

The following file contains two documents for the listed taxon:

- 1) Federal Conservation Advice¹
and
- 2) Victorian Threatened Species Assessment²

This taxon is listed under the *Flora and Fauna Guarantee Act 1988* (FFG Act), and uses the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) conservation status.

The Threatened Species Assessment Report is the outcome from the bulk assessment process held between 2018 and 2021, and documents the Victorian conservation status, listing criteria and the reasons for satisfying those criteria. All these assessments were conducted in accordance with the national Common Assessment Method ([CAM](#)).

The EPBC conservation advice is the report of the national assessment under the EPBC Act, also conducted in accordance with the CAM.

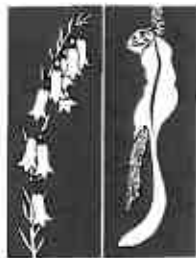
Both documents help inform the threats and management actions relevant to the species in Victoria.

Under the CAM, Victoria adopts the conservation category and extinction risk for all taxa that have been assessed as nationally threatened, and listed under the EPBC Act. Over time, this alignment at the state and national level will lead to a Single Operational List (SOL) – a list where all FFG-listed taxa have the EPBC status, if that status has been applied in accordance with the CAM.

However, we do not yet have a SOL, because many EPBC taxa (mostly prior to 2014) are not compliant with the CAM (i.e., are 'legacy' taxa), and there will be inconsistencies between the FFG and EPBC lists until these legacy taxa are re-assessed.

¹National assessment under the national *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

² Victorian assessment under the *Flora and Fauna Guarantee Act 1988* (FFG Act).



FLORA & FAUNA

GUARANTEE

FLORA AND FAUNA GUARANTEE - SCIENTIFIC ADVISORY COMMITTEE

FINAL RECOMMENDATION ON A NOMINATION FOR LISTING

Keyacris scurra Rehn 1952 - Matchstick Grasshopper

Date of receipt of nomination: 25 September 2017

File No.: FF/54/3784

Date of preliminary recommendation: 4 December 2017

Date of final recommendation: 12 February 2018

Validity: The nomination is for a valid item.

Prescribed Information: The prescribed information was provided.

Name of the Nominator is adequately provided.

Name of the item is adequately provided.

The nominated taxon is accepted by the Scientific Advisory Committee (SAC) as a valid taxon because it has been formally described and it is accepted as a valid taxon by Museum Victoria.

Keyacris (formerly *Moraba*) *scurra* (Rehn 1952) is a morabine grasshopper. The morabines fall into a family of grasshoppers that is uniquely Australian. Grasshoppers in this group are flightless and have a characteristic matchstick-like appearance. The morabines consist of 250 species and 40 genera, and have been recorded from across Australia. The habitats they occur in include a range of heath, grassland, tree and shrub types. *Keyacris* was named after entomologist Ken Key, and studied by the eminent Australian geneticist and evolutionary biologist Michael White (1956). The group was used by White to develop a model of speciation where chromosomal differences among races drive the speciation process (see references).

The species is confined to habitats of a special type in which the tall perennial grass *Themeda australis* usually predominates. This, however, is not eaten by the insect, but may be important in other ways (e.g. by providing protection from predators)(White 1956). In captivity the species feeds on native daisies which are also present in the grasslands and probably constitute its main food plant. White (op. cit.) noted that "Suitable habitats occur in grassland, savannah woodland country and on the ecotones between this and both 'dry' and 'wet' sclerophyll forest."

Mulvaney (2012) noted that the species was once common in grasslands and grassy woodlands in south-eastern Australia, but is sensitive to habitat modification by sheep and cattle grazing and is now uncommon in the ACT region.

Eligibility for listing as a taxon under the Flora and Fauna Guarantee

The nominated item satisfies at least one criterion of the set of criteria prepared and maintained under Section 11 of the *Flora and Fauna Guarantee Act 1988*, and stated in Schedule 1 of the *Flora and Fauna Guarantee Regulations 2011*.

Based on the evidence that the Matchstick Grasshopper has declined in range and abundance to the point of extinction in Victoria, and that the processes thought to be responsible still exist and are likely to continue, the SAC believes the nomination meets the following Flora and Fauna Guarantee listing criteria:

Evidence that criteria are satisfied:

Criterion 1.1 *The taxon is in a demonstrable state of decline which is likely to result in extinction*

Evidence:

Keyacris scurra occurs within one of the most modified regions of Australia where almost no original habitat remains. The species has very limited dispersal ability due to its flightless habit. The main threat currently is the way in which vegetation around cemeteries is now being managed (i.e. cemeteries are now managed by repeated mowing close to ground level which destroys the habitat of *K. scurra*).

Sub-criterion 1.1.1 *The taxon is known to have occurred in Victoria after European settlement but has not been sighted in Victoria for 40 years*

Evidence:

The Matchstick Grasshopper originally occurred in northern Victoria in the wheat/grazing belt. It was also found in the wheat/grazing belt of NSW from the border to Goulburn. White (1956) noted that *Keyacris scurra* was already threatened in 1956 when he indicated that their occurrence was limited to "relatively minute 'islands'" in the general area of the species potential range. Many of these "ecological islands" are the cemeteries of small human

communities, i.e. areas of one to several acres which have been fenced for many years to exclude grazing animals, and hence retain much of the native vegetation that has largely disappeared from the heavily grazed land outside". The species may now be locally extinct in Victoria despite previously being very widespread. In a recent survey in NSW the species was only found in one site from 8 listed by White (1956) (additional expert advice). New (2011) noted that a number of Morabine grasshopper species have been lost in Australia following changes in native vegetation composition as a result of grazing by introduced herbivores.

Sub-criterion 1.2.1 *The taxon is very rare in terms of abundance or distribution.*

Evidence

It is likely that most *Themeda* patches in cemeteries have now been destroyed or severely reduced. The species was already confined to a few cemetery sites in 1956 and is now extremely rare. Recent surveys for the species indicated that populations in cemeteries such as at Murrumbateman (NSW) and Wodonga (Vic), which were studied previously, no longer support populations (additional expert advice). New (2011) also noted that the species *K. scurra* is either extinct in Victoria or confined to one or two patches of suitable habitat at unknown locations in the state.

Sub-criterion 1.2.3 *The reproduction or recruitment of the taxon has seriously declined or is not occurring.*

Evidence

Many morabine grasshoppers are known to have very low reproduction. New (2011) noted that a number of species produce only around 20 eggs over a lifetime. It is likely that *Keyacris scurra* also has low reproduction rates.

The data presented on distribution and abundance are the result of reasonable surveys and provide clear evidence that the taxon is rare in terms of abundance and distribution.

Further information

Mulvaney (2012) made the following comments on the species for populations in the ACT

- In Gungahlin it has been recorded at the National Transmission Authority land at Crace, Mulligans Flat Nature Reserve and Crace Nature Reserve.
- The species has also been observed at Hall Cemetery. Rowell and Crawford (1995) estimated populations of 470 at Mulligans Flat and 1330 at the Transmission site grassland. The latter is one of the largest populations recorded in the ACT. All of the known locations in Gungahlin are under conservation management.
- This species may also occur within the diverse *Themeda* understorey that occurs at the base of One Tree Hill, within Kinlyside, at Moncrieff and to the north of Bonner.

Blackith and Blackith (1966) found that *M. scurra* consumed at least 27 native and introduced plant taxa during feeding experiments in laboratory conditions.

The known distribution of *K. scurra* is largely confined to the temperate grassland of the south-eastern highlands. This is a nationally protected ecological community (Anon. 2016)

Documentation

The published information provided to the SAC has been assessed. Based on the available evidence, the SAC believes that the data presented are not the subject of scientific dispute and the inferences drawn are reasonable and well supported.

Final Recommendation of the Scientific Advisory Committee

The SAC concludes that on the evidence available the nominated item is eligible for listing in accordance with Section 11(1) of the Act because criteria 1.1 and subcriteria 1.1.1, 1.2.1 and 1.2.3 of the Flora and Fauna Guarantee Regulations 2011 have been satisfied.

The Scientific Advisory Committee therefore makes a final recommendation that the nominated item be supported for listing under the *Flora and Fauna Guarantee Act 1988*.

References:

Anon. (2016) *Natural Temperate Grassland of the South Eastern Highlands: a nationally protected ecological community*. Department of the Environment and Energy, Canberra.

<http://www.environment.gov.au/biodiversity/threatened/publications/natural-temperate-grassland-se-highlands-guide> (accessed February 2018)

Blackith, R.E. & Blackith, R.M. (1966) The food of Morabine grasshoppers. *Aust. J. Zoology* 14: 877-894.

- Key, K.H.L. (1965) Generic assignment of the species hitherto known as *Moraba scurra* Rehn (Orthoptera : Acridoidea). *J. Entomol. Soc. Qld.* **4**: 39.
- Mulvaney, M. (2012) *The Extent and Significance of Gungahlin's Biodiversity Values*. Conservation Planning and Research, Policy Division. Environment and Sustainable Development Directorate, Canberra.
- New, T.R. (2011) *'In Considerable Variety': Introducing the Diversity of Australia's Insects*. p. 158. Springer: London.
- Rehn, J.A.G. (1952) *The Grasshoppers and Locusts (Acridoidea) of Australia. Vol. 1. Tetrigidae to Eumastacidae*. Genus *Moraba* page 221, Plate 15. CSIRO Melbourne.
- Rowell, A. & Crawford, I. (1995) Survey of the Morabine Grasshopper *Keyacris scurra* (Rehn) in the ACT. Unpublished report to the Wildlife Research Unit, ACT Parks and Conservation Service, Canberra.
- White, M.J.D. (1956) Adaptive chromosomal polymorphism in an Australian grasshopper. *Evolution* **10**: 298-313.
- (1963) Cytogenetics of the grasshopper *Moraba scurra*. *Chromosoma* **14** (2): 140-145.
- White, M.J.D., Carson, H.L. & Cheney, J. (1964) Chromosomal races in the Australian grasshopper *Moraba viatica* in a zone of geographic overlap. *Evolution* **18** (3): 417-429.

Relevant website

Managing native vegetation in Victorian cemeteries

- <https://www2.health.vic.gov.au/public-health/cemeteries-and-crematoria/guidelines-policies-reports/cemetery-land-development/cemeteries-managing-native-vegetation>

Endorsement by the Convenor of the Scientific Advisory Committee

Date



19/2/2018

Prof Emeritus Barbara Evans,
Convenor

THREATENED SPECIES SCIENTIFIC COMMITTEE

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

The Minister approved this conservation advice and included this species in the Endangered category, effective from 05/10/2022

Conservation Advice

Keyacris scurra

Key's matchstick grasshopper

Summary of assessment

Conservation status

Keyacris scurra has been found to be eligible for listing in the Endangered category, as outlined in the attached assessment.

Reason for conservation assessment by the Threatened Species Scientific Committee

This advice follows assessment of information provided by New South Wales as part of the Common Assessment Method process, to systematically review species that are inconsistently listed under the EPBC Act and relevant state/territory legislation or lists.

More information on the Common Assessment Method is available at:

<http://www.environment.gov.au/biodiversity/threatened/cam>

The information in this assessment has been compiled by the relevant state/territory government. In adopting this assessment under the EPBC Act, this document forms the Approved Conservation Advice for this species as required under s266B of the EPBC Act.

Public consultation

Notice of the proposed amendment and a consultation document was made available for public comment for 31 business days between 14 December 2021 and 31 January 2022. Any comments received that were relevant to the survival of the species were considered by the Committee as part of the assessment process.

Recovery plan

A recovery plan for this species under the EPBC Act is not recommended, because the Approved Conservation Advice provides sufficient direction to implement priority actions and mitigate against key threats. The relevant state/territory may decide to develop a plan under its equivalent legislation.

Recommendations

- (i) The Committee recommends that the list referred to in section 178 of the EPBC Act be amended by **including** in the list in the Endangered category:
Keyacris scurra
- (ii) The Committee recommends that there not be a recovery plan for this species.

Threatened Species Scientific Committee

1 February 2022

NSW Threatened Species Scientific Committee

Conservation Assessment of *Keyacris scurra* (Rehn 1952) Key's Matchstick Grasshopper (Morabidae)

Ben Hope, Brad Law, Version 2, June 2020
NSW Threatened Species Scientific Committee

Keyacris scurra (Rehn 1952) (family Morabidae), Key's Matchstick Grasshopper



Photo: Michael Kearney

Distribution: Endemic to NSW/ ACT/ VIC
Current EPBC Act Status: Not listed
Current NSW TSC Act Status: Not listed
Current VIC Flora and Fauna Guarantee Act status: Threatened
Proposed listing on NSW BC Act and EPBC Act: Endangered

Summary of Conservation Assessment

Keyacris scurra Key's Matchstick Grasshopper was found to be eligible for listing as Endangered B2ab(ii,iii,iv,v)c(iv). This species is endemic to NSW, the ACT and Victoria. The main reasons for this species being eligible are i) inferred restricted geographical range (AOO = 124 km²), ii) severe fragmentation, iii) historical and inferred ongoing decline in abundance, habitat availability and quality and iv) ongoing threats (and poorly understood management requirements). This species was the focus of early chromosomal research (see Grodwohl 2017 for a summary) and unlike many insects, there was extensive survey work performed in the past which along with recent surveys of known sites, allows an historical assessment of the species' decline. This species is now locally extinct at many previously known locations.

Description and Taxonomy

Keyacris scurra (Rehn 1952) Key's Matchstick Grasshopper is a small (females ~25 mm, males ~18mm), slender, wingless grasshopper characterised by its slanted face, splayed hind femora and ensiform antennae. This species occurs in several colour forms, with brown being the most common (Farrow 2018). A full description is found in Rehn (1952) and Rentz (1991) also has information on this species. Within this species there are two parapatric chromosome races (15 chromosome and 17 chromosome), which are not distinguishable by external features (Key 1987). A similar-looking species which occurs in the same area are nymphs of *Acrida conica* (Giant Green Slantface), although *A. conica* develops wing buds which allow differentiation from *K. scurra* (R. Farrow *in litt.* 15 Sept 2018). Additionally, *A. conica* lacks a triangular gap between the base of the head and the thorax, which is present on all matchstick grasshoppers (M. Kearney *in litt.* Dec 2019). Species from the genera *Achurimima*, *Heidi* and *Vandiemenna* are also similar in appearance to *Keyacris* and the collection of specimens from novel locations allows the presence of this species to be unambiguously determined. Another similar species, *K. marcida*, occurs to the west of *K. scurra* and is apparently parapatric. At three places in NSW these species (*K. scurra* and the related *K. marcida*) occur within 14-16 km of each other (Key 1981). *Keyacris scurra* was originally described as *Moraba scurra* Rehn and was later transferred to the genus *Keyacris* Rehn (Key 1965). *Keyacris scurra* is in the subfamily Morabinae (Australian Faunal Directory 2018). The Morabinae is endemic to Australia and includes ~41 genera of flightless grasshoppers grouped into five tribes; many species are undescribed. *Keyacris* is in the tribe Keyacidini (Key 1976; Australian Faunal Directory 2018).

Distribution and Abundance

Historical distribution

Keyacris scurra Key's Matchstick grasshopper was originally distributed from Victoria (Vic.) to Orange (NSW) across the wheat/sheep belt (White 1956, 1957, 1963; Rowell and Crawford 1995, 1999) although in recent times the range has contracted. This species is typically recorded in native grasslands, secondary native grasslands or areas that contain the native grass *Themeda* with appropriate disturbance regimes. These disturbance regimes are more typically found in the following land-uses which are characterised by infrequent disturbance: cemeteries, along railway easements, travelling stock routes and more recently conservation reserves in the ACT. Disturbance appears to be an important determinant of site occupancy and it appears to be absent from sites that are disturbed during inappropriate times of the year (and interrupt the short non-overlapping lifecycle) or have been subjected to erratic management (e.g. periods of over and under grazing) (Rowell and Crawford 1995, 1999; New 2019).

Specimens

The Australian National Insect Collection (ANIC 2018) includes preserved (dry) specimens from most sites in historical surveys (White 1956, 1957, 1963) and the most recent specimen is from 1986 and the collection was accessed on 27 July 2018. Some locations noted in the ANIC collection (e.g. in the general vicinity of Bright, Corryong, Omeo and Hinnomunjie) are outside the distribution documented by White (1956, 1957, 1963) and this species has recently (2019) been recorded in the Omeo area (VIC) following targeted surveys (M Kearney *in litt.* Dec 2019). After 1986, ANIC has received an unknown number of specimens which are held in a wet collection, however this collection is yet to be catalogued and was not available for this review.

1950-1990 records

This species was recorded at approximately seventy-five sites in the 1950s and 1960s (for maps and lists see White 1956, 1957, 1963; Blackith and Blackith 1969; Rowell and Crawford 1995; 1999). Due to vague location descriptions the total number of known sites is uncertain, however at least 200 2x2 kilometre AOO squares appear to have been occupied in the 1950s, which is indicative of at least 200 populations, given collection sites were typically not connected by suitable habitat (fragmented) and the spacing of sites rendered movement by individuals between sites improbable. This estimate includes records from the 1990-2000s (Rowell and Crawford 1995, 1999) and from 2009-2019 (detailed below), noting that colonisation of new habitat during this period is unlikely. White (1963) recorded this species at four Victorian sites (Merton, Benalla, Beechworth and Wodonga) and there are records in the ANIC collection in the general vicinity of Bright, Corryong, Omeo and Hinnomunjie.

1990-2000s records

Between the 1970s and 1990s there is a lack of records and published research on *K. scurra* as this species was not being actively investigated. In the mid-1990s surveys for this species were undertaken in the ACT (Rowell and Crawford 1995, 1999). These surveys revealed three new sites, with the species confirmed to occur on seven known sites in the ACT. The species could not be located (and therefore may be locally extinct) at two known sites. Rowell and Crawford (1999) stated that by 1999 the species had also disappeared from 'Greenhills' Oval, Brindabella Road, Tidbinbilla Station and Condor Camp (paratype location). Of the seven confirmed ACT sites, five were on conservation reserves (Rowell and Crawford 1995). While it is possible for this species to evade detection during a single survey event (Rowell and Crawford 1999), lack of detection may indicate localised extinction or a very small population (which ultimately leads to a genetic bottleneck and reduced population viability). In cases where habitat has been totally removed, localised extinctions are unambiguous. Butz (2004) reported this species as absent at Blundells Flat (ACT), a site with historical records. Pullen (2000) listed the following occupied locations in the ACT: along the railway easement between 'Tralee' and Williamsdale [this is most likely the "Royalla" site studied extensively in the 1950's]; Captains Flat cemetery; on the lower slopes of Mount Jerrabomberra; and on the southern slopes of, Tuggeranong Hill in the Canberra suburb of Conder. Both Mount Jerrabomberra and Tuggeranong Hill are threatened by housing developments and the Mount

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Jerrabomberra population's habitat had apparently already been at least partly cleared in 2000 (Pullen 2000). Very little information is available about this species in NSW in the 1990-2000 period, although Jones (1993) who surveyed sites in the ACT and NSW (Southern Highlands), did not detect this species in NSW. Credible Bionet records of this species include sites within NSW on the Monaro Plain (e.g. Bredbo Cemetery 1997 although no habitat remains in 2019, M Kearney *in litt.* Dec 2019), Yaouk (2000) and Adaminaby (1997)), which is an area that this species was not reported from by White and other researchers, although the habitat is suitable and contiguous with other known sites. These Bionet records were attributed to Rainer Rehwinkel who 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 (G Robertson *in litt.* June 2019).

Contemporary distribution

There are recent (2009-2019) credible records from 31 (AOO = 124 km²) well-dispersed (the EOO is 32,809 km²), 2 km x 2 km AOO grid squares in NSW (15, 2 km x 2 km grid squares) ACT (10, grid squares) and VIC (6, grid squares). M. Kearney and A. Hoffman between 2017 and 2019 performed a targeted survey of known sites and found that most historical sites were easy to locate (e.g. cemeteries) and for other sites where they were not able to accurately locate, suitable habitat was not present within a large radius of the site, and the conclusion in these cases was that local extinction had occurred (Kearney *in litt.* Dec 2019). These recent surveys found *K. scurra* at a total of 23 sites which are summarised in the remainder of this paragraph. These 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). At all known sites (except Murrumbateman), 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 rate of decline over a ten-year period of 25.4% (using an exponential rate of decline from 1950 as the start point and 2019 as the end point with the number of sites used as a coarse index of abundance). Changes in the management of cemeteries (e.g. mowing) may have contributed to the extinction at some NSW sites. At Murrumbateman suitable habitat remained in 2019, however no *K. scurra* were found after five site visits. A further 30 sites with apparently suitable habitat (i.e. some *Themeda* that was more than 5-10 cm tall, and food plants present) were surveyed. These sites were either recommended by a botanist with knowledge of remnant *Themeda* grasslands or were Travelling Stock Route reserves within the historical distribution of this species. *Keyacris scurra* was detected at 12 of the 30 sites targeted.

Databases list recent records for a further three sites on (at least in part) conservation reserves in NSW and there are recent records from the ACT attributed to this species at Kambah, Tuggeranong Hills and Mulligans Flat (ALA Accessed March 2018). Kambah (ACT) and Mulligans Flat (ACT) were sites where Rowell and Crawford (1995) detected this species so these incidental records are likely to have been correctly identified. Tuggeranong Hills (ACT) is listed as a known site in Pullen (2000), which again adds credibility to this sighting. Mulvaney (2012) noted the presence of this species in the ACT at Gungahlin (National Transmission Authority land at Crace, Mulligans Flat NR and Crace NR), Hall cemetery (confirmed as present in 2019, Kearney *in litt.* Feb 2019) and possibly at the base of One Tree Hill (Kinlyside, at Moncrieff and to the north of Bonner).

Ecology

Keyacris scurra Key's Matchstick Grasshopper is usually found in native grasslands but it has also been recorded in other vegetation associations containing a native grass understory (especially kangaroo grass *Themeda triandra*) and known food plants (particularly Asteraceae). Although it does not feed on *Themeda*, it may be important for providing protection from predators (White 1956).

In captivity, Key's Matchstick Grasshopper feeds readily on *Helichrysum* spp. (White 1956). Later work found they consume a wide range of species, preferring smaller ephemeral plants to larger perennial species which are taken when small ephemerals are not available (Blackith and Blackith 1966). Both native and introduced species are consumed. Blackith and Blackith (1966) list the following plants as food sources

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(see original paper for preference category, taxonomy as published follows in brackets as does common name): *Aira caryophyllea* (Silver hairgrass), *Scirpus* sp. (sedges), *Wurmbea dioica* (Early Nancy), *Bulbine bulbosa* (Native Leek), *Calochilus paludosus* (Red Beard Orchid), *Rumex crispus* (Curled Dock), *Acetosella vulgaris*, (*Rumex acetosella*) (Sorrel), *Cerastium glomeratum* (Mouse-ear Chickweed), *Ranunculus lappaceus* (Common Buttercup), *Rosa rubiginosa* (Sweet Briar), *Acaena ovina* (Orchid), *Trifolium subterraneum* (Subterranean Clover), *Trifolium arvense* (Haresfoot Clover), *Poranthera microphylla*, *Stackhousia monogyna* (Creamy Candles), *Hibbertia sericea*, *Lavandula stoechas* (Lavender), *Salvia verbenaca* (Vervain), *Verbascum thapsus* (Great Mullein), *Sherardia arvensis* (Field Madder), *Galium tricornatum* (Rough Fruited Bedstraw), *Helichrysum apiculatum* (Common Everlasting), *Ozothamnus retusus* or *O. scaber* (*Helichrysum bilobum*), *Podolepis jaceoides* (*Podolepis acuminata*) (Showy Copper-wire Daisy) and *Craspedia uniflora*.

Breeding

There is only one generation a year with no overlapping generations. Hatching from the egg takes place from December to January and eggs are buried in the soil (Rowell and Crawford 1995). Most males become adult by May, but females overwinter as nymphs and do not mature until the spring. Copulation has been observed in nature from September to the end of November. Fecundity is low; the maximum number of eggs obtained from a pair mating in captivity was 21 (White 1956) and eggs are laid in the soil (Rowell and Crawford 1995). Rowell and Crawford (1995) performed surveys between August and November and this period was chosen to coincide with the presence of mature males and mature/maturing females.

Threats

The principal threats to *Keyacris scurra* are: loss of habitat, small colony size, inappropriate disturbance (e.g. mowing, too frequent or poorly timed burning or over-grazing), lack of disturbance leading to regeneration of eucalypts or weed invasion, new burials (at active cemetery sites), cultivation, pasture improvement, urban development, insecticides, climate change, weed invasion and poor understanding on management requirements (Key 1981; Rowell and Crawford 1995; New 2011). Tall native grassland (usually *Themeda*) with native daisies (or other food sources) is the habitat that most historical records are associated with and such habitat has been widely grazed, cleared, modified and/or burned throughout its original range (Keith 2004). Native grassland remnants suitable for *K. scurra* have survived almost exclusively in local cemeteries (or railway easements) which have not been extensively grazed and which are not burned as part of hazard reduction burns or agricultural activities, although localised excavation and stockpiling of material occurs in active cemeteries. Some of the historical sites for this species are no longer active cemeteries. Cemeteries often occur on arable, long ungrazed land and are spared some of the impacts of surrounding arable lands that have long been targeted for agriculture (Prober 1996). Prober (1996) found that a lack of disturbance favoured *Poa sieberiana* over *Themeda triandra*, so appropriately timed disturbance may also benefit *Keyacris scurra* but the ideal frequency or timing is unknown. Unless *Themeda* grasslands are subject to intermittent grazing by domestic stock or native animals and/or burning, *Themeda* develops a dense thatch that excludes other plants, potentially reducing food availability. Secondary *Themeda* grasslands, when fenced off from stock, are also subject to tree and shrub invasion that has, for example, degraded the grassland habitat at Captains Flat cemetery and is a potential threat to this species (R Farrow *in litt.* July 2018).

Cemetery management, although site specific, often includes mowing grassy areas, and if sufficient habitat is not retained they are unable to support populations of *Keyacris scurra*. Modern management expectations of an intensively managed lawn aesthetic (without ornate gardens), which occurred after World War II may have exacerbated habitat loss in recent times (Clayden *et al.* 2018). The decline of this species in cemeteries may be more severe than elsewhere in the range, however long-term data is limited outside such environments.

Because of their very limited ability to migrate between islands of suitable habitat and (in some locations) persistence in very small habitat patches, a single poorly timed mowing or fire event can destroy a population. *Keyacris scurra* is a winter active species and control burns between autumn and spring may

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have an adverse impact because of its lack of mobility (R. Farrow *in litt.* July 2018). Reduced population size can also lead to inbreeding and consequent loss of genetic fitness in the species. White (1957) has estimated, on cytological grounds, that F1 hybrids between the races of *K. scurra* may suffer a reduction in fertility of up to 10% (Key 1981). It is possible that *K. scurra* could be reintroduced into areas of suitable habitat, provided source populations remain available (A. Hoffman, *in litt.* 2017 September 2017).

Climate change could plausibly affect phenology of emergence, hence food availability, susceptibility to wildfires and breeding success, as well as affecting those processes through other mechanisms, for example increased frequency and severity of droughts. Insecticides (e.g. as used for Plague Locust) may impact this species.

Assessment against IUCN Red List criteria

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

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 surveyed 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 expressed 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 limited 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%

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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 1995 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.

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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%*

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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 km² (based on a 2 km x2 km grid) and extent of occurrence EOO is 32,809 km². Based on all available records the AOO in the 1950s is estimated to have been 800 km² (below the threshold for Vulnerable). In 1995 the AOO was estimated to have been 156km². Further survey will refine this estimate, however the AOO is not considered likely to exceed the upper threshold for Endangered (500 km²) 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.

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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."

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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

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Justification: See clause B (sub clause b) above.

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 km²) 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 km².

Criterion E Quantitative Analysis

Assessment Outcome: Data Deficient

Justification: Population viability analysis not performed.

Conservation and Management Actions

Habitat loss, disturbance and modification

- Prevent further loss of habitat.
- Avoid/minimise mowing and slashing of vegetation at cemeteries and other habitat remnants. Where these management actions are required provide land managers with information on how to minimise impacts.
- Adaptive management of disturbance regime with monitoring to maintain grassland (or other suitable) habitat and ensure persistence at known sites and inform future management.

Invasive species

- Careful weed control at known sites with monitoring to measure impact given that non-natives are palatable to this species and may provide a food resource. This may include measures to prevent native trees colonising grassland areas or maintaining grasslands at desirable densities.

Ex situ conservation

- Captive breeding and release at new sites (or known sites where this species no longer occurs) is likely to be feasible

Stakeholder Management

- Inform land owners and managers of sites where there are known populations and consult with these groups regarding options for conservation management and protection of the species.

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Survey and Monitoring priorities

- Habitat monitoring for increased habitat degradation or loss
- Regular, range-wide surveys of the species to determine whether there is a decline in the population and estimate the number of mature individuals
- Monitoring for recruitment.
- Research on species detectability (repeat surveys)
- Targeted survey for new populations

Information and Research priorities

- Research on required management actions and actions with negative impacts. e.g. positive and negative impacts of fire, slashing or grazing in relation to intensity, type, size and timing.
- Improved knowledge on basic life history, phenology, sensitivity to climate, drought response, population recovery rates (from drought or disturbance), maximum and minimum population sizes at known sites (to document fluctuation sizes and assess long-term population trends).

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APPENDIX 1

Assessment against BC Act criteria

Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)

Assessment Outcome: Vulnerable under clause 4.2 1(c), 2(c)

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

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Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)

Assessment Outcome: Endangered under Clause 4.3 (b) (d) (e i, ii, iii & iv).

The geographic distribution of the species is:		
	(a)	for critically endangered species very highly restricted, or
	(b)	for endangered species highly restricted, or
	(c)	for vulnerable species moderately restricted.
and at least 2 of the following 3 conditions apply:		
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,
	(e)	there is a projected or continuing decline in any of the following:
		(i) an index of abundance appropriate to the taxon,
		(ii) the geographic distribution of the species,
		(iii) habitat area, extent or quality,
		(iv) the number of locations in which the species occurs or of populations of the species.
	(f)	extreme fluctuations occur in any of the following:
		(i) an index of abundance appropriate to the taxon,
		(ii) the geographic distribution of the species,
		(iii) the number of locations in which the species occur or of populations of the species.

Clause 4.4 - Low numbers of mature individuals of species and other conditions
(Equivalent to IUCN criterion Clause C)

Assessment Outcome: Data Deficient

The estimated total number of mature individuals of the species is:		
	(a)	for critically endangered species very low, or
	(b)	for endangered species low, or
	(c)	for vulnerable species moderately low.
and either of the following 2 conditions apply:		
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):
		(i) for critically endangered species very large, or
		(ii) for endangered species large, or
		(iii) for vulnerable species moderate,
	(e)	both of the following apply:
		(i) a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and
		(ii) at least one of the following applies:
		(A) the number of individuals in each population of the species is:
		(I) for critically endangered species extremely low, or
		(II) for endangered species very low, or
		(III) for vulnerable species low,
		(B) all or nearly all mature individuals of the species occur within one population,
		(C) extreme fluctuations occur in an index of abundance appropriate to the species.

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Clause 4.5 - Low total numbers of mature individuals of species
(Equivalent to IUCN criterion D)
Assessment Outcome: Data Deficient

The total number of mature individuals of the species is:			
	(a)	for critically endangered species	extremely low, or
	(b)	for endangered species	very low, or
	(c)	for vulnerable species	low.

