

**ORANGE-BELLIED AND WHITE-BELLIED
FROGS RECOVERY PLAN**

2nd Edition
1995

by

G Wardell-Johnson¹, J D Roberts², D Driscoll² and K Williams³

for the Geocrinia Recovery Team

¹ Department of Conservation and Land Management
Wildlife Research Centre
PO Box 51 Wanneroo, WA 6065

² Department of Zoology
The University of Western Australia
Nedlands, WA 6907

¹ Department of Conservation and Land Management
Central Forest Region
Boyanup Road, Bunbury, WA 6230

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Department of Conservation and Land Management
PO Box 104
COMO WA 6152

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by Jane McRae

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PO Box 51 Wanneroo, Western Australia 6065
Telephone: (09) 405 5128 Fax: (09) 306 1066

Preparation by: Jill Pryde

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FOREWORD

The Western Australian Department of Conservation and Land Management (CALM) publishes Wildlife Management Programs to provide detailed information and management actions for the conservation of threatened or harvested species of flora and fauna.

Recovery Plans delineate, justify and schedule management actions necessary to support the recovery of an endangered or vulnerable species or ecological community. The attainment of objectives and the provision of funds is subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities. Recovery Plans do not necessarily represent the views nor the official positions of any individuals or agencies represented on the Recovery Team. This Recovery Plan has been approved by the Executive Director, Department of Conservation and Land Management, the National Parks and Nature Conservation Authority, the Lands and Forest Commission, and the Minister for the Environment.

Approved Recovery Plans are subject to modification as directed by new findings, changes in species' status and completion of recovery actions.

Information in the Plan is accurate at December 1994.

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SUMMARY

CURRENT SPECIES STATUS: Orange-bellied Frog: Endangered (Commonwealth *Endangered Species Protection Act 1992*), Rare or likely to become extinct (State *Wildlife Conservation Act 1950*). Known from six creeks, all located in State Forest. No recorded decline in distribution. White-bellied Frog: Vulnerable (Commonwealth *Endangered Species Protection Act 1992*), Rare or likely to become extinct (State *Wildlife Conservation Act 1950*). Recorded from 54 sites, 36 on privately-owned land, 15 at least partly within State forest or vacant Crown Land and three in National Parks. Of these 54 sites, frogs have disappeared from six since 1983. Agricultural clearing has reduced the probable original range of this species by about 70 percent.

HABITAT REQUIREMENTS AND LIMITING FACTORS: The Orange-bellied Frog has an area of occupancy of about 20 ha making this species vulnerable to localised disturbance. The White-bellied Frog has an area of occupancy of about 193 ha where it persists along creeklines within agricultural landscapes, provided suitable riparian habitat remains intact. The major threats to White-bellied Frog habitat on private land are clearing, grazing and trampling of riparian vegetation by cattle, and weed invasion. Other threats to the Orange-bellied and White-bellied Frogs include habitat destruction by fire and feral pigs, water pollution in swamps from fertiliser and pesticide runoff and changes to the hydrology of their sites due to the removal of vegetation cover in the subcatchment, dieback disease or upstream dams.

RECOVERY PLAN OBJECTIVES: Downlisting to conservation dependent (Orange-bellied Frog) and vulnerable (White-bellied Frog) within ten years by protecting existing populations and, if necessary, establishing additional populations.

RECOVERY CRITERIA:

2 years. Accurate knowledge of the number of naturally occurring populations.

7 years. Habitat conservation for all Orange-bellied Frog sites and at least 75 % (41) of currently known White-bellied Frog populations to ensure effective genetic and geographic spread.

10 years. Management and monitoring to ensure sustainability of all populations.

ACTIONS NEEDED: The following actions will be overseen by a Recovery Team comprised of people from the Department of Conservation and Land Management, Australian Nature Conservation Agency, Lower Blackwood Land Conservation District Committee, the Augusta/Margaret River Shire Council, local voluntary conservation interests and the University of Western Australia.

1. Survey habitat.
2. Land tenure and management.
3. Fire management and research.
4. Habitat protection.
5. Community participation.
6. Population monitoring.
7. Population genetics.
8. Translocations and captive breeding.

BIODIVERSITY BENEFITS: The maintenance of corridors of native vegetation between the Blackwood Plateau and Leeuwin-Naturaliste Ridge are envisaged. Protection of riparian zones on private land will promote conservation by the broader community. Three species of declared threatened (*Chamelaucium erythrochloia*) or priority flora (*Anthodium junctiforma* and *Acacia tayloriana*) and two species of threatened mammal (*Pseudocheirus occidentalis* and *Dasyurus geoffroii*) will also benefit from this recovery plan.

ESTIMATED COST OF RECOVERY: (Orange-bellied Frog) : \$000s/year in 1993 dollars
Total Cost (TC) Endangered Species Program (ESP)

Actions(1)	(2)		(3)		(4)		(5)		(6)		(7)		(8)		Total		
	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC
1992	1.01.0	-	-	2.0	2.0	-	-	-	-	3.5	3.5	2.5	2.5	-	-	9.0	9.0
1993	1.01.0	-	-	2.0	2.0	-	-	-	-	2.5	2.5	3.5	3.5	-	-	9.0	9.0
1994	-	-	-	2.0	2.0	1.1	1.1	-	-	2.5	2.5	2.5	2.5	-	-	8.1	8.1
1995	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	-	-	1.2	1.2
1996	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	2.5	2.5	3.7	3.7
1997	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	2.5	2.5	3.7	3.7
1998	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	2.5	2.5	3.7	3.7
1999	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	-	-	1.2	1.2
2000	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	-	-	1.2	1.2
2001	-	-	-	-	-	1.1	1.1	-	-	0.1	0.1	-	-	-	-	1.2	1.2
Total	2.02.0	-	-	6.0	6.0	8.8	8.8	-	-	9.2	9.2	8.5	8.5	7.5	7.5	42.0	42.0

ESTIMATED COST OF RECOVERY: (White-bellied Frog) : \$000s/year in 1993 dollars
Total Cost (TC) Endangered Species Program (ESP)

