EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

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Pest Risk Analysis for *Cinnamomum camphora*

2017

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This pest risk analysis scheme has been specifically amended from the EPPO Decision-Support Scheme for an Express Pest Risk Analysis document PM 5/5(1) to incorporate the minimum requirements for risk assessment when considering invasive alien plant species under the EU Regulation 1143/2014. Amendments and use are specific to the LIFE Project (LIFE15 PRE FR 001) 'Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014'.

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Photo: *Cinnamomum camphora* (Forest and Kim Starr, Starr Environmental, Bugwood.org)

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

Pest risk analysis for *Cinnamomum camphora (L.) J. Presl*

This PRA follows EPPO Standard PM5/5 Decision support scheme for an Express Pest Risk Analysis

PRA area: EPPO region
First draft prepared by: S. Luke Flory,

Location and date: Paris (FR), 2016-10-17/21

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The pest risk analysis for *Cinnamomum camphora* has been performed under the LIFE funded project:

LIFE15 PRE FR 001

Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014

In partnership with

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION

And

NERC CENTRE FOR ECOLOGY AND HYDROLOGY

Review Process

- This PRA on *Cinnamomum camphora* was first drafted by S. Luke Flory
- The PRA was evaluated under an Expert Working Group (EWG) at the EPPO headquarters between 2016-10-17/21
- Following the finalisation of the document by the Expert Working Group the PRA was peer reviewed by the following:

  (1) The EPPO Panel on Invasive Alien Plants (November and December 2016)
  (2) The EPPO PRA Core members (December and January2016/17)

Contents

Summary[1] of the Express Pest Risk Analysis for *Cinnamomum camphora* (L.) J. Presl
PRA area: EPPO region (see https://www.eppo.int/ABOUT_EPPO/images/clickable_map.htm.).
Describe the endangered area: The endangered area includes the following countries: Albania, Algeria, Bosnia and Herzegovina, Croatia, Portugal, Georgia, Italy, Tunisia and Turkey and the following biogeographical regions: the Mediterranean and Black Sea. Currently, in the EPPO region, both the incidences of occurrence and their densities are limited (See Appendix 1). Species distribution models conducted for this PRA suggest that there are no areas within the EPPO region that have high suitability for establishment given the current climate conditions, and that only limited areas in the Mediterranean and Black Sea biogeographical regions have marginal suitability for the species (see Appendix 1). Given realistic climate change scenarios (i.e., RCP8.5) expanded areas of suitable establishment are predicted for large parts of the Atlantic, Continental, and Black Sea biogeographic regions. Thus, the future distribution of this potentially problematic species may increase under climate change scenarios, particularly due to temperature increases. However, current documentation of soil, habitat conditions, temperature, and precipitation requirements is limited for *C. camphora.* Habitats within the endangered area include evergreen forests, cleared land, mixed forests and moist forests that are widespread within the EPPO region. In the EPPO region *Cinnamomum camphora* is recorded (but not as invasive) in France, Portugal, and Spain. In France, a single occurrence is recorded, apparently casual, growing near Bordeaux. The species occurs in other European countries (for example, the Netherlands, Italy and Germany) as planted specimens in gardens.
Main conclusions *Cinnamomum camphora* presents a low phytosanitary risk for the endangered area within the EPPO region with a moderate uncertainty. *Cinnamomum camphora* has been planted regularly for more than 150 years as an ornamental and urban landscaping plant (McPherson 2003; Stubbs 2012, Firth and Ensbey 2014) and is found as single specimens in managed areas (i.e., parks and gardens) in the PRA area. Further spread within and among countries is low with a moderate uncertainty. The overall likelihood of *C. camphora* continuing to enter the EPPO region is moderate as the species is traded. **Entry and establishment** The pathways identified are: Plants or seed for planting (moderate likelihood of entry) Within the EPPO region *Cinnamomum camphora* is recorded (but not as invasive) in France, Portugal and Spain. In France, the species is regarded as casual. There is a single record of the plant on GBIF (www.gbif.org) growing near Bordeaux. The species occurs in other European countries (for example, the Netherlands, Italy and Germany) as planted specimens in gardens. Deliberate planting of *C. camphora* seeds or young plants remains the most likely form of human assisted spread. The small inedible drupes that hold the seeds currently are unlikely to be

[1] The summary should be elaborated once the analysis is completed

accidentally spread via human operations. In addition, dispersal by frugivorous birds is likely to occur.

Potential impacts in the EPPO region

Potential impact on biodiversity and ecosystem services in the EPPO region are likely to be low with a moderate uncertainty. Considering the low likelihood of establishment and spread within the EPPO region, due to the lack of suitable climate, soils and habitat, it is perceived that the impacts of *C. camphora* under current climate conditions will be low compared to the current range of the species. No impacts are envisaged on red list species and species listed in the Birds and Habitats Directives in the near future though this could potentially change if the species establishes under future climate conditions.

Given that this plant has been present in the EPPO region since at the turn 18th Century (Eaton 1912), it appears at least some of the factors that influenced the Australian invasion are not present in the EPPO region. The combination of climate, soils, and lack of cleared forest and abandoned land, which represents the main types of habitats affected by near monotypic camphor stands in Australia, is not common in the region. There may be limited areas susceptible to invasion that should be monitored for natural colonisation of this potential invader.

Impacts of *C. camphora* invasions in the EPPO area are likely attenuated by current climatic suitability. In areas suited to the spread and establishment of the species the main question is whether we can expect an invasion similar to what has occurred in parts of Australia.

Climate change
By the 2070s, under climate change scenario RCP8.5, projected suitability for *C. camphora* in Europe increases substantially. Much of Mediterranean and western Europe is predicted to become suitable for the species including the countries Albania, Belgium, Bosnia and Herzegovina, Croatia, France, Portugal, Georgia, Italy, Netherlands and Turkey.

The results of this PRA show that *Cinnamomum camphora* poses a low risk to the endangered area (Mediterranean and Black Sea biogeographical regions) under current climatic projections with moderate uncertainty.

The Expert Working Group recommends limited phytosanitary measures for this species given the overall low phytosanitary risk within the endangered area:

- a thorough review of identity and establishment status of *Cinnamomum* species within the endangered area,
- *Cinnamomum camphora* should be monitored for establishment and spread. Casual occurrences should be eradicated,
- industry correctly labels species in trade, including hybrids,
- the PRA is reviewed every ten years or when significant new information (e.g. naturalisation in the environment of the endangered area or ecological data) becomes available.

Phytosanitary risk for the *endangered area* (current/future climate) **Pathway for entry** Plants for planting: Moderate/Moderate Likelihood of establishment in natural areas: Low/High Likelihood of establishment in managed areas: Moderate/High Spread: Low/Low **Impacts (EPPO region)** Biodiversity: Low/Moderate Ecosystem services: Low/Moderate Socio-economic: Low/Moderate	High ☐	Moderate ☐	Low X
Level of uncertainty of assessment (current/future climate) **Pathway for entry** Plants for planting: Low/Moderate Likelihood of establishment in natural areas: Moderate/High Likelihood of establishment in managed areas: Moderate/High Spread: Moderate/Moderate **Impacts (EPPO region)** Biodiversity: Moderate/High Ecosystem services: Moderate/High Socio-economic: Moderate/High	High ☐	Moderate X	Low ☐

Express Pest Risk Analysis: *Cinnamomum camphora* (L.) J. Presl

Prepared by:

First draft: S. Luke Flory, University of Florida, Gainesville, FL. E-mail: flory@ufl.edu; tel.: 352-294-1581 (with support from Austin Young, ayoung@ufl.edu)

Date:

Stage 1. Initiation

1. Reason for performing the PRA:

Cinnamomum camphora was identified as a species of interest during an EU-wide "horizon scanning" effort, led by Roy *et al.* (2015), to identify potentially Invasive Alien Species (IAS) and prevent and mitigate their ecological effects. They developed a ranked list of species that are likely to be introduced, spread, and have significant impacts on biodiversity, and should be further evaluated with risk assessment approaches. Subsequently, EPPO included the species as one of concern in having the potential to establish and spread in novel areas within the next ten years. *Cinnamomum camphora* was identified as 1 of 16 species with high priority for a PRA given its known ecological impacts in its invasive range, coupled with the potential for spread in natural areas within the EPPO region, and cost effectiveness of management efforts. The species is a large tree native to Asia that has been intentionally introduced for ornamental, timber, and industrial purposes in regions around the world. In some regions (e.g., South-eastern Australia, South Africa, USA) *C. camphora* is often considered highly problematic because of its significant effects on native biodiversity and forest regeneration. Initial distribution maps indicated the potential occurrence of *C. camphora* is limited to southern areas of the EPPO region under current climate conditions but the projected range is expected to expand under future climate scenarios. In 2016, the species was prioritized (along with 36 additional species from the EPPO List of Invasive Alien Plants and a recent horizon scanning study[2]) for PRA within the LIFE funded project "Mitigating the threat of invasive alien plants to the EU through pest risk analysis to support the Regulation 1143/2014'. *C. camphora* was one of 16 species identified as having a high priority for PRA.

PRA area:
The EPPO region (see https://www.eppo.int/ABOUT_EPPO/images/clickable_map.htm.).

[2] http://ec.europa.eu/environment/nature/invasivealien/docs/Prioritising%20prevention%20efforts%20through%20horizon%20scanning.pdf

Stage 2. Pest risk assessment

Taxonomy:
Cinnamomum camphora (L.) J. Presl (Kingdom Plantae; Subkingdom Tracheobionta; Superdivision Spermatophyta; Division Magnoliophyta; Class Magnoliopsida; Subclass Magnoliidae; Order Laurales; Family Lauraceae; Genus *Cinnamomum*).
(USDA http://plants.usda.gov/core/profile?symbol=CICA, Accessed 8-19-2016)

Basionym: *Laurus camphora* L.

EPPO Code: CINCA

Synonymy:
Camphora officinarum Nees; *Camphora officinarum* var. glaucescens A. Braun; *Cinnamomum camphora* var. glaucescens (A. Braun) Meisn.; *Cinnamomum camphoroides* Hayata; *Cinnamomum nominale* (Hats. & Hