NOMINATION OF A TARGET WEED
FOR BIOLOGICAL CONTROL

TARGET: *Sonchus oleraceus* L. (Asteraceae)

Common sowthistle

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NOMINATING ORGANISATION:

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Summary

This document presents issues relevant to determining the suitability of common sowthistle (*Sonchus oleraceus*) as a target for biological control in Australia.

Common sowthistle is an increasingly important weed in Australia, especially in cropping systems. Predominant in the fallow period, it uses vital stored soil moisture during this period, acts as an alternate host for insects and is difficult to control. Development of resistance to herbicides is making populations increasingly difficult to manage in agricultural environments. Leaves and young stems of this species are edible, but rarely consumed in Australia. This species has no beneficial aspects in Australia, except that Maori communities settled in Australia sometimes consume its edible leaves.

Given the success of previous biological control programs against other weeds in the Asteraceae family (e.g. *Onopordum* and *Cirsium* thistles), there are promising prospects of establishing an effective program for the management of common sowthistle. Of the 59 fungal pathogens and 83 insect species recorded as infecting and feeding on common sowthistle around the world, at least 10 may hold promise for biological control in Australia. In Australia, common sowthistle is one of three naturalised *Sonchus* species and there is only one native *Sonchus* species, *S. hydrophilus*, which will be a key species to test with any potential candidate biological control agents.

1. Taxonomy

Scientific name: *Sonchus oleraceus* Linnaeus 1753

Synonyms: *Sonchus angustissimus* Hook.f., *Sonchus australis* Trevir., *Sonchus ciliatus* Lam., *Sonchus fabrae* Sennen, *Sonchus glaber* Gilib., *Sonchus gracilis* Phil., *Sonchus gracilis* Sennen, *Sonchus lacerus* Willd., *Sonchus laevis* Vill., *Sonchus longifolius* Trevir., *Sonchus macrotus* Fenzl, *Sonchus pallescens* Pančić, *Sonchus parviflorus* Lej. ex Rchb., *Sonchus reversus* E.Mey. ex DC., *Sonchus rivularis* Phil., *Sonchus roseus* Besser ex Spreng., *Sonchus royleanus* DC., *Sonchus runcinatus* (Fiori) Zenari, *Sonchus schimperi* A.Braun & Bouché, *Sonchus schmidianus* K.Koch, *Sonchus spinulifoius* Sennen, *Sonchus subbipinnatifidus* (Guss.) Zenari, *Sonchus sundaicus* Blume, *Sonchus tenerrimus* Schur 1866 not L. 1753, *Sonchus umbellifer* Thunb., *Sonchus zacinthoides* DC.

Common names: Common sowthistle, annual sowthistle, colewort, field sowthistle, hare’s colewart, hare’s lettuce, hare’s thistle, milky tassel, milk thistle, pualele, small sow thistle, smooth sowthistle, soft thistle, sow thistle, swinies, thalaak.

Family: Asteraceae

1.1 Description

Common sowthistle (*Sonchus oleraceus*) is an annual, biennial or perennial herb, 40–150 cm tall, containing white latex in all plant parts. The taproot is upright with many branches, especially near the soil surface. The stem below the capitulescence[1] is simple or branched and glabrous. Basal and lower stem leaves with basal portion petiole-like and attenuate, mostly smaller than middle stem leaves, otherwise similar. Middle and upper stem leaves extremely variable, elliptic, oblanceolate, or lanceolate, 6–20 × 2–9 cm, almost entire to ± irregularly, soft, glabrous, adaxially dull green, base auriculately clasping with auricles usually acutely prostrate, margin ± coarsely spinulosely dentate, apex acute; lateral lobes triangular to elliptic, usually recurved, apex acute to acuminate; terminal lobe larger than others, broadly triangular, broadly hastate, or obovate-cordate. The flower-head has a green involucre consisting of 27–35 lance-shaped bracts, 10–13 mm long and hairy while young. Each flower-head contains 80–250 ligulate flowers which are longer than the involucre. The flowers are yellow and the ligule is about as long as the corolla tube Achenes are brown, 2.5–3.75 x 0.7–1 mm, oblanceolate, and transversely tuberculate-rugose. Thistledown is white and persistent. (Hutchinson et al. 1984; CABI 2015) (Fig. 1).

1.2 Phylogenetic relationships

The Asteraceae represents one of the largest families within the Asterales. The family contains 12 subfamilies, 1,600–1,700 genera and approximately 24,000–30,000 species equating to approximately 8% of all flowering plants (Funk et al. 2005; Panero & Funk 2008; Stevens 2012). Members of the Asteraceae have a global distribution and can be found on every continent except Antarctica (Funk et al. 2005). Distinguishing morphological features of the Asteraceae include the inflorescence, which usually occur in a disk arrangement, the presence of achenes and the development of the calyx into a pappus (Funk et al. 2005). The Asteraceae are also characterised by florets that are arranged on a receptacle in centripetal heads surrounded by bracts and anthers that are fused in a circle with pollen that is pushed out by the style (Funk et al. 2005).

[1] Secondary inflorescence where the floral units are heads; the arrangement of these heads in the Compositae (Roque et al. 2009).

Figure 1: General morphological characteristics of common sowthistle (*Sonchus oleraceus*). (**A**) Terminal yellow flower head, (**B**) Involucral scales exposing the maturing achenes, (**C**) Basal caudical leaves with large terminal lobes, (**D**) Erect sparsely branched stems.

The Asteraceae subfamily Cichorioideae contains at least eight tribes (Funk et al. 2009). One of these is the Cichorieae, which accommodates approximately 1550 species distributed across 86–100 genera (Funk et al. 2009; Tremetsberger et al. 2013). Members of the Cichorieae are predominantly distributed in the Mediterranean and central Asia and grow in dry and sub-humid areas (Tremetsberger et al. 2013). This tribe can be distinguished from other tribes within the Cichorioideae by the production of milky latex and the presence of a ligullate corolla (Dasgupta & Mukherjee 2007; Kim et al. 2007). Kilian et al. (2009) recognised 11 subtribes within the Cichorieae based on DNA sequence data from the nuclear ITS region and morphological characteristics (Fig. 2), but noted however that the taxonomy of the Cichorieae remains unrefined and will likely be amended in the future.

Within the tribe Cichorieae, Bremer (1993) reclassified subtribe Crepidinae into four subtribes namely Crepidinae *sensu stricto*, Hieraviinae, Lactucinae and Sonchinae. However, through several subsequent studies, using DNA sequence data from informative gene regions, it has been shown that Crepidinae is not a suitable name for the subtribe and that Hyoseridinae is a more appropriate name (Kim et al. 1996; 2004; Killian et al. 2009). As it is currently circumscribed, Hyoseridinae therefore accommodates the *Sonchus-Launaea* alliance, *Reichardia*, *Hyoseris* and *Aposeris* (Fig. 3).

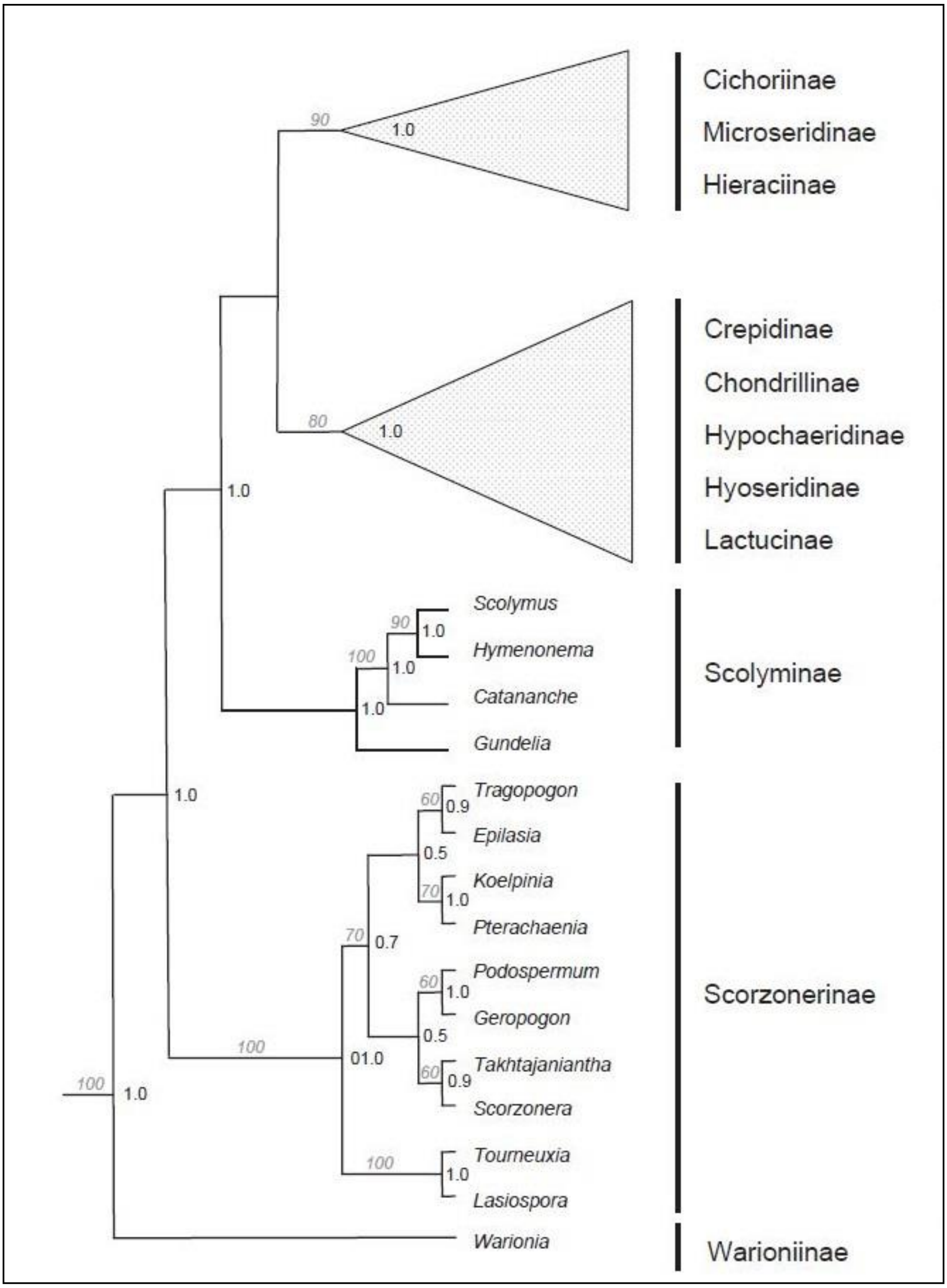

Figure 2. A phylogenetic reconstruction of tribe Cichorieae, based on DNA sequence data from the nuclear Internal Transcribed Spacer (ITS) rDNA operon, depicting evolutionary relationships of genera with subtribes Scolyminae, Scorzonerinae and Warioniinae as presented in Kilian et al. (2009).

