Australian Capital Territory

Nature Conservation (Golden Sun Moth) Conservation Advice 2023

Notifiable instrument NI2023–221

made under the

Nature Conservation Act 2014, s 90C (Conservation advice)

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1 Name of instrument

This instrument is the *Nature Conservation (Golden Sun Moth) Conservation Advice 2023*.

2 Commencement

This instrument commences on the day after its notification day.

3 Conservation advice for Golden Sun Moth

Schedule 1 sets out the conservation advice for Golden Sun Moth (*Synemon plana*).

4 Revocation

This instrument revokes the *Nature Conservation (Golden Sun Moth) Conservation Advice 2020* (NI2020-566).

Arthur Georges
Chair, Scientific Committee
14 April 2023

Schedule 1

(see s 3)

CONSERVATION ADVICE

GOLDEN SUN MOTH – *Synemon plana*

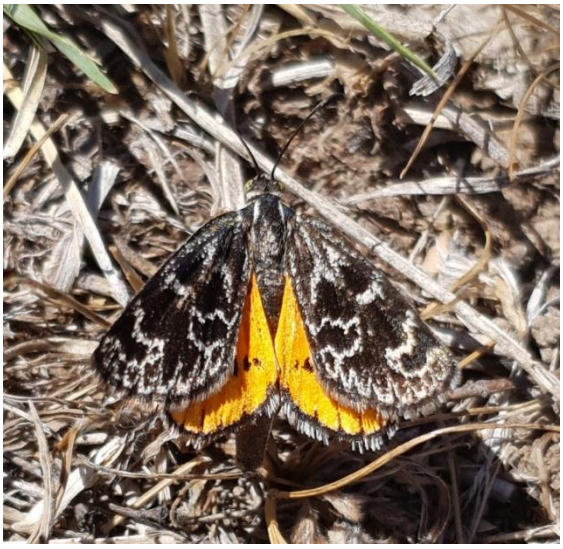
CONSERVATION STATUS

The Golden Sun Moth *Synemon plana* Walker, 1854, is recognised as threatened in the following jurisdictions:

National	**Vulnerable**, *Environment Protection and Biodiversity Conservation Act 1999.*
ACT	**Vulnerable**, *Nature Conservation Act 2014*
NSW	**Vulnerable**, *Biodiversity Conservation Act 2016*
VIC	**Vulnerable**, *The Flora and Fauna Guarantee Act 1988*

ELIGIBILITY

The Golden Sun Moth is listed as Vulnerable in the ACT Threatened Native Species List under IUCN Criterion – B2ab(ii,iii,iv,v), at the national level (Attachment A). The factors that make it eligible include a limited area of occupancy, severe fragmentation, and a continuing decline in the area of occupancy, area, extent, and quality of habitat, number of locations or subpopulations and number of mature individuals (DAWE 2021). At the time when the species was initially listed under the EPBC Act in 2002, the area of occupancy (AOO) was estimated at 8.8 km^2, meeting the Critically Endangered threshold (TSSC 2002) and is now estimated to be at least 1,596 km^2, meeting the Vulnerable threshold (DAWE 2021). Since the initial listing was made the understanding of the species distribution and habitat has improved due to an increase in survey effort in areas proposed for development and an increased conservation interest in the species (DAWE 2021).

Golden Sun Moth male perched (left) and female on ground (right) (Emma Carlson EPSDD)

DESCRIPTION AND ECOLOGY

Golden Sun Moth adults are medium-sized moths within the family Castniidae. Males have dark brown upper forewings with pale grey patterning, bronzy hind wings with dark brown patches, and the undersides of both wings are pale grey with dark brown spots. Females have dark grey upper forewings with pale grey patterning, bright orange hind wings with black submarginal spots, and the undersides of both wings are silky white with small black submarginal spots.

Adult moths have clubbed antenna and no functional mouth parts, so cannot feed or drink and most live for only one or two days (Edwards 1993, Edwards 1994, Harwood et al. 1995, Rowell 2007, Rowell 2012). The sex ratio on emergence is about 60% males and 40% females. (Richter 2010, Richter et al. 2012). Females have a wingspan of about 31 mm and are only able to walk or flutter for short distances (Edwards 1994, Richter 2010). Males have slightly larger wingspan (34 mm on average) and are active fliers, able to move several hundred metres over suitable habitat (Richter et al. 2013).

Males fly low and rapidly over the grassland during the late morning and early afternoon on suitably warm days, searching for females. Males do not fly far from habitat, and usually turn back after 50 metres or less when they enter unsuitable vegetation. Females sit on the ground, exposing their golden hindwings when a male flies overhead (Edwards 1994, Gibson 2006). In the ACT, the flying period is usually between late spring to early summer, varying according to seasonal conditions (ACT Government 2017a).

