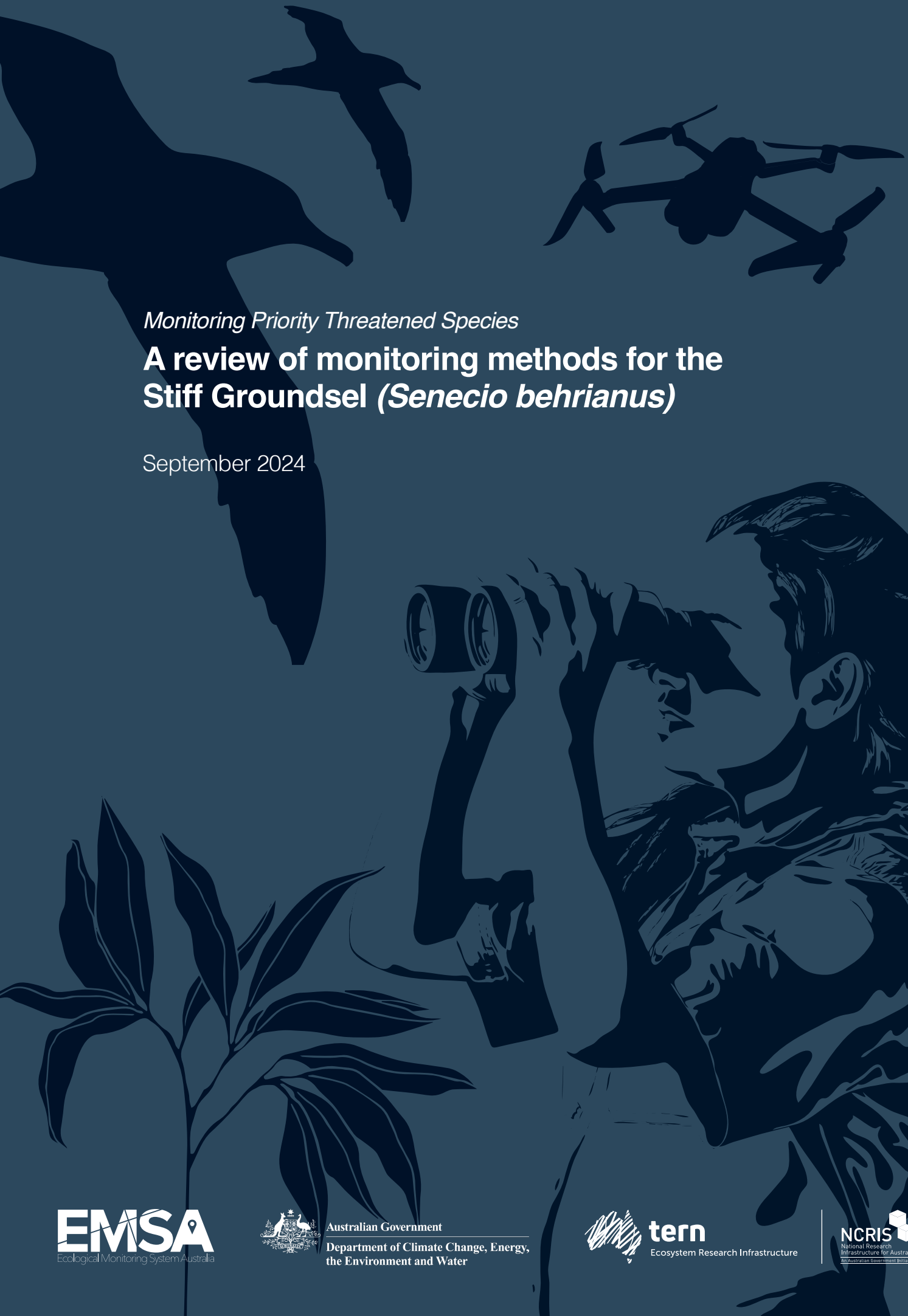

Monitoring Priority Threatened Species

A review of monitoring methods for the Stiff Groundsel *(Senecio behrianus)*

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EMSA
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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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About This literature review collates information on one of the 110 priority threatened species identified in the *Threatened Species Action Plan 2022-2032* and has been reviewed by invited practitioners experienced in monitoring the species.

The *Survey Guidelines for Monitoring Threatened Species* project, a collaboration of the Department of Climate Change, Energy, the Environment, and Water (DCCEEW) and the Terrestrial Ecosystem Research Network (TERN), aims to improve our knowledge of threatened species by enhancing accessibility and sharing of quality scientific threatened species data. By developing best practice field survey guidelines and recommendations, practitioners will be better equipped to conduct standardised, repeatable surveys.