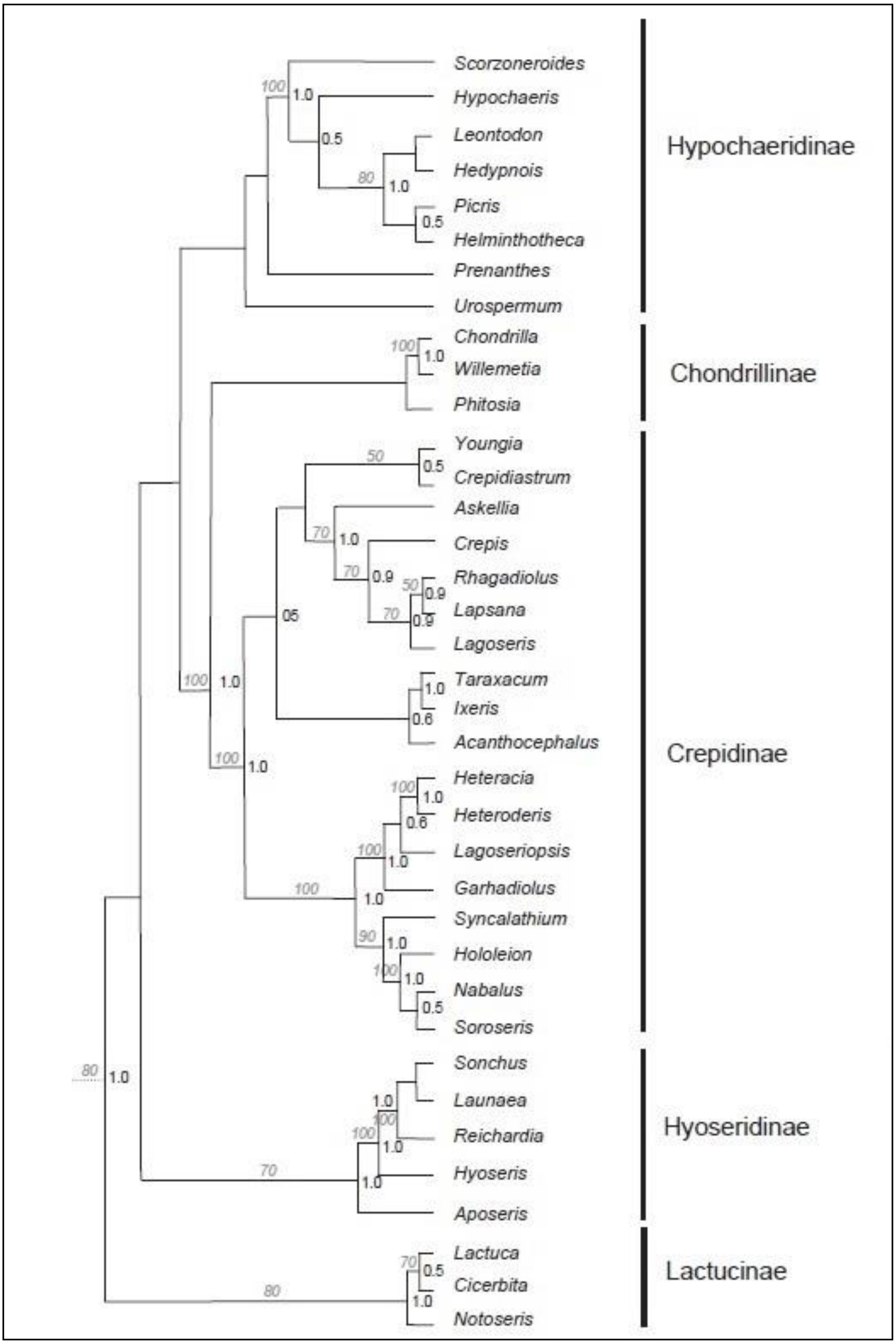

Figure 3: A phylogenetic reconstruction of Cichorieae subtribes Hypochaeridinae, Chondrillinae, Crepidinae, Hyoseridinae and Lactucinae and their associated genera based on DNA sequence data from the nuclear ITS rDNA operon, as presented in Kilian et al. (2009). Note the phylogenetic placement of *Sonchus* within subtribe Hyoseridinae.

Sonchus is a cosmopolitan genus and currently accommodates 55–60 species (Thompson 2007, 2015a). *Sonchus* species vary from annual to biennial and perennial (Boulos 1960; Nessler 1976; Healy 1982; Thompson 2007). Most however, are biennial or perennial with woody roots or rhizomes (Boulos 1960). Morphologically, species of *Sonchus* are characterised by their simple, glandular or eglandular hairs, basal and cauline leaves, cymose capitulescence, pedunculated capitula, multiseriate involucral bracts that are reflexed at maturity, yellow flowers, homomorphic achenes that are unbeaked and compressed, pappus of partially persistent almost smooth bristles of two types (Thompson 2007, 2015a). Within Australia, there is one native *Sonchus* species, *S. hydrophilus*, and three naturalised species: *S. oleraceus*, *S. asper* and *S. asper* var. *asper* (Thompson 2007, 2015a).

1.3 Close relatives in Australia

Investigations of the Australian Virtual Herbarium and the Australian Plant Name Index indicate that there are several species from genera phylogenetically related to *Sonchus* and grouped within the Hyoseridinae that are known to occur in Australia.

Several species of *Sonchus* have become naturalised within Australia. For example, *S. asper*, a European native, is now a widespread weed in Australia and occurs in Western Australia, South Eastern Australia (from Brisbane to Victoria), Southern Australia and Tasmania (Thompson 2007). The Australian native *S. hydrophilus* can be found in Western Australia (Geraldton south east to Esperance), Central and South Australia and South Eastern Australia (from south-eastern Queensland south through New South Wales into Victoria and Tasmania) (Thompson 2007).

The genus *Launaea* is closely related to *Sonchus* (Fig. 3) and accommodates approximately 54 species, the majority of which are native to Africa, South West Asia and the Mediterranean (Stebbins 1953; Thompson 2007, 2015c; Kilian et al. 2009). *Launaea sarmentosa* is the only species of this genus that is native to Australia and it occurs between Exmouth and Karratha on the Western Australian coastline growing on coastal sands and flowering for a large part of the year (Thompson 2007, 2015c).

Reichardia is the next genus related to *Sonchus* and *Launaea*. It is a small genus of approximately eight species that is native to the Mediterranean and two species of this genus, *R. tingitana* and *R. picroides* have become naturalised in Australia (Kim et al. 2007; Thompson 2015d). *Reichardia tingitana* grows in semi-arid and coastal environments on the west coast of Western Australia, southern Western Australia, South Australia and South-Eastern Australia (Thompson 2007). *Reichardia picroides* however, has only been recorded once in Western Australia on Mt. Melville, where it grows extensively (Thompson 2007, 2015d).

Hyoseris and *Aposeris* are the last two genera in the subtribe Hyoseridinae. Searches of the Australian Plant Census (APC) revealed that four species of *Hyoseris* were previously identified in Australia: *H. cretica*, *H. hedypnois*, *H. minima*, *H. rhagadioloides* and *H. taraxacoides.* Taxonomically, *Hyoseris* was long regarded as a genus of the Hypochaeridinae and accommodated species native to the Mediterranean and South-East Asia (Anderberg et al. 2007; Thompson 2007). However, studies employing DNA sequence data cast doubt on this taxonomic placement and have shown instead that *Hyoseris* is more appropriately grouped within the Hyoseridinae, sister to the *Sonchus-Launaea-Reichardia* alliance (Samuel et al. 2003; Killian et al. 2009). Furthermore, the *Hyoseris* species previously known to occur in Australia were synonomised initially into *Hedypnois* and more recently into *Leontodon sensu stricto* within subtribe Hypochaeridinae and *Arnoseris* within the Cichoriinae (Kilian et al. 2009; Enke et al. 2012; Thompson 2015e). Due to these taxonomic revisions there are no species of *Hyoseris* which currently occur in Australia.

Aposeris is a monotypic genus accommodating the single species *A. foetida*, a perennial plant native to Central Europe (Šircelj & Batič 2007). Searches of the Global Biodiversity Information Facility (GBIF 2016) returned over 6,000 records of this species distributed in several European countries including Austria, France, Germany, Italy, Poland, Switzerland and Slovenia. There is no record of *A. foetida* occurring in Australia.

2. Distribution

2.1 Native geographic range and probable origin

Common sowthistle is native to Europe, Macaronesia (Madeira Islands, Canary Islands), North Africa (Algeria, Egypt, Libya, Morocco, and Tunisia) and South-Western Asia (Black 1986; Auld & Medd 1987; Mejias & Andres 2004; Thompson 2007; CABI 2015). The greatest diversity of *Sonchus* is regarded to be in the Western Mediterranean (Mejias & Andres 2004).

Members of the subtribe Hyoseridinae have dispersed centers of origin including the Mediterranean, the mid-Atlantic Islands, Central and North Eurasia, tropical Africa, Southwest and South Asia, Australia, New Zealand, North America and the South Pacific Islands (Kilian et al. 2009). In relation to *Sonchus*, Boulos (1960), considered subgenus *Origosonchus* to represent the primitive type of *Sonchus sensu lato* followed by *Dendrosonchus* and hypothesised that *Sonchus* most likely originated from *Launaea* in Central Africa (Boulos 1960).

2.2 Present distribution

Common sowthistle has a very broad geographic distribution and can be found in temperate, tropical and subtropical climates (Boulos 1960; Kilian et al. 2009) (Fig. 4). This species is now known to occur in at least 150 countries across Asia, Africa, Central America, Caribbean, North America, South America, Europe and the Oceania Region (CABI 2015). Human mediated dispersal has aided in the movement of common sowthistle within both the Northern and Southern Hemispheres (Lewin 1948).

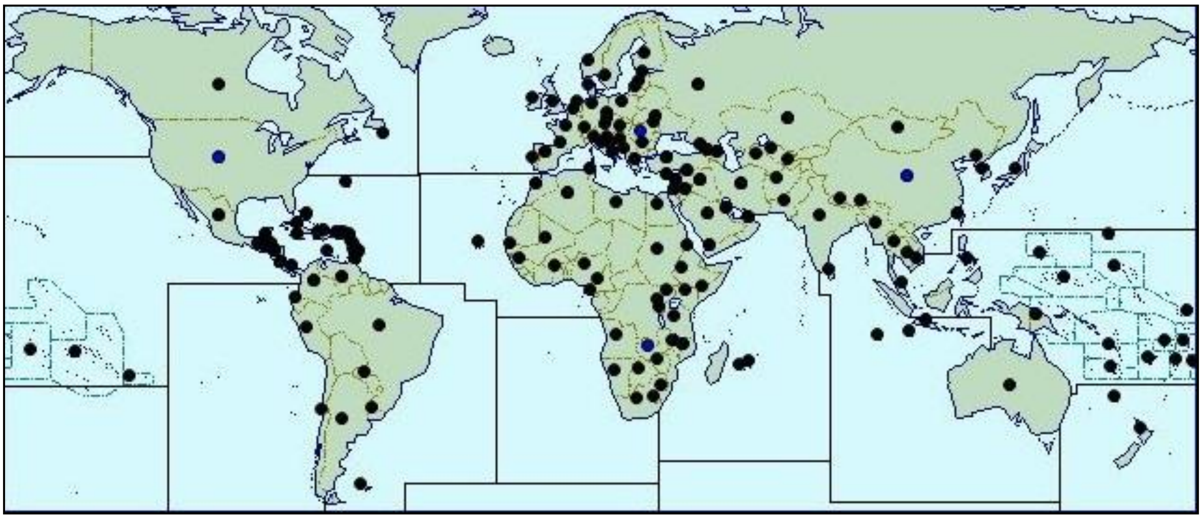

Figure 4: Graphical representation of the worldwide distribution of common sowthistle (*Sonchus oleraceus*) (CABI 2015).