Adult females contain, on average, 74 fully formed eggs (>2 mm long) on emerging from pupation. After mating, the females move, up to only a few metres (Gibson 2006), from tussock to tussock, laying eggs into the tussock bases. The cream-colored larvae develop and feed underground for one to three years (Edwards 1994, Richter 2013). They have been found associated with the roots of a few species of grasses or at the upper end of silk-lined tunnels below the tussock base (Richter 2010). Golden Sun Moth larvae primarily consume native temperate grasses, especially Wallaby Grasses (*Rytidosperma* spp., formerly *Austrodanthonia*) and Spear Grasses (*Austrostipa* spp.), as well as the introduced Chilean Needle Grass (*Nassella neesiana*) (Edwards 1994, Braby and Dunford 2006, Gibson 2006, Gilmore et al. 2008, Brown and

Tolsma 2010, Richter et al. 2011, 2013, Sea and Downey 2014), which is a listed Weed of National Significance (WONS)).

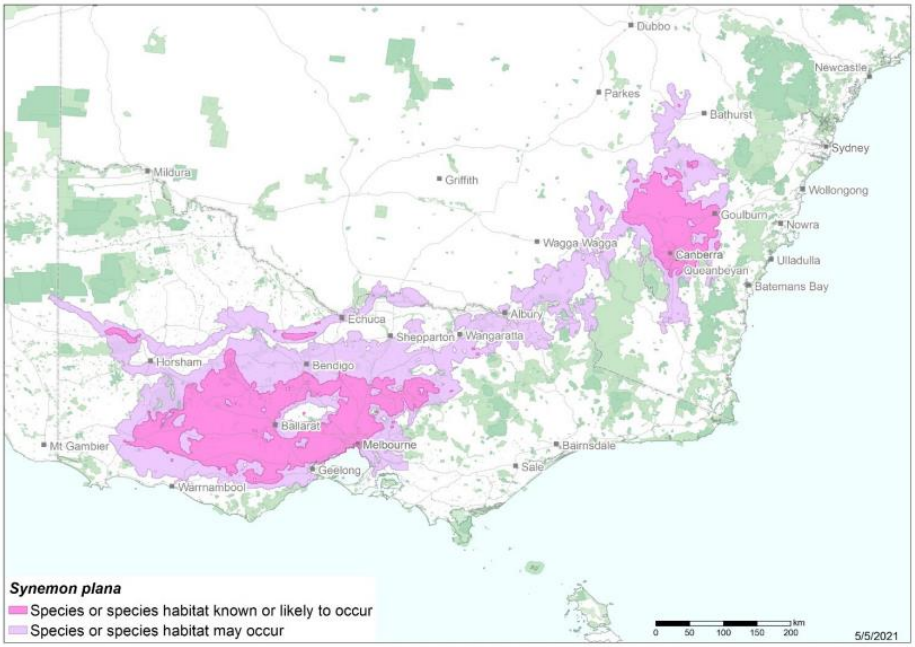
DISTRIBUTION AND HABITAT

Historically, the Golden Sun Moth was widespread in south-eastern Australia and relatively continuous throughout its range, showing a close correlation with the distribution of temperate grasslands dominated by Wallaby Grasses (Edwards 1993, O'Dwyer and Attiwill 1999). Museum records indicate the Golden Sun Moth was still common and widespread prior to 1950 (Edwards 1993).

The modelled distribution of the Golden Sun Moth is shown in Map 1. The Golden Sun Moth has been recorded across 104 (mainly small) sites north and west of Melbourne and in south-west Victoria (Brown and Tolsma 2010, Brown et al. 2011, DSE 2013, DAWE 2022), at least 59 sites in NSW (OEH 2012, Gibbons and Reid 2013) and 78 sites in the ACT.

In the ACT, the Golden Sun Moth occurs in lowland areas on land under a range of tenures and land management regimes in and adjacent to the city of Canberra. Most of the populations of the Golden Sun Moth in the ACT region are smaller than five hectares and lie within an area about 100 km long and 30 km wide, extending from the Queanbeyan district in the south-east to the Boorowa area in the north-west (Clarke and Whyte 2003, NSW Government 2015). The area of potential habitat in the ACT is estimated at 1800 hectares (ACT Government 2017).

Map 1 Modelled distribution of Golden Sun Moth



Source: DAWE 2021– Base map Geoscience Australia; species distribution data Species of National Environmental Significance database.

Some of the largest numbers of Golden Sun Moth have been recorded in the Majura West grassland and Jerrabomberra West Grasslands Nature Reserve. There are also large populations on Commonwealth Land at the Majura Training Area and Canberra Airport in the Majura Valley, and at the Lawson grasslands (former Belconnen Naval Transmission Station site). The West Macgregor Nature Reserve has a significant population and less extensive populations occur in

the Dunlop Grasslands Reserve and Jarramlee Nature Reserve in Belconnen; in the Cookanalla and Jerrabomberra East grasslands; along Woolshed Creek in the Majura Valley; and in Throsby East, Throsby North and the Mulanggari, Crace, Kinlyside, Mulligans Flat and Goorooyarroo nature reserves in Gungahlin. Based on the known former distribution of lowland temperate grassland in the ACT and areas surveyed for the Golden Sun Moth, it is likely that all significant populations of the species in the ACT have been identified.