By identifying the monitoring methods typically implemented by practitioners, documenting and assessing the techniques known to work, and identifying opportunities to standardise the methods, we can move towards ensuring all monitoring is species-appropriate, comparable between practitioners and populations, and repeatable over time. Further, together with consistent terminology, guidelines, instructions, and data collection, we can refine efforts and resources to measure and share information. Data collected using robust, standardised methods will improve our knowledge of threatened species and underpin threatened species recovery at scale. This project is essential to establishing monitoring protocols and data repositories to enhance the accessibility and sharing of threatened species data.

TERN has prepared the literature reviews for the Department of Climate Change, Energy, the Environment, and Water. For further information, please visit the EMSA Threatened Species Survey Guidelines website. Additional information, particularly monitoring methods and techniques not included that should be considered, can be brought to the author's attention by emailing tern@adelaide.edu.au for consideration for future updates.

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1 Background

1.1 Species name

The Stiff Groundsel (*Senecio behrianus*) (Sond. & F.Muell. ex Sond. Linnaea 25: 527 (1853)), is sometimes referred to as Behr's Groundsel (ALA 2023), although Stiff Groundsel is the more widely used of these common names (e.g. Nevill and Camilleri 2010).

1.2 Conservation status

The Stiff Groundsel is listed as Endangered under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth). The species is one of 30 priority plants identified in *The Threatened Species Action Plan 2022-2032*. Table 1 identifies the Stiff Groundsel's conservation status under Commonwealth and State listings. The species is not currently listed on the International Union of Conservation for Nature (IUCN) Red List of Threatened Species.

Table 1. National, international and state conservation status for the Stiff Groundsel.

Jurisdiction	Status	Legislation
Commonwealth	Endangered	*Environment Protection and Biodiversity Conservation Act 1999*
New South Wales	Extinct	*Biodiversity Conservation Act 2016*
Victoria	Critically Endangered	*Flora and Fauna Guarantee Act 1988*
South Australia	Endangered	*National Parks and Wildlife Act 1972*

1.3 Summary of data held in the Threatened Species Index

The Threatened Species Index (TSX) provides reliable and robust measures of change in the relative abundance of Australia's threatened and near-threatened species at national, state and regional levels. Understanding these changes in species populations is crucial for monitoring Australia's conservation progress and allows users to measure and report on the benefits of conservation investments and to justify and design targeted management responses. Currently, the index is restricted to birds, plants and mammals, with new groups to be added in the near future.

The table below summarises Stiff Groundsel data held in the TSX. More information on the TSX, including how to contribute threatened species monitoring data to the index, can be found on the TSX website.

Table 2. Summary of Stiff Groundsel data held in the TSX

TSX information	Stiff Groundsel data held in the TSX
Data held in the TSX	Yes
Number of data sources	1
Number of unique sites	4
Average time series length (years)	3.8
Average number of sampling years	2.5

1.4 Distribution and abundance

The Stiff Groundsel is endemic to south-eastern Australia. It once occurred in south-west New South Wales along the Darling River and south-east South Australia along the River Murray but the species is now restricted to Victoria, where it occurs around Corop, Ballarat, Gunbower and Kerang (Nevill & Camilleri 2010). The reasons for the species' decline are somewhat speculative and include altered flow regimes, reduced flooding, drying of floodplains, grazing and habitat loss (Silcock et al. 2021).

There are seven known wild subpopulations of the Stiff Groundsel and a further seven translocated subpopulations (Table 2) (Silcock et al. 2021). Two of the wild subpopulations are thought to be declining and the statuses of the other five known wild subpopulations are unknown. Vegetative recruitment has been recorded at five of the translocated subpopulations (Silcock et al. 2021). All wild subpopulations are <0.25 ha in extent, and the total number of individuals in the population is estimated to be <250 (Cook pers. comm. cited in Silcock *et al.* 2021).