Common sowthistle has a widespread distribution within Australia and can be found in all States and Territories, but appears to be most prevalent in the southern half of the continent (Auld & Medd 1987; Thompson 2007). There are more than 33,000 records of common sowthistle in the Atlas of Living Australia (Fig. 5; ALA 2017b).

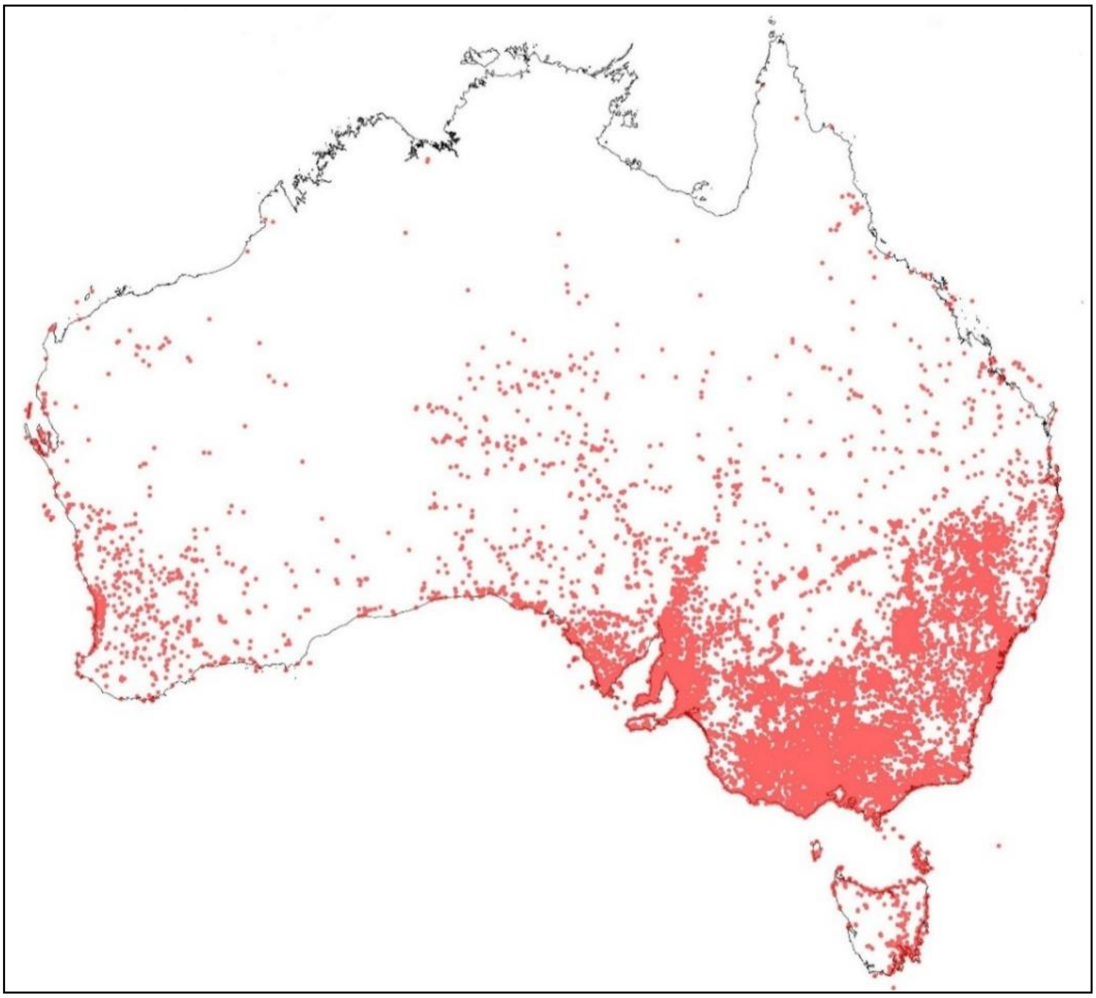

Figure 5: Occurrence records of common sowthistle (*Sonchus oleraceus*) in Australia (ALA 2017b).

2.4 Potential geographic range in Australia

Common sowthistle is a truly cosmopolitan weed, with a wide tolerance to a variety of climatic and edaphic conditions (Chauhan et al. 2006a, 2006b; Dahlquist et al. 2007; Gresta et al. 2010; Gomaa et al*.* 2012; Widderick et al. 2004, 2010). The potential geographic range of common sowthistle in Australia has been predicted to be quite broad and incorporates all major cropping regions (Fig. 6) (McCarren & Scott 2013; McCarren & Scott *unpublished*). While the weed already appears to occupy many of these climatically suitable regions (Fig. 5, Fig. 6), and may therefore have reached the limits of its spread, it is highly likely that it will continue to spread and increase in abundance in and amongst these areas.