The Golden Sun Moth often occurs on sites that contain the Critically Endangered Natural Temperate Grassland ecological community and other threatened grassland species, and sometimes within remnants of the Critically Endangered Yellow Box–Blakely's Red Gum Grassy Woodland ecological community. The vast majority (88%) of Golden Sun Moth habitat in the ACT occurs in areas with less than 5% canopy cover (Mulvaney 2012) that generally have not been heavily fertilised or ploughed (Richter et al. 2010)

Habitat for the Golden Sun Moth is characterised by the moderate abundance of larval food plants and the structure of the grassy layer. The Golden Sun Moth is most often found at sites with higher cover of Wallaby Grasses, provided that the tussock structure and inter-tussock bare ground is maintained (Gibbons and Reid 2013). Important structural features appear to be tussocks for shelter, egg-laying and larval development, and inter-tussock spaces for basking to increase body temperature and for females to display and attract mates (Edwards 1994, Gibson 2006, Gibbons and Reid 2013). Where vegetation height and density vary, male moths show a preference for flying over areas of relatively low open grassland with reduced herbage mass (Gibson 2006, Gilmore et al. 2008, Brown et al. 2011).

Because males are unlikely to fly more than 100 metres away from suitable habitat (Clarke and O'Dwyer 2000), and females move even less distance, populations separated by 200 metres or more are likely to be isolated and are therefore treated as separate sites. Populations of the Golden Sun Moth tend to have a patchy distribution within an area of apparently suitable habitat (ACT Government 2017a).

The use of Chilean Needle Grass as a food plant by the Golden Sun Moth larvae (Braby and Dunford 2006, Gilmore et al. 2008) has allowed the moth to survive in disturbed and degraded habitats and to spread along roadsides and creek lines, potentially connecting populations which are currently isolated on native-dominated sites (ACT Government 2017a). Despite the potential opportunities of this relationship, there are risks that need to be assessed with Chilean Needle Grass as it is a Weed of National Significance (WONS). For example, one risk of the introduction of Chilean Needle Grass into Critically Endangered ecological communities is the potential for it to drive genetic change in the Golden Sun Moth, which could eventually lead to genetic barriers between isolated populations adapted to different conditions.

THREATS

The Golden Sun Moth is mainly restricted to areas of Natural Temperate Grassland, a Critically Endangered ecological community under the *Nature Conservation Act 2014* (NC Act). The main threats provided in the ACT Action Plan for the species (ACT Government 2017a) include:

- habitat loss and fragmentation through urban development, leading to loss of small sites and fragmentation of larger sites
- habitat degradation through weed invasion, reducing the density and quality of larval food sources

- other conservation programs, specifically those that target Chilean Needle Grass as a Weed of National Significance, as this has become an additional food source
- grassfire or inappropriate fire regimes, especially frequent or intense burns within the pupation and flight period, as well as changes in the fire regime in the ACT or a longer fire season
- inappropriate disturbance regime leading to either accumulation of biomass and the formation of a tall grass sward with low bare ground (low disturbance), or formation of a very short sparse vegetation structure with high bare ground (frequent intense disturbance)
- land management regimens such as pasture improvement, ploughing, or excessive fertiliser use may reduce available grass, damage larvae, or encourage invasive weeds
- shading by plantings or by buildings that alter ideal soil temperature and moisture presumed necessary for the Golden Sun Moth life cycle.

MAJOR CONSERVATION OBJECTIVE

The overall objective of the action plan (ACT Government 2017a) is to preserve viable, wild populations of the Golden Sun Moth in the ACT.

CONSERVATION PRIORITIES

The preservation of appropriately sized and connected areas of Golden Sun Moth habitat is necessary for species survival. Priorities include to:

- conserve larger populations on larger sites
- conserve optimal habitat quality, particularly through an appropriate herbage mass management regime
- establish relevant monitoring and research for adaptive management of habitat
- manage adjacent grassland to increase habitat area and connect populations or establish/re-establish populations
- identify opportunities and collaborate with research institutions and non-government organisations, especially citizen science and volunteer efforts.
- explore the implications of climate change for population persistence and conduct climate sensitive management actions where feasible. Systematic monitoring and collection of population data, including reproduction and survival data when available, should be used to assess population viability and species distribution. For species whose physiological limits are known, biophysical models can provide a predictive understanding of the habitats required for persistence in the face of climate change through an integration of data on climate and other environmental variables with measures of morphology, behaviour, physiology and life history of the species. Opportunities to address knowledge gaps for this species to establish climate change ready management actions may include university and interjurisdictional research collaborations.

OTHER RELEVANT ADVICE, PLANS OR PRESCRIPTIONS

- ACT Action Plan – Golden Sun Moth (ACT Government 2017a)
- ACT Native Grassland Conservation Strategy (ACT Government 2017b)
- Commonwealth Conservation Advice – Golden Sun Moth (DAWE 2021)

LISTING BACKGROUND

The Golden Sun Moth was listed in the ACT as an Endangered species on 1 February 1996 in accordance with section 21 of the *Nature Conservation Act 1980.* At that time, the Flora and Fauna Committee (now the Scientific Committee) concluded that the assessment satisfied the following criteria:

1.2 Species is observed, estimated, inferred or suspected to be at risk of premature extinction in the ACT region in the near future, as demonstrated by:

1.2.1 Current severe decline in population or distribution from evidence based on:

1.2.1.1 Direct observation, including comparison of current and historical records.

1.2.1.3 Severe decline in quality or quantity of habitat.

1.2.5 Continuing decline or severe fragmentation in population, for species with a small current population.

The Flora and Fauna Committee assessed that this species met the above criteria for listing as Endangered for the following reasons:

- There was a serious decline in the quality and quantity of habitat for this species throughout its range, including the ACT, and known populations are now fragmented in distribution.
- The grassland habitat of this species has been and continues to be exploited for agricultural, urban and industrial development. The remaining areas are vulnerable to further fragmentation associated with urban infrastructure and there is no practical way of connecting the remaining disjunct areas.

In 2002, the Golden Sun Moth was eligible for listing as Critically Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) as assessed against Criterion 2 – small geographic distribution. The main reasons that the species was eligible for listing in this category, at that time, were that the remaining distribution was highly fragmented in small, isolated fragments constituting an estimated area occupancy of 8.8 km^2 across 65 sites with the habitat facing ongoing threats (Threatened Species Scientific Committee (TSSC) 2002). However, areas of potential habitat had not been comprehensively mapped or surveyed and more recent targeted surveys for the species around Melbourne and in regional Victoria (Brown and Tolsma 2010, Brown et al. 2011) substantially increased the number of known localities.

The species was reassessed and listed as Vulnerable under the EPBC Act on 7 December 2021. In response, the ACT Scientific Committee recommended the Golden Sun Moth be transferred to the Vulnerable category in the ACT Threatened Native Species List under the *Nature Conservation Act 2014*, to align with the EPBC Act listing.

ACTION PLAN DECISION

The ACT Scientific Committee recommends that the Minister for the Environment should make the decision to continue the current action plan (ACT Government 2017a) for the species in the ACT under the *Nature Conservation Act 2014*.

Nearly all the habitat on ACT-owned land is within either conservation or offset areas and actively managed appropriately for conservation. However, it has an uncertain and some-what perilous future on Commonwealth-owned land in the ACT, and a national recovery plan should

be developed if this would prove advantageous to managing this species well on Commonwealth land. Additionally, like Victoria, development frequently impacts the species in the ACT and the Golden Sun Moth habitat and thus population numbers are likely declining. Nation-wide guidance is necessary to ensure long-term conservation of the species and therefore complex planning needs may continue to be best served by a National Recovery Plan.

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FURTHER INFORMATION

Further information on the related Action Plan or other threatened species and ecological communities can be obtained from: Environment, Planning and Sustainable Development Directorate (EPSDD). Phone: (02) 132281, EPSDD Website: https://www.environment.act.gov.au/

ATTACHMENT A: NATIONAL LISTING ASSESSMENT (DAWE 2021)

THREATENED SPECIES SCIENTIFIC COMMITTEE

Established under the *Environment Protection and Biodiversity Conservation Act 1999*

The Threatened Species Scientific Committee draft assessment

Attachment A: Listing Assessment for *Synemon plana*

Reason for assessment

The Golden Sun Moth was listed as Critically Endangered under the EPBC Act in 2002.

This assessment follows prioritisation of a nomination from the Committee.

Assessment of eligibility for listing

This assessment uses the criteria set out in the EPBC Regulations. The thresholds used correspond with those in the IUCN Red List criteria except where noted in Criterion 4, sub-Criterion D2. The IUCN criteria are used by Australian jurisdictions to achieve consistent listing assessments through the Common Assessment Method (CAM).

Key assessment parameters

Table 3 includes the key assessment parameters used in the assessment of eligibility for listing against the criteria.

