Invasive Ant Risk Assessment

Lasius neglectus

Harris, R.

(A) PEST INFORMATION

A1. Classification

Family:	Formicidae
Subfamily:	Formicinae
Tribe:	Lasiini
Genus:	*Lasius*
Subgenus:	*Lasius*
Species:	*neglectus*

Juan Jesús López (Mijas, Spain)

A2. Common name(s)

None reported.

A3. Original name

Lasius neglectus Van Loon, Boomsma & Andrásfalvy

A4. Synonyms or changes in combination or taxonomy

Lasius neglectus was synonymised with *L. turcicus* Santschi, 1921 (=*Lasius niger* var. *turcica* Santschi) by Seifert (1992), but was later considered to be a separate species that split from its sister species *L. turcicus* by rapid species divergence (Seifert 1992, 2000). Morphology, genetics, and zoogeography suggest a very recent separation from *Lasisus turcicus* Santschi with a most probable radiation centre in Asia Minor (Seifert 2000).

A5. General description (worker)

Identification

Size: body length 2.5–3.5 mm.

Colour: body brown (Fig. 1), unicolorous, sometimes head and gaster slightly darker than alitrunk; upper legs same colour as body, lower legs paler. Antennal scapes pale brown, antennae darkening towards tip.

Surface sculpture: head and alitrunk rather smooth, only finely reticulate. Gaster smooth.

General description: antennae 12-segmented, last segment twice the length of preceding segment, but not conspicuously wider. Antennal sockets situated very close to posterior clypeal margin. Eyes relatively large (Fig. 1). Mandibles with 7 teeth. Clypeus without or with only a faint medial longitudinal carina. Metapleuron with distinct metapleural gland lined with a row of setae, situated just above hind coxa. Propodeum without spines, propodeal spiracle round to weakly ovate, located close to posterior propodeal margin. One node (petiole) present. Head and body covered with erect setae standing above general pubesence but short, particularly on alitrunk. Scape and fore tibiae without erect hairs; middle and hind tibiae may have occasional erect hairs. Stinger lacking; acidopore present (small circular opening surrounded by a fringe of setae at the tip of the gaster that produces formic acid).

Notes:

1. Ants of the genera *Lasius* and *Formica* are the most dominant and abundant in the Holarctic region but they are difficult to distinguish. Generic diagnostic characters are given in Agosti & Bolton (1990).

2. *L. neglectus* shows extreme morphological similarity to *L. turcicus*. According to Seifert (2000), absolute size differences remain the only way to distinguish the female castes: maximum head width is smaller than 840 µm in *neglectus* workers and larger than 850 µm in *turcicus* workers. Mandibular dentition is reduced compared with the related species *L. lasioides*, *L. alienus*, *L. psammophilus*, *L. paralienus* and *L. piliferus*, although this difference can only be identified by statistical comparison.

3. Finding many dealate queens in a nest is a key diagnostic characteristic of *L. neglectus* , as it is the only polygynous European *Lasius* (s.str.) species. This biological aspect is probably the best way to identify *L. neglectus*, although identifications should be verified with the morphology.

Sources: Espadaler & Bernal 2004; Seifert 2000

Formal description: *Van Loon et al. 1990*

Voucher specimens of *L. neglectus* originating from Spain are deposited in the NZAC Tamaki.

Due to the morphological difficulties in discriminating this species from close relatives it would be useful to have a genetic characterisation of *L. neglectus* from verified collections. This would allow more rapid positive identification of any interceptions or incursions of this species at the New Zealand border.

a)

b)

Fig. 1: Images of Lasius neglectus; a) lateral view of worker, b)dorsal view of group of ants feeding (Source: Juan Jesús López (Mijas, Spain)).

A6. Behavioural and biological characteristics

A6.1 Feeding and foraging

Lasius neglectus makes extensive use of aphid honeydew for food (Espadaler & Bernal 2004). In north-east Spain, during the early spring, when leaves are still lacking on trees or tree aphids are scarce, this ant constructs earth tents over small herbs protecting the stem and root aphids. In summer foragers visit aphids on different tree species in huge numbers and are occasionally seen carrying small prey (Collembola, Psocoptera). From late April to late October (northern hemisphere) foragers are active continuously tending aphids. Preliminary quantitative measures indicate ants can extract a mean of 250 ml of honeydew per month from evergreen oak (*Quercus ilex*), and as much as 950 ml honeydew per month from poplar trees (*Populus nigra*) (Espadaler & Bernal 2004). Foragers dominate an area, displacing other ant species (Espadaler & Bernal 2004).

In three studied populations from NE Spain, activity was similar throughout the year, beginning in early March and continuing until late November, when certain colonies in warm micro-climates were still active (Fig. 2; Espadaler & Bernal 2004).

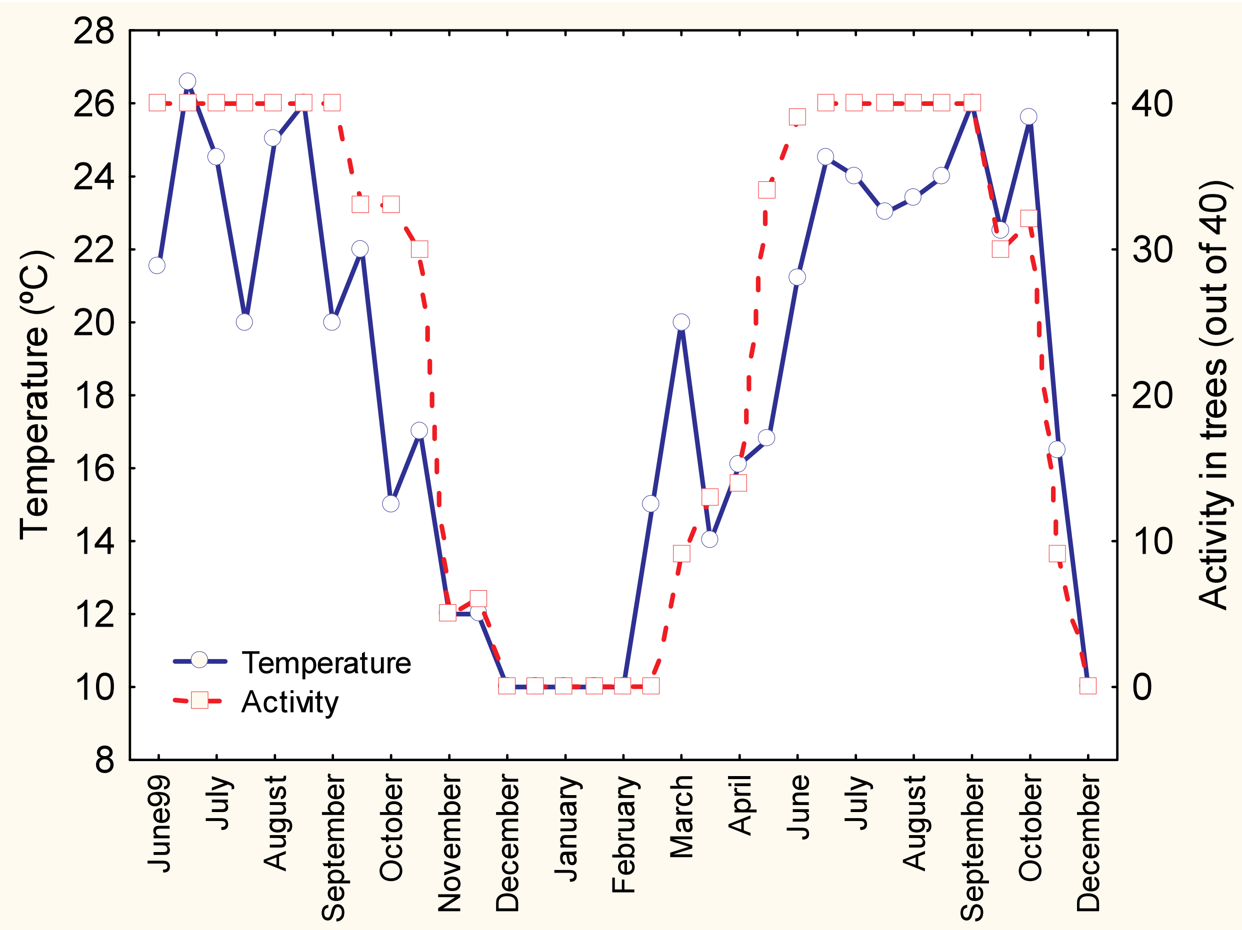


Fig. 2: *Forager activity (presence on 40 trees) in Seva, Spain. Fortnight data from June 2000 to December 2001 (Source: Espadaler & Bernal 2004).*

A6.2 Colony characteristics

Lasius neglectus is uncolonial and polygynous (Espadaler & Bernal 2004). Nests are often very difficult to delimit as they may coalesce into supercolonies occupying areas as large as 14 ha. The colonies may be more discrete in urban areas where the population has not achieved high densities and may occupy a single tree. Compared with other *Lasius* species, the sexuals appear earlier in the year: as early as March in heated buildings in Budapest. Nests can occur in a wide variety of sites including: under stones, temporal refuges with aphids at the base of herbs, and rubbish (Espadaler & Bernal 2004).

The number of queens in a 14 ha supercolony was estimated to be about 35 500 ± 10 000, by counting queens under stones in Seva, Spain, with queens present in similar densities in the middle and edges of the supercolony (Espadaler et al. 2004). In addition, queens were sampled in soil cores and densities were extrapolated to over 350 000 queens in the soil away from rocks. Using soil cores, worker number for the entire population in May 2002, was estimated as 112 million or about 800 workers/m^2 (excluding workers foraging in trees).

A7. Pest significance and description of range of impacts

A7.1 Natural environment

L. neglectus has principally been found in close association with urban areas and impacts on natural environments have not been reported. Natural and semi-natural open habitat may be at risk although dispersal to and within these habitats would be slow due to the principal forms of dispersal (budding and human-assisted dispersal). In Asia Minor *L. neglectus* was observed in natural steppe habitats (Seifert 2000), but no details of the locality or densities at the site were given.

In areas where *L. neglectus* is abundant in disturbed habitat, other surface feeding ant species have either vanished or have very reduced populations (Tartally 2000; Espadaler & Rey 2001; Dekoninck et al. 2002; Espadaler & Bernal 2004). Some arthropod groups appear to be enhanced (e.g., aphids) and others negatively impacted (e.g. Lepidoptera larvae) (Espadaler & Bernal 2004).

A7.2 Horticulture

The ability of *L. neglectus* to become abundant at a site seems to be highly dependent on aphid honeydew, and they exploit aphids of many species (Van Loon et al. 1990). They forage continuously with potentially significant impacts on plant health, possibly killing some affected trees (Espadaler & Rey 2001; Espadaler & Bernal 2004). They can also cause problems in glasshouses (Van Loon et al. 1990). There are no other specific reports from horticultural habitats of pest impacts, but their localised abundance and high use of honeydew would likely cause them to be considered a pest should they establish in areas where in horticulture crops are grown. This may especially be the case where crops are grown organically and minimal insecticides are applied, situations where *L. humile* has become a pest (Davis & Van Schagen 1993).

A7.3 Human impacts

Some populations of *L. neglectus* have attained pest status, affecting man or other biodiversity (Espadaler & Bernal 2004). Other populations are still in the establishment phase, which may simply reflect the lag phase found in many invaders (Espadaler & Bernal 2004). Where abundant (e.g., Seva, Taradell, and Matadepera, Spain; Paris, France) ants enter and spread throughout buildings (Espadaler & Bernal 2004). They seem to be attracted to electrical fields, occupying electrical plugs, connection boxes or electro-mechanical devices, such as automatic blinds and cause failure and/or damage by shorting (Jolivet 1986 (as *L. alienus*); Espadaler & Bernal 2004).

A8. Global distribution

A8.1 Native range

Lasius neglectus is most likely native to Asia Minor (Seifert 2000), although to date there are no collection records clearly stated as being from within its native range.

