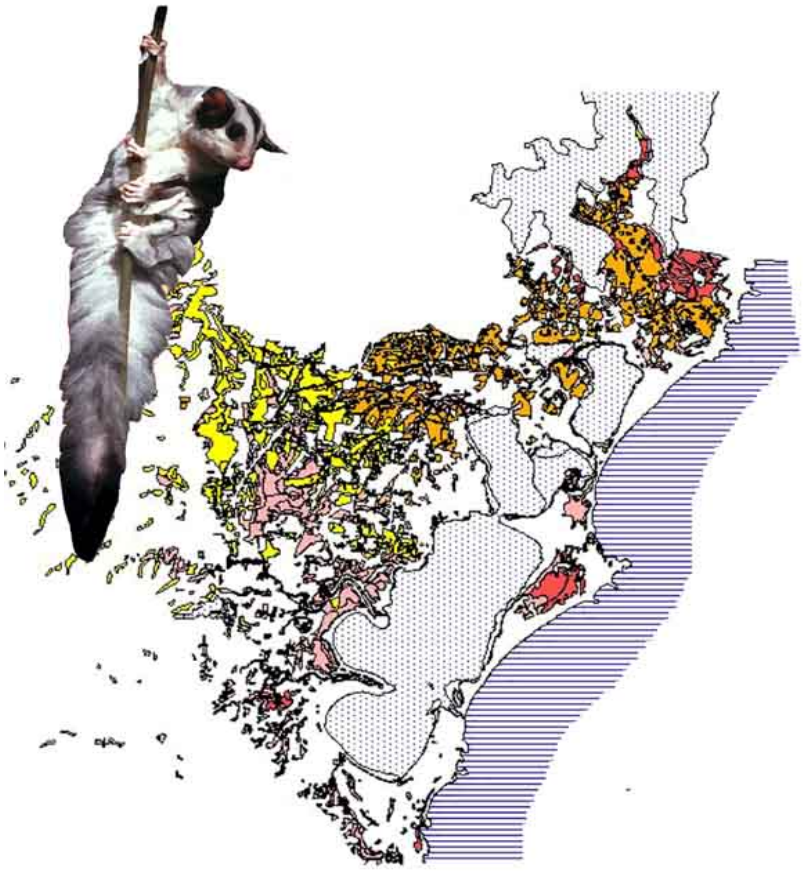
Squirrel Glider (*Petaurus norfolcensis*)
Conservation Management Plan: Wyong Shire



Prepared by Andrew Smith for

Wyong Shire Council

November 2002

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This report may be cited as:
Smith A. P., (2002) Squirrel Glider (*Petaurus norfolcensis*) Conservation Management Plan: Wyong Shire. Wyong Shire Council, Wyong.

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ACKNOWLEDGMENTS

This plan was prepared by Dr. Andrew Smith of Austeco Environmental Consultants. Scott Duncan, Strategic Land Use Planner for Wyong Shire Council was the liaison officer and project manager for Wyong Council. The plan was reviewed by Scott Duncan, Garron Staines and David Tierney. This plan incorporates unpublished data provided by Michael Murray, Rodney van der Ree and Andrew Smith.

Front cover: Squirrel Glider and map of preferred Squirrel Glider vegetation types in Wyong Shire (pink=swamp forest, red= dry sclerophyll, yellow= spotted gum, orange = Angophora-Scribbly Gum woodland) © Andrew Smith.

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INTRODUCTION

Objectives

The purpose of the Squirrel Glider (*Petaurus norfolcensis*) Conservation Management Plan in Wyong Shire is to:

1. Improve knowledge and awareness of the distribution and habitat requirements of the Squirrel Glider in Wyong Shire;

2. Identify threats to Squirrel Gliders in Wyong Shire;

3. Clarify the conservation status of the squirrel Glider in Wyong Shire;

4. Identify recovery actions and conservation targets for sustaining a viable population of Squirrel Gliders in Wyong Shire.

The Study Area

Wyong Shire is located on the Central Coast of NSW between Sydney and Newcastle. It is bounded to the south by the City of Gosford local government area, to the north-west by Cessnock Shire and to the north east by the City of Lake Macquarie. Wyong Shire is 75000 hectares in area of which about 66% is vegetated. Geographically the Shire can be divided into three zones, a plateau to the west, mountains and valleys in the central west and a coastal plain to the east.

The plateau, mountains and valleys are dominated by Hawkesbury dry sclerophyll forests, wet forests and rainforests. With the exception of the river valleys and plateaus most of this habitat falls within state forests where it receives limited protection from clearing and loss of biodiversity. The coastal plains are dominated by spotted gum-ironbark forests, scribbly gum-Angophora woodlands and swamp forests that are the preferred habitat of the Squirrel Glider. These habitats fall primarily within freehold lands under pressure for urban and residential development.

Development & Threatened Species

Wyong Shire is one of Australia's most rapidly urbanizing coastal areas. At the last census it recorded the second highest rate of population growth of all local government areas in New South Wales. Wyong Shire aims to allow growth on

the coastal plain while at the same time sustaining viable populations of threatened species.

A total of 63 endangered and vulnerable species listed under schedules 1 & 2 of the NSW Threatened Species Conservation Act 1995 have been recorded in Wyong Shire including 8 frog species, 5 reptile species, 35 bird species and 15 mammal species. Most of these species are uncommon in the Shire and reach their greatest concentrations in other regions. However, two species, the Squirrel Glider and the Green-thighed Frog (*Litoria brevipalmata*), are more abundant in Wyong Shire than elsewhere in NSW. The largest known population of the Squirrel Glider occurs in Wyong Shire. This population is considered to be of State and National significance because of its large size (about 5000 individuals).

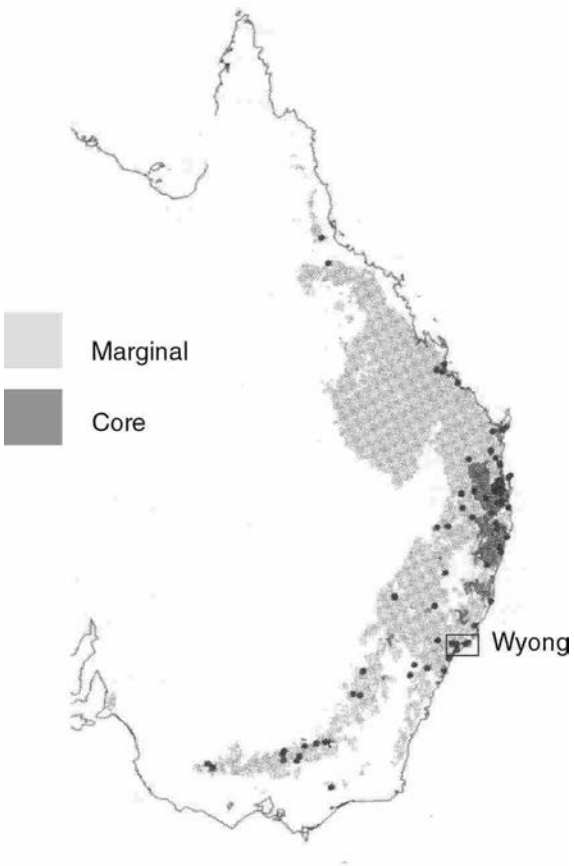

Figure 1. Distribution of the Squirrel Glider.

THE SQUIRREL GLIDER

Description

Scientific Name: *Petaurus norfolcensis*
Family: Petauridae
Common Name: Squirrel Glider

Taxonomy: The species was first described but not named by an anonymous author in early accounts of the new colony (Phillip 1789). It was named the Norfolk Island Flying Squirrel (*Sciurus norfolcensis*) by Kerr in 1792 based on an incorrect assumption that the first specimen came from Norfolk Island, possibly because it was obtained from a crew member of the vessel *Supply* after its return from the island. It was initially assigned to the genus *Sciurus* of the squirrel family because of its superficial resemblance to flying squirrels of the northern hemisphere. Later it was assigned to the marsupial genus *Petaurus* which includes three other Australian gliding possums, the Yellow-bellied Glider (*P. australis*), Mahogany Glider (*P. gracilis*) and Sugar Glider (*P. breviceps*).

Distinguishing Features: The squirrel glider is a medium sized (170-300 grams or 170-240 cm head body length) gliding marsupial with long, light grey fur and a pronounced black dorsal stripe extending from between the eyes to the base of the tail. The belly fur is white and the tail is grey and fluffy at the base tapering to black tip. The patagium (gliding membrane) extends from wrist to ankle and is apparent as a wavy white line edged with black when folded against the body. It is similar in appearance to the more common Sugar Glider and can only be reliably distinguished in the field by experienced naturalists. The Squirrel Glider is larger, has a more pointed muzzle and relatively longer fur at the base of the tail.

Life History

Reproduction: Females give birth to one or two tiny young in autumn/winter and again in spring/summer if conditions are favourable. The pouch has four teats but no more than 2 young are weaned. Reported Annual birth rates average 1.9 young per adult female at Euroa in Victoria and 2.3 at Lime Burners Creek Nature Reserve in NSW. Young leave the pouch after about 70 days and remain in the nest for a further 30 days before venturing forth with the mother. Young are weaned at about 120 days and disperse at a mean age of 12 months. Females may reproduce in their second year and are thought to live to an age of 5-6 years. Under ideal conditions Squirrel Glider populations have the capacity to double approximately every one and a half years.

Social Organization: Squirrel Gliders live in social groups of 2-19 individuals that occupy leaf lined nests in tree hollows. Groups typically include single pairs, one male with two females and their offspring or multiple pairs and their offspring. Group living provides thermoregulatory benefits (huddling) in cold climates and may assist in group defence against predators such as owls. Males are larger than females and occupy larger home ranges. Social groups often include more females than males and the mating system is thought to be polygynous with dominant males having access to more than one adult female and surplus males living in bachelor groups.

Activity: The Squirrel Glider is nocturnal, generally emerging at dusk from trees hollows and gliding quickly to preferred feeding sites such as sap feeding scars. It moves by bounding along branches and gliding from stems and outer branches to the base of nearby trees. Gliders descend at a minimum angle of 31 degrees over distances of up to 50m depending on launch height. To glide 40m gliders must launch from a height of 20m. Squirrel Gliders are rarely observed on the ground but will come to the ground to cross short distances between trees in open woodland. Squirrel Gliders are usually quiet but may emit a gurgling call when handled or involved in territorial disputes and a yapping alarm call similar (but deeper) to that of the Sugar Glider when disturbed by potential predators.

