Australian Capital Territory

Nature Conservation (Key's Matchstick Grasshopper) Conservation Advice 2023

Notifiable instrument NI2023–222

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 (Key's Matchstick Grasshopper) Conservation Advice 2023*.

2 Commencement

This instrument commences on the day after its notification day.

3 Conservation advice for Key's Matchstick Grasshopper

Schedule 1 sets out the conservation advice for Key's Matchstick Grasshopper (*Keyacris scurra*).

Arthur Georges
Chair, Scientific Committee
14 April 2023

Schedule 1

(see s 3)

CONSERVATION ADVICE

KEY'S MATCHSTICK GRASSHOPPER – *Keyacris scurra*

CONSERVATION STATUS

The species *Keyacris scurra* (Rehn 1952) is recognised as threatened in the following jurisdictions:

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

ELIGIBILITY

The Key's Matchstick Grasshopper is listed as Endangered in the ACT Threatened Native Species List under Criterion B – B2ab(ii,iii,iv,v)c(iv) primarily due to a restricted geographical range at the national level (Attachment A). Other supporting factors include severe fragmentation; historical and inferred ongoing decline across the entire distribution in abundance (25.4% over the last ten years), habitat availability and quality; and ongoing threats including poorly understood management requirements (NSW Threatened Species Scientific Committee (NSW TSSC) 2020).

DESCRIPTION AND ECOLOGY

The Key's Matchstick Grasshopper is a very small (18–25 mm), wingless, morabine grasshopper, found in native grasslands, particularly Natural Temperate Grassland. Individuals are most often greyish brown in colour, although colour morphs may vary with habitat through to bright green (Farrow 2018). They have a characteristic slanted face with short sword like antennae. Adults are similar in appearance to Giant Green Slantface (*Acrida conica*) nymphs, however, may be distinguished by the lack of wing buds at all life stages. The Key's Matchstick Grasshopper is more active in the evening, climbing onto grasses (Farrow 2018). As it is flightless, it does not move more than about 200–300 m over the course of its lifetime (Key 1987).

Key's Matchstick Grasshopper (Hannah Zurcher – EPSDD)

The Key's Matchstick Grasshopper lays eggs at the beginning of summer, that hatch between December and January. Males mature by May, however females overwinter as nymphs and mating occurs from September through to the end of November. Eggs are laid in soil (Rowell and

Crawford 1995), and clutches have low fecundity with an average of 25 eggs per female (White 1977). It is probable that Kangaroo Grass (*Themeda triandra*) is the main host plant that provides protection from predators (White 1956), especially during reproduction. Generation length is one year as adults die after eggs are laid.

Key's Matchstick Grasshopper is herbivorous and feeds on a range of native and exotic species, preferring smaller ephemeral plants (particularly Asteraceae) but will consume larger perennial species if the former are not available (Blackith and Blackith 1966) but does not feed on Kangaroo Grass. There may be differences in diet between adults and nymphs (Unsicker et al. 2008). While this might explain the range of plant life in the sites in which it is found, it is also likely that a diversity of suboptimal food plants confers significant survival advantages (Miura and Ohsaki 2004).

Although no work has been undertaken to identify predators of the Key's Matchstick Grasshopper, parasitic wasps (*Scelio* spp.) in south-eastern Australia have been shown to regulate some populations of acridid grasshoppers (Baker et al. 1996). Morabine grasshoppers are known to be parasitised by Braconidae (Blackith 1967a). There is also the possibility of parasitism by tachinid species such as *Myothyria fergusoni*, although this is often highly variable (Blackith 1967b). Predators of the Key's Matchstick Grasshopper are likely to include birds, such as magpies (*Cracticus tibicen*) (Calver 1985) and the local Wolf Spiders (specifically *Lycosa godeffroyi*), which are known to eat other ACT grassland grasshoppers (A. Rowell pers. obs. 2016).

There are two different chromosomal races of the Key's Matchstick Grasshopper, but there is a reasonable amount of genetic diversity within larger populations (those with available habitat 100–500 m from the survey site). In smaller populations (those restricted to much smaller patches of un-mowed land, with limited habitat outside 50 m from the survey site), there is a high degree of inbreeding. Separate populations across the range of the species do not exhibit a great amount of gene flow. The genetic diversity of populations is not related to habitat availability or quality (Hoffman 2021).

