WHAT ARE RESERVES FOR?

Three goals are often given for setting aside a site as a nature reserve. First is the protection of particular species of interest, such as endangered or endemic species. Among American refuges established to protect particular species are those for the California condor *Gymnogyps californianus*, saguaro *Carnegia gigantia*, Kirtland's warbler *Dendroica kirtlandii*, and redwoods *Sequoia sempervirens* and *S. gigantea*. Second, as the science of ecology has matured, there has been increasing interest in preserving entire functioning communities. Finally, there is concern for preserving biotic diversity, *per se*, or the maximum number of species.

Usually, these goals are complementary aspects of the same overall principle of protecting nature; in practice most conservation programmes are also complementary. For example, in the southeastern US, one does not preserve red-cockaded woodpeckers *Picoides borealis* in the abstract. The reason the bird is endangered is that its habitat is rapidly disappearing—particularly the old, dying longleaf and loblolly pines that it uses for nesting. Consequently, one can preserve the woodpecker only by maintaining the sort of ecosystem in which these pines are allowed to reach the age when they begin to die. Such an ecosystem, in turn, will likely be quite similar to one that occupied the southeastern coastal plain before the arrival of Europeans, and will also likely contain a higher number of species than those with which humans have been replacing it.

There have been disputes within the conservation community, however, about whether species-oriented conservation projects might detract from goals of preserving entire, diverse ecosystems. Since economic and human resources are always limited, one can question whether efforts to preserve a particular species could endanger projects with broader objectives. In a world where choices are always required, is the particular habitat of a given species always the optimal choice for conservation?

WHERE SHOULD NATURE RESERVES BE LOCATED?

Cultural, political and economic factors often determine where reserves will be sited. In many instances, governmental or private conservation organisations are given the choice of either accepting a site for conservation management or allowing it to be put to some other use, and we do not have the luxury of saying that a different site would be better for conserving a particular species or community type. There may, in such instances, be valid reasons for rejecting the offer and letting a site be developed. For example, the management cost may be sufficiently large to detract from other conservation efforts, and the conservation value (in terms of the above three goals) may be negligible. As we discuss below, however, refuges that are admittedly suboptimal can be of great value, even aside from potential educational benefits.

Cultural, political and economic factors, then, constitute the first class of criteria for nature reserve location. There are several biological criteria. First, one should ask whether a particular site has optimal habitat for one or more species of special concern. The habitat requirements of some species are sufficiently narrow that there are very few choices. Second, one may seek areas where habitat and species diversity are greatest. Third, sites of maximum endemicity are of great value, particularly for the retention of biotic diversity. Finally, sites that are particularly secure for long-term conservation are desirable. The relationship of these criteria to the above motivations for setting aside reserves is apparent, but the last two criteria deserve further comment because their importance has not been universally appreciated.

Most of us intuitively grasp the value of rare or unique objects. Leaving aside the physiological basis of such aesthetic values, we are arguing that conservation ought sometimes to be based on uniqueness and endemicity, rather than on utilitarian considerations such as the possible future use of genetic resources. Though there is no objective way to determine how important endemicity is relative to other site criteria, it is possible to rank habitats as to endemicity. For example, Senanayake *et al.* (1977) found the value of upland forests to be about 50 times that of lowland forests in Sri Lanka.

Terborgh & Winter (1983) have observed that some conventional criteria for siting reserves show little correspondence with points of maximum endemism, an especially serious problem in the Neotropics, where a very high fraction of species are endemics (Gentry, 1978). For example, Terborgh & Winter found that South America harbours 440 endemic land birds with ranges less than 50 000 km^2. This constitutes about a fourth of the continent's avifauna, in contrast to North America, where the respective values are eight species and 2%. They note that in Colombia and Ecuador, 'none of the crucial areas [for preserving endemics] are contained within the existing or projected park systems of either country'. Therefore, in some regions at least, the use of Holdridge life zones (Holdridge, 1967) or similar systems as a guide for the identification of potential reserve sites is clearly insufficient. Small reserves can be important for preserving endemic species of certain taxa (as we discuss below) but must be rigorously protected and may require intensive management (Terborgh, 1974, 1976; East, 1981*a*). This brings us to the issue of reserve integrity and long-term security.

Even large reserves may be threatened by disturbances in surrounding regions, because ecosystems are never completely isolated from one another. Biogeochemical cycles in particular are often regional or even global, so that developments outside a refuge may greatly affect its biota. No aquatic or terrestrial reserve in the northeastern United States or northern Europe, no matter how large and well managed, is immune to the effects of acid rain, which must be ameliorated by regional or national planning. Similarly, the Everglades in southern Florida are threatened by diversion of water that is occurring outside the park (Kushlan, 1979). Wherever possible, reserves should contain complete watersheds.

In summary, non-biological factors usually dictate the sites of large reserves. Except in the high latitudes, the opportunities for establishing large reserves will soon be past. Elsewhere, as more land is disturbed, small reserves will be established to protect the last refugia of endangered species and habitats. Such small 'garrison reserves' will often be expensive to protect and manage because of their high ratios of edge to area. For these reasons and others, traditional biogeographic criteria for the establishment of reserves must be complemented by those that are more sensitive to species diversity and to minimising disturbance within the reserves by development in the surrounding region.

HOW SHOULD RESERVES BE DESIGNED?

There are three separate questions: How big? How many? How arranged? In many places it is already too late to do much about design. The historical phase of establishing reserves is drawing to a close (Amazonia is the only major exception in the tropics), and, as discussed above, socioeconomic exigencies often preclude choice of size and shape. There is, nevertheless, much to be accomplished in establishing new reserves and in securing those that already exist.

One important means of protecting refuges that already exist is by providing buffer zones to insulate them from many of the detrimental effects that unhindered human activity might produce. This need not always mean that the buffer zones themselves become parks, only that activities within them would be regulated so that they would impinge only minimally on the refuge. For example, the Government of India is considering a plan to establish seven Biosphere Reserves. The plan includes buffer zones that would encourage reafforestation, the restoration of degraded habitats and other programmes of eco-development (Anon., 1982). Local people would be trained as wardens and managers and would benefit economically from tourism in the core areas.

A recent debate, represented by the acronym SLOSS, has focused on the relative value of a Single Large or Several Small refuges, where the summed areas of the small reserves equal that of the large reserve. The history of this debate has been reviewed recently by Simberloff & Abele (1982), and we hope here to put the issue finally to rest. In brief, the debate was initiated when Simberloff and Abele (1976*a*,*b*) criticised the contention of Wilson & Willis (1975), Diamond & May (1976), Diamond (1975, 1976) and Terborgh (1975, 1976) that the equilibrium theory of island biogeography dictates that single large refuges are generally preferable to groups of small ones. Their recommendations received wide attention and were incorporated into the World Conservation Strategy (IUCN, 1980).

Recent studies have resolved the primary issue. The equilibrium theory is neutral on the matter (Abele & Connor, 1979; Gilpin & Diamond, 1980; Higgs *et al.*, 1981). Observational studies suggest that a few, dispersed, small sites usually contain at least as many species as does a single site of equal area. For example, Gilpin & Diamond (1980) found that pairs of islands in the New Hebrides typically contain 5% to 10% more species of lowland forest birds than do single islands with equal total areas. It is important to note, however, that this result has limited applicability in conservation practice. The reasons include:

(1) The possible slight advantage of several small sites is predicated on habitat being identical in the large and small sites. In nature, this requirement is never met, and habitat differences will almost certainly affect any real decision about which sites to preserve. That is, it is inconceivable that conservationists will ever be presented with the choice

of preserving either site A or sites B and C (which together equal size A in area), where habitat differences among the sites will not be sufficiently pronounced as to indicate a particular course of action.

(2) The only aspect of conservation that the result directly addresses is numbers of species present at a particular time, that is, the moment of demarcation. It does not refer to attempts to conserve particular species or entire functioning ecosystems. The reason is that most of the data, consisting of surveys of species present now on sites of different sizes, are not very informative about whether these species would persist on these same sites for long periods of time.

(3) Whatever the advantage of several small sites over single large ones for particular groups of species, the advantage would surely be sensitive to the degree of subdivision. For example, Gilpin & Diamond (1980) found that ten small islands usually have fewer species than does a single large one. The particular point at which the small sites would become problematic depends on several factors, including the penetration of reserves by biotic and abiotic effects including wind, disease, exotic species and an increase in the densities of species that prefer 'edge' habitats (e.g. Janzen, 1983). It also depends on the minimum sizes of viable populations for the species of interest, a matter we discuss below.

(4) The effect is sensitive to the dispersal of the small sites. Obviously, two sites of 1 km^2 each on different continents will have more species than a 2 km^2 site on one continent, at least for most taxa. This is because most taxa on different continents have separate evolutionary histories, and most of their species are different. It is likely, however, that the same sort of effect would obtain over much shorter distances, for ecological rather than evolutionary reasons. Even within the same region, two separated sites are likely on average to differ more in habitat than are two contiguous sites, and so might be expected to be suitable for more species, so long as the areas were not too small (see below). Simberloff & Gotelli (1984) and many others have hypothesised that it may be precisely this increased habitat diversity with dispersion that accounts for the common observation that a few small sites sometimes contain more species than single large ones, but the hypothesis has never been rigorously tested, or even examined with field data except by Kitchener *et al.* (1980).

(5) In some parts of the world, large areas have been set aside for conservation purposes because they have little or no agricultural,

pastoral or other economic value (East, 1981*a*), whereas less marginal regions tend to have smaller reserves. For example, of the 15 largest protected areas in the USA listed by IUCN (1977), five are located in the arid west, three in Alaska and four in mountainous regions of the far west. In contrast, none of the 15 smallest protected areas in the USA are located in these agriculturally marginal regions. Therefore, the apparent diversity advantage of several small over single large sites may sometimes be exaggerated when the sampling units are existing refuges.

(6) The SLOSS effect, and the size range of refuges at which it breaks down, depends on the taxon. For example, plant species occupy sites of less than a square kilometre on narrow strata of the Green River shale of the Uinta Basin, apparently because of precise soil chemistry and drainage requirements. These include the columbine *Aquilegia barnebyi*, the beardtongue *Penstemon grahamii* and the milk-vetch *Astragalus lutosus*. The geological history of this part of Utah and Colorado suggests that these species have been narrowly restricted for many thousands of years, yet they have not been extinguished in spite of undoubted fluctuations in numbers. It is reasonable to expect that, if their habitat is rigorously protected, they will persist for millennia. Thus a group of very small sites may be quite adequate for the plants in some communities but would be useless for some of the animals (and thus for the system as a whole) because not one of them is large enough to support a population.

The SLOSS debate is, therefore, no longer an issue as regards numbers of species at the time reserves are founded. Virtually all conservation biologists agree that several small reserves can contain as many species as a single large one at the time of demarcation from their natural surroundings. The aspect of the SLOSS question that remains unanswered is the dynamics of species extinction *after* the reserves are set up and surrounded by habitat modified by human activities. The implications of size are great if rates of extinction depend on it.

To address this matter, we must consider the concept of *minimum viable population* (MVP). Nature reserves, like time capsules, are successful to the degree that their contents retain their integrity. They fail to the degree that their contents are destroyed. Reserves prevent extinctions by providing enough habitat and space. How much is enough? There are two answers. First, we must be sure that the dynamics of succession do not eliminate critical habitat within the landscape mosaic (Pickett & Thompson, 1978; Foster, 1980; Gilbert, 1980). But even a reserve that is large enough to ensure the perennial persistence of all habitats and successional stages is not necessarily immune to extinctions. For example, a succession of managers might contrive to provide a large, dead tree as a nesting site for a pair of spotted owls *Strix occidentalis* or red-cockaded woodpeckers only to discover that, despite their good intentions, the birds always die out within a few generations. Obviously, one pair is not enough to ensure long-term viability.

This brings us to the second answer—we will have gone a long way towards answering the question of how large a reserve must be when we are able to determine the minimum number of individuals in a population needed to guarantee a high probability of survival. This is because a minimum number requires a minimum area. In investigating this question we are led to the study of those factors that determine the MVP and the distribution of the MVPs in space.

POPULATION VIABILITY AS A CRITERION FOR RESERVE DESIGN

Before setting out on a long and difficult journey we carefully pack those things we think will make the way safe and comfortable. For a species, the nature refuge is also a kind of journey, though it is a journey through time rather than space. It is a journey of millennia. The destination is survival. We humans are the travel agents; we try to anticipate the problems that might arise for our charges, and do our best to prepare them for any probable circumstance. As a general rule, everything needed by these passengers should be stocked in advance because the future is uncertain and there are no supplies along the way.

The metaphor of a journey suggests that we should ask if each species has some minimum (effective) population size (N_e) for long-term survival. The relationship between the size of *effective* populations and the size of censused populations is a matter of genetic calculations that need not concern us here (see Frankel & Soulé, 1981; Barrowclough & Coats, in press), except to know that effective population size is almost always less than the number of mature individuals that one would simply count, and is often much less. Extinction is a question of risk; it is a probabilistic matter, and it is not crucial to our thesis that we be able to specify a particular magic number (e.g. 173) such that swift extinction is highly probable below, but not above, this number.

Rather, it is only necessary to accept that the expected time to extinction is shorter for small populations and that the time becomes very short (a matter of a few years or decades at most) at some size. If a refuge is so small that populations cannot exceed this size, then the species is doomed to quick extinction. Therefore, even if a refuge contains all of the habitats necessary for all species of concern, there will still be quick extinction of those species that cannot maintain an MVP.

Over geological time spans, all species are doomed to extinction (Raup & Sepkoski, 1984). But the scale of 'background' extinction is very long compared to current anthropogenic rates. In any case, conservationists are concerned with preserving species for a few thousand years, not for an eternity. Similarly, even very large local populations occasionally go extinct even without human activity (MacArthur & Wilson, 1967; Karr, 1982*b*; Ehrlich, 1983), but such normal 'turnover' is not usually of great concern because it is redressed by immigration from other populations that are still extant. As the earth is degraded, however, to a point where a large fraction of species are maintained *only* in reserves, there are few or even no other populations to redress an extinction—the local population at this point *is* the species, and normal turnover becomes species extinction. Thus, even when reserves are established, the smaller they are, the more quickly they will lose species, and a reserve so small that it approaches the MVPs of many species will soon be beset by many extinctions.

The forces that drive a species to extinction are exactly those forces that normally determine distribution and abundance. In other words, the MVP problem is no less complex than population biology itself, though it is focused on one particular boundary region in the abstract, multidimensional space of distribution and abundance in time. This is the boundary or threshold below which the probability of long-term survival is unacceptably low.

The forces and factors that have been considered (Terborgh, 1974; Shaffer, 1981; Soulé, 1983) can be classified conveniently, if arbitrarily, into two categories, extrinsic and intrinsic. Extrinsic forces include deleterious interactions with other species (increases in predation, competition, parasitism, disease or decreases in mutualistic interactions) and deleterious events or changes in habitat or the physical environment.

Intrinsic factors include random variation in genetically based traits of the species and interactions of these traits with the environment. These include: (1) demographic stochasticity, which is random variation in sex ratio, in birth and death rates, and in certain abstractions of these traits, including the intrinsic rate of increase of the population (r); (2) social dysfunction or behaviours that become maladaptive at small population sizes; (3) genetic deterioration brought on by inbreeding, genetic drift and other factors. We will explain the impacts of some of these forces in greater detail.

Demographic stochasticity

This factor can contribute to fluctuations in population size, even driving populations to extinction. It is a far greater threat to small than to large populations; for example, the probability that all individuals in some generation will be male is higher the smaller the population. Simple models suggest that demographic stochasticity alone is unlikely to cause extinctions unless the population becomes very small, say, less than 20 (MacArthur & Wilson, 1967; Richter-Dyn & Goel, 1972).

It is obviously unrealistic to consider this factor in isolation from other factors that cause random or systematic changes in population size, but very few studies have attempted more comprehensive approaches. Leigh (1981) and Goodman (unpublished work) have provided some analytical solutions. Shaffer & Samson (1985) have simulated the probable persistence of grizzly bears *Ursus arctos* in the Yellowstone National Park region, combining actual life history data and the effects of environmental variation on birth and death rates. In their simulation, the average time to extinction was 114 years for an environment with a carrying capacity of 50 animals. In 300 years 94 out of 100 such simulated populations would have failed. For this species, then, the model suggests that a census population of 50 is much too low to guarantee long-term survival in a refuge, even when other forces (genetics, disease, poaching, catastrophe) are ignored.

Genetic deterioration

There are three overlapping aspects of genetic deterioration. First are the *immediate* consequences of the erosion of heterozygosity. In outbreeding species that are heterozygous at many loci, more heterozygous individuals are in general more fit than less heterozygous ones. Many fitness criteria have been studied, including growth rates, scope for growth, viability, longevity, morphological symmetry, metabolic efficiency, frequency of disease and abnormality, and survival during stress (Schaal & Levin, 1976; Botviniev *et al.*, 1980; Zouros *et al.*, 1980; Ballou & Ralls, 1982; Beardmore, 1983; Leary *et al.*, 1984; Samallow & Soulé, 1983; Garton *et al.*, 1984; Mitton & Grant, 1984). The implications of these results for conservation are that any loss of heterozygosity for many species probably increases the mortality rate, especially during periods of stress or environmental change. Therefore, MVPs should be sufficiently large to maintain existing levels of heterozygosity.

Another aspect of genetic deterioration is *inbreeding*. Evidence is accumulating that most outbreeding species of animals avoid mating with close relatives, particularly siblings, even when they are raised apart (Packer, 1979; Pusey, 1980; Hoogland, 1982; Ballou & Ralls, 1982). Many geneticists believe that the avoidance of inbreeding has resulted from natural selection. Inbreeding among normally outbreeding organisms usually results in a sharp decrease in fitness, especially fecundity and viability, and even small amounts of inbreeding have been shown to produce deleterious effects in wild species of primates (Ralls & Ballou, 1982*a*), ungulates (Ballou & Ralls, 1982) and small mammals (Ralls & Ballou, 1982*b*). Such inbreeding depression can bring species to the brink of extinction. For example, in the endangered Brazilian golden lion tamarin *Leontopithecus rosalia* the high incidence of a genetic defect of the diaphragm is almost certainly caused by the high rate of inbreeding.

The third aspect of genetic deterioration is the long-term, evolutionary consequences of the erosion of genetic variation, the rate of which is roughly proportional to $1/2N_e$. It is an article of faith in evolutionary genetics that adaptability, the rate of evolution, can be limited by the availability of genetic variation. Several laboratory experiments demonstrate enhanced rates of evolution following an increase in genetic variability (Ayala, 1969; Chao *et al.*, 1983). Notwithstanding the implications of such results, however, technical problems preclude experimental field tests establishing that limited genetic variability is a major factor in the extinction of a particular local population. In spite of these methodological difficulties, it is probable that very small populations are more vulnerable to environmental change than larger ones, because small populations will always have less genetic variation than large ones, everything else being equal.

Conservationists must know the minimum effective size of a population for which deleterious inbreeding effects are balanced by natural selection against homozygotes for deleterious recessives. This size depends on the genetic load of the species, and some species (those with high rates of inbreeding in nature) may require only a few individuals for this balance. But for outbreeding animals, especially vertebrates, Franklin (1980) and Soulé (1980) suggested that the experience of breeders leads to an estimate of about 50 breeding individuals.

In the long term, however, even an effective size of 50 cannot prevent the gradual loss of heterozygosity; such a population will lose most of its selectively neutral genetic variation in less than 100 generations (Senner, 1980). There is a growing consensus that a population should be large enough so that the input of new genetic variation from mutation balances the loss from genetic drift. An unresolved problem is that the population size at such a balance point depends critically on (1) the kinds of genetic variation being considered, (2) their respective mutation rates, and (3) the kinds of natural selection that act on these kinds of variation, all of which are difficult to define and estimate. This issue will be the focus of much research in coming years.

Social dysfunction

The third intrinsic force is maladaptive behaviour or social dysfunction. Such behaviour can lead to a precipitous decline in species that either forage in large groups or form large breeding congregations (Soulé, 1983). In the USA the extinctions of the Carolina parakeet, the passenger pigeon and the heath hen may have been facilitated by this force.

Extrinsic factors

Consideration of environmental or extrinsic factors usually dictates either an increase in MVP or an increase in the number of populations that must be maintained for long-term survival of the species or both. One such factor is disturbance. Many species use resources that exist only in temporary habitats. Natural disturbances, such as tree falls and fires, often initiate successional processes that produce these resources. The amount of suitable habitat, therefore, depends on the frequency and scale of such disturbances (Pickett & Thompson, 1978; Foster, 1980). In small reserves the rate of occurrence of such disturbances may be sufficiently low that critical habitat will occasionally disappear completely.

Contagious disease is another extrinsic force that can suddenly expunge a population or reduce it in size, enabling the intrinsic factors to weaken further or threaten the population (Frankel & Soulé, 1981). The provision of more than one reserve sufficient for the MVP is therefore highly desirable, if not a design imperative.

Environmental variation and catastrophe are extrinsic forces that are on the same continuum, differing only in degree and frequency. Thunderstorms are just commoner and less severe than hurricanes. Events of this sort, which are relatively insignificant in a large reserve, can completely eliminate a particular habitat type in a small one. An entire small population can be extinguished by such events as fires, floods, mud slides, avalanches and wind storms. For example, Jones & Diamond (1976) reported that a fire in 1959 on Santa Barbara Island off the coast of California temporarily eliminated nearly all the habitat of several bird species and, in combination with introduced rabbits, led to the extinction of the song sparrow *Melospiza melodia*. Similarly, a gale-driven fire destroyed nearly all of the habitat of the heath hen's *Tympanuchus cupido cupido* last redoubt in 1916, and this, combined with an unusually high density of the predatory goshawks *Accipiter gentilis* the next winter, drove the hen almost to extinction, an event that was completed by 1932 (Drury, 1974, and references therein). Therefore, persistence in a small reserve depends on whether a single population can survive such events as, say, the 300-year flood or the 200-year drought, and whether such events so reduce the numbers that the intrinsic factors such as inbreeding can exacerbate fitness further. Obviously, the smaller the refuge, the greater the chance that a given event will be devastating over its entire area.

What, then, is the minimum size of a viable population? And how does this size translate into a design criterion? Clearly, there is no magic number. Not only is each species in each location a unique situation, but even if we could ignore taxonomic, genetic and ecological heterogeneity, the problem would still be difficult. A genetically derived MVP depends on assumptions about selection and on other parameters for which there are few data. The same could be said for analytical solutions that attempt to integrate demographic and environmental stochasticity (Leigh, 1975). To our knowledge, no one has even attempted the heroic task of producing a sophisticated model incorporating inbreeding effects with the other forces.

Thus, not only is there no magic number, there is no magic algorithm or protocol. Intuition, common sense and the judicious use of available data are still the state of the art. All these caveats accepted, MVPs on the order of a few hundred to several thousand genetically effective individuals are within the range that satisfy those scientists who have attempted to deal with real management situations (Schonewald-Cox, 1983; Salwasser *et al.*, 1984). For large animals, such numbers translate into very large areas (Terborgh, 1974; Frankel & Soulé, 1981). This means that in order to maintain the large predators in a community, and, with them, the critical regulatory roles that they perform, reserves the size of thousands of square kilometres are often necessary. On the other hand, small reserves and their remnant populations can often be salvaged, especially when a species is managed by a consortium of reserves. In addition, the co-operation of zoos in the captive breeding and enhancement of wild populations is becoming increasingly significant.

CONCLUSIONS—A PLEA FOR BIGNESS AND MULTIPLICITY

Nature reserves should be as large as possible, and there should be many of them. The question then becomes how large and how many. There is no general answer. For many species, it is likely that there must be vast areas, while for others, smaller sites may suffice so long as they are stringently protected and, in most instances, managed. If there is a target species, then the key criterion is habitat suitability. Suitability requires intensive study, especially in taxa that contain species with narrow habitat requirements. In other cases, however, the historical presence of the species (ideally, there would be long-term observations of the population that establish its continuous existence at densities with a typical mean and variance) may have to suffice as evidence of suitability, especially for large, generalist herbivores and carnivores.

The requirements of appropriate habitat and of sufficient knowledge of the habitat may seem too obvious to mention. Nevertheless, this issue often is ignored, sometimes because of the financial and logistical difficulties in gathering the information. We would emphasise, however, that the entire argument over SLOSS, MVPs and minimum areas may be rendered irrelevant where ecological data are unavailable.

Habitat requirements for particular species may not be an issue if there are no target species, or if the goal is to protect biotic diversity *per se*, as in centres of endemism. Even for such situations, however, it is prudent to assume that keystone species exist. Such species are likely to include trophically or reproductively important plants (Gilbert, 1980) as well as the largest carnivores and herbivores in the community. Once we have a good idea of the habitat requirements for real or probable target species, we can deal more efficiently with the matter of how large refuges must be, and how many of them will be necessary.

For two reasons, the smallest site occupied by a species is not necessarily the minimum feasible refuge, even if the habitat is optimal. First, the probability of extinction in the reserve might be unacceptably high, especially if the available habitat in and around the area has contracted in historical time because of habitat destruction and disturbance. On the other hand, it is conceivable that even smaller sites might be able to sustain a population (Simberloff & Gotelli, 1984). In most cases, however, a detailed habitat study or historical records, combined with observed occupancy data, will provide evidence that persistence is unlikely in refuges below a certain size.

The matter of how many reserves must be established for a particular species is similarly difficult to deduce *a priori*, but historical records of population and even species extinctions brought about by many of the forces we have discussed above suggest that the prudent course would be to establish several refuges. Many 'contagious' agents of extinction—disease, fire, introduced predators—can devastate or annihilate a species in a single reserve. For example, in 1984 alone 20 of the remaining 60 Javan rhinoceroses *Rhinoceros sondiacus* have died of a disease of unknown etiology (Anon., 1984).

The issue of contagion and quarantine is relevant to the desirability of corridors between reserves. The obvious virtues of corridors include facilitating gene flow and dispersal of individuals between components of the reserve system. This, in turn, decreases the rate of extinction of semi-isolated groups (Brown & Kodric-Brown, 1977), increases the effective size of the populations, and the recolonisation rate of extinct patches.

The benefits of corridors must be weighed against their costs, and against the possibility that the corridors will not work. Rivers and riparian habitats are mentioned most frequently as sites for corridors. One problem is that many deep forest species may not venture into such habitats (Frankel & Soulé, 1981). For example, the red tree vole *Arborimus longicaudus* and the California red-backed vole *Clethrionomys* *californicus* would probably avoid riparian corridors between patches of mature Douglas-fir *Pseudotsuga menziesii* forest. A more serious problem is that corridors increase the exposure of animals to humans, increasing the amount of poaching and their exposure to disease harboured in domesticated species. They also negate the quarantine advantage inherent in a system of isolated reserves.

In any case, political and economic exigencies often will prevent the establishment of corridors. In the absence of natural or of effective artificial corridors, management must deal with local extinctions and with deficits in gene flow by transferring individuals, where necessary, and by founding new colonies. In general, decisions about corridors must be considered on a case by case basis.

This discussion of size, number and connectivity of refuges is obviously germane if our motivation is to conserve particular species. As we stated at the outset, however, there are two other conservation goals—maximising biotic diversity and maintaining functioning ecosystems—that are at least as important. These goals may also demand large refuges, since they will necessitate sizes large enough to maintain the MVPs of all the species in the system. The most vulnerable species will often be either the large predators or else those species that are characteristically rare, even in the habitats to which they are adapted. Large mammals, especially predators, are among the rarest in most systems (e.g. Eisenberg, 1980; East, 1981*a*,*b*). East's studies have shown that many of the large savanna carnivores do not attain census numbers over 100 in many of the great African parks. In addition, large mammals are often jeopardised by poaching and disease.

One may question the necessity of designing and managing reserves for the benefit of relatively rare species. There are sound ecological reasons, however, why their maintenance is often necessary. The interrelationships of species within ecosystems may be subtle yet important. Mutualisms such as pollination abound, and many plant species constitute the necessary habitat for certain animals. It is part of the conventional ecological wisdom that predation (Paine, 1966; Connell, 1971; Karr, 1982*a*) and herbivory (Darwin, 1859; Harper, 1969; Lubchenco, 1978; Hay, 1981) help to maintain species diversity by preventing competitive exclusion among prey species. Thus it may not be possible to save only certain common species in a community, even if we wanted to.

We are not saying that an entire community must be conserved if there is to be any conservation at all, especially in arid or cold regions. We are arguing, though, that saving the largest possible fraction of a community will usually facilitate saving any particular species. In addition, the ecological literature is rife with examples of recondite relationships among species that became apparent only when the decrease or disappearance of one has cascading detrimental effects on the others (Wilson & Willis, 1975; Raven, 1976; Gilbert, 1980; Terborgh & Winter, 1980). So prudence also dictates that we attempt to save the largest possible fraction of a community.

As a rule, then, we suggest it would be wise to design refuges to conserve large fractions of a functioning community whenever possible. Though rigorous and intensive management may allow small sites to maintain populations of certain species, others will require much larger sites, and the larger the site, the larger the fractions of the community that one can expect to persist. The probabilistic nature of most of the forces that threaten small populations, as well as the difficulty in deducing very good estimates of MVPs, also imply that the prudent course is to establish large refuges wherever possible. Finally, the probabilistic aspects of extinction militate for multiple refuges, as does the contagious nature of some of the extrinsic forces.

We are aware that much of the argumentation in this paper is moot in many places and circumstances. Not only is the protection of nature perceived to be an elitist luxury in many nations, but even in the best of circumstances, public policies affecting conservation programmes can change overnight, subject to the inevitable succession of regimes, whether accompanied or not by violence. On the other hand, there are good reasons for suggesting scientifically based guidelines and standards for the practice of conservation. Without them, pro-conservation individuals and groups, in and out of governments, hardly have a leg to stand on when competing for land and resources with powerful elements arguing for appealing, short-term or ill-conceived development activities.

Recent events in conservation biology also suggest that guidelines, whether accepted or not by one's peers, provoke further research and interest, thus accelerating both the pace of research in the discipline and the reaching of consensus on controversial matters. It is in this spirit—of faith in the scientific approach to conservation, of urgency in reaching consensus on vital issues—that we present this status report.

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POTENTIAL IMPACTS OF PROPOSED URBAN DEVELOPMENT ON RAPTORS IN THE MOLONGLO VALLEY, ACT

REPORT TO ACT PLANNING & LAND AUTHORITY

Stephen Debus PhD, Division of Zoology, University of New England, Armidale NSW 2351

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Executive summary

The Molonglo Valley is regarded as significant within Canberra city and the ACT for its diversity and abundance of raptors (birds of prey and owls). There are twelve species of raptor in the Valley, of which ten are breeding residents and two others may breed there. The raptor population living within Canberra is attributed to the amount of open space and bushland, the many parks and native plantings, the presence of wetlands, and the remoteness of river gorges that provide secure nest sites.

A proposal for new suburbs in the Valley is likely to remove some foraging habitat, food resources and breeding sites of seven species, disturb the breeding sites of several of these species in remaining woodland adjacent to the new suburbs, and disturb the nest sites of three species that breed or possibly breed in the Molonglo Gorge. Two species are likely to adapt to and live in the new suburbs.

Most of the affected species are among the most abundant, widespread and secure raptors in the ACT Region and beyond, and loss of a few pairs from within Canberra city is unlikely to compromise their regional conservation status. Two others, the aquatic Whistling Kite and White-bellied Sea-Eagle, are rare in the ACT. Any nest sites of the Kite or Sea-Eagle in the Molonglo Gorge (yet to be confirmed) may be disturbed by the proximity of new suburbs and human activity, but these two species are otherwise unlikely to be affected by the proposal.

Recommendations concerning planning and design of the new suburbs, for minimising impact on raptors, mainly concern maximising native tree and shrub cover within the development zone; maximising the amount of woodland retained in urban open space; maximising setback distances of development from the Molonglo River; maximising the width of the buffer zone along the Molonglo River corridor; and incorporating devices in the new suburbs to minimise raptor mortality from collisions with vehicles or infrastructure.

1. Introduction

This investigation and report is in response to the ACTPLA requirement for a case analysis concerning the raptors of the Molonglo Valley, their local and regional conservation status, and the potential impacts on them of proposed urban development. Because of their position at the top of the food chain, raptor populations and breeding success are indicators of ecological sustainability. This report:

- briefly outlines the diurnal birds of prey and owls of the study area and evaluates the species richness of this community;
- assesses the likely impacts of proposed development on the raptor species present;
- assesses the implications for conserving these species in the ACT Region; and
- makes recommendations, concerning design and planning issues, for minimising impacts on raptors.

2. Methods

The study area was inspected on 20 December 2004 under the guidance of Sally Kirkland (ACTPLA) and Dr Murray Evans (Environment ACT), with the aid of appropriate maps and aerial photographs showing vegetation cover, existing urban areas and boundaries of potential future urban areas. Boundaries from both the Canberra Spatial Plan, and as proposed in a draft suitability study being undertaken jointly by ACTPLA and the National Capital Authority (NCA), were delineated and considered.

The proposed development footprint consists of several discrete areas, designated for the purpose of this report as follows using the ACTPLA/NCA draft suitability study boundaries (see map):

Area 1 = largest, south-eastern block to the north-east of Mt Stromlo, in two halves bisected by the Molonglo River corridor. Bounded by William Hovell Drive, Tuggeranong Parkway, Cotter Road and Uriarra Road, and bisected by Coppins Crossing

Road. This area is former exotic pine plantation, destroyed by the recent ACT fires and now grassland.

Area 2 = north-west of Area 1 and to the north of the Molonglo River corridor, bounded by William Hovell Drive (west), Drake Brockman Drive and Stockdill Drive. This area is grassy open woodland, grassy paddocks and vineyards. A patch of dense woodland, adjoining a wildlife corridor of Yellow Box/Red Gum, occurs on the eastern boundary near the intersection of William Hovell Drive and Drake Brockman Drive.

Area 3 = small outlying area north-west of Area 2 and separated by Stockdill Drive. This area is sparsely treed, and mostly cleared in the north.

Area 4, 'deferred area' = area of grassy open woodland to the north of Mt Stromlo and west of Area 1, bounded by Uriarra Road to the south and the Molonglo River corridor to the north. This is the only area, other than part of Area 1, that is south of the Molonglo River. Area 4 was identified by ACTPLA as potential future urban area, but was excluded from the options considered in the ACTPLA/NCA draft suitability report.

The raptors of the Molonglo Valley, and their local and regional conservation status, were assessed on the basis of relevant literature (Barrer 1992, Olsen 1992, Taylor & COG 1992, Marchant & Higgins 1993, Higgins 1999, Fennell 2000, Veerman 2003, Olsen & Fuentes 2004). Relevant aspects of their local ecology were also taken from these sources, particularly Olsen & Fuentes (2004).

3. Raptors of the Molonglo Valley

The Molonglo Valley has been identified as an exceptional area within the ACT for its diversity and abundance of raptors, their habitats and prey species (Barrer 1992, Olsen & Fuentes 2004). The following raptor species have been recorded in the Molonglo Valley

(Taylor & COG 1992, Olsen & Fuentes 2004). Olsen & Fuentes (2004) listed nine breeding species, but they implied that a tenth (Black-shouldered Kite) also breeds in the Molonglo Valley, and it has been recorded breeding in outer urban Canberra (Barnes 2005). Asterisk (*) denotes breeding.

Hawks and eagles: *Black-shouldered Kite *Elanus axillaris*, Whistling Kite *Haliastur sphenurus*, White-bellied Sea-Eagle *Haliaeetus leucogaster*, *Brown Goshawk *Accipiter fasciatus*, *Collared Sparrowhawk *Accipiter cirrhocephalus*, *Wedge-tailed Eagle *Aquila audax*, *Little Eagle *Hieraaetus morphnoides*

Falcons: *Nankeen Kestrel *Falco cenchroides*, *Brown Falcon *F. berigora*, *Australian Hobby *F. longipennis*, *Peregrine Falcon *F. peregrinus*

Owls: *Southern Boobook *Ninox novaeseelandiae*

Of these, the Sea-Eagle is rare in the ACT, although not afforded special protection by ACT legislation. However, it is listed under the federal *EPBC Act* as subject to international agreements on migratory birds, as are all Australian members of the families Accipitridae (hawks, eagles) and Falconidae (falcons).

Most of the other species have been recorded breeding in the Molonglo Valley. Although the Whistling Kite has not been confirmed breeding in the area of concern, it has recently been found breeding near the Molonglo River in the north-east of the ACT (Fuentes *et al.* 2005).

There is only one alleged breeding record for the Sea-Eagle in the ACT, on the west bank of the Molonglo River below Shepherds Lookout (McWilliam & Olsen 2001). However, this nest, which is remote from the development proposal, may have been a misidentified Wedge-tailed Eagle nest as it has not been satisfactorily confirmed as Sea-Eagle (J. Olsen per. comm.). During the site inspection in December 2004 a large old (dilapidated, disused) stick nest, in the top of a large River She-oak *Casuarina cunninghamiana*, was seen in the Molonglo River gorge within Area 1. Because of the viewing distance and condition of the nest, it was difficult to determine whether it had been that of a Whistling Kite or Sea-Eagle, but the estimated size suggested possibly the latter. A nest of either species in the Molonglo Gorge would be significant in the local context.

Of the above species, the hawks and eagles build their own stick nests in patches of woodland, the falcons variously use old stick nests of hawks and ravens, or ledges on cliffs, and the Kestrel and Boobook use tree hollows. The Black-shouldered Kite, Kestrel and Brown Falcon can forage in treeless grassland by hovering, but the other raptors or their key prey species require at least some tree cover. The Boobook requires hollows or thick tree or shrub cover for daytime roosting. Of the above species, only the Sparrowhawk and Hobby can breed in suburbia, although the Brown Goshawk and Peregrine will forage in or over suburbia and the Boobook can forage therein if foliage cover exists and there is bushland nearby. The other species retreat from expanding surburbia, as it does not provide their prey, foraging habitats, nest sites or security from disturbance.

The diversity and abundance of raptors within Canberra city is attributable to the generous amounts of open space and bushland distributed within and between clusters of suburbs, the many parks and native plantings, the presence of wetlands, and the remoteness (from suburbia) of the Murrumbidgee and Molonglo Gorges that provide secure nest sites for cliff-nesting or shy species.

4. The Molonglo raptors in context

Defining the raptor community within Canberra is a function of where the city limits are drawn, in relation to non-urbanised land adjoining existing suburbs. The few other temperate-zone Australian capital cities studied in this respect have comparable raptor assemblages on their periphery, though fewer species recorded breeding (Baker-Gabb 1984, Starr *et al.* 2004).

The Molonglo Valley supports almost all of the regularly occurring and breeding raptors of the ACT, the exceptions being the Swamp Harrier *Circus approximans* that breeds on large wetlands and the Powerful Owl *Ninox strenua* that occurs and breeds in the forested ranges of Namadgi National Park and Tidbinbilla Nature Reserve (Taylor & COG 1992, Veerman 2003). The Barn Owl *Tyto alba* probably also breeds in the Molonglo Valley and similar parts of the wider ACT, and the Masked Owl *Tyto novaehollandiae* may breed in the same areas as the Powerful Owl, but there has been insufficient survey work to confirm these possibilities.

The breeding raptor community of the Molonglo Valley is typical of the assemblage that may be expected in other lower-elevation, woodland and rural areas of the ACT and adjoining parts of the NSW tablelands (Taylor & COG 1992, Barrett *et al.* 2003). Within the ACT, raptor species richness is concentrated in the drier, lower-elevation, open forest, woodland and grassland areas in the north and east of the ACT outside the urbanised areas (Taylor & COG 1992). The concentration in the Molonglo Valley and similar areas, such as the Murrumbidgee and lower Gudgenby/Naas Valleys, is attributable to the presence of rivers flanked by open and wooded habitats. According to reporting rates of raptor species in Taylor & COG (1992), the raptor diversity of the Molonglo Valley is unexceptional within the ACT Region, but the concentration of breeding species in the Molonglo Valley is noteworthy (Olsen & Fuentes 2004).

5. Likely impacts of proposed development

Predicted impacts on raptors are presented in Table 1, rated by the degree of likely impacts on foraging habitat, food resources, breeding sites, and the species' susceptibility to disturbance. On the basis of those predictions, the response of each species is discussed below in terms of whether they are likely to abandon breeding territories (i.e. pairs are lost), only visit suburbs on foraging forays, or remain and breed within the proposed new suburbs. The species are here ranked in order of expected level of impact.

Species minimally affected

Collared Sparrowhawk: likely to remain and breed within suburbia.

Australian Hobby: likely to remain and breed within suburbia.

Species moderately affected

Whistling Kite: a mainly aquatic species locally, largely restricted to the Molonglo River. Likely to be unaffected unless suburbia and human activity encroach close to nest sites in the Gorge. Non-breeding individuals may still visit the river to forage.

White-bellied Sea-Eagle: an aquatic species, restricted to the Molonglo River; breeding is adversely affected by human disturbance. Likely to abandon breeding sites in the Gorge if suburbia and human activity encroach on the river. Non-breeding individuals may still visit the river to forage.

Peregrine Falcon: likely to abandon nest sites in the Molonglo Gorge if suburbia encroaches and human activity increases in the Gorge. Individuals are likely to visit suburbs to forage aerially. May also roost or breed on very tall structures (towers, office blocks) in urban areas.

Species most affected

Black-shouldered Kite: Valley population likely to be reduced commensurate with the area of tall grassland converted to suburbia. Individuals may visit extensive areas of rank grass within suburbia to forage.

Brown Goshawk: Valley breeding population likely to be reduced commensurate with the area of woodland converted to suburbia. Some pairs in adjoining bushland may also abandon breeding territories if human activity increases there. Individuals are likely to visit well-vegetated suburbs to forage.

Wedge-tailed Eagle: Valley population likely to be reduced commensurate with the area of woodland converted to suburbia. Adversely affected by human disturbance near nest sites. Pairs in woodland near expanding suburbia and increasing human activity are also likely to abandon nest sites.

Little Eagle: Valley population likely to be reduced commensurate with the area of woodland converted to suburbia. Also likely to retreat from woodland near expanding suburbia and human activity, though breeding pairs are more tolerant than Wedge-tailed Eagle.

Nankeen Kestrel: Valley breeding population likely to be reduced commensurate with the area of woodland and grassland converted to suburbia. Individuals may visit extensive open areas within suburbia to forage, or to roost on tall structures within urban areas near foraging sites.

Brown Falcon: Valley population likely to be reduced commensurate with the area of woodland and grassland converted to suburbia. Some pairs in land adjoining suburbia may also abandon breeding territories if human activity increases there.

Southern Boobook: Valley breeding population likely to be reduced commensurate with the area of woodland converted to suburbia. Individuals are likely to visit well-vegetated suburbs to forage.

On the basis of predicted impacts on raptors, it is also predictable that Area 1 (largely treeless former pine plantation) would have least impact, affecting mainly the common grassland species (Black-shouldered Kite, Kestrel, Brown Falcon), and perhaps the Whistling Kite or Sea-Eagle where development is close to the river. Impact would increase incrementally with the development of Area 2 (woodland), Area 3 (open woodland) and Area 4 (open woodland), affecting also the woodland species and a further section of river near the southern extremity of Area 2. Impact on the Molonglo Gorge would increase with the addition of Area 4, as the length of river having suburbia on both sides would be increased.

6. Conservation implications for ACT raptors

Predicted effects on the regional conservation status of raptors are presented in Table 2, according to their abundance and the likely effect of the proposal on their local population trend. Most species are common and widespread, but are likely to decline locally in the Molonglo Valley with urbanisation. Two (Whistling Kite and Sea-Eagle) are rare and local but may decline little if at all, and one common species (Peregrine Falcon) may also decline little. Two others (Sparrowhawk and Hobby) are common and may benefit from urbanisation. Further justification for these conclusions is given below.

Apart from the Whistling Kite and Sea-Eagle, the other raptors of the Molonglo Valley are the most numerous and widespread raptor species in the ACT (Taylor & COG 1992, Fennell 2000, Veerman 2003). All twelve species are distributed Australia-wide (the Sea-Eagle peripherally, though extending far inland in NSW), and are common in south-eastern Australia, New South Wales, and in the South Eastern Highlands Bioregion that contains the ACT (Marchant & Higgins 1993, Barrett *et al.* 2003).

Given the likely responses of the raptor species to encroachment of suburbia (Olsen & Fuentes 2004), it is likely that the development proposal will remove the foraging habitat and nest sites of several pairs each of Black-shouldered Kites, Brown Goshawks, Kestrels, Brown Falcons and Boobooks, and one or more pairs of Wedge-tailed Eagles and Little Eagles, and so displace some pairs of these species. Proximity of suburbia, and hence human disturbance encroaching on the Molonglo Gorge, could cause Whistling Kites (one pair?), Sea-Eagles (one pair?), Brown Goshawks (several pairs), Wedge-tailed Eagles (2-3 pairs) and Peregrines (two pairs) to abandon nesting territories in the Gorge. Conversely, it is likely that Sparrowhawks and Hobbies would establish breeding pairs in new suburbs, in woodlots and parks (Sparrowhawk) or in raven nests in tall trees and artificial structures (Hobby).

Given the local significance of the Molonglo Valley for raptors, loss of several pairs of most of these species would reduce the total number of pairs, and hence the diversity and abundance, of raptors within the Canberra city limits. The more common species (Black-shouldered Kite, Brown Goshawk, Kestrel, Brown Falcon, Boobook), that forage and breed in the woodland and grassland habitats within the development footprint, are likely to be affected the most. However, loss of a few pairs from Canberra is unlikely to compromise their conservation status within the wider ACT or the South Eastern Highlands Bioregion. These species, and most of the others except Whistling Kite and Sea-Eagle, are well represented in the ACT outside the Canberra urban area (Taylor & COG 1992). However, it is noted that most are likely to be more numerous in lowland, rural parts (i.e. unprotected lands) of the ACT, subject to ongoing development pressures, than in the rugged, forested ranges of Namadgi National Park or Tidbinbilla Nature Reserve. These reserves are likely to conserve populations of Brown Goshawks, Sparrowhawks, Wedge-tailed Eagles, Peregrines and Boobooks, but few individuals of the other relevant species which mainly inhabit woodland, grassland or wetland at lower elevations.

7. Recommendations for mitigation of impact

As well as potential loss of foraging habitat, food resources and breeding sites, and an increase in human disturbance to adjacent areas, aspects of urbanisation may increase the likelihood of raptor mortality through collision hazards such as wires and vehicles, and predation on the smaller species (e.g. owlets) and raptor prey by domestic or stray cats.

The following recommendations for planning and design are made with a view to minimising the various direct and indirect effects of urbanisation on the local raptors and their habitats, and maximising the retention of prey species and other raptor resources within the planned suburbs.

i. Pre-development survey to identify nest sites of the Whistling Kite and Sea-Eagle in the Molonglo Gorge, and provide a generous setback from the Gorge for any development in their vicinity;
ii. Clearing of development sites only in the non-breeding season for raptor species;
iii. A tree-preservation order in the development footprint, to as far as practicable retain some mature native trees on building blocks (and make established tree cover a positive marketing point?);
iv. Incorporate areas of dense woodland (e.g. in Area 3) into urban open space;
v. Designate low-use zones of urban open space adjacent to woodland raptor habitat and near the Molonglo Gorge (discourage human activity, e.g. no facilities or tracks, leave the outer periphery of open space ‘rough’ for prey populations);
vi. Provide a generous setback from the Molonglo River in Area 1 where the development footprint crosses the river;
vii. Increase the setback from the Molonglo River at the southern extremity of Area 2;
viii. Refrain from developing Area 4;
ix. Install all new utility wires (e.g. powerlines) underground;
x. Enforce a ban on free-range domestic cats (i.e. development controls regarding confinement of domestic cats in new suburbs);
xi. Install traffic-calming devices in new suburbs;
xii. Increase the width of the buffer zone along the river corridor;
xiii. Rehabilitate drainage lines, and the Molonglo River from Lake Burley Griffin to Area 1, with native riparian vegetation and streamside buffers;
xiv. Protect the water quality of the Molonglo River by appropriate treatment of urban run-off from the proposed suburbs;
xv. Encourage public amenity plantings of local native trees and shrubs;

xvi. Provide incentives for planting of local native trees and shrubs in suburban gardens.

There are no empirical data on appropriate radii for buffer zones around nests of Australian raptors, and few for equivalent species in other countries. Relevant buffer zones recommended for active nests of species in the same genus, or possibly equivalent genera, are as follow (from Richardson & Miller 1997). The range and mean or mode are given, and apply to the duration of the breeding cycle.

Sea-eagles *Haliaeetus*: 250–800 m (550 m).
Goshawks *Accipiter*: 400–600 m (400–500 m).
Large eagles *Aquila*: 200–1600 m (800 m)
Hawks *Buteo* (≈ large kites *Haliastur*/small eagles *Hieraaetus*?): 200–800 m (570 m)
Peregrine Falcon: 200–1600 m (lower values apply to cliff tops; 800 m)
Kestrels: 50–400 m (200 m).

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Table 1. Predicted impacts of the proposed development on raptors in the Molonglo Valley. FH = extent of foraging habitat, FR = availability of food resources, B = availability of breeding sites, D = human disturbance. Degree of impact: H = high, M = medium, L = low, C = co-existence (i.e. tolerant of urbanisation). *Aquatic species largely restricted to Molonglo River. **Nesting restricted to cliffs in Molonglo Gorge.

Species	FH	FR	B	D
Black-shouldered Kite	H	M	H	L
*Whistling Kite	L	L	L	M
*White-bellied Sea-Eagle	L	L	L	H
Brown Goshawk	M	M	H	H
Collared Sparrowhawk	C	C	C	C
Wedge-tailed Eagle	H	H	H	H
Little Eagle	H	H	H	M
Nankeen Kestrel	H	M	H	L
Brown Falcon	H	M	H	H
Australian Hobby	C	C	C	C
**Peregrine Falcon	M	L	L	H
Southern Boobook	M	L	H	L

Table 2. Predicted effects of the proposed development on the conservation status of raptors in the Molonglo Valley. SH = Southern Highlands Bioregion; Impact = likely population trend in the Valley if proposal proceeds. CW = common/widespread; RL = rare and local; D = decline; S = stable; I = increase.

Species	ACT	SH	NSW	Local impact
Black-shouldered Kite	CW	CW	CW	D
Whistling Kite	RL	W	CW	S/D
White-bellied Sea-Eagle	RL	W	CW	S/D
Brown Goshawk	CW	CW	CW	D
Collared Sparrowhawk	CW	CW	CW	S/I
Wedge-tailed Eagle	CW	CW	CW	D
Little Eagle	CW	CW	CW	D
Nankeen Kestrel	CW	CW	CW	D
Brown Falcon	CW	CW	CW	D
Australian Hobby	CW	CW	CW	S/I
Peregrine Falcon	CW	CW	CW	S/D
Southern Boobook	CW	CW	CW	D

RAPTORS AND THE PROPOSED CENTRAL MOLONGLO DEVELOPMENT

Stephen Debus

Zoology, University of New England, Armidale, NSW 2351

The subject of raptors in the Molonglo Valley, and the potential effects of development of the Central Molonglo precinct on raptors, has been controversial. As the author of one report (Debus 2005) and field surveyor and principal author of a second report (EA Systems 2006), it might help to provide some commentary and a revised assessment of some issues in the light of recent data. Some explanation is required, because those reports have been used to justify the proposed development or suggest minimal impact on raptors, but for a few species (notably the Little Eagle *Hieraaetus morphnoides*) the situation has changed in recent years. The Little Eagle is now listed as Vulnerable in the ACT, which supersedes statements that none of the raptors in the Molonglo Valley is threatened.