Table 3 Key assessment parameters

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Number of mature individuals	>10 000	>10 000	>10 000	There are insufficient data available to determine a minimum and maximum plausible value of the number of mature individuals. However, given the large number of known occurrences of the species and available survey data from many sites, it is highly likely that the number of mature individuals exceeds 10 000. The Victorian threatened species assessment inferred the state of Victoria had 13 500 mature individuals (DELWP 2020b), and in ACT an estimate of 17 250 has been used (see Criterion 3 below). In addition, 59 subpopulations are known from the state of NSW (OEH 2012; Gibbons & Reid 2013). These figures are based on available information and may not account for sites impacted/lost and discovered in recent years. Pupal case surveys have indicated that a male biased sex ratio exists, with a mean of 1.9 (range: 0.6 to 3.5). Using the mean value, any estimate of population size should be reduced by approximately 31 percent to obtain an estimate of mature individuals.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Declining			Insufficient monitoring data to demonstrate the trend in number of mature individuals in extant sites. There is a known ongoing decline in the extent, area, and quality of native grassland habitats due to a number of ongoing threats. As such, it is inferred that the number of mature individuals of the species is likely to be declining.
Generation time (years)	2-3 years	2 years	3 years	The larval period is thought to be two to three years (Edwards 1994 cited in DEWHA 2009; Richter et al. 2013a), after which adult moths emerge, living for only a few days to breed (O'Dwyer & Attiwill 2000; Gibson & New 2007).
Extent of occurrence	145 322 km²	145 322 km²	171 536 km²	The minimum plausible value has been estimated based on known occurrences, using record data from the past 20 years (2000-2019) and applying the shortest continuous imaginary boundary that can be drawn to encompass these records as outlined in the *Guidelines for Using the IUCN Red List Categories and Criteria* (IUCN 2019). With such a wide-ranging species with many occurrence records and ongoing threats, the data are not available to confirm the status (i.e. extant or extinct) of the species in all recorded locations. The TSSC's standard approach is to use the last 20 years of record data, unless there is evidence that a different time period is more appropriate. As the species is not well surveyed across its range, a shorter time-frame was not considered appropriate. The maximum plausible value has been calculated using the same method but utilising all record data for the species (dating back to 1897). Use of all data to estimate the maximum EOO is considered appropriate as subpopulations near/ at the edge of the species range may still persist, and this value represents the maximum potential EOO based on the known historic distribution of the species. It should be noted that even using just the most recent one year of data (2019), the EOO estimate would be 24 692 km², which is above any of the threatened category thresholds under the listing assessment Criteria.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Unknown			There are insufficient data to show the trend in the species EOO. The known EOO for the species has been increasing since its discovery, with more rapid increases since the species listing under the EPBC Act likely due to increased survey effort (Hogg 2010 cited in ACT Government 2017).
Area of Occupancy	~1596 km^2	Insufficient data	Insufficient data	The estimate has been calculated based on known occurrences, using record data for the past 20 years (2000-2019) and applying 2 x 2 km grid cells as outlined in the *Guidelines for Using the IUCN Red List Categories and Criteria* (IUCN 2019). For such a wide-ranging species, with many occurrence records and ongoing threats, the data are not available to confirm the status (i.e. extant or extinct) of the species in all recorded locations. The TSSC's standard approach is to use the last 20 years of record data, unless there is evidence that a different time period is more appropriate. As the species is not well surveyed across its range, a shorter time-frame was not considered appropriate. This is discussed further under Criterion 2. There are insufficient data to estimate a minimum or maximum plausible value of AOO. New occurrences of the species are continuing to be discovered from increased awareness and survey for the species across its range. As such, it is expected that new occurrences of the species will continue to be discovered. However, many threats continue to operate on the species, in particular the threats of habitat loss to development and agriculture, and degradation of habitat from weed invasion are very high risk. In recent years considerable amounts of habitat, particularly in urban areas such as Canberra and Melbourne, have been lost to development and it is expected that this will continue. As such, the AOO was calculated based on known records for the species, with the acknowledgement that this is an estimate only.

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
Trend	Declining			There are insufficient data to demonstrate a rate of decline in the species AOO. Further survey data would be required to gain a comprehensive understanding of the species current occurrence within its range. It is thought that the species was once more abundant across its range, based on past habitat availability and genetic evidence suggesting recent fragmentation. Additionally, many threats continue to operate on the species and areas of habitat are known to have been lost in more recent years, predominately from urban development.
Number of subpopulations	164	<164	>164	This species is known from 104 sites in Victoria, of which at least 36 are extant (ACT Government 2017; V Craigie 2020. pers comm 7 October; DELWP 2020a), 59 sites in NSW (OEH 2012; Gibbons & Reid 2013) and 78 sites in the ACT (ACT Government 2017), totalling 164 sites. These figures are based on available information and may not account for sites impacted/lost and discovered in recent years. The number of sites may not necessarily represent individual subpopulations; however, the species has a limited dispersal capability, and as such, sites separated by more than 200 m of unsuitable habitat are likely to be geographically isolated. An assumption has been made that known sites are not within 200 m of another known site nor are connected by suitable habitat.
Trend	Declining			It is thought that the species was once more abundant across its range based on past habitat availability and genetic evidence suggesting recent fragmentation. The species continues to face ongoing threats and a considerable amount of habitat is known to have been lost in recent years to urban development. As such, a decline in the number of subpopulations is inferred.
Basis of assessment of subpopulation number	The limited dispersal ability of the species indicates that all sites separated by greater than 200 m of unsuitable habitat are likely to be geographically isolated and therefore represent individual subpopulations.			

Metric	Estimate used in the assessment	Minimum plausible value	Maximum plausible value	Justification
No. locations	>10-164	>10	>164	This species is known from 104 sites in Victoria, of which at least 36 are extant (ACT Government, 2017; V Craigie 2020. pers comm 7 October; DELWP 2020a), 59 sites in NSW (OEH 2012; Gibbons & Reid 2013) and 78 sites in the ACT (ACT Government 2017), totalling 164 sites. The biggest ongoing threat to the species is habitat loss, degradation and fragmentation from urban development and agricultural expansion. Depending on the scale of a development or agricultural threat, several sites/subpopulations could be encompassed in one location. For example, a new residential development in outer Melbourne could threaten several sites and would therefore be considered one location in the face of this particular threat. However, based on the relatively large distribution of sites and likely scale of primary threats (e.g. habitat loss occurring from developments, where each development proposal is treated separately), the minimum plausible value estimate would be greater than 10 locations. Further analysis to get a more accurate estimate of locations is not required as the estimate of >10 locations is above any of the threatened category thresholds under the listing assessment Criteria.
Trend	The number of locations is likely to decline in response to the inferred decline in subpopulations/sites.			As described above.
Basis of assessment of location number	Any single development proposal or land use change due to agricultural practices is likely to impact on only a small number of sites.			
Fragmentation	The species is considered to be severely fragmented due to the known subpopulations of the species occurring predominately in small sites, the limited dispersal ability of the species, and the remaining extent of native habitat across the species range.			
Fluctuations	There is no evidence that the species experiences wide, rapid and frequent variation in populations size or distribution.			

