ACT Government

Golden Sun Moth Habitat Improvement Plan

A plan for the management, monitoring and improvement of Golden Sun Moth *Synemon plana* habitat in the Gungahlin Strategic Assessment area

Plan Implementation Team for the Gungahlin Strategic Assessment Biodiversity Plan

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Version control

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0.1	5 June 2014	Initial Draft	Michael Mulvaney, Conservation Planning and Research, Environment and Planning Directorate
1.0	21 October 2014	Submission to Commonwealth Department of the Environment	Dan Stewart/Deputy Director-General, Economic Development Directorate
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List of Abbreviations

ACT	Australian Capital Territory
CEMP	Construction Environment Management Plan (interchangeable with EMP)
CPR	Conservation Planning and Research unit (under EPD)
CMTEDD	Chief Minister, Treasury and Economic Development Directorate
DoE	Department of the Environment (Commonwealth) previously SEWPaC
ED	Economic Development (Part of CMTEDD)
EDP	Estate Development Plan
EIS	Environmental Impact Statement
EP Act	*Environment Protection Act 1997* (ACT)
EPA	Environment Protection Agency
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Cwth)
EPIP Act EMP	*Environment Protection (Impact of Proposals) Act 1974* (Cwth, repealed) Environment Management Plan (interchangeable with CEMP)
ESA	Emergency Services Authority
EPD	Environment and Planning Directorate (Previously Environment and Sustainable Development Directorate)
LDA	Land Development Agency (under CMTEDD)
MNES	Matters of National Environmental Significance
NC Act	*Nature Conservation Act 1980* (ACT)
NCA	National Capital Authority
NCP	National Capital Plan
NSW	New South Wales
PA	Preliminary Assessment
PALM Act	*Australian Capital Territory (Planning and Land Management) Act 1988* (Cwth)
PD Act	*Planning and Development Act 2007* (ACT)
PIT	Plan Implementation Team
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities (now Commonwealth Department of the Environment)
TaMS	Territory and Municipal Services Directorate

General Introduction

The Gungahlin Strategic Assessment Biodiversity Plan (the Plan) commits the ACT Government to maintain and improve, Matters of National Environmental Significance (MNES) within set aside conservation areas. The relevant matters are:

- White Box - Yellow Box – Blakely's Red Gum Grassy Woodland and Derived Native Grassland (Box Gum Woodland),
- Golden Sun Moth, *Synemon plana* (GSM),
- Superb Parrot *Polytelis swainsonii* and
- Striped Legless Lizard, *Delma impar* (SLL).

The basic measures within the Plan to maintain and improve habitat include:

- Reservation of lands that support habitat for MNES that have previously been identified for urban purposes;
- increased investment in habitat enhancement beyond the minimum level required under the Territory's statutory obligation; and
- increased investment in research targeted at the affected MNES and guided by action planning objectives.

Habitat Improvement plans have been prepared for each of the MNES. These plans:

- describe the current extent, condition and or population size of a particular value;
- outline what actions will be taken to seek improvement in condition, extent or population size;
- detail how improvements will be measured, monitored and reported;
- detail the research focus areas;
- contain commitments to adapt management depending on research results; and
- outline potential remedial actions should monitoring indicate a decline in a MNES matter

Over much of the offset areas, there is an overlap in the distribution of MNES values. Management favouring one particular value may not always be compatible with actions that enhance another value. For example, the condition of Box Gum Woodland can be improved by encouraging regeneration of sapling and tree growth, but the shading that would result from this regrowth may reduce habitat suitable for the GSM or Striped Legless Lizard, which are essentially grassland species. Therefore the plans define where a matter of interest will be the primary focus of improvement actions and where they will be a secondary consideration.

While the plans outline and list the management actions that will be undertaken for particular MNES values, details on how management actions will be implemented will be included within Offset Management Plans that are required as part of the Strategic Assessment approval. A purpose of the habitat improvement plans is to guide and inform the preparation of the area specific management plans.

Conservation outcomes for GSM from the Plan

- Persistence of a viable local population of GSM in northern ACT.
- No net reduction over the life of the Plan in areas occupied by GSM for retained and reserved populations.
- Management of secondary grassland where the species occurs within a matrix of regenerating box gum woodland.
- Encouragement of golden sun moth colonisation of areas along the proposed unreserved urban fringe where appropriate and practicable.

Outcome Commitments

- Prior to the construction of Throsby, commence management of additional 300 hectares to the Mulligan's Flat – Goorooyarroo nature reserve complex. Land to be excised from the future urban area of Throsby and the 'Kenny Broadacre' area and managed for the protection of MNES (see Figure 1).
- Within 2 years of approval of the Biodiversity Plan, commence management of a nature reserve in Kinlyside (201 hectares/previously zoned Residential land).
- Prior to the construction of Taylor, commence management of additional 120 hectares to the north-western Hills, Ridges and buffers zone from the urban areas of Taylor and Jacka in addition to the entire area of the north Horse Park Broadacre area (see Figure 1).
- 140 ha targeted for GSM habitat improvement (see Figure 5).
- Research into the potential compatibility of bushfire hazard management requirements with habitat requirements of the species.
- Research GSM habitat requirements that may include:
    - Research into translocation of GSMs or
    - Fragmentation and proximity to urban areas, including fuel management standards and treatments.
- Research control programs of exotic species (those encouraged by urban development which aren't usually a focus of control) such as of European wasp (which may prey on GSM), Common Myna, Noisy Miner and stray cats (through cat containment policy).

Current Extent of Habitat

The GSM is known from 73 sites within the ACT with a total habitat area of around 1800 hectares. This equates to about 12% of the known national habitat and about a third of the known sites (Mulvaney 2012). The extent of habitat across the Gungahlin Strategic Assessment area has been determined through targeted surveys for GSM, and collation of all known sighting locations. These surveys are described in the *Assessment Report (*Umwelt 2013*).* Where a moth is observed it is assumed that all similar vegetation within 100m (and sometimes further) of the location is habitat of this species.

Survey's were undertaken across Gungahlin during the spring summer of 2009/10, 2010/11 and 2011/ 2012. In some areas multiple surveys occurred, while previous surveys had also occurred within the existing Gungahlin grassland reserves.

This effort resulted in 32 sites being located and a total habitat area of 812ha. As shown in Table 1, the habitat at Gungahlin consists of nearly half of the total ACT moth habitat area, but supports only around 10% of the moth population. This estimate is based on totalling the maximum number of flying adult moths seen over a survey period at a particular site, and thus provides a means of gauging relative population size, but not a total population. Females and larvae are not counted at all, while moths will fly outside of the survey period. Nevertheless, it can be said that Gungahlin has relatively large habitat areas that appear to support relatively low density of moths.

Table 1 Distribution of GSM sites, habitat and moth numbers amongst ACT valleys

District	No of sites	Habitat area (ha)	%of habitat	Max no of moths	% of moths
Belconnen	9	355	19.7	3083	27
Central Canberra	25	110	6.1	1484	13
Gungahlin	32	812	45.0	991	9
Jerrabomberra	7	60	3.3	502	4

Majura	5	466	25.8	5444	47

As part of the Gungahlin Strategic Assessment and as approved by the DoE, up to 180 ha of habitat can be impacted as part of urban development in Moncrieff, Taylor, Jacka, Kenny and Throsby, while 148 ha will be added to the reserve network at Throsby North (114 ha), Throsby East (10 ha) and Kinlyside (24 ha). In total 560 ha of known habitat is reserved or will be added to the reserve, across Gungahlin. Large areas of known habitat are reserved within Mulligan's Flat (115 ha including the East Bonner addition) and Goorooyarroo (150 ha) which are within the bounds of the Strategic Assessment, and also at Crace (65ha) and Mulanggari (82ha) that lie outside of the area of interest. There is also a small area of habitat at Gungaderra Nature Reserve (see Figure 1). 81% of the GSM habitat being impacted in Gungahlin occurs within exotic pasture (not native grasslands)

The Plan requires no net reduction in the known extent of retained (the 148 ha within the offset areas) and reserved populations (the 265ha within Mulligan's Flat and Goorooyarroo). Hence within these conservation areas at least 413 ha of GSM habitat must be maintained. It is also required that actions are taken to improve GSM habitat in up to 140ha.

A conservative approach has been applied to the amount of impact and conservation land applicable to the GSM. It is unknown how long moth larvae may exist, 2-3 years has been suggested, so the number of moths observed in a flight season is simply one annual cohort of a larger (and possibly more widespread) resident population (Gibson and New 2006). Within the ACT, the 2010/11 season was about average in relation to the number of moths observed at benchmark locations such as York Park and Canberra Airport, while the 2011/2012 season was cool and wet, with only relatively low levels of emergence. In relation to retained and reserved areas, Kinlyside was surveyed in 2010/11 and 2011/12, Throsby North in 2010/11, Mulligan's Flat in 2011/12, Throsby East 2010/11 and part area of the area again in 2011/2012 and Goorooyarroo in 2011/12.

The Draft National Recovery Plan (NSW Office of Environment and Heritage 2012) infers that GSMs prefer native grasslands or derived grasslands in which *Austrodanthonia* is a common element. GSM are also considered to mainly occur on slightly sloping sites (at 3° or less) and that are exposed to full sun. Mulvaney (2012) mapped open areas, with a slight slope supporting native *Austrodanthonia/Austrostipa* grassland in order to identify likely potential habitat, within the ACT. Known and potential habitat within the area of interest is shown in Figure 2. The mapping suggests that there is an additional 24.5 ha of potential habitat at North Throsby, 25.5 ha at East Throsby and 17.5 ha at Kinlyside to what was mapped in the Strategic Assessment.

Habitat condition

Umwelt (2013) recorded 137 ha of low-moderate quality habitat and 11 ha of low quality habitat within the Throsby and Kinlyside offset area. Their rating of habitat condition derived from combining a landscape score (habitat that is isolated, poorly connected or well connected) with a habitat quality score (exotic understorey, exotic/native understorey or native understorey). The dedication of the offset areas as a reserve does much to improve the landscape score (and hence overall habitat score) of habitat both within and adjoining the development avoidance or offset areas.

Ecological (2012 + 2013) mapped the quality of habitat across Kinlyside, Throsby and Mulligan's Flat according to the following classification:

> ***Low Quality***: characterised by a low proportion of *Austrodanthonia spp.* and *Austrostipa spp.* (<20%), in comparison to other species. These areas are often dominated by exotic species or native species which do not provide potential habitat;
> ***Low-Moderate Quality***: characterised by patchy habitat quality. They have moderate levels of weed invasion and the proportion of suitable native species tends to vary (20-50%) at a small scale;
> ***Moderate Quality***: characterised by habitat of consistent quality, with some weed invasion (both annuals and perennials). The percentage cover of suitable native species tends to be up to 70%.
> ***Moderate-High Quality***: characterised by habitat which varies in quality between high and moderate and may include some areas of weed invasion. These areas are characterised by around 80% coverage of suitable native species;
> ***High Quality***: consistently high quality habitat with greater than 80% dominance of suitable native species with a particularly high dominance of *Austrodanthonia spp.* These areas may still include some areas of weed invasion; however, exotic species compose less than 10% of the floral biodiversity;

The habitat assessment done by Ecological occurred at a broad scale and they cautioned that is indicative of quality only. Their assessment of habitat in the Kinlyside and Mulligan's Flat – Throsby North and Throsby East areas are shown in Figure 2 and Figure 3. Most of the habitat within Mulligan's Flat was assessed as being in a high or moderate to high condition. Despite the GSM only having a restricted known occurrence in East Throsby, over half of this area was considered to be in a moderate to high habitat condition. Habitat quality in Throsby North was considered to mainly be in a moderate or low condition, with best quality areas being in the north-east and south-west of this offset area. The area where moths have been observed in Kinlyside was assessed as high or moderate –high quality.

Figure 1 Known GSM Habitat in Gungahlin

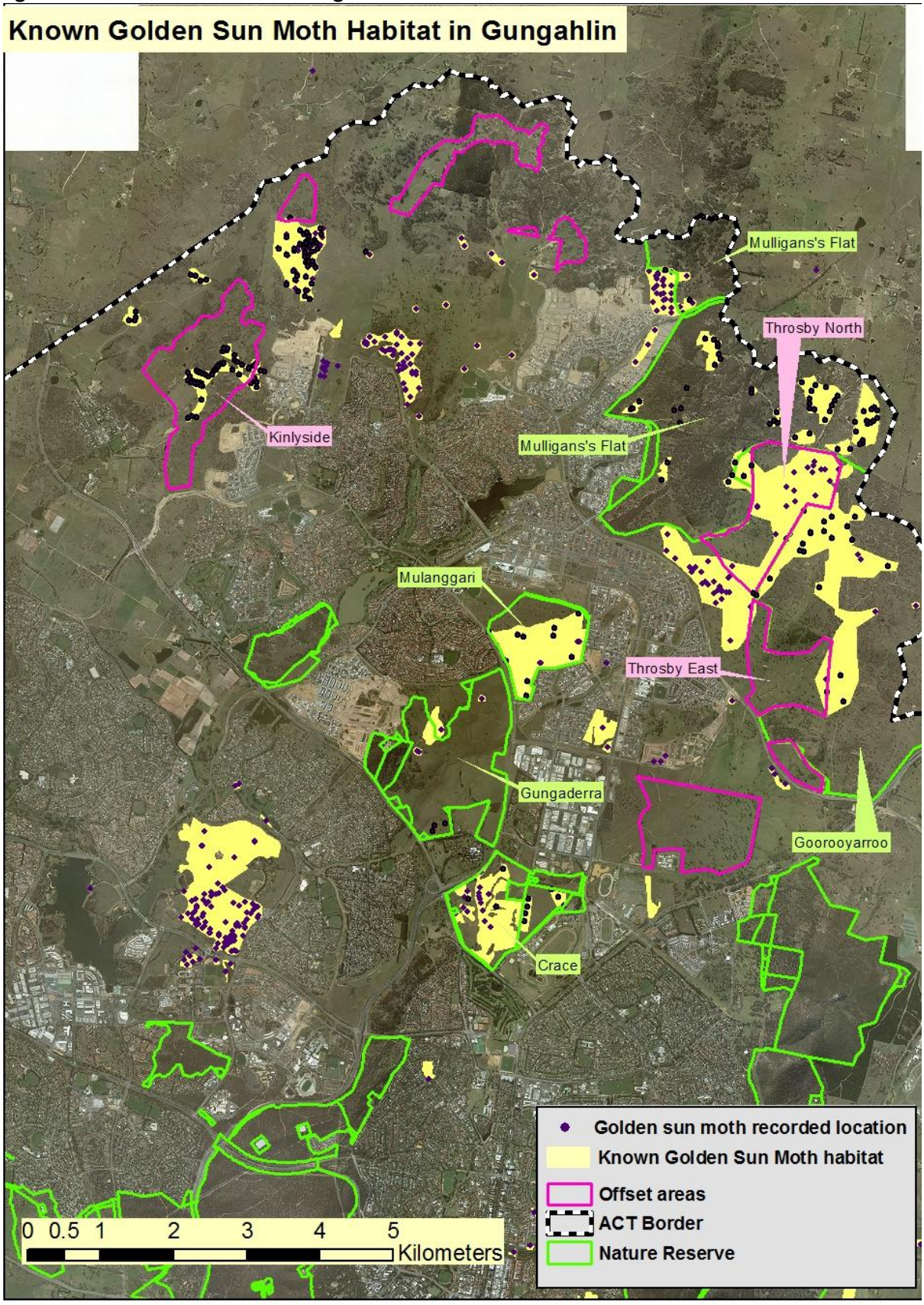
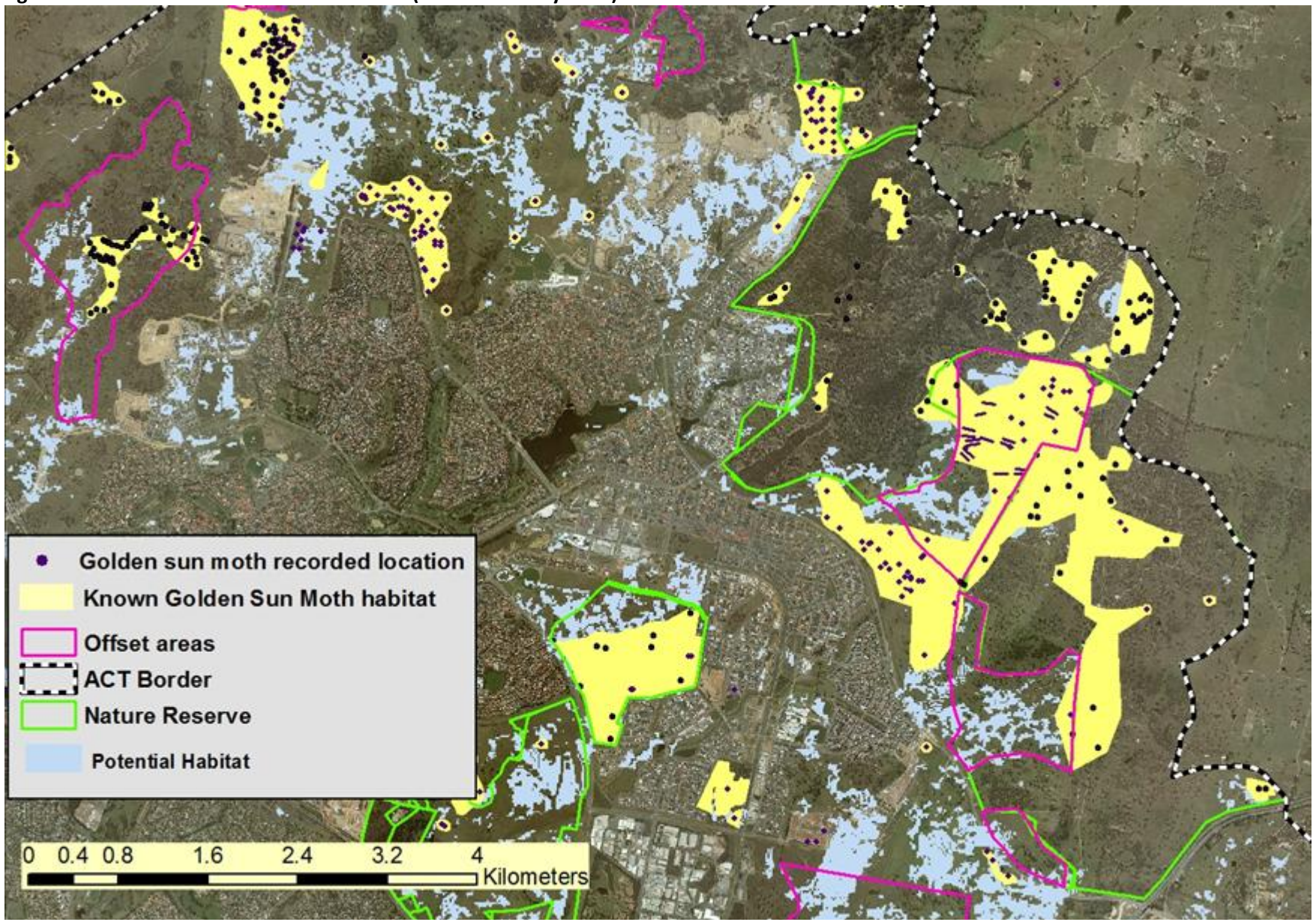


Figure 2 Potential Golden Sum Moth Habitat (After Mulvaney 2012).



Habitat condition and presence of C3 grasses

Adult GSMs lack functional mouthparts. Therefore species feeding behaviour is restricted to the larvae stages. Richter et al (2011) collected larvae from ACT and Victorian sites and undertook molecular and stable isotope analyses to determine the diet composition. The study found that GSM feeds on wallaby grasses (*Austrodanthonia species),* spear grasses (*Austrostip*a species), and Chilean needlegrass (*Nasella neesiana)*. These are all C3 species. GSM avoids C4 grasses including kangaroo grass (*Themeda australis),* hairy panic (*Panicum effusum),* redleg grass (*Bothrichloa macra)* and African lovegrass (*Eragrostis curvula).* It is possible that GSM feeds on other C3 grasses, not present at the particular collection sites. Larvae recovered from the roots of the Chilean needlegrass were larger than those feeding on the native grasses. Downey and Sea (2012) report that in the Ginninderra Creek area the highest larval densities were found under the introduced Chilean needle grass (*Nassella neesiana*) tussocks (5-8 individuals/m^2) and lowest under native speargrass (*Austrostipa bigeniculata*) tussocks (<2 individuals/m^2). The long term suitability of Chilean needle grass as habitat is uncertain, while the invasion of this exotic grass species has undesirable effects on other native animal and plant species. Chilean needle grass is only sparsely established within the retained and reserved areas and it will be controlled despite providing potential GSM habitat.

O'Dwyer and Attiwill (1999) studied 14 known sites of GSM, including eight in the ACT, and found that all sites had a greater than 40% cover of *Austrodanthonia* and had soils low in Phosphorus. Subsequent surveys have found moths in habitat with less than 10% *Austrodanthonia* cover (Brown and Tolsma 2010, Brown et al 2011, Gibson 2006). Precise cover rates are not available for all the ACT sites, but many have less than 40% *Austrodanthonia* coverage. Although GSM can exist in areas with low *Austrodanthonia* cover, within the ACT sites at which relatively large numbers of GSM have been recorded do tend to have a high *Austrodanthonia* cover. Of the nine sites at which over 200 moths have been recorded on a single day, *Austrodanthonia* is a dominant species, with a high percentage cover at eight of the sites. The only exception is West Macgregor where a large population is associated with Chilean Needle grass. Gibson (2006) also found that the highest densities of GSM on Craigieburn grassland reserve (Victoria) were in areas with high *Austrodanthonia* cover, while Brown et al (2012) found a positive relationship between the cover of wallaby grasses and the number of GSM sighted amongst 46 sites surveyed across the Victorian Volcanic Plains.

The current and future habitat quality within the Strategic Assessment area will be measured by the relative cover of native C3 grasses (particularly *Austrodanthonia)* as opposed to native C4 gasses, exotic grasses and herbs. Total cover as utilised by Ecological (2012 + 2013) will be avoided as the ability of males to find females appears to be increased when the female is displaying within inter tussock spaces, so that a 100% grass cover is likely to be detrimental to the species.

Figure 3 GSM Habitat condition

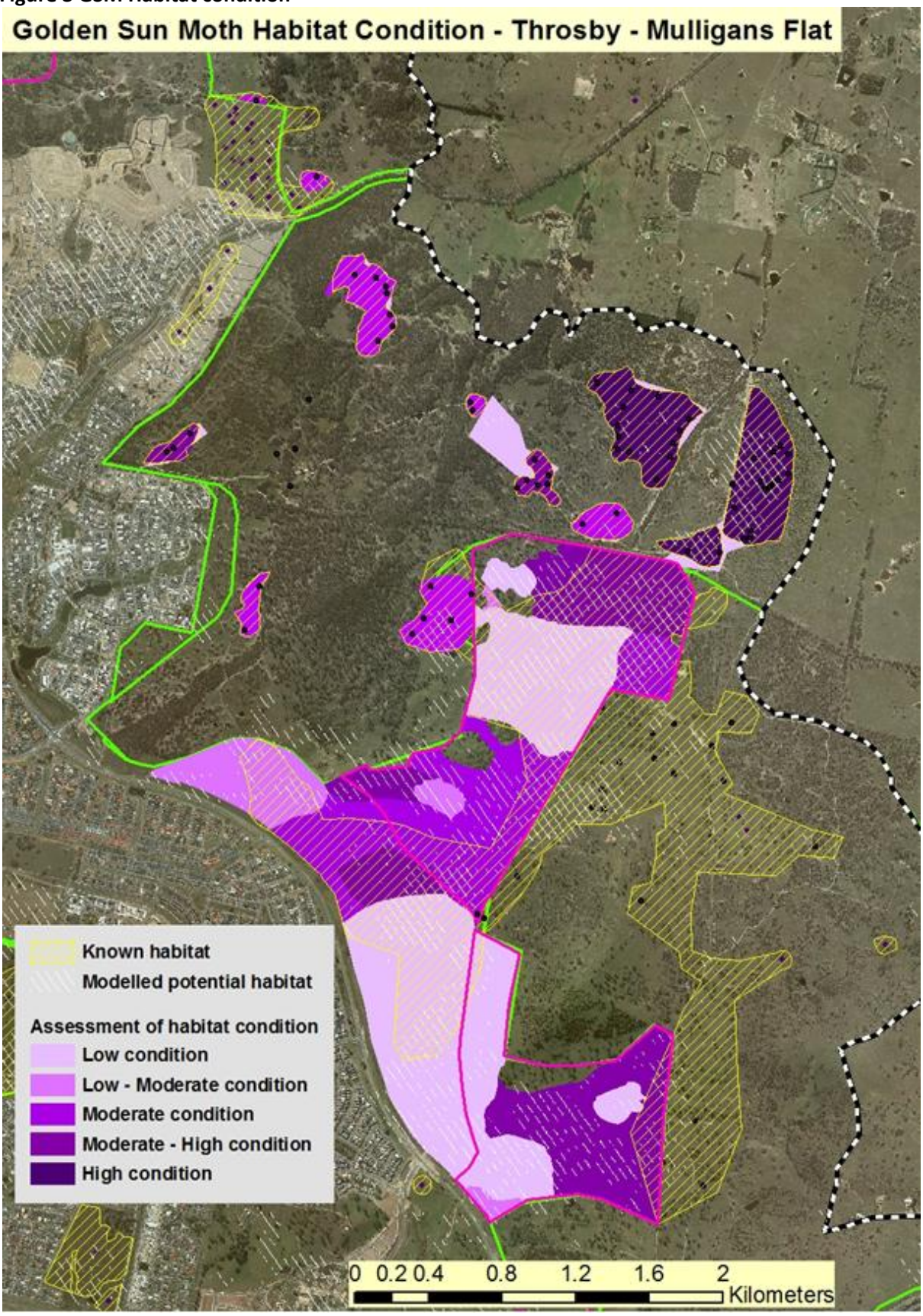
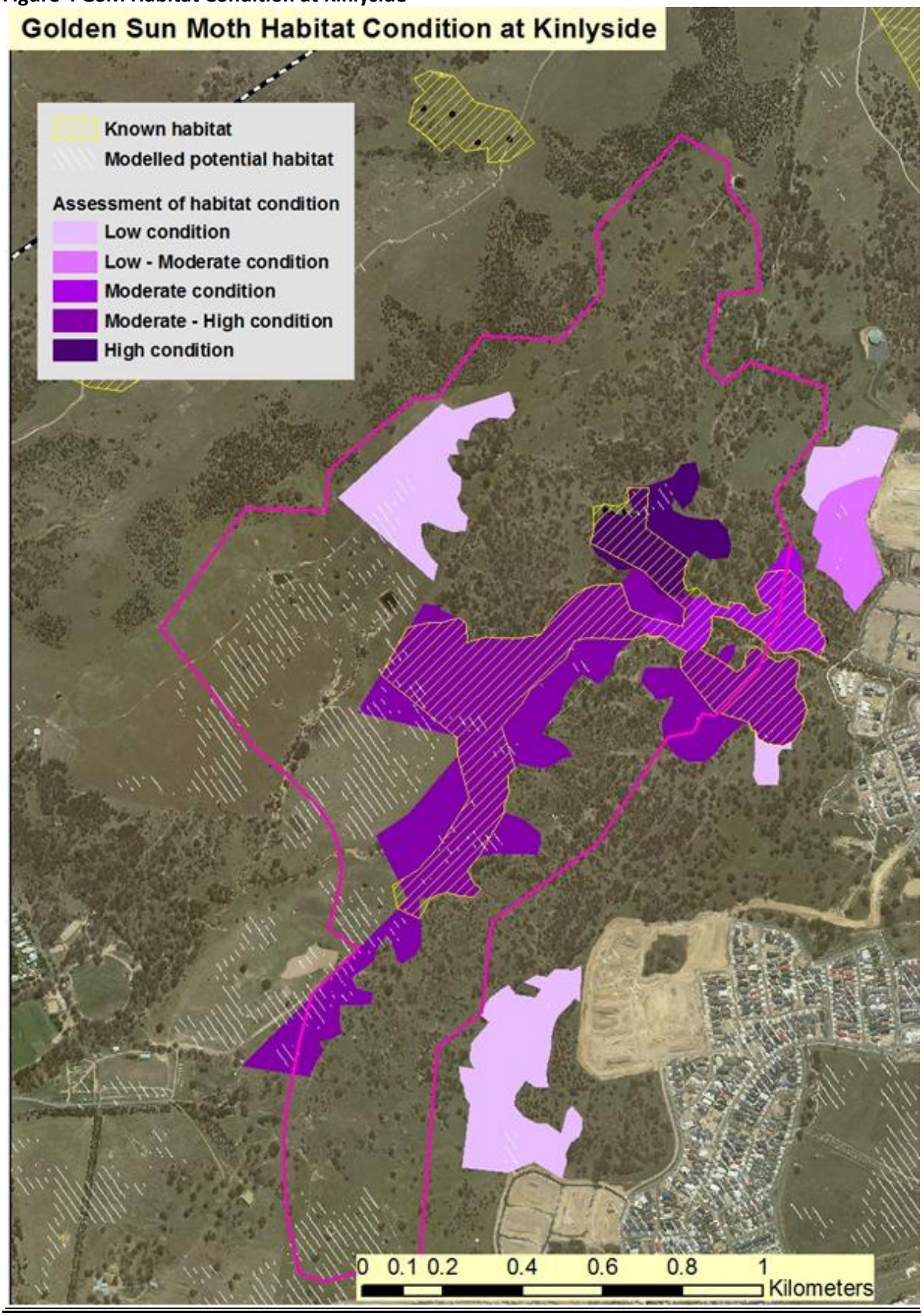


