Invasive Ant Risk Assessment

Monomorium destructor

Harris, R.

(A) PEST INFORMATION

Richard Toft , Landcare Research

A1. Classification

Family:	Formicidae
Subfamily:	Myrmicinae
Tribe:	Solenopsidini
Genus:	*Monomorium*
Species:	*destructor*

A2. Common names

Singapore ant (Davis et al. 1993a), Mizo-hime-ari (Japan – www39), Destructive trailing ant (wwwnew44).

A3. Original name

Atta destructor Jerdon

A4. Synonyms or changes in combination or taxonomy

Myrmica basalis Smith, *Myrmica gracillima* Smith, *Myrmica vexator* Smith, *Myrmica atomaria* Gerstaecker, *Myrmica ominosa* Gerstaecker, *Monomorium ominosa* (Gerstaecker), *Monomorium basale* (Smith).

A5. General description (worker)

Identification

Size: a relatively large *Monomorium* species. Total length highly variable, from 1.8 to 3.5 mm.

Colour: body from head to postpetiole uniformly light yellow to dull brownish yellow. Gaster always darker (Fig. 1), dark brown to blackish brown, and usually with a conspicuous yellow area mediobasally.

Surface sculpture: head and body mostly smooth and shining, unsculptured except on very top of head (inconspicuous); dorsal surface of propodeum with transverse rugae; most of lateral surface of alitrunk (except anteriorly) and sections of lateral surfaces of propodeum with fine puncturation.

General description: antennae 12-segmented, including a 3-segmented club; club segments increasing in size toward the apex. Eyes relatively small, with 4-6 ommatidia in longest row. Mandibles each with 3 strong teeth, the fourth (topmost) minute. Paired longitudinal carinae on clypeus obscure. Metanotal groove distinct. Propodeum without spines, posterodorsal border angulate; the area of petiolar insertion carinate. Two nodes (petiole and postpetiole) present. Petiole higher and less broadly rounded than postpetiole and its ventral outline less convex than in other species. Postpetiole 1.1–1.2 times as long as broad. All dorsal surfaces of head and body with erect setae.

Note: *M. destructor* is similar to *M. latinode*, but is distinguished by the presence of 4 teeth on each mandible (versus 5 in *latinode*), the distinct metanotal groove (shallow and indistinct in *latinode*), and the narrower postpetiole (1.5 times as long as broad in *latinode*).

Sources: Japanese Ant Database (www39), Bolton 1987.

Formal description and synonymy: Bolton 1987: 324–325, 1 figure.

MAF BIOSECURITY NEW ZEALAND

Manaaki Whenua Landcare Research

a)

antweb.org, California Academy of Sciences

b)

antweb.org, California Academy of Sciences

c)

antweb.org, California Academy of Sciences

Fig. 1: Images of Monomorium destructor*; a) Lateral view of worker, b) dordal view of worker, c) head of worker (Source: amtweb.org, California Academy of Sciences).*

A6. Behavioural and biological characteristics

A6.1 Feeding and foraging

A slow moving ant that forages along narrow trails (wwwnew44). A generalist with a broad diet of living and dead insects, insect eggs, carbohydrates from tending sap-sucking insects, nectar, and seeds (Bolton 1987; Jaffe et al. 1990; wwwnew44; Deyrup et al. 2000). In households they will feed on almost any food available (Smith 1965). *Monomorium destructor* foragers are slow to find food compared with other tramp ants (Lee 2002). In Sri Lanka, *M. destructor* was recorded primarily foraging in the crown of Coconut trees, but was also seen at the base of trees (Way et al. 1989). They were a minor component of the ant fauna, with *M. floricola*, *Oecophylla smaragdina*, *Crematogaster* sp. and *P. longicornis* the most common ants (Way et al. 1989).

A6.2 Colony characteristics

Monomorium destructor forms large polygyne colonies (Smith 1965). They nest predominantly arboreally in coconut plantations (Way et al. 1989), but can also nest in soil in tropical regions (Smith 1965). In citrus orchards in the Caribbean they were found nesting in trees (in hollow twigs and branches) and on the ground (Jaffe et al. 1990). They nest inside and outside of buildings on Tiwi Island, northern Australia, including in pot plants (B. Hoffmann, pers. comm.). They may have relatively mobile nests. In Darwin, Australia, they have been observed to move around in the wet season (B. Hoffmann, pers. comm.). Within urban areas on Tiwi Island populations can become abundant, with many individuals and nests, giving the appearance of a super-colony (B. Hoffmann, pers. comm.).

A7. Pest significance and description of range of impacts

A7.1 Natural environment

Monomorium destructor may have some effect on other ant species. It was new to Floreana Island in the Galapagos archipelago in 1996–7, and 7 years later was still restricted to the one village site, but its abundance had increased, while other ant species sampled at the site had reduced from 9 to 5 (Von-Aesch & Cherix 2003). No information was found on changes in ant or other invertebrate community composition in the presence and *M. destructor* in any natural environments. *Monomorium destructor* is a relatively minor component of the ant community where it has been reported outside of urban areas (e.g., Way et al. 1989; Jaffe et al. 1990; Way et al. 1998; Ballmer 2003) and any effects on the invertebrate community are likely to be minor.

Monomorium destructor is not mentioned in a recent review of “the causes and consequences of ant invasions” (Holway et al. 2002a), and it appears there are few, if any, environmental consequences of this ant establishing outside its native range.

A7.2 Horticulture

Monomorium destructor is not recorded as a horticultural or agricultural pest in Western Australia (Davis et al. 1993a). However, it does tend sap-sucking insects (Smith 1965), and take seeds (wwwnew43), but no reports have been found of it being abundant in crops, and it does not appear to form close mutualistic associations with sap-sucking insects (Ballmer 2003), as some pests ants do (e.g., Ballmer 2003; Costa et al. 1996; Holway et al. 2002a).

M. destructor has been observed to kill caged rats (Mayor 1922, cited in Wetterer & O’Hara 2002), and where abundant could potentially be a pest to other caged animals.

A7.3 Human impacts

This species is a major urban pest in some locations (e.g., northern Western Australia (Davis et al. 1993a)). Foragers gnaw holes in fabric and rubber goods, remove rubber insulation from electric and phone lines, and damage polyethylene cable (Smith 1965; Krombein et al. 1979, cited in Bolton 1987). Cars parked overnight in infested areas can fail to start the next day after the ants have shorted ignition systems (Davis et al. 1993a). They also forage for sugars, fats and proteins in houses (Smith 1965).

Where abundant in urban areas their activities can result in high costs in terms of property damage (cars, telecommunication equipment, TVs, etc.) and treatment ($200 000 annually in one West Australian Shire (Davis et al. 1993a)). Several house and car fires have been attributed to the ant (Davis et al. 1993a).

In Malaysia, *M. destructor* was the third most abundant ant taxon trapped in residential premises (behind *Pheidole* sp., and *Tapinoma melanocephalum*) (Lee 2002). In some locations *Monomorium* spp. (*M. pharaonis, M. destructor,* and *M. floricola*) were numerically dominant until baited, when *Paratrechina longicornis* and *T. melanocephalum* became abundant (Lee 2002). Lee (2002) stated *M. destructor* generally nested outdoors in Malaysia, especially in soil with vegetation and shrubs. Surveys in retail food outlets found *M. destructor* to be numerically dominant, and a range of microorganisms were isolated from collected ants (Lee 2002), although it was not stated which microorganism came from which ant. Smith (1965) also highlighted the disease-carrying potential of *M. destructor*, reporting one study that found bubonic plague bacteria in the faces of foragers that had fed on plague-infected rats.

It is capable of biting, and people have reported being attacked fiercely in bed (Smith 1965), but the frequency of such events is unknown. Mayor (1922, cited in Wetterer & O'Hara 2002) described it as capable of biting out pieces of skin, and went to great lengths to exclude the ant from his bed at a field station at Tortugas, Loggerhead Key, Florida. Since this building was torn down this species has not subsequently been collected on Loggerhead Key (Wetterer & O'Hara 2002).

In the USA, *M. destructor* may be a relatively localised and minor pest. It is the dominant urban ant in Key West, but may be on the decline elsewhere in the Keys in Florida (Deyrup et al. 1988). It is included in Smith's (1965) review of eastern US pest species, but is not mentioned in Thompson's (1990) review of ant pests in the USA.

A8. Global distribution

A8.1 Native range

Monomorium destructor is probably native to India (Bolton 1987), where it is widespread (Jerdon 1851, cited in Bolton 1987), and may be native to other countries in the Oriental region (www39) (Fig. 2).

A8.2 Introduced range

This species has been widely distributed throughout the tropical zones of the world and is being spread increasingly into temperate zones (Fig. 2; Bolton 1987), where it is able to survive in heated buildings. For some locations reported as the origin of freight interceptions at the New Zealand, Hawaiian, and Australian borders (East Timor, Hungary, Tonga, South Korea, California, and Oregon) no records confirming their presence were found and these locations were not included in the distribution map (Fig. 2).

The distribution of *M. destructor* in Australia presented by Clark (1941) lists *M. destructor* (and its synonym *M. gracillimum*) in many more locations than indicated by Shattuck (www36) suggesting it might not have not established in the more southern cites listed by Clark (e.g., Adelaide, Sydney, and Melbourne).

A8.3 History of spread

Monomorium destructor is a successful tramp species that has become very widely dispersed by trade (Bolton 1987). In Western Australia, it has been a pest since the 1970s, and has probably been there since the 1950s (Davis et al. 1993a). In Florida, the first published record is from 1933 (Deyrup et al. 2000). It has established in some localities, but has subsequently either become rare or extinct as it has not been collected in later surveys (e.g., Island of Tenerife (Espadaler & Bernal 2003), and Loggerhead Key, Florida (Wetterer & O'Hara 2002)). In Tenerife, *Linepithema humile*, *Pheidole* *megacephala*, *M. pharaonis*, and more recently *Lasius neglectus*, are all now present (Espadaler & Bernal 2003), so it is not surprising *M. destructor* is hard to find. On Loggerhead Key, *M. destructor* may have only dominated the Tortugas laboratory buildings, which have subsequently been torn down, and the ant may subsequently have been eliminated by *Ph. megacephala* and/or *Solenopsis geminata* (Wetterer & O'Hara 2002).

On Floreana Island in the Galapagos, *M. destructor* was first recorded December 1996 in samples from the village of Puerto Velasco Ibarra, where ships regularly unload supplies to the Island (Pezzatti et al. 1998). How long it has been present is unclear as it is still only in the village 7 years later, but in greater abundance (Von-Aesch & Cherix 2003).

A9. Habitat range

Monomorium destructor nest outdoors or in buildings, depending largely on whether they occur in tropical, semitropical or temperate regions (Smith 1965). In northern Western Australia they do not live far from houses, in which they can live above the ground in wall and roof cavities (Davis et al. 1993a). In the United Arab Emirates they are present in a wide range of habitats, especially irrigated gardens and disturbed habitats close to water (Collingwood et al. 1997). They are present in some tropical, irrigated, lowland rice fields in the Philippines (Way et al. 1998), and coconut plantations in Sri Lanka (Way et al. 1989). In Florida they nest in soil (lawns) or buildings (wwwnew44). On Tiwi Island and in Australia's Northern Territory, *M. destructor* nests were only associated with urban areas; while there was some spread into surrounding bush land, they appear to be unable to establish in undisturbed habitat (B. Hoffmann, pers. comm.). "Urban areas" can also include a single house and the surrounding sheds within bush (B. Hoffmann, pers. comm.).

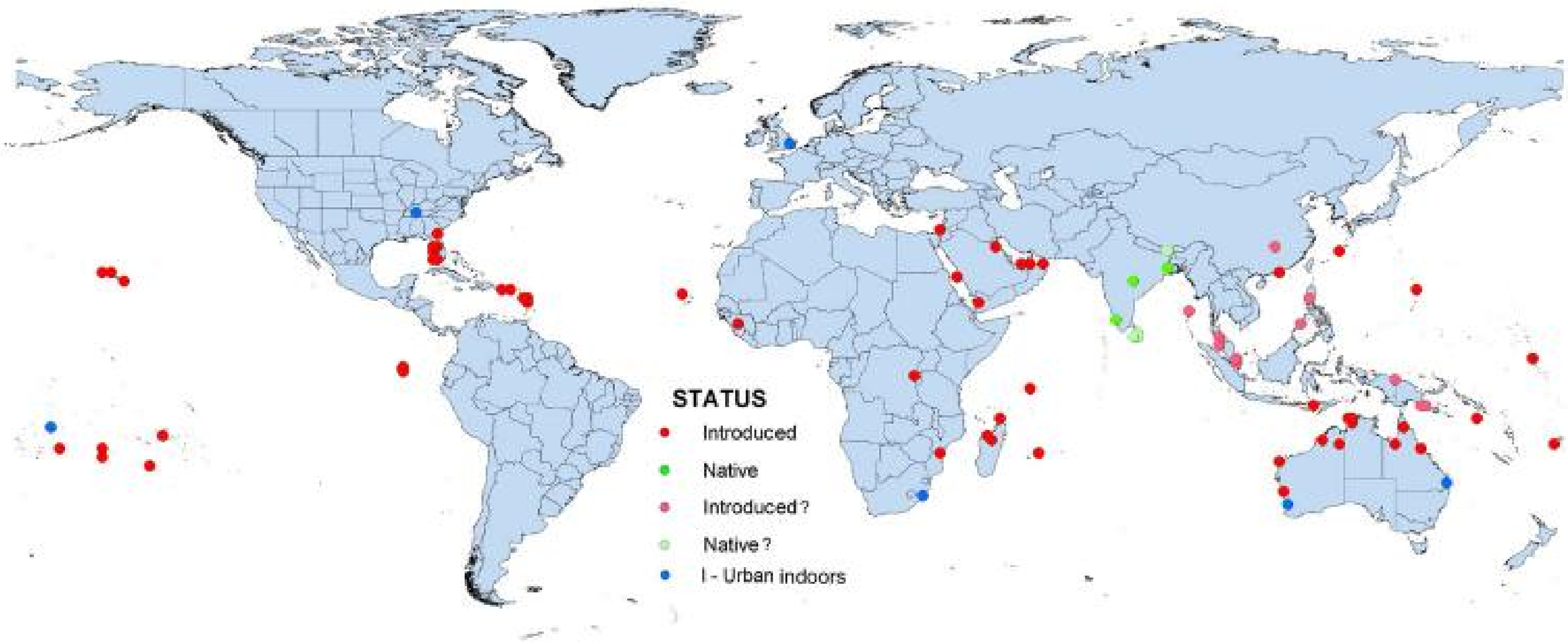

Fig. 2: Distribution records of Monomorium destructor *in Landcare Research Invasive Ant Database, as at December 2004.*

(B) LIKELIHOOD OF ENTRY

B1. Identification of potential pathways

Monomorium destructor has been intercepted at our border relatively commonly in recent years. The first record in the MAF database was 1997, with a total of 9 separate interceptions reported up to 2003. Since a directive to submit all ant interceptions for ID, a further 12 interceptions have been reported, which may indicate under-reporting of this species historically. Workers have been intercepted on a range of commodities, with containers (none specifically listed as empty) and fresh produce predominating (Table 1), although only for coconuts is there more than a single interception. A queen has been intercepted once, associated with a container (from an unknown origin in the Pacific).