Criterion 1 Population size reduction

Reduction in total numbers (measured over the longer of 10 years or 3 generations) based on any of A1 to A4			
	Critically Endangered **Very severe reduction**	**Endangered** **Severe reduction**	**Vulnerable** **Substantial reduction**
A1	≥ 90%	≥ 70%	≥ 50%
A2, A3, A4	≥ 80%	≥ 50%	≥ 30%

A1 Population reduction observed, estimated, inferred or suspected in the past and the causes of the reduction are clearly reversible AND understood AND ceased.

A2 Population reduction observed, estimated, inferred or suspected in the past where the causes of the reduction may not have ceased OR may not be understood OR may not be reversible.

A3 Population reduction, projected or suspected to be met in the future (up to a maximum of 100 years) [(*a*) *cannot be used for A3*]

A4 An observed, estimated, inferred, projected or suspected population reduction where the time period must include both the past and the future (up to a max. of 100 years in future), and where the causes of reduction may not have ceased OR may not be understood OR may not be reversible.

Based on any of the following

(a) direct observation [except A3]
(b) an index of abundance appropriate to the taxon
(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat
(d) actual or potential levels of exploitation
(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites

Criterion 1 evidence

Insufficient data to determine eligibility

It is well understood that the habitat for the Golden Sun Moth (temperate grassland) has been severely reduced, fragmented and degraded since European settlement. The species and its habitat continue to face a number of significant ongoing threats. A considerable portion of known subpopulations of Golden Sun Moth overlap with urban growth areas or already occur within a matrix of housing and industrial development (Gilmore et al. 2008; Mata et al. 2017). Continued development and agricultural practices are the most prominent threat to the species. In 2012, 21 percent of known Golden Sun Moth habitat within the ACT had been approved or proposed for clearance, with an additional 23 percent on Commonwealth land with an uncertain future (Mulvaney 2012). In Vic, the Melbourne Strategic Assessment included planning measures to mitigate impacts to the Golden Sun Moth, however, collective habitat clearance will be significant (DEPI 2013). Departmental records show that in NSW, the species has been facing development pressure from the renewable energy sector. Between 2010-2018, 11 referrals for renewable energy projects in NSW were submitted to the Commonwealth with potential impacts to the Golden Sun Moth. Of these, four triggered the EPBC Act for the species and have been approved with conditions. The species' ability to persist and thrive in some degraded and exotic grasslands has undoubtably mitigated some of the population decline previously inferred to have been associated with the decline in native temperate grassland habitat across its range. While a decline in population size can be inferred from the significant loss and degradation of native temperate grassland habitat, there are insufficient monitoring and absence data available to estimate extent of past and ongoing declines in the population over a ten-year period. Some data are available surrounding urban areas that have been subject to development pressure (i.e.

in the ACT) which could be used to estimate potential declines in AOO due to habitat clearing in recent years (EPSDD 2021. pers comm 23 February). However, this data is not considered representative of the broader distribution of the species where the threat of urban development is not as prominent.

The Committee considers that there is insufficient information to determine the eligibility of the species for listing in any category under this Criterion.

Criterion 2 Geographic distribution as indicators for either extent of occurrence AND/OR area of occupancy

		Critically Endangered Very restricted	Endangered Restricted	Vulnerable Limited
B1.	Extent of occurrence (EOO)	**< 100 km²**	**< 5,000 km²**	**< 20,000 km²**
B2.	Area of occupancy (AOO)	**< 10 km²**	**< 500 km²**	**< 2,000 km²**
AND at least 2 of the following 3 conditions:				
(a)	Severely fragmented OR Number of locations	**= 1**	**≤ 5**	**≤ 10**
(b)	Continuing decline observed, estimated, inferred or projected in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) area, extent and/or quality of habitat; (iv) number of locations or subpopulations; (v) number of mature individuals			
(c)	Extreme fluctuations in any of: (i) extent of occurrence; (ii) area of occupancy; (iii) number of locations or subpopulations; (iv) number of mature individuals			

Criterion 2 evidence

Eligible under Criterion 2 B2ab(ii,iii,iv,v) for listing as Vulnerable

The species EOO was estimated using record data from the past 20 years (2000-2019) and applying the shortest continuous imaginary boundary that can be drawn to encompass these records as outlined in the IUCN guidelines (IUCN 2019). The EOO of 145 322 km² does not meet the criteria for listing in any category under B1. The use of most recent 20 years of data is a standard approach by the TSSC, however it should be noted that even with the use of only the most recent one year of record data (2019), the species would still not meet the EOO thresholds under B1 (see Table 4).