Figure 4 GSM Habitat Condition at Kinlyside



Habitat condition within secondary grassland

Across Australia most of the known habitat of GSM is within areas of natural temperate grassland. Gungahlin, along with a few sites in NSW, is unusual in that the habitat is secondary grassland derived from the clearing of either Box Gum Woodland or Dry Red Stringybark Open Forest. This may be one reason why the density of GSM at Gungahlin is lower than other areas in the ACT. Regeneration of this woodland and open forest may shade and thereby degrade the habitat for the GSM. The conservation areas created by the Biodiversity Plan will require specific and focused management of regeneration to prevent increased sapling and shrub growth from having a significant impact on the occurrence and viability of GSM.

Major regeneration of C4 grasses within the understorey is also likely to be detrimental to GSM. It has long been recognised that the level of grazing impacts the composition of particular grass species. More palatable species, such as *Themeda*, are sensitive to grazing, while wallaby and spear grasses are favoured under a moderate grazing regime (Moore 1970).

Fire

GSM are known to occur in areas where controlled burning has been regularly undertaken (Gilmore and Mueck 2010). ACT Government guidelines for hazard reduction burns (Kitchin and Mathews 2012) recommend that:

- within GSM habitat, burns be restricted to between March and October to avoid the summer adult flying season; and
- burns in GSM habitat must be patchy and low-intensity.

ACT Government guidelines also consider that within habitat slashing is a preferable means of fuel biomass control to burning.

GSM Primary Habitat Management Areas

A feature of the Gungahlin habitat is that the 380 ha area across Goorooyarroo, East Throsby, North Throsby and Mulligan's Flat is the second largest remaining habitat area in the ACT and one of the largest patches of continuous habitat nationally. 148ha of GSM habitat was avoided as part of the Gungahlin Strategic Assessment Biodiversity Plan. The relative large size of the habitat increases its resilience. Maintaining and enhancing the size of habitat will be a key management focus, as will be maintaining a viable population within the Kinlyside reserve.

Figure 5 describes the 169 ha (approximate) of existing and potential GSM habitat that will be subject to specific habitat improvement measures. It is probable that specific measures will also be undertaken within particular areas of Mulligan's Flat and Goorooyarroo, but these measures will need to occur within a wider program of research and woodland restoration. This research and restoration is of international significance and in some cases may conflict with enhancing GSM habitat. Thus these reserves have not been included within areas subject to specific habitat improvement. Nevertheless, there are likely to be some areas where the priorities of research and woodland restoration match the habitat requirements for GSM. For example a program to re-introduce the Bush Stone Curlew (*Burhinus grallarius*) to the ACT is currently underway, with Mulligan's Flat as the initial re-introduction site. This bird feeds on low open grasslands and its habitat requirements are likely to be similar to that the GSM. The initial area that will be managed for the Bush Stone Curlew is also shown in Figure 5, as are areas likely to be managed as open grassy woodland.

Management Actions within Habitat Improvement Areas

Management within the habitat improvement areas will:

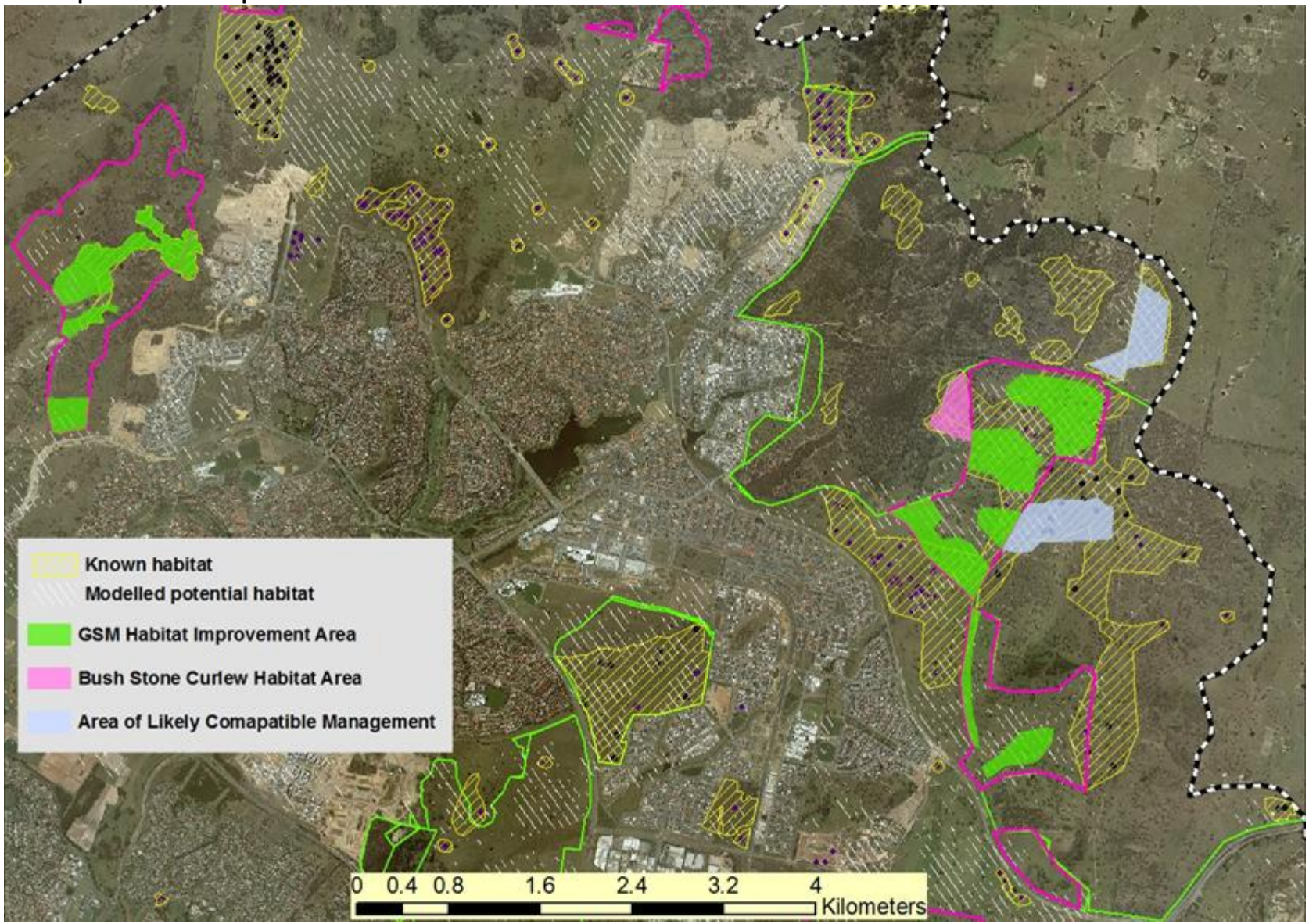
1. Maintain and/or increase the presence of native C3 grasses within GSM habitat to between 40% - 75% of the cover;
2. Maintain between 1 -5% bare ground amongst the grass cover and
3. Maintain tree, sapling and shrub cover below 10%.

These goals will be achieved through a number of management approaches including:

- Biomass control through conservation grazing , where stock (either sheep or cattle)and/ or kangaroos will be utilised to control both woody tree and shrub and *Themeda* regeneration, and to prevent wallaby grass dominated areas from becoming tall and lanky (i.e. above 20cm in height). Stock grazing may decline if Kangaroo grazing increases ;
- Weed control of exotic species and if required spraying of woody regrowth. Exotic perennial tussock grasses such as African Lovegrass, Serrated Tussock and Chilean Needlegrass will be a particular focus for control;
- Excluding the addition of fertilizers; and
- Conservation burning widely (or slashing within relevant Outer Asset Protection Zones).

In addition larvae will be translocated within soil and grass “turf” cuttings from the Throsby development area into adjacent outer asset protection zones and into the Habitat Improvement Area that has been identified as potential habitat within East Throsby. The techniques utilised will be similar to the recently successful translocation undertaken by SMEC, of larvae from within the footprint of the Majura Parkway to adjacent potential grassland habitat. The translocation will be undertaken according to a research design endorsed by Conservation, Planning and Research, Environment and Planning Directorate.

Figure 5 Proposed Habitat Improvement Areas



Monitoring program

Rowell and Evans (2014) have established an ACT GSM Monitoring Plan to guide specific site monitoring so as to provide reliable and efficient data that can be compared with other monitored sites across the ACT and used to evaluate long-term trends in GSM populations across the ACT. The monitoring proposed within the Gungahlin Strategic Assessment area is consistent with the Monitoring Plan and contributes to ACT wide monitoring of the species. It aims to provide information on the size of the populations within the offset and reserved areas. It also enables comparison of population fluctuations within the offset areas to be compared to those observed elsewhere in the ACT. Data sheets relevant to GSM and vegetation monitoring can be found in the ACT GSM Monitoring Plan (Rowell and Evans 2014).

Methods for monitoring GSM

The methods to be employed are in accordance with and are detailed in *ACT GSM Survey Guidelines* (CPR 2013) and the *GSM Monitoring Plan* (Rowell and Evans 2014). The methods utilised include extensive survey over all habitat areas and intensive survey over key and representative sites.

Extensive survey of total habitat area

In order to monitor whether 148ha of GSM habitat is being maintained within the conservation areas, surveys for GSM across these areas will be repeated, using the same survey methodology as utilised for the Gungahlin Strategic Assessment. That is, surveys will be undertaken four times over the flying season and will only occur in the following weather conditions:

- Warm to hot day (above 20^{o}C by 10 am);
- Surveys undertaken during the warmest part of the day (between 10 am and 2 pm);
- Clear or mostly cloudless sky;
- Still or relatively still wind conditions; and
- At least 2 days since rain.

Extensive surveys will occur at least 3 times over the next twenty years and once within every 7 year period. Surveys will be timed to coincide with major moth emergence events, as evidenced by moth activity across the ACT, or by the intensive survey program. The locations at which moths occur together with the number observed will be recorded as a GPS point and mapped. The extent of probable active habitat will be determined from these locations as per the studies undertaken for the Gungahlin Strategic Assessment (Ecological 2012 + 2013).

Intensive surveys: Timing

Moths will be intensively surveyed at Throsby and Kinlyside (see Appendix 1). Surveys will be undertaken during the moth emergence season, which in the ACT is usually from October to December. Surveys will be timed to coincide with the peak emergence (or 'flying') period, which is from about mid-November to mid-December in the ACT, but varies with seasonal and site conditions. For example, warm dry weather in early spring may lead to an earlier and shorter than average flying season, while a cool wet start to the season is likely to delay the beginning of the emergence period. Surveys will be undertaken only if it has been determined that the flying season is well underway (as indicated by GSM emergence being recorded at a range of sites in the ACT). Surveys will be undertaken on days with suitable weather conditions (refer to the *ACT Golden Sun Moth Survey Guidelines*).

Surveys for GSMs will be undertaken annually within the Throsby and Kinlyside monitoring areas for the first three years (to provide an initial estimate of annual variability in moth emergence numbers) and then every third year thereafter (to provide data for long-term abundance trends at sites).