Interceptions in freight have originated from a range of countries, with Fiji being the most common (Table 2). Records of live ants from two containers originating from the UK may indicate that survival is possible for considerable periods. It is not confirmed, however, that *M. destructor* is still present in the UK, and if it is, distribution is likely to be highly restricted. It is not listed in Cornwell's (1978) article on "Pest ants in Britain" or from Wales (Fowles 1996). It appears more likely contamination in transit has occurred. *Monomorium destructor* is established in Singapore and Hong Kong, which are common ports of call for container ships. The UK records may involve containers from the same consignment, as the reporting dates are only 5 days apart. The US record is from air freighted asparagus.

In Australia, *M. destructor* has also been intercepted from a wide variety of commodities and origins (Tables 3 & 4). Twenty-five interceptions from Hawaii (data from January 1995 to May 2004; Source: Hawaii Department of Agriculture) list the Marshall Is., Hungary, and the US states of California, Oregon and Florida as origins not recorded in the Australia and New Zealand data.

The Landcare Research Invasive Ant Database does not currently have records confirming the presence of ants for several of the reported origins of interceptions at the New Zealand, Hawaiian and Australian borders (East Timor, Hungary, the Marshall Islands, Tonga, Taiwan, South Korea, California, and Oregon). If these origins are correct (and not errors, or ants picked up in transit), this would further increase the risk pathways to New Zealand.

No incursions of this species in New Zealand have been reported.

B2. Association with the pathway

This ant is commonly associated with urban areas and buildings. Interceptions showing its association with a wide range of commodities suggest it is usually a stowaway, rather than having host-specific associations; this makes it difficult to target particular commodities for scrutiny. In addition, the wide range of countries in which it is established, and from which contaminated freight has been intercepted in New Zealand (and in Hawaii and Australia) makes targeting specific pathways difficult.

B3. Summary of pathways

A summary of freight coming to New Zealand from localities within 100 km of known sites of *M. destructor* infestation is presented in Figure 3 (also see Appendix 1). Total volumes of freight from localities with this ant nearby between 2001 and 2003 were relatively high, representing about 21% of total airfreight and 16.6% of sea freight (21.1% of sea freight where country of origin was reported). However, at many of these locations the distribution of *M. destructor* is very restricted (e.g., Perth (P. Davis, pers. comm.), and Brisbane (C. Vauderwoude, pers. comm.)) and therefore the risk of contamination of freight is much lower than if the species was widespread. Also, high sea-freight volumes from the Middle East predominantly represent tankers shipping crude oil, likely to be a low risk pathway for transport of invasive ants.

Table 1: Commodities from which *M. destructor* has been intercepted at the New Zealand border.

	1964–2002		2003–March 2004	
Commodity	**interceptions**	**Queenspresent**	**interceptions**	**Queenspresent**
Fresh produce	3		4	
Miscellaneous	1			
Personal effects	3		1	
Timber			2	
Container	2		5	1

Table 2: Origin of freight intercepted at the New Zealand border containing *M. destructor.*

Origin	1964–2002interceptions	2003–March 2004interceptions
Cambodia		1
Fiji	2	5
Indonesia		1
Malaysia		1
PNG		2
Solomon Islands		1
Sri Lanka	1	
Taiwan	1	
Thailand	1	
Tonga	1	
UK	2	
Unknown Pacific	1	
USA	1	

Table 3: Reported origin of Australian border interceptions of *M. destructor*. Data from January 1986 to 30 June 2003 (Source: Department of Agriculture, Fisheries and Forestry, Canberra).

Origin	No.
East Timor	1
Indonesia	1
Korea (South)	1
Malaysia	1
Mauritius	1
Papua New Guinea	1
Philippines	1
Singapore	3
South Africa	1
Sri Lanka	3
Taiwan Province	1
Thailand	2
Vietnam	1
Brunei	1
Christmas Is.	1
Maldives	1
Unknown	1

Table 4: Commodities from which *M. destructor* has been intercepted at the Australian border. Data from January 1986 to 30 June 2003 (Source: Department of Agriculture, Fisheries and Forestry, Canberra).

Commodity	No.
Cane furniture	1
Cut flowers	2
Empty container	1
Foodstuffs	1
Fresh produce	1
Household effects	1
Personal effects	7
Plants	1
Post	2
Ships food stores	1
Timber and Timber products	3
Wooden handcrafts	1

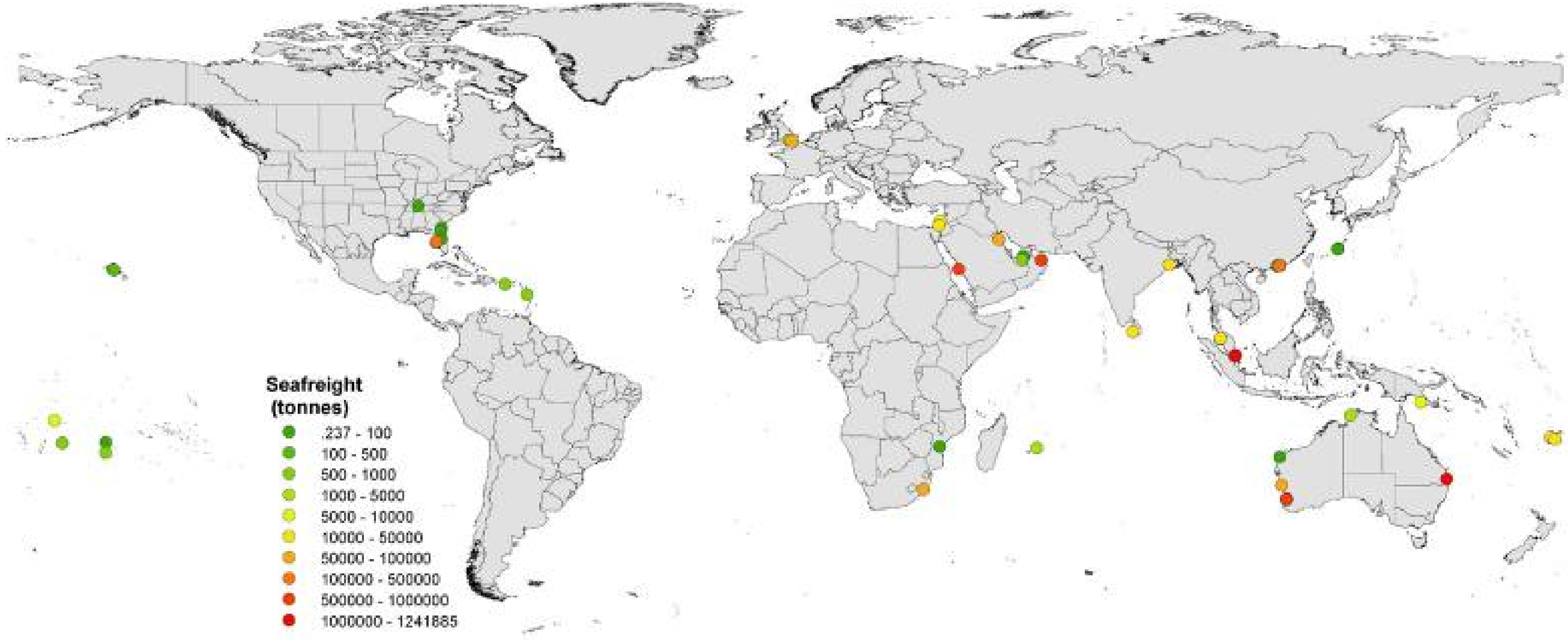

Fig. 3a: Summary of sea freight coming to New Zealand from localities within 100 km of known sites with M. destructor. *Values represent the total freight (tonnes) during 2001, 2002 and 2003 (source: Statistics New Zealand). Details of locations and freight types are given in Appendix 1.*

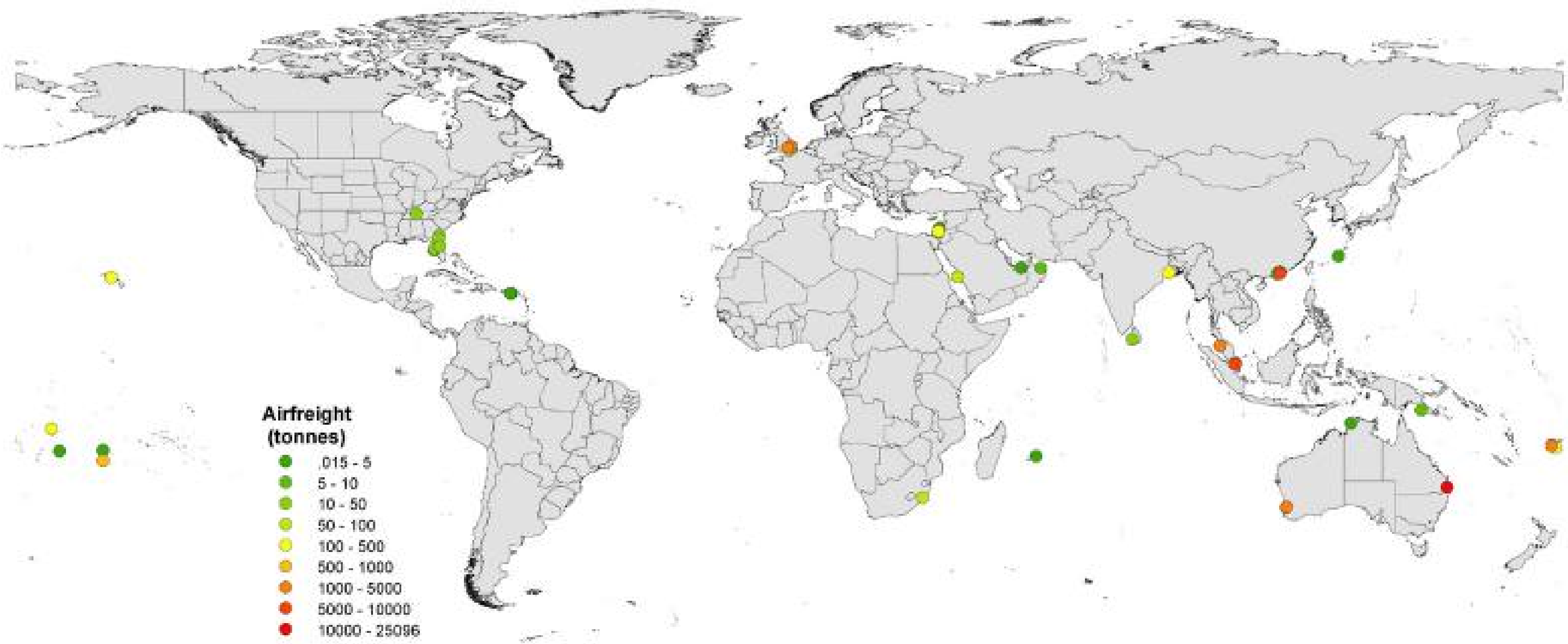

Fig. 3b: *Summary of air freight coming to New Zealand from localities within 100 km of known sites with* M. destructor. *Values represent the total freight (tonnes) during 2001, 2002 and 2003 (source: Statistics New Zealand). Details of locations and freight types are given in Appendix 1.*

(C) LIKELIHOOD OF ESTABLISHMENT

C1. Climatic suitability of regions within New Zealand for the establishment of the ant species

The aim of this section is to compare the similarity of the New Zealand climate with the locations where the ant is native or introduced using the risk assessment tool BIOSECURE (see Appendix 2 for more detail). The predictions are compared with two species that are already established in New Zealand (*Ph. megacephala* and *L. humile*) (Appendix 3). In addition a summary climate risk map for New Zealand is presented; this combines climate layers that most closely approximate those generated by the risk assessment tool Climex.

C1.1 Climate limitations to ants

Given the depauperate ant fauna of New Zealand (only 11 native species), and the success of many invasive ants throughout the world in locations with diverse ant faunas (e.g., Human & Gordon 1996), competition with New Zealand native ant species is unlikely to be a major factor restricting the establishment of invasive ants in New Zealand, although competition may be important in native forest where native ant abundance and diversity is higher (R. Harris, pers. obs.). For some species, the presence of other adventive ants in human-modified environments could limit their distribution (e.g., *Solenopsis invicta* has severely restricted the distribution of *S. richteri* and *L. humile* within the USA (Hung & Vinson 1978; Porter et al. 1988)) or reduce their chances of establishment. However, in most cases the main factors influencing establishment in New Zealand, should queens or colonies arrive here, are likely to be climatic.

A significant relationship between maximum (and mean) daily temperature and foraging activity for both dominant and subordinate ants species indicated temperature rather than inter-specific competition primarily determined the temporal activity of ant communities in open Mediterranean habitats (Cerda et al. 1998). Subordinates are active over a wider range of temperatures (Cerda et al. 1998). In California, *L. humile* foraging activity was restricted by temperature attaining maximum abundance at bait at 34°C and bait was abandoned at 41.6°C (Holway et al. 2002b).

Temperature generally controls ant colony metabolism and activity, and extremes of temperature can kill adults or whole colonies (Korzukhin et al. 2001). Oviposition rates can be slow and may not occur at cooler temperatures (e.g., *L. humile* does not lay eggs below a daily mean air temperature of 18.3°C (Newell & Barber (1913) quoted in Vega & Rust 2001)). At the local scale, queens may select warmer sites to nest (Chen et al. 2002).

Environments with high rainfall reduce foraging time and may reduce the probability of establishment (Cole et al. 1992; Vega & Rust 2001). High rainfall also contributes to low soil temperatures. In high rainfall areas, it may not necessarily be rainfall per se that limits distribution but the permeability of the soil and the availability of relatively dry areas to nest (Chen et al. 2002). Conversely, in arid climates, a lack of water probably restricts ant distribution, for example *L. humile* (Ward 1987; Van Schagen et al. 1993; Kennedy 1998), although the species survives in some arid locations due to anthropogenic influences or the presence of standing water (e.g., United Arab Emirates (Collingwood et al. 1997) and Arizona (Suarez et al. 2001)).

New Zealand has a cool temperate climate, and most non-native ant species established here have restricted northern distributions, with most of the lower South Island containing only native species (see distribution maps in New Zealand information sheets (wwwnew83)). Few adventive species currently established in New Zealand have been collected outside urban areas in the cooler lower North Island and upper South Island (R. Harris, unpubl. data). For some, this could reflect a lack of sampling, but the pattern generally reflects climatic limitations. In urban areas, temperatures are elevated compared with non-urban sites due to the warming effects of buildings and large areas of concrete – the “Urban Heat Island” effect (Changnon 1999). In addition, thermo-regulated habitats within urban areas (e.g., buildings) can allow ants to avoid outdoor temperature extremes by foraging indoors when temperatures are too hot or cold (Gordon et al. 2001).

C1.2 Specific information on M. destructor

No specific information relating to development or foraging in relation to temperature was found for *M. destructor.*

The risk to New Zealand might usefully be assessed from the distribution of *M. destructor* in Hawaii, where it is restricted to the dry lowlands (< 900 m) (Reimer 1994). This may indicate that New Zealand is too cold for establishment outdoors. Ant species that occur in Hawaii's colder mountainous areas (900–1800 m, Reimer 1994) include *Pheidole megacephala* (which has a very restricted northern distribution in New Zealand (Appendix 3)) and *Linepithema humile*. *Linepithema humile* also extends into the dry subalpine communities in Hawaii (1800–2700 m (Reimer 1994)), and its New Zealand distribution extends into the South Island (Appendix 3).

C1.3 BIOSECURE analysis

62 locality records were used for the assessment of *M. destructor* (Fig. 4). Climate parameters used in the analysis are defined in Appendix 2. Native range data suggest New Zealand is too cold with no overlap in mean annual temperature (MAT), and mean minimum temperature of the coldest month (MINT) showing only some overlap with northern New Zealand and coastal areas in the southern North Island (compare Table 5 & 6). The native + introduced range overlaps with most of New Zealand for MAT and MINT (Fig. 5). This is due to two outliers: collection records from Tennessee (Creighton 1950) and London (Bolton 1987), which are almost certainly from heated buildings, although few details are given.

The native + introduced (non-urban) range shows no overlap with mainland New Zealand for MAT (Fig. 6), except for the Three Kings Islands. Overlap occurs for MINT only with northern New Zealand. Vapour pressure (VP) shows a low degree of similarity with most of New Zealand, and mean annual solar radiation (MAS) shows similarity for all but the lower half of the South Island (Fig. 7). Precipitation (PREC) is probably too high in south-western and alpine areas. Other climate parameters show high similarity with New Zealand (Table 5).

Climate summary

The general climate summary for the international range of *M. destructor* indicates low similarity to New Zealand, particularly compared with *L. humile* (Fig. 8). Climate summary graphs are less useful than individual climate layers, as contrast between species and regions of New Zealand are less evident.

Climate match conclusions

Monomorium destructor originated in Asia, and although we only have limited collection records from its native range, it appears to be a tropical/subtropical species occurring in areas of moderate rainfall. It has been widely dispersed to similar climates. Available data from climate matching indicates that outside heated buildings summers in New Zealand will probably be too cold for *M. destructor* brood to develop and populations to be maintained. No experimental data were found on temperatures that limit development to back up conclusions for climate matching. The BIOSECURE assessment probably overstates the risk for native habitat (suggesting some overlap with the Three Kings Islands as the coldest records, with the two temperate indoor records removed, were also from urban areas (e.g., Perth (Van Schagen et al. 1993), and Durban (Bolton 1987)). In Western Australia this species is abundant in and around buildings in tropical northern areas, but is less abundant further south. A small population is established in Perth, but takes all summer to build up in numbers and is not the pest it is further north (P. Davis, pers. comm.). It has not established further south. In urban areas in New Zealand, nests may be restricted to permanently heated buildings, possibly with some foraging outdoors on hot days. It is capable of surviving, at least temporarily, in temperate climates within constantly heated buildings (Creighton 1950; Bolton 1997), but it is not known if these records represent permanent or temporary establishments.

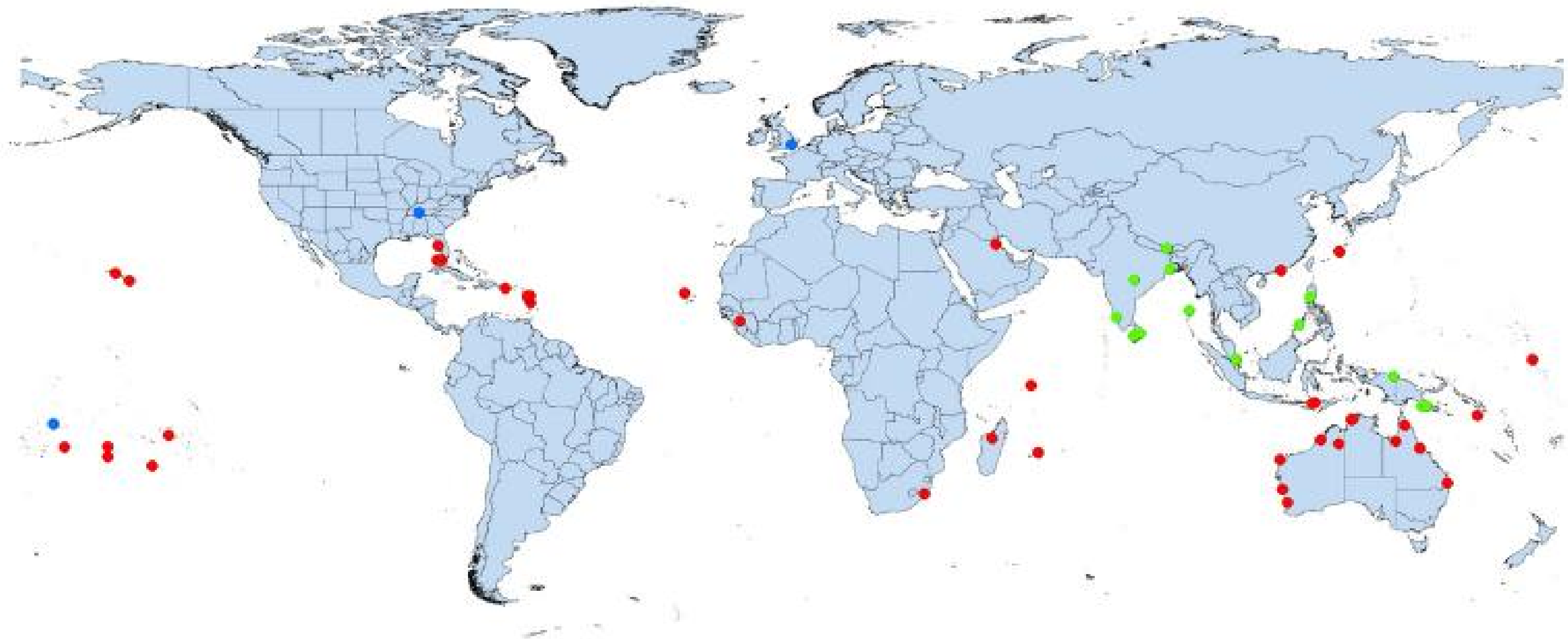

Fig. 4: *Distribution records available at the time the BIOSECURE analysis of* Monomorium destructor *was run. The green dots are records assumed to be the native range, the red the introduced range, and the yellow dots are those records from within buildings.*

Table 5: Comparison of climate parameters for native and introduced range of *Monomorium destructor.*

Parameter	n	Mean	Minimum	Maximum
Mean Annual Temperature (°C)				
Native Range	16.0	25.4	16.5	27.8
Introduced Range	46.0	24.0	9.3	27.9
Introduced non-urban range	43.0	24.4	18.1	27.9
Minimum Temperature (°C)				
Native Range	16.0	17.4	5.0	24.8
Introduced Range	46.0	16.4	-2.1	24.1
Introduced non-urban range	43.0	17.1	5.7	23.7
Mean Annual Precipitation (mm)				
Native Range	16.0	2194.0	1402.0	3059.0
Introduced Range	46.0	1504.0	89.0	2932.0
Introduced non-urban range	43.0	1493.0	89.0	2932.0
Mean Annual Solar Radiation				
Native Range	16.0	16.4	14.3	19.6
Introduced Range	46.0	16.9	9.9	22.1
Introduced non-urban range	43.0	17.2	13.9	22.1
Vapour Pressure (millibars)				
Native Range	16.0	25.3	15.0	31.0
Introduced Range	46.0	21.2	8.0	29.0
Introduced non-urban range	43.0	21.6	9.0	28.0
Seasonality of Temperature (°C)				
Native Range	16.0	5.2	1.4	15.7
Introduced Range	46.0	8.9	1.2	23.5
Introduced non-urban range	43.0	8.6	1.6	23.5
Seasonality of Precipitation (mm)				
Native Range	16.0	344.4	101.0	754.0
Introduced Range	46.0	189.3	19.0	448.0
Introduced non-urban range	43.0	192.1	19.0	44.0
Seasonality of Vapour Pressure (millibars)				
Native Range	16.0	6.8	2.0	18.0
Introduced Range	46.0	8.7	3.0	19.0
Introduced non-urban range	43.0	8.7	3.0	19.0

Table 6: Range of climate parameters from New Zealand (N = 196 GRIDS at 0.5 degree resolution). Data excluding distant island groups (Chatham, Bounty, Antipodes, Campbell, Auckland, and Kermadec Islands).

Parameter	Min	Max	Mean
MAT	-0.5	16.6	10.9
MINT	-8.3	7.8	3.0
PREC	356.0	5182.0	1765.0
MAS	11.2	14.3	13.0
VP	4.0	15.0	9.7
MATS	6.4	10.6	8.8
PRECS	23.0	175.0	60.5
VPS	4.0	8.0	5.9

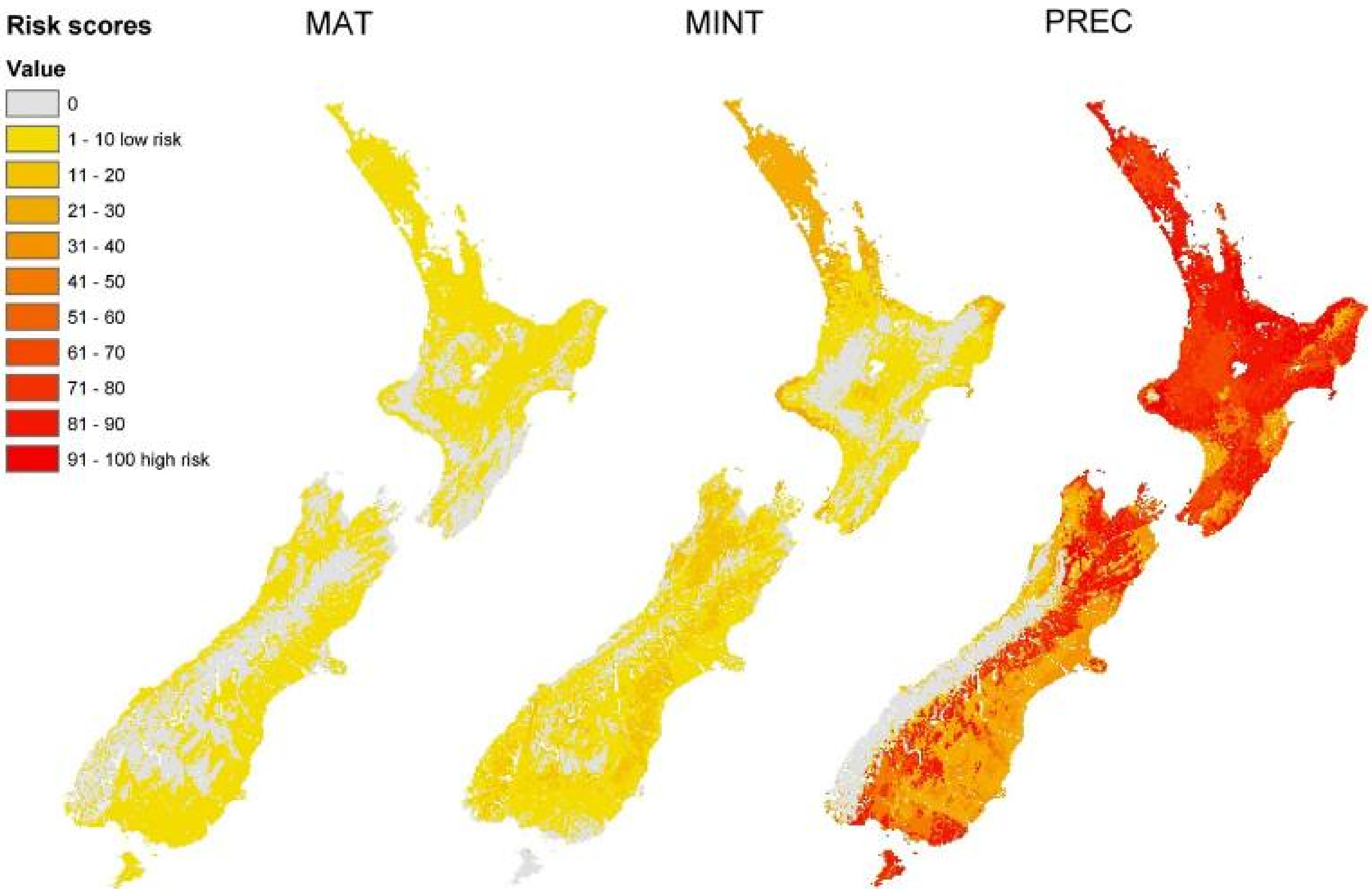

Fig. 5: *Similarity of native + introduced ranges of* Monomorium destructor *to New Zealand for MAT, MINT, and PREC.*

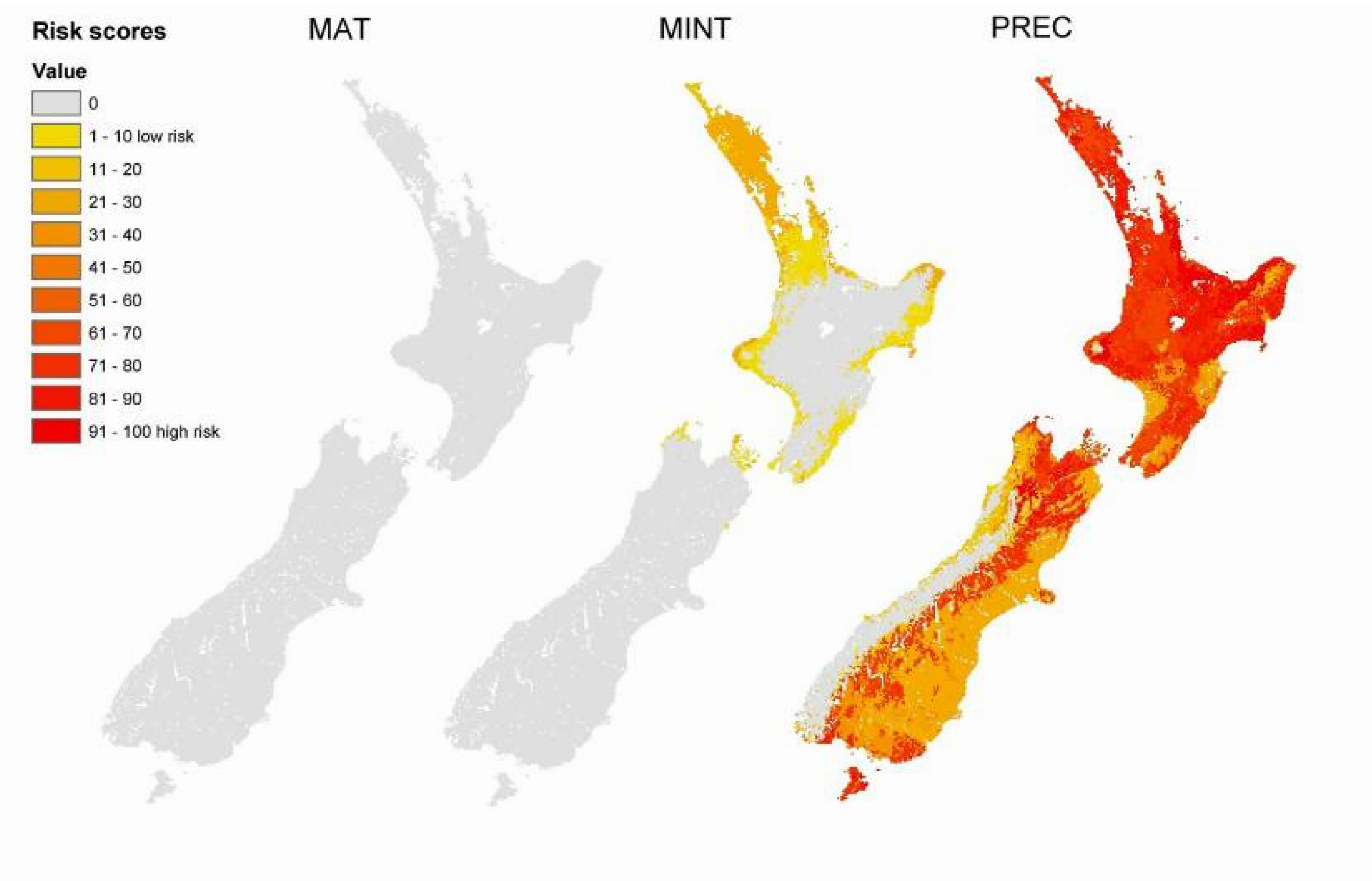

Fig. 6: Similarity of native + non-urban introduced ranges of *Monomorium destructor* to New Zealand for MAT, MINT, and PREC.