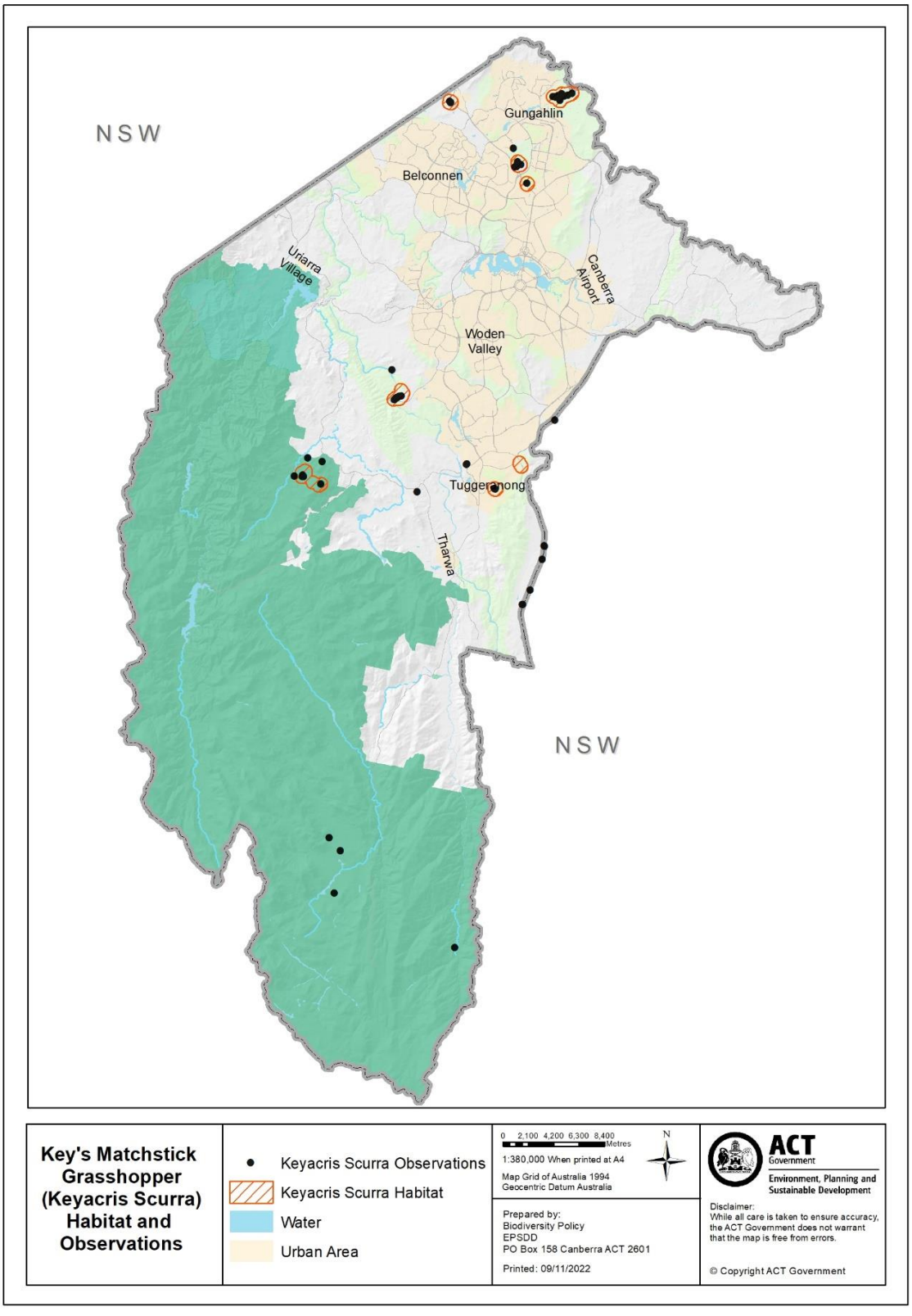
DISTRIBUTION AND HABITAT

The Morabinae are an endemic Australian grasshopper subfamily, with members found across the whole range of rainfall and temperature in Australia (Key 1987). The historic distribution of Key's Matchstick Grasshopper, as with many other Kangaroo Grass associated grassland species, ranged from central-west NSW to northern Victoria (NSW TSSC 2020). Based on all records available for the period 2009–2019 the Area of Occupancy (AOO) is 124 km^2 nationally (using a 2x2 km grid cell). The current distribution of Key's Matchstick Grasshopper has similarly contracted with the significant loss of Kangaroo Grass dominated Natural Temperate Grassland. Current known locations of the Key's Matchstick Grasshopper outside the ACT include Bungendore, Cooma in NSW and Omeo in Victoria (Hoffmann et al. 2021).

Sites known to host current populations of Key's Matchstick Grasshopper in the ACT include Gibraltar Saddle in Namadgi National Park, Mulligans Flat, Hall Cemetery, and Kambah Pool (NSW TSSC 2020, Hoffmann et al. 2021). The Key's Matchstick Grasshopper has also been recorded in the ACT at Gungahlin, Kaleen, Crace Grasslands, Kaleen, Murrumbidgee River, Tuggeranong Hill, Paddys River, Tidbinbilla and Royalla (Canberra.naturemapr.org 2021). Sightings have recently occurred for the first time at the Lawson grasslands (E. Cook pers. comm.). The distribution of the species in the ACT is shown in Map 1.

While the Key's Matchstick Grasshopper is often found in grassland dominated by Kangaroo Grass (White 1956), it is also found in locations dominated by other native grass species. Occupation of habitats dominated by species of grass other than Kangaroo Grass may be a result of range fragmentation, or the species' adaptation to cooler temperatures. The restriction of the species to relatively small areas may be because of habitat preference or interactions with other species (Key 1987).

Map 1: Distribution of Key's Matchstick Grasshopper records and habitat in the ACT