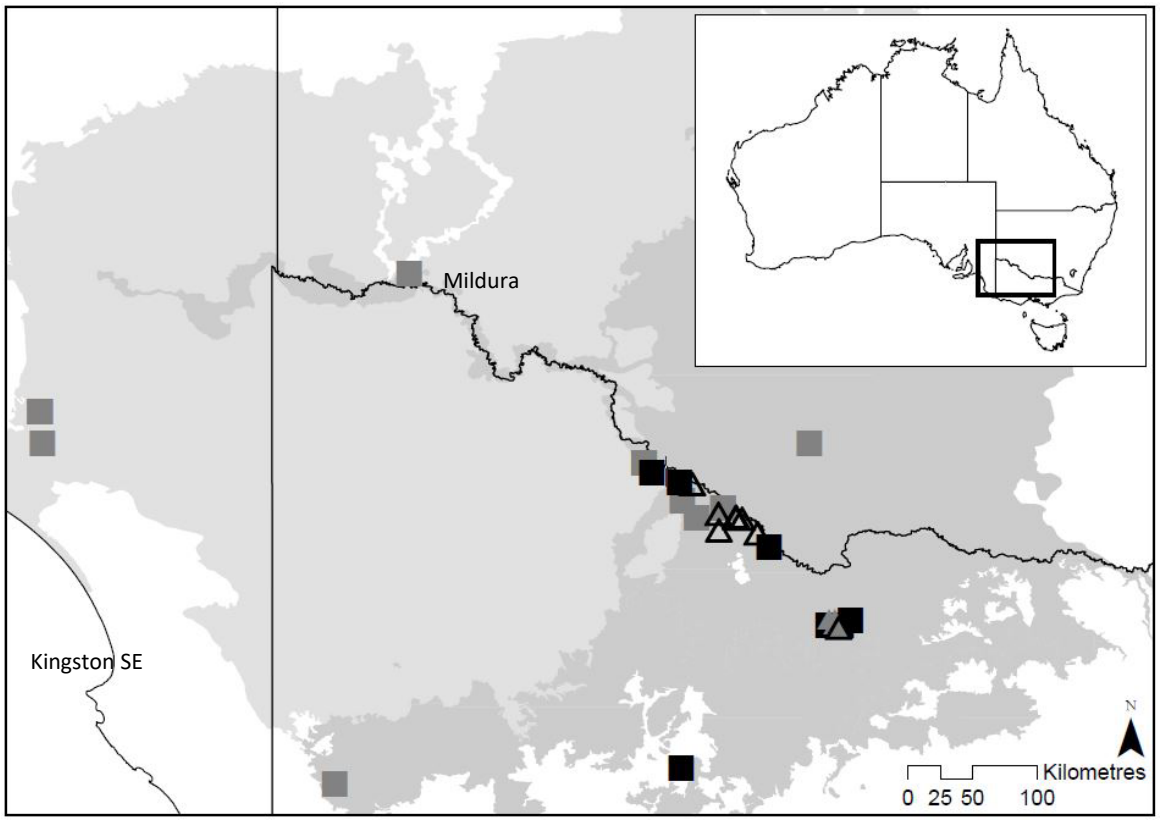
Table 3. Stiff Groundsel monitoring data for existing subpopulations, 1993-2020

Subpopulation (tenure)	Number of mature individuals (juveniles)	Trend
1 Miners Rest, Ballarat (Wetland Reserve)	2015: 5 patches over 2000 m2	Unknown
2 Gilmour Road, Corop (Shire roadside/private property)	2015: 6 patches over 100 m2	Unknown
3 Grinter Road S, Corop (Shire roadside/private property)	2015: 10 patches over 200 m2	Unknown
4 Grinter Road N, Corop (Shire roadside/private property	2015: 2 patches over 10 m2	Decreasing
5 McGillivray Road, Gunbower (Shire roadside)	2015: 3 patches over 10 m2	Decreasing
6 North-west of Lake Boga (private property)	2015: 10 patches over 20 m2	Unknown
7 Winlaton (private property)	2020: 20-30 plants (estimated)	Unknown
8 (T) Between Reedy Lagoon and Black Swamp, Gunbower Forest (National Park)	2016: 50T 2017: 25T 2020: 9T	9 plants now well established and spreading via rhizomes
9 (T) Hudson Track, Gunbower Forest (National Park)	2016: 7 planted 2017: 7 planted 2020: 2T	2 plants now well established and spreading via rhizomes
10 (T) Spur Creek, Gunbower Forest (National Park)	2016: 80T 2017: 40T	Unknown
11 (T) Two Tree Swamp, Corop (wildlife reserve)*	2003 and 2005: 200T 2015: 100T over 100 m2	Stable
12 (T) Wirralo Wetlands, Murrabit West (covenanted private property)	2016-2020: 75 planted	Some plants well- established and spreading via rhizomes
13 (T) Johnson Swamp Wildlife Reserve (State Game Reserve)	2018: 40T planted	Some plants well- established and spreading via rhizomes
14 (T) McDonalds Swamp Wildlife Reserve (State Game Reserve)	2016-2018: 40T planted	Some plants well- established and spreading via rhizomes

Source: Adapted from Silcock et al. 2021 (Cook 2015; Nevill and Camelleri 2010; Silcock et al. 2019, Cook pers. comm. 2020 cited in Silcock et al. 2021).