Home Range: Home range size varies with habitat quality from about 1.5 – 10 hectares. Home ranges have been reported to be 2.5 - 4 hectares at Lime Burners Creek Nature Reserve near Port Macquarie and 6.3 hectares at Lake Macquarie adjacent to Wyong Shire. Home ranges are smaller in linear (roadside) habitats and high site quality habitats at Euroa in northern Victoria. Dispersing individuals and males seeking mating opportunities may have larger home ranges. Nightly ranges vary from 300-500m. The longest reported distance travelled by a glider in one night is 1605m at Euroa.

Density: Squirrel Glider density varies with habitat quality from approximately 0.1 – 1.9 animals per hectare. Low average densities (0.4) have been reported at Bungawalbin in NSW and low site quality box–ironbark forests at Chiltern in northern Victoria. Higher average densities (0.9 -1.5) have been reported at Limeburners Creek and high site quality agricultural remnants at Euroa in northern Victoria. In Wyong Shire Squirrel Glider density varies from zero to 1.9 animals per hectare (average 0.46) depending on habitat quality.

Ecology

Distribution The Squirrel Glider is distributed from central northern Victoria to the base of Cape York (see Figure 1). In Victoria it is confined to dry forests and woodlands below 250 m altitude inland from the Great Divide. In NSW it occurs on western slopes of the Great Dividing Range and on the foot slopes and coastal plains of the east coast north of Sydney. Prior to the early 1980's the Squirrel Glider was not known from the north coast of NSW. The first edition of the complete book of Australian Mammals (1984) shows this species to be absent from the east coast of Australia. This error can be attributed to early confusion between Squirrel Gliders as Sugar Gliders. Following the confirmed identification of Squirrel Gliders at Limeburners Creek near Port Macquarie on the NSW north coast in the early 1980's there was a steady increase in reported sightings on the north coast from Sydney to Brisbane. Coastal habitats are now considered the stronghold of the Squirrel Glider in NSW.

Squirrel Glider location records in the NSW National Parks and Wildlife Service Wildlife Atlas since 1980 show the greatest concentration of records to be in the Wyong Lake Macquarie region. The locations of Squirrel Glider records in Wyong Shire have been statistically correlated with a wide range of mapped environmental parameters including climate, topography, soils and vegetation to develop a predictive model of Squirrel Glider distribution in Wyong Shire. This model (Figure 2) identifies areas of high medium and low suitability for Squirrel Gliders. Areas of high and medium suitability occur in warmer climates of the coastal plains and are dominated by winter flowering vegetation communities including spotted gum-ironbark forest, swamp mahogany forests, and various coastal dry sclerophyll forests and scribbly gum-Angophora woodlands with Banksia understoreys. The total area of predicted high quality habitat in Wyong Shire is 6,926 hectares and the area of medium quality habitat is 4,351 hectares.

Diet The Squirrel Glider feeds on sugary exudates (nectar, saps, honeydews and gums) to obtain energy and insects and pollen to obtain protein. Squirrel Gliders also obtain energy by scarring the bark of certain eucalypts (*Angophora woodsiana, Eucalyptus gummifera, Eucalyptus intermedia*) and feeding on the sugary sap that flows from the wound, by licking the sugar coating on leaves and buds referred to as "honeydew" that seeps from wounds made by sap sucking insects, and by harvesting the gums secreted by certain Wattle trees (*Acacia spp*.) in wounds made by insects or gliders.

Winter is a time of critical food shortage because insects and exudates are scarce and energy requirements are high, particularly in cold climates. Squirrel Gliders are most often found where there is a reliable supply of winter nectar and pollen. The most important winter flowering plants include Spotted Gum (*Eucalyptus maculata*), Red Gums (*E. tereticornis*) various ironbarks (*E. sideroxylon, E. siderophloia, E. paniculata*) Swamp Mahogany (*E. robusta*) and a number of Banksias (*B. integrifolia, B. spinulosa, and B. aemula*). Acacias that

produce or retain gum nodules over winter such as *Acacia mearnsii, and Acacia paramattensis*) may provide an alternative to nectar and pollen in some areas. Gliders also feed on nectar, pollen and gums during summer so the best habitats are those with a high diversity of Eucalypts, Banksias and Acacias that provide a reliable supply of exudates and pollen year round.

Squirrel Gliders are known to chew holes in the bark of certain eucalypts, particularly Bloodwoods (*Eucalyptus gummifera*), and feed on the exuding phloem sap. This habitat may be particularly important in seasons and years when eucalypts fail to flower. Bloodwoods are widespread and abundant throughout the Wyong coastal plains and many individual trees have visible feed incisions on outer branches consistent with Squirrel Glider sap feeding.

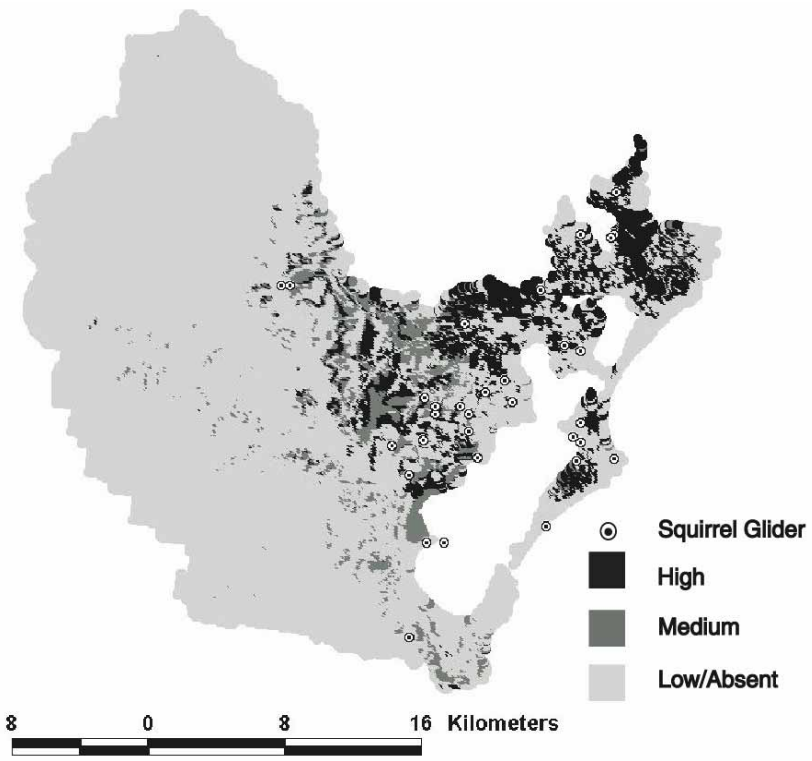

Figure 2. Modelled distribution of the Squirrel Glider in Wyong Shire**.**

Table 1. Important known food plants of the Squirrel Glider in Wyong Shire

Food Plants		**Food Item/Season of Importance**
Eucalyptus	*siderophloia*	nectar winter
	tereticornis	nectar winter
	pilularis	nectar winter
	robusta	nectar winter
	maculata	nectar winter
	gummifera	sap, nectar summer
Melaleuca	*quinquenervia*	nectar autumn, insect bark feed
Acacia	*irrorata*	gum
	longifolia	gum
Banksia	*integrifolia*	nectar and pollen winter
	oblongifolia	nectar and pollen summer
	serrata	nectar and pollen summer autumn
	spinulosa	nectar and pollen winter
Xanthorrhoea	*spp.*	nectar, gum

Habitat Throughout it's range the Squirrel Glider is found in dry forest and woodland associations dominated by winter flowering eucalypts or with and understorey of winter flowering Banksias or gum producing Acacias. These habitats may be broadly classified into the following types:

Type 1 Box-ironbark forests of the inland or western slopes of the Great Dividing Range;

Type 2 Gum-ironbark forests of the inland rivers, western slopes and the coastal foothills and plains;

Type 3 Eucalyptus-Banksia forests and woodlands of the coastal plains and tablelands;

Type 4 Swamp forests of the coastal plains dominated by winter flowering Swamp Mahogany and *Melaleuca* spp.

Type 5 Eucalypt-Acacia forests and woodlands with an understorey of winter gum producing *Acacia spp*.

The last four of these habitat types occur in Wyong Shire. Estimated average glider densities in examples of these habitat types in Wyong Shire are shown below.

Table 2 Density of the Squirrel Glider in different overstorey vegetation types.

Type	**Vegetation Association**	**Squirrel Glider Density** (no/ha.)
2	Spotted Gum-Ironbark	0.45
3	Scribbly Gum-Angophora-Banksia Woodland	0.37
4	Swamp Mahogany	0.38
5	Sydney Peppermint-*Acacia irrorata* Dry Forest	0.30

The abundance of Squirrel Gliders in dry forest and woodlands in the Wyong coastal plains varies with understorey vegetation type. Squirrel Gliders are most abundant in forests with an understorey of winter flowering Banksias (*B. spinulosa*) or gum producing acacias (eg *A. irrorata*). Average Squirrel Glider density in forests and woodlands of the Wyong coastal plains with different understorey types is shown below.

Table 3 Density of the Squirrel Glider in different understorey vegetation types.

Understorey Association	**Squirrel Glider Density** (no/ha.)
Banksia spinulosa (winter flowering) > 5% cover	0.71
Acacia irrorata	0.48
Melaleuca spp	0.33
Banksia oblongifolia	0.25
Xanthorrhoea spp	0.25
Allocasuarina spp	0.13
Other *Acacia* spp	0.06

Den Trees: Squirrel gliders nest in tree hollows or “dens”. Trees with hollows suitable for gliders are often referred to as habitat trees or den trees. Den trees are typically large (> 60 cm diameter at 1.3 m above ground) and old (>200 years) with hollowed out branches and stems caused by decay and termite activity. Hollows may occur in smaller trees when they are dead or have been damaged by fires or windstorms. At Euroa in Victoria the mean diameter of den trees used by Squirrel Gliders was 88 cm (range 24-156cm). Den trees may be living or dead. Living trees have greater long term value for conservation as they persist longer in the environment and are less likely to fall after control burning or wildfire.

Squirrel Glider colonies and individual gliders may change nest sites frequently within their home range. At Euroa individual gliders used an average of 5 different trees with hollows over a 100 day period and stayed in the same tree for an average period of only 5 days. A small number of den trees within the home range were used more frequently than others. Gliders may move nest trees to exploit different patches of food, assist with territorial defence and reduce parasite burdens in their nests.