Walked Transects

Surveys at monitoring sites will use walked transects, as detailed in the ACT GSM Survey Guidelines. Each year that a monitoring site is surveyed, at least two full day surveys should be undertaken about one to two weeks apart, and on days of good mid-season weather conditions for moth emergence. Surveys will not be undertaken less than two days after substantial rain.

Transects will be walked in reverse order in the second survey, to counter time-of-day effects. If the results of the two surveys are significantly different, and especially if moth numbers are higher in the second survey (suggesting that the first survey was too early in the season), a third survey be undertaken. This will consist of a repeat survey of only those transects with the 5 highest counts in the previous surveys.

The start and finish time for each transect and for the survey day will be recorded, so that the number of GSMs seen per hour and for the daily session can be calculated.

Transects used for long-term monitoring have been mapped for each site and are shown in Appendix 1. The same transects will be used for each monitoring survey. Transects will be walked using a GPS and compass to help stay close (within 10 m) to the mapped transect line. Note that it is more important to be continually scanning for flying moths than to spend much time looking at the GPS/compass in an effort to stay exactly on the transect line.

Surveyors will walk at a steady pace along transects, recording the number of flying moths seen using a clicker counter within 25m on each side of the observer. Thus the surveyor is recording all moths in a belt transect that is 50 m wide. The total number of moths seen per 100 m segment of the transect is recorded. The GPS unit can be used to identify the start/finish of the 100 m segments of each transect.

Any moths seen while walking between transects or during other tasks (such as vegetation monitoring or searching for pupal cases will also be separately recorded.

Searches for females and pupal cases

On moth survey days, observers (surveyors) will return after 1300 hrs to the transect sections (100 x 50 m = 0.5 ha) that contained the highest numbers of flying males and conduct timed searches for females and pupal cases. Females are more easily seen when laying eggs, which usually takes place in mid to late afternoon. Females are found by scanning open areas between tussocks, where they walk rapidly from one oviposition site to another. Pupal cases protrude from bare ground or through litter. The selected 0.5 ha strips will each be searched for ten minutes, with five searches undertaken on each site. All locations of females and pupal cases will be recorded with a GPS, as they indicate egg-laying and larval development sites. Pupal cases persist for days or weeks in some conditions, so searches for pupal cases will also be undertaken during later habitat condition surveys.

Methods for monitoring habitat

Standard 100 metre step-point vegetation transects will be undertaken utilising selected segments of the moth survey transects at Throsby and Kinlyside and along another 5 transects monitoring habitat within the habitat improvement areas not subject to detailed moth survey. The habitat surveys will occur in years when the moths are surveyed. The vegetation transects comprise a set of permanent transects and a set of 'seasonal' transects, whose locations depend on seasonal moth abundance/distribution at the site. Vegetation transects should be measured late in the flying season, ideally between the 2nd week to the end of December. This will allow selection of seasonal transects using recently collected moth density/habitat data, identification of grasses, and increase the chance of finding pupal cases.

The vegetation transects can be undertaken using various types of 'pointers', such as a hand-held stick pointer, a mark drawn on the front of a boot or the 1 m divisions on a 50 m or 100 m measuring tape. A line drawn at the tip of a boot is commonly used by CPR staff as a rapid method for recording ground cover in grasslands. At each step (or 1 m mark on a tape) the dominant ground feature indicated at the 'pointer' is recorded, which allows the counts of bare ground, litter, native and exotic vegetation, GSM food plants etc to be tallied and the proportions expressed as percentages. The GSM transect segments used for vegetation surveys should be recorded on datasheets (using the transect segment label on the maps in Appendix 1).

The vegetation transects are of two types:

- Permanent transects to be surveyed in each GSM survey year. This includes five transect lengths at Throsby and Kinlyside and 1500m of transects within other Habitat Improvement Areas. The location of permanent transects are shown on the maps at Appendix 1.
- Seasonal transects placed in areas where females, pupal cases or high numbers of flying males are observed in the year of survey. The number of seasonal transects on a site should be similar to the number of permanent transects.

Photographic monitoring

Reference photographs of habitat will be undertaken in conjunction with vegetation transects (at Reference Sites and Long-term Sites). Photographs will be taken each year that the vegetation transects at a site are undertaken. These photographs provide a visual representation of the habitat conditions at a site for the survey year.

Photographs will be taken from fixed locations, with the same location (and photo direction) used each time the reference photographs are taken. The fixed locations are placed at one end of the permanent vegetation transects. The fixed locations for photographs at Throsby and Kinlyside are shown at Appendix 1. Photographic monitoring involves taking a photograph of vegetation cover and a photograph of the landscape at each vegetation transect. Appropriate information will be recorded to enable the photographs to be matched with the site, date and vegetation transect. A 'marker stake'(a 1 m wooden stake with alternating black and white sections that are 10 cm long (two other contrasting colours can be used)). will be used in the photos.

At each fixed-point photo location, a 'Cover' photo and a 'Landscape' photo will be taken from one end of each vegetation transect, in the direction of the vegetation transect. An example photo is given at Appendix 3.

Corrective actions in relation to monitored decline in habitat condition

The ACT Government is committed to maintaining 413 hectares of GSM habitat within the Gungahlin Strategic Assessment Area. Mapping of occupied habitat is reliant on male moth activity which is variable from year to year and under differing climatic conditions. By undertaking survey during a year of relatively high emergence of the moth across the ACT, the impact of this variability will be reduced. Nevertheless, moth habitat will only be considered to have declined if mapping of occupied habitat falls below 316 hectares (which is the combined area of avoided (148ha) and previously conserved habitat (168ha) in Gungahlin). If a decline in overall moth extent is observed, then measures to improve habitat condition will be undertaken within habitat that is outside of the Habitat Improvement Areas. These measures could include thinning of sapling regrowth, increased weed control or changing the grazing regime. Liaison with the land manager will ensure that these measures do not significantly impact on other MNES values or impinge on experiments or restoration efforts undertaken with existing reserves.

If moth extent is still below that recorded previously during the subsequent surveyed large emergence event, survey will also occur within open space and remaining rural lease areas within the Plan area that contain known or potential habitat. If suitable habitat is located, management will be directed to enhancing GSM habitat at these locations in order to maintain 148ha of moth habitat across the site. In this context it is also possible that translocation programs may have lead to an increase in the extent of habitat occupied by the moth, and this is most likely to occur within the East Throsby offset area.

Within the Habitat Improvement Areas the following triggers and corrective actions will apply

Table 2 Triggers and corrective actions

Habitat Parameter	Trigger for Action	Action to be taken
% C3 grass cover	< 40% cover	Increase grazing and/or weed (exotic grass control)
% grass cover	>90% cover	Increase grazing or undertake fuel reduction burn if appropriate
% bare ground	>10% cover	Remove Grazing
	<2% cover	Increase grazing and/or undertake weed control or undertake fuel reduction burn if appropriate
%Exotic plant cover	>5% cover	Undertake weed control
% Litter	<5%	Reduce grazing
	>15%	Increase grazing or undertake fuel reduction burn if appropriate

Research

The monitoring program of moths and habitat will contribute to a basic understanding of how moth populations vary from year to year and in response to particular climatic conditions. The monitoring will also provide information on the importance of micro-site variations to moth breeding and emergence. Research projects that utilise or build on this information will be encouraged and supported.

