RECOVERY PLAN FOR THE ORANGE-BELLIED (*GEOCRINIA VITELLINA*) AND WHITE-BELLIED (*GEOCRINIA ALBA*) FROGS

by

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CONTENTS

SUMMARY

Current species status:

Geocrinia vitellina: vulnerable (ANZECC 1991), threatened (CALM 1991). Known from four populations, all located in State forest. No recorded decline in distribution.

Geocrinia alba: endangered (ANZECC 1991), threatened (CALM 1991). Recorded from 26 sites, 19 on privately-owned land and seven at least partly within State forest. Of these, six have died out since 1983. Agricultural clearing has reduced the area of suitable habitat (ASH) for this species by about 70 percent.

Habitat requirements and limiting factors:

The known ASH of *G. vitellina* is 20 ha making this species vulnerable to localised disturbance.

G. alba persists along creeklines within agricultural landscapes, provided suitable riparian habitat remains intact. The major threats to *G. alba* habitat on private land are clearing, grazing and trampling of riparian vegetation by cattle, and weed invasion.

Other threats to *G. vitellina* and *G. alba* include, habitat destruction by fire and feral pigs, and changes to the hydrology of their sites.

Recovery plan objectives:

Downlisting to rare (*G. vitellina*) and vulnerable (*G. alba*) within ten years by protecting existing populations and establishing additional populations.

Recovery criteria:

2 years. Determine the total number of naturally occurring, genetically stable populations.
7 years. Ensure habitat is secure for at least 8 (20 for *G. alba*) genetically stable populations.
10 years. Manage and monitor all known populations.

Actions needed:

The following actions will be overseen by a Recovery Team comprised of people from CALM, ANPWS and other organisations relevant to the recovery process.

G. vitellina

1. Survey riparian habitat.
2. Land tenure changes.
3. Fire management and research.
4. Introduced threats.
5. Population monitoring.
6. Genetic studies.
7. Translocations.

G. alba

1. Survey riparian habitat.
2. Land tenure changes.
3. Fire management and research.
4. Private land habitat protection.
5. Public information.
6. Population monitoring.
7. Genetic studies.
8. Translocations.

Total estimated cost of recovery of *G. vitellina*
(1991 prices in $000's/year):

Year	Action															
	1		2		3		4		5		6		7		Total	
	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP	TC	ESP
1992	1.0	1.0	-	-	2.0	2.0	2.0	1.0	3.5	3.5	2.0	2.0	-	-	12.5	9.5
1993	1.0	1.0	-	-	4.0	2.0	-	-	2.5	2.5	-	-	-	-	7.5	5.5
1994	-	-	-	-	2.0	1.4	2.0	1.0	2.5	2.5	-	-	2.5	2.5	9.0	7.4
1995	-	-	-	-	-	-	-	-	2.5	2.5	-	-	2.5	2.5	5.0	5.0
1996	-	-	-	-	2.0	-	2.0	1.0	2.5	2.5	-	-	2.5	2.5	9.0	6.0
1997	-	-	-	-	-	-	-	-	2.5	2.5	-	-	2.5	2.5	5.0	5.0
1998	-	-	-	-	2.0	-	2.0	1.0	2.5	2.5	-	-	2.5	2.5	9.0	6.0
1999	-	-	-	-	-	-	-	-	2.5	2.5	-	-	-	-	2.5	2.5
2000	-	-	-	-	2.0	-	2.0	1.0	2.5	2.5	-	-	-	-	6.5	3.5
2001	-	-	-	-	-	-	-	-	2.5	2.5	-	-	-	-	2.5	2.5
Total	2.0	2.0	-	-	15.4	5.4	10.0	5.0	26.0	26.0	2.0	2.0	12.5	12.5	67.9	52.9

Total cost (TC) and Endangered Species Program (ESP).
CALM administrative costs not included in budget.

Total estimated cost of recovery of *G. alba* (1991 prices in $000's/year):

Year	Action																	
	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	ESP
1992	1.7	1.7	-	-	2.0	2.0	45.8	41.8	6.7	2.7	4.5	4.5	3.7	3.7	-	-	64.4	56.4
1993	1.7	1.7	-	-	2.0	2.0	45.8	41.8	2.7	0.7	3.1	3.1	-	-	-	-	55.3	49.3
1994	-	-	-	-	1.4	1.4	45.8	41.8	2.7	0.7	3.1	3.1	-	-	3.0	3.0	56.0	50.0
1995	-	-	60	-	-	-	31.3	29.3	1.3	0.3	3.1	3.1	-	-	3.0	3.0	98.7	35.7
1996	-	-	60	-	-	-	31.3	29.3	1.3	0.3	3.1	3.1	-	-	3.0	3.0	98.7	35.7
1997	-	-	60	-	-	-	5.3	4.0	1.3	0.3	3.1	3.1	-	-	3.0	3.0	72.7	10.4
1998	-	-	-	-	-	-	5.3	4.0	1.3	0.3	3.1	3.1	-	-	3.0	3.0	12.7	10.4
1999	-	-	-	-	-	-	5.3	4.0	1.3	0.3	3.1	3.1	-	-	-	-	9.7	7.4
2000	-	-	-	-	-	-	5.3	4.0	1.3	0.3	3.1	3.1	-	-	-	-	9.7	7.4
2001	-	-	-	-	-	-	5.3	4.0	1.3	0.3	3.1	3.1	-	-	-	-	9.7	7.4
Total	3.4	3.4	180	-	5.4	5.4	226.5	204	21.2	6.2	32.4	32.4	3.7	3.7	15.0	15.0	487.6	270.1

Total cost (TC) and Endangered Species Program (ESP).
CALM administrative costs not included in budget.

Biodiversity benefits:

Significant increases in land designated for conservation in the region, and 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 rare or priority listed flora and two species of endangered mammal will also benefit from this recovery plan.

1. INTRODUCTION

1.1 Taxonomy and description

Geocrinia vitellina and *G. alba* 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.

G. vitellina and *G. alba* 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 (ranges separated by 9 km at the nearest point) in jarrah forest in the Witchcliffe-Karridale district in the far south-west corner of Western Australia (Fig. 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.

G. vitellina occurs over a range of 6.3 km^2. Its area of suitable habitat (ASH) is just over 0.2 km^2 (Wardell-Johnson and Roberts 1991) or approximately 3 percent of its range. It is known from the lower reaches of four unconnected creeklines which all drain south into the Blackwood River (Fig. 2). The largest population occurs at Spearwood Creek, from upstream of the Denny Road crossing, to the Blackwood River. The remaining three populations occur in smaller, adjacent creek systems between Denny Road and the Blackwood River. A further 45 creeks visited within a 10 km radius of the type locality (Spearwood Creek) did not extend the range of this species.

The riparian habitat of *G. vitellina* 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 *G. vitellina* 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 *G. vitellina* appears to reflect very localised suitable habitat conditions.

