Ecological Risk Assessment of Exotic Ant Species in the Tasman Region

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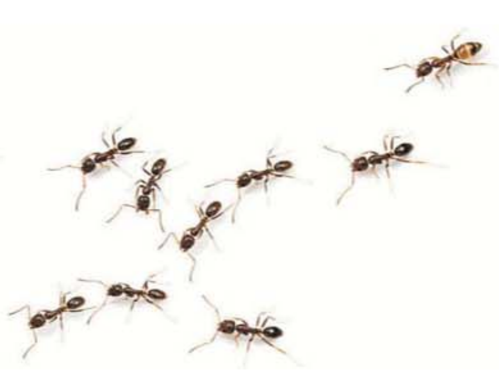

PREPARED FOR:
Tasman District Council
Envirolink Project: TSDC18

DATE: June 2007

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Landcare Research Contract Report: 0607/137

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Contents

Summary

Project and Client

- A project to evaluate the negative impacts of established exotic ant species in the Tasman region was undertaken for Tasman District Council by Landcare Research in April–June 2007.
- Two issues are addressed: 1) a prioritised risk assessment of established exotic ant species, and 2) distribution modelling to determine areas in the Tasman region most at risk (climatically suitable).

Methods

- Assessment of the risk of established exotic ant species was made via a modified scorecard used previously for pre-border risk assessment of exotic ant species.
- Species of highest risk were modelled using mean annual temperature and mean annual precipitation.
- Two models identifying current and potential distribution were mapped for the whole of New Zealand and the Tasman region.

Results

- Twenty-eight exotic ant species were scored on 26 characters in 7 categories, weighted to give more emphasis to the categories of: pest status to humans, impact on native environments, and establishment success in natural environments.
- Eight species were deemed the highest risk (in order of risk ranking): *Technomyrmex albipes*, *Linepithema humile*, *Doleromyrma darwiniana*, *Pheidole megacephala*, *Ochetellus glaber*, *Pheidole rugosula*, *Paratrechina* spp. and *Iridomyrmex* sp.
- *Technomyrmex albipes* is also the species with the largest potential distribution in the Tasman region. It is predicted to occur in all areas except the Cobb region.
- The Argentine ant, *Linepithema humile*, is predicted to have a relatively restricted distribution in the Tasman region: Farewell Spit, coastal Takaka and Motueka, Moutere and Nelson city surrounds. Inland areas appear too cold for their establishment.
- The Tasman region is predicted not to be suitable for *Pheidole megacephala*.
- Areas most at risk from exotic ant species in the Tasman region are: coastal areas of Tasman Bay and Golden Bay, the Nelson city area, and the Moutere and Golden Downs areas. A number of low-lying river valleys are also potentially suitable (e.g. Motupiko, Motueka, Takaka, Wai-iti).
- This assessment includes those ant species which are most likely to impact on the horticultural industry.

Recommendations

- The first priority for the Tasman region should be the development of a targeted surveillance program for *Linepithema humile* and *Doleromyrma darwiniana*.
- Understanding how these two species are spread by human activity and the sites where this will most likely occur, is a key aspect to their control that needs further research.
- The results of this report suggest other exotic ant species also warrant consideration to be included as containment pests, particularly, *Technomyrmex albipes*.

1. Introduction

1.1 Exotic ant species

Exotic ant species are currently receiving considerable attention around the globe. There is increasing evidence of economic and agricultural losses, health effects on humans, and disruption to natural ecosystems as a result of invasion (Holway et al. 2002). Although only a handful of exotic ant species are well studied, there are many other ant species with the opportunity to become invasive (McGlynn 1999, Lester 2005, Suarez et al. 2005, Ward et al. 2006). Ants are the second most common family of insects intercepted by quarantine personnel at the New Zealand border (Keall 1980). A total of 115 ant species from >4300 interceptions have been detected over the last 50 years at the New Zealand border (Ward et al. 2006). Many of the species commonly intercepted are invasive species, and several have already become established in New Zealand.

In New Zealand, much of the attention surrounding exotic ants has focused on the Argentine ant (*Linepithema humile*), whose negative impact on native biodiversity and horticulture has been well documented overseas (Holway et al. 2002). New Zealand habitats most at risk of invasion by Argentine ants are open canopy environments (scrub, coastal open forest, mangroves); forests are less susceptible (Harris 2002, Harris et al. 2002, Ward & Harris 2005). However, currently there is a total of 28 exotic ant species established in New Zealand (Ward 2005, Appendix 1). Thus, species other than Argentine ants may also pose threats to the environment and to industry in New Zealand. Several of these exotic ant species are widespread throughout the country, especially the North Island (Ward 2007). They are usually conspicuous, as they often occur in residential areas and houses.

1.2 Assessment of threat of exotic ant species

There is increasing demand for assessment system of exotic species, both as pre-border (quarantine) systems or to prioritise the management of existing exotic species (Williams et al. 2002). Risk assessment systems have been extensively used for evaluating the threats posed by weeds for different regions and globally, including New Zealand (Williams et al. 2002). For exotic ants, the only assessment system is a scorecard produced recently by Harris et al. (2005) to assess the risk posed by exotic ant species that may potentially enter New Zealand.

In general terms, risk assessment scorecards used to prioritise existing exotic species attempt to identify categories that exotic species will affect, and rank species on their effects from high to low risk. Categories are user defined, and thus provide significant flexibility, depending on the user’s requirements. For example, categories may change depending on geographic scale (region, national boundary, globe), whether economic, human health or ecological impacts are to be assessed, or whether the assessment is for existing established species or ‘future invaders’ that have the potential to establish but have not yet done so.

Once high risk species have been identified and prioritised, further information can be evaluated. Of major importance to managing exotic species is the identification of their current and potential distribution, which is important in planning and prioritising areas for surveillance and for the success of control programmes. Thus, understanding, and being able to predict the distribution of a species represents an important tool for invasive species management (Anderson et al. 2003).

Species distribution modelling (SDM) aims to predict areas where environmental conditions are suitable for the survival of the species. In general, these modelling methods combine species locality data (geo-referenced coordinates of latitude and longitude from confirmed presence and/or absence) with environmental variables to create a model of the species' requirements (Anderson et al. 2003). The resulting model is then projected onto a GIS map (termed a habitat suitability map) of the study region showing the potential geographic distribution of a species. For invasive species management, habitat suitability maps identify areas where 1) invasive species may actually be present (but are as yet undetected), and 2) where invasive species may disperse to in the future, thus providing assistance for planning and prioritising areas for surveillance.

It is well known that climatic variables, especially temperature and rainfall, play a large role in determining the distribution of exotic ant species. On large spatial scales ant abundance is strongly correlated with net primary productivity (a function of solar radiation and rainfall) (Kaspari et al. 2000). Temperature also plays an important role in the abundance of ants by restricting foraging activity and regulating seasonal productivity (Kaspari et al. 2000). Environments with high rainfall reduce the time spent foraging, and conversely, in xeric habitats, the lack of water and soil moisture can also limit the distribution of some species (Holway & Suarez 2006).

At the level of the colony, the location and construction of nests play an important role in regulating temperature and humidity (Hölldobler & Wilson 1990). For example, nests can also provide a thermal refuge in hot environments, allowing workers to retreat to a cool nest in the hottest part of the day. Temperature primarily controls the development of the eggs, larvae and pupae (Hartley & Lester 2003). Some ant species are known to move brood vertically within the nest to keep them at the optimum temperature for development (Hölldobler & Wilson 1990). Extremes of temperature are known to severely limit, or stop, the production of workers and reproductive castes, which can ultimately kill the colony (Korzukhin et al. 2001).

In New Zealand, climate variables are likely to play a significant role in determining the distribution of exotic ant species. Many currently established exotic ant species in New Zealand show restricted northern distributions which are associated with warmer temperatures (Harris et al. 2005). When exotic ant species are discovered in cooler environments, they are often closely associated with artificial heating sources in urban areas (e.g. buildings, concrete, etc.).

Thus, to reduce the threat of exotic ants, two major issues need to be addressed: 1) a national priority list of exotic ant species; and 2) the regions and habitats most at risk (Anon 2006). The overall aim of this report is to address these two issues for New Zealand, and specifically the Tasman region.

2. Objectives

The aim of this report is to evaluate the relative risk of established exotic ant species having a negative impact in the Tasman region. This will be achieved through the use of a risk assessment scorecard that ranks species on numerous criteria including: invasion history and spread; impacts on humans; impacts on the environment; and establishment success. The current and potential geographic distribution of species deemed high risk will then be modelled for the Tasman region and New Zealand.

In this report we focus on the Tasman region, which encompasses the Tasman District Council and the Nelson City Council. The evaluation is restricted to currently established exotic ant species in New Zealand, as defined by Ward (2005) and which are listed in Appendix 1.

3. Methods

3.1 Risk Assessment Scorecard

A scorecard used previously for pre-border risk assessment of exotic ant species (Harris et al. 2005, see Table 1) was modified to assess the risk of currently established species in New Zealand (Table 2).

Modifications included deleting the following characters that did not apply to established ant species: 1) under pathways – “future interceptions”, “have nests or queens been intercepted”, “established at sites with direct trade pathways”, “commodity compatibility”, 2) under establishment success – “incursions previously (colonies detected post border clearance)”, and “incursions previously produced sexual stages”.

A number of terms were also changed for clarification, including: 1) under invasive history – “established outside native range (excluding New Zealand)”; 2) under pathways – changes to clarify origin of pathways; 3) under establishment success – climate match changed to habitat match, better reflecting the information available; 4) under small size/cryptic nature – a correction to original scorecard that previously gave higher risk to easily detected species, when this is wrong; and 5) under likely pest status to humans – garden nuisance changed to outdoor nuisance,

Modifications resulted in seven categories and 26 characters to assess in the scorecard. Information on each species was obtained, primarily from Harris et al. (2005), but also from an online distribution database (Landcare Research 2006), the author’s field experience and knowledge of each species, and discussions with other ant researchers (Richard Toft, Margaret Stanley). The 26 characters in the scorecard were scored (either 0, 0.5, or 1) according to how the information on each species fitted the characters. An average score of characters per category was obtained and summed for a total score. For scoring, the category of establishment success was split into two sections – one for natural environments (forest, open non-urban), the other to reflect more urban environments (urban outdoor, inside buildings).

