Potential beneficial and adverse effects to be addressed in the EPA application to introduce two moths, *Wheeleria spilodactyla* and *Chamaesphecia mysiniformis*, as biological control agents for horehound.

Richard Hill, Richard Hill & Associates, hillr@landcareresearch.co.nz, 021 1376919

The potential beneficial and adverse effects of new control agents for a range of terrestrial weeds have been identified systematically over the last ten years through formal brainstorming and through consultation with the public and professionals. This process has shown there is a suite of possible risks, costs and benefits that are common to most weed biocontrol proposals. Other effects are specific to particular agents. Effects can result from:

- Introduction of a new element into the New Zealand fauna
- Reduction in density and abundance of the weed through successful biological control

Here is the list of effects identified. Those potential risks or benefits considered to be significant (the product of the magnitude of the effect and the frequency or likelihood of the effect) have been highlighted, and will be addressed fully in the application. Those not considered to be significant (because they are speculative, or because the magnitude and/or likelihood of the effect is low or cannot be clearly envisaged) will probably not be addressed.

Please contact Richard Hill, preferably before 28 February 2018 if you have any comments about the approach to be used in the application, or to report additional potential effects.

Potential impacts on Māori values are addressed in a separate consultation process

Potential beneficial effects

On the Environment

The ability of the weed to persist in existing infestations is reduced when leaf damage or destruction of roots by control agents limits seed production	See Section 5.1.1
Dispersal of seeds to new sites by animals is reduced when leaf damage or destruction of roots by control agents limits bur production	See Section 5.1.1
Reduced damage to underlying foliage from reduced reliance on herbicides for horehound management	See Section 5.1.1
Reduced contamination of air, soil and water from reduced spraying	See Section 5.1.1
Successful BC of horehound reduces competition for water in dry regions	Not seen as a critical impact of horehound

Reduced competition with native seedlings improves plant diversity	Effect uncertain. It is not clear whether horehound is detrimental to any native plants growing below it.
Reduced incidence of horehound partially restores former natural vegetation, trophic webs and ecosystems	Although recognised as a weed of disturbed natural grasslands in Australia, DoC does not considered horehound to be a significant weed in the conservation estate in NZ
Nutrient cycles enhanced by increased leaf fall and nutrient turnover in the litter	Although likely, this effect could only be very local and therefore not significant
Regeneration of native species is improved by Increased/decreased nutrient flows in weed patches	DoC does not considered horehound to be a significant weed in the conservation estate in NZ
Habitat for pest insects is reduced with declining horehound	Horehound is not known to harbour significant pests (Groentemann et al., 2017)
Introduction of new insect species increases biodiversity	Addition of two species is not a significant effect
Reduced fire risk in fire-prone habitats	Horehound provides fuel in dry habitats but is not itself a notable fire risk
Benefits to parasitoid, predator and disease relationships in trophic webs	See section 5.1.2. Beneficial effects, like adverse effects, are not expected to be significant
Improved look and feel of native grasslands for visitors	Visitors probably perceive horehound as native
Successful control of horehound leads to improved invertebrate biodiversity in grasslands. Loss of endangered species through horehound invasion is slowed.	Little is known about the current effect of horehound on native species. Any effects would be local to horehound infestations in unimproved pastures, and therefore rare.
Reduced cover for pest animals as horehound size and density is decreased by biological control	Benefit uncertain. Habitats with horehound may harbour more predators than habitats without it. Rats and mice sheltered by horehound may affect populations of reptiles and large invertebrates.

On Human Health

Mental health in land managers is improved	See Section 5.2.1
Health of occupiers, conservation staff and volunteers is improved by reduced occupational exposure to herbicides	Herbicides applied according to label should not pose significant environmental risk. This effect is considered to be negligible

On the Market Economy

Proportion of downgraded fleeces is reduced as biological control reduces the incidence of horehound burs	See Section 5.3.1
Productivity of affected land is increased as biological control reduces the density and/or size of horehound plants	See Section 5.3.1
Cost of control for occupiers, regional councils, DOC, is reduced when successful biological control leads to reduction in horehound	See Section 5.3.1
Management of control agents creates business opportunities for Manaaki Whenua Landcare Research and other entities	Not significant. Minimal and temporary benefit to a single entity.