A8.2 Introduced range

First detected in Budapest, *L. neglectus* has been collected from other locations within Hungary and from Belgium, Bulgaria, France, Georgia, Germany, Greece, Italy, Kyrgyzstan, Poland, Rumania, Spain, Turkey, and the Canary Islands (Fig. 3; Seifert 2000; Espadaler & Bernal 2003; Espadaler & Bernal 2004).

A8.3 History of spread

It was first noticed in Budapest, Hungary, in the early 1970s, but mistaken at the time for *L. alienus* (Forester) (Van Loon et al. 1990). Van Loon et al. (1990) formally described the species from Budapest specimens. In Belgium it was collected in 1978, but also mistaken for *L. alienus*, and not correctly identified until 2001 (Dekoninck et al. 2002). The rapid expansion of its range in recent years in part probably reflects both clarification of identification due to the morphological similarity to native *Lasius* species, and rapid spread in Europe (Seifert 2000). It is highly likely that it is present in a number of other cities in Europe, but is yet to reach high densities and be identified and reported.

A.9 Habitat range

Lasius neglectus has been found in Europe between sea level and 1750 m, with 88% of sites situated below 1000 m (Seifert 2000). Across its current geographical range, populations live in a variety of conditions, including strictly urban habitats, e.g., streets with heavy traffic, to semi-urban sites, mildly degraded habitats, and seemingly undisturbed localities (Espadaler & Bernal 2004). Populations have been observed in anthropogenically disturbed grassland outside of human settlements and in light coniferous and deciduous woodland. In Asia Minor *L. neglectus* was observed in natural steppe habitats (A. Schulz, pers. comm., cited in Seifert 2000). A common feature of all such places is the presence of trees, on whose aphid populations these ants depend (Espadaler & Bernal 2004).

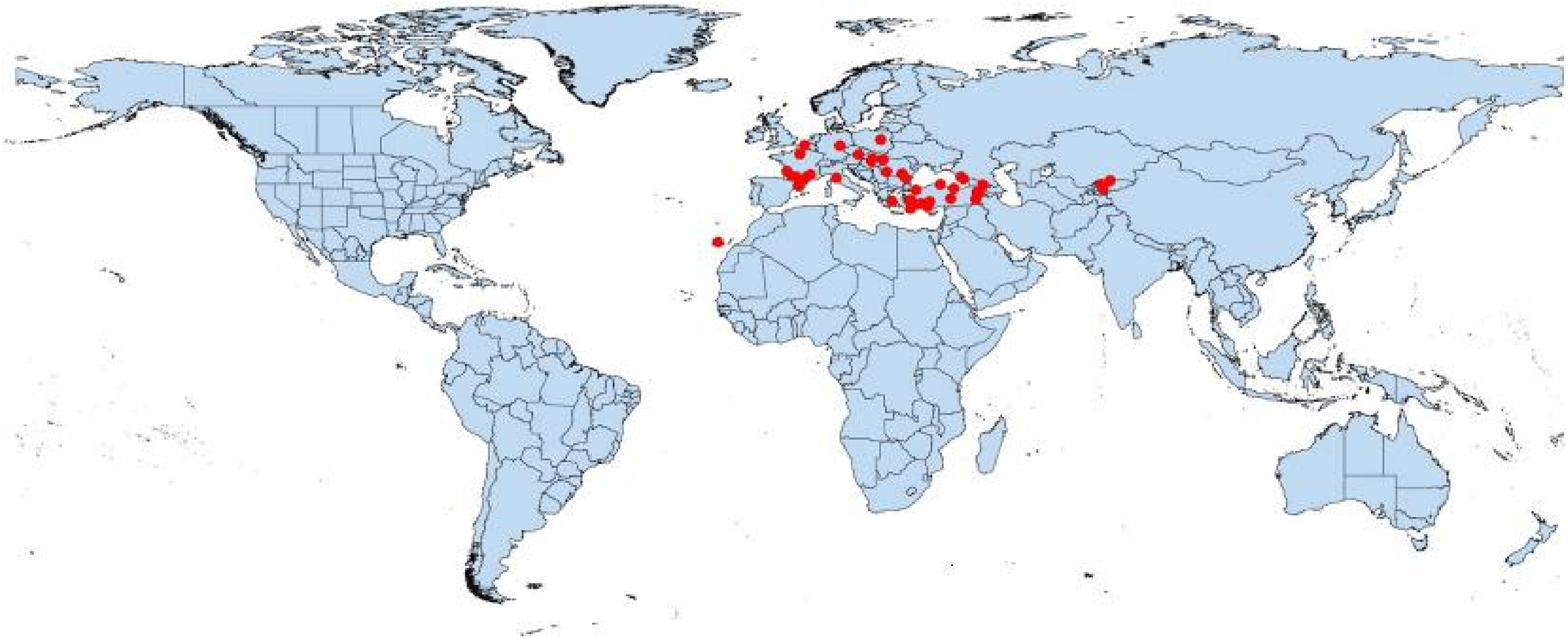


Fig. 3: Distribution records in Landcare Research Invasive Ant Database of Lasius neglectus *as at December 2004. It is unclear if any current collection records are from the native range, thought to be somewhere in Asia Minor.*

(B) LIKELIHOOD OF ENTRY

B1. Identification of potential pathways

In Budapest it was transported to new areas within the city in potted plants (Van Loon et al. 1990). There is currently no other information on the type of commodities on which the ants might travel between countries (X. Espadaler, pers. comm.). An unconfirmed source of populations in Seva, Spain, is soil transported by ship during urbanisation (X. Espadaler, pers. comm.).

B2. Association with the pathway

Records indicate *L. neglectus* has a close association with human settlement and often nests in human-modified habitats, e.g., amid rubbish, in buildings, pavement edges (Van Loon et al. 1990; Espadaler & Bernal 2004). It also nests under stones, in temporary refuges with aphids at the base of herbs, in grassy slopes, among tree roots, and in apparently barren solid soil. *Lasius neglectus* is considered a "tramp" ant species (Holldobler & Wilson 1990; Passera 1994) because it lacks nuptial flights, its spread through Europe via urban centres suggesting a reliance on human-mediated dispersal, and it has a close association with humans where it establishes. The species also nests in a variety of locations. As a consequence of its nesting habits can close association with humans it is likely to have casual associations with a range of commodities as a hitchhiker, rather than host specific associations.

As of March 2004, there had been no confirmed interceptions of *L. neglectus* at the New Zealand border (MAF Interceptions database). There are two records of unidentified *Lasius* species (one from Japan in 1999 and one from the USA in 2000). These records are outside the known range of *L. neglectus* and so are unlikely to be this species. There have also been no confirmed interceptions of *L. neglectus* at the Australian (data from January 1986 to 30 June 2003; source: Department of Agriculture, Fisheries and Forestry, Canberra) or Hawaiian borders (data from January 1995 to May 2004; Source: Hawaii Department of Agriculture). In Hawaii there were two interceptions of unidentified *Lasius* from California, outside the known range of *L. neglectus*.

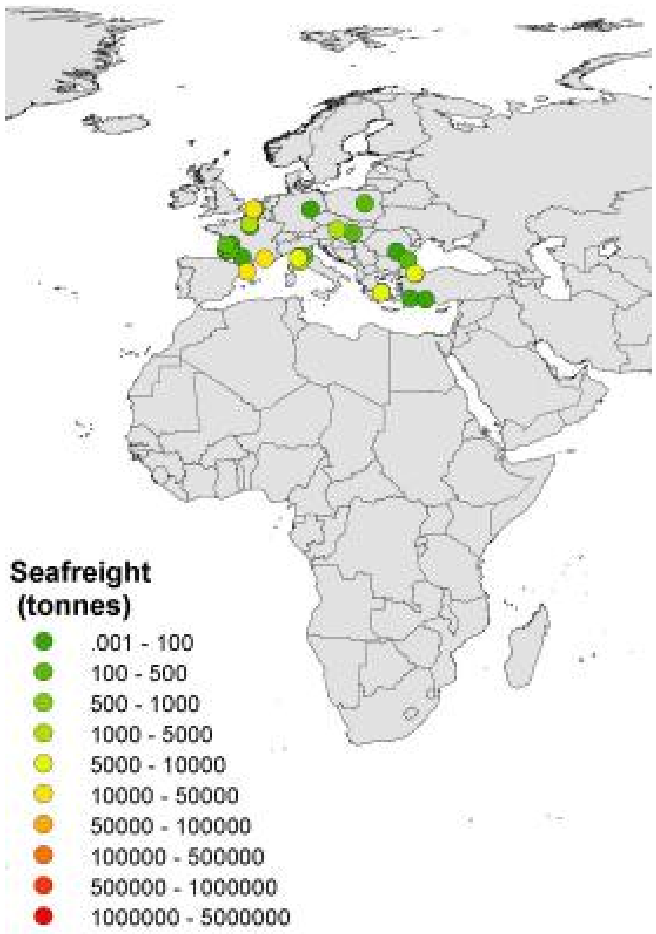
Historically there has been a relatively low risk of freight arriving in New Zealand contaminated with *L. neglectus*, since it has only relatively recently established near ports with which New Zealand trades (Van Loon et al. 1990; Espadaler & Bernal 2004). Also, in many sites of recent spread it is yet to reach high population levels or become widely dispersed. Chances of freight contamination in the future will likely be higher as *L. neglectus* continues to spread to new locations, and it becomes more abundant at sites already invaded. This pattern of human-assisted "jump dispersal" with slow radiation from infested areas is similar to that reported for *Linepithema humile* (Suarez et al. 2001; Ward et al. 2005).

B3. Summary of pathways

A summary of freight coming to New Zealand from localities within 100 km of sites known to have *L. neglectus* infestations is presented in figure 4 (also see Appendix 1). The total volumes of freight from localities with this ant between 2001 and 2003 were relatively low, representing about 1.2% of total air freight and less than 0.3% of sea freight.

In the first 3 months of 2004, at least 492 containers (0.8% of total) originated from risk locations (MAF container origins dataset). The majority of these originated from Fos-sur-Mer in France (36%), Barcelona in Spain (32%), Istanbul in Turkey (13%), and Livorno (9%) and Trieste in France (7%). Of the 492 containers, 79% landed at Auckland, Tauranga or Napier with the remainder spread around New Zealand (including 81 to South Island ports).

a)



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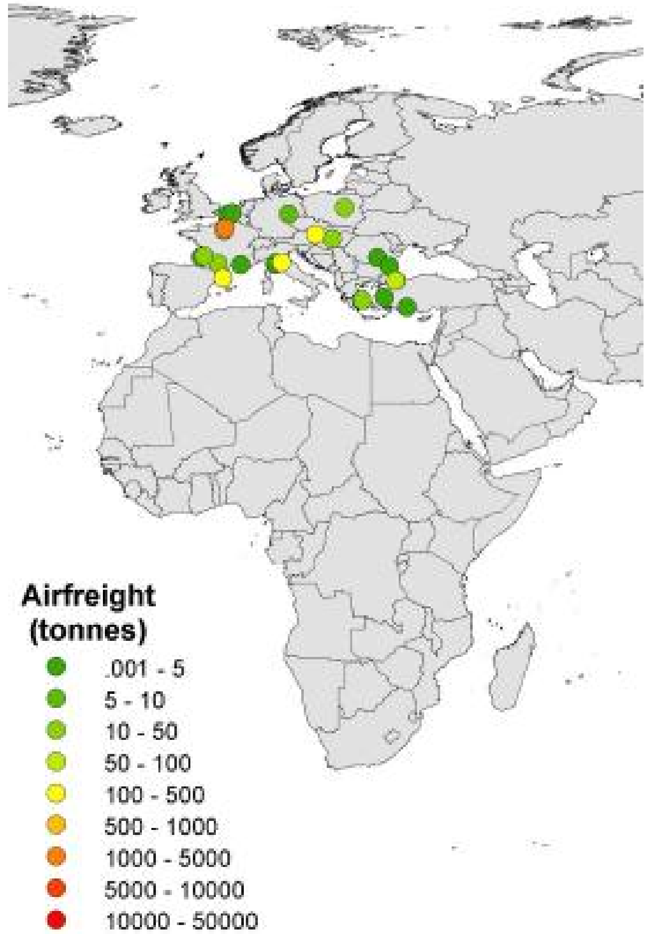

Fig. 4: *Summary of a) sea freight and b) air freight coming to New Zealand from localities within 100 km of sites where* L. neglectus *has been reported. Values represent the total freight (tonnes) during 2001, 2002 and 2003 (source: Statistics New Zealand). Details of locations and freight types are 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 to 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 those for 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 might 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 ant species indicated that temperature rather than interspecific competition primarily determined the temporal activity of ant communities in open Mediterranean habitats (Cerda et al. 1998). Subordinates were active over a wider range of temperatures (Cerda et al. 1998). In California, *L. humile* foraging was restricted by temperature; ants were most abundant at bait at 34°C and bait was abandoned at 41.6°C (Holway et al. 2002b).