The survey and reports were principally targeted at icon and ‘umbrella’ species (White-bellied Sea-Eagle *Haliaeetus leucogaster*, Wedge-tailed Eagle *Aquila audax* and Peregrine Falcon *Falco peregrinus*), with the realisation in 2005 that the Little Eagle should be included in this category. The brief for the 2006 report was, on the basis of field survey, to suggest adjustments to the proposed development footprint, and to make other recommendations, in order to minimise impacts on raptor nest sites.

We now know that the Little Eagle population in the ACT has crashed from 13 breeding pairs to two known pairs that did not breed successfully in 2005-06 (Olsen and Fuentes 2005; Olsen and Osgood 2006), and its reporting rate has about halved in south-eastern NSW since the 1970s (NSW Bird Atlas data): results that invalidate some of the statements in my 2005 report. That’s the nature of science; previous conclusions must be rejected when new data show them to be wrong. Furthermore, in 2007, the last Little Eagle breeding territory in the Lower Molonglo Valley was abandoned, and intensive survey found only three pairs, that raised four young between them, in the entire ACT (Olsen et al. 2008).

In my second report (EA Systems 2006) there were caveats about the number of breeding pairs of raptors being underestimated because of the survey limitations (e.g. a single survey week in October, partly in bad weather, when some pairs may have already failed). We also now know that Little Eagle sightings and nests interpreted as possibly two pairs were in fact referable to a single pair (Olsen and Fuentes 2005; Olsen and Osgood 2006). Therefore, the Little Eagle map in my report (which is labelled ‘approximate’ and only shows areas where the birds were actually seen foraging) is a gross underestimate of total foraging range; they are probably 'snapshot' points in a single home range. Little Eagle home ranges in the ACT are likely to be considerably larger than previous published densities of 16-27 km^2 per pair obtained in the 1980s (Marchant and Higgins 1993). I agree with Olsen and Fuentes (2004) and Olsen et al. (2008) that radio-tracking would be required in order to delineate foraging ranges accurately.

I did not, in either report, state or imply that the highest value habitat for raptors in the Molonglo Valley is located only in the Molonglo River gorge (i.e. downstream from Coppins Crossing), which is not directly affected by the proposed development. What I did say (EA Systems 2006) is 'locally important areas within the Molonglo Valley for breeding raptors are the Molonglo riparian corridor; *dense woodland patches bounded by the river, Coppins Crossing Road, William Hovell Drive and Stockdill Drive* [my emphasis]; and the Murrumbidgee confluence area'. I also said (2005) 'The concentration [of raptors] in the Molonglo Valley … is attributable to the presence of rivers *flanked by open and wooded habitats*' [my emphasis]. It is true that most raptor nests were found in the riparian zone, which I take to be the trees on the river banks, but if one includes cliffs in the definition then Peregrines also nest in the riparian zone.

I did not say (in EA Systems 2006) that the Wedge-tailed Eagle, Brown Goshawk *Accipiter fasciatus* and Brown Falcon *Falco berigora* were dependent on the riparian zone for foraging. The maps clearly show observed foraging areas, and predicted minimum foraging areas, for the eagle and falcon extending well beyond the riparian zone, and half of the observed goshawk nests, and one foraging area, well away from the riparian zone. I flagged three woodland remnants along William Hovell Drive, Drake-Brockman Drive and Stockdill Drive (all on the south side of these roads) as important foraging and breeding habitat. The map of Molonglo raptor nests and foraging areas produced by ACTPLA (2007) omits the indicative minimum home ranges for Wedge-tailed Eagle and Brown Falcon shown in the EA Systems report (2006). In that report I used published densities and inter-nest distances (Marchant and Higgins 1993) to draw a 3 km radius (~30 km^2) around the two eagle nests and 1.3 km radius (~4 km^2) around the falcon nests, and said in the text that these would be minimum foraging ranges with the likelihood of larger and overlapping foraging ranges; these circles effectively covered most of East and Central Molonglo.

Both of my reports are tempered in several places with caveats about the need for adequate foraging habitat around nest sites. For instance, in 2005, I said 'The [more sensitive] species retreat from expanding suburbia, as it does not provide their *prey, foraging habitats*, nest sites or security from disturbance' [my emphasis], and 'the development proposal will remove the foraging habitat … of … one or more pairs of

Wedge-tailed Eagles and Little Eagles, and so displace [effectively eliminate] some pairs'. The 2006 report reinforced the points made in the 2005 report.

My reports and survey were completed without knowledge of the subsequently announced dam proposal on the Molonglo River. Discussion of potential impacts therefore omits reference to any likely impacts, including the possibility of drowning one occupied Wedge-tailed Eagle nest, and inundation of raptor breeding and foraging habitat and prey resources.

People concerned about the Molonglo Valley raptors are encouraged to obtain my reports under freedom of information provisions, and compare what I said with what apologists for the development are saying (or implying I said), bearing in mind more recent data on the raptor populations (e.g. Little Eagle). The executive summary of the 2006 report concludes by saying 'It should be noted that any assessment of actual impact on raptor species from development would require a much more in-depth study'. The 2006 report also makes many recommendations for minimising impacts on raptors, including protecting the woodland remnants in Central Molonglo. Finally, among the other threatened birds admitted by the Preliminary Assessment (ACTPLA 2007) to occur in the woodland remnants in Central Molonglo, there is no mention of the Superb Parrots *Polytelis swainsonii* that I reported (EA Systems 2006) in the woodland patch adjoining the historic cemetery on William Hovell Drive.

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Little Eagles in the ACT

Stephen Debus
Zoology, University of New England, Armidale, NSW 2351

Here I consider several matters pertinent to the discussion about the potential impact of urban development on the pair of Little Eagles recently breeding at Strathnairn.

The adequacy of a 200 m buffer around the nest

This figure was drawn from a report I prepared for ACTPLA in late 2005 (released in 2006). However, the buffer figure I gave (as explained in my 2006 report) was a range of 200 to 800 m (average 570 m) for surrogate overseas species of similar size and/or ecology, in the absence of data on Australian species. Therefore, the 200 m is a bare minimum and an honest appraisal would have discussed or included the range of buffer radii (up to 800 m) given, and the average (570 m). Furthermore, the context for buffers in the review paper that I consulted (Richardson & Miller 1999) was primarily the avoidance of acute, direct human disturbance, intrusion or presence on raptors nesting in otherwise natural or semi-natural situations (i.e. their flushing response to human approach), not the preservation of nesting populations in the face of major landscape-changing developments such as urbanisation. The officially released version of my 2006 report deleted (ignored) my conservative assessment of likely foraging areas around nests identified at the time. An implicit (though not stated) assumption in my report to ACTPLA was that any urbanisation would approach nesting raptors in the Molonglo Valley from one side only, i.e. extend from existing suburbs and leave the remaining sides undeveloped, and not completely surround nests except for a 200 m exclusion zone. Science is iterative, therefore the 200 m buffer should not be seen as final and irrevocable, but should be open to modification in the light of new knowledge in the past 10 years. This is especially the case if, post-2006, a 200 m buffer is scientifically determined to be inadequate for Little Eagles in the context of landscape-changing urbanisation.

Raptor home ranges

Natural or semi-natural (e.g. grazing rangeland) landscapes can be thought of as 'raptor real estate' of varying quality, occupied by a succession of individuals that at any given time represent the 'owning' pair. That is, over time there is a turnover of birds. Home ranges (foraging ranges, within which there may be alternative nest sites) can vary in size and shape, depending on site productivity (available resources), presence or absence of neighbours of the same species, competing species etc. The location of nest sites and boundaries may change over time, as individuals or environmental circumstances change. Superimposed on the territorial mosaic are 'floating' birds (immature or subadult): pre-breeders looking for a vacancy but meanwhile existing in areas substandard for breeding and/or on the edge of occupied and defended home ranges. Floaters become conspicuous at the start of the breeding season as they prospect for potential nest sites within the existing territorial mosaic, but sightings of them, including near possible stick nests, does not mean that they can or do breed.

The Strathnairn Little Eagle home range

The resident male was the first adult Little Eagle to be radio-tracked, after his breeding attempt that year failed. The results found a larger home range than anticipated, for several possible reasons: (i) he needed a large, elongated foraging range around the urban fringe in order to survive; (ii) the neighbouring pair had disappeared, allowing him to extend into their former range unchallenged; (iii) his non-breeding home range was larger than might have been if he had a dependent juvenile to support, i.e. he was free to wander more widely. His winter migration to the NT was likely true migration, i.e. if he survives the hazardous journey he is likely to return to the same territory and attempt to breed there again, if his home range is still intact. Whether he survives and returns or not, his home range (if still substantially unaltered by urbanisation) will be (re)occupied either by him or a successor.

Regarding the alleged absence of a Little Eagle nest in the Kama woodland, which is part of the Strathnairn home range, my 2006 report in fact identified a possible Little Eagle nest in the adjoining woodland towards the junction of William Hovell Drive and Drake-Brockman Drive, only 2 km away and well within a Little Eagle's flight distance from Kama.

Post-2005 data on Little Eagles

Data on Little Eagles, including their response to urbanisation, were limited in 2005. In a subsequent series of studies I documented, among other things, the response of Little Eagles to expanding residential and rural-residential developments around Armidale, NSW (Northern Tablelands, similar environment to Canberra). I found that urban expansion displaced some pairs, and caused others to shift their nest site (Debus *et al.* 2007; Debus & Ley 2009; Debus 2011) – these developments being on a smaller scale (new subdivisions rather than whole new suburbs) than around Canberra.

Data on an equivalent species

A study on a closely related species, the Booted Eagle *Hieraaetus pennatus*, recommended a buffer of at least 1 km around nests (López-López *et al.* 2016), in a probably more productive Mediterranean landscape in Spain than around Canberra. Booted Eagles in Spain have home ranges of 88–233 km^2 and 10–20 km across (Martínez *et al*. 2007), larger than the sole short-term value of 65 km^2 for the ACT. This would suggest the need for a more conservative approach in the ACT, and the likelihood that over the course of a year the Strathnairn male's home range would be more than 65 km^2.

The Little Eagle's status in NSW

The Little Eagle is now known to show a corresponding (to the ACT) decline in adjoining NSW. It is listed as Vulnerable in NSW, and recent trends there now indicate likely Endangered status in NSW as well as the ACT (i.e. greater than 50% decline in index of abundance in three eagle generations). A large data set for NSW, from 1986 to 2006, found a 70% decline in reporting rate over 20 years in NSW overall (Cooper *et al.* 2014). Thus, it can no longer be assumed that NSW provides a ready reservoir of Little Eagles for supporting the ACT population.

Pindone

A consequence of nearby urban development is the likelihood of secondary poisoning of breeding Little Eagles and their offspring by pindone, used to control rabbits in peri-urban areas where, for human and pet safety reasons, 1080 cannot be used (Olsen *et al.* 2013).

The impact of urbanisation on the Strathnairn Little Eagles

Given current knowledge on the Little Eagle and its ecological requirements, it is a reasonable prediction, based on available scientific evidence, that urbanisation of the Strathnairn home range will displace (and hence eliminate) that pair, because other available home ranges of sufficient quality are occupied by other pairs of Little Eagles or by Wedge-tailed Eagles. If the Strathnairn male returns from his migration to the NT and finds his home range alienated by urban development, he would be unlikely to be able to settle there or breed. Thus, progressive urbanisation of Little Eagle territories will continue the decline in the number of pairs able to breed, and their breeding productivity, in the ACT.

Jerry Olsen's evidence

Jerry Olsen's evidence is based on empirical field data and current science on raptor (and especially Little Eagle) population ecology and behaviour, and there is nothing in his documentation of the situation, or his critique of current ACT urbanisation policy, that I can fault or disagree with.

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Reports & News

Little Eagles in the Australian Capital Territory during two breeding seasons: 2015 and 2016, and the myth of 'buffers' and 'corridors'

Previously we reported on the collapse of breeding Little Eagles *Hieraaetus morphnoides* in the ACT from about 13 territories in the 1980s and 1990s to one to four breeding territories, depending on the year, between 2005 and 2014 (Olsen *et al.* 2015). Causes of the decline could be the use of the poison Pindone to control rabbits, or breeding Wedge-tailed Eagles *Aquila audax* displaced from other locations and displacing Little Eagles, but mainly suburban development in the northern ACT. Little Eagles have not been found breeding in heavily forested Namadgi in the southern ACT, but breed mainly in open forest and woodland in the north, areas susceptible to urban sprawl.

Radio-tagged juvenile Little Eagle at Strathnairn, as a nestling and just fledged. This bird and its parents were never seen foraging within 200 metres of the nest site. Photo—S. Trost & J. Olsen

Results

In the two breeding seasons, 2015 and 2016, breeding attempts (eggs or young) were reported to us for Little Eagles in the ACT. The total across the ACT was one fledged young from two active nests in 2015 (Campbell Park and Strathnairn), and one fledged young each from two active nests in 2016 (Campbell Park and Strathnairn). That translates to 0.75 young per territory per year, low productivity for this species (Olsen 2014), even compared to recent years such as 2008 when a total of four young were fledged from four breeding territories in one year (Olsen *et. al.* 2009).

Because Wedge-tailed Eagles might usurp Little Eagles breeding territories, we monitor as many Wedge-tailed Eagle territories as possible near Canberra. In 2016 we checked nine Wedge-tailed Eagle territories close to the city. In contrast to Little Eagles, they fledged a total of 11 young, 1.2 young per territory per year, high productivity for this species (Olsen 2014).

Discussion

Little Eagles still breed at low levels in the ACT, but because of increased urbanisation, and, possibly, Pindone, and interference from Wedge-tailed Eagles, Little Eagle breeding success is poor.

Property developers have set up 'buffers' around eagle nests, including the Little Eagle nest at Strathnairn. The developers claim that no development, including infrastructure and construction-related activities, is permitted within 200 m of the Little Eagle nesting tree and immediate foraging area. This is junk science. 'Buffers' set around raptor nests by ACT real estate developers and government planners are not based on evidence. The buffers are arbitrary, always too small, and set to advantage land developers, not eagles.

In *Australian High Country Raptors* JO said (page 232), "Three concepts need to be mentioned that can help a developer more than raptors. A **buffer** set around an active eagle nest is often of little use because the buffers are too small, and they don't consider the size of the whole home range and how eagles move nests sites as far as 5 km within a breeding home range. Buffers may stop some disturbance for a short time, but free developers to destroy foraging habitat and areas for alternative nests, so the eagles eventually abandon the area. **Corridors** set in the ACT, said to link areas of habitat, are usually too narrow to sustain pairs of eagles, so eagles will eventually be lost in these areas, unless adjoining farmland outside of the corridor is kept free from development. **Trade-offs**, where bodies claim to retain, for example, an area of box woodland in one place if they can destroy it in another place, are often a form of sleight-of-hand because both areas of woodland should be retained, not one. These trade-offs or offsets rarely trade like for like, and can't truly be offsets unless new habitat is created, which takes decades."

These myths about 'buffers', 'corridors' and 'trade-offs' are hard to kill off. Land developers love them. And the problem is, ACT developers always find a compliant ecologist who, for pay, will support these bogus notions, and pretend there is evidence to back them, though no evidence is ever produced. This happened with the Strathnairn Little Eagles. The eagles were never seen foraging within 200 m of their nest. This was a foraging -free-zone. So developers set up a buffer area in a 200 m radius of the nest to protect the area for foraging (in the area Little Eagles were never seen foraging). Stephen Debus (pers. comm.) has never seen Little Eagles foraging within 200 m of the Little Eagle nests he studied.

We did see Little Eagles foraging outside of this 200 m 'buffer' zone, in areas now being destroyed by developers and the government to build suburban residences.

Reports & News

And developers cannot buffer the Strathnairn Little Eagles from disturbance because these Little Eagles are only 50 metres from a major public facility, the Strathnairn Homestead Gallery. The Gallery has regular public functions that can be noisy. The people and noise haven't deterred the Little Eagles, but loss of foraging habitat outside of the 200 m buffer zone, we believe, will deter them. We suspect that Little Eagles routinely nest close to houses in the ACT and nearby New South Wales as protection from Wedge-tailed Eagles, which don't nest so close to houses.

There is a good reason why eagles forage less frequently close to their nests. Prey animals, such as rabbits, magpies or corvids, close to the Little Eagle nest, learn the habits of the nesting eagles, so the element of surprise is lost. So most hunting is done at some distance from the nest, where eagles can surprise prey, and carry it back. 'Corridors' matter little to the eagles we study in Canberra because eagles can carry prey over houses to their nests, and we've seen them do this. What eagles need is extensive home-range areas to hunt in. And these areas are being destroyed while 'corridors' and 'offsets' are being offered up as sweeteners, 'corridors' and 'offsets' that are substandard for Little Eagle breeding. The 'corridors', 'buffer zones' and 'offset areas' give limited foraging opportunities, and some are within the home ranges of hunting Wedge-tailed Eagles. So we have predicted that this Strathnairn Little Eagle home range will eventually be abandoned because suburban development there will destroy foraging areas.

A buffer around a Little Eagle nest, meant to protect the eagles from disturbance, and maintain foraging areas, should be a minimum of 1 km radius from the nest if the buffer is based on similar species such as the Booted Eagle *Hieraaetus pennatus* in Spain (López-López *et al.* 2016, *Journal of Ornithology* DOI 10.1007/s10336-016-1357-z), and it should be more than 2 km away from breeding Wedge-tailed Eagles, to protect them from these larger eagles in the ACT where numbers of macropod prey are artificially inflated and benefit breeding and non-breeding Wedge-tailed Eagles. The situation may be different in other parts of Australia.

Acknowledgements
Thanks to Stephen Debus for helpful comments, and to COG members, especially Martin Butterfield, Rosemary Blemings, Con Boekel, Steve Holliday, Chris Davey, Barbara Allan, Michael Lenz, Peter Christian, Roger Curnow, Rod Mackay and Graeme Clifton. Thanks also to Rob Armstrong, James Overall, Bernd Gruber, Renee Brawata, Kym Bradley, Tom Long, Michael Maconachie and McComas Taylor, who gave much appreciated advice. Thanks to the ABBBS and David Drynan for assistance with eagle bands.

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Jerry Olsen and Susan Trost

Canberra Wedge-tailed Eagle surveyed in 2016
Photo—S. Trost & J. Olsen

BirdLife Australia's EagleCAM

As at 21 January there was no more news about juvenile SE17 [since 16 Dec. – see last issue]. The adults have been coming to the nest again from time to time and are seen regularly on the river.

As at 19 May, the Sea-Eagle pair were repairing and preparing their nest for new eggs. There was extensive damage to a camera and other data and electrical equipment that is essential for the sea-eagle cam to record and broadcast.

Our volunteers have been working feverishly installing replacement equipment and testing connections to make sure that the Eagle-Cam is working; they don't want to interfere with nesting activity.

As at 17 June, the eagles are on the nest and preparing for eggs. The cameras and equipment have been replaced and/or repaired and are running, though still without sound.

Thank you for all of your efforts and support: Judy Harrington, Stephen Davey, Geoff Hutchinson, Cathy Cook, Helen Stibbs, Shirley McGregor plus many more at home and abroad. Thank you to those generous donors who have contributed much-needed funds to help with the replacement and repair costs. Please click on the following link to view the EagleCam: http://www.sea-eaglecam.org/video.html

from BirdLife Southern NSW
e-news 21.01.2017, 19.05.2017, 17.06.2017

Canberra Bird Notes 42(2) (2017):134-139

LITTLE EAGLES IN THE AUSTRALIAN CAPITAL TERRITORY DURING TWO BREEDING SEASONS: 2015 AND 2016

JERRY OLSEN[A, B], SUSAN TROST[C] AND GEOFFREY DABB[D]

[A]*Institute for Applied Ecology, University of Canberra, ACT 2601, Australia*

[C]*44 Wybalena Grove, Cook ACT 2614, Australia*

[D]*24 Brockman Street, Narrabundah, ACT 2604, Australia*

[B]*To whom correspondence should be addressed. Jerry.Olsen@canberra.edu.au*

Abstract. *In two breeding seasons, 2015 and 2016, breeding attempts (eggs or young) were reported to us for Little Eagles in the ACT. Strathnairn fledged no young in 2015 and 1 in 2016. Campbell Park fledged 1 young in 2015 and 1 in 2016 making a total of 3 young across two breeding seasons. In contrast, Wedge-tailed Eagle territories we checked near the city in 2016 fledged 11 young from 9 territories.*

1. Introduction and Methods

In previous reports (*e.g.* Olsen *et al*. 2010) we discussed the collapse of breeding Little Eagles *Hieraaetus morphnoides* in the ACT and possible links to suburban development and breeding Wedge-tailed Eagles *Aquila audax*. Here we present data for the 2015 and 2016 breeding seasons. Methods followed those used in Olsen *et al*. (2010).

2. Results

2.1. Little Eagle

Black Mountain: The nests on Black Mountain (Con Boekel northern side, J. Olsen unpublished data for the southern slope of Black Mountain) were not used.

Campbell Park/Jerrabomberra Wetlands: The territory near Campbell Park Offices (Michael Lenz) fledged 1 young in 2015 and 1 in 2016 (Fig. 1).

Lions Youth Haven: The Little Eagle pair at Lions Youth Haven in Kambah (Nick Webb) was not present however a pair of Wedge-tailed Eagles was resident on this territory and they fledged 1 young in 2015 and 1 in 2016.

Dunlop and Strathnairn: The Little Eagle nest at Dunlop (Roger Curnow) was not used. The nest at the Strathnairn Art Galleries (Peter Christian) failed in 2015 and fledged 1 young in 2016, about three weeks later than is normal for this territory, and for other Little Eagles in the area. Late breeding pairs of raptors are generally less successful than early breeders, and their fledglings have lower survival (Newton 1986). The last date we saw the Strathnairn fledgling was 4 Feb 2017 (Rosemary Blemings).

In 2015, after the Strathnairn nest failed, JO banded and radio-tagged the adult male. In the first weeks this male ranged from Uriarra East on the Murrumbidgee River in the south to the CSIRO Field Station near Fraser and Spence in the north, the home range previously used by the North ACT Little Eagle pair (see below and Figure 1).

Figure 1. Campbell Park fledgling (*Geoffrey Dabb*).

<u>North ACT</u>: A Little Eagle pair reported to us at the CSIRO Field Station in 2014 was checked by JO and Sue Trost. It fledged 1 young in 2014 but the pair disappeared soon after and no breeding pairs were found after 2014, though the radio-tagged Strathnairn male ranged over this area in 2015 (Figure 1).

2.2. Floaters

'Floaters' are individuals or pairs that have failed to find a breeding territory. They reside in low-quality areas between the home ranges of breeding pairs, in this case, between breeding pairs of Little Eagles and Wedge-tailed Eagles. Newton (1979, 1998, 2013) uses the term 'floaters' and 'non-breeders' interchangeably, perhaps indicating a stage in a bird's life-cycle that can lead to acquiring a breeding territory.

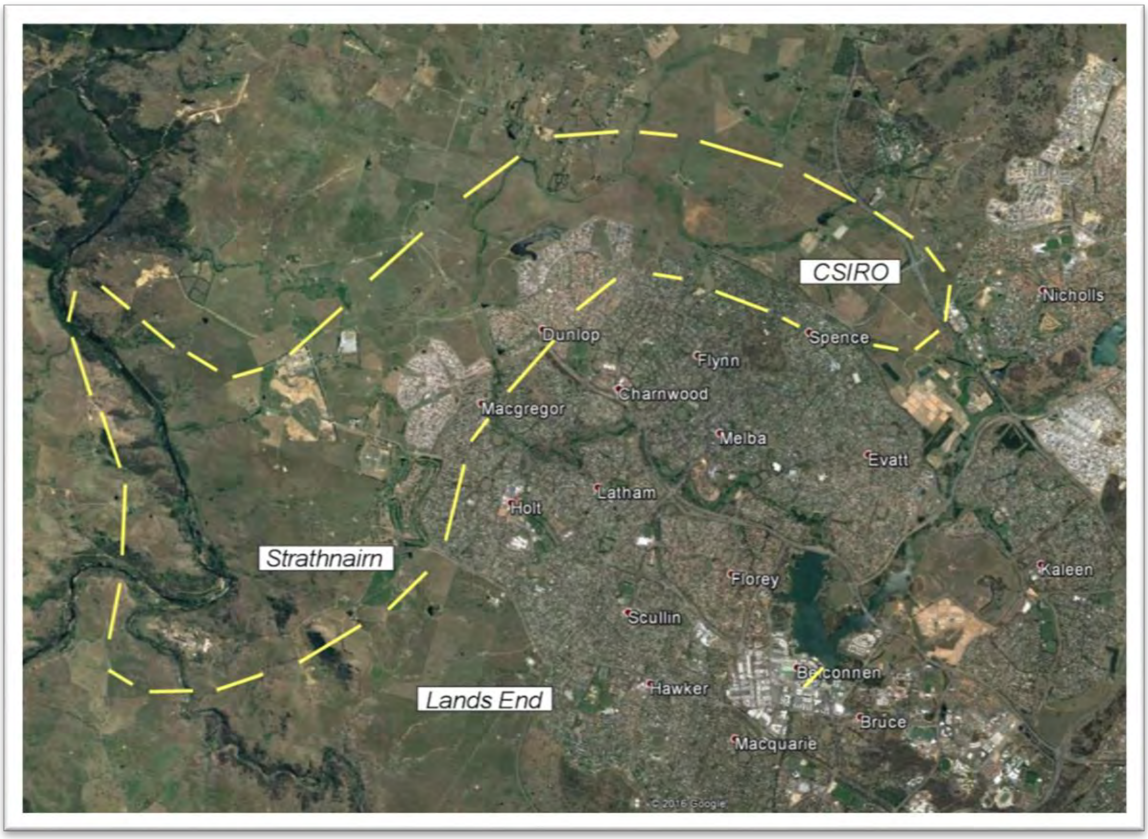

Figure 1 – Approximate first few weeks ranging behaviour (inside the yellow dashed line) of the Strathnairn Little Eagle male radio-tagged in 2015.

2.2.1. Land's End

In 2016 a pair of Little Eagles was observed by Chris Davey near a nest for several days in woodland at Land's End. There was no observation of incubating, or evidence of eggs or young; and no evidence of courting behaviour was reported (Little Eagles tend to be noisy and obvious in courtship, JO and ST unpublished, S. Debus pers comm). This woodland contains a traditional Brown Goshawk *Accipiter fasciatus* territory and ST and JO checked this woodland for raptor nests each year from 2005 to 2013. There were a number of nests built by goshawks and Australian Ravens *Corvus coronoides* but none by Little Eagles. On 19 December 2016 JO and ST visited this woodland and observed a Little Eagle fly from a nest tree previously used by Brown Goshawks, but found no evidence of a breeding event, *i.e.* prey remains under any of the nests. We found no Little Eagles there on a visit 21 Jan 2017.

A Little Eagle pair nested on the Land's End property in 2011 but not close to this location (Chris Davey) and no other breeding pairs were found at Strathnairn, Pegasus or Dunlop that year. This 2011 male was observed foraging west to Stockdill Drive and returning with prey to Land's End, over home range later used by the radio-tagged Strathnairn male in 2015. This illustrates that territory borders for Little Eagles in the ACT are currently fluid; they can change in different years according to the behaviour of nearby pairs of Wedge-tailed Eagles or Little Eagles. There is no evidence to link the 2016 Land's End pair to the disappeared pair at the CSIRO Field Station territory, but this could be determined through radio-tracking.

The behaviour of the 3 pairs of Wedge-tailed Eagles and the Strathnairn Little Eagles that border Land's End may, in part, determine if this pair breeds. If this becomes a breeding territory, it will be important for the success of any attempted breeding to ban any development from a minimum of 1 km of this site.

2.2.2. Mount Mugga/Red Hill/Woden area.

At least one individual Little Eagle has been repeatedly seen around the Mount Mugga/Red Hill/Woden area. We failed to locate a Little Eagle nest but there are two Wedge-tailed Eagle nests close by. This Little Eagle could be a floater. However, JO and ST watched this individual for two days in 2015 and believe he was attached to the Campbell Park breeding pair. That is, home ranges are changing each year for Little Eagles in the ACT. In this example, the former 3 breeding pairs resident in the 1990s at: 1) Campbell Park/Jerrabomberra, 2) Mt Mugga/O'Malley and 3) Isaacs Ridge - appear now to be one breeding pair in one large home range.

2.2.3. Mount Stromlo/Rivett

An individual Little Eagle was seen repeatedly in the area of Mount Stromlo/Rivett (Michael Maconachie and Anthony Moore) but no nest was found and this needs to be followed up.

2.3. 2015 and 2016 breeding success

The total then, for the 2015 and 2016 breeding seasons, was 3 young fledged from 2 territories in two breeding seasons: 0.75 young per territory per year, or 0.6 young per territory per year if the Land's End pair is counted for 2016. This is low productivity for this species (Olsen 2014), even compared to recent years such as 2008 when a total of 4 young were fledged from 4 breeding territories in one year (Olsen *et. al*. 2009) and lower than the productivity for 11 territories in the early 1990s.

2.3. Wedge-tailed Eagle

We monitor as many Wedge-tailed Eagle territories as possible near Canberra because two possible causes of the decline of Little Eagles in the ACT could be habitat loss from urbanisation, and Wedge-tailed Eagles usurping Little Eagle territories. In 2016 we checked 9 Wedge-tailed Eagle territories (Fig. 3) around Canberra. They fledged a total of 11 young, 1.2 young per territory per year, high productivity for this species (Olsen 2014).

The pair of Wedge-tailed Eagles that attempted to breed near the Glenloch Interchange in 2014 but failed (probably because of disturbance from photographers and bird watchers) found a secluded spot and fledged 1 young in 2016.

A different pair built a new nest in 2016 near Gungahlin Hill and this pair also fledged 1 young. Gungahlin Hill was previously a Little Eagle territory until around 2003, but in the 1960s was a Wedge-tailed Eagle territory (Leopold and Wolfe

1970). This Wedge-tail pair may have been displaced from Lawson as the pair that bred there around 2004 was displaced by disturbance and suburban growth.

Figure 3. Belconnen Wedge-tailed Eagle nest, 28 Sep 2016 (*Jerry Olsen, Susan Trost*).

3. Discussion and Conclusions

Little Eagles still breed at low levels in the ACT. Because of increased urbanisation, and, possibly, interference from displaced Wedge-tailed Eagles, Little Eagle home range sizes, shapes and borders are changing each year. Consequently, home range data from one year will not necessarily apply to the next year, or a few years after. For example, in 2015 the radio-tagged Strathnairn male used part of the home range of the (abandoned) CSIRO Field Station pair in 2014.

The statutory Action Plan for protection of the Little Eagle as a vulnerable species (ACT Government 2013) noted that the main threat to the species was loss of habitat which was 'mostly due to the encroachment of urban development on remnant woodland and grassland'. The 'primary conservation issue' was stated to be 'retention of adequate foraging and breeding habitat'.

Among proposed actions was giving 'identified nest sites and foraging sites a high priority for protection', and to 'protect known previous nest sites … with a buffer'.

None of the 'buffers' observed by ACT real estate developers and planners are based on science. They are arbitrary and always too small. For example, the Molonglo Valley real estate development considered 'buffers' for breeding raptors there. Pre-development, east (upstream) of Coppin's Crossing we found 5 raptor species breeding along the river in 2004 – 2005: Wedge-tailed Eagle, Brown Goshawk, Collared Sparrowhawk *Accipiter cirrocephalus*, Brown Falcon *Falco berigora*, and Black-shouldered Kite *Elanus notatus,* and we gathered prey remains from all of these (E. Fuentes and J. Olsen unpublished data). All these pairs have now disappeared, so the prey data we gathered there is now historic and cannot be replicated, unless the planned Molonglo River Reserve is a success and all 5 species return to the river as breeders.

ACT eagles, including Little Eagles, use rivers for foraging and nesting. ACT rivers, including the Molonglo and Murrumbidgee contain more biodiversity than any artificial constructions, such as Mulligan's Flat, will ever contain. Eagles should be used as 'umbrella' species to protect ACT rivers and nearby environments from development (Olsen 2014).

We would expect the ACT government to conform to its own Action Plan, without the need for many hours of work from volunteers and constant representations by concerned members of the public. All documented breeding events, and all trapped, banded, and radio-tagged Little Eagles in the ACT in 2015 and 2016 were the result of the work of volunteers.

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Thanks to COG members, especially Martin Butterfield, Rosemary Blemings, Con Boekel, Steve Holliday, Chris Davey, Barbara Allan, Michael Lenz, Peter Christian, Roger Curnow, Rod Mackay and Graeme Clifton. Thanks also to Rob Armstrong, David Drynan and the ABBBS, James Overall, Bernd Gruber, Renee Brawata, Kym Bradley, Tom Long, Michael Maconachie, Brett McNamara and Darren Rosso, and to Greg Hayes. Stephen Debus and McComas Taylor gave much appreciated advice.

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ARTICLES

LITTLE EAGLES IN THE AUSTRALIAN CAPITAL TERRITORY IN 2014

JERRY OLSEN OLSEN[A,D], MARK OSGOODD[B] AND GEOFFREY DABB[C]

[A]*Institute for Applied Ecology, University of Canberra, ACT 2601*
[B]*32 Bertel Crescent, Chapman, ACT 2611*
[C]*24 Brockman Street, Narrabundah, ACT 2604*
[D]*To whom correspondence should be addressed. Jerry.Olsen@canberra.edu.au*

Abstract. *In 2014 we surveyed Little Eagles* (Hieraaetus morphnoides) *in the Australian Capital Territory. Three successful Little Eagle nests were reported to us, at Campbell Park, at Strathnairn, and in the northern ACT. Each pair fledged one young making three young fledged in the ACT in 2014. The ACT Government has planned a housing development at the Strathnairn breeding site which may destroy this territory.*

1. Introduction and Methods

In previous reports (*i.e*. Olsen *et al.* 2010) we discussed the collapse of breeding Little Eagles (*Hieraaetus morphnoides*) in the ACT. Here we present data for the 2014 breeding season. Methods followed those described in Olsen *et al*. (2010).

2. Results

Black Mountain - The nests on Black Mountain (Con Boekel, northern side; J. Olsen unpublished data for the southern slope of Black Mountain) were not used though a pair of Wedge-tailed Eagles (*Aquila audax*) attempted to breed near the Glenloch Interchange. These eagles failed because of disturbance from photographers and bird watchers.

Lions Youth Haven **-** The Little Eagle pair at Lions Youth Haven in Kambah (Nick Webb) was not present. However, a pair of Wedge-tailed Eagles was resident on this territory and they fledged one young.

Dunlop and Strathnairn – The Little Eagle nest at Dunlop (Roger Curnow) was not used. The nest at the Strathnairn Art Galleries (Peter Christian) fledged one young that we colour-banded and radio-tagged. Susan Trost and Thomas Long followed the fledged juvenile for some two months before the juvenile and adults dispersed (see Olsen *et al.* 2015, this issue).

Campbell Park/Jerrabomberra Wetlands - The territory near Campbell Park Offices (Michael Lenz), fledged one young, and Little Eagles were commonly seen at Jerrabomberra Wetlands, even before the breeding season. However, GD photographically compared colours of the eagles at the Wetlands to adults that later nested at Campbell Park (Fig. 1). Some did not match, that is, other Little Eagles besides the territorial pair were sometimes present. Jerrabomberra Wetlands may serve as wintering habitat for this apparently migratory species.

Northern ACT **-** A third Little Eagle pair was reported to us in the northern ACT, checked by JO and Sue Trost. The property manager insisted that a condition for checking this pair was that we did not reveal its location. We agreed. This territory fledged one young. Little Eagles had been sporadically reported to us near in the northern ACT for several years by observers such as Mark Clayton but nobody had pinned down a nest. This territory probably was not so much a new one, but one that was not counted in earlier surveys in the 1980s and 1990s and not found in our more recent surveys after 2005 because access to the area was blocked.

The total then, for 2014, was three young fledged from three territories, lower than the productivity for 11 territories in the early 1990's (which in reality was probably closer to 20 territories), and with no 'twin' nestlings, something we commonly found back in the 1980s and 1990s.

Figure 1. Little Eagles (*Geoffrey Dabb*) from left to right, i) light morph adult, ii) fledged juvenile, iii) dark morph adult, iv) dark morph adult, all at the Jerrabomberra Wetlands/Campbell territory. Both partners of the breeding pair were light morphs, so other adults come into this area during the non-breeding season.

3. Discussion and Conclusions

Little Eagles are stable at low levels in the ACT. A problem is that the ACT government continues to direct housing development to areas needed for Little Eagle nesting. By one territory at a time the government is reducing the species in the ACT and that policy may be responsible for the loss of the species as a breeder here. The government was warned by JO and others that the O'Malley/Mount Mugga pair, the Gungahlin Hill pair, and now the Strathnairn pair, would disappear if housing projects proceeded near these nests. The O'Malley and Gungahlin developments went ahead anyway and the eagles were lost. The Strathnairn development is going ahead. Because Little Eagles occur only in the northern part of the ACT, not in Namadgi, these remaining pairs will eventually be forced out. The ACT government continues a 'plan' of suburban sprawl across the northern ACT that ruins species-rich habitat, such as in Gungahlin, the Molonglo Valley, and now Strathnairn.

The statutory Action Plan for protection of the Little Eagle as a vulnerable species (ACT Government 2013) noted that the main threat to the species was loss of habitat which was 'mostly due to the encroachment of urban development on remnant woodland and grassland'. The 'primary conservation issue' was stated to be 'retention of adequate foraging and breeding habitat'.

Among proposed actions was giving 'identified nest sites and foraging sites a high priority for protection', and to 'protect known previous nest sites … with a buffer'. The Strathnairn site is one of very few left, and has been used in successive seasons.

We would expect the ACT government to conform to its own Action Plan, without need for constant representations by concerned members of the public.

Acknowledgements

Thanks to COG members, especially Martin Butterfield, Con Boekel, Steve Holliday, Chris Davey, Barbara Allan, Michael Lenz, Peter Christian, Roger Curnow, Rod Mackay and Graeme Clifton. Thanks also to Oliver Orgill, Felicity Hatton, Nick Webb, and John McRae who passed along Little Eagle and Swamp Harrier sightings for the survey and Christie Gould, David Shorthouse, Murray Evans, Don Fletcher, Michael Mulvaney, Tom Long, Michael Maconachie, Brett McNamara and Darren Roso, and to Greg Hayes. Sue Trost gave invaluable assistance in the field; Stephen Debus and McComas Taylor gave much appreciated advice.

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Little Eagles in the Australian Capital Territory

Jerry Olsen

Institute for Applied Ecology, University of Canberra, ACT 2601

24 July 2017

Introduction

Numbers of breeding Little Eagles *Hieraaetus morphnoides* in the Australian Capital Territory collapsed from about 13 breeding pairs in the 1980s and 1990s to 1 to 4 breeding pairs, depending on the year, between 2005 and 2014 (Olsen *et al*. 2015). Consequently, Little Eagles were listed as *vulnerable* by the ACT Government (see ACT Government 2013). Causes of the decline were said to be breeding Wedge-tailed Eagles *Aquila audax* displacing Little Eagles, and suburban development in the northern ACT. Little Eagles have not been found breeding in heavily forested Namadgi in the southern ACT; they breed mainly in open forest and woodland in the north, areas susceptible to urban sprawl.

Evidence for the Little Eagle decline

Evidence for the decline of Little Eagles came from comparing earlier raptor surveys in the ACT (J. Olsen unpublished data, Olsen 1992, Mallinson *et al*. 1990, Taylor and Canberra Ornithologists Group 1992), when about 13 pairs of Little

Eagles were detected, to surveys of raptors done from 2004 to 2014 by Esteban Fuentes, J. Olsen and others. Most raptor species remained stable, but breeding pairs of Little Eagles had declined (Olsen and Fuentes 2005, Olsen *et al*. 2015).

An important point needs to be made about breeding home ranges. Breeding home ranges are areas of suitable habitat occupied by generations of breeding pairs. A home range in 2017 will not necessarily contain the same individual eagles it contained in 1990 or 2000. Think of suitable habitat, and a good (breeding) home range, as a valuable storefront property. It will continue to be successful (productive) for a succession of owners over many years, but the owner in 1950 may be different to the owner in 2017.

Reasons for the Little Eagle decline

At least two factors were associated with the disappearance of each Little Eagle breeding pair in the ACT, i) Wedge-tailed Eagles were now occupying the former Little Eagle home range and/or, ii) urban or suburban development occurred nearby just before the Little Eagle pair disappeared. Because of this pattern of disappearance, ecologists began to predict the loss of Little Eagle pairs before the loss happened. For example, when the O'Malley suburb was expanded around 2004 a number of ornithologists including Geoffrey Dabb from Canberra Ornithologists Group, and Richard Schodde, former Director of the Australian National Wildlife Collection at CSIRO predicted that this Little Eagle pair (documented in the Mallinson *et al.* 1990 paper) would disappear, which it did. Where there had been space for a pair of Little Eagles, and a pair of Wedge-tailed Eagles around Mount Mugga, now only the Wedge-tailed Eagles remained. Predictions were made about the loss of breeding pairs at Gungahlin, because of residential development in Gungahlin, and at the CSIRO Field Station near Evatt because of suburban development at Lawson. These Little Eagle home ranges were abandoned after urban development started. Consequently, it was predicted that the Strathnairn Little Eagle pair would eventually disappear because of development there (Olsen *et. al.* 2015). No ecologist or government agency has challenged this prediction.

Another characteristic of the few remaining Little Eagle home ranges was their size. They appeared much larger than Little Eagle home ranges in the 1980s and 1990s, as if they needed more space to complete a breeding effort; 2 or 3 previous home ranges (holding 2 or 3 breeding pairs) were now absorbed into 1 larger home range holding only 1 breeding pair. And the nest one year could be kilometres away from the nest in the next year, inside this expanded home range. Different pairs of Little Eagles in the 1980s might breed 2 kilometres apart, but, after 2004, Little Eagles tended to breed about 7 kilometres apart, and range over a much larger area.

In the last 2 breeding seasons in the ACT, 2015 and 2016, the total number of Little Eagle breeding attempts (eggs or young) reported to us was 1 fledged young from 2 active nests in 2015 (Campbell Park and Strathnairn), and 2 fledged young each from 2 active nests in 2016 (Campbell Park and Strathnairn). This is low productivity for this species (Olsen 2014), even compared to recent years such as 2008 when a total of 4 young were fledged from 4 breeding territories in 1 year (Olsen *et. al*. 2009).

Buffers

Property developers have set up 'buffers' around eagle nests, including the Little Eagle nest at Strathnairn. The developers claim that no development, including infrastructure and construction-related activities, would be permitted within 200 metres of the Little Eagle nesting tree and immediate foraging area. This is junk science. 'Buffers' set around raptor nests by ACT real estate developers and government planners are not based on evidence. The buffers are arbitrary, always too small, and set to advantage land developers, not eagles.

In *Australian High Country Raptors* I said, "Three concepts need to be mentioned that can help a developer more than raptors. A **buffer** set around an active eagle nest is often of little use because the buffers are too small, and they don't consider the size of the whole home range and how eagles move nests sites as far as 5 km within a breeding home range. Buffers may stop some disturbance for a short time, but free developers to destroy foraging habitat and areas for alternative nests, so the eagles eventually abandon the area. **Corridors** set in the ACT, said to link areas of habitat, are usually too narrow to sustain pairs of eagles, so eagles will eventually be lost in these areas, unless adjoining farmland outside of the corridor is kept free from development. **Trade-offs**, where bodies claim to retain, for example, an area of box woodland in one place if they can destroy it in another place, are often a form of sleight-of-hand because both areas of woodland should be retained, not one. These trade-offs or offsets rarely trade like for like, and can't truly be offsets unless new habitat is created, which takes decades." (page 232).

This happened with the Strathnairn Little Eagles. The eagles were never seen foraging within 200 metres of their nest. This was a foraging-free-zone. So developers set up a buffer area inside a 200 metre radius of the nest to protect the area for foraging (in the area where Little Eagles were never seen foraging). Stephen Debus (pers comm) has never seen Little Eagles foraging within 200 metres of the Little Eagle nests he studied. Researchers *did* see Little Eagles foraging outside of this 200 metre 'buffer' zone, in areas now being destroyed by developers and the government to build suburban residences.

Developers cannot buffer the Strathnairn Little Eagles from human disturbance (noise and activity) because these Little Eagles nest only 50 metres from a major public facility, the Strathnairn Homestead Gallery. The Gallery has regular public functions that can be noisy. The people and noise haven't deterred the Little Eagles, but loss of foraging habitat outside of the 200 metre buffer zone, we believe, will deter them.

There is a good reason why eagles forage less frequently close to their nests. Prey animals, such as rabbits, magpies or corvids, close to the Little Eagle nest, learn the habits of the nesting eagles, so the element of surprise is lost. So most hunting is done at some distance from the nest in a large home range, where eagles can surprise prey, and carry it back. 'Corridors' matter little to the eagles we study in Canberra because eagles can carry prey over houses to their nests, and we've seen them do this. What eagles need is extensive home range areas to hunt in. And these areas are being destroyed while 'corridors' and 'offsets' are being offered up as sweeteners, 'corridors' and 'offsets' that are substandard for Little Eagle breeding. The 'corridors', 'buffer zones' and 'offset areas' give limited foraging opportunities, and some are within the home ranges of hunting Wedge-tailed Eagles. So we have predicted that this Strathnairn Little Eagle home range will eventually be abandoned because suburban development will destroy foraging areas.

A buffer around a Little Eagle nest, meant to protect the eagles from disturbance, and maintain foraging areas, should be a minimum of 1 km radius of the nest if the buffer is based on similar species such as the Booted Eagle *Aquila pennatus* in Spain (López-López *et al.* 2016) and it should be more than 2 km away from breeding Wedge-tailed Eagles to protect Little Eagles from these larger eagles in the ACT where numbers of macropod prey are inflated and benefit breeding and non-breeding Wedge-tailed Eagles.

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PRESS RELEASE:

Little Eagles and development in the ACT

Two aspects relating to the decline of the Little Eagle in the ACT exemplify the continual pressure on this species and its habitat around inland cities. The first is the expanding suburbs of Canberra. Raptor biologists have long been warning of the collapse of the eagle's breeding population and productivity in the ACT, and its ongoing decline as new suburbs keep targeting Little Eagle breeding and foraging habitat, and displacing some of the few remaining pairs. Annual surveys and reports since 2005, by Jerry Olsen and colleagues, have predicted that the eagle could be eliminated as a breeding species in the ACT, because it favours the lowland, grassy eucalypt woodlands in the north – being replaced by suburbs – not the protected highland forests of Namadgi National Park. To conserve Little Eagles and other raptors in the 'Bush Capital', foraging habitat and space need to be conserved as well as breeding habitat and nest sites. Buffer (disturbance-free exclusion) zones around nests are ineffectual if there is no foraging habitat and prey within energy-efficient commuting distance of nests. Following a commissioned survey of raptors and their nests in the Molonglo Valley (a raptor hotspot slated for development) in 2005, the official, publicly released version of the consultant's report showed the raptor sightings but deleted the indicative (and likely underestimated) foraging areas around nests[1]. The deleted foraging areas covered most of the East and Central Molonglo development zones, and a proposed lake (i.e. drowning part of the valley and some raptor nests and habitat) was not announced, to the consultant at least, in time to factor it into the impact assessment report on raptors. An official assessment also omitted reference to another threatened (non-raptor but popular, iconic) species – the Superb Parrot – reported for those woodland remnants. I can attest that the consultant was under subtle pressure to give the proponent (a government agency) the desired pro-development, or at least not anti-development, answer with respect to impact on raptors. It all sounds like something out of the satirical series *Yes, Minister*! To quote Jerry Olsen[2]:

> A problem is that the ACT government continues to direct housing development to areas needed for Little Eagle nesting. By one territory at a time the government is reducing the species in the ACT and that policy may be responsible for the loss of the species as a breeder here. The government was warned… that the O'Malley/Mount Mugga pair, the Gungahlin Hill pair, and now the Strathnairn pair, would disappear if housing projects proceeded near these nests. The O'Malley and Gungahlin developments went ahead anyway and the eagles were lost. The Strathnairn development is going ahead. Because Little Eagles occur only in the northern part of the ACT, not in Namadgi, these remaining pairs will eventually be forced out. The ACT government continues a 'plan' of suburban sprawl across the northern ACT that ruins species-rich habitat, such as in Gungahlin, the Molonglo Valley, and now Strathnairn.
>
> The statutory Action Plan for protection of the Little Eagle as a vulnerable species (ACT Government 2013) noted that the main threat to the species was loss of habitat which was 'mostly due to the encroachment of urban development on remnant woodland and grassland'. The 'primary conservation issue' was stated to be 'retention of adequate foraging and breeding habitat'.
>
> Among proposed actions was giving 'identified nest sites and foraging sites a high priority for protection', and to 'protect known previous nest sites … with a buffer'. The Strathnairn site is one of very few left, and has been used in successive seasons.
>
> We would expect the ACT government to conform to its own Action Plan…

A satellite-telemetry study has since confirmed that the Strathnairn adult male Little Eagle and his fledgling made significant use of woodland and grassland habitats in the proposed development area[3].

The other aspect is possible secondary poisoning of Little Eagles by pindone used to control rabbits. The problem is that pindone is safe for humans and dogs around settlements because there is an antidote for it, whereas there is no antidote for 1080, which consequently cannot be used near urban areas. Again, there is not only official resistance to the notion that pindone may be an issue for Little Eagles, but also obstruction of investigation of the matter by keeping and providing virtually useless information on pindone use, and by discarding raptor carcasses that were supposed to be analysed for pindone and other toxins[4]. Given that foraging adult Little Eagles range at least 10 km from the nest, the current 5-km pindone exclusion zone around their active nests is likely to be inadequate[3].

Related to both issues is official refusal to consider or recognise the Little Eagle as qualifying for Endangered status in the ACT, on the spurious grounds that (i) mapped historical nests in the ACT supposedly represent alternative nests of individual pair(s), when in fact at the scale of mapping concerned the dots represent clusters of nests in separate territories; and (ii) the Little Eagle supposedly shows no corresponding decline in adjoining NSW. In fact, it is Vulnerable in NSW and recent trends there now indicate likely Endangered status in NSW too (i.e. greater than 50% decline in index of abundance in three eagle generations)[5]. Commentaries annually since 2005 on the ACT situation have appeared in *Canberra Bird Notes*, freely available online from the Canberra Ornithologists Group website <canberrabirds.org.au>

Finally, at least some of the woodland remnants flagged as important raptor habitat in the ACT are Yellow Box–Blakely's Red Gum grassy woodland, a federally listed Critically Endangered Ecological Community on the grounds that a minuscule percentage of its original extent still survives in the sheep–wheat belt of eastern Australia. These woodland remnants support a suite of declining birds, notably certain parrots and songbirds, many of them listed as threatened in the ACT and/or NSW and a few of them federally listed as well. Yet, development targets these national treasures instead of, for example, degraded and treeless sheep or cattle paddocks where ecologically sensitive human settlement and amenity plantings of local native flora could improve wildlife values. Even somewhat degraded secondary grassland and open woodland or paddock trees, situated between urban areas and key habitats, have value as, or could be regenerated to become, important foraging habitat and home-range buffers for raptors or other significant species as well as~~and~~ movement corridors for a variety of species.

[1]Debus S (2008) Raptors and the proposed Central Molonglo development. *Canberra Bird Notes* **33**, 81–83.

[2]Olsen J, Osgood M and Dabb G (2015) Little Eagles in the Australian Capital Territory in 2014. *Canberra Bird Notes* **40**, 207–209.

[3]Brawata R and Gruber B (2016) Movements of the Little Eagle (*Hieraaetus morphnoides*) surrounding the proposed Riverview Development Area, Australian Capital Territory. Report by the Institute for Applied Ecology, University of Canberra, Canberra.