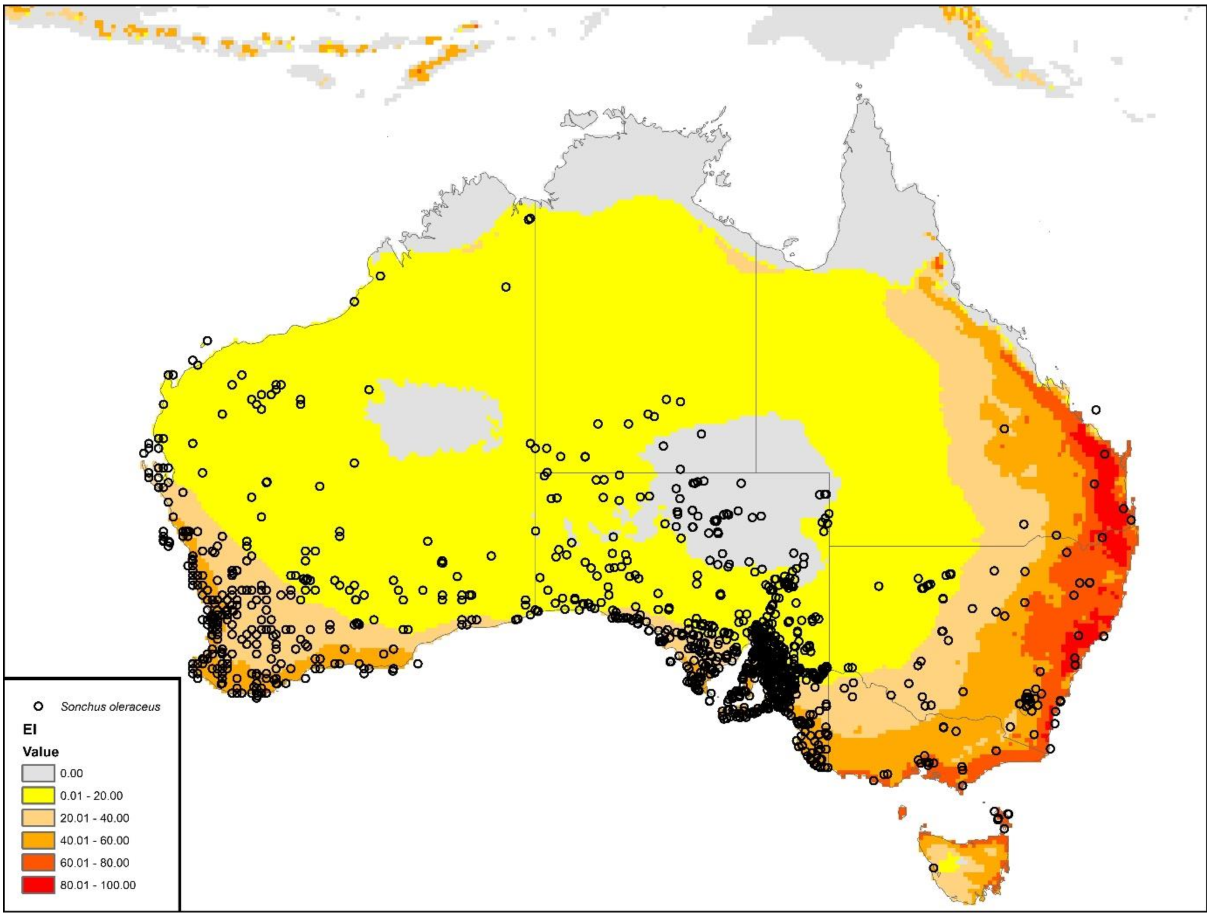

Figure 6. Projected climatic suitability model for common sowthistle (*Sonchus oleraceus*) in Australia. The projection is under the 1961-1990 climate normals, as modelled using CLIMEX. Climatic suitability and the projected distribution is shown by the Ecoclimatic Index (EI), as indicated by the changing colour scale: Unsuitable, EI = 0: grey, increasing suitability from yellow to red. Distribution of *S. oleraceus* as recorded in GBIF in 2013. Figure reproduced from McCarren & Scott (2017).

3. Control methods

Current recommended control strategies for common sowthistle are largely based on the use of herbicides, within an integrated weed management framework designed to prevent the evolution of herbicide resistance (see section 4 and PestGenie 2010; Pubcris 2010; St John-Sweeting 2011 for further details on herbicide resistance). An integrated and sustainable approach to management of common sowthistle should include: herbicide resistance testing, farm hygiene, strategies to reduce seed set and deplete the seed bed, growing competitive crops, strategic crop rotation and tillage, follow up/double-knock herbicide applications and rotation of herbicide groups (Widderick 2014; Widderick & van der Meulen 2016; Widderick et al. 2004). As the weed can germinate all year round, and particularly following rains, diligence and monitoring is required for its effective management (Widderick et al. 2004).

Careful herbicide selection and application should form the cornerstone of an effective integrated weed management strategy for common sowthistle. This should include herbicide resistance testing in the first instance, to identify which herbicides will work on individual farms, followed by efforts to treat all weeds and eliminate seed set for 2 to 3 years, in order to reduce emergence to manageable levels in the following years (Widderick & van der Meulen 2016). When relying on knockdowns in fallow, the use of planned “double knock” herbicide applications, applying herbicides of different modes of action closely one after the other (not always as mixes, as these can be problematic and less efficacious), and the application of residual herbicides early in the fallow period and to small seedlings are recommended (Widderick & van der Meulen 2016; Widderick et al. 2004). For both large scale and survivor follow-up treatments, young, small weeds should be targeted where possible, to ensure greatest level of control (Widderick & van der Meulen 2016). Where this is not possible, farmers may consider the use of automated “Weed Seeker” technologies to apply higher rates of herbicide to ensure maximum knockdown (Widderick & van der Meulen 2016).