The Key's Matchstick Grasshopper has been found on a range of native and introduced plants (Blackith and Blackith, 1966). Native plants include Early Nancy (*Wurmbea dioica*), Golden Lily (*Bulbine bulbosa*), Red Beard Orchid (*Calochilus paludosus*), Australian Buttercup (*Ranunculus lappaceus*), Sheep's Burr (*Acaena ovina*), Small Poranthera (*Poranthera microphylla*), Creamy Candles (*Stackhousia monogyna*), Guinea Flower (*Hibbertia sericea*), Common Everlasting (*Chrysocephalum apiculatum*), Rough Everlasting (*Ozothamnus retusus*), Showy Copper-wire Daisy (*Podolepis jaceoides*) and Billy Buttons (*Craspedia variabilis*).

Introduced food plants include common pasture and weeds, such as Silver hairgrass (*Aira caryophyllea*), dock/sorrel (*Rumex* spp.), clover (*Trifolium* spp.), Vervain (*Salvia verbenaca*), Great Mullein (*Verbascum thapsus*) and Lavender (*Lavandula stoechas*) (Blackith and Blackith, 1966).

THREATS

The Key's Matchstick Grasshopper is known primarily from areas of Natural Temperate Grassland, a Critically Endangered ecological community under the *Nature Conservation Act 2014* (NC Act). The main threats include:

- habitat loss of Natural Temperate Grassland
- habitat degradation of native plant species through inappropriate management strategies that reduce grassland structure or allow colonisation of native grasslands by exotic plant species
- habitat fragmentation compounded by the flightless nature of adults that restricts movement between fragments and recolonisation
- inappropriate large-scale fire regimes in autumn/winter that may endanger nymphs
- climate change effects combined with the species' limited mobility makes it less able to adapt by moving to accommodate habitat change.

The Key's Matchstick Grasshopper is threatened by inappropriate management of vegetation, further complicated by potential competition between necessary habitat and feed species. While it appears that Kangaroo Grass is necessary for some aspect of their life cycle, their dietary preferences are overwhelmingly for forbs, and Kangaroo Grass-dominated grassland can crowd out the herbaceous plants on which they feed. Their restriction to cemeteries and other minimally maintained land such as railway cuttings suggests that, regardless of dietary preferences, the Key's Matchstick Grasshopper is threatened by frequent mowing and extensive maintenance regimes. Similarly, weed invasion may also crowd out their food or breeding plants.

