned fires.

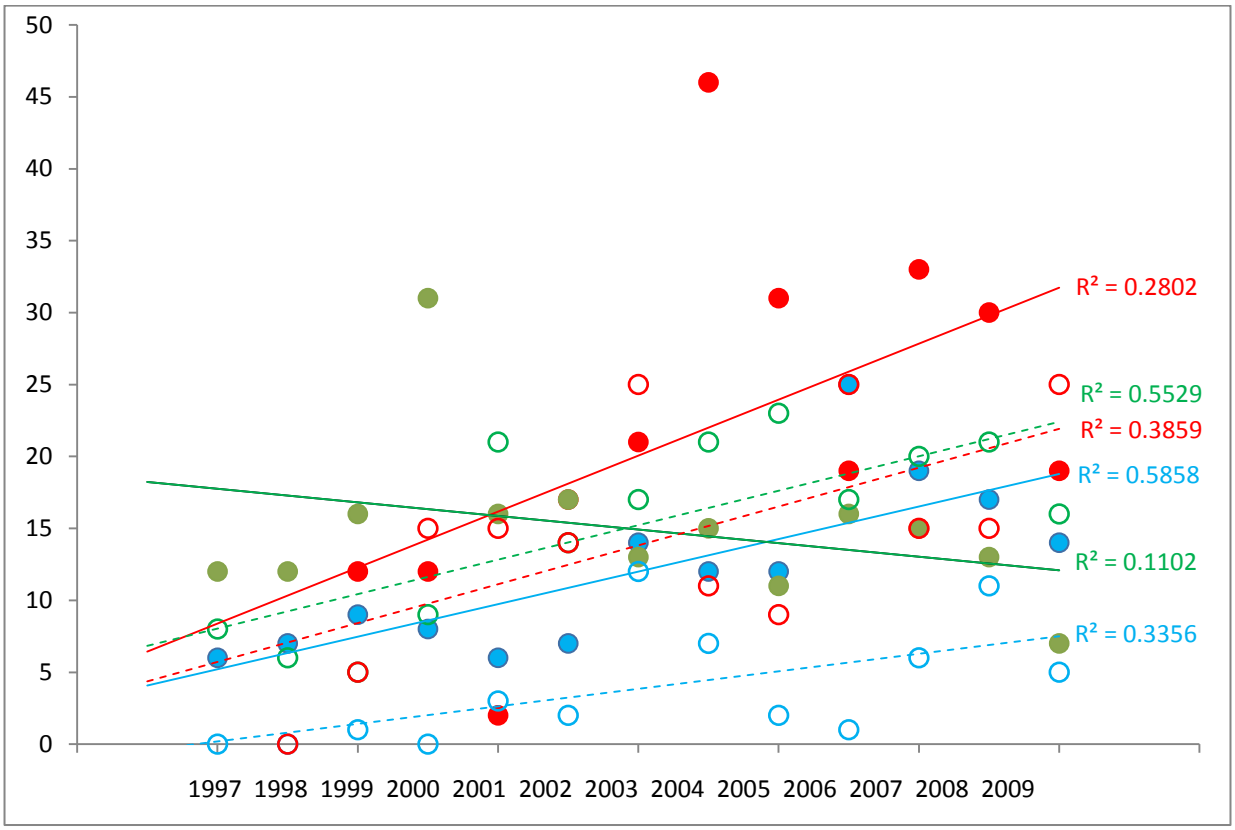

Figure 9: Points and linear regression of the number of calling *G. vitellina* males in three burnt (open circles and dashed lines) and three unburnt (solid circle and solid lines) populations between 1997 and 2009. The wildfire occurred in 1997 prior to measurement.

Habitat Protection

The major action to protect habitat of *G. alba* on private property is to protect it from livestock. Approximately 13km of conservation fences have been constructed and maintained across 19 properties protecting approximately 17ha of riparian habitat from livestock damage. Selection criteria for candidate properties included properties where:

- the ongoing presence of stock was likely;
- representative examples of frog populations existed - at both the northern and southern range extents and central core habitat along the McLeod Creek; and
- the property owners were receptive to the concept of fencing (Williams, 1998).

The major action to protect habitat of *G. vitellina* is to reduce the threat of disturbance from feral pigs. Annual pig control has been maintained for the sites with *G. vitellina* and surrounding areas. Detailed interviews of landowners with *G. alba* on their properties were conducted in October 2005. All 18 interviewees commented that they had not observed any damage from pigs in the watercourses on their properties. Although this may lead to the assumption that feral pigs are not a threat to this species, vigilance is required given pigs may move into the area (either naturally, or through introduction by humans).

In partnership with the Department of Parks and Wildlife, South West Catchment Council has coordinated, delivered and funded on-ground projects which have contributed to the protection of *Geocrinia* habitat on both public and private land. These have included, but are not limited to, the funding of feral pig control programs, and ecosystem protection and rehabilitation.

Habitat protection has also been supported through the introduction of enhanced clearing regulations. Amendments to the Western Australian *Environmental Protection Act 1986* in 2004 provide greater capacity for the regulation of vegetation clearing. Under the Act, it is a principle that native vegetation should not be cleared if it comprises the whole or part of, or is necessary for the maintenance of, a significant habitat for fauna indigenous to WA.

Wider Community Participation

A coordinated public information program was developed because private land owners are in a good position to regularly assess the condition of the riparian habitat on their properties, identify habitat destruction from pigs and cattle, and reduce the threat of fire (Wardell-Johnson *et al.* 1995).