Actions(1)	(2)		(3)		(4)		(5)		(6)		(7)		(8)		Total		
	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC
1992	4.04.0	-	-	2.0	2.0	5.0	5.0	2.0	2.0	10.0	10.0	8.0	8.0	-	-	31.0	31.0
1993	4.04.0	-	-	2.0	2.0	5.0	5.0	2.0	2.0	10.0	10.0	11.4	11.4	-	-	34.4	34.4
1994	-	-	-	2.0	2.0	32.4	32.4	6.2	6.2	10.5	10.5	11.4	11.4	2.3	2.3	64.8	64.8
1995	-	-	-	-	-	20.0	20.0	3.7	3.7	17.0	17.0	-	-	1.2	1.2	41.9	41.9
1996	-	-	-	-	-	20.0	20.0	3.7	3.7	15.0	15.0	-	-	1.2	1.2	39.9	39.9
1997	-	-	-	-	-	20.0	20.0	3.7	3.7	15.0	15.0	-	-	1.2	1.2	39.9	39.9
1998	-	-	-	-	-	20.0	20.0	1.5	1.5	2.5	2.5	-	-	1.2	1.2	25.2	25.2
1999	-	-	-	-	-	4.0	4.0	1.5	1.5	2.5	2.5	-	-	-	-	8.0	8.0
2000	-	-	-	-	-	4.0	4.0	1.5	1.5	2.5	2.5	-	-	-	-	8.0	8.0
2001	-	-	-	-	-	4.0	4.0	1.5	1.5	2.5	2.5	-	-	-	-	8.0	8.0
Total	8.08.0	-	-	6.0	6.0	134.4	134.4	27.3	27.3	87.5	87.5	30.8	30.8	7.1	7.1	301.1	301.1

1. INTRODUCTION

1.1 Taxonomy and description

The Orange-bellied Frog (*Geocrinia vitellina* Wardell-Johnson and Roberts 1989) and White-bellied Frog (*Geocrinia alba* Wardell-Johnson and Roberts 1989) are both members of the *Geocrinia rosea* frog complex (Anura: Myobatrachidae). This group includes four allopatric species restricted to the lower south-west of Western Australia. 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.

The Orange-bellied and White-bellied Frogs were recently described by Wardell-Johnson and Roberts (1989; see also Roberts, Wardell-Johnson and Barendse 1990). Their recognition as distinct species within *Geocrinia* is justified on the grounds of distinct differences in ventral colouration, less obvious differences in male call and significant levels of genetic divergence.

1.2 Distribution and habitat

The two species occur in close proximity to one another (extent of occurrences separated by 8 km at the nearest point) in riparian habitat in jarrah forest in the Witchcliffe-Karridale area in the far south-west corner of Western Australia (Figure 1, Wardell-Johnson and Roberts 1991). The region receives a mean annual rainfall of between 1100 and 1200 mm, of which over 75 percent falls between May and September. Broad U-shaped valleys supporting dense shrubland provide habitat for these species.

The Orange-bellied Frog's extent of occurrence is 6.3 km². Its area of occupancy is just over 0.2 km² (Wardell-Johnson and Roberts 1991) or approximately three percent of its extent of occurrence. It is known from the lower reaches of six creeklines which drain south into the Blackwood River (Figure 2). The largest population occurs at Spearwood Creek, from upstream of the Denny Road crossing, to the Blackwood River. The remaining five populations occur in smaller, nearby creek systems between Denny Road and the Blackwood River.

The riparian habitat of the Orange-bellied Frog occurs within broad U-shaped valleys (up to 100 m wide) with sources of at least 120 m elevation. Dominant plant species in these sites include *Homalospermum firmum*, *Pseudoloxocarya grossa*, *Loxocarya* sp. nov., *Boronia molloyae*, *Acacia uliginosa*, *Agonis linearifolia* and *Astartea fascicularis*. Sites where the Orange-bellied Frog is not found vary from rocky to wide flat-bottomed creeks similar to Spearwood Creek, but where topographic relief is not marked. The restricted occurrence of the Orange-bellied Frog appears to reflect very localised suitable habitat conditions.

At 101 km², the extent of occurrence of the White-bellied Frog is considerably larger than that of the Orange-bellied Frog. The White-bellied Frog occurs at 54 sites (Figure 3, Appendix 2 lists all sites and subsites) all within one of three land units described by Tille and Lantzke (1990). The Wvw (Wilyabrub Wet Valleys, 4 sites) and Hvw (Glengarty Wet Valleys 39 sites) land units are characterised by broad U-shaped drainage depressions with swampy floors in land systems of subdued topography on Leeuwin Block granite. The Tv land unit (Treeton Valleys, 11 sites) occurs in narrow V shaped valleys on laterized Perth Basin sediments. The area of suitable habitat of the White-bellied Frog was estimated, in 1986, to be 193.2 ha or approximately three percent of the species extent of occurrence (Wardell-Johnson and Roberts 1991). However this may be an overestimate, as not all potential sites support populations of the White-bellied Frog (see below). Undisturbed sites in these three land units also extend beyond the range of White-bellied Frog. Thus there is an imperfect match between suitable land units and habitat occupied by this species.

Figure 1 (not available)
General locality showing distribution (extent of occurrence) of the
Orange-bellied and White-bellied Frogs

It is unlikely that many additional undetected populations exist for the Orange-bellied Frog due to the high level of searching effort carried out prior to, and in the first two years of the implementation of the Recovery Plan. A small part of the extent of occurrence of the White-bellied Frog is yet to be surveyed, primarily on private property (Location 83). Survey was carried out both within and adjoining their current ranges.

In contrast with the Orange-bellied Frog, 36 of 54 sites, 81 percent of the extent of occurrence and 82 percent of the area of occupancy of the White-bellied Frog exists on private land. Much of the private land in this region has been cleared for agriculture. There has been a probable decline of over 70 percent of the range of the White-bellied Frog. Clearing of riparian habitat has led to the loss of White-bellied Frog populations. However this species can persist if the riparian vegetation remains intact following the loss of the adjacent upland vegetation. Small populations of the White-bellied Frog still occur at two locations where the upland vegetation has been cleared for over 20 years (e.g. GA4b, GA15, GA16, GA17). The impact of adjacent land management practices on these remnant riparian zones is likely to be critical to the long term survival of these populations. This species was not heard at six sites in 1991, where it had previously been heard between 1983 and 1989 (Appendix 2). Of these sites, five occur on private property. Although they have retained some native riparian vegetation, all of these sites have been degraded.