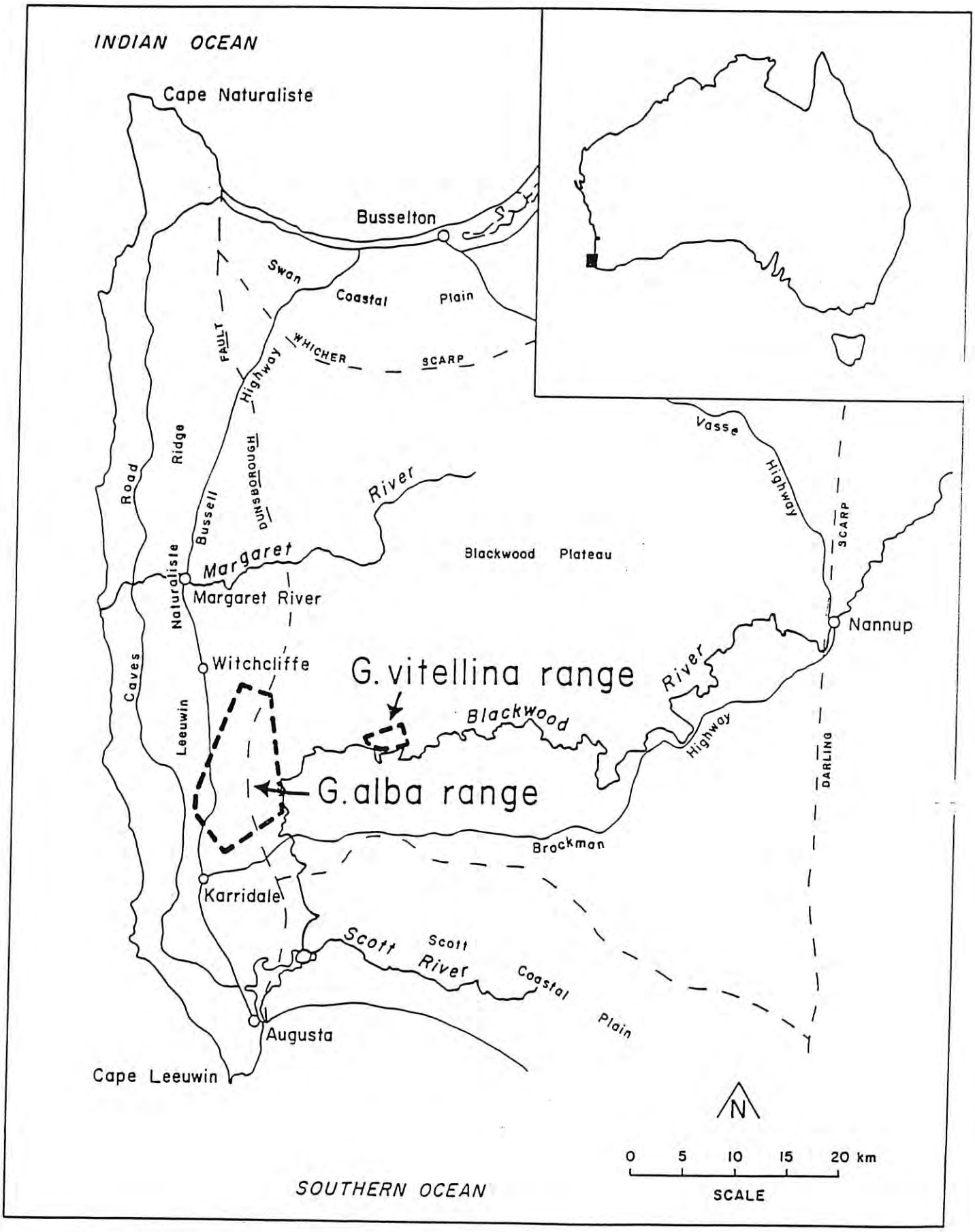
The range of *G. alba* is considerably larger than that of *G. vitellina* and extends over 101 km^2. The known distribution of *G. alba* consists of 26 sites (Fig. 3) all within one of three land units described by Tille and Lantzke (1990). The Wvw (Wilyabrub Wet Valleys, 1 site) and Hvw (Glengarty Wet Valleys 19 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, 6 sites) occurs in narrow V shaped valleys on laterized Perth Basin sediments. The ASH for *G. alba* was estimated, in 1986, to be 193.2 ha or approximately 3 percent of the species range (Wardell-Johnson and Roberts 1991). However this may be an overestimate, as not all potential sites support populations of *G. alba* (see below). Undisturbed sites in these three land units also extend beyond the range of *G. alba*. Thus there is an imperfect match between suitable land units and habitat occupied by this species.

Additional undetected populations may exist of both species within, and adjoining their current ranges (Fig. 2, 3).

1.3 Breeding biology and population studies

Little is known of the breeding biology or life history of either *G. vitellina* or *G. alba*. Males of both species call on land from small depressions in soil under litter and dense vegetation cover. Egg masses are often found close to calling males and are typical of frogs of the *G. rosea* complex i.e. deposited in small depressions,

Figure 1: General locality of currently known ranges (1991 records) for G. vitellina and G. alba in Western Australia.



eggs hatch, and the tadpoles develop in a jelly mass with no free swimming or feeding stage.

Some monitoring of populations of *G. vitellina* (one site - GV1) and *G. alba* (two sites - GA1a, GA24a) to examine seasonal, annual and spatial variability in abundance has taken place.(see Appendix 1 for location and description of all sites). Peak calling activity occurred for both species during the Spring months of September and October (see Wardell-Johnson and Roberts 1991, Fig. 4). Calling activity begins in late July and ceases by early December. End of calling corresponds to a rapid increase in soil dryness index in early summer. The number of calling males of *G. vitellina* has remained relatively constant over the last four years. Only in 1990 were counts less than in other years (Fig. 4). By contrast, there has been considerable variation in the abundance of *G. alba* (Fig. 4). The number of calling males of *G. alba* were higher in 1988 than in either 1983 or 1991. None were recorded at site GA1a in 1991.

Maximum densities of calling males of *G. vitellina* at Spearwood Creek occurred on the eastern side of the creek adjacent to seepage sites at the base of alcoves which fringe the U-shaped valleys (see Wardell-Johnson and Roberts 1991, Fig. 3). They were less common over the flat bottom of the creek valley. By contrast the population density of *G. alba* was found to be relatively even over the floor of the creeklines occupied by this species. Population densities within quadrats are considerably higher for *G. vitellina* than for *G. alba*. However quadrats are at sites of greatest calling density for each species, so are likely to provide an over-estimate of total population size, particularly for *G. vitellina* (see below).

In 1989 all quadrats at Spearwood Creek (GV1) were burnt. The fire was an early Spring burn of low intensity and so did not burn all ground cover (G. Wardell-Johnson unpublished data). Based on the number of calling males, the fire had little impact on *G. vitellina* in the two subsequent years (Fig. 4). A fire of high intensity burnt site GA1a in May 1991. This fire consumed the litter-layer within the riparian habitat of *G. alba*. Initial monitoring results suggest that this fire had a detrimental effect on the population of *G. alba* (Fig. 4).

The impact of fire on the *Geocrinia rosea* complex is thus not well understood, and research is required. The limited data gathered to date suggest that either *G. vitellina* is less susceptible to fire than *G. alba* or, that low intensity fire in Spring is less detrimental to population survival than high intensity fire in Autumn.

1.4 Justification for proposed conservation strategy

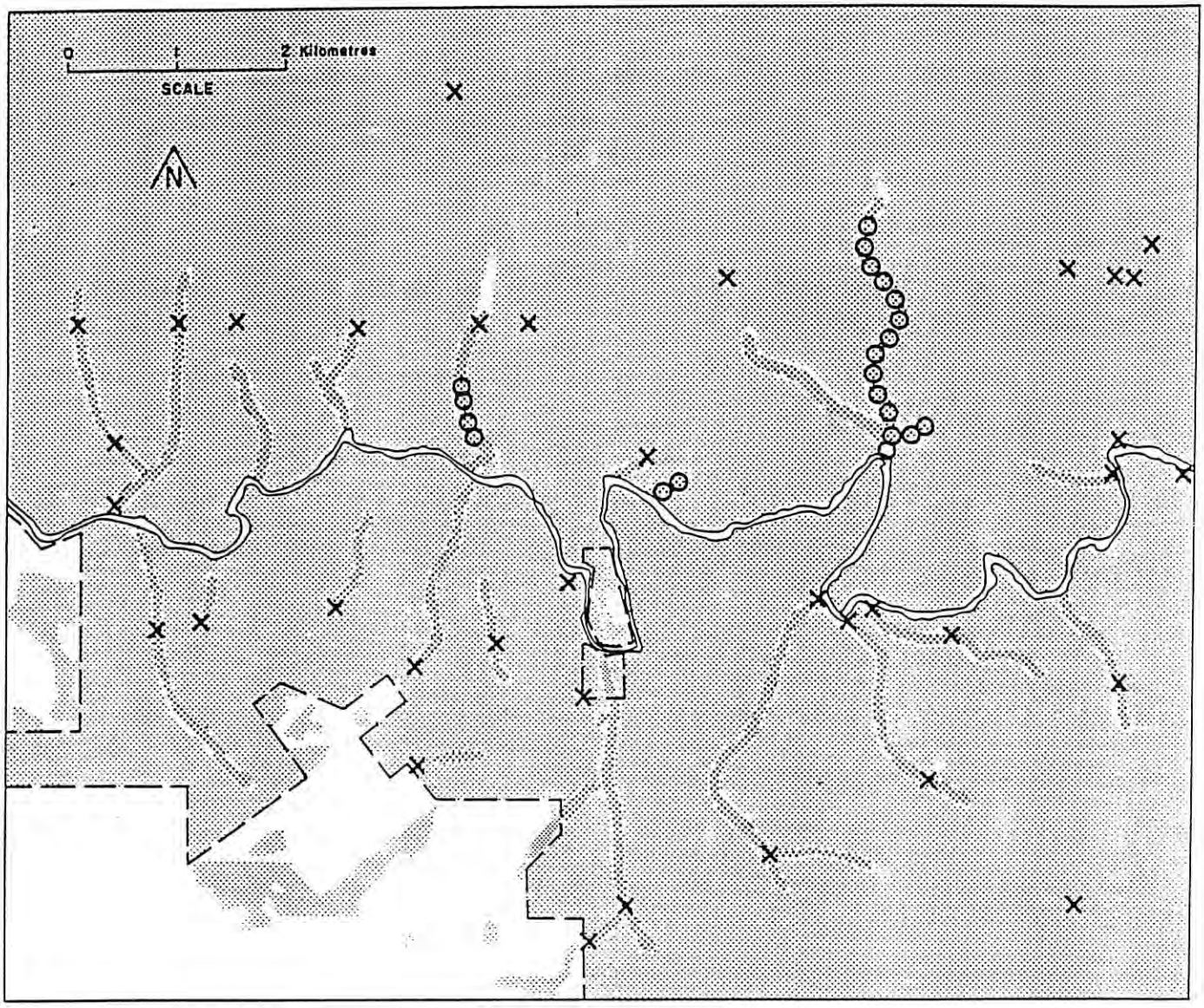
The very restricted distributions of *G. vitellina* and *G. alba* make both species a high priority for research and management. The considerable recent decline in suitable habitat of *G. alba* suggests that this species is the more vulnerable of the two (Wardell-Johnson and Roberts 1991).