A 'Frog Recovery Kit' was produced which outlined information about the species and the recovery process. An intensive program to confirm contact details of landowners with *G. alba* on their property, field visits with the landowners and discussion on the future management of the habitat occurred from August – December 2005. Twenty-five landowners were contacted, and 12 field visits were conducted with the owners.

Two sites occupied with *G. alba* have been protected by the establishment of conservation covenants on the title of the properties (GA 26a, 26b). The conservation of these species is a shared responsibility between Department of Parks and Wildlife, land-owners and the community. Good communications and actions between the Department of Parks and Wildlife and landowners will facilitate effective recovery actions, especially for *G. alba*. Despite efforts, the majority of property owners exhibit a lack of interest or are indifferent to the fact they have this threatened species present on their property. This coupled with the technical nature of the monitoring and translocation actions, means there is limited engagement and opportunities for community participation in the recovery process.

Population Monitoring

In 1995, there was limited information concerning the long-term trends in the frog numbers and little was known in relation to the impact of disturbance on these species. A strategy aimed at understanding patterns and trends within populations was implemented. Annual monitoring has been conducted on both species to detect impacts of human-related disturbances and to assess the effectiveness of management practices. This information has additional relevance for assessing long-term trends that may occur as a consequence of climate change.

There were three types of male call counting methods applied; point counts, transect counts and linear counts. All known sites of *Geocrinia* had a point count monitoring site established and a subset of these had transects established. Over the last decade the number of sites where transect count are conducted has been reduced and superseded by linear count monitoring methods. This occurred because the linear count method allows the extent of the population to be monitored by locating the first and last calling male of a population. This type of monitoring has revealed dispersal/expansion or contraction trends in addition to population size (see Figure 10 as an example).

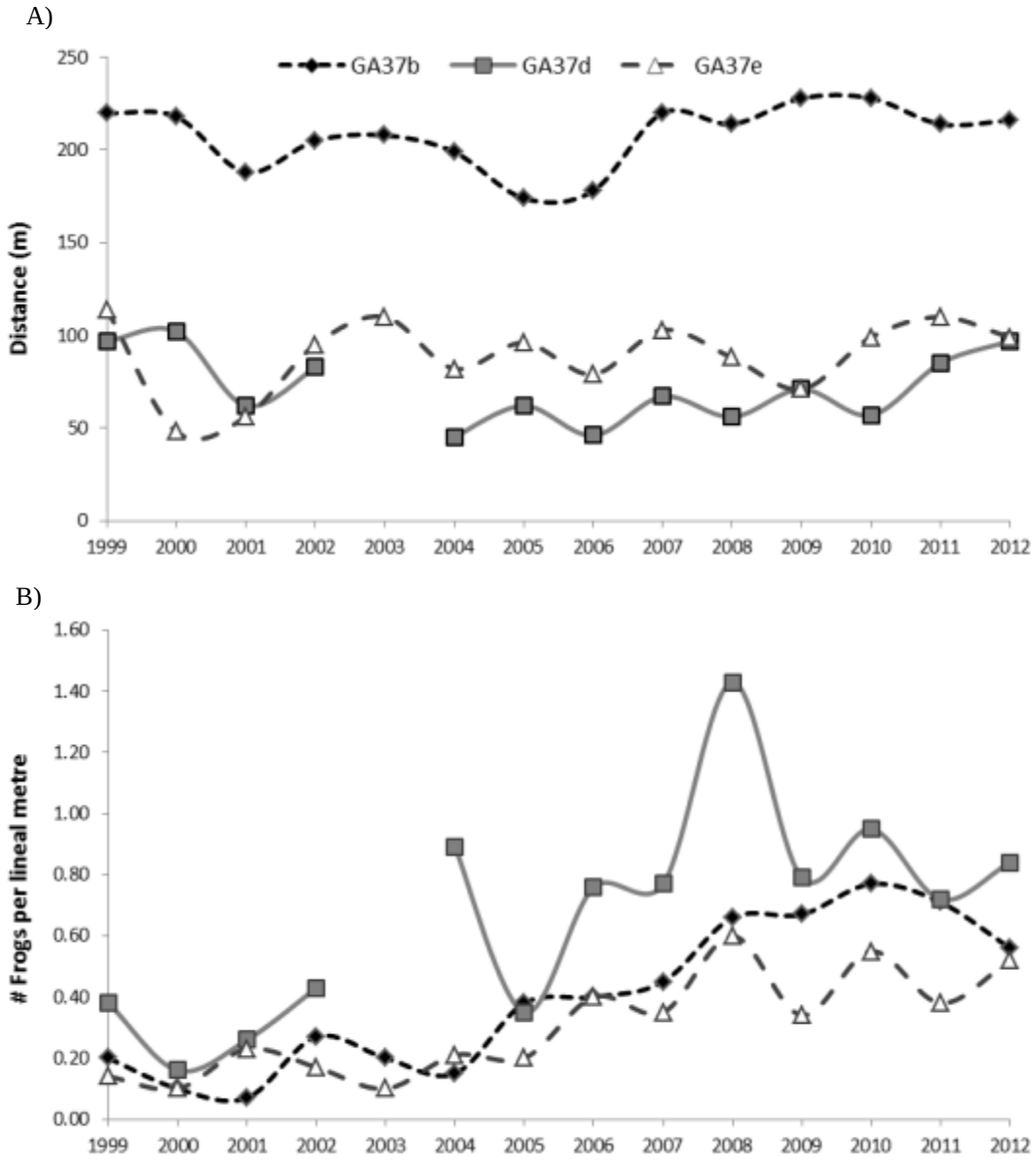

Figure 10: A) Population extent (m), and B) population size (number of frogs per linear metre) of three *Geocrinia alba* subpopulations between 1999 and 2012.

Genetic Studies

At the commencement of the plan, there was limited information on the genetic variability of either species, particularly between populations. In 1995 it was determined that there was considerable genetic structuring in both species (Driscoll *et al.* 1995; Driscoll 1999). The magnitude of the genetic differences suggests that each population should be protected from extinction and high rates of introgression because this would result in a loss of genetic diversity in both species (Wardell-Johnson *et al.* 1995; Driscoll 1998a).

The strategy to maximise the conservation of genetic diversity is to:

- protect as many populations as possible;
- augment very small populations by release of captive bred stock taken originally from the same population;
- ensure stock for translocation into unoccupied habitat has the same genetic profile as the nearest occupied site.

Translocations

Four translocation options were outlined in the plan:

- translocation of egg masses in the field;
- translocation of egg masses to the laboratory which are raised to adult stage for release;
- translocation of adult individuals to new sites from existing populations;
- captive breeding.

The translocations of eggs were the preferred option.

There are few examples in the published literature of translocation programs for amphibians. This issue first received serious consideration and review in the early 1990s (Burke 1991; Dodd & Seigel 1991; Reinert 1991), and more recent publications (Marsh & Trenham 2001; Seigel & Dodd 2002; Trenham & Marsh 2002) from the northern hemisphere provide a good basis for discussion and analysis of this method of conserving threatened amphibians.

As *G. vitellina* is categorised as having a lesser risk of extinction, translocations were conducted on this species to develop and optimise the translocation processes before work was undertaken on the more threatened *G. alba*.

In 2000, seven *G. vitellina* egg masses from Spearwood Creek North and 13 egg masses from Geo Creek were translocated to two release sites in the Adelaide Creek (GV7a and GV7b respectively). This activity has been partially successful with one of the sites (GV7b) recording low numbers of calling males annually between 2003 and 2009 (Figure 11). However, the translocation to GV7a appears to have failed (Figure 11). This demonstrated that Adelaide Creek habitat is capable of supporting and sustaining frogs for an extended period including periods of summer drought, but that the founding population may have been too small to provide population stability and compensate for annual mortalities and resilience to annual weather variation.

In 2005 a single calling male was discovered approximately 40m downstream of GV7b and subsequently 34 *G. vitellina* egg masses were translocated to this site (GV7c). As at December 2009 there is little evidence to suggest this action was successful with only two calling males recorded in 2009 (Figure 11).

In 2006 Perth Zoo commenced a captive breeding project for the *Geocrinia* species. *Geocrinia alba* egg nests collected from the wild have been successfully maintained and metamorphs reared to one year old. This species requires more than a year to reach sexual maturity in captivity. Attempts at breeding and rearing *G. vitellina* have been less successful. Unfertilised egg nests were laid in 2008 and adults in 2009 did not appear to come into breeding condition properly (H. Robertson, Perth Zoo, pers. comm.).

A translocation of *G. alba* was undertaken in September 2010 to Witchcliffe Forest Block. A total of 70 individuals (62 metamorphs < 1 year old, 6 sub-adults > 1 year old, and 2 adults > 2 years old) that were captive reared at Perth Zoo were released. Monitoring post release recorded 25 individual males calling in September 2011. In October 2011, an additional 31 (22 adults, 9 juveniles) *G. alba* from Perth Zoo were released to the same site. Future translocations and captive breeding are required to meet recovery objectives.

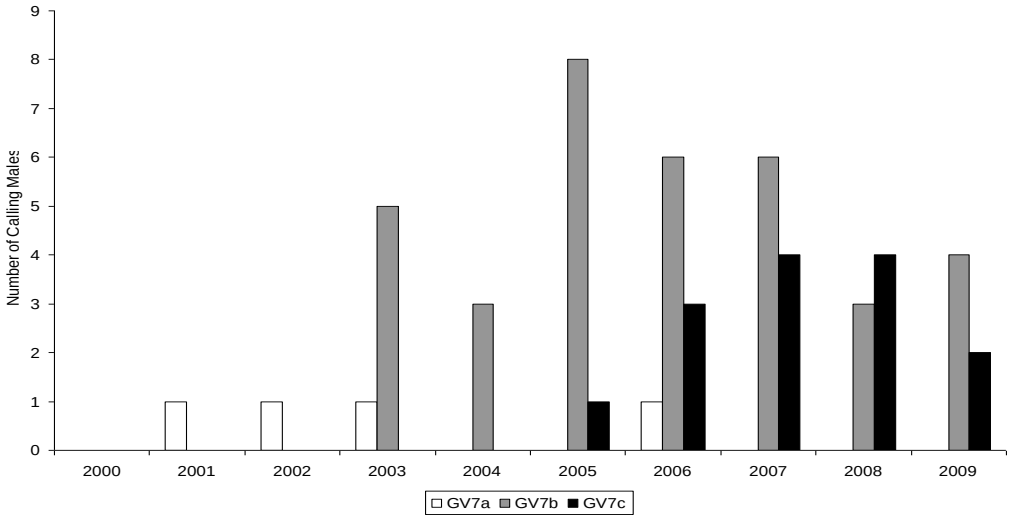

Figure11: Monitoring results (2000 – 2009) of *G. vitellina* translocations at three release sites in the Blackwood River National Park.