*Notes: Translocated individuals/subpopulation (T). *An earlier translocation (1994) of >50 plants at this site failed and is not shown here.*

Figure 1. Known distribution of the Stiff Groundsel



Source: Adapted from Silcock et al. (2021)

Notes: Grey squares represent historic distribution, black squares represent current distribution, hollow triangles represent established translocations and grey triangles represent failed translocations.

1.5 Habitat requirements

The Stiff Groundsel occurs on poorly-drained sedimentary grey clays or sandy clays, on or close to floodplains, and on basalt-derived grey cracking clays in periodically flooded depressions (Nevill & Camilleri 2010). Seasonal inundation is a common feature of its habitat, and the species appears to grow more vigorously at sites that experience flooding to a depth of >30 cm (Nevill & Camilleri 2010). Moreover, a translocated subpopulation in a regularly inundated wetland was observed to grow vigorously, flower abundantly and produce large amounts of seed (Cook pers. comm. cited in Silcock *et al.* 2021). This contrasted with wild subpopulations nearby, which did not experience regular inundation over the same period and was observed to remain stable or decline and produce few flowers and little seed (Cook pers. comm. cited in Silcock *et al.* 2021). Apart from the bottom of depressions, the species will also grow on marginally raised areas such as banks and natural mounds (Nevill & Camilleri 2010). Native plants known to occur with the Stiff Groundsel include Cumbungi (*Typha spp.*), Lignum (*Meuhlenbeckia florulenta*), Blue devil (*Eryngium ovinum*), Common nardoo (*Marsilea drummondii*), Cotton fireweed (*Senecio quadridentatus*), Grey gernander (*Teucrium racemosum*), Common-blown-grass (*Arostis avenaceae*) and Prickfoot (*Eryngium vesiculosum*) (Nevill & Camilleri 2010).

1.6 Biology and ecology

The Stiff Groundsel is an erect, woolly perennial herb reaching a height of up to 1 m and forming large rhizomatous clumps (Walsh 1999). Leaves are grey-green, linear, alternate, 2-8 cm long, 1-5 mm wide and are initially pubescent but become glabrous, although the underside may remain mealy (Silcock et al. 2021). Leaf margins are entirely or irregularly denticulate and generally recurved (Walsh 1999). Inflorescences are small and yellow, consisting of 6 ray florets and 13–15 disc florets in terminal,

loose clusters (Walsh 1999). Flowering is from January to May (Walsh 1999). Seeds are dark brown, flattened and 2-2.5 mm long (Walsh 1999).

The Stiff Groundsel is capable of resprouting after disturbances such as fire, drought and grazing (Silcock et al. 2020; Silcock et al. 2021). The species can reproduce vegetatively, and many individuals in subpopulations are connected via woody rhizomes, making it difficult to count individual plants and most likely limiting genetic diversity (Nevill & Camilleri 2010). Stiff Groundsel has not been observed recruiting from seed in situ, although high germination rates have been observed under experimental conditions (Lindner & Nevill pers. comm. cited in Nevill & Camilleri 2010). The pollination mechanism for the species is unknown.

1.7 Threats

Extant populations of the Stiff Groundsel face a variety of threats. Grazing and trampling by domestic stock is suspected to be a driver of the species' historic decline and a number of extant subpopulations have been fenced to prevent stock access (Nevill & Camilleri 2010). However, fencing is not always effective against rabbits, hares and native herbivores which may pose a threat to subpopulations. Invasive grasses and woody weeds also compete with the species. Invasive species observed at extant subpopulations include Blackberry (*Rubus parvifolius*), Canary grass (*Phalaris aquatica*), Wild oats (*Avena fatua*), Onion grass (*Romulea rosea*), Strawberry clover (*Trifolium fragiferum*) and thistles (*Sonchus spp.*) (Nevill & Camilleri 2010). The location of some subpopulations on roadsides and irrigation channels means that maintenance also poses a threat to the species (Nevill & Camilleri 2010). Plants have previously been impacted by grading and could conceivably be impacted by slashing, herbicide spraying, earthworks or any other maintenance activities (Silcock et al. 2020; Silcock et al. 2021).