[4]Anon. [= Editor, S Debus] (2012) Little Eagles and pindone in the ACT. *Boobook* **30**, 35.

[5]Debus S (in press) *Australasian Eagles and Eagle-like Birds*. CSIRO Publishing, Melbourne.

Dr Stephen Debus is an independent ecologist associated with the Division of Zoology, University of New England. This commentary is an extract (adapted) from his forthcoming book on Australian eagles.

A Preliminary Biodiversity Survey of the Ginninderra Falls Area

A report commissioned by the Riverview Group

Prepared by Ginninderra Catchment Group
Phone: (02) 6278 3309 Email: projects@ginninderralandcare.org.au
www.ginninderralandcare.org.au
Post: PO Box 446, Holt, ACT, 2615
Office: Kippax Health Centre, Kippax Place, Holt

Survey Team

This survey was undertaken by the staff of Ginninderra Catchment Group with the support of skilled volunteers and leading experts.

For further information on the Ginninderra Falls Biodiversity Survey, contact Ginninderra Catchment Group survey team:

Dr David Wong (Author) - Lead Ecologist and Project Coordinator

Damon Cusack (Author) – Camera Trapping and Project Coordinator

Kathryn Vincent – Data management, research and field survey

Anke Maria Hoefer - Frog survey

Karissa Preuss – Frog survey

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We thank the landholders, Anna and John Hyles, Gib Moore and Phyllis Fleming, and Manny Notaras who kindly allowed us access to their properties in order to conduct the surveys.

Cover Image: Ginninderra Creek in the Ginninderra Falls area. Photo: David Wong, Ginninderra Catchment Group.

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Introduction

Background

The Ginninderra Falls area is a unique environment within the Australian Capital Territory (ACT) region, containing spectacular landscape, ecological and geological features not seen elsewhere in the region. The falls area held great significance for the local Aboriginal people, the Ngunawal, for thousands of years prior to European occupation of the area, and continues to be a highly significant site for Ngunawal custodians. The significance of the area was also appreciated by early Europeans living in the region. In a paper presented to a meeting to discuss the merits of Canberra as the national capital site in 1907, John Gale described the site as "the magnificent Ginninderra Falls". This paper proved critical in Canberra being chosen as the nation's capital over Dalgety. Whilst the natural, cultural heritage, geological and aesthetic values of Ginninderra falls are acknowledged to a degree, there is a lack of information on the site, including on the flora and fauna of the area. There have been some surveys conducted on the vegetation of the area (Jessop 2015) as well as flora and fauna surveys that have focussed on adjacent areas in the proposed development area and River Corridor (Kevin Mills and Associates 2009, 2013a, 2013b; Nash and Hogg 2013; Osborne and Wong 2013; Rowell 2013) but further study of the Ginninderra Falls area specifically is warranted.

Whilst threatened species (e.g. Pale Pomaderris *Pomaderris pallida*, Rosenberg's Goanna *Varanus rosenbergi*) and regionally significant or locally uncommon species (e.g. Tree Skink *Egernia striolata*) have been recorded or reported in the area, no comprehensive fauna surveys have been undertaken in the area to our knowledge. It is also likely that the endangered Spotted-tailed Quoll *Dasyurus maculatus maculatus* uses the area as the species has been recorded in suburbs of Belconnen including in the adjacent suburb of Macgregor (ACT Vertebrate Atlas). The Ginninderra Falls area is both close in proximity to these records and has habitat that is suitable for quolls. There may also be other species of interest present in the Ginninderra Falls area that have as yet not been recorded at the site. A preliminary assessment of the area conducted by NSW National Parks and Wildlife service identified Spotted-tailed Quoll and a number of other threatened species as being very likely to occur in the area.

The aim of the current survey is to increase the existing knowledge of the flora and fauna using survey techniques that can be undertaken rapidly and within the available budget and time constraints. It is by no means an exhaustive biodiversity survey of the area and more detailed survey work for mammals, frogs and reptiles could be undertaken in the future. No surveys for birds, bats or invertebrates were undertaken. These groups could be surveyed in future.

Study area

The study area takes in the Ginninderra Creek from the Ginninderra Falls down to the confluence of the Murrumbidgee River and the Ginninderra Creek as well as surrounding areas of forest and woodland that are mostly dominated by Callitris forest and woodlands (Black Cypress Pine *Callitris endlicheri* / Scribbly Gum *Eucalyptus rossii*) and Eucalypt open forest (Scribbly Gum *Eucalyptus rossii* / Red Stringybark *Eucalyptus macrorhyncha*). Most sites have a layer of shrubs of varying heights between 0.5m and 2m, depending on the site and a usually sparse ground layer of grasses forbs, geophytes (plants with an underground storage organ such as orchids and lilies), twiners and sedges.

Geology in the general area is dominated by Silurian-age volcanic geology from the Hawkins Volcanic Suite and the Laidlaw Volcanic Suite (Finlayson 2008). There is an abundance of surface rock in the area as well as large areas of complex rocky outcrops that provide habitat for a range of fauna. The geology of the study area is Ginninderra Porphyry and is distinct from adjacent geology types.

The study area, as well as the adjoining farmland, is zoned as E3 (Environmental Management). Probably as a result of the inaccessibility of the terrain, the study area has undergone much lower levels of human-induced disturbance when compared with adjacent farmland where land uses include agricultural and quarrying.

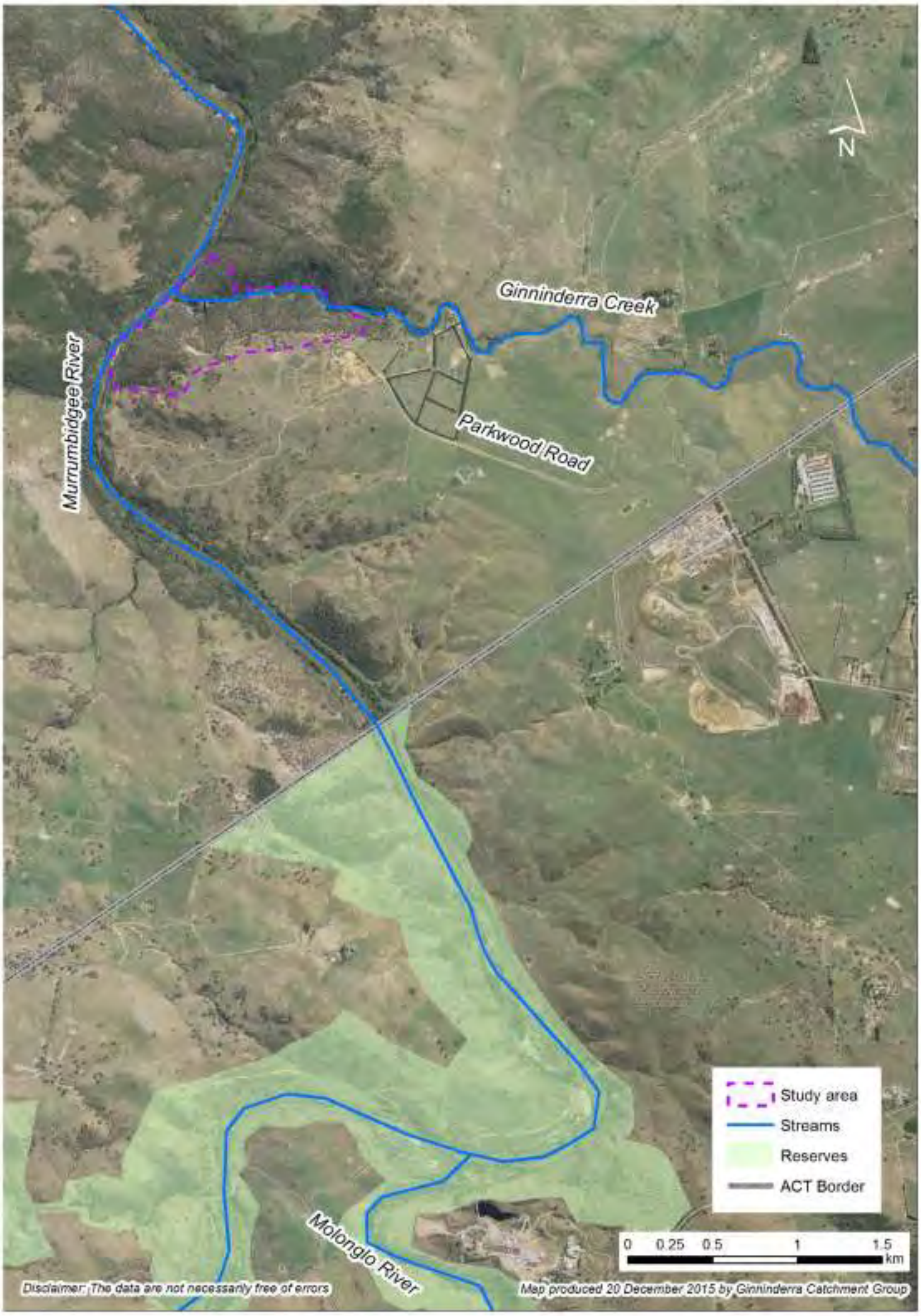

Figure 1: Map showing study area and surrounding land.

Methods

Reptile and frog survey

Active searches were undertaken at eight sites, using quadrats of 50 x 100m, between 15 September and 18 September 2015. One additional meandering active search was also undertaken by two people for 30 minutes (Figure 4). Searches were undertaken between approximately 9:00am and 11:30am. Each site was surveyed by three people, evenly spaced along the short side of the quadrat and, searching lengthways along the quadrat in a band of ground approximately 15-20 m wide in order to cover the whole quadrat. Available substrate (e.g. rocks, logs, fallen bark) were searched and replaced carefully in the original position. Vertebrates found under rocks were identified where possible and recorded. Binoculars were used to search for basking reptiles. Incidental sightings in September and October in or near the study area were also recorded.

A single survey was undertaken for calling frogs on the night of 15 September 2015. For this survey, the Ginninderra Creek was walked from the lower Ginninderra Falls to the confluence of Ginninderra Creek over a period of two hours starting just after dark, with two observers stopping at sites where frogs would be likely to be calling (e.g. still pools).

Figure 2: Example of habitat at one of the active search sites (GF7). The site is Black Cypress Pine *Callitris endlicheri* /Scribbly Gum *Eucalyptus rossii* forest/woodland with a low shrubby understorey, sparse cover of grass and abundant surface rock, litter and logs. Photo: *David Wong, Ginninderra Catchment Group.*

Camera trapping

Camera trapping sites (Figure 4), were selected in a range of vegetation and habitat types to give the greatest opportunity to record a broad range of species. Habitat preference of threatened species (e.g. Rosenberg's Goanna and Spotted-tailed Quoll) was considered however the primary aim was to record as broad a range of fauna as possible.

Cameras were set for 49 days from the 9 September to 28 October 2015. Four traps (Cam 02, Cam 04, Cam 06 and Cam 08) remained in the original set up position for the seven week monitoring period. Cam 01, Cam 03, Cam 05, Cam 07, Cam 09 and Cam 10 were moved after three weeks and were renamed as Cams 11-16. Cam 17 was set up an additional day following the sighting of a juvenile Rosenberg's Goanna at a burrow near a termite mound during collection of cameras. This equated to a total of 491 camera nights (one camera night = a 24 hour period for which a camera was set up).

The terrain presented some problems relating to access with some areas deemed too dangerous to survey safely within the scope of this project. It should be noted that many of these areas would be excellent habitat for Spotted-tailed Quolls and a survey targeting this species should be undertaken in future.

As the main aim was to record as many fauna species as possible, traps were baited with a variety of attractants including standard oat, honey and peanut butter mix in bait holders, chicken wings placed under rocks and; fish sauce placed on rocks within the field of view of the camera. Traps were rebaited during camera checks and, at some traps, a second bait holder containing chicken hearts was added at the 3 week mark.

Cameras were set up on the tree nearest to the bait between 0.5m -1.5m off the ground to get the best view of the selected area (Figure 3). Baits were placed as close to the centre of the camera's field of view as possible. Plants that were likely to cause false triggers were removed or rocks placed on top of them (without harming the plant), for the duration survey period.

Taxa in photos were identified by trained staff and students at CIT as well as by GCG staff. Identifications of each of the two independent groups of identifiers were then cross-referenced and re-assessed where identifications differed. When clear identifications were made they were recorded to species level. Where identification was uncertain, camera captures were recorded to the most precise level of classification possible (e.g. "unidentified macropod"). Camera captures that were too unclear to identify were recorded as "unidentified". Each trigger consisted of 3 photos at 5 second intervals. Multiple triggers (caused by an animal of the same species, in the same size class, within 10mins of the previous trigger) were recorded as a single camera capture (e.g. a rat that triggered the camera 20 times in an hour would be recorded as just one camera capture).

At the completion of the first stage of identification, images of species that were classed as "unidentified" or "to be confirmed" were sent to experts for verification (e.g. all Rosenberg's Goanna and unconfirmed lizards were verified by Dr Will Osborne). The date, time, species identification and ID numbers for photos were collated in a spreadsheet. A table showing the list of sites and number of each species recorded was produced.

Figure 3: Example of camera trap (Camera 06) set to capture animals moving along a well-used fauna path. *Photo: Karissa Preuss, Ginninderra Catchment Group.*

Vegetation survey

A meandering transect, approximately 1850m in length (Figure 4), was undertaken on 24 September 2015 with three plant experts identifying all species sighted. The area of coverage was generally up to 30m on either side of the line walked, but on occasion, plants were detected up to 50m off the transect. Species that were not recorded by Jessop (2015) in late November 2014 were added to the plant list for the area. Plants opportunistically recorded during visits to the study area during September and October 2015 were also added to the list. A number of species noted by members of the Australian Native Plants Society (ANPS) during visits to the site were also added to the list.

Threatened species

Locations of threatened species sightings were recorded. Known and probable habitat in the area was mapped and other relevant information such as existing knowledge about home range was mapped where appropriate.

Other species and communities of interest or conservation concern

Species not classified as threatened but of particular interest in the area or the region were identified and their areas mapped where possible. Conservation issues are discussed.

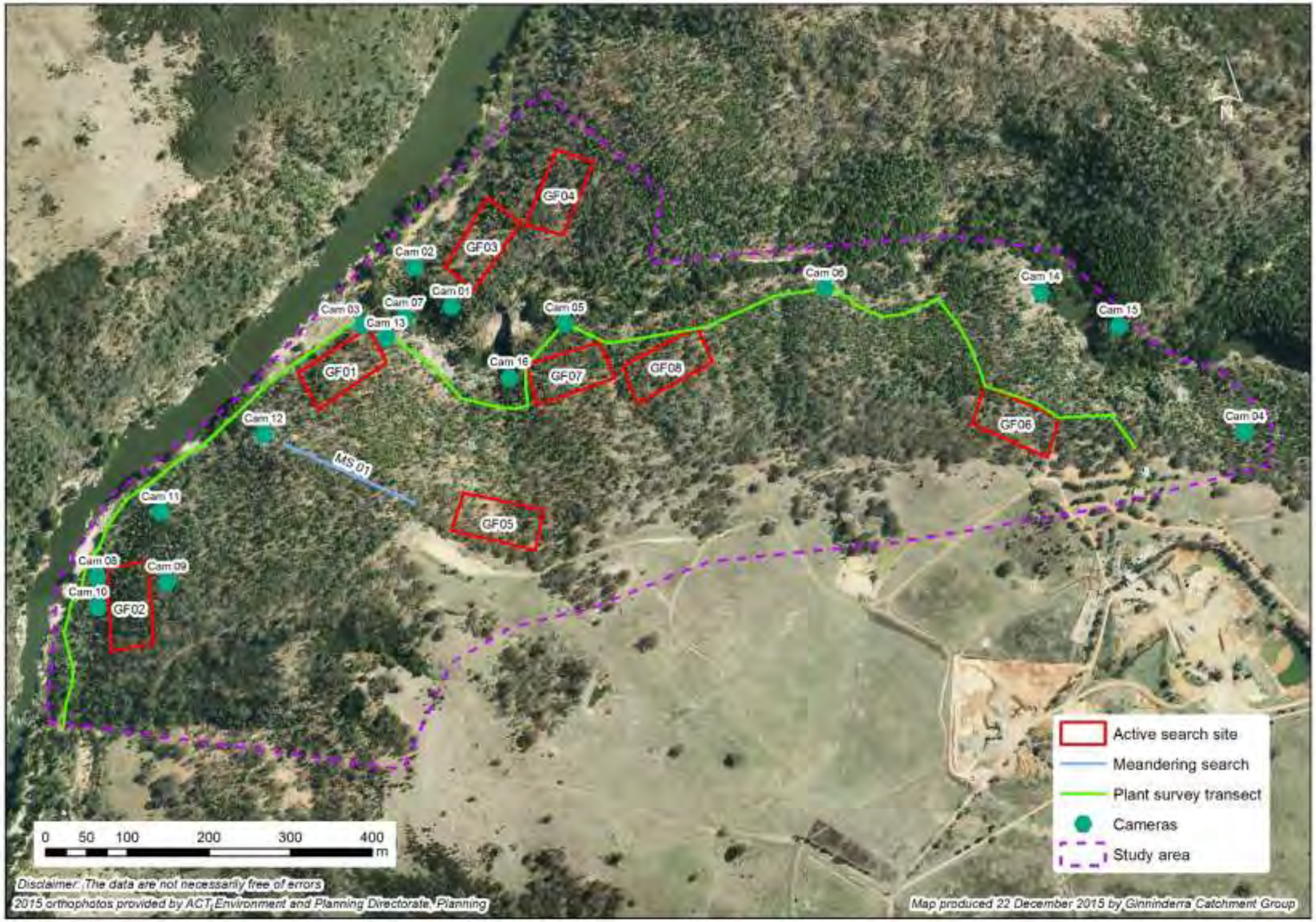

Figure 4: Locations of camera traps, active search and visual encounter sites, meandering search transect and plant species search transect.

Results

Reptile and Frog survey

Twenty-one reptile species from seven families were recorded during the survey period (Table 1). Eight species of reptile and two species of frog were detected in the active searches and meandering search. Six species of reptile were detected on camera traps and nine species of reptile were recorded as incidental sightings. A number of threatened, rare and uncommon species were detected. These included: the Pink-tailed Worm-lizard *Aprasia parapulchella* (listed as Vulnerable in the ACT and nationally and as Endangered in Victoria); Rosenberg's Goanna *Varanus rosenbergi* (listed as vulnerable in NSW and SA and as Threatened in Victoria); Burton's Legless Lizard *Lialis burtonis*; Nobbi Dragon *Amphibolurus nobbi*, Eastern Stone Gecko *Diplodactylus vittatus* and Tree Skink *Egernia striolata*.

Figure 5: Juvenile Stone Gecko *Diplodactylus vittatus*. *Photo: David Wong, Ginninderra Catchment Group*.

Camera trapping

A total of 4012 triggers (12029 photos) were recorded over the 491 camera nights (across 17 sites). After reviewing all photos the triggers were refined to 743 camera captures (Table 2). The survey identified 22 species including six reptile species, five pest animal species, four species of macropod, three bird species, two species of possum, wombats and echidnas. Rarer camera captures are highlighted in Table 2.

Of particular importance are the two camera captures of Rosenberg's Goanna *Varanus rosenbergi* at sites Cam 02 and Cam 07. Other significant camera captures include Tree Skink *Egernia striolata* one camera capture being the only record of this species during the biodiversity survey; Echidna *Tachyglossus aculeatus* with 14 camera captures at seven sites (indicating a substantial resident population). Echidnas were also frequently sighted incidentally during field surveys. Numbers of camera captures of the introduced species European Red Fox *Vulpes vulpes* (37 camera captures at 8 sites) and Black Rat *Rattus rattus* (235 camera captures at 11 sites) were high.

Vegetation survey

Our surveys took the total number of species recorded in the in study area in 2014 (Jessop 2015) from 118 to 207 (see Appendix 1 for full species list). An additional 89 species were added to the plant species list recorded by Jessop (2015) during the late spring of 2014 (76 of these additional species were native). Of these, one threatened species Pale Pomaderris *Pomaderris pallida* and 11 rare, uncommon or significant species (based on a list of proposed protected species obtained from the ACT Government) were added to the species list. Some of the species classified by Jessop (2015) as rare were reclassified as not rare based on the ACT Government list and advice from experts (i.e. *Diurus sulphurea*, *Pterostylis sp.* and *Casuarina cunninghamiana* subsp. *cunninghamiana*). In addition, Small Crowea *Crowea exalata* subsp. *exalata* was classified as a rare or uncommon plant owing to the small number of records in the ACT region.

Rare, uncommon or significant species included trees: Currawang *Acacia doratoxylon;* Shrubs: Mountain Hickory *Acacia penninervis,* Varnish Wattle *Acacia verniciflua*, *Bertya rosemarinifolia*, Common Fringe Myrtle *Calytrix tetragona,* Tree Pomaderris *Pomaderris intermedia,* Pale Pomaderris *Pomaderris pallida* and Small Crowea *Crowea exalata* subsp. *exalata* and; forbs ferns and geophytes[1]: Bristly Cloak Fern *Cheilanthes distans,* Shining Pennywort *Hydrocotyle sybthorpioides,* Yam Daisy *Microseris lanceolata*.

Six declared pest plant species were recorded in this survey and the previous survey (Jessop 2015). These were: Thistle *Carduus sp.*, Paterson's Curse *Echium plantagineum*, African Love Grass *Eragrostis curvula*, St John's Wort *Hypericum perforatum*, Sweet Briar *Rosa rubiginosa*

The lists of Jessop (2015) and GCG and the Australian Native Plants Society complemented each other with unique species associated with each survey.

Threatened species

Two threatened reptiles and one threatened plant were recorded during the survey. These were: Pink-tailed Worm-lizard (Vulnerable – Cwlth, ACT, NSW; Endangered – VIC); Rosenberg's Goanna (Vulnerable –NSW, SA; Threatened in Victoria) and Pale Pomaderris *Pomaderris pallida* (Vulnerable – Cwlth, NSW).

Pink-tailed Worm Lizard *Aprasia parapulchella*

We recorded five Pink-tailed Worm-lizards at 3 sites (GF02, GF07 and GF08). Based on these findings, we mapped broad areas similar to the sites where the species was found (based on interpretation of aerial images in a Geographical Information System (GIS)). Inspection of the imagery revealed areas that may contain additional habitat in the surrounding area, so these were mapped as well (Figure 6). There was some indication in the field that some habitat classified as degraded habitat may now be classified as potential habitat and some patches of habitat may have been missed in the original mapping done by Osborne and Wong (2013) (Figure 6).

Rosenberg's Goanna *Varanus rosenbergi*

Rosenberg's Goanna was recorded at two of the camera trap sites. In addition, a larger adult as well as a sub-adult or juvenile emerging from a burrow in a termite mound, were sighted opportunistically at separate locations in the study area. Using maximum home range values for available studies on Rosenberg's Goanna, we generated buffers of records from our survey as well as historical records (Will Osborne, pers. comm. 2015) in GIS.

[1] Geophytes are species with an underground storage organ such as lilies and orchids

Pale Pomaderris *Pomaderris Pallida*

We mapped patches of Pale Pomaderris in the field using GPS and estimated the number of individuals for each patch. A total of 0.3 ha of patches of Pale Pomaderris was mapped with individual patches varying between 21m^2 and 0.1ha within a greater area of approximately 1.5 ha (Figure 8).

Other species and communities of interest or conservation concern

A number of rare plants and disturbance-sensitive species were recorded during the survey. Much of the area is Black Cypress Pine *Callitris endlicheri* / Eucalypt woodland and forest. This is a regionally significant community as Black Cypress Pine is a fire-sensitive species and there do not appear to be many examples of large stands of this fire-sensitive community in the ACT region. Areas of forest and woodland that contained Black Cypress Pine were mapped using orthophoto interpretation in GIS. There was approximately 80ha of the land in and around the Ginninderra Falls area containing Black Cypress Pine. Sixty hectares occur on the eastern side of the Murrumbidgee River (Figure 9). These figures are based on a two dimensional image, so the actual figure would be higher.

Small Crowea *Crowea exalata* subsp. *exalata* was recorded incidentally and during the plant survey. Locations of plants of areas where plants occurred were mapped (Figure 9) but no systematic search was undertaken for this species.

Red-necked Wallaby *Macropus rufogriseus* was recorded at the site. This species is sensitive to the effects of urbanisation.

One species from the genus of Peacock Spiders (*Maratus plumosus*), *Maratus plumosus* was recorded incidentally during the surveys. There are very few records of species from this genus known from the ACT region.

Tree Skink *Egernia striolata* was recorded at a camera trap site. The Ginninderra Falls area represents the extreme south-eastern edge of its known distribution.

Table 1: List of reptiles and frogs recorded in the Ginninderra Falls area (GF 1 – GF8 = active search sites; MS1 = Meandering search site). Dark grey shading indicates threatened species. Light grey shading indicates locally uncommon or rare species.

FAMILY and Species	Common Name	GF1	GF2	GF3	GF4	GF5	GF6	GF7	GF8	MS1	Camera traps	Incidental	Frog survey	Total
MYOBATRACHIDAE - Frogs														
Crinia signifera	Common Eastern Froglet												1	**1**
Limnodynastes tasmaniensis	Spotted Grass Frog						1							**1**
Uperoleia laevigata	Smooth Toadlet	1												**1**
CHELIDAE - Turtles														
Chelodina longicollis	Eastern Long-necked Turtle											1		**1**
GEKKONIDAE - Geckos														
Diplodactylus vittatus	Stone Gecko	2	1					1						**4**
PYGOPODIDAE - Legless Lizards														
Aprasia parapulchella	Pink-tailed Worm-lizard		3					1	1					**5**
Delma inornata	Olive Legless Lizard											1		**1**
Lialis burtonis	Burton's Legless Lizard											1		**1**
AGAMIDAE - Dragons														
Amphibolurus nobbi	Nobbi Dragon											2		**2**
Amphibolurus sp.	Nobbi Dragon or Jacky Lizard	1		1	1							1		**4**
Intellagama lesueurii	Gippsland Water Dragon										1	10		**11**
Pogona barbata	Eastern Bearded Dragon											1		**1**
VARANIDAE - Goannas and Monitors														
Varanus rosenbergi	Rosenberg's Goanna										2	2		**4**
SCINCIDAE - Skinks														
Ctenotus robustus	Striped Skink											1		**1**
Ctenotus taeniolatus	Copper-tailed Skink											1		**1**
Ctenotus sp.											1			**1**
Eulamprus heatwolei	Heatwole's Water Skink											1		**1**
Egernia cunninghami	Cunningham's Skink										2			**2**
Egernia striolata	Tree Skink										1			**1**
Hemiergis decresiensis	Three-toed Skink							1						**1**
Lampropholis delicata	Delicate Skink		1	5	4	2	1		1					**14**
Lampropholis guitchenoti	Garden Skink				2									**2**
Morethia boulengeri	Boulenger's Skink			1		1	3		2	2				**9**
Tiliqua scincoides	Eastern Blue-tonged Lizard										1			**1**
Unidentified small skink			1			1	1	1						**4**
ELAPIDAE - Venomous Snakes														
Pseudonaja textilis	Eastern Brown Snake											3		**3**

Table 2: List of Camera trap results for Ginninderra falls area 09/09/2015-29/10/2015

Species	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	Site 13	Site 14	Site 15	Site 16	Site 17	Total no. camera captures	Total no. Sites Recorded
Native Mammals																			
Brush- tailed Possum *Trichosurus vulpecula*	0	5	0	2	4	6	0	1	0	0	0	0	1	0	0	0	0	19	6
Eastern Grey Kangaroo *Macropus giganteus*	0	5	7	0	3	8	0	1	11	9	2	2	1	0	0	0	0	49	10
Echidna *Tachyglossus aculeatus*	3	4	0	2	0	1	2	0	0	0	1	0	0	0	1	0	0	14	7
Red-necked Wallaby *Macropus rufogriseus*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Common Ringtail Possum *Pseudocheirus peregrinus*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Swamp Wallaby *Wallabia bicolor*	2	3	10	12	4	26	4	2	8	3	0	0	2	0	3	2	1	82	14
Wallaroo *Macropus robustus*	0	1	6	0	3	4	0	0	0	0	1	0	0	0	0	2	0	17	6
Wombat *Vombatus ursinus*	3	10	12	0	8	11	11	3	0	7	0	0	3	0	3	0	1	72	11
Macropod sp.	2	8	6	5	1	0	0	0	0	0	0	0	0	0	1	1	0	24	7
Reptiles																			
Eastern Blue-tongue Lizard *Tiliqua scincoides*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1
Cunningham's Skink *Ergernia cunninghami*	0	0	0	0	0	0	3	0	0	0	0	0	0	1	0	0	0	4	2
Gippsland Water Dragon *Intellagama lesueurii*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
Rosenberg's Goanna *Varanus rosenbergi*	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	2	2
Tree Skink *Egernia striolata*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	1
Unconfirmed Skink *Ctenotus sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1
Birds																			
Australian Raven *Corvus coronoides*	17	7	6	0	0	0	14	12	5	13	8	13	10	0	0	0	0	105	10
Pied Currawong *Strepera graculina*	2	0	1	0	15	0	0	0	0	0	0	0	0	0	0	0	0	18	3
Superb Fairy Wren *Malurus cyaneus*	0	1	0	0	0	0	16	0	0	0	0	0	0	2	0	0	0	19	3
Pest Animals																			
Cat *Felis catus*	0	2	1	0	0	1	0	0	0	1	0	0	1	0	0	0	0	6	5
Sambar Deer *Rusa unicolor*	0	1	3	0	3	0	0	0	2	0	0	0	0	0	0	0	0	9	4
Red Fox *Vulpes vulpes*	8	11	1	9	0	2	3	0	0	0	0	0	0	0	2	1	0	37	8
European Hare *Lepus europeaus*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1
Black Rat *Rattus rattus*	14	40	3	42	10	43	32	6	0	0	0	0	0	21	21	3	0	235	11
Unidentified	0	4	1	2	3	3	2	0	2	2	0	0	0	1	4	0	0	24	10
No. Species identified	8	17	12	7	10	11	11	7	5	6	4	2	6	6	7	5	2	22	
Total no. Camera captures	51	105	57	74	54	106	89	26	28	35	12	15	18	27	35	9	2	743	
Camera nights (cameras active 24 hr per day)	27	49	27	49	27	49	27	27	49	27	22	22	22	22	22	22	1	491	

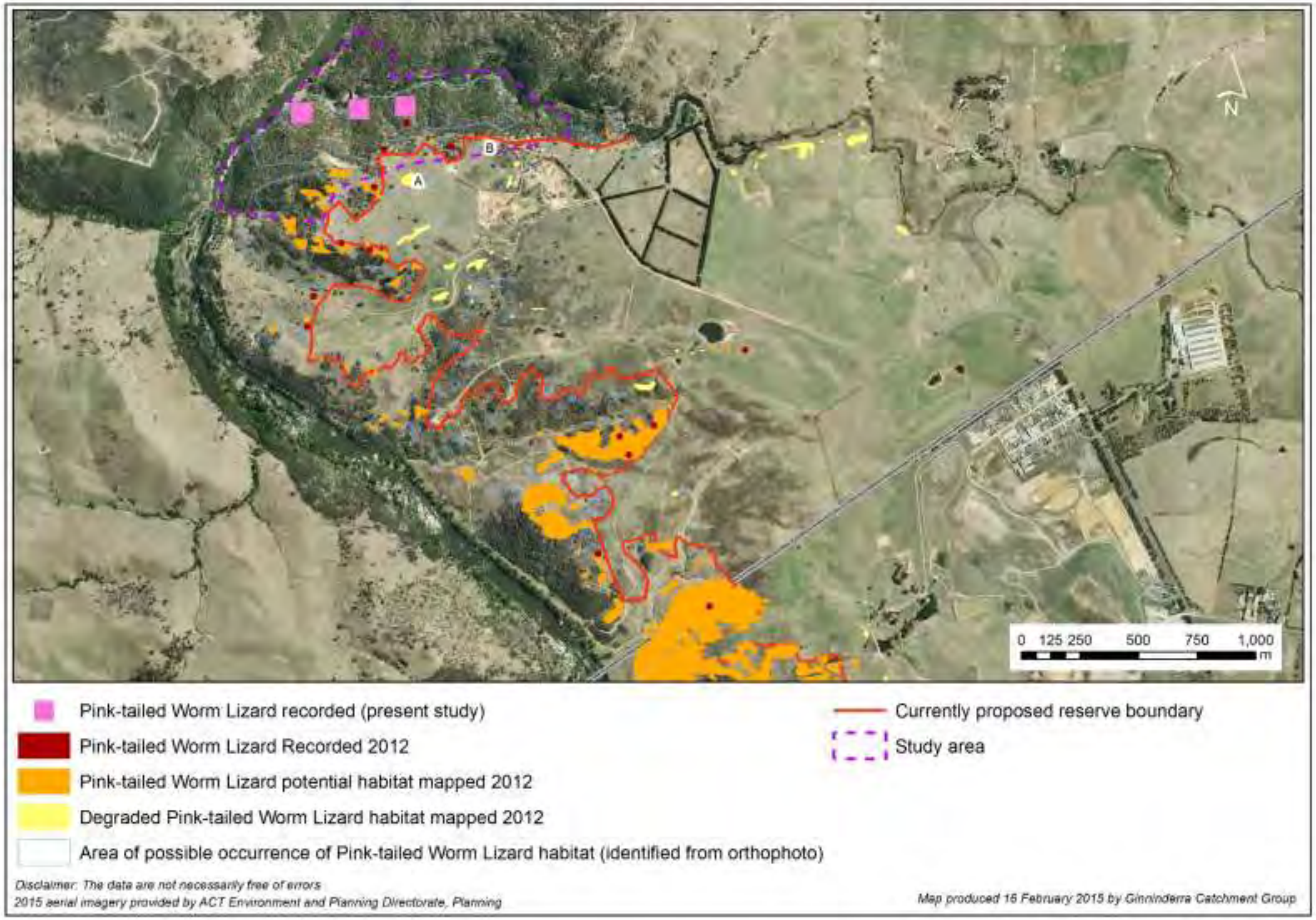

Figure 6: Pink-tailed Worm Lizard *Aprasia parapulchella* records and previously mapped habitat and records from 2012 (Osborne and Wong 2013 - data provided by Riverview Group) as well as other areas of habitat identified from orthophoto interpretation. The area marked "A" indicates an area classified at low quality habitat that now appears to be moderate quality habitat. The area marked "B" indicates an area of habitat that was not previously mapped.

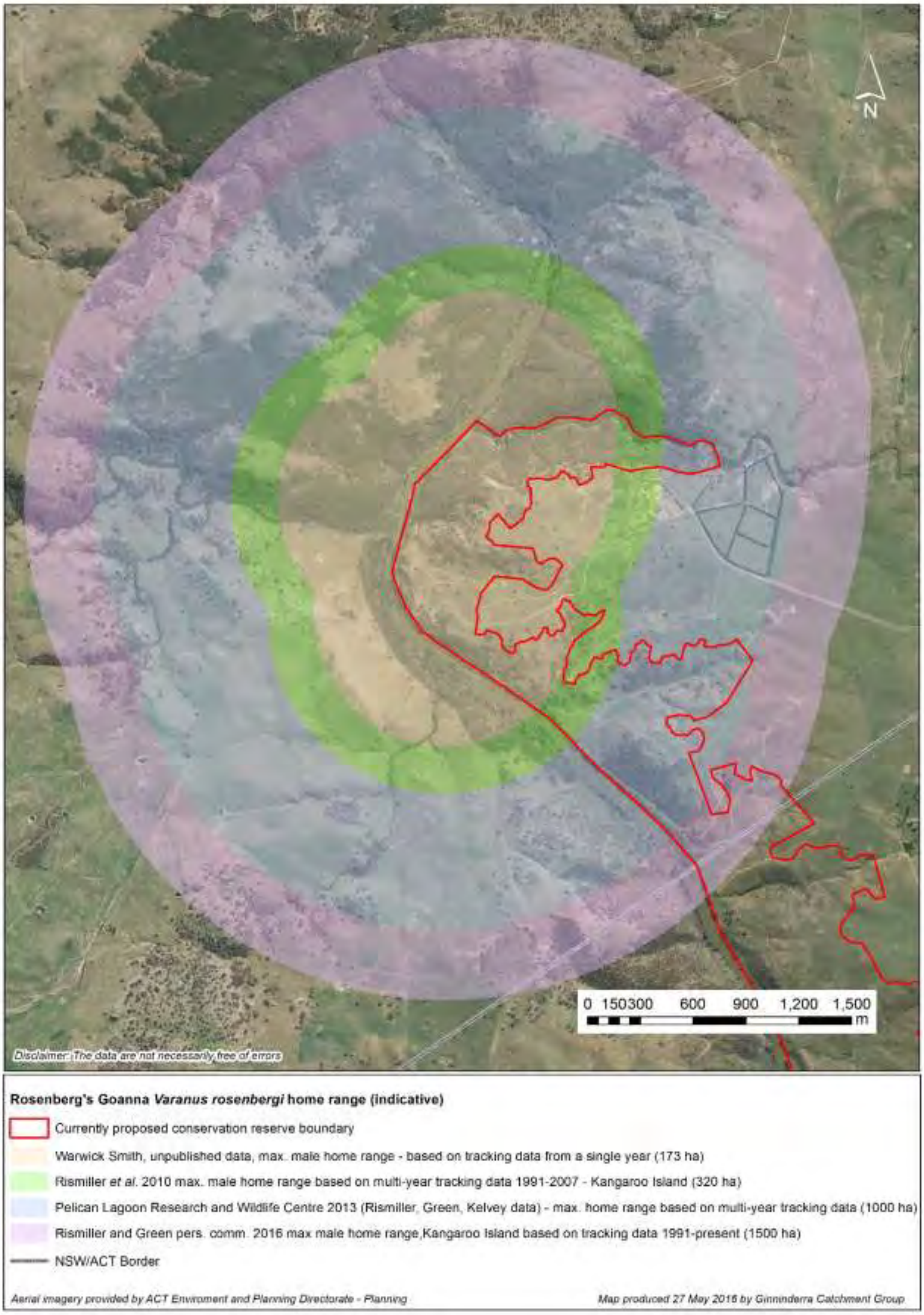

Figure 7: Rosenberg's Goanna *Varanus rosenbergi* records in the area buffered to a distance of available home range estimates. N.B. Buffers in this figure are only shown for known records. It is almost certain that the species would occur in adjacent areas and any decisions relevant to the conservation of the species should take this to account and extrapolate as appropriate to determine likely home range.

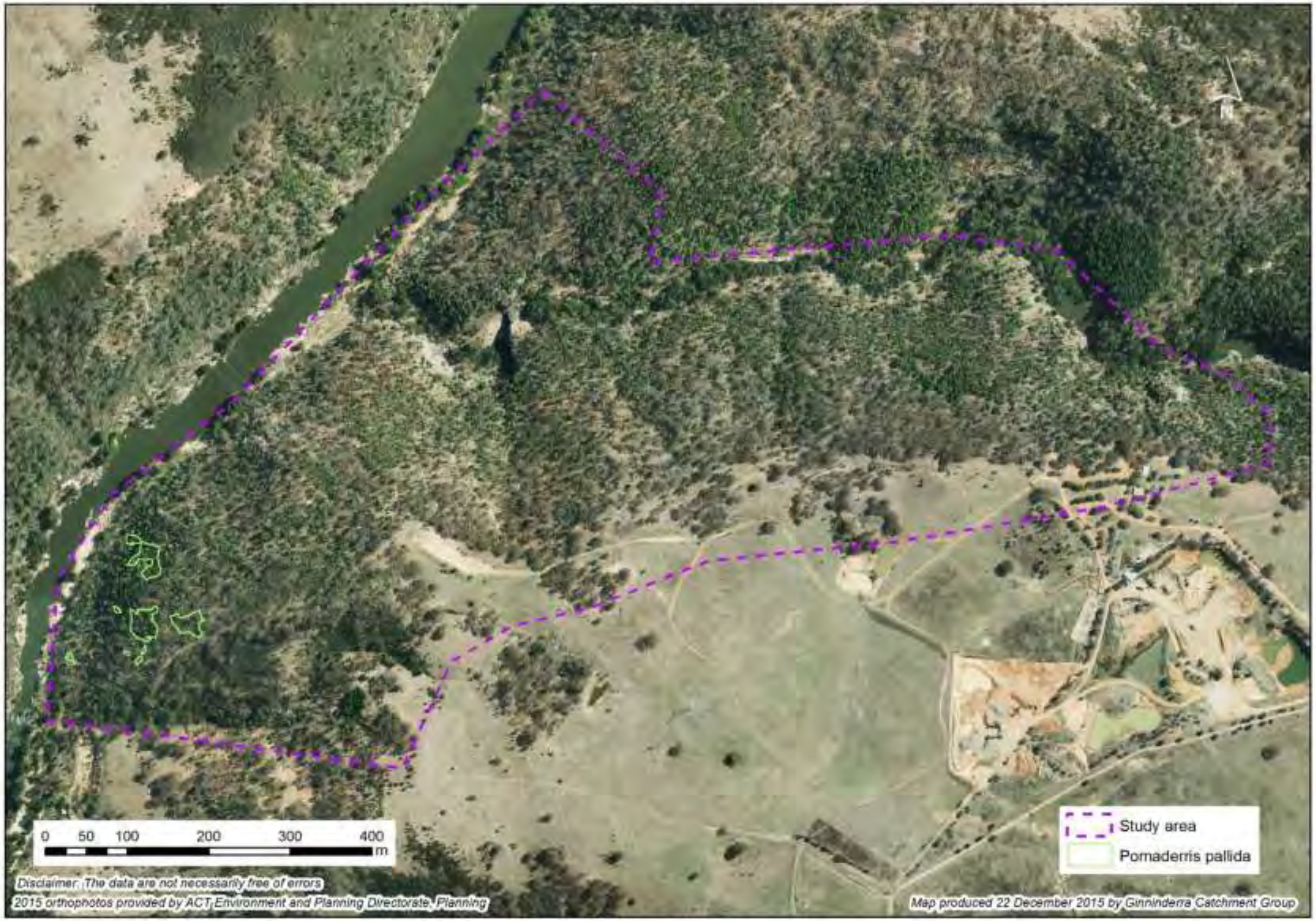

Figure 8: Areas of Pale Pomaderris *Pomaderris pallida* mapped in the field

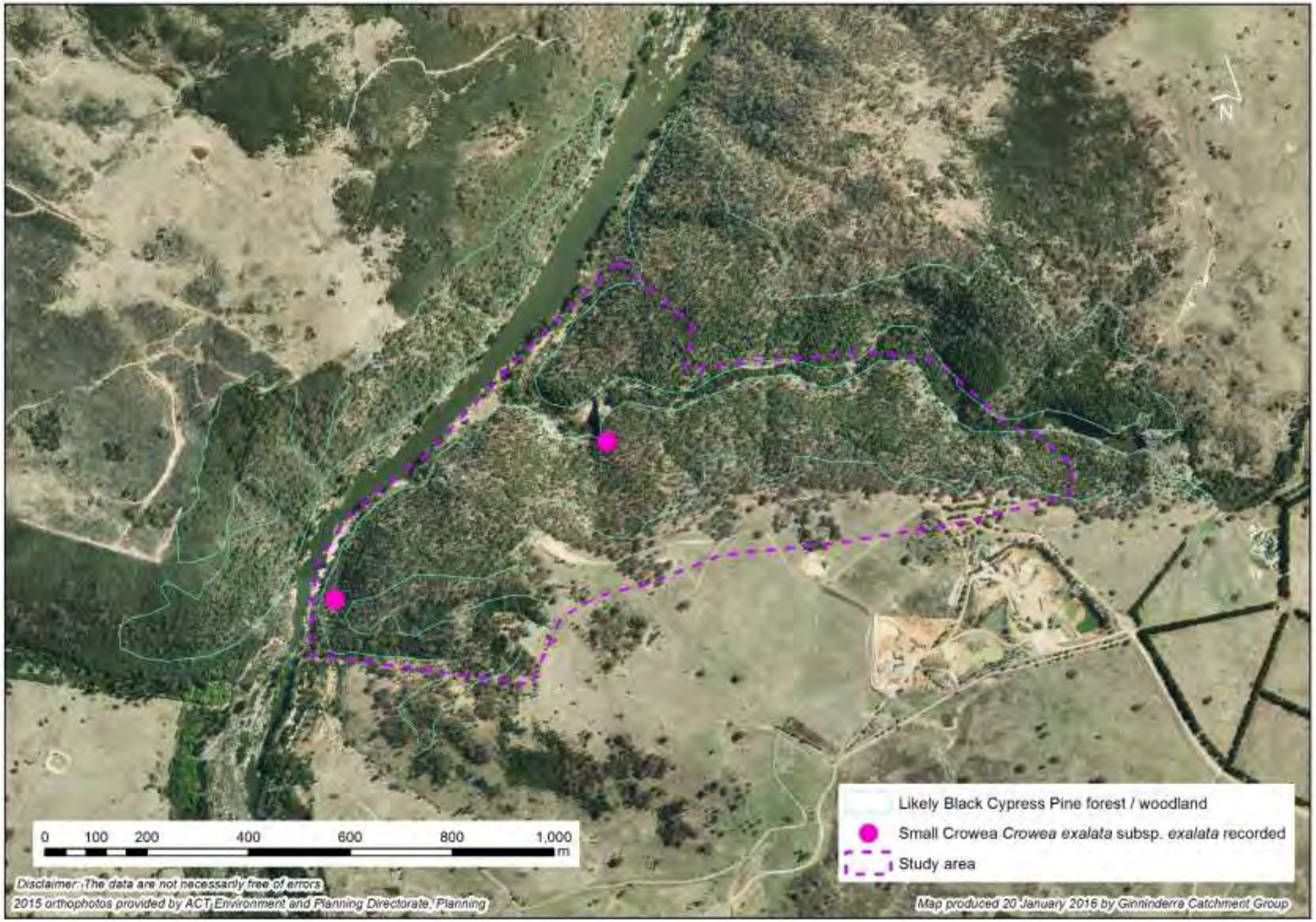

Figure 9: Likely Black Cypress Pine *Callitris endlicheri* / Eucalypt and forest and woodland identified using orthophoto interpretation. Incidental records of occurrence of Small Crowea *Crowea exalata* subsp. *exalata* are shown.

Discussion

Reptiles and Frogs

The 20 reptiles found during the survey is comparable with other surveys of reserves in the region. Barrer (1992) found 20 species of reptile in the Lower Molonglo River Gorge. Rauhala (1993b; 1995) found 24 and 23 species at Stony Creek Nature Reserve and Gigerline Nature Reserve respectively. Kukolic (1990) recorded 20 species at Mount Ainslie and Osborne and McKergow (1993) found 19 species across 12 reserves in Canberra Nature Park. However, survey effort for all of these surveys was much more intensive than that of our surveys and covered much larger geographical areas (e.g. Rauhala (1993b) used pitfall traps as well as active searches over two survey periods of 1 month and 6 weeks). It is therefore highly likely that more intensive surveys and the inclusion of pitfall trapping would result in more species being detected and that the list of reptile species at this reasonably small site would likely be amongst the highest in the region, of sites at a similar altitude (based on the number of species detected in the studies outlined above).

A number of species that were not recorded in the present study were recorded in land to the south of the study area (Kevin Mills and Associates 2013a). These included: Four-fingered Skink *Carlia tetradactyla,* Eastern Three-lined Skink *Bassiana duperreyi*, Red-throated Skink *Pseudemoia platynota* and Red-bellied Black Snake *Pseudechis porphyriacus*. Given the close proximity to the study area, it is likely that some or all of these species also occur in the study area. Other species of reptile that may be expected to occur at the site include: Marbled Gecko *Christinus marmoratus,* Spotted-back Skink *Ctenotus orientalis*, Common Dwarf Skink *Menetia greyi*, Shingleback *Tiliqua rugosa*, Jacky Lizard *Amphibolurus muricatus*, Blind Snake *Ramphotyphlops nigrescens*, and Dwyer's Snake *Suta dwyeri*. Some of these species were recorded by Barrer (1992) in the Lower Molonglo River Corridor. Barrer's survey was conducted within a much bigger study area over a long period of time (around 1 year) (W. Osborne, University of Canberra, pers. comm. 2016).

Figure 10: Male Nobbi Dragon *Amphibolurus nobbi* found near the Murrumbidgee River in the Ginninderra Falls area. *Photo: David Wong, Ginninderra Catchment Group.*

The richness of reptile species present in the Ginninderra Falls area is likely to be a result of a combination of factors. The area has undergone low levels of human-induced disturbance when compared with surrounding farmland. There is also a diverse range of habitats in the area (e.g. forest, woodland, riparian areas and secondary grassland) and an abundance of complex rocky habitat in many areas. The distinct geology and geomorphology of the area is likely to be an important underlying factor influencing the rich biological diversity observed in the area.

Camera trapping was a useful method for supplementing active searches. In particular, larger species and cryptic species, unlikely to be encountered during active searches were detected using camera traps. Four species, Eastern Blue-tongued Lizard *Tiliqua scincoides*, Cunningham's Skink *Egernia cunninghami*, Tree Skink *Egernia striolata* and, importantly, Rosenberg's Goanna *Varanus Rosenbergi* were detected by camera traps.

A number of the reptile species recorded are threatened, rare or uncommon (Hogg 1990; Rauhala 1993a) and are generally only found in areas that have not undergone high levels of modification. These include: the Pink-tailed Worm-lizard *Aprasia parapulchella* (listed as vulnerable in ACT, NSW and nationally and as endangered in Victoria); Rosenberg's Goanna *Varanus rosenbergi* (listed as vulnerable in NSW and SA and threatened in Victoria); Burton's Legless Lizard *Lialis burtonis*; Nobbi Dragon *Amphibolurus nobbi*, Eastern Stone Gecko *Diplodactylus vittatus* and Tree Skink *Egernia striolata*. This indicates that ecological integrity and habitat values in the area are high.

Figure 11: Spotted Grass Frog *Limnodynastes tasmaniensis* found under a rock in grassland. *Photo: David Wong, Ginninderra Catchment Group.*

Only three species of frog were recorded during the survey. However, the results should be interpreted with caution as there was only one targeted survey undertaken for frogs. Future surveys should undertake repeated visit surveys in order to better assess the frog fauna in the area. Frog call surveys along the creek may also not pick up all the species present in the area as the nature of the gorge and falls may provide barriers that may reduce the likelihood of frogs occupying pools. It is expected that a range of other species may occur in the area (e.g. Peron's Tree Frog *Litoria peroni,* Eastern Banjo Frog *Limnodynastes dumerilii* etc.). Of particular interest would be determining whether the Broad-palmed Frog *Litoria latopalmata* is present at the site as the species has been recorded on the Murrumbidgee River approximately 5km upstream of the study area(ALA 2016d). Further work is recommended to establish the status of the frog fauna in the area.

Camera trapping

Camera trapping was a quick and cost effective method to detect the presence of fauna within the survey area and proved critical in detecting Rosenberg's Goanna and a number of other species which are rarely encountered (e.g. Red-necked Wallaby, Tree Skink and Common Ring-tail Possum). The lack of public access to the area meant that the security of equipment was maintained with only one occurrence of human intervention. Although limited by time, every effort was taken to sample as broad a range of habitats as possible within the survey area.

The generalised approach of this camera trapping survey has proved successful for the purposes of a pilot survey to gauge the general diversity of fauna in the area. However, the fact that some species recorded were represented by just a single camera capture highlights the potential to miss species that are not readily recorded using camera traps. These species could have easily been missed and therefore not recorded for this area. It is almost certain that more targeted camera trapping and/or additional survey techniques would allow for further species to be detected.