Eggs are vulnerable to increased summer temperatures, and an unexpectedly intense localised grass fire event may pose a significant threat to populations as well as disrupting habitat. Changes in temperature may also impact life stage cues (White 2018). Increases in humidity may reduce the success rate of moulting and lead to increased mortality (White 2018).

The Key's Matchstick Grasshopper is currently only extant in fragmented areas of remnant grassland within the ACT. This heightens the risk of population loss or collapse due to a single threatening event. While inbreeding rates do not limit heterozygosity except for in exceptionally small populations (Hoffmann et al. 2021), changes to environment or populations could easily reduce population sizes.

MAJOR CONSERVATION OBJECTIVE

The priority management objective is to maintain in the long term, viable, wild populations of the Key's Matchstick Grasshopper as a component of the indigenous biological resources of the ACT and region.

CONSERVATION PRIORITIES

The long-term conservation of the Key's Matchstick Grasshopper depends on protecting its native grassy habitat. Conservation priorities should include to:

- conserve important ACT populations such as the populations at Mulligans Flat and Hall Cemetery
- manage the species and its habitat to maintain the potential for evolutionary development in the wild, particularly through:
    - avoiding overgrazing of Kangaroo Grass during drought
    - avoiding or at least reducing controlled burns during at-risk life stages
    - fencing suitable habitat and not regularly mowing, especially at cemetery sites
    - removing weeds
- enhance the long-term viability of populations through management of adjacent grassland to increase habitat area and connect populations
- promote awareness of the species in grassland monitoring programs to inform possible targeted surveys and encourage the recording of all sightings on Canberra Nature Map
- add the species to the list of threatened species included in the Natural Temperate Grassland Action Plan (ACT Government 2017b)
- collaborate with research institutions and non-government organisations to encourage citizen science, volunteering and knowledge exchange with the Ngunnawal community
- 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 Native Grassland Conservation Strategy (ACT Government 2017a)
- ACT Natural Temperate Grassland Action Plan (ACT Government 2017b)
- NSW Conservation Assessment – Key's Matchstick Grasshopper (NSW TSSC 2020)

LISTING BACKGROUND

The Key's Matchstick Grasshopper is listed as an Endangered species under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), effective 10 October 2022, under Criterion 2 B2ab(ii,iii,iv,v)c(iv). In 2023, the ACT Scientific Committee recommended the Key's Matchstick Grasshopper be listed in the Endangered 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 not have an action plan for the species in the ACT under the *Nature Conservation Act 2014* at this time. As a listed threatened species the Key's Matchstick Grasshopper is managed under the Natural Temperate Grassland Action Plan (ACT Government 2017b) with a key objective of this plan to conserve biodiversity, including by maintaining and improving

threatened species habitat structure. The species should be added to the list of threatened species included in this Action 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/

Assessment against IUCN Red List criteria

For this assessment is it considered that the survey of *Keyacris scurra* has been adequate and there is sufficient scientific evidence to support the listing outcome.

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 A Population Size reduction

Assessment Outcome: Vulnerable A2

Justification: Available evidence indicates this species is in decline and has declined historically with declines starting following European clearing and grazing. The clearest evidence of decline is measured by localised extinctions (when surveyed in 2019 as reported by M Kearney *in litt.* Dec 2019) at study sites used by White in the 1950s and 1960s and others which has resulted in a reduction of geographic range over time. The 2019 surveys resulted in the detection of *K. scurra* at 11 of 62 known sites (sites documented by White or others in the 1950s and 1960s), and at all sites (except Murrumbateman, which was survey 5 times without a positive detection) where they were not detected, suitable habitat (tall *Themeda* grass) was completely absent, hence localised extinction in these cases is highly probable. This represents a mean decadal rate of decline of 25.4% (using an exponential rate of decline and using 1960 as the start point and 2019 as the end point with the number of sites used as a coarse index of abundance). The period used for this estimate is 1960 to 2019, however the IUCN (2017) method requires assessment over a ten year period (or three generation, whichever is longer) so rate of decline are express as decadal rates of decline. This decline estimate relies on using localised extinctions to measure decline. As there is evidence that both the abundance at known sites and geographic range is also declining the true rate of decline could feasibly be higher as not all populations were the same size and some extant population may now be considerably smaller. The decline in AOO was therefore also considered (see tables 1a,b,c below), and while these declines were also generally less severe than 30% over a ten year period (the threshold for vulnerable under this clause) when biases in the method are considered it is reasonable to assume that a 30% decline in AOO has occurred in the recent past. Based on available records the AOO has apparently contracted at a rate of 27.1% over a ten year period between 1960 and 2019 and at a rate of 39% between 1960 and 1995. This precautionary assessment does not alter overall assessment outcome as this species was found to be Endangered in Clause B, a higher threat category than in this clause.