All of the range, ASH and catchments of creeklines containing *G. vitellina* occur within State forest which has remained uncleared. It is unlikely that there has been any recent decline in the distribution of this species despite the limited human-induced disturbance in the area of its habitat (fuel reduction burning and some timber harvesting within the catchments of each of the populations has taken place).

The goal of the recovery plan for *G. vitellina* is to ensure that all existing populations continue to persist. The establishment of additional populations of *G. vitellina* may prevent any future localised disturbance leading to the extinction of this species.

In contrast with *G. vitellina*, 19 of 26 sites, 81% of ASH and 82% of the range of *G. alba* exists on private land. Much of the private land in this region has been cleared for agriculture. There has been a decline of over 70 percent of the ASH of *G. alba*. Clearing of riparian habitat has almost certainly lead to the loss of *G. alba* populations. However this species can persist if the riparian vegetation remains intact following the loss of the adjacent upland vegetation. Small populations of *G. alba* still occur at two locations where the upland vegetation has been cleared for over 20 years (GA4b, GA15). 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 1). Of these sites, five occur on private property.

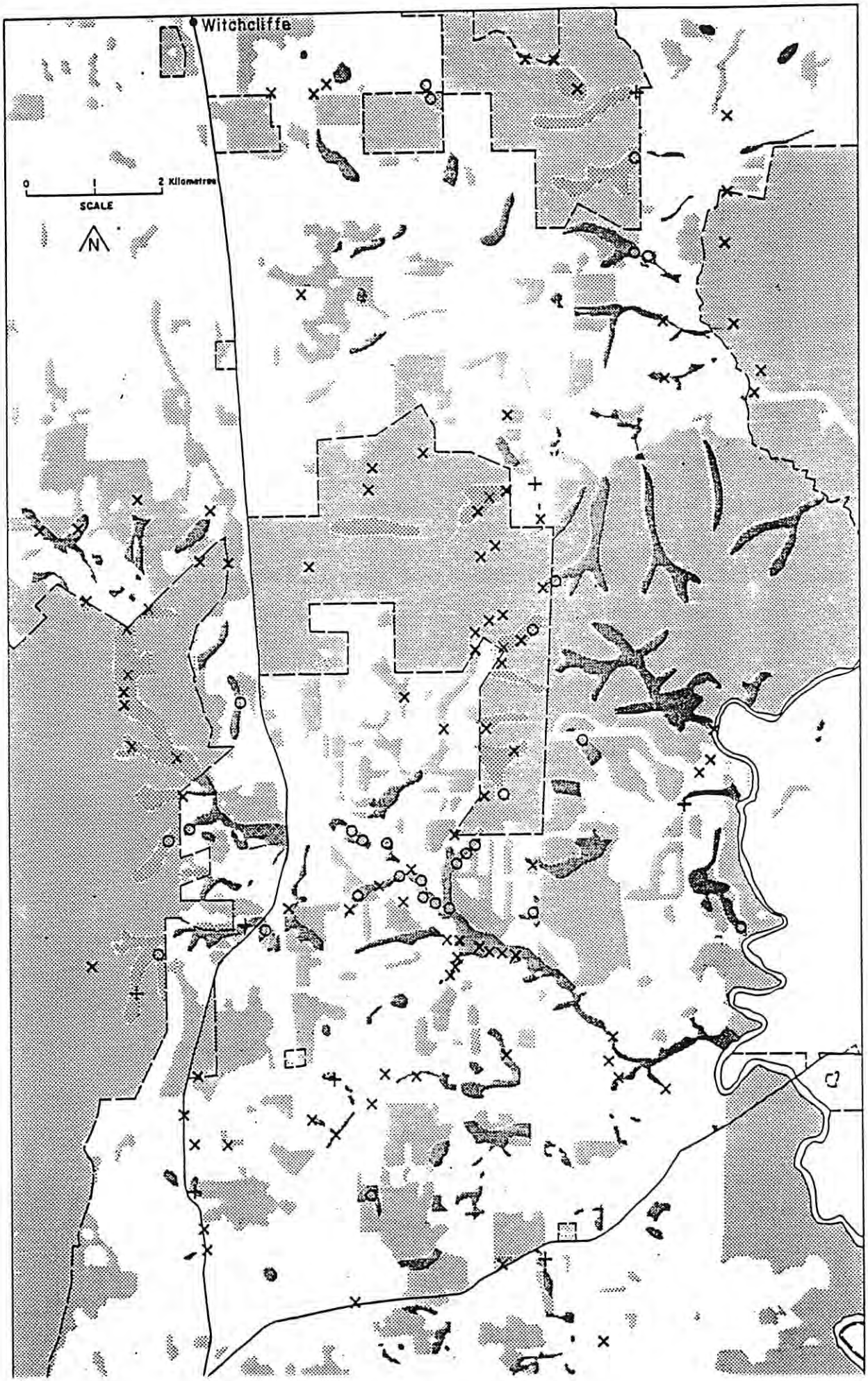
Figure 2: Surveyed and unsurveyed riparian sites worthy of survey for G. vitellina.



KEY to figures 2 & 3

- O Existing populations in Oct. 1991.
- \+ Previous populations inaudible in 1991.
- × Surveyed sites with no record of Geocrinia.
- Remnant riparian habitat worthy of survey on private property in Jan. 1990.
- Remnant riparian habitat worthy of survey on public land in Jan. 1990.
- Other native vegetation on private and public land.
- Boundary between major areas of private and public land.
- Highway.

Figure 3: Surveyed and unsurveyed riparian sites worthy of survey for G. alba.



Although they have retained some native riparian vegetation, all of these sites have become degraded.

The goal of the recovery plan for *G. alba* is to ensure that there is no further decline in the number of populations. The re-establishment of individuals to formerly occupied sites and the translocation of unprotected populations on private land to secure sites will help to ensure that the total number of populations of this species is maintained.

The conservation of *G. alba* is more difficult to achieve than that of *G. vitellina* because most populations of *G. alba* are located on private property and subject to various levels of human-related disturbances as a result of farming practices in the region. *G. vitellina* and *G. alba* have only recently been described. Thus, there are few conservation measures currently in place to protect either species. Both are included on the current list of "fauna which is rare or likely to become extinct" under the Western Australian Wildlife Conservation Act. *G. vitellina* is also listed as "vulnerable" and *G. alba* as "endangered" by ANZECC (1991). Two *G. alba* sites occur on land recommended to be included within the Leeuwin-Naturaliste National Park (CALM 1987). However, no populations of either species occur within land currently designated as National Park or Nature Reserve.