1.3 Breeding biology and population studies

Males of both species call on land from small depressions in moist soil under litter and dense vegetation cover. Egg masses are deposited in small depressions, the eggs hatch, and the tadpoles develop in a jelly mass with no free swimming or feeding stage.

There are large genetic differences between populations of both Orange-bellied and White-bellied Frogs. These differences exist both within a single creek and between creeks, at a scale of less than five kilometres (Driscoll *et al.* 1995) indicating at most, limited movement between populations. Consequently many populations will need to be conserved to enable their continued survival and evolution.

1.4 Existing conservation measures

Three White-bellied Frog sites are in National Park, nine in State Forest and two in vacant Crown Land. All creeks with Orange-bellied Frogs are in State Forest. White-bellied and Orange-bellied Frog habitat is currently affected by human activities including clearing, logging, prescribed burning and recreation. Despite these activities these frogs have survived in their habitat in riparian sites in jarrah forest. However recent clearing and increasing activity in the areas of these species poses a significant threat to their survival. The conservation of these species is significantly enhanced by the protection of their riparian habitat.

Detailed distribution mapping to determine their extent of occurrence, and studies of their biology have contributed to knowledge of their requirements. Regular articles in local news media and public information sessions have encouraged local awareness and support for their conservation. Regular monitoring has contributed to developing a prognosis for their future. Fire management has included protecting some creeks from fire. Major fencing programs are now in place to protect White-bellied Frog habitat.

In Western Australia, both the Orange-bellied and White-bellied Frog have been declared to be threatened fauna (i.e., declared under Section 14 (2) (ba) of the Wildlife Conservation Act 1950 as “fauna which is rare or likely to become extinct”). Both species are also included in the Australian and New Zealand Environment and Conservation Council (ANZECC) *List of Endangered Vertebrate Fauna*. On this list, the White-bellied Frog is listed as ‘Endangered’, while the Orange-bellied Frog is listed as ‘Vulnerable’. These listings were intended to be the other way around; the error was made due to confusion between the species before they were officially named. ANZECC is in the process of

changing the status of the two frogs; however, at the time of writing these changes had not been officially adopted.

Both species are also listed in Schedule 1 of the Commonwealth Endangered Species Protection Act 1992. The initial listings under this Act followed ANZECC so the Orange-bellied Frog is in 'Schedule 1, Part 1 - species that are endangered', and the White-bellied Frog is in 'Schedule 1, Part 2 - species that are vulnerable'. Review of the status of both species under the Endangered Species Protection Act will take place when the changes to the ANZECC list are completed.

1.5 Recovery Team

Co-ordination of the recovery of the Orange-bellied and White-bellied Frogs is supervised by a Recovery Team. Membership of the team includes representatives from the Department of Conservation and Land Management (CALM) Central Forest Region, Science & Information Division, Busselton District and the Western Australian Threatened Species and Communities Unit, The University of Western Australia, Australian Nature Conservation Agency (ANCA), Augusta-Margaret River Shire, local voluntary conservation interests and the Lower Blackwood Land Conservation District Committee (LCDC).

The Recovery Team will report annually on the implementation of the Plan to CALM's Corporate Executive and funding agencies.

1.6 Strategy for recovery

This revised (2nd edition) Recovery Plan has six strategies, all of which can be run concurrently.

1.6.1 Survey habitat

As these species are relatively non-mobile, cryptic and occupy a small area within the landscape, an accurate knowledge of their current distribution is the first step towards achieving recovery. Although much of the ranges of the two species had been surveyed prior to the implementation of the Recovery Plan, extensive areas, particularly on private land and distant from access roads, had not. With the exception of an area of private property on the eastern limits of the extent of occurrence of the White-bellied Frog, a thorough survey of the area has now been achieved (Driscoll *et al.* 1995). Appendix 2 lists the 54 sites and 72 subsites where the White-bellied Frog occurs and the six creeks where the Orange-bellied Frog occurs.

1.6.2 Habitat protection

These species occur in very specific habitat over a very restricted range. Protection of this habitat is essential for the viability of these species.

As these species are of recent discovery, allocation of land tenure has not taken account of the unusual patterns of distribution of the species complex of which they are members. Recent discoveries of small vertebrates and invertebrates in the south-west demonstrate a much more complex environmental patterning than had previously been the case (Wardell-Johnson and Roberts 1993). Steps are now in place to recognise the conservation significance of the public land remnants in the domain of these species. Protection of habitat on private land is thought to be most effectively achieved by information exchange and encouragement of local landowners.

Most of the range of the White-bellied Frog has been cleared for agriculture. There has been at least some clearing of adjoining upland vegetation in all but four White-bellied Frog sites on private land. Populations of the White-bellied Frog can persist within this modified environment, at least in the short term, provided the original riparian vegetation cover remains intact. Individuals of the White-

bellied Frog were not found at any sites where the riparian vegetation was cleared or severely degraded. It is necessary to protect sites on private land if these populations are to be conserved.

The viability of populations of White-bellied Frog on privately-owned land is critical to the survival of the species. Thirty-six of the 54 sites are entirely on private land. Four of the remaining 18 sites also exist partly on private land. Management practices on private land may also be of significance to the survival of adjoining public land populations.

Extensive and frequent fires in the area of their occurrence, and the unusual breeding biology of these species indicate that fire management will be required for the conservation of these species. Monitoring of particular fire events as well as research of specific management regimes will be required. Knowledge of the fire response of these species is limited. It will be necessary to research their fire ecology to determine the most appropriate fire regimes. Where possible, fire should be excluded from swamp habitat, while surrounding land should include a variety of fire regimes. Where prescribed burning is necessary in the forest blocks surrounding the habitat of these frogs, it should be carried out in early Spring using prescriptions that account for seasonal conditions and to lessen the likelihood of burning the microhabitat of these frogs. Preliminary results suggest that fire in Autumn can burn the substrate of the calling sites of this species complex. One moderate intensity summer fire led to a severe reduction in numbers of the White-bellied Frog at the Davis Road site.

Fire exclusion is recommended from White-bellied Frog sites on private land because of the risk of weed invasion and the decline in habitat quality that follows from fire in small remnants. Whilst all landowners surveyed indicated they would not burn gully vegetation during the frog's breeding season, they also felt that fire should not be excluded permanently (Sutton 1990). Burning of riparian vegetation is likely to facilitate weed invasion where riparian habitat adjoins pasture, and provide easier access to cattle. Microclimatic variables within riparian habitat adjoining cleared land are likely to differ from those where riparian habitat is adjoined by forest. This difference may become further pronounced when the vegetation cover is removed by fire. Firebreaks along fenced riparian habitat will help reduce the risk of fire.

Feral pigs (*Sus scrofa*) occur throughout the south-west of Western Australia where they are capable of causing severe localised soil disturbance. Pigs pose the greatest threat to *Geocrinia* habitat during summer when they concentrate their activity within riparian zones. These frogs are particularly vulnerable to the threat of feral pigs because of their extremely localised distribution. Total eradication of feral pigs is not currently feasible because methods used in feral pig control, such as poisoning with 1080, shooting and trapping, are not highly effective. In addition feral pigs tend to occur at low densities and are highly mobile. They are also often reintroduced by hunters.

The breeding biology of the *G. rosea* complex makes this group particularly vulnerable to changes in hydrology. Threats to water quality that could affect frogs include herbicide, pesticide and fertilizer applications to the adjoining agricultural land, increased salinity levels associated with a higher water table and siltation of creek systems due to soil disturbance.

In addition, altering surface or sub-surface water flow may lead to desiccation or flooding of habitat. Clearing, logging and plantations can all alter upland vegetation which may affect streamflow. The construction of dams and roads can impede the flow of surface water and may represent a major threat to a population. Only six percent of landowners intended damming creeks on their property while 75 percent indicated that they would ensure the natural flow of water along creeklines (Sutton 1990). Roads and bridges will need to be carefully designed and installed to ensure that hydrological patterns are not disrupted. The habitat of these species should be taken into account in all proposed and existing roads. Reconstruction of some existing roads across creeklines will thus be necessary. Road or bridge construction on private land should occur concurrently with fencing.

1.6.3 Community participation

Since both species occur over a range of land tenures, including private property and State Forest used for recreation, a coordinated public information program is an essential strategy for the Recovery Plan.

Populations of White-bellied Frog are unlikely to survive on private land without the active support by landowners for the actions in this Recovery Plan. Eighty per cent of landowners have indicated that they would consider taking some level of action to protect the frog and its habitat (Sutton 1990). However, good communication between the Department of Conservation and Land Management (CALM), the Recovery Team and individual landowners will be necessary for this to be effective. This would include liaison concerning all research and management actions that involve private land populations, and information dissemination such as feedback of monitoring results, publications and other relevant material.

There is an overall need to instil an attitude that the conservation of this species is a shared responsibility of CALM, land-owners and the community. Land-owners are in a good position to regularly assess the condition of riparian habitat on their properties. They are able to identify habitat destruction caused by feral pigs, prevent the threat of fire, and also recognise damage caused to any fence which may allow cattle to enter the riparian zone. Changes recently recommended to the Wildlife Conservation Act may be helpful in promoting habitat protection for this species on private land. The need for landowners to support and adhere to the management recommendations outlined above is essential to ensure the species has the best possible chance of survival.

1.6.4 Population monitoring

Few data exist concerning the long-term trends in populations of frog species. Even less is known in relation to disturbance. Hence a strategy towards understanding patterns and trends within populations has already been implemented.

Monitoring will be carried out on both Orange-bellied and White-bellied Frogs to detect any effect of human-related disturbances on both private and public land. It will also enable the effectiveness of the management practices (including translocations) adopted to be assessed. Although populations can persist on disturbed private land, the long term viability of these populations has yet to be established. The advocated changes to land management practices are likely to improve the chances of survival of populations of White-bellied Frog on private land. However, there may still be a considerable threat to the persistence of private land populations due to continuing changes in the wider catchments of these riparian habitats. Monitoring will determine whether populations are able to persist under management practices that take into account both farming and *Geocrinia* conservation. Conversely a general decline in population levels across all sites may be indicative of more widespread factors such as changes in climatic regime, altered salinity or ground water levels.

To date, monitoring has principally taken place in quadrats within suitable habitat. However in the long term there is likely to be an impact on the riparian vegetation created by the observer's presence. Indeed the reduced numbers of calling males of the White-bellied Frog in some quadrats since 1983 may already indicate that such an effect has occurred.

Likely future threats from climate changes (Pittock 1988) also support the need to maintain a long-term monitoring programme for populations of the Orange-bellied and White-bellied Frogs. Changes to populations of these species resulting from global threats may also be used to infer the impact on other frog species.

Two different levels of monitoring will be used depending on the size of population, the width of the riparian vegetation and the level of information required at each site.

1. The establishment of two 20 m long board-walk transects parallel to one another and 5 m apart. The numbers of calling males are counted 2.5 meters either side of each transect. Capture data shows that this is an accurate estimate of the number of calling males at that time. Recapture data can be used to calibrate these counts to estimate the total male population and the total population size assuming a 1:1 sex ratio. Experience with capturing frogs under a variety of weather conditions suggests that such conditions have little influence on the number of frogs calling. Repeated surveys throughout the night suggest that any time of night is suitable for conducting these surveys.
2. A point count is used where either the total number of calling males is small (<5) or if only a quick estimate of the population size is required. This method involves recording the total number of calling males heard from a fixed position adjacent to the riparian zone. Where the total number of individuals is large (>5), population sizes are estimated within categories (i.e. 6-10, 11-20, 21-100, >100).

All monitoring transects are permanently established in the field at all sites so they can be readily repeated in subsequent years.

A geographic database of *Geocrinia* locations has been established and population information is maintained on a micro-computer using MAPINFO and EXCEL software.

1.6.5 Population biology

Research to understand the mechanisms causing a decline in populations will specifically need to examine population demography (levels of recruitment and adult mortality rates) and habitat use (breeding and non-breeding) as well as measuring environmental variables such as water quality and soil moisture. A study in eastern Australia has demonstrated that survival prior to metamorphic climax appeared to be most strongly affected by desiccation of oviposition sites for *Philoria frosti* (Malone 1985).

A thorough knowledge of the population biology of these species will be crucial to understanding any changes in abundance, in deciding how to remedy declines and in predicting the viability of populations under varying conditions. Thus it is a priority to investigate recruitment, mortality, longevity and factors which interact with these parameters, including demographic, genetic and environmental effects.