10.2 Review of 1995 Recovery Plan

The recovery objective in the 1995 plan was:

"*Downlisting to conservation dependant (Orange-bellied Frog) and vulnerable (White-bellied Frog) within 10 years by protecting existing populations and, if necessary, establish additional populations.*"

The overall recovery objectives from the 1995 plan have therefore not been achieved as neither species has been downlisted (see section 2.4). In fact, monitoring conducted over the course of the 1995 Recovery Plan highlighted declining trends in some populations, especially those with less than five calling males.

The recovery criteria stated in the 1995 plan were divided into time categories and are presented in Table 1 below along with an evaluation of their achievements to date. These indicate that the recovery criteria were achieved.

Table 1: Recovery criteria from the 1995 recovery plan and an evaluation of their achievement.

Time Frame	1995 Recovery Criteria	Evaluation
2 years	Accurate knowledge of the number, distribution and abundance of naturally occurring populations	Achieved
7 years	Habitat conservation for all orange-bellied frog sites and at least 75 per cent of currently known white-bellied frog populations to ensure effective genetic geographic spread.	All orange-bellied frog populations are secured for conservation within the Blackwood River National Park. Habitat conservation measures have been undertaken in all known white-bellied frog populations.
10 years	Management and monitoring to ensure sustainability of all populations	Annual monitoring and proactive management of threats are undertaken and although these alone cannot ensure the sustainability of all populations, the data provide a sound basis from which trends can be determined, and the effectiveness of management actions evaluated. Significant information is now known about the population dynamics and genetic structuring of the species which contribute to enhancing appropriate management actions

11 Management practices

Management practices (policies, strategies, plans) that have a role in the protection of the species include but are not limited to the following:

- Leeuwin-Naturaliste Cape Area Parks and Reserves Draft Management Plan 2010 (DEC 2010)
- Blackwood River Foundation Strategic Plan 2010-2015 (Blackwood River Foundation 2010)
- Forest Management Plan 2014-2023 (Conservation Commission of WA 2013)
- Policy Statement No. 3 Management of *Phytophthora* disease (DPaW 2014)
- Policy Statement No. 29 Translocation of threatened flora and fauna (CALM 1995)
- Policy Statement No. 33 Conservation of endangered and specially protected fauna in the wild (CALM 1991)
- Fire Management Guideline No. S1 Nornalup, White-bellied & Orange-bellied Frogs (DEC 2008)
- Shire of Augusta Margaret River Biodiversity Conservation Strategy (SAMR 2005)
- Augusta-Margaret River Landscape – a conservation action plan (CCCG 2011)
- Leeuwin-Naturaliste Ridge Statement of Planning Policy Report (WAPC 1998)
- Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis (DEH 2006)
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs (DEH 2005)
- The South West Regional Natural Resource Management (NRM) Strategy 2014-20 (SWCC 2014)

12 Guide for decision makers

Possible future actions that may constitute a 'significant impact' on *G. alba* and *G. vitellina* include:

- any action that leads to clearing or disturbance of *Geocrinia* habitat (e.g. physical removal of vegetation);
- any action that leads to an alteration in vegetation composition, density and structure of *Geocrinia* habitat;
- any action that increases the likelihood of soil disturbance within *Geocrinia* habitat (e.g. plantation establishment and harvesting, siltation);
- any action that is likely to alter the hydrological balance (increase or decrease) of *Geocrinia* sites and habitat (e.g. dam establishment, drainage projects within or adjacent to habitat, ground water extraction);
- any action that is likely to impact on the water or soil quality within *Geocrinia* habitat (e.g. fertiliser run-off, chemical overspray);
- any action that increases the isolation of known *Geocrinia* populations and as such reduces the ability of *Geocrinia* to disperse (road/track construction, dams).

Alterations to existing land-uses and the creation of sub-divisions may significantly affect the species and could therefore require environmental impact assessment under the Western Australian *Environmental Protection Act 1986* and/or the Commonwealth EPBC Act. These activities are regulated by the shire's town planning scheme and the Western Australian Planning Commission. It is vital that any land-use planning activities that occur in or adjacent to known frog populations are assessed for their potential impacts on the species survival. Consideration is also required for potential infrastructure developments (e.g. power/phone services) and water allocation/extraction schemes, (e.g. groundwater extraction proposals). Future developments of the Yarragadee groundwater resource (which lies beneath the *Geocrinia* habitat) should be preceded by research to better understand the potential disturbance effects on the species, before ground water extraction is approved.

13 Recovery goal and objectives

Recovery plan goal

The overarching goal of the recovery program is to maintain or increase the current extent and viability of these species.

Recovery Objectives
• To protect and effectively manage populations and the habitat critical for their survival
• To increase species viability through population augmentation and establishment
• To achieve an evidence-based management approach
• To increase community awareness and understanding

Geocrinia alba **criteria for success:**

This Recovery Plan will be deemed successful if, within the initial 10 year period, all of the following are achieved:

- The rate of loss of subpopulations is reduced and the total number of extant subpopulations of *G. alba* does not decrease by more than 20 per cent (using 2012 data as a baseline).
- There is no permanent reduction (using a five year rolling average) in the number of calling *G. alba* males in the McCleod Creek core habitat populations that had greater than 10 calling males in 2009.
- At least two *G. alba* populations with a minimum 10 calling males are successfully established via translocation.
- An evidence-based management approach is applied to conserve and manage *G. alba*.

