APPLICATION FORM

Release

To obtain approval to release new organisms

(Through importing for release or releasing from containment)

Send to Environmental Protection Authority preferably by email (neworganisms@epa.govt.nz) or alternatively by post (Private Bag 63002, Wellington 6140)
Payment must accompany final application; see our fees and charges schedule for details.

Figure 1. Sydney golden wattle dominating dunes on the Horowhenua coast.

Application Number

APP203934

Date

10th August 2022

Completing this application form

1. This form has been approved under section 34 of the Hazardous Substances and New Organisms (HSNO) Act 1996. It covers the release without controls of any new organism (including genetically modified organisms (GMOs)) that is to be imported for release or released from containment. It also covers the release with or without controls of low risk new organisms (qualifying organisms) in human and veterinary medicines. If you wish to make an application for another type of approval or for another use (such as an emergency, special emergency, conditional release or containment), a different form will have to be used. All forms are available on our website.
2. It is recommended that you contact an Advisor at the Environmental Protection Authority (EPA) as early in the application process as possible. An Advisor can assist you with any questions you have during the preparation of your application including providing advice on any consultation requirements.
3. Unless otherwise indicated, all sections of this form must be completed for the application to be formally received and assessed. If a section is not relevant to your application, please provide a comprehensive explanation why this does not apply. If you choose not to provide the specific information, you will need to apply for a waiver under section 59(3)(a)(ii) of the HSNO Act. This can be done by completing the section on the last page of this form.
4. Any extra material that does not fit in the application form must be clearly labelled, cross-referenced, and included with the application form when it is submitted.
5. Please add extra rows/tables where needed.
6. You must sign the final form (the EPA will accept electronically signed forms) and pay the application fee (including GST) unless you are already an approved EPA customer. To be recognised by the EPA as an “approved customer”, you must have submitted more than one application per month over the preceding six months, and have no history of delay in making payments, at the time of presenting an application.
7. Information about application fees is available on the EPA website.
8. All application communications from the EPA will be provided electronically, unless you specifically request otherwise.

Commercially sensitive information

9. Commercially sensitive information must be included in an appendix to this form and be identified as confidential. If you consider any information to be commercially sensitive, please show this in the relevant section of this form and cross reference to where that information is located in the confidential appendix.
10. Any information you supply to the EPA prior to formal lodgement of your application will not be publicly released. Following formal lodgement of your application any information in the body of this application form and any non-confidential appendices will become publicly available.

11. Once you have formally lodged your application with the EPA, any information you have supplied to the EPA about your application is subject to the Official Information Act 1982 (OIA). If a request is made for the release of information that you consider to be confidential, your view will be considered in a manner consistent with the OIA and with section 57 of the HSNO Act. You may be required to provide further justification for your claim of confidentiality.

Definitions

Containment	Restricting an organism or substance to a secure location or facility to prevent escape. In respect to genetically modified organisms, this includes field testing and large scale fermentation
Controls	Any obligation or restrictions imposed on any new organism, or any person in relation to any new organism, by the HSNO Act or any other Act or any regulations, rules, codes, or other documents made in accordance with the provisions of the HSNO Act or any other Act for the purposes of controlling the adverse effects of that organism on people or the environment
Genetically Modified Organism (GMO)	Any organism in which any of the genes or other genetic material: Have been modified by *in vitro* techniques, or Are inherited or otherwise derived, through any number of replications, from any genes or other genetic material which has been modified by *in vitro* techniques
Medicine	As defined in section 3 of the Medicines Act 1981 http://www.legislation.govt.nz/act/public/1981/0118/latest/DLM53790.html?src=qs
New Organism	A new organism is an organism that is any of the following: An organism belonging to a species that was not present in New Zealand immediately before 29 July 1998; An organism belonging to a species, subspecies, infrasubspecies, variety, strain, or cultivar prescribed as a risk species, where that organism was not present in New Zealand at the time of promulgation of the relevant regulation; An organism for which a containment approval has been given under the HSNO Act; An organism for which a conditional release approval has been given under the HSNO Act; A qualifying organism approved for release with controls under the HSNO Act; A genetically modified organism; An organism belonging to a species, subspecies, infrasubspecies, variety, strain, or cultivar that has been eradicated from New Zealand; An organism present in New Zealand before 29 July 1998 in contravention of the Animals Act 1967 or the Plants Act 1970. This does not apply to the organism known as rabbit haemorrhagic disease virus, or rabbit calicivirus A new organism does not cease to be a new organism because: It is subject to a conditional release approval; or It is a qualifying organism approved for release with controls; or

	It is an incidentally imported new organism
Qualifying Organism	As defined in sections 2 and 38I of the HSNO Act
Release	To allow the organism to move within New Zealand free of any restrictions other than those imposed in accordance with the Biosecurity Act 1993 or the Conservation Act 1987
Unwanted Organism	As defined in section 2 of the Biosecurity Act 1993 http://www.legislation.govt.nz/act/public/1993/0095/latest/DLM314623.html?src=qs
Veterinary Medicine	As defined in section 2(1) of the Agricultural Compounds and Veterinary Medicines Act 1997 http://www.legislation.govt.nz/act/public/1997/0087/latest/DLM414577.html?search=ts_act%40bill%40regulation%40deemedreg_Agricultural+Compounds+and+Veterinary+Medicines+Act+_resel_25_a&p=1

Applicant details

Applicant

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Information about the application

Brief application description

Approximately 30 words about what you are applying to do

An application to release the bud-galling wasp *Trichilogaster acaciaelongifoliae* as a biological control agent for Sydney golden wattle, *Acacia longifolia.*

Summary of application

Provide a plain English, non-technical description of what you are applying to do and why you want to do it

This is an application to introduce a biological control agent to New Zealand for the weed *Acacia longifolia*, or Sydney golden wattle (SGW). The agent is a small wasp, *Trichilogaster acaciaelongifoliae,* which induces galls in flower buds, preventing the formation of flowers and thus preventing seed production. Galls can also form in growing points, preventing shoot growth.

SGW is a shrub or small tree native to Australia. It is also known as sallow wattle or coastal wattle. SGW was introduced to New Zealand as an ornamental and became naturalised before 1897. It invades open habitats and scrubland, especially in coastal areas. It can form dense stands that modify vegetation and ecological processes and threaten regeneration patterns, particularly in native habitats recovering from the effects of fire. Invasion seems to be accelerating, and SGW now competes with small pine trees in some plantations in the Far North district and Bay of Plenty. It is invasive in the dune ecosystems of several North Island regions and is a key threat to the conservation of Horowhenua dunes and the nationally significant Kaimaumau swamp in Northland.

SGW is too widespread and technically difficult for conventional control to achieve the desired conservation gains in either habitat, and even if control could be achieved, the threat of re-invasion from infestations in neighbouring dunes or gum-lands is high. Similar threats to biodiversity are developing in Bay of Plenty, and biological control is the only sustainable option if the damage caused by this weed is to be contained in the long term. Horizons Regional Council is the applicant on behalf of the National Biocontrol Collective, a grouping of regional and district councils and the Department of Conservation (DOC). Manaaki Whenua – Landcare Research staff provided the research described in the application, prepared the application, and managed the application process.

SGW is a weed in several countries, and it was once regarded as a serious threat to the fynbos, an extensive low shrubland ecosystem in South Africa. Two biological control agents (*T.acaciaelongifoliae* and the seed weevil *Melantarius ventralis*) were imported from Australia and released widely there in 1982. Together the insects have achieved such control that SGW is no longer considered a serious threat. Galling by *T. acaciaelongifoliae* is sometimes so severe in South Africa that SGW plants die. Galls have been recorded on two closely related species of acacia on rare occasions in South Africa, but no non-target plants have been significantly affected by *T. acaciaelongifoliae* since its introduction in 1981/1982. SGW threatens to dominate vast fire-prone coastal landscapes, riverine and mountainous habitats (López-Núñez *et al.,* 2017*)*. Building on the considerable body of research in South Africa, *T. acaciaelongifoliae* was released in Portugal in 2015. The research conducted in South Africa and the application prepared to allow the introduction of *T. acaciaelongifoliae* to the EU form the basis of the risk assessment in this application.

The application addresses the potential risks, costs and benefits of the proposed introduction. The expected positive effects of biological control of SGW include:

- reduced invasion of un-infested sites (section 5.1.1)
- conservation gains from the medium- and long-term reduction of SGW density within existing sites (section 5.1.1)
- reduced control costs to managers of reserved land and to the general public (section 5.3.1)
- improved allocation of resources to maintain biodiversity values (section 5.4.1).

Introduced natural enemies must be safe if this weed management tactic is to be environmentally acceptable in New Zealand. Significant adverse environmental or economic effects would occur if *T. acaciaelongifoliae* caused damaging galls on any valued plant. The application presents evidence that the risk of this is negligible. There is sufficient published evidence to indicate that no native or other valued plants in New Zealand are at risk, and no additional testing was considered necessary to confirm the narrow host range of this agent. The application considers other environmental, economic and social risks of introduction, but none are considered significant (section 5).

Background and aims of application

This section is intended to put the new organism(s) in perspective of the wider activitie(s) that they will be used in. You may use more technical language but all technical words must be included in a glossary.

2.3.1 Purpose

The purpose of this project is to establish biological control of the weed *Acacia longifolia,* or Sydney golden wattle (SGW). The agent selected to achieve this aim is the small bud-galling wasp *Trichilogaster acaciaelongifoliae.* Approval is sought to import this new organism from South Africa and release it in New Zealand.

Successful establishment of the gall wasp would:

- reduce the proportion of flower-buds surviving to produce flowers
- reduce seed production
- reduce the biomass and density of SGW plants in the long term.

Successful and safe biological control would:

- affect a high proportion of SGW wherever plants occur
- reduce the rate of spread to new sites by reducing the number of seeds available for dispersal
- cause progressive decline in the seedbank of SGW in areas that are already infested, and eventually a decline in plant density
- decrease the dominance of SGW in affected native habitats over time, helping to restore ecosystems and reducing management costs
- debilitate existing plants by intense galling.

In 2017, all regional councils, DOC and a range of other organisations were consulted so that their knowledge and opinions could be included in this application. Excerpts from their submissions are quoted through this application. Quotations from Iwi responses are included in section 4.

2.3.2 Biology and pest status of Sydney golden wattle

SGW is a fast-growing shrub or small tree that is native to south-eastern Australia. It can grow in a range of habitats, but it flourishes in coastal areas, riparian zones (bordering waterways), scrub, grassland and woodland. It has been introduced to many parts of the world as an ornamental or for soil stabilisation and has established widely. SWG can form dense thickets in naturally open habitats (Figure 2). The presence of SGW thickets increases the frequency and intensity of fires, and the long-lived seedbank and high growth rate hinder regeneration of native flora after fire. The development of thickets can result in severe modification of habitats and consequent ecosystem degradation.

Figure 2.

Acacia longifolia invading coastal habitats in Portugal.

There have been many studies of the adverse environmental effects of SGW in South Africa, New Zealand, Portugal, and even areas of Australia where SGW is considered a weed outside its native range (ISSG, 2018). These effects include:

- modification of shade regimes in riparian areas, resulting in habitat loss (Marchante *et al*., 2009 in Marchante *et al.,* 2015)
- simplification of vegetation structure and changes in the structure of plant communities (Marchante *et al*. 2003 in Marchante *et al.*, 2015)
- a reduction in biodiversity of plants and invertebrates (Hicks *et al*., 2001; Marchante *et al.,* 2015)
- increased flammability of vegetation (McQueen & Forrester, 2000; van Wilgen *et al.*, 2004)
- modification of substrates (ISSG, 2018)
- modification of soil microbiota and soil chemistry (Marchante *et al*., 2008a in Marchante *et al.,* 2015).

Control measures to limit damage fail because the large seedbank allows populations to bounce back (Marchante *et al*., 2010 in Marchante *et al.,* 2015).

Figure 3. Distribution of *Acacia longifolia* (red dots), *A. sophorae* (green) and *A. floribunda* (yellow) populations, as recorded in the Australasian Virtual Herbarium and in Department of Conservation records (D. Havell, DOC, pers. comm.) *A. sophorae* is now considered to be a subspecies of *A. longifolia. A. floribunda* is the closest relative *to A. longifolia*

SGW was naturalised in New Zealand sometime before 1897 and has established widely (Figure 3), especially in coastal North Island (Figure 1). For the most part it is found as isolated plants or in small groves that do not cause ecological damage. However, it is a major pest in Northland (especially near Kaitaia), on the Horowhenua coast, and the Bay of Plenty coast (Figure 3). In the South Island it is established at Motueka Inlet (Webb *et al.,* 1988) and has been recorded growing wild in Christchurch. SGW is not generally regarded as a weed of national importance, but it can be very important locally.

The Horowhenua to Whanganui coastal ecosystem is progressively being overtaken by SGW. The weed has consolidated greatly in the last 10 years and continues to invade new habitat. This consolidation can be seen in the series of images contained in Appendix 1. SGW occupies a 75-100m strip along this coast totalling approximately 225ha ([redacted], Biosecurity Officer, Horizons Regional Council, pers. comm.). This is approximately 7.5-10 ha per km of coast, but it is also invading inland (Appendix 1.), threatening farmland. Its invasive nature has allowed SGW to spread and outcompete native species as well as disrupting the ecological balance of the dune environment. Infestations can start from the immediate rear dune (Appendix 1) and spread through until forest or pasture hampers further invasion. Mature trees can be over 6 m high and provide such a dense canopy that it prevents the regeneration of naturally occurring species. The ability of branches to layer (grow roots and form new plants when in contact with the ground) has created impenetrable thickets, fuelling the rapid expansion of the infestations and growing dunes to unnatural heights as plants layer, trap wind-blown sand, then layer again. The size and density of the stands prevents natural ecosystem processes from occurring, such as native plant succession, dune formation and movement, and the formation of dune wetlands and lakes.

Local stakeholders in the Horowhenua to Whanganui area (Iwi, community groups, NZ Defence Force, DOC), are concerned about the impact of the plant on coastal surroundings. Horizons and DOC have been active since the early 2000s with the Waitārere and/or Whanganui infestation, undertaking sporadic efforts of direct control to reclaim small amounts of sensitive dunes such as the Whitiau Scientific Reserve. This has also taken the form of assisting community groups (Waitārere Beach Progressive and Ratepayers Association via a targeted rate (Figure 4, and Progress Castlecliff via support and information) to turn SGW-affected dunes into stable and sensitively planted areas for the community.