Temperature generally controls the metabolism and activity of ant colonies, 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 nest sites (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; most of the lower South Island contains 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 because of 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 Lasius neglectus

No specific experimental data on climatic tolerances were found for this species. The known range of *L. neglectus* is temperate, unlike most of the other invasive ants threats to New Zealand. It occurs in sites in Turkey and Kyrgyzstan with mean air temperature of the coldest month of -4.4 and -5.5ºC respectively (Seifert 2000). Although this ant species obviously survives very cold winters, these are continental locations that have contrastingly warm summers. For all known sites of establishment before 2000 with available climate data mean air temperature for July (summer in Northern hemisphere) varied between 19 and 30ºC and annual precipitation between 230 and 2000 mm (the latter achieved in the subtropical climate of the eastern Black Sea coast (Seifert 2000). In cooler climates precipitation above 600 mm may limit distribution (Seifert 2000).

Data from Spain suggests that high temperatures and low rainfall are restricting further spread of *L. neglectus* and increase in abundance in some areas (X. Espadaler, pers. comm.), as is reported for *L. humile*, another temperate climate invasive species (Ward 1987; Van Schagen et al. 1993; Kennedy 1998).

C1.3 BIOSECURE analysis

52 locality records were used for the assessment of *L. neglectus* (Fig. 5). Climate parameters used are defined in Appendix 2. This species was described from its introduced range only. The native range is assumed to be Asia Minor (Seifert 2000), but no collection records have so far been reported from this area. It is a relatively newly reported pest with a rapidly increasing distribution in Europe. To date, it has primarily been found closely associated with urban areas.

The introduced range of *L. neglectus* suggests overlap with virtually all of New Zealand for mean annual temperature (MAT) and mean minimum temperature of coldest month (MINT) (Fig. 6). There is one very cold outlier (Igdir in Turkey (Seifert 2000)) that is colder than temperatures in New Zealand. Rainfall (PREC) is higher over much of New Zealand than the known range, with large areas of New Zealand being wetter than the sites it has been and the data include a high rainfall outlier in Georgia. Despite similarities of MAT and MINT, seasonality of temperature (MATS) shows low similarity, reflecting the predominantly continental distribution in Europe. Data for vapour pressure (VP) from know range does not overlap with the northern North Island (Fig. 7). Other parameters are less discriminating across New Zealand.

Climate summary

The general climate summary for the international range of *L. neglectus* indicates similarity to New Zealand roughly equivalent to *L. humile* (Fig. 8). Climate similarity is higher in southern and central regions, in contrast to *L. humile* which shows greater similarity in northern New Zealand. Climate summary graphs are less useful than individual climate layers to compare risk between species and across regions of New Zealand, as differences are less evident.

Climate match conclusions

Available data indicate that temperature would not limit *L. neglectus* over most of New Zealand. *Lasius neglectus* is a cold climate species and winter and mean annual temperatures are likely to be suitable across much of New Zealand, unlike conditions for many other invasive ants. However, its current known distribution is predominantly in close association with urban areas and the risk of this species establishing outside of such areas is largely unknown. The low similarity in seasonality of temperature reflects the largely continental distribution of the ant in Europe. Also mean air temperatures of the hottest month in summer across much of New Zealand are low compared to those reported from its European range (19 to 30ºC (Seifert 2000)). Such summer temperatures only occur in northern New Zealand (Fig. 9). If high summer temperatures are critical for its development and are not offset by generally more moderate winter temperatures, the distribution may be more restricted by summer temperature than predicted by comparisons of MAT and MINT.

Other climate parameters may be more limiting than temperature as rainfall in New Zealand is generally higher than the known range. However, the species is clearly still spreading in Europe, and there is no detailed information on the extent of its native range and associated climate. It is likely that the climate envelope will expand as the distribution increases, at least for some climate parameters.

Fig. 5: *Distribution records available at the time the BIOSECURE analysis of* Lasius neglectus *was run*.

Table 1: Comparison of climate parameters for introduced range of *L. neglectus*

Parameter	n	Mean	Minimum	Maximum
Mean Annual Temperature (°C)				
Introduced Range	52.0	12.0	-4.2	18.7
Minimum Temperature (°C)				
Introduced Range	52.0	-0.3	-19.4	9.3
Mean Annual Precipitation (mm)				
Introduced Range	52.0	663.0	324.0	1224.0
Mean Annual Solar Radiation				
Introduced Range	52.0	15.1	10.3	19.4
Vapour Pressure (millibars)				
Introduced Range	52.0	9.4	3.0	13.0
Seasonality of Temperature (°C)				
Introduced Range	52.0	20.0	12.3	33.3
Seasonality of Precipitation (mm)				
Introduced Range	52.0	70.4	21.0	156.0
Seasonality of Vapour Pressure (millibars)				
Introduced Range	52.0	9.5	45.0	15.0

Table 2: Range of climate parameters from New Zealand (N = 196 GRIDS at 0.5 degree resolution). Data exclude 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

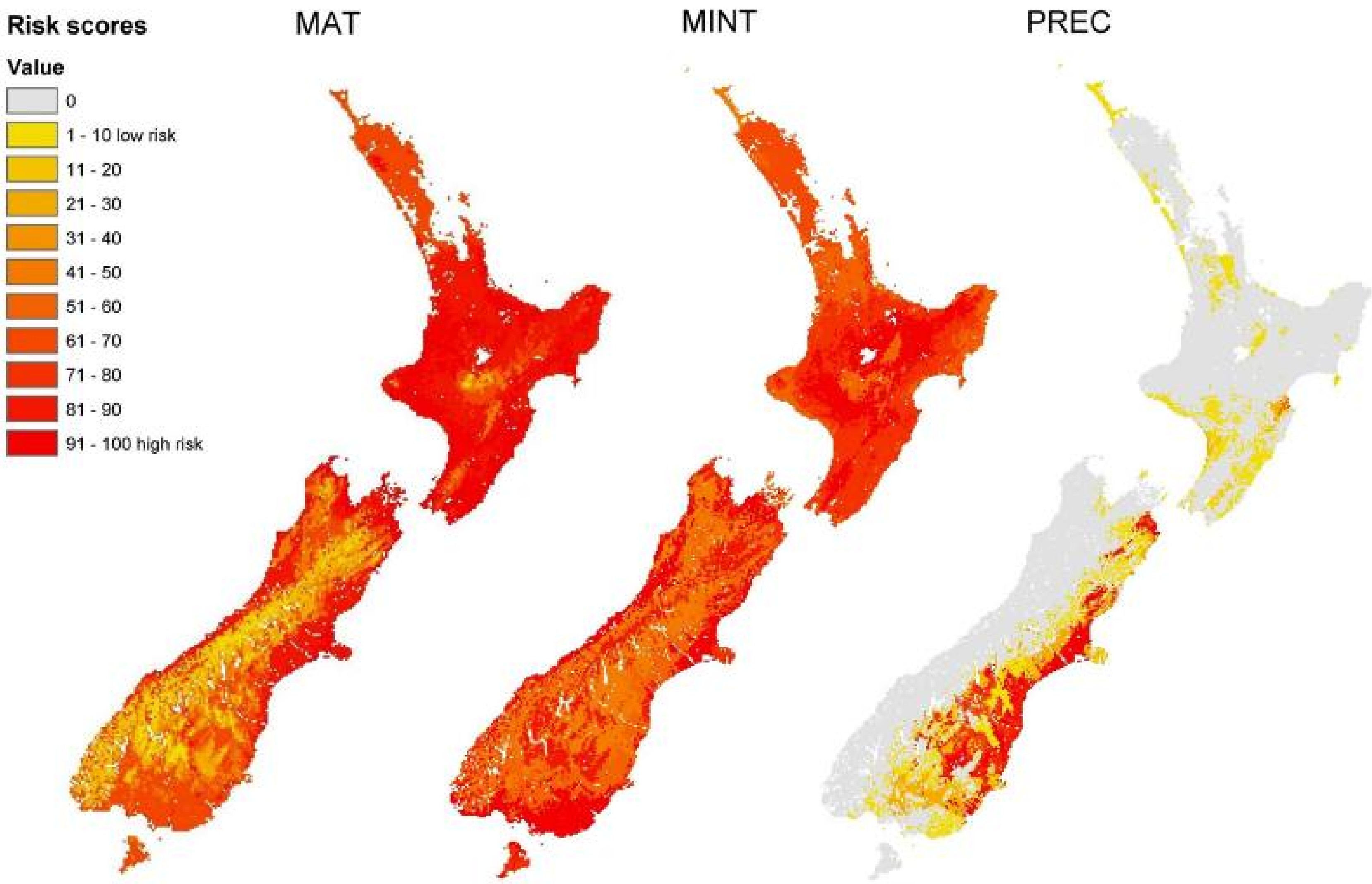

Fig. 6: *Similarity of known range of* L. neglectus *to New Zealand for MAT, MINT, and PREC.*