Declines 1820 to 1950

The rate of decline from 1820 to 1950 was estimated by White (1956) to be equivalent to around 25% per ten-year period (using an exponential rate of decline calculated over a ten year period as per IUCN recommendations), however this was a very coarse estimate and as such is of limit utility. White (1956) speculated that "the natural distribution of the species 130 years ago resembled a jigsaw puzzle from which a half or two-thirds of the pieces have been removed, but was to a large extent continuous except for the mountains". By the 1950s White (1956) considered that the proportion of the landscape occupied by this species had been reduced from about 40% total landscape cover (prior to 1820) to about 1% of the landscape. Decline in the distribution of *Keyacris scurra* prior to the 1950's was driven by the clearing of suitable habitat coupled with the grazing of native grasslands by exotic herbivores (and associated pasture improvement, see Reed 2014). These changes occurred over multiple decades, a long period relative to the short generation length of this species (1 year). Assuming the estimated decline in the total area occupied occurred over 13 decades, then the average 10 year exponential rate of decline from 40%

landscape cover to 1% landscape cover was approximately 25% (although this is a very coarse estimate). However, if this rate of decline continued from 1950 it would have resulted in the total extinction of the species by about 1980, which did not occur as the remaining refugia (e.g. cemeteries) were not exposed to the same threats present in the wider landscape.

Declines in AOO

The AOO has apparently contracted at a mean decadal rate of 27.1% between 1960 and 2019 and at a rate of 39% between 1960 and 1995. The apparent reduction in the rate of decline in the 1960 to 2019 period (compared with the 1960 to 199 period) is likely to be an artefact of the timing and location of surveys. The modest declines in EOO and AOO (9.1 and 9.7%, respectively) from 1995 to the present are also probably an under-estimate as surveys covered a much larger area in 2019 (survey occurring in VIC, NSW and ACT) compared with 1995 survey which were focused on the ACT and a few NSW sites. An additional bias is that any site found in 2019 was also assumed to have been occupied in 1995 further compounding temporal survey bias. A precautionary approach is taken here which assumes that decline exceeding 30% in AOO over a ten year period is likely to have occurred in recent times. The approach taken which is based directly on local extinctions assumes that remaining populations have been stable and that all population were of the same size. For instance, Wombat Cemetery may have once contained 10,000 animals (according to White 1957) and recent surveys did not detect this species on the site and no habitat remained on the cemetery itself (M Kearney *in litt.* Dec 2019). Given the threats (e.g. mowing), some local declines in abundance may have occurred and these estimates therefore represent the lower bound of estimated decline in the number of mature individuals as both the number of sites and the abundance with it site is likely to be declining.

The estimated average decadal decline between 1960 and 2019 (as the generation length is one year, the 10 year period applies) is 27.1% in AOO and 17.1% in EOO (Table 1b). These estimates assume the species occupied 800 2 km x 2 km grid squares in 1960 as indicated by records from the literature, databases and researchers. All available records were used in the baseline period, this included recent records which were assumed to have been present but undetected in the 1950-1960s baseline period. This assumption is based on the limited dispersal ability of this grasshopper and the heavily fragmented nature of the habitat. This approach creates a bias where more survey effort was expended to establish the baseline, however when viewed in conjunction with resurveys of known sites (in 2019 *K. scurra* was found to be locally extinct at 51 of 62 known sites) it is clear the species is declining. Note also that the estimation of decline over decadal periods requires an assumption that clearing/ grazing/ burning occurred at a steady rate throughout the period 1950 to present, which is unlikely to be true. It is also possible (and indeed likely) that local extinctions are not random and if, for instance, are linked to drought, the decadal rate of decline would be much higher than the average rate during drought events.