The adverse effects of SGW are not restricted to the Horowhenua dunes. The Kaimaumau gum-lands are a unique landscape of flats and ridges that stretch 11 km north of the Rangaunu Harbour mouth (Northland). SGW has been invasive in this area for many decades, and it is having a devastating effect on ecosystem values there. The flats have impeded drainage, leading to wetland formation. This is the only remaining freshwater wetland in Northland exceeding 1,000 ha. An area of 955 ha has been designated as a scientific reserve because of its outstanding conservation values (McQueen & Forester, 2000), and a further 2,312 ha is designated as a conservation area. The native vegetation of Kaimaumau is adapted to grow in low pH, nutrient-poor, waterlogged conditions. Eleven species of plants growing in the conserved area are listed as threatened, including four that are critically endangered (Hicks *et al.,* 2001). The rest are range-restricted or habitat-restricted. SGW and gorse are the most important weeds that have invaded the dry ridges and then spread into seasonally wet areas, establishing huge, long-lived seedbanks (McQueen & Forester, 2000). Both fix nitrogen, which increases soil nutrient status and changes the soil characteristics vital to the native plants that grow there.

Figure 4. SGW at Waitārere. In the foreground herbicide has been applied to rescue dune land; the background shows SGW growing from forest to foredune.

McQueen & Forester (2000) monitored the recovery of vegetation following a major fire in Kaimaumau in 1988. They found that the native vegetation recovered to pre-disturbance character over time in plots without weeds. However, observations on weed-infested plots led them to conclude that the abundance of weeds was likely to increase over time with future disturbance. The large seedbank allowed SGW to increase dramatically in one plot after fire, forming a monocultural stand with few species in the understorey. The absence of understorey species and the huge amounts of wattle seed present suggest that these stands will regrow following disturbance. Mixed gorse/kānuka stands suggested that gorse may act as a nurse crop in this area, which will eventually give rise to kānuka and mānuka stands. However, SGW outcompetes gorse on dry sites and is likely to become increasingly dominant with successive disturbances.

McQueen and Forester (2000) also noted that wattle and gorse produce high fuel loads that increase fire risk and have fire adaptations that are superior to the natives present. The aesthetic values of the area are degraded because wattle is taller than the native vegetation. The Kaimaumau area is drying, and the incursion of SGW into the wetland is likely to accelerate this phenomenon.

> *It has altered this wetland environment significantly and because there is so much of it, creates major issues for fire.* [redacted]*, Northland Regional Council, 2019)*

The threat of fires exacerbated by SGW was realised recently when more than 2,500 ha of the wetland burning over the summer of 2021/22. The fires were difficult to control because stands of SGW prevented firefighters and machinery from accessing hotspots and the fire front. It is not clear exactly how SGW contributed to the intensity and persistence of the fire.

McQueen & Forrester (2000) predicted that the burnt areas would provide the perfect conditions for SGW seedling germination and regrowth, making it less likely that desirable native plants would re-establish in the area. Recent assessments indicate that in firebreaks, and in areas where the canopy burnt quickly, the density of SGW seedlings regenerating from the seedbank is approximately 1,000 per m^{-2}. Where fire burned more intensely, seed in the soil surface was destroyed along with the canopy and regeneration of SGW there is approximately 150 m^{-2} ([redacted], DOC, pers. comm.). In either case it is not unlikely that the outcome of the fire in these areas will be a monoculture of SGW.

> *'Yes, from Waikawa beach in the South through to and beyond the mouth of the Whanganui river. Between the rearward face of the foredune and inland for some distance the problem of spreading SGW is worsening'. ([redacted], Horizons Regional Council)*
>
> *'There are two main isolated patches that we currently know about – Matakana Island on the southern ocean side, and Waihī beach. I haven't been to the Waihī beach site, but I believe the Matakana Island site is the largest we have on our BOP coast. The infestation is increasing to a point that SGW may become an issue to our region if nothing is done'. [redacted], Bay of Plenty Regional Council)*
>
> *'SGW grows so rampantly that it outcompetes the native species easily. This leads to erosion of the dunes as the root system is not designed to hold the dunes together. Residents of Matakana have told many stories about how the health of the dunes affects them and their responsibility for these ecosystems. Due to the size of the infestations, control efforts by residents haven't decreased the SGW sites. The plant is difficult to control on such an unstable and delicate substrate. If the plants were left then the dunes would become a monoculture of SGW which will accelerate the erosion of the dunes. This would impact on the forestry that sits parallel to the dunes'. ([redacted], Bay of Plenty Regional Council)*

On Matakana Island, SGW occurs predominantly in the zone between the mid-dunes and the commercial pine forest that runs parallel to the dunes. It is spreading further inland at a rapid rate, into the dunes and into logged forest areas. This is causing competition with existing native species and leading to erosion of the dunes as the root system of SGW is not able to hold the dunes together. The plant is difficult to control in such an unstable and delicate environment. Residents of Matakana and the forestry company have invested considerable time and money to control SGW but this has failed to halt the spread. The dunes could become a monoculture of SGW which will accelerate the erosion ([redacted], Bay of Plenty Regional Council, pers. comm).

SGW is a common shrub or tree throughout the North Island (Figure 3), but it usually occurs in isolation or in small insignificant groves. As its spread in Horowhenua has demonstrated, this could change quickly. Unless the potential for SGW to invade is slowed, the effects that have been measured at Kaimaumau, Horowhenua and Matakana are likely to increase and be repeated in other important dune and wetland/lake systems elsewhere.

Information about the new organism(s)

Name of organism

Identify the organism as fully as possible

Non-GMOs - Provide a taxonomic description of the new organism(s).

GMOs – Provide a taxonomic description of the host organism(s) and describe the genetic modification.

Both -

- Describe the biology and main features of the organism including if it has inseparable organisms.
- Describe if the organism has affinities (e.g. close taxonomic relationships) with other organisms in New Zealand.
- Could the organism form an undesirable self-sustaining population? If not, why not?
- How easily could the new organism be recovered or eradicated if it established an undesirable self-sustaining population?

3.1.1 Taxonomy of the agent

Order	Hymenoptera
Superfamily	Chalcidoidea
Family	Pteromalidae
Sub-family	Ormocerinae
Genus	*Trichilogaster*
Species	*acaciaelongifoliae* (Froggatt, 1892).

(Prinsloo & Neser, 2007; Noyes, J.S. accessed 2019).

3.1.2 Biology and ecology of *T. acaciaelongifoliae*

Trichilogaster acaciaelongifoliae is a small (3–4 mm) wasp (Pteromalidae, Figure 5a) that induces globular galls on *Acacia longifolia* plants where flower buds would normally develop. Galls can also form in growing points of shoots. A gall is an abnormal, localised outgrowth or swelling of plant tissue (Figure 5b). The native range of the wasp is south-east Australia, the same distribution as its primary host, *Acacia longifolia.* Hill (2005) has summarised the extensive published information describing the biology and ecology of the wasp.

Figure 5. (a) Adult wasp and (b) galls on *Acacia longifolia*.

T. acaciaelongifoliae is largely parthenogenetic (females can produce young without mating) and males are uncommon. There is one generation each year. Adult females emerge in November and December. The buds that will flower in the following August are just beginning to form at this time. These buds remain dormant for at least four months before slowly developing to produce flowers in early spring. Each wasp lives for only 3–4 days, but in that time can lay up to 400 eggs into those buds. Several eggs can be laid into each bud. The eggs hatch inside the plant, and chemical signals from newly hatched larvae induce the formation of a gall instead of a flower. Each larva forms a cell within the developing gall and feeds on the fleshy interior. The timing of development and the position of the gall can vary but galling of a reproductive bud prevents the development of the flower and generally no seeds are produced from that bud (Noble, 1940). Although galls are most prevalent on reproductive buds, the wasp also attacks vegetative buds, limiting shoot growth and biomass accumulation (references in Hill, 2005, Noble, 1940). Galls can be large and act as energy sinks, diverting the plant's resources from seed production and growth.

Noble (1940) reared *T. acaciaelongifoliae* in Australia from *Acacia longifolia* subspecies *longifolia*, *A. longifolia* subspecies *sophorae*, and *A. floribunda* (a sister species to *A. longifolia*). These species belong to the *longifolia* subclade (Kleinjan & Hoffman, 2013a, b). There is also one unconfirmed record from *A. implexa.* In South Africa, small, sparsely distributed galls have been observed on trees of *A. melanoxylon* and *Paraserianthes lophantha* growing in the vicinity of heavily galled *A. longifolia* (Dennill *et al.,* 1999). This damage has been insignificant to the non-target plants because galling has been so weak and rare. The incidence of attack has not increased over time and does not represent a change in primary host range (see section 5.3.2). We conclude that *T. acaciaelongifoliae* is highly host-specific and can consistently attack only three closely related host plant species (summarised in Kleinjan & Hoffman, 2013a; see section 3).

This insect was introduced into South Africa in 1981 and 1982 (see section 3.1.4). The suppression of seed production there was found to be greater than could be explained by infestation of buds alone – even unaffected pods produced fewer seeds. When 50% or more branches on a tree were galled, pod production was often reduced by 90% or more. Heavy gall formation also causes the abscission (leaf fall) of mature phyllodes (the 'leaves' of acacias) and dieback of shoots. This reduces growth rate and biomass accumulation in the tree. Dennill (1985) claimed that the wasp has a disproportionately negative effect on plants because gall formation is more resource intensive than normal growth and reproduction, debilitating the plant. When *A. longifolia* plants are under environmental stress, such as moisture deficit, heavy galling by *T. acaciaelongifoliae* can even kill plants (Impson *et al.*, 2011).

Froggatt noted that in its Australian home range wasp galls could sometimes suppress acacia seeding by 100%, but this effect was patchy, presumably because wasp numbers were regulated to below outbreak levels by parasitoids and predators in many places (Dennill & Donnelly, 1991). The patchy effectiveness recorded by Froggatt in Australia is not apparent in South Africa and seed suppression is very high.

This insect has markedly reduced the seed production of *A. longifolia* in South Africa. It was initially thought that certain climate types in South Africa restricted the efficacy of the gall wasp (references in Hill, 2005), but it is now known that the effects simply took longer to develop in hotter dryland areas, and that the gall wasp is adaptable to different climate types (Impson *et al.,* 2011).

In Portugal, extensive thickets of SGW have formed in coastal sand dunes, river margins, and hillsides and the negative impact of SGW on the functioning of native ecosystems has been studied extensively (see section 2.3.2). *T. acaciaelongifoliae* was released at 61 sites in Portugal from 2015 to 2019 (Marchante *et al.,* 2017) and has established at 36 of these. The impact of *T. acaciaelongifoliae* on vegetative and reproductive growth of *A. longifolia* was assessed at three sites where 59 galled trees and 62 ungalled trees were assessed. Impacts are already measurable within just a few years of establishment. Branches on galled trees produced 84% fewer pods and 95% fewer seeds than branches on ungalled trees. All branches on galled trees had 33% fewer side branches and fewer phyllodes, and the main stem was longer (López-Núñez *et al.,* 2021). Although large, these differences were not significant, but suggest that the robustness of galled trees may be declining.

Growth in wasp numbers has been exponential, from 66 galls in 2016 to 24,000 by 2018. In just six years *T. acaciaelongifoliae* seems to be on track to repeat the successful control that was achieved in South Africa. Suppression of seed production by biological control provides a mechanism for slowing invasion.

The likely effects of climate change on biological control success

Climate change is expected to raise average temperatures in New Zealand and to create drier climates in some regions. Plants native to warmer climates that are already growing here are expected to escape environmental constraints such as frost and increase their range. Some plants will also be able to exploit climate change-induced disturbances such as fire, expanding their range and impact. In fact, amongst the world's temperate zones, New Zealand has been identified as a 'hot spot' for invasion under climate change, regardless of the climate change scenario employed. Sheppard *et al*. (2016) argue strongly that the most effective (and cost-effective) response to this threat is to institute management of potentially hazardous weeds while populations are low and dispersed, before climate change enables rapid invasion and consolidation. The deployment of *T. acaciaelongifoliae* to largely eliminate SGW seed production in New Zealand would be a good example of such a tactic.

Even though there is a general expectation that the ecological risk of weeds will increase, this is not necessarily so for all weeds, and there is little information to confidently predict which weed species will benefit from climate change (Sheppard *et al.*, 2016). However, several characteristics and observations indicate that SGW could respond strongly to climate change:

- SGW is a weed overseas in slightly warmer habitats than exist in New Zealand (e.g. South Africa and Portugal)
- the example of rapid invasion of dune habitats in the past 10 years (Appendix 1)
- SGW is not yet widely established in the South Island
- the fires in Kaimaumau may indicate that the fire risk from SGW has already risen.

The success of *T. acaciaelongifoliae* in South Africa, and now in Portugal, areas that are warmer than New Zealand, indicate that biological control success is likely to improve with warming from climate change.

3.1.3 Affinities with the New Zealand fauna

Related species in the native fauna

Prinsloo and Neser (2007) recognised nine species of *Trichilogaster* worldwide, eight of which are native to Australia and one from Saudi Arabia. All form galls on species of the genus *Acacia* (although there have been incidental galls formed by *T. acaciaelongifoliae* on *Paraserianthes lophantha*, see section 3.1.2). There are no native *Trichilogaster* species in New Zealand.

T. acaciaelongifoliae belongs to the sub-family Ormocerinae. All species in this sub-family seem to be associated with galls, not always as gall-formers but sometimes as parasitoids and in other roles (Berry & Withers, 2002). There are only two representatives of the sub-family Ormocerinae known in New Zealand:

- *Systasis lelex* (Walker). The biology of this insect is unknown. Like other ormocerines it may form galls, or it may be parasitic on other species within galls. The host plant is unknown. This species is only known from New Zealand.

- *Nambouria xanthops* Berry & Withers. This is a recently self-introduced species that forms galls on eucalypts (Berry & Withers, 2002).

Noyes (2019) lists 56 species belonging to the family Pteromalidae from New Zealand.

Possible shared native natural enemies in New Zealand

The known parasitoids of *T. acaciaelongifoliae* are not known to be present in New Zealand. Parasitoids already present in New Zealand might move to attack the SGW gall wasp. It is expected that these would:

- belong to the same families as parasitoids observed in Australia (the native range) and South Africa
- specialise on hosts that inhabit galls.