2. MANAGEMENT

A recovery team entrusted to oversee the implementation and to evaluate the success of this recovery plan will consist of nine people (Table 1). Three members of the recovery team will be representatives from ANPWS, the Augusta-Margaret River Shire and the Wildlife Branch of CALM. A Consultant Scientist, funded by ANPWS and based at the Manjimup Research Centre, will be responsible for all field study components to the recovery plan, including survey of riparian habitat, population monitoring and translocation of unprotected populations.

The CALM Central Forest Region will oversee the implementation of all other management strategies including the implementation of burn regimes, feral pig control, fencing of habitat and other strategies on private property. The CALM Regional Information Officer for the Central Forest Region will undertake to improve both landowner and local community awareness, and support for the Recovery Plan.

Table 1. Recovery team for *Geocrinia* Recovery Plan

Position	Organisation
Research Scientist	Conservation and Land Management
Specialist Biologist	University of Western Australia
Consultant Scientist	Conservation and Land Management
Regional Ecologist	Conservation and Land Management
Information Officer	Conservation and Land Management
	Australian National Parks and Wildlife Service
Wildlife Branch	Conservation and Land Management
	Augusta-Margaret River Shire
Land-owner	Private

Initially it will be necessary for the recovery team to meet three times each year: prior to the breeding season (August), post-breeding season and prior to fencing of riparian habitat (November) and at the completion of habitat fencing for that year (April). After year five, when fencing of habitat on private property is completed, the number of meetings will be reduced to twice a year. Progress with the implementation of the recovery plan will be reviewed each year. The review will be based on an annual report from the recovery team to the Executive Director.

2.1 *Geocrinia vitellina*

2.1.1 Objectives and Criteria

Objective: Downlisting to rare within ten years by protecting existing populations and establishing additional populations.

Criteria:

1 year.	Determine the total number of naturally occurring, genetically stable populations.
7 years.	Ensure habitat is secure for at least 8 genetically stable populations.
10 years.	Manage and monitor all populations.

2.1.2 Description of Recovery Actions

2.1.2.1 Survey of riparian habitat

Unsurveyed creeklines in the vicinity of the current range of *G. vitellina* both to the north and south of the Blackwood River may contain suitable habitat for this species (Fig. 2).

Budget allocation: Consultant Scientist (one week per year 1992/1993) $700.
Travel $300.
Duration: Two years.

2.1.2.2 Land tenure

The Department of Conservation and Land Management will act to gazette land in Spearwood Creek as Nature Reserve, as envisaged in this plan. The proposed reserve would include the catchments of the four creek systems in which *G. vitellina* is known to occur. It would also include similar nearby sites for future translocation. This reserve would cover an area of 4617 ha (Fig. 5).

Gazettal of the proposed Nature Reserve will significantly increase the area of land designated for nature conservation in the region. One declared rare plant species (*Chamelaucium erythrochloia* Wildlife Conservation Act 1950) and two species of priority listed flora (*Anthodium junctiforma* and *Acacia tayloriana* Wildlife Conservation Act 1950) occur within this proposed reserve. *Dasyurus geoffroyi,* listed as Endangered (ANZECC 1991), occurs within the proposed reserve.

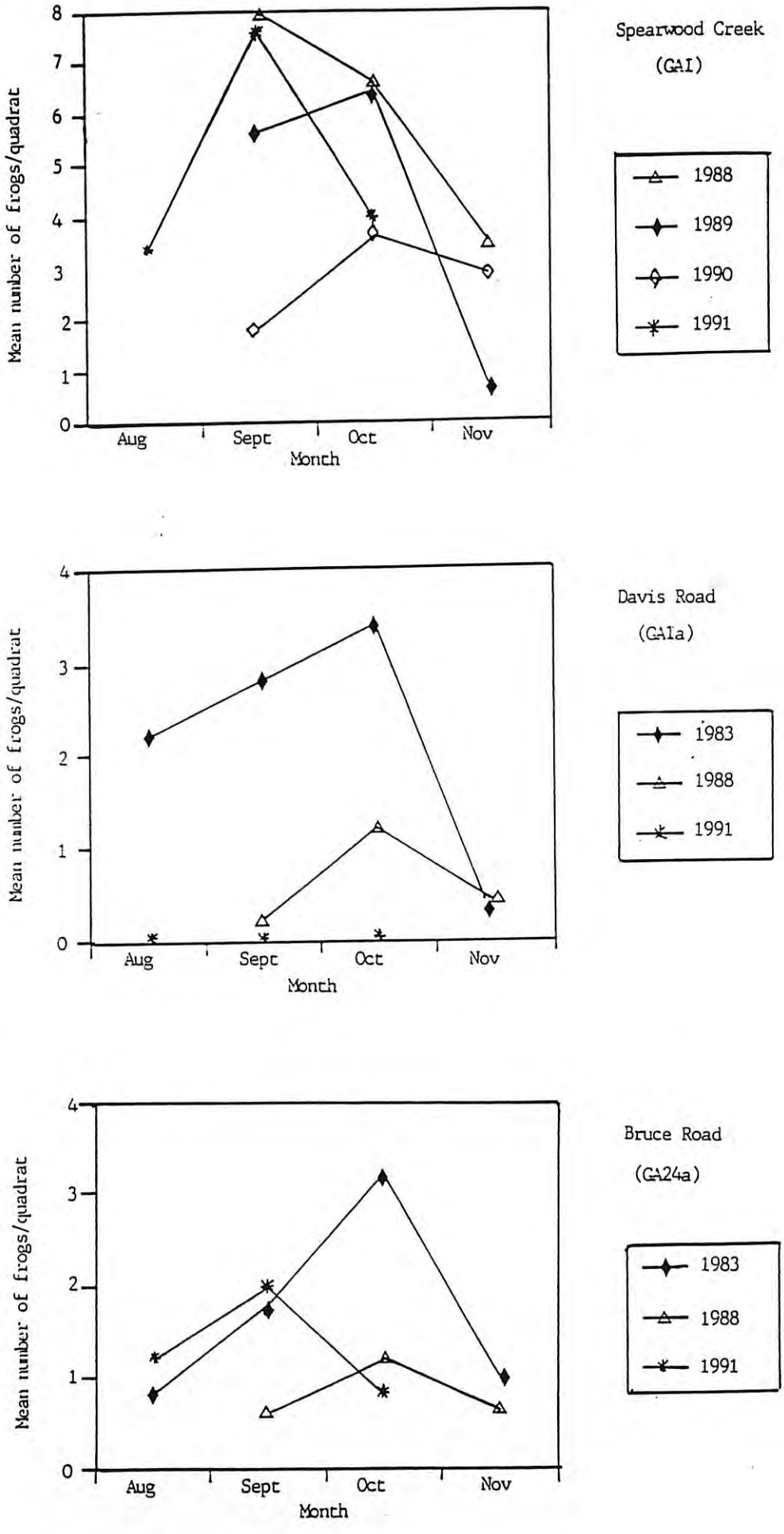
Budget allocation: CALM Administrative costs.
Duration: Two years.

2.1.2.3 Fire management and research

The proposed fire regimes (Fig. 5) are designed to reduce the risk of fire impacting on populations of *G. vitellina.* It will be necessary to investigate the fire ecology of this species to determine the adequacy of proposed fire regimes and those most appropriate in the future. In the meantime, fire exclusion would be expedient except in areas of high fire risk that threaten life and private property. Where prescribed burning is necessary it should be carried out in early Spring to reduce intensity, and to minimize the likelihood of burning the microhabitat of these frogs.

The Blackwood River and adjacent land within the range of *G. vitellina* receives a high level of recreational use and a single landowner also borders on the proposed Nature Reserve. For these reasons an Intermediate Burn Regime (IBR, 10-14 year cycle) is recommended for the upland forest between Denny Road and the Blackwood River.

Figure 4: Population monitoring of G. vitellina and G. alba at three sites over three years.



Existing tracks between Denny Road and the Blackwood River that extend either side of the two largest populations of *G. vitellina* (GV1 and GV4) will be used as firebreaks so that the riparian habitat and immediate upland vegetation are excluded from the IBR.