Altered hydrology in existing Stiff Groundsel habitat has changed the timing, depth and duration of flooding, usually resulting in less frequent and less extensive floods (Nevill & Camilleri 2010). Observations of improved plant growth at sites that are regularly flooded to a depth of >30cm suggests that flooding regime is an important factor in the species' survival, however, there is still insufficient information about the Stiff Groundsel's natural or preferred flooding regime (Nevill & Camilleri 2010). Changed flooding regimes may be partly responsible for the lack of sexual recruitment in wild populations as suitable germination conditions may not be occurring. Because recruitment in the wild has only been observed through vegetative reproduction, it is likely that subpopulations consist of very few genetically distinct individuals (Nevill & Camilleri 2010). Low genetic diversity across a small number of subpopulations leaves the species susceptible to pests, disease and stochastic events (Nevill & Camilleri 2010). Additionally, rising water tables may threaten the Stiff Groundsel through increased soil salinity, although this has not been observed yet (Nevill & Camilleri 2010).

2 Existing monitoring

2.1 Overview of monitoring methods

The Stiff Groundsel should be directly observed to confirm its presence at a site. A systematic ground survey is the most suitable survey technique for monitoring wild and translocated populations of the species. Active searches may also be employed to search for novel populations of the Stiff Groundsel in historic and suitable habitat.

Key population monitoring indices include:

- Patch size (m^2)
- Number of patches
- Stem count (number of individuals is difficult to determine due to rhizomatous habit)
- Recruitment (evidence of shooting from rhizomes)
- Population extent (m^2)
- Survival rate (for translocations)
- Weed abundance (various measures)

2.2 Monitoring resources

Key resources with information for monitoring the Stiff Groundsel include:

- National Recovery Plan for the Stiff Groundsel *Senecio behrianus* (Nevill & Camilleri 2010).

  Identifies recovery actions including:

  - Develop population monitoring protocols
  - Monitor population trends and responses against recovery actions
  - Determine the extent and abundance of existing populations
  - Search for new populations, including locations of previously recorded populations and other potential locations with similar habitat type
  - Map existing and new populations
  - Maintain and monitor reintroduced plants
- Guidelines for the Translocation of Threatened Plants in Australia (Commander 2018)

  Provides guidelines for best practice monitoring of translocation projects
- Action Plan for Australia's Imperilled Plants (Silcock et al. 2020; Silcock et al. 2021)

  Sets out conservation objectives for the Stiff Groundsel including:

  - Targeted surveys in historic locations and suitable habitat
  - Monitor population response to recovery actions

2.3 Survey methods

The Stiff Groundsel requires surveys of wild and translocated subpopulations and active searches for novel subpopulations. Where possible, monitoring of extant populations should be designed to detect changes resulting from management actions such as weed control, grazing exclusion, and allocation of environmental water. The best time to observe Stiff Groundsel is between January and May when it is flowering as it will be easier to locate and more readily distinguishable from other *Senecio spp*. Following prolonged dry conditions, Stiff Groundsel may die back to below ground rhizomes, complicating detection and surveying. As such, populations might be best evaluated in

spring following average to above average autumn and winter rainfall as less dieback would be expected under these conditions. The presence of associated native plant species at a site may be used by surveyors to gauge the suitability of a given habitat for Stiff Groundsel (see *1.2 Habitat Requirements*). Areas that are periodically inundated, such as floodplains and depressions, and close to existing subpopulations are ideal places to search for the species. Based on its current distribution, Stiff Groundsel plants are likely to be detected on poorly-drained sedimentary grey clays or sandy clays and on basalt-derived grey cracking clays (Nevill & Camilleri 2010).

Given that in the wild the Stiff Groundsel has only been observed reproducing vegetatively via rhizomes, it will not always be possible or straightforward to count individual plants (Silcock et al. 2021). Instead, alternative measures of population size such as stem counts and patch size estimates may be required. Furthermore, genetic analysis may be useful to investigate the extent of clonality within and between subpopulations (Commander 2018). Other information which could be collected during population surveys includes evidence of grazing or trampling, presence of weeds, climate variables (e.g. temperature, precipitation), and soil moisture (Commander 2018; Rakali Ecological Consulting 2018).