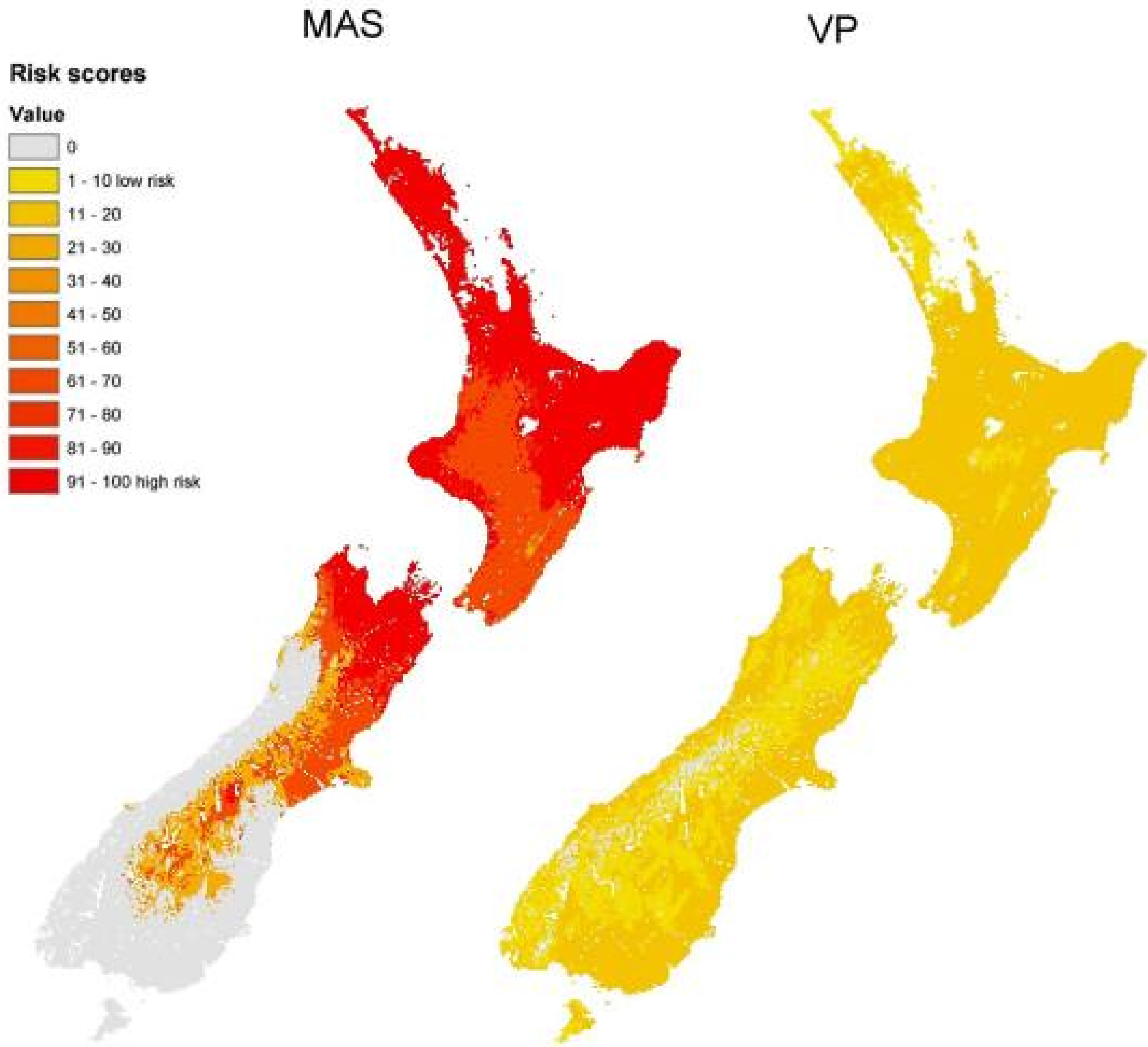

Fig. 7: Similarity of native + non-urban introduced ranges of *Monomorium destructor* to New Zealand for MAS and VP.

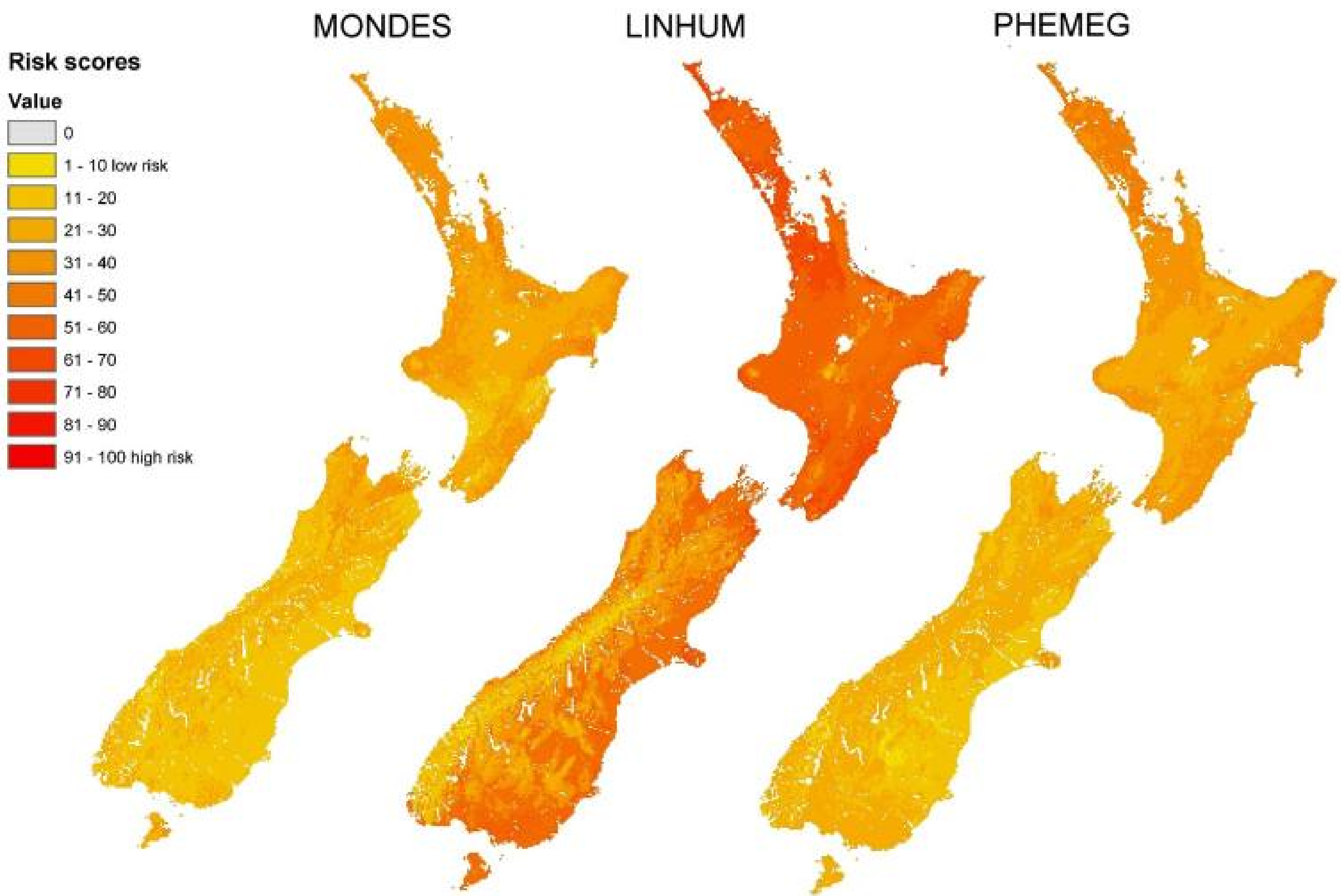

Fig. 8: *Comparison of climate similarity to New Zealand of the international non-urban ranges of* M. destructor, L. humile *and* Ph. megacephala *based on the mean of the similarity scores of five climate layers (MAT, MINT, PREC, VP, PRECS). This presentation approximates that produced by the risk assessment tool Climex.*

C2. Potential to establish in protected environments

Monomorium destructor, of tropical origin, has demonstrated its ability to establish in urban areas in a number of locations, but with no evidence for spread into other habitats, probably due to climatic limitations and/or competition with native ants (e.g., England (Bolton 1987), Perth (P. Davis, pers. comm.), and Florida (Deyrup et al. 2000)).

C3. Documented evidence of potential for adaptation of the pest

Behaviourally, *M. destructor* copes with extreme temperatures by nesting in permanently heated buildings. This use of buildings may also reflect its arboreal habits in non-urban tropical locations (Jaffe et al. 1990) as is the case for other urban-building invading tramp ants (e.g., *Technomyrmex albipes* and *Tapinoma melanocephalum* (Way et al. 1989)).

Monomorium destructor appears to have limited ability to compete with diverse ant faunas in topical locations. Where it occurs outside urban areas in its introduced range, it is a minor member of the non-urban ant community (e.g., Way et al. 1989; Jaffe et al. 1990; Way et al. 1998; Ballmer 2003).

C4. Reproductive strategy of the pest

This ant forms large polygyne colonies in urban areas. No information was found indicating the size of nests in tropical non-urban locations, no references confirming *M. destructor* colonies undergo budding, but the observation of the slow spread of an infestation across a five acre block in Darwin (B. Hoffmann, pers. comm.) and the presence of multiple queens and many nest sites that appear to be unicolonial, suggests budding does occur. Nuptial flights occur, possibly allowing *M. destructor* to disperse locally (B. Hoffmann, pers. comm.), but the relative importance of solitary queens with budding and human-assisted dispersal in its spread is unknown. Winged dispersal may allow the ant to disperse within urban areas if suitably heated buildings are patchily distributed. The close association of this ant with urban areas and its propensity to nest in a variety of locations, at least in tropical locations (B. Hoffmann, pers. comm.), suggests potential for human-assisted dispersal of queens or whole colonies, as commonly occurs with *Linepithema humile* (Suarez et al. 2001).

C5. Number of individuals needed to found a population in a new location

No research information was found on this aspect of the biology of *M. destructor.* Budding and human-assisted dispersal are probably the primary means of population establishment in new areas, and would require workers accompanied by at least one queen to be transported. While this species does have nuptial flights, the capacity of queens to found a nest independently has not been confirmed. Workers alone are incapable of founding a new nest (Holldobler & Wilson 1990).

C6. Likely competition from existing species for ecological niche

The presence of *M. destructor* in urban areas may reduce the diversity of other ants (Lee 2002; Von-Aesch & Cherix 2003), but these studies are in tropical rather than temperate climates. In New Zealand, there are currently thought to be one native (*M. antipodum*) and two adventive species (*M. pharaonis* and *Technomyrmex albipes*) that nest within buildings. *Monomorium antipodum* has not been reported as abundant, but the other two species can reach high densities. The distribution of *M. pharaonis* and *T. albipes* is patchy within urban areas where they are established, with *T. albipes* more widespread than *M. pharaonis*. *Monomorium pharaonis* has only been reported from large centrally heated commercial buildings (e.g., hospitals), *M. antipodum* predominantly from residential properties, and *T. albipes* from both residential and commercial properties (R. Harris, unpubl. data). It is unclear if the patchy distributions reflect limited dispersal abilities or the limited availability of suitable nest sites. Both *M. pharaonis* and *T. albipes* would be likely competitors for nesting sites with *M. destructor*, and occur within the same ant communities elsewhere (Lee 2004), but it is not clear if they coexist on the same trees or within the same buildings.

C7. Presence of natural enemies

No reports of natural enemies of *M. destructor* were found, and establishment in New Zealand is only likely to be hindered by other ant species.

C8. Cultural practices and control measures applied in New Zealand that may affect the ant's ability to establish

There are no routine treatments of port areas that would decrease the chances of survival of *M. destructor*. Treatment of incursions of other invasive ant species in and around ports, or sites of freight unloading, may have little impact on the survival of new propagules as treatment is typically outdoors and not targeted to species nesting and foraging indoors.

Existing invasive ant surveillance in and around ports would only detect an incursion of *M. destructor* if there is foraging outdoors (unknown if this will occur to some degree in summer) as no surveillance is currently conducted in buildings. Its indoor nesting may impede the detection of an incursion of this species. Ant infestations in buildings are often treated by pest controllers, but specimens are seldom identified (there are relatively few records in New Zealand's entomological collections of *M. pharaonis* and *T. albipes* in buildings, although the latter species is widespread in urban areas of New Zealand).

Surveys within heated buildings at ports and transitional facilities may be necessary to detect this species. This may also be the case for other predominantly tropical species that are likely to be closely associated with urban buildings if they establish here (e.g., *Tapinoma melanocephalum*).

(D) LIKELIHOOD OF SPREAD AFTER ESTABLISHMENT

An ant's potential to spread determines how quickly its environmental and economic impact is expressed, and how readily it could be contained.

D1. Dispersal mechanisms

There are three methods of dispersal that, combined, help the spread of *M. destructor* at local, regional, national, and international scales. Most significant is human-mediated dispersal, without which the ant may never have reached its current locations. *Monomorium destructor* is a 'tramp' ant (Holldobler & Wilson 1990), renowned for transportation via human commerce and trade. It is associated with a wide range of freight types (see section B1. Identification of potential pathways), making it difficult to target any particular pathways.