Table 1 (a,b,c) Decline in geographic range between 1960, 1995 and 2019 and the AOO and EOO for each time period. A constant exponential rate of decline is used and the rate is calculated over a 10-year period following IUCN guidelines. *indicate probable underestimate due to uneven survey effort over time (survey intensity was high in 1950/1960s, moderate in 1995 and high again in 2019. In the intervening periods there was almost no survey performed).

Table 1a

	1960	**1995**	**Average % Change over 10 year period**
AOO ($km^{2)}$	800	156	-39.0%
EOO ($km^{2)}$	98,922	41,912	-21.8%

Table 1b 1960 to 2019

	1960	**2019**	**Average % Change over 10 year period**
AOO ($km^{2)}$	800	124	-27.1%
EOO ($km^{2)}$	98,922	32,809	-17.1%

Table 1c 1995 to 2019

	1995	**2019**	**Average % Change over 10 year period**
AOO ($km^{2)}$	156	124	-9.1%*
EOO ($km^{2)}$	41,912	32,809	-9.7%*

Criterion B Geographic range

Assessment Outcome: Endangered under Criterion B2ab(ii,iii,iv,v)c(iv)

- Justification: The number of known sites currently (using records from 2009- 2019) occupied indicates that the AOO is 124 km^2 (based on a 2 km x2 km grid) and extent of occurrence EOO is 32,809 km^2. Based on all available records the AOO in the 1950s is estimated to have been 800 km^2 (below the threshold for Vulnerable). In 1995 the AOO was estimated to have been 156km^2. Further survey will refine this estimate, however the AOO is not considered likely to exceed the upper threshold for Endangered (500 km^2) based on the availability of suitable habitat. Surveys in 2019 covered a large proportion of the known sites and also surveyed other suitable sites across the range of this species and the AOO for the 2009-2019 period is considered to be an accurate representation of the true distribution. Additionally, surveys by White and others were relatively intense (compared to other invertebrates) in the 1950s and 1960s. In recent times other surveyors were aware of this species and surveying suitable habitat, but the species was recorded infrequently, for instance Friends of Grasslands (G Robertson *in litt.* June 2019) reported the following "FOG member, Rainer Rehwinkel, working with the NSW environment departments (NPWS, DECC, OEH, etc.) in surveys over a 20 year period in grasslands and grassy woodlands in south east NSW, found populations of this species at less than 10 sites, during c. 7500 site visits during that time. Those data are in the Grassy Ecosystems Database (GEDB), which is lodged in NSW Bionet and the Atlas of Living Australia". The Friends of Grasslands submission also noted that "Alison Rowell agrees that local sightings are rare now compared to the 1990s".

In addition to these thresholds, at least two of three other conditions must be met. These conditions are:

a) The population or habitat is observed or inferred to be severely fragmented or there is 1 (CR), ≤5 (EN) or ≤10 (VU) locations.

Assessment Outcome: Severely fragmented (>10 locations)

Justification: this species and its habitat is severely fragmented (over 50% of the AOO corresponds to locations with a very high risk of a single disturbance event leading to localised extinction). The number of confirmed populations detected within the last 10 years is >10. Known populations are isolated, typically small, vulnerable to extinction from a single poorly timed disturbance event and this species has a limited dispersal ability. Therefore, there is very low likelihood of migration between isolated habitat patches.

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

Assessment Outcome: Continuing decline is inferred in all categories (i – v)

Justification: There is evidence that the number of sites is reducing over time and that habitat quality is declining. This leads to a reduction in geographic range and total abundance. The lack of information on how to manage the habitat of *Keyacris scurra* means that even in conservation reserves habitat quality may be in decline.

Extreme fluctuations.