The relationships between the insects inhabiting *T. acaciaelongifoliae* galls in Australia are complex. Noble (1940) recorded nine species belonging to the superfamily Chalcidoidea associated with *Trichilogaster* galls in Australia, some of which fed on the flesh of the gall, while others were parasitic or hyperparasitic (parasitoids of parasitoids) on *T. acaciaelongifoliae*. The principal parasitoid appeared to be *Eurytoma gahani* (Eurytomidae). Bashford (2004) found that over 90% of the chalcidoid insects reared from *T. acaciaelongifoliae* galls in Tasmania were *Eurytoma gahani* and *Chromeurytoma noblei* (Pteromalidae) and suggested that these feed on gall tissue and kill life stages of *T. acaciaelongifoliae* only late in their development. Bashford (2004) recorded 12 to 61% parasitism of *T. acaciaelongifoliae* in Tasmania, depending on the site and size of the gall. Eurytomid species dominated the parasitoid profile, but two *Megastigmus* species (Torymidae) were reared from galls at lower rates (Bashford, 2004). None of these species mentioned here are known to be present in New Zealand.

In South Africa, a *Pseudotorymus* sp., has been recorded attacking 21.3% of gall wasp larvae in the Western Cape and 60–80% in the Eastern Cape (Dennill & Donnelly, 1991; Dennill et al., 1999). Manongi and Hoffman (1995) found that another native torymid species had adopted *T. acaciaelongifoliae* as a host in South Africa, but parasitism did not exceed 21%.

There are few potential parasitoids of *T. acaciaelongifoliae* known in New Zealand, for several reasons.

There are no native insects that are closely related to *T. acaciaelongifoliae* (except *Systasis lelex*), and none that are known to form galls. It is therefore unlikely that there is a significant natural enemy fauna specific to ormocerine galls that predisposes *T. acaciaelongifoliae* to attack in New Zealand.

Noyes and Valentine (1989) list eight species in New Zealand belonging to the same family as the principal Australian parasitoids of *T. acaciaelongifoliae* (Eurytomidae), but only one is a parasitoid (of cicada eggs). There are no *Eurytoma* species in New Zealand.

There are about 12 torymid species known in New Zealand. Some feed on seeds. *Torymoides antipoda* is parasitic on galls formed by cecidomyiid flies on *Carmichaelia* spp., and four more torymid species are found in cecidomyiid galls on species of *Carmichaelia, Podocarpus, Coprosma, Veronica* and *Carpodetus*. The galls of Cecidomyiidae are small, and the parasitoids are consequently minute. These are likely too small to parasitise *T. acaciaelongifoliae* larvae deep in large SGW galls.

The most likely candidates to be primary parasitoids of *T. acaciaelongifoliae* in New Zealand appear to be torymid species, and the most likely of these is an un-named *Megastigmus* species, a parasitoid of the gall-forming fly *Procecidochares utilis* (Tephritidae). This is a biological control agent for Mexican devil weed in New Zealand. However, *T. acaciaelongifoliae* may be immune even from this species because it appears to be active in summer, after *T. acaciaelongifoliae* have emerged from galls. It therefore remains uncertain whether any native insects could colonise *T. acaciaelongifoliae* galls.

Paynter *et al*. (2010) found that biocontrol agents that escape attack from parasitoids in their new range are more likely to suppress weed populations and should be less likely to have significant indirect non-target effects in food webs. Selecting agents that are less likely to be attacked in the new range maximises this effect. They recommended avoiding agents that have ‘ecological analogues’ awaiting them in the introduced range The lack of equivalent galls in New Zealand implies that there are no ecological analogues here.

Relationship to the existing fauna of SGW in New Zealand

A brief survey of the arthropod fauna associated with the foliage of *A. longifolia* was undertaken at five sites north of Coopers Beach (Northland region) in late spring 2018. Seed pods were collected at those sites as well as at two sites in coastal Horowhenua (Manawatū-Whanganui region). The aims of the survey were to:

- assess the invertebrate fauna associated with *A. longifolia* in New Zealand, and identify the herbivores and their associated predators and parasitoids
- determine the rate of infestation of seeds by resident seed feeders
- determine whether the candidate biocontrol agent, *T. acaciaelongifoliae,* was already present in New Zealand.

Although only five sites were surveyed, there was evidence that only a limited range of native invertebrates are associated with SGW in New Zealand. No galls were observed. There was no evidence that SGW hosted significant populations of any key native herbivore species. Exotic species specialising on acacias were abundant and damaging, but none would provide direct competition to *T. acaciaelongifoliae.* Details of this survey can be found here: https://www.landcareresearch.co.nz/uploads/public/Discover-Our-Research/Biosecurity/Biocontrol-ecology-of-weeds/3-applications/final-report-Invertebrates-associated-with-Acacia-longifoliae.pdf.

3.1.4 Potential for safe biological control

Why biological control?

Weed biological control seeks to establish natural enemies in New Zealand that suppress the population dynamics or limit the adverse effects of target weeds. Successful biological control helps restore the natural balance that existed before invasion by the weed. Biological control is an appropriate tactic to apply against SGW because, once established, introduced natural enemies would colonise and damage the plant wherever it occurs, and would be widespread and persistent from year to year. Any benefits of biological control would accrue even in areas where it is not feasible to deploy other management options.

Defining the impact of an agent on a target weed in its home range is often difficult because control agents are often hard to find, and because encountering evidence of heavy damage during short-term surveys is a matter of chance. The impact of a single biological control agent on its target weed varies from place to place and from time to time. This is not the case for *T. acaciaelongifoliae*, however, because its role in the successful control of SGW in South Africa has been well documented (Impson *et al.,* 2011), and the host utilisation has been well studied (e.g. Dennill et al., 1993; Kleinjan & Hoffman, 2013a). *Trichilogaster acaciaelongifoliae* was also the subject of a risk assessment by the European Food Safety Authority before permission was granted to release this species into the EU (EFSA, 2015).

Acacias have been moved freely around the world as ornamentals, for soil or sand stabilisation, and for other economic purposes. Twenty-three acacias are now considered invasive outside Australia, a higher proportion than any other legume group, and more species are likely to be invasive in the future (Miller & Seigler, 2012). Some species have even become invasive within Australia outside their native range.

Various acacias were introduced to South Africa in the 19th century to provide a range of benefits such as soil stabilisation and tannin production. Most have become invasive and now dominate landscapes and ecosystems throughout South Africa. They have detrimental effects on biodiversity, water resources and plantation forestry, though some continue to provide social and commercial value as sources of firewood, timber, tannin, and pulp for paper (Dennill *et al.,* 1999).

Since 1982, ten species of *Acacia* and the closely related *Paraserianthes lophantha* have been the subject of biological control programmes in South Africa (Impson *et al*., 2011). As these species had value to local communities, efforts to develop effective biological control agents were restricted to those control agents that merely limit reproduction (although *T. acaciaelongifoliae* also proved to be detrimental to plant survival, see section 3.1.2). The control agents introduced to South Africa included two *Trichilogaster* species targeting two *Acacia* species (Impson *et al.,* 2011). Kleinjan and Hoffman (2013a) have reviewed the known host range of these species, as revealed by laboratory experiments and by field monitoring following release in South Africa. They have related this to the latest information regarding the phylogenetic relatedness of potential hosts. The base information for this review is contained in an appendix that was not published with the review (Kleinjan & Hoffman, 2013b.). *Trichilogaster signiventris* proved to be specific to its target, *A. pycnantha*. The specificity of *T. acaciaelongifoliae* is discussed below.

Marchante *et al.* (2011) reviewed the suitability of *T. acaciaelongifoliae* as a biological control agent for SGW in Portugal and reported the results of additional host range tests (see below). The European Food Safety Authority completed a risk assessment (EFSA, 2015) and approval was granted to introduce this control agent to Portugal (Marchante *et al*, 2017).

Taxonomy of *Acacia longifolia* in relation to biological control

The legume plant family (Leguminosae) is divided into two distinct groups. The *Acacia* genus belongs to the 'mimosoid' clade (defined as a natural grouping of a common ancestor and its lineal descendants). This group contains other 'wattle-like' species such as *Albizzia, Prosopis, Leucaena, Mimosa* and *Paraserianthes*. This group has always been regarded as fundamentally distinct from the 'papilionoid' or 'faboid' clade' of the legume family. This group contains economically important crop, forage and vegetable legumes such as clover, lucerne, peas, beans, and other pulses, and the four genera native to New Zealand (*Sophora, Clianthus, Carmichaelia* and *Montigena*). Apart from all being legumes, these members of the 'papilionoid' clade are only distantly related to *Acacia.*

Recent research has revised the taxonomy of worldwide acacias and split the genus (Murphy *et al*., 2010). Of the approximately 1,000 species now thought to belong to the genus *Acacia*, 98% are native to Australia. More recent molecular studies have explored how species within the genus *Acacia* are related and grouped, and this is an area of active research. Interpretation of results from different studies is challenging because not all species are included in all studies and methodologies differ (e.g. Miller *et al*., 2011; Miller & Seigler, 2012), but there are consistent groupings that have been summarised by Kleinjan & Hoffman (2013a, b) in relation to the host specificity of biocontrol agents released in South Africa, including *T. acaciaelongifoliae*. *A. floribunda* belongs to the *Acacia longifolia* subclade (Figure 6). These two species are the only known hosts of *T. acaciaelongifoliae* in Australia (Noble, 1940). There are other *Acacia* species in this subclade, but these are not known hosts of *T. acaciaelongifoliae*. The next most closely related acacias belong to the neighbouring *cognata* subclade (Figure 6).One of these, *Acacia melanoxylon*, has occasionally been recorded as an occasional inferior host of *T. acaciaelongifoliae* in South Africa (see section 5.3.2 for further discussion on this) although it has never been recorded as a host in Australia (Noble, 1940). Other species in this subclade occur in South Africa but have never been recorded as hosts. The remaining 900+

Australian *Acacia* species belong to clades that are far less related to *A. longifolia.* None of these are are known hosts in Australia (Noble, 1940) or South Africa.

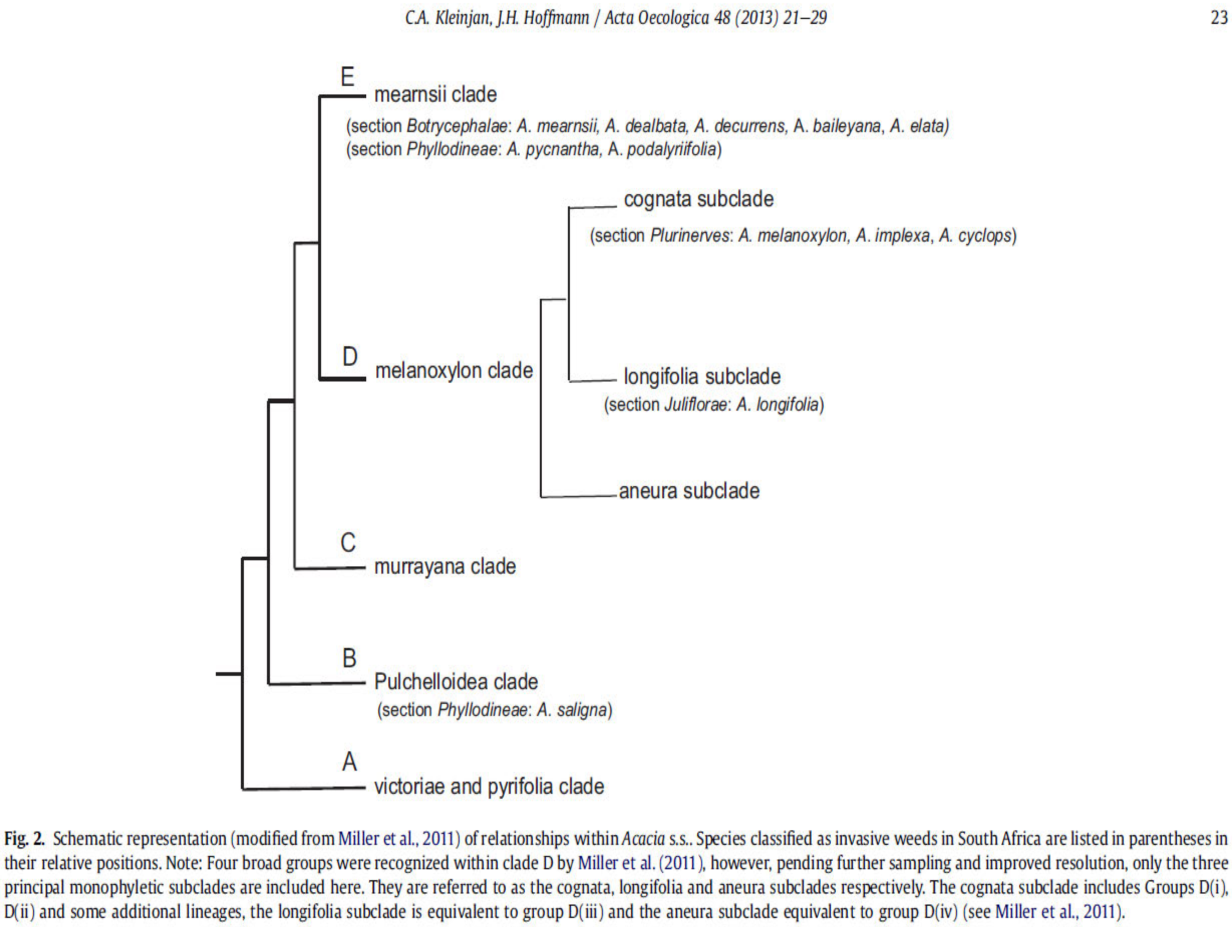

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Fig. 2. Schematic representation (modified from Miller et al., 2011) of relationships within *Acacia* s.s.. Species classified as invasive weeds in South Africa are listed in parentheses in their relative positions. Note: Four broad groups were recognized within clade D by Miller et al. (2011), however, pending further sampling and improved resolution, only the three principal monophyletic subclades are included here. They are referred to as the cognata, longifolia and aneura subclades respectively. The cognata subclade includes Groups D(i), D(ii) and some additional lineages, the longifolia subclade is equivalent to group D(iii) and the aneura subclade equivalent to group D(iv) (see Miller et al., 2011).

Figure 6. Schematic representation of the relatedness of selected species of *Acacia* in five clades (from Kleinjan & Hoffman, 2013a).

Occasional galls of *T. acaciaelongifoliae* have been found on *Paraserianthes lophantha* (tribe Ingeae) in South Africa (see below). This genus is considered the sister taxon to *Acacia* (Murphy *et al.,* 2010) but the position of this species within the *Acacia* grouping remains equivocal.

Acacia cognata and *A. verticillata* are the base species for two cultivars marketed as ornamentals in New Zealand (*Acacia* ‘Limelight’ and *Acacia* ‘Rewa’) and *A. melanoxylon* is grown in New Zealand as a timber tree for woodworking (Tasmanian blackwood) (see section 5.3.2). All other acacias growing in New Zealand are less closely related to *A. longifolia* than the *cognata* subclade (Kleinjan & Hoffman, 2013a).

Predicting the host range of *Trichilogaster acaciaelongifoliae* in New Zealand

Host range tests in South Africa

Kleinjan and Hoffman (2013 a, b) have summarised the results of tests conducted to define the host range of the gall wasp prior to release in South Africa. Noble (1940) stated that the host range of *T. acaciaelongifoliae* in Australia was restricted to 3 *Acacia* species (wo of these species are now sub-species of *A. longifolia*). No galls had been recorded from other *Acacia* species or from other legumes in Australia. Based on this evidence, researchers In South Africa concluded that the gall wasp would not pose a risk to any species there other than *Acacia* species. The potential host range of *T. acaciaelongifoliae* was assessed before it was release in South Africa, but tests were restricted to *Acacia* species.

Gall-forming insects use complex behaviours to select host plants and to precisely deposit eggs so that galls will form successfully. It is very difficult to design experiments and experimental arenas that do not influence those behaviours, and there is always a risk that experiments (especially in the laboratory) will yield misleading and anomalous results. No laboratory tests were conducted in South Africa. Instead, *T. acaciaelongifoliae* adults were placed on host plants growing in the field using fine mesh bags to enclose branches. The results of these tests are summarised in Kleinjan & Hoffman (2013b) and their as Table 4 is reproduced in Appendix 2.

Nine species of *Acacia* native to Africa (now re-assigned to the genera *Senegalia and Vachellia*) and 13 Australian *Acacia* species were exposed to the wasp. Galls only formed on *A. longifolia.* There are two anomalies with these results. Galls did not form on *A. floribunda* even though this was an acknowledged host in Australia. The reason for this is unknown. Adult wasps probed *A. melanoxylon* flower buds but no galls formed. *A. melanoxylon* later proved to be a (poor) host in the field in South Africa. The tests did not predict this. *Paraserianthes lophantha,* another inferior host in South Africa, was not tested.

T. acaciaelongifoliae has increased to enormous numbers since its release in South Africa. As in its native range, the primary hosts are *A. longifolia* (including subspecies *sophorae*) and *A. floribunda.* Stunted gall formation has been observed on *P. lophantha* and *A. melanoxylon* but this has proven to be uncommon, negligible and temporary (Dennill *et al*., 1999, see section 5.3.2). No other non-target attack has been observed in the field despite 40 years of observations (Impson et al, 2021).

Host range tests in Portugal

T. acaciaelongifoliae is only the second biological control agent approved for introduction into the EU for control of a weed. A rigorous risk assessment was required before approval to introduce the agent was granted by the European Food Safety Authority (EFSA, 2015). The steps leading up to that approval have been described by Marchante *et al.* (2011). By contrast with the limited testing undertaken before introduction to South Africa, tests undertaken in Portugal included laboratory experimentation and species outside the mimosoid clade. Tests on 40 plant species were required, 30 of which belonged to families outside the Leguminosae (Appendix 3). Tests were conducted in containment in Coimbra, Portugal, using wasps imported from South Africa.

The details of the experimental design and the results have been reported by Marchante *et al.* (2011). Small shoots bearing reproductive buds were presented to individual female wasps in the laboratory. The buds were dissected after exposure to check whether eggs had been laid. If eggs were laid, potted plants of those species were exposed to adults and then held for many months to check whether galls formed.

The buds of most test plants presented in Petri dish tests were never visited, but wasps were observed to probe in the buds of several plant species other than mimosoid species (Marchante *et al*., 2011). This was confirmed by later dissections. *Acacia longifolia* controls proved to be the most acceptable hosts and eggs were laid in 31.8% of the buds presented. As expected, eggs were also laid on *A. melanoxylon*, a species closely related to *A. longifolia* and a known inferior host in South Africa. No eggs were detected in peas or beans or medics (forage legumes like lucerne), nor in three legume shrubs native to Europe. However, there were several anomalous results from these laboratory experiments. Eggs were laid consistently (four of nine tests) on the buds of *Cytisus striatus*, a European shrub. Further, 4.3% of *Vitis vinifera* (grape) buds in two tests contained eggs, although these were laid on the outside of buds rather than within bud tissue.

When whole plants were presented to the gall wasp, galls formed on potted *A. longifolia* plants but did not form on *C. striatus* or *V. vinifera* plants (Marchante *et al*., 2011) indicating that these were not true hosts. Field surveys were conducted to confirm that grapes were not a host in South Africa or Australia where *T. acaciaelongifoliae* is resident. No galls were found. This species is clearly not a field host in either country (Figure 7). *Cytisus striatus* does not grow in Australia or South Africa, so *Genista monspessulana* and *Spartium junceum*, two related species in the tribe Genisteae, were surveyed instead. Neither was a host for *T. acaciaelongifoliae* (Figure 7, Marchante *et al*., 2011).

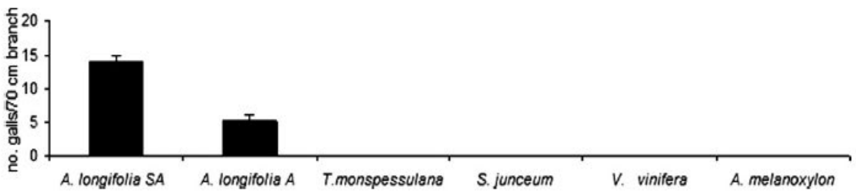

Fig. 5. The abundance of galls of *Trichilogaster acaciaelongifoliae*, on the terminal 70 cm of branches, on five plant species including the target, *Acacia longifolia*, in South Africa (SA) (Western Cape) and Australia (A) (New South Wales). The non-target species included two species (*Vitis vinifera* and *Acacia melanoxylon*) where the wasps laid eggs during no-choice tests, and two species closely related to *Cytisus striatus*. Non-target species were sampled in SA and A, except for *Spartium junceum*.

Figure 7. The results of a field survey in South Africa and Australia. No galls were found on plants on which eggs were laid in laboratory tests (Figure 5 from Marchante et al. (2011)

Evidence for the high degree of host specificity of the gall wasp can be inferred from a range of sources:

- knowledge of the narrow host range of all *Trichilogaster* species (Kleinjan & Hoffman, 2013a, b)
- host surveys in the native range in Australia (Noble, 1940)
- post-release host records in South Africa (Dennill *et al*., 1999)
- results of host-range tests conducted before release in South Africa (van den Berg, 1980 in Kleinjan & Hoffman, 2013a.b)
- results of host range tests completed before release in Portugal (Marchante *et al*., 2011).

From these sources we can conclude that the host range of *T. acaciaelongifoliae* is restricted to *Acacia* species belonging to mimosoid clade of legumes. Its primary hosts belong to the *longifolia* subclade, but the consistent observation of inferior gall formation on *A. melanoxylon* suggests that species of the closely related *cognata* subclade that occasional galls might also form on species in this subclade.

Observations of galls on *Paraserianthes lophantha* in South Africa remain anomalous and rare. The ability of *T. acaciaelongifoliae* to lay eggs in *Cytisus striatus* in oviposition tests also remains anomalous. Three other members of the tribe Genisteae did not receive eggs in tests, and two others were not field hosts in Australia. It seems likely that the observation of eggs on detached *C. striatus* buds in Petri dish tests was a laboratory artifact. No galls formed in potted *C. striatus* plants. Even if galls did form on the flower buds of these sub-optimal species, it is unlikely these could develop sufficiently well to cause vegetative damage to growing plants. All species of the tribe Genisteae present in New Zealand are regarded either as weeds or as potential weeds, including gorse and broom. *Cytisus striatus* is not naturalised in New Zealand.

The New Zealand Flora records four genera of indigenous legumes growing in New Zealand: *Sophora* (8 species, kōwhai), *Carmichaelia* (23 species), *Montigena* (one species), and *Clianthus* (two species, ngutukākā) (http://www.nzflora.info/). These genera belong to the papilionoid clade of the Leguminosae and so are only distantly related to wattles. None of these species have been tested. It is considered highly unlikely that these could be potential hosts of *T. acaciaelongifoliae*, for the following reasons.

> All *Trichilogaster* species have a narrow host range and are strictly associated with *Acacia* species (Kleinjan & Hoffman, 2013 a, b).
>
> In its native range *T. acaciaelongifoliae* galls have only been recorded from *A. longifolia* and *A. floribunda* (e.g. Noble 1940). There are no records of any papilionoid species in Australia being hosts for *T. acaciaelongifoliae*.
>
> Tests in South Africa indicate that the fundamental host range is limited to a small subset of *Acacia* species.

Extensive field research in South Africa since *T. acaciaelongifoliae* was released in 1981/2 has recorded consistent attack on three acacias closely related to SGW.

Spillover gall production has been observed on two further mimosoid species, *A. melanoxylon* and *P. lophantha* in South Africa, but both are marginal hosts and galls form only sporadically with negligible effects (EFSA, 2015, see section 5.3.2).

> In tests prior to introduction to Portugal, no galls were observed on any plants outside the genus *Acacia*.

Trichilogaster acaciaelongifoliae galls are not thought to mar the value of ornamental acacias in Australia or South Africa other than *A. longifolia* and *A. floribunda*.

Survey of New Zealand legumes in Australia

A field survey was conducted in Australia to confirm the conclusion that New Zealand native species would not be at risk from *T. acaciaelongifoliae* . *Acacia longifolia* is native to south-east Australia, and the gall wasp is abundant over the same range. New Zealand native legume species can be found in plant collections in those regions, and kōwhai are sometimes used as amenity plants on roadsides. These plants are exposed to natural colonisation by the gall wasp annually. A survey was conducted in Australia in December 2019 to see whether natural exposure of New Zealand legumes to the gall wasp leads to gall formation. Plants were checked for green, current-season galls, as well as for old, woody galls indicating infestation in the previous season. A detailed account of the survey can be found here: https://www.landcareresearch.co.nz/uploads/public/Discover-Our-Research/Biosecurity/Biocontrol-ecology-of-weeds/3-applications/survey-nz-native-legumes-growing-australia.pdf.

Acacia longifolia was consistently heavily galled wherever it was observed, and the relative distributions of both the plant and the gall wasp in south-east Australia suggest that this is likely to be true throughout the natural range of *A. longifolia*. Apart from fresh green galls, SGW plants carried old woody galls, indicating a similar level of attack in at least one previous year.

At least eight species of New Zealand native legumes plus four closely related surrogate species were found at three sites in Sydney, Melbourne and rural Victoria, and 53 plants were examined. No galls were observed on New Zealand natives, indicating there had been no infestation by gall wasps, either in the current or the previous season.

There was no evidence that New Zealand species of *Sophora*, *Carmichaelia* or *Clianthus* growing in the native range of *T. acaciaelongifoliae* were susceptible to this gall wasp. *Montigena novae-zelandiae* could not be surveyed in Australia but no galls were found on *Swainsona sejuncta*, a closely related species. This confirms the conclusions drawn from field observations in Australia and South Africa, and from experimental studies in South Africa and Portugal, that the gall wasp poses negligible risk to non-target plants in New Zealand.

Conclusion

There is sufficient evidence to conclude, without additional testing, that *T. acaciaelongifoliae* would pose negligible risk to non-target native, economic or ornamental legume species in New Zealand.

Regulatory status of the organism

Is the organism that is the subject of this application also the subject of:

An innovative medicine application as defined in section 23A of the Medicines Act 1981?

☐ Yes ☒ No

An innovative agricultural compound application as defined in Part 6 of the Agricultural Compounds and Veterinary Medicines Act 1997?

☐ Yes ☒ No

Māori engagement

Discuss any engagement or consultation with Māori undertaken and summarise the outcomes. Please refer to the EPA policy 'Engaging with Māori for applications to the EPA' on our website (www.epa.govt.nz) or contact the EPA for advice.

Māori views on this proposal have been sought by five routes:

consultation with members of Te Herenga

consideration of issues raised in previous similar applications

consideration of generic issues by an EPA reference group

consultation with iwi and Treaty settlement authorities in the Manawatū-Whanganui region

consultation with the Ngāpuhi Hazardous Substances and New Organisms (HSNO) komiti and the Ngāi Tahu HSNO komiti.

Consultation with Te Herenga

Te Herenga, the EPA's national network, comprises approximately 80 iwi, hapū or Māori organisation representatives with national geographical and subject-matter coverage. Information about proposed biological control of SGW was distributed to members of Te Herenga in February 2019. The announcement directed readers to the Manaaki Whenua – Landcare Research (MWLR) website for further details, and invited dialogue and feedback (http://www.landcareresearch.co.nz/science/plants-animals-fungi/plants/weeds/biocontrol/approvals/current-applications/sydney-golden-wattle). It described how the applicant intended to assess the risks, costs and benefits associated with the proposed introductions and invited members to identify any issues they would like to have addressed in the applications.

One respondent noted that the proposal should be the subject of a cultural impact assessment. Impacts on cultural values are discussed below (sections 4.2, 4.3, and 4.4).

Any further issues brought to the attention of the applicant before formal consideration of this application will be made available to the EPA. Members of Te Herenga will also be specifically informed by the EPA when each application is open for public submission and will be able to comment on how the applicant has addressed issues raised during consultation.

4.2 Issues raised in previous consultations

This application resembles other applications submitted over the last 15 years to introduce new biological control agents for weeds. Communications with Māori over previous applications are relevant here. The key areas identified in consultations over this period are:

- possible direct effects on native plant species (see section 5.1.2)
- possible indirect effects on native flora and fauna, and other valued species (see sections 5.1.2 and 5.3.2)
- the need to monitor future effects (see section 7)
- predictability of effects (see section 5.1.2)
- specific benefits to Māori (see below)
- effects on cultural and spiritual values (see below)
- integration of control methods, and indigenous solutions (see below)
- herbicides and biological control (see section 5.1.1)
- aversion to the introduction of new organisms
- lack of capacity precludes comment.
- ‘Is the weed present in our rohe?’

Benefits accruing to New Zealand from the introduction of the control agent are explained in section 5. No benefits or costs of this proposal are exclusive to Māori. However, the current adverse effects of SGW are most evident on Māori-controlled land or Māori-dominated businesses (see section 2.3.2) and manawhenua in those areas are likely to be the greatest and earliest beneficiaries of successful biological control.

SGW is not listed in the MWLR Māori plant use database (http://Māoriplantuse.landcareresearch.co.nz/ WebForms/PeoplePlantSearch.aspx). The New Zealand Flora records four genera of indigenous papilionoid legumes growing on the mainland: *Sophora* (8 species), *Carmichaelia* (23 species), *Montigena* (one species), and *Clianthus* (two species) (http://www.nzflora.info/). The database records a range of uses for kōwhai (*Sophora* sp.), including as rongoā, as a dye, and as timber, but not for the other native legume genera. None of the New Zealand native species belong to the same sub-family as *Acacia* and so are only distantly related.

The introduction of *T. acaciaelongifoliae* would have no direct impact on the use of any non-target plants as natural resources because the results of host range studies indicate that no native plants will be at risk (see sections 3.1.4, 5.1.2). Any indirect impact of *T. acaciaelongifoliae* through changes of relationships with other flora and fauna will be minimal because evidence suggests there will be no such interactions and because any interactions would be restricted to the immediate vicinity of SGW (see section 5.1).

Māori reference group

The EPA convened a Māori reference group (MRG) in 2015 to discuss the potential issues of significance to Māori relating to an application to introduce new organisms for biological control of weeds. The MRG was made up of four members with expertise and/or experience relevant to biocontrol proposals. After undertaking a review of the information available on the proposals, the MRG identified initial draft principles or themes that apply to biological control proposals generally (Manaaki Whenua – Landcare Research 2022). The following key principles were identified:

- kaitiakitanga – the responsibility of Māori to manage natural resources within and beyond hapū and iwi boundaries. Te Ao Māori values mean that Māori have a special obligation as kaitiaki to help maintain the environment (te taiao) in balance.
- manaakitanga – the ability of Māori to protect cultural rights and ownership within hapū and iwi boundaries
- whakapapa – as the foundation for kaitiakitanga, and the need to consider the potential impacts of biocontrol agents across the breadth of trophic and ecosystem levels (see section 5.1.2)
- the requirement for applicants to provide comment and/or data to evaluate potential impacts (see section 7)

- the need to define the regional scope of effects, and effectively consider effects on iwi and hapū at a local level (see below)
- the desirability of making vegetation restoration an integral component of biocontrol
- the need to specifically address benefits to Māori.

With reference to the initial draft principles, the MRG noted that the proposed introduction of these control agents might have significant direct beneficial effects on culturally valued species, and indirect benefits to the wider native ecosystem. The MRG specifically commented that weeds of significant stature within affected areas (such as dunes and wetlands) adversely affect our appreciation of those habitats.

The focus of this application is to establish biological control of SGW to reduce environmental damage and control costs. Successful biological control would eventually reduce the amount of herbicide currently applied to SGW in sensitive areas such as dunes (see section 5.1; Figure 4).

The benefits and costs of successful control would accrue generally to the environment and (to a lesser extent) to the market economy (see sections 5.1 and 5.3). None of the **benefits, risks or costs** identified are exclusive to Māori. However, specific Māori enterprises, such as Māori forestry in the far north, would benefit directly from successful control (see section 5.3.1). Te Ao Māori values mean that Māori have a special obligation as kaitiaki to help maintain the environment (te taiao) in balance. Therefore, successful biocontrol will enable Māori to better enact kaitiakitanga, a core cultural value.

The addition of *T. acaciaelongifoliae* would change the fauna within hapū and iwi boundaries. However, the insect is host-specific, with a low ecological footprint (see section 5.1.2). This species is not expected to materially change the function of ecosystems. Infestations of SGW are growing and encroaching on Māori values, and successful biological control would mitigate the onset of those effects.

A brief survey of the fauna already exploiting SGW in Northland and Horowhenua did not identify the immature stages of any native species that might be displaced by the control agents. There were no native species present that could be used as control agents, although several self-introduced insects were inflicting damage on plants (https://www.landcareresearch.co.nz/uploads/public/Discover-Our-Research/Biosecurity/Biocontrol-ecology-of-weeds/3-applications/final-report-Invertebrates-associated-with-Acacia-longifoliae.pdf).The self-introduced seed weevil *Storeus albosignatus* destroyed 20–60% of seeds produced by SGW. The actions of this weevil are expected to enhance the effects of *T. acaciaelongifoliae*.

4.4 Regional consultation

SGW has a wide distribution in New Zealand (Figure 3) but at present has become sufficiently abundant to be regarded as a serious weed problem in only three regions - Northland, Horowhenua, and Bay of Plenty (Matakana Island). However, its future weed potential is huge.

The Horizons Region is home to almost 30 Iwi and over 100 Hapū. To undertake a full, meaningful engagement on any subject is complex given the diversity of conversations that need to be undertaken as well as resources available. It was determined that our engagement would primarily be with Iwi & Hapū who will be primarily affected by this activity. Those affected parties are:

Ngāti Raukawa
Muaupoko
Rangitāne o Manawatū
Ngā Wairiki Ngāti Apa
Te Rūnanga o Tūpoho

Consultation began in May 2021 and ended in April 2022. Consultation activities were:

An initial field trip was set up for early June 2021 that involved a visit to Himatangi beach to view the plant and discuss the proposal and its effects.

A second email was sent in September 2021 for a further meeting with the parties to discuss this proposal further. No responses were received.

A further email was sent in December 2021 for a further meeting to be held in January 2022. We received responses from parties confirming their attendance to this meeting and we received a query from Ngāti Raukawa seeking to understand this situation better. This was responded to in December 2021.

On 25 January 2022 there was a virtual meeting but none of the invited parties attended.

In March 2022, a further email was sent advising of our proposed close off date for April 2022. Following this, we received two responses from Ngā Wairiki, Ngāti Apa & Rangitāne o Manawatū which were addressed.

One respondent stated that their area had limited native vegetation that could act as a seed source for future regeneration as SGW declined. They asked Horizons what support there would be for native revegetation as SGW populations declined over time. Horizons was unable to commit to supporting replanting at the time. Given this lack of commitment to future support, the respondent reserved their right to express opposition to the application once formal submissions are sought. Further to this issue, it is likely that the area currently occupied by SGW already has a native seed and seedling bank beneath it, including species such as taupata and mānuka. If biological control succeeds, it is likely that the monoculture of SGW will be replaced over the following 10-20 years by a mosaic of vegetation including SGW, other exotic shrubs and native species originating from the seedbank and from native seeds distributed by wind or birds. It is unlikely that the land will be bare, A draft application was supplied to another respondent on request, but no further correspondence was received.

SGW is degrading the ecology of the conservation estate in the Kaimaumau gum-lands (see section 2.3.2) and has a direct impact on the productivity of Te Hiku Forests (see section 5.3.1). Consultation in the Northland region began in 2018. Northland Regional Council (NRC) Māori Engagement staff were able to put this project to Te Tai Tokerau Māori and Council Working Party in mid-2019 but this did not lead to significant engagement with Iwi or Hapū. Attempts at consultation in Northland ended when responsibility for the project was transferred to the Horizons Regional Council in May 2021.

The Kaimaumau region was devastated by fires in early 2022 and recovery of ecosystem and cultural values of the areas will be seriously hampered by SGW (see Section 2.3.2). A Technical Advisory Group for ecosystem recovery of the Kaimaumau-Motutangi fire has been established comprising Manawhenua, DOC and others. Consultation with this group about control of SGW is underway. It is expected that their views will be presented in a submission during public consultation.

> *'If there's a something that will eat every blade, twig and branch of this pest tree it should be considered an option – having been out on the fire ground those trees are rampant' ([redacted], DOC, Northland)*

The tangata whenua of Matakana are kaitiaki of the health of the dunes and guardians of the mana related to protecting these ecosystems. Five hapū on Matakana Island and Rangiwāea Island operate a common management plan. Local regional council staff are in dialogue with two representatives of the local Resource Management Unit over this proposal. It is expected that their views will be provided during the public submission process.

Experience overseas indicates that biological control would likely achieve control of SGW in New Zealand in the long-term (section 3.1.4). Te Ao Māori values mean that Māori have a special obligation as kaitiaki to help maintain the environment (te taiao) in balance. Therefore, successful biocontrol would enable Māori to better enact kaitiakitanga, a core cultural value. Further, given the current difficulties faced by tangata whenua in maintaining this weed by conventional means in Horowhenua, Kaimaumau and Matakana, biological control may be the only option for discharging kaitiakitanga safely and effectively.

4.5 Consultation with HSNO komiti

Information about the proposed biological control programme was provided to the Ngāi Tahu and Ngāpuhi HSNO komiti in January 2019 to facilitate dialogue on the proposal.

No information was received from the Ngāpuhi komiti at that time, but contact has been established recently and it is expected that a response will be made during public submissions.

The Ngāi Tahu komiti has considered this proposal and has no concerns:

> *'the proposed introduction of two insects originating from Australia as biological control agents for the Sydney golden wattle has been considered by the Ngai Tahu HSNO Committee, and we have no issue with the proposal'. (*[redacted] *Chair, NT HSNO komiti)*

Risks, costs and benefits

Provide information of the risks, costs and benefits of the new organism(s).

These are the positive and adverse effects referred to in the HSNO Act. It is easier to regard risks and costs as being adverse (or negative) and benefits as being positive. In considering risks, cost and benefits, it is important to look at both the likelihood of occurrence (probability) and the potential magnitude of the consequences, and to look at distribution effects (who bears the costs, benefits and risks).

Consider the adverse or positive effects in the context of this application on the environment (e.g. could the organism cause any significant displacement of any native species within its natural habitat, cause any significant deterioration of natural habitats or cause significant adverse effect to New Zealand's inherent genetic diversity, or is the organism likely to cause disease, be parasitic, or become a vector for animal or plant disease?), human health and safety, the relationship of Māori to the environment, the principles of the Treaty of Waitangi, society and the community, the market economy and New Zealand's international obligations.

You must fully complete this section referencing supporting material. You will need to provide a description of where the information in the application has been sourced from, e.g. from in-house research, independent research, technical literature, community or other consultation, and provide that information with this application.

The potential risks, costs and benefits of the proposed introduction to New Zealand of *T. acaciaelongifoliae* have been identified by literature review, by review of issues raised in previous applications to ERMA/EPA to introduce biocontrol agents for weeds, and by consultation with stakeholders. All of the potential effect of this proposal have been identified, and those considered to be potentially significant are highlighted on this list: (https://www.landcareresearch.co.nz/uploads/public/Discover-Our-Research/Biosecurity/Biocontrol-ecology-of-weeds/3-applications/sydney-golden-wattle-potential-beneficial-and-adverse-effects.pdf). All significant effects identified on the list are addressed in this section. Quotes and citations obtained during the pre-application processes are reproduced here.

Potential effects are associated with permanent establishment of the insect in New Zealand, reduction in the rate of spread of Sydney golden wattle and/or reduction in the abundance and vigour of existing Sydney golden wattle infestations.

Potential effects on the environment

5.1.1 Potential beneficial effects on the environment

Successful biological control would be achieved if the rate of colonisation of new areas by SGW were reduced to low levels and if reduction in the competitive dominance of SGW in affected habitats led to partial restoration of ecosystems. The introduction of *T. acaciaelongifoliae* would result in successful biological control if populations grew large enough to:

- suppress seed production low enough to stop the development of new infestations
- suppress seed production low enough to cause long-term decline in wattle populations in existing sites
- produce galls large enough to cause thinning of existing plants and replacement with native vegetation.

Could the spread of SGW be halted by suppression of seed production?

The gall wasp was introduced to South Africa in 1982 and (with the seed beetle *Melanterius ventralis*) has achieved a high degree of control of SGW (Impson *et al*., 2011). It established at all sites where it was released, and populations grew rapidly. Dennill (1985) measured the impact of the gall wasp on seed production. Comparisons between un-infested trees and heavily galled (>75% of branches with galls) trees at five sites revealed 85–100% reduction in seed production. This level of reduction was not just through direct destruction of flower spikes by galls. He showed that the relationship between galling intensity and the number of pods produced per tree was non-linear, because heavy galling caused changes in the whole tree, resulting in increased abscission of unaffected flower spikes. Pod production was inversely proportional to the proportion of galled branches and was reduced by 89–95% when more than 50% of branches had galls, irrespective of tree size.

Colonisation of new sites by SGW requires the transport of seed from site to site, probably by water, by wind, on roving animals, in mud attached to vehicles, etc. The likelihood of colonisation success at a site is related to the number of seeds migrating onto a site. Any reduction in seed production by the action of biological control agents would reduce the number of propagules available to migrate between sites and reduce the probability of colonisation success. In South Africa, *T. acaciaelongifoliae* and a seed weevil now act together to suppress seed production by SGW to approximately 5% of pre-biocontrol levels. If this level of control could be achieved in New Zealand using *T. acaciaelongifoliae* and the already resident seed weevil *Storeus albosignatus*, then the rate of colonisation of new sites by SGW would be drastically reduced.

> *The rate of growth on Matakana Island is astonishing. SGW grows so rampantly that it outcompetes the native species easily.* [redacted]*, Bay of Plenty Regional Council)*

Could populations of SGW in existing sites be reduced?

Areas already heavily affected by SGW plants will have a significant seedbank from which the population can be regenerated following a disturbance such as fire. Successful biocontrol would limit the contribution of new seed to the seedbank, but it would be several decades before the number of seeds in the seedbank fell low enough to cause population decline. However, SGW does not form monocultures wherever it occurs in New Zealand, and its distribution within infested areas is patchy. SGW-free areas between patches are likely to have no or few seeds in the soil. As seed spreads, existing populations are likely to fill in over time to create monocultures such as those causing ecological damage in Horowhenua (Figures 1 & 4).

A high level of seed suppression by the gall wasp followed by predation of the remaining seed by the resident seed weevil *Storeus albosignata* would limit the accumulation of SGW seed in areas adjacent to existing stands, slowing, and possibly eliminating the in-filling of existing infestations.