1.6.6 Population genetics studies and translocations

At the commencement of the Recovery Plan, there was little knowledge of the between population genetic variability of either species. Knowledge of genetic variation may assist decisions on priority populations and translocation programs. It is now known that considerable genetic structuring exists in both species (Driscoll *et al.* 1995).

The magnitude of the genetic differences suggests that each population should be assumed to have a unique genome. Therefore every population should be protected from extinction and from high rates of introgression because both of these processes will result in loss of genetic diversity at the species level.

The strategy to maximise the conservation of genetic diversity should therefore include:

1. Protect as many populations as possible.
2. Boost very small populations by captive breeding and release of stock taken originally from the same population.

3. Stock for translocation into unoccupied swamps should come from the nearest occupied site.

The high levels of genetic subdivision also suggest that there is very little movement between sites. Genetic studies of the Karri Frog (*G. rosea*) and Walpole Frog (*G. lutea*) have been undertaken to help explain this. These studies will put the results for the White-bellied and Orange-bellied Frog in context as well as address specific questions about movement in relation to rivers, forest type and dry ridges.

Four options for translocation have been considered:

- translocate egg masses in the field;
- translocate egg masses to the laboratory and raise to adult stage for release;
- translocate adult individuals to new sites from existing populations; and
- captive breeding.

The small size of populations of White-bellied Frog may preclude the third option. In addition there is some evidence that adults may have low survivorship if moved from their area of occupancy. Translocation of eggs or juveniles is therefore preferred. The success of translocating egg masses in the field may depend upon the natural levels of pre- and post-hatching mortality prior to metamorphic climax. Malone (1985) found for *Philoria frosti* in eastern Australia that the embryonic and larval survivorship was less than 10 percent. Translocations may achieve greater success by allowing *Geocrinia* to develop to metamorphosis under laboratory conditions where many of the causes of mortality such as predation and fungal infection of eggs and oviposition site desiccation can be eliminated. However, the likely detrimental impacts of removing eggs from an existing population need to be considered.

Agreements between the Geocrinia Recovery Team and the Melbourne Zoo have been reached about the captive raising and breeding of *Geocrinia*. A successful captive breeding programme for an amphibian species with a similar breeding biology (i.e. direct-developing eggs) has been achieved in the past with *Leiopelma sp.* in New Zealand (Bell 1985). However there has yet to be a single documented successful re-establishment of an endangered or threatened amphibian species from captivity into the field anywhere in the world (Dodd and Seigel 1991).

2. RECOVERY OBJECTIVES AND CRITERIA

2.1 Objective

Downlisting to conservation dependent (Orange-bellied Frog) and vulnerable (White-bellied Frog) within ten years by protecting existing populations and, if necessary establishing additional populations.

2.2 Criteria

Recovery criteria

- 2 years. Accurate knowledge of the number of naturally occurring populations.
- 7 years. Habitat conservation for all Orange-bellied Frog sites and at least 75 percent (41) of currently known White-bellied Frog populations to ensure effective genetic and geographic spread.
- 10 years. Management and monitoring to ensure sustainability of all populations.

3. RECOVERY ACTIONS

3.1 Orange-bellied Frog

3.1.1 Survey of riparian habitat

At the time of implementation of this Recovery Plan, unsurveyed creeklines existed in the vicinity of the current range of the Orange-bellied Frog, both to the north and south of the Blackwood River, that may have contained suitable habitat for this species (Figure 2). Each of these areas has since been surveyed thoroughly during the peak calling season.

- Budget allocation: Consultant Scientist
- one week per year 1992/93 \$700
- Travel - 92/93 \$300
-
- Duration: Two years
-

3.1.2 Land tenure and management

All known sites of the Orange-bellied Frog are in State forest. Some of the habitat of the Orange-bellied Frog lies within a proposed Conservation Park located along the Blackwood River. In the Forest Management Plan 1994 - 2003 (CALM 1994), CALM undertook to defer all major land disturbance activities where the frog occurs pending the conclusion of the research included in this Recovery Plan. Activities on adjoining CALM-managed areas will be modified to minimise impact on frog habitat. The Plan also states that 'a further option which may be considered during the life of the Forest Management Plan will be to create a special reserve over the Crown Lands in which the frogs occur. This would affect forests in the `... Adelaide and Chapman Blocks`'.

The Recovery Team will report to CALM's Corporate Executive on the results of research included in the Recovery Plan and on progress with the recovery actions and recommend whether special reserves are needed.

- Budget allocation: CALM Administrative costs
-
- Duration: Ten years

3.1.3 Fire management and research

Until more detailed understanding of the impact of fire on this species complex is achieved, it is planned to maintain a fire-free zone for the largest area of habitat of the Orange-bellied Frog. Because the Blackwood River and adjacent land within the range of Orange-bellied Frog receives a high level of recreational use, it is not possible to retain all areas of catchment vegetation unburnt. Rather it is proposed to exclude fire from specific swamp habitat. Existing tracks between Denny Road and the Blackwood River that extend either side of the two largest populations of Orange-bellied Frog (GV1 and GV4) will be used as firebreaks so that the riparian habitat and immediate upland vegetation are excluded from fire. Other sites will be prescribed burnt in early spring to reduce the likelihood of intense summer fire in the area.

Figure 2 (not available)
Distribution showing area of occupancy of the Orange-bellied Frog

Figure 3 (not available)
Distribution showing area of occupancy of the White-bellied Frog

Two experiments have been set up to investigate the impact of fire on *Geocrinia*. One will determine the impact of a spring burn on the Walpole Frog and the other will provide information on an intense summer fire on the Karri Frog. Both these experiments use transects as described in section 1.6.4.

- Budget allocation: Consultant Scientist
- two weeks per year \$1400
- Travel - 92/94 \$600
-
- Duration: Three years 1992-94

3.1.4 Habitat protection

As all creek systems including Orange-bellied Frogs are on public land, the major threat to this species is likely to come from habitat disturbance. Reducing the threat of feral pigs occurring in catchments of Orange-bellied Frog is necessary and is best achieved by baiting in nearby catchments. This would initially require a baiting program lasting for at least one month, allowing an estimate to be made of the local abundance of feral pigs. Once the pigs had become accustomed to visiting the bait station, poison bait would then be used. In this Recovery Plan, it is projected that control of feral pigs will take place every two years. However, this will depend on the abundance of pigs at the initial baiting stage and any subsequent signs of activity.