Assessment Outcome: Extreme fluctuations are likely to occur (R. Farrow *in litt.* June 2018)

Justification: As a short-lived species with non-overlapping generations, the population each year is dependent on the conditions in years' previous (although this species is not a prolific breeder like many grasshoppers that fluctuate over many orders of magnitude). It is therefore plausible that the number of mature individuals would be expected to vary within a range of 1-2 orders of magnitude between years. The geographic range does not fluctuate due to the very low vagility (mobility) of this species.

		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 C Small population size and decline
Assessment Outcome: Near Threatened
Justification: Ongoing decline has been established under Clause A and B and extreme fluctuations occur. A comprehensive population estimate has not been undertaken in recent times. Recent surveys have detected a total of 376 animals (of any sex) which forms the lower bound of the population estimate (although this is considered to be an underestimate). It is not possible under this clause for a Critically Endangered outcome (as the population exceeds 250), and under Clause B this species is already considered Endangered based on distribution so while the data are uncertain, further work to refine the abundance estimate will not lead to an increased threat status under this clause.

Population density is difficult to measure or estimate in such species (Farrow *in litt.* July 2018). It is a cryptic species and, like most Morabines, is probably more active at night when it ascends the vegetation to feed. More intense surveys in known sites are likely to increase this population estimate, plausibly to above the threshold for endangered (2,500) or vulnerable (10,000). It is also very likely that further surveys will increase the number of total populations as recent targeted surveys have detected this species at 12 out of 30 new survey sites (survey result from M Kearney *in litt.* 2019) and it is expected new sites will continue to be found. It should be noted that targeted surveys looking for new sites have been undertaken in the best quality habitat which is limited in supply and the discovery of new sites is not expected to continue at the same rate with further survey. Historical estimates (see below) indicate that a single site could contain over 10,000 animals (with sites often containing 1000s of animals) and the life history strategy (r-selected) used by most invertebrates favours a relatively high abundance, with considerable year to year variation, however it is the lower end of these variations that should be considered under this clause. Recent declines due to threats may also mean that the abundances recorded historically may no longer be applicable, however there are a few large sites on conservations reserves that are expected to yield high numbers of this species based on the size of the reserves and the amount of available habitat.

Population estimates in the 1950s (VIC, NSW, ACT) and in 1995 (ACT survey only based on seven sites and excludes NSW and VIC sites) are informative. White, across multiple sites, destructively sampled 4,227 males (i.e. the total population including females was at least 8,450) in 1955 (White 1956). In 1955/56 White (1963) destructively sampled at least 7,830 males from 55 sites, with the minimum harvest at a site of three, the maximum recorded 1,377 and the average 142. White *et al.* (1963) destructively sampled 6,085 males from 15 sites between 1958 and 1961 (most sites were visited once with "Wombat" visited twice 1958 and 1959). The White (1957) estimate included a figure from the "Wombat" site of 1,000 individuals, but the text notes this site could have contained 10,000 individuals (so this estimate and the estimates above are a minimum). White *et al.* (1963) sampled a total of 11,142 males from eight intensively studied sites, probably selected for their large size, over the period 1955-1961 with most sites studied for up to four years. White also found 1,647 animals present at Murrumbateman (this site was studied intensively) and this species now appear to be extinct at this location. The total population in the 1950s vastly exceeded 10,000 mature individuals as these estimates do not include females.

Rowell and Crawford (1995) estimated that in seven sites in the ACT the population was >3,830 (of both sexes) and this is only a subset of known sites. The effective population size is also a consideration, Rowell and Crawford (1995) stated that "*K. scurra* now typically occurs as 'colonies', on the grounds that, in some of the larger units encountered, the genetically effective population size would have been smaller than the total number of individuals present, due to the low mobility of the species (e.g. the Wombat Cemetery colony with up to 10,000 individuals in 1956). [note: The Wombat Cemetery no longer contains habitat although there is roadside habitat adjacent that appears suitable, however this species was not found in this location in 2019 (M Kearney *in litt.* 2019).] He [White] regarded a colony of 1,000 as large, and considered that some of the smaller cemetery colonies, containing fewer than 50 individuals per generation, had persisted in isolation from other populations for well over 50 years by 1957."

At least one of two additional conditions must be met. These are:

C1. An observed, estimated or projected continuing decline of at least: 25% in 3 years or 1 generation (whichever is longer) (CE); 20% in 5 years or 2 generations (whichever is longer) (EN); or 10% in 10 years or 3 generations (whichever is longer) (VU).