Geocrinia alba **criteria for failure:**

This Recovery Plan will be deemed to have failed if, within the initial 10 year period, any of the following are achieved:

- The total number of extant subpopulations of *G. alba* declines by more than 20 per cent (using 2012 data as a baseline).
- There is permanent reduction of 40 per cent or more (using a five year rolling average) in the number of calling *G. alba* males in the McCleod Creek habitat populations that had greater than 10 calling males in 2009.
- No *G. alba* populations (with a minimum 10 calling males) are successfully established via translocation.
- An evidence-based management approach cannot be applied to conserve and manage *G. alba*.

Geocrinia vitellina criteria for success:

This Recovery Plan will be deemed successful if, within the initial 10 year period, all of the following are achieved:

- The number, distribution and size of subpopulations of *G. vitellina* known in the wild remains stable or increases (based on a five year rolling average of male call counts).
- At least one *G. vitellina* population with a minimum of 10 calling males is successfully established via translocation.
- An evidence-based management approach is applied to conserve and manage *G. vitellina*.

Geocrinia vitellina criteria for failure:

This Recovery Plan will be deemed to have failed if, within the initial 10 year period, any of the following are achieved:

- Any naturally occurring (i.e. non-translocated) *G. vitellina* population becomes extinct as a result of controllable anthropogenic threats (e.g. fire, feral pigs, deliberate habitat destruction).
- No *G. vitellina* populations (with a minimum 10 calling males) are successfully established via translocation.

14 Recovery actions

Recovery actions associated with each of the recovery objectives identified for the recovery of *G. alba* and *G. vitellina* are described below. The actions refer to both *G. alba* and *G. vitellina* unless stated otherwise. All recovery actions are assigned a priority ranking, this priority order is based on the recovery needs of the overall population over the next 10 years. The three levels of priorities should be interpreted as follows:

- Priority 1: Taking prompt action is necessary in order to mitigate the threats and ensure the persistence of these species.
- Priority 2: Action is necessary to mitigate threats and work towards the long-term recovery of these species.
- Priority 3: Action is desirable, but not critical to recovery at this point in time but will provide for longer term maintenance of recovery.

Objective 1: To protect and effectively manage populations and the habitat critical for their survival.

The protection and effective management of populations and their associated habitats is essential to maintain or increase the number, distribution and size of subpopulations. It is recognised that the degradation or loss of habitat critical for the survival of *G. alba* and *G. vitellina* will not only result in a loss of individuals and populations, but also reduce the ability for recovery into the future. In order to prevent further habitat loss or degradation, coordinated management on both public and private lands where these species occur or could potentially occur, is required. It is also recognised that some land uses adjacent to populations or habitat may cause degradation and thus management of adjacent habitat is also required. This may include the development of guidelines and/or the setting of buffers for some land uses. Additionally the amphibian disease chytridiomycosis (*Bactrachochytrium dendrobatidis*) has been implicated as one of the major factors that has caused amphibian decline worldwide, and has been detected for both *G. vitellina* (Aplin and Kirkpatrick 2000) and *G. alba* (H. Robertson, Perth Zoo, pers. comm.). Despite detection there is no evidence to indicate that it has had, or is having any significant impact on the species. However to protect these species from the potential impacts of disease continued efforts are required regarding hygiene, monitoring and research.

Action	Description	Priority	Performance Criteria	Responsibility	Duration
1.1	Incorporate *G. alba* and *G. vitellina* habitat management and protection into the appropriate management plans and programs including: • zoning mechanisms; • access rationalisation; • interpretive information and signage for visitors (while not disclosing exact locations); and • management of disturbances to minimise impacts on *Geocrinia* habitat such as prescribed fire, track construction and maintenance, and visitor amenities.	1	*G. alba* and *G. vitellina* habitat is recognised in management plans with appropriate management practices.	DPaW	On-going

Action	Description	Priority	Performance Criteria	Responsibility	Duration
1.2	Liaise and work with landholders to ensure they are implementing the most up to date land management practices, to minimise the impacts on *G. alba* populations, including: • maintain regular contact with landholders; • reinforce the importance of management practices to minimise disturbance or direct impact on populations; and • disseminate new information on land management practices.	1	Landholders are informed and avoid management practices that may impact *G. alba* populations.	DPaW, private landholders	On-going
1.3	Identify and implement strategies to achieve protection of *G. alba* habitat on private land including consideration of populations and important habitat as part of environmental impact assessments and assessment of vegetation clearing applications.	2	Effective strategies to protect populations and habitat on private land.	DPaW, DER, EPA, WAPC	On-going
1.4	Maintain pig control programs on DPaW-managed lands and liaise with landowners to monitor disturbance by pigs and take actions if required.	2	Impact of pigs on known populations and habitat is reduced.	DPaW, private landholders	On-going
1.5	Install and assist in the maintenance of fences to exclude livestock from known and potential habitat on private land.	1	Livestock is excluded from known and potential habitat on private land.	DPaW, private landholders	As required
1.6	Develop habitat protection guidelines for land uses such as tree plantations, vineyards and other horticultural pursuits on land adjacent to *G. alba* sites. Define acceptable limits and thresholds and outline suitable parameters to guide the development of these agricultural activities that include vegetation buffers, water interception system setbacks and water system offsets.	2	Land uses that may impact adjacent habitat are identified and guidelines developed and disseminated to landholders.	DPaW, LGA, private landholders	Yr 1-5

Action	Description	Priority	Performance Criteria	Responsibility	Duration
1.7	Undertake research and monitoring to determine the presences and potential effects of chemicals (e.g. herbicides, pesticides, fertilizers, wetting agents) on the frogs and their habitat, and develop guidelines for their use in areas adjacent to occupied or suitable habitat.	2	Impacts of chemicals determined and guidelines developed and disseminated.	DPaW, researchers	Yr 1-5
1.8	Ensure appropriate fire management (on private and public land) is conducted in all known and potential habitat and includes: • excluding fire from swamp habitat; • early spring prescribed burns in adjacent forested areas to prevent wildfire – at a minimum frequency of eight years; • locating fire breaks near but not within swamp habitat; and • monitoring if fire does occur to determine the impact on frog populations.	2	Appropriate fire management is applied to all known and potential habitat.	DPaW, private landholders. Shire fire control officers, local brigade, DFES	On-going
1.9	As opportunities arise, add lands containing *G. alba* populations to the conservation estate.	2	All core populations are contained within the conservation estate.	DPaW	On-going
1.10	Continue to implement hygiene standards to minimise spread of Chytrid fungus by all persons accessing sites, and particularly those moving between sites.	1	Hygiene protocols developed by NSW Department of Environment and Climate Change are implemented to limit the transmission of the disease between sites (DECC 2008, Murray *et al*. 2011)).	DPaW, researchers, landholders, Perth Zoo	On going

Action	Description	Priority	Performance Criteria	Responsibility	Duration
1.11	Establish quarantine reference sites where access into the swamp habitat is prohibited. Sites with the following characteristics would be suitable candidates: • Contain a single isolated subpopulation of size class 10-20, or a subpopulation that occurs upstream (preferably at the head of the creek) and separated from the next population by a significant distance. • The site is not accessed by the public, agencies or researchers. *Geocrinia* monitoring practices are restricted to those techniques that do not require entering the swamp – i.e. all monitoring activities performed on the dryland edge of the habitat.	1	Quarantine reference sites established.	DPaW	On-going
1.12	Support research into field detection and treatment of disease, and apply to sub-populations experiencing unexplained declines in population size.	2	Field detection and treatment developed and applied.	DPaW, researchers, Perth Zoo	On-going

Objective 2: To increase species viability through population augmentation and establishment

These species are currently at risk of extinction due to their small population size, limited area of occupancy and extent of occurrence, and restricted ability to disperse. Translocations, introduction and population augmentations are key tools to assist in the recovery of species with limited distribution and population size. Preferably captive bred stock taken originally from the same populations or the nearest occupied site will be used however, adding new genetic material may result in an increase in the population's genetic viability and fitness. Translocations have previously played an important role in increasing the distribution of *G. vitellina* along the Blackwood River, and currently it is considered a viable option for the recovery of these species.

Action	Description	Priority	Performance Criteria	Responsibility	Duration
2.1	Maintain captive program at Perth Zoo to provide stock for actions 2.2 - 2.4.	1	Captive program maintained at Perth Zoo.	Perth Zoo, DPaW	Minimum 5 years
2.2	Translocate captive reared *G. alba* to augment existing small, but declining populations.	1	At least two small populations successfully augmented.	DPaW, Perth Zoo	Year 1-2
2.3	Translocate captive reared *G. alba* into areas of suitable habitat (possibly recently extinct sites), increasing the area of occurrence of the species and avoiding potential outbreeding impacts.	1	At least two new populations of *G. alba* successfully established.	DPaW, Perth Zoo	Year 2-5
2.4	Translocation captive reared *G. vitellina* to augment GV7 sites and establish up to two additional populations in suitable habitats south of the Blackwood River to reduce the risk of all existing populations being impacted by a major fire event.	1	At least one new population of *G. vitellina* established south of Blackwood River. Sub-populations at site GV7 successfully augmented.	DPaW, Perth Zoo	Year 1-3
2.5	Develop a captive breeding strategy to inform the selection of release sites and genetic management.	2	Captive breeding strategy developed.	DPaW, Perth Zoo	Year 1-5

Objective 3: To achieve an evidence-based management approach

Applying an evidence-based management approach requires pursuing the gaps in our knowledge required to make strategic and effective decisions. There is currently a limited understanding of the essential habitat characteristics for these species and what management intervention options will be effective. This includes an understanding of both landscape scale and site specific characteristics, particularly relating to hydrology and water quality.

Information regarding population trends is essential to evaluate management effectiveness and ensure that decisions and strategies to mitigate threats are evidence-based. Monitoring protocols have been developed and are applied annually for both species to detect population trends. This information has additional relevance for assessing long-term trends that may occur as a consequence of climate change. Three main techniques are currently used to monitor the number of calling adult males of both species; point counts, transect counts and linear counts. These techniques determine trends in the abundance of calling males and dispersal. Appendix 1 lists all of the known populations, their location in terms of land tenure and the monitoring technique used. In addition, as sites are regularly visited for monitoring, they can be assessed for damage from fire, feral pigs, and human activity.

Action	Description	Priority	Performance Criteria	Responsibility	Duration
3.1	Monitoring conducted annually during the peak breeding season (refer to Appendix 1).	1	Annual monitoring is undertaken to evaluate population trends, management effectiveness and threats.	DPaW	On-going
3.2	Identify and quantify the specific landscape and catchment characters and elements that potentially impact on existing populations.	2	Landscape and catchment characters and elements that potentially impact populations identified.	DPaW, researchers	Year 1-4
3.3	Determine specific site/system hydrology and the ecological water requirements to maintain sites which consider future changes resulting in climate change and land use changes. Continue monitoring variables (e.g. ground water levels, rainfall, temperature etc.).	1	Hydrological requirement defined for each site and strategies developed to maintain integrity, considering future impacts.	DPaW, researchers	Year 1-5

Action	Description	Priority	Performance Criteria	Responsibility	Duration
3.4	Determine the influence of condition/structure of vegetation on habitat use. Identify key site specific characteristics, their natural limits of variation and what parameters should be measured.	1	Vegetation requirements defined with thresholds, and monitoring protocols developed.	DPaW, researchers	Year 2-4
3.5	Investigate habitat manipulation (e.g. artificial water systems) as mitigation against future threats such a climate change.	1	Habitat manipulation options tested.	DPaW, researchers	Year 2-4
3.6	Determine the biomass accumulation rate and other properties of the organic litter/humus layer favoured by the species and evaluate the role of fire to maintain riparian vegetation and/or produce these properties. Investigate the extent of upland use to inform fire management guidelines.	2	Fire management guidelines developed to produce favourable habitat properties and reduce risk to frog populations.	DPaW	On-going
3.7	Increased monitoring of response of *Geocrinia lutea* (located in the Warren Region) to fire, at a minimum of every second year to determine the long-term effect of fire on a congener species.	2	Monitoring of *G. lutea* sites undertaken at least every two years.	DPaW	On-going

Objective 4: To increase community awareness and understanding

A coordinated public information program was developed to encourage private land owners to assess and manage the condition of the riparian habitat on their properties (including habitat destruction from pigs and cattle, and reduce the threat of fire). This had led to increased community involvement, although there still remains a general lack of broad scale awareness of the conservation status and plight of these species within the community. To ensure the recovery of these species, there needs to be targeted efforts to increase community awareness and understanding of these species.

Action	Description	Priority	Performance Criteria	Responsibility	Duration
4.1	Provide public information to landholders in the Shire of Augusta - Margaret River and the broader community including: • distribution of annual frog newsletter on *G. alba* (particularly to landholders with and adjacent to known populations); • displays at community events; • articles in local press; and • targeted rehabilitation of riparian habitats, though Natural Resource Management (NRM) incentives and initiatives.	1	An observed increase in community awareness and landholder participation in mitigation and protection actions.	DPaW, NRM, Shire of Augusta-Margaret River	On-going
4.2	Update the 'Frog Recovery Kit' to include current knowledge, trends and management actions, and distribute.	2	'Frog Recovery Kit' updated and disseminated.	DPaW	Year 1

15 Implementation and evaluation

This Recovery Plan guides the recovery actions for two species; *G. alba* and *G. vitellina*. The plan will be implemented and managed by Department of Parks and Wildlife, with the support of other relevant agencies, non-government organisations, educational institutions, regional natural resource management authorities and community groups as appropriate, most likely in the form of a Recovery Team or similar advisory group. Technical, scientific, habitat management or education components of the Recovery Plan may be referred to specialist groups as required. The plan will run for a maximum of 10 years from the date of its adoption, or until replaced. The recovery plan will be reviewed by Department of Parks and Wildlife, in consultation with the Recovery Team within five years of the date of its adoption, or sooner if necessary. Table 2 provides a summary of the recovery actions and estimates of the associated costs for the first five years. Note that estimated costs do not account for inflation and do not include recurrent management activities undertaken on conservation estate.

Table 2: Recovery actions, priorities, responsibilities and estimated costs ($000's) for the first five years.

Action	Priority	Responsibility	Total cost	Year 1	Year 2	Year 3	Year 4	Year 5
1 To protect and effectively manage populations and the habitat critical for their survival								
Incorporate into management plans	1	DPaW	$75	$15	$15	$15	$15	$15
Liaise with landholders	1	DPaW, Private Landholders	$25	$5	$5	$5	$5	$5
Implement strategies on private land	2	DPaW, DER, EPA, WAPC	$20	$4	$4	$4	$4	$4
Pig control programs	2	DPaW, private landholders	$29	$3	$10	$3	$3	$10
Fence habitat	1	DPaW, private landholders	*					
Develop habitat protection guidelines	2	DPaW, private landholders, LGA	$50	$10	$10	$10	$10	$10
Effects of chemical and guidelines	2	DPaW, researchers	$35	$10	$10	$5	$5	$5
Implement hygiene standards	1	DPaW, researchers, landholders, Perth Zoo	$5	$1	$1	$1	$1	$1
Establish quarantine reference sites	1	DPaW	$5	$1	$1	$1	$1	$1
Support disease research	2	DPaW, researchers, Perth Zoo	$60		$20	$20	$20	
2 To increase species viability through population augmentation and establishment								
Captive breeding program	1	Perth Zoo, DPaW	$600	$120	$120	$120	$120	$120
Translocate *G. alba* for augmentation	1	DPaW, Perth Zoo	$20	$10	$10			
Translocate *G. alba* for establishment	1	DPaW, Perth Zoo	$40		$10	$10	$10	$10
Translocation o. *vitellina* for augmentation and establishment	1	DPaW, Perth Zoo	$45	$15	$15	$15		
Develop captive breeding strategy	2	DPaW, Perth Zoo	$10	$2	$2	$2	$2	$2
3 To achieve an evidence-based management approach								
Monitor known populations	1	DPaW	$175	$30	$30	$35	$40	$40
Investigate catchment characteristics	2	DPaW, researchers	$5	$1	$2	$1	$1	
Investigate habitat hydrology	1	DPaW, researchers	$100	$16	$40	$40	$2	$2
Determine critical habitat characteristics	1	DPaW, researchers	$81		$27	$27	$27	
Investigate habitat manipulation	1	DPaW, researchers	$81		$27	$27	$27	
Determine response to fire	2	DPaW	$15	$1	$5	$5	$2	$2
Geocrinia fire impact monitoring	2	DPaW	$15	$5		$5		$5
4 To increase community awareness and understanding								
Provide public information to landholders and broader community	1	DPaW/NRM/Shire	$5	$1	$1	$1	$1	$1
Update and distribute frog recovery kit	2	DPaW	$5		$5			
		TOTAL	**$1,501**	**$250**	**$370**	**$352**	**$296**	**$233**

*Timing and amount dependant on when opportunities arise

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Personal Communication References

K. Williams – Kim Williams (Department of Parks and Wildlife South West Region)

H. Robertson – Helen Robertson (Perth Zoo)

Appendix I

List of known population, land tenure, monitoring technique used and status at 2012.

Site Name	Land Tenure	Monitoring Method	Extinct
GA10	PP	PC	X
GA102	SF/UCL	PC	
GA11	PP	PC	
GA117	PP	PC	
GA12a	PP	PC	
GA12b	PP	PC	
GA12c	PP	PC	
GA12d	PP	PC	
GA12e	PP	PC, Ex	
GA13	PP	PC	
GA14	PP	PC, Ex	
GA15	PP	PC, Ex	
GA16	PP	PC	
GA17a	PP	PC	
GA17b	PP	PC	
GA17c	PP	PC	
GA17d	RR	PC	X
GA18	PP	PC	X
GA19	PP	PC	X
GA1a	SF/UCL	PC, T	
GA1b	PP	PC	
GA2	PP	PC	X
GA20	PP	PC	X
GA21	PP	PC	X
GA22	PP	PC	X
GA23a	RR	PC	X
GA23b	PP	PC	X
GA24a	NP	PC	
GA24b	PP	PC	
GA24c	PP	PC	
GA24d	PP	PC	
GA24e	PP	PC	
GA25a	NP	PC	X
GA25b	PP	PC	X
GA25c	NP	PC	X
GA26a	PP	PC	X
GA26b	PP	PC	X

Site Name	Land Tenure	Monitoring Method	Extinct
GA38	PP	PC	X
GA39a	PP	PC	
GA39b	PP	PC	
GA39c	PP	PC	X
GA40	PP	PC	
GA41	NP	PC	
GA41b	NP	PC	
GA42	SF/UCL	PC	X
GA42b2010	SF/UCL	PC, SC	
GA43	SF/UCL	PC, Ex	
GA44	PP	PC, Ex	
GA45a	PP	PC, T	
GA45b	PP	PC, Ex	
GA46	NP	PC	X
GA47a	NP	PC	X
GA47a_20	NP	PC	
GA47b	NP	PC	X
GA47c	NP	PC	
GA47d	NP	PC	X
GA47e	NP	PC	X
GA47f	NP	PC	
GA47g	NP	PC	
GA48	NP	PC, Ex	
GA49	NP	PC	X
GA4a	PP	PC	
GA4b	PP	PC	X
GA4j	PP	PC	
GA5	PP	PC	X
GA50a	NP	PC	
GA50b	NP	PC	
GA50c	NP	PC	X
GA51	NP	PC	
GA53	PP	PC	X
GA54	NP	PC	X
GA55a	PP	PC	
GA55b	NP	PC	
GA55c	NP	PC, Ex	

Site Name	Land Tenure	Monitoring Method	Extinct
GA27	PP	PC	
GA28	PP	PC	X
GA29	PP	PC	
GA3	PP	PC	X
GA30	PP	PC	
GA30b	PP	PC	X
GA31a	PP	PC, Ex	
GA31b	PP	PC	
GA31c	PP	PC, Ex	
GA32	PP	PC	X
GA33	NP	PC,Ex	
GA34a	PP	PC, Ex	
GA34b	PP	PC, Ex	
GA35a	NP	PC, Ex	
GA35b	NP	PC, Ex	
GA36	NP	PC	
GA37a	NP	PC, LT	
GA37b	NP	PC, LT	
GA37c	NP	PC, Ex	
GA37d	NP	PC, LT	
GA37e	NP	PC, LT	
GA37f	NP	PC	X
GA37g	NP	PC	X
GA37i	NP	PC, Ex	
Ga37j	NP	PC	
GA37k	NP	PC	
GA37L	NP	PC	X
GA37M	NP	PC	
GA37_99	NP	PC, Ex	
GA55d	PP	PC, Ex	
GA55e	PP	PC	X
GA56	PP	PC	
GA57	NP	PC	X
GA6a	NP	PC	X
GA6b	NP	PC, Ex	
GA6c	NP	PC, Ex	
GA6e	NP	PC, Ex	
GA7	NP	PC, Ex	
GA8	NP	PC, Ex	
GA9	PP	PC	
GA-TAN-A-98	PP	PC	
GA-TAN-B-98	PP	PC	
GV1a	NP	PC, T	
GV1b	NP	PC, T	
GV1c	NP	PC, T	
GV1d	NP	PC	
GV2	NP	PC, T	
GV3a	NP	PC	
GV3B	NP	PC, SC	
GV4A	NP	PC, T	
GV4a_98	NP	PC, T	
GV4b	NP	PC, T	
GV5	NP	PC, T	
GV6	NP	PC, T	
GV7A	NP	PC	X
GV7B	NP	PC, SC	
GV7C	NP	PC, SC	

Tenure: PP: private property, NP: National Park, SF/UCL: State Forest/Unallocated crown Land, RR: Shire road reserve

Monitoring Method: PC: Point count, T: Transect, LT: Linear transect, Ex: Extent, SC: Search count

Extinct: refers to any site which has had a minimum of four consecutive years of no calling activity (1983 to 2012)