Clause 4.6 - Quantitative analysis of extinction probability
(Equivalent to IUCN criterion E)
Assessment Outcome: Data Deficient

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

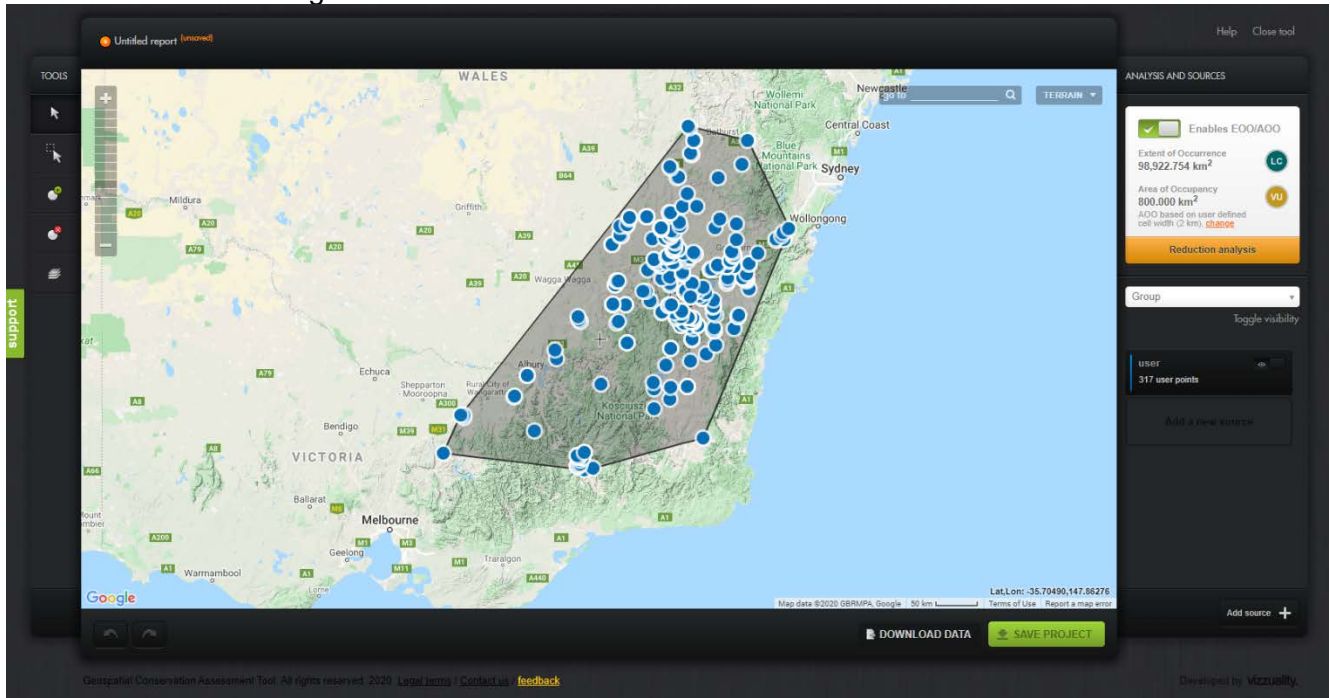
Clause 4.7 - Very highly restricted geographic distribution of species—vulnerable species (Equivalent to IUCN criterion D2)
Assessment Outcome: Not met.

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.
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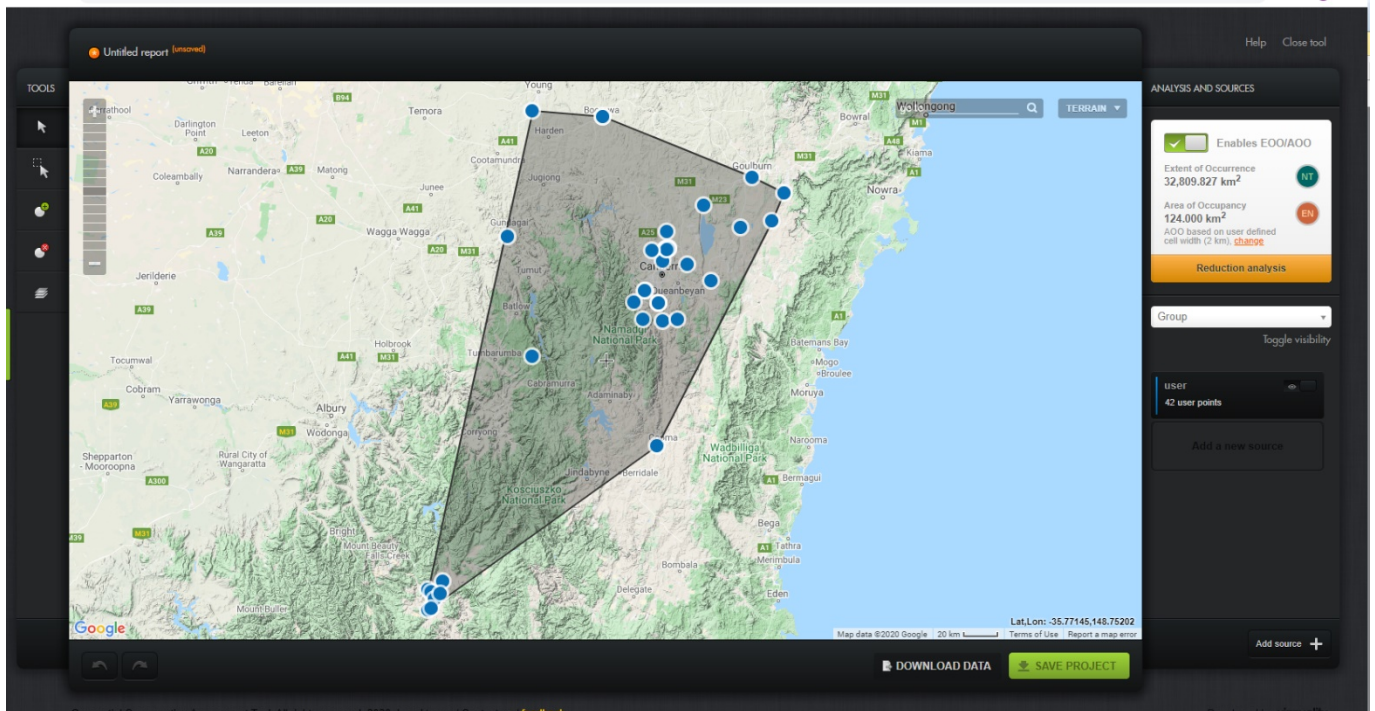
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Appendix 2 Location and source for *K. scurra* records (tables and maps)

All known sites including ANIC records



Recent records (2009 to present)



Notice of and reasons for the Final Determination

The NSW Threatened Species Scientific Committee, established under the *Biodiversity Conservation Act 2016* (the Act), has made a Final Determination to list Key's Matchstick Grasshopper *Keyacris scurra* (Rehn, 1952) as an ENDANGERED SPECIES under Part 2 of Schedule 1 of the Act. Listing of Endangered species is provided for by Part 4 of the Act.

Summary of Conservation Assessment

Keyacris scurra is eligible for listing as Endangered, as the highest threat category met by the taxon across all categories, under Clause 4.3 (b) (d) (e ii, iii & iv), because: i) the distribution of the species is very highly restricted with an area of occupancy of approximately 124 km²; ii) the population and habitat of the species is severely fragmented; and iii) there is continuing decline in abundance, distribution, habitat area and quality, and number of individuals.