The presence of den sites is essential for the persistence of Squirrel Gliders in isolated remnants. Areas of habitat that lack den sites may be used as feeding areas by Squirrel Gliders if accessible den sites are available nearby. Squirrel Gliders have been reported to travel up to 800m from den sites to feeding areas where den trees are scarce. In Wyong Shire Squirrel Gliders have been captured foraging up to 200m from the nearest den tree.

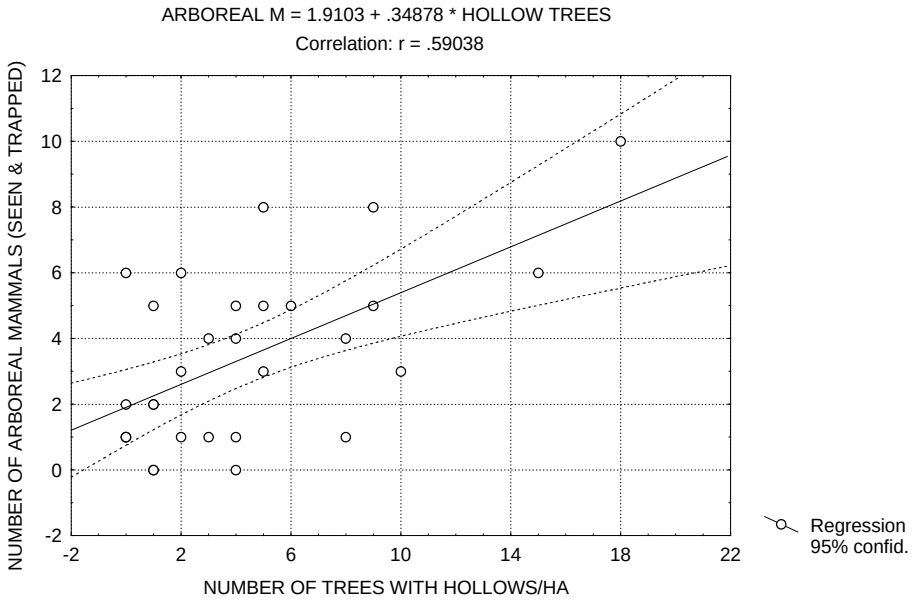

Figure 3 Relationship between the number of possums and gliders (arboreal mammals) detected by spotlighting and trapping and the number of trees with hollows in survey plots on the Wyong coastal plain.

Squirrel Gliders will use hollows with a range of entrance diameters (4 -15 cm) but prefer those with small entrance diameters that exclude other larger animals that may compete for hollows such as ringtail possums (*Pseudocheirus peregrinus*) and Common Brushtail Possums (*Trichosurus vulpecula*). There is a strong correlation between the numbers of all possums and gliders in forests and woodlands of the Wyong coastal plain and the number of den trees (Figure 3). Possum and glider abundance is highest in forests with 18 or more habitat trees per hectare. High densities of den trees such as this are generally only found in oldgrowth forests that have not been heavily disturbed by previously clearing or logging. Regrowth forest and forests that have been logged, ringbarked or cut over for firewood often have only one or two den trees per hectare.

Population Structure A snapshot of the age structure of the Squirrel Glider population in the Wyong coastal plains in spring 1999 is shown in Figure 4. This structure is indicative of a healthy reproducing population. The relative shortage of animals less than 1 year old indicates that most females give birth only once each year in late winter or early spring, similar to the pattern further north at Port Macquarie where most births occur in July/August with a minor secondary birth season in summer during favourable years.

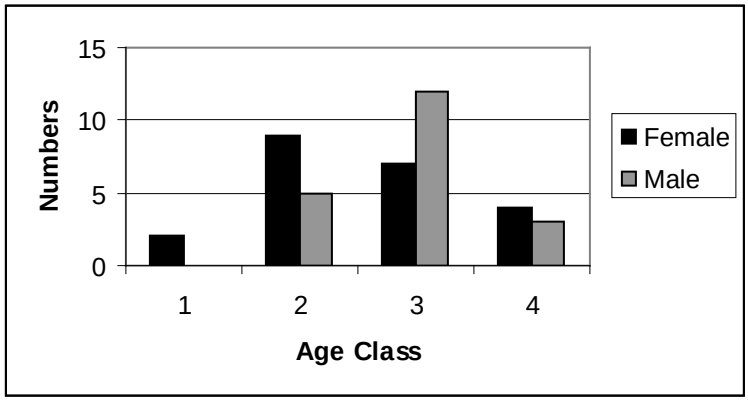

Figure 4 Age structure of the Squirrel Glider population in the Wyong coastal plains (1= < 1 year; 2= 1-2 years, 3= 2-3 years, 4 = > 3 years).

THREATS TO THE SQUIRREL GLIDER

Rarity

Squirrel Gliders are widespread in dry sclerophyll forests and woodlands from central Victoria to the base of Cape York but are rare or uncommon in most parts of their range. Rarity can be attributed to a shortage of habitats with a reliable, year round supply of nectar, saps or gums. The National Parks and Wildlife Service Atlas of NSW Wildlife listed approximately only 30 known localities for this species in the whole of NSW in 1992. By 1998 two major concentrations of records had become apparent one in the region from Wyong to Lake Macquarie on the central NSW coast another in north-east NSW and south-east Queensland extending from around Grafton to Brisbane.

Predation

Squirrel Gliders are preyed on by owls, and goannas (*Varanus varius*) and to a lessor extent by cats and foxes. Owl predators include the Powerful Owl (*Ninox strenua*), Barking Owl (*Ninox connivens*), Masked Owl (*Tyto novaehollandiae*) and Boobook (*Ninox novaeseelandiae*), all of which occur in Wyong Shire. Squirrel Gliders may be taken by foxes and cats when moving or foraging close to the ground. Cat predation is likely to be a problem in remnants close to residential areas where Gliders come to the ground to feed on understorey shrubs such as *Banksia* and *Xanthorrhoea*. In Victoria owls have been reported to account for 80% of observed Squirrel Glider mortality in agricultural remnants and a single pair of Powerful Owls has been reported to take at least 40 Squirrel Gliders and 18 Sugar Gliders within its home range over a two and a half year period.

Predation is likely to cause periodic local extinction of colonies and populations in small patches. Under natural circumstances these patches will be rapidly re-colonized by Squirrel Gliders dispersing from nearby areas. However, where predation occurs in small isolated fragments recolonization may not be possible or may occur very infrequently. Consequently predation is likely to be the major cause of glider extinction in small isolated or partially isolated remnants of 30 hectares of less in size.

Competition

The ecology of the Squirrel Glider is very similar to that of the Sugar Glider. Sugar Gliders are more widely distributed in Australia and occupy a broader range of forest and woodland habitats. Their diet is more varied and they are considered more adaptable to disturbed and fragmented landscapes. It is likely that these species compete for food resources where they co-exist. Sugar

Gliders are more abundant in the wet mountain forests of west Wyong Shire and Squirrel Gliders are more abundant in the coastal plains. Where both species co-exist Squirrel Gliders occupy the taller, better quality habitat with a more reliable winter nectar supply. Squirrel Gliders dominate Sugar Gliders in social interactions because of their larger size and are likely to exclude Sugar Gliders from key food sources such as sap and gum feeding sites. Studies using artificial nest boxes have shown that Squirrel Gliders exclude Sugar Gliders from hollows with entrances large enough for both species to enter, and that Sugar Glider numbers only increase when hollows with entrances too small for the Squirrel Glider are available. In Wyong Shire there is a significant negative correlation between Sugar Gliders and Squirrel Gliders. Where Squirrel Glider density is high Sugar Glider density is low and vice-versa. Sugar Gliders are uncommon in Spotted Gum forests and Angophora-Scribbly Gum woodlands with a Banksia understorey preferred by Squirrel Gliders. They are more common in the wet forests of the ranges and foothills to the west and in low site quality shrub woodlands, particularly those with a grassy rather than Banksia understorey in areas such as the Munmorah State Recreation Area.

It is possible that the relative abundance of Squirrel Gliders and Sugar Gliders in coastal Wyong Shire will change over time. Sugar Gliders can be expected to increase during and after periods of stress such as drought or wildfire, because their smaller size and more diverse diet allows them to survive better during periods of food shortage.

Wildfire

Wildfire is a potential hazard to Squirrel Glider populations in Wyong Shire. Squirrel Glider mortality and dispersal was observed to increase after fire at Limeburners Creek, an effect attributed to loss of Banksia from the understorey and to failure of some eucalypts to flower for up to two years after fire. Understorey Acacias and Banksias are particularly susceptible to fire. Both species soon regenerate after fire. However, the density of flower heads in Banksia increases with plant size and age and peak habitat suitability does not occur until the understorey has been left unburnt for 10 or more years. Large old Banksias provide a greater abundance of nectar and pollen than small young shrubs and also reduce exposure to ground predators such as foxes and cats.

The best insurance against fire is dedication of large replicated reserves with a range of habitat types including those in wet areas (swamp forests) less prone to fire. The current spatial distribution of Squirrel Glider habitat in Wyong Shire occurs across a large number of fragments separated by roads and fire breaks that provide good insurance against catastrophic wildfire events. Not all fragments are likely to be burnt at any one time and fragments that are destroyed may be re-colonized by gliders from nearby unburnt fragments where habitat corridors and links are maintained.

Burning & Under-scrubbing

Removal of understorey food plants (Banksias and Acacias) by frequent (fuel reduction) burning, grazing or slashing (underscrubbing) is a potentially significant threat to Squirrel Glider habitat in Wyong Shire. Care needs to be taken to ensure that planned fires are conducted in a mozaic pattern that retains a large portion of unburnt habitat at any one time. Under-scrubbing (removal of understorey vegetation) should be precluded from areas where Squirrel Glider conservation is a priority. Surveys in the coastal plains of Wyong Shire have revealed that possums and gliders are scarce or absent from habitats burnt within the previous 12 months and reach peak abundance in sites that have not been burnt for more than 10 years (Figure 5).