2.3.1 Ground survey

Ground surveys are systematic surveys of known Stiff Groundsel subpopulations where key population variables are assessed in situ. Permanent photopoints (e.g. at the corners of plots or at fixed points along transects) can complement the data from ground surveys and may provide additional context to the survey findings.

Specific survey methods for translocated subpopulations will differ slightly to those for wild subpopulations.

Wild subpopulation

There are no documented methods for surveying wild populations of the Stiff Groundsel. The most commonly reported measures of population trend are the number and size of Stiff Groundsel patches. Estimations of patch number and patch size in square meters (m^2) will be appropriate where Stiff Groundsel occurs in discrete patches. Patch size can be estimated by placing a quadrat of a known size (e.g. 1 m^2) over a patch and estimating the percent cover (Commander 2018). A stem count is another measure of population size which could be considered alongside patch size and patch number. Ground surveys of wild subpopulations may be achieved through establishing and surveying permanent transects, as has been done for another *Senecio* species (S. macrocarpus; DELWP 2015). Transects should cover the extent of all known plants/patches at a site and the width of transects should enable surveyors to locate all plants/patches without having to stray far from the transect centre line. For example, if transects are 4 m wide then a surveyor will be searching for plants/patches 2 m either side of the centre line. The height and density of vegetation at a site will influence visibility and thus determine the required transect width. For subpopulations occupying a smaller extent, a simple monitoring plot with permanently marked corners may be a suitable alternative to transects.

Translocated subpopulation

Translocations are a common recovery action for threatened plant species such as the Stiff Groundsel and monitoring translocated populations is crucial to their success. In a translocation setting there is an opportunity to tag and identify individual Stiff Groundsel plants which is not always possible due to the species' rhizomatous habit. Therefore, the survival rate of translocated populations can be monitored by recording the number of plants with live aerial stems and the number without live aerial stems (Rakali Ecological Consulting 2018). The recruitment of the translocated population can also be monitored by recording the number of plants shooting from rhizomes (Rakali Ecological Consulting 2018). If there is a comparable wild reference population, this

can be used as a benchmark to measure the translocation against (Commander 2018). Translocations should be monitored several times in the first year and then annually once the population is considered established (Commander 2018).

2.3.2 Active search

Active searches will be required to locate novel populations of the Stiff Groundsel in historic and suitable habitat, particularly on private land in the Kerang and Corop regions (D Cook pers. comm. cited in Silcock *et al.* 2021). A systematic active search may be achieved through a parallel field traverse along transects established in the historic/suitable habitat area (DPIE 2020). For herbs and subshrubs such as the Stiff Groundsel, transects should be spaced 10-15 m apart and surveyors should walk at a reasonable pace visually inspecting each side of the transect (DPIE 2020). Typical survey time using this method in open vegetation is approximately 15 minutes per ha (DPIE 2020). Detected individuals and patches should be accurately recorded on a GPS device.

3 Key agencies and organisations involved in the species research and recovery

Key agencies, organisations or individuals identified as having been previously, or currently involved in monitoring the Stiff Groundsel include:

- North Central Catchment Management Authority
- White Hills Botanic Garden, Bendigo
- Ballarat Botanical Garden, City of Ballarat
- Damien Cook, Wetland Revival Trust
- Geoff Nevill, Victorian Department of Energy, Environment and Climate Action
- Mary Camilleri, Victorian Department of Energy, Environment and Climate Action

4 Survey guideline recommendations gathered from the literature

This literature review of monitoring methods for the Stiff Groundsel has identified some key points to be addressed when developing species-specific survey guidelines:

- This species will be most conspicuous and identifiable during its flowering period from January to May
- After prolonged dry conditions, this species may dieback to below ground parts and therefore populations might be best evaluated in spring following average to above average autumn and winter rainfall as less dieback would be expected under these conditions
- Because individual plants are not easily counted, particularly in wild subpopulations, patch size, number of patches, and stem counts should be considered the primary monitoring indices for this species
- The survival and recruitment of translocated subpopulations can be assessed if individual plants are tagged for identification
- Sites could be systematically surveyed using permanent transects (for larger populations) or monitoring plots (for smaller populations)
- Photopoint monitoring should be considered as this will complement other methods by providing additional information about site conditions
- The Stiff Groundsel has specific habitat preferences and active searches for new occurrences of the species should focus on sites with suitable habitat characteristics such as periodic flooding
- Covariates to record with population indices include evidence of grazing or trampling, presence of weeds, climate variables (e.g. temperature, precipitation), and soil moisture

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