Unlike Harris et al. (2005), a weighting percentage was used to give some categories more importance in the priority rankings of species. The weighting percentages are given in Table 3 and give more emphasis to the categories of pest status to humans, impact on native environments, establishment success in natural environments, and difficulty in containment. Less emphasis is given to biological traits inferring invasiveness, invasive history, pathways and establishment success in urban environments.

3.2 Species Distribution Modelling

Species deemed to be high risk from the risk assessment scorecard were selected for distribution modelling. This modelling identifies the current and potential distribution of a species based on climate information.

Distribution records (geo-referenced coordinates of latitude and longitude from confirmed presence) of each species were obtained from an online database of exotic ant species in New Zealand (Landcare Research 2006). Climate information (mean annual temperature °C, MAT; and mean annual rainfall in mm, MAR) was obtained from Landcare Research and matched to these distribution records. Models and maps were created in ArcMap 9.2 Spatial Analyst extension. The resolution of the climate layers was 100m.

To examine the relationship between MAT and MAR, bivariate plots were made of each species. These plots also allowed outlying data points to be assessed and excluded. Data points were excluded for three species (number of records): *Technomyrmex albipes* (1); *Ochetellus glaber* (2); and *Paratrechina* spp. (2). These records are excluded because it is not certain if the species is permanently established in those locations, or if the records represent errors in the distribution database.

Two distribution models were created (Figure 1). The first model creates a box around all the records and generates the lowest and highest values of MAT and MAR (Figure 1A). It is possible that the box is not completely filled with distribution records (graph points). These unfilled spaces represent climates likely to be suitable for the survival of the species, but the species has not yet spread there. This model therefore represents climates of potential distribution.

The second model is more restrictive and represents *climates* that already have, and are most similar to, confirmed records of the presence of the species (Figure 1B, and red coloured areas on species maps). Note – this does not mean a species is present in all red areas. The model builds a series of small boxes, determined by a 1°C range in MAT, around certain climate points.

The resulting models were then projected onto a GIS map of 1) New Zealand, and 2) the Tasman region, showing the current and potential geographic distribution of each species. Maps of New Zealand are not presented in this report but are freely available from the author. The New Zealand Topographical map series (NZMS 260) is used to describe the extent of distribution.

4. Results

4.1 Risk Assessment Scorecard

Results of the scorecard are shown in Table 3, with *Technomyrmex albipes* (White-footed house ant) and *Linepithema humile* (Argentine ant) the top two species.

Technomyrmex albipes out scores *L. humile* in two important categories: establishment success in natural environments, and difficulty in containment. Reproductive males and female *T. albipes* have the ability to disperse by flight and are thus able to spread more easily than *L. humile* which have no flight capacity. *Technomyrmex albipes* are also found in forested habitats so have a broader range of ecosystems they can invade compared with Argentine ants, which appear to favour more open canopy ecosystems.

Species ranked third to eighth are relatively widespread, frequently collected, and can occur in very large numbers. One exception to this is *Pheidole megacephala* (the big-headed ant). In New Zealand it is only known from Auckland and is rarely collected. However, it is ranked high because of its known impacts overseas (Holway et al. 2002). This species is an invasive species around the globe and can have severe impacts in horticulture and natural ecosystems.

The remaining species are species of which no negative impacts have been reported. They are generally either regionally restricted species, or are widespread but not collected in large numbers.

One species that is ranked very low but is widespread and very frequently collected is *Tetramorium grassi*. This species occurs in low numbers and its pest status to humans or impact on the natural environment are regarded as negligible.

4.2 Species Distribution Modelling

There is no cut-off to determine what is high or low risk species using this type of scorecard. However, the top eight species were chosen for distribution modelling because they are widespread and abundant in many regions in New Zealand, and are assessed by the author to be the most likely of any current exotic ant species to negatively affect the natural environment and economic sectors.

The species chosen for distribution modelling are (in order of risk ranking): *Technomyrmex albipes*, *Linepithema humile*, *Doleromyrma darwiniana*, *Pheidole megacephala*, *Ochetellus glaber*, *Pheidole rugosula*, *Paratrechina* spp., and *Iridomyrmex* sp (Table 3).

A summary of MAT and MAR are shown in Table 4, and corresponds to the data used in model one (representing potentially suitable areas, coloured yellow in the species maps). Most species have a lower MAT of between 10 and 12 °C, with *Technomyrmex albipes* having the lowest MAT of 8.3 °C, and *Pheidole megacephala* the highest with 14.7 °C. There is a wide range for MAR across species (Table 4), although the known distribution of *Technomyrmex albipes* encompasses this entire range of 500–2244 mm.

The results of the distribution modelling are shown in Figures 2–9, presented in order of largest potential distribution to the smallest: *Technomyrmex albipes* (Figure 2), *Doleromyrma* *darwiniana* (Figure 3), *Ochetellus glaber* (Figure 4), *Iridomyrmex* sp. (Figure 5), *Paratrechina* spp. (Figure 6), *Linepithema humile* (Figure 7), *Pheidole rugosula* (Figure 8) and *Pheidole megacephala* (Figure 9).

Technomyrmex albipes is the species with the largest potential distribution in the Tasman region. It is predicted to occur in all areas except the Cobb region (NZMS 260: M25). This species has been found previously in the Tasman region from several urban locations in Nelson and Stoke, from Takaka, Ngaio Bay, in *Nothofagus* forest at Spooners Range, and at the foot of Black Hill by St Arnaud.

Four species – *Ochetellus glaber*, *Iridomyrmex* sp., *Paratrechina* spp., and *Doleromyrma darwiniana* – have a similar potential distribution. Areas predicted to be suitable for these species include: Farewell Spit, coastal Takaka and Motueka, Moutere, Nelson city surrounds, and also the inland areas of Golden Downs and Murchison. Another species, *Pheidole rugosula*, has a similar, but slightly less potential distribution than the above four species.

The Argentine ant, *Linepithema humile*, is predicted to have a relatively restricted distribution in the Tasman region – Farewell Spit, coastal Takaka and Motueka, Moutere and Nelson city surrounds. Inland areas appear too cold. Therefore, even though the Argentine ant was the second highest ranked species from the scorecard, distribution modelling suggests it will have a more localised distribution than other species in the Tasman region.

The Tasman region is predicted to be unsuitable for *Pheidole megacephala*, a highly invasive tropical species with demonstrated ecological impacts. It is likely the Tasman region is outside the climatic conditions it requires to become very abundant and a pest. The Northland region is more at risk than other regions in New Zealand from *Pheidole megacephala*.

Areas most at risk from exotic ant species in the Tasman region are (see Figure 10): coastal areas of Tasman Bay and Golden Bay, the Nelson city area, the Moutere and Golden Downs areas, and Murchison. A number of low-lying river valleys are also potentially suitable (e.g. Motupiko, Motueka, Wai-iti, Takaka), but the tops of these valleys are unsuitable.

5. Conclusions & Recommendations

The species of greatest threat to the Tasman region is *Technomyrmex albipes*, which was ranked top for the risk assessment scored, and is also predicted to have the largest potential distribution. Despite this species being a significant residential pest, little is known about its role in natural ecosystems.

The Argentine ant, *Linepithema humile*, can be a significant pest, and has already become so in the Tasman region. However, distribution modelling suggests its impacts could be relatively localised around the Tasman Bay area.

Several other species, *Doleromyrma darwiniana*, *Ochetellus glaber*, *Paratrechina* spp. and *Iridomyrmex* sp., also have the potential to become relatively widespread in the Tasman region. However, the impacts of these species in natural ecosystems are unknown.

The big-headed ant*, Pheidole megacephala*, is not predicted to be a threat in the Tasman region because of climatic limitations.

Areas in the Tasman reagion most at risk from exotic ant species are the coastal areas of Tasman Bay and Golden Bay, the Nelson city area, the Moutere and Golden Downs areas, and Murchison. A number of low-lying river valleys are also potentially suitable (e.g. Motupiko, Motueka, Wai-iti, Takaka) for many species. Essentially these are the warmer parts of the Tasman region, with higher elevations less suitable for these exotic ant species because of cooler conditions.

This risk assessment incorporated several aspects of 'pest status towards humans', and included the horticultural industry – an important economic sector in the Tasman region. It is possible that invasive ant species may represent a significant threat to New Zealand horticulture (Stanley 2006). Invasive ants could affect pollination or seed dispersal of crops. They may also cause significant increases in sap-sucking insects (e.g. aphids, scale insects), which may in-turn cause more damage directly to plants but also act as vectors for plant diseases (Stanley 2006). A number of invasive ant species have previously been found on many horticultural crops in northern New Zealand (Lester et al. 2003). Although this was not a specific assessment for the horticultural industry, the rankings of risk species (Table 3) include those ant species which are most likely to impact on the horticultural industry.

5.1 Priorities for the Tasman region

The Tasman-Nelson Regional Pest Management Strategy currently has two exotic ant species (*Linepithema humile* and *Doleromyrma darwiniana*) listed as containment pests. However, the results of this report suggest other species also warrant consideration as containment pests, particularly, *Technomyrmex albipes*, but also *Ochetellus glaber*, *Iridomyrmex* sp., and *Paratrechina* spp. The known locality records of these exotic ant species suggest they are very limited in their distribution in the Tasman region. Therefore, they could be excellent candidates for containment pests. *Technomyrmex albipes*, in particular, should be considered: it was ranked the highest on the risk scorecard and potentially has the greatest extent in the region. It can become a considerable nuisance in buildings and urban areas; however, its impacts on native ecosystems are unknown. Understanding more about the impacts and control of this species should be given some priority.

It is not difficult to survey for a wide variety of exotic ant species at once, as all ants could be included as part of any ant surveillance programme. However, some exotic ant species would be more difficult to contain because they all have flying reproductive castes and can self-disperse considerable distances. Essentially, this means there would be a higher cost for their surveillance because a wider area would need to be surveyed. This is particularly so for *Technomyrmex albipes*, which has a very large potential distribution. A decision therefore needs to be made on the costs and benefits of including other exotic ant species as containment pests. Further information on their biology, and in particular their impact on native ecosystems, would assist decision making.

However, the first priority for the Tasman region should be the development of a targeted surveillance program for *Linepithema humile* and *Doleromyrma darwiniana*. Due to their limited self-dispersal (of only a few hundred metres per year), *Linepithema humile* and *Doleromyrma darwiniana* are spread primarily by humans (Ward et al. 2005). Thus, surveillance can be specifically targeted in areas closely associated with human activity and settlement, making early detection of new populations more likely (Ward 2006). With early detection it is possible to contain, and even eradicate, these two species from small areas. Understanding how these two species are spread by human activity and the sites where this will most likely occur, is a key aspect to their control that needs further research.

Control programmes for these two species have technical and logistical problems, and are based on a strategy of 'putting out spot-fires'. However, these small-scale efforts (spot-fires) are the only way of preventing a larger problem in the Tasman region in the future. If small populations are not eradicated they will grow and provide the propagules for new populations at an ever increasing rate. For the Tasman region, surveillance and early detection of new populations of *Linepithema humile* and *Doleromyrma darwiniana*, coupled with their control and eradication is therefore a first priority.

6. Acknowledgements

Many thanks to Lindsay Vaughan (Tasman District Council) and Margaret Stanley (Landcare Research) for initiating and supporting this project. Many thanks to Anne Sutherland (Landcare Research) for production of the GIS maps and underlying climate layers, and to Richard Toft for comments on an earlier draft.

7. References

Anderson RP, Lew D, Peterson AT 2003. Evaluating predictive models of species' distributions: criteria for selecting optimal models. Ecological Modelling 162: 211–232.

Anon 2006. Threat abatement plan to reduce the impacts of tramp ants on biodiversity in Australia and it territories. Canberra, Australia, Department of the Environment and Heritage.

Harris RJ 2002. Potential impact of the Argentine ant (*Linepithema humile*) in New Zealand. Wellington, Department of Conservation.

Harris R, Ward D, Sutherland MA 2002. A survey of the current distribution of Argentine ants, *Linepithema humile*, in native habitats in New Zealand, and assessment of future risk of establishment. Unpublished Landcare Research Contract Report: LC0102/105 to Ministry of Agriculture and Forestry, Biosecurity Authority.

Harris RJ, Abbott K, Barton K, Berry J, Don W, Gunawardana D, Lester P, Rees J, Stanley M, Sutherland A, Toft R 2005. Invasive ant pest risk assessment project for Biosecurity New Zealand. Series of unpublished Landcare Research contract reports to Biosecurity New Zealand. BAH/35/2004-1.

Hartley S, Lester PJ 2003. Temperature-dependent development of the Argentine ant, *Linepithema humile* (Mayr) (Hymenoptera: Formicidae): a degree-day model with implications for range limits in New Zealand. New Zealand Entomologist 26: 91–100.

Hölldobler B, Wilson EO 1990. The ants. Cambridge MASS, Harvard Univ. Press.

Holway DA, Lach L, Suarez AV, Tsutsui ND, Case TJ 2002. The causes and consequences of ant invasions. Annual Review Ecology and Systematics 33: 181–233.

Holway DA, Suarez AV 2006. Homogenization of ant communities in Mediterranean California: the effects of urbanization and invasion. Biological Conservation 127: 319–326.

Kaspari M, Alonso A, O'Donnell S 2000. Three energy variables predict ant abundance at a geographical scale. Proceedings of the Royal Society of London B 267: 485–489.

Keall JB. 1980. Some ants recently intercepted entering New Zealand (Hymenoptera: Formicidae). New Zealand Entomologist 7: 119–122.

Korzukhin MD, Porter SD, Thompson LC, Wiley S. 2001. Modelling temperature-dependent range limits for the fire ant *Solenopsis invicta* (Hymenoptera: Formicidae) in the United States. Environmental Entomology 30: 645–655.

Landcare Research. 2006. Online Ant Distribution Database. Accessed 20 September 2006. http://www.landcareresearch.co.nz/research/biocons/invertebrates/ants/distribution/

Lester PJ 2005. Determinants for the successful establishment of exotic ants in New Zealand. Diversity & Distributions 11: 279–288.

Lester PJ, Baring CW, Longson CG & Hartley S 2003. Argentine and other ants (Hymenoptera: Formicidae) in New Zealand horticultural ecosystems: distribution, hemipteran hosts, and review. New Zealand Entomologist 26: 79-90.

McGlynn TP 1999. The worldwide transfer of ants: geographical distribution and ecological invasions. Journal of Biogeography 26: 535–548.

Stanley MC 2006. Ants in your orchard? Treecropper 48: 13-15.

Suarez AV, Holway DA, Ward PS 2005. The role of opportunity in the unintentional introduction of non-native species. Proceedings of the National Academy of Sciences 102: 17032–17035.

Ward DF 2005. Changes to the classification of ants (Hymenoptera: Formicidae). The Weta 30: 16–18.

Ward DF 2006. Prioritised surveillance strategy for invasive ant species in Northland. Landcare Research Report 0607/044 to Northland Regional Council.

Ward DF 2007. Modelling the potential geographic distribution of invasive ant species in New Zealand. Biological Invasions. In Press.

Ward DF, Beggs JR, Clout MN, Harris RJ, O'Connor S 2006. The diversity and origin of exotic ants arriving to New Zealand via human-mediated dispersal. Diversity and Distributions 12: 601–609.

Ward DF, Harris RJ 2005. Invasibility of native habitats by Argentine ants, *Linepithema humile*, in New Zealand. New Zealand Journal of Ecology 29: 215–219.

Ward DF, Harris RJ, Stanley MC 2005. Human-mediated range expansion of Argentine ants *Linepithema humile* (Hymenoptera: Formicidae) in New Zealand. Sociobiology 45: 401–407.

Williams PA, Wilton A, Spencer N 2002. A proposed conservation weed risk assessment system for the New Zealand border. Science for Conservation 208. Wellington, Department of Conservation.

Table 1. A risk assessment scorecard used by Harris et al. (2005) to evaluate pre-border risk posed by exotic ant species to New Zealand.

Category (Characters)	**Scoring**			**Justification for inclusion**
	0	**0.5**	**1**	
Biological traits inferring invasiveness				
Recruits in large numbers to food and monopolises it	No	?	Yes	Likely to displace competitors and be ecologically dominant and/or be significant pest in an urban setting
Reproductive queens	Monogyne	?	Polygyne	Multiple queened colonies often have greater potential for rapid increase
Supercolonies known	No	Polydomous	Yes	Allows maintenance of elevated densities and ecological domination of an area
Invasive history				
Established outside native range	0	1–2 times	> 2	Infers some potential for spread (although plenty of historical examples of ants establishing in NZ, particularly from Australia, with no invasive history)
Pathways				
Common association with anthropogenic environments	No	?/some	Yes	Higher likelihood of being transported to NZ through freight movement. Less likelihood of forest species being transported
Future interceptions	Similar	?	Increase	Within the next 50 years there will be more potential pathways to New Zealand increasing the risk of establishment
In Australia	No		Yes	Historical origin of many of our introduced species, so elevated risk if species present there
In the Pacific	No (or unknown)		Yes	Container review showed this is a region with high levels of contamination of containers
In southern hemisphere	No		Yes	Greater likelihood that the seasons match and reproductive queens arrive at suitable times for nest establishment.

Table 1 continued.

Intercepted at NZ border	No	Occasional (at least once)	Frequently (> 5)	If there is no recent history of interception of a species there is a lower risk it will establish here (assuming static trade partners)
Have nests or queens been intercepted	No	?	Yes	Workers are frequently intercepted but a colony and/or fertile queen needed to establish
Established at sites with direct trade pathways	No	?	Yes	If this species is present at localities where there are significant trade links to NZ, the probability of establishment here is greater
Commodity compatibility	No	?	Yes	Are trade goods from regions with this species likely to transport queens – this is less likely for forest species
Establishment success				
Climate match (forest)	Low	Limited	High	Does information available on the taxon suggest forest is a suitable habitat risk and climate is likely to be suitable
Climate match (inside buildings)	Low	Limited	High	Is there a history of association with buildings in temperate areas
Climate match (open non-urban)	Low	Limited	High	Does information available on taxon suggest non-forest habitat outside urban areas is suitable habitat and the climate likely to be suitable
Climate match (urban outdoors)	Low	Limited	High	Does information available on taxon suggest urban habitat outside heated buildings is suitable and climate likely to be suitable
Incursions previously (colonies detected post border clearance)	No	1	>1	Demonstrated history of being able to survive and establish a nest (at least temporarily) in NZ
Incursions previously produced sexual stages	No		Yes	Demonstrates greater likelihood of establishment

Table 1 continued.

Difficulty in containment of inclusion				
Small size/cryptic nature	No	Probably	Yes	Feature of the species that would make incursion difficult to detect and eradicate
Flighted dispersals	No	Probably/some	Yes	If flighted dispersals, containment of an inclusion will be more difficult
Likely pest status to humans in NZ				
Bites and spreads formic acid	No	Unknown	Yes	Potential for heath consequences of incursion
Stings	No	Stings but not severe	Yes	Has potential to sting and this is commonly reported and has potential health implications
Damages structures	No	?/some	Yes	Attracted to electrical fields (financial and potential health risks – fires been caused) or damages wood (financial implications)
Workers enter buildings	No (rare)	?/occasional	Yes	Likely to result in greater expenditure on pest control and/or contamination of products in manufacturing
Hygiene pest (disease spreading)	Not reported	Limited	Yes	Evidence of the species being a significant contaminant in hospitals and commercial premises and associated with spreading of disease and/or direct impacts on patients
Garden nuisance	No	Possibly	Yes	Likely to reach significant densities in this environment to impact on enjoyment of outdoors and prompt control measures, or if a large ant or a species with a painful sting, its presence in even low numbers may be an actual or perceived threat
Horticultural/ agricultural pest	No	Unknown/possibly	Yes	Likely to impact on horticultural/agricultural production through impact of stock or farm scale affecting plant growth or crop value, or stinging of staff

Table 1 continued.

Impact on native environment				
Competitive advantage over other ants	Unlikely	Some species	Most species	Impact on native ants known in literature – often reflects impacts on other invertebrates as well as ants where such studies have been conducted
Detrimental impacts on vertebrates	Unlikely	Possibly	Yes	Is there any literature suggesting they may impact on vertebrates through foraging traits, nesting behaviours or defence mechanisms
Detrimental impacts on native invertebrates (other than other ants)	Unlikely	Likely	Severe	Given likely climate match and habitat, is this species likely to have significant and potentially quantifiable impacts on native species (it is likely most new species cause some change)
Harms indigenous flora or disrupts through seed feeding or scale farming	No	Possible	Yes	Seed-feeding ants absent from native ant fauna, and species that farm exotic scales shown to have impacts on plant growth and disease transmission

Table 2. The risk assessment scorecard used to evaluate the risk posed by currently established exotic ant species to New Zealand (modified from Harris et al. 2005, Table 1).

Category (Characters)	Scoring			Justification for inclusion
	0	0.5	1	
Biological traits inferring invasiveness				
Recruits in large numbers to food and monopolises it	No	?	Yes	Likely to displace competitors and be ecologically dominant and/or be significant pest in an urban setting
Reproductive queens	Monogyne	?	Polygyne	Multiple queened colonies often have greater potential for rapid increase
Supercolonies known	No	Polydomous	Yes	Allows maintenance of elevated densities and ecological domination of an area
Invasive history				
Established outside native range (excluding New Zealand)	0	1–2 times	> 2	May infer some potential for invasiveness
Pathways				
Association with anthropogenic environments	No	?/some	Yes	Higher likelihood of being transported
In Australia	No		Yes	Historical origin of many established species in NZ
In the Pacific (but not Australia)	No (or unknown)		Yes	MAF container review showed this is a high risk pathway
In southern hemisphere (but not Australia or the Pacific)	No (or unknown)		Yes	Greater likelihood that seasons match and reproductive queens arrive at suitable times for nest establishment
Intercepted at NZ border	No	Occasional (at least once)	Frequently (> 5)	If there is no recent history of interception of a species then there is a lower risk that it will establish here (assuming static trade partners)
Establishment success				
Habitat match (forest)	Low	Limited	High	Forest is a suitable habitat
Habitat match (open non-urban)	Low	Limited	High	Non-forest habitat outside urban areas is suitable

Table 2 continued.

Habitat match (urban outdoors)	Low	Limited	High	Urban habitat outside heated buildings is suitable
Habitat match (inside buildings)	Low	Limited	High	Association with buildings
Difficulty in containment of inclusion				
Small size/cryptic nature	No	Probably	Yes	Small size decreases detection and eradication
Flighted dispersals	No	Probably/some	Yes	If flighted dispersals, containment of an inclusion will be more difficult
Likely pest status to humans in NZ				
Hygiene pest (disease spreading)	Not reported	Limited	Yes	Potential for heath consequences
Bites and spreads formic acid	No	Unknown	Yes	Potential for heath consequences
Stings	No	Stings-not severe	Yes	Potential for heath consequences
Damages structures	No	?/some	Yes	Financial and potential health risks
Workers enter buildings	No (rare)	?/occasional	Yes	Greater expenditure on pest control
Outdoor nuisance	No	Possibly	Yes	Impacts on outdoor enjoyment
Horticultural/agricultural pest	No	Unknown/possibly	Yes	Impact on horticultural/agricultural
Impact on native environment				
Competitive advantage over other ants	Unlikely	Some species	Yes	Impact on native ants
Detrimental impacts on native invertebrates (other than other ants)	Unlikely	Likely	Severe	Impacts on native invertebrates
Detrimental impacts on vertebrates	Unlikely	Possibly	Yes	Impact on vertebrates
Harms indigenous flora or disrupts through seed feeding or scale farming	No	Possible	Yes	Seed-feeding ants absent from native ant fauna, and species that farm exotic scales shown to have impacts on plant growth and disease transmission

Table 3. Results of the risk assessment scoring using a weighting percentage to rank exotic ant species. Species are ranked from highest to lowest risk. Species in grey are used in distribution modelling. Scores are rounded to 1 dp.

Risk Assessment Category	**Biological traits**	**Invasive history**	**Pathways**	**Difficulty in Containment**	**Establishment success-URBAN**	**Establishment success-NATURAL**	**Pest status - humans**	**Impact on native environment**	**Total Score**	**Total Ranking**
Weighting (%)	**5**	**5**	**5**	**10**	**5**	**20**	**25**	**25**		**100**
Technomyrmex albipes	0.8	1.0	1.0	0.5	1.0	0.8	0.6	0.5	6.2	67.7
Linepithema humile	1.0	1.0	0.8	0.0	1.0	0.5	0.6	0.9	5.8	66.9
Doleromyrma darwiniana	0.7	0.0	0.5	0.5	1.0	0.8	0.6	0.5	4.6	60.4
Pheidole megacephala	1.0	1.0	1.0	0.0	0.8	0.0	0.6	0.9	5.2	55.0
Ochetellus glaber	0.7	1.0	0.8	0.5	1.0	0.5	0.4	0.4	5.2	50.6
Pheidole rugosula	0.7	0.0	0.5	0.8	0.8	0.5	0.2	0.6	4.0	48.1
Paratrechina spp.	0.5	0.0	0.5	0.5	0.8	0.5	0.4	0.5	3.7	47.0
Iridomyrmex sp.	0.7	0.0	0.5	0.3	0.5	0.5	0.4	0.6	3.4	45.4
Pheidole vigilans	0.7	0.0	0.4	0.8	0.5	0.5	0.1	0.5	3.5	41.4
Pheidole proxima	0.3	0.0	0.4	0.8	0.5	0.5	0.1	0.5	3.1	39.7
Hypoponera eduardi	0.0	1.0	0.3	1.0	0.5	1.0	0.0	0.0	3.8	39.0
Monomorium fieldi	0.3	0.5	0.5	0.8	0.8	0.5	0.1	0.1	3.6	34.6
Monomorium pharaonis	1.0	1.0	1.0	0.5	0.5	0.0	0.4	0.1	4.5	34.6
Ponera leae	0.0	0.5	0.5	0.8	0.0	1.0	0.0	0.0	2.8	32.5
Rhytidoponera chalybaea	0.0	0.5	0.5	0.8	0.0	1.0	0.0	0.0	2.8	32.5
Amblyopone australis	0.0	0.0	0.6	0.5	0.5	1.0	0.1	0.0	2.7	32.3
Tetramorium bicarinatum	0.0	1.0	0.8	0.8	0.8	0.3	0.1	0.1	3.8	31.9
Orectognathus antennatus	0.0	0.0	0.2	1.0	0.0	1.0	0.0	0.0	2.2	31.0
Mayriella abstinens	0.3	0.0	0.3	0.8	0.5	0.8	0.0	0.0	2.6	28.2
Hypoponera punctatissima	0.0	1.0	0.6	1.0	0.5	0.0	0.3	0.0	3.4	27.8
Rhytidoponera metallica	0.7	0.0	0.5	0.3	0.5	0.5	0.1	0.1	2.7	27.5
Strumigenys perplexa	0.0	0.0	0.4	0.8	0.5	0.8	0.0	0.0	2.4	27.0
Tetramorium grassii	0.0	0.0	0.6	1.0	0.5	0.5	0.0	0.0	2.6	25.5
Monomorium sydneyense	0.3	0.0	0.4	0.8	0.8	0.3	0.1	0.1	2.7	24.8
Solenopsis sp.	0.3	0.0	0.4	0.8	0.5	0.5	0.0	0.0	2.5	23.7
Cardiocondyla minutior	0.0	0.0	0.4	0.8	0.8	0.3	0.1	0.0	2.2	20.0
Strumigenys xenos	0.0	0.0	0.2	1.0	0.0	0.0	0.0	0.0	1.2	11.0

Table 4. Summary of ranges for mean annual temperature °C (MAT) and mean annual rainfall in mm (MAR). These data used in model one – representing potentially suitable areas (coloured yellow in the following maps of each species).

	Lower MAT °C	**Lower MAR (mm)**	**Upper MAR (mm)**
Doleromyrma darwiniana	10.0	628	1655
Iridomyrmex sp.	11.0	776	2104
Linepithema humile	11.6	659	1803
Ochetellus glaber	11.0	776	2159
Paratrechina spp	10.8	703	1954
Pheidole megacephala	14.7	1188	1430
Pheidole rugosula	12.1	652	1998
Technomyrmex albipes	8.3	500	2244

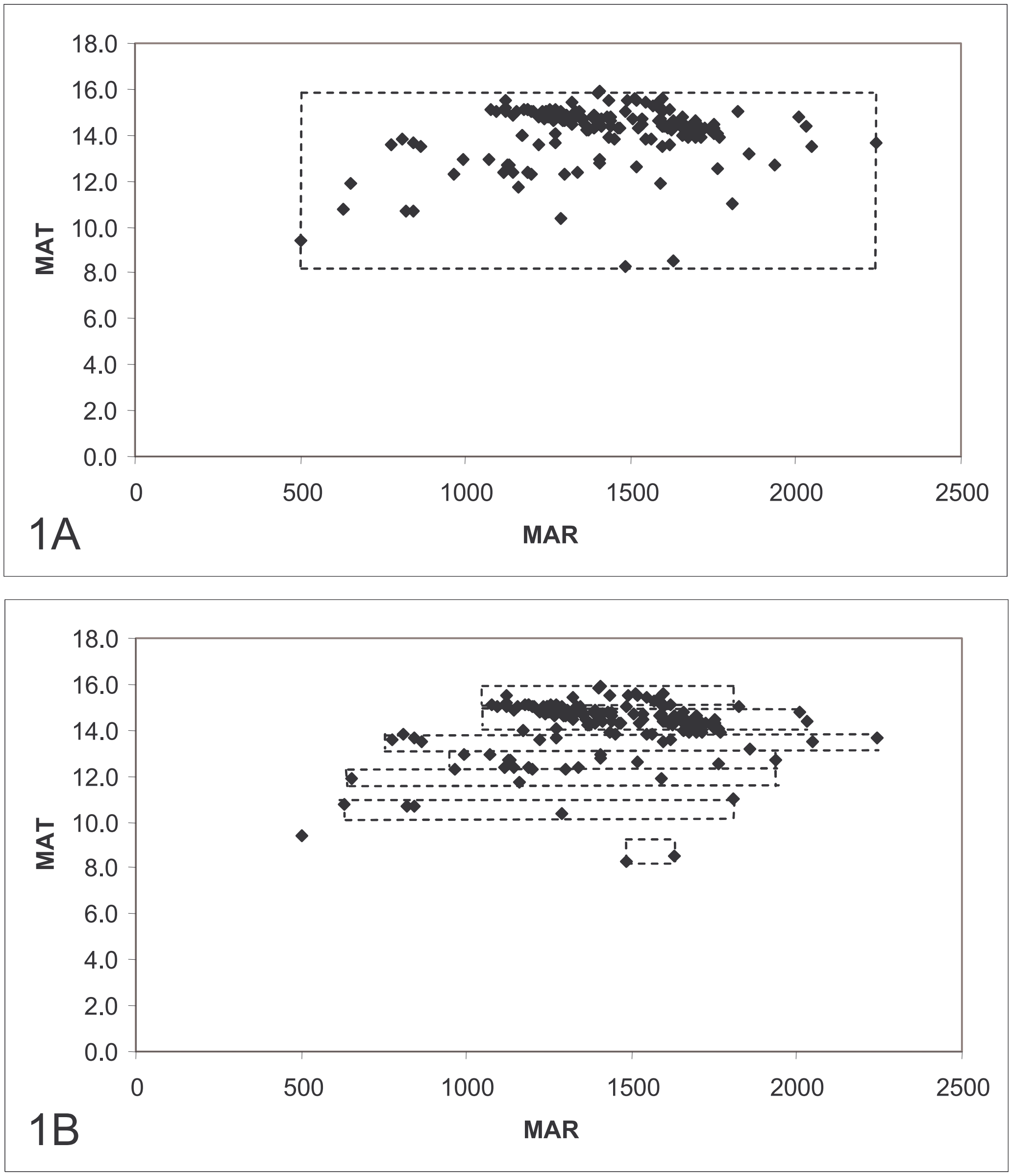

Figure 1. A bivariate plot of mean annual temperature (MAT) and mean annual rainfall (MAR) conceptualising the two model approaches for the A) potential and B) current distribution of a species. Climates(MAT and MAR) within the dashed boxes are modelled.

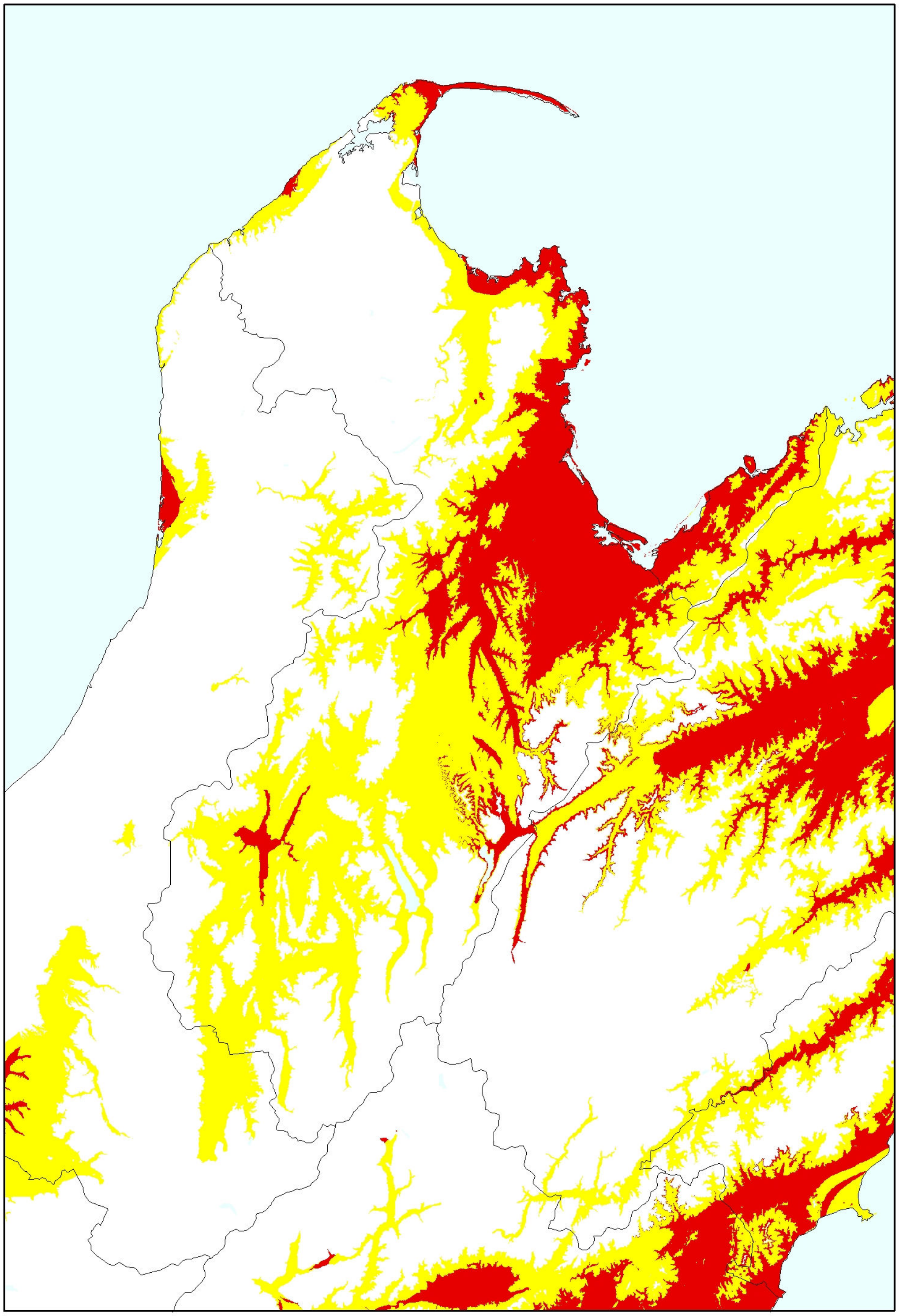

Figure 2. The potential distribution of *Technomyrmex albipes* in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

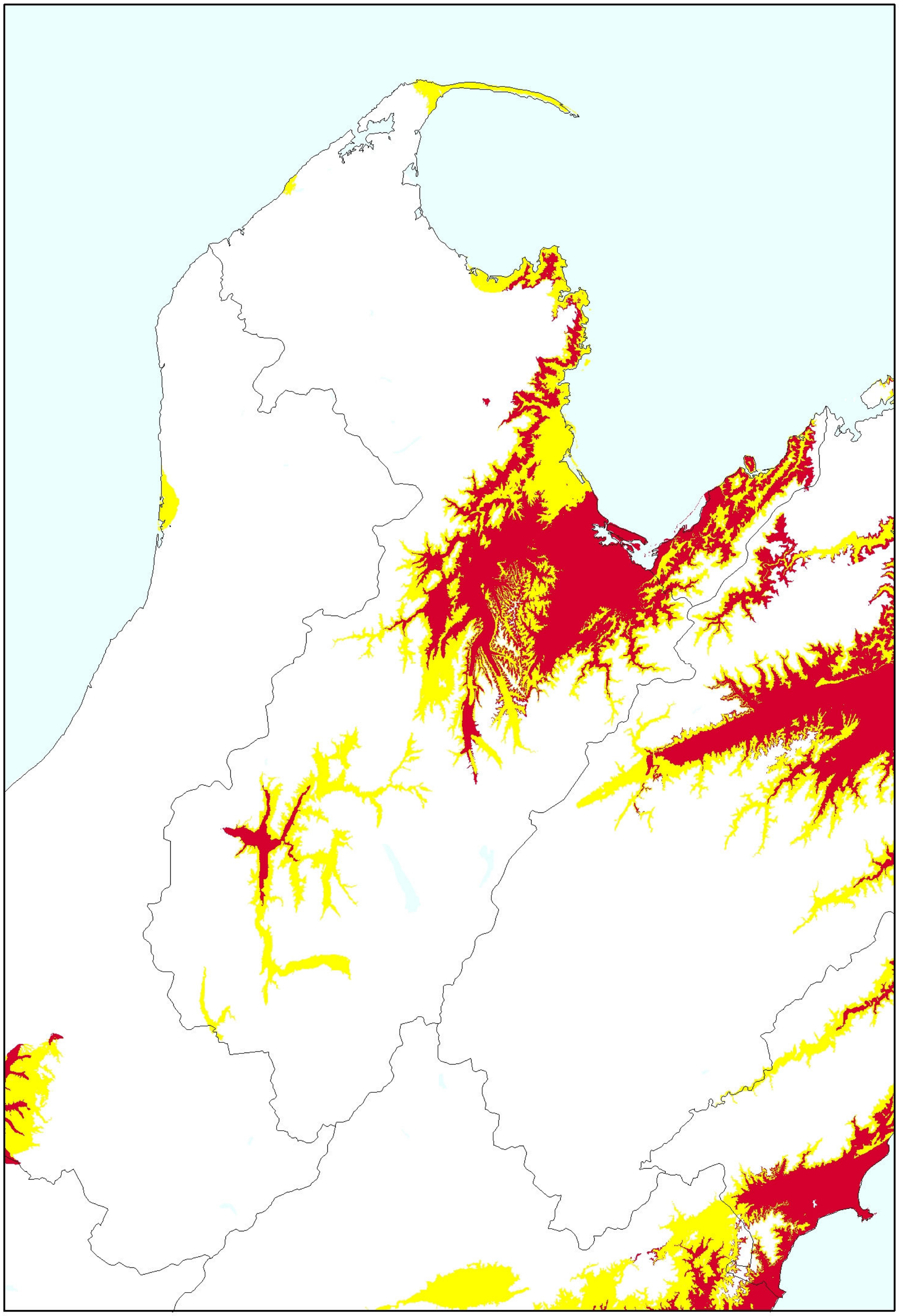

Figure 3. The potential distribution of *Doleromyrma darwiniana* in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