On Society and Communities

Conservation values are improved following successful biological control as horehound is replaced with native vegetation	Not significant. DoC does not considered horehound to be a significant weed in the conservation estate in NZ
Conservation volunteers and community resources are used better as the need to manage horehound is removed by biological control	Not significant. Horehound is not currently considered to be a significant weed in natural ecosystems in NZ.
Landscape values improved by decline in horehound density	Many would consider the presence of horehound to enhance landscape values, others to detract. Overall this effect is not significant nationally.
Stress in conservation workers is reduced	Not significant. DoC does not considered horehound to be a significant weed in the conservation estate in NZ.
Reduced incidence of horehound burrs following biological control	Burrs catching on socks is perceived as a nuisance for visitors, especially trampers and horse-riders

Potential Adverse Effects

On the Environment

Native plant populations decline because control agents attack non-target plants	See Section 5.1.2
Worse weeds invade habitats as horehound declines	See Section 5.2.1
Native parasitoid, predator and disease relationships are adversely affected by the Introduction of the control agents to native habitats	See Section 5.2.1
Food web interactions are adversely affected by the introduction of a new prey species. Indirect competition causes extinction of native insects	See Section 5.2.1
Selecting agent populations other than those tested leads to unpredicted non-target effects	See Section 5.2.1
Swift evolutionary change in insects leads to unexpected non-target damage to valued plants and/or alterations to food webs	Not a significant risk. Rapid evolution to expand the host range of a biological control agents has never been observed
Control agents hybridise with related resident insects	Not significant. There is no reason to suspect that either northern hemisphere agent is capable of hybridising with NZ species
Susceptibility of horehound to herbicides is reduced by insect feeding, and application rates increase	There was no suggestion of reduced susceptibility to chemicals in Australian trials
Habitat quality for native fauna is reduced as horehound declines. Successful control leads to reduced invertebrate biodiversity in affected land	Not significant. Horehound does not appear to host native species to any significant extent
Changes in nutrient flows in weed patches adversely affects ecosystems	Horehound is typically found in dry grazed grasslands. Nutrient flows are more likely to be structured by other disturbances than horehound dynamics.
The ability of horehound to rehabilitate contaminated soils is reduced by successful biological control	Horehound is not used for this purpose in NZ at present. Other plants can fulfil this role.
Horehound as a source of future pesticide, food additive, corrosion inhibitor for steel, or as a flavour for beer reduced through successful biological control	Not significant as horehound is not currently used for these purposes in NZ. Biological control does not preclude the future cultivation of horehound as a source of active substances, but protection of plants from the biological control agents using organic treatments might add to production costs

On Human Health

Control causes loss of a unique phytomedicine	See Section 5.2.2
Insects cause a nuisance indoors, public is fearful of insects, control agents bite or sting, control agents generate allergic response	Moths are host specific and will be rare except in the immediate vicinity of large horehound infestations. Dense stands of horehound are typical in broad acre grasslands, not near dwellings. The moths will not bite or sting.
Control agents need spraying with adverse effects to humans	Extremely unlikely that the control agents will require treatment

On the Market Economy

Damage to leaves, and/or reduction in horehound density reduces the viability of wild harvest of the plant for pharmaceutical production	See Section 5.2.3
Damage on leaves significantly reduces the usefulness of valued culinary plants, making sale in nurseries unprofitable	See Section 5.2.3
Successful biological control negatively impacts honey production by reducing a source of nectar for honeybees	See Section 5.2.3. Although in parts of the native range horehound is valued as a source of early season nectar for honeybees, New Zealand apiculture industry does not rely on horehound as a significant resource.
Successful biological control reduces revenue for contractors	See Section 5.2.3.
Successful biological control leads to reduced herbicide sales significantly affecting vendors' businesses	Not significant. Horehound herbicides currently occupy an insignificant part of the pesticide market
Costs of controlling replacement weeds is higher than horehound	No similar replacement weeds are expected.
Feeding on agents increases wasp populations and hence wasp control costs	Horehound habitats are not associated with high wasp populations or with systematic wasp control. Predation of *Wheeleria* larvae by wasps is likely, but it is likely to make up only a small proportion of the diet of wasps in this habitat.
Adverse effects require costly agent eradication campaign	Agents are not expected to have significant adverse effects

On Society and Communities

Damage on leaves significantly reduces the usefulness of valued culinary plants growing in hone gardens	See Section 5.2.3
Significantly increased incidence of wasp stings by wasp populations increased by eating agents	Not expected to contribute to higher wasp populations, see above.
Fear and distrust of exotic species and their possible non-target effects.	Cannot be mitigated, but occurrence would be vanishingly rare. Introduction of these species would not add significantly to this risk.