Information about GB Non-native Species Risk Assessments

Please see important information specific to this risk assessment on the next page.

The Convention on Biological Diversity (CBD) emphasises the need for a precautionary approach towards non-native species where there is often a lack of firm scientific evidence. It also strongly promotes the use of good quality risk assessment to help underpin this approach. The GB risk analysis mechanism has been developed to help facilitate such an approach in Great Britain. It complies with the CBD and reflects standards used by other schemes such as the Intergovernmental Panel on Climate Change, European Plant Protection Organisation and European Food Safety Authority to ensure good practice.

Risk assessments, along with other information, are used to help support decision making in Great Britain. They do not in themselves determine government policy.

The Non-native Species Secretariat (NNSS) manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. Risk assessments are carried out by independent experts from a range of organisations. As part of the risk analysis process risk assessments are:

- Completed using a consistent risk assessment template to ensure that the full range of issues recognised in international standards are addressed.
- Drafted by an independent expert on the species and peer reviewed by a different expert.
- Approved by an independent risk analysis panel (known as the Non-native Species Risk Analysis Panel or NNRAP) only when they are satisfied the assessment is fit-for-purpose.
- Approved for publication by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP.

To find out more about the risk analysis mechanism go to: www.nonnativespecies.org

Common misconceptions about risk assessments

To address a number of common misconceptions about non-native species risk assessments, the following points should be noted:

- Risk assessments consider only the risks posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Risk assessments are about negative impacts and are not meant to consider positive impacts that may also occur. The positive impacts would be considered as part of an overall policy decision.
- Risk assessments are advisory and therefore part of the suite of information on which policy decisions are based.
- Completed risk assessments are not final and absolute. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Draft risk assessments are available for a period of three months from the date of posting on the NNSS website*. During this time stakeholders are invited to comment on the scientific evidence which underpins the assessments or provide information on other relevant evidence or research that may be available. Relevant comments are collated by the NNSS and sent to the risk assessor. The assessor reviews the comments and, if necessary, amends the risk assessment. The final risk assessment is then checked and approved by the NNRAP.

*risk assessments are posted online at:
https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51
comments should be emailed to nnss@fera.gsi.gov.uk

Important information specific to this Risk Assessment

This risk assessment was updated in July 2013 to reflect significant new evidence that has been provided since its original publication in 2009. The update was carried out by an independent expert; it was then peer reviewed and approved by the Non-native Species Risk Analysis Panel before being placed onto the GB Non-native Species Secretariat website.

Since the update of the assessment in July 2013 a new paper has been published containing evidence relevant to the risk assessment (Graystock *et al* 2013). While some of the data (at the time unpublished) from this research has been considered in the updated risk assessment, the final paper was not available to be taken into account.

At the end of the 3 month comment period, the paper by Graystock *et al* 2013, along with any other evidence provided by stakeholders, will be taken into account and used, if relevant, to modify the risk assessment. When commenting on the current risk assessment, stakeholders may wish to include reference to this paper and whether it has a bearing on the risk assessment scores.

Graystock, P., Yates, K., Evison, S. E. F., Darvill, B., Goulson, D., Hughes, W. O. H. (2013). The Trojan hives: pollinator pathogens, imported and distributed in bumblebee colonies. Journal of Applied Ecology. doi: 10.1111/1365-2664.12134

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

For more information visit: www.nonnativespecies.org

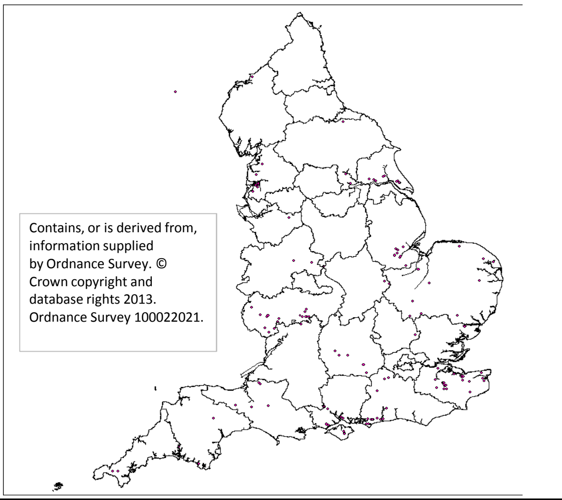
Name of Organism:	***Bombus terrestris -subspecies not native to the GB e.g. B.terrestris terrestris, B.terrestris dalmatinus***	
Objectives:	Assess the risks associated with this species in GB	
Updated version:	Placed on NNSS website: 03/09/13	
Original version:	2009	

N	QUESTION	RESPONSE	COMMENT
1	What is the reason for performing the Risk Assessment?	A previous Risk Assessment is being re-evaluated.	A meeting between the commercial producers and DEFRA in September 2012 resulted in new research being raised. This led DEFRA to commission a revision of the existing Risk Assessment to consider all relevant data pertaining to the risk of introducing *B. t. terrestris* and *B. t. dalmatinus* as commercial pollinators to GB
2	What is the Risk Assessment area?	GB	
3	Does a relevant earlier Risk Assessment exist?	YES (Go to 4)	Yes. Previous GB risk assessment 21/3/2011 (2). Also - Australia: *Bombus terrestris* importation (1); California USA:*Bombus impatiens* importation (3); Restrictions on *B. terrestris* importation have been imposed in Norway, Canary Islands Spain, Turkey, Israel, South Africa, Japan, China, Brazil, Mexico & North America (4,5) although it should be noted that restrictions appear to have eased in Norway (pers. comm. Atle Mjelde) and China (Biobest news article 15/06/2012 http://www.biobest.be/nieuws/199/3/0/)
4	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTLY VALID OR NOT VALID (Go to 5)	The previous GB Risk Assessment needs to be updated based on new published and confidential evidence, and work in progress
	Stage 2: Organism Risk Assessment SECTION A: Organism Screening		
5	Identify the Organism. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	NO (Go to 6)	*Bombus terrestris terrestris* (B.t.t.) and *Bombus terrestris dalmatinus* (B.t.d.) are the focus of the risk assessment - they are used for commercial production. Evidence suggests that some admixture between these subspecies may have taken place during commercial breeding, but this is not definitive (6). Further research is required, but either way commercial bumblebees are 'not of a kind'. This assessment evaluates the threat to *Bombus terrestris audax* (B.t.a.) which is described as an "island" subspecies native to the GB & Ireland, GB members of the genus *Bombus* more broadly, as well as other components of the GB native flora and fauna. B.t.t and B.t.d. have slightly different colour patterns to B.t.a. (primarily broader and brighter bands, and shorter hair)(7; 8; 9), and different ecological characteristics (5; 10; 11) but there is considerable overlap (12; 13). Colour patterning is highly variable within and among *Bombus* species (14) and thus cannot be used to identify the origin of a particular specimen beyond doubt. Recent DNA barcode analyses indicate that B.t.a. is likely to be genetically distinct from B.t.t. and B.t.d., although the latter two subspecies do not exhibit reciprocal monophyly (15)
6	If not a single taxonomic entity, can it be redefined?	YES (Go to 7)	Probably, although not enough evidence yet. Two genetic studies found B.t.a. had different haplotypes to B.t.t. and B.t.d (15; 16). Estoup *et al.* (17) found significant and strong genetic differentiation between island B.t. populations and continental B.t., but B.t.a. was not included in that study. Continental populations (incl. B.t.t. & B.t.d.) are genetically homogenous (12; 13) or distributed apparently randomly across haplotypes (15). Genetic analysis in progress in Ireland will create a phylogenetic tree for all European B.t., evaluating the distinction between commercial subspecies and B.t.a. (18). Work in progress suggests that commercial B.t. can be distinguished from Irish B.t.a. using microsatellites (19).
7	Is the organism in its present range known to be invasive, i.e. to threaten species, habitats or ecosystems?	NO or Uncertain (Go to 8)	*Bombus terrestris* as a species is not considered invasive in its "native" range, although commercial sub-species have been suggested to be so. Recent genetic studies provide some evidence for establishment of commercial poopulations and admixture with native sub-species, which is a threat to their genetic integrity and potentially adaptation to local conditions (19; 20). Following recent establishment, *B.terrestris* commercially produced subspecies are invasive in Japan, Chile and Argentina (21; 22; 23), all of which have a native bumblebee fauna, and in Tasmania (which has no native bumblebees) (5; 24; 25). In Japan, the invasive threat includes disruption of native bumblebee mating systems (26) and disruption of plant-pollinator interactions (27). In Chile and Argentina, invasion has been associated with the rapid decline of a native bumblebee species, although causal data are lacking (28). In contrast to these regions, there is evidence for a failed invasion by *B. t. sassaricus* in southern France (29).
8	Does the organism have intrinsic attributes that indicate that it could be invasive, i.e. threaten species, habitats or ecosystems?	YES or UNCERTAIN (Go to 9)	Intrinsic attributes: broad climate suitability in GB; generalist & flexible, efficient foragers; ability to overwinter without diapause; can fly several km suggesting rapid dispersal; high reproductive rate; easy to establish colonies (4; 5; 10; 11). However, it has been imported for 18 years and we have no evidence that the most closely related UK species have declined (14). It does not pose a risk to human health & it is not parasitic or predatory on other species. It uses rodent burrows for nest-sites (although not-exclusively, as it can nest at the surface under objects or in cavities above ground), but there is no evidence for negative interactions as a result of this habit.
9	Does the organism occur outside effective containment in the Risk Assessment area?	YES (Go to 10)	It occurs where it is imported for pollination of greenhouse crops (greenhouse ventilation enables the free egress of commercial bees), open polytunnel crops, open-field crops, and in gardens (they are marketed widely to gardeners). In none of these cases is there 'effective containment' as bumblebees have been shown to forage outside of greenhouses (30; 31). A thorough national survey is required, particularly near horticultural production areas. A study on the Isle of Wight found no evidence for existence of naturalised colonies (32), but further genetic studies are essential to confirm this result. Ongoing work in Ireland suggests that similar conditions have resulted in either establishment, hybridisation, or both, of commercial subspecies (19). Genetic studies in Poland also demonstrate potential establishment or introgression away from commercial sites (20).
10	Is the organism widely distributed in the Risk Assessment area?	YES & Future conditions/management procedures/policies are being considered (Go to 19)	Yes - when and where imported. However, the degree, if any, of establishment in GB is unknown - see Qu 9. More detailed evidence required.
11	Does at least one species (for herbivores, predators and parasites) or suitable habitat vital for the survival, development and multiplication of the organism occur in the Risk Assessment area, in the open, in protected conditions or both?	YES (Go to 12)	Requirements of non-native subspecies (B.t.t and B.t.d.) e.g. nest sites, food, hibernation sites etc. are likely to be met by the UK landscape. No great differences in habitat requirements have been documented for B.t.t. and B.t.d. compared to B.t.a.
12	Does the organism require another species for critical stages in its life cycle such as growth (e.g. root symbionts), reproduction (e.g. pollinators; egg incubators), spread (e.g. seed dispersers) and transmission, (e.g. vectors)?	NO (Go to 14)	It requires food plants for nectar and pollen (it can exploit a wide array of flowering plants), and rodents that provide one of the major nesting habitats for this species
13	Is the other critical species identified in question 12 (or a similar species that may provide a similar function) present in the Risk Assessment area or likely to be introduced? If in doubt, then a separate assessment of the probability of introduction of this species may be needed.	YES (Go to 14)	Yes, both forage and rodents are present in the Risk Assessment area as natural parts of the ecosystem
14	Does the known geographical distribution of the organism include ecoclimatic zones comparable with those of the Risk Assessment area or sufficiently similar for the organism to survive and thrive?	YES (Go to 16)	Very similar ecoclimatic conditions. See NHM website (13) for distribution of *B.terrestris*, over most of Europe and North Africa.
15	Could the organism establish under protected conditions (e.g. glasshouses, aquaculture facilities, terraria, zoological gardens) in the Risk Assessment area?	NO (Go to 20)	No
16	Has the organism entered and established viable (reproducing) populations in new areas outside its original range, either as a direct or indirect result of man's activities?	YES (Go to 17)	Japan - B.t.t. or B.t.d. via commercial importation, now established (23); New Zealand - B.t.a. introduced by man from 1875 onwards and is well established; Tasmania - B.t.a. first seen in 1992, uncertain origin, now established (24; 25). B.t.t and/or B.t.d. has been introduced to Chile commercially, escaped and is now established and widespread and also invading Argentina (21; 22). B.t. has been commercially introduced to at least 57 countries but establishment not well recorded. Some notes on this for Brazil, Chile, Israel, Mexico, and Africa (4; 33).