The other main area of GSM Research that will be undertaken will be into the success and trialling of translocation. A detailed research plan will be developed for the translocation, but it will expand on the work undertaken by the SMEC for ACT Roads, where moth larvae occurring within the development footprint of the Majura Parkway were successfully transferred within a scrapping of soil and grasses to an adjacent area in which moths have not previously been recorded (see Figures 6, 7 and 8).

Following a similar technique, swards of grass and soil to a depth of about 20 -30 cm will be excavated from know moth locations within the Throsby development footprint. This will involve an initial ripping to determine where concentrations of moths are occurring. The number of larvae within each sward will estimated and swards placed within small and shallow dugout squares within potential habitat, in which moths have not be observed within the East Throsby Habitat Improvement areas. A few of the bedded in translocation areas will be netted and the emergence of moths monitored. Once it has been demonstrated that moths have emerged from the translocated soil and grass, the nets will be removed and viability of moths in the area monitored as part of the wider monitoring program.

Some of the translocation sites will be within areas managed as Outer Asset Protection Zones. Monitoring of the success of translocation and the wider habitat mapping will provide information as to how successfully moths can be conserved within fire asset protection zones.

Figure 6 Soil and grass containing moth larvae excavated from the Majura Parkway

Figure 7 Netted translocation sites

Figure 8 Successful moth emergence under net

Research Collaboration

Monitoring programs and research will be presented to the research management group of The Mulligan's Flat Woodland Sanctuary, with the aim of fostering coordination and collaboration and avoiding any potential conflicts.

Research and Monitoring Costs

The cost estimate of the translocation work is based on heavy machinery already being available on site, and translocation of approximately 100 square metres of swards in 12 plots of which three will be netted, to determine whether moths have successfully emerged. The cost estimate also includes initial watering in of swards, and monitoring in spring to check emergence.

The costs of intensive survey are based on the two checks specified and the extensive habitat mapping includes costing to cover three separate surveys of the same habitat within a season. These research and monitoring activities may change and be subject to review by the PIT.

Year	Activity	Cost ($) per annum
1	Throsby "Urban Edge" translocation and rehabilitation project	20 000
	Intensive Moth Count	4 000
	Moth Translocation	23 000
2	Intensive Moth Count	4 000
3	Intensive Moth Count	4 000
	Extensive Habitat Mapping	12 000
6	Intensive Moth Count	4 000
9	Intensive Moth Count	4 000
10	Extensive Habitat Mapping	12 000
12	Intensive Moth Count	4 000
15	Intensive Moth Count	4 000
17	Extensive Habitat Mapping	12 000
18	Intensive Moth Count	4 000
20	Extensive Habitat Mapping (final)	12 000
TOTAL		**123 000**

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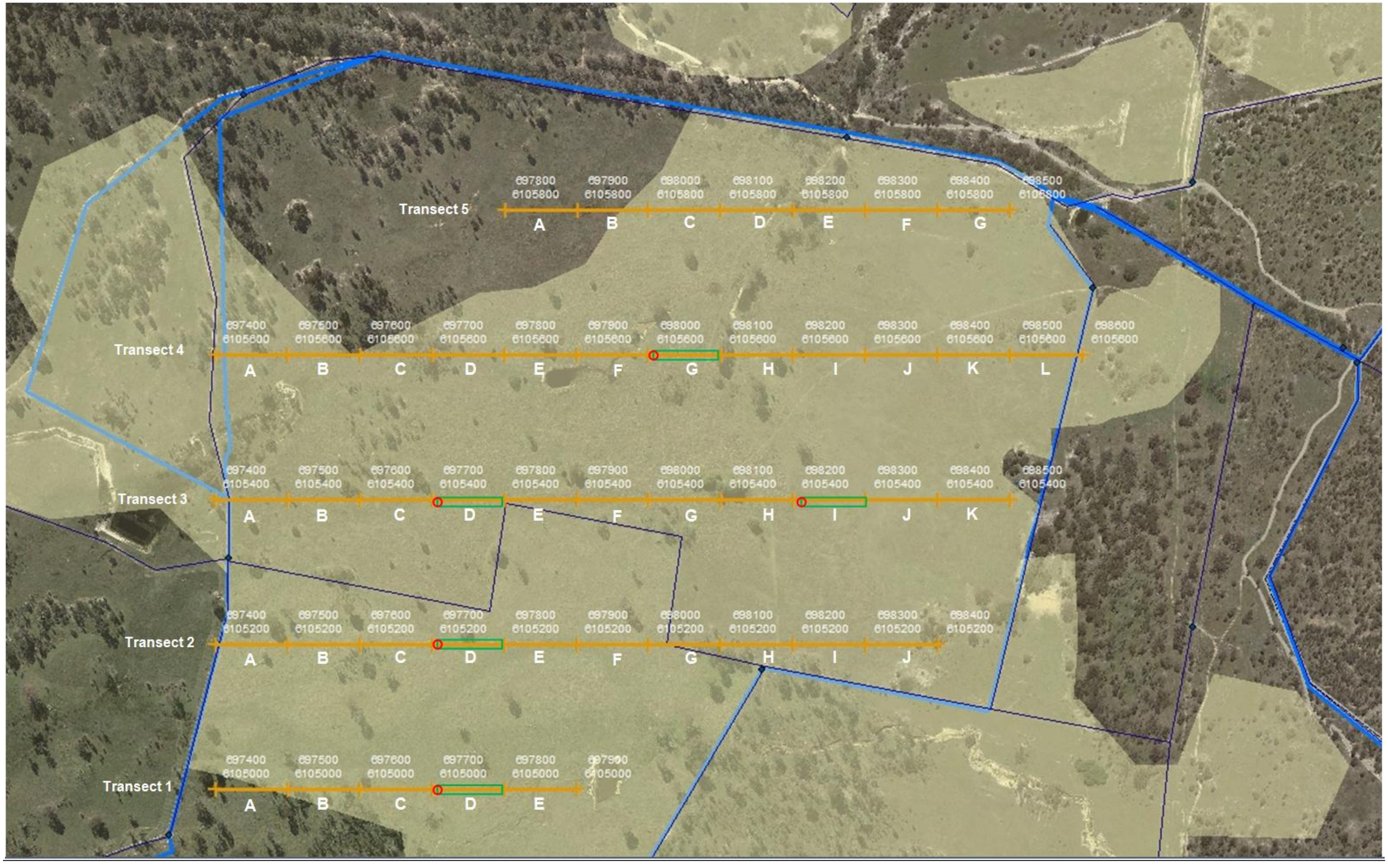
Appendix 1

Monitoring Locations for Throsby and Kinlyside



Kinlyside Golden Sun Moth monitoring transects

GSM transect with 100m divisions

Vegetation transect (rectangle) with fixed photo-point (circle)