Vegetation

The vegetation survey demonstrated that the Ginninderra Falls area has a rich plant community which includes a number of highly significant species. It should be noted that the majority of the survey was conducted along a single transect (and supplemented with incidental observations). It is highly likely that a much more comprehensive survey would yield many more species. The number of native species added to the existing list (76, including 11 rare or uncommon species) highlights the importance of timing of survey and repeat visits to capture species that flower at different times and may otherwise be inconspicuous in the landscape.

Figure 12: Thin-clubbed Mantis Orchid *Caladenia atrovespa* in the Ginninderra Falls area. Photo: *David Wong, Ginninderra Catchment Group.*

Many of the species identified were disturbance-sensitive species, indicating that the area has a high level of ecological integrity and has been spared from much of the degradation that surrounding agricultural land has undergone. Geophytes (plants with an underground storage organ such as orchids and lilies), ferns and shrubs are particularly sensitive to grazing and fertiliser addition, with geophytes being the most sensitive (Dorrough and Scroggie 2008). There were nine species of orchid recorded during the survey and orchids were abundant across the area (particularly Dusky Fingers *Caladenia fuscata* and, in parts, Needle-point Rustyhood *Pterostylis aciculiformis* and Tiger Orchid *Diurus sulphurea*). It is likely that further species of orchid will be recorded in the study area in the future as orchids are often inconspicuous unless flowering and different species flower at different times of the year. Twining Fringe Lily *Thysanotus patersonii* was abundant across much of the study area and Vanilla Lily *Arthropodium minus* was abundant in some areas. A range of fern species occur across the site including the rare Bristly Cloak fern *Cheilanthes distans*. A diverse range of shrubs occur at the site including a number of Pomaderris species, one threatened (Pale Pomaderris *Pomaderris pallida*) and one rare, uncommon or significant (Tree Pomaderris *Pomaderris intermedia*). A range of other rare, uncommon or significant shrub or small tree species occur in the study area including: Currawang *Acacia doratoxylon;* Mountain Hickory *Acacia penninervis,* Varnish Wattle *Acacia verniciflua*, *Bertya rosemarinifolia*, Common Fringe Myrtle *Calytrix tetragona* and Small Crowea *Crowea exalata* subsp. *exalata*. The ACT region is the extreme south-eastern edge of the range of *Acacia doratoxylon* (ALA 2016a). Other shrub species that occur at the site, are characteristic of rocky sites in the riverine environment, similar to those described by Barrer (1992) in the Lower Molonglo River Corridor (e.g. Slender Westringia *Westringia eremicola*, Common Correa *Correa reflexa* and Small Crowea *Crowea exalata* subsp. *exalata*, though Small Crowea is only known from a handful of locations in the ACT and surrounding area (ALA 2016b)).

Threatened species

Pink-tailed Worm Lizard *Aprasia parapulchella*

Figure 13: Adult Pink-tailed Worm Lizard *Aprasia parapulchella*. *Photo: David Wong, Ginninderra Catchment Group.*

The Pink-tailed Worm Lizard is listed as vulnerable nationally (*Environment Protection and Biodiversity Conservation Act 1999*), in the ACT (*Nature Conservation Act 2014*) and in NSW (*Threatened Species Conservation Act 1995*) and as endangered in Victoria (*Flora and Fauna Guarantee Act 1988*). A number of new occurrences of the species were recorded in the course of the surveys. The fact that these individuals were found in woodland and forest is significant as there are very few records in the ACT region known from forested sites (Wong *et al.* 2011).

The presence of Pink-tailed Worm Lizard in the Ginninderra Falls area has implications for conservation strategies in the greater proposed reserve area as maintaining connectivity for the species between this area and other occupied areas south of the study area is crucial for maintaining gene flow. This is important in ensuring that the population in the Ginninderra Falls area does not become unviable and go locally extinct.

Between the ACT border and the Ginninderra Falls area, there is significantly less Pink-tailed Worm Lizard habitat when compared to the ACT. This makes the role of existing habitat all the more important in facilitating movement through the landscape. Conservation strategies that aim to conserve Rosenberg's Goanna will also allow for the protection of Pink-tailed Worm Lizard (e.g. maintaining within reserve additional open areas to cater for home range needs of Rosenberg's Goanna will allow for more patches of Pink-tailed Worm Lizard habitat to be protected and facilitate movement of the species as open areas are likely to be more permeable than wooded areas with respect to movement of Pink-tailed Worm Lizards).

Our visits to the field suggest that there may be habitat that was not identified in earlier surveys (Osborne and Wong 2013) (possibly due to lower quality aerial imagery available at the time for identifying rocky areas or high vegetation obscuring visibility of rocks in the field). There was also at least one area assessed as low quality in the field previously (Osborne and Wong 2013) that appeared to be potential habitat on inspection in the field during this study. This highlights the challenge of assessing habitat based on a single visit as vegetation may change over time and other factors such as overgrazing can make assessment of habitat challenging. Repeated survey of habitat would clarify the status of habitat previously mapped in the area.

Figure 14: Pink-tailed Worm Lizard *Aprasia parapulchella* habitat in the study area. This habitat is different to the typical rocky grassland or grassy open woodland /woodland habitat with which Pink-tailed Worm Lizards are most often associated. There is a sparse cover of grass and it is under tree canopy (albeit quite open at this site). *Photo: David Wong, Ginninderra Catchment Group.*

Rosenberg's Goanna *Varanus rosenbergi*

Figure 15: Adult Rosenberg's Monitor *Varanus rosenbergi*. *Photo: Damon Cusack, Ginninderra Catchment Group.*

The Rosenberg's Goanna is listed as Vulnerable in NSW (*Threatened Species Conservation Act* 1995) and SA (National Parks and Wildlife Act 1972) and Threatened in Victoria (*Flora and Fauna Guarantee Act* 1988). It has declined markedly across its natural range on mainland Australia. It is the largest native terrestrial vertebrate predator in the Ginninderra Falls area and is therefore likely to play a crucial role in ecosystem regulation.

A number of studies have illustrated the importance of goannas in an ecosystem by documenting the impact of their loss from that ecosystem or of their increase as a result of the removal of another predator (see Dickman *et al.* 2014 for a review of these studies). It has been suggested (Dickman *et al.* 2014) that the Sand Goanna *Varanus gouldii* acts as a keystone species in semi-arid shrub land in western New South Wales. Increased abundance of Sand Goannas in this ecosystem, as a result of fox baiting, led to increases in the abundance of small lizards (Olsson *et al* 2005). Whilst Gecko abundance decreased where Sand Goannas were more abundant, gecko diversity was higher in these areas (Olsson *et al* 2005). Doody *et al.* (2006) found that Yellow-spotted Monitor Dragon *Varanus panoptes* on the Daley River, Northern Territory, declined markedly as a result of consuming toxic Cane Toads *Bufo marinus* This meant that the monitor was no longer a significant predator of Pig-nosed Turtle *Carettochelys insculpta* eggs. Increase in survival of Pig-nosed Turtles as well as other species of sea turtle (Blamires 2004) could in turn could lead to reductions in the animal and plants that the turtles consume and result in trophic cascades (Dickman *et al.* 2014). A decrease in Yellow-spotted Monitor on the Adelaide River, Northern Territory, coincided with increases in the Frog-eating Keelback *Tropidonophis mairii* snakes (Brown *et al.*2011; Brown *et al.*

2013), posing a threat to native frog populations (Dickman *et al.* 2014). Kangaroo Island is the last remaining stronghold of Rosenberg's Goanna. The species is a key part of the ecosystem here and their role as predators has been linked with the failure of rabbits to establish on the island (Rismiller *et al.* 2010). They also play an important role in the cultivation of ecosystems (Pelican Lagoon Research and Wildlife Centre 2013). Turning over of the soil by animals has a range of benefits for ecosystem functioning such as aiding decomposition, increasing infiltration of water and facilitating seed germination (Eldridge and James 2009).

The results of our survey, combined with analysis of the existing species occurrence records, suggest that the Ginninderra Falls area is highly likely to support a significant population of Rosenberg's Goanna. The species was sighted twice in different locations and recorded at two camera trap locations. The sighting of a juvenile or sub-adult Rosenberg's Goanna emerging from a burrow in a termite mound suggests a breeding population. There have also been historical sightings of the species in the area (Will Osborne, pers. comm. 2015). Rosenberg's Goanna is a cryptic species which is rarely sighted, with only 36 records existing in the ACT and surrounding NSW (ACT Conservation Research Fauna Atlas, December 2015). The vast majority of these records are in the upland areas of the ACT in Namadgi National Park and the Cotter Catchment as well as in the Googong area. The closest existing record to the study area is from 12km away (as the crow flies) in the Stony Creek Nature Reserve. Therefore, the frequency of encounter of the species during the survey period is significant. The records in the Ginninderra Falls area are the only ones known within the Ginninderra Catchment (excluding a roadkill specimen subsequently found by one of the authors on the Barton Highway near Hall. Damon Cusack, pers obs. 2015. Fig 16.). Based on the habitat quality of the area, it is highly likely that the Ginninderra Falls area supports a regionally significant breeding population of the species. Ensuring that this meta-population persists in the Ginninderra Falls area is important not only for the intrinsic value that the species holds as a long-standing part of the local landscape but also for facilitating gene flow between this population and other significant populations, thus buffering the regional population against extinction.

Inspection of aerial imagery in GIS suggested that similar habitat may extend for approximately 1km north of Ginninderra Creek. Beyond 1km north of Ginninderra Creek, the vegetation appears to change markedly, with dense understorey shrubs (likely to be Burgan *Kunzea ericoides*) becoming a dominant feature of the landscape and fewer habitat features are apparent (e.g. large complex rocky areas and large areas of forest that provide habitat such as fallen logs). It is therefore likely that the best habitat for Rosenberg's Goanna in the Ginninderra Falls area is contained within an area as small as 100 – 150 ha. [2] As such, it will be important to create a reserve that includes not only the best habitat but incorporates adequate measures to protect that habitat and account for home range size (e.g. including additional areas adjacent to key habitat within reserve to protect that habitat from direct and indirect impacts of urbanisation and to increase reserve size). Such a reserve would also benefit a range of species (e.g. see Ikin *et al.* 2015 and Rayner *et al.* 2015).

Home range and movements

The large home range of Rosenberg's Goanna means that it requires large protected areas for it to persist. Of 47 islands in the Archipelago of the Recherche, off the south coast of Western Australia, Rosenberg's Goanna only persisted on the largest, Middle Island (1080 ha) (Smith and Johnstone 1996; Short and Parsons 2004). It is likely that the population at Ginninderra Falls has persisted as a result of having a high quality habitat resource in the Ginninderra Falls area and adjacent land uses (agricultural – E3 Environmental Management) that, although not optimal habitat, allow free ranging movements and a very large buffer from many of the impacts associated with urban development (e.g. roadkill, predation from cats and dogs, disturbance to habitat and increased encounters with humans).

Home range and movement of the Rosenberg's Goanna has been studied extensively on Kangaroo Island (Rismiller *et al.* 2010; P. Rismiller, Pelican Lagoon Research Centre and B. Green, University of

Canberra, pers. comm. 2016) and to a much lesser degree in the Googong Nature Reserve area (W. Smith, unpublished data).

On the Dudley Peninsula, Kangaroo Island (SA), long-term monitoring of Rosenberg's Goanna population is ongoing with some known individuals having been monitored for 28 years. Radio-tracking data on this population, spanning from 1991 to present, has revealed that male Rosenberg's Goannas have a home range of 140-1,500 ha and females have a home range of 60-100Ha) (Rismiller, Pelican Lagoon Research Centre and B. Green, University of Canberra, pers. comm. 2016). One individual that has been tracked for 20 years has used the entire 15km ^{2} peninsula (P. Rismiller, University of Adelaide and B. Green University of Canberra, pers. comm. 2016). In one published study (Rismiller *et al.* 2010), based on data spanning from 1991 – 2007 (a total of 205 individuals were tracked on Kangaroo Island (71 Males, 77 Females and 57 sub-adult or gender indeterminate). Average home range for males was 257.5 ± 21 ha (range, 178–320 ha). Average female home range was 96 ± 3.7-ha (range, 85–110 ha) (Rismiller *et al.* 2010).

A small sample of six Rosenberg's Goannas (3 males, 2 females, 1 sub-adult or gender indeterminate) were tracked in the Googong Nature Reserve area (W. Smith, unpublished data). These results should be treated with caution due to the small sample size and associated large margin of error, as well as the fact that they were based on a short period of radio-tracking when compared with other studies on the species. Smith (unpublished data) found that adult males had an average home range of 134.7 ha (range, 103-173 ha). Adult females had an average home range of 142 ha (range 119 – 165 ha). The sub-adult had a home range of 39 ha. Average daily movement for adults was 102.2m and the maximum daily movement recorded was 1,950m. This figure was "as the crow flies" and the actual distance travelled would have been much greater (W. Smith, pers. comm. 2015). In addition, some animals went out of tracking range during tracking and could have made larger movements (W. Smith, pers. comm. 2015). The Kangaroo Island experience suggests that home range of tracked individuals increases over time as a given population is tracked and it has taken almost 30 years to arrive at the current home range estimates. Therefore, it is likely that the Googong data significantly underestimates true home range in that area. In addition, the terrain in the Googong area is highly dissected compared with the Ginninderra Falls area which has both steep and undulating topography; the Dudley Peninsular on Kangaroo Island has similar topography to the Ginninderra Falls area so home ranges of individuals in the Ginninderra Falls area may more closely approximate those observed on Kangaroo Island (P. Rismiller Pelican Lagoon Research Centre and B. Green, University of Canberra, pers. comm. 2016).

One Rosenberg's Goanna has been recorded in a West Belconnen suburb (Hayes, pers. comm., cited in Barrer 1992). The individual was released in the Lower Molonglo River Corridor as this is where it was suspected to have come from, but based on the location, the individual could also have come from the Ginninderra Falls or Riverview area. Whatever the case, this illustrates the fact that Rosenberg's Goannas travel through agricultural landscapes and open areas and underscores the importance of taking into consideration the wide ranging nature of the species into planning of reserves where the species is present if it is to be successfully protected. A roadkill specimen was also recently found by one of the authors on the Barton Highway (approximately 11 km from Ginninderra Falls).

Threats and conservation considerations

This study suggests that the resident population of Rosenberg's Goanna at the Ginninderra Falls is highly significant from a conservation perspective at both a local and regional scale. The population is on the edge of the range of the species (ALA 2016f; ACT Conservation Research Fauna Atlas 2016) and is disjunct from other known populations in the ACT region (i.e. Namadgi National Park; Cotter Dam / Stony Creek Nature Reserve area; Namadgi National Park; Lower Cotter Catchment; Googong area, Bywong area and; Mount Ainslie Nature Reserve) (ALA 2016 f; ACT Government Conservation Research Fauna Atlas 2016). It the only population in the Ginninderra catchment. The Ginninderra Falls area features large areas of high quality habitat for the species necessary for supporting a breeding population of the species (e.g. complex rocky habitat; termite mounds and fallen trees). The area is therefore critical when considering maintaining gene flow of populations of Rosenberg's Goanna in the region. It is likely that the resident population in the Ginninderra Falls area is relatively small when compared with other populations (e.g. Namadgi National Park). This makes the conservation planning of the area even more important as small populations are prone to extinction particularly in fragmented habitats (Henle *et al.* 2004; Foufopoulos and Ives 1999). Habitat specialisation (relying on specific habitat features) puts species further at risk of extinction (Foufopoulos and Ives 1999). Rosenberg's Goanna falls under this category, particularly in relation to its breeding biology and reliance on termite mounds (Rismiller *et al.* 2010).

Rosenberg's Goannas are particularly at risk in urban areas (White and Burgin 2004). Pressure on habitat (including the termite mounds they rely on for breeding), increased road traffic leading to increases in roadkill and predation by feral animals (particularly foxes and cats) are cited as major causes for their decline in Southern Australia (Rismiller *et al.* 2007). Of 10 known females monitored on Kangaroo Island that had bred for more than three breeding cycles, three were killed by cats and one died as a result of roadkill (Rismiller 2010). There are at least two records of Rosenberg's Goanna road-kills that were reported in 2015 (one on the Barton Highway and one on Mount Ainslie) (ACT Conservation Research Fauna Atlas). Even single losses from populations are significant when the populations are likely to be relatively small. Dogs are another threat that is likely to increase with urbanisation (Will Osborne, University of Canberra, pers. comm. 2015). A range of other direct and indirect impacts of development threaten the species. These include: reduction in prey availability as a result of increased predation of small lizards associated with the urban edge (Anderson and Burgin 2008), increase in (negative) encounters with roads, paths or people as a result of their large home range and wide ranging foraging habits and; illegal collection of the species (White and Burgin 2004).

Figure 16: Roadkill Rosenberg's Goanna *Varanus rosenbergi* found approximately 11km from the study area on the Barton Highway. Rosenberg's Goanna are particularly susceptible to roadkill as they are attracted to carrion. *Photo: Damon Cusack, Ginninderra Catchment Group December 2015.*

Rosenberg's Goanna has only been recorded in one nature reserve which is adjacent to urban development in the ACT region (Mt Ainslie Nature Reserve) and is likely to have gone locally extinct from most of the urban reserves in the ACT area, as has occurred with goannas in urban reserves in Sydney (White and Burgin 2004). Therefore, we calculated corrected perimeter-area ratio (Farina

2008) for Mt Ainslie Nature Reserve and the proposed reserve in West Belconnen. The below figure illustrates the difference between the corrected perimeter-area ratio of the only urban reserve that supports Rosenberg's Goanna and the proposed reserve (and NSW section of the reserve). This is largely a result of the convoluted nature of the proposed reserve boundary, which does not take into account a principle of reserve design that has been well established in ecological theory (i.e. minimizing ratio of perimeter to interior of reserves in order to reduce the impacts of edge effects such as increases in invasive species and predation and to cater for larger animals with large home ranges) (Anderson and Burgin 2008; Piper and Catterall 2004; Soule and Simberloff 1986).

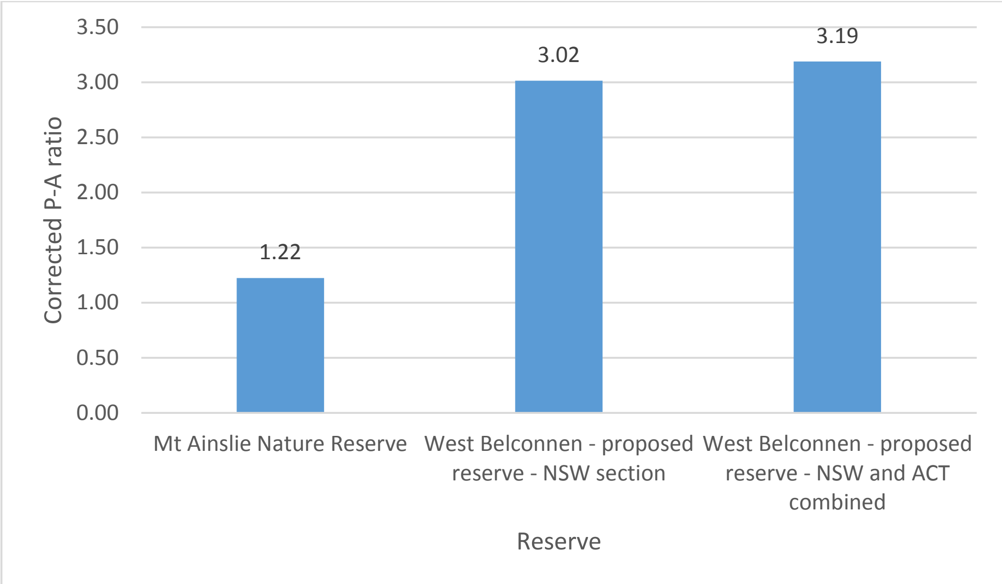

Figure 17: Corrected perimeter-area ratio (Farina 2008) for Mt Ainslie Nature Reserve and proposed reserve in the West Belconnen area (NSW section and whole reserve).

Key ways of protecting Rosenberg's Goanna would include:

- Incorporating home range of Rosenberg's Goanna into reserves (P. Rismiller, Pelican Lagoon Research Centre and B. Green, University of Canberra, pers. comm. 2016)
- Redesigning the proposed reserve to reduce corrected perimeter-area ratio to a much smaller figure (incorporating home range of Rosenberg's Goanna would help to achieve this).
- Restrict construction of roads to outside reserved areas (as Rosenberg's Goanna is very susceptible to death by roadkill)
- Slowing traffic speeds on roads adjacent to reserves (e.g. using speed humps, reduced speed limits etc.).
- Managing feral predator populations
- Prevention of dogs and cats from establishing in reserves or from roaming free in reserves
- Protecting termite mounds as key breeding resources (Sass 2008).
- Protecting shelter sites rocky outcrops, rocks, fallen timber and burrows (Rosenberg's Goanna may also occupy rabbit burrows (Sass 2008, W. Smith, unpublished data).

These management actions will also increase the likelihood that Spotted-tailed Quolls *Dasyurus maculatus maculatus* (Endangered: Cwlth, SA, Qld; Vulnerable: ACT, NSW) which are likely to occur in the area based on historical records in nearby suburbs, and which have an even bigger home range than Rosenberg's Goanna, may be able to persist in the area if present. The Ginninderra Falls area has large areas of complex rocky habitat that are suitable for Spotted-tailed Quolls. The Rosenberg's Goanna and Spotted-tailed Quoll could be considered umbrella species in the context of the West Belconnen area. Designing reserves that appropriately protect these species will allow other important species such as the Pink-tailed Worm Lizard as well as the range of significant plants found in the Ginninderra Falls area to also be protected.

Pale Pomaderris *Pomaderris pallida*

A large area of Pale Pomaderris *Pomaderris pallida* was recorded during our surveys. Pale Pomaderris is listed as Vulnerable nationally (*Environment Protection and Biodiversity Conservation Act 1999*) and in NSW (*Threatened Species Conservation Act 1995*). It is known from around 15 populations in south-eastern Australia and most of the populations are found along the Murrumbidgee, Cotter and Paddy's Rivers (Department of Environment 2008).

Figure 18: Pale Pomaderris *Pomaderris pallida* in bud. *Photo: David Wong, Ginninderra Catchment Group.*

In the areas that the species is conserved (Namadgi National Park, Bullen Range Nature Reserve and Stony Creek Nature Reserve in the ACT), populations of less than 1000 individuals occur (Briggs and Leigh 1995).

We estimated that the area we mapped contained 800-1000 Pale Pomaderris plants and a more comprehensive search is likely to identify further areas where the species occurs. Therefore, this population is likely to be a highly significant one and could become the largest population of Pale Pomaderris in the country under formal protection if the area becomes a nature reserve.

The main threats to Pale Pomaderris include residential development, weed competition (particularly Blackberry *Rubus sp*.); browsing by Feral Goats (*Capra hircus*); inappropriate fire regimes; increased fragmentation; and loss of remnants (Moore 2005; ANRA 2007a; ANRA, 2007b - cited in: Australian Department of Environment 2008; OEH 2013). The species should not be burnt more than once in 20 years (NSW RFS, 2004).

The main potential threat to *P. pallida* is extinction through stochastic processes (random environmental and demographic events that are a significant threat to small populations) (Australian Department of Environment 2008). Therefore, ensuring that the current population does not decline (and hopefully expands) is extremely important as small populations are more susceptible to stochastic processes (Soule and Simberloff 1986; Reed and Bryant).

We observed in the field that a few smaller plants were dead or in poor condition. Establishing whether this is due to natural plant death or another potential threat (e.g. disease) should be addressed as a matter of priority.

Conservation actions that will be important for the species include:

- Conducting a detailed survey for the species to identify other plants or populations in the area
- Monitoring plant survival and investigating possibility of disease
- Avoiding fire or prescribed burning in the area as unplanned fire on top of prescribed burning could threaten the population
- Monitoring browsing of the species by herbivores and controlling pest herbivores such as deer as appropriate.

Gang-gang Cockatoo *Callocephalon fimbriatum*

The Gang-gang Cockatoo *Callocephalon fimbriatum* is listed as Vulnerable in NSW (*Threatened Species Conservation Act 1995*). Gang-Gang Cockatoos are commonly seen in the Ginninderra Falls area and there has been a sighting by one of the authors of up to 50 of the species in a single tree located near the study area. Loss or degradation of hollow bearing trees (nest resources) and loss of foraging and roosting resources as a result of clearing of native vegetation or changed fire regime are key threatening processes for the species.

Other species and communities of interest or conservation concern

Black Cypress Pine / Eucalypt woodland and forest

Figure 19: Black Cypress Pine *Callitris endlicheri* dominated forest and woodland occur throughout most of the study area. *Photo: David Wong, Ginninderra Catchment Group.*

Black Cypress Pine *Callitris endlicheri* communities are fire-sensitive (Zimmer *et al.* 2009) and there is at least one example of a population, in the Woronora Plateau in the local government area of Wollongong, NSW that has been listed as endangered (Mackenzie and Keith 2008; OEH 2004). It is likely that the Ginninderra Falls area is one of the largest and best examples of this community in the region and may, therefore, be a highly significant population.

The recommended fire prescription for the species is that it not be burnt more than once in 20 years. This suggests that any fire in the area may be inappropriate as the community has evolved with infrequent fire and unplanned fire in addition to prescribed burning is likely to have detrimental effect on the community, especially when considering the likelihood of more frequent wildfire with climate change.

Research has shown that post-fire survival of seedlings within an endangered population of the community has been impacted upon by deer browsing and that interventions such as control of deer populations and use of woody debris to protect seedlings may be necessary interventions to protect seedlings (Mackenzie and Keith 2008).

Small Crowea *Crowea exalata* subsp. *Exalata*

Figure 20: Small Crowea *Crowea exalata* subsp. *exalata* plant near lower Ginninderra Falls. *Photo: David Wong, Ginninderra Catchment Group.*

The Ginninderra Falls area is the only recorded location for the Small Crowea *Crowea exalata* subsp. *exalata* in the area immediately surrounding the ACT. It is from this population from that the nursery cultivar *Crowea exalata* 'Ginninderra Falls' was sourced. As such, Small Crowea is a species that has a 'special place' in the area. There are only two known location of occurrence in the ACT (Woodstock Nature Reserve at Shepherds Lookout and the Lower Molonglo River Corridor). The next closest known population is located in the Burrinjuck Dam area approximately 40km to the northwest (ALA 2016b). There is at least one area with a large number of plants. As we did not undertake a targeted search for the species, it is likely that there are quite a few more sites where the species occurs in the Ginninderra Falls area. More detailed survey and mapping of species of particular interest such as Small Crowea is warranted.

Red-necked Wallaby *Macropus rufogiseus*

The Red-necked Wallaby *Macropus rufogiseus* is a species that is thought to have declined as a result of urbanisation. This species appears to have disappeared from many areas close to suburbia around Sydney and the ACT as a result of urbanisation (Zusi 2010; D. Fletcher, ACT Government, pers. comm. 2016). Unlike the Swamp Wallaby *Wallabia bicolor*, a species with which Red-necked Wallabies ordinarily co-occur, Red-necked Wallabies are habitat specialists and appear to prefer open and flat areas and to avoid urban environments (Zusi 2010). Red-necked Wallabies are ecotone specialists (D. Fletcher, ACT Government, pers. comm. 2016); that is they specialise in the transition zone between two biomes (such as forest and grassland or woodland). Maintaining a range of habitats within reserve (e.g. grasslands, woodlands and forests) and adequate areas of these habitats is therefore important for this species in order to avoid the loss of the species from the Ginninderra Falls area (D. Fletcher, pers. comm. 2016).

Maratus plumosus

There are only a handful of records of this species in the ACT region (ALA 2016e). Further survey is recommended in the area in order to gain more information about the population as well as to identify other species that may occur at the site. This genus of spiders has recently captured the attention of the public and there has recently been a film, *Maratus, made* about the discovery of a new species from the genus in the ACT.

Figure 21: *Maratus plumosus,* Members of this genus are referred to as Peacock Spiders due to their bright colouration. The species is much more brightly coloured at a certain time of the year than it appears in this photo. *Photo: David Wong, Ginninderra Catchment Group.*

Tree Skink *Egernia striolata*

The Tree Skink record is significant as the Ginninderra Falls area appears to be the extreme south-eastern edge of its geographical range with the next closest record occurring in the Tantangara Dam / Wee Jasper area approximately 40 km to the north-west (ALA 2016c). The species had been recorded approximately 20 years ago (W. Osborne pers. comm. 2015). The fact that it was recorded in this survey confirms that the species is still persisting at the site. Further survey for the species in the area is warranted.

Threatened species likely to occur in the Ginninderra Falls area

Whilst no systematic survey of the Ginninderra Falls area has been undertaken, a number of threatened species (Vulnerable in NSW *Threatened Species Conservation Act 1995*) that have been identified as present in surveys mainly conducted in the river corridor to the south of the Ginninderra Falls area and on adjacent farmland (Kevin Mills and Associates 2013a; 2013b). It is, therefore highly likely that some or all of these species occur in the Ginninderra Falls area. The threatened species recorded:

- Flame Robin *Petoica phoenicea* (Vulnerable NSW)
- Gang-Gang Cockatoo *Callocephalon fimbriatum* (Vulnerable NSW)
- Scarlet Robin *Petroica boodang* (Vulnerable NSW and ACT)
- Speckled Warbler *Chthonicola sagittata* (Vulnerable NSW)
- Spotted Harrier *Circus assimilis* (Vulnerable NSW)
- Superb Parrot *Polytelis swainsonii* (Vulnerable: Cwlth, NSW and ACT)
- Eastern Bent-wing Bat *Miniopterus schreibersii* (confirmation needed as to exact species)

The report noted that Flame Robin, Scarlet Robin and Spotted harrier were all recorded on open farming land in winter (Kevin Mills and Associates 2013). Recent research indicates that many species, including many species that have been recorded in the development area (Kevin Mills and Associates 2013b) (e.g. Scarlet Robin, Striated Thornbill, Rufous Whistler, Sacred Kingfisher, Dusky Woodswallow and others) avoid urban areas and the effects of urbanisation can extend far into reserve areas (Rayner *et al.* 2015; Ikin *et al.* 2015). These findings suggest that it is important to include additional areas into reserves if biodiversity is to be effectively protected.

Other threatened species that were identified (Kevin Mills and Associates 2013a) as having been previously recorded in the area were:

- Koala *Phascolarctos cinereus* (Vulnerable, NSW)
- Spotted-tailed Quoll *Dasyurus maculatus maculatus* (Vulnerable NSW; Endangered Cwlth)
- Brown Treecreeper *Climacteris picumnus* (Vulnerable NSW)
- Diamond Firetail *Stagonopleura guttata* (Vulnerable NSW)
- Flame Robin *Petroica phoenicea* (Vulnerable NSW)
- Hooded Robin *Melanodryas cucullata* (Vulnerable NSW)
- Little Eagle *Hieraaetus morphnoides* (Vulnerable NSW)
- Painted Honeyeater *Grantiella picta* (Vulnerable NSW)
- Regent Honeyeater *Xanthomyza Phrygia* (Endangered NSW and Cwlth)
- Varied Sittella *Daphoenositta chrysoptera* (Vulnerable NSW)
- Green and Golden Bell Frog *Litoria aurea* (Vulnerable: Cwlth; Endangered: NSW)
- Golden Sun Moth *Synemon plana* (Critically Endangered: Cwlth; Endangered: NSW and ACT)

Of these species, some are no longer likely to occur in the study area (e.g. Koala, Green and Golden Bell Frog) but others could occur.

A preliminary assessment of the Ginninderra Falls area, associated with a proposal to create a National Park in the area, has been conducted by NSW National Parks and Wildlife (M. Boak, NSW Office of Environment and Heritage, pers. comm. 2015). The internal report concluded that the Ginninderra Falls area contains significant scenic as well as natural and heritage values and identified a number of species that are highly likely to occur in the area. These include:

- Glossy black Cockatoo *Calyptorhynchus lathami* (Vulnerable NSW and ACT)
- Gang-gang Cockatoo *Callocephalon fimbriatum* (Vunerable NSW)
- Spotted-tailed Quoll *Dasyurus maculatus* (Endangered Cwlth; Vulnerable: NSW and ACT)
- Sooty Owl *Tyto tenebricos* (Vulnerable NSW)
- Masked Owl *Tyto novaehollandiae* (Vulnerable NSW)

Other threatened fauna listed as possibly occurring in the area include:

- Booralong Frog *Litoria booroolongensis* (Endangered Cwlth and NSW)
- Eastern Pygmy Possum *Cercartetus nanus* (Vulnerable NSW)
- Rosenberg's Goanna *Varanus rosenbergi* (Vulnerable NSW)

Our surveys confirmed the presence of Rosenberg's Goanna and Gang-gang Cockatoo and no systematic, targeted surveys were conducted for the other species, so it is highly likely that further investigation would reveal one or more of the species to be present. It is therefore recommended that targeted surveys be undertaken to determine whether any of the above species or other significant species are present.

The Spotted-tailed Quoll is worthy of special mention. The species has been recorded in Macgregor, in close proximity to the Ginninderra Falls area. The species has very large home range (e.g. males 621 ha to at least 2561 ha; females: 88 ha to at least 653 ha) (Claridge *et al.* 2005). Major threats to the species include: habitat loss and competition; competition from cats and foxes; deliberate killing by humans and roadkill (OEH 2014). High priority should be given to undertaking targeted survey for this species.

Limitations and further research

This survey should be viewed as a preliminary study of a subset of the terrestrial biodiversity of the Ginninderra Falls area. A more detailed study of threatened species found during this survey and those likely to occur should be undertaken to gain a more complete understanding of the likely impacts of development close to the Ginninderra Falls area.

Many sections of the study area were considered too dangerous to safely survey within the scope of this study. Further work on threatened species such as Rosenberg's Goanna and Spotted-tailed Quoll would need to include survey in these more inaccessible areas as they represent some of the best habitat (i.e. complex rocky habitat). A comprehensive Spotted-tailed Quoll survey should be undertaken as a matter of priority. A range of techniques (including less traditional techniques such as the use of detection dogs) may be necessary as Spotted-tailed Quolls are very difficult to detect. Other surveys that could be undertaken include small mammal trapping (Elliott and pitfall trapping), bat surveys, pitfall trapping for reptiles, survey of invertebrates, bird surveys and nesting surveys.

Whilst it is likely that many more species could be found during additional survey it is recognised that applying the precautionary principle by managing for the larger home range species such as Rosenberg's Goanna and Spotted-tailed Quoll would be the most effective way to ensure the protection of the majority of other species. Such an approach would therefore represent best practice.

Due to the broad methodology used during the camera trapping in order to maximise the range of species camera captured, quantitative analysis should be assessed with caution. The numbers of less cautious or more broadly ranging species may be over-represented as they could possibly visit numerous sites on a single night. Conversely more shy or cryptic species may be under-represented or may not have been detected. Methods that target particular species or groups (e.g. small mammals) should be used in order to provide a more comprehensive picture of the presence or estimated relative abundance of these species.

General discussion and planning considerations

This survey has provided valuable data on the biodiversity of the Ginninderra Falls area. Whilst more study is needed, with respect to specific taxa and groups, there is enough research available in the existing scientific literature to assist in making suitable, precautionary planning decisions with respect to reserve design that take into account the ecological factors of the area. Such planning outcomes would benefit not only Rosenberg's Goanna, but also a range of other species (e.g. threatened species, ecotone specialists and mobile species) and values (e.g. cultural heritage and aesthetic). Whilst the presence of Rosenberg's Goanna was previously suspected in the Ginninderra

Falls area, it has now been confirmed. This population is the only known population of the species in the Ginninderra Creek catchment, and from our analysis, appears to be a highly significant population (appears to be a breeding population; geographically distant from other populations). In light of this, a re-evaluation of the proposed reserve (e.g. size, shape and management) is warranted in order to ensure the long-term survival of the species in the Ginninderra Falls area. A range of other species including the Spotted-tailed Quoll, Pink-tailed Worm Lizard, Red-necked Wallaby and a range of birds of conservation interest should also be considered.

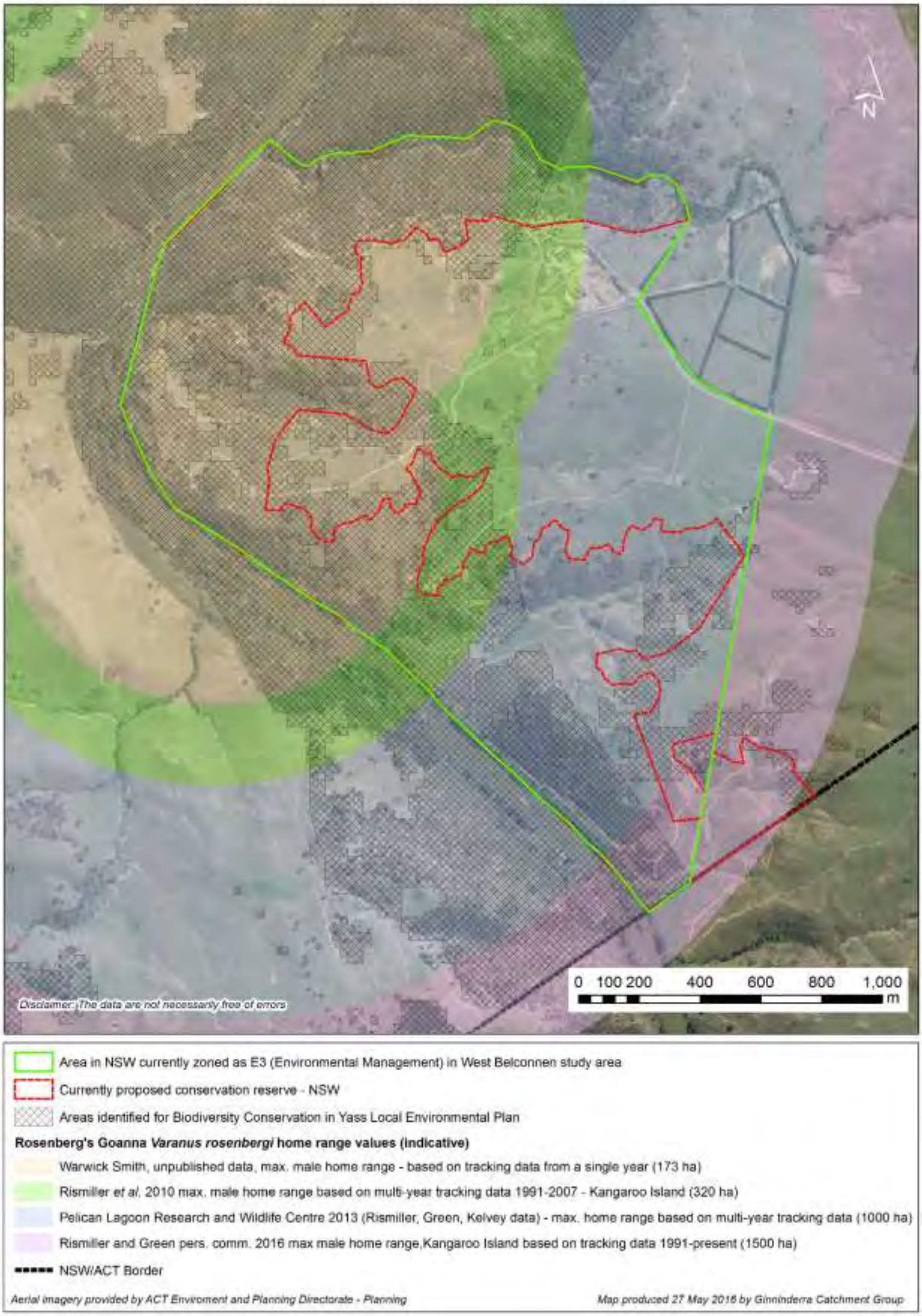

Figure 22: Currently proposed conservation reserve and current E3 (Environmental Management) land in the NSW section of the West Belconnen development area

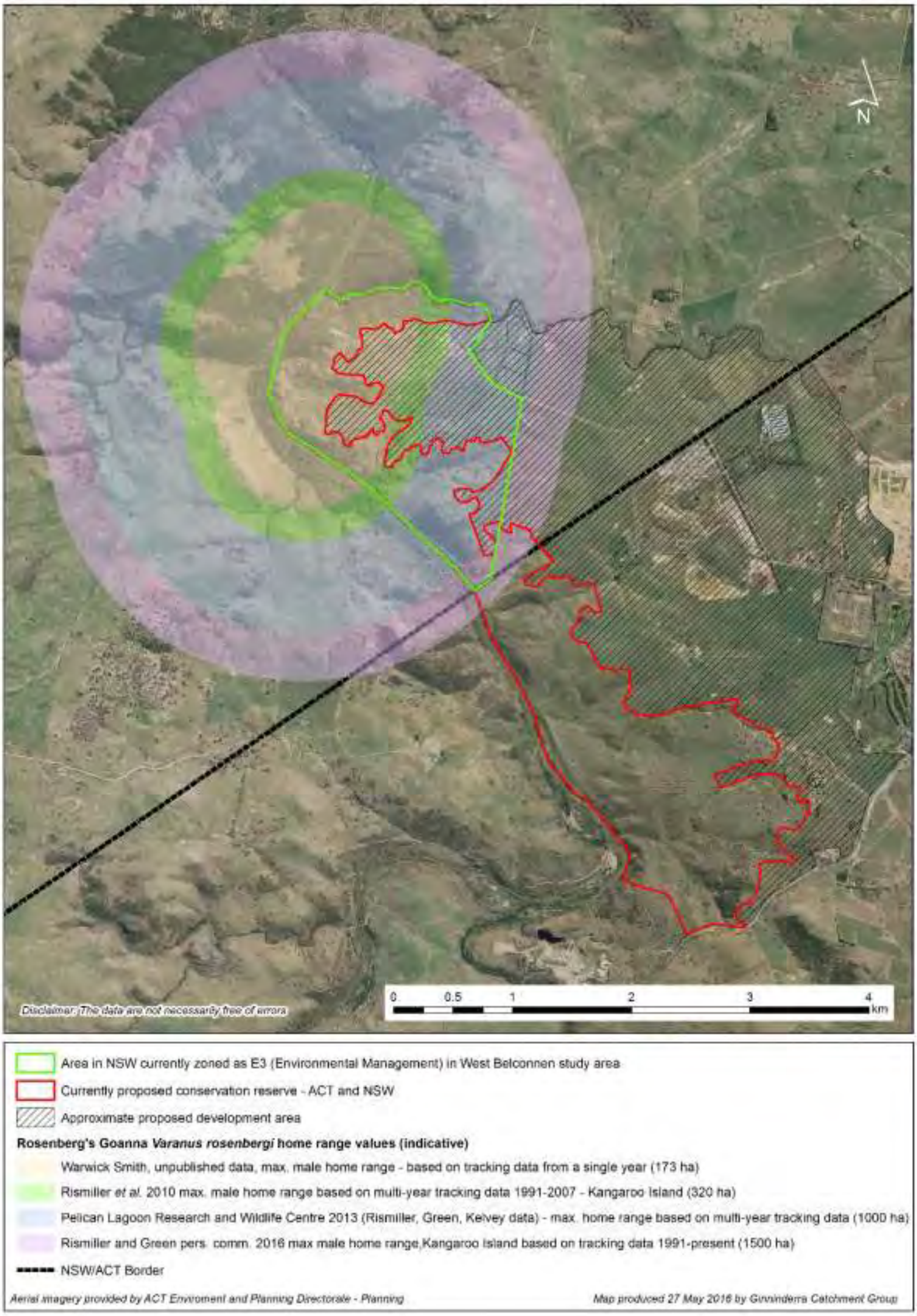

Figure 23: Currently proposed conservation reserve and current E3 (Environmental Management) land in NSW section of West Belconnen development within context of whole development.

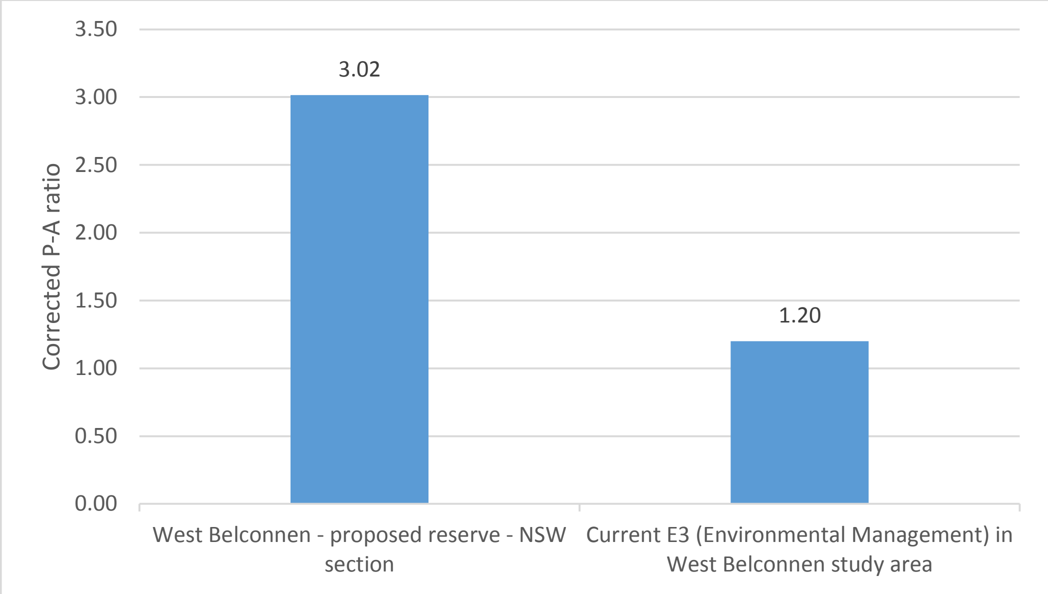

Figure 24: Corrected Perimeter – Area ratios for proposed conservation reserve and existing land zoned as E3 in the NSW section of the West Belconnen development.

The currently proposed approach of protecting within a conservation reserve areas that coincide with matters of national environmental significance (as well as areas that are deemed as of ecological value under a limited set of criteria) does not incorporate well established ecological principles relating to reserve design (e.g. size and configuration) and does not cater for the needs of large-home range threatened species that are sensitive to urbanisation. In addition, this approach does not incorporate relevant scientific knowledge about the sensitivity of species such as Rosenberg's Goanna and a range of birds to the proximity of urban development (Rayner *et al.* 2015). Much larger areas of land are protected in the south of the development (in the ACT) when compared with the NSW section of the proposed conservation reserve (Figure 23). The southern part of the proposed conservation reserve coincides with large areas of Box Gum Woodland. By contrast, the area near the Ginninderra Falls is underrepresented in the conservation reserve even though the values of the Ginninderra Falls area are high and the species and ecosystem that occur there are more intact ecologically and are more unique in a regional context than those in the ACT section of the reserve. Figure 24 illustrates the difference between the corrected perimeter-area ratio of the proposed conservation reserve in the NSW section and that of the land currently zoned as E3 in the West Belconnen study area. This highlights significant concerns about the proposed reserve boundary in relation to conservation and ongoing management. It is recommended that the proposed conservation reserve boundary be re-assessed with respect to reserve size and configuration and the needs of large home-range species. This assessment should incorporate ecological principles of reserve design and expert opinion of the leading researchers in the fields of the large home-range species concerned.

The current E3-zoned land provides adequate protection for larger home range species such as Rosenberg's Goanna and Spotted-tailed Quoll. In addition, the rural land between the E3 land and West Macgregor provides an extra buffer between the Ginninderra Falls area and suburbia. It is likely that the urban development in the proposed West Belconnen development area will have impacts on biodiversity in the Ginninderra Falls area, particularly for large home range species and a range of birds.

From a biodiversity conservation perspective, protecting the area currently zoned as E3 within a nature reserve would provide the best protection for Rosenberg's Goanna, as it would best approximate the outer home range values of Rosenberg's Goanna. This would represent the most precautionary approach and would be in keeping with advice provided by experts on the species (Dr Peggy Rismiller, Pelican Lagoon Research and Wildlife Centre; Dr Brian. Green, University of

Canberra; Dr Will Osborne, University of Canberra and; Dr Damian Michael, ANU) to incorporate the home range of Rosenberg's Goanna within the conservation reserve. Conserving this area would also be more appropriate for protecting Spotted-tailed Quoll, and would allow for movement of Pink-tailed Worm Lizard and a range of macropods and mammals. It would also protect a range of birds sensitive to urban development (Rayner *et al.* 2015). Whilst there is no guarantee that these species would not be impacted upon, such a precautionary approach would be broadly consistent with the Riverview Group's stated Guiding Principles for Sustainable Results (Eco 1; Eco 2; Eco 7)(The Riverview Group 2016); that is:

- Acknowledging the intrinsic value of all species and the special role and regional significance of the Murrumbidgee river corridor and Ginninderra Creek
- Respecting and supporting the ecosystem functions of air, soil and water, recognising the importance of living and non-living environmental resources
- Fostering a deep sense of respect for and connection to the land, flora and fauna.

The more that urban development encroaches into the E3 land, the greater the impact will be on large home-range species, species sensitive to urbanisation and general biodiversity. Further work that incorporates ecological reserve design principles and the best scientific research is required in order to design a conservation reserve that will be suitable to protect the significant species and biodiversity within the area.

Conclusion

This survey has highlighted the biodiversity values of the Ginninderra Falls and suggests that the area could be considered as an outstanding and unique ecosystem. These values are one aspect of the many features that make Ginninderra Falls the "magnificent place" that John Gale described and Aboriginal people have held, and continue to hold sacred. The rugged terrain and relative isolation has protected this area from many of the impacts associated with agricultural land use and urbanisation. Designing a reserve that adequately protects large home-range species such as Rosenberg's Goanna and Spotted-tailed Quoll would protect other threatened species; maintain connectivity, facilitating movement of fauna through the landscape; protect valuable ecotone resources; conserve cultural heritage and; maintain aesthetic values and sight lines. Such a reserve would be a key feature of a sustainable community in West Belconnen.