> *Between the rearward face of the foredune and inland for some distance the problem of spreading SGW is worsening. The area described is not a thicket, yet, but many areas within are if not totally, then SGW is the dominant vegetation… So a major modifier of our coastal habitat for hundreds of metres inland. Dunes attain great height.* [redacted]*, Horizons Regional Council)*

> *If the plants were left then the dunes would become a monoculture of SGW which will accelerate the erosion of the dunes. This would impact on the forestry that sits parallel to the dunes, to the residents and public who use the dunes for recreational purposes and the fact that the dunes are home to a variety of sea birds including dotterels.* [redacted]*, Bay of Plenty Regional Council)*

Would biological control of SGW lead to the improvement of invaded native ecosystems?

T. acaciaelongifoliae not only suppresses seed production but can also suppress vegetative growth (Dennill, 1985). Heavy galling can cause abscission of phyllodes (the ‘leaves’ of acacias), the death of growing points, and marked reduction in lateral branching. The gall wasp had caused at least some mortality of existing trees at about 30% of release sites in South Africa by 1990.

Reduced vigour of SGW would allow desirable plants to compete for space more effectively. Native habitats already invaded by SGW would be improved if biological control created gaps.

The effect of SGW decline on ecosystem structure and function has not been formally studied in South Africa, but in the 40 years since biological control was initiated, the importance of this weed has fallen significantly. Once regarded as one of South Africa's top five invasive weeds, it is no longer considered among the 20 most damaging weeds (Impson *et al.*, 2011). This outcome cannot be attributed to the decline of population dynamics through seed suppression alone because the seeds of SGW can last a long time in the soil and germination would replace damaged plants over time. Equally important must be the reduced growth rate, dieback, and death of plants caused by the whole-tree effects of heavy galling, and the resulting reduction in competitive ability.

Putting aside the importance of protecting native ecosystems from future effects of SGW, the likelihood of significant reversal of the adverse effects of existing SGW depends on whether the intensity of galling in New Zealand would be large enough to cause the whole-tree effects observed in South Africa. This will remain uncertain until populations of the gall wasp have established. If galling can reduce canopy density to reduce the shade cast by SGW, or create canopy gaps through plant death or dieback, then native vegetation will have a greater opportunity to outcompete the weed. The ecological benefits that might ensue will vary from place to place.

5.1.2 Potential adverse effects on the environment

The establishment of *T. acaciaelongifoliae* in New Zealand would have adverse effects on the environment if:

- damage caused by the agent to native plants reduced native plant populations
- relationships within native ecosystems were adversely affected
- the presence of the gall wasp sufficiently altered food web interactions to cause significant displacement of native organisms through apparent competition (see below).

Successful biological control in New Zealand would have adverse ecological consequences if:

decline in SGW abundance through successful biological control led to invasion of sensitive habitats by worse weeds.

Could the gall wasp affect native plant populations?

The native plant populations potentially at risk in New Zealand are the legumes kōwhai (*Sophora* spp), brooms (*Carmichaelia* spp.), kākā beak (*Clianthus* spp.) and *Montigena novaezelandiae.* All belong to tribes within the papilionoid clade (or subfamily) of the Leguminosae. The agent is highly specific to hosts within the genus *Acacia*, and the New Zealand legume flora is only distantly related to *Acacia* species, which belong to the mimosoid clade (section 3.1.4). The host range of *T. acaciaelongifoliae* in its native Australia is restricted to the closely related *A. longifolia, A. sophorae* (both now subspecies of *A. longifolia*) and *A. floribunda* (Noble, 1940). Host range tests conducted in South Africa and

Portugal predicted that *T. acaciaelongifoliae* could only form galls on several sister species within the genus *Acacia*. New Zealand native legumes are not hosts for *T. acaciaelongifoliae* in south-east Australia, where the agent is common (see section 3.1.4).

Following release in South Africa, *T. acaciaelongifoliae* formed galls on *A. floribunda*, and sporadic and poorly formed galls have been observed occasionally on *A. melanoxylon* and *Paraserianthes lophantha.* Gall wasp populations cannot persist on these non-target hosts and no significant damage has been recorded. *T. acaciaelongifoliae* galls have not been recorded on any other plant species in South Africa in the 40 years since its release.

T. acaciaelongifoliae adults are not thought to feed during their short 3–4-day life (F. Impson, University of Capetown, pers. comm.) and cannot affect non-target plants.

It is **highly unlikely** that native species could be hosts to *T. acaciaelongifoliae* in New Zealand. The risk of significant damage to native plant populations is **negligible.**

Could gall wasp populations interfere with the existing relationships between native species?

The introduction of *T. acaciaelongifoliae* might adversely affect existing ecosystem relationships if predation or parasitism of these new hosts led to significant population changes in other native species. A brief survey of the native fauna already utilising SGW did not reveal any native species likely to be displaced directly by the introduced control agents. The most likely mechanism for adverse interaction would be ‘apparent competition’.

Apparent competition between two species can occur when both are preyed upon by the same natural enemy. For example, if species A and species B are both prey for a predator or parasitoid, a population increase of A could lead to an increase in predator or parasitoid numbers, which in turn could exert unnatural downward pressure on populations of species B. A trophic web is the notional representation of all the biotic interactions affecting the population of a single species; in this case, interactions between biocontrol agents and potential parasitoids, predators and diseases.

The term ‘apparent competition’ commonly denotes negative indirect interactions between victim species that arise because they share a natural enemy. This indirect interaction, which in principle can be reflected in many facets of the distribution and abundance of individual species and more broadly govern the structure of ecological communities in time and space, pervades many natural ecosystems (Q. Paynter, MWLR, pers. comm.). The introduction of a control agent would cause adverse effects on trophic webs if populations developed that generated apparent competition in sensitive habitats, leading to significant displacement of valued native species.

Kaser and Ode (2016) point out that trophic webs are complex, and that signs and strengths of interactions between elements of trophic webs can be difficult to measure or predict. Few trophic webs have been adequately described anywhere. It is therefore not possible to define with any certainty the effect of introducing a new organism to such a web (see here for an example, (http://www.landcareresearch.co.nz/publications/newsletters/biological-control-of-weeds/issue-69/food-web-inside-broom-galls).

Trichilogaster acaciaelongifoliae was released in Portugal in 2014 and has established widely (López Núñez *et al.,* 2021). López Núñez *et al. (*2021) analysed ecological networks to define the role SGW played in dune habitats in Portugal and its influence on gall-forming species, and to predict the consequences of apparent competition from introducing *Trichilogaster acaciaelongifoliae* to this network. They found that the weed had a profound adverse effect on habitats through simplification of plant communities, with cascading effects to higher trophic levels, including a decline of overall gall biomass, and on the richness, abundance and biomass of gall-insects, their parasitoids, and inquilines (species that live incidentally in galls). However, when testing the likely consequences of introducing a new gall-former, they found that predictions of indirect effects of the biocontrol on native gallers via apparent competition ranged from negligible to highly significant. They concluded (like Kaser and Ode, 2016) that scenarios are difficult to predict, but that risks of indirect effects should be weighed carefully against the consequences of doing nothing. Frago (2016) and Kaser and Ode (2016) also point out that habitat complexity and fragmentation can modify interactions between members of a trophic web, and so ecosystem effects may be site-specific rather than general.

Despite the difficulty of predicting interactions, the relative importance of *T. acaciaelongifoliae* in web dynamics can be inferred from the biology and ecology of the agent and the target weed, as follows:

- If the agent fails to establish, or does not achieve high abundance following release, it is highly unlikely that *T. acaciaelongifoliae* could become a key prey item in any trophic web.
- The immature stages of *T. acaciaelongifoliae* are embedded in the plant and not freely available to generalist parasitoids and predators. Only parasitoids of insects that inhabit galls or pods could use this new resource. Few such organisms are known in New Zealand (see section 3.1.3).
- For 10–11 months of the year the entire population of *T. acaciaelongifoliae* is confined inside galls and cannot interact with the wider ecosystem except through parasitism.
- *T. acaciaelongifoliae* is specific to SGW (see section 3.1.4). Any significant interactions with native species would be localised around SGW plants. Interactions with trophic webs elsewhere are likely to be trivial because individuals will be rare.
- A brief survey indicated that there are no native species currently using SGW pods as a host, and natural enemy associations appear to be simple (see section 3.1.3). The most abundant insects found in the survey were self-introduced species that feed only on acacias. Few native species were encountered overall, and these were in low numbers.
- The survey did not reveal any native species on SGW in Northland or Horowhenua for which this plant might be a critically important host (section 3.1.3).
- While it can be abundant in or near native habitats, the total area of land heavily infested with SGW is currently limited (Figure 3). There is therefore limited opportunity for the control agents to significantly influence trophic webs at a landscape level.

- Some native invertebrate populations might benefit from the additional prey available, while others might suffer. The overall effects on the quality of trophic webs are as likely to be beneficial as adverse (e.g. Kaser & Ode, 2016). Any effect would only be evident for the 4–6 weeks of the year that free-living adults occur.
- SGW itself is an ecosystem modifier and is likely to be the dominant influence on trophic webs within infested sites, outweighing any effects the control agents might have. Biological control aims to reduce the physical dominance of SGW and its influence on trophic webs.

Little can be said about other potential trophic interactions with native organisms, such as diseases in common with native species, but any apparent competition will be restricted to where the control agents are abundant – the vicinity of SGW infestations.

Given the available information, the applicant concludes that *T. acaciaelongifoliae* is **unlikely** to significantly influence the quality of trophic webs outside SGW infestations and the risk is **minimal**. Successful biological control would partially reverse any effects on trophic webs of SGW itself and would progressively reduce any influence of the agents on trophic webs over time.

Could SGW be replaced by a more damaging weed?

It is unlikely that any weed that replaced SGW in affected areas could be significantly more damaging to the environment.

SGW plays a similar role to gorse in the Kaimaumau wetland, but monitoring indicates that SGW can outcompete gorse, and will in fact replace it (see section 2.3.2). This is likely to be true elsewhere in New Zealand. The weed prickly hakea is common in the Kaimaumau wetland but does not have the same long-lived seedbank as SGW (McQueen & Forester, 2000). The dynamics of this weed are more likely to be driven by fire effects than the presence/absence of SGW. Other weeds are therefore unlikely to be more damaging than SGW in Kaimaumau.

Potential effects on human health

5.2.1 Potential beneficial effects on human health

There would be no significant benefit for human health in New Zealand from the establishment of *T. acaciaelongifoliae* or from the successful control of SGW. Successful biological control may limit the future use of herbicides for SGW management, but little herbicide is applied to this weed at present and any benefits would be small (see section 5.3.1).

5.2.2 Potential adverse effects on human health

There would be no significant adverse effects on human health in New Zealand from the establishment of *T. acaciaelongifoliae* or from the successful control of SGW. The agents do not bite or sting. The fauna of pteromalid wasps already resident in New Zealand is large, and none are known to cause allergic reactions. SGW does not appear to be a significant source of phytochemicals with medicinal or commercial potential. Biological control would not preclude future development of SGW as a crop for this purpose.

Potential effects on the market economy

5.3.1 Potential beneficial effects on the market economy

Management of SGW to maintain environmental and amenity values is currently a cost to territorial authorities, DOC, NZ Defence Force and other land managers. Management of SGW to maintain forest health will be an increasing cost for forestry companies in affected areas. Successful biological control of SGW would benefit the market economy if it:

- reduced the current costs of SGW management and allowed more sustainable control options in existing infestations
- reduced seed production enough to eliminate future invasion risk

Could biological control generate significant savings in control costs?

Apart from its effects on biodiversity values (see section 5.1.1), SGW:

- reduces the landscape values of invaded land and amenity values such as access
- outcompetes establishing plantation trees for moisture and light (see section 3.1.1.).

SGW is already imposing costs on the market economy, both directly through production losses in plantation forestry, and indirectly through the costs of control to manage adverse environmental and economic effects. It is difficult to isolate specific costs of SGW control by DOC and the regional councils. Waitarere Beach residents spend $7,000 per year maintaining a now cleared area (Figure 4) but would like to triple the budget to extend control over SGW and other weeds ([redacted], Horizons Regional Council, pers. comm.).

SGW imposes added establishment and management costs to plantation managers in the Far North, but the potential for future damage to the forestry industry in other parts of the country is clear.

> *[Pre-plant] spray is to remove any weeds that may compete with the newly planted trees. We can remove all the growing wattle at this stage by using a reasonably strong brew ... a higher brew than what we would normally use for non-Acacia areas. … if the area has a history of heavy wattle these seeds will germinate the following season and then start competing with the newly planted pine seedlings…. The wattle plants [can] soon out-grow the young pine seedlings… trees need to be released. … Longifolia then it is mostly cut by hand as there is no chemical that will take the Longifolia out without harming the pine seedlings.*
>
> *We are planting up areas now which have had a history of wattle… much higher requirement on releasing…. I estimate that fifty percent of the area planted in the coming years will need some releasing. Costs for manual releasing … can reach $600 / ha for heavily infested areas…. Aerial Spraying … including chemical is usually around $300 / ha. We normally plant around 500 ha per year so a rough count up of costs would be around $100,000 per year.* [redacted]*, Summit Forest Ltd/Te Hiku Forest)*
>
> *We are also now starting to notice SGW growing under pine canopy roughly 10-20m in from access roads. This is concerning for the forestry companies as it is adding another dimension to their control programmes when culling, harvesting and prepping sites for new trees.* [redacted]*, Bay of Plenty Regional Council)*

SGW is one of the major weed species present at Raumai Air Weapons Range, west of Ohakea. It compromises access, increases fire risk and threatens the ecological stewardship of the NZ Defence Force. NZDF currently budgets $40,000 per annum for SGW control on this property ([redacted], Land Management Officer Central, Defence Estate and Infrastructure, Te Ope Kātua o Aotearoa | New Zealand Defence Force, pers. comm)

> *[The acacia] is one of the major weed species at Raumai Air Weapons Range. It has now formed dense thickets along the backdunes (and encroaching into the foredunes) and is spreading every year (google map images from even just 3 years ago show a difference in wattle cover). We have only just gained funding this financial year to begin its control, and this year we are spending 40k on it, although we could easily spend a lot more.*
>
> *It is a major ecosystem modifier, and eventually with no control, would cover the Raumati dunes. It is also a fire risk for us. A successful biological control agent for this species would be a godsend, and we would be very supportive of any introduction.* [redacted]*, New Zealand Defence Force*)

The total cost of control nationally is currently low because of the present limited distribution and abundance of SGW in New Zealand. Without intervention these costs will grow as SGW consolidates (Figure 3).