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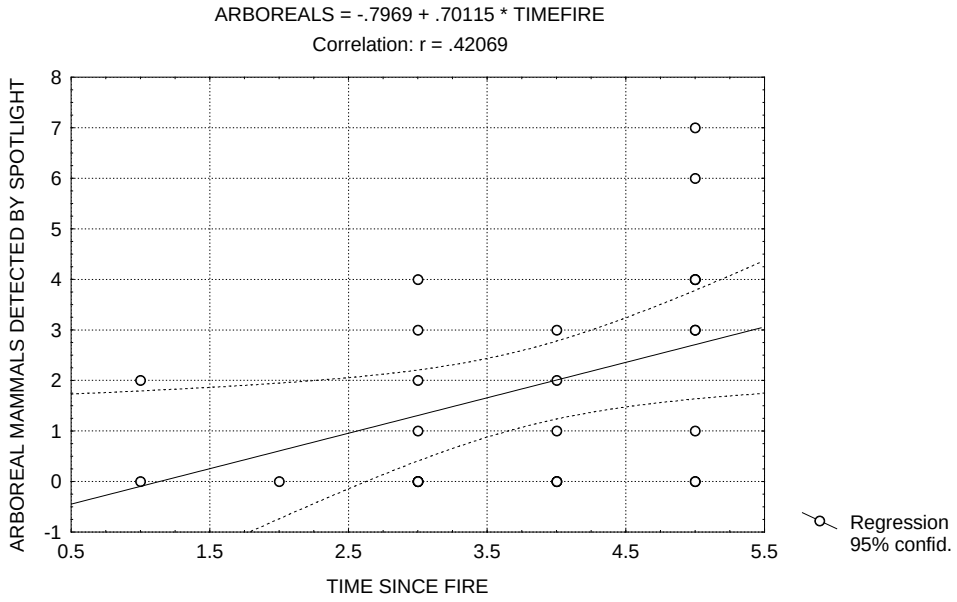


Figure 5. Relationship between number of possums and gliders counted during spotlight surveys and estimated time since last fire at survey sites on the Wyong coastal plain (1= 1 yrs, 2= 2 yrs, 3 = 3-5 yrs, 4= 6-10 yrs , 5 = > 10 yrs).

Roadkill

Squirrel Gliders are killed by vehicles when crossing roads but this is only likely to be a significant cause of population decline in small isolated habitat remnants. Gliders are at risk of roadkill when crossing road gaps that exceed maximum glide distances. Comfortable glide distance for typical woodland habitat (15m height) on the Wyong Coastal plain is likely to be about 20 m. Most minor roads with vegetation on either side can be readily crossed. The effect of vehicle impact on Squirrel Glider populations crossing wider roads will be determined by the size of the glider population either side of the road and the frequency of road crossing. A Squirrel Glider population has been found in a 28 ha. island of

vegetation surrounded on all sides by highways or expressways in coastal Wyong Shire. This remnant is, however, surrounded by extensive areas of Squirrel Glider habitat across the highway on all sides so that any animals killed are soon likely to be replaced by dispersing individuals. It would be less likely for gliders to persist in a remnant of this size surrounded by busy roads if there was no re-colonization source nearby.

Habitat Clearing & Fragmentation

Habitat clearing and fragmentation is the greatest threat to Squirrel Gliders in Wyong Shire. Squirrel Gliders have limited powers of dispersal and soon become extinct in small habitat patches isolated by clearing. Surveys of Squirrel Gliders in remnants on the Wyong coastal plain have shown that glider density and probability of occurrence in remnants increases significantly with increasing remnant size, increasing area of suitable habitat within remnants, decreasing distance to the nearest remnant, and increasing size of the nearest remnant. Glider density and occurrence in remnants is also related to the presence and size of corridor links with adjoining remnants and the width of any gaps in corridors and links.

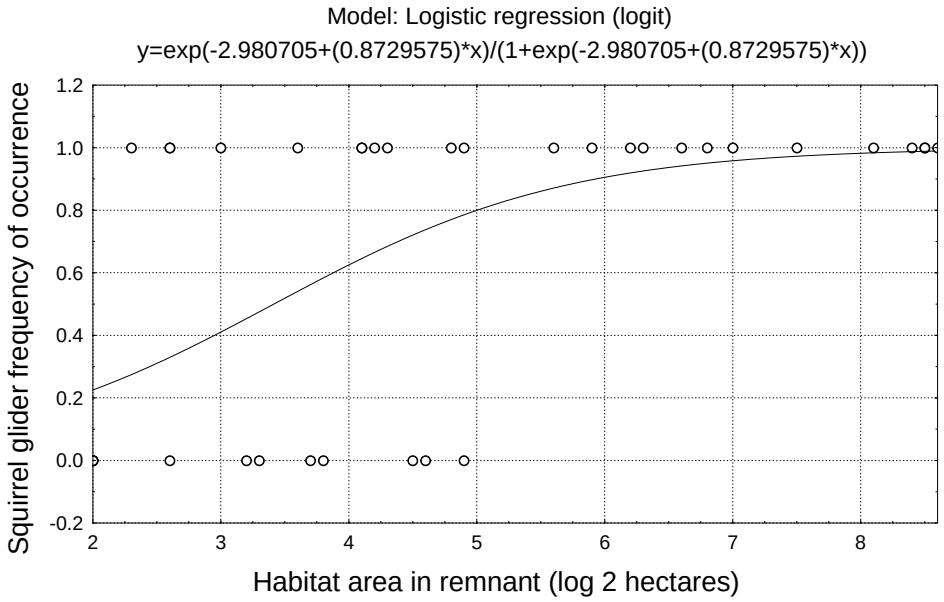


Figure 6 Frequency of occurrence of Squirrel Gliders as a function of log (base 2) of the area of suitable habitat (forest and woodland) within remnants of increasing size on the Wyong coastal plain (1= 2 ha, 2 = 4 ha, 3 = 8 ha, 4 = 16 ha., 5 = 32 ha., 6= 64 ha, 7= 128 ha., 8= 256 ha.).

Remnant Size The relationship between Squirrel Glider density and frequency of occurrence and remnant size on the coastal plains of Wyong Shire is shown in Figure 6. Glider density and frequency of occurrence is predicted to

begin to fall when remnant size is less than about 100 hectares. This model is not, however, a particularly good predictor of Squirrel Glider occurrence in remnants. Small remnants that are close to large remnants have a higher probability of sustaining Squirrel Gliders than predicted by size alone, and large remnants with only a small area of suitable habitat have a lower probability of sustaining gliders than predicted by size alone. One large remnant in the Wyong Coastal plain (74 hectares) was not found to support Squirrel Gliders because it had only small islands of forest and woodland habitat surrounded by extensive areas of unsuitable heath vegetation.

The Effects of Corridors & Gaps Patches of remnant Squirrel Glider habitat in Wyong Shire can be classified into one of the forms shown in Figure 7, referred to as "isolation classes" according to their pattern of isolation. These isolation classes can be defined as follows:
Class 1 = remnants connected to other remnants by a narrow corridor (single tree to 250 m wide);
Class 2 = remnants separated from other remnants by a cleared gap (eg road or utility line) up to 75 m wide, but with a wide area of contact including native vegetation on both sides of the gap for a distance of at least 250m;
Class 3 = as in 2 (above) but the width of vegetation on either side of the gap is narrow (less than 250 m wide);
Class 4 = remnants separated from other remnants by cleared areas of 75 – 400m in rural (pasture) environments or 75-200 m in urban environments;
Class 5 = remnants separated by more than 200m of urban habitat or 400m of cleared habitat, and class 2, 3 or 4 remnants separated by impassable barriers (eg rivers, or expressways with barrier fencing).

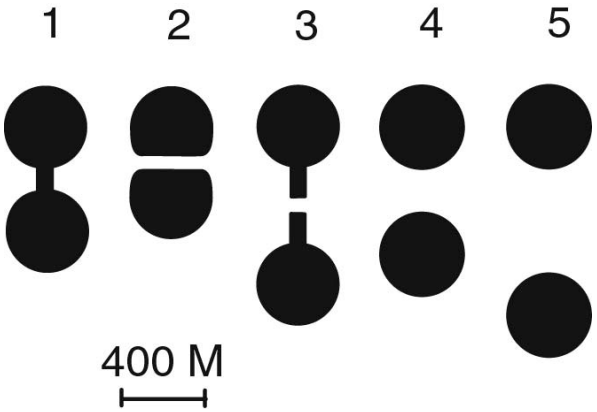


Figure 7 Remnant isolation classes

Squirrel Glider density and frequency of occurrence in remnants on the coastal plain of Wyong Shire has been found to be significantly correlated with isolation

class (Figure 8). Small remnants separated by isolation class 1 (corridor) and class 2 (narrow road) have the same glider frequency of occurrence as large continuous remnants (100%). Neither of these isolation classes can be considered barriers to Squirrel Glider movement and dispersal. Small remnants separated by class 3 isolation (gaps up to 75 m in narrow corridors) only had a 45% probability of supporting gliders. Small remnants isolated by class 4 gaps (distances of 75- 400 m across grassland or unsuitable natural habitat or 75-200m across urban development) had less than a 10% probability of supporting gliders.

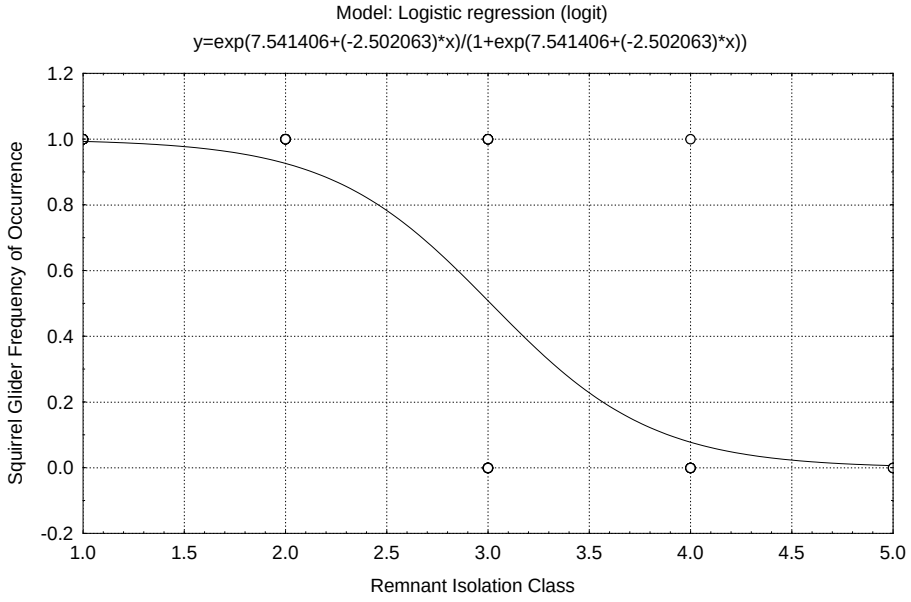


Figure 8 Frequency of occurrence of Squirrel Gliders in remnant vegetation patches with increasing levels of isolation from adjacent remnants (for isolation class see figure 7).