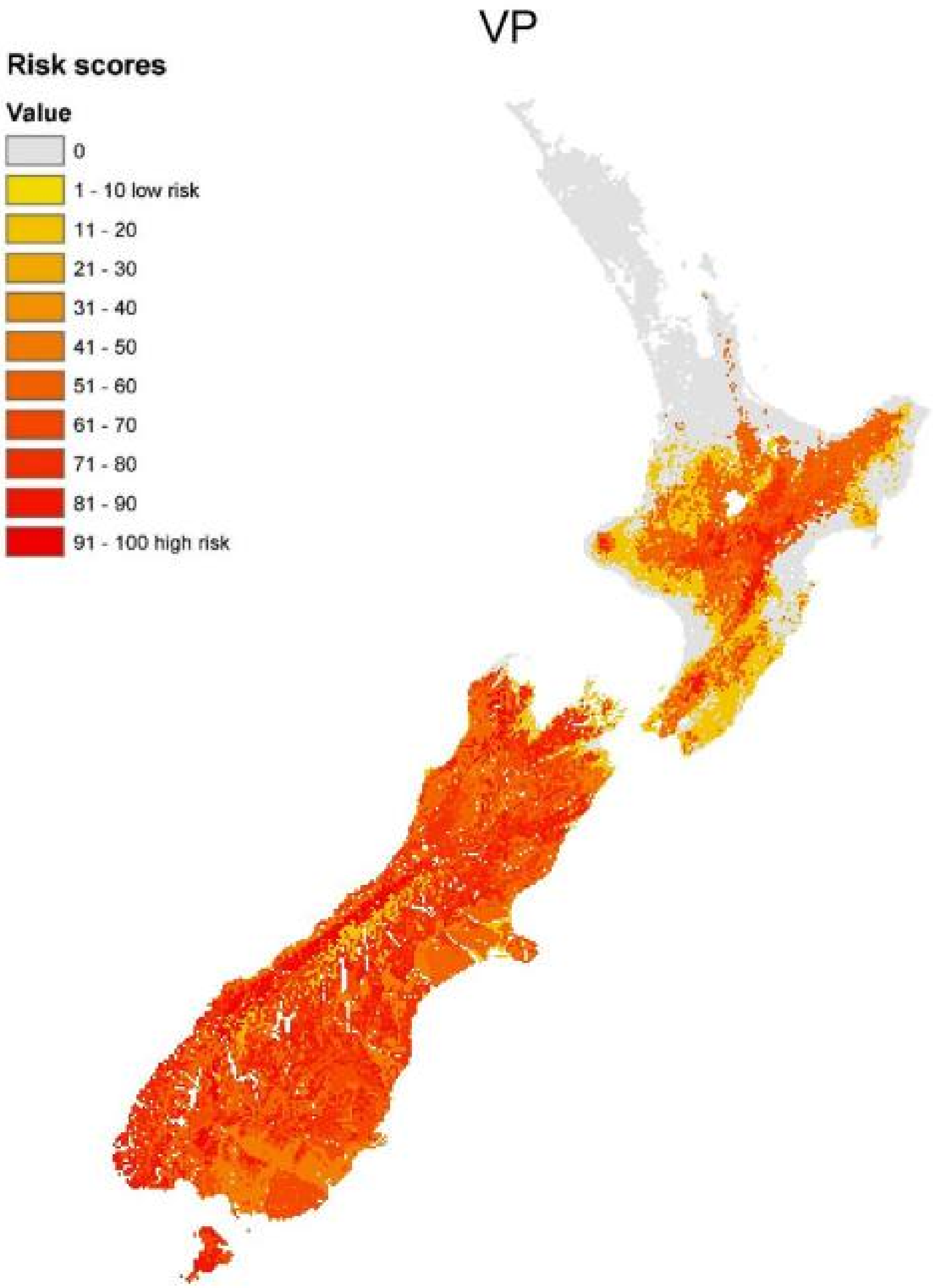

Fig. 7: Similarity of known range of L. neglectus *to New Zealand for VP.*

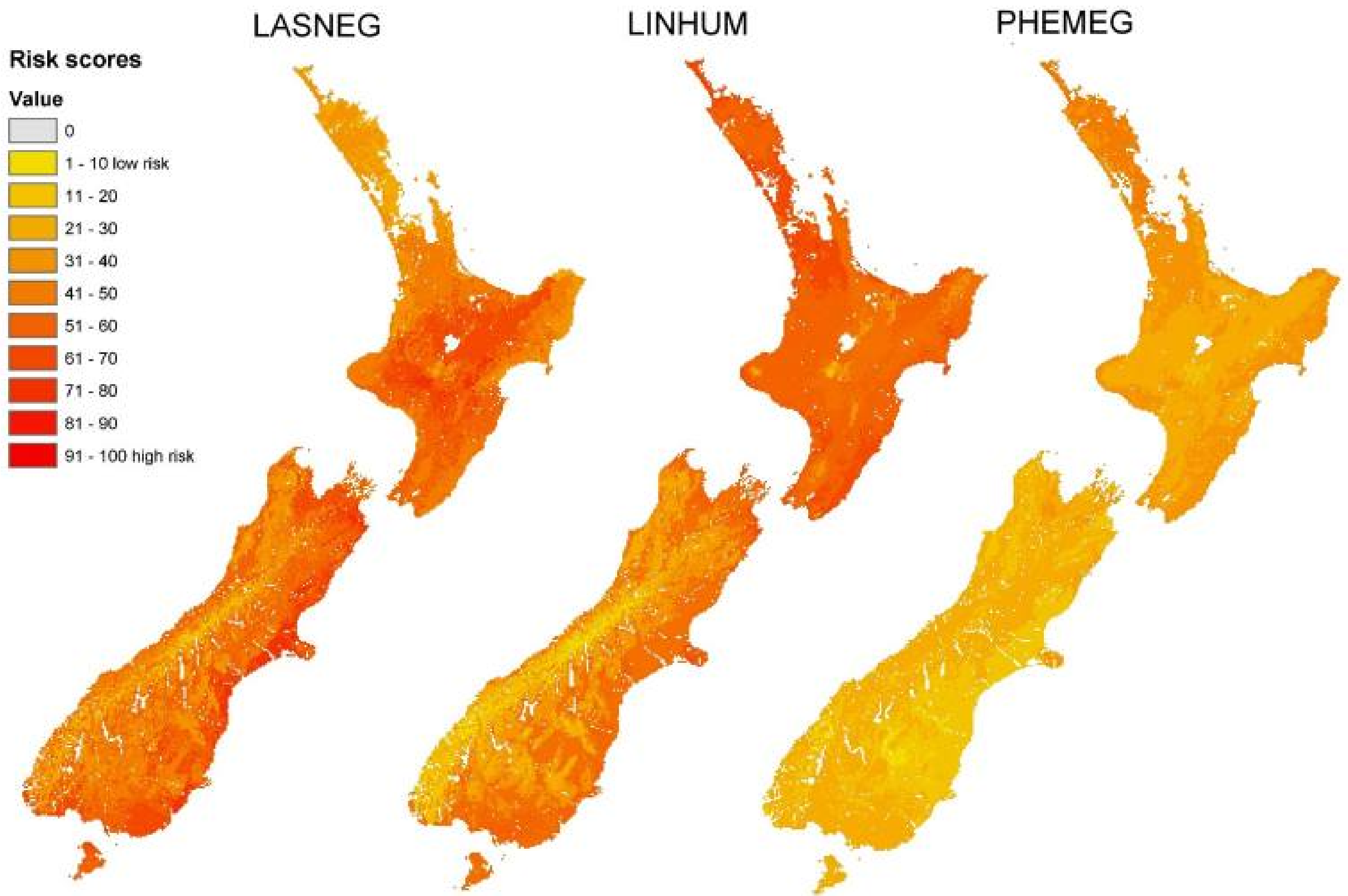

***Fig. 8:** Comparison of climate similarity to New Zealand of the international ranges of* L. neglectus, L. humile *and* Ph. megacephala *based on the mean of the similarity scores of five climate layers (MAT, MINT, PREC, VP, PRECS). This presentation approximates that produced by the risk assessment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

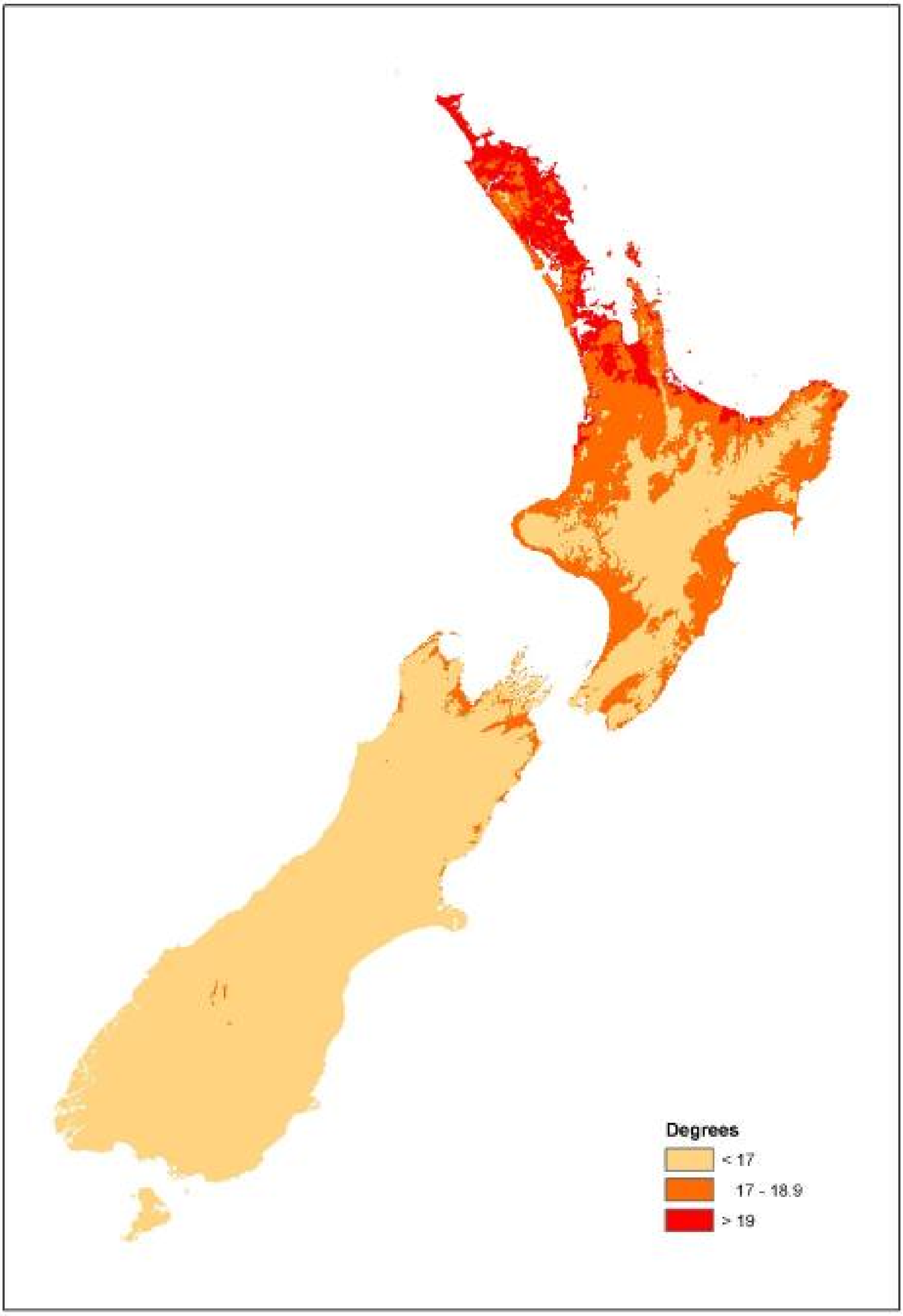

Fig. 9: *Average February temperatures across New Zealand.*

C2. Potential to establish in protected environments

In Europe, *L. neglectus* occupies a diverse range of locations within buildings (Espadaler & Bernal 2004), and has been reported to cause problems in glasshouses (Van Loon et al. 1990). Known records are predominantly from urban areas and this species will likely have a close association with urban environments over most of New Zealand. High rainfall may restrict its distribution outdoors, and protection provided by urban habitat may allow establishment in otherwise unsuitable high rainfall areas.

C3. Documented evidence of potential for adaptation of the pest

Lasius neglectus appears to have very broad temperature tolerances, having established permanent colonies in regions with mean January (winter) temperatures of -5°C (Seifert 2000) through to tropical locations (the Canary Islands).

The ant has highly mobile colonies and appears to be adapted to disturbed habitats that would be encountered at arrival points in New Zealand.

C4. Reproductive strategy of the pest

Nuptial flight seems to be absent in this species. Queens still show the morpho-physical adaptations for flight-dispersal and claustral colony foundation, though the corresponding behavioural repertoire seems to be lost (Seifert 2000). In a single instance alate males and queens were found in a spider web on a house wall (Seifert 2000), although this is not definite proof of flying behaviour. Except for this case, sexuals have never been detected flying out of the nest and although newly emerged queens have full sized wings, their total carbohydrate content is intermediate between species with flying and non-flying queens (Espadaler & Rey 2001). Colonies are polygyne unlike other *Lasius* occurring in Europe (Espadaler & Bernal 2004). Thus intranidal (within nest) mating is probably the rule with retention of newly emerged queens in the parental nest (Van Loon et al. 1990; Espadaler & Rey 2001). Queen morphology and physiological state at maturity indicate that *L. neglectus* can be considered intermediate between a monogyne independent colony forming ant and other polygyne invasive tramp ant species (Espadaler & Rey 2001).

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

Queens do not lay down large fat stores between emergence and mating. It is thought that queens may only succeed in dependant colony founding, even though independent colony founding was demonstrated in the laboratory (Espadaler & Rey 2001). An individual queen is unlikely to survive a sea voyage to New Zealand from Europe and be able to establish a new colony. A queen accompanied by workers would be needed to found a population in a new locality. However, as colonies are commonly found in rubbish, pot-plants and such disturbed habitat, there is a high likelihood that entire colonies would be transported.

Historical evidence suggests that the likelihood of successful establishment of a European ant species in New Zealand is low. Australia is the source of most of our introduced ant fauna (17 of 28 species) and another 7 species have wider distributions, but also occur in Australia and could have spread from there to New Zealand rather than directly from more distant locations (R. Harris, unpubl. data). There is no verified establishment of an ant species in New Zealand directly from the northern hemisphere. However, interception records (as at March 2003 (MAF Interceptions database)) indicate that at least ten live nests and 9 live queens (none *L. neglectus*) have been intercepted from Northern hemisphere locations. The reproductive fitness of these colonies and queens upon arrival is unknown. Historical data may underestimate risk of colonies surviving transport from the northern hemisphere as the volume of airfreight is ever increasing, and the voyage times for sea freight have, in some cases, shortened.