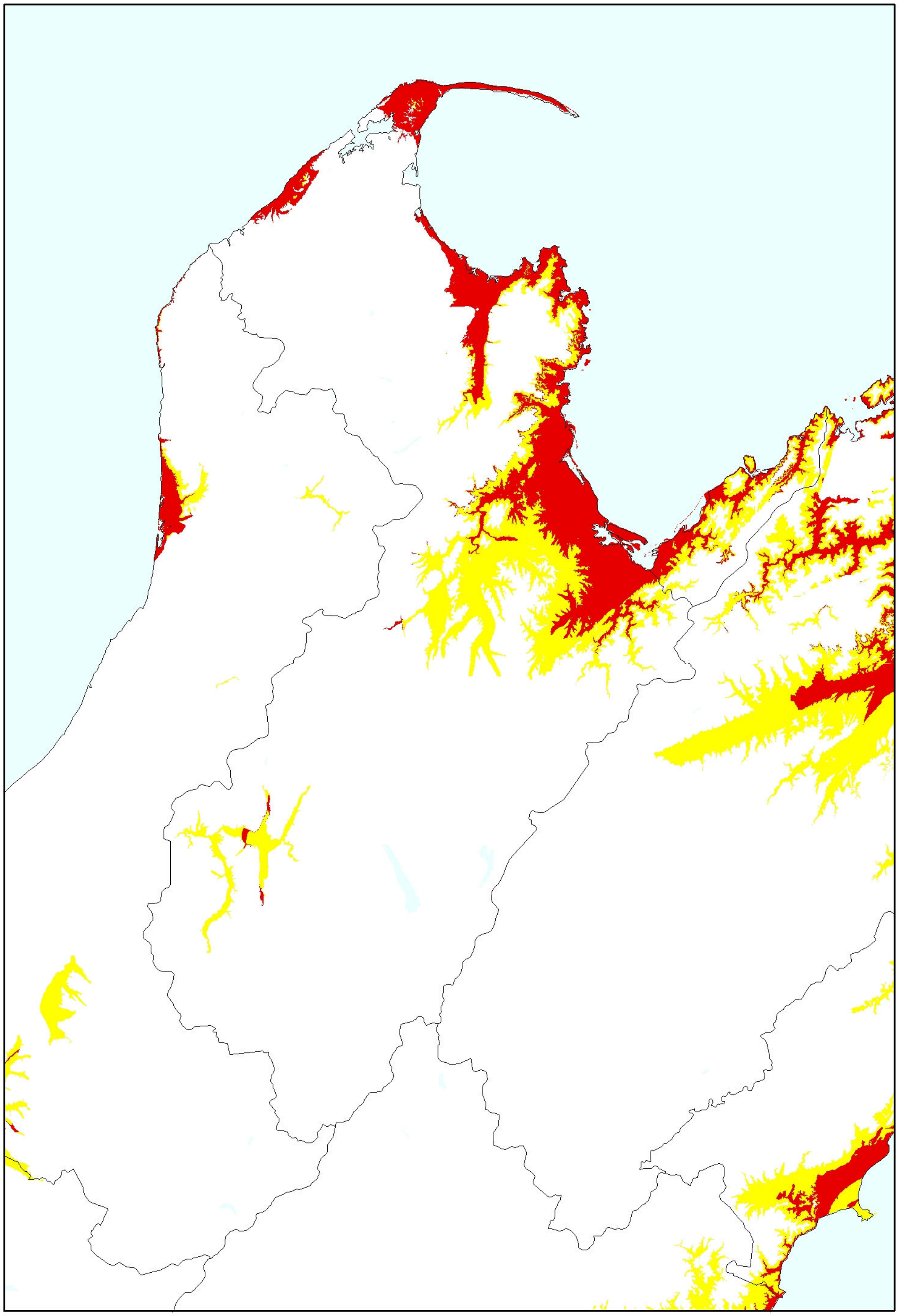

Figure 4. The potential distribution of *Ochetellus glaber* in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

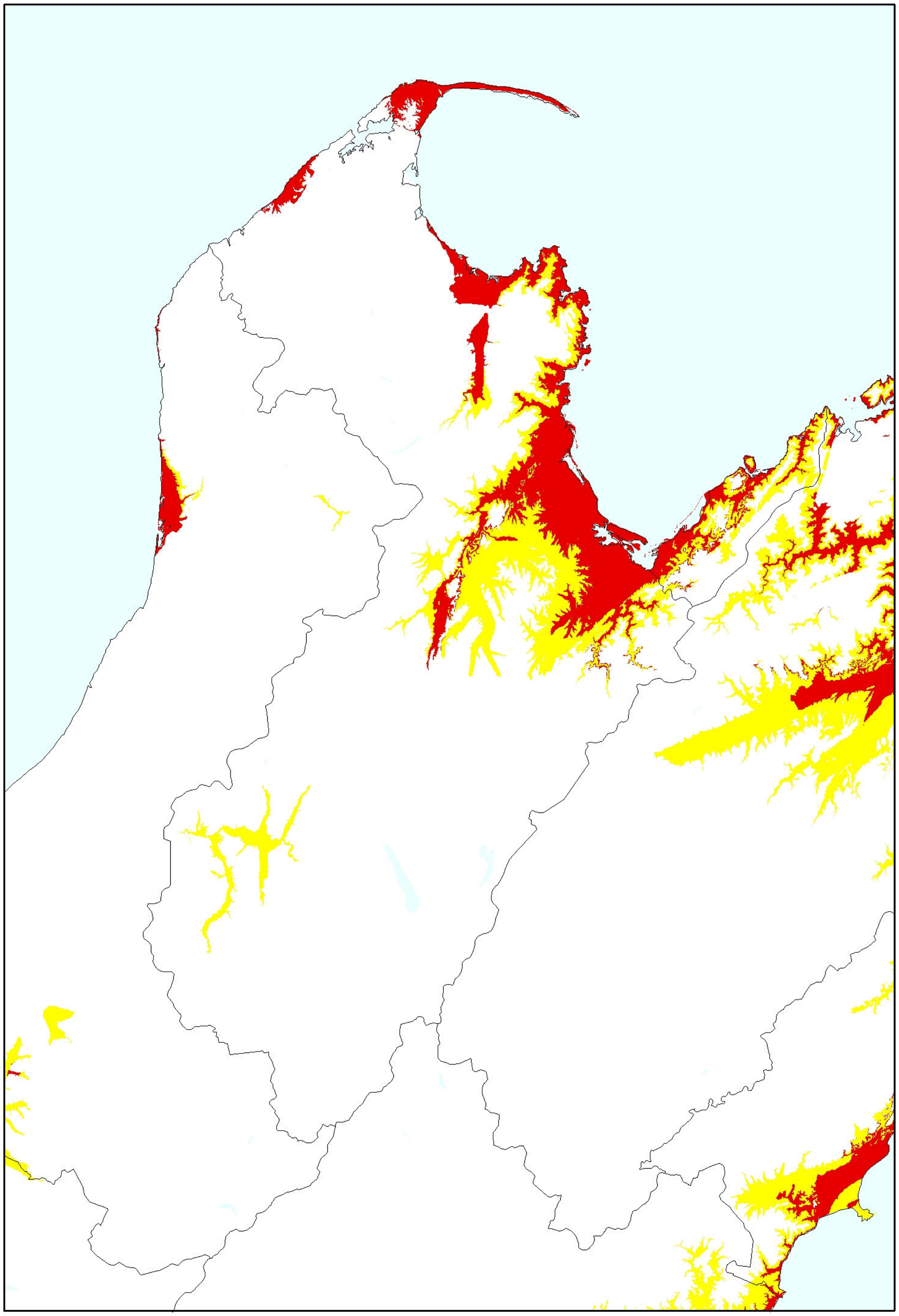

Figure 5. The potential distribution of *Iridomyrmex* sp. in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