- Budget allocation: CALM and APB officer
- for feral pig control \$1100
-
- Duration: Ongoing - every year from 1994

3.1.5 Wider community participation

Providing public information within the range of Orange-bellied Frog will assist in reducing the risk of wildfire. The Department of Conservation and Land Management (CALM) will act to encourage people to behave responsibly in this area of considerable conservation significance. The upgrading of Sues Road for mining access may increase the public use of the area, and hence the risk of fire.

- Budget allocation: CALM Administrative costs
-
- Duration: Five years

3.1.6 Population monitoring

Survey transects have been established at nine Orange-bellied Frog sites. These are monitored three times in the peak breeding season (mid September-late October). Data are stored in a micro-computer using MAPINFO and EXCEL software.

- Budget allocation: Consultant Scientist
- 4 weeks 1992 \$2800
- 3 weeks 1993-2001 \$2100 per annum
- Travel -1992 \$700
- 1993-2001 \$400 per annum
- Duration: Ongoing

3.1.7 Genetic studies

All populations of the Orange-bellied Frog (including successive samples within a year and between years) were sampled to investigate genetic stability and diversity. Toe biopsies were used to obtain genetic material, allowing all frogs to be released at the point of capture. Allozyme electrophoresis was carried out at the Department of Zoology, UWA.

–	Budget allocation:	Consultant Scientist	
–		3 weeks per year field	\$2000
–		Travel	\$500
–		Allozyme electrophoresis - 1993	\$1000
–	Duration	Three years 1992-94	

3.1.8 Translocations

Translocation may be carried out from Spearwood Creek to two nearby creek systems to the east of Spearwood Creek and north of the Blackwood River as an experimental option to determine the feasibility of eggmass translocation. Sites that are now suitable may not yet have been colonised due to current edaphic or climatic barriers between suitable riparian sites.

A captive breeding population of the Karri Frog has been established at Melbourne Zoo to determine the techniques needed to successfully raise and breed *Geocrinia*.

–	Budget allocation:	Consultant Scientist	
–		3 weeks field/lab	\$2000
–		Travel	\$500
–	Duration:	Three years 1996-1998	

3.2 White-bellied Frog

3.2.1 Survey of riparian habitat

At the time of implementation of this Recovery Plan, unsurveyed creeklines occurred on both private property and State Forest within the range of the White-bellied Frog (Figure 3). Forest Grove State Forest and the privately-owned Boathaugh block (Location 83) were of special significance. The latter includes the last remaining uncleared forest linking the Leeuwin-Naturaliste Ridge with the Blackwood Plateau. Since then, all unsurveyed areas but for a small area of Location 83 have been visited and mapped. A small number of populations may exist in Location 83.

–	Budget allocation:	Consultant Scientist	
–		four weeks per year	\$2800
–		Travel costs	\$1200
–	Duration:	Two years 1992-93	

3.2.2 Land tenure and management

Eleven sites where the White-bellied Frog occurs lie partly (two) or completely (nine) within State forest. There are also three sites in National Park and two in vacant Crown Land. In the Forest Management Plan 1994 - 2003 (CALM 1994), CALM undertook to defer all major land disturbance activities where the frog occurs pending the conclusion of the research included in this Recovery Plan. Activities on adjoining CALM-managed areas will be modified to minimise impact on frog habitat. The Plan also states that 'a further option which may be considered during the life of the Forest Management Plan will be to create a special reserve over the Crown Lands in which the frogs occur. This would affect forests in the ... Forest Grove and Witchcliffe areas'.

The Recovery Team will report to CALM's Corporate Executive on the results of research included in the Recovery Plan and on progress with the recovery actions and recommend whether special reserves are needed.

- Budget allocation: CALM Administrative costs
- Duration: Ten years

Private Land: The majority of White-bellied Frog sites occur on private land as narrow corridors of vegetation amongst extensive areas of cleared farmland. With the exception of one location which has not been cleared, purchase of this riparian habitat is not a practical option. Management strategies for these sites are outlined in section 3.2.4.

- Budget allocation: CALM Administrative costs
- Purchase of private land 1995-1997
- Duration: Three years

3.2.3 Fire management and research

Because private property adjoins most State Forest in which the White-bellied Frog occurs, it is not possible to retain unburnt all areas of catchment vegetation. Rather it is proposed to exclude fire from specific swamp habitat using fire breaks near swamp habitat.

- Budget allocation: Consultant Scientist
- two weeks 1992-94 \$1400
- Travel - 2 years 1992-93 \$600
- Duration: Three years
-

3.2.4 Habitat protection

Fencing habitat

Fencing of riparian habitat to exclude livestock will be carried out at all White-bellied Frog sites on private property where cooperative arrangements can be made. This work will be carried out over five years. Prioritising of sites has been done by considering the immediate threats posed to the population and by the size of the population (Appendix 1). Some provision for fencing construction within the Total Estimated Cost of Recovery (TC) was made for additional sites on private land where White-bellied Frog was thought likely to occur.

–	Budget allocation:	Consultant Scientist	
–		4 weeks/year 1992-93	\$2800
–		Travel costs - 1992/93	\$2200
–		Information Officer	
–		4 weeks/year	
–		Fence construction 1994	\$32 400
–		1995/98	\$20 000
–	Duration:	Five years	

3.2.5 Wider community participation

An initial source of information, "The Frog Recovery Kit", will be used to disseminate information about White-bellied Frog and the Recovery Plan. A cassette tape containing recordings of the White-bellied Frog and other species of frogs of the area will be included. This will encourage increased community awareness of frogs and enhance the likelihood of any further populations of White-bellied Frog being detected. This information will also be made more widely available to the local community so that the efforts of landowners can be fully recognised and the general public can become involved in the recovery process.

Information nights and the local press are additional means by which the general public can become informed. Land-owner participation may also be encouraged in cooperation with the Augusta-Margaret River Shire. Local community participation in both the rehabilitation of land and the monitoring of frog populations will be encouraged. Revegetation of farmland for the protection of the White-bellied Frog and its habitat may also be beneficial to the long-term livelihoods of landowners.