M. destructor also spreads naturally from established colonies in two ways: colony budding (B. Hoffmann, pers. comm.), where queens walk on foot accompanied by workers to a new nesting site; and winged dispersal of inseminated queens to uninfested areas where they start a new colony. This latter mechanism needs to be confirmed (B. Hoffmann, pers. comm.); it is most likely colony budding is the primary natural dispersal method.

D2. Factors that facilitate dispersal

Natural: Budding will likely occur in the expansion phase of a colony when the new workers and queens are being produced and available nesting space becomes limiting. Disturbance of colonies may also facilitate movement or all or part of the colony to a new location. This dispersal will likely be over very limited distances, and in temperate areas may only occur within buildings. The occurrence of winged dispersal, and the ability of solitary queens to found nests (though there is not yet conclusive evidence of this) would greatly aid the ants ability to establish in patchily distributed suitable conditions in New Zealand (due to unsuitable conditions outdoors). Occurrence of winged dispersals would make eradication of an incursion much more difficult, unless the incursion was found before nuptial flights and successful establishment of any new colony occurred.

Artificial: Commerce has clearly helped this ant become widely dispersed globally, and its habit of nesting in close association to urban environments helps dispersal. Human-mediated dispersal of colonies that have moved into pot plants, containers, rubbish bins etc., is probably of greatest importance to the risk of *M. destructor* becoming widespread within New Zealand. The cessation of movement of goods within an incursion zone would be critical to the successful eradication of this species.

D3. Potential rate of spread in its habitat range(s)

The only information on the rate of spread of *M. destructor* was the observation of the "slow spread of an infestation across a five acre block in Darwin" (B. Hoffmann, pers. comm.). This ant is a tropical species and available climate information suggests it is unlikely to establish outdoors in New Zealand. Production of winged dispersers, and independent colony founding, would likely allow the ant to spread several kilometres a year in urban areas and find suitably heated buildings. Movement between urban areas would likely only occur through human-mediated dispersal.

Currently no baits are registered here to use in an incursion event, but if Amdro® (granular bait containing hydramethylnon) is registered for use against various invasive ants in New Zealand, its use against *M. destructor* would likely reduce its spread (see section E1.6).

(E) THE ENVIRONMENTAL, HUMAN HEALTH AND ECONOMIC CONSEQUENCES OF INTRODUCTION

E1. Direct effects

E1.1 Potential for predation on, or competition with New Zealand's indigenous fauna

This species has potential to establish in urban areas, but these generally have low native biodiversity values, and the ant will principally be found in buildings. It is considered highly unlikely the ant will establish outside urban areas due to temperature limitations, and even if it did, there is no evidence internationally that it would be a significant component of the invertebrate community.

E1.2 Human health-related impacts

This species does not appear to sting, but has been reported to bite en mass and could be a significant nuisance if it were to establish in heated buildings. The ant forages in large number indoors and can be abundant in food premises (Lee 2002). It probably would have a role in the spread of microorganisms in kitchens and commercial food preparation areas (Smith 1965; Lee 2002), as do other building invading ants (Fowler et al. 1993). There is the potential for this species to cause house fires through damage to electrical equipment as has been reported in Northern Western Australia (Davis et al. 1993b)).

E1.3 Social impacts

Establishment is most likely in some urban buildings. Populations may take some years to build up to pestiferous levels due to suboptimal temperatures, and in some areas may remain at relatively low densities, as appears to be the case in climates warmer than New Zealand (e.g., Perth (P. Davis, pers. comm.)). Foragers would feed on any food left out, and there is a high likelihood of damage to electrical equipment. Populations will likely be sufficiently abundant in heated buildings for pest control measures to be instigated, particularly in commercial premises where product contamination is a concern.

E1.4 Agricultural/horticultural losses

No information was found indicating direct agricultural/horticultural losses caused by *M. destructor.* However, establishment in commercial premises such as horticultural processing plants could result in product contamination, and there is also potential for electrical damage to horticultural machinery and processing plants.

In glass houses growing fresh produce or flowers the ant could be a pest (biting pickers, crop contamination), but this could be offset by predation of other invertebrates that could be pests (Jaffe et al. 1990). Establishment in facilities with captive animals (e.g., medical research laboratories or chicken farms) could have detrimental implications for caged animals as deaths of caged rats have been reported (Mayor 1922, cited in Wetterer & O'Hara 2002).

E1.5 Effect(s) on existing production practices

None are foreseen, other than the implementation of ant control should *M. destructor* become established in urban areas where *Technomyrmex albipes* or *M. pharaonis* are not already a pest.

E1.6 Control measures

This section uses information from a review of baiting by Stanley 2004.

Direct treatment and residue applications used currently by pest controllers in commercial and residential properties in New Zealand to manage infestations of *T. albipes* or *M. pharaonis* will likely have some effect on *M. destructor.* However, as for most ant species, killing the queens using baits is the key to effective management (Stanley 2004).

Bait matrix (attractant + carrier): Field trials in Malaysia using food attractants found peanut butter (80%) was strongly preferred over honey (20%) by *M. destructor* (Lee 2002). Lee and Kooi (2004) recommend using protein or sugar-based attractants in baits targeting *M. destructor*.

Davis et al. (1993b) found the soybean oil on the corn-grit-bait matrix used for *S. invicta* toxic baits is attractive to *M. destructor* in Western Australia. In food preference tests, plain white bread proved to be the most attractive of a range of food types to *M. destructor*, and was used to monitor ant activity before and after treatments were applied (Davis et al. 1993b).

Toxicants and commercial baits: Davis et al. (1993b) trialled several commercial ant baits developed for *S. invicta* based on soybean oil on corn-grit-bait matrix: Finitron® (sulfluramid); Ascend® (abamectin); Award® (fenoxycarb); Amdro® (hydramethylnon); and Bushwacker® (boric acid in ground shrimp offal bait matrix). Field trials (2–3 ha plots, monitored for 6 months) showed Finitron®, followed by Ascend® and Amdro®, were the most effective ant baits, with ant abundance reduced to almost zero (Davis et al. 1993b). At least 6 months control of *M. destructor* was achieved from one application of Finitron®. *Monomorium destructor* did not pick up any of the Bushwacker® or Award® granules, and there was some recovery in the Ascend® plot after 2 weeks (Davis et al. 1993b). However, while there was an untreated 'control' plot, there was no replication in this field trial, making it difficult to interpret the results.

The efficacy of Finitron®, Ascend® and Amdro® was also tested in replicated laboratory trials with *M. destructor* colonies (Davis et al. 1993b). After 21 days, all treatments proved equally effective at killing workers. However, Amdro® caused significantly more queen mortality (75% queen mortality) than the Finitron® and Ascend® (Davis et al. 1993b). Finitron® (sulfluramid) has subsequently been withdrawn from the US market since the Western Australian trials. Therefore, Amdro® (highest queen mortality) is the most effective of the available commercial baits tested by Davis et al. (1993b). The trials resulted in the registration of Amdro® throughout Australia for the control of *M. destructor* (J. van Scahgen, pers. comm.; M. Widmer, pers. comm.).

Several of the more recent commercial baits developed for *S. invicta* control, such as indoxacarb and those containing insect growth regulators (IGRs), would also likely be candidates for the effective control of *M. destructor*, although they have not been tested.

At least three formulations containing 7.3 g/kg hydramethylnon (Drax Ant Kil Granular with Hydramethylnon; Garrards Granular Ant Bait; Faslane Granular Ant Bait), and one containing 10 g/kg hydramethylnon (Maxforce Granular Insect Bait) are registered for use against *M. destructor* in Australia (wwwnew48) in addition to Amdro® (7.3 g/kg hydramethylnon). These baits are also recommended for use against *Pheidole megacephala* and *Solenopsis geminata*, or ants in general but many species would not feed on granular baits (e.g., *Paratrechina lonicornis* and *Linepithema humile*).

E2. Indirect effects

E2.1 Effects on domestic and export markets

Establishment at a port, and subsequent export to another country that does not have this species, could lead to changes in import health standards for NZ export goods.

E2.2 Environmental and other undesired effects of control measures

There have been no documented cases of adverse non-target effects arising directly from the use of toxic baits for control of *M. destructor*. However, the baits recommended for control will be toxic to other invertebrates that consume them. There is no documented evidence of resistance of any ant to pesticides.

(F) LIKELIHOOD AND CONSEQUENCES ANALYSIS

F1. Estimate of the likelihood

F1.1 Entry

Monomorium destructor currently has a *medium/high* risk of entry.

This assessment is based on:

- *M. destructor* having been moderately frequently intercepted at the New Zealand border in recent times (first record in 1997 and a total of 9 interceptions up to March 2003, and 12 further interceptions during the period of full reporting). This species is also relatively frequently intercepted at the Hawaiian and Australian borders.
- interception records indicating ability to stowaway on a wide variety of commodities.
- dispersal being primarily by budding, colonies being polygyne, and possibly polydomus, and mobile. It nests inside buildings and other man-made objects, characteristics that promote the chances of queens with workers being transported.
- *M. destructor* being widespread in the Pacific – a high risk pathway for ants entering New Zealand.

Data deficiencies:

- not all ants intercepted at the New Zealand border are reported and it is likely entry of this species is underestimated (as evident by the increase in interception reports during full reporting). It is not always clear in interception data if castes other than workers were intercepted.

F1.2 Establishment

Monomorium destructor currently has a *medium* risk of establishment.

This assessment is based on:

- available information suggesting this tropical species is highly unlikely to establish outdoors in New Zealand.
- *M. destructor* being able to establish in temperate regions in close association with heated buildings, and such habitats being in close proximity to ports of entry and transitional facilities.
- a single mated queen or a queen accompanied by workers being required for successful establishment.
- it being unlikely to encounter natural enemies; however, there would be competition from other adventive ants that occasionally occur in buildings in urban areas.
- there being numerous pathways from Pacific neighbours for budded colonies to arrive in New Zealand in a fit reproductive state. However, only a single queen and no colonies having been intercepted at the New Zealand border up to December 2004.
- surveillance targeting of other invasive ants (particularly *S. invicta*) being inefficient at detecting this species as it will likely nest indoors.
- Amdro® (or equivalent soybean oil on a corn grit matrix bait containing hydramethylnon) being proved effective against this species in Australia and its use to treat an incursion would reduce chances of establishment.

Data deficiencies:

- there are no experimental data on developmental rates or foraging activity in relation to temperature. The climate assessment is based on consideration of climate estimates from known sites of establishment of *M. destructor* and considering its distributions in Hawaii and Australia.
- there are no established protocols for successful eradication of a large incursion of this species.
- it is unclear if *M. destructor* queens can establish nests independently.
- although recorded in heated buildings in temperate locations, it is not known if *M. destructor* has established in these locations permanently.

F1.3 Spread

Monomorium destructor has a *low/medium* risk of spread from a site of establishment.

This assessment is based on:

- areas of New Zealand considered climatically suitable to spread into being available, although limited to heated buildings in urban areas.
- suitably heated buildings for establishment being patchily distributed restricting dispersal by natural means.
- colony development being relatively slow. It is likely sub-optimal temperatures will restrict foraging outdoors and the rate of colony development. This will extend the period from colony founding to the production of reproductives and colonies of sufficient size to undergo budding.
- colonies being primarily spread inadvertently by humans.
- isolated urban populations able to be controlled effectively using Amdro®, which would further reduce rates of spread. Small populations of this ant in commercial premises might go unnoticed.

Data deficiencies:

- the types of building that would be sufficiently warm for this ant to establish in are unknown.
- there is a lack of experimental data on the colony status (size and abiotic cues) that promotes budding in polygyne species.
- it is assumed unlikely, in the absence of information on spread in temperate urban areas, that queens will fly to locations and establish nests independently, but there is no data to back up this assumption. Conformation as to whether this species can found nests independently is needed as it has significant implications for the management of incursions.

F1.4. Consequences

The consequences of the presence of *M. destructor* in New Zealand are considered *low/medium*.

This assessment is based on:

- there being few medical consequences of establishment as *M. destructor* does not sting or spray formic acid, but has been recorded biting people.
- *M. destructor* being a likely significant nuisance pest indoors. It can have significant consequences in terms of property damage (particularly electrical equipment), which would be over and above impacts of currently established species. It may also be an occasional pest in commercial premises through product contamination. Pest control

would likely be initiated anywhere it was abundant.

- *M. destructor* occurring in similar situations to *M. pharaonis*, which in New Zealand is reported occasionally in hospitals and commercial buildings.
- it being considered extremely unlikely there will be environmental consequences even if the ant does establish in native habitats. In optimal climates, this species is not ecologically dominant, foraging in low numbers and often being displaced by other ant species. Detrimental impacts have only been reported in urban areas.

Data deficiencies:

- although it was predicted that pest control would likely be initiated anywhere this ant was abundant, it is unknown what conditions in urban areas would promote attainment of high population densities. This may more likely occur in large, centrally heated buildings like hospitals, than in domestic dwellings.

F2. Summary table

Ant species: ***Monomorium destructor***

Category			Overall risk
Likelihood of entry	Medium–high	Relatively commonly intercepted. Many potential pathways. Wide range of potential commodity associations.	Medium
Likelihood of establishment	Medium	Tropical species but can establish indoors in temperate regions. Attractive baits available.	
Likelihood of spread	Low-medium	Climate suboptimal so slow rate of increase and spread. Some human-assisted spread likely. Restricted habitat (permanently heated buildings). Good options for management.	
Consequence	Low–medium	No impact outside of urban areas. Climate may restrict urban impacts.	

A detailed assessment of the Kermadec Islands is beyond the scope of this assessment.

(G) References

(NB: a copy of all web page references is held by Landcare Research (M. Stanley) should links change)

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Appendix 1: Freight summary

Table a. Summary of sea freight coming to New Zealand from localities within 100 km of known sites with *M. destructor.* Values represent the total freight (tonnes) during 2001, 2002 and 2003 (source: Statistics New Zealand). Total freight is broken into different commodity types. NB: New Zealand received some freight from all locations listed, but if total freight is below 500 kg it is listed as 0 tonnes. Details of the freight types that comprise each category are given (c) as are the categories (HS2 Chapters) used to classify incoming freight in the Statistics New Zealand database (d).