Distance to Nearest Remnant The relationship between Squirrel Glider frequency of occurrence in remnants and distance to the nearest remnant larger than 5ha in size is shown in figure 9. This relationship indicates that small remnants isolated by gaps wider than 32 m have less than a 50% chance of supporting Squirrel Glider populations and that small remnants isolated by gaps of more than 250m are unlikely to support gliders. This pattern is consistent with anecdotal observations that Squirrel Gliders are reluctant to come to the ground to cross gaps but will bound (walk) across clear ground for short distances (up to 50m) when necessary. In Ravensworth State Forest west of Newcastle Squirrel Gliders have been observed to regularly inhabit a den tree more than 800 metres from a forest edge by gliding between scattered paddock trees and gliding to the ground to cross a wide gap (about 70m) at one point. However, coming to the ground increases the risk of mortality from predation by cats and foxes and by roadkill.

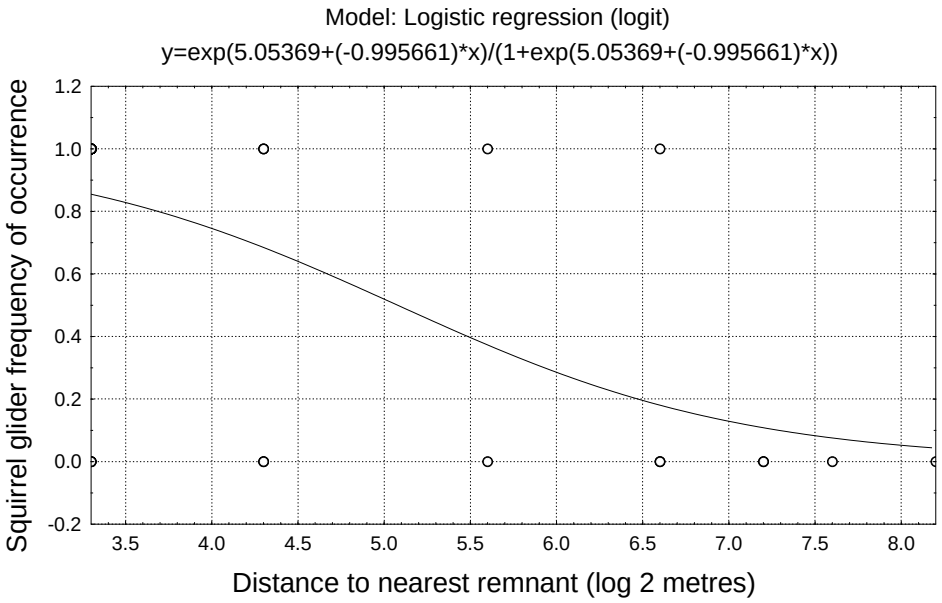


Figure 9. Frequency of occurrence of squirrel gliders in small remnant vegetation patches with increasing levels of isolation (log 2 distance in metres) from adjacent remnants more than 5 hectares in size. (4=16 m, 5= 32m, 6 =64m, 7= 128m, 8 = 256m)

Size of Adjacent Remnant Squirrel Glider frequency of occurrence on the Wyong coastal plain was also found to be related to the size of the largest adjacent patch with an isolation score of 3 or 4. Small remnants adjacent to large patches had a higher frequency of glider occurrence than those adjacent to small patches.

Effective remnant size The most useful predictor of Squirrel Glider occurrence for planning and management purposes is so called “effective remnant size”. Effective remnant size is a measure that was specifically developed to take into account the combined effects of remnant size, remnant isolation, size of adjacent remnant, and corridor and gap width on Squirrel Glider abundance on the Wyong coastal plain. Effective remnant size can be considered the “true size” of a remnant when the area of all adjoining remnants joined by corridors (class 1 isolation) or separated by gaps that do not impede squirrel glider movement (gaps less than 75m or class 2 isolation) is added and area of unsuitable habitat for gliders is subtracted. Effective remnant size is a much better predictor of glider occurrence than remnant size alone because it takes into account the higher probability of glider occurrence in small remnants that are close to large remnants. The relationship between glider frequency of occurrence and effective remnant size declines more steeply as remnants become smaller than it does in the relationship with remnant size alone Figure 10). This model predicts that isolated remnants have only a 50% probability of sustaining Squirrel Glider populations in the short term once they fall below an effective area of about 20 hectares.

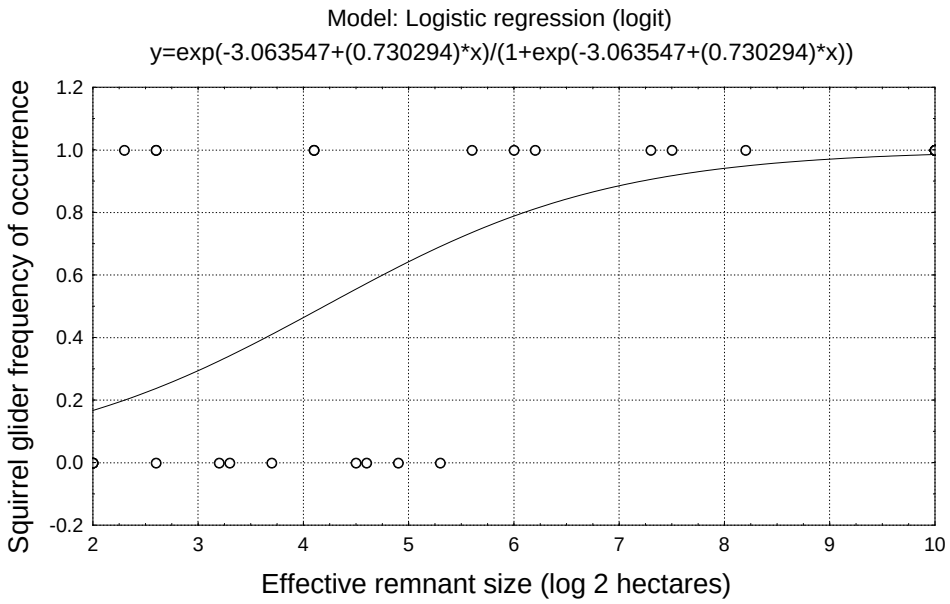


Figure 10. Squirrel glider frequency of occurrence in remnants as a logistic function of effective remnant size (the area of habitat in the remnant plus the area of habitat in adjacent remnants joined by corridors or separated by isolation class 2 gaps). (1= 2 ha, 2 = 4 ha, 3 = 8 ha, 4 = 16 ha., 5 = 32 ha., 6= 64 ha, 7= 128 ha., 8= 256 ha., 9= 512 ha. and 10= 1024 ha).

CONSERVATION STATUS

The conservation status of the Squirrel Glider is determined by:

1. The size of the population
2. The proportion of the population in protected areas
3. The fragmentation of protected areas

Population Size

The size of the Squirrel Glider population in Wyong Shire can be estimated by multiplying the area of potential habitat by estimated average glider density. Potential Squirrel Glider habitat in Wyong Shire has been statistically modelled (Figure 2) and found to include 4,351 hectares of medium quality habitat and 6,926 hectares of high quality habitat. This model has not been empirically validated by field surveys but density estimates are available for 40 survey sites throughout areas of predominantly medium and high quality habitat in the Wyong coastal plain. Average Squirrel Glider density in medium and high quality habitat was 0.46 +/- 0.08 animals per hectare. At this density the population of Squirrel Gliders is likely to be around 5187 +/- 900 individuals in areas of predicted medium and high quality habitat on the Wyong coastal plain. Gliders were absent from 3 out of 4 sites in low site quality habitat. Approximately 90% of the medium and high quality habitat occurs within large remnants linked by corridors and isolation gaps of less than 75m. This is the largest continuous population of Squirrel Gliders recorded in Australia, and as such can be considered to have national, state and regional significance.

Minimum Viable Population Size The probability of Squirrel Glider populations becoming extinct increases rapidly when they fall below a certain minimum size or minimum habitat area. Populations in small isolated habitats are more susceptible to a range of threatening processes including inbreeding, the chance birth of young of all one sex, seasonal shortages in food supply, wildfire, predation and roadkill. Once an isolated population has been exterminated by fire or predation there is no opportunity for re-colonization. A key aim of management is to determine the minimum size that a Squirrel Glider population can be without having an unacceptably high risk of extinction. This is sometimes referred to as the Minimum Viable Population size (MVP). A minimum viable population is the smallest isolated population with a specified high (eg 99%) chance of remaining extant for a specified time (eg 1000 years).

The relationship between glider density or frequency of occurrence and effective area of remnants can be used to estimate short term minimum viable population size in Wyong Shire. The x-axis on these relationships (effective habitat area) can be changed from area to population size (by multiplying area by average glider density of 0.46 animals per hectare) and minimum viable population size can be identified as the point where the relationship reaches an asymptote or

plateau. This point has been identified by a method called break point regression to be about 250 hectares or a population of 115 individuals for recently isolated remnants in the Wyong coastal plain (Figure 11). This finding indicates that remnants greater than 250 ha. or populations of more than 90 individuals should have close to a 100% probability of surviving in the short term (for a period of about 40-60 years). Examination of historical air photos indicates that small and medium size fragments on the Wyong coastal plain became isolated after 1960 in the north east (Summerland Point) region, around 1950 in the Warnervale to Gorokan areas and around 1940 and earlier in the Korakoa to Tuggerawong areas. Larger minimum habitat areas or population sizes are likely to be required to ensure that Squirrel Glider populations are viable for longer time periods.

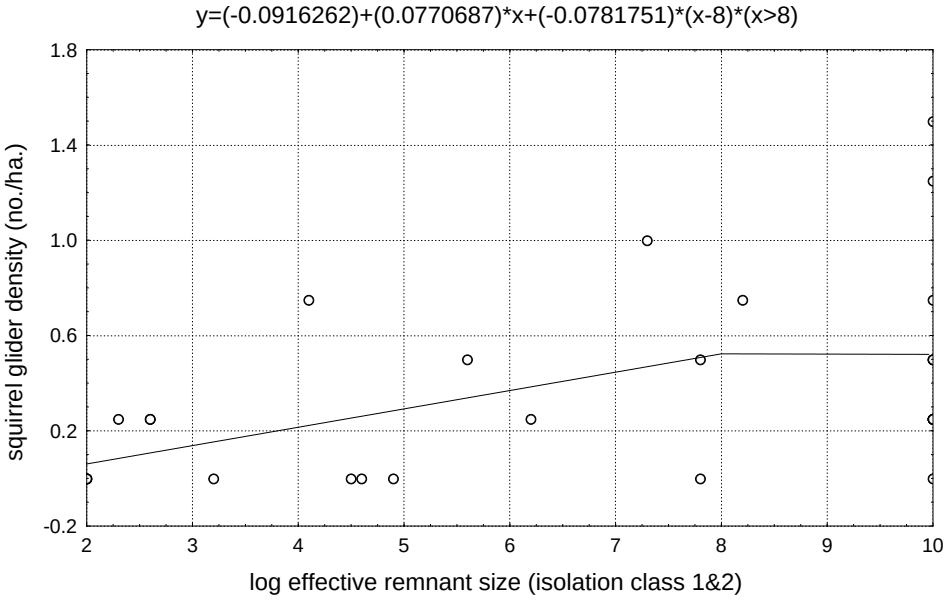


Figure 11. Break point regression model for squirrel glider density in remnants as a function of effective remnant size (log2 hectares, 3= 8ha, 4=16 ha, 5= 32 ha, 6 = 64 ha, 7=128 ha, 8=256 ha)

As remnants become isolated for longer time periods they will experience more extreme disturbance events and will require larger minimum population sizes to remain viable. Minimum viable population sizes determined empirically from surveys of cleared landscapes over short time periods (since European settlement of Australia) are typically an order of magnitude lower than those determined from studies of species extinction on offshore islands isolated by rising sea levels during the Pleistocene some 10,000 years ago. This discrepancy can be attributed to the increased likelihood of major disturbances, such as one in thousand years fires or drought events occurring over much longer time scales. At present there are no useful data on the frequency of

occurrence of gliders on different sized land bridge islands to provide an estimate of long term minimum viable population size. However, it has been shown that islands of about 40,000 hectares were necessary to sustain complete mammal faunas during the Pleistocene in Australia. Islands of this size can be expected to have carried minimum populations of about 1,000-2,000 individuals of the least common (largest) mammal species such as large macropods and top predators. Based on this evidence minimum populations of around 1,000-2,000 individuals may be required to sustain glider populations over the long term. This target is 10-20 times higher than the minimum viable population (115 individuals) considered necessary to sustain populations of squirrel gliders in the short term (40-100 years) and would require reservation of 2,500-5,000 hectares of Squirrel Glider habitat in Wyong Shire. Given that much of the Squirrel Glider habitat in Wyong Shire occurs on freehold land where it is at some risk of modification and disturbance a larger target area of 7,500 hectares is recommended for long term Squirrel Glider conservation as a precautionary measure.

Management Thresholds Minimum viable population sizes can be reduced by management intervention. This has been demonstrated for many threatened species with tiny populations (eg Lord Howe Island Wood Hen) that have recovered after control or elimination of predators and re-introduction to restored habitats. Small Squirrel Glider populations can easily be restored after disturbance events (fire predation, inbreeding) by actions such as monitoring and translocation or restoration of corridors and links. This level of intervention can, however, be expensive and is likely to be impractical for very small remnants (< 20 ha.) but may only be required every 10 - 50 years for medium sized remnants (10-100 hectares). For this reason upper and lower threshold remnant sizes have been identified for the Squirrel Glider management in Wyong Shire. The lower threshold has been set at an effective remnant size of 20 hectares or a population size of 10 individual gliders and the upper threshold has been set at an effective remnant size of 100 hectares or 50 individuals. Remnants larger than the upper threshold of 100 hectares should be considered viable without management intervention unless evidence is available to the contrary. Remnants between the upper and lower threshold (remnants with 10 - 50 individuals or an effective area between 20 and 100 hectares) should be considered viable over the short term with an appropriate level of management intervention.

Protected Areas

The total area of potential Squirrel Glider habitat of medium and high quality in Wyong Shire is about 11,000 hectares. Most of this habitat falls within freehold land where it is at some risk of clearing for future development. The distribution of preferred habitat of the Squirrel Glider in Wyong Shire corresponds closely with the distribution of four broad vegetation communities, spotted gum, Angophora-scribbly gum woodland, coastal dry sclerophyll forest and swamp forest. The proportion of these habitat types in National parks or under local council conservation zonings is summarized in Table 4. Only 498 hectares

occurs within National Park. A further 3055 hectares occurs within Council conservation zones where it has some security against future clearing. However, Council conservation zonings do not guarantee good land management unless supplemented with conservation incentives.

Conservation zonings over private lands cannot be considered secure unless native vegetation is protected by an irrevocable Property Agreement (within the meaning of the Native Vegetation Protection Act 1995) or similar agreement that identifies vegetation to be conserved and runs with the title to the land. At present some habitat areas in private ownership are at risk of progressive degradation from overgrazing, under-scrubbing (clearing of understorey) and other management problems.

Vegetation communities most preferred by Squirrel Gliders, Spotted Gum-Ironbark, and Angophora- Scribbly Gum Woodland are the least well represented in state and regional national parks and typically occur in coastal areas under high development pressure. Wyong Shire proposes to address this deficiency by reviewing and expanding its system of conservation zonings to include a greater area of poorly represented vegetation communities and Squirrel Glider habitat.

Table 4 Representation of fauna habitats in existing conservation tenures (LEP 1991) in Wyong Shire,

	National Park (8a)	Conservation Areas (7a)	Wetlands Management (7g)	Coastal Lands Acquisition (7e)	Total Protected	Total Wyong	% protected
Dry Sclerophyll Forest	246	25	0	47	318	890	36
Spotted Gum Forest	0	1,245	320	0	1,565	4,209	37
Dry Woodland	195	58	757	0	1,010	3,517	29
Swamp Mahogany Paperbark Forest	57	256	347	0	659	1,256	53
Total Area	**498**	**1584**	**1424**	**47**	**3552**	**9872**	

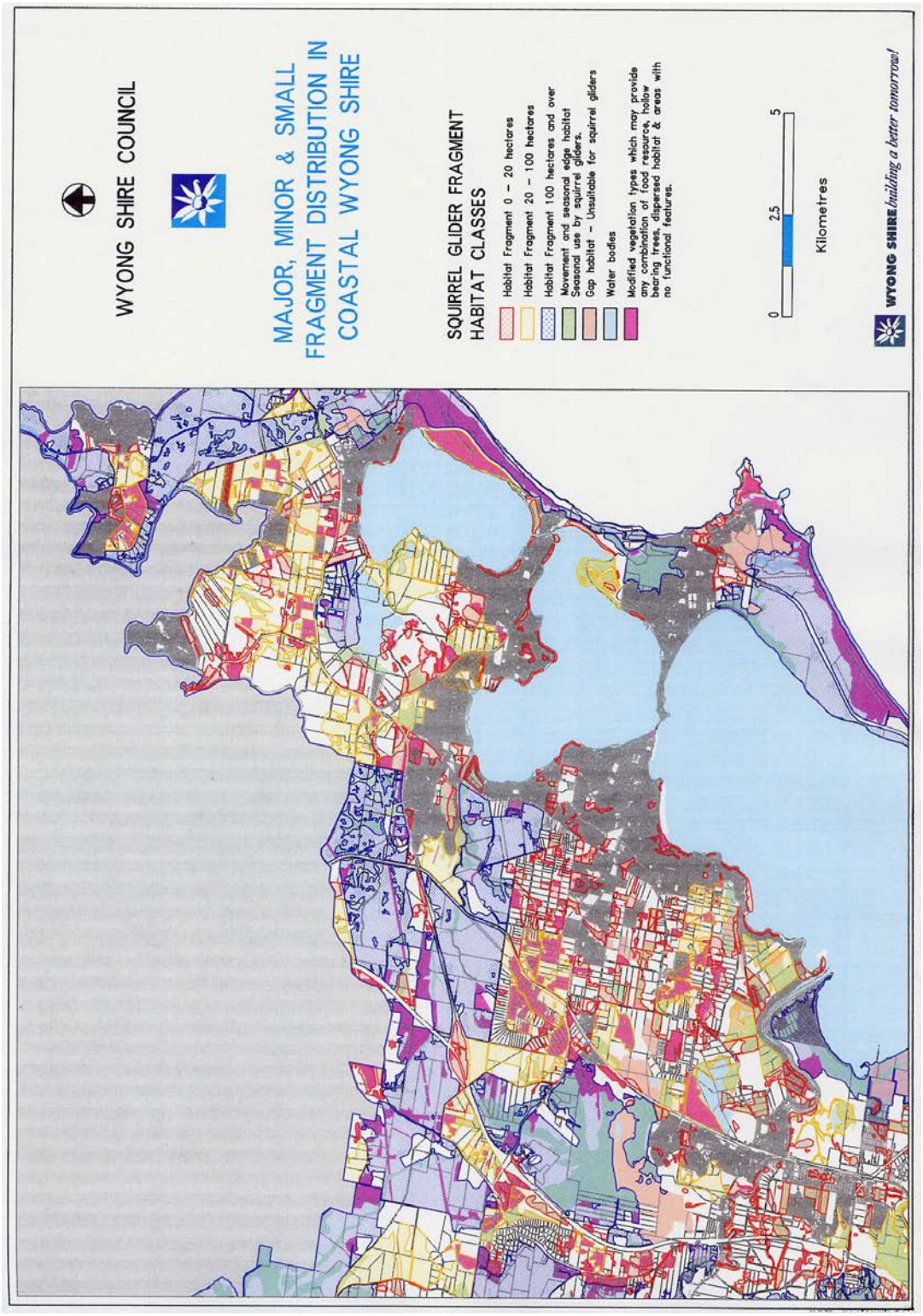
Fragmentation

All vegetation fragments in Wyong Shire down to 1 hectare in area have been numbered and mapped. A fragment is a natural vegetation remnant surrounded by a cleared area or barrier including roads, rivers, pasture, and urban areas. For the purpose of Squirrel Glider planning and management each fragment has been examined and amalgamated with its neighbour if joined by a corridor or separated by a gap less than 75 m wide over a distance not less than 250 m. The new combined fragments, referred to as “effective fragments” have been classified and mapped as either:

1. Major fragments: all effective fragments greater than 100 hectares;
2. Minor fragments: all effective fragments greater than of 20-99 hectares in size.
3. Small fragments: all effective fragments less than 20 hectares in size

A preliminary (draft) map of major, minor and small fragments in a sample portion of the Wyong coastal plain is shown in Figure 12. This map shows that the majority of natural vegetation in Wyong Shire (93.6%) occurs in major fragments. Only 1518 hectares occurs in minor fragments and 1738 hectares in small fragments. Thus there is great scope for planning the conservation of Squirrel Gliders within a network of linked remnants each large enough to sustain short term viable populations.

Figure 12 Map of major, minor and small fragment distribution in coastal Wyong Shire.



RECOVERY PLANNING & MANAGEMENT

Legislative Requirements

Threatened Species Conservation Act & Environmental Planning and Assessment Act . The Squirrel Glider (*Petaurus norfolcensis*) is listed as vulnerable on Schedule 2 of the NSW *Threatened Species Conservation Act* (TSC Act) 1995. It is an offence to harm or damage the habitat of a threatened species unless the damage is a result of activities that have been licensed under Section 91 of the TSC Act or have otherwise gained approval under the Environmental Planning and Assessment Act (EPA) Act 1979. The TSC Act amends the EPA Act to require that an 8 part test (EPA Act s5A) be undertaken for proposed activities that may have a significant impact on threatened species, populations or their habitats. Wyong Shire Council is required to take into account the findings of the 8 part test when considering development applications that affect threatened species habitat. Where a significant impact is likely a Species Impact Statement must be prepared and submitted to the Director General of the National Parks and Wildlife Service for concurrence (approval, modification or rejection).

The TSC Act also requires the production of recovery plans for all threatened species and threat abatement plans for key threatening processes. At the time of preparation of this plan no state wide recovery plan had been prepared for the Squirrel Glider in NSW and no threat abatement plans had been prepared for listed key threatening processes affecting the Squirrel Glider including clearing of native vegetation and fires that are too frequent.

Native Vegetation Conservation Act Clearing of Squirrel Glider habitat, including the removal of trees and understorey vegetation is subject to the consent from the Department of Land and Water Conservation in accordance with the Native Vegetation Conservation Act (NVCA) 1997. Lands excluded from the NVCA Act include those zoned residential, village or township (but not rural – residential).

Recovery Objectives & Targets

Recovery Objectives Wyong Shire aims to:

1. Protect (maintain and enhance) a minimum viable population of 3000 Squirrel Gliders in a network of linked medium and high quality Squirrel Glider habitat remnants totalling a minimum 7500 hectares.
2. Link all protected Squirrel Glider habitat remnants with an effective system of protected and managed corridors and pathways.
3. Provide necessary management incentives, actions and controls to ensure that Squirrel Glider habitat condition is maintained or improved in designated protected (conservation) areas and corridors.

Conservation Potential Wyong Shire has lost approximately 34% (25,000 hectares) of natural vegetation cover since European settlement. Most of this clearing has occurred on the coastal plains and river valleys which support the preferred habitat of the Squirrel Glider. The area of remaining medium and high quality Squirrel Glider habitat in the Shire is approximately 11, 000 hectares. Most of this habitat falls within a broad band extending across the northern boundary of Wyong Shire from Munmorah State Recreation Area in the north-east to Olney State Forest in the West. This habitat is moderately continuous, particularly in the north, being dissected only by narrow roads and utility lines that do not provide a barrier to Squirrel Glider movement. Consequently there is scope to conserve a significant area of Squirrel Glider habitat in a system of protected areas in Wyong Shire while at the same time allowing for future population growth.

Performance Targets The following performance targets have been set to measure success in achieving squirrel glider management objectives:

Habitat Area Target: an initial target of 7,500 hectares or greater of high and medium quality Squirrel Glider habitat to be protected from clearing and modification in restrictive (conservation) land use zonings. Over time conservation strategies which result in higher levels of conservation security will be employed which may include national park reserves, council reserves and protective covenants. Within ten years a minimum 5,000 hectares of high and medium quality habitat is to be protected in national parks, nature reserves, Council conservation reserves, and private land under some form of protective conservation covenant that runs with title to the land.

Fragmentation Target: all protected areas to be included within the target area of 7,500 hectares will be major fragments (fragments with an effective habitat area of 100 hectares or more in size). Minor fragments may be included in the protected area network where they provide corridors and links or for other management reasons but will not count toward the habitat area target.

Corridor Target: all individual (major) remnants included in the target protected area will be linked by at least one designated corridor with a minimum width of 250 m (where existing vegetation cover allows). Gaps within designated corridors (across roads and utility lines) will be as narrow as possible and not more than 40 m where possible. Vegetation on either side of gaps will be maintained or enhanced to facilitate glider dispersal. Individual corridor lengths will not be more than 1000m where possible.

Management Target: Average habitat condition in the protected area network will be determined by a standardised habitat monitoring program and will be maintained or improved over time.

Management Actions

Previous Management Actions

Interim Conservation Areas

Wyong Shire Council has introduced a Development Control Plan (DCP 13) that identifies interim conservation areas for protection of Squirrel Glider Habitat and habitat of importance to other threatened species in Wyong Shire. The representation of vegetation communities preferred by the Squirrel Glider within this area is shown in Table 5. The total area of preferred Squirrel Glider forest and woodland types encompassed within this policy (5,800 hectares) is close to the conservation target to enable a long term viable population of Squirrel Gliders to be conserved.

Table 5 Representation of preferred Squirrel Glider vegetation types in proposed environmental protection (conservation) zones in Wyong Shire.

Habitat Type	Proposed Conservation Area (Hectares)	Total Wyong Shire Area (Hectares)	Percentage in Conservation Zone
Dry Sclerophyll Forest	729.34	889.81	81.97%
Spotted Gum Forest	2,123.86	4,208.92	50.46%
Dry Woodland	2,377.35	3,516.69	67.60%
Swamp Mahogany/Paperbark Forest	633.57	1,255.53	50.46%
Total Area	**5,863**	**9,869**	

Interim Corridors

Wyong Council has a Development Control Plan (DCP 13) which identifies a set of interim corridors that link major vegetation remnants in Wyong Shire.

Development Applications to Clear Squirrel Glider Habitat

Until such time as the area of Squirrel Glider habitat in protected areas has reached the target level of 7,500 hectares and a network of protected corridors and management prescriptions is in place, applications to clear Squirrel Glider habitat in Wyong Shire will continue to be assessed on their individual merit according to the guidelines outlined below.

Developments will be classified as having Class 1, 2, 3 or 4 impacts.

Class 1 impacts will generally be refused or require the preparation of a Species Impact Statement. Any decisions to clear in such areas will be deferred if

possible until the Squirrel Glider habitat protection and management targets have been met.

Class 2 impacts will be considered on their individual merits but will generally require a Species Impact Statement if scheduled for implementation before Squirrel Glider habitat protection and management targets have been met. Decisions to clear will be deferred or referred for a Species Impact Statement if they fall within an Interim Conservation Area, interim corridor area or any area being considered by Council for inclusion in future conservation areas for Squirrel Gliders or other threatened species.

Class 3 impacts will be assessed on their individual merits but will not generally be considered significant within the meaning of the 8 part test (will not require an SIS). Conditions may be imposed on developments to compensate for habitat loss or to allow for the natural removal of animals from the site.

Class 4 impacts not generally considered likely to have a significant impact on the Squirrel Glider. Mitigation of impacts on resident animals or populations will be at the discretion of the landowner.

Impacts will be classified as Class 1, 2,3 or 4 as follows:

Class 1 impacts:

a) clearing or modification of Squirrel Glider habitat in mapped corridor areas, interim corridor areas or any connecting corridors or pathways between major remnants being considered by Council for inclusion in a protected corridor network;
b) clearing or modification of Squirrel Glider habitat in interim conservation areas or any areas being considered by Council for inclusion in future Squirrel Glider conservation areas.

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Class 2 impacts:

a) clearing or adverse modification of Squirrel Glider habitat in any major remnant or corridor linking major remnants outside interim conservation areas under consideration for possible inclusion in Squirrel Glider conservation or corridor areas.
b) any clearing or modification of a minor Squirrel Glider habitat remnant with a resident breeding Squirrel Glider population that is connected to a remnant (or effective remnant) greater than 100 ha in area by isolation classes 1 to 3.
c) Any network of minor Squirrel Glider habitat remnants connected by isolation classes 1 to 3 that together comprise 100 hectares or more in area.

Class 3 impacts:

a) Clearing or modification of small remnants (those less than 20 hectares) with resident breeding Squirrel Gliders and an isolation score for the remnant of 4 or 5;

b) All other impacts that are not class 1, 2 or 4 impacts.

Class 4 impacts:

a) Clearing or modification of small remnants (those less than 20 hectares) without resident breeding Squirrel Gliders; and an isolation score for the remnant of 4 or 5.

MODIFIER

Any Squirrel Glider habitat which occurs in vegetation which falls into one of the following modified vegetation classes will not be subjected to the impact assessment classes except in situations where this vegetation forms part of a wildlife corridor.

Regenerating Vegetation - previously cleared habitat with some regeneration of native species. Vegetation is generally characterised by few habitat trees and simplistic vegetation structure e.g. coastal vegetation growing on land which has been previously sand-mined.

Disturbed Vegetation – thinned native tree cover with significantly modified understorey e.g. scattered tree cover on rural-residential land with introduced pasture grasses in grazed or mowed understorey.

Clearing proposals falling into disturbed and regenerating vegetation classes will be assessed on their merits using the guidelines in Appendix 1. The modified vegetation codes prepared by Bell(2002) as part of the Shire wide Vegetation Mapping Project can be used as a guide. These types of vegetation have sub-unit codes xr and xs. However, detailed mapping at a site scale will be required to map the extent of disturbed and regenerating vegetation. The mapping will need to be done to the satisfaction of Council's Development Ecologist. The reason for the inclusion of this modifier is due to the more limited functional habitat values that these types of vegetation sometimes provide for Squirrel Gliders (e.g. fewer hollow trees, reduced resource availability and habitat variety).