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Appendices

Appendix 1: Plant species list for the Ginninderra Falls Area

GENUS	SPECIES	INTRASPECIES	Common Name	Type	Indigenous/ Exotic	Declared	Rare	Threatened	Jessop 2014 1=recorded	GCG 2015 or ANPS 1=recorded 1*=new record	All surveys 1=recorded
AA Exotic or non-indigenous species				Ex							
Acetosella	*vulgaris*		Sheep Sorrel	Ex	E				1		1
Aira	*sp*		Hairgrass	Ex	E				1		1
Anagallis	*arvensis*		Scarlet Pimpernel	Ex	E				1		1
Arctotheca	*calendula*		Cape Weed	Ex	E					1*	1
Briza	*minor*		Shivery Grass	Ex	E				1		1
Bromus	*diandrus*		Great Brome	Ex	E				1		1
Bromus	*hordeaceus*		Soft Brome	Ex	E				1		1
Bromus	*rubens*		Red Brome	Ex	E				1		1
Carduus	*sp.*		Thistle	Ex	E	D			1		1
Centaurium	*erythraea*		Common Centaury	Ex	E					1	1
Cerastium	*glomeratum*		Sticky Mouse-ear	Ex	E					1*	1
Cerastium	*vulgare*		Mouse-ear Chickweed	Ex	E				1		1
Conium	*maculatum*		Hemlock	Ex	E					1*	1
Conzya	*sp*		Fleabane	Ex	E				1		1
Conyza	*bonariensis*		Flaxleaf Fleabane	Ex	E					1*	1
Conyza	*canadensis*		Canadian Fleabane	Ex	E					1*	1
Echium	*plantagineum*		Patersons Curse	Ex	E	D				1*	1
Eragrostis	*curvula*		African Love Grass	Ex	E	D			1	1	1
Eschscholzia	*californica*		California Poppy	Ex	E					1*	1
Fumaria	*muralis*		Fumitory	Ex	E					1*	1
Galium	*aparine*		Sticky Weed	Ex	E					1*	1
Grevillea	*rosmarinifolia*	subsp. *rosmarinifolia*	Rosemary Grevillea	Ex	E					1*	1
Holcus	*lanatus*		Yorkshire Fog	Ex	E				1		1
Hypericum	*perforatum*	subsp. *veronense*	St John's Wort	Ex	E	D			1	1	1
Hypochaeris	*glabra*		Smooth Catsear	Ex	E					1	1
Hypochaeris	*radicata*		Flatweed	Ex	E				1		1
Linaria	*pelisseriana*		Pelisser's Toadflax	Ex	E				1	1	1
Lolium	*rigidum*		Wimmera Ryegrass	Ex	E				1		1

Orobanche	*minor*		Broomrape	Ex	E				1		1
Oxalis	*corniculata*		Yellow Woodsorrrel	Ex	E					1*	1
Petrorhagia	*nantueilii*		Proliferous Pink	Ex	E				1		1
Plantago	*lanceolata*		Ribwort Plantain	Ex	E				1		1
Rosa	*rubiginosa*		Sweet Briar	Ex	E	D			1	1	1
Rubus	*fruticosus complex*		A blackberry	Ex	E	D			1		1
Rumex	*crispus*		Curled Dock	Ex	E					1*	1
Silybum	*marianum*		Variegated thistle	Ex	E				1		1
Solanum	*nigrum*		Black nightshade	Ex	E					1*	1
Stelleria	*media*			Ex	E				1	1	1
Taraxacum	*officinale*		Dandelion	Ex	E					1*	1
Trifolium	*arvense*	var. *arvense*	Haresfoot Clover	Ex	E				1	1	1
Verbascum	*thapsus*	subsp. *thapsus*	Great Mullein	Ex	E					1*	1
Verbena	*bonariensis*		Purpletop	Ex	E					1*	1
Vulpia	*sp.*		Fescue	Ex	E				1	1	1
AA Native Trees and Tall Shrubs											
Acacia	*dealbata*	subsp. *dealbata*	Silver Wattle	TS	N					1*	1
Acacia	*doratoxylon*		Currawang	TS	N		R			1*	1
Acacia	*mearnsii*		Black Wattle	TS	N					1*	1
Acacia	*melanoxylon*		Blackwood	TS	N					1*+	1
Acacia	*penninervis*		Mountain Hickory	TS	N		R			1*	1
Acacia	*rubida*		Red Leaved Wattle	TS	N				1	1	1
Acacia	*verniciflua*		Varnish Wattle	TS	N		R			1*	1
Bertya	*rosmarinifolia*			TS	N		R			1*	1
Brachychiton	*populneus*	subsp. *populneus*	Kurrajong	TS	N					1*	1
Callitris	*endlicheri*		Black Cyprus Pine	TS	N				1	1	1
Casuarina	*cunninghamiana*	subsp. *cunninghamiana*	River She-oak	TS	N					1*	1
Dodonaea	*viscosa*	subsp. *angustissima*	Narrow-leaf Hop-bush	TS	N					1*	1
Eucalyptus	*blakelyi*		Blakely's Red Gum	TS	N				1	1	1
Eucalyptus	*bridgesiana*		Apple Box	TS	N				1		1
Eucalyptus	*macrorhyncha*	subsp. *macrorhyncha*	Red Stringybark	TS	N				1	1	1
Eucalyptus	*melliodora*		Yellow Box	TS	N				1	1	1
Eucalyptus	*nortonii*		Large-flowered Bundy	TS	N				1	1	1
Eucalyptus	*rossii*		Inland Scribbly Gum	TS	N				1	1	1
AA Shrubs 1 - 2 m											

Astroloma	*humifusum*	var. *humifusum*	Native Cranberry	S	N				1	1	1
Bossiaea	*sp.*			S	N					1*	1
Bossiaea	*buxifolia*		Matted Bossia	S	N				1	1	1
Brachyloma	*daphnoides*	var. *daphnoides*	Daphne Heath	S	N				1	1	1
Bursaria	*spinosa*	subsp. *lasiophylla*	Native Blackthorn	S	N				1	1	1
Calytrix	*tetragona*		Common Fringe Myrtle	S	N		R		1	1	1
Callistemon	*sieberi*		River Bottlebrush	S	N					1*	1
Cassinia	*longifolia*		Shiny Cassinia	S	N				1	1	1
Cassinia	*quinquefaria*		Coughbush	S	N				1	1	1
Correa	*reflexa*		Common Correa	S	N				1	1	1
Crowea	*exalata*	subsp. exalata	Small Crowea	S	N		R			1*	1
Cryptandra	*amara*	var. *amara*	Sweet Cryptandra	S	N				1		1
Cryptandra	*propinqua*			S	N					1*	1
Daviesia	*mimosoides*	subsp. *mimosoides*	Narrow-leaf Bitter Pea	S	N				1	1	1
Dillwynia	*sericea*	var. *sericea*	Showy Parrot Pea	S	N					1*	1
Dillwynia	*sieberi*			S	N					1*	1
Dodonaea	*viscosa*	subsp. *angustissima*	Hopbush	S	N				1		1
Grevillea	*juniperina*	subsp. *fortis*	Prickly Spiderflower	S	N				1		1
Grevillea	*juniperina*			S	N					1*	1
Hakea	*decurrens*		Bushy Needlewood	S	N					1*	1
Hardenbergia	*violacea*		False Sarsparilla	S	N				1	1	1
Hibbertia	*calycina*		Lesser Guinea-flower	S	N					1*	1
Hibbertia	*obtusifolia*		Hoary Guinea-flower	S	N				1	1	1
Hibbertia	*riparia*		Erect Ginea-flower	S	N				1	1	1
Indigofera	*adesmiifolia*		Leafless Indigo	S	N				1	1	1
Kunzea	*ericoides*		Burgan	S	N				1	1	1
Leptospermum	*sp.*		Teatree	S	N				1		1
Lissanthe	*strigosa*	subsp. *subulata*	Peach Heath	S	N				1	1	1
Phebalium	*squamulosum*	subsp. *ozothamnoides*	Alpine Phebalium	S	N					1*	1
Pomaderris	*andromedifolia*	subsp. *confusa*		S	N				1	1	1
Pomaderris	*angustifolia*		Narrow-leaved Pomaderris	S	N				1	1	1
Pomaderris	*betulina*	subsp. *actensis*	A pomaderris	S	N					1*	1
Pomaderris	*betulina*	subsp. *betulina*	A pomaderris	S	N					1*	1
Pomaderris	*eriocephala*			S	N					1*	1
Pomaderris	*intermedia*		Tree Pomaderris	S	N		R			1*	1
Pomaderris	*pallida*		Pale Pomaderris	S	N		R	T		1*	1

Pomaderris	*prunifolia*		Plum-leaf Pomaderris	S	N				1		1
Pomaderris	*subcapitata*			S	N					1*	1
Poranthera	*microphylla*			S	N				1		1
Pultenaea	*spinosa*		Spiny Bush Pea	S	N				1	1	1
Solanum	*cinereum*		Narrawa Burr	S	N					1*	1
Westringia	*Eremicola*		Slender Westringia	S	N					1*	1
AA Other (native forbs, rushes and sedges, creepers)											
Acaena	*novae-zelandiae*		Bidgee Widgee	F	N					1*	1
Acaena	*ovina*		Sheep's Burr	F	N				1		1
Ajuga	*australis*		Austral Bugloss	F	N				1	1	1
Arthropodium	*minus*		Small Vanilla Lily	F	N					1*	1
Blechnum	*nudum*		Fishbone Water Fern	F	N					1*	1
Brachyscome	*diversifolia*	var. *diversifolia?*		F	N					1*	
Brachyscome	*rigidula*		Cutleaf Daisy	F	N					1*	1
Bulbine	*glauca*		Rock Lily	F	N					1*	1
Caladenia	*atrovespa*		Thin-clubbed Mantis Orchid	F	N					1*	1
Caladenia	*carnea*		Pink Fingers	F	N					1*	1
Caladenia	*fuscata*		Dusky Fingers	F	N					1*	1
Calandrinia	*eremaea*			F	N					1*	1
Carex	*breviculmis*		Short-stem Sedge	F	N				1	1	1
Carex	*inversa*		Knob Sedge	F	N				1		1
Cassytha	*pubescens*		Common Devil's Twine	F	N					1*	1
Chamaesyce	*drummondii*		Caustic Weed	F	N				1		1
Cheilanthes	*sp*		Rock Fern	F	N				1	1	1
Cheilanthes	*austrotenuifolia*		Rock Fern	F	N					1	1
Cheilanthes	*distans*		Bristly Cloak Fern	F	N		R			1*	1
Chrysocephalum	*apiculatum*		Common Everlasting	F	N					1*	1
Chrysocephalum	*semipapposum*		Clustered Everlasting	F	N				1	1	1
Clematis	*leptophylla*			F	N				1		1
Clematis	*microphylla*		Small-leaved Clematis	F	N					1*	1
Cotula	*australis*		Bachelor's Button	F	N					1*	1
Convolvulus	*angustissimus*	subsp. *angustissimus*	Pink Bindweed	F	N				1		1
Crassula	*sieberiana*		Austral Stonecrop	F	N				1	1	1

Cyanicula	*caerulea*		Blue Fingers	F	N					1*	1
Cymbonotus	*lawsonianus*		Bear's Ear	F	N				1	1	1
Cynoglossum	*australe*		Australian Forget-me-not	F	N					1*	1
Cynoglossum	*suaveolens*		Sweet Houndstongue	F	N				1		1
Daucus	*glochidiatus*		Native Carrot	F	N				1	1	1
Desmodium	*varians*		Slender Tick-trefoil	F	N				1	1	1
Dianella	*revoluta*	var. *revoluta*	Black-anther Flax Lily	F	N				1	1	1
Dichondra	*repens*		Kidney Weed	F	N				1	1	1
Dichopogon	*fimbriatus*		Nodding Chocolate Lily	F	N				1		1
Diuris	*pardina*		Leopard Orchid	F	N					1*	1
Diuris	*sulphurea*		Tiger Orchid	F	N		R			1*	1
Einadia	*hastata*		Berry Saltbush	F	N					1*	1
Einadia	*nutans*	subsp. *nutans*	Climbing Saltbush	F	N				1	1	1
Euchiton	*sp.*		Cudweed	F	N				1	1	1
Geranium	*solanderi*	var. *solanderi*	Native Geranium	F	N				1	1	1
Geum	*urbanum*		Herb Bennet	F	N					1*	1
Glycine	*clandestina*	var. *clandestina*	Twining Glycine	F	N					1*	1
Glycine	*tabacina*		Variable Glycine	F	N					1*	1
Gonocarpus	*tetragynus*		Common Raspwort	F	N				1	1	1
Hydrocotyle	*laxiflora*		Stinking Pennywort	F	N				1	1	1
Hydrocotyle	*sibthorpioides*		Shining Pennywort	F	N		R			1	1
Hymenochilus	*sp.*			F	N					1	1
Hypericum	*gramineum*		Small St John's Wort	F	N				1	1	1
Juncus	*sp*			F	N				1	1	1
Lepidosperma	*laterale*		Variable Sword Sedge	F	N				1	1	1
Lobelia	*sp.*			F	N					1*	1
Lomandra	*filiformis*	subsp. *coriacea*	Wattle Matrush	F	N				1		1
Lomandra	*filiformis*	subsp. *filiformis*	Wattle Matrush	F	N				1	1	1
Lomandra	*longifolia*		Spiny-headed Matrush	F	N				1	1	1
Lomandra	*multiflora*	subsp. *multiflora*	Many-flowered Matrush	F	N					1*	1
Luzula	*densiflora*		Woodrush	F	N					1*	1
Microseris	*lanceolata*		Yam Daisy	F	N		R			1*	1
Microtis	*sp*			F	N					1*	1
Opercularia	*hispida*		Hairy Stinkweed	F	N				1	1	1
Oreomyrrhis	*eriopoda*		Australian Carraway	F	N					1*	1
Oxalis	*perennans*		Grassland	F	N				1		1

			Woodsorrel								
Poranthera	*microphylla*			F	N					1*	1
Pterostylis			Greenhood	F	N					1*	1
Pterostylis	*aciculilformis*		Needle-point Rustyhood	F	N					1*	1
Pterostylis	*nutans*		Nodding Greenhood	F	N					1*	1
Rumex	*brownii*		Swamp Dock	F	N				1	1	1
Senecio	*hispidulus*	var. *hispidulus*	Rough Fireweed	F	N					1*	1
Senecio	*quadridentatus*		Cotton Fireweed	F	N					1*	1
Senecio	*sp. (native)*		Fireweed	F	N				1		1
Stackhousia	*monogyna*		Creamy Candles	F	N				1		1
Stellaria	*pungens*		Prickly Starwort	F	N					1*	1
Thelymitra	*sp.*		Orchid sp.	F	N					1*	1
Thysanotus	*Patersonii*		Twining Fringe Lily	F	N					1*	1
Tricoryne	*elatior*		Yellow Rush Lily	F	N				1		1
Triptilodiscus	*pygmaeus*		Common Sunray	F	N				1	1*	1
Vittadinia	*cuneata*	var. *cuneata*	Fuzzy New Holland Daisy	F	N					1*	1
Vittadinia	*gracilis*		New Holland Daisy	F	N					1*	1
Vittadinia	*muelleri*		Narrow-leafed New Holland Daisy	F	N				1	1	1
Wahlenbergia	*communis*		Tufted Bluebell	F	N				1		1
Wahlenbergia	*multicaulis*		Tadgell's Bluebell	F	N				1		1
Wahlenbergia	*stricta*	subsp. *stricta*	Tall Bluebell	F	N				1	1	1
Wurmbea	*dioica*	subsp. *dioica*	Early Nancy	F	N					1*	1
AA Grasses				G	N						
Aristida	*ramosa*		Purple Wire Grass	G	N				1	1	1
Austrostipa	*densiflora*		Foxtail Speargrass	G	N				1	1	1
Austrostipa	*scabra*	subsp. *falcata*	Sickle Speargrass	G	N				1		1
Bothriochloa	*macra*		Redleg Grass	G	N				1		1
Cymbopogon	*refractus*		Barbed-Wire Grass	G	N				1	1	1
Dichelachne	*sp*		Plume Grass	G	N				1	1	1
Digitaria	*brownii*		Cotton Panic Grass	G	N					1*	1
Elymus	*scaber*	var. *scaber*	Common Wheat Grass	G	N				1	1	1
Microlaena	*stipoides*	var. *stipoides*	Weeping Grass	G	N				1	1	1
Panicum	*effusum*		Hairy Panic Grass	G	N				1		1
Phragmites	*australis*		Southern Reed	G	N					1*	1
Poa	*sp.*			G	N					1*	1
Poa	*meionectes*			G	N					1*	1
Poa	*sieberiana*		A tussock grass	G	N				1	1	1
Rytidosperma	*carphoides*		Short Wallaby Grass	G	N				1		1

Rytidosperma	*laevis*		Bare-backed Wallaby Grass	G	N					1*	1
Rytidosperma	*pallidum*		Redanther Wallaby Grass	G	N				1	1	1
Rytidosperma	*sp.*		Wallaby Grass	G	N				1	1	1
Sorghum	*leiocladum*		Wild Sorghum	G	N					1*	1
Themeda	*triandra*		Kangaroo Grass	G	N				1	1	1
Native species									88	139	164
Native non-grass (forbs) understorey species									39	69	83
Native grass species									14	16	20
Native tall shrubs and trees									10	17	18
Native shrubs									25	36	42
No. important species									21	40	42
Rare species									1	11	11
Threatened species									0	1	1
Declared pest species									5	4	6
Exotic or non-local species									30	25	43
Total species									**118**	**164**	**207**

Appendix 2: Camera trapping examples of each identified species.

Brush tailed possum (*Trichosurus vulpecula*)

Eastern Grey Kangaroo (*Macropus giganteus*)

Echidna (*Tachyglossus aculeatus*)

Red-necked Wallaby (*Macropus rufogriseus*)

Ring-tail possum (*Pseudocheirus peregrinus*)

Swamp Wallaby (*Wallabia bicolor*)

Wallaroo (*Macropus robustus*)

Wombat (*Vombatus ursinus*)

Blue Tongue Lizard (*Tiliqua scincoides*)

Cunningham's Skink (*Ergernia cunninghami*)

Gippsland water dragon (*Intellagama lesueurii*)

Rosenberg's Goanna(*Varanus rosenbergi*)

Tree Skink(*Egernia striolata*)

Unconfirmed skink (*Ctenotus sp.*)

Australian Raven (*Corvus coronoides*)

Currawong (*Strepera graculina*)

Superb Fairy Wren (*Malurus cyaneus*)

Cat (*Felis catus*)

Sambar Deer (*Rusa unicolor*)

Fox (*Vulpes vulpes*)

Hare (*Lepus europeaus*)

Rat (*Rattus rattus*)

Unidentified macropod (possibly wallaroo)

False Trigger windy day shadow and plant movement

Appendix 3: Examples of reptile and frog species recorded in the Ginninderra Falls area

Rosenberg's Goanna *Varanus rosenbergi*

Eastern Stone Gecko *Diplodactylus vittatus*

Pink-tailed Worm Lizard *Aprasia parapulchella*

Burton's Legless Lizard *Lialis burtonis*

Three-toed Skink *Hemiergis decresiensis*

Nobbi Dragon *Amphibolurus nobbi*

Bearded Dragon *Pogona barbata*

Spotted Grass Frog *Limnodynastes tasmaniensis*

Copper-tailed Skink *Ctenotus taeniolatus*

Appendix 4: Examples of trees and shrubs in the Ginninderra Falls area

Black Cypress Pine *Callitris endlicheri*

Pale Pomaderris *Pomaderris pallida*

Bertya rosmarinifolia

Common Fringe Myrtle *Calytrix tetrogyna*

Small Crowea
Crowea exalata subsp. *exalata*

Alpine Phebalium *Phebalium squamulosum* subsp. *ozothamnoides*

Common Correa *Correa reflexa*

Slender Westringia *Westringia eremicola*

Tree Pomaderris *Pomaderris intermedia*

Appendix 5: Examples of orchid species recorded in the Ginninderra Falls area

Nodding Greenhood *Pterostylis nutans*

Late Leopard Orchid *Diuris Pardina*

Dusky Fingers *Caladenia fuscata*

Waxlip Orchid *Glossodia major*

Thin-clubbed Mantis Orchid
Caladenia atrovespa

Needle-point Rustyhood
Pterostylis aciculiformis

Tiger Orchid *Diuris sulphurea*

Blue Fingers *Cyanicula caerulea*

Pink Fingers *Caladenia carnea*

Appendix 6: Examples of lilies, forbs and ferns in the Ginninderra Falls area

Bristly Cloak Fern *Cheilanthes distans*

Yam Daisy *Microseris lanceoloata*

Brachyscome diversifolia var. *diversifolia*

Chocolate Lily *Dichopogon fimbriatus*

Early Nancy *Wurmbea dioica*

Small Vanilla Lily *Arthropodium minus*

Twining Fringe Lily *Thysanotus patersonii*

Rock Lily *Bulbine glauca*

Calandrinia eremaea

Monitoring the monitor

The dawn chorus at Horse Gully Hut in the Naas Valley in mid December was palpable, led by kookaburras and a strident oriole, supported by a chorus of lyrebirds, magpies, tree-creepers, whistlers and small birds; it lasted a good half hour. The four campers so gloriously awakened were preparing for a long day, arming the southern half of the 21 monitor traps distributed at 400 m intervals along the Naas Firetrail from a few hundred metres south of Horse Gully Hut. They were half of the project team. They met the other half at the midway point after it had 'commuted' from the northern end arming traps. We then did the rounds twice more each day to clear any captures, record details of the captured animals, and finally close the traps for the night ahead.

Don Fletcher (retired, but now an ANU researcher) led the field trip and did most of the preparatory work, assembling the traps, collecting the rabbits and baiting the traps. The other campers were Katherine Jenkins aka Kat (ACT Conservation Research), Matthew Higgins (independent researcher) and Kevin McCue (NPA). The second group of researchers, commuters from Canberra, included Brian Green and Enzo Guarino (University of Canberra), and Deklyn Townsend (ACT Parks and Conservation) or Melissa Snape (ACT Conservation Research).

Once distributed from east to west coasts of southern Australia, Rosenberg's Monitor is now found in just three unconnected patches; at each end and in the centre of its former range. Its status in NSW, Victoria and SA is threatened, so the precautionary principle would dictate that we assume it is equally threatened in the ACT, at least until proven otherwise. Its close relative, the Lace Monitor, has all but disappeared from the ACT.

Most of the only published research on these amazing, large (to 1.5 m), ground-dwelling reptiles has been undertaken by our co-worker Brian Green and colleagues, on the Kangaroo Island (KI) population. These are only two-thirds the size of ACT specimens. Little research has been done on the local population before now and the first thing that needs to be established is their abundance. Insights into their life history, home range, nesting sites, size, weight etc. will be a bonus.

Because the home range of females was presumed to be smaller than that of males, and their use of habitat and breeding site of more interest to researchers, we had hoped to attach wireless trackers purchased by NPA to two large females (minimum weight 1.6 kg). Only one of the nine captured lizards was female (same ratio on KI), however, and its weight was too close to the minimum. The males were all about 2.5 kg, so after painting ID numbers on their backs (sloughed off at the next moult), Brian kitted up two of them with transmitters. We kept them captive for as short a time as possible and, after numbering them 0 to 8, released them where they were trapped. Two of the nine lizards Deklyn and Enzo managed to run down or snag with Don's 'noose on a fishing pole'; one escaped after capture.

At least we answered one question – can Rosenberg's Goannas climb trees? One example may not mean that all of them can or could, unlike their cousin the Lace Monitor. Some were carrying ticks and others were scarred, had broken ribs, or had lost the tips of their tails (cars, fighting or predator?) but all appeared to Brian to be in good shape. They were very quiet after being transferred to the hessian or denim bags and didn't rush away on being released. In fact, we caught one twice, so much did he like the dead rabbit bait on offer.

There are now two numbered, randy male Rosenberg's Goannas carrying tracking equipment wandering Nass Valley looking for love and we hope to monitor their activity for as long as possible to establish a database of their movements. If anyone spots a large goanna with a white number on its back we would appreciate a report giving the date, time and location. They mate in December, the females every second year, and lay about a dozen eggs in a nest excavated by the female in a termite mound. The clutch is guarded for 2–3 weeks by their mother, sometimes with help from her mate (see Matthew Higgins' article in the June 2017 *NPA Bulletin*). The young, not always from the same male progenitor, hatch after about 8 months and feed on their hosts, the termites, before digging themselves out of the mound.

Kat, Deklyn and/or Mel drove us skilfully on the trip and around the traps. So interesting are these creatures that Brian is planning to publish a book on the Rosenberg's Monitor this year. We will notify you when it happens.

In January and February, under Don Fletcher's guiding hand, new teams, including NPA members Sonja Lenz, Philip and Jan Gatenby, Isobel Crawford and John Brickhill, installed 56 cameras at 19 sites along the central part of the Naas Valley, the cameras focussed on a bait of putrid chicken, to start studying the monitors' distribution and density. We have downloaded data and resited and reset the cameras and traps, Don and Enzo even reattached the collar on one of the monitors and retrieved the discarded collar of the other. Invaluable, interesting information has already been obtained on our Monitors in the Naas Valley guaranteeing the success of the pilot project to trap, mark and track them.

Kevin McCue

(continued next page)

Rosenberg's Monitor No 1 marked and measured before return to its capture site.
Photo by Kevin McCue.

Strategy for managing feral horses in the Alpine National Park

All of the national parks across Australia's alpine region are facing sustained pressure from feral horses. NPA ACT members have first-hand experience of the degradation of some of Australia's most iconic sites. So the NPA ACT was pleased to see the issue of a draft strategic action plan ('the Plan') for feral horses in Victoria's Alpine National Park (ANP). The Plan outlined five objectives:

- Reduce damage to alpine wetland and other vegetation communities by expanding and improving feral horse control.
- Improve knowledge of the relationship between feral horse impacts and environmental condition through monitoring and research.
- Protect Aboriginal cultural heritage.
- Prevent the establishment of new populations of feral horses in the Greater Alpine national parks.
- Remove small populations.

In its recent submission to Parks Victoria, the NPA ACT welcomed the general thrust of the Plan, being the active and humane reduction of the numbers of feral horses in the ANP, utilising a strategic and evidence-based approach. However, the NPA ACT questioned whether the long timescale involved in reducing the feral horse population and the size of the proposed remnant population will lead to efficient, effective and economic management of the feral horse population in the ANP.

In general, the NPA ACT supported:

- the expanded horse control program, which would focus on increased feral horse removal and the prevention of the establishment of new populations within the ANP
- the five key core conservation objectives of the Plan
- the Plan's recognition of, and emphasis on, protecting Aboriginal cultural heritage and working with traditional owners
- the removal of all horses from the highly ecologically sensitive Bogong High Plains–Cobungra area
- the introduction of a systematic and realistic monitoring and evaluation system, featuring annual reviews of the efficiency and effectiveness of the feral horse control operations
- plans to undertake practical, applied research on key feral horse control issues.

The NPA ACT was concerned that the Plan:

- severely limits the number of feral horses to be removed from the eastern Alps over the next 3 years, given the level and extent of damage that they are causing to this area
- excludes ground and aerial shooting as a control method during the first 3 years of Plan implementation, solely on the basis of public expectations, when there is evidence that, when properly done, it is the most inexpensive and humane way of managing feral animals
- fails to recognise the importance of prioritising the removal of all feral horses from the Murray River catchment area.

The full version of the NPA ACT's submission can be found at http://www.npaact.org.au/.

Rod Griffiths

Monitoring the monitor *(continued)*

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Notes from Weavers' paper:

- Gogerley (1922) speculated that some species of 'low-nesting birds' including the superb lyrebird (*Menura superba*), nest during winter to avoid predation by the Goanna (*Varanus varius*).
- Weavers collected stomach contents or scats from 52 trapped *V. varius* and four samples from specimens at the Australian Museum. Remains of exotic mammals were identified in 38 per cent of the samples, native mammal remains were in 36 per cent, and all mammals combined were represented in 78 per cent of samples … At least 38 per cent of the samples contained carrion. Cat (*Felis cattus*) was the only species of mammal, exotic or native, observed at Bendethera that did not appear in the dietary samples from the site.
- Clearly, introduced mammals are now a major part of the diet of *V. varius* in the study areas. However, it should not be assumed automatically that the introduction of exotic mammals to south-eastern Australia has been of net benefit to *V. varius*. Certainly some of them (e.g. cattle, horses, rabbits and probably sheep) have become food for the lace monitor, but the provision of grazing land for these exotic animals has dramatically reduced the mature forest available in south-eastern Australia for *V. varius* and its native prey. Additionally, introduced exotic mammals such as dogs, cats and foxes prey on smaller *V. varius*.
- Many types of large food items e.g. rabbits, adult birds, macropod carrion, and small food items e.g. arthropods are all taken by *V. varius* of a wide range of lengths. The very smallest *V. varius* had dined on grey kangaroo (*Macropus giganteus*) while large Lace Monitors were recorded taking Lepidoptera larvae as well as larger items.

Taking the vital statistics. Photo by Kevin McCue.

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Incorporating ember attack in bushfire risk assessment: a case study of the Ginninderry region

Melanie E. Roberts [a,b], **Jason J. Sharples** [c], **Andrew A. Rawlinson**[a]

[a]*IBM Research - Australia*
[b]*University of Melbourne*
[c]*University of New South Wales Canberra*
Email: j.sharples@adfa.edu.au

Abstract: Current methods for assessing the risk of bushfire to built structures are based on the assumption that the majority of structure loss is due to radiant heat exposure. However, data collected in the aftermath of recent destructive bushfires indicates that the impacts of radiant heat are insignificant compared to the impact of ember attack. Recent work by the Bureau of Meteorology has provided fundamental information on how embers are distributed by a convective plume. These ember distributions have subsequently been incorporated into a model that permits estimation of the likelihood of ember attack downwind from an active fire. In this paper we employ the ember load model to incorporate ember attack into bushfire risk assessment. In particular, we consider the case of the Ginninderry region, which is a tract of land currently subject to rezoning for urban development. The Ginninderry region is of interest because it is prone to dynamic modes of fire spread such as eruptive fire spread and vorticity-driven lateral spread, the latter of which is known to result in enhanced production of embers. The ember load model is used to assess the risk of the Ginninderry region to ember attack and compare the inferred risk to that informed by traditional risk assessment methods based on radiant heat thresholds.

The results of this case study indicated that risk of ember attack had a distinct directional signature, which is accounted for in the current approach to bushfire risk assessment. Moreover, the ember load model indicated that many areas at considerable risk of ember attack are further than $100m$ from the urban edge. Such areas are not currently required to have any special resilience to embers. As such the results indicate that current methods of risk assessment could significantly underestimate the risk of house loss from bushfire, and that current requirements for construction standards should be extended further than 100m.

The present analysis contains a number of fairly crude assumptions, and so the results should be considered preliminary. Nevertheless, with some refinement, the ember load model could play an important role in more accurately informing bushfire risk assessment and provide a more quantitative basis for revising and improving the Australian standard for building in bushfire prone areas.

Keywords: *Bushfire risk, Ember attack, Australian standard, dynamic fire spread*

1 Introduction

The losses caused by large bushfires over the last decade or so have prompted questions about the changing nature of bushfire events and how they impact densely populated areas. In particular, concern is centred on an apparent shift to a significantly more hazardous fire regime, characterised by increasing fire frequency and intensity associated with dynamic fire propagation, and the development of catastrophic 'firestorms'. Given the likely effects of climate change, the expectation is that large destructive fires will become more prevalent in the future (Sharples et al. 2016). This trend, combined with the increasing expansion of urban centres into wildland areas, will present an increasingly challenging problem to land managers and fire agencies.

In order to mitigate the impacts caused by large bushfires, a number of protective measures have been developed and implemented. These include: enhanced hazard reduction programs (e.g. prescribed burning), revised public warning systems, community engagement and eduction, enhancement of fire trail networks, and improved building design and construction guidelines combined with better informed urban planning. In particular, the Australian Standard for building in bushfire-prone areas AS3959 (Standards Australia, 2009) specifies requirements in order to improve the resilience of buildings against bushfire attack. In its current form, AS3959 is predicated on the assumptions that fires propagate at a quasi-steady rate of spread and that the main cause of house loss during bushfires is radiant heat exposure.

Specifically, AS3959 informs the design and construction of buildings in bushfire-prone areas through the concept of Bushfire Attack Level (BAL). In principle, BAL can be determined through application of the Standard to any site in the landscape, thereby providing the appropriate design and construction measures required to reduce the risk of bushfire igniting a building situated at the site. The calculation of BAL at a site relies on the following four main factors: Fire danger index, typically the McArthur Mark 5 FFDI; Vegetation type; Distance of the site from the classified vegetation; and Topographic slope on which the vegetation is situated. These quantities are combined to calculate the level of radiant heat exposure of the site. The level of radiant heat exposure is then classified into one of six BAL categories.

Recent research, however, has demonstrated that in the most devastating fires, which are responsible for the majority of damage (e.g. Canberra 2003, Black Saturday 2009), the main cause of house loss is ember attack (Leonard and Blanchi, 2005). While AS3959 does incorporate ember attack to a certain degree, it is based on the unsubstantiated assumption that ember intensity increases roughly in proportion to increases in radiant heat exposure. This may be approximately true in the case of short-range spotting, but the arrival of long-range embers at a built structure should not be expected to have any relationship with radiant heat exposure from flames. Indeed, there are a number of examples of intense ember attack occurring in the complete absence of flames – the embers originate from a fire some distance (perhaps several kilometres) upwind of the structure.

Research has also suggested that embers (both short- and long-range) are more efficiently generated and lofted in connection with extreme and dynamic fire behaviour. The convective intensity and high levels of turbulence associated with extreme fire behaviours (e.g. VLS (vorticity-driven lateral spread), fire eruptions) can more readily tear bark and other burning debris from trees and from the surface, and these firebrands can then be lofted high into the air and transported further downwind from the fire.

In this paper we draw on recent research to develop a model for ember attack, which acknowledges the enhanced effect that dynamic fire spread can have on ember intensity. The model accounts for both short-range and long-range spotting. Long-range spotting refers to embers entrained in the fire plume, and therefore lofted high above the fire before being dispersed by background winds, while short-range embers are those projected directly forward of the fire. The efficacy of the model is investigated using the Ginninderry region as a case study. The Ginninderry region lies to the west of the Australian Capital Territory, and is of interest for two reasons. Firstly, the region is currently subject to rezoning, to allow for urban development; ultimately the region is proposed to house around 30,000 people. As such, it is paramount to provide an accurate risk assessment of the region that better reflects the main bushfire attack mechanism responsible for house loss. Secondly, the landscape to the west and northwest of the region is highly prone to the occurrence of dynamic fire behaviour and extreme bushfire development. As such, the Ginninderry region provides a good opportunity to investigate how incorporation of ember attack and dynamic modes of fire propagation into bushfire risk assessment affects the way bushfire risk is perceived.

2 Ember Load Model

The ember risk of a property is a function of many factors of the built and natural environment, and is further influenced by actions taken to defend a property during a bushfire. Factors include local vegetation and topography, weather conditions, construction materials and layout of a property, and the availability and appropriateness of firefighting resources such as water supplies and personnel. These factors have been the focus of extensive research, including the generation, flight and ignition properties of embers (Tarifa et al., 1965; Albini, 1983; Woycheese et al., 1999; Manzello et al., 2006; Thurston et al., 2017), vulnerability of structures to ember attack (Cohen, 2001; Blanchi et al., 2006), and risks and benefits of active defence (Wilson, 1988; Haynes et al., 2010; McLennan et al., 2012).

Recent work by the Bureau of Meteorology has provided fundamental information on how embers are distributed by a convective plume. This information, together with observations of ember damage during post-fire analysis, enabled the development of a model to estimate the likelihood of ember attack downwind from an active fire (Roberts et al., 2017). Used predictively, this ember attack model provides a measure of the ember risk at a property, should a bushfire burn through local vegetation. The ember risk is defined as the potential ember load that a property could be subject to during a bushfire, due to local bushland such as national parks, state parks, and community green spaces, and the prevailing wind conditions. The model leverages public spatial datasets, which allows for the dynamic updating of the risk score across large geographic areas. The model however introduces a number of simplifications. The resilience or vulnerability of a property to ember attack is not considered; the results therefore only indicate the potential for impact, with higher scores requiring a more resilient property. Moreover, the reliance on vegetation information requires that the ember generation potential for forested areas is approximated. For a detailed description of the model and its implementation, we refer the reader to Roberts et al. (2017), and provide only a brief overview.

The distribution of embers originating from a unit area of forest is given by the probability density function (PDF) ρ_E, where the form of ρ_E is dependent on the underlying mechanisms spreading the embers. Two mechanisms are considered in this model, short-range processes and long-range processes. While short-range embers can be lofted by thermals from the fire directly (Antheniena et al., 2006) and dispersed by background winds, long-range embers are entrained in the buoyant fire plume and are carried into the upper atmosphere before being dispersed. As suggested by the name, long-range embers can travel significantly further than short-range embers; during the Victorian Black Saturday bushfires spotting up to 30km was observed (Cruz et al., 2012). Short-range embers occur on the order of hundreds of meters, while long-range embers occur on the order of kilometres. Although PDFs can be generated for each species individually, this would require detailed vegetation data, that is typically not available, as well as additional research into how embers from different plant species are dispersed.

The PDF ρ_E gives the distribution of embers from a source, however our interest is in the potential collective impact of all vegetation in a region on an individual property. Convolution is used to sum across all vegetation in a region to obtain the cumulative ember load for a property. Thus the ember distribution due to a forest η_{EF} is obtained by convolving the number density function (NDF) of the forest η_F with the PDF for the embers ρ_E:

$$\begin{aligned} \eta_{\mathrm{EF}}(x,y) &= (\rho_{\mathrm{E}} * \eta_{\mathrm{F}})(x,y) \\ &= \int dx \int dy \rho_{\mathrm{E}}(x,y)\eta_{\mathrm{F}}(x_1 - x, y_1 - y), \end{aligned} \tag{1}$$

where the NDF of the forest η_F describes the spatial distribution of the corrected fine fuel load, and (x, y) is the location of the property of interest. Ideally, the NDF of the forest should reflect the propensity for the vegetation to generate embers, however here we approximate this value through the fine fuel load.

In this study we examine the effects of increased ember generation by the occurrence of dynamic fire spread. Specifically, we focus on the potential effects of VLS on ember generation. Sharples et al. (2012) derived the following model (characteristic function) to identify parts of the landscape prone to VLS occurrence:

$$\chi(S,a,\theta) = \begin{cases} 1 & S \geq 20^\circ, |\theta - a| \leq 40^\circ \\ 0 & \text{otherwise.} \end{cases} \tag{2}$$

Here S is the terrain slope, θ is the direction the wind is blowing and a is the terrain aspect (the compass direction that the slope faces). The NDF of the forest is therefore given by

$$\eta_{\mathrm{F}} = (\beta\chi + 1)L \tag{3}$$

where L is the spatial distribution of the fine fuel load of the vegetation. β represents the increase in ember load due to VLS. While there is evidence in linescans and photographs that indicates VLS occurrence does increase ember generation, it is not currently known by how much exactly. Hence, to examine the potential and relative effects of VLS on the overall ember load across a landscape we make the crude assumption that $\beta = 1$, so that regions prone to VLS produce double the ember load otherwise produced by fine fuel loads.

As mentioned above, two mechanisms of ember spread are considered, short-range and long-range processes. Post-fire analysis of ember damage indicates that the density of embers decreases exponentially with distance from vegetation (Ellis, 2003; Tolhurst and Howlett, 2003). The PDF for short range embers is therefore

$$\rho_{E_{\text{short}}} = \frac{\lambda^2}{\pi}\sqrt{\frac{\kappa}{u}}\exp\left(-\lambda\sqrt{\frac{\kappa}{u}x^2 + y^2}\right), \tag{4}$$

where u is the $10m$ wind speed $[m/s]$, x and y are the distance in the downwind and transverse directions, and λ and κ are positive scaling parameters. The above equation assumes that the wind is travelling in the positive x-direction (westerly wind), and therefore a simple rotation is employed to account for variations in the wind direction. Eq. (4) represents embers travelling predominantly in the wind direction, with some transversal spread (controlled by κ). Ideally, the scaling parameters λ and κ are determined from observations or fitted to data, however here they have been assumed based on a rudimentary comparison with observed data from the Hastings Bushfire. Specifically, we assume $\lambda = 0.05$ and $\kappa = 0.1$.

The PDF for long-range processes is based on the findings of Thurston et al. (2014), who investigated the downwind and transverse spread of embers due to interactions between a plume updraft and background wind speeds, for wind speeds between 5 and $15m/s$. They found that, as with short-range processes, embers travelled predominantly in the wind direction with some transversal spread, where the degree of spread was a function of the wind speed. Higher wind speeds were observed to carry embers further from the origin and exhibited reduced spread compared with lower wind speeds. Based on the findings of Thurston et al. (2014) we use the following PDF to describe long-range ember dispersal:

$$\rho_{E_{\text{long}}}(x,y) = \frac{1}{2\pi N\sigma_x\frac{\sigma_y(x+2)}{\mu_x}}\exp\left[-\frac{1}{2}\left(\left(\frac{x-\mu_x}{\sigma_x}\right)^2 + \left(\frac{y-\mu_y}{\frac{\sigma_y(x+2)}{\mu_x}}\right)^2\right)\right], \tag{5}$$

where μ_x is the mean dispersal in the downwind x direction, the mean dispersal in the transverse y direction $\mu_y = 0$, and σ_x and σ_y are the standard deviations of the dispersal in the x and y direction respectively. The normalisation constant N is defined so that

$$\int_0^\infty dx\int_{-\infty}^\infty dy\,\rho_{E_{\text{long}}}(x,y) = 1. \tag{6}$$

The means and standard deviations used in this case are those given by Thurston et al. (2014). For a wind speed of $15m/s$, which is representative of days with fire danger rated at Severe or higher, this is $\mu_x = 8.3$, $\sigma_x = 3.29$, and $\sigma_y = 0.16$.

The total ember risk at a property is the sum of the short-range and long-range risk. As an individual ember will be carried by either long-range or short-range processes, it is necessary to determine the proportion of potential embers at a site that will be subject to short- or long-range processes. We assume that the proportion of available embers that are entrained in the plume is a function of the background wind speed, specifically that the proportion increases quadratically with the fire intensity. As fire intensity has a third order relationship with the wind speed, it is therefore assumed that the proportion of embers entrained in the plume has a 5th order relationship with the wind speed, and is given by $p = 0.01 + 0.0004(u + 10^{-4}u^5)$. One limitation of this approach is that differences in bark characteristics are not accounted for. This is a necessary assumption, given limitations in the current state of public vegetation data. The total ember risk is therefore

$$\rho_E = \rho_{E_{\text{short}}}(1-p) + \rho_{E_{\text{long}}}p. \tag{7}$$

The ember risk model given by Eq. (1) – Eq. (7) is applied to the Ginninderry region to identify the ember risk across the site. For computational purposes, the region is discretised into 0.0001 arc second cells, that is, approximately $11m \times 11m$. In the next section, the data used to identify ρ_{EF}, including the VLS correction, is summarised.

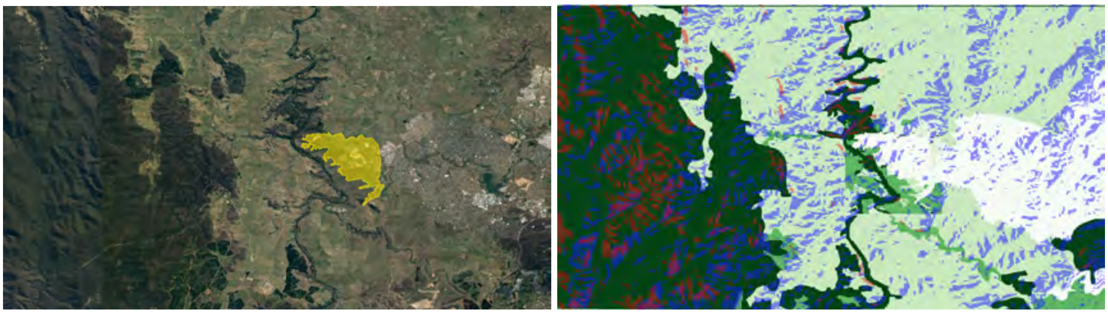

Figure 1. The site of the proposed development is indicated by the yellow polygon, shown overlaying satellite imagery of the region. The right hand figure shows the assumed fuel load for the region. Darker greens correspond to higher fuel loads. Forested areas have an assumed fuel load of 25 t/ha, shrubland and woodland areas 15 t/ha, mixed grassland-woodland areas 7 t/ha, grasslands 4.5 t/ha, and urban areas (proposed or current) 1 t/ha. Areas satisfying the aspect (blue) and slope (red) requirements for VLS for a north-westerly wind are shown overlaying the assumed fuel load for the region.

3 DATA

The general region of interest, including Ginninderry, is shown in Fig. 1. Detailed vegetation classifications for the area immediately surrounding the proposed development were obtained from EcoLogical Australia (2014). The vegetation classification of EcoLogical Australia (2014) was manually digitised using QGIS (v2.14) and supplemented with broad classifications taken from a Google Earth image of the region. The assumed fuel load distribution L is shown in Fig. 1.

The slope and aspect information is determined from the Geoscience Australia hydrologically corrected 1 arc second digital elevation model ANZCW0703014615 for the region using standard techniques in QGIS. Fig. 1 shows areas prone to VLS ($\chi = 1$) for a northwesterly wind ($\theta = 135°$).

4 RESULTS AND DISCUSSION

The potential ember load for Ginninderry is determined for a northwesterly wind of $15m/s$. North-westerly winds are associated with dangerous fire activity in the region, and as well as being a focus of Thurston et al.'s (2014) study, a $15m/s$ wind speed is consistent with a high fire d anger. The relative ember risk across the proposed development is shown in Fig. 2. The ember risk is observed to be non-uniform across the region, with the northern and western fringes being of substantially higher risk than central or eastern areas of the proposed development. The ember load model provides a measure of the relative risk for an area, rather than an absolute measure. However, comparisons can be made with the results of the Hastings Bushfire case study given in Roberts et al. (2017). In January 2015 the Mornington Peninsula, Victoria, experienced their worst bushfire in a decade. Fire burnt through sections of the Warringine Park (Coastal Section) resulting in damage to 32 properties, although no houses were destroyed. Post-fire analysis determined that all damage was the result of ember attack, rather than radiant heat or direct flame contact (Terramatrix, 2 015). Fig. 2 shows the ember load for the proposed development, rescaled as multiples of the maximum ember load calculated for the Hastings Bushfire case study. That is, the maximum ember load calculated for any cell within a damaged property is used to scale the calculated ember load for the Ginninderry region. The potential ember load within the development ranges from 13 to 115 times the Hastings maximum. This result implies that, in the absence of significant resilience to ember attack, property damage can be expected due to ember attack in the event of a large bushfire. However, further research, in particular improvements to the estimation of the input parameters, is required before this result can be considered definitive. Post-impact data is also required to validate the model.

AS3959 stipulates that for buildings more than $100m$ from bush fire prone vegetation, no special construction requirements are required, although 'homewoners are encouraged to provide basic measures such as suitable window screening and gutter guards to minimise the impacts of ember attack (as embers can travel distances greater than 100 metres)' (NSW Rural Fire Service, 2012). As evident in Fig. 3, which shows the proximity of areas within the proposed development to vegetation (excluding grasslands), many areas at risk of ember attack fall beyond the $100m$ mark and therefore are not required under AS3959 to have any special resilience to embers.

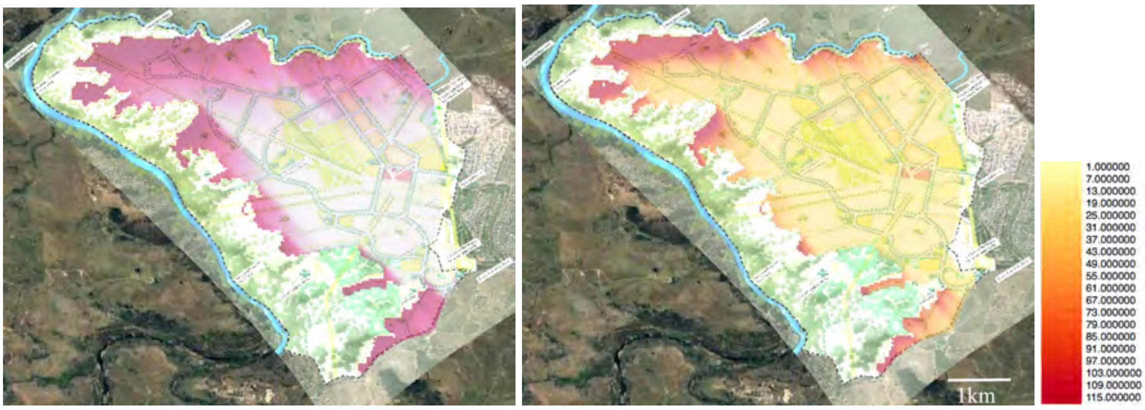

Figure 2. Ember risk for the proposed Ginninderry development is shown for two scalings. On the left, the relative ember load is shown using a log scale with darker colours corresponding to higher risk, and lighter colours to lower risk. On the right, the ember load is scaled against the maximum ember load calculated for properties damaged in the Hastings Bushfire. The minimum ember load for the proposed development, relative to the Hastings scale, is 13 times, with the maximum being 115 times.

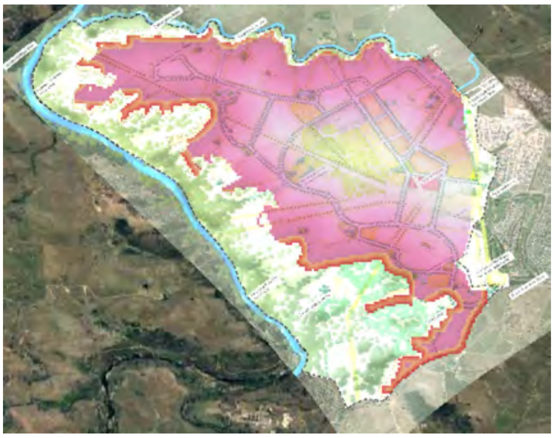

Figure 3. Proximity of areas within the proposed development to vegetation (fuel load $\geq$ 7 t/ha). Areas within 100m of vegetation are shown with a red – yellow colour scheme. Areas greater than 100m from vegetation are shown with a purple colour scheme, with lighter colours corresponding to greater distances.

5 CONCLUSION

We have considered the effect that ember attack has on the level of bushfire risk across the Ginninderry region to the west of the ACT. Due to limitations in the current understanding of ember processes, a number of assumptions and simplifications have been necessary. Changes to these assumptions would affect the results obtained. Nevertheless, these assumptions enable us to present a proof-of-concept, despite the limitations in public data on ember impacts and transport. Further scrutiny and refinement of these assumptions will be a necessary step towards adoption of an ember load measure of bushfire risk such as has been presented.

Although the assessment of probable ember attack was underpinned by a number of assumptions, the results indicated the potential impact that embers could have on the region. Most importantly, the pattern of likely ember impact formed quite a different picture of building vulnerability than that provided by AS3959, which basically assigns building construction standards based on distance from vegetation. In contrast, the ember load model showed a strong directional effect and indicated that embers could impact structures well into parts of the region not normally assessed as vulnerable. The results presented will be refined in further work and as more data becomes available to better calibrate the ember load model. It is expected that the ember load model has the potential to provide more information to inform decisions regarding construction standard requirements.

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A T Adams Consulting

URBAN DEVELOPMENT AT WEST BELCONNEN

Program Report

prepared for:

Riverview Projects (ACT) Pty Ltd

18 April 2017

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Abbreviations and Definitions

NCA = National Capital Authority (Commonwealth)

EDD = Economic Development Directorate (inclusive of LDA – Land Development Agency, ACT)

EPBC Act = *Environment Protection and Biodiversity Conservation Act 1999*

ESD Environmentally Sustainable Development (principles as defined in section 3A of the EPBC Act)

ESDD = Environment and Sustainable Development Directorate (inclusive of CPR – Conservation, Planning and Research & EPA – Environment Protection Agency)

DoE= Commonwealth Department of the Environment

DV 351 = Draft Variation 351 to the Territory Plan

LEP Local Environment Plan

YLEP Yass Valley Local Environment Plan

TaMS = Territory and Municipal Services Directorate

YVC = Yass valley Shire Council

Box Gum Woodland = yellow box-red gum grassy woodland

PTWL = Pink Tailed Worm Lizard (*Aprasia parapulchella*)

GSM = Golden Sun Moth (*Synemon plana*)

OEH = NSW Office of Environment and Heritage

EMT = West Belconnen and Parkwood Environmental Management Trust.

VBC = Village Building Company

WBCC = West Belconnen Conservation Corridor

RMP = Reserve management plan

'Proponent' = Riverview Projects (ACT) Pty Ltd acting on behalf of the ACT Government with respect to land in the ACT and Land in NSW owned by the ACT Government, acting on behalf of other NSW landowners within the project area and on its own behalf with respect to its related entity landholdings within the project area in NSW.

'Construction' includes actions that may impact on MNES habitats such as preparatory works required to be undertaken including clearing vegetation and temporary structures and the use of construction or excavation equipment on site for the purpose of breaking the ground for buildings or infrastructure but does not include site surveys and investigatory work including geotechnical investigations or fencing and other stock management measures.