–	Budget allocation:	Production of "Frog Recovery Kit" 1994	\$4200
–		Information Officer	
–		2 weeks 1992-94	
–		4 weeks 1995-2001	
–		Travel 1994	\$2000
–		1992-1994	\$3700
–		1995-97	\$1500
–		1998-2001	
–	Duration:	Ongoing	

3.2.6 Population monitoring

To date survey transects have been established at 20 White-bellied Frog sites. These are monitored three times in the peak breeding season (mid September-late October). The point count method is used in all White-bellied Frog sites that do not have transects. These include sites from which the White-bellied Frog has apparently disappeared since 1983. Data are stored in a micro-computer using MAPINFO and EXCEL software.

–	Budget Allocation:	Consultant Scientist	
–		3 months 1992-94	\$7000
–		2 months 1995-97	\$5000
–		Travel 1992-2001	\$2500
–		Materials 1995	\$7500
–	Duration:	Ongoing	

3.2.7 Genetic studies

Twenty five populations of the White-bellied Frog have been sampled for allozyme electrophoresis. Toe biopsies were used as the genetic material. Three of these sites were sampled repeatedly in 1993 to investigate genetic stability.

Additional genetic samples of 27 Karri Frog and 28 Walpole Frog populations have been taken to investigate the influence of landscape features on the genetic structure of populations of *Geocrinia*.

–	Budget Allocation:	Consultant Scientist		
–			two months 1992-94	\$5000
–		Travel 1992-94	\$3000	
–		Allozyme electrophoresis 1993-4	\$3400	
–	Duration:	Three years 1992-94		

3.2.8 Translocations

Initial work at the Melbourne Zoo involves running trials with the more widespread and abundant Karri Frog to establish the techniques needed to successfully raise and breed *Geocrinia*.

–	Budget allocation:	Captive breeding 1994	\$1300	
–			1995-98	\$200
–		Travel 1994-1998	\$1000	
–	Duration:	Five years 1994-98		

3.1 IMPLEMENTATION SCHEDULE (ORANGE-BELLIED FROG)

Task	Priority	Feasibility	Responsible party	Cost estimate (\$000s/year, 1992 dollars)										Total	
				1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
3.1.1 Survey of riparian habitat	1	100%	CALM/ESP	1.0	1.0	-	-	-	-	-	-	-	-	-	2.0
3.1.2 Land tenure and management	1	100%	CALM		-	-	-	-	-	-	-	-	-	-	-
3.1.3 Fire management and research															
Fire protection	2	100%	CALM		-	-	-	-	-	-	-	-	-	-	-
Fire research	2	100%	ESP/CALM	2.0	2.0	2.0	-	-	-	-	-	-	-	-	6.0
3.1.4 Habitat protection	2	70%	ESP/CALM		-	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	8.8
3.1.5 Wider community participation	2	90%	CALM		-	-	-	-	-	-	-	-	-	-	-
3.1.6 Population monitoring	1	100%	ESP/CALM	3.5	2.5	2.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	9.2
3.1.7 Genetic studies	1	100%	ESP/CALM	2.5	3.5	2.5	-	-	-	-	-	-	-	-	8.5
3.1.8 Translocation	1	50%	ESP/CALM		-	-	-	2.5	2.5	2.5	-	-	-	-	7.5
Total				9.0	9.0	8.1	1.2	3.7	3.7	3.7	1.2	1.2	1.2	42.0	

CALM: Department of Conservation and Land Mangement, Western Australia.
 ESP: Endangered Species Program, ANCA, Canberra.

3.2 IMPLEMENTATION SCHEDULE (WHITE-BELLIED FROG)

Task	Priority	Feasibility	Responsible party	Cost estimate (\$000's/year, 1992 dollars)											Total	
				1992	1993	1994	1995	1996	1997	1998	1999	2000	2001			
3.2.1	Survey of riparian habitat	1	100%	CALM/ESP	4.0	4.0	-	-	-	-	-	-	-	-	-	8.0
3.2.2	Land tenure and management	1	70%	CALM	-	-	-	-	-	-	-	-	-	-	-	-
3.2.3	Fire management and research	2	100%	ESP/CALM	2.0	2.0	2.0	-	-	-	-	-	-	-	-	6.0
3.2.4	Riparian protection Fencing habitat	1	60%	ESP/CALM	5.0	5.0	32.4	20.0	20.0	20.0	20.0	4.0	4.0	4.0	134.4	
3.2.5	Wider community participation	1	80%	ESP/CALM	2.0	2.0	6.2	3.7	3.7	3.7	1.5	1.5	1.5	1.5	27.3	
3.2.6	Population monitoring	1	100%	ESP/CALM	10.0	10.0	10.5	17.0	15.0	15.0	2.5	2.5	2.5	2.5	87.5	
3.2.7	Genetic studies	1	100%	ESP/CALM	8.0	11.4	11.4	-	-	-	-	-	-	-	-	30.8
3.2.8	Experimental translocation	1	50%	ESP/CALM	-	-	2.3	1.2	1.2	1.2	1.2	-	-	-	-	7.1
Total					31.0	34.4	64.8	41.9	39.9	39.9	25.2	8.0	8.0	8.0	301.1	

CALM: Department of Conservation and Land Management, Western Australia.
 ESP: Endangered Species Program, ANCA, Canberra.

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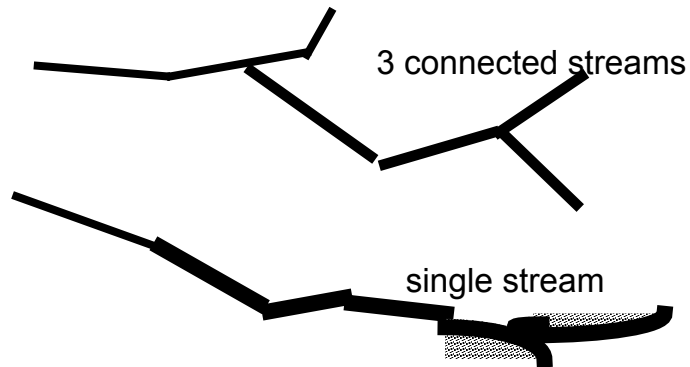
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Appendix 1:
Criteria for "population" recognition in the Orange-bellied and White-bellied Frogs

The recognition of discrete populations is simple with species with major disjunctions in range: e.g. populations of woylies at the Perup and Dryandra. However, where the scale of isolation is much smaller and, there is implied connectedness along drainage systems this definition is less obvious. Definition of populations below deals with these issues.