The Golden Sun Moth qualifies for a limited AOO (<2000 km²) under Criterion 2B2. A range of estimates of AOO have been considered to determine the most appropriate threshold category under B2. Estimates for AOO were calculated using the standard 2 x 2 km grid cell method outlined in the IUCN guidelines (IUCN 2019). The estimate used in the assessment (~1596 km²) was calculated using species record data from the most recent 20 years (i.e. records from 2000–2019) and fits within the threshold values for the Vulnerable category under Criterion 2B2. The TSSC's standard approach is to use the most recent 20 years of record data, unless there is evidence that a different time period is more appropriate. As the species is not well surveyed across its entire range, a shorter time-frame was not considered appropriate. Conversely a longer time period was not used to calculate the most plausible estimate, as the species has a short generation length and considerable ongoing threats. Despite such, even if all available record data was used, the AOO estimate would be 1792 km², which remains consistent with the thresholds for the Vulnerable category.

The Golden Sun Moth is a wide-ranging species with many occurrence records, however, the data are not available to confirm the status (i.e. extant or extinct) of the species in all recorded

locations. In the ACT, a large number of records have been identified to be no longer extant due to recent development (EPSDD 2021. pers comm 23 February). Records within the ACT that were clearly no longer extant due to recent land clearing for development were removed for the purpose of calculating the AOO and resulted in a reduction of the species AOO a marginal amount. This is because extant records occur nearby and within the same grid cells, resulting in a reduction of site numbers but not AOO. This was not undertaken for records within NSW or Vic, however, is expected to have a similarly negligible impact on the AOO and would certainly not impact the category outcome of the assessment. While the species has undoubtedly been lost from a number of recorded locations, predominantly around Melbourne (and potentially others in the ACT) due to urban development, there are also extensive areas of potential habitat, particularly in NSW, which have not been surveyed for the species and their presence is unknown.

Therefore, the estimate used in this assessment is not considered to be an accurate figure but is considered to be the most plausible estimate based on available data and is suitable for the purpose of the assessment. Table 4 below sets out the AOO values estimated from the inclusion of record data dating back 20 years from 2019. Only the seven most recent years of record data (2012-2019) are necessary for the estimation of AOO to meet the lower Vulnerable threshold. This provides more confidence that even with the known loss of the species from many recorded sites, the AOO is still beyond the threshold for Endangered (<500 km^2), and undoubtedly beyond that of the listing category it was in at the time the current assessment commenced (Critically Endangered (<10 km^2)). It should also be made explicit, that the inclusion of records within all habitat (exotic and native) have been used in the assessment as guided by the IUCN. Records within Chilean Needlegrass habitat have been included as the species is known to be able to utilise and persist in this habitat.

Table 4 Golden Sun Moth AOO and EOO calculations using up to 20 years of record data (2000-2019)

Year(s) of record data	AOO (km^2)	EOO (km^2)
2019	80	24 692
2018-19	176	54 692
2017-19	200	54 692
2016-19	308	56 372
2015-19	412	119 422
2014-19	468	119 422
2013-19	512	120 554
2012-19	684	126 574
2011-19	872	132 324

2010-19	972	134 206
2009-2019	1228	145 282
2008-2019	1404	145 286
2007-2019	1436	145 322
2006-2019	1456	145 322
2005-2019	1472	145 322
2004-2019	1480	145 322
2003-2019	1492	145 322
2002-2019	1492	145 322
2001-2019	1492	145 322
2000-2019	1596	145 322

With respect to the most plausible estimate of AOO described above it is noteworthy that the species known range (EOO and AOO) has continued to grow from its initial discovery until now (Table 4). The most significant increases are observed following attention being drawn to the conservation position of the species and its subsequent listing under the EPBC Act in 2002. The increase in AOO observed since its listing has resulted from the increased survey effort due to conservation interest and requirements under the EPBC Act and relevant state and territory legislation, as well as increased knowledge on the species' habitat requirements and survey techniques. Since 2002, the AOO for the species based on all record data has increased by over 1300 km^2. New locations are frequently being identified and it is anticipated that in coming years, with continued survey, the knowledge of the species occupancy will continue to improve, providing a more accurate estimate of AOO based on record data.

The species distribution is considered to be severely fragmented due to the known subpopulations of the species occurring predominately in small, discrete sites (Gibson & New 2007; Richter et al. 2013b; EPSDD 2020), the limited dispersal ability of the species (Clarke & O'Dwyer 2000), and the remaining extent of native habitat across the species range (DAWE 2020). Genetic studies have suggested that the lack of genetic differentiation between closely located subpopulations may indicate recent fragmentation of historically connected subpopulations (Clarke & O'Dwyer 2000). The NSW/ACT subpopulations are thought to have derived from a small founding subpopulation that underwent rapid demographic expansion in ancient times. This was then followed by more recent population bottlenecks resulting from habitat fragmentation associated with the widespread introduction of agriculture into the region (Clarke & Whyte, 2003).

Many sites containing the Golden Sun Moth are on private lands that are generally not managed for conservation and some are under threat from development and agricultural expansion (Gilmore et al. 2008). All three jurisdictions (Vic, NSW, ACT) in which the species occurs, are

facing development pressures from various land uses, with current protection for the species mitigating some of the impacts. Further, invasion of weeds into native grassland is also considered to be a major threat to the species and habitats in which the species depend on Chilean Needlegrass may be lost from weed control. A complex issue as while the invasion of Chilean Needlegrass into native grasslands may lead to a decline in the quality of habitat, its removal may contribute to the decline in the area of habitat for the Golden Sun Moth where suitable native grasses do not persist/ occur. These threats are inferred to result in a continuing decline in the AOO (ii) and the area, extent and quality of habitat available (iii). As reductions in AOO and available habitat are inferred due to threats operating on the species, it is also considered likely that the number of subpopulations (iv), and the number of mature individuals (v) will also face ongoing declines.