Common sowthistle has a short-lived seed bank of only 2 to 3 years, ideal for targeting in an integrated weed management framework, often utilising herbicides selectively at key times on young and individual plants (Widderick 2009; Widderick et al. 2004). Strategies to control seed set and diligent control of seedlings during the fallow period greatly exhaust the seed bank, resulting in a minimal weed problem in the following crops, assuming that seeds are not blown in from other areas. (Widderick et al. 2010). In the case of windblown seed, it is important to extend management of common sowthistle to non-cropping areas such as fence lines and roadsides, to reduce the amount of seed entering the field in this way (Widderick et al. 2004). Strategies aimed at reducing the weed seed bank will also reduce the level of resistant plants, as gene flow of Group B herbicide resistance in common sowthistle is mainly by seed movement, with very little outcrossing of these resistance (St John-Sweeting 2011).

Drawbacks of both residual and knock-down herbicide control techniques are that they require chemical intensification of the cropping system, and may involve the use of herbicides that are not environmentally friendly (Stewart et al. 2011). No matter the application method, many residual herbicides can remain in the soil for a long period, limiting growth of native plant species and successive crops. Planting periods, crop rotation and retention of desirable trees needs to be taken into consideration when considering herbicides (Widderick et al. 2011). Continued use of the same herbicide can lead to resistance development in weed populations (see Section 4). In order to reduce the risk of herbicide resistance and to maintain the usefulness of commonly used herbicides, mode of action groups should be rotated and herbicide use should be well integrated with knowledge of the weed’s ecology to effectively target and reduce weed populations (Widderick et al. 2004).

Alternative non-chemical control options recommended for common sowthistle include farm hygiene, growing competitive crops, and strategic crop rotation and tillage (Widderick & van der Meulen 2016). A competitive crop (or crop variety), such as barley, or wheat grown at narrow row spacing (25 cm) and high plant density (≥100 plants m^2) greatly reduces the number of common sowthistle plants, their biomass and their potential to set seed (Widderick et al. 2004), and can do so even in the absence of herbicide application (Widderick 2014). Pulse crops, on the other hand, are poorly competitive, and should therefore be avoided while trying to reduce the weed population, especially in the absence of intensive herbicide application (Widderick & van der Meulen 2016; Widderick et al. 2004). Avoidance of chickpea as a rotation crop in areas known to have large populations of common sowthistle has been suggested as a component of best management practices, as the weed is very difficult to control in this crop (Widderick & van der Meulen 2016). And while no-till farming practices create environments favourable to the proliferation of the weed (Widderick et al. 2002; Widderick et al. 2010), strategic use of tillage to bury seed below 2cm depth can likewise be adopted to reduce seed set and deplete the seed bed (Widderick 2014; Widderick & van der Meulen 2016). Growers that keep stock may also choose to graze their fallows to control survivor weeds (Widderick et al. 2004).

Many of the best management approaches considered above will cost more than current practice (see Table 2, Widderick 2009), and may be less viable and difficult to implement as they may run contrary to current agricultural practices (e.g. minimum tillage farming adopted to minimise top soil loss). However, considerable cost-benefits in improved quality and yield and prevention of herbicide resistance are to be expected in an integrated weed management approach. Once glyphosate resistance is common in a weed population, alternatives to glyphosate have to be used to control that population all the time, increasing costs on a recurring basis (Widderick 2009). While alternative herbicides will cost more in the short term, this is not a recurring cost, as glyphosate will remain an important tactic that works (Widderick 2009). Increasing costs can be minimised by a gradual approach, reducing the weed population on the weediest paddocks first and then rotating efforts to provide greater coverage (Widderick 2009).

4. Importance

4.1 Detrimental aspects

Common sowthistle is a major weed of cropping in northern (subtropical) grain and cotton regions, from central Queensland to northern New South Wales, and a common and increasingly prevalent weed elsewhere in Australia (Alemseged et al. 2001; Amor & Ridge 1987; Chauhan et al. 2006a; Llewellyn et al. 2016; Osten et al. 2007; Werth et al. 2011; Widderick 2014). While most common in zero or reduced tillage farming systems (Widderick et al. 2002; Widderick et al. 2010), it occurs in both fallow and cropped areas (Llewellyn et al. 2016; Widderick 2014), and is a problem in many different production systems, including dryland irrigated broad acre cereal and grains production (including pulses), cotton, horticultural crops, vineyards and tree crops, and is frequently found in non-cropping areas such as roadsides and nature reserves (Widderick et al. 2004). It is an increasingly difficult and costly weed to control, particularly since herbicide resistance has developed (Llewellyn et al. 2016). The weed’s main detrimental impacts are as a user of resources in fallow, as a host for pests and diseases, as a contaminant at harvest, and occasionally as direct competition for resources in crops.

Economically and spatially, common sowthistle consistently ranks in the top 10 of residual and fallow weeds of both summer and winter grains crops nationally. It is calculated to affect an area of nearly 600,000 ha, causing revenue losses in excess of $13 million annually (Llewellyn et al. 2016). It has increased in prevalence in northern grains regions over the past 30 years, and is now regarded as the most common weed in the region (Jones et al. 2000; Llewellyn et al. 2016; Martin et al. 1988; Osten et al. 2007; Walker et al. 2005). In the northern grains region it is regarded as the number one weed of winter fallow (by both cost and crop area) and the sixth most costly weed to control year-round (Llewellyn et al. 2016).

While not considered to compete heavily with crops, common sowthistle can contribute to green matter at harvest and lead to grain quality problems, and uses precious water resources during the fallow period (Widderick 2014). It is also an alternative host for: i) *Helicoverpa* species (i.e. cotton bollworm/corn earworm and native budworm) (Walter & Benfield 1994), which cause major crop damage to a wide range of field crops and pastures across Australia (Bailey 2007), ii) many species of aphids, which can transmit viral diseases hosted by the weed to economically important crops (Holm et al. 1977; Hutchinson et al. 1984; Jones & Jones 1974; O'Loughlin & Chambers 1969; Wallis 1967) and, iii) nematodes (Holm et al. 1977; Hutchinson et al. 1984; Townshend & Davidson 1960), which cause major root disorders in many agricultural crops.