"Government" means the ACT, NSW and or Commonwealth Governments as appropriate.

1.0 Introduction

1.1 Background

In July 2014, Riverview Projects (ACT) Pty Ltd (Riverview) and the Commonwealth Government commenced a Strategic Assessment under Part 10 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The focus of the agreement is to assess the potential impacts from development of the West Belconnen project area (referred to as "the development" in this report), on Matters of National Environmental Significance (MNES) protected under the EPBC Act. For the purposes of the preparation of this assessment Riverview is acting for the ACT Government with respect to land within the ACT and in its own right as owner of part of the NSW land and as an agent for the other four owners of the NSW land. Riverview, representing the land owners in NSW and the ACT Government is referred to as "the proponent" in this report.

1.2 Purpose of this Document

This is one of 2 documents relating to the Strategic Assessment of the West Belconnen urban development in accord with the EPBC Act as follows:

- **Program Report (this report, A T Adams Consulting)** which sets out the program of works, actions, management and funding arrangements, and commitments for the protection of matters of national environmental significance. The program is to be presented to the Minister for the Environment for endorsement and consideration of an approval for a class of actions for urban development under Part 10 of the EPBC Act.
- **Assessment report (Umwelt Pty Ltd)** which presents an assessment of the impacts of the program on Matters of National Environmental Significance and the extent to which those impacts will be avoided, mitigated or offset by actions proposed as part of the program.

2.0 Site Description

2.1 Location

The project site is at West Belconnen, in the north west of the Canberra metropolitan area, generally to the west of the suburbs of Holt and Macgregor, and extending into NSW, as shown in a regional context on Figure 1 and locally on Figure 2 This area will be rezoned for a variety of development and conservation uses as discussed in Section 3.0 below. Figure 2 also shows the proposed alignment for the completion of Ginninderra Drive. The proposed alignment traverses the Jarramlee and Macgregor offset areas. No development (other than the road extension) is proposed in these offset areas.

Figure 1: West Belconnen regional location

A portion of the site was included in an earlier assessment under the EPBC Act (ACTPLA, 2011); the specific area was labelled "West Molonglo" at that time and is shown on Figure 2 also.

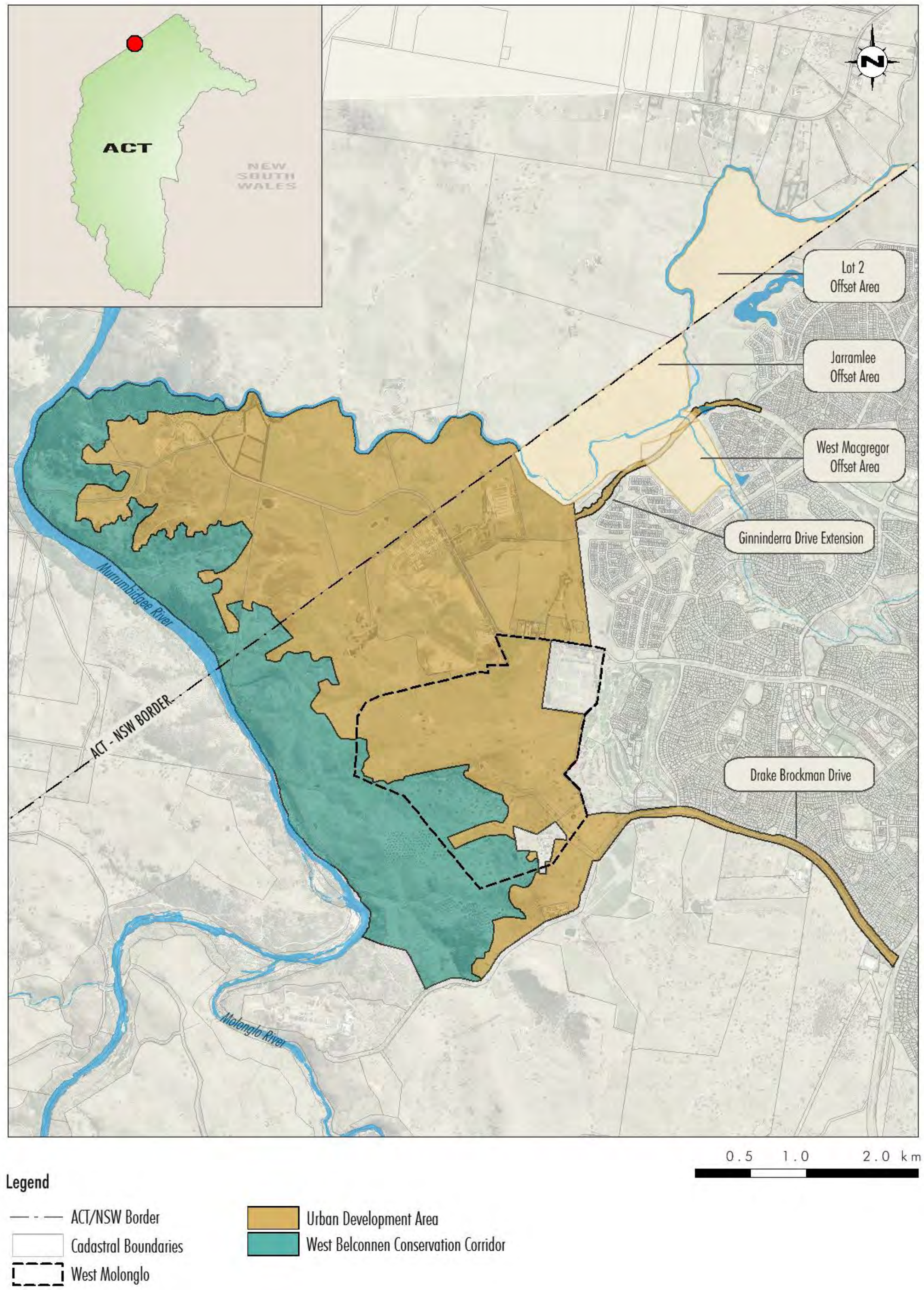

Figure 2: Project site

2.2 Molonglo Valley NES Plan

The Molonglo Valley plan for the protection of Matters of National Environmental Significance (the NES Plan) was published by the ACT Government in September 2011 and endorsed by the Commonwealth Minister for the Environment on 7th October 2011. The plan focused on urban development in the area known as east Molonglo but also included west Molonglo (the area shown on Figure 2). In the Molonglo NES Plan the ACT Government committed to avoiding impacts on MNES within west Molonglo and undertook to deliver the following conservation outcome:

> *"e) Maintenance and enhancement of the Box-Gum Woodland that occurs within the West Molonglo component of the strategic assessment area".*

This commitment was reflected in two proposed actions. The first (action item 21) related to the ongoing management of box gum woodland under current land use arrangements; these consist of a rural lease management plan that has been prepared by the current lessee and approved by the ACT Government (Territory and Municipal Services Directorate). The management plan dates from the period prior to the preparation of the Molonglo Valley NES plan and does not specifically provide for the management of the woodland for conservation purposes. The intent was that it be revised to meet the NES commitment however this intention will now be overtaken by the outcomes of this program. The second (action item 22) is relevant to the West Belconnen program, the two action items are as follows:

Table 1: Extract from Molonglo Valley NES Plan

Action	*Responsibility*	*Timing*
21. Manage the Box-Gum Woodland that occurs in West Molonglo in accordance with the terms of a Land Management Agreement (LMA). LMAs are required by Part 9.7 of the Planning and Development Act 2007 for all non-urban leases. The LMA covering the BGW in West Molonglo contains a Land Action Plan which ensures that: • the ecological functioning and integrity of BGW on the lease is retained and improved; • the extent and character of the BGW is preserved; and • there is an Action Plan which details the activities, timeframes and performance measures put in place to ensure the conservation outcomes are met.	Territory and Municipal Services Directorate	Ongoing
22. West Molonglo is zoned broadacre and is not part of the ACT Government's current land release program. In the event that West Molonglo is developed in the future for broadacre uses or residential development then, subject to confirmatory ecological assessment of Box-Gum Woodland, the area of EPBC Act Box-Gum Woodland that occurs there will be set aside as a Nature Reserve.	Environment and Sustainable Development Directorate	The Nature Reserve will be established prior to construction in West Molonglo commencing

The actions that will be undertaken in accord with this (West Belconnen) program will fulfill the requirements of Action 22 of the Molonglo Valley NES Plan.

3.0 The development

The general intent of the development is discussed in detail in the reports “West Belconnen Draft Variation 351 Planning Study” (A T Adams Consulting, 2014b) and “Planning Proposal for Parkwood being the NSW part of the West Belconnen Project” (Knight Frank, 2014) . The master plan that describes the proposed development is provided below (Figure 3). The master plan will be put into effect by way of a series of rezonings which are discussed in subsequent sections.

The Project Area included in the master plan covers 1,583.3 hectares of land that straddles the Australian Capital Territory and New South Wales border, west of the Canberra suburbs of Higgins, Holt, and Macgregor. It is bounded by the Murrumbidgee River to the west, Ginninderra Creek to the north, Macgregor to the east, and Stockdill Drive to the south. Land that will be impacted by the proposed Ginninderra Drive Extension, which links the current Ginninderra Drive terminus to the proposed development area is also subject to assessment. The Strathnairn Arts Association land is not included in the Project Area.

The proposed land use zones are based on the approach that has been taken to the project which has been to develop the master plan in response to:

- The physical form of the site
- The landscape setting, particularly the dramatic visual relationship of the site to the Brindabella ranges and to the hills to the north and north west
- The need to protect the local and global environment and to achieve a 6 star new community rating
- The extensive urban edge between residential development and the Conservation corridor
- The need for a full spectrum variety of housing types across all affordability levels
- The need, recognising that Canberra land prices are amongst the highest in Australia, to achieve land development economies wherever practical
- The need to focus density along transport routes and near centres
- The need to create a sense of place for West Belconnen as a whole and for neighbourhood scale precincts within it; this is an essential element if resilient and robust communities are to form, and grow over time

The zones that reflect the intent of the master plan and which are therefore to be applied at west Belconnen include in the ACT:

- NUZ1 Broadacre
- NUZ3 Hills ridges and buffers
- NUZ4 River corridor
- CFZ Community facility (including areas nominated as indicative school sites)
- CZ1 Commercial core
- CZ3 Commercial services
- CZ5 Commercial mixed use

- RZ1 Suburban residential
- RZ3 Urban residential
- RZ5 High density residential
- IZ2 industrial mixed use
- PRZ1 Urban parks and recreation
- TSZ2 Transport and services zone

and in NSW:

- E3 Environmental protection
- R1 General residential

Specific controls within these zones will be tailored to meet the intent of the master plan and respond to the particular characteristics of the site. Additions and amendments to these zones may occur over time as detailed implementation of the project proceeds.

The land fill site is currently being utilised for several waste disposal and management functions within the terms of its current licensing arrangements. These functions will continue for a 5 – 10 year period following which the site is expected to be converted to a range of uses including parkland, community uses, recycling activities and the like. Residential development will not be permitted. The range and pattern of uses will be determined following a master planning process that will be a prescribed outcome of DV 351.

DV 351 prescribes a series of "clearance zones" within which residential and other uses sensitive to odour are prohibited, pending the modification or relocation of the activities that create the potential nuisance. The clearance zones are as follows:

Land fill site:	500m
Green Waste facility:	1000m
Poultry (egg) farm:	750m
Lower Molonglo Water Quality Control Centre:	2400m

The Program aims to provide a third urban development front within the ACT (in addition to Gungahlin and Molonglo), which extends into bordering NSW. This will occur by extending the existing urban area of Belconnen west and north. It is anticipated that a total of 11,500 dwellings over a 30 to 40 year period (approximately 300 dwellings per year) will be provided to house approximately 30,000 people (A T Adams Consulting, 2014b). This long timeframe is a key aspect of the project; the development area has been nominally divided into 29 stages which will be progressively developed, commencing in the vicinity of Stockdill Drive, as illustrated on Figure 4.

The Riverview Group is aiming to create a sustainable community in the nation's capital that will be recognised with a 'six star – a world leader in sustainability' rating under the Green Building Council of Australia's Green Star Community Pilot Rating Program (Green Community Rating). The Program has the opportunity to incorporate best practice sustainability design, building and urban management techniques into a suburban scale development that also aligns with ESD principles.

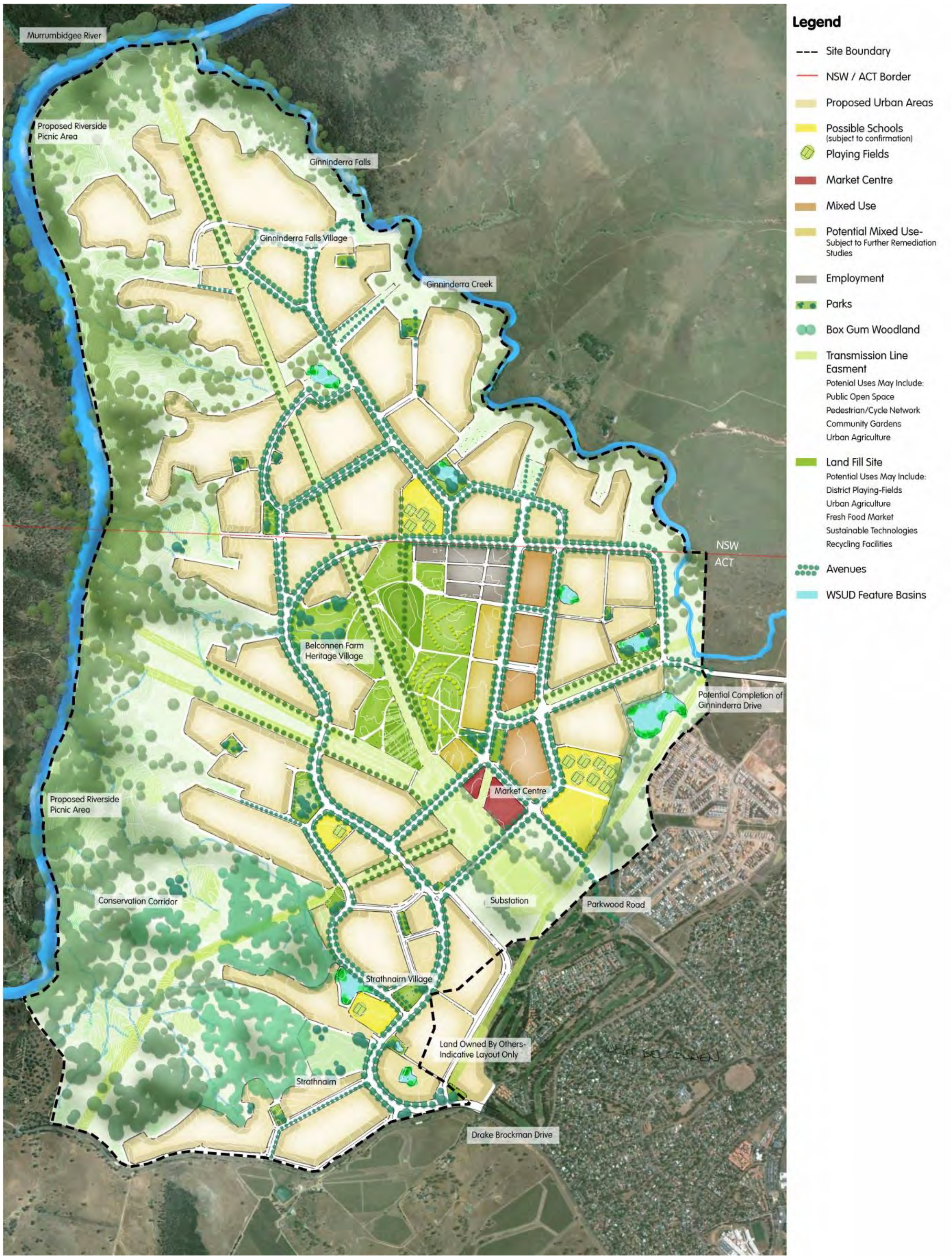

Figure 3: West Belconnen illustrative master plan

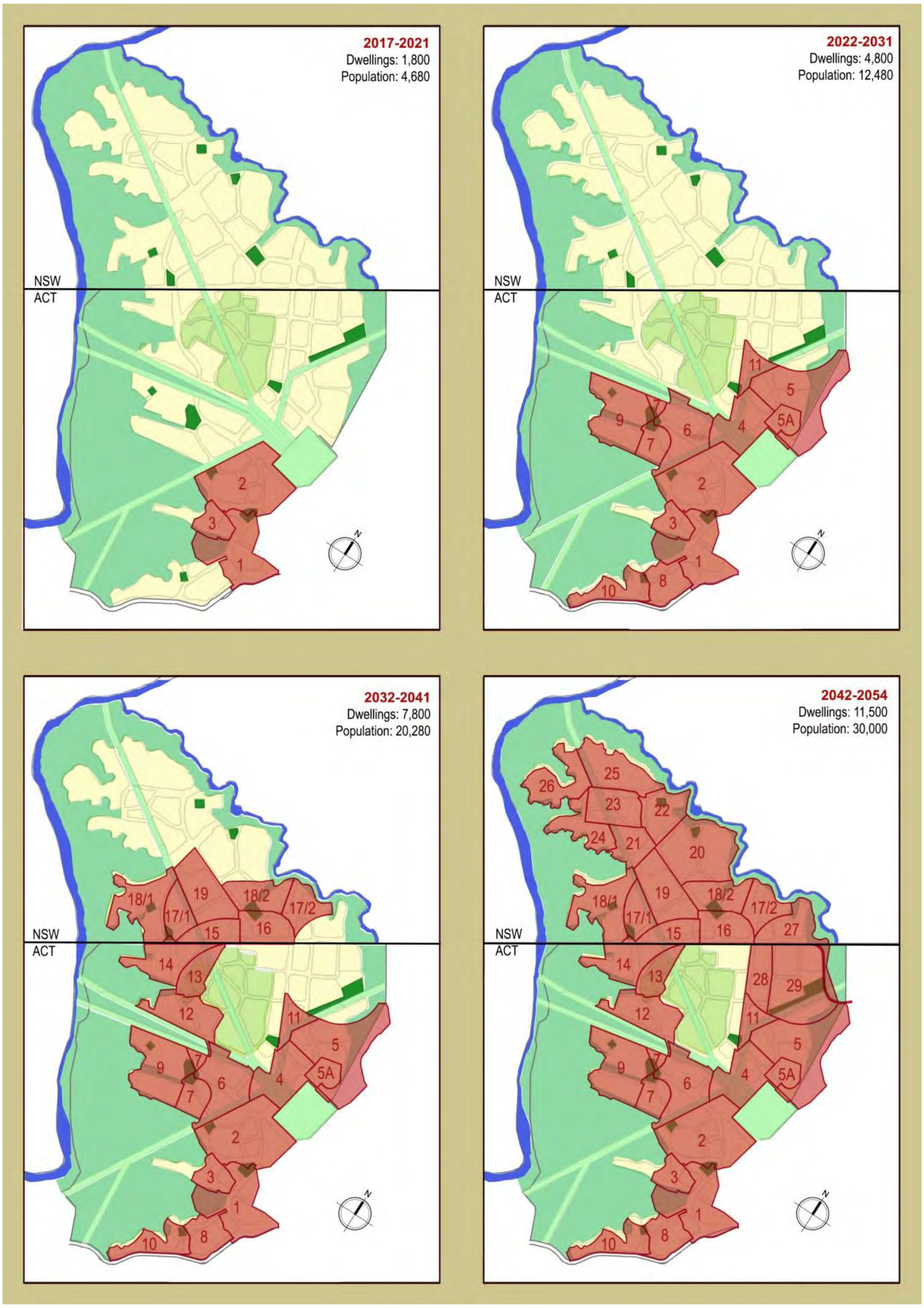

Figure 4: Indicative Project Staging

3.1 Summary of actions

The west Belconnen project envisages the construction of an extensive urban area, to accommodate ultimately a population of about 30,000 people. This will include a great variety of actions to be implemented over a long, 40 year, timeframe. At this point the project will be notionally complete but, as with any such area, renewal and rejuvenation of land uses and infrastructure will continue indefinitely within the urban area and in the land devoted to conservation purposes. All future actions will be subject to statutory approval processes discussed in Section 3.3; these processes will incorporate the requirements of this Strategic Assessment.

With the exception of two significant actions discussed at Section 3.2, the scale and timeframe of the program is such that identification of specific actions is not practical. In general terms the program will provide for urban development and conservation at West Belconnen, including:

- Construction and operation of residential, commercial, community, light industrial and open space land uses, and related urban development and infrastructure, including the completion of Ginninderra Drive (refer to Section 3.2.1), within the district of Belconnen in the ACT and the Shire of Yass in NSW over the next 40 years subject to approval under the ACT Planning and Development Act 2007 and the Yass Valley Shire Local Environment Plan (YLEP) ;
- Variation to the Territory Plan and an amendment to the National Capital Plan to reflect changes in land use in the ACT identified in this document;
- Rezoning of land by way of an amendment to the YLEP, to reflect changes in land use in NSW identified in this document;
- A biodiversity offsets package for GSM which will place an additional 86.8 hectare site (lot 2 Wallaroo Road NSW) supporting threatened species into protected areas; The site includes 11.9 ha of land currently occupied by GSM and 19.4 ha suitable for GSM, currently unoccupied.
- Construction of Ginninderra Drive extension
- Off site road improvement works on local and arterial roads within the existing Western Belconnen urban area (discussed in detail in (Aecom, 2014a) including:
  - Southern Cross Drive
  - the existing portion of Ginninderra Drive and
  - local streets
  - Widening of Drake Brockman Drive to create a dual carriageway road between the project area and William Hovell Drive.
- The creation of a conservation corridor along the Murrumbidgee River and Ginninderra Creek totaling 549.9 ha encompassing PTWL habitat and an area of box gum woodland. Works will occur within this corridor in locations that will be specified progressively as development applications for works are lodged and approved over the course of the project development phase, including
  - Construction of a sewer tunnel within the river corridor by direct drilling so as to pass beneath Pink tailed worm lizard (PTWL) and box gum woodland habitat and involve limited surface works outside but close to PTWL habitat refer to (refer to Section 3.2.2)

- Recreation and tourist facilities including buildings picnic areas, carparking and access roads and walking and cycling tracks
- Bushfire and maintenance management access tracks
- Bushfire management measures including vegetation management by way of slashing, controlled burning and livestock, including access tracks.

The corridor will incorporate 100% of the box gum woodland that is within the project area, and 145.8 ha of PTWL habitat. The status of the land will be upgraded to “nature reserve” ensuring the long term protection of the MNES; this together with enhancements to the connectivity between PTWL areas and an increase in overall area of PTWL habitat will offset the loss of 16.4 ha of disaggregated patches of PTWL habitat that will be subsumed with in the urban development area.

3.2 Significant actions that may directly impact MNES

3.2.1 Ginninderra Drive extension

The Program proposes to extend Ginninderra Drive (see Figure 5) to provide a third arterial road access to the Project Area and service the final stages of the development. The road will be a two lane carriageway (single lane in each direction) with a posted speed limit of 60 kilometres per hour and will be in addition to the two other arterial road connections at Drake Brockman / Stockdill Drive and Parkwood Road/Southern Cross Drive (Brown, 2014a).

The first alternative for the Ginninderra Drive Extension is to not proceed and exclude this aspect of the proposal from the Program. This would result in the development having to depend on the connections at Drake Brockman/Stockdill Drive and Parkwood Road/Southern Cross Drive. Under this option there would be no impacts to the established environmental offset areas and associated MNES.

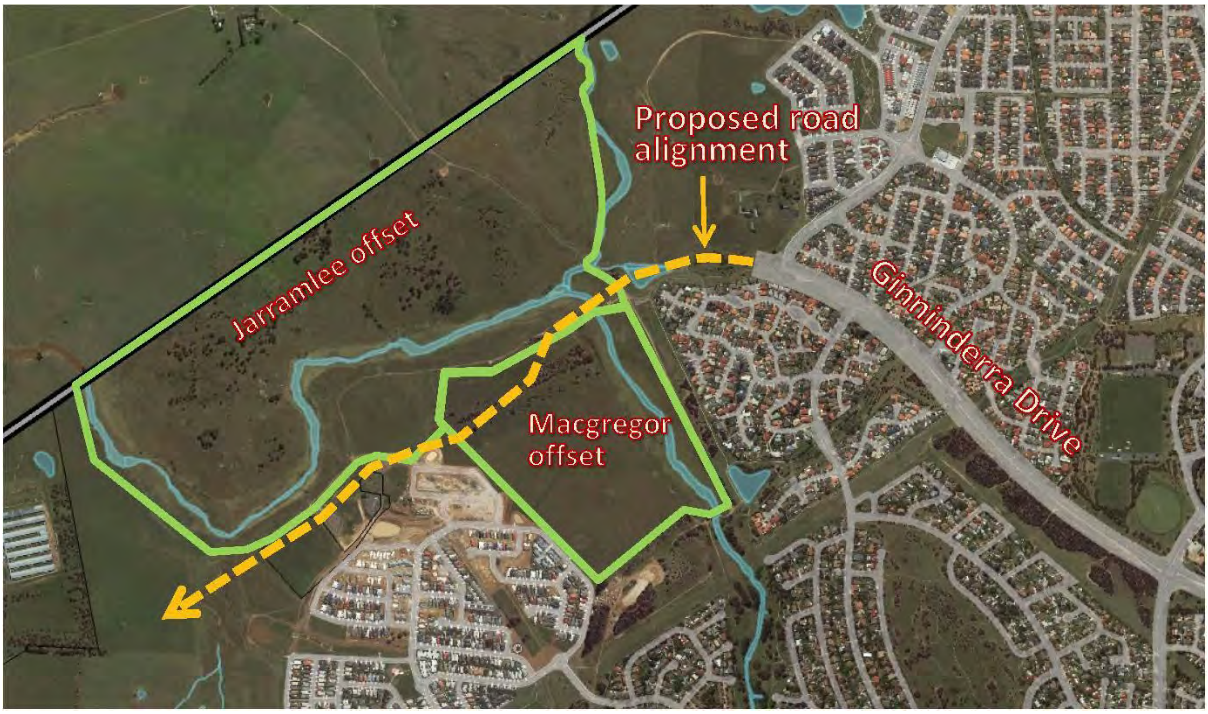

Figure 5: Ginninderra Drive proposed alignment

Although technically feasible, not constructing the Ginninderra Drive extension will result in a need to upgrade the capacity of both Drake Brockman/Stockdill Drive and Parkwood Road/Southern Cross Drive. These upgrade works would require additional maintenance and infrastructure works to occur before the Program is completed (Brown Consulting, 2014a). Traffic modelling has also indicated that the longer travel times and distances lead to significantly increased greenhouse gas emissions and other associated impacts such as reduced efficiency of public transport networks. Given these factors, the option to not construct the Ginninderra Drive extension is undesirable as it will lead to significant, adverse social and environmental impacts that would otherwise be avoidable and by limiting access to the Project Area to two arterial connections, sustainability of the Program is not optimised.

The current alignment of Ginninderra Drive has been designed and built to service the increased usage levels that will be associated with the Program. Extending Ginninderra Drive is not only consistent with the original design intent, but also realises the value of the original investment in constructing Ginninderra Drive to its existing standard. It is therefore a more sustainable alternative as construction costs will be limited and existing infrastructure will be used more efficiently.

In planning for the extension of Ginninderra Drive, a total of eleven alignment options have been considered. The route options, and the characteristics of each are discussed in detail in Brown 2014a.

3.2.2 Sewer tunnel alignment

An important component of the Program that must be considered is the provision of infrastructure for services and utilities such as sewerage, potable water, electricity, gas, and communications. Of these, the sewer alignment requires further discussion due to the potential for impacts to MNES as a result of its development.

Existing sewer services within west Belconnen converge upon the Ginninderra sewer tunnel, which runs generally north – south through the ACT portion of the Project Area, and empties at the Lower Molonglo Valley Water Quality Control Centre (located approximately one kilometre to the southwest of the Project Area). The Ginninderra sewer tunnel includes an overflow structure and sewer vent, three mechanised odour / scrubbing control units, and an adjoining gravity sewer that runs through Macgregor West. The sewer infrastructure plans are explained in detail in (Brown, 2014). A key element is a trunk sewer connection from the urban area to the Ginninderra sewer tunnel that will traverse the proposed conservation corridor.

The existing Ginninderra sewer tunnel has sufficient capacity to service the urban development proposed under the Program, therefore both trunk sewers will empty into it. There are a number of construction methods that may be used for these connections, which in turn influence their final alignment. The range of alignment options are discussed below and form part of the analysis of alternatives for the Program.

The two key methods of construction for the sewer are trenching and micro-tunnelling. In general, trenching is limited to following the natural contours of the land in order to take advantage of gravity for flow and is generally the cheapest construction method. It can be augmented with pump stations at locations where gravity cannot be relied upon; or through the installation of above ground pipes to cross watercourses or other features whilst maintaining a gravity-fed flow. These additional elements are engineering solutions that add additional cost and ongoing maintenance liabilities. This includes the requirement of the provision and maintenance of an access road along the alignment in order to maintain the serviceability of the sewer over its operational life. In areas of steep country, this can lead to extensive cut and fill requirements to facilitate stable and safe access.

Alternatively, micro-tunnelling results in minimal surface impacts. It is typically used to install pipes under areas that are constrained by natural values or other high value or critical infrastructure (e.g. railways, roads, rivers, or environmentally sensitive areas). Surface impacts are limited to an approximately 20 metre by 20 metre construction area for each of seven vertical shafts. These shafts are used to lower the tunnelling equipment which bore tunnels to the next shaft, and are then used to fit and grout the pipes into place. The shafts are retained after construction is complete as manhole access points (Brown, 2014). While this construction method is more expensive in terms of capital outlay, it has negligible surface impacts, allows for the entire system to be gravity-fed, and avoids many ongoing liabilities.

The alternatives considered for the Murrumbidgee River catchment are discussed in detail in (Brown, 2014), the selected option is for microtunneling.

Microtunneling has been selected as it:

- decrease the environmental impacts within the Murrumbidgee River corridor;
- maximise the size of the catchment serviced by gravity sewers;
- has lower ongoing operational costs; and
- has no requirements for noise or odour buffers compared with pump station options.

The high upfront costs of microtunneling may be mitigated by implementing staged construction that will delay these costs over a period of time (Brown, 2014a).

3.3 The development approval process

The rezoning processes described above do not, of themselves, provide for any development activities to occur. Rather, the various zones prescribe the types of development that may be permitted as well as development that is prohibited within the zone.

Different types of development are permissible or prohibited in different zones; for example in the River Corridor zone in the ACT the types of development that are permitted are limited to those that are compatible with the objectives, including the conservation objectives, of the zone. Conversely a much broader range of development types are permitted within the residential and commercial zones. It is also common for the zoning controls to include limitations on the design and siting, scale and other aspects of a particular type of development. The full suite of controls applicable to development proposals within the zones are complex, they are set out in the relevant statutory planning instruments: the Territory Plan in the ACT and the Yass Valley Local Environmental Plan in NSW.

Any proposal for development must be submitted as a development application to the relevant responsible authority, the Yass Valley Shire in NSW and the ACT Planning Authority in the ACT. The development application will be assessed against the requirements of the statutory planning instrument and any other relevant matters, and either approved or refused as appropriate.

In the ACT a development application may be required to be assessed under the “impact” track if certain environmental impact criteria are triggered because of the nature of the proposed development. This will be the case at West Belconnen because of the presence of a variety of listed species and ecological communities and ordinarily an environmental impact assessment would be required prior to a development application being considered. The opportunity exists under section 211 of the ACT Planning and Development Act for a proposal to be exempted from the requirement for an impact assessment if sufficient recent studies have been completed. The suite of studies that support this assessment together with a number of studies that have been completed as background documentation for draft Territory Plan Variation 351 constitute the necessary "recent studies" and will be cited in an application under section 211 for an exemption from the requirement to prepare an impact assessment.

For a development application to be approved it must be compliant with all relevant requirements and in the case of West Belconnen this will include any requirements prescribed by an endorsed MNES program. This is because a development approval is required to be compliant with Commonwealth legislation.

Where an endorsed MNES plan includes specific requirements applicable to a particular activity or place then these can be taken directly into account in the assessment of a development application. Alternatively where an endorsed MNES plan requires an action to be taken such as the preparation of a reserve management plan then a development application will be assessed for compatibility with the reserve management plan.

Importantly, where an endorsed MNES plan requires something such as a reserve management plan, but the plan has not yet been produced, then a development application would have to be set aside pending completion of the reserve management plan. This is not an unusual process and is analogous to a requirement for a "development control plan" to be prepared for a precinct to provide a context within which subsequent development applications may be assessed.

3.4 The ACT Rezoning

The ACT component of the development at West Belconnen will be achieved through approval by the (ACT) Minister for Planning of a variation to the Territory Plan as well as a number of other administrative processes discussed in more detail in the planning report that supports the rezoning proposal (A T Adams Consulting, 2014b). The proposed zoning is shown at Figure 6.

The rezoning coverage differs in some respects from the development area identified at Figure 2 above; the differences and reasoning are set out below:

- The substation (refer to Figure 2) is excluded from the program area because no changes are proposed to the land use in either the sub-station or its surrounding buffer area. The Territory Planning Authority has determined that a more appropriate zoning for this site would be "TSZ2 Services" rather than its current "Broadacre" zoning and this change has been included in DV351 as a matter of convenience.
- The Macgregor offset area is incorporated in total in the proposed rezoning, again as a matter of convenience. Only a small area of the reserve is likely to be impacted by the development proposal and consequently only that area was included in the development area but it is nevertheless logical that the entire site be rezoned to reflect its reserve status.
- The Strathnairn property (refer to Figure 2) is excluded from the development area because no changes are proposed to the land use on this site. The Territory Planning Authority has determined that a more appropriate zoning for this site would be "CFZ Community Facility" rather than its current "Broadacre" zoning and this change has been included in DV351 as a matter of convenience.

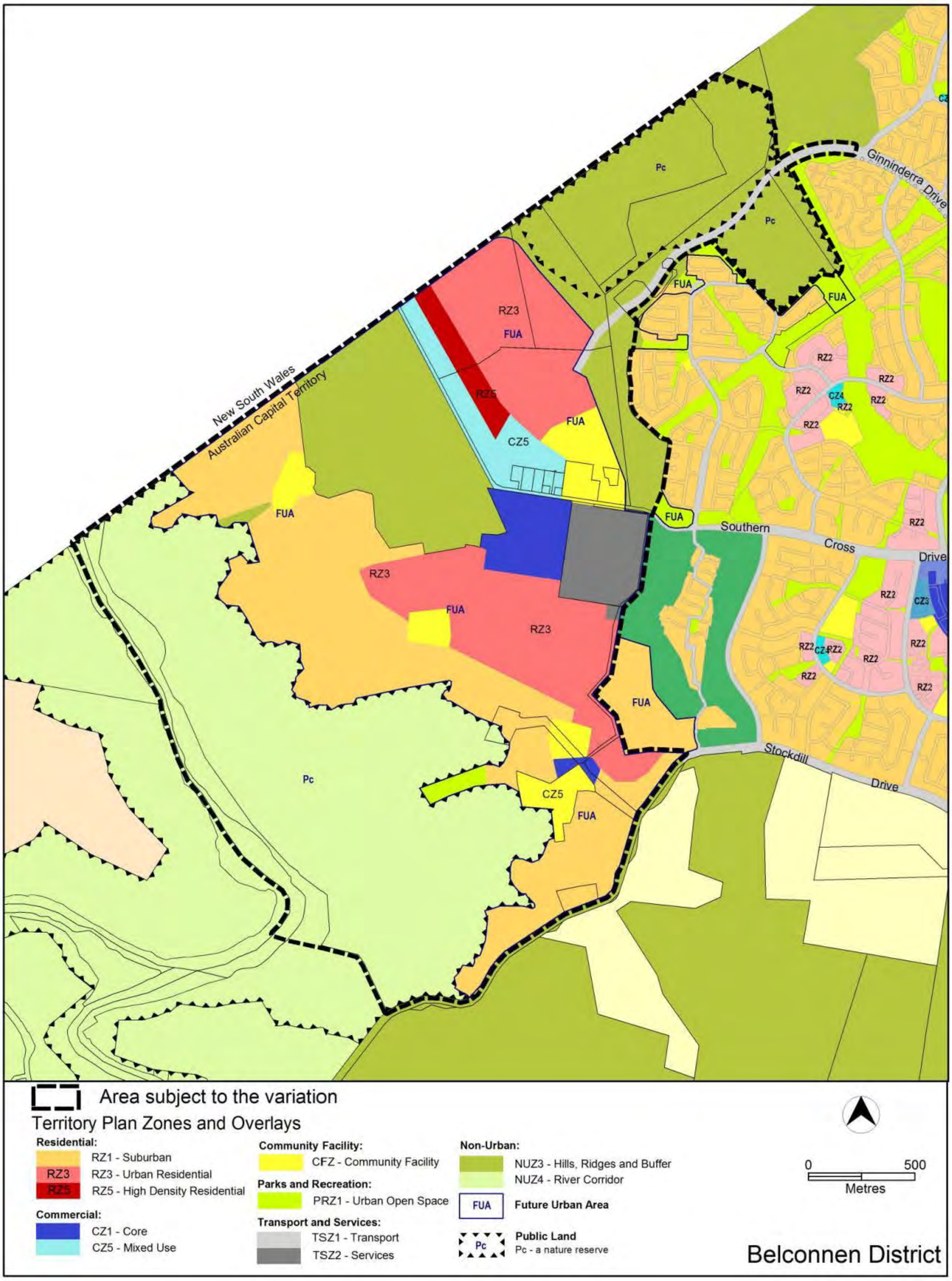

Figure 6: Proposed ACT zoning

3.5 NSW Rezoning

The purpose of the Planning Proposal seeks the following amendments to the Yass Valley Local Environmental Plan 2013 (YLEP) to enable the urban development and the setting aside of lands for conservation purposes by:

1) Amending of the YLEP ‘Land Application Map’ to remove the subject land from the YLEP and replacing the YLEP with a principal LEP applying only to the subject land and to be referred to as the draft Yass Valley Local Environmental Plan (Parkwood).

2) To make provision in the draft Yass Valley Local Environmental Plan (Parkwood) for the following specific planning controls :

The zoning of the land from RU1 Primary Production to principally R1 General Residential and part E3 Environmental Management

To modify the existing E3 Environmental Management zone boundary to more accurately reflects the known ecological values of the land

The applying of a minimum E3 Environmental Management zone and the R1 General Residential zone with additional uses in addition to those applying in the YLEP. The additional uses are consistent with the proposed approach to a sustainable urban community and the use of the land to be set aside for conservation purposes.

Consideration to two potential options as the determining of minimum lot sizes consistent with ensuring an integrated approach to the design and siting of dwellings at the neighbourhood scale.

The applying of an amended Natural Resources Biodiversity Map based on the ecological surveys and studies supporting this Planning Proposal.

The application of provisions in the Yass Valley Local Environmental Plan (Parkwood) that address the proposed urban release area by specific reference to infrastructure, servicing and a development control plan.

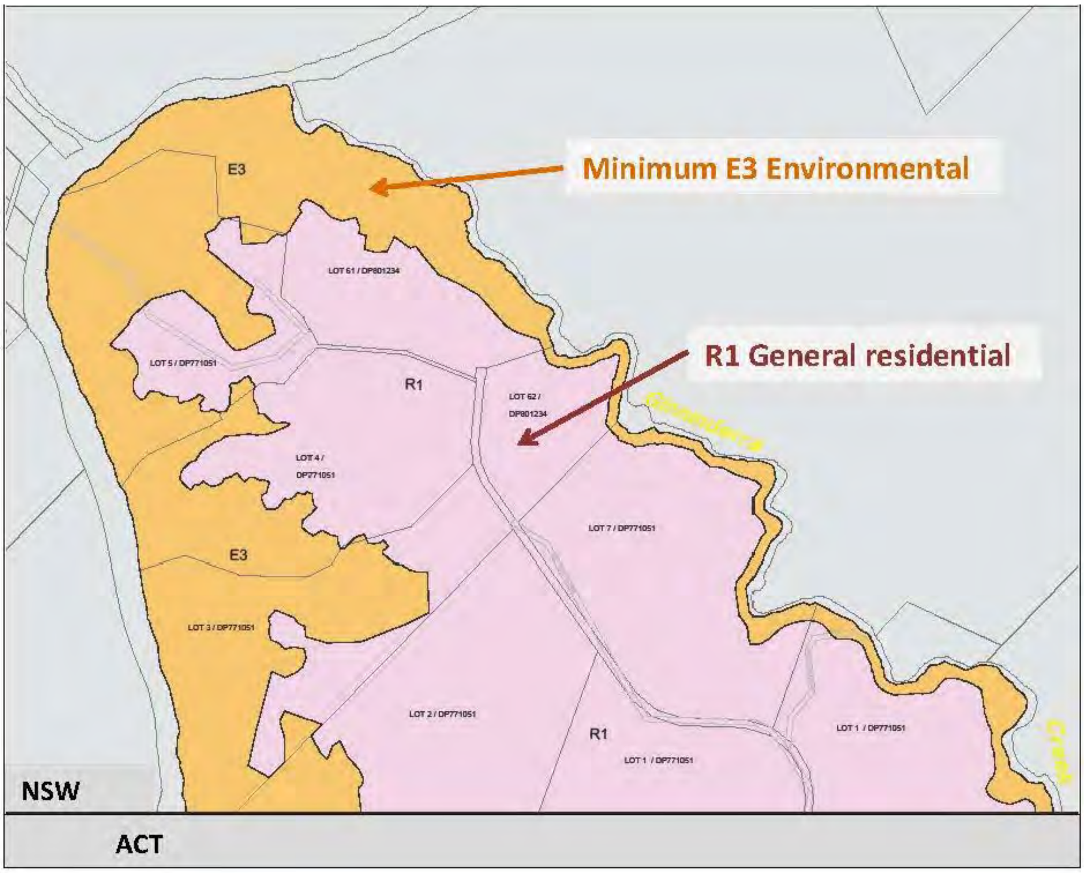

Figure 7: Proposed NSW zoning

3.6 The proposed Conservation corridor

A conservation corridor (illustrated at Figure 3 & Figure 11) encompassing areas of habitat for the endangered Pink tailed worm lizard and Yellow Box Red Gum Grassy woodland will be created. The corridor adjoins both the Murrumbidgee River and Ginninderra Creek and makes up a total area of 549.9ha (ACT and NSW). In addition to the protection that will be afforded to the vulnerable species and communities existing in the corridor the creation of this reserve will mean that the Ginninderra Creek corridor, which commences at Mulligans Flat in Gungahlin and extends through Gungahlin and Belconnen, will be linked to the Murrumbidgee River which in turn connects to the Molonglo and upstream Murrumbidgee corridors, which respectively link to Canberra City and Namadgi National Park.

The corridor will be managed as an IUCN1 Category IV reserve that employs a best-practice approach to:

- protect and restore biodiversity and ecosystem functions and ecological connectivity across the regional landscape to the Murrumbidgee River Corridor and other reserves
- manage the urban edge to protect both the values of the Reserve and the amenity, health and safety of the urban community
- provide quality recreation experiences for the enjoyment of visitors and local residents
- encourage active learning and engagement in management by the community, organisations, the local Aboriginal community and research and educational institutions
- provide an adaptive management framework through monitoring, research and periodic review of the management plan enabling evidence-based adjustments as needed.

The activities within the corridor will be limited by the statutory zoning provisions (“River Corridor” zone with a “nature reserve” overlay In the ACT, and “Environmental Management” zoning in NSW), and will include:

- Ecological restoration and threatened habitat protection
- Riverside management
- Managing the urban edge
- Science, active learning and community stewardship
- Integration of Aboriginal values
- Sustainable recreation and commercial uses (including interpretation).

Conservation will be the primary use of the proposed conservation corridor and other uses, such as recreation will only be allowed where they are compatible or have no significant adverse impact on conservation.

The creation of the corridor will be achieved by rezoning the land as discussed above. Separate rezoning processes are applicable in the ACT and NSW which are discussed below. In summary:

- A river corridor currently exists in the ACT, zoned as “river corridor” consisting of two parts

- The bulk of the corridor (within block 1605, totaling about 260 ha) has a "special purpose reserve" overlay, which is intended for recreation and other uses, without specific reference to conservation values.
- A second smaller portion comprises a narrow strip of land along the immediate river frontage (within block 1631, approx. 30 Ha) which is part of the larger Woodstock nature reserve and consequently has a "nature reserve" overlay.

The total corridor area is to be enlarged from 290.8ha to 359.2ha and have a "nature reserve" overlay applied which is specifically aimed at achieving environmental conservation outcomes.

- In NSW the corridor is largely contained within an existing "Environmental management (E3)" zoning which is defined by arbitrary property boundaries and does not reflect environmental values. The boundary is to be realigned to reflect the findings of scientific field investigations, particularly related to the Pink tailed worm lizard habitat areas (Osborne & Wong, 2013) .

Definition of the new eastern boundary of the proposed river corridor conservation areas, which differs from the existing zoning boundaries, was driven by the location and extent of (i) the Pink-tailed Worm Lizard habitat and (ii) the Box-Gum Woodland; less important criteria are (iii) topography and (iv) management practicality. Application of these criteria to define a new corridor boundary was undertaken in two steps based on ground-truthing of habitat features guided by expert ecological and management advice.

Initially, confirmed Pink-tailed Worm Lizard habitat (Osborne & Wong, 2013) was marked out using aerial photography backed up by field inspections. This was followed by careful testing of the entire boundary by on-ground inspections, first by the consultant team and later with ACT government officers from ESDD and TAMS and NSW DoP. The proposed boundary and the ecological, habitat, and management criteria used to derive it were agreed to by all parties.

The eastern edge of the proposed reserve was determined on site through agreement of the study team and ACT and NSW government officers and recorded using GPS equipment.

Figure 8 & Figure 9 illustrate the box gum woodland and PTWL habitat areas within the project area. Key elements are:

in the ACT portion of the corridor:

- 11.7 Ha of box gum woodland that is currently within the existing river corridor zone will have enhanced protection as the reserve status is upgraded from "special reserve" to "nature reserve"
- 59 Ha of box gum woodland that is currently unprotected in the "broadacre" zone will be included in the enlarged river corridor zone with a nature reserve overlay ensuring enhanced protection.
- This will result in 100% of the box gum woodland area (68.2ha) being included in the River Corridor zone with "nature reserve" status.
- There are a total of 133.7 Ha of high quality PTWL habitat in the ACT. 114.4 Ha (86%) of this is currently in the River corridor zone; the enlargement of the zone will encompass a total of 124.3 Ha of high quality PTWL habitat, 93% of the total. The level of protection will be enhanced by the upgrading of the reserve status to "nature reserve".
- 7% (9.4 ha) of the high quality PTWL habitat in vestigial patches will be subsumed in the urban development area.

- There are a total of 7.9 Ha of low quality PTWL habitat in the ACT. 3.2 Ha of this (41%) is currently within the river corridor zone. the enlargement of the zone will encompass a total of 4.3 Ha of low quality PTWL habitat, 54% of the total. The level of protection will be enhanced by the upgrading of the reserve status to "nature reserve".
- 46% or 3.6 Ha of low quality PTWL habitat in vestigial patches will be subsumed in the urban development area.

in the NSW portion of the corridor:

- There are a total of 16.7 Ha of high quality PTWL habitat in the NSW portion of the project area. Of this 15.9 Ha or 95% will be included in the River corridor subject to an "environmental management" zoning. 0.8 Ha or 5% of the total will be subsumed within the urban development area.
- There is a small area (2.8 ha) of low quality PTWL habitat in the NSW portion of the project area. Of this 0.2 Ha or 7% will be included in the River corridor subject to an "environmental management" zoning. 2.6 Ha or 93% of the total will be subsumed within the urban development area.

The above outcomes are summarised in Table 2.