Restricting public access within the range of *G. vitellina* will assist in reducing the risk of wildfire. The Department of Conservation and Land Management will act to close existing tracks between Denny Road and the Blackwood River from Spearwood Road to Leath Road, with the exception of Great North Road. This would include proposed firebreaks. Wapet Road, which runs through the upper catchment of Spearwood Creek, has become badly eroded and will also be closed. Restricting public access should also assist in minimizing the spread of dieback disease. Hutt Pool at the intersection of the Blackwood River and Great North Road is considered the most appropriate site to continue to allow public access to the river. Picnic and barbecue facilities are already available at this site. Effort will be made to ensure the risk of fire spreading from Hutt Pool is reduced. The upgrading of Sues Road for mining access may increase the public use of the area, and hence the risk of fire.

Budget allocation: Road closure and fire-break maintenance $2000
Duration; Ongoing (every two years).
Consultant Scientist (two weeks per year) $1400.
Duration; Three years
Travel (92/93) $600.

2.1.2.4 Introduced threats

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

Reducing the threat of feral pigs occurring in catchments of *G. vitellina*, is best achieved by baiting in nearby catchments. This would initially require a baiting schedule of at least a month which would also allow some 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 $1000.
Duration: Ongoing (every two years).

2.1.2.5 Population monitoring

The restricted distribution of *G. vitellina* makes it vulnerable to localized disturbance. Thus some level of long term monitoring of populations of *G. vitellina* is necessary to detect any decline in population size. The long term monitoring of translocated populations will also be necessary to determine the success of these populations (i.e. self sustaining populations - see appendix 2 for monitoring designs).

Likely future threats from climate changes also support the need to maintain a long-term monitoring programme for populations of *G. vitellina*. Changes to populations of this species resulting from global threats may also be used to infer the impact on other frog species.

Budget allocation: Consultant Scientist (4 weeks 1992 $2800, 3 weeks 1993-2001 $2100); travel 1992 $700, 1993-2001 $400.
Duration: Ongoing.

2.1.2.6 Genetic studies

Genetic studies to determine whether separate sites support discrete populations will also determine whether this species has poor dispersal ability between microcatchments. The assessment of the genetic stability of separate populations will allow translocation programmes for this species to be designed.

Budget allocation: Consultant Scientist (1 week field) $700; Travel $300; DNA fingerprinting $1000.
Duration: One year 1992.

2.1.2.7 Translocations

Translocation will be carried out from three sites to four nearby creek systems to protect against future catastrophe. Sites that are now suitable may not yet have been colonised due to current edaphic or climatic barriers between suitable riparian sites.

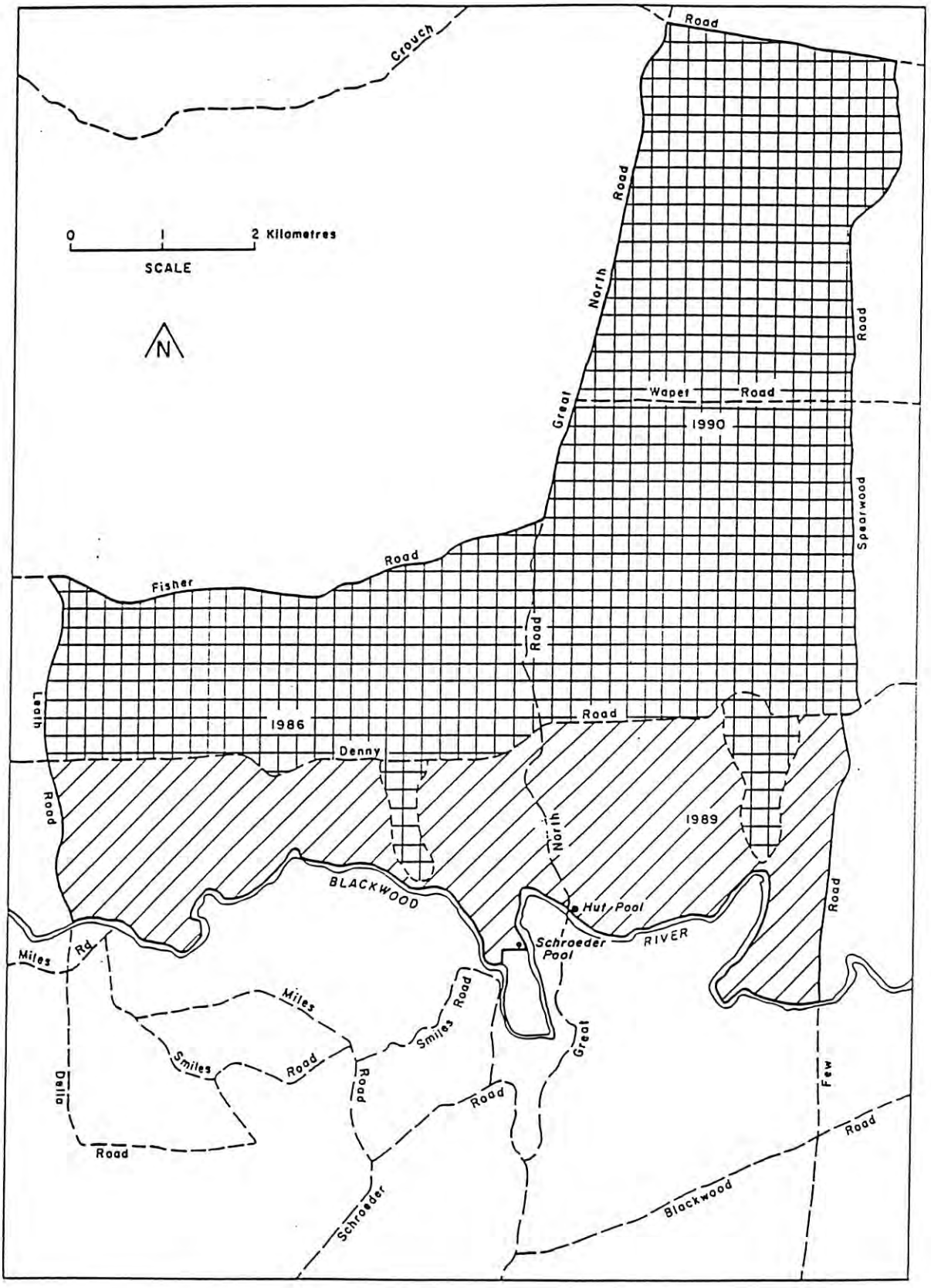
Budget allocation: Consultant Scientist (3 weeks field/lab) $2100; Travel $400.
Duration: Five years 1994-1998.

2.1.3 Implementation schedule (*G. vitellina*)

Task#	Task Description	Priority	Feasibility	Respon sibility	Estimated ESP Cost ($000's)										
					1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total
1	Survey of habitat	1	100%	CALM/ESP	1.0	1.0	-	-	-	-	-	-	-		2.0
2	Land Tenure	1	100%	CALM	-	-	-	-	-	-	-	-	-	-	-
3	Fire Management														
	Fire Protection	2	100%	CALM	-	-	-	-	-	-	-	-	-	-	-
	Fire Research	2	100%	ESP/CALM	2.0	2.0	1.4	-	-	-	-	-	-	-	5.4
4	Introduced Threats	2	70%	ESP/CALM	1.0	-	1.0	-	1.0	-	1.0	-	1.0	-	5.0
5	Population Monitoring	1	100%	ESP/CALM	3.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	26.0
6	Genetic studies	1	100%	ESP/CALM	2.0	-	-	-	-	-	-	-	-	-	2.0
7	Translocation	1	50%	ESP/CALM	-	-	2.5	2.5	2.5	2.5	2.5	-	-	-	12.5
	Total				9.5	5.5	7.4	5.0	6.0	5.0	6.0	2.5	3.5	2.5	52.9

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

Figure 5: Proposed changes in land tenure and fire regime for G. vitellina.



KEY

Proposed Nature Reserve boundary.

10-14 year burning cycle.

No planned burn.

1986 Year of most recent burn.

2.2 *GEOCRINIA ALBA*

2.2.1 Objectives and criteria

Objective: **Downlisting to vulnerable within 10 years by preventing the decline of existing populations and establishing additional populations.**

Criteria:

2 years.	Determine the total number of naturally occurring, genetically stable populations.
7 years.	Ensure habitat is secure for at least 20 genetically stable populations.
10 years.	Manage and monitor all populations.