Country	Port of export	Total freight	Appliances	Fibres	Bulk	Foodstuffs	Furniture	Furs	Glass	Metals	Produce	Wood	Other
Australia	Brisbane, QL	1241885	55439	5267	382987	440174	7092	489	112104	128971	18011	61131	30221
Australia	Darwin, NT	1035	134	9	463	142	3	0	1	109	0	16	158
Australia	Exmouth Gulf, WA	1	1	0	0	0	0	0	0	0	0	0	0
Australia	Fremantle, WA	989264	7243	338	873646	13793	2055	563	54063	25388	2	8948	3226
Australia	Geraldton, WA	66215	0	0	0	66215	0	0	0	0	0	0	0
Australia	Kwinana, WA	492392	0	0	492392	0	0	0	0	0	0	0	0
Australia	Perth, WA	3980	592	31	248	225	77	1	511	429	0	1760	106
China	Chiwan	2957	203	65	1851	189	155	5	31	281	71	40	68
China	Shekou	2013	87	30	106	170	149	5	889	314	35	104	124
China	Shenzhen	3347	288	54	105	106	392	52	1913	254	0	55	130
China	Yantian	13267	3561	167	95	103	3887	183	1961	1923	6	321	1062
China (Hong Kong)	Hong Kong SAR	455059	64385	33371	154811	27265	32065	5596	27075	60995	3831	9946	35718
China (Hong Kong)	Kowloon	188	10	20	0	0	42	30	1	36	0	37	14
China (Macau)	Macau	26	7	12	0	0	0	1	0	1	0	1	4
Cook Islands	Aitutaki	93	67	0	0	0	0	0	0	2	22	0	1
Cook Islands	Rarotonga	927	127	0	0	404	9	0	109	147	9	13	109
Dominica	Portsmouth	976	913	0	0	25	4	0	0	31	0	1	1
Fiji	Nadi	839	4	2	0	16	0	0	0	14	774	0	28
Fiji	Suva	40544	940	464	83	8512	290	3	82	2211	18069	9328	562
India	Calcutta	13477	28	2441	423	118	2	75	522	9724	35	1	107
India	Haldia	4588	67	117	843	0	0	0	47	3497	0	2	13
Israel	Haifa	9932	506	1547	1542	504	310	1	14	4315	5	27	1162
Israel	Tel Aviv	311	17	154	65	0	11	0	1	63	0	0	0
Japan	Naha, Okinawa	53	44	1	0	0	0	0	0	8	0	0	0
Japan	Okinawa, Okinawa	31	26	0	0	0	0	0	0	5	0	0	0
Malaysia	Bagan Luar (Butterworth)	299	0	0	0	279	0	0	0	0	0	0	20
Malaysia	Pasir Gudang, Johor	120238	2267	181	177	92311	3555	5	10597	7282	5	2952	908
Malaysia	Prai	15	0	0	0	0	0	0	0	2	0	13	0

Country	Port of export	Total freight	Appliances	Fibres	Bulk	Foodstuffs	Furniture	Furs	Glass	Metals	Produce	Wood	Other
Malaysia	Tanjong Pelepas	270508	16335	5043	105266	26303	5137	420	37261	38394	3643	24399	8308
Mauritius	Port Louis	1257	67	12	0	788	7	0	0	361	0	2	19
Mozambique	Beira	22	0	0	0	0	0	0	0	0	0	0	22
Niue	Niue Island	606	9	0	0	42	5	0	0	5	544	0	0
Oman	Min-al-Fahal	862459	0	0	862459	0	0	0	0	0	0	0	0
Oman	Muscat	351	2	0	0	312	0	0	0	38	0	0	0
Oman	Port Qaboos	180	0	0	0	174	0	0	0	6	0	0	0
Papua New Guinea	Port Moresby	7025	248	0	10	1208	1	0	0	79	0	5467	11
Philippines	Batangas, Luzon	521	0	0	0	151	0	0	0	0	370	0	0
Philippines	Manila	25224	924	1401	720	9993	666	37	295	6839	2947	451	951
Puerto Rico	Ponce	703	0	0	0	699	0	0	0	0	0	0	5
Samoa	Apia	6594	412	14	1	3275	1	0	0	666	2166	38	23
Saudi Arabia	Jeddah	557670	56	2517	537416	1366	0	0	9228	7067	0	0	19
Saudi Arabia	Ras al Khafji	62998	0	0	62998	0	0	0	0	0	0	0	0
Singapore	Jurong	46	44	0	0	0	1	0	0	1	0	0	0
Singapore	Singapore	1204093	60294	16705	641019	76567	9858	583	47443	257168	7200	44352	42903
Singapore	Singapore Container Terminal	95555	8284	4242	10745	11364	1671	70	7422	37763	1991	6455	5547
South Africa	Durban	59503	3535	1071	7339	8560	241	4	1567	12990	234	13539	10423
Sri Lanka	Colombo	11891	38	1241	218	5417	18	0	1266	2149	717	479	348
UK	London	6203	799	275	348	329	80	100	479	1676	0	193	1924
UK	London-Heathrow Apt	769	130	10	164	197	8	0	19	58	0	25	158
UK	Newhaven	1	1	0	0	0	0	0	0	0	0	0	0
UK	Sheerness	524	288	0	0	0	0	0	0	193	0	43	1
UK	Shoreham	1	1	0	0	0	0	0	0	0	0	0	0
UK	Tilbury	94435	13019	2031	2016	28947	710	22	3341	28214	17	2796	13322
United Arab Emirates	Abu Dhabi	946	6	10	0	19	9	0	2	899	0	0	1
United Arab Emirates	Dubai	95457	61	4	1054	981	20	0	91870	1392	6	5	65
United Arab Emirates	Jebel Ali	99733	45	10	90472	1148	4	0	5593	2391	36	0	33
United Arab Emirates	Jebel Dhanna	415091	0	0	415091	0	0	0	0	0	0	0	0
United Arab Emirates	Mina Zayed	17	0	0	0	0	0	0	0	17	0	0	0
USA	Buffalo, NY	0	0	0	0	0	0	0	0	0	0	0	0
USA	Honolulu, HI	335	43	3	0	16	19	0	0	219	0	0	35
USA	Jacksonville, FL	0	0	0	0	0	0	0	0	0	0	0	0
USA	Nashville, TN	43	3	0	20	14	0	0	0	6	0	0	0
USA	Orlando, FL	80	4	0	9	0	2	0	0	29	0	0	36
USA	Pearl Harbour, HI	2	2	0	0	0	0	0	0	0	0	0	0
USA	St Petersburg, FL	51	0	0	0	0	0	0	0	51	0	0	0
USA	Tampa, FL	272758	23	0	272714	0	0	0	0	20	0	0	1

Table b. Summary of air freight coming to New Zealand from localities within 100 km of known sites with *M. destructor.* Values represent the total freight (tonnes) during 2001, 2002 and 2003 (source: Statistics New Zealand). Total freight is broken into different commodity types. NB: New Zealand received some freight from all locations listed, but if total freight is below 500 kg it is listed as 0 tonnes. Details of the freight types that comprise each category are given (c) as are the categories (HS2 Chapters) used to classify incoming freight in the Statistics New Zealand database (d).

Country	Port of export	Total freight	Appliances	Produce	Pharmaceuticals	Metals	Glass	Furniture	Fur	Footwear	Foodstuffs	Fibres	Other
Antigua and Barbuda	Antigua	0	0	0	0	0	0	0	0	0	0	0	0
Australia	Brisbane, QL	25096	1931	16253	222	1315	90	487	157	139	2484	609	1409
Australia	Darwin, NT	5	4	0	0	0	0	0	0	0	0	0	1
Australia	Fremantle, WA	3	2	0	1	1	0	0	0	0	0	0	0
Australia	Perth, WA	1294	365	50	149	221	19	21	41	2	58	172	198
China	Shekou	1	0	0	0	0	0	0	0	0	0	1	0
China	Shenzhen	8	2	0	0	1	0	1	0	0	0	2	2
China	Yantian	0	0	0	0	0	0	0	0	0	0	0	0
China (Hong Kong)	Hong Kong SAR	7514	2458	2	53	615	51	434	203	237	87	2301	1073
China (Hong Kong)	Kowloon	2	1	0	0	0	0	0	0	0	0	1	0
China (Macau)	Macau	6	2	0	0	4	0	0	0	0	0	0	0
Cook Islands	Aitutaki	4	1	2	0	0	0	0	0	0	1	0	0
Cook Islands	Rarotonga	696	86	548	0	1	0	1	0	0	26	26	8
Fiji	Lautoka	37	0	24	0	1	0	0	0	3	7	2	0
Fiji	Suva	128	5	5	0	0	0	0	0	64	17	29	7
India	Calcutta	171	11	0	0	7	0	0	104	0	1	43	3
Israel	Ashdod	0	0	0	0	0	0	0	0	0	0	0	0
Israel	Haifa	5	4	0	0	1	0	0	0	0	0	0	0
Japan	Okinawa, Okinawa	0	0	0	0	0	0	0	0	0	0	0	0
Malaysia	Pasir Gudang, Johor	16	0	0	0	16	0	0	0	0	0	0	0
Malaysia	Penang	1675	1569	0	1	24	0	6	21	0	20	7	27
Malaysia	Tanjong Pelepas	22	4	0	0	4	1	0	1	0	3	4	3
Mauritius	Port Louis	4	0	1	0	0	0	0	0	0	0	0	3
Niue	Niue Island	1	0	0	0	0	0	0	0	0	0	0	0
Oman	Muscat	7	0	0	0	6	0	0	0	0	0	0	0
Papua New Guinea	Port Moresby	7	2	0	0	0	0	0	0	0	4	0	0
Philippines	Manila	232	156	4	2	33	1	8	3	0	2	7	15
Samoa	Apia	265	8	179	1	1	0	0	0	0	70	3	4
Saudi Arabia	Jeddah	58	17	0	0	42	0	0	0	0	0	0	0
Singapore	Singapore	9844	5382	168	114	1000	105	125	71	66	278	544	1994
South Africa	Durban	85	21	0	2	22	1	6	1	0	3	12	18
Sri Lanka	Colombo	34	3	0	0	1	0	2	0	0	11	14	3
UK	London	1927	508	0	256	224	40	54	9	5	45	153	634
UK	London-Gatwick	57	19	0	4	8	1	1	0	0	1	2	21

Country	Port of export	Total freight	Appliances	Produce	Pharmaceuticals	Metals	Glass	Furniture	Fur	Footwear	Foodstuffs	Fibres	Other
UK	London-Heathrow	4629	1240	3	266	628	63	75	17	17	182	343	1794
UK	London-Stansted	0	0	0	0	0	0	0	0	0	0	0	0
UK	Tilbury	11	6	0	1	1	0	0	0	0	0	0	3
United Arab Emirates	Abu Dhabi	1	0	0	0	0	0	0	0	0	0	0	1
United Arab Emirates	Dubai	57	12	0	0	7	1	2	0	1	13	3	17
United Arab Emirates	Jebel Ali	0	0	0	0	0	0	0	0	0	0	0	0
United Arab Emirates	Sharjah	1	0	0	0	0	0	0	0	0	0	1	0
US Virgin Islands	St Croix Island Apt	0	0	0	0	0	0	0	0	0	0	0	0
USA	Brunswick, GA	0	0	0	0	0	0	0	0	0	0	0	0
USA	Honolulu, HI	386	185	4	3	26	4	12	4	0	14	16	118
USA	Jacksonville, FL	11	1	0	0	0	0	0	0	0	0	0	10
USA	Nashville, TN	30	21	0	1	2	0	0	0	0	0	1	6
USA	Orlando, FL	44	7	25	1	7	0	1	0	0	0	0	3
USA	St Petersburg, FL	0	0	0	0	0	0	0	0	0	0	0	0
USA	Tampa, FL	33	22	0	0	2	0	1	0	0	0	0	8

Table c. Details of the freight types that comprise each category and the categories (HS2 Chapters) used to classify incoming freight in the Statistics New Zealand database (source: Statistics New Zealand). Description of categories provided in Table d.

Mode of transport	Type of freight	HS2 Chapters
Sea freight	Appliances and machinery	84–89
	Fibres etc	50–63
	Bulk freight	25, 27, 28, 31
	Foodstuffs	2–4, 9–23
	Furniture/toys etc	94, 95
	Furs and skins	41–43
	Glass, ceramics etc	68–70
	Metals, plastics, organic chemicals etc	72–81, 26, 29, 32, 39, 40
	Produce	6–8
	Wood based products	44–48
	Other	All remaining chapters
Air freight	Appliances and machinery	84–89
	Produce	6–8
	Pharmaceutical products	30
	Metals, plastics, organic chemicals etc	72–81, 26, 29, 32, 39, 40, 83
	Glass, ceramics etc	68–70
	Furniture/toys etc	94, 95
	Fur and skins	41–43
	Footwear	64
	Foodstuffs	2–4, 9–23
	Fibres etc	50–63
	Other	All remaining chapters

Table d. Description of categories (HS2 Chapters) used to classify incoming freight in the Statistics New Zealand database.

Categories	Description
01	Animals; live
02	Meat and edible meat offal
03	Fish and crustaceans, molluscs and other aquatic invertebrates
04	Dairy produce; birds' eggs; natural honey; edible products of animal origin, not elsewhere specified or included
05	Animal originated products; not elsewhere specified or included
06	Trees and other plants, live; bulbs, roots and the like; cut flowers and ornamental foliage
07	Vegetables and certain roots and tubers; edible
08	Fruit and nuts, edible; peel of citrus fruit or melons
09	Coffee, tea, mate and spices
10	Cereals
11	Products of the milling industry; malt, starches, inulin, wheat gluten
12	Oil seeds and oleaginous fruits; miscellaneous grains, seeds and fruit, industrial or medicinal plants; straw and fodder
13	Lac; gums, resins and other vegetable saps and extracts
14	Vegetable plaiting materials; vegetable products not elsewhere specified or included
15	Animal or vegetable fats and oils and their cleavage products; prepared animal fats; animal or vegetable waxes
16	Meat, fish or crustaceans, molluscs or other aquatic invertebrates; preparations thereof
17	Sugars and sugar confectionery
18	Cocoa and cocoa preparations
19	Preparations of cereals, flour, starch or milk; pastrycooks' products
20	Preparations of vegetables, fruit, nuts or other parts of plants
21	Miscellaneous edible preparations
22	Beverages, spirits and vinegar
23	Food industries, residues and wastes thereof; prepared animal fodder
24	Tobacco and manufactured tobacco substitutes
25	Salt; sulphur; earths, stone; plastering materials, lime and cement
26	Ores, slag and ash
27	Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes
28	Inorganic chemicals; organic and inorganic compounds of precious metals; of rare earth

Categories	Description
	metals, of radio-active elements and of isotopes
29	Organic chemicals
30	Pharmaceutical products
31	Fertilizers
32	Tanning or dyeing extracts; tannins and their derivatives; dyes, pigments and other colouring matter; paints, varnishes; putty, other mastics; inks
33	Essential oils and resinoids; perfumery, cosmetic or toilet preparations
34	Soap, organic surface-active agents; washing, lubricating, polishing or scouring preparations; artificial or prepared waxes, candles and similar articles, modelling pastes, dental waxes and dental preparations with a basis of plaster
35	Albuminoidal substances; modified starches; glues; enzymes
36	Explosives; pyrotechnic products; matches; pyrophoric alloys; certain combustible preparations
37	Photographic or cinematographic goods
38	Chemical products n.e.s.
39	Plastics and articles thereof
40	Rubber and articles thereof
41	Raw hides and skins (other than furskins) and leather
42	Articles of leather; saddlery and harness; travel goods, handbags and similar containers; articles of animal gut (other than silk-worm gut)
43	Furskins and artificial fur; manufactures thereof
44	Wood and articles of wood; wood charcoal
45	Cork and articles of cork
46	Manufactures of straw, esparto or other plaiting materials; basketware and wickerwork
47	Pulp of wood or other fibrous cellulosic material; recovered (waste and scrap) paper or paperboard
48	Paper and paperboard; articles of paper pulp, of paper or paperboard
49	Printed books, newspapers, pictures and other products of the printing industry; manuscripts, typescripts and plans
50	Silk
51	Wool, fine or coarse animal hair; horsehair yarn and woven fabric
52	Cotton
53	Vegetable textile fibres; paper yarn and woven fabrics of paper yarn
54	Man-made filaments
55	Man-made staple fibres
56	Wadding, felt and non-wovens, special yarns; twine, cordage, ropes and cables and articles thereof

Categories	Description
57	Carpets and other textile floor coverings
58	Fabrics; special woven fabrics, tufted textile fabrics, lace, tapestries, trimmings, embroidery
59	Textile fabrics; impregnated, coated, covered or laminated; textile articles of a kind suitable for industrial use
60	Fabrics; knitted or crocheted
61	Apparel and clothing accessories; knitted or crocheted
62	Apparel and clothing accessories; not knitted or crocheted
63	Textiles, made up articles; sets; worn clothing and worn textile articles; rags
64	Footwear; gaiters and the like; parts of such articles
65	Headgear and parts thereof
66	Umbrellas, sun umbrellas, walking-sticks, seat sticks, whips, riding crops; and parts thereof
67	Feathers and down, prepared; and articles made of feather or of down; artificial flowers; articles of human hair
68	Stone, plaster, cement, asbestos, mica or similar materials; articles thereof
69	Ceramic products
70	Glass and glassware
71	Natural, cultured pearls; precious, semi-precious stones; precious metals, metals clad with precious metal, and articles thereof; imitation jewellery; coin
72	Iron and steel
73	Iron or steel articles
74	Copper and articles thereof
75	Nickel and articles thereof
76	Aluminium and articles thereof
78	Lead and articles thereof
79	Zinc and articles thereof
80	Tin; articles thereof
81	Metals; n.e.s., cermets and articles thereof
82	Tools, implements, cutlery, spoons and forks, of base metal; parts thereof, of base metal
83	Metal; miscellaneous products of base metal
84	Nuclear reactors, boilers, machinery and mechanical appliances; parts thereof
85	Electrical machinery and equipment and parts thereof; sound recorders and reproducers; television image and sound recorders and reproducers, parts and accessories of such articles
86	Railway, tramway locomotives, rolling-stock and parts thereof; railway or tramway track fixtures and fittings and parts thereof; mechanical (including electro-mechanical) traffic signalling equipment of all kinds

Categories	Description
87	Vehicles; other than railway or tramway rolling stock, and parts and accessories thereof
88	Aircraft, spacecraft and parts thereof
89	Ships, boats and floating structures
90	Optical, photographic, cinematographic, measuring, checking, medical or surgical instruments and apparatus; parts and accessories
91	Clocks and watches and parts thereof
92	Musical instruments; parts and accessories of such articles
93	Arms and ammunition; parts and accessories thereof
94	Furniture; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings; lamps and lighting fittings, n.e.s.; illuminated signs, illuminated name-plates and the like; prefabricated buildings
95	Toys, games and sports requisites; parts and accessories thereof
96	Miscellaneous manufactured articles
97	Works of art; collectors' pieces and antiques
98	New Zealand miscellaneous provisions

Appendix 2: Details of BIOSECURE methodology

BIOSECURE is a computer-based decision tool for management of biosecurity risks to New Zealand's indigenous ecosystems. The model runs over Landcare Research's intranet using specifically designed software with links to databases and GIS software.

Methods

Input data

Records of species occurrence are obtained from the scientific literature, ant collections records available on the web, and from communication with various researchers. Records for an exact locality or relatively defined area are predominantly used. For the mainland USA some data on county records are included (e.g., Callcott & Collins 1996) with the county seat used as the data point, and for many islands presence/absence information is all that was available. Data points are separated into those of introduced and native range. Within the introduced range, records closely associated with urban areas are identified and a separate analysis conducted excluding these data in order to separate risks associated with urban areas and heated buildings from other habitats. These data sets are submitted to BIOSECURE.

Climate summary

For each location, climate data was obtained for eight parameters (Table A2.1) from global climate surfaces based on half-degree grid square resolution. Summary data for each parameter (N, mean, minimum, maximum) are presented for native and introduced range separately.

Table A2.1: Global climate surfaces used in BIOSECURE.

Abbreviation	**Climate Parameters**
MAT	Annual mean of the monthly mean temperature (°C)
MINT	Mean temperature of the coldest month (°C)
MATS	Seasonality of temperature - absolute difference in mean temperature between the warmest and coldest months (°C)
PREC	Mean annual precipitation (mm)
PRECS	Seasonality of precipitation - absolute difference in mean precipitation between the wettest and driest months (mm)
VP	Annual mean of the monthly mean vapour pressure (kPa)
VPS	Seasonality of vapour pressure - absolute differences in mean vapour pressure between the most humid and the least humid months (kPa)
MAS	Annual mean of monthly mean solar radiation (MJ/m^2/day)

Climate similarity scores

For each climate parameter a frequency distribution of the data points is produced. The frequency distribution is then divided into 10 equal bins between the minimum and maximum values. Two additional bins of the same size are added, one above and one below the outermost values. Each bin gets a score between 1 (the additional two bins) and 100 based on the rescaled frequency of occurrence of the data within each bin (Fig. A2.1). Then all global grids are allocated a similarity (or risk) score between 0 (the climate parameters value for that grid square is outside the values in the bins) and 100.

The climate similarity scores for New Zealand are projected onto a 25 m resolution climate surface that forms part of the LENZ environmental domains (Leathwick et al. 2003).

Outlier data in each climate layer are checked. Data points are removed and the analysis re-run only if they are identified as entry errors, or the collection site was not well defined. In addition, if the outlying data point falls on the margin between two grids it is automatically allocated to a grid in the processing. If this automatic allocation results in an outlier (e.g., the grid is predominantly mountainous and has extreme temperature values) then the data are altered to move the point into the neighbouring grid.

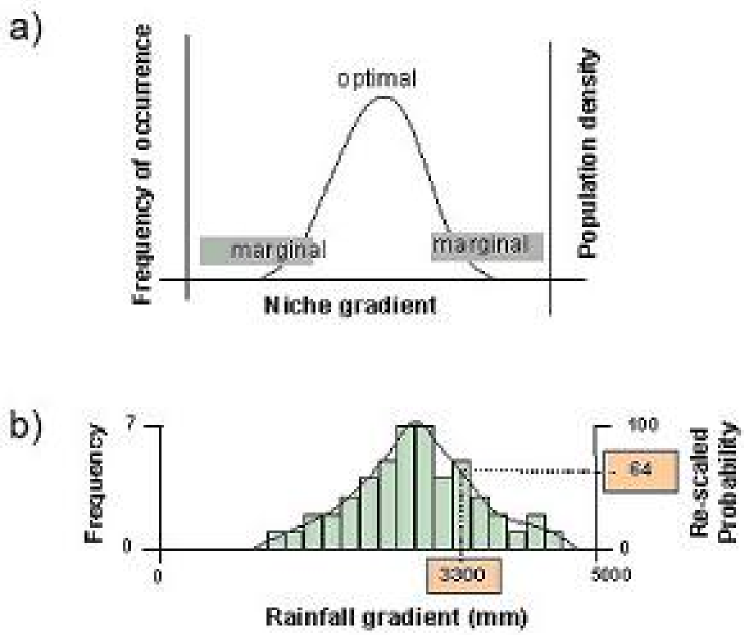

Fig. A2.1: *Stylised representation of the conversion of input data points to similarity scores. (a) The input data are assumed to represent the niche of the species for a particular parameter. (b) The frequency distribution is divided into a series of bins across the range of the data, allowing any point on the globe to be compared with this distribution and given a similarity score from 0 (outside the range of the data) to 100 (bin with highest frequency of data = optimal climate) (figure modified from a presentation of G. Barker).*

Individual climate layers are assessed for distinctiveness between the international data and New Zealand, and presented in the results if they show a high degree of discrimination (large areas of New Zealand with no similarity or in the marginal zone relative to the international data. MAT, MINT and PREC are routinely presented to allow comparison between species).

An overall summary risk map is also presented; this represents the mean of the similarity scores of five climate layers (MAT, MINT, PREC, VP, PRECS). This presentation approximates the summary map produced by the risk assessment tool Climex.

Appendix 3: Summary of current known distribution and BIOSECURE analysis for two ant species already established in New Zealand.

Linepithema humile is widely distributed in northern New Zealand while *Pheidole megacephala* is restricted to Auckland despite being established since the 1940s (Fig. A3.1).

Prediction of New Zealand range for Linepithema humile *(Argentine ant)*

Native range data for this species overlap with northern New Zealand for MAT. MINT shows similarity for a greater area, but still within northern New Zealand. MAS shows low similarity with New Zealand. The other parameters show some discrimination within New Zealand. The introduced range greatly extends the areas of similarity of New Zealand, as the ant has become widely distributed globally, particularly in areas of anthropogenic disturbance. Large areas of the North Island and the northern South Island show overlap for MAT (Fig. A3.2), and all other parameters show greater overlap. For many areas where temperature parameters show high similarity there is marginal similarity for rainfall (at the high end), which may restrict its distribution (Fig. A3.2).

For MAT the climate in the native + introduced non-urban sites still shows considerable overlap with New Zealand (Fig. A3.3). However, this may be overstated as 3 cold outliers, from native habitat in Chile (Snelling 1975), contribute to the overlap of MAT across southern New Zealand, and these records may be a different species, as the taxonomy of *Linepithema* in South America is in need of revision (A. Wild, pers. comm.).

Predictions of New Zealand range for Pheidole megacephala *(big-headed ant)*

Native range data suggest most of New Zealand is too cold for *Ph. megacephala*, with overlap for MAT only for the far north of the North Island. This overlap results from a single record from grassland by a highway in Pietermaritzburg, South Africa (Samways et al. 1997). The native + introduced range suggests potential range overlap with Northern NZ for MAT (Fig. A3.4) which results principally from urban records, from Sana'a in Yemen (Collingwood & Agosti 1996) and from an imprecise record from "central Spain" (Collingwood 1978). Most of the North Island and coastal South Island is within the range of data for MINT. Precipitation is too high in south-western and alpine areas, and these areas are also too cold (Fig. A3.4). Other climate parameters are highly suitable across much of New Zealand.

For the native + introduced (non-urban range), MAT overlap is minimal (Fig. A3.5), and caused only by the single point from Pietermaritzburg, South Africa. Overlap of MINT is reduced but there is still overlap for large areas of northern New Zealand. Results for the other climate parameters are the same as for the analysis of native + introduced range.

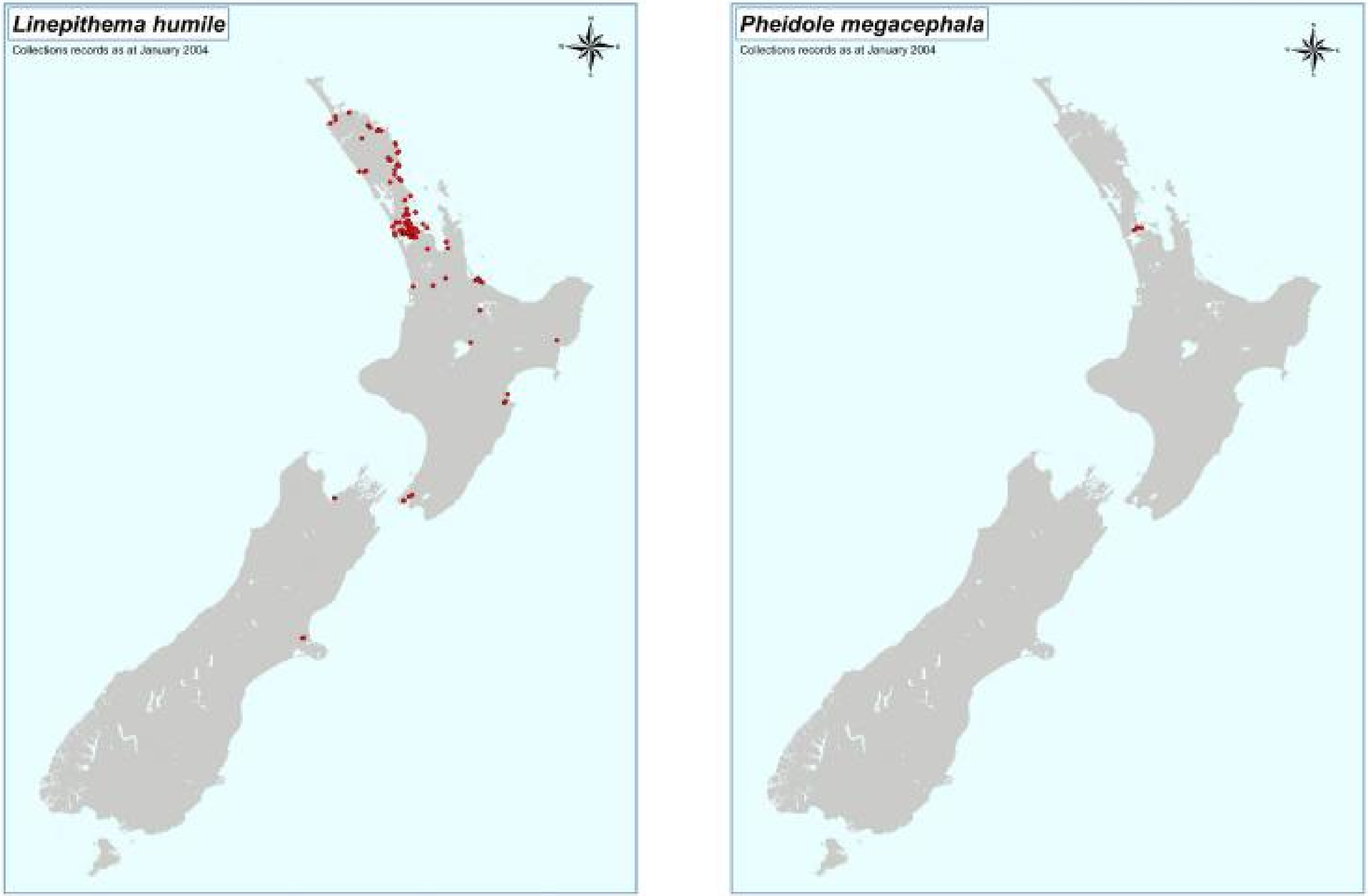

Fig. A3.1: *New Zealand sites where* L. humile *and* Ph. megacephala *are known to be established.*