Table 2: River corridor habitat areas

River corridor habitat areas (ha.)	*ACT*	*NSW*	*Total*
Box gum woodland retained	70.7	0	70.7
Box gum woodland within development area	0	0	0
High quality PTWL habitat retained	125.3	15.9	141.2
High quality PTWL habitat within development area	9.4	0.8	10.2
Low quality PTWL habitat retained	4.3	0.2	4.5
Low quality PTWL habitat within development area	3.6	2.6	6.2

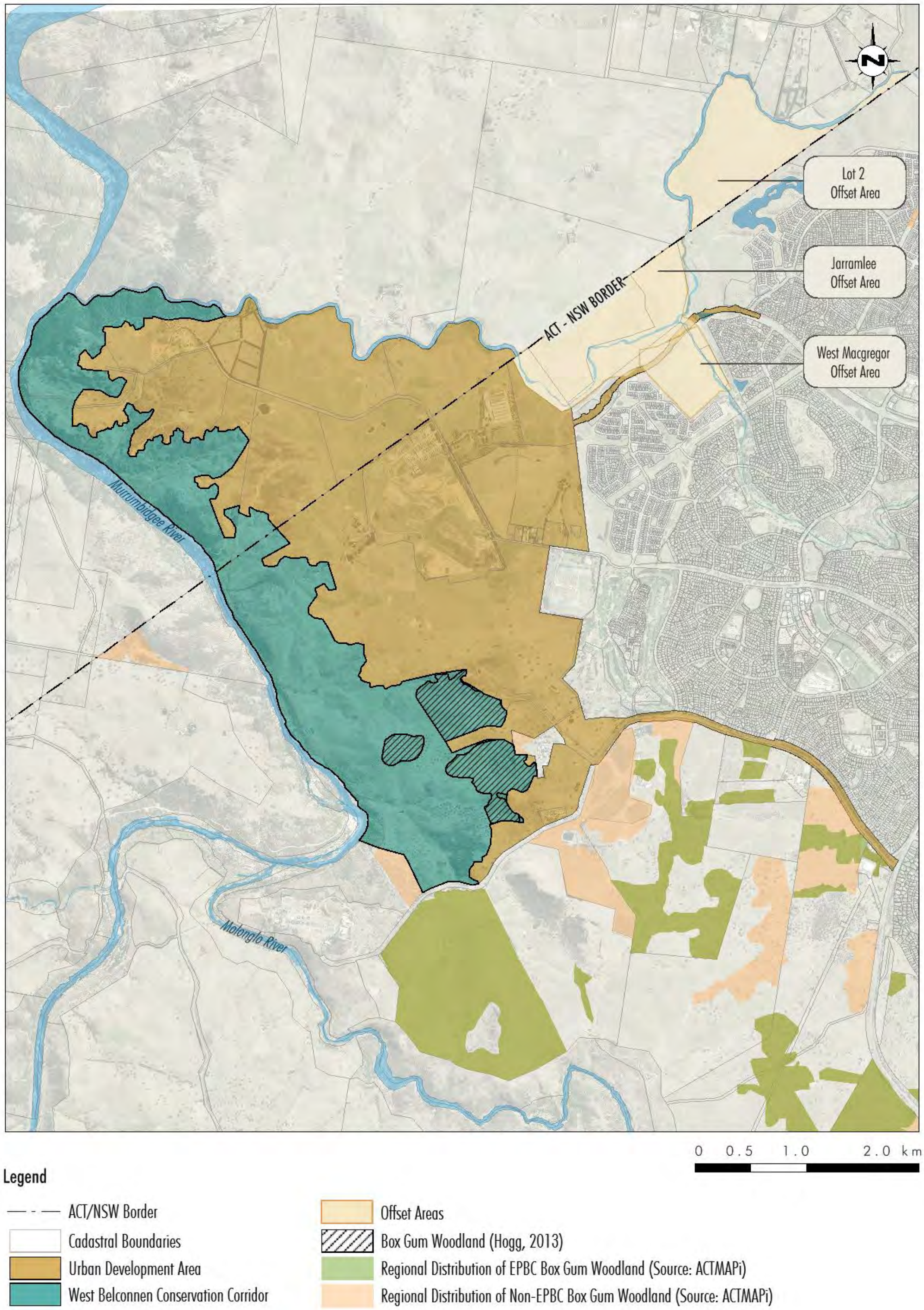

Figure 8: Yellow box red gum grassy woodland

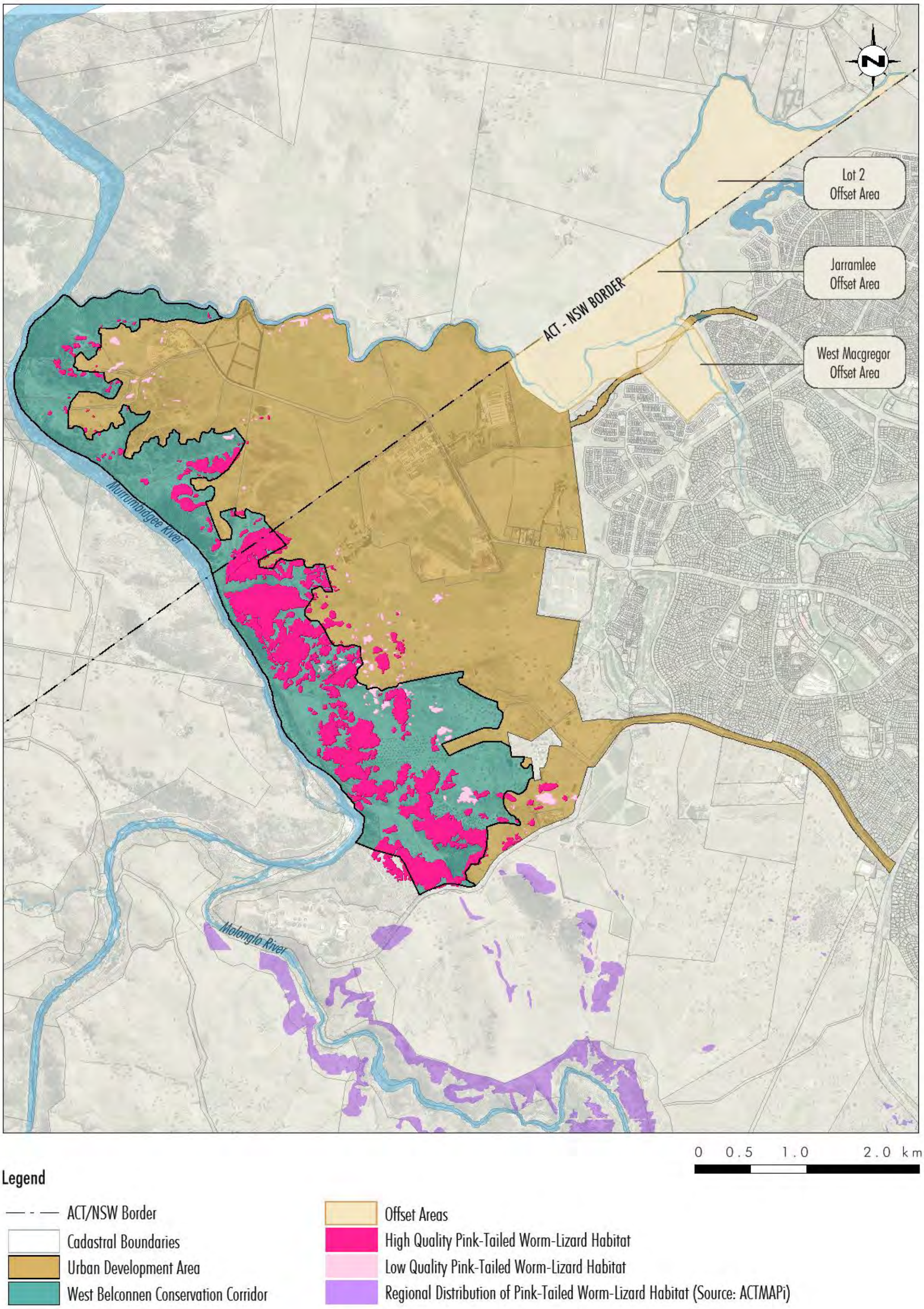

Figure 9: Pink tailed worm lizard habitat

3.6.1 Conservation corridor timing of implementation

Control of the conservation corridor will be transferred to the proposed environmental management trust (EMT) in stages as the project development proceeds. The corridor transfer staging areas will be defined by catchment boundaries as described indicatively on Figure 10. Transfers will be timed to precede any construction on adjacent development zones occurring that would affect the catchment or catchments contained within each transfer stage area.

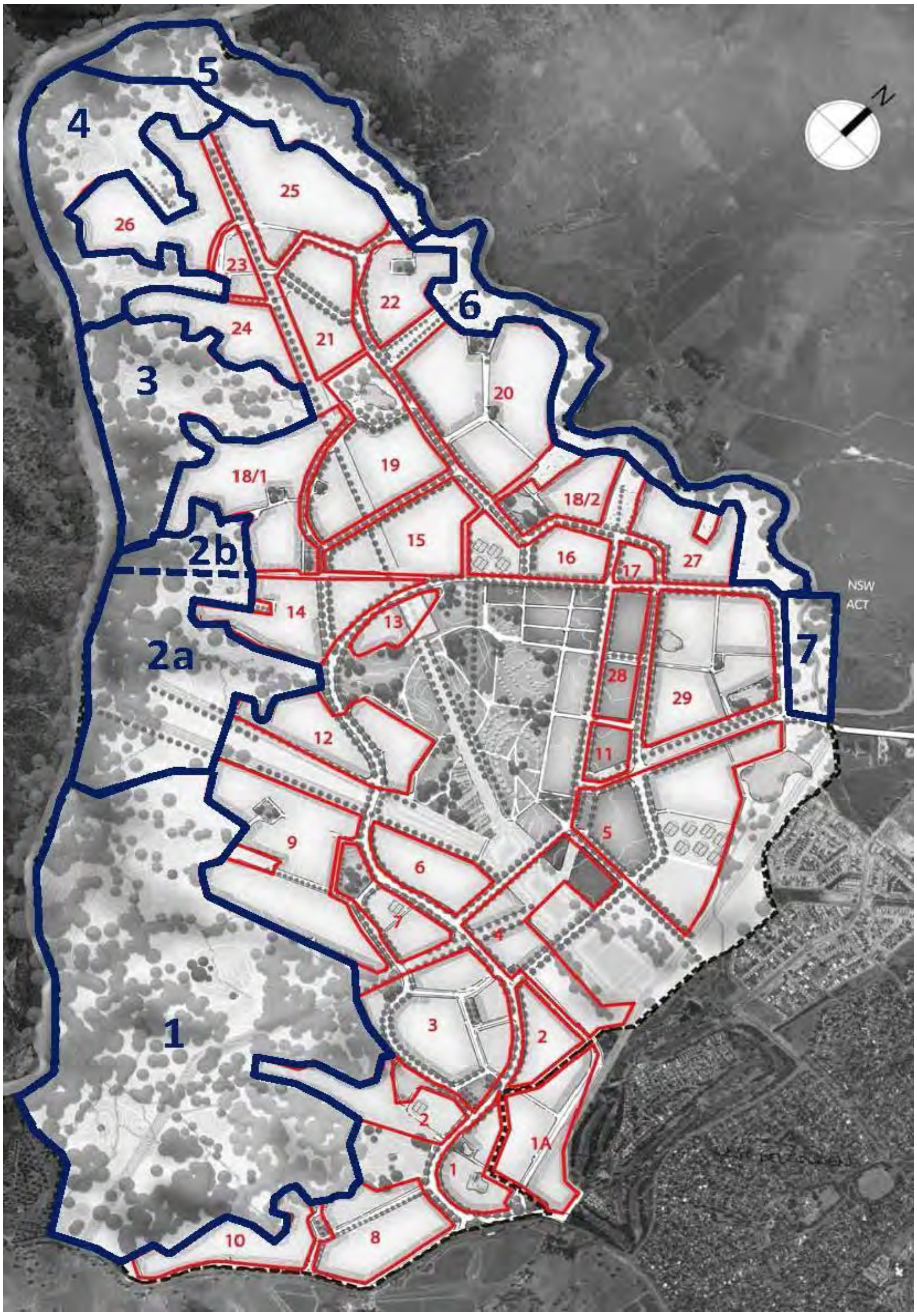

Figure 10: Conservation corridor indicative staging

3.6.2 Conservation Corridor access and activity nodes

Potential use and development options for the conservation corridor (refer to Section 3.6) are discussed in a report by McGregor Coxall that sets out proposals for the open space within the urban area and for the conservation corridor, including a draft plan for the corridor (McGC, 2014). The draft plan is at Figure 11; it provides for recreation and picnic areas, vehicular access to the River at two points and a number of unsealed tracks and trails for pedestrian and cycle access and bushfire management. This is a draft plan and will be reviewed and revised by the EMT prior to adoption as part of the RMP. Implementation of all infrastructure within the corridor, including access roads and tracks, picnic areas and visitor facilities, interpretative and other signage, fencing, and service infrastructure will adhere to the following principles:

- Recognise the importance of enhancing connectivity between MNES habitat areas.
- Ensure that there is no net reduction in total MNES habitat areas.
- The design of all infrastructure will be informed by advice from relevant scientific experts, particularly with regard to protecting and avoiding impacts to MNES and their habitat areas.
- Roads and tracks will follow existing alignments where feasible.
- Unused existing tracks will be rehabilitated to enhance connectivity between habitat areas where they fragment existing habitat areas.
- Roads and tracks will incorporate raised grating or similar design techniques to enhance connectivity between habitat areas that will be bisected or separated by a road or track.
- Vehicle track widths will be a maximum width of 6m, other tracks and trails a maximum width of 2.5m.
- Prior to development of WBCC infrastructure, site surveys of threatened flora and fauna species will be conducted and populations of threatened flora and fauna species will be avoided or impacts managed in accord with the RMP and EPBC Act.

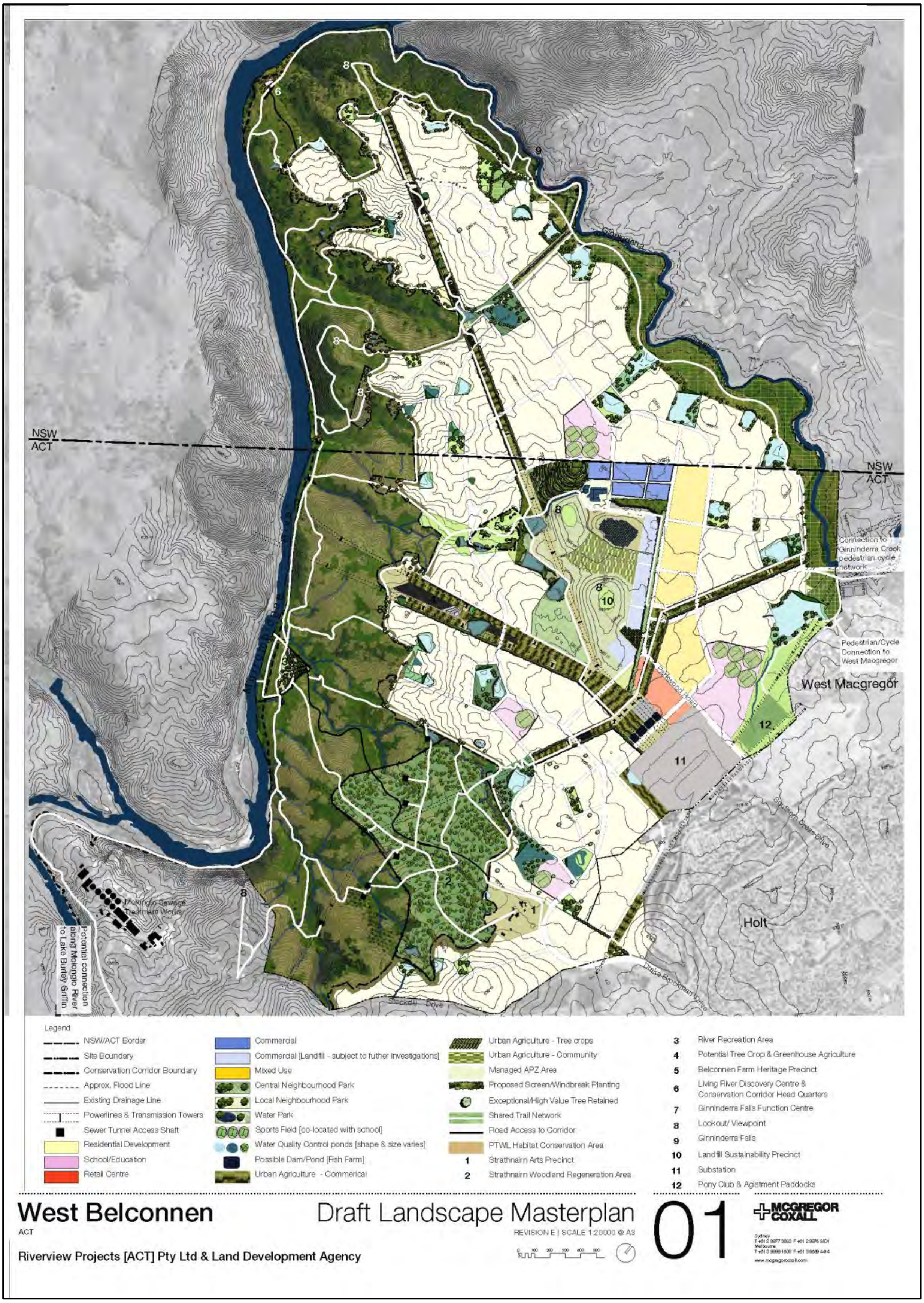

Figure 11: Conservation corridor

3.6.3 Conservation boundary relative to the Molonglo MNES report

The conservation reserve boundary shown on Figure 11 differs slightly from the area of box gum woodland identified by Hogg (2013) as shown on Figure 10. The differences are caused by two factors:

- Following finalisation of the Hogg study the boundary was refined with further on-site inspection, having regard particularly to the definition of a practical boundary for management purposes. This process is described in Ecological (June 2014) which says as follows: "The eastern edge of the proposed river and woodland reserve was determined on site through agreement of the study team and ACT government officers (from ESDD and TAMS)".
- A small area of woodland is within the boundary of the Strathnairn property (Block 1332 Belconnen) which is excluded from the west Belconnen assessment study area.

A strict interpretation of the commitment made under The Molonglo Valley NES Plan has led to the conclusion that the plan does not provide for the type of boundary adjustment set out in the first item above, the Molonglo NES Plan commitment is as follows (Action 22):

"West Molonglo is zoned broadacre and is not part of the ACT Government's current land release program. In the event that West Molonglo is developed in the future for broadacre uses or residential development then, subject to confirmatory ecological assessment of Box-Gum Woodland, the area of EPBC Act Box-Gum Woodland that occurs there will be set aside as a Nature Reserve."

It is therefore necessary that the entirety of the woodland that is the subject of this assessment be placed within the river corridor/nature reserve area. The rezoning that will create the conservation corridor as described on Figure 3.2 is in train and will be finalised. In order to meet the Molonglo NES commitment the boundary will subsequently be amended to incorporate all of the woodland identified by Hogg within the reserve area (excepting the Strathnairn part, see below). This is a straightforward matter[1] and will be implemented under the provisions of Part 96A of the (ACT) Planning and Development Act (2007), which says as follows:

"96A Rezoning—boundary changes

(1) The planning and land authority may vary the territory plan under section 89 (Making technical amendments) to change the boundary of a zone or overlay if the change is consistent with—

(a) the apparent intent of the original boundary line; and

(b) the objective for the zone.

(2) ………."

The woodland area within the boundary of the Strathnairn block will be a matter for later consideration and action by the ACT Government, which is the owner of the land.

The outcomes discussed below take into account the boundary adjustment discussed above.

[1] Part 96A of the Act cannot be applied to leased land; block 1605 is currently leased but will be surrendered to the Territory when the land is rezoned and will become unleased territory land, it will then be able to be dealt with under Part 96A.

4.0 MNES Impacts

This section provides a detailed analysis of the MNES that have been identified as potentially being affected by the Program.

The beginning of this section provides a description of the avoidance and mitigation strategies that are used for a number of threatened communities and species under the Program. These are the WBCC and associated Management Plan, CEMPs, and Water Sensitive Urban Design (WSUD) principles.

For the purposes of this discussion, the Murrumbidgee River and Ginninderra Creek have been included within the Project Area as many actions undertaken by the Program will have impacts upon them. It should be noted however, that management measures will not occur within the aquatic areas themselves. Rather they will extend to the south bank of Ginninderra Creek and the east bank of the Murrumbidgee River, and will occur with the cooperation of the ACT and NSW Governments who have management responsibility for the aquatic areas.

4.1 Threatened Ecological Communities

The Project Area was once typified by a range of natural habitats including grasslands, woodlands, open forest, and riparian corridors. Most of the communities that were present at lower elevations (namely box gum woodland and small areas of natural temperate grassland) have been severely modified by agricultural and urban land uses post 1750. Ecological communities that occur at higher elevations and within the Murrumbidgee River Corridor have been less severely modified, and provide important habitat connectivity for threatened fauna species.

Two threatened ecological communities that are listed under the EPBC Act occur within the Project Area. These are:

- white box – yellow box – Blakely's red gum grassy woodland and derived native grasslands (box gum woodland); and
- Natural Temperate Grassland of the South Eastern Highlands (natural temperate grassland).

Direct impacts to natural temperate grassland will be avoided by the Program of urban development and the alignment of Ginninderra Drive and is not discussed further in this section. Impacts to box gum woodland as a result of the Program are discussed below. The grassland is within the Jarramlee reserve as illustrated on Figure 12 which is extracted from the Jarramlee Offset Management Plan (ACT Government, 2013).

4.1.1 Box Gum Woodland

White box – yellow box – Blakely's red gum grassy woodland and derived native grasslands (box gum woodland) is listed under the EPBC Act as a CEEC, and under the NC Act and the TSC Act as an EEC.

Box gum woodland has been extensively mapped and assessed within the ACT. It is considered that the distribution of the community within the ACT is generally well understood, however the knowledge of woodland quality is considered to represent a gap.

Information utilised for the identification of box gum woodland has included the following data sources:

Targeted Surveys:

- David Hogg Pty Ltd (2013) West Belconnen Woodland Areas: Confirmatory Ecological Assessment;
- KMA (2014) Ecological Studies West Belconnen Australian Capital Territory; and
- KMA (2009b) West Belconnen Project ACT and NSW Land Flora and Fauna Studies.

Information in the David Hogg Pty Ltd (2013) assessment was prioritised as it is the most recent, was conducted at the Project Area scale, and utilised the EPBC Act definition of box gum woodland to identify patches.

Subsequent to the detailed analysis by David Hogg Pty Ltd (2013), KMA (2014) undertook further targeted validation of vegetation boundaries in collaboration with ACT Government specialists. This resulted in slight amendments to the extent of the woodland community as previously mapped such that a total of 72 hectares is considered to be present within the Project Area. This figure includes approximately 3.8 hectares of vegetation assumed to be box gum woodland on a precautionary basis within the Drake Brockman Drive corridor and the remaining 68.2 hectares associated with the west Molonglo component of the Project Area.

As a consequence of this, the concept master plan for the Program was developed in order to avoid all direct impacts to the West Molonglo Woodland community (as defined in the Molonglo Valley NES Plan discussed at Section 2.2).

Figure 12: Jarramlee reserve grasslands

Direct, Indirect, Cumulative, and Facilitated Impacts

Indirect impacts that may affect retained box gum woodland within the Project Area include edge effects, weed invasion, and changes in hydrological conditions that could affect species composition.

Cumulative impacts to retained box gum woodland may arise from increased public access to the WBCC and the introduction of associated services and infrastructure. These may lead to damage to the understorey and regrowth success, invasive species introduction, eutrophication and other pollution. The provision of visitor infrastructure may also facilitate further impacts in the foreseeable future, as it promotes the use of the WBCC for recreational purposes and makes it more accessible to the public.

Measures to Avoid and Mitigate

Impacts to box gum woodland will be avoided by inclusion of all existing patches as mapped by KMA (2014) within the WBCC. The WBCC will connect the remnant box gum woodland to forest and woodland patches along the Murrumbidgee River and Ginninderra Creek. The WBCC RMP will also contain provisions to enhance the quality of this woodland in the long-term.

Impacts (indirect and cumulative) that will occur within the WBCC as a result of recreational activities, increased public access, and service delivery (e.g. sewerage pipes) will be avoided during the design and planning phase, and mitigated through CEMPs and the WBCC RMP.

Indirect impacts to retained box gum woodland from the urban development component of the Program will be mitigated through the implementation of CEMPs, WSUD principles, and the WBCC Management Plan. These processes are outlined in more detail in Section 5.0 of this report. Actions specific to box gum woodland protection will include:

- WSUD principles:
  - Stormwater flow retardation based on geotechnical, surface water, and groundwater assessments to reduce impacts to hydrological systems.
- CEMPs that:
  - Define clearing procedures and boundaries, including the retention of selected significant trees, clearing outside of threatened bird breeding seasons, and fauna rescue procedures.
  - Implement weed management during construction.
  - Enforce sediment and erosion controls to prevent site run-off during construction.
- WBCC RMP:
  - ongoing habitat improvement;
  - ongoing quality monitoring; and
  - avoidance of box gum woodland patches.

These plans will be prepared prior to construction commencing in accordance with relevant guidelines.

Facilitated impacts within the WBCC will be avoided or mitigated by the WBCC RMP.

Measures to Offset Impacts

Impacts on the 3.8 hectares Drake Brockman Drive woodland patch will be offset by enhanced management of the West Molonglo patch to achieve biodiversity outcomes over and above the requirements of the Molonglo NES Report.

Upon approval of the Program, measures to transfer the entirety of the WBCC into secure tenure and conservation zoning will be implemented in addition to the commencement of management consistent with the Program objectives. A further twenty years has been allowed for in order to implement management practices that will enhance the site condition by targeting diversity of ground layer vegetation, condition in relation to the prevalence of non-native species and improvements in structure by encouraging natural and assisted regeneration of currently degraded sections. The entire area of box gum woodland within the WBCC will be subject to offsetting actions under the Program, above the commitment by the Molonglo Strategic Assessment which proposed only to protect the woodland from future development. The modest improvement in quality is achieved by targeting site condition. This would result in a wider extent of box gum woodland that is recognisable by its woodland form as opposed to the derived native grassland, a reduced incidence of non-native species and an increase in the diversity of associated diagnostic flora species.

4.2 Threatened Fauna

This section provides a detailed discussion of the potential impacts of development on the threatened fauna species considered likely to be affected by the Program.

4.2.1 Birds

Five bird species listed as threatened under the EPBC Act were identified as having the potential to be affected by the Program. These were Australian painted snipe, regent honeyeater, swift parrot, superb parrot and painted honeyeater. Impacts to these species are assessed together in the following section due to the impacts and the avoidance, mitigation, and offset measures being the same for each species.

Information utilised for the identification of threatened bird species has included the following data sources:

- Targeted Surveys:
    - KMA (2013b) West Belconnen Woodland Project ACT and NSW Land Targeted Bird Surveys;
    - KMA (2014) Ecological Studies West Belconnen Australian Capital Territory;
    - KMA (2013a) West Belconnen Project NSW Land Flora and Fauna Studies;
    - KMA (2009b) West Belconnen Project ACT and NSW Land Flora and Fauna Studies; and
    - Geoff Butler and Associates (2000) The Revegetation of Ginninderra Creek Between Barton Highway and Macgregor, ACT.

Information in the KMA (2013b) assessment is the most recent and targeted assessment of avian diversity within the Project Area and also targeted the threatened species of interest to this assessment.

Direct, Indirect, Cumulative, and Facilitated Impacts

The Program will impact woodland vegetation of low quality, none of which meets the criteria to be considered box gum woodland in accordance with the EPBC Act. It will also result in the loss of selected mature trees across the Project Area (both within and outside of the WBCC).

The forest, woodland, and riparian areas to be protected within the WBCC will potentially be impacted (indirectly and cumulatively) by increased public access, recreational activities, and service provision (including maintenance). These may result in localised removal or damage to habitat structures (e.g. fallen timber, river banks), pollution, increased disturbance due to human presence and activities, and invasive species introduction. However, as a consequence of the comprehensive approach to planning the proposed development in addition to the geographic and topographic characteristics of the Project Area, there are unlikely to be additional developments facilitated by implementing the Program beyond the program area. The primary impacts to woodland birds and Australian painted snipe as a consequence of the proposed action relates to indirect impacts within the riparian corridor and WBCC, in general as a result of activities already identified.

Indirect impacts from the urban development component of the Program that may affect threatened bird species include edge effects, weed invasion, and changes in hydrological conditions. While the Program commits to 100 percent containment of cats there may also be the chance of occasional disturbance and predation by other unrestrained domestic animals.

Measures to Avoid and Mitigate

The primary avoidance strategy with regards to habitat for threatened bird species is creation of the WBCC. Detailed planning of the urban open spaces will also result in the retention of a range of mature trees and as part of a mitigation plan, will enhance the value of retained trees with an open space tree management and replacement strategy.

Potential impacts to habitat values in the WBCC as a result of increased public access, recreational activities, and service delivery (e.g. sewerage pipes) will be avoided during the design and planning phase, and mitigated through the implementation of CEMPs and the WBCC RMP. This management plan will be overseen by a single entity proposed to be under a trust structure that coordinates management of values in both the ACT and NSW parts of the Project Area.

Indirect impacts from the urban development component of the Program will be mitigated through implementation of CEMPs, WSUD principles, and the WBCC RMP. This process is outlined in more detail in Sections 5.0 and 6.0 of this report and Sections 4.0 and 5.0 of the Strategic Assessment Report. Specific actions targeting impacts to birds including threatened species involve:

- WSUD principles based on geotechnical, surface water, and groundwater assessments that:
  - retard stormwater flows and the increased run-off from the urban development area before they enter the WBCC. This will minimise the impact of altered hydrological regimes on vegetation upon which avifauna will rely; and
  - provide suitable wetland habitat for water birds where appropriate.
- Mitigation actions during the construction phase implemented through CEMPs prepared prior to construction commencing in accordance with relevant guidelines:

- Definition of clearing procedures and boundaries that include the retention of trees; avoid with appropriate buffers threatened bird species nesting trees; clear outside of threatened bird species' breeding seasons, and outline faunal rescue procedures.
- Recovery and beneficial use for the purpose of fauna habitat enhancement of fallen timber, including logs and tree sections containing hollows.
- Invasive species management.
- Sediment and erosion controls to prevent site run-off.
  - Operation phase management including:
- Domestic pet containment policies within the proposed residential development.
- Ongoing management actions as outlined in the WBCC Management Plan.

Facilitated impacts will be avoided or mitigated through the implementation of the WBCC Management Plan.

4.2.2 Fish and Amphibians

Three species of EPBC Act threatened fish species were identified as having the potential to be impacted by the Program. Macquarie perch and trout cod are listed as endangered, and Murray cod is listed as vulnerable. One EPBC Act listed amphibian – Booroolong frog (endangered) may also be affected by the Program.

There has been no detailed assessment of the presence of fish or amphibian species within the Project Area (inclusive of the relevant reaches of the Murrumbidgee River and Ginninderra Creek). ACT and Australian Government landscape and regional scale mapping and survey databases were examined as outlined below:

- ACT Government (2015a) ACTmapi ACT Government Online Interactive Maps;
- ACT Government (2007) Action Plan No. 29 Ribbons of Life: ACT Aquatic Species and Riparian Zone Conservation Strategy; and
- Australian Government (2015b) Species Profile and Threats Database.

Records within these data sets only indicate presence, not absence. Where no records of a species within the Project Area were identified, details of habitat preference and location of the nearest known populations were used to determine the likelihood of occurrence.

Direct, Indirect, Cumulative, and Facilitated Impacts

As the Program does not include works within the Murrumbidgee River or associated creeks it will not directly impact threatened fish or amphibian species.

Indirect impacts may occur from increased public access (and its associated infrastructure) into the Murrumbidgee River and Ginninderra Creek for recreational purposes including an increased incidence of recreational angling, and the proposed urban development upstream in accordance with the concept master plan. These impacts include changes to hydrology (increases in run-off and associated changes to flow regimes), increased erosion and stream incision, sedimentation, pollution, weed invasion, and habitat disturbance. With respect to Booroolong frog, this may also include the inadvertent introduction of chitrid fungus from increased human presence. The RMP will include provision for monitoring frogs and include measures to manage the risk of Chitrid introduction.

Facilitated impacts that may be foreseeable include increased public access into and use of the WBCC however these are generally included in the range of activities proposed within the river corridor. These will result from the introduction of infrastructure that will increase ease of access and encourage recreational use of the riparian areas within or adjacent to the WBCC.

Measures to Avoid and Mitigate

Direct impacts to threatened fish and amphibian species will be avoided by the Program.

Indirect and cumulative impacts to threatened fish and amphibian species will be managed through the implementation of a number of mechanisms:

- WBCC RMP Plan to be implemented prior to allowing public access to include reference to:
  - Controls on recreational fishing such as bag limits, prohibitions on taking certain species, and licensing requirements in line with those that already exist within the ACT and NSW.
  - Controls to public access and use of the riparian areas post construction.
- Incorporation of WSUD principles into the Master Plan that aim to:
  - maintain stormwater run-off to acceptable levels; and
  - treat urban runoff to reduce urban pollutants to acceptable levels before discharge to the Murrumbidgee River or Ginninderra Creek.
- Implementation of CEMPs to be prepared prior to construction commencing, in accordance with relevant guidelines. CEMPs will target among other environmental values:
  - erosion and sediment controls;
  - water treatment standards before release in the Murrumbidgee River or Ginninderra Creek;
  - flow controls;
  - pollution and waste management; and
  - avoidance of riparian habitat areas.

Facilitated impacts have been anticipated by the Program, and will be avoided or managed through the WBCC Management Plan.

4.2.3 Golden Sun Moth

Golden sun moth is an EPBC Act critically endangered species that historically occurs in natural temperate grasslands and open grassy woodlands. Flying season generally runs from late spring into early summer, though exact timing varies depending upon weather conditions. During this time adults live for up to four days after they emerge, and males fly over the grassland in search of females. Its habitat requirements are very specific as its larvae feed only on the roots of C3 grasses (namely wallaby grasses, spear grasses, and the exotic Chilean needle grass), and females require bare ground between tussocks from which they display.

Targeted surveys for golden sun moth and its required habitat have been conducted throughout the Project Area (Rowell 2013 and 2015), the Jarramlee offset (Biosis, 2015; ACT Gov't 2013), and the Macgregor offset (Braby 2005).

Information utilised for the identification of golden sun moth habitats has included the following Targeted Surveys:

- Rowell Ginninderra Drive extension golden sun moth Surveys (Rowell A. , 2015);
- Rowell West Belconnen golden sun moth Surveys (Rowell A. , 2013);

Current Condition and Threats

Prior to European settlement the species was widespread throughout southeast Australia; occupying primary and secondary native grasslands and open woodland. Now, it is estimated that less than one percent of this habitat remains; and the species is only found in a few small areas within its historical range (Rowell A. , 2013).

Within the broader west Belconnen area, there are several populations known along Ginninderra Creek and its tributaries. These occur on the north-eastern boundary of the Project Area and denote the western limit of ACT golden sun moth distribution (Rowell A. , 2013). In 2010, David Hogg Pty Ltd (David Hogg Pty Ltd, 2010) classified habitat throughout Canberra, based on vegetation quality and patch size. Whilst new populations have been identified since this study, it established the importance of the broader west Belconnen area populations for the region.

Direct, Indirect, Cumulative, and Facilitated Impacts

Rowell (2013) identified areas of land within the Project Area as being potentially suitable for golden sun moth, but unoccupied now and never having been known to be occupied. This land will be directly impacted by the urban development of the Program. Some low quality patches will be avoided by their placement within the WBCC, however this is due to other environmental values they hold (e.g. secondary box gum woodland). These unoccupied areas are considered unlikely to be utilised by golden sun moth in the future as a result of separation distance from the nearest golden sun moth populations. Owing to the limited dispersal ability of females it is highly unlikely recolonisation of areas formerly occupied will occur naturally. Therefore impacts to these areas are not considered to be of relevance to golden sun moth (Rowell A. , 2013).

Direct impacts to occupied habitat for the species will occur as a result of the Ginninderra Drive extension. Whilst the areas with the greatest densities of golden sun moth within the existing offset areas will be avoided, the current preferred alignment (route 5) is proposed to remove 0.85 hectares of golden sun moth habitat. A further 0.96 hectares of habitat may be affected as a result of overshadowing by the proposed bridge over Ginninderra Creek. The total impact will therefore be in the order of 1.8 hectares of golden sun moth habitat affected. There are unlikely to be any facilitated impacts as a result of the Program that will affect golden sun moth.

As shown in Figure 13 direct impacts resulting from the preferred alignment are minimised by route selection. The bridge is indicated by the grey section within which direct impacts from construction will be limited to the driving of piles in order to support the bridge with smaller areas of habitat removed as a result of the construction. The estimates of impact to habitat have been based on the footprint design with the addition of a further two metres buffer to account for access and other unavoidable impacts during construction.

As noted above, the alignment of the Ginninderra Drive extension has also been selected to correspond with an area that does not support golden sun moth as a result of tree plantings that are now well established. Golden sun moths are absent from this area potentially as a result of reduced grass growth under the trees and the barrier to flight created by the trees themselves. During the most recent surveys (Rowell A. , 2015) in addition to earlier assessments, there were no moths observed flying through this area of tree plantings supporting the conclusion that it presently represents a barrier to movement between proximate areas of habitat.

The bridge design has considered minimising impacts to golden sun moth habitat connectivity and appreciation for the Chilean needle-grass paradox. The height of the bridge is proposed to be in the order of four metres above ground level at the point where it crosses Ginninderra Creek and the location where golden sun moth numbers are their highest along the alignment. This design option seeks to mitigate the potential impact of introducing an overhead structure which may impact the willingness for flying moths to move under the bridge. In comparison to the current situation in the Macgregor offset where the tree plantings are, the bridge scenario differs in at least one important aspect. Habitat on the other side of the trees may not be visible to the moths, plus the obstacles the trees are likely to represent at flying height will limit the ability of moths to traverse the woodlot. The bridge by comparison will have a clear view from one side to the other with the only obstructions being the piles spaced at 50 metre intervals and the overhead structure itself which will be above usual moth flying height.

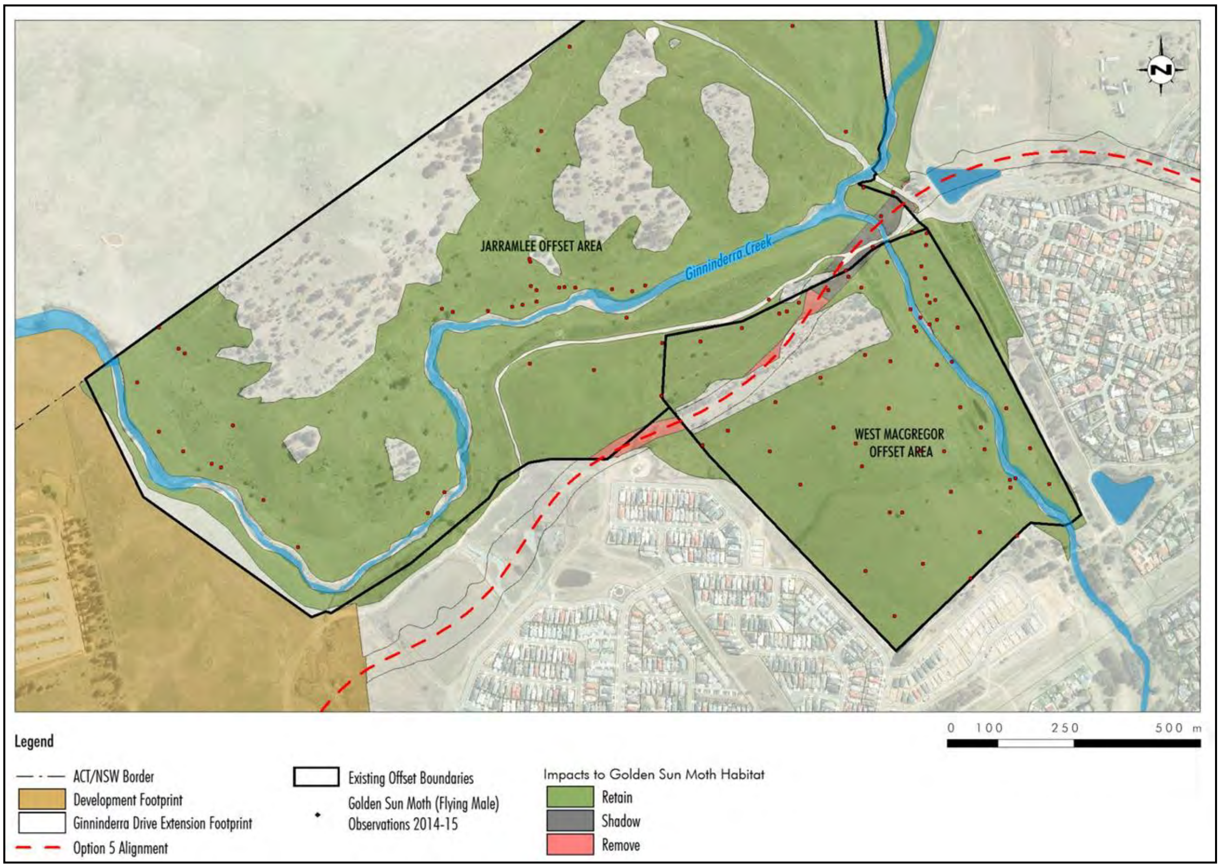

Figure 13: Ginninderra Drive impacts

Measures to Avoid and Mitigate

Selection of the proposed Ginninderra Drive extension alignment has been based on a comprehensive assessment of alternative alignments from the perspective of social, economic and environmental values. In general it was found that:

- The alternative of not constructing the Ginninderra Drive extension results in no impacts to golden sun moth, however has significant adverse impacts to the environment and overall sustainability as a result of increased travel time, compromised public transport options, and upgrades to existing infrastructure that are necessary to support the increased traffic volumes. This avoidance strategy is unacceptable.
- To completely avoid impacts to the existing offset areas and the golden sun moth habitat it supports will have unacceptable impacts to community values in terms of aesthetics and noise by constructing an arterial road within the power easement in a location where original planning for the affected communities did not allow for vehicle noise and where the construction of a road immediately adjacent to power line towers poses a safety risk.
- Minimising the area of golden sun moth habitat affected by following the existing alignment of the Jarramlee homestead access road resulted in significant engineering costs (two bridges plus cut and fill due to terrain) and also had the effect of impacting other values for MNES such as woodland birds and natural temperate grassland while still resulting in fragmentation of golden sun moth habitat.
- Alternatives that included minor variants to the preferred option also had the effect of either increasing the footprint of the road construction over golden sun moth habitat or increasing other social and/or economic impacts.
- The preferred option represents the optimal outcome from a triple bottom line perspective.

By considering direct impacts to golden sun moth habitat throughout the design phase of the Ginninderra Drive extension, impacts to habitat along Ginninderra Creek have been minimised by selecting an alignment that coincides with unsuitable habitat (see Section 3.2.1 and Figure 13) as defined by the presence of tree plantings. Given characteristics of all the other options, no other avoidance option is considered feasible.

Design features of the road and treatments following the conclusion of construction activities are also aimed at mitigating the impact of the road. Such treatments include landscaping with native grass species in order to restore golden sun moth habitat to sections that are 'at grade'. It is also proposed to remove all trees within the area that presently do not support golden sun moth in the Macgregor offset. The planting of trees in this area has reduced viability of the habitat although the ground layer vegetation in this area retains the necessary native grasses that would otherwise be suitable for golden sun moth. By restoring this area to grassland, the Program seeks to mitigate a component of the impact of habitat removal and improve the potential for movement across the road to occur in the future. As the construction of the Ginninderra Drive extension is unlikely to be required for about 20 years after commencement of the proposed action, it allows for a substantial period during which habitat enhancement can be undertaken in order to minimise the magnitude of direct impacts.

Detailed design of the extension will also provide opportunities for mitigating direct and indirect impacts as a result of changes to hydrology and the design standard of the road. This would be carried through into the construction phase for which the implementation of a CEMP would ensure there are no inadvertent impacts to adjacent habitat that is not within the footprint of the construction area. This will also include anticipating and managing the potential effects of weed invasion through the construction and operation phases as a result of poor site hygiene and landscaping species selection. Road mortality is unlikely to be a significant threat to the local population however may be the cause of death for an occasional moth.

It is also proposed that upon approval of the Program, the management plans for Jarramlee and Macgregor West will be consolidated and incorporated into the Reserve Management Plan (RMP) in order to simplify management of golden sun moth and other environmental values. While this is effectively an administrative mitigation measure, the simplified approach to ongoing management will reduce overhead costs of maintaining separate reporting, monitoring and review processes. This will lead to a reduced proportion of available resources being expended on measures that have no direct benefit on the environmental values of the affected area.

It is also proposed as part of the overall conservation works within the environmental offset area to enhance connectivity between the existing habitat patches supporting golden sun moth and other patches supporting the species. This will also be accompanied by stream bank restoration along Gooromon Ponds Creek as part of a riparian strategy that extends from the Murrumbidgee River, along Ginninderra Creek and further on Gooromon Ponds Creek up to Wallaroo Road. This will

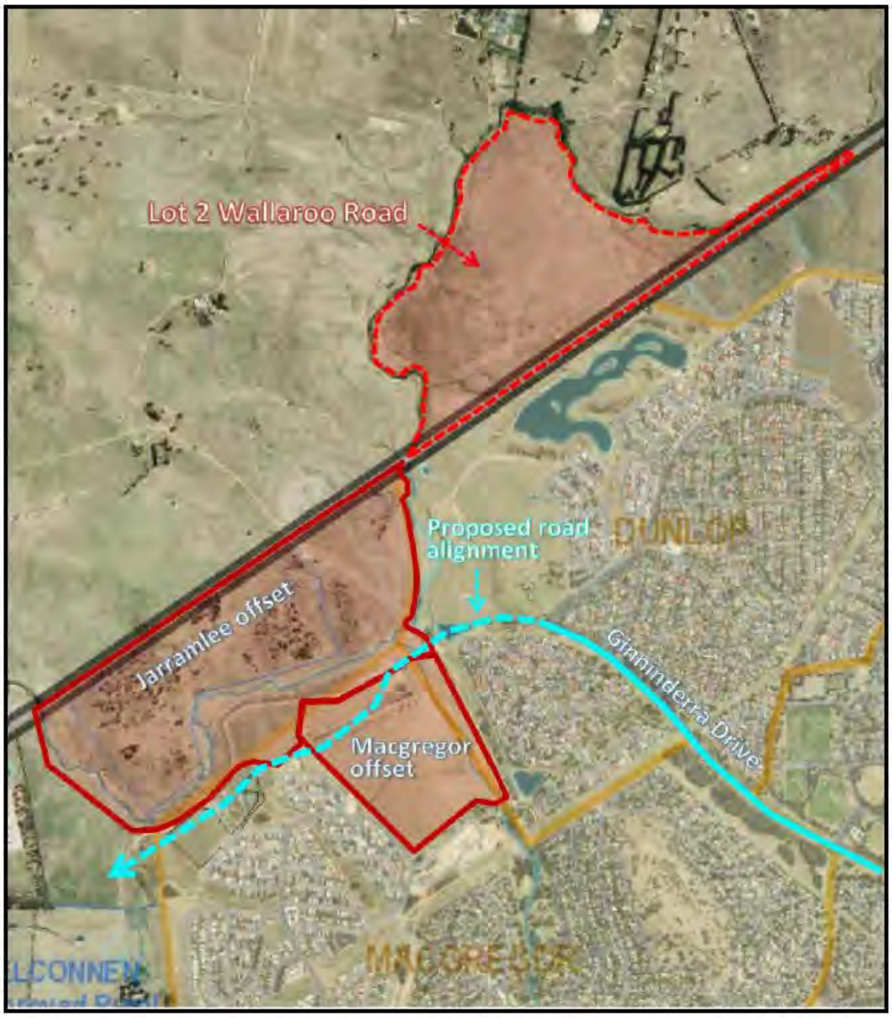

Figure 14: Environmental offset areas

further enhance the environmental outcomes of the Program by addressing a regional connectivity objective to improve linkages along the western side of the ACT, between the northern woodlands and the Murrumbidgee River.

Measures to offset impacts

Field research by Rowell (Rowell A. , 2015) has confirmed the presence of a substantial population of golden sun moth on a parcel of land in NSW adjacent to the ACT border and in close proximity to the Jarramlee reserve – Lot 2 Wallaroo Road, which totals some 86.8 ha.in area (Figure 14). The site includes 11.9 ha of land currently occupied by GSM and a further 19.4 ha suitable for GSM but currently unoccupied. The ACT Government has purchased this land to use it as an environmental offset against the impacts on 1.8 Ha of golden sun moth habitat that will be caused by the Ginninderra Drive extension. The new site (Lot 2) will be managed in combination with the West Macgregor and Jarramlee reserves as a single complex. The objectives of the existing reserves as well as those to be formulated for the additional site will be incorporated in the RMP. There is potential for this offset area is rezoned as E3 Environmental Management as part of the overall NSW West Belconnen rezoning process.

4.2.4 Pink-Tailed Worm-Lizard

Pink-tailed worm-lizard is listed as vulnerable under the EPBC Act, the NC Act, and the TSC Act. It is most commonly found sheltering under small, shallowly embedded rocks where it may remain for long periods.

Information for the assessment of impacts to pink-tailed worm-lizard predominantly used data from targeted surveys conducted by Osborne and Wong (Osborne & Wong, 2013) throughout the Project Area, which also incorporated results from previous surveys.

Quality of habitat was determined by the level of disturbance at a site. Suitable habitat was ranked as either high or moderate and contained areas that were well drained, with a partial cover of 10 – 30 centimetre, igneous or metamorphic embedded rocks. Highest quality sites were dominated by kangaroo grass and other disturbance sensitive species. Moderate quality sites contained a less diverse ground cover, usually dominated by wallaby or spear grasses and had a lower abundance of native forb species. Low quality habitat was considered to be highly disturbed and degraded and would be likely to no longer support the species.

The maps produced by Osborne and Wong (2013) did not delineate high and moderate quality habitat due to the large amount of fragmentation of high quality habitat across the Project Area. Both habitat types have thus been treated equally within this impact assessment.

Direct, Indirect, Cumulative, and Facilitated Impacts

There is a total of 162.1 hectares of pink-tailed worm-lizard habitat within the Project Area. Of this area, approximately ten percent will be affected by the proposed action comprising 10.1 hectares of high/moderate quality habitat and 6.2 hectares of low quality habitat. Of these areas, a number are uninhabited however display attributes conducive to the species requirements. Table 3 summarises the split between quality and impact of the Program on pink-tailed worm-lizard habitat.

Table 3: Summary of impacts on Pink-tailed Worm Lizard habitat (Ha)

	Avoided	Impacted	Total
High Quality	141.3	10.1	151.4
Low Quality	4.5	6.2	10.7
Total	145.8	16.3	162.1

The areas affected by the urban footprint are generally small and isolated and have therefore been assessed as not playing an important role in the overall population's viability. They have been mapped as 176 discrete patches with an average area of 0.09 hectares, only three of which exceed one hectare and none exceed 1.4 hectares in size. However, it has been noted in a general sense by Osborne and Wong (2013) that:

> *Although the long-term survival of such small populations is very unlikely – it does indicate that small isolated patches of habitat should still be considered if these areas are subject to further development. Moreover if the patches occur close together they may act as a corridor for movement through poorer quality parts of the landscape. This highlights the importance of such small and less obvious habitat patches in maintaining connectivity and assisting in the long-term conservation of the species. Small patches located at important points in the landscape are likely to be important (for example near and within the Lower Molonglo Water Quality Control Centre and in the extreme north of the study area near Ginninderra Creek). It is very likely that they will act as steppingstones between larger areas of occupied habitat.*

Indirect impacts to the habitat retained within the WBCC potentially include edge effects such as weed invasion, changes to hydrological conditions, pollution, and sedimentation and erosion.

Cumulative impacts will arise from increased public access to the WBCC for recreational purposes. The provision of infrastructure and services to accommodate visitor use combined with the promotion of the area as an important aspect of the lifestyle and identity of the west Belconnen community will facilitate further impacts in the foreseeable future as access and use are increased.

As a result of the alignment selected for the sewer construction, additional impacts to pink-tailed worm-lizard habitat will not occur. Disturbance to small areas (20m x 20m) to enable tunnelling and shaft construction will occur. The access to the shaft locations and construction sites, have been located in order to avoid direct impacts on habitat areas.

Measures to Avoid and Mitigate

The boundary of the WBCC has been designed so that the vast majority of pink-tailed worm-lizard habitat will be avoided and subsequently protected under the Program. Direct impacts to approximately 16 hectares of habitat from the installation of sewer pipes through the WBCC have also been avoided through the choice of construction method and alignment options.

Direct impacts (clearing 16.3ha) to the areas of habitat within the footprint of the proposed urban area are not considered important for maintenance of the local population due to the low occupancy rates of these small and isolated patches and the likelihood that they do not contribute to the gene pool of the rest of the population. Following the conclusions of Osborne and Wong (2013) such areas may retain importance for pink-tailed worm-lizard however given the spatial arrangement of these affected patches of habitat within the Project Area, they are unlikely to be considered important.

Patches that may provide "stepping stone" connectivity to the north and south are included in the corridor; these are considered to be significant by Osborne and Wong who say (in the summary to their report):

> *The extensive habitat found along the Murrumbidgee River Corridor, including the more isolated patches that form "stepping stones" through the landscape in NSW, provide a link with the rugged, rocky woodlands near Ginninderra Falls (Hyles property). To the north of Ginninderra Creek there is a potential link through private properties to the few poorly known sites that have been found north of this area near the Murrumbidgee River. To the south, the large population in the Murrumbidgee Corridor links directly with the regionally important populations along the Molonglo River in the ACT.*

The majority of pink-tailed worm-lizard habitat is retained within the WBCC on steeper slopes and in areas that have a substantially better quality of understorey vegetation.

Areas retained within the WBCC may also be subject to limited indirect impacts as a result of developing recreational and management infrastructure such as walking trails and access tracks. Where such development occurs, design will need to ensure connectivity between patches is not compromised. Connectivity is likely to be severed by expanses of bare ground, paved surfaces (including pathways) and while there is already likely to be an element of fragmentation from the existing farm track network, objectives of the RMP will include measures to enhance connectivity through design responses that adopt a philosophy of avoidance and mitigation and rehabilitation.

Areas of habitat have been included within the development footprint as a result of a process of design including consideration of the longer term viability of small isolated patches, feasibility of their management for conservation values and determining an optimal configuration for retention of areas of conservation value. The avoidance strategy has incorporated all medium-high quality habitats in the WBCC in a configuration that minimises management costs and the risk of failure.

Indirect impacts to pink-tailed worm-lizard will be mitigated through the implementation of a number of mechanisms:

- WBCC RMP (refer also to Section 3.6):
  - controls to guide public access within the WBCC;
  - controls of permitted activities within the WBCC;
  - implementation of measures as appropriate that are prescribed by the ACT Government's Action Plan 29 (ACT Gov't 2007) and recovery planning documents specific to pink-tailed worm-lizard ((ACT Government, 1995) (NSW Government, 2015c) (ACT Government, 2007), and Australian Government Conservation Advice;
  - consideration of pink-tailed worm-lizard habitat when designing infrastructure and services, including maintaining an effective buffer around known populations; and
  - implementation of habitat improvement strategies (such as controlled grazing and fire management) targeting pink-tailed worm-lizard.
- Incorporation of WSUD principles into the Master Plan to maintain stormwater run-off and associated pollutants to acceptable levels or better.

- Implementation of CEMPs, particularly targeting
  - erosion and sediment controls;
  - water treatment standards before release;
  - flow controls;
  - pollution and waste management; and
  - avoidance of riparian habitat areas.

CEMPs will also be prepared to guide pre-construction activities such as geotechnical sampling and ensuring direct and indirect impacts to sensitive areas are avoided. The primary risks during these activities are from uncontrolled vehicle access and discharge of sediment laden water from the drilling process or as runoff from excavated soil. Best practice measures to manage the potential effects from these activities will be incorporated in to the CEMPs.

These mechanisms will be developed prior to construction and public access to the WBCC beginning. Cumulative and facilitated impacts will be avoided or mitigated through the WBCC RMP.

Measures to Offset Impacts

The entirety of the avoided area of habitat will be brought into the 549.9 hectare WBCC and managed as a conservation area. This is comprised of numerous patches of habitat separated by areas of native vegetation within the river corridor and currently by exotic pastures across the proposed urban development area.

Without the proposed offset, the calculations predict a decline in quality of the pink-tailed worm-lizard habitat. This is based on the encroachment of weeds and an associated change in diversity, particularly within areas along the upper slope, nearer to the pasture. As a result of the change in the management there will be improvements to habitat quality variables due to a decrease in threats and weed management in addition to increased certainty from the transition to conservation zoning.

It is the intent of the Program to establish the WBCC with a formalised plan for recreation that will direct human activity away from areas of greatest ecological sensitivity such as pink-tailed worm-lizard habitat. This concept will be effective in avoiding incursions into areas of ecological value. With implementation of the management plan and avoidance of pink-tailed worm-lizard habitat on the layout of the proposed facilities and movement corridors (e.g. vehicle access, walking trails, etc.), the effect of any future recreation is likely to be negligible.

4.3 Threatened Flora

Five flora species listed as being either endangered or threatened under the EPBC Act were identified as having the potential to be impacted by the Program. Small purple pea, Tarengo leek orchid, and Hoary sunray are all listed as endangered; Pale pomaderris and Austral toadflax are both listed as vulnerable under the EPBC Act.

Despite none of these species being known to exist within the Project Area it is considered likely that Small purple pea, Pale pomaderris and Austral toadflax occur and that there is potential habitat for Tarengo leek orchid and Hoary sunray.

In the following section, impacts to these species will be discussed together as the impacts and the avoidance, mitigation, and offset measures are the same for each species.

Numerous flora and vegetation assessments have been undertaken within the Project Area. Earlier studies focused on classifying vegetation types to guide future, more targeted flora surveys that occurred on the developable land.

Information utilised for the identification of threatened flora species has included the following data sources:

- Targeted Surveys:
  - KMA (2014) Ecological Studies West Belconnen Australian Capital Territory;
  - KMA (2013a) West Belconnen Project NSW Land Flora and Fauna Studies;
  - KMA (2009a) Further Flora and Fauna Studies: Land at West Molonglo and Ginninderra Creek New South Wales Australian Capital Territory;
  - KMA (2009b) West Belconnen Project ACT and NSW Land Flora and Fauna Studies;
  - David Hogg Pty Ltd (2013) West Belconnen Woodland Areas: Confirmatory Ecological Assessment; and
  - Geoff Butler and Associates (2000) The Revegetation of Ginninderra Creek Between Barton Highway and Macgregor, ACT.

Direct, Indirect, Cumulative, and Facilitated Impacts

There are no known threatened flora species within the Project Area; therefore there will be no direct impacts expected to these species. Areas of potential habitat include the woodland or riparian areas that would be protected by the WBCC and therefore not directly impacted by the Program.

Indirect impacts from the Program that may affect the WBCC include edge effects such as weed invasion and changes to microclimates, changes to hydrological conditions, fire regimes, pollution, sedimentation, and erosion.

Cumulative and facilitated impacts to threatened flora habitat may occur as a result of increased public access to the WBCC for recreational use. These may include disturbance and destruction of habitat from the provision of infrastructure, pollution, and damage to plant growth as a result of informal track creation.

Measures to Avoid and Mitigate

All potential threatened flora habitats within the Project Area will be avoided and protected by the creation of the WBCC.

Indirect impacts to the WBCC will be managed through the implementation of CEMPs during the construction phase, WSUD principles within the Master Plan, and the WBCC RMP during the operational phase of the Program. These mechanisms should specifically include:

- Implementation of CEMPs, particularly targeting
  - prescriptions for pre-clearing surveys for listed species prior to the commencement of any construction activities such that further avoidance and mitigation measures can be incorporated where cost effective and practicable;
  - erosion and sediment controls;

  - water treatment standards before release;
  - flow controls;
  - pollution and waste management;
  - weed management;
  - appropriate definition of clearing boundaries; and
  - avoidance of the WBCC.
- Appropriate storm water management based on geotechnical, surface water, and groundwater assessments and WSUD principles to reduce impacts to hydrological systems.
- WBCC RMP:
  - controls to public access and use of the habitats within the WBCC;
  - bushfire hazard and fuel management prescriptions that are not inconsistent with biodiversity conservation objectives; and.
  - conservation management actions that target the improvement of overall environmental and habitat values of the area (i.e. a landscape approach).

5.0 Outcomes and commitments for MNES

5.1 Summary of conservation actions targeting MNES

The proposed conservation outcomes relevant to each MNES are summarised in Table 4.

Table 4: Conservation outcomes and actions for MNES

Conservation outcome	*Action*		*Responsibility*	*Timing*
Previously unidentified MNES				
Protection of Matters of National Environmental Significance that are identified in pre-construction surveys for permitted construction work in the WBCC	1	Prior to development of WBCC infrastructure, site surveys of threatened flora and fauna species will be conducted and populations of threatened flora and fauna species will be avoided or impacts managed in accord with the RMP and EPBC Act.	Riverview Group Environmental Management Trust	Ongoing The survey of PTWL and NTG will occur within 12 months of Ministerial endorsement of the Program, and will be made public.
Golden Sun Moth				
Protection and enhancement of habitat whilst allowing for the intrusion of the Ginninderra drive alignment. (refer to (ACT Government, 2013) (David Hogg Pty Ltd, 2011)	2	Vary the Territory Plan to establish conservation reserves at the Jarramlee and West Macgregor offset areas, with provision for Ginninderra Drive	Riverview Group	Prior to commencement of construction of Ginninderra Drive extension
Mitigation of the impact of Ginninderra Drive extension on GSM habitat in Jarramlee and West Macgregor offset areas	3	ACT Government to Purchase Lot 2 Wallaroo Road (86.8 Ha) from the Commonwealth catering for the following components: • 1.8 Ha as replacement of impacted areas of occupied GSM habitat, • 11.9 Ha of occupied GSM habitat,	Economic Development Directorate	Land purchase prior to commencement of construction of infrastructure to service the residential estate, habitat restoration prior to commencement of construction of Ginninderra Drive extension

Conservation outcome	Action		Responsibility	Timing
		• 19.4 Ha of unoccupied GSM habitat, and, • Implementation of GSM habitat restoration as a connectivity measure between Jarramlee and Dunlop Grasslands Reserve.		
	4	Apply a conservation covenant requiring the long term protection and enhancement of GSM habitat on lot 2 Wallaroo Road Whilst the covenant will provide long term protection for the Wallaroo Rd offset area, further investigations should occur for the potential to rezone the land to E3 Environmental Management.	Riverview Group to request Yass Valley Council to implement the statutory covenant.	To be implemented concurrently with the amendment to the Yass Valley LEP.
	5	Prepare a combined offset management plan (OMP) addressing the preservation and enhancement of GSM habitat in Jarramlee and West Macgregor offset areas and Lot 2. Actions in the OMP to include research and trials for golden sun moth larvae translocation. Incorporate the management plan into the WBCC RMP. Lot 2 GSM habitat area to be increased from current 11.9 Ha to 33.1 Ha.	Riverview Group to prepare first draft. Environmental Management Trust to seek approval and implement the plan. Plan to be endorsed by the ACT Conservator and approved by the Minister for the Environment (ACT component) and endorsed by the ACT Conservator of Flora and Fauna (NSW component) in consultation with the NSW Office of Environment and Heritage	Plan to be finalised within 2 years of Ministerial endorsement of the Program, reviewed at intervals of no more than five years thereafter. GSM habitat area increase to be achieved prior to construction of Ginninderra Drive extension
Establishment of a governance regime for reserve land (Macgregor, Jarramlee and	6	Establish a West Belconnen Environmental Management Trust (EMT).	Riverview Group	Within 2 years of Ministerial endorsement of the Program and prior to construction of

Conservation outcome	Action		Responsibility	Timing
Lot 2).				Ginninderra Drive extension.
Implementation of program for research and trials for the translocation of golden sun moth larvae	7	Research and trials to be undertaken to assist habitat restoration and golden sun moth larvae translocation	Environmental Management Trust	Research programs and trials to begin with the commencement of the OMP plus 5 years.
Restoration of GSM habitat	8	Restore habitat area into which golden sun moth larvae will be translocated, subject to concurrence by the EMT that sufficient evidence exists to ensure a successful outcome. May include further translocation trials of golden sun moth subject to consultation with the Conservator of Flora and Fauna and approval by the Department of the Environment. Restoration may also include stream bank restoration from the Murrumbidgee River along Ginninderra Creek and along Gooromon Ponds Creek up to Wallaroo Road to improve linkages along the riparian areas.	Environmental Management Trust Restoration area should be a site of importance to landscape connectivity determined in conjunction with the ACT Environment and Planning Directorate.	Completion of restoration and then monitored for 15 years.
Translocation of GSM larvae from sites that will be impacted by construction of the Ginninderra Drive extension	9	Translocate GSM larvae from sites that will be impacted by construction of the Ginninderra Drive extension to suitable habitat restoration sites at lot 2 Wallaroo Road using method as refined through the program of research and trials.	Environmental Management Trust Translocation research should build on existing knowledge and trials, undertaken elsewhere in the ACT	Approval of the OMP plus 20 years, and prior to the construction of Ginninderra Drive extension.
Ongoing monitoring of	10	Adopt field data recorded by Rowell (Rowell A. , 2015)	Environmental Management Trust	Every two years from date of endorsement.

Conservation outcome	Action		Responsibility	Timing
impacts on habitat		as baseline data and ensure that monitoring methods are consistent with those used to measure GSM population and habitat quality and extent across the ACT.	Monitoring to be timed so that it is consistent with GSM monitoring across the ACT.	Monitoring period to be reviewed if impacts have stabilised.
Establishment of a process of independent third party review of RMP	11	Prepare an annual report addressing MNES outcomes achieved in the previous year; lessons learned; include a financial audit; report to be made publicly available. Report to be submitted to the ACT Conservator of Flora and Fauna.	Environmental Management Trust.	Within 2 months of the end of each financial year
Box Gum Woodland				
A conservation area that includes 100% of identified box gum woodland (68.2 Ha) in conservation area.	12	Vary the Territory Plan, amend the National Capital Plan for all proposed land use changes	Riverview Group to obtain relevant rezoning and related approvals	Zoning to be in place prior to commencement of construction in ACT.
Preservation and enhancement of woodland habitats. Actual hectares will be used in area measurements.	13	Manage activities in the WBCC in accordance with a Reserve Management Plan. A Reserve Management Plan is a statutory document under the provisions of the Nature Conservation Act. It will need to be determined whether to do a RMP over that area of land not already covered by the Murrumbidgee River Corridor Plan of Management, or whether one plan will be produced for the entire corridor.	Riverview Group to prepare first draft RMP. Environmental Management Trust to seek approval and implement the plan. Plan to be approved by the ACT Conservator and Minister for the Environment (ACT component) and endorsed by the ACT Conservator (NSW component) in consultation with the NSW Office of Environment and Heritage	Plan to be finalised within 2 years of Ministerial endorsement of MNES plan, reviewed at intervals of no more than five years thereafter.
Establishment of a land management	14	Establish a West Belconnen Environmental	Riverview Group	Within 2 years of Ministerial

Conservation outcome	Action		Responsibility	Timing
governance regime.		Management Trust (EMT)		endorsement of the MNES plan and prior to commencement of construction.
Maintenance and enhancement of connectivity between box gum woodland habitat areas. No appreciable long term net reduction in total box gum woodland habitat areas.	15	All works that may affect box gum woodland to be informed by relevant scientific expert advice and:- Roads and tracks to follow existing alignments where feasible and incorporate appropriate design techniques such as raised grating Vehicle tracks max 6m wide other tracks/trails max 2.5m wide Unused existing tracks to be rehabilitated Picnic and other facilities involving buildings and car parking to avoid known high value habitat areas	Environmental Management Trust	Ongoing
Protect habitat from domestic predators	16	Impose a cat containment policy for the entire West Belconnen development area and prohibit off-leash dogs in the Conservation corridor	TAMS Environmental Management Trust	Cat Containment mandated by changes to the relevant instrument under the provisions of the Domestic Animals Act prior to commencement of any works in the ACT Cat containment in NSW to be implemented if suitable legislation comes in to force. In the absence of specific legislation, environmental planning laws such as planning agreements and/or conditions attached to

Conservation outcome	Action		Responsibility	Timing
				development consents will be used to impose the controls. Dog control regime to be established by the EMT.
Monitoring of impacts on habitat is ongoing Monitoring will be consistent with box gum woodland monitoring across the ACT.	17	Adopt field data recorded by Nash & Hogg 2013 as baseline data. Periodic field research will be conducted to assess change in the extent and quality of BGW habitat.	Environmental Management Trust	Every two years from date of endorsement. Monitoring period to be reviewed if impacts have stabilised.
Establishment of a process of independent third party review of RMP	18	Prepare an annual report addressing MNES outcomes achieved in the previous year; lessons learned; include a financial audit; report to be made publicly available Report to be submitted to the ACT Conservator of Flora and Fauna	Environmental Management Trust	Within 2 months of the end of each financial year
Pink Tailed Worm Lizard				
A conservation area that includes 90% of identified PTWL habitat (146.4 Ha).	19	Variation to the Territory Plan, amendment to the National Capital Plan and amendment to the Yass Valley Shire local Environment Plan for all proposed land use changes	Riverview Group to obtain relevant rezoning and related approvals	ACT zoning to be in place prior to commencement of construction in ACT. NSW zoning to be in place prior to commencement of construction in NSW
Preservation and enhancement of PTWL habitats. Actual hectares will be used in area measurements.	20	Manage activities in the WBCC in accordance with a Reserve Management Plan.	Riverview Group to prepare first draft. Environmental Management Trust to review the draft and adopt and implement the plan when approved by the Conservator. Plan to be approved by the	Plan to be finalised within 2 years of Ministerial endorsement of the Program, reviewed at intervals of no more than five years thereafter.

Conservation outcome	***Action***		***Responsibility***	***Timing***
			ACT Conservator and Minister for the Environment (ACT component) and endorsed by the ACT Conservator (NSW component) in consultation with the NSW Office of Environment and Heritage	
Establishment of a land management governance regime	21	Establish a West Belconnen Environmental Management Trust.	Riverview Group	Within 2 years of Ministerial endorsement of the Program and prior to commencement of construction.
Maintenance and enhancement of connectivity between PTWL habitat areas. No appreciable long term net reduction in total PTWL habitat areas.	22	All works that may affect PTWL habitat to be informed by relevant scientific expert advice and:- Roads and tracks to follow existing alignments where feasible and incorporate appropriate design techniques such as raised grating Vehicle tracks max 6m wide other tracks/trails max 2.5m wide Unused existing tracks to be rehabilitated Picnic and other facilities involving buildings and car parking to avoid known high value habitat areas Active habitat restoration works will be undertaken.	Environmental Management Trust	Ongoing
Pink tailed worm lizard protected from domestic predators	23	Impose a cat containment policy in the for the entire West Belconnen development area. Prohibit off-leash dogs in the Conservation corridor	TAMS Yass valley Shire Council Environmental Management Trust	Cat Containment in the ACT to be mandated by changes to the relevant instrument under the provisions of the Domestic Animals Act prior to commencement of any

Conservation outcome		Action	Responsibility	Timing
				works. Cat containment in NSW to be implemented if suitable legislation comes in to force. In the absence of specific legislation, environmental planning laws such as planning agreements and/or conditions attached to development consents will be used to impose the controls. Dog control regime to be established by the EMT.
Ongoing monitoring of impact on habitat. Monitoring will be consistent with PTWL monitoring across the ACT.	24	Adopt field data recorded by Osborne & Wong 2013 as baseline data. Conduct periodic field research to assess change in the extent and quality of PTWL habitat.	Environmental Management Trust	Every two years from date of endorsement. Ability to review monitoring period if impacts have stabilised.
Establishment of a process of independent third party review of RMP	25	Prepare an annual report addressing MNES outcomes achieved in the previous year; lessons learned; include a financial audit; report to be made publicly available Report to be submitted to the ACT Conservator of Flora and Fauna	Environmental Management Trust	Within 2 months of the end of each financial year
Natural temperate grassland				
Management Actions as prescribed in the most recent approved version of the Jarramlee	26	In accord with the Jarramlee Offset Management Plan	Environmental Management Trust	Ongoing

Conservation outcome	Action		Responsibility	Timing
Offset Management Plan (ACT Government, 2013)				
Implementation of assessment process for additional unanticipated impacts to any area dominated by native grasses that is part of a larger patch of native grassland which includes high or moderate quality pink-tailed worm-lizard habitat as mapped by Osborne and Wong (2013).	27	Follow the defined process strategy (see s5.3.4 of this Program Report). When triggered the strategy involves: 1. Assess the impact using data collected from site-based field verified surveys as per EPBC guidelines 2. Implement avoidance & mitigation measures where practicable 3. Determine offset requirements for any residual impacts 4. Identify an appropriate offset and establish Prepare & implement an offset management plan to incorporate in the WBCC management plan or a standalone plan	Riverview Group Environmental Management Trust	Ongoing
Major changes to infrastructure location (e.g. sewer alignment)				
Implementation of assessment process for additional unanticipated impacts to MNES within the Project Area due to major changes to infrastructure location (e.g. sewer alignment).	28	Follow the defined process strategy (see s5.3.4 of this Program Report). When triggered the strategy involves: 1. Assess the impact using data collected from site-based field verified surveys as per EPBC guidelines 2. Implement avoidance & mitigation measures where practicable 3. Determine offset requirements for any residual impacts 4. Identify an appropriate	Riverview Group Environmental Management Trust	Ongoing

Conservation outcome	Action		Responsibility	Timing
		offset and establish 5. Prepare & implement an offset management plan to incorporate in the WBCC management plan or a standalone plan		
Threatened Bird Species				
Mitigate indirect impacts from urban development on threatened bird species.	29	Implementation of CEMP's, WSUD principles, and the WBCC RMP. Replace affected farm dams with the provision of constructed wetlands where possible.	Riverview Group Environmental Management Trust	Ongoing

5.2 Environmental Management Trust

5.2.1 Background

The West Belconnen Conservation Corridor will be managed as a single unit (including both the ACT & NSW components) which is logical given that it is a single landscape unit. Management will be by way of an independently funded community trust, referred to herein as the West Belconnen Environmental Management Trust or the EMT. The EMT and board will be established by the proponent and will include community and relevant Government agency representatives. Conservation, fire management and recreation and indigenous and European cultural objectives will be equally represented (Elton, 2014g). In the initial 5 year period an interim board may be established comprising Riverview, Government and community representatives. This arrangement is proposed as an alternative to the “business as usual” approach whereby the relevant ACT Government agencies will be directly responsible for the management of the ACT component of the Corridor and, separately, a specialist EMT being responsible for the NSW component.

The approach, based on sustainability principles, that has been taken to the West Belconnen project includes community ownership and respect for ecosystem functions, the intrinsic value for the Murrumbidgee River corridor and Ginninderra Creek environments, ecological restoration of conservation areas and recognition of Aboriginal and non-Aboriginal cultural values.

The Conservation corridor will be established as a best-practice protected area that will:

- extend across the ACT/NSW border and the existing ACT Murrumbidgee River Corridor
- be a single, cross-border governance arrangement
- be established under a secure method that enable long term protection and restoration of MNES
- contribute to biodiversity conservation, the protection of other natural and cultural values, public appreciation those of values and sustainable public recreation and tourism
- contribute to local and regional connectivity conservation through linkages to protected and other natural areas
- be of a standard to be classified as an IUCN Category IV protected area (a habitat/species management, defined as an area of small, semi-natural or modified ecosystems close to urban areas that require active conservation intervention for restoration and management)
- be accepted as part of the National Reserve System
- be managed collaboratively with the community.

To achieve these outcomes an EMT entity will be established that will have responsibility for the management of the conservation corridor in perpetuity.

Additionally, the EMT will take responsibility for the management of environmental offset areas for PTWL and GSM;

The ACT currently has responsibility for the management of the Jarramlee Offset area and it is understood from discussion with the Village Building Company (VBC) that responsibility for the Macgregor offset area will pass from VBC to the Territory in due course in accordance with the EPBC agreement that covers this site.

An additional offset area is to be established on Lot 2 Wallaroo Road NSW, discussed at section 0.

5.2.2 Objectives and structure of the EMT

The primary objectives of the EMT will be conservation of MNES, other natural values and bushfire fuel management. Other objectives pertaining to education, heritage, research, recreation, tourism, and community involvement will also inform EMT operations. The EMT will be administered as a not-for-profit entity by a company (the Company) with a skills-based board comprising government, community, and other relevant stakeholder representatives. A Land Management Committee, a Social Sustainability Committee, and a Public Fund Committee will be set up to ensure objectives pertaining to land management, community engagement, and funds management is achieved, respectively.

Subject to the overarching control of the Board, the Land Management Committee will be responsible for upholding and reviewing a reserve management plan that meets legislative obligations and provides for conservation of natural values and bushfire fuel management. It will provide technical advice as necessary, manage recreational uses of the land, and facilitate tertiary-level research opportunities in the corridor.

The Social Sustainability Committee will be responsible for ensuring participatory process through liaising with residents regarding community aspirations and priorities, informing the community about activities, facilitating community participation in events, and managing volunteers interested in contributing to management of the corridor.

The Public Fund Committee will assist with the financial sustainability of the EMT by recommending to the board how budgets are allocated and spent and by investigating fundraising opportunities. Such opportunities may be through government grants, various types of private contributions, or through other forms of social enterprise within West Belconnen.

The Project will deliver, through a staged approach, the initial capital works within the corridor and offset areas and absorb any related costs until such assets are handed over to the EMT. The EMT will acquire annual income for its operations through the contribution of a percentage of sale proceeds from NSW lots(to establish a capital fund that will generate income in perpetuity) and an annual contribution from the ACT Government equal to those costs of managing the ACT portion of the corridor and the offset areas.

The proposed management arrangement will have the following characteristics:

- Not-for-profit Company limited by guarantee
- Incorporated under ASIC
- Cross-border scope
- Membership based (local community membership)
- Establishes the ‘Trust’ through a Trust Deed
- Establishes a Public Fund Committee to administer EMT
- Can undertake ‘operational’ activities through NFP company and administer donations received through the EMT
- Members elect Board members, but Riverview, Yass Valley Council and ACT Government reserved one spot each on the board

The not for profit company will have the following purpose:

- Own the NSW land, hold the lease of the ACT land and manage the land in the Corridor and offset areas seamlessly
- Deliver conservation objectives of the Program relevant to the WBCC, Jaramlee, West Macgregor and Wallaroo Rd offset areas
- Develop, maintain, have approved, and deliver the Reserve Management Plan and the management plans relevant to offset areas
- Annually report performance against the RMP
- Establish the Trust (money into the Trust must be spent in accordance with its purpose)
- Seek deductible-gift-recipient status for the Trust

The principal purpose of the EMT will be to deliver protection and management of the West Belconnen Conservation Corridor and offset areas. In pursuit of this purpose, the EMT shall:

- restore, regenerate and manage the natural environment in the West Belconnen Conservation Corridor and offset areas;
- implement the RMP for the West Belconnen Conservation Corridor and offset areas;
- provide education and information related to the natural environment in the ACT and surrounding regions;
- engage volunteers in natural environment restoration, regeneration, investigation and monitoring activities in the Murrumbidgee Conservation Corridor and offset areas;
- innovation to improve the understanding, restoration, regeneration, management and promotion of the natural environment in the Murrumbidgee Conservation Corridor and offset areas;
- provide recreation, education and eco-tourism initiatives that help connect the community to the natural environment and inspire them to care for it;
- support broader regional initiatives that will have a positive impact on the biodiversity and cultural values of the Murrumbidgee Conservation Corridor and offset areas; and
- manage activities that have potential for environmental impacts (including recreation) consistent with environmental protection objectives.

5.3 Avoidance and Mitigation Strategies

This section outlines the overarching avoidance and mitigation strategies that have been incorporated into the Program. These strategies are discussed in general here and where they apply to specific MNES in Sections 4.1, 4.2 & 4.3.

5.3.1 West Belconnen Conservation Corridor Reserve Management Plan

The EMT will be responsible for the development, effective implementation, and the ongoing review of the West Belconnen Conservation Corridor (WBCC) Reserve Management Plan (RMP). Details of the EMT structure and funding for the WBCC are outlined in section 0.

The primary role of the WBCC is to deliver the conservation outcomes of the Program, including avoidance and offsets for MNES. The primary strategy is to protect the natural environmental and heritage values within and adjacent to the riparian corridors by limiting development within these areas to that which is compatible with the conservation objectives. This is particularly important for protecting the pink-tailed worm-lizard population and box gum woodland patches.

This primary aim is integrated with the development goals of the Program that intend to produce a sustainable, integrated, and collaborative community (Roberts Day, 2014). The proximity of the WBCC to the residential area of west Belconnen creates the opportunity for these values to improve the overall amenity and vitality of the community.

The EMT will operate in accord with a "reserve management plan" that will be prepared in accord with part 10.4 of the (ACT) Planning and Development Act 1997 (and pursuant to part 8.3 of the Nature Conservation Act). The plan will cover all of the land under the control of the EMT including the conservation corridor, the existing Jarramlee and Macgregor offset areas and the Lot 2 Wallaroo Road offset area. The preparation of such a plan is a statutory requirement in the ACT as the land will be defined as "public land" under the Territory Plan. The terms of the EMT deed will require that a similar process be followed for NSW land. Incorporation of the Jarramlee and West Macgregor reserves into a new combined offset area will necessitate an amendment to the existing Jarramlee and Macgregor offset agreements. Provision for varying these agreements is available under Section 143 of the EPBC Act.

The RMP must be prepared in consultation with the public, the ACT Planning Authority, and the Conservator of Flora and Fauna, NSW OEH, and Yass valley Shire Council. It must be periodically updated as required. A maximum period between reviews of 10 years is specified in the legislation, a five yearly review is recommended.

The ACT component of the plan will be subject to the approval of the ACT Minister for the Environment and Conservator.

The NSW component of the plan will require the endorsement of the ACT Conservator of Flora and Fauna who will consult with the NSW OEH.

The reserve management plan will include, but will not be limited to:

- Measures for the conservation and enhancement of MNES including but not limited to:
  - Measures regarding the fragmentation of habitat areas
  - Weed management
  - Stock management
  - Management arrangements for walking, cycling, fishing, swimming and boating
  - Feral animal control including the imposition of a cat containment policy in the entire West Belconnen development area and prohibitions on off-leash dogs in the Conservation corridor.
  - Rock and firewood collection to be prohibited, educational signage to be installed
  - Horses will not be permitted within the reserve.
- Bushfire management measures to protect the conservation values of the corridor; note that fire management within the corridor is not intended to

provide protection for urban areas. Fire protection measures for urban areas will be provided in an asset protection zone external to the conservation corridor.

- Indicative monitoring program for:
  - All MNES affected by the Program,
  - MNES not affected by the program but which are listed at the time of endorsement of the program (including the small purple pea, Tarengo leek orchid and hoary sunray), and MNES not listed which may be listed in the future, to ensure that appropriate measures will be incorporated in the management plan. If a significant impact is anticipated the impact will be avoided if possible otherwise mitigation measures based on scientific advice will be incorporated in the RMP. Residual impacts following mitigation will be offset in accord with EPBC Act offset policies.
- reporting requirements and frequency for:
  - standard activities including monitoring, financial performance, measured outcomes;
  - reporting requirements for unanticipated or unapproved incidents.
- process for review, improvement, approval and incorporation of new procedures within an adaptive management framework;
- Guidelines and protocols for the construction of infrastructure, for education, recreation, tourism and other activities within the conservation corridor and offset areas.
- Protocols for visitor management

In regard to cat containment across the project area, the ACT component of the development will be a cat containment area where the provisions of the *Domestic Animals Act* relating to cat containment apply.

This Program will also impose cat containment within the NSW portion of the development. However there is currently no equivalent to the ACT *Domestic Animals Act.* The NSW Natural Resources Commission highlighted in its "Shared *Problem, Shared Solution: Pest Animal Management Review "(2016)* report to the Premier of NSW (August 2016) that the use of these mechanisms (such as planning agreements and/or conditions attached to development consents, to either impose controls or prohibit the ownership of domestic cats) to achieve control is unwieldly, difficult to implement and a barrier to adoption.

The NSW Natural Resources Commission submitted the above report to the NSW Premier in August 2016 with a recommendation that the NSW Government should amend the *NSW Companion Animals Act 1998* to enable local governments to declare and enforce cat confinement areas. If this occurred cat containment could easily be achieved on the Parkwood peninsula and provide greater opportunities to link with other landscape conservation measures to protect native wildlife. We understand that the NSW Government is still to consider the Natural Resources Commissions report and release their response.

Urban development within the NSW portion of the site is not programed to occur until after 2032. It is therefore realistic to expect the NSW Government will introduce legislative amendments to enable local governments to declare and enforce cat confinement areas prior to the commencement of residential development on the Parkwood peninsula. In the unlikely absence of specific legislation to declare and enforce cat confinement areas in NSW, environmental planning laws, such as planning agreements and/or conditions attached to development consents, will be used to impose controls on the ownership of domestic cats.

The reserve management plan will be subject to periodic review and re-approval at five yearly intervals.

The RMP will meet Commonwealth, ACT, and NSW legislative requirements in a cross-border and cohesive framework.

Implementation of the WBCC RMP will be staged to coincide with the urban development. The first stage will target core management operations, basic visitor infrastructure, and aim to establish the importance of the conservation principles to the community. It will be operational prior to the first residents moving in so that strategies may form a part of the community from the outset, and protect values from early visitor access (TRC Tourism, 2015b).

A draft WBCC Management Plan (TRC Tourism, 2015a) has been prepared for consideration, finalisation and adoption by the EMT immediately on the establishment of the EMT. The Plan prioritises the numerous environmental commitments of this program with cultural, recreational, and amenity values present within the WBCC (refer to Section 3.6). In general this will require the protection of the MNES values and broader natural values (e.g. habitat and species diversity, connectivity, and ecosystem function) whilst permitting certain recreational activities (e.g. walking, cycling, fishing, swimming, boating). Cultural integration, active learning, and community awareness initiatives will also be promoted and will link with other community spaces within the development (TRC Tourism, 2015b; TRC Tourism, 2015a)

These activities and the infrastructure associated with them will create impacts within the WBCC as discussed in this program report (Section 4.0). These will be addressed by the EMT and through the implementation and review of the RMP. In this way the management of the WBCC also acts as an avoidance and mitigation strategy for ongoing and potential future impacts.

Management strategies and principles that will be included in the RMP are:

- Identification of management zones so that direct impacts to MNES and their habitats do not occur. This includes the development of visitor hubs which will form the centre of access networks.
- Mechanisms (such as stakeholder engagement) that allow for the integrated consideration of all values.
- Consultation and collaboration with community, government, and expert stakeholders.
- Utilisation of existing infrastructure and resources, including knowledge and experience of existing conservation and land managers;
- Compliance with legislative requirements.
- An adaptive management process based on a monitoring regime that will address cumulative impacts and changing knowledge frameworks in future planning and management actions.

5.3.2 Construction Environment Management Plans

CEMPs are implemented to avoid and mitigate impacts that may occur throughout the construction phase of the Program. They will specify regulations for practices such as erosion and sediment control, clearing procedures, boundary identification, rehabilitation activities, and monitoring and reporting requirements.

In addition to the specific requirements set out in the following sections and discussed in Section 4.0 (sections 4.1.1.2, 4.2.1.2, 4.2.2.2, 4.2.3.3, 4.2.4.2, & 4.3.1.2) for impacted MNES, CEMPs implemented under the Program must ensure that the following are implemented:

- waste management procedures;
- worker and public health and safety policies;
- traffic and access controls;
- monitoring and compliance strategies;
- appropriate surface remediation post-construction; and
- buffer zones around sensitive values.

The CEMPs will be prepared in accordance with Government guidelines in addition to any specific requirements of the WBCC RMP for mitigation of indirect impacts from adjacent development. CEMPs will be prepared prior to construction commencing and be maintained until after construction and remediation activities have been finalised.

5.3.3 Water Sensitive Urban Design

The change in surface run-off that will occur as a result of the Program will need to be managed so that it will not result in unacceptable changes to the hydrology within surrounding riparian corridors. This is necessary not only for environmental health in general but also in order to avoid potential impacts to MNES including threatened fish species that occur in the Murrumbidgee and lower reaches of Ginninderra Creek below the falls, and to migratory birds.

In the ACT, stormwater management is subject to two separate codes:

- the 'Water Use and Catchment General Code' (ACT Government, 2009b); and
- the 'Waterways Water Sensitive Urban Design General Code' (ACT Government, 2009c).

The purpose of the 'Water Use and Catchment Code' is to identify the environmental values and permitted water uses of ACT waterways, and note criteria for water quality and streamflow that will protect these uses and values.

The purpose of the 'Waterways Water Sensitive Urban Design General Code' is to implement the principles of WSUD, so that the water cycle may be integrated into the urban development process.

A number of water-sensitive urban design guides are available through NSW Government agencies and where appropriate these will be applied to land development in the Yass Valley Shire.

WSUD within the Program includes a broad range of measures that aim to:

- reduce reliance on the town water supply system;
- optimise the opportunities for the use of stormwater and reuse of wastewater;

- maintain the export of stormwater run-off and associated pollutants to pre-development levels or better;
- work within existing natural ephemeral drainage lines;
- avoid MNES habitat and significant trees;
- minimise the take of developable land, development costs, and affects to existing infrastructure;
- consolidate the number of ponds and infrastructure required;
- consider maintenance requirements; and
- fit within the urban open space system of the Master Plan (Aecom, 2014).

Key components that could potentially be incorporated in the stormwater system include a network of bio-retention swales, wetlands, and basins that will capture, cleanse, recycle, and infiltrate water on-site, before discharging environmental flows into the Murrumbidgee River and Ginninderra Creek. Rainwater collected at households can be harvested for household use and will then be used for passive street scaping. Water quality of stormwater collected in wetlands and ponds will be improved by filtration through aquatic vegetation. A centralised harvesting and treatment scheme will supply recycled stormwater throughout the residential areas, with potential for off-site irrigation also. Any excess stormwater will be held in detention ponds and discharged at pre-development peak flows to the existing drainage lines.

Combinations of these measures, integrated into a system that will meet and exceed the regulatory requirements and which will contribute to the Green Star Rating for the Program are under investigation and will be subject to a triple bottom line evaluation to be conducted by specialist consultants Aither (Aecom, 2014).

5.3.4 Defined Process Strategy

This component of the Program seeks to define a process that will apply to future development within the Project Area; which will be implemented when either of the following occurs:

- Proposal to develop any area dominated by native grasses that is part of a larger patch of native grassland which includes high or moderate quality pink-tailed worm-lizard habitat as mapped by Osborne and Wong (2013). (Action 27)

- Additional servicing or infrastructure requirements within the WBCC that impact MNES beyond what is already described by the Program. (Action 28)

In these instances, the Defined Process will provide the Commonwealth with the confidence that impacts to MNES from actions outside of those specified in the Program will be consistently and appropriately assessed and managed. In achieving this outcome the relevant conservation advice, recovery plans, significant impact assessment guidelines and offset policy under the EPBC Act will be applied in order to ensure a consistent outcome for MNES across the implementation of the Program.

In summary, the Defined Process relating to MNES within the Project Area is as follows:

1. Where development within the Project Area triggers the need to implement the Defined Process Strategy, assess the impact of the proposed development using data collected from site-based, field verified surveys that are consistent with EPBC Guidelines.

2. Implement avoidance and mitigation measures to the greatest extent practicable through design.

3. Determine offset requirements for any residual impacts using the criteria outlined above and applied in assessment of the Program.

4. Identify an appropriate offset and establish according to the relevant State or Territory jurisdiction.

5. Prepare and implement an offset management plan either for incorporation into the WBCC management plan or as a stand-alone plan in the instance that the offset cannot be co-located in or adjoining the WBCC. Any management plan will include all aspects that apply to other MNES such as adaptive management and ensuring delivery of the offset and environmental values in perpetuity.

Any actions undertaken and offsets established using the Defined Process will be included in the Program's annual report. Any amendments to the Defined Process or offset assessment criteria will be managed through the adaptive management process and also reported annually.

As no impacts are currently known, the Defined Process Strategy is not subject to detailed assessment in this report. In lieu of this, two scenarios are described in Section 4.7 of the Strategic Assessment Report to demonstrate the application of the Defined Process.

The following two hypothetical examples are provided to demonstrate the application of the Defined Process Strategy:

- 'Scenario One' considers impacts to natural temperate grassland as a result of development within the Urban Development Area.

- 'Scenario Two' demonstrates the application of the Defined Process Strategy in the event that detailed design of infrastructure within the WBCC exceeds the impacts assessed in this report.

In each scenario, the design process will address feasible alternatives in terms of the key components of sustainability. This would adopt a triple bottom line approach to cost-benefit analysis triggered by a previously unquantified impact to any MNES. Considerations will include the cumulative effect of previous small scale impacts that have not been addressed through a targeted offset in addition to the current matter being considered. Specifically this will involve the following considerations (but not be limited to):

- Ecological benefit / cost for avoidance, including consideration of:
    - connectivity to other retained areas
    - relative condition of the vegetation

  - overall area / size of impacted patch; and
  - presence of other MNES or species of statutory conservation value in NSW or the ACT.
- Economic implications of avoidance, including consideration of:
  - ongoing cost of maintenance to conserve ecological benefits in perpetuity; and
  - cost implications of service provision and construction.
- Social aspects including consideration of:
  - practicality of protection of avoided area from uncontrolled access and other threats to biodiversity from unrestrained dogs and vehicles
  - impacts to urban connectivity; and
  - other potential social costs or benefits through opportunities for education, research, and monitoring.

Scenario One

Due to the revised listing criteria for natural temperate grassland, vegetation that meets the current definition of the CEEC has not been identified prior to the preparation of the Strategic Assessment; therefore, impacts have not been quantitatively assessed to the same level of detail as other MNES.

In this hypothetical scenario, a two hectare patch of pink-tailed worm lizard habitat within the urban development area has been identified within an area to be impacted. While this assessment report has considered the impacts to pink-tailed worm-lizard, due to natural temperate grassland also being generally coincident consideration of the impact to the grassland community is required. Due to this, the Defined Process will be applied to determine the significance of this impact and identify the need for and what represents an appropriate offset in the event that offsets are required.

Step 1 – Identify Extent and Quality of Affected Area

Targeted survey for natural temperate grassland be undertaken in accordance with criteria set out in the Commonwealth Conservation Advice (TSSC 2016), including consideration for survey timing and plot size and number. In addition, surveys will gather data sufficient for determining the quality of habitat using the criteria established in this report; and map the results at a refined scale.

The data provided by the surveys will then be used to assess the potential impacts of the Program on natural temperate grassland. The impact assessment will be undertaken in accordance with EPBC Policy with consideration for the Significant Impact Guidelines 1.1.

For this scenario, it is found through field survey that the area of natural temperate grassland is approximately 3.5 hectares and includes the entirety of the pink-tailed worm-lizard habitat.

Step 2 – Assess Relative Benefits of Avoidance

Once the extent and condition of the natural temperate grassland is known in the area to be affected, avoidance and mitigation measures will be considered for their practicality and cost effectiveness. At Step 2 the triple bottom line considerations identified above will be addressed in order to determine the most appropriate design response from a sustainability perspective.

For the purpose of this scenario, it has been determined that avoidance is impractical as a result of adverse social and economic impacts that cannot be balanced against the potential ecological benefits of avoiding the area of the community.

Mitigation measures consistent with those discussed in Section 4.3 of the Strategic Assessment Report will be incorporated into the preferred option to ensure that indirect impacts do not affect reserved areas, including MNES within the WBCC.

Step 3 – Assess Significance of Impact

As natural temperate grassland is a critically endangered ecological community, assessment against the Significant Impact Guidelines 1.1 determines that a significant impact would result from most instances. For the scenario, impact to 3.5 hectares is considered a significant impact; therefore, an offset is required.

Using the criteria set out in Section 5.2.4 of the Strategic Assessment Report, the quality of natural temperate grassland would need to be quantified.

Step 4 – Identification and Assessment of Suitable Offset

In order to consolidate the ecological benefits of the WBCC and in acknowledgement that the extent of the endangered ecological community is probably more extensive than the mapped habitat of pink-tailed worm-lizard, the first offset opportunity to be investigated are areas within the WBCC. Based on the ecological principles outlined in general for the Defined Process Strategy, areas of pink-tailed worm-lizard habitat will be targeted to identify natural temperate grassland. This will include addressing for each potential offset area, consideration of Steps 1-2 for the offset scenario as opposed to the development scenario.

Once identified and described in terms of its extent and habitat quality the potential offset area will be assessed against the criteria described in Section 5. The preferred offset will be the outcome that is consistent with the EPBC Act offset policy in meeting more than 90 percent of the required offset as a land-based offset.

Once identified, the WBCC RMP will be updated to designate the relevant area as also being an offset for natural temperate grassland. Management measures will be incorporated into the RMP to ensure appropriate actions including monitoring and reporting in accordance with the RMP framework are implemented.

In the event that no suitable areas are available within the WBCC, additional locations may be considered in order to meet the offset requirement. This should initially consider the Lot 2 Wallaroo Road offset site and then subsequently any other site with a preference for locations closer to the impact area.

Scenario 1 Outcome

The outcome for MNES under scenario one would include:

- loss of 3.5 hectares of natural temperate grassland
- dedication of an area of appropriate size and quality to be recognised as being an offset for natural temperate grassland; and

- consolidation of offset areas within the WBCC.

In most circumstances it is anticipated that pink-tailed worm-lizard habitat will also be natural temperate grassland. However, it is also anticipated that areas of natural temperate grassland will be more extensive than the lizard habitat.

As the offset outcome for each MNES is being considered under this strategic assessment concurrently and in recognition of the patchiness of the pink-tailed worm-lizard habitat, a good environmental outcome would be for the concurrent development of offsets for the lizard and the grassland in the WBCC. This would result in a more coherent offset strategy and conservation area of greater overall ecological value.

This outcome is considered appropriate and consistent with the EPBC Act offset policy.

Scenario Two

While the Program considers the river access road and sewer construction in addition to a range of recreational facilities within the WBCC, this scenario considers the potential for a previously unidentified infrastructure requirement within the WBCC, which results in an impact to any MNES. This scenario only applies to development activities associated with and as described by the Program or as necessary to implement the Program. Ancillary and third party infrastructure is not considered part of the Strategic Assessment and would not be consistent with actions associated with implementing the Program.

For the purpose of this hypothetical scenario, the need for a sewer rising main from a recreational facility which forms part of the Program is identified as being necessary to give effect to the Master Plan. As this has not been a specifically identified component of the master plan and implementation would affect areas of MNES within the WBCC, this triggers the need to apply the Defined Process Strategy.

Approach

This approach would initially consider the Strategic Design Principles (Section 1.2.3 of the Strategic Assessment Report); however, in the event that those principles cannot be complied with the second scenario would need to apply Steps 1-3 of the Defined Process (discussed above). This would identify the impact, assess the relative impact, and determine the need for an offset.

The likely outcome in this scenario if the Strategic Design Principles cannot be satisfied is that any impacts to MNES within the WBCC from activities not addressed by the Program would result in an impact to an existing offset. In this case the infrastructure must either be reconsidered through an alternative design solution that does not compromise on the ecological outcomes or be abandoned.

Where an existing offset is not impacted, the offset identification process generally as described by Step 4 would be implemented.

For the purpose of this scenario, an existing offset would include:

- any area of pink-tailed worm-lizard habitat within the WBCC as mapped by Osborne and Wong (2013)
- any part of the Jarramlee or West Macgregor offset areas
- any part of the golden sun moth habitat dedicated as offset on Lot 2 Wallaroo Road; or

- any area of natural temperate grassland already dedicated as offset through implementation of the Defined Process Strategy.

In the event that an existing offset will be affected, the action cannot be considered through the Defined Process Strategy and must be referred to the Minister for the Environment under Part 3 of the EPBC Act.

Outcome for Scenario 2

Under Scenario Two, outcomes are guided by the intent of the offset policy to establish offsets in perpetuity and drive to solutions that do not compromise the perceived strategic benefits of implementing the Program as it has been considered in this assessment. As an impact to an offset introduces a greater deal of complexity to an assessment, it is considered appropriate that should this eventuality arise, it is appropriate that it be subject to additional public scrutiny and assessment by DoEE through the referral process.

6.0 Program timeframes

6.1 Environmental Management Trust

The EMT will be established as a legal entity as described in section 5.2 above as a first step in the implementation of the program, and prior to any construction. It is envisaged that this will occur immediately following the rezoning of the land. On its establishment the EMT will take responsibility for the ongoing preparation and periodic review of the reserve management plan and for administration and management of the conservation lands (including the conservation corridor and offset reserves) in perpetuity.

6.2 Reserve management plan

The proponent will prepare a draft reserve management plan in consultation with relevant agencies and make this available to the EMT within 2 years for adoption as the initial reserve management plan immediately on its establishment. This will be subject to periodic review as discussed in section 7.0. The reserve management plan, with periodic updates, will continue in perpetuity.

7.0 Evaluation and Monitoring

7.1 Monitoring and Reporting Program Outcomes

In order to measure the efficacy of the Program, it is necessary to establish a framework for monitoring and reporting on the process of implementation of each of the main actions and the results or outcomes, against a set of relevant biodiversity measures. This framework will encompass each of the three MNES for which actions are proposed to be taken under the program as a direct consequence of the development:

- Yellow Box Red Gum Grassy Woodland
- Pink tailed worm lizard
- Golden sun moth

The program will also incorporate the programs previously approved for the Jarramlee and Macgregor offset areas. Consequently monitoring will also be required for a fourth MNES that, whilst not affected by the West Belconnen project, is included in these two reserves:

- Natural temperate grassland

There are four main elements to the reporting framework:

1) A public annual report including but not limited to:
    - Commentary on the progress of implementation of each of the actions;
    - Commentary on the conservation outcomes, referenced against the outcomes listed in Table 4, achieved in the previous year, assessed against relevant biodiversity measures;
    - Commentary on governance and financial matters
2) A review of the Program every five years (measured from the date of endorsement of the program) for the life of the Program to assess progress in achieving the objectives of the Program and ensuring investments remain targeted to the affected matters in the most effective manner.
3) An independent audit every five years (measured from the date of endorsement of the Plan) for the period of the Program.

The monitoring and reporting process will provide the basis for the five yearly revision of the reserve management plan discussed at section 5.3.1.

7.1.1 Annual Report

An annual report highlighting the implementation of the actions and relevant conservation outcomes achieved in the reporting period (financial year) will be published by the Proponent and provided to DoE. This report will be completed within two (2) months of the end of the reporting period and will be made publicly available on the internet. The report will address objectives described in the Program with respect to MNES and provide an update on the status of investments, project success or failure.

The key aspects of the annual report will be to provide an understanding where relevant of the:

- report on commitments for conservation actions identified in the Program and EMT reserve management plan;
- progress in meeting commitments for the affected MNES;
- lessons learnt from project implementation and opportunities for improvement;
- changes with respect to management and resourcing of the proponent;
- summary of findings from monitoring activity associated with implementing the Plan;
- findings of any internal reviews into implementation and management of the Plan;
- amount of investment in each of the direct and indirect actions; and
- innovations or design adaptations that might have resulted from the design review and assessment process and how these will be implemented through the adaptive management process described in 7.2.

This report will be published on the internet for public information, and in order to meet the criteria for suitable offsets under the EPBC Act offset policy, in particular ensuring transparent reporting including having performance being readily measured, monitored, reviewed and enforced.

7.1.2 Five yearly Program Review Report

The second element in the evaluation framework for the Program will be a concurrent review of both the relevant biodiversity measures and the RMP every five years. The purpose of the review will be to summarise progress over the preceding five years in achieving the conservation gains as defined by the Program, referenced against the outcomes at Table 4. This will also allow for review of the specific actions in light of knowledge gained through implementation of the Program and consider consistency with action plans, policy and legislation by allowing for flexibility in the event of statutory review of these guiding documents. The Program Review Report will be submitted within six months of the end of the reporting period (five years from endorsement of the Plan). The preparation of the Program Review Report will follow the preparation and submission of the Annual Report for that year to allow incorporation of its findings into the Plan review.

Following consultation with the NSW Office of Environment and Heritage the report will be submitted to the ACT Conservator of Flora and Fauna for endorsement; in considering whether or not to endorse the report the Conservator will have regard to the views of the NSW Office of Environment and Heritage. The Conservator may require amendments to the report or additional information prior to providing an endorsement of the report. The finalised report will be provided to DoE and also be made publically available.

7.1.3 Independent Audit

The final element in the evaluation framework for the Program will be an independent audit of the Program every five years for the life of the Program. The purpose of the audit is to independently verify the outcomes being reported in the Annual and Program review reports.

The audit will be conducted by a person with appropriate scientific qualifications who is independent of the project. The auditor will be appointed by the EMT with advice from the ACT Conservator of Flora and Fauna and relevant NSW agencies. The audit will be completed within a timeframe that enables the results to inform the Program Review Report.

7.1.4 Summary of Monitoring and Reporting Commitments

The following table summarises the proposed monitoring and reporting commitments. In all instances the 'reporting period' commences from the endorsement of the plan.

Table 5: Monitoring & reporting commitments

Monitoring and reporting Commitments related to: • Yellow Box Red Gum Grassy Woodland • Pink-Tail Worm-Lizard • Golden Sun Moth • Natural Temperate Grassland	
Public annual report	
Purpose and content	To highlight the implementation of actions and relevant conservation outcomes achieved in the prior financial year. To contain:- • Reports on commitments for conservation actions identified in the Program and WBCC reserve management plan • Progress in meeting commitments for the affected MNES • Lessons learned from project implementation and opportunities for improvement • Changes with respect to management and resourcing of the proponent • Summary findings from monitoring activity associated with implementing the Plan • Findings of any internal reviews into implementation and management of the Plan • Amount of investment in each of the direct and indirect actions • Innovations or design adaptations that might have resulted from the design review and assessment process and how these will be implemented through the adaptive management process.
Timing	Annually, within two months of the end of the reporting period
Responsibility	Riverview Group
Consultation and endorsement	Nil
Distribution	Provided to DoE To be made publically available on the internet
Review of program every five years	
Purpose and content	To summarise progress over the preceding five years in achieving conservation gains, as defined by the Program
Timing	Every five years, to be prepared within six months of the end of the reporting period (five years from the endorsement of the plan) To be prepared following the preparation of the Annual Report for the year preceding, to allow its findings to be incorporated into the review.