Oviposition is absent in workers (Espadaler & Rey 2001), so workers alone pose no risk of establishment.

C6. Likely competition from existing species for ecological niche

Lasius neglectus appears to occupy very similar habitats to *Linepithema humile* (Argentine ant). Where *L. humile* is established, establishment of *L. neglectus* may be inhibited and the two are unlikely to coexist, as *L. humile* typically only coexists with scavengers and cryptic species (Heterick et al. 2000). Temperature comparisons (see section C1.3) suggest that *L. neglectus* could establish further south than is predicted for *L. humile* (Harris 2002; Hartley & Lester 2003). In urban areas over most of the lower South Island there would be little completion from other ants. *Doleromyrma darwiniana* is becoming more widespread in urban areas of New Zealand and does not appear to coexist with many other species (R. Toft, pers. comm.). It may compete with *L. neglectus* thereby reducing the latter's chance of successful establishment. However, the outcome of specific competitive interactions between *D. darwiniana, L. humile* and *L. neglectus* is unknown. No other non-native ant species currently in New Zealand is likely to significantly compete with *L. neglectus*, and native ant species are typically not in high abundance in disturbed habitats.

C7. Presence of natural enemies

At present, no parasites or pathogens of *L. neglectus* are known, but surveys are planned for 2005 (Rey & Espadaler, in prep.).

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

Practices at the point of incursion (e.g., seaports and airports) are likely to affect the ability of *L. neglectus* to enter and establish at those sites. Presently, there are no routine treatments of port areas that would decrease the chances of survival for *L. neglectus*. Treatment of incursions of other invasive ant species in and around ports, and any management of *Linepithema humile* or *Doleromyrma darwiniana* using *Xstinguish* (considered likely to be attractive to *L. neglectus* (see section D)) is likely to reduce the chances of survival of new propagules of *L. neglectus*.

Existing invasive ant surveillance in and around ports should detect any significant *L. neglectus* incursions at the northern ports where effort is focused. However, the likelihood is that this species could also establish at colder southern ports that are not the focus of existing surveillance.

(D) LIKELIHOOD OF SPREAD AFTER ESTABLISHMENT

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

D1. Dispersal mechanisms

The dispersal of *L. neglectus* involves two discrete processes: colony diffusion (budding) and long distance dispersal mediated by humans. During budding new colonies are formed by inseminated queens walking with a group of workers to form a new colony nearby. These budded colonies can form new nests in a range of anthropogenic items. Human-mediated dispersal of colonies is probably of greatest importance to the ongoing spread of *L. neglectus* between and within countries (see section B2).

D2. Factors that facilitate dispersal

Natural: Budding occurs in the expansion phase of a colony and is probably triggered by density dependent pressure as in *Linepithema humile* (Krushelnycky et al. 2004). Disturbance of colonies will also increase the risk of movement to a new location. Dispersal of colonies by clumping together in floods has been reported for disturbance specialists like *Linepithema humile,* but so far has not been reported for *L. neglectus*.

Artificial: Human-mediated dispersal of colonies in pot plants, containers, rubbish bins etc. is probably of greater importance than natural spread. 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)

Lasius neglectus is likely to have a similar pattern of spread to *Linepithema humile*; a mix of jump dispersal to new areas through passive anthropogenic transport and slow spread from these localities by budding (Suarez et al. 200l; Ward et al. 2005). The rate of spread through budding will be dependant on habitat suitability, but is likely to be less than 1 km per year. For *L. humile*, expansion typically occurs over a relatively small scale of <150 meters per year, with estimates ranging from near zero in areas of climatic extremes up to 800 m/yr in highly favourable habitat invaded recently (Holway 1998; Way et al. 1997; Suarez et al. 2001). In Spain, relatively slow expansion of *L. neglectus* through budding is occurring in a subdivision that has been cleared of native vegetation (and native ants) (Fig. 10; Espadaler & Bernal 2004).

Patterns of human-mediated dispersal and budding of *L. neglectus* would likely follow similar patterns in New Zealand to that of *L. humile*, where median human-mediated dispersal distance has been estimated to be between 10 and 72 km, and is primarily responsible for the range expansion of *L. humile* in New Zealand (Ward et al. 2005).

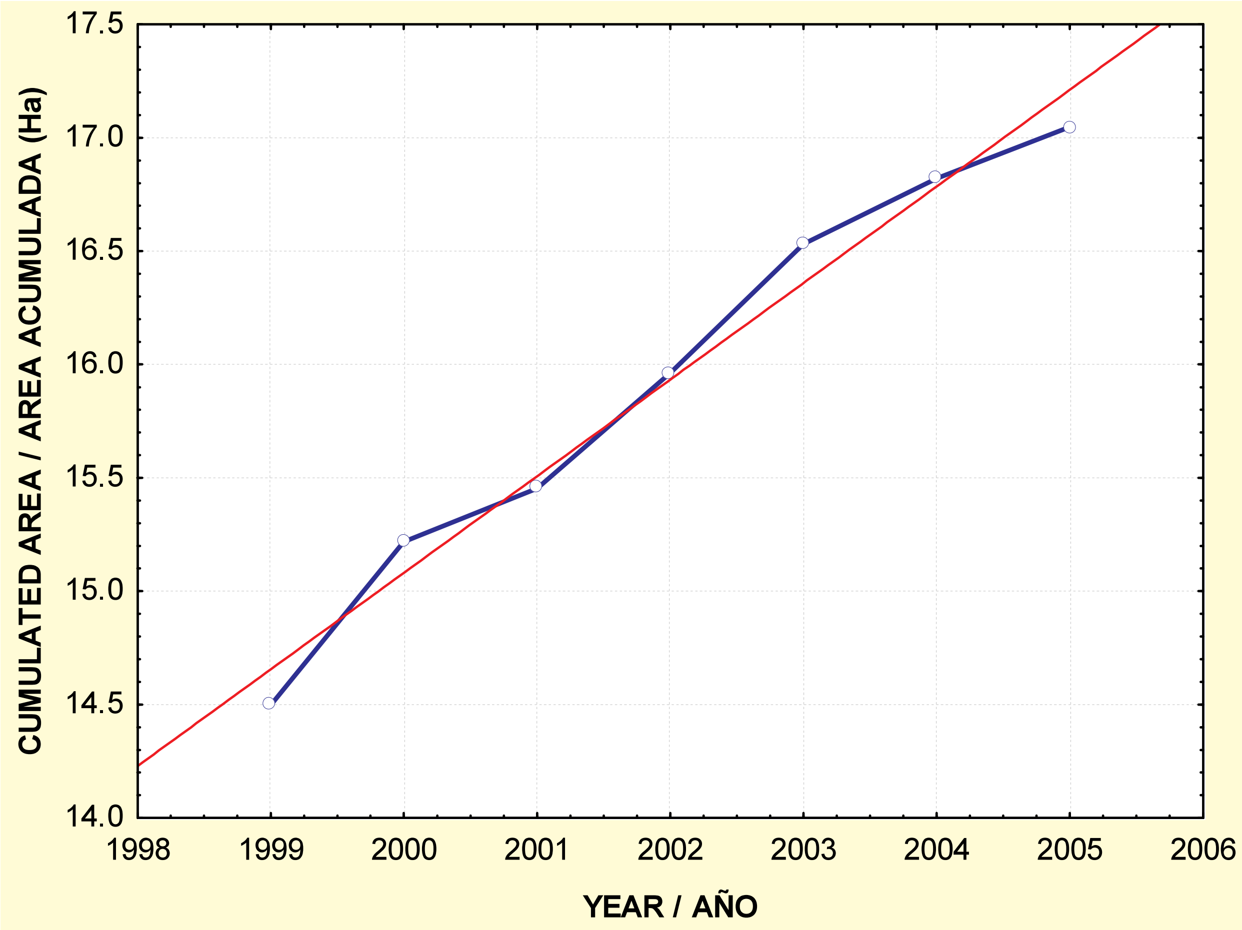

Fig. 10: *Rate of spread of a L. neglectus supercolony in a subdivision in Spain showing a relatively gradual increase in the area of infestation (Source: Espadaler & Bernal 2004)*

(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

The biology of *L. neglectus* indicates many similarities to *Linepithema humile* (X. Espadaler, pers. comm.), and the consequences of establishment in New Zealand are likely to mirror those predicted for *L.humile* (Harris 2002; Harris et al. 2002), although the limits of *L. neglectus* range may be further south than predicted for *L. humile*. *Lasius neglectus* will establish in urban areas, but these generally have a relatively low native biodiversity value. What other habitat types are invaded is less clear and more information will become available as its distribution expands in Europe. Open (high light) habitat and relatively open canopy scrub environments are probably at risk. Indigenous forests are likely to be unsuitable habitat, and likely to have *L. neglectus* present only in relatively low densities at the boundary with open habitat, but the extent of these margins could be significant in highly fragmented landscapes. In Europe, *L. neglectus* has only reached very high populations in some urban areas. Where it does establish and build up high population densities in New Zealand it will likely displace most other ants (the outcome of interactions between *L. humile* and *L. neglectus* is unknown but coexistence is unlikely) and alter invertebrate communities (limited studies in areas invaded by *L. neglectus* demonstrate the disappearance of other ants, reductions in Lepidoptera, and an increase in aphids (Espadaler & Bernal 2004)). Invertebrate species with very restricted distributions may be at risk. No native ant would be at risk of extinction due to their wide distribution and presence in forests that would serve as refuges. Detrimental impacts on nesting birds and reptiles are possible, as have been reported for *L. humile*. *Lasius neglectus* may form mutualisms with New Zealand honeydew-producing hemipterans and as a consequence increase their population numbers to damaging levels.

Spread into native habitats will probably take many years because of the dispersal mechanisms of *L. neglectus*. Localities with low visitation rates, especially by boat or vehicle, should have very low risk of invasion and, if natural dispersal rates by budding are similar to those of *L. humile* (around 150 m/yr (Suarez et al. 2001)), could remain free of *L. neglectus* for centuries. For example, at the rate of 150 m/yr from budding the ants would take over 600 years to spread from Kaitaia to Cape Reinga.

E1.2 Human health-related impacts

Lasius neglectus has not been reported to sting or spray formic acid on humans so no health related impacts are known. As the ant forages inside buildings in large numbers when very abundant it has the potential to spread disease (Fowler et al. 1993).

E1.3 Social impacts

Lasius neglectus is likely to invade urban areas. Where abundant, foragers will enter and possibly nest in buildings, foraging on any food left out, and may damage electrical equipment. In the garden abundant populations will be a nuisance, restricting the use of the garden for some activities (e.g., picnics), scales and aphid populations on plants may increase as a result of tending by ants. Populations of ants will likely be sufficiently abundant for pest control measures to be instigated by some people.

E1.4 Agricultural/horticultural losses

No reports were found of this ant as a horticultural pest, but in urban areas in north eastern Spain it is highly dependent on aphid honeydew (Espadaler & Bernal 2004). Foragers construct earth tents over small herbs protecting stem and root aphids and visit aphids on different tree species in huge numbers. They tend aphids continuously over summer, probably imposing a measurable cost on the energetic budget of individual trees. *L. neglectus* forage on a wide range of trees in urban environments including species of *Pinus* and *Citrus*. Preliminary quantitative measures of foraging indicate that ants can extract a mean of 250 ml honeydew per month from evergreen oak (*Quercus ilex*) and as much as 950 ml honeydew per month from poplar trees (*Populus nigra*). The effect of elevated fluid removal on tree growth is unknown, and may not occur in a plantation environment.

Should *L. neglectus* establish in orchards, it may become a pest through maintaining elevated aphid and/or scale densities. Such impacts are unlikely to be significant in conventional orchards that use insecticides. Also their densities would need to be greater than those of ant populations that already occur in such situations at low densities (Lester et al. 2003). Any detrimental impacts would in part be offset by beneficial impacts of the ant as a predator of other pest species, such as Lepidoptera (Espadaler & Bernal 2004).

Populations could be sufficiently abundant for pest control measures to be instigated in commercial premises where product contamination is a possibility. In urban areas where crops are grown in glasshouses the ant will also likely be a pest. No impacts on beehives have been reported but are also a possibility.

E1.5 Effect(s) on existing production practices

Changes to current organic horticultural practices may be necessary if the ant became established in orchards. It is still unclear if similar pest species like *L. humile* will establish in orchard habitats in New Zealand (Lester et al. 2003).

E1.6 Control measures

(This section makes extensive use of the review of baiting by Stanley (2004)).

Bait matrix (attractant + carrier): There is a lack of specific information on the attractants preferred by *L. neglectus*, but in Spain it appears highly dependent on honeydew sources and so may be attracted to sweet baits (Espadaler & Bernal 2004). No trials on food attractants have been carried out, but *L. neglectus* has similar food preferences to *L. humile* (X. Espadaler, pers. comm.).

Toxicants and commercial baits: A variety of toxins, primarily contact insecticide sprays, have been tested against *L. neglectus* in Spain (Espadaler & Bernal 2004; Rey & Espadaler, in prep.). Within houses Blattanex® bait stations (0.08% foxim + sugar matrix) were trialled. Bait stations were used continuously, rather than in one-off applications suitable for large-scale control programmes. Reductions in populations densities were achieved (Rey & Espadaler, in prep.), but none appear as effective as Xstinguish™ treatments of *L. humile* (Harris et al. 2002).

Advance Granular Carpenter® ant bait (0.011% avermectin, soy bean oil on corn grit combined with meat meal and sugar), which is effective against *Lasius neoniger* in the USA (Lopez et al. 2000), is ineffective in controlling *L. humile* in Spain (somewhat attractive, but low mortality) and probably would be unattractive to *L. neglectus* (X. Espadaler, pers. comm.). Products used to control *L. humile* effectively (e.g., Xstinguish™) would be the most likely candidates for control of *L. neglectus* (X. Espadaler, pers. comm.).

In an incursion of *L. neglectus,* direct treatment of nests would be the first priority. Protein and carbohydrate baits should be used rather than lipid-based baits (Stanley 2004). Xstinguish™ (already registered and available in New Zealand) should be uses as it is expected to be attractive to and effective at controlling *L. neglectus*, but the relative attractiveness and efficacy of Maxforce®; Presto®; Xstinguish™ should be tested against *L. neglectus*. Lopez et al. (2000) found Maxforce to be especially effective against *Lasius neoniger* with an 88 to 97% reduction after 3 days.

E2. Indirect effects

E2.1 Effects on domestic and export markets

Establishment at a port and contamination of goods exported to another country free of this species could lead to changes in import health standards for exports from New Zealand.

E2.2 Environmental and other undesired effects of control measures

Treatments used against *L. neglectus* are unlikely to be totally specific. There have been no documented cases of unacceptable adverse non-target effects arising directly from the use of Xstinguish®, should it be used to control the ant. However, the toxicant fipronil, widely used in ant control programs, is currently under review in Australia due to reports of negative effects to non-target species and human health (APVMA 2003). Fipronil is a broad-spectrum phenylpyrazole insecticide, which acts to disrupt the central nervous system of insects. It will kill any invertebrate via contact and ingestion, and therefore may represent a threat to invertebrates within the direct baiting area, or within foraging distance of the bait. It is also highly toxic to some fish and aquatic invertebrates (wwwnew81), so extreme care its needed when using fipronil near waterways.

There has been no documented instance of resistance in Formicidae to any insecticide.

(F) LIKELIHOOD AND CONSEQUENCES ANALYSIS

F1. Estimate of the likelihood

F1.1 Entry

Lasius neglectus currently has a *low* risk of entry.

This assessment is based on:

- *L. neglectus* not having been intercepted at the New Zealand border (or in Australia or Hawaii).
- this species having the potential to stowaway in freight. It nests in urban areas and in close association with goods that could be transported. Colonies are polygyne, mobile and disperse by budding promoting the chances of queens with workers being transported.
- this species currently having a restricted European distribution (53 sites of establishment known at April 2005).
- there being freight (sea and air) pathways with links to New Zealand within 100 km of sites of known infestation that could be potential pathways of entry as the distribution of the ant expands, but the volume of freight from this region to New Zealand is currently relatively low.

The distribution of this ant has increased dramatically since it was first recorded as a pest in Budapest in the 1970s. This assessment of low risk of entry should be reconsidered if the distribution expands beyond Europe.

Data deficiencies

- only limited data are available on the commodities with which this ant is associated. It was assumed from its behaviour to have the potential to be a stowaway on a wide range of commodities.
- not all ants intercepted at the New Zealand border are reported, and not all that are reported are identified to species, so interception records likely underestimate the entry of species. It is also not always clear if castes other than workers are intercepted.

F1.2 Establishment

Lasius neglectus currently has a *medium* risk of establishment.

This assessment is based on:

- the ant being primarily established in urban areas that would be the likely habitat experienced on arrival.
- New Zealand's climate being considered suitable for establishment. It is currently established in cool temperate climates, unlike most of the other invasive ants that are a risk to New Zealand. Winter temperatures are unlikely to kill colonies and summer temperatures may be warm enough for establishment over large areas of New Zealand. High rainfall may limit establishment in some areas, as it is currently not known from temperate areas with high rainfall.
- historically no ants have established directly in New Zealand from the northern hemisphere.
- it is unlikely to encounter natural enemies, but there would be competition from other adventive ants.
- a queen associated with workers is required for successful establishment.

Data deficiencies

- there are a lack of experimental data on climate tolerances of this species, and the climate assessment is based principally on climate estimates from known sites of establishment. It is unknown if differences between the temperate continental climate of Europe (very cold winters and mild/hot summers) and the temperate island climate of New Zealand (mild summer and winter) would influence establishment success.
- the ability of ants to be transported from the northern hemisphere to New Zealand, arrive in a reproductively fit state, and successfully establish when arriving in the opposite season to the locality of departure is unknown, but assumed to be unlikely based on the lack of historical precedence.
- the ability of *L. neglectus* to establish in areas with *Linepithema humile* present is unknown.

F1.3 Spread

Lasius neglectus has a *high* risk of spread from a site of establishment.

This assessment is based on:

- large areas of New Zealand being considered climatically suitable, accept possibly areas with cool summer temperatures or high rainfall.
- the assumption that colonies would attain sufficient size to undergo budding.
- dispersal occurring via budding and human assistance. It is assumed that dispersal rates would similar to those of *Linepithema humile* in New Zealand.
- large areas of suitable habitat occurring in New Zealand. A range of low vegetation cover habitats are favoured, including urban areas and grasslands, but forest is unlikely to be colonised. Habitat preferences are assumed to similar to *L. humile*.
- it is unlikely *L. neglectus* and *L. humile* would coexist which may restrict spread into areas where this ant is abundant. However, *L. humile* does not yet occupy all habitat considered suitable to both species, and *L. neglectus* may establish in colder areas that *L. humile*.
- a lack of winged dispersals would aid eradication if an incursion was detected sufficiently early.

Data deficiencies

- the restricted European distribution of this species and the lack of experimental data on temperature limits to foraging and development limit the reliability of predictions of climatic suitability in New Zealand.
- control measures to achieve eradication have not been tested for this species and only limited trials testing baits have been undertaken. Baits attractive to Argentine ants may be attractive to *L. neglectus* but this has not been tested.
- the outcome of competitive interactions between *L. neglectus* and *L. humile* is unknown.

F1.4. Consequences

The consequences of the presence of *L. neglectus* in New Zealand are considered *moderate* to *high*.

This assessment is based on:

- the assumption, from the known biology of the ant, that the habitat types invaded and the impacts of invasion at a site would be similar to those of *Linepithema humile*. However, the climatic limits of *L. neglectus* in New Zealand may be different to *L. humile*.

- there being no medical consequences of establishment - no sting, painful bite, or formic acid spraying.
- some urban, horticultural, and scrub habitats being invaded, but not forests.
- this unicolonial species attaining high densities at some sites of establishment. Most other ants would be displaced and other components of the invertebrate communities altered wherever *L. neglectus* was abundant. Mutualisms with honeydew-producing hemipterans are likely, and these may build up population numbers to damaging levels in some natural and agricultural/horticultural systems.
- urban populations being sufficiently large for pest control to be instigated. This could include commercial premises where product contamination was a possibility.
- there being no reports to indicate detrimental impacts on native vertebrates.

Data deficiencies

- there are currently only limited impacts studies on this species, and none outside of heavily human modified habitat.

F2. Summary table

Ant species: *Lasius neglectus*

Category			**Overall risk**
Likelihood of entry	Low	No interceptions to date. Limited pathways. A wide range of potential commodity associations.	Medium–High
Likelihood of establishment	Medium	Temperate species so climate likely suitable. Not established in southern hemisphere. Whole nest transportation needed.	
Likelihood of spread	High	Generally optimal conditions, especially lower rainfall areas. Summers may be too cold in some areas. Potentially have the widest distribution of species assessed.	
Consequence	Medium–high	Likely to be widely dispersed and dominant. Impact outside disturbed habitats unclear.	

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

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

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(J) Appendices

Appendix 1: Freight summary

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

Country	Port of export	Total seafreight	Appliances	Fibres	Bulk	Foodstuffs	Furniture	Furs	Glass	Metals	Produce	Wood	Other
Austria	Wien (Vienna)	1750	460	5	13	223	0	0	22	75	0	935	17
Belgium	Zeebrugge	36045	34464	1	0	1052	0	0	0	474	0	0	54
Bulgaria	Varna	215	2	0	0	123	0	0	0	53	37	0	1
Bulgaria	Varna-Zapad	2	0	0	0	0	0	0	0	0	0	2	0
France	Arcachon	36	0	0	0	0	0	0	36	0	0	0	0
France	Bordeaux	116	1	0	0	15	0	0	16	18	0	67	0
France	Cognac	21	10	0	0	0	0	0	7	1	0	2	0
France	Fos-sur-Mer	21243	3805	52	3212	3030	119	13	1141	7372	67	1748	687
France	Le Verdon	463	16	0	22	0	0	0	0	30	0	394	1
France	Melun	0	0	0	0	0	0	0	0	0	0	0	0
France	Paris	1874	618	22	52	270	15	1	136	446	3	125	186
France	Paris-Charles De Gaulle Apt	346	74	5	2	19	33	0	171	24	0	1	17
France	Toulouse Apt	5	0	0	0	0	0	0	0	5	0	0	0
Germany	Leipzig Apt	28	0	0	0	0	0	0	0	28	0	0	0
Greece	Athens (Athinai)	113	0	22	22	42	0	0	5	22	0	0	0
Greece	Piraeus	5928	50	14	171	1643	34	0	105	3241	544	40	88
Hungary	Budapest	177	31	0	0	69	0	0	0	69	0	5	2
Italy	Firenze	261	38	19	19	11	13	10	135	0	0	2	14
Italy	Livorno	9552	1251	186	93	1302	63	7	5008	617	40	447	538
Italy	Pisa	47	34	0	0	13	0	0	0	0	0	0	0
Italy	Trieste	2607	124	0	0	138	315	0	160	673	0	1155	43
Netherland	Vlissingen	11	1	0	0	0	0	0	0	0	0	0	10
Poland	Warszawa	141	42	0	0	29	0	0	29	41	0	0	1
Romania	Bucharest Otopeni Airport	34	33	0	0	0	1	0	0	0	0	0	0
Spain	Barcelona	40661	5373	800	3659	6490	599	9	10320	6644	484	1417	4867
Turkey	Antalya	44	0	1	0	0	0	0	20	0	23	0	0
Turkey	Gallipoli	1	0	0	0	0	1	0	0	0	0	0	0
Turkey	Haydarpasa, Istanbul	294	21	12	0	70	7	0	122	41	22	0	0
Turkey	Istanbul	6805	534	593	172	687	94	0	1935	2139	619	0	32