17	Can the organism spread rapidly by natural means or by human assistance?	YES (Go to 18)	Queens and workers can fly several kilometres easily, although dispersal rates of bumblebees are not well documented. Recent work on related species showed that queens disperse at least up to 5km from their natal colony prior to founding a new nest (34). In Tasmania (no other bumblebees) B.t. spread 12.5km/year (35). Also commercial colonies are imported to growers throughout GB
18	Could the organism as such, or acting as a vector, cause economic, environmental or social harm in the Risk Assessment area?	YES OR UNCERTAIN (Go to 19)	Main risks would be: a) establishment & competition with native bees; b) hybridisation with B.t.a. changing the genetic identity of native populations and c) transfer of pathogens/pests to native bees. No evidence of these actually occurring in the GB as yet, with one study based on chemical, not genetic, techniques, showing no evidence for b) (32). Further research in GB is urgently required for all of these risks. In other areas where commercial bees have been imported there is evidence for a) (21; 36), b) (19; 20) and c) (37; 38; 39). Might also alter balance of pollination systems (27) but in the UK it is expected to visit similar plants to B.t.a.
19	This organism could present a risk to the Risk Assessment area and a detailed risk assessment is appropriate.	Detailed Risk Assessment Appropriate GO TO SECTION B	N.B. (i) B.t.t. & B.t.d. have been imported in large quantities since 1989 but none positively identified in the wild in the Risk Assessment Area, although they have been in neighbouring countries under similar circumstances. (ii) We are not considering a non-native "species" which was the case in other countries of establishment. (iii) As it is a "subspecies" issue, there are parallels with the regular importation of different honeybee races by beekeepers (40).
20	This organism is not likely to be a harmful non-native organism in the Risk Assessment area and the assessment can stop.		
B	**SECTION B: Detailed assessment of an organism's probability of entry, establishment and spread and the magnitude of the economic, environmental and social consequences**		

	Probability of Entry	RESPONSE	UNCERTAINTY	COMMENT
1.1	List the pathways that the organism could be carried on. How many relevant pathways can the organism be carried on?	few - 1	LOW - 0	1) Importation of commercial bumblebee colonies for pollination in glasshouses/tunnel and open field crops (38,770 in 2010; 38,485 in 2011; 27,964 in 2012; the recent decline is due to the introduction of commercial B.t.a.)(41) - and a very small number of colonies for research purposes and hobby gardeners. 2) Possible natural invasion/dispersal by flight from mainland Europe.
1.2	Choose one pathway from the list of pathways selected in 1.1 to begin the pathway assessments.	Commercial importation		
1.3	How likely is the organism to be associated with the pathway at origin?	very likely - 4	LOW - 0	Intentional importation throughout GB.
1.4	Is the concentration of the organism on the pathway at origin likely to be high?	very likely - 4	LOW - 0	
1.5	How likely is the organism to survive existing cultivation or commercial practices?	very likely - 4	LOW - 0	
1.6	How likely is the organism to survive or remain undetected by existing measures?	very likely - 4	LOW - 0	Commercial companies rear and protect the bees during importation to ensure survival for pollination purposes. If they transfer from crop into the wild, they may not easily be detected because of difficulties in taxonomic separation (see Qu. 5 & 6) and there are no current monitoring procedures.
1.7	How likely is the organism to survive during transport /storage?	very likely - 4	LOW - 0	Commercial companies have developed very good boxed systems to ensure their survival.
1.8	How likely is the organism to multiply/increase in prevalence during transport /storage?	unlikely - 1	LOW - 0	Colonies are imported in a range of sizes, with 10s to 100s of workers, and the colony grows quickly during the first few weeks after importation, producing primarily worker bees which do not reproduce. After a few weeks the colony is likely to produce new queens and males which could mate and establish if they leave the colony and glasshouse/open polytunnel/open-field.
1.9	What is the volume of movement along the pathway?	massive - 4	LOW - 0	Data for England show a total of 38,770 in 2010, 38,485 in 2011, and 27,964 in 2012 (the recent decline is due to the introduction of commercial B.t.a.). Recent data from Scotland and Wales are lacking, but in 2008 stood at 3,367 and 4,329 respectively (42)
1.10	How frequent is movement along the pathway?	very often - 4	LOW - 0	Importation occurs all year round for pollination of glasshouse-grown crops, although detailed figures have not been supplied by industry. The new licensing regime (43) will gather such data for future assessments
1.11	How widely could the organism be distributed throughout the Risk Assessment area?	very widely - 4	LOW - 0	Imported throughout GB (currently no detailed data on geographical spread, but new licensing regime (43) will rectify this) and can escape confinement.
1.12	How likely is the organism to arrive during the months of the year most appropriate for establishment ?	very likely - 4	LOW - 0	
1.13	How likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) or other material with which the organism is associated to aid transfer to a suitable habitat?	very likely - 4	LOW - 0	Importation is of the bees themselves and areas around horticultural production are likely to provide suitable habitat.
1.14	How likely is the organism to be able to transfer from the pathway to a suitable habitat?	likely - 3	MEDIUM -1	The species can survive in most habitats in the UK, so they will have no difficulty transferring to suitable habitats if they escape from the confined crops which they are pollinating. The level of uncertainty is specified as medium because, although escape from glasshouses to suitable habitat is likely to occur, and has been shown in Poland (20) and Ireland (19), it is unclear what proportion of bees escape.

	Probability of Establishment	RESPONSE	UNCERTAINTY	COMMENT
1.15	How similar are the climatic conditions that would affect establishment in the Risk Assessment area and in the area of current distribution?	very similar - 4	LOW - 0	Commercial subspecies live in wide range of climatic conditions in Europe, and can survive and reproduce in the UK climate (11). Native B.t.a is found throughout UK, except in northern Scotland and surrounding islands, although it has been spreading north (44).
1.16	How similar are other abiotic factors that would affect establishment in the Risk Assessment area and in the area of present distribution?	very similar - 4	MEDIUM -1	Level of uncertainty specified as medium because no literature found to confirm this.
1.17	How many species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism species are present in the Risk Assessment area? Specify the species or habitats and indicate the	very many - 4	LOW - 0	*B.terrestris* (all subspecies) are generalist in their choice of habitat. They require nesting sites (any undisturbed vegetation - often underground in rodent nests) and pollen and nectar for food. They feed from a wide range of flowers found in most managed and unmanaged landscapes. Typical nesting sites are gardens, field margins, hedgerows, woodland, grassland and scrub (45; 46).
1.18	How widespread are the species (for herbivores, predators and parasites) or suitable habitats vital for the survival, development and multiplication of the organism in the Risk Assessment area?	widespread - 4	LOW - 0	Suitable habitats & food plants occur all over the UK.
1.19	If the organism requires another species for critical stages in its life cycle then how likely is the organism to become associated with such species in the risk assessment area?	very likely - 4	LOW - 0	Rodent burrows, which are a favoured nesting habitat, are widespread and abundant throughout the GB
1.20	How likely is it that establishment will not be prevented by competition from existing species in the Risk Assessment area?	moderately likely - 2	MEDIUM -1	Imported subspecies can have large colonies, nectar collecting efficiency and flexibility in food choice (10; 11), so they are likely to be "competitive". Research with captive but free-flying colonies in GB suggests that they could outcompete our native B.t.a. subspecies (11). Evidence from Poland and Ireland is strongly indicative of establishment and hybridisation (19; 20) However, *B.t.sassaricus* (different subspecies) was imported to southern Europe and extensive surveys (29) have found no evidence of establishment, whilst the 3 native subspecies still coexist there. One hypothesis for this example is that niche overlap with native subspecies prevents establishment. A second hypothesis is that B.t.s. is not pre-adapted for invasion like B.t.t. and B.t.d. are. Need research on likelihood of competition.
1.21	How likely is it that establishment will not be prevented by natural enemies already present in the Risk Assessment area?	likely - 3	HIGH -2	Natural enemies of bumblebees are largely parasites, although some bird predation and nest parasitism takes place (47). One study showed local adaptation between B.t.t. and a trypanosome parasite *Crithidia bombi* (48), suggesting that enemies may have a higher or lower impact on B.t.t. or B.t.d. in the UK. Further research is needed
1.22	If there are differences in man's management of the environment/habitat in the Risk Assessment area from that in the area of present distribution, are they likely to aid establishment? (specify)	N/A		Land management considered similar in UK to mainland Europe from perspective of niche requirements of B.t subspecies.
1.23	How likely is it that existing control or husbandry measures will fail to prevent establishment of the organism?	very likely - 4	MEDIUM -1	Greenhouses have vents allowing bees to escape and many colonies are used in open tunnel and field crops (9620 in England & Scotland)(42). Imported colonies have excluders to prevent queen escape, but males and small queens can escape and hybridise. Research is needed to determine what proportion of queens may escape. Colony destruction may be too late to prevent escape of sexuals - advice to growers is to destroy by 12 weeks (49). Colonies imported all year, so often production of sexuals will be out of synchrony with native bee phenology, though not always. Studies in Ireland provide evidence for hibernation and spring emergence of commercial queens (19).
1.24	How often has the organism been recorded in protected conditions, e.g. glasshouses, elsewhere?	N/A		Present when & where deliberately introduced.
1.25	How likely is the reproductive strategy of the organism and duration of its life cycle to aid establishment?	likely - 3	MEDIUM -1	Annual life cycle, but can develop colonies through winter in suitably warm climates (4). Recently, B.t. observed foraging throughout winter in UK - unclear if this is B.t.a. or commercial imports - ongoing genetic studies will address this (Ings, pers. comm). Commercial bees produce larger colonies with more sexuals than native B.t.a. (11), but recorded differences may be due to commercial breeding methods rather than innate subspecies differences. Unpublished studies of colony growth until death in resource poor and rich conditions show no difference in colony size between native and non-native subspecies (pers. comm. M Heard, CEH). Producers say choice of subspecies for production was because of large colony size and ease of breeding (50). Queens will mate with B.t.a. males in confined conditions, although they "prefer" their own subspecies (32; 50). More evidence required on whether hybridisation is common in the wild. Genetic studies provide evidence for introgression via hynridisation (19; 20), in contrast to male gland chemistry (32). Further research in GB needed.
1.26	How likely is it that the organism's capacity to spread will aid establishment?	likely - 3	MEDIUM -1	Bumblebees can fly several kilometres easily, although dispersal rates not well documented (34). Also commercial colonies are imported to growers throughout the U.K. Data on geographical use of Bt will be collected under the new NE licensing regime (43). No definitive records of B.t.t. and B.t.d. establishment in the wild in GB but difficult to separate morphologically. A non-native species of bumblebee, *B.hypnorum* , first seen in UK in 2001 has now spread over 200km from first record.
1.27	How adaptable is the organism?	moderately adaptable - 2	MEDIUM -1	Most B.t. subspecies noted as being adaptable because they are generalist and flexible learners (4; 5; 51). Evidence of adaptation to different environments not well tested, but has successfully invaded varying environments in Japan, Chile, Argentina, New Zealand and Tasmania (21; 22; 23; 24; 25)
1.28	How likely is it that low genetic diversity in the founder population of the organism will not prevent establishment?	very likely - 4	LOW - 0	Genetic diversity of founder (imported) population has not been measured but it is likely to be high as producers have taken original stock from many sites across Europe (4). Schmid Hempel *et al.* (24) show B.t.a. population in Tasmania was possibly founded from only 2 individuals, suggesting it is invasive despite severe genetic bottleneck - but there were no other bumblebees in the country. Establishment in Japan and South America has been successful from commercial stocks (21; 22; 23).
1.29	How often has the organism entered and established in new areas outside its original range as a result of man's activities?	moderate number - 2	LOW - 0	*B.terrestris* imported into 57 countries. Confirmed establishment in Japan (B.t.t./B.t.d.); Tasmania (B.t.a.); and NZ (B.t.a) & South America (also see qu.16) - B.t. not native to any of these. For *B.terrestris* subspecies, *B.t.sassaricus* was imported to Southern Europe but extensive surveys have found no evidence of establishment and the 3 native subspecies still coexist there (29).
1.30	How likely is it that the organism could survive eradication campaigns in the Risk Assessment area?	very likely - 4	LOW - 0	Eradication has not been tried so no evidence, but unlikely to work because it would be difficult/impossible to target the imported subspecies, a) because of similar biology/ecology, and b) because of difficulty of field identification. Studies suggest that eradication campaigns in Japan are unlikely to succeed (52).
1.31	Even if permanent establishment of the organism is unlikely, how likely is it that transient populations will be maintained in the Risk Assessment area through natural migration or entry through man's activities (including intentional release into the outdoor environment)?	very likely - 4	LOW - 0	Propagule pressure is high. Previous RA suggested 40,000-50,000 colonies/year imported to UK, with open field crop pollination requirements (currently 1000 colonies/year) increasing (Companies, pers.comm. to previous risk assessor). Natural England Licence Returns data for England show 38,770 and 38,485 for 2010 and 2011, and 27,964 in 2012 due to gradual introduction of commercial B.t.a.

	Spread	RESPONSE	UNCERTAINTY	COMMENT
2.1	How rapidly is the organism liable to spread in the Risk Assessment area by natural means?	intermediate - 2	MEDIUM -1	No spread has been documented so far - but may be due to taxonomic difficulties. Colonies can grow quickly and large once suitable nest sites are found and bees can disperse over kilometres. Limits to spread rate might be: (1) finding nest sites or forage (if these are limiting in competition with native bees); (ii) timing of emergence of sexuals from imported colonies; or (3) cold winters may limit survival. Need research on spread rates. Commercial B.t. have spread in Japan, where there is a diverse native bumblebee assemblage, at >200km over 10 years (53).
2.2	How rapidly is the organism liable to spread in the Risk Assessment area by human assistance?	rapid - 3	MEDIUM -1	Large number of colonies imported each year throughout the UK. Map shows the location of sites where growers have registered to use non native bumblebees under the 2013 Natural England growers class licence (Natural England 2013). 
2.3	How difficult would it be to contain the organism within the Risk Assessment area?	difficult - 3	LOW - 0	Not easy to contain, but B.t.t. & B.t.d. occur on mainland Europe & are imported into Ireland anyway, so natural dispersal out of the Risk Assessment Area would not cause invasion of novel areas. Colonies are not likely to be exported from UK intentionally.
2.4	Based on the answers to questions on the potential for establishment and spread define the area endangered by the organism.			Whole of UK, but focussed on South (warmer areas) and areas with substantial horticultural crop production. Northern Scotland and Isles could be at risk if temperatures increase.