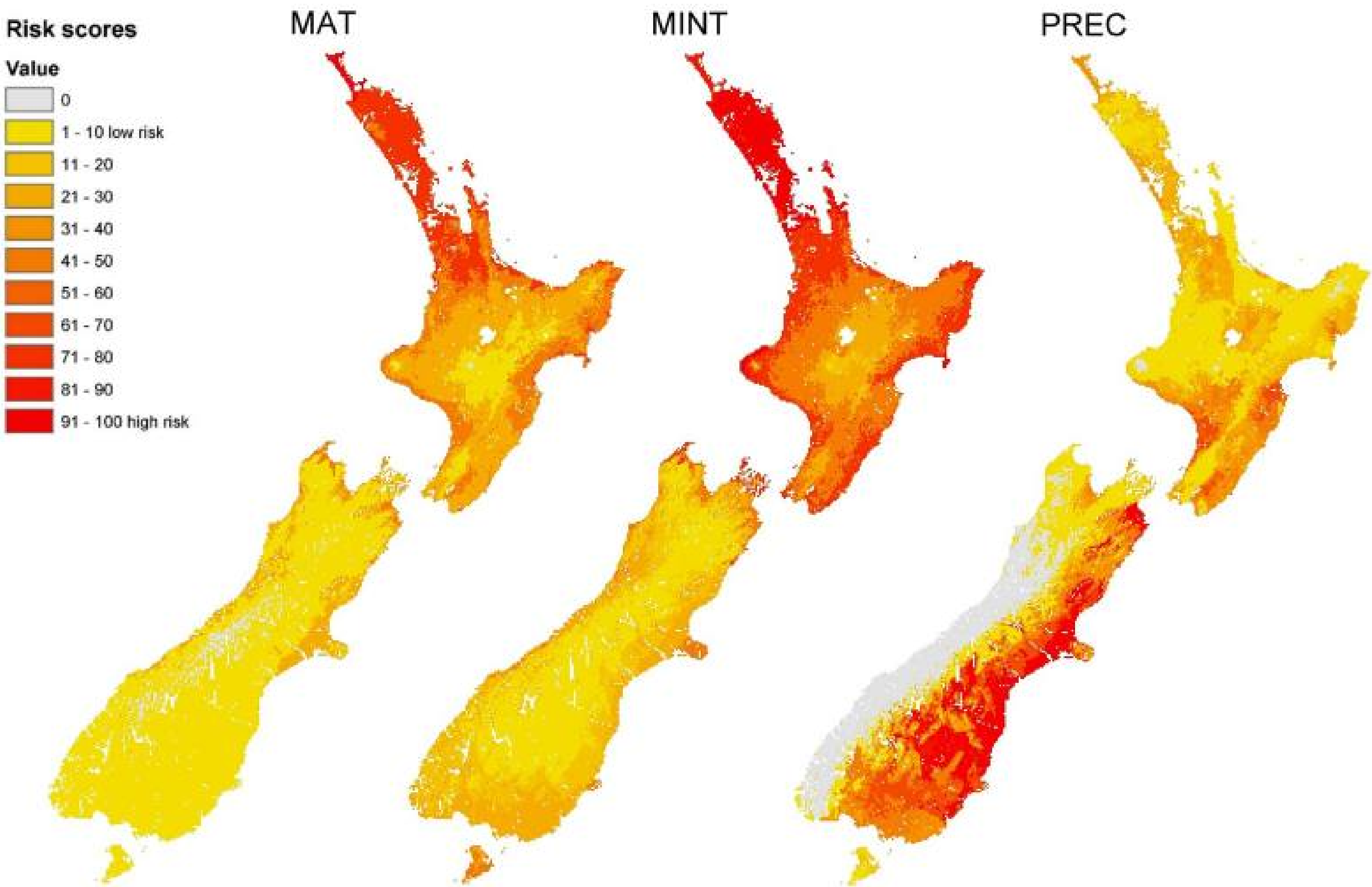

***Fig. A3.2:** Similarity of native + introduced ranges of* L. humile *to New Zealand for MAT, MINT and PREC.*

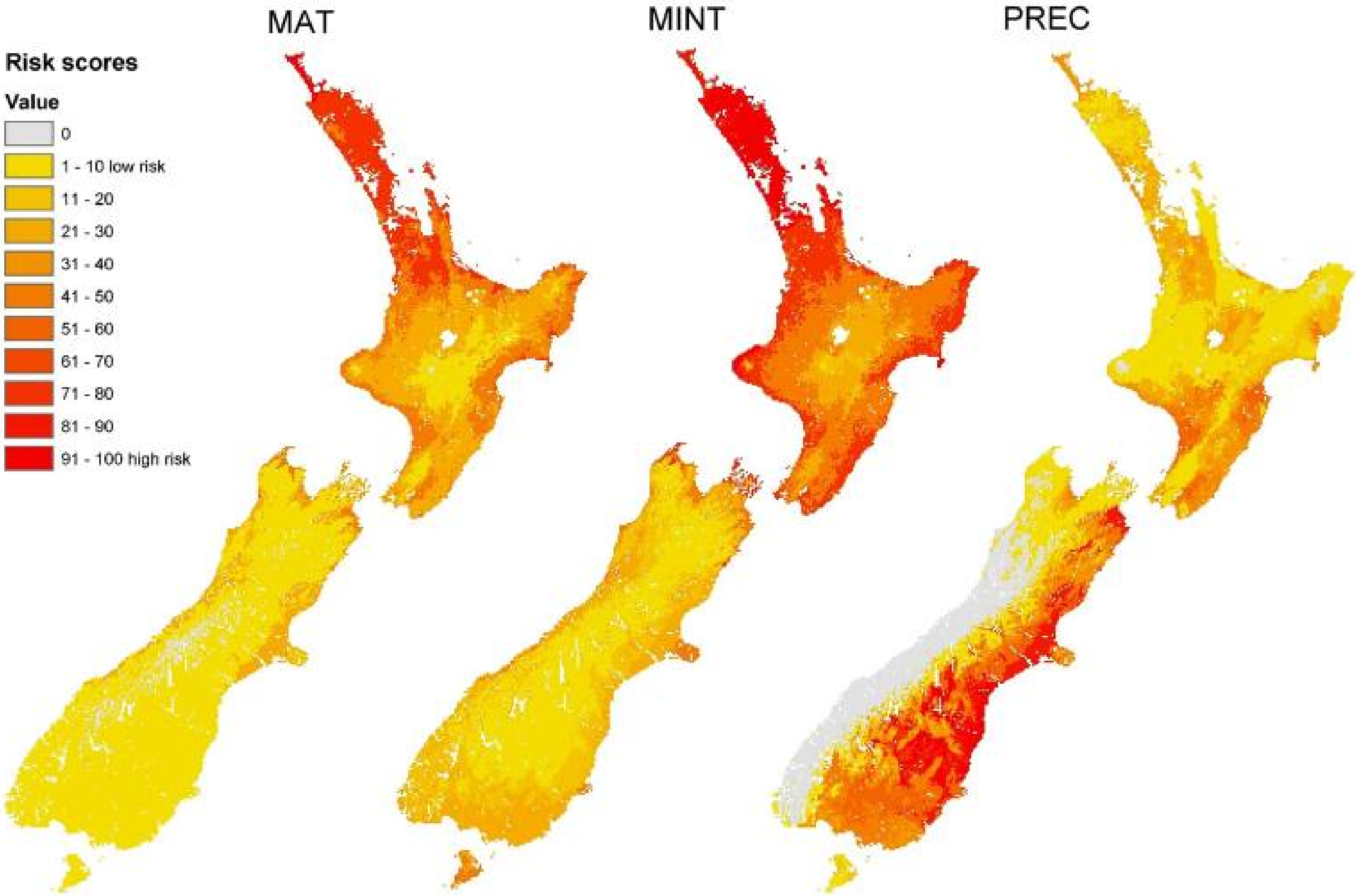

Fig. A3.3: *Similarity of native + non-urban introduced ranges of* L. humile *to New Zealand for MAT, MINT and PREC.*

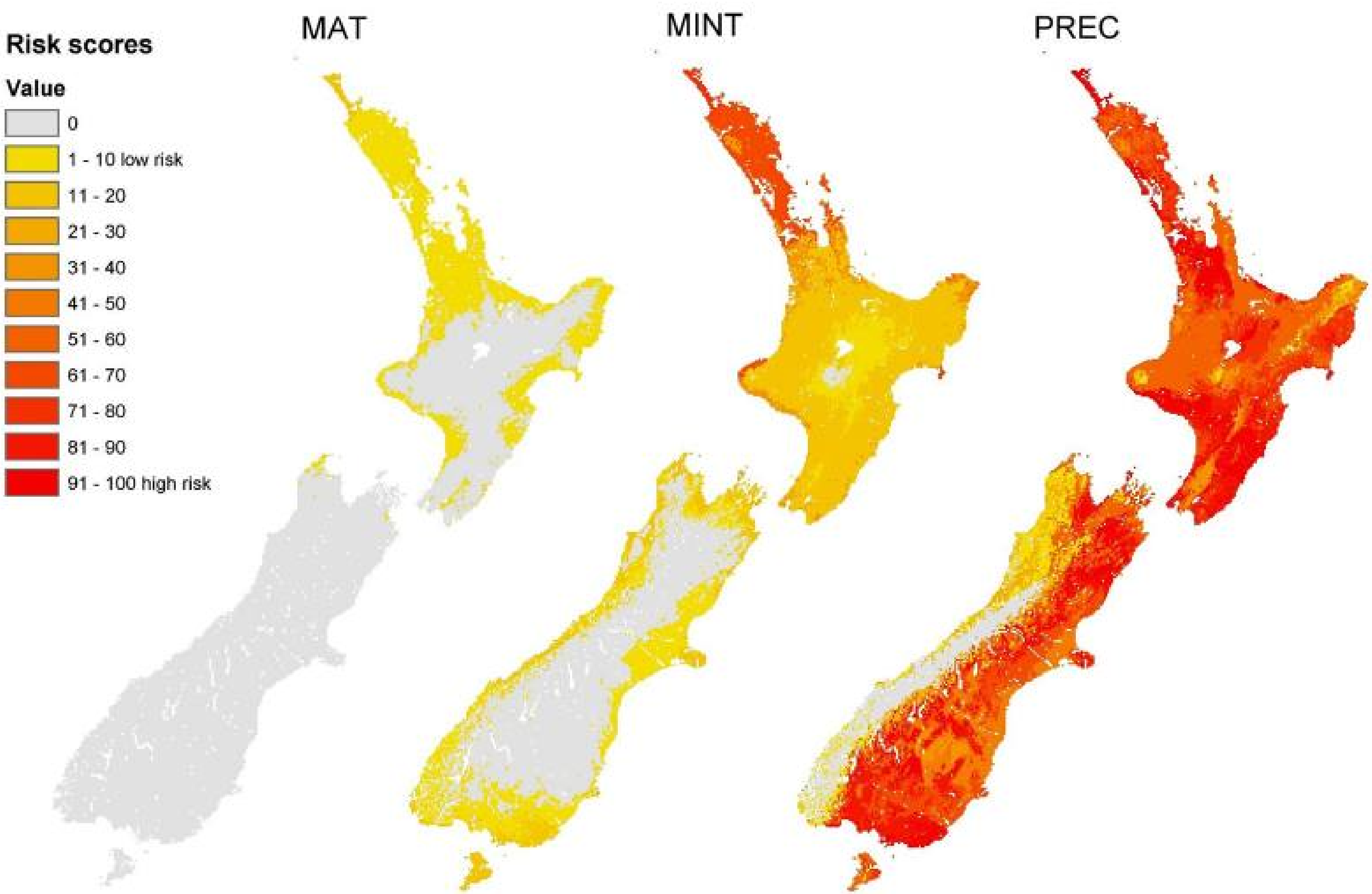

Fig. A3.4: *Similarity of native + introduced ranges of* Ph. megacephala *to New Zealand for MAT, MINT and PREC.*

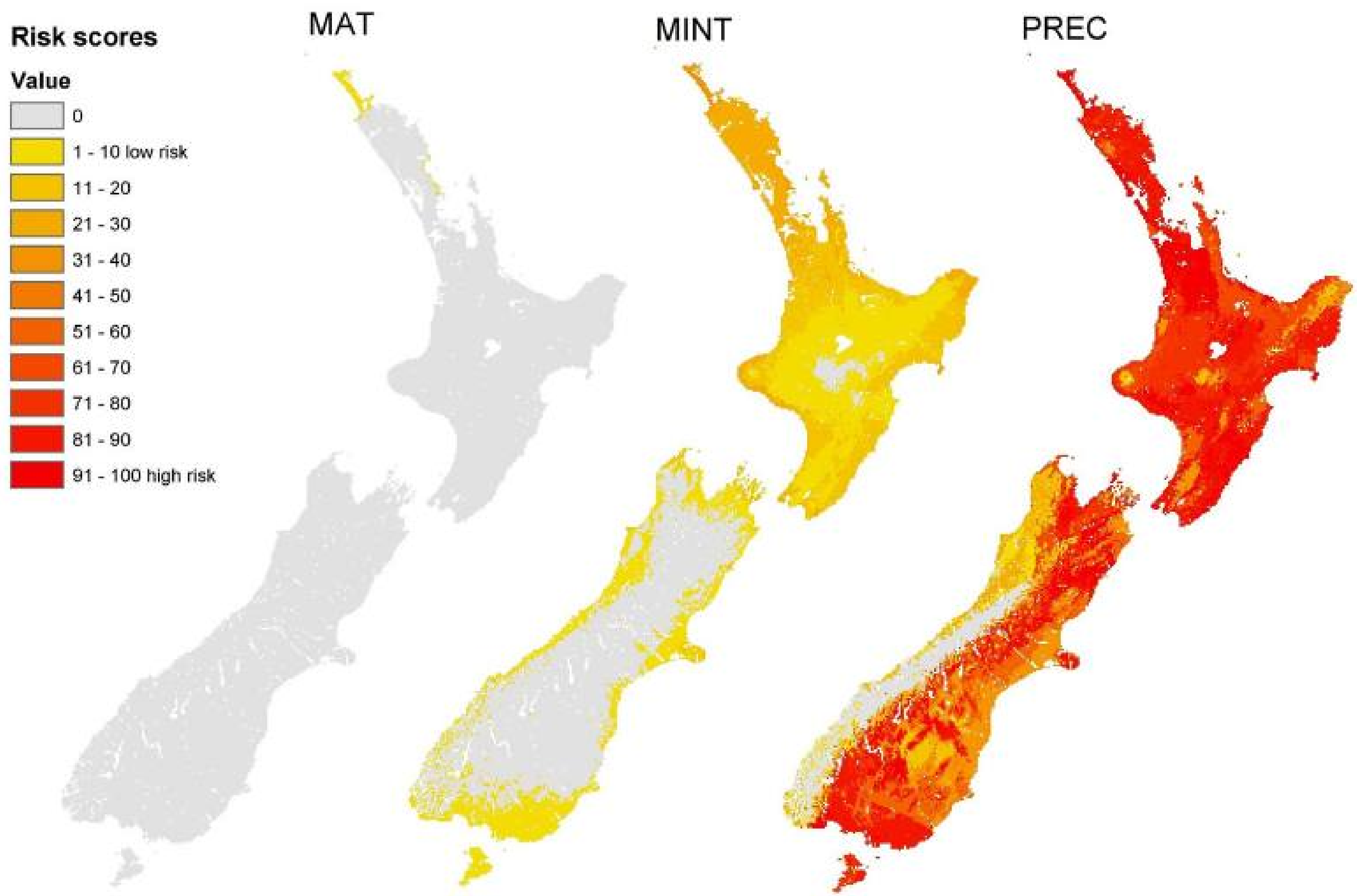

Fig. A3.5: *Similarity of native + non-urban introduced ranges of* Ph. megacephala *to New Zealand for MAT, MINT and PREC.*