Interim ecological assessment information required to assess clearing impacts within Squirrel Glider Habitat in Wyong Shire is required to be filled out for all "merit" based classes of development. This document lists a range of considerations in addition to the above, which are used by Council to determine which developments are likely to be deemed significant and require preparation of an SIS.

Habitat Clearing Protocol

Where clearing of habitat with known Squirrel Glider populations occurs the following procedures will be observed:

1. All occupied Squirrel Glider habitat trees in the area to be cleared will be identified (by survey) and marked;
2. Marked habitat trees and corridors of retained trees linking marked habitat trees with the nearest uncleared (secure) habitat areas will be left standing after initial vegetation clearing for a period of at least 3 weeks (to encourage gliders to disperse into adjacent uncleared habitat);
3. After the three week waiting period standing habitat trees and corridors may be felled commencing with the most distant trees from secure habitat;
4. Clearing should be undertaken in the Spring to Autumn period to facilitate survival of displaced animals;
5. If habitat trees are in short supply (< 4 suitable trees per hectare) artificial nest sites (nest boxes) should be installed in adjacent (secure) habitat before clearing;
6. If no secure habitat exists nearby to areas to be cleared land owners should seek advice from the NSW National Parks and Wildlife Service before proceeding with clearing.

Future Management Actions

Scientific Survey

A Shire Wide targeted survey of the Squirrel Glider will be undertaken to test and validate Squirrel Glider habitat models.

Squirrel Glider Conservation Zone

Current conservation zonings will be revised and expanded to ensure that the total area of medium and high quality Squirrel Glider habitat in Wyong Shire exceeds the target area of 5000 hectares.

Corridors

Interim corridor areas will be mapped and evaluated by ground survey to identify optimum areas for corridor location, current condition and future management requirements. Measured corridor attributes will include

- corridor dimensions
- vegetation condition,
- barriers to animal movement,
- height of vegetation adjacent to gaps,
- gap hazards (traffic levels, fences etc) and
- recreational and other threatening processes in corridors.

This information will be used to designate, protect and manage corridor habitats.

Monitoring

A standardized procedure for monitoring Squirrel Glider habitat and populations will be prepared based on a combination of ground survey and remote sensing changes in vegetation extent and condition. Emphasis will be on periodic (eg 10

yearly) remote sensing throughout conservation areas, establishment of fixed monitoring points and random habitat condition sampling.

Management

Council will deliver a range of incentives to improve conservation security for Squirrel Glider habitat on public and private lands. These may include but will not be limited to rate relief, trade offs (development approvals in some areas in return for conservation in others), use of fees for development approvals that involve land clearing to purchase and maintain high conservation value lands, land purchase by Council, preparation of Property Management Plans (under the Native Vegetation Conservation Act) or Voluntary Conservation Agreements (Under the National Parks and Wildlife Act), and conservation covenanting by registered environmental organizations (eg NSW Nature Conservation Trust).

Education and Extension

Council will develop and implement a Squirrel Glider education and awareness program focusing on residents adjoining conservation areas.

Implementation Schedule

The completion schedule for recovery actions is as follows:

Recovery Action	**Scheduled Completion Date**
Scientific Survey	
Conservation zones finalized	
Finalize Squirrel Glider habitat corridors	
Monitoring Program Established	
Management Plan Implemented	

Review Date

This plan will be reviewed in 5 years from the date of adoption and publication by Wyong Shire Council.

Further Reading

Quin D. (1995) Population ecology of the Squirrel Glider (*Petaurus norfolcensis*) and the Sugar Glider (P. breviceps) (Marsupialia Petauridae) at Limeburners Creek, on the central north coast of NSW Wildlife Research **22**, 471-505.

Sharpe and Goldingay R. (1998) Feeding behaviour of the Squirrel Glider at Bungawalbin Nature Reserve, north-eastern NSW. Wild. Research 25, 243-254.

*Smith A. (2002) Effects of clearing and fragmentation on the Squirrel Glider (*Petaurus norfolcensis*) . Report to Wyong Shire Council.

*Smith A. and Murray, M. (2003) Habitat requirements of the Squirrel Glider (*Petaurus norfolcensis*) and associated possums and gliders on the NSW Central Coast. Wildlife Research (in press).

*Smith, A., Watson G. and Murray M. (2002) Fauna habitat modelling and wildlife linkages in Wyong Shire. Austeco Environmental Consultants, Armidale.

Trail B. and Lill A. (1997) Use of tree hollows by two sympatric gliding possums , the squirrel Glider , *Petaurus norfolcensis,* and the Sugar Glider, *P. breviceps*. Australian Mammalogy 20:79-88.

Trail B. J. (1995) Co-existence and competition in a community of forest vertebrates. Ph.D thesis, Department of Ecology and Evolutionary Biology Monash University, Clayton Vic.

van der Ree, R. (2000) Ecology of arboreal marsupials in a network of remnant linear habitats. Ph.D thesis, School of Ecology and Environment, Deakin University, Melbourne.

Wyong Shire Council (1999/2000) State of the Environment Report. Wyong Shire.

* copies of these reports are available in Wyong Shire Library.

APPENDIX 1: HABITAT INFORMATION TO ASSIST ASSESSMENT OF SIGNIFICANCE OF DEVELOPMENT IMPACTS ON SQUIRREL GLIDER HABITAT

Until such time that sufficient conservation measures have been introduced to improve the conservation security of Squirrel Gliders it will be necessary to consult with Council about the type of clearing impacts which will occur within potential Squirrel Glider habitat. A ranking system has been developed to assist with the determination of impact "significance" on local populations of Squirrel Gliders within the meaning of the *Threatened Species Conservation Act, 1995*.

In order to provide a local context for making decisions on the relative impacts of various clearing proposals, a series of impact classes ranging from 1 to 4 have been developed. You will need to contact Council's Development Ecologist to find out which impact class your clearing proposal falls into. The ranking procedure for dealing with clearing impacts within Squirrel Glider habitat is outlined as follows:

1.0 Habitat Information Required to Assist in Making Any Merit Based Assessment

If the following information has not already been collected as part of the environmental process, the following information will need to be available to permit a merits based assessment to occur for clearing proposals within potential Squirrel Glider habitat. The following survey based information should be made available to Council:

◊ Detailed plan of remnant patch showing locations of adjacent patches and main vegetation assemblages.

◊ Microhabitat features of each vegetation assemblage should be described such as dominant species, mature trees, percentage cover of different plant species, presence of introduced species.

◊ Map locations of habitat trees (trees with visible hollows > 5cm diameter).

◊ Show area to be disturbed by development proposal and outline any mitigative measures (eg. clearing, underscrubbing, boring, grazing).

◊ Show level of disturbance and discuss disturbance history.

◊ Provide distance measurements to adjoining areas of remnant vegetation and size (area) of adjoining patches.

1.1 Habitat Suitability

a Habitat Quality

Assess relative predominance of optimum Squirrel Glider microhabitat types according to vegetation assemblage type:

	Habitat Area	% Habitat Type Within Patch	
1 Stringybark/Gum with Acacia/Melaleuca/Grass understorey			
2 Spotted Gum/Ironbark/Gum			
3 Stringybark with Banksia/Allocasuarina/Melaleuca understorey			
4 Sydney Red Gum/Scribbly Gum with Allocasuarina/Melaleuca understorey			
5 Sydney Red Gum/Scribbly Gum with Banksia understorey			

Less optimum ↕ More optimum

6 If plant assemblage type does not fit well with the above describe below:			
.....			
.....			

b Remnant Patch Size

Assess patch size on site according to the scale outlined below:

Patch < 5 hectares in size	
Patch > 5 hectares but less than 10 hectares in size	
Patch > 10 hectares but less than 30 hectares in size	
Patch > 30 hectares but less than 90 hectares in size	

Less optimum ↕ More optimum

c Density Habitat Trees

Average number of trees with hollows per hectare < 2 habitat trees / hectare	
Average number of trees with hollows per hectare > 2 habitat trees / hectare	

Less important ↕ More important

d Abundance of Food Plants of Squirrel Glider

Quantitatively assess using plot based data, the proportion of Squirrel Glider food plants which occur on the site and show plot locations on map. Field survey effort for measuring food plant abundance should be applied as per Council's Flora and Fauna Guidelines for Development (see section on survey effort for vegetation plots). A summary of locally occurring food resources for Squirrel Gliders is provided below:

Local Food Plants in Study Area		Food Item	Average No of Plants/ Hectare	% of Vegetation Assemblage
Angophora/	*costata*	sap, nectar & pollen		
Eucalyptus	*haemastoma*	sap, nectar & pollen		
	racemosa	sap, nectar & pollen		
	robusta	sap, nectar & pollen		
	siderophloia	sap, nectar & pollen		
	paniculata	sap, nectar & pollen		
	fibrosa	sap, nectar & pollen		
	gummifera	sap, nectar & pollen		
	maculata	nectar & pollen		
Melaleuca	*linariifolia*	nectar & insect bark food		
	nodosa	nectar & insect bark food		
	quinqueneria	nectar & insect bark food		
	sieberi	nectar & insect bark food		
Acacia	*spp.*	seeds & gum		
Banksia	*spimbosa*	nectar & pollen		
	serrata	nectar & pollen		
	integrafolia	nectar & pollen		
	oblongifola	nectar & pollen		
Xanthorrhoea	*spp.*	nectar & potential gum		

* Council staff will have regard to the availability of food resources and continuity of flowering times of different plant species in making any assessment.

1.2 Habitat Vulnerability

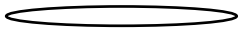
Factors to be assessed include area, edge/area ratio of the habitat, presence of disturbed or weed invaded vegetation within remnant patch, presence of threatening processes and impact of surrounding land use proposals. Assessment criteria are outlined below.

a Edge to Width Ratio

Which shape is the patch size most similar to?


Round


Oval Shaped


Narrow Linear Fragment

b Habitat Disturbance

What % of the patch area has experienced disturbance by weed invasion, underscrubbing, fire or other understorey disturbance?

.....

c Proximity to Existing or Future Residential Development

Is the fragment within 200 metres of an existing or future residential development? Yes ☐ No ☐

2.3 Resident Breeding Squirrel Gliders

Presence / absence of resident breeding Squirrel Gliders in patch? Yes ☐ No ☐

Applicants must supply details from trapping programme.