The NSW Threatened Species Scientific Committee has found that:

1. *Keyacris scurra* (Rehn, 1952), Key's Matchstick Grasshopper (family Morabidae) are small (females ~25 mm, males ~18mm), slender, wingless grasshoppers characterised by slant faces, splayed hind femora and ensiform antennae. This species occurs in several colour forms, with brown being the most common (Farrow 2018). Within the species there are two parapatric chromosomal races (15 chromosome and 17 chromosome), which are indistinguishable by external features (Key 1987). The distribution of *Keyacris scurra* overlaps with that of *Acrida conica* (Giant Green Slantface), the nymphs of which resemble *Keyacris scurra*. *Acrida conica* can be differentiated from *K. scurra* once wing buds appear (which are absent in *K. scurra*) (R. Farrow *in litt.* Sept 2018). Additionally, *A. conica* lacks a triangular gap between the base of the head and the thorax, which is present on all matchstick grasshoppers (M. Kearney *in litt.* Dec 2019). Species from the genera *Achurimima*, *Heidi* and *Vandiemenna* are also similar in appearance to *Keyacris* and the collection of specimens from novel locations allows the presence of this species to be unambiguously determined. Another similar species, *K. marcida*, occurs to the west of *K. scurra* and is apparently parapatric. At three places in NSW these species (*K. scurra* and the related *K. marcida*) occur within 14-16 km of each other (Key 1981).
2. Historical records of *Keyacris scurra*, occur across the wheat and grazing belt in Victoria (Vic.), Australian Capital Territory (ACT) and NSW (White 1956, 1957, 1963; White *et al.* 1963; Rowell and Crawford 1995, 1999). Most occurrence records for *K. scurra* are from primary and secondary native grasslands with areas containing tall stands of *Themeda triandra* and known food plants (particularly species of the family Asteraceae) (Rowell and Crawford 1995). Land uses where the species is most often reported include cemeteries, railway easements, travelling stock routes and conservation reserves.
3. The current geographic distribution of *Keyacris scurra* is inferred to be highly restricted. Based on all records available in the period 2009-2019, including 23 locations from a recent survey of 62 known sites and 30 previously unsurveyed sites (M Kearney *in litt.* December 2019) and other available records (ALA 2018; A. Hoffman *in litt.* Feb 2018; R. Farrow *in litt.* June 2018; Canberra Nature Map 2018), the extent of occurrence (EOO) is 32,809 km² and the area of occupancy (AOO) is 124 km². The EOO is based on a minimum convex polygon encompassing

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all known locations, the method for assessing EOO recommended by IUCN (2017). The area of occupancy is estimated using a 2 km x 2 km grid cell, the scale recommended for assessing AOO by IUCN (2017). While new sites are expected to be found the geographic range estimates are not expected to significantly increase as the extent of native grasslands and grassy woodlands with a suitable disturbance history is also highly restricted (see Keith 2004; Environment ACT 2006). The species is now absent from many previously known sites. Surveys undertaken between 2017 and 2019 found this species at 23 locations (including 11 new locations) (M. Kearney *in litt.* December 2019). Other local extinctions in NSW and ACT have been documented; Jones (1993, cited by Rowell and Crawford 1995) revisited 13 known sites in the ACT and NSW and found the species was absent from all of these sites. Rowell and Crawford (1995, 1999) either did not detect the species or found the habitat was unsuitable at 4 known sites. The species is apparently locally extinct at Blundells Flat in the ACT (Butz 2004).

4. *Keyacris scurra* is a herbivore and feeds on a range of native and introduced species, preferring smaller ephemeral plants to larger perennial species, the latter consumed when small ephemerals are not available (Blackith and Blackith 1966). Although *K. scurra* does not feed on *Themeda*, this grass may provide protection from predators or climatic stressors and it is present at most known localities (White 1956).
5. Observations on breeding suggest that *Keyacris scurra* only produces a single generation per year with eggs hatching over December and January (White 1956). Most males reach maturity by May but females overwinter as nymphs and do not mature until the spring (White 1956). Copulation has been observed in the wild from September to the end of November (White 1956). Fecundity is low with the maximum number of eggs reported per female being 40 with an average of 25 (White 1977).
6. White (1956) considered that *Keyacris scurra* was already geographically restricted and had undergone decline at that time. Since the 1950s and 1960s the geographic distribution of *K. scurra* appears to have continued to decline as this species is now locally extinct at many of the study sites from that period. Sixty-two sites known to be occupied in the 1960s were resurveyed and this species was found to be locally extinct at 51 of these (M. Kearney *in litt.* December 2019), representing a 25.4% reduction over a ten-year period (The IUCN standard period for assessing decline). During the 1950s and 1960s the EOO was estimated to be 98,922 km² and AOO was 800 km² (using locations from: White 1956, 1957, 1963; Rowell and Crawford 1995, 1999; Pullen 2000; Mulvaney 2012; Atlas of Living Australia 2018; R. Farrow *in litt.* June 2018; OEH Bionet 2018; Canberra Nature Map 2018; ANIC 2018; Kearney *in litt.* Feb 2019). The geographic range has apparently contracted with average reductions over a ten-year period of 27.1% (AOO) and 17.7% (EOO) calculated between 1960 and 2019 (Hope and Law 2020). The rate of decline in AOO between 1960 and 1995 was 39% (Hope and Law 2020). Survey effort for *K. scurra* was higher in the 1950s and 1960s (when this species was used extensively in cytological investigations, see Grodwohl 2017) than the following decades so available data are temporally biased and these rates of decline are therefore indicative. Given the uncertainty a precautionary interpretation is warranted and for the purpose of this assessment it is assumed the rate of decline in recent decades exceeded 30%.
7. Loss of habitat, small colony size, weed invasion, expansion of cemeteries, cultivation, pasture improvement, urban development and poor understanding of management requirements have been identified as current threats to *Keyacris scurra* (Key 1981; Rowell and Crawford 1995; New 2011). Disturbance is an important ecological process within the habitat of this species

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(Keith 2004), although the disturbance regime that favours the species itself is not well known. Insufficient disturbance has the potential to decrease habitat quality (e.g., regeneration of eucalypts, dense thatch formation or a reduction in food availability). Conversely, disturbance events that are too frequent or poorly timed, and that impact entire populations may lead to localised extinctions in isolated habitat patches. With their very limited ability to disperse between islands of suitable habitat (and in some locations persistence in very small habitat patches) and a non-overlapping annual lifecycle, a single poorly timed mowing or fire event may lead to local extinction (Rowell and Crawford 1999). *Keyacris scurra* is a winter active species and control-burns between autumn and spring may have an adverse impact, as the slow-moving adults and nymphs are killed by fire (Rowell and Crawford 1995; R. Farrow *in litt.* July 2018). Over-grazing, where soils are compacted and eroded and above ground vegetation substantially removed, is also expected to have negative impacts. 'Clearing of native vegetation' and 'High frequency fire resulting in the disruption of life cycle processes in plants and animals and loss of vegetation structure and composition' are listed as Key Threatening Processes under the Act.

8. Most historical records of *Keyacris scurra* are associated with tall native grassland (usually *Themeda*) with native daisies (or other food sources). This vegetation has been widely grazed, cleared and/or burned throughout its original range (Prober 1996; Keith 2004; Environment ACT 2006). Native grassland remnants suitable for *K. scurra* commonly occur in cemeteries which have not been intensively grazed and which are not subject to fire hazard management or other agricultural activities. Habitat modification (e.g. cultivation, pasture improvement) and disturbance history appears to be an important determinant of site occupancy and the species appears to be absent from heavily modified sites, and those with historic disturbance regimes incompatible with the lifecycle of this species. Cemeteries often occur on arable, long ungrazed land and are spared some of the impacts of surrounding lands that have long been targeted for agriculture (Prober 1996). After World War II, cemetery management practices shifted away from ornate landscaping towards a more homogenous landscape of mown lawns (Clayden *et.al* 2018), leading to the loss of small refugia and is the probable cause of local extinction at some cemetery sites. The decline of *K. scurra* in cemeteries may be more severe than elsewhere in the range, however long-term data are limited outside such environments.
9. The current number of populations and population size of *Keyacris scurra* is unknown, however a review of all records and published literature indicate this species was present in approximately 200 2 km x 2 km grid squares at some stage in the period 1950 to the present (Hope and Law 2020). Of these, there are recent (2009-2019) credible records from thirty-one well-dispersed, 2 km x 2 km AOO grid squares; fifteen in NSW, six in Vic. and ten in the ACT.
10. *Keyacris scurra*, (Rehn 1952) Key's Matchstick Grasshopper is not eligible to be listed as a Critically endangered species.
11. *Keyacris scurra* (Rehn 1952) Key's Matchstick Grasshopper is eligible to be listed as an Endangered species as, in the opinion of the NSW Threatened Species Scientific Committee, it is facing a very high risk of extinction in Australia in the near future as determined in accordance with the following criteria as prescribed by the Biodiversity Conservation Regulation 2017:

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Clause 4.2 – Reduction in population size of species
(Equivalent to IUCN criterion A)

Assessment Outcome: Vulnerable under clause 4.2 1(c), 2(c)

(1) - The species has undergone or is likely to undergo within a time frame appropriate to the life cycle and habitat characteristics of the taxon:			
	(a)	for critically endangered species	a very large reduction in population size, or
	(b)	for endangered species	a large reduction in population size, or
	(c)	for vulnerable species	a moderate reduction in population size.
(2) - The determination of that criteria is to be based on any of the following:			
	(a)	direct observation,	
	(b)	an index of abundance appropriate to the taxon,	
	(c)	a decline in the geographic distribution or habitat quality,	
	(d)	the actual or potential levels of exploitation of the species,	
	(e)	the effects of introduced taxa, hybridisation, pathogens, pollutants, competitors or parasites.	

Clause 4.3 - Restricted geographic distribution of species and other conditions
(Equivalent to IUCN criterion B)

Assessment Outcome: Endangered under Clause 4.3 (b) (d) (e ii, iii & iv).

The geographic distribution of the species is:			
	(a)	for critically endangered species	very highly restricted, or
	(b)	for endangered species	highly restricted, or
	(c)	for vulnerable species	moderately restricted.
and at least 2 of the following 3 conditions apply:			
	(d)	the population or habitat of the species is severely fragmented or nearly all the mature individuals of the species occur within a small number of locations,	
	(e)	there is a projected or continuing decline in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	habitat area, extent or quality,
		(iv)	the number of locations in which the species occurs or of populations of the species.
	(f)	extreme fluctuations occur in any of the following:	
		(i)	an index of abundance appropriate to the taxon,
		(ii)	the geographic distribution of the species,
		(iii)	the number of locations in which the species occur or of populations of the species.

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Clause 4.4 - Low numbers of mature individuals of species and other conditions
 (Equivalent to IUCN criterion C)
 Assessment Outcome: Data Deficient

The estimated total number of mature individuals of the species is:			
	(a)	for critically endangered species	very low, or
	(b)	for endangered species	low, or
	(c)	for vulnerable species	moderately low.
and either of the following 2 conditions apply:			
	(d)	a continuing decline in the number of mature individuals that is (according to an index of abundance appropriate to the species):	
		(i) for critically endangered species	very large, or
		(ii) for endangered species	large, or
		(iii) for vulnerable species	moderate,
	(e)	both of the following apply:	
		(i)	a continuing decline in the number of mature individuals (according to an index of abundance appropriate to the species), and
		(ii)	at least one of the following applies:
		(A)	the number of individuals in each population of the species is:
			(I) for critically endangered species extremely low, or
			(II) for endangered species very low, or
			(III) for vulnerable species low,
		(B)	all or nearly all mature individuals of the species occur within one population,
		(C)	extreme fluctuations occur in an index of abundance appropriate to the species.

Clause 4.5 - Low total numbers of mature individuals of species
 (Equivalent to IUCN criterion D)
 Assessment Outcome: Data Deficient

The total number of mature individuals of the species is:		
	(a)	for critically endangered species extremely low, or
	(b)	for endangered species very low, or
	(c)	for vulnerable species low.

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Clause 4.6 - Quantitative analysis of extinction probability

(Equivalent to IUCN criterion E)

Assessment Outcome: Data Deficient under Clause 4.6

The probability of extinction of the species is estimated to be:			
	(a)	for critically endangered species	extremely high, or
	(b)	for endangered species	very high, or
	(c)	for vulnerable species	high.

Clause 4.7 - Very highly restricted geographic distribution of species–vulnerable species

(Equivalent to IUCN criterion D2)

Assessment Outcome: Clause 4.7 Not met.

For vulnerable species,	the geographic distribution of the species or the number of locations of the species is very highly restricted such that the species is prone to the effects of human activities or stochastic events within a very short time period.
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Dr Anne Kerle

Chairperson

NSW Threatened Species Scientific Committee

Supporting Document:

Hope B, Law B (2020) Conservation Assessment of *Keyacris scurra* (Rehn 1952) Key's Matchstick Grasshopper. Version 2. NSW Threatened Species Scientific Committee.

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