2.2.2 Description of recovery actions

2.2.2.1 Survey of riparian habitat

Unsurveyed creeklines occur on both private property and State forest within the range of *G. alba* (Fig. 3). Forest Grove State Forest and the privately-owned Boathaugh block (83) are of special significance. The latter includes a large area worthy of survey for *G. alba* as well as the last remaining uncleared forest linking the Leeuwin-Naturaliste Ridge with the Blackwood Plateau. The location of all remaining sites on farmland should be determined so that ongoing degradation of habitat can be prevented. Sites from which *G. alba* has apparently disappeared since 1983 should also be revisited to test 1991 survey results.

Budget allocation: Consultant Scientist (two weeks per year) $1400; travel costs $300.
Duration: Two years.

2.2.2.2 Land tenure changes

Public land: At least two populations of *G. alba* occur within the Boranup State Forest (GA24a, GA25). These border private property but are located upstream of private land, and have their headwaters in undisturbed forest. Declaration of this land (605ha) as part of the Leeuwin-Naturaliste National Park as proposed by CALM (1987) will provide additional protection for these two sites.

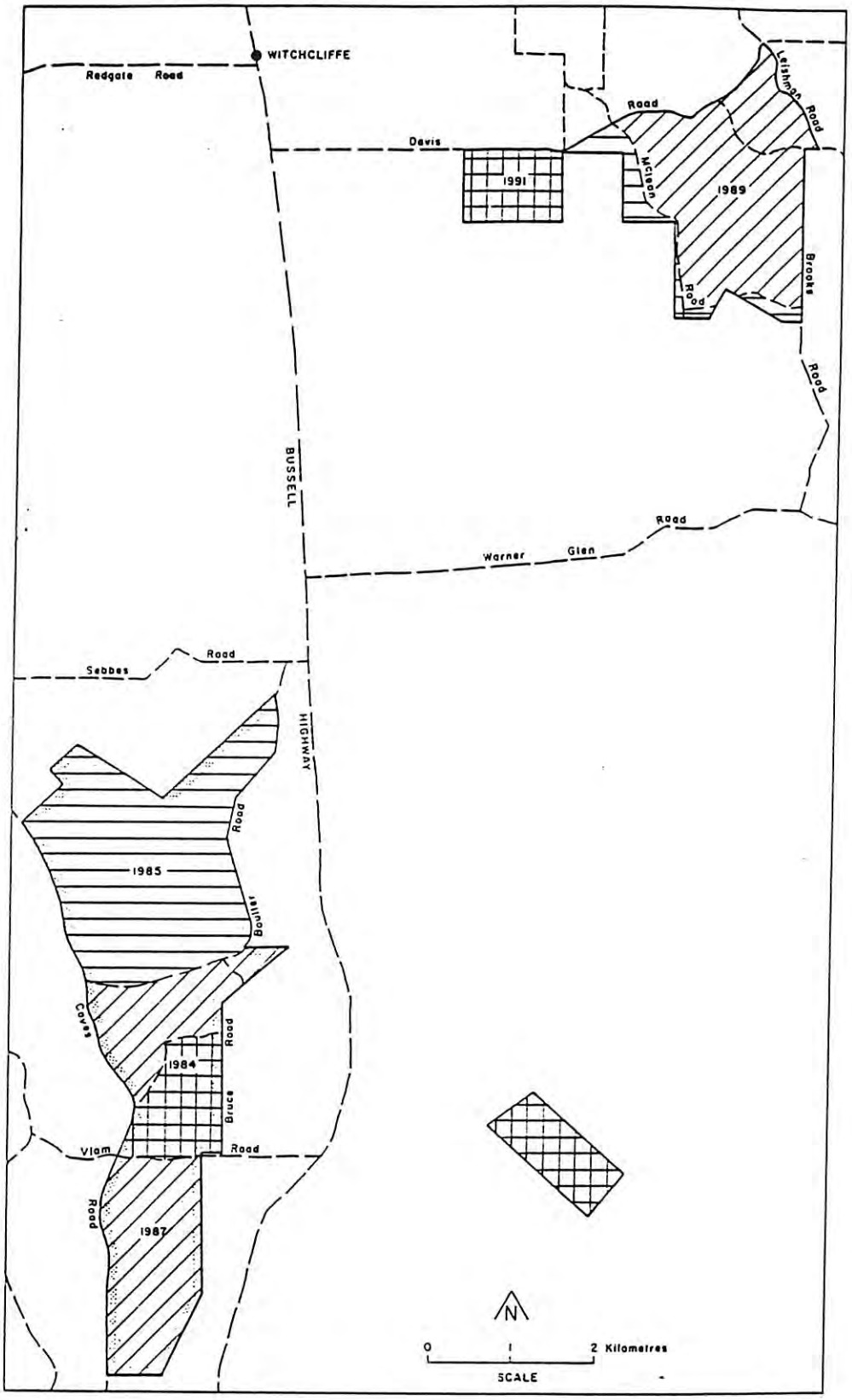
The Department of Conservation and Land Management will act to gazette land within Witchcliffe State Forest, as Nature Reserve as envisaged in this plan. At least three populations of *G. alba* (GA1-3) are located within this area. These occur within two separate forest blocks south of Davis Road, collectively extending over 420 ha (Fig. 6). These sites all adjoin private property. However, unsurveyed riparian habitat which is likely to support additional populations exists upstream of these sites. Indeed one explanation of the only "extinction" not to have occurred on private property (GA2) is that individuals were washed downstream from suitable habitat to the site at which they were heard on Brooks Road.

Two small populations of *G. alba* (GA7, GA8) occur within Forest Grove State Forest and the adjoining Government Requirements block (4578). This area occupies 1631 ha and includes the only known populations of this species not located on, or immediately adjacent to, private property. It is likely that future survey would locate other populations in this forest block.

Declaration of land as Nature Reserve and National Park for the protection of *G. alba* will significantly increase the area of land designated for nature conservation in the region, particularly along the Blackwood River and the area in the vicinity of the Dunsborough fault. Most land in this area is privately owned. This land represents the western-most extent of the jarrah forest of the Blackwood Plateau. In addition these areas of forest (when considered with Block 83) provide the only remaining corridor of native vegetation between the Leeuwin-Naturaliste Ridge and the Blackwood Plateau. Two species of mammal listed as Endangered (ANZECC 1991), *Dasyurus geoffroii* and *Pseudocheirus occidentalis*, also occur within the area of the proposed Nature Reserve and extension of the Leeuwin-Naturaliste National Park.

Budget allocation: CALM Administrative costs.
Duration: Two years.

Figure 6: Proposed changes in land tenure and fire regime for G. alba.



KEY

- Proposed National Park boundary.
- Proposed Nature Reserve boundary.
- 5-7 year burning cycle.
- 10-14 year burning cycle.
- No planned burn.
- Year of most recent burn

Private Land: The majority of *G. alba* sites occur on private land as narrow corridors of vegetation amongst extensive areas of cleared farmland. In general, purchase of this riparian habitat is not a practical option. Management strategies for these sites are outlined below.

The McLeod Creek catchment represents the present day centre of distribution for *G. alba*. A section of the McLeod Creek which has remained uncleared on private property contains the largest remaining contiguous area of suitable habitat for this species. In addition, the immediate upland vegetation at this site has also remained uncleared. The total area of 109 ha extends over two properties (4590 and 2719), of which approximately half is riparian habitat. An initial survey of the area indicates that *G. alba* occurs at six different locations along this creek system. Unsurveyed riparian habitat at which additional sites are likely to be found also exists on block 2719.

The acquisition of this land as a Nature Reserve would significantly enhance the long-term survival prospects of *G. alba*. This might best be achieved by the purchase of one of the privately-owned blocks (e.g. 2719) and exchanging the cleared land on this property for the equivalent sized area of suitable habitat on the adjoining block (4590).

Four populations in three separate creeklines occur immediately upstream of this site on adjacent private land. This area is of considerable importance for the conservation of *G. alba*. The endangered *Pseudocheirus occidentalis* (ANZECC 1991) has also been observed within this block of remnant vegetation (1991 record). This site also represents the western-most record of *Reedia spathacea*, a relictual plant associated with peat swamps from Walpole to Northcliffe. Disjunct populations of this species have also been recorded at Spearwood Creek and nearby creeklines.

Budget allocation: CALM Administrative costs; purchase of private land (1995-1997).
Duration: Three years.