Could biological control eliminate the need for future management of SGW?

SGW is spreading rapidly in areas such as the Horowhenua coast. The future costs of controlling SGW to maintain environmental and economic values in newly invaded areas is likely to be massive. Experience in South Africa suggests that successful biological control could reduce SGW seed production in New Zealand by up to 95%, reducing the risk of development of new monocultures in new sites. Successful biological control could eliminate mass colonisation of new sites within 20 years, minimising or eliminating those future costs.

Galling by *T. acaciaelongifoliae* can adversely affect the health of growing plants, but in the short- to medium-term, biological control is unlikely to significantly reduce management costs in existing stands of SGW. However, in the long-term, the ability of SGW populations to regenerate monocultures is likely to decline, as it has in South Africa over the last 40 years (see section 3.1.2). Sites where the weed is already present will have a seedbank capable of regenerating SGW populations. Suppression of seed production will lead to a continuous decline in seedbanks under existing SGW stands, and to reduced plant health in a proportion of the population. Successful biological control will therefore eventually reduce the weed potential of SGW and its associated costs.

5.3.2 Potential adverse effects on the market economy

Successful biological control of SGW would have adverse effects on the market economy if:

- gall formation ruined the aesthetics of ornamental species, making sale in nurseries unprofitable
- suppression of flowering significantly affected the beekeeping industry
- gall formation affected the productivity of Tasmanian blackwood plantations

Could biological control affect the value of ornamental acacias?

Non-native plants grown for ornamental purposes should be seen as part of New Zealand's heritage and valued along with other biodiversity (New Zealand Plant Producers Inc in correspondence with Manaaki Whenua – Landcare Research).

SGW is not a restricted plant under the NZ Pest Plant Accord and has been used in civic plantings in the past. It is not clear whether SGW is still used for this purpose. *T. acaciaelongifoliae* primarily influences seed production, but galls could be seen as unsightly, particularly when they become dry. *T. acaciaelongifoliae* galls could reduce the aesthetic appeal of individual SGW planted as amenity trees. Death of specimen plants from galling is possible, but likely to be rare.

There are many alternative plants available for future plantings or for the replacement of degraded plants. This includes other non-weedy *Acacia* species (https://nzseeds.co.nz/collections/flowering-plants/acacia). *Acacia cognata* and *A. verticillata* are the base species for two cultivars marketed as ornamentals in New Zealand (*Acacia* 'Limelight' and *Acacia* 'Rewa'), and *A. melanoxylon* is grown in New Zealand as a timber tree and for woodworking (Tasmanian blackwood) (see section 5.3.2).

Evidence suggests that these cultivars will not be at risk from the control agent. Less closely related ornamentals such as kōwhai will be even less likely to be at risk.

Could suppression of SGW flowering significantly affect the beekeeping industry?

Beekeepers value plants that produce pollen in early spring because flowers are rare at this time of year, and there is a dearth of pollen to feed new brood after winter. SGW flowers produce both pollen and nectar in August, but the nutritive value of SGW pollen is unknown. SGW is not among the bee-friendly plants recommended for planting in urban areas (http://www.treesforbees.org.nz/__data/assets/pdf_file/0014/60422/TfB_2012_Urban-Trees-for-Bees_Brochure.pdf).

T. acaciaelongifoliae galls would replace a proportion of flower spikes on SGW wherever it occurs and would reduce the number of flowers available to bees (Figure 5b). There are no places in New Zealand where SGW is so abundant that it currently provides a dominant source of nectar or pollen (Figure 3) and so it is not a significant pollen source nationally. The risk to the beekeeping industry is likely to be minimal. Should any value of SGW to beekeepers in New Zealand decline, effects could be mitigated by promoting non-weedy alternatives.

Could gall formation affect the productivity of plantation forests?

Tasmanian blackwood (*Acacia melanoxylon*) is valued in New Zealand as a decorative timber for joinery and furniture (http://www.nzffa.org.nz/farm-forestry-model/resource-centre/tree-grower-articles/tree-grower-august-2006/blackwood-an-overview/). Blackwood grows alongside SGW in eastern Australia and is exposed to *T. acaciaelongifoliae* there. *T. acaciaelongifoliae* was recorded only from *A. longifolia* and *A. floribunda* in Australia before the insect was introduced to South Africa (Noble, 1940). Blackwood was not a recorded host. However, following its release in South Africa *T. acaciaelongifoliae* was also recorded forming galls on flower buds of blackwood.

Dennill et al. (1993) compared the performance of *T. acaciaelongifoliae* on host plants. While 95–100% of SGW trees monitored had galls, only 10% of blackwood trees were affected. Further, whereas 89% of SGW branches were galled, only 1% of blackwood branches were affected. The galls on blackwood were small and rare (Figure 8), so that the gall to pod dry-mass ratio was very low. This indicates that the ‘nutrient sink’ effect of *T. acaciaelongifoliae* on blackwood was negligible in South Africa and would have no effect on growth rates or morbidity (Dennill *et al.*,1993). Pupal mass and percentage successful emergence of wasps from galls were also much lower for blackwood than for SGW. Blackwood is clearly a poor host for *T. acaciaelongifoliae*.

Marchante *et al*. (2011) showed that *T. acaciaelongifoliae* was able to lay eggs into blackwood buds in the laboratory, but follow-up surveys in Australia did not find any galls on blackwood.

Bashford (2004) examined the effect of *T. acaciaelongifoliae* on acacias used as amenity plantings in Tasmania. No galls were observed on blackwood. He also observed that blackwood plantations were not at risk in Tasmania because no galls had been observed in routine plant health monitoring of plantations.

The unexpected formation of galls on blackwood in South Africa seems to be a 'spillover' effect resulting from the high populations of *T. acaciaelongifoliae* on SGW, creating intense pressure on females to find alternative sites to lay eggs. Dennill *et al*. (1993) suggested that galls on blackwood may be present in Australia but too rare for detection, driven by the low quality of blackwood as a host and high levels of parasitism.

Figure 8. Insignificant *T. acaciaelongifoliae* galls that form on *Acacia melanoxylon* in South Africa.

The rarity and poor quality of galls, even in South Africa, suggests that it is highly unlikely that damaging, self-sustaining populations of *T. acaciaelongifoliae* could develop on *A. melanoxylon* in New Zealand. This species is not a host in Australia. While it is possible that occasional galls might be found on blackwood here, this would only occur where populations of *T. acaciaelongifoliae* were present on SGW close by. There will be few sites where this is true. Even in this situation, published information suggests that the risk that low-level gall-formation on blackwood could adversely affect growth patterns or growth rates of blackwood in plantations is **minimal**.

Occasional galling of *Paraserianthes lophantha* has also been observed in South Africa (see section 3.1.3), though this species is not a host in Australia. In New Zealand this plant is called brush wattle and is regarded as a weed (e.g. https://www.weedbusters.org.nz/what-are-weeds/weed-list/brush-wattle/). No significant adverse effects would accrue from occasional galling of this species in New Zealand.

Potential effects on society and communities

5.4.1 Potential beneficial effects on society and communities

No nationally significant beneficial effects to society or communities were identified, other than those associated with the success of forestry (sections 5.1.1, 5.3.1). However, SGW affects the ability of a small number of coastal communities in New Zealand to enjoy their local environment (Figure 9).

> *SGW alters dune shape creating tall dunes, displaces more desirable vegetation and creates social effects – blocks sea views, prevents free access across the dune scape as it becomes impenetrable, forming areas which are suitable for rubbish dumping and rough sleepers seem to inhabit older infestations…. This was instigated by coastal residents identifying SGW was reducing their view, forming dunes of a great height that enabled wind-blown sand to travel far from these high take off points and it seemed the sand hills were rapidly encroaching on once clear land to the extent of moving into private property. ([redacted], Horizons Regional Council)*
>
> *Residents of Matakana have told many stories about how the health of the dunes affects them and their responsibility for these ecosystems. Due to the size of the infestations, control efforts by residents haven't decreased the SGW sites. [redacted], Bay of Plenty Regional Council)*

Figure 9. *Acacia longifolia* dominating access to a Horowhenua beach.

Successful biological control would benefit society and communities by restoring these amenity values, and perceived conservation values (section 5.1.1).

McQueen and Forester (2000) noted that SGW is taller than native vegetation in Kaimaumau and this affects the aesthetics of the conservation area. Like gorse, SGW also has masses of yellow flowers in August, whereas none of the native plants in this area do. Yellow flowers in native habitats look wrong. *T. acaciaelongifoliae* galls would reduce the adverse look of yellow flowering in the conservation area and in Horowhenua dunes.

5.4.2 Potential adverse effects for society and communities

There are no potential adverse effects others than those already discussed above.

Pathway determination and rapid assessment

Under sections 38I and 35 of the HSNO Act your application may be eligible for a rapid assessment. The pathway for your application will be determined after its formal receipt, based on the data provided in this application form. If you would like your application to be considered for rapid assessment (as per the criteria below), we require you to complete one of the below sections. **Fill in the section that is relevant to your application only.**

6A. New organism that is or is contained within a veterinary or human medicine (section 38I)

Controls for organism

Describe the controls you propose to mitigate potential risks (if any). Discuss what controls may be imposed under the ACVM Act (for veterinary medicines) or the Medicines Act (for human medicines)

Not applicable

Discuss if it is highly improbable (after taking into account controls if any):

The doses and routes of administration of the medicine would have significant adverse effects on the health of the public or any valued species; and

The organism could form an undesirable self-sustaining population and have significant adverse effects on the health and safety of the public, any valued species, natural habitats or the environment

Do not include effects of the medicine or new organism on the person or animal being treated with the medicine

Not applicable

6B. New organism (excluding genetically modified organisms) (section 35)

Discuss if your organism is an unwanted organism as defined in the Biosecurity Act 1993

Neither agent is listed on the Unwanted Organisms Register (https://www1.maf.govt.nz/uor/searchframe.htm)

Discuss if it is highly improbable, after taking into account the proposed controls, that the organism after release:

Could form self-sustaining populations anywhere in New Zealand (taking into account the ease of eradication)
Could displace or reduce a valued species
Could cause deterioration of natural habitats,
Will be disease-causing or be a parasite, or be a vector or reservoir for human, animal, or plant disease
Will have adverse effects on human health and safety or the environment

6.4.1 Risk of unwanted populations

It is very unlikely that the agent could be successfully eradicated once established, so release into the New Zealand environment should be considered as irreversible (section 3.1). The object of introducing *T. acaciaelongifoliae* is to establish desirable, self-sustaining populations wherever Sydney golden wattle infestations exist in New Zealand. The agent would only be considered undesirable if it adversely affected the ecological or environmental values of desirable plants or ecosystems. *T. acaciaelongifoliae* is not expected to have significant adverse economic or environmental effects in New Zealand (see sections 3.1.4, 5.1.2, and 5.4.2). Given the potential benefits of the introduction, no populations of these agents are expected to be unwanted.

6.4.2 Risk of displacement of valued species

Significant displacement of valued species following the release of *T. acaciaelongifoliae* is considered improbable for the following reasons.

- The evidence presented in sections 3.1.4, 5.1.2 and 5.3.2 indicates that native or valued exotic plant species are not at significant risk of attack by *T. acaciaelongifoliae.*
- It is improbable that any native plant or invertebrate species would be significantly displaced (section 5.1.2). There do not appear to be native invertebrate species intimately associated with SGW that could be significantly displaced by *T. acaciaelongifoliae* (see section 3.1.3).

- Any change in SGW abundance resulting from biological control is likely to be gradual (over years). It is highly improbable that this control agent will cause rapid and catastrophic decline in any SGW that might lead to widespread rapid change in a native habitat. Successful biocontrol will tend to restore affected habitats to a pre-invasion state over time.
- Permanent reductions in SGW biomass could theoretically result in replacement in existing sites by equally or more damaging invasive species (see section 5.1.2). This potential effect is not considered significant because it is unlikely that those weeds would be any more damaging than SGW in affected habitats. In native habitats SGW is more likely to be displaced by native species. Any effect is likely to be variable from place to place.

6.4.3 Risk of deterioration of natural habitats

If galling by *T. acaciaelongifoliae* becomes severe, then stems or branches of SGW trees, or even whole shrubs, could be killed. Founding populations of the gall wasp will be relatively small, and it will take several years before the density of galls on SGW reaches damaging levels. SGW is perennial, with significant reserves. Suppression of growth or deterioration of trees through gall formation will be gradual (over years), and it is unlikely that plants would die within a single season. Change in SGW biomass and abundance is likely to be gradual, allowing time for surrounding vegetation to regain the space occupied by SGW. Deterioration of natural habitats is therefore highly improbable.

6.4.4 Risk of vectoring disease

The gall wasp could not cause plant disease and it is not parasitic on vertebrates. Insects can transmit disease-forming organisms from plant to plant by:

- passive transmission of disease propagules on the integument or on the ovipositor of adults
- active transmission into the plant through adult feeding
- trans-ovariole transmission through oviposition.

Adult gall wasps survive only days and probably do not feed at all. The host range of the wasp is restricted to SGW and possibly several closely related plants (see section 5.1.2). Interaction between gall wasp adults and valued non-target vegetation is likely to be rare and fleeting. Passive transmission is therefore improbable. There are no records of trans-ovariole disease transmission by this species. If there were, transmission could only occur within the narrow range of hosts on which it has been found.

6.4.5 Risk of adverse effects on human health

Short-lived adults (3–4 days) are the only free-living stage of the 3–4 mm gall wasp. Most of the life cycle of the agent (eggs, larvae, pupae) is spent within the pod of the host plant, with no prospect of interaction with humans. A short literature search (PUBMED) revealed no records of pteromalid wasps implicated in adverse effects on human health. No credible mechanism for adverse effects of small wasps on human health and safety has been suggested. Significant adverse effects on human health are improbable (see section 5.2.2)

Other information

Add here any further information you wish to include in this application including if there are any ethical considerations that you are aware of in relation to your application.

Ethical considerations

This application raises no known ethical considerations.

Monitoring and measurement of impact

The development of biocontrol agents for weeds is mostly funded by the National Biocontrol Collective. The collective has stated its commitment to the evaluation of target and non-target effects of the agents developed, as and when this is appropriate, with the support of Manaaki Whenua – Landcare Research (MWLR). MWLR will provide founding populations of the gall wasp to the applicant, regional councils and other organisations. Application to introduce *T. acaciaelongifoliae* is made by the Horizons Regional Council on behalf of the National Biocontrol Collective. Release sites will be monitored for establishment success, and simple baseline estimates of weed abundance will be made (http://www.landcareresearch.co.nz/__data/assets/pdf_file/0005/83318/Basics_National_Assessment_Protocol.pdf). If it becomes abundant, members of the collective will then undertake measurement of their effects.

Initial releases will be made in Horowhenua. As soon as possible after release the sites will be checked for non-target effects (though none are expected). In August of the first year following release, HRC or MWLR staff will examine the SGW trees and any other leguminous plants within a 50 m radius of each release point for the presence of *T. acaciaelongifoliae* galls. A sample of any galls present will be harvested and incubated to determine the presence of *T. acaciaelongifoliae* or any associated species.

The impact of the agent on the annual seed production of SGW can only be reliably assessed once populations have saturated release sites This is likely to take at least 3 years, and no fixed plans can be made at this point. In principle, HRC or MWLR will assess what proportion of buds are galled by *T.*

acaciaelongifoliae, what proportion of the seeds in surviving pods are destroyed by seed weevils, and hence the annual degree of suppression of seed production. Long-term changes in plant biodiversity over time could potentially be monitored using permanent plots of the long-term National Vegetation Survey that are situated near release sites.

MWLR is focused on constant improvement in biological control of weeds practice in New Zealand, including world-leading research into minimising the interactions of introduced agents with existing trophic webs (Paynter *et al.*, 2010; Fowler *et al.*, 2012), better prediction of success (Paynter *et al.*, 2012), how agents disperse (Paynter & Bellgard, 2011), the accuracy of host range testing in predicting eventual host range following release (Paynter *et al.*, 2014), and monitoring the safety of biological control using insects in New Zealand (Paynter *et al.*, 2004).

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Checklist

This checklist is to be completed by the applicant

Application		**Comments/justifications**
All sections of the application form completed or you have requested an information waiver under section 59 of the HSNO Act	☒ Yes ☐ No (If No, please discuss with an Advisor to enable your application to be further processed)	
Confidential data as part of a separate, identified appendix	☐ Yes ☒ No	
Supplementary optional information attached:		
• Copies of additional references	☒ Yes ☐ No	
• Relevant correspondence	☐ Yes ☒ No	
Administration		

Are you an approved EPA customer?	☒ Yes ☐ No If Yes are you an: Applicant: ☐ Agent: ☒	Fee already paid by Landcare Research
If you are not an approved customer, payment of fee will be by:		Fee already paid by Landcare Research
- Direct credit made to the EPA bank account (preferred method of payment) Date of direct credit:	☐ Yes ☐ No ☐ Payment to follow	
- Cheque for application fee enclosed	☒ Yes ☐ No ☐ Payment to follow	
Electronic, signed copy of application e-mailed to the EPA	☒ Yes	

Signature of applicant or person authorised to sign on behalf of applicant

☒ I am making this application or am authorised to sign on behalf of the applicant or applicant organisation.

☒ I have completed this application to the best of my ability and, as far as I am aware, the information I have provided in this application form is correct.

[redacted]

10/08/2022

Signature **Date**

Request for information waiver under section 59 of the HSNO Act

☒ I request for the Authority to waive any legislative information requirements (i.e. concerning the information that has been supplied in my application) that my application does not meet (tick if applicable).

Please list below which section(s) of this form are relevant to the information waiver request:

Appendices and referenced material (if any) and glossary (if required)

Appendix 1. Images illustrating the invasion and consolidation of SGW at two sites in the Horizons Region from 2011 to 2021

(a) Himatangi 2011 **2016** **2021**

(b) Bulls 2011 **2016** **2021**

Appendix 2. Summary of results of host range tests conducted before the release of *T. acaciaelongifoliae* in South Africa (image from Kleinjan & Hoffman, 2013b)

A *Trichilogaster acaciaelongifoliae*

(*Vachellia*)		*davyi, exuvialis, kirkii, permixta*, tortilis*, xanthophloea*
(*Senegalia*)		*erubescens, nigrescens, schweinfurthii,*
Paraserianthes (Ingeae)		[1]
Acacia s.s.		
clade A		
clade B		*saligna*
clade C		
clade D	aneura subclade	
	longifolia subclade	*floribunda*[2], *longifolia*
	cognata subclade	*cyclops, implexa, melanoxylon*[3]
clade E		*baileyana, dealbata, decurrens, elata, mearnsii, neriifolia, podalyriifolia*

* All the test plants listed above, except these two species, were exposed to *T. acaciaelongifoliae* under choice conditions. In addition, a series of no-choice tests was conducted on branches of indigenous acacias and these two species have been included because they had flower buds during the testing procedure. The remaining test species did not have flower buds and have not been included as *T. acaciaelongifoliae* oviposits primarily in the flower buds of its hosts.

[1] *Paraserianthes lophantha* was not tested but *T. acaciaelongifoliae* gall symptoms were encountered on this species in the field subsequent to its establishment

[2] The only test plant which supported development of galls in the choice tests was the control, *A. longifolia* (Neser 1982). During testing *Acacia floribunda* must thus have been negative, although it is a known field host.

[3] *Acacia melanoxylon* did not develop galls in the choice tests, although ovipositional probing by adults did occur. Subsequent to the establishment of *T. acaciaelongifoliae*, gall symptoms were encountered on *A. melanoxylon* in the field and Marchante et al. (2010) subsequently showed that oviposition does occur on this species under no-choice conditions.

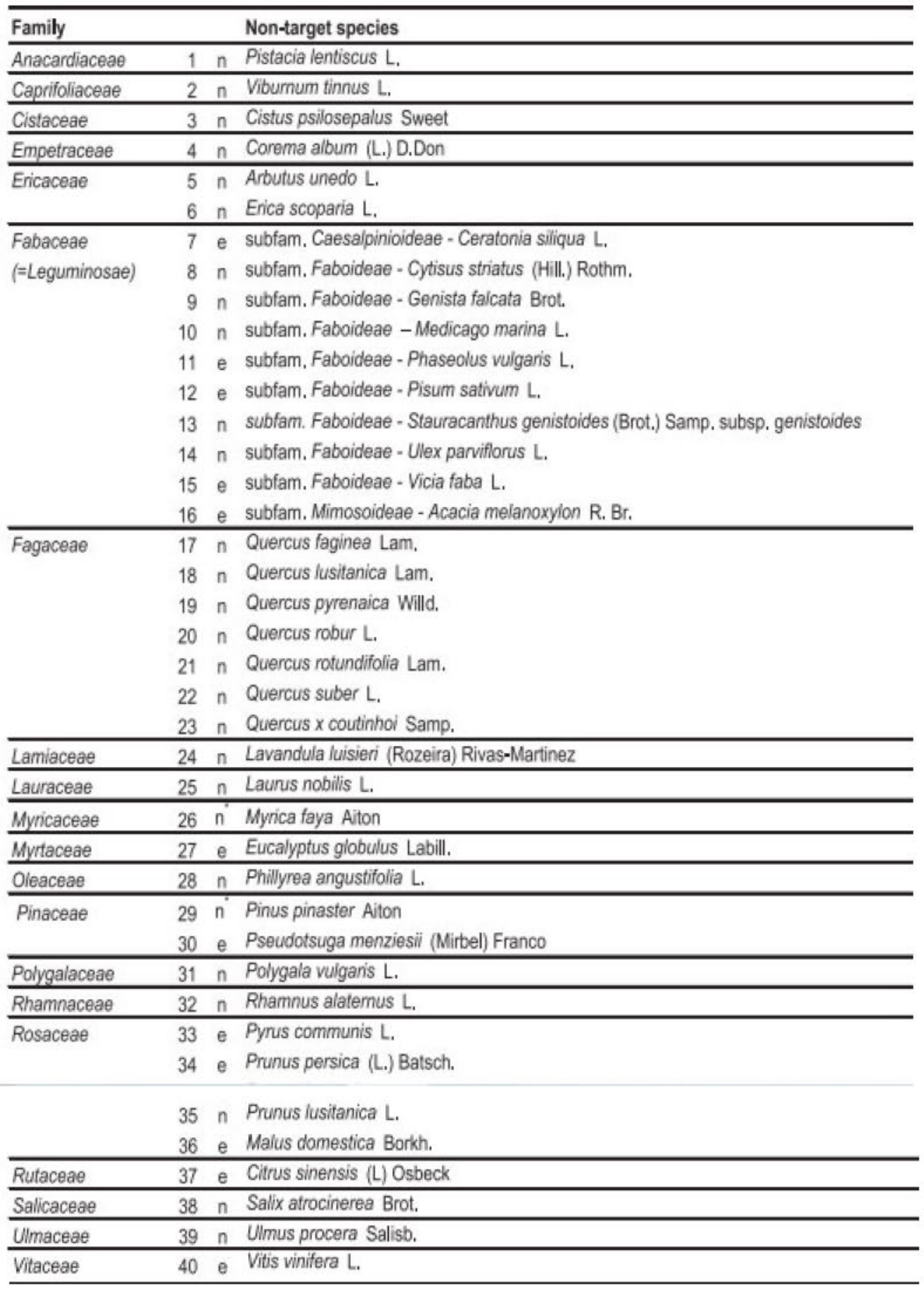
The false negatives obtained for *A. floribunda* and *A. melanoxylon* may be testing artifacts, as test plants were maintained under quarantine conditions for an extended time period and/or because the *T. acaciaelongifoliae* adults were simultaneously offered a selection of test plants.

The natural field hosts for *T. acaciaelongifoliae* include *A. longifolia*, *A. sophorae* and *A. floribunda*, which were all previously considered variants of *A. longifolia* (Neser 1982). Populations released in South Africa were widely sourced and included cohorts from both *A. longifolia* and *A. floribunda* (Neser 1985), it is abundant on both these plant species in South Africa. The identity of the host plant or plants from which *T. acaciaelongifoliae* used for testing was sourced is not stated, but is more likely to have been *A. longifolia* and/or *A. sophorae*. *Trichilogaster acaciaelongifoliae* is largely parthenogenetic but variation occurs in the frequency of males in populations (Neser 1985, Noble 1940), Noble (1940) also noted that in Australia *A. floribunda* galls developed not only in buds but also in growing tips, these observations may indicate that substantial genotypic variation exists between populations (Hill 2005). As populations released in South Africa were widely sourced the possibility that more than one genotypic entity became established exists, however *T. acaciaelongifoliae* populations in South Africa exhibit limited genetic variation (Lado 2008).

The observation that *T. acaciaelongifoliae* may be able to induce galls in shoots or vegetative buds of hosts led to additional no-choice tests on young shoots of several indigenous "Vachellia" and "Senegalia" species (listed below). *Faidherbia albida* (previously *Acacia albida*)) was included. No gall symptoms developed.

Faidherbia (Ingeae)	*albida*
(*Vachellia*)	*davyi, erioloba, exuvialis, gerrardi, grandicornuta, haemotoxylon, hebeclada, karroo, nilotica, robusta, sieberiana, stuhlmanii, tortilis, xanthophloea*
(Senegalia)	*ataxacantha, brevispica, burkei, erubescens, galpinii, mellifera, montis-usti, nigrescens, polyacantha, reficiens, schweinfurthii, senegal*

Appendix 3. List of plants tested before the release of *T. acaciaelongifoliae* in Portugal (image from Marchante *et al.*, 2011)



Family			Non-target species
Anacardiaceae	1	n	*Pistacia lentiscus* L.
Caprifoliaceae	2	n	*Viburnum tinnus* L.
Cistaceae	3	n	*Cistus psilosepalus* Sweet
Empetraceae	4	n	*Corema album* (L.) D.Don
Ericaceae	5	n	*Arbutus unedo* L.
	6	n	*Erica scoparia* L.
Fabaceae	7	e	subfam. *Caesalpinioideae* - *Ceratonia siliqua* L.
(=Leguminosae)	8	n	subfam. *Faboideae* - *Cytisus striatus* (Hill.) Rothm.
	9	n	subfam. *Faboideae* - *Genista falcata* Brot.
	10	n	subfam. *Faboideae* – *Medicago marina* L.
	11	e	subfam. *Faboideae* - *Phaseolus vulgaris* L.
	12	e	subfam. *Faboideae* - *Pisum sativum* L.
	13	n	subfam. *Faboideae* - *Stauracanthus genistoides* (Brot.) Samp. subsp. *genistoides*
	14	n	subfam. *Faboideae* - *Ulex parviflorus* L.
	15	e	subfam. *Faboideae* - *Vicia faba* L.
	16	e	subfam. *Mimosoideae* - *Acacia melanoxylon* R. Br.
Fagaceae	17	n	*Quercus faginea* Lam.
	18	n	*Quercus lusitanica* Lam.
	19	n	*Quercus pyrenaica* Willd.
	20	n	*Quercus robur* L.
	21	n	*Quercus rotundifolia* Lam.
	22	n	*Quercus suber* L.
	23	n	*Quercus x coutinhoi* Samp.
Lamiaceae	24	n	*Lavandula luisieri* (Rozeira) Rivas-Martinez
Lauraceae	25	n	*Laurus nobilis* L.
Myricaceae	26	n	*Myrica faya* Aiton
Myrtaceae	27	e	*Eucalyptus globulus* Labill.
Oleaceae	28	n	*Phillyrea angustifolia* L.
Pinaceae	29	n	*Pinus pinaster* Aiton
	30	e	*Pseudotsuga menziesii* (Mirbel) Franco
Polygalaceae	31	n	*Polygala vulgaris* L.
Rhamnaceae	32	n	*Rhamnus alaternus* L.
Rosaceae	33	e	*Pyrus communis* L.
	34	e	*Prunus persica* (L.) Batsch.
	35	n	*Prunus lusitanica* L.
	36	e	*Malus domestica* Borkh.
Rutaceae	37	e	*Citrus sinensis* (L) Osbeck
Salicaceae	38	n	*Salix atrocinerea* Brot.
Ulmaceae	39	n	*Ulmus procera* Salisb.
Vitaceae	40	e	*Vitis vinifera* L.