The Committee considers that the species' AOO is limited (B2), its distribution is severely fragmented (a), and continuing decline (b) is inferred in the area of occupancy (ii), area, extent and/or quality of habitat (iii), number of locations or subpopulations (iv), and number of mature individuals (v). Therefore, the species has met the relevant elements of Criterion 2 to make it eligible for listing as Vulnerable.

Criterion 3 Population size and decline

	Critically Endangered Very low	Endangered Low	Vulnerable Limited
Estimated number of mature individuals	< 250	< 2,500	< 10,000
AND either (C1) or (C2) is true			
C1. An observed, estimated or projected continuing decline of at least (up to a max. of 100 years in future)	Very high rate 25% in 3 years or 1 generation (whichever is longer)	High rate 20% in 5 years or 2 generation (whichever is longer)	Substantial rate 10% in 10 years or 3 generations (whichever is longer)
C2. An observed, estimated, projected or inferred continuing decline AND its geographic distribution is precarious for its survival based on at least 1 of the following 3 conditions:			
(a) (i) Number of mature individuals in each subpopulation	≤ 50	≤ 250	≤ 1,000
(a) (ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals			

Criterion 3 evidence

Not eligible

The biology of the Golden Sun Moth creates difficulties in quantitative population assessments and comparisons of subpopulations (Gibson & New 2007). There is no robust estimate of the national population size for the Golden Sun Moth, however the number of mature individuals exceeds 10 000.

The Threatened Species Assessment undertaken by the Victorian Government in 2020 states the inferred number of mature individuals to be 13 500 within the state of Victoria. Mulvaney (2012) specifies a rough estimate of the total ACT population to be around 25 000 individuals based on maximum male moth counts from all ACT sites and a male to female moth ratio of 1.5 (Richter et al. 2009 cited in Mulvaney 2012). Discounting the population estimate by 31 percent[1], gives a rough estimate of at least 17 250 mature individuals in the ACT. There are no comprehensive monitoring or survey data to indicate population size in NSW. The estimate of

[1] It should be noted that pupal case surveys have indicated that a male biased sex ratio exists, with a mean of 1.9 (range: 0.6 to 3.5). Any future calculations of mature individuals should consider this information; and using the mean value, it would be appropriate for estimates of population size to be reduced by approximately 31 percent.

mature number of individuals in the ACT and Vic is therefore 30 750, and without an estimate for NSW, still exceeds any thresholds for eligibly under Criterion 3.

The total number of mature individuals is greater than 10 000 which exceeds the threshold for listing under Criterion 3. Therefore, the species has not met this required element of this criterion.

Criterion 4 Number of mature individuals

	Critically Endangered Extremely low	Endangered Very Low	Vulnerable Low
D. Number of mature individuals	< 50	< 250	< 1,000
D2.[1] *Only applies to the Vulnerable category* Restricted area of occupancy or number of locations with a plausible future threat that could drive the species to critically endangered or Extinct in a very short time			D2. Typically: area of occupancy < 20 km² or number of locations ≤ 5

[1] The IUCN Red List Criterion D allows for species to be listed as Vulnerable under Criterion D2. The corresponding Criterion 4 in the EPBC Regulations does not currently include the provision for listing a species under D2. As such, a species cannot currently be listed under the EPBC Act under Criterion D2 only. However, assessments may include information relevant to D2. This information will not be considered by the Committee in making its recommendation of the species' eligibility for listing under the EPBC Act, but may assist other jurisdictions to adopt the assessment outcome under the *common assessment method*.

Criterion 4 evidence

Not eligible

There is no robust estimate of population size or number of mature individuals for the Golden Sun Moth. However, as per the evidence above under Criterion 3, the number of mature individuals exceeds 1000. Therefore, the species has not met this required element of this criterion. Additionally, the Golden Sun Moth does not meet the quantitative threshold for Vulnerable under sub-criterion D2.

Criterion 5 Quantitative analysis

	Critically Endangered Immediate future	Endangered Near future	Vulnerable Medium-term future
Indicating the probability of extinction in the wild to be:	≥ 50% in 10 years or 3 generations, whichever is longer (100 years max.)	≥ 20% in 20 years or 5 generations, whichever is longer (100 years max.)	≥ 10% in 100 years

Criterion 5 evidence

Insufficient data to determine eligibility

A population viability analysis has not been undertaken. Therefore, there is insufficient information to determine the eligibility of the species for listing in any category under this Criterion.

Adequacy of survey

The survey effort has been considered adequate and there is sufficient scientific evidence to support the assessment.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 34 business days between 5 January 2021 and 23 February 2021.

Listing and Recovery Plan Recommendations

The Threatened Species Scientific Committee recommends:

(i) that the list referred to in section 178 of the EPBC Act be amended by transferring *Synemon plana* from the Critically Endangered category to the Vulnerable category.

(ii) that there not be a recovery plan for this species.