2.2.2.3 Fire management and research

The proposed fire regimes (Fig. 6) are designed to reduce the risk of fire impacting on populations of *G. alba* while knowledge of fire response is limited. It will be necessary to research the fire ecology of this species to determine both the adequacy of proposed fire regimes and those most appropriate for the future. In the meantime, Fire exclusion would be expedient except in areas of high fire risk that threaten life and private property. Where prescribed burning is necessary, it should be carried out in early Spring to reduce intensity and to minimize the likelihood of burning the microhabitat of these frogs.

Because private property adjoins most State forest in which *G. alba* occurs, it is not possible to retain unburnt, all areas of catchment vegetation. Instead No Planned Burn (NPL) areas are restricted to three smaller areas located throughout the range of this species. All remaining catchment areas will be burnt on an Intermediate Burn Regime (IBR). Some land within the proposed Nature Reserve and National Park boundaries, will continue to be burnt on a Fuel Reduction Regime (FRR). This land does not include areas within the catchments of *G. alba*.

Budget allocation: Consultant Scientist (two weeks 1992-94) $1400, travel (two years 1992-93) $600
Duration: Three years.

2.2.2.4 Private land habitat protection

The viability of populations of *G. alba* on privately-owned land is critical to the survival of the species. Nineteen of the 26 sites are entirely on private land. Two of the remaining seven populations also exist partly on private land. Management practices on private land may also be of significance to the survival of adjoining public land populations (five of seven sites).

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

A recent survey found that over 80 percent of private landowners in the district value, and intend to keep, existing riparian vegetation on their property (Sutton 1990). However few are willing to exclude cattle from these sites. This is because such areas are seen to represent important summer shade and feed sites. Cattle destruction of riparian vegetation represents one of the major threats to *G. alba* on private land. Cattle also prevent regeneration and facilitate the spread of weeds.

Of the five extinctions on private land, three were unprotected from cattle and one from sheep. Cattle currently have access to 12 of the 21 *G. alba* sites on private land. Populations of *G. alba* on private land should not only remain uncleared, but should also be permanently excluded from cattle. It will thus be necessary for these areas to be fenced off (see Appendix 1 for size of areas to be fenced at each site). Fencing also protects habitat where cattle are not currently present but where they may be subsequently introduced. Fencing also provides a visible delineation of the riparian habitat of most importance for the conservation of *G. alba*. Similarly the protection of any remaining upland forest vegetation within these catchments should also be encouraged. However there may be a need to permit access to cattle to parts of these areas to meet the needs of landowners.

Many environmental changes are likely to occur along a riparian zone when the surrounding vegetation is cleared (altered hydrological patterns, weed invasion, salinity, pesticide and nutrient buildup). Clearing took place to the edge of the narrow riparian zone at one site (GA10) less than 15 years ago. Although it was fenced to exclude cattle, extensive weed invasion has taken place. *G. alba* has not been heard at this site since 1988. The protection of remnant upland and riparian vegetation may be necessary to act as a buffer to changes and to preserve the ecological integrity of riparian habitat. A minimum of 20m either side of the existing riparian vegetation is thus recommended to be included within the fenced area. These areas should be revegetated where they have already been cleared for pasture.

Fencing of riparian habitat will be carried out at all *G. alba* 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) has been made for additional sites on private land where *G. alba* is likely to occur.

Budget allocation: Consultant Scientist (4 weeks/year 1992-94, $2800, 2 weeks/year 1995-96, $1400, 1 week 1997-2001, $700) travel costs $600 1992-96.
Information Officer (4 weeks/year).
Fence construction $32 400 1992-96.
Duration: Five years.

Habitat rehabilitation: Rehabilitation will be necessary where *G. alba* occurs in remnant riparian vegetation surrounded by cleared pasture. Species endemic to the area will be replanted by volunteers. This will ensure local community involvement in the recovery process.

Budget Allocation: Seed collection and propagation of seedlings, $4 000 per year 1992-2001.
Duration: 10 years.

Other threats: 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 (Tyler 1979).

In addition, altering surface or sub-surface water flow may lead to desiccation or flooding of habitat. The construction of dams and roads can impede the flow of surface water and may represent a major threat to a population. Only 6 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). The construction of all roads and bridges will need to be carefully designed and installed to

ensure that hydrological patterns are not disrupted. The habitat of *G. alba* 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 would occur concurrently with fencing.

Fire should also be excluded from *G. alba* sites on private land. Whilst all landowners surveyed indicated they would not burn gully vegetation during the frogs 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.

Budget allocation: Road/bridge construction and repair across creeklines $2 000 per year.
Duration: Five years.

2.2.2.5 Public information and land-owner participation

Populations *of G. alba* are unlikely to survive on private land without the active support by landowners for the recommendations 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, 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.

An initial source of information, "The Frog Recovery Kit", will be used to disseminate information about *G. alba* and the recovery plan. A cassette containing recordings of *G. alba* and other species of frogs of the area will also be included. This will encourage increased community awareness of frogs generally, and enhance the likelihood of further populations of *G. alba* 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 *G. alba* and its habitat may also be beneficial to the long-term livelihoods of landowners.

There is an overall need to instil an attitude that the conservation of this species is the responsibility of both 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 recognize 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 ensuring 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.

Budget allocation: Production of "Frog Recovery Kit", $2000 Information Officer (2 weeks 1992-94, 1 week 1995-2001): Travel $700 1992-94, $300 1995-2001 .
Duration: Ongoing.

2.2.2.6 Population monitoring

Monitoring will be carried out to detect any effect of human-related disturbances on private land, to determine the significance of the management practises advocated, and to determine the success of translocations. 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 *G. alba* 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.

Sites on both private and public land should be monitored to determine whether there is a continuing impact of disturbance on populations of *G. alba* on private land. This 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 a more widespread factor such as changes in climatic regime, altered salinity or ground water levels. Monitoring of *G. alba* populations has to date examined only sites in State forest.

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 for *Philoria frosti* that survival prior to metamorphic climax appeared to be most strongly affected by desiccation of oviposition sites (Malone 1985).

Likely future threats from climate changes also support the need to maintain a long-term monitoring programme for populations of *G. alba*. Changes to populations of this species resulting from global threats may also be used to infer the impact on other frog species.

Budget Allocation: Consultant Scientist (4 weeks 1992 $2800, 3 weeks 1993-2001 $2100); travel 1992 $1700, 1993-2001 $1000.
Duration: Ongoing.

2.2.2.7 Genetic studies

Genetic studies to determine whether separate sites support discrete populations will also determine whether this species has poor dispersal ability between microcatchments. Populations of *G. alba* may have now become completely isolated by the removal of riparian habitat on private land. Maintaining levels of genetic diversity within populations may also be critical to population viability. This work will also be critical in planning translocation programmes for this species.

Budget Allocation: Consultant Scientist (two weeks 1992) $1400 Travel $300, DNA fingerprinting $2000.
Duration: one year.

2.2.2.8 Translocations

Not all land-owners are likely to agree to permanently fence off part of their property to protect *G. alba* sites. Where management practices threaten populations, translocation of individuals to another protected riparian site should be attempted. The success of this translocation can be determined, if *G. alba* does not already occur at the new site. Sites where *G. alba* has recently become extinct may become suitable again after being fenced-off and rehabilitated. Thus fencing and rehabilitation should include the five sites on private property where populations have recently become extinct. These sites represent areas of known suitable habitat in the recent past.

Three options for translocation should be considered; translocate egg masses in the field; translocate egg masses to the laboratory and raise to adult stage for release; or translocate adult individuals to new sites from existing populations. The small size of populations of *G. alba* may preclude the third option. The success of translocating egg masses in the field may depend upon the natural levels of pre- and post-hatching mortality suffered 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 and reach maturity 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, whether eggs can be obtained direct from the field will depend on how readily egg masses can be found and the

likely detrimental impact this may have on the existing population. Raising egg masses under laboratory conditions will require some knowledge of the diet of the frogs.

Captive breeding represents a fourth option for translocation but is not considered further because of its cost and the low chances of success. 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, despite numerous attempts, there has not been a single documented successful re-establishment of an endangered or threatened amphibian species from captivity into the field anywhere in the world (Dodd and Siegal 1991).

Budget allocation: Consultant Scientist (three weeks/year) $2100, travel $700, cassette recorder $200.
Duration: Five years.