	Impacts	RESPONSE	UNCERTAINTY	COMMENT
2.5	How important is economic loss caused by the organism within its existing geographic range?	minimal - 0	LOW - 0	No evidence of economic loss.
2.6	Considering the ecological conditions in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, livestock health and production, likely to be? (describe) in the Risk Assessment area, how serious is the direct negative economic effect of the organism, e.g. on crop yield and/or quality, likely to	minimal - 0	LOW - 0	No evidence of economic loss.
2.7	How great a loss in producer profits is the organism likely to cause due to changes in production costs, yields, etc., in the Risk Assessment area?	minimal - 0	LOW - 0	Importing bumblebees increases fruit growers profits by improving yields (18).
2.8	How great a reduction in consumer demand is the organism likely to cause in the Risk Assessment area?	minimal - 0	LOW - 0	Bumblebee importation means fruits can be produced locally, more cheaply; and this may increase consumer demand
2.9	How likely is the presence of the organism in the Risk Assessment area to cause losses in export markets?	very unlikely - 0	LOW - 0	
2.10	How important would other economic costs resulting from introduction be? (specify)	moderate - 2	MEDIUM -1	Future costs (which are likely to involve both public and private elements) could include: 1) licensing; 2) screening of imported bees for diseases; 3) research to confirm subspecies identity and degree of establishment, spread & hybridisation in UK. While the use of non-native strains of bumblebee may have some beneficial impacts, these are not considered by this risk assessment.
2.11	How important is environmental harm caused by the organism within its existing geographic range?	moderate - 2	LOW - 0	No identified case of harm caused by B.t.t. or B.t.d. in their native range. Indeed they provide an important pollination service to wild flowers. However, research in Poland and Ireland provides strong evidence that commercial genotypes are either escaping into the wild or hybridising with native populations of the same and different subspecies (19; 20). In Japan, the invasive population of *B. terrestris* may be having significant effects on the reproductive success of native species through interspecific mating (which renders native queens infertile)(26), disruption of pollination of native plants (27), and competition for food and nest sites (52). In Chile and Argentina, the spread of *B terrestris* is associated with declines in the native *B dahlbommi*, with circumstantial evidence that parasite spillover may be the causal mechanism (ref).
2.12	How important is environmental harm likely to be in the Risk Assessment area?	moderate - 2	HIGH -2	B.t.t. & B.t.d. may: (a) compete with native sub-species or other species of bumblebee for food or nest sites; (b) hybridise with B.t.a.; (c) spread disease or pests to native bees; (d) change the balance of wild plant/weed pollination (30). Some researchers think this could therefore have a "major" impact (8; 17; 30). The score of "moderate" has been given because the bees have been imported for 18 years, and none of the above have been confirmed, although this could well be because of difficulties in separating B.t.t. & B.t.d. from native B.t.a. & no large projects have been undertaken - hence the score of "high" uncertainty. No reduction in range of related subspecies has been documented (although other bumblebees have decreased in range). Research in Poland and Ireland provides evidence for either spread or introgression/hybridisation (19; 20), although a chemical study found no evidence for this on the Isle of Wight (32). A recent study in Ireland found evidence for pathogen spread from commercial hives (31) and studies on commercially imported colonies in the UK found high parasite prevalence (54). The new disease screening protocol required by Natural England of commercial producers should significantly limit the opportunity for pathogen spread (55). More research in the UK is required on (a) - (c), and an independent check on commercial parasite screening protocols is required (already present for one commercial producer, pers. comm). Effects on pollination would be very difficult to detect as we already have similar generalist flower visitors and pollinators and any changes would already have happened since first importation.
2.13	How important is social and other harm caused by the organism within its existing geographic range?	minimal - 0	LOW - 0	
2.14	How important is the social harm likely to be in the Risk Assessment area?	minimal - 0	LOW - 0	
2.15	How likely is it that genetic traits can be carried to native species, modifying their genetic nature and making their economic, environmental or social effects more serious?	likely - 3	MEDIUM -1	Subspecies can hybridise in the lab (4; 50) but they "prefer" to mate with same subspecies, probably due to pheromonal differences (50). In the field, there may also be behavioural barriers to hybridisation. Environmental effect would be on the genetic integrity of B.t.a. Need genetic markers to distinguish subspecies and hybrids, and more research on mating behaviour. Published and ongoing genetic studies provide potential evidence for hybridisation (19; 20), whilst chemical studies point in the opposite direction, with no evidence of *B. t. audax* & *B. t. dalmatinus* hybridisation in 180 bumblebees collected outdoors on the Isle of Wight (32). Further research in GB is urgently needed
2.16	How probable is it that natural enemies, already present in the Risk Assessment area, will have no affect on populations of the organism if introduced?	unlikely - 1	HIGH -2	Imported subspecies are likely to be affected by same pests, pathogens and predators as native bees. But effect of natural enemies on UK bumblebee populations, or imported ones, has not been studied. Research in Switzerland suggests that parasites may exhibit local adaptation, and thus impact of natural enemies is hard to predict (48)
2.17	How easily can the organism be controlled?	with some difficulty - 2	LOW - 0	If importation is stopped then propagule pressure drops, although B.t.t. & B.t.d may already be established. If importation continues then control is difficult because of difficulty in separating imports from related species/subspecies, and nests are difficult to find in the wild. The only current control measures to prevent imported colonies releasing sexuals are the queen excluder to prevent escape of queens (does not contain males or small queens), and advice to growers to destroy colonies after use - but these are difficult to enforce and unlikely to prevent escapes since colonies are still useful for pollination when they are producing sexuals. In Japan, the use of screens on greenhouses is an effective way to prevent further escapes (56). Banning of use in open polytunnels would also be a valuable control measure. All of these measures, including the use of queen excluders, require research to assess their effectiveness
2.18	How likely are control measures to disrupt existing biological or integrated systems for control of other organisms?	unlikely - 1	MEDIUM -1	It is unlikely that control would be attempted in the field, since such control would not be specific and would affect native bumblebees. Controls on the continuing import of bees would not disrupt other control systems
2.19	How likely is the organism to act as food, a host, a symbiont or a vector for other damaging organisms?	very likely - 4	MEDIUM -1	Considered very important issue and more research is required. Imported bumblebees may host pathogens, parasites or pests of native bumblebee species such as *Nosema bombi*, *Crithidia bombi, Apicystis bombi,* and RNA viruses (review in 5). There is evidence that pests and disease in commercial colonies can affect native bees in Canada (39), Japan (37, 38) and Ireland (31). Companies have extensive parasite and disease screening protocols (DEFRA, pers. comm.) but no independent screening has been done in GB. This is important because unpublished studies show high prevalence of parasites and pathogens in commercial colonies imported into GB, despite commercial screening protocols (54). The new licensing regime disease screening protocol should significantly reduce this risk (55), but it requires independent monitoring. This importation may also be a route of entry for the small hive beetle, *Aethina tumida* which can devastate honeybee populations and affect bumblebees (57) although imported honeybees are a much more likely route of entry for this species.
2.20	Highlight those parts of the endangered area where economic, environmental and social impacts are most likely to occur			Land surrounding horticultural crop production areas, particularly where bee imports are for open crop and open tunnel pollination. Most of UK up to southern Scotland where native B.t.a. is present, so possible hybridisation.

Summarise Entry	very likely - 4	LOW - 0	Definite, commercial importation since 1989, perhaps 40k colonies per year (although recent available data are for England - 2012 = 27,964 colonies). Distributed throughout U.K. and can escape confinement. Natural dispersal to UK also possible.
Summarise Establishment	likely - 3	MEDIUM -1	Needs similar climate, habitats and food to native species and it can hybridise with B.t.a. It is a flexible generalist, with large colonies of efficient nectar collectors. It is likely to disperse rapidly. Propagule pressure and intrinsic attributes suggest establishment is likely but, although it has been imported for 18 years, it has not been confirmed to have established in the UK. This maybe because it hasn't established or because of difficulties in identification and lack of large scale surveys. One unpublished study (31) provides tentative evidence against non-establishment at one site, but genetic studies are required
Summarise Spread	rapid - 3	HIGH -2	Not researched in UK, hence high uncertainty. The commercial subspecies could spread (by establishment or hybridisation) through the whole of the UK, although spread into Scotland may be limited by climate. We do not have good information on dispersal rates for any bumblebees, and rates may be affected by niche overlap with native species. Studies in Japan suggest spread >200km over 10 years (53)
Summarise Impacts	moderate - 2	HIGH -2	There are potential, but unmeasured (hence high uncertainty), negative environmental impacts: B.t.t. & B.t.d. may (a) compete with native bumblebees (not just B.t.a.) for food or nest sites; (b) hybridise with B.t.a.; (c) spread disease or pests to native bees; (d) change the balance of wild plant/weed pollination. We have no evidence that any of the above have, or have not, occurred, possibly because of difficulties in separating B.t.t. & B.t.d. from native B.t.a. & the almost complete absence of studies in GB. Competition & disease issues could still be risks even if native subspecies were bred commercially. Research needed on (a)-(c).
Conclusion of the risk assessment	MEDIUM -1	HIGH -2	As given in summaries above - more knowledge is required of the effect that 18 years of importation have had on native populations. Action will depend on a judgement about whether the subspecies are indeed distinct and the importance of retaining such subspecies.
Conclusions on Uncertainty		HIGH -2	Major obstacle is lack of tools to separate subspecies. Research required in order of priority: 1) Genetic & morphometric survey in GB comparing old (museum) *vs.* new specimens and imported *vs.* native specimens; 2) Examine evidence of establishment - including focussed survey on bees foraging in winter - are they B.t.t. or B.t.d? (study ongoing; Ings pers. comm.) 3) Evaluating disease & pest burden in imported colonies and possible effects on natives (current unpublished data; Greystock & Hughes, pers. comm.); 4) Reproductive behavioural ecology & realistic chances of hybridisation, including pheromone biology & spread rates; 5) Improved methods of preventing sexuals from escaping from commercial colonies; 6) Examine likelihood of competition in the field. The current research project in Ireland (14) will provide useful information to address issues 1-3, but not specifically for the UK.
Should risk management options be considered?			Independent screening of imported bees for pests and diseases should be considered essential to check the effectiveness of new screening protocols (see also Defra "Bee diseases & pest control order 2006 No.342"). Management options using current bee subspecies to reduce chances of establishment include: 1) improved queen excluders; 2) only using colonies in bee-proofed glasshouses; 3) companies taking responsibility for colony destruction. While new licensing conditions will address some of these, all are expensive, difficult to enforce, and unlikely to be 100% effective at controlling escape of sexuals. If importation of bees was banned there would be a substantial economic impact on fruit growers. One option would be to insist that companies sell native B.t.a. in UK (as in NZ and Tasmania) which would eliminate hybridisation risk and competition risk, but may not reduce disease risk to wild colonies. This would also face the problem that, under commercial selection, B.t.a. would become "not of a kind" and thus their use poses the same problems under the Country and Wildlife Act as the import of B.t.t. and B.t.d.

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