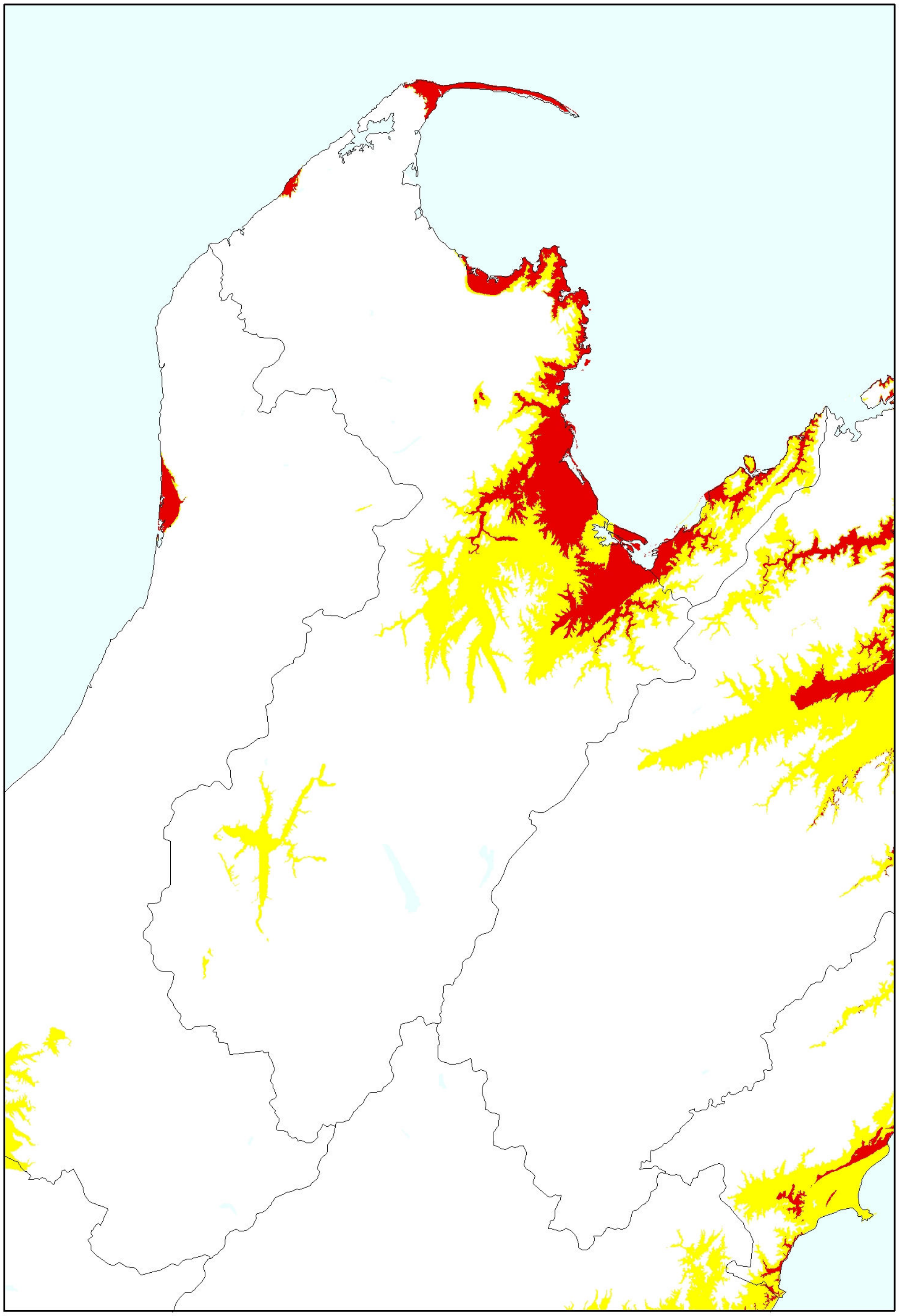

Figure 6. The potential distribution of *Paratrechina* spp. in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

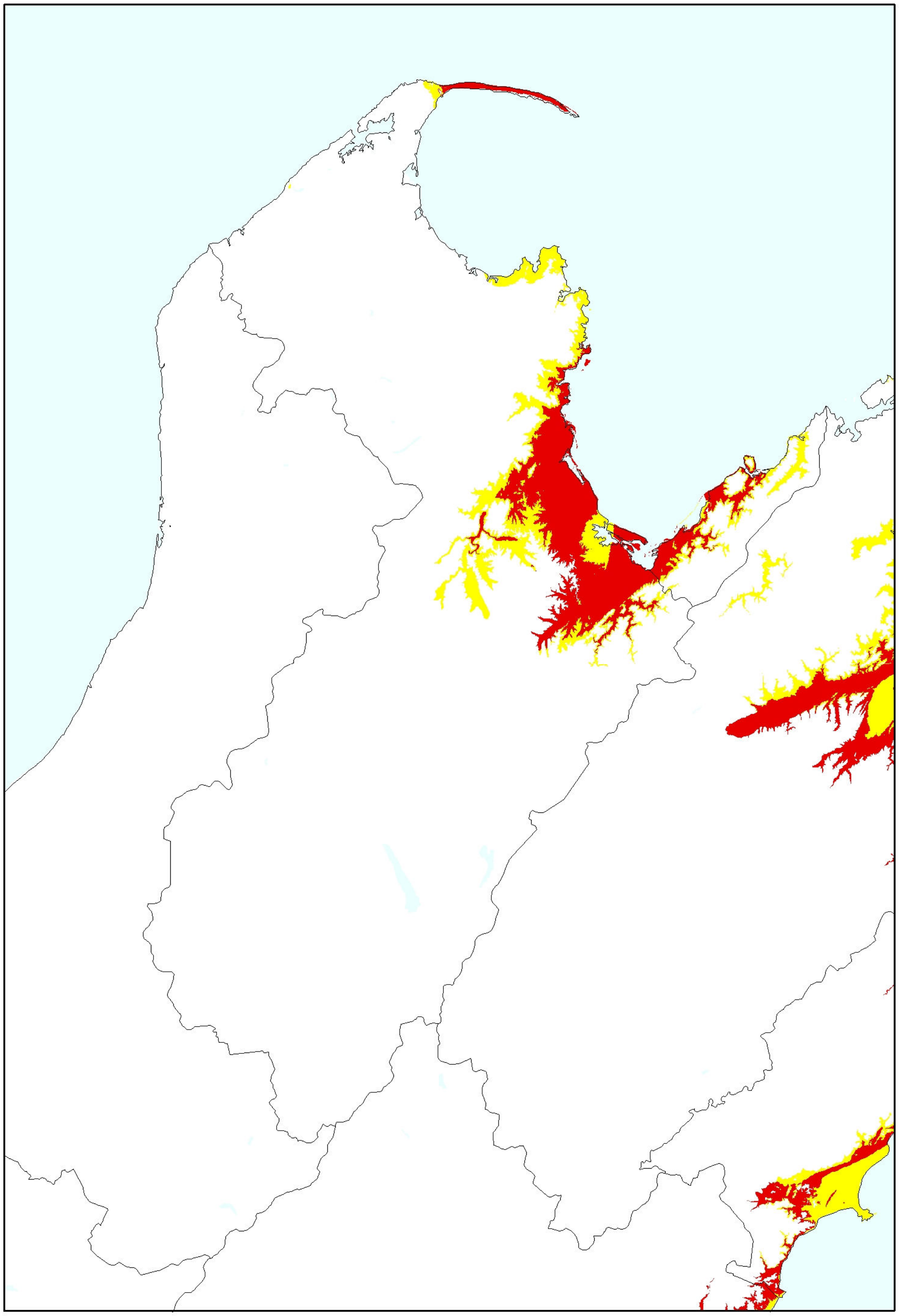

Figure 7. The potential distribution of *Linepithema humile* in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

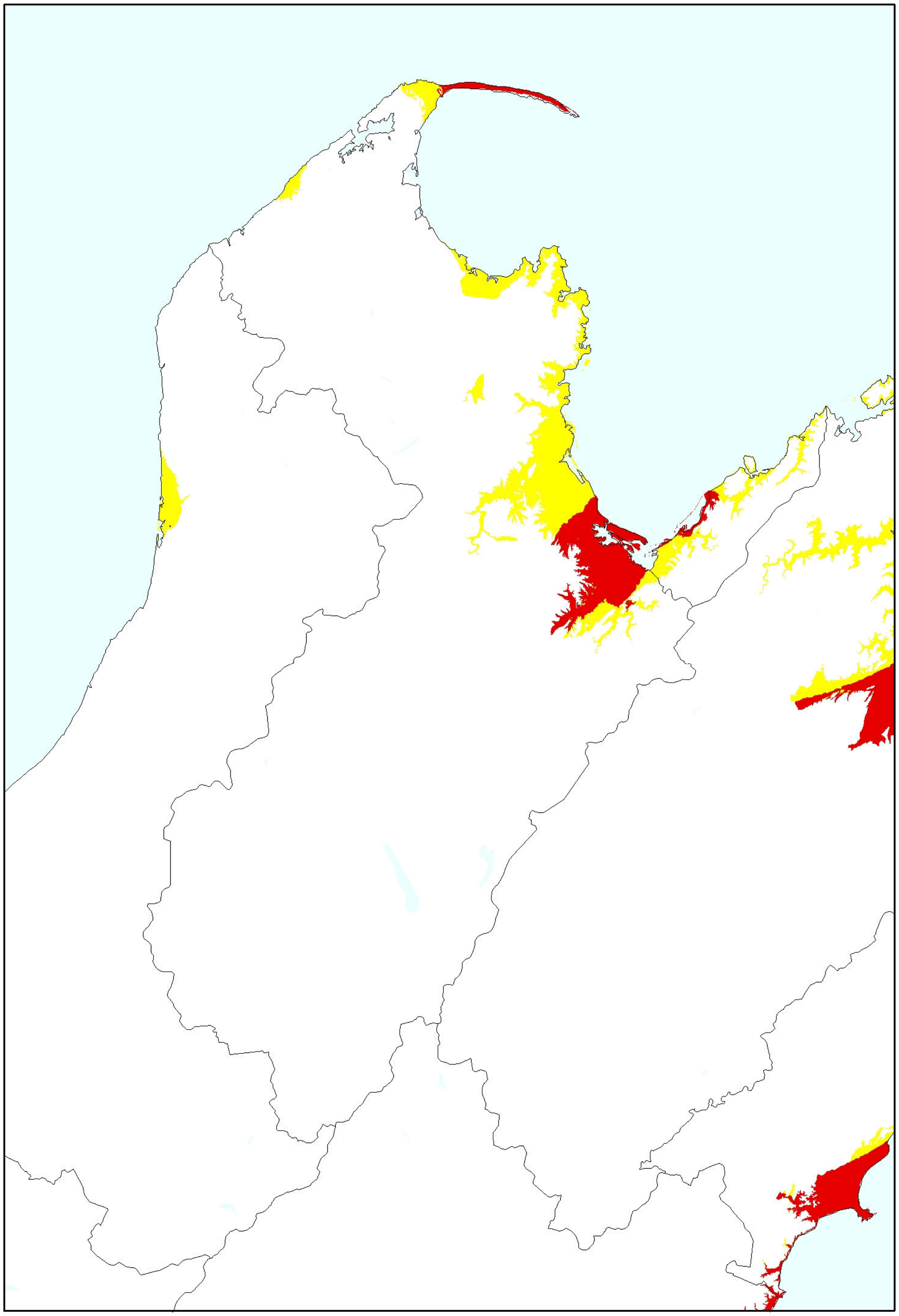

Figure 8. The potential distribution of *Pheidole rugosula* in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

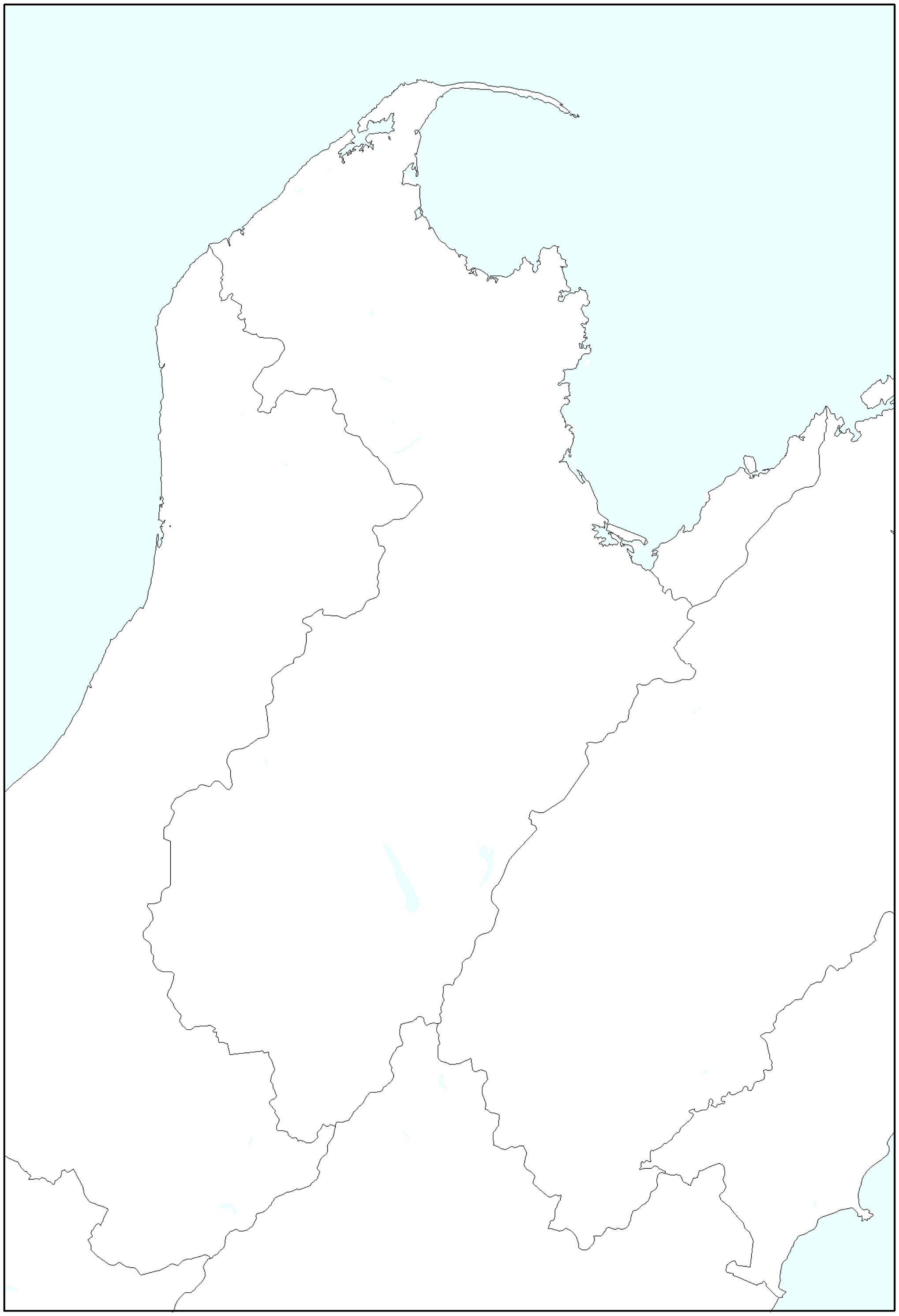

Figure 9. The potential distribution of *Pheidole megacephala* in the Tasman region of New Zealand. Grey boundaries are of Territorial Authorities. Red represents climatic conditions most associated with currently known locality records. Yellow represents potentially suitable areas.

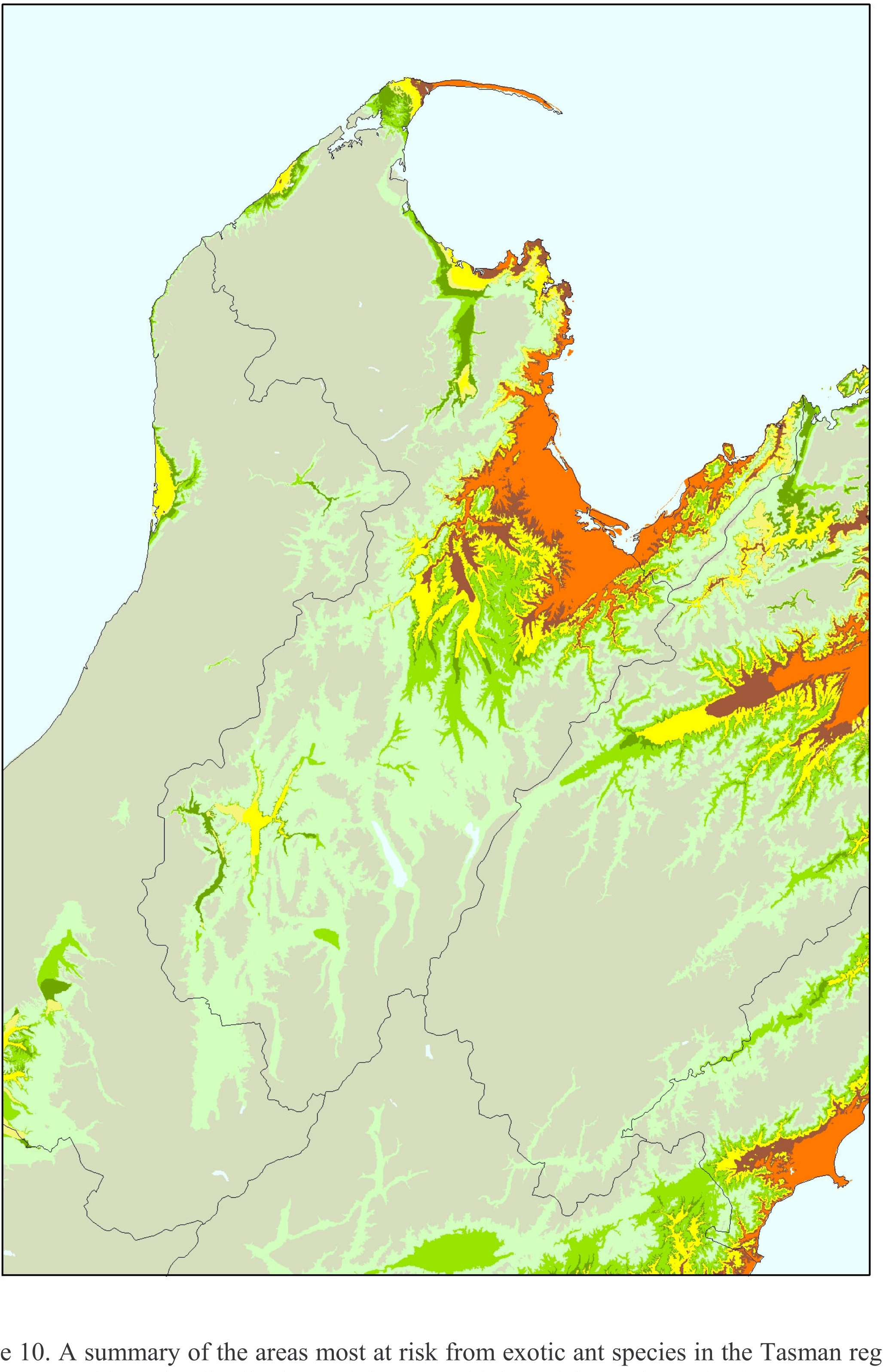

Figure 10. A summary of the areas most at risk from exotic ant species in the Tasman region. This map combines the distributions of the seven highest risk species (*Pheidole megacephala* is excluded, see Figure 9). Areas most at risk: Orange = areas with 7 species; Crimson = 6; Dark yellow = 5; Light yellow = 4; Dark green = 3; Mid green = 2; Light green = 1; Grey = 0.

8. Appendix

Appendix 1. Exotic ant species recorded from the Tasman region (source Landcare Research 2006).

Present (n = 13)	First Record in Tasman (+ NZ)	Absent (n = 15)
Doleromyrma darwiniana	2000 (1959)	*Amblyopone australis*
Hypoponera eduardi	1925 (1895)	*Cardiocondyla minutior*
Iridomyrmex sp.	2001 (1916)	*Hypoponera punctatissima*
Linepithema humile	2001 (1990)	*Mayriella abstinens*
Monomorium fieldi (antipodum)	1999 (~1950s)	*Monomorium pharaonis*
Ochetellus glaber	1962 (1927)	*Monomorium sydneyense*
Paratrechina sp.A	1995 (1941)	*Orectognathus antennatus*
Paratrechina sp.B	1995 (1941)	*Pheidole megacephala*
Pheidole rugosula	2001 (1958)	*Pheidole proxima*
Ponera leae	1997 (1958)	*Pheidole vigilans*
Strumigenys perplexa	2002 (1876)	*Rhytidoponera chalybaea*
Technomyrmex albipes	1952 (1924)	*Rhytidoponera metallica*
Tetramorium grassii	2002 (1941)	*Solenopsis* sp.
		Strumigenys xenos
		Tetramorium bicarinatum