2.2.4 Implementation schedule (*G. alba*)

Task#	Task Description	Priority	Feasibility	Respon sibility	Estimated ESP Cost ($000's)										
					1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Total
1	Survey of habitat	1	100%	CALM/ESP	1.7	1.7	-	-	-	-	-	-	-		3.4
2	Land Tenure	1	70%	CALM	-	-	-	-	-	-	-	-	-	-	-
3	Fire Management and Research	2	100%	ESP/CALM	2.0	2.0	1.4	-	-	-	-	-	-	-	5.4
4	Riparian Habitat Protection														
4.1	Fencing-off habitat	1	80%	ESP/CALM	35.8	35.8	35.8	23.3	23.3	-	-	-	-	-	154
4.2	Habitat rehabilitation	2	90%	ESP/CALM	4	4	4	4	4	4	4	4	4	4	40
4.3	Other threats	2	90%	ESP/CALM	2	2	2	2	2	-	-	-	-	-	10
5	Landowner participation	1	80%	ESP/CALM	2.7	0.7	0.7	0.3	0.3	0.3	0.3	0.3	0.3	0.3	6.2
6	Population monitoring	1	100%	ESP/CALM	4.5	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	32.4
7	Genetic studies	1	100%	ESP/CALM	3.7	-	-	-	-	-	-	-	-	-	3.7
8	Experimental translocation	1	50%	ESP/CALM	-	-	3.0	3.0	3.0	3.0	3.0	-	-	-	15.0
	Total				56.4	49.7	50	35.7	35.7	10.4	10.4	7.4	7.4	7.4	270.1

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

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APPENDIX 1. Site information.

SITE	LOCN. (LAT.LONG)	LAND TENURE	PRESENCE/ ABSENCE	POP. SIZE	SIZE ASH	PERIMETER ASH	CATTLE	UPLAND VEG.	CONSERVATION VALUE	MONITORING METHOD	OTHER INFORMATION
GV 1	(Spearwood Ck)	State Forest	Pres: 83, 85-91 Abs:_	>100	97.4	-	No	Yes	1	Line Transect (Riparian)	Burn Sept 1988
GV 2		State Forest	Pres: 83, 85-91 Abs:_	>30		-	No	Yes	1	Line Transect (Upland)	
GV 3	(Hutt Pool)	State Forest (Adelaide)	Pres: 83, 85-91 Abs:_	2		-	No	Yes	2	Point Transect	Adjacent to picnic site
GV 4	(Wendy Rd)	State Forest (Adelaide)	Pres: 90, 91 Abs:_	>50	50.0	-	No	Yes	1	Line Transect (Upland)	
GA 1a	(Davis Rd)	State Forest (Witchcliffe)	Pres: 83, 88-91 Abs:_	1		-	No	Yes		Line Transect (Upland)	Burn March 1991
GA 1b	(Davis Rd)	Private (2802)	Pres: 91 Abs:_	5	2.1	705	Yes	No		Point Transect	
GA 2	(Brooks Rd)	State Forest (Witchcliffe)	Pres: 83 Abs: 85, 90, 91	0		-	No	Yes		-	Extinct? Unsurvey ASH
GA 3	(Brooks Rd)	State Forest (Witchcliffe)	Pres: 83, 85, 91 Abs: 90	3		-	No	Yes		Point Transect	Unsurveyed ASH
GA 4a	(Brooks Rd)	Private (2780)	Pres: 91 Abs:_	2	7.8	2866	No	Yes		Point Transect	Unsurveyed ASH
GA 4b	(Brooks Rd)	Private (2779)	Pres: 85, 88, 91 Abs: 90	1	4.7	1433	Yes	No		Line Transect (Upland)	Heard 150m from Brooks Rd
GA 5		Private (2760)	Pres: 88 Abs: 91	0	2.9	1091	Yes	No			Extinction?
GA 6		Private (83)	Pres: 91 Abs:_	2	29.1	5633	No	Yes		Point Transect	Unsurveyed ASH
GA 7		State Forest (Forest Grove)	Pres: 91 Abs:_	3			No	Yes		Line Transect (Upland)	

SITE	LOCN. (LAT.LONG)	LAND TENURE	PRESENCE/ ABSENCE	POP. SIZE	SIZE ASH	PERIMETER ASH	CATTLE	UPLAND VEG.	CONSERVATION VALUE	MONITORING METHOD	OTHER INFORMATION
GA 8		State Forest (Forest Grove)	Pres: 91 Abs:_	6-10			No	Yes		Point Transect	
GA 9		Private (83)	Pres: 89, 91 Abs:_	2	5.2	1637	No	Yes		Point Transect	
GA 10		Private (83)	Pres: 83, 85 Abs: 88, 91	0	7.0	1790	No	No		-	Extinction?
GA 11		Private (83)	Pres: 83, 85, 91 Abs:_	4	58.9	5182	No	Partial		Point Transect	Unsurveyed ASH
GA 12		Private (4588)	Pres: 89, 91 Abs:_	>30	10.6	1909	Yes	Partial		Line Transect (Riparian)	Dam at head-water (1990)
GA 13		Private (4588)	Pres: 91 Abs:_	10-20	6.9	1595	Yes	Partial		Line Transect (Upland)	
GA 14		Private (4590)	Pres: 91 Abs:_	4		4446	No	Yes			Proposed Nature Res.
GA 15		Private (2718)	Pres: 91 Abs:_	10-20	10.3	2050	Yes	No		Line Transect (Upland)	
GA 16		Private (2718)	Pres: 91 Abs:_	2	2.2	608	Yes	No		Line Transect (Upland)	
GA 17		Private (2718)	Pres: 91 Abs:_	3			Yes	No		Point Transect	
GA 18		Private (4109)	Pres: 91 Abs:_	6-10		Yes	No			Line Transect (Upland)	
GA 19	(McLeod Rd)	Private	Pres: 89 Abs: 91	0	1.2	565	Yes (Sheep)	No		-	Extinction?
GA 20		Private (3413)	Pres: 91 Abs:_	2	1.8	603	No	Yes		Point Transect	Burn 1990
GA 21	(Brockman)	Private (2946)	Pres: 83 Abs: 85, 88, 91	0	3.6	1234	Yes	No		-	Extinction?

SITE	LOCN. (LAT.LONG)	LAND TENURE	PRESENCE/ ABSENCE	POP. SIZE	SIZE ASH	PERIMETER ASH	CATTLE	UPLAND VEG.	CONSERVATION VALUE	MONITORING METHOD	OTHER INFORMATION
GA 22	(S of Wall Rd)	Private (3926)	Pres: 83 Abs: 85, 88, 91	0	1.5	705	Yes	No		-	Extinction?
GA 23a	(Vlam Rd)	Private (4471)	Pres: 83, 85 Abs: 91	0	22.1	5159	Yes	No		-	Extinction?
GA 23b	(Opp Vlam Rd)	Private (1965)	Pres: 91 Abs:_	5	1.7	608	Yes	No		Point Transect	Unsurveyed ASH

APPENDIX 2. Monitoring methods.

Monitoring will initially aim to establish inherent population fluctuations as a result of yearly variation in habitat variables such as soil moisture. This will then provide the basis from which to infer a decline in population size following disturbance. Monitoring of populations is undertaken by counting the number of calling males. 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 observers presence. Indeed the reduced numbers of calling males in quadrats for *G. alba* since 1983 may already indicate that such an effect has occurred.

Three 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.

The following monitoring methods are proposed for each site:

1. Determine the number of calling males five meters either side of a line transect that passes through the riparian vegetation. This is unlikely to cause localised disturbance as severe as monitoring by quadrats particularly at sites of greatest calling density where quadrats were generally located. In addition transects will provide a more complete assessment of the entire population, particularly if calling individuals are recorded at set intervals along the transect. A standard transect length should be chosen.

2. Record the total number of calling individuals along a transect but which is positioned adjacent and lies parallel to the riparian zone. This is only possible where the width of the riparian zone is narrow and individuals can be differentiated from one another at a short distance from the observer.

3. A point transect is most suited to sites where either the total number of calling males is small (<5) or 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) designating categories may be more useful (i.e. 6-10, 10-20).

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

Surveys should take place twice a year, in mid-September and mid-October; and occur over a single night. Some knowledge of the factors, such as temperature and rainfall, influencing variability in calling will initially need to be established, by monitoring at hourly intervals throughout a single night and over successive nights.