Assessment Outcome: sub-clause met for Endangered (although as C above is only Near threatened this is not applicable)

Justification: The AOO rate of reduction between 1960 and 1995 was calculated using available records at 20.8% for a 5 year period (using the RAMAS program). The rate of decline appears to have slowed down however in the absence of other data and due to the uneven survey effort over time this estimate is very approximate. Also see clause A above.

C2. An observed, estimated, projected or inferred continuing decline in number of mature individuals.

Assessment Outcome: continuing decline inferred

Justification: See clause A above

In addition, at least 1 of the following 3 conditions:

a (i). Number of mature individuals in each subpopulation ≤50 (CR); ≤250 (EN) or ≤1000 (VU).

Assessment Outcome: unknown

Justification: Recent surveys have detected a total of 376 animals across 23 sites (of any sex) with 100 detected at one site, however these surveys were not designed to estimate total population and are therefore minimum estimates. Historical estimates indicate that at a small proportion of known sites the population exceeded 1000. For instance, In the ACT, Rowell and Crawford (1995) found that there were "470 at Mulligans Flat (RC64,65) and 1330 at NTA/Gungahlin" (RC16)". Kambah Pool (RC41) contained a large population which was fragmented and dispersed over 14 ha containing 2 plant communities. In the 1950's three sites had more than 1000 individuals removed (and the total population was larger by an unknown amount as only males were removed): Hall (1377), Royalla A (1325) and Wombat (1000). White *et al.* (1963) using data from 1955-1961 estimated that 6 sites had more than 1000 individuals each, these were: Tarago Swamp (1219), Wombat (2363), Hall (1377), Royalla (1682), Murrumbateman (1647, now apparently extinct, Hoffman and Kearney 2018) and Michelago (1811).

The only other known population estimate for an ACT site is that '2000 adults could occur under optimum conditions' at the Gibraltar Rocks Saddle site (K Key, in Greenslade 1991, unpublished) and the population outside of optimal conditions is not known. It is likely but unconfirmed that at least one population exceeding 1000 animals persists. Many of the populations are very small (<50) so factors such as bottle necking, genetic drift and isolation may lead to low genetic variability and the effective population size at these larger sites may therefore be considered to be below 1000 (although this requires further genetic research).

A (ii). Percentage of mature individuals in one subpopulation is 90-100% (CR); 95-100% (EN) or 100% (VU)

Assessment Outcome: clause not met

Justification: There are 31 AOO squares currently occupied. Given the spacing of these records there are assumed to be at least 31 sub-populations. It is unlikely that a single sub-population would contain more than 90% of all mature individuals.

b. Extreme fluctuations in the number of mature individuals

Assessment Outcome: Extreme fluctuations are likely to occur

		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
	(ii) % of mature individuals in one subpopulation =	90 – 100%	95 – 100%	100%
(b) Extreme fluctuations in the number of mature individuals				

Criterion D Very small or restricted population
Assessment Outcome: Least concern
Justification: Population suspected to exceed 1000, although there is no accurate population estimate. See Clause C for more details.

To be listed as Vulnerable under D, a species must meet at least one of the two following conditions:

D1. Population size estimated to number fewer than 1,000 mature individuals

Assessment Outcome: Least concern

Justification: There is no accurate population estimate, however present information indicates at least 376 animals are known to exist and it assumed the total population exceeds 1000 when individuals present but not detected at surveys sites and individuals at sites not yet surveyed are included (although the upper bound of the population estimate has not been established). The ability to recover from drought is not understood. Further surveys following drought are required to increase certainty of population estimates. See Clause C for more details.

D2. Restricted area of occupancy (typically <20 km^2) or number of locations (typically <5) with a plausible future threat that could drive the taxon to CR or EX in a very short time.

Assessment Outcome: Sub clause not met

Justification: There are >5 locations with current records and the AOO greatly exceeds 20 km^2.

	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 km^2 or number of locations ≤ 5

Criterion E Quantitative Analysis
Assessment Outcome: Data Deficient
Justification: Population viability analysis not performed.

	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