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

Country	Port of export	Total air freight	Appliances	Produce	Pharmaceuticals	Metals	Glass	Furniture	Fur	Footwear	Foodstuffs	Fibres	Other
Austria	Wien (Vienna)	389	194	0	23	52	6	22	2	2	3	49	37
Belgium	Oostende	0	0	0	0	0	0	0	0	0	0	0	0
Bulgaria	Varna	2	0	0	0	0	0	0	0	0	2	0	0
France	Arcachon	0	0	0	0	0	0	0	0	0	0	0	0
France	Bordeaux	35	6	0	2	4	0	0	0	0	9	0	12
France	Fos-sur-Mer	0	0	0	0	0	0	0	0	0	0	0	0
France	Paris	539	174	0	34	53	9	13	8	4	12	22	210
France	Paris-Charles De Gaulle Apt	1059	441	0	31	112	37	34	9	6	30	76	282
France	Paris-Orly Apt	129	11	0	0	2	1	1	1	0	0	2	112
France	Toulouse Apt	30	8	0	0	2	0	1	0	0	13	2	4
Germany	Leipzig Apt	8	6	0	0	1	1	0	0	0	0	0	0
Greece	Athens (Athinai)	21	4	0	0	13	1	0	0	0	0	1	2
Greece	Piraeus	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	Budapest	29	10	0	0	13	1	0	0	0	0	0	6
Italy	Firenze	270	37	0	17	10	3	79	24	12	3	74	13
Italy	Livorno	0	0	0	0	0	0	0	0	0	0	0	0
Italy	Pisa	2	0	0	0	0	0	0	0	0	0	1	0
Netherland	Vlissingen	1	0	0	0	0	0	0	0	0	0	0	0
Poland	Warszawa	17	4	0	0	0	2	0	0	0	10	0	1
Romania	Bucharest Otopeni Airport	1	0	0	0	0	0	1	0	0	0	0	0
Spain	Barcelona	385	113	0	60	59	8	21	5	9	1	78	32
Turkey	Antalya	0	0	0	0	0	0	0	0	0	0	0	0
Turkey	Haydarpasa, Istanbul	1	0	0	0	0	0	0	0	0	0	1	0
Turkey	Istanbul	86	9	2	4	4	8	4	0	1	15	33	7
Turkey	Izmir (Smyrna)	1	1	0	0	0	0	0	0	0	0	1	0

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. Total air freight is broken into different commodity types (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 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

Categories	Description
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
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

Categories	Description
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
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 the 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 collection 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 were 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 (ºC)
MINT	Mean temperature of the coldest month (ºC)
MATS	Seasonality of temperature - absolute difference in mean temperature between the warmest and coldest months (ºC)
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.

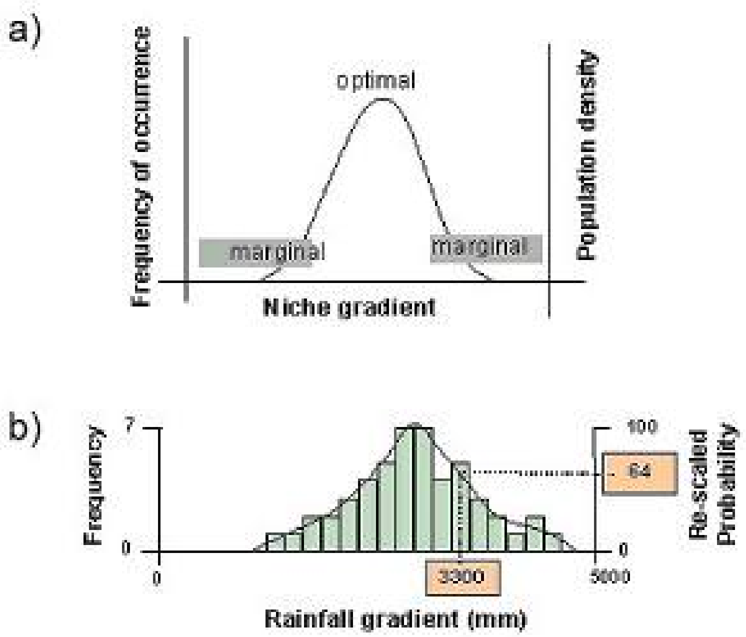

Fig. A2.1: *Stylised representation of the conversion of input data points to similarity scores. (a) The input data are assumed to represent the niche of the species for a particular parameter. (b) The frequency distribution is divided into a series of bins across the range of the data, allowing any 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 in 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.

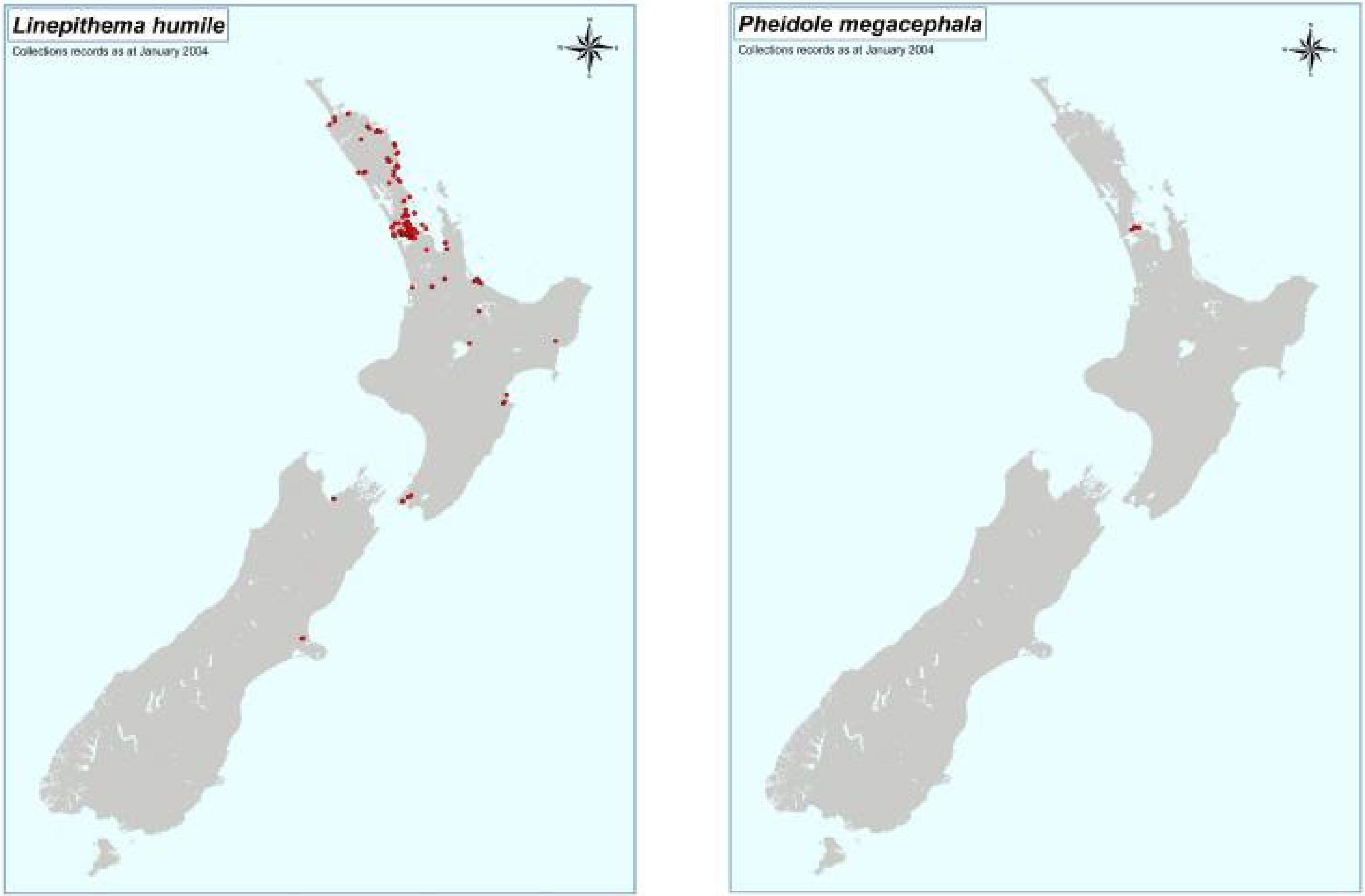

Fig. A3.1: *New Zealand sites where* L. humile *and* Ph. megacephala *are known to be established.*

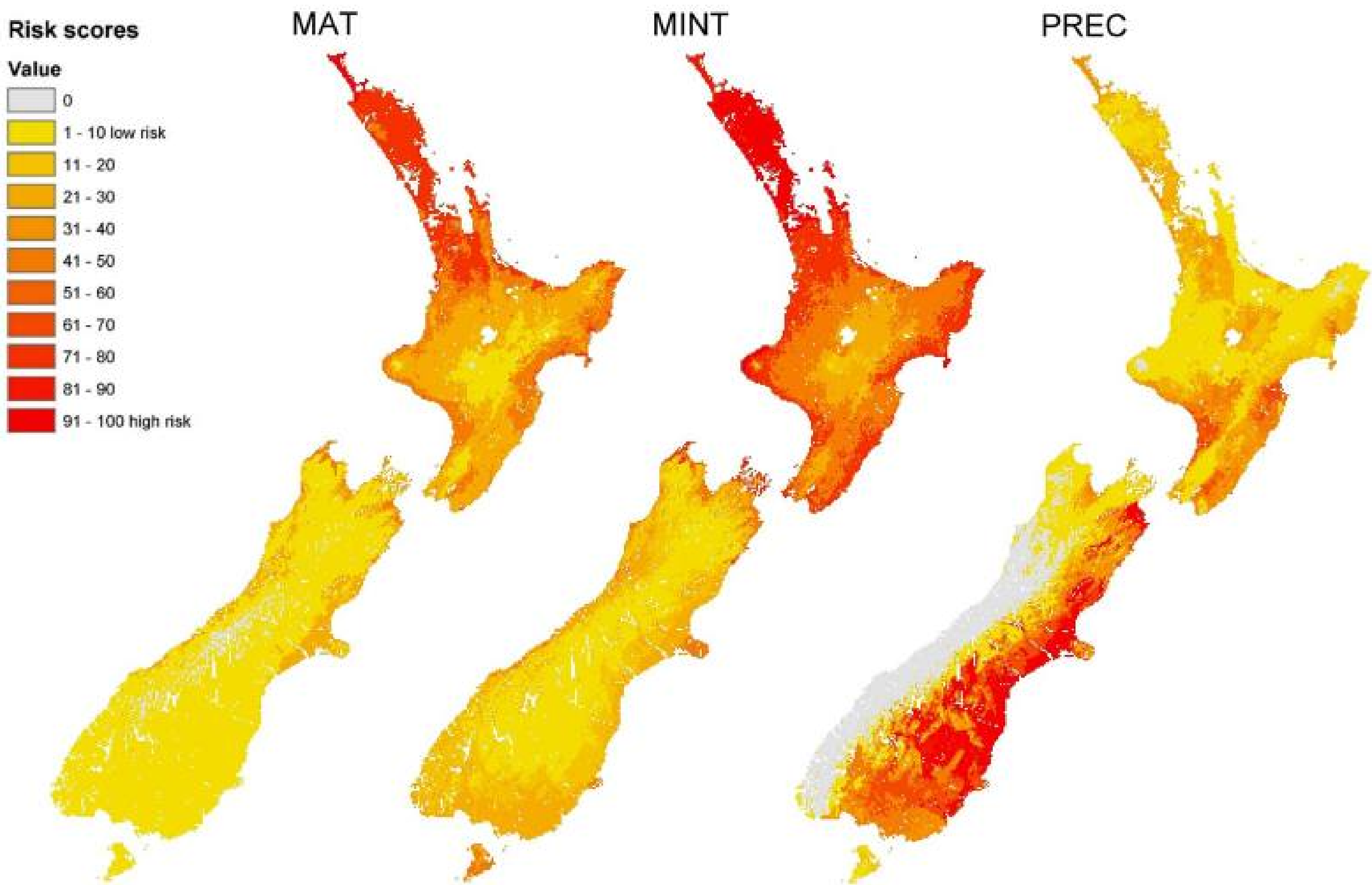

Fig. A3.2: Similarity of native + introduced ranges of L. humile *to New Zealand for MAT, MINT and PREC.*

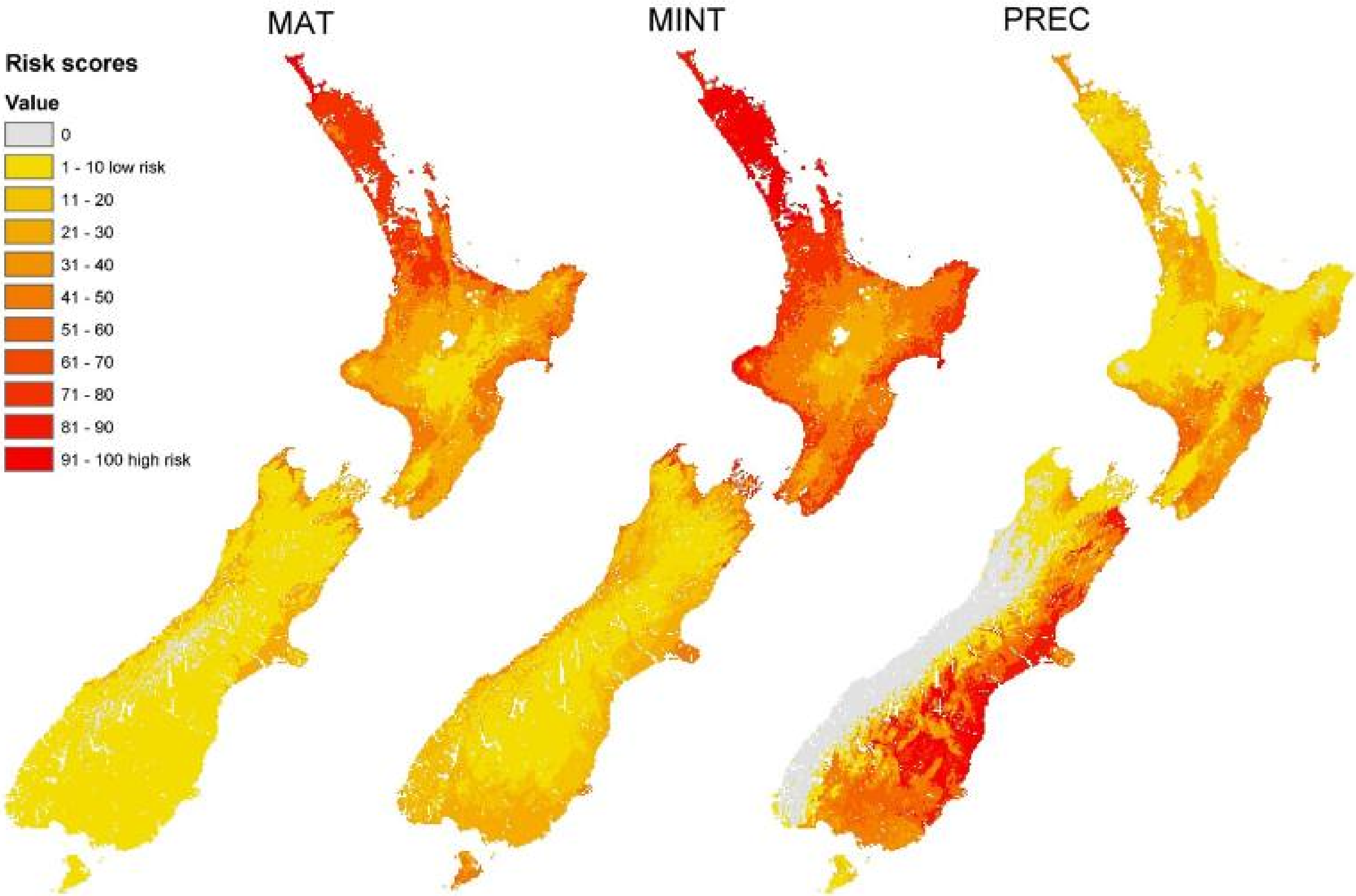

Fig. A3.3: *Similarity of native + non-urban introduced ranges of* L. humile *to New Zealand for MAT, MINT and PREC.*

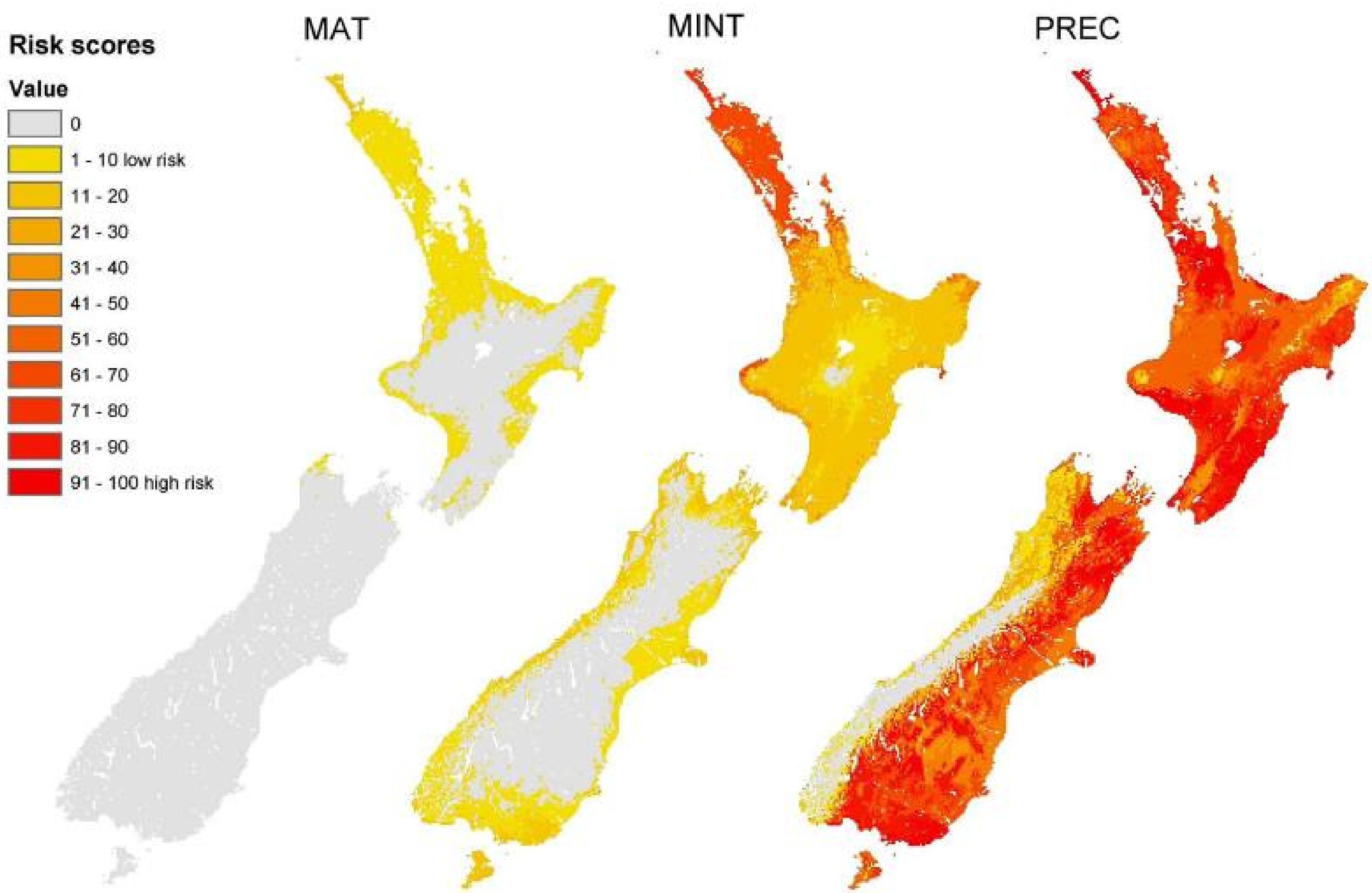

Fig. A3.4: *Similarity of native + introduced ranges of* Ph. megacephala *to New Zealand for MAT, MINT and PREC.*

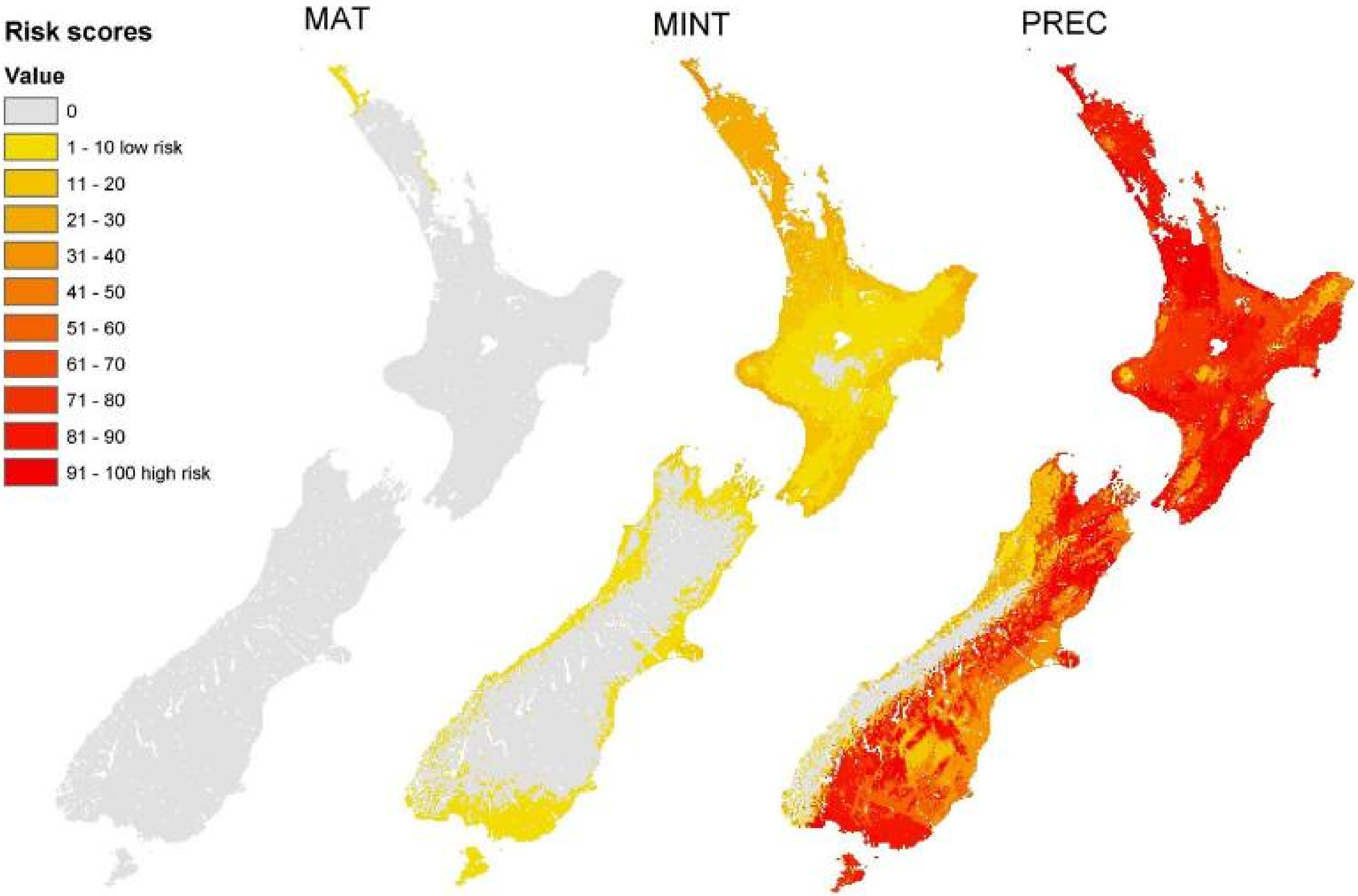

Fig. A3.5: *Similarity of native + non-urban introduced ranges of* Ph. megacephala *to New Zealand for MAT, MINT and PREC.*