Sites in all categories may represent discrete populations centred on one creek line or on a set of connecting tributaries.



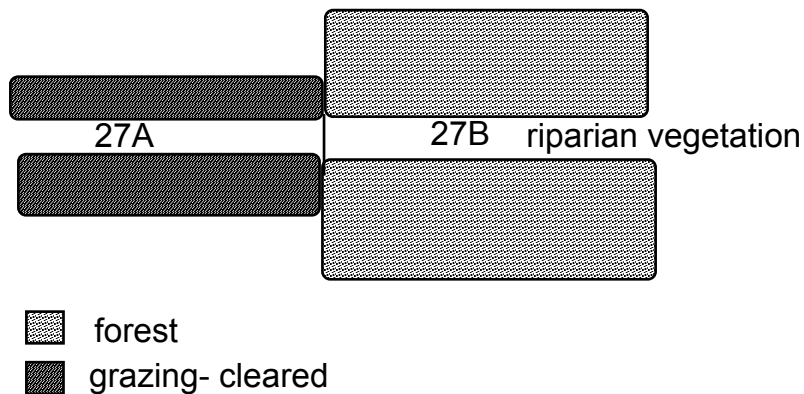
1. Sites are given a discrete number plus a following letter (A - D) if:

- a) an area of occupancy interrupted by a road crossing the habitat.

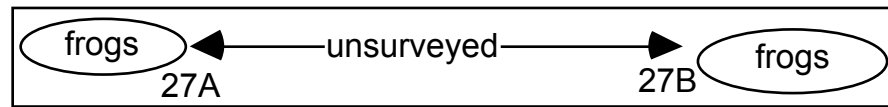


27A, 27B Population numbers

- b) land use adjacent to an area occupancy changes along the creek system:
 e.g. from forest to plantation or cleared land.



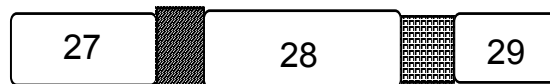
- c) an area of occupancy contains frogs at either end but the intervening area has not been surveyed.



The numbered site represents a continuous area of habitat. The subdivisions represent units that might be affected differentially by adjacent land use or road impacts. For example, plantations might cause local groundwater changes that do not affect upstream sites in forest. Roads or debris accumulating at culverts might cause damming and local upstream flooding without significantly altering downstream groundwater values. Despite short-term loss or decline within subdivisions these sites have the potential for relatively rapid rehabilitation if impacts are recognised quickly.

2. Sites are given a discrete number with no following letter if:

- a) There is a block of occupancy containing 1 or more calling males, separated, by a cleared gap or gap of unsuitable habitat more than 50 m wide, from adjacent similar habitat blocks. Unsuitable habitat must be obvious: e.g. rocky substrates, flooded areas and the like. A 50 m gap was chosen as this is greater than the estimated neighbourhood diameter from demographic data (means of: 37.9 m, White-bellied Frog, 29.2 m, Orange-bellied Frog) and it represents the maximum recorded dispersal distance for a male.



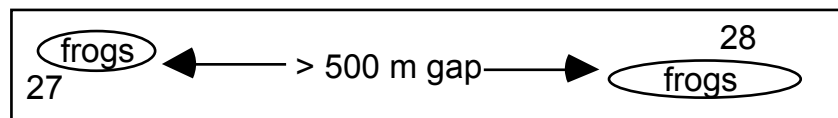
cleared - grazed land, > 50 m

flooded creek line, > 50 m

27 population number

- b) In a creek line with a continuous area of occupancy, survey along the creek indicates adjacent groups of calling males are separated by distances of more than 500 m. 500 m is an arbitrary gap indicating

substantial isolation.



Known sites: based on these criteria, there are:

- a) White-bellied Frog - 54 known sites. Of these, 12 sites have gone extinct since 1983, i.e. 22.2 percent. If subdivisions of sites are added there are a total of 72 locations. Of these, 14 have gone extinct since 1983, i.e. 19.4 percent. Extinction is based on absence in 1994.
- b) Orange-bellied Frog - 6 known sites. With subdivisions, this rises to 7. There are no known extinctions.

Size categories

We have scored all subdivisions within sites or undivided sites into creek length categories, ignoring width. Group 1, < 500 m, Group 2, 500 - 1000m, Group 3, 1 - 1.5 km, Group 4, 1.5 - 2 km, Group 5, 2 - 2.5 km

etc. To assess total creek length we have taken class length as $[0.25 + 0.5(n - 1)]$ km, where n is the length class number and summed over all sites.

White-bellied Frog : in 1994 there was 27.75 km of creek system known (1983 - 1994) to have held this species but it was absent from 4.0 km, i.e. 14.4 percent loss.

Orange-bellied Frog was known from 3.0 km with no losses.

Assessing persistence

For the purposes of assessing population persistence all sites and subdivisions within sites should be surveyed for the presence or absence of calling males on a biennial basis: either all sites in one year, or, half one, the remainder, the next. The count of sites should include all sites known to have contained Orange-bellied Frog or White-bellied Frog since 1983, the year these species were discovered.

Population size

Detailed counts to assess population size and its variation have been done by transect counts or by spot counts in small populations.

- a) these should continue on a biennial basis as above.
- b) any site should be counted twice in one season: September and October

Measures of success

- a) 75 percent of all whole sites should contain frogs: i.e. 5 for the Orange-bellied Frog, 41 sites for the White-bellied Frog.
- b) 75 percent of total creek length should also contain frogs. Only length by numbered site, not subdivision is used.
- c) Criteria for assessing local population decline are less obvious. If recruitment is regular at all sites then a concerted decline over more than the maximum life-span should be cause for concern. If there are pulses of recruitment, e.g. in high rainfall years, there may be periods of concerted decline interrupted by population highs following from effective recruitment one to two years earlier. If any single, undisturbed population declines continuously over 5 years - possible local causes should be investigated. If ten or more, undisturbed populations show a concerted decline over five years - global causes should be investigated.

Appendix 2 (not available)