Common sowthistle has developed populations resistant to acetolactate synthase (ALS) inhibiting herbicides (Group B), cellulose synthesis inhibitors (Group O) and glyphosate (Group M) herbicides over the last three decades (Heap 2017; St John-Sweeting 2011; Werth et al. 2011). The first ALS inhibiting herbicide resistance in Australia was recorded in 1991, in cereal crops at Goondiwindi in south-east Queensland (Boutsalis & Powles 1995). Glyphosate resistance was confirmed in 2014, following initial reports from cotton systems earlier this decade (Werth et al. 2011), and confirmation in grains cropping systems more recently (Widderick & van der Meulen 2016). While common sowthistle (including those populations resistant to ALS inhibiting herbicides (Boutsalis & Powles 1995)) is still susceptible to a wide range of pre-emergence and foliar herbicides from a number of herbicide groups in Australia (Fryer & Makepeace 1982; Hutchinson et al. 1984; Spencer 1982; Widderick et al. 2004), care must still be taken to reduce the risk of additional herbicide resistance developing. Populations of the closely related *S. asper* have developed resistance to photosystem II inhibitors (Group C) herbicides in France since the 1980s (Heap 2017), which may indicate the genus has the capacity to evolve resistance to further modes of herbicide action.

Infestations of common sowthistle have also been observed at low levels in some National Parks in south-east Queensland (Ngugi et al. 2014). The impacts of the weed in these natural ecosystems could warrant further attention given that it has been identified as an invasive and noxious environmental weed in North America (see Ansong & Pickering 2013 and references therein).

4.2 Beneficial aspects

Common sowthistle has been used as a food source for both humans and animals, both within the native European range (Neal 1965; Perrino et al. 2014) and further afield in Java (Burkill 1935). It has also been investigated as a potential source of natural rubber (Kassner 1885) and as a biofuel crop (Hutchinson et al. 1984). While common sowthistle leaves are sometimes consumed by Maori communities settled in Australia (Adam Jalaludin, QDAF, pers. comm.), overall the species has no beneficial aspects recorded in Australia.

5. Stakeholders

Considering common sowthistle is a troublesome weed in the northern and western grain region of Australia (Widderick & Walker 2009; Cattanach et al. 2013; Chauhan et al. 2015), agricultural stakeholders are likely to be most seriously affected. These stakeholders include:

- Agricultural landholders and grains producers
- Cotton Research and Development Corporation (CRDC)
- Grains Research and Development Corporation (GRDC)
- Grain Producers Australia (GPA)
- GrainGrowers
- NSW Department of Primary Industries (NSW DPI)
- NSW Farmers Association
- Queensland Department of Agriculture and Fisheries (QDAF)

Common sowthistle is also problematic in vegetable production sites on clay and loamy soils of Southern Queensland and New South Wales (Henderson 1998). Members of the vegetable industry in these areas represent additional stakeholders, and specifically include:

- Horticulture Innovation Australia
- AUSVEG

Other stakeholders may also be affected if the weed spreads and establishes major infestations in natural areas or in parks adjoining agricultural and horticultural properties. These stakeholders include:

- State and National Parks staff and agencies
- Landcare groups

6. Potential for biological control

Common sowthistle is host to a number of fungi, nematodes, viruses and insects (Hutchinson et al. 1984). To date, close to 60 fungal (and fungal-like) and 80 insect species have been recorded as infecting or feeding on common sowthistle (Barreto & Vieira 2008, Farr & Rossman 2017, Hutchinson et al. 1984, Lima et al. 2003, Plant Health Australia 2017, Scott & McCarren 2012, Smith et al. 2015). At least ten of these may hold promise as classical biological control agents for common sowthistle in Australia.

Based on the literature, there are four exotic fungi and one oomycete that are host-specific to *Sonchus* and promising for biological control: *Bremia sonchi*, *Entyloma bullulum*, *Peronospora sonchi*, *Protomyces sonchi* and *Macrosporium sonchi* (Farr & Rossman 2017). All species are foliar pathogens of Palearctic origin, except for *M. sonchi* which has only been reported from Japan (Farr & Rossman 2017). All have been reported as infecting only common sowthistle, except for *B. sonchi* which has also been reported on perennial sowthistle (*S. arvenis*) (Farr & Rossman 2017), another weed within the genus *Sonchus* that does not occur in Australia (ALA 2017a).

Ten insect herbivores specific to *Sonchus* spp. have been identified in the literature, including the cecidomyiid gall midge, *Cystiphora sonchi* and the flower feeding tephritid *Tephritis dilacerata* (Berube 1978; Peschken 1979, 1982), that were introduced in Canada in the 1980s for the biological control of *Sonchus* species (*S. arvensis*, *S. oleraceus* and *S. asper*) (Peschken 1984; Winston et al. 2014). While *T. dilacerata* failed to establish, *C. sonchi* did establish, but has not caused sufficient damage to *S. arvensis* in Canada to be considered effective (Peschken 1984; Winston et al. 2014). Two other insect species *Contarinia schlechtendaliana* (Cecidomyiidae) and *Botanophila sonchi* (Anthomyiidae) known to feed on *Sonchus* flower heads (Peschken 1984; Schroeder 1973) may also offer promise as potential agents. The eriophyid mite *Aceria sonchi* has also been recorded on *Sonchus* species in Europe and Africa (Knihinicki et al. 2009); and could be a potential agent as it feeds on leaves and forms leaf galls.

Systematic native range surveys will assist greatly in assessing impact of these potential agents as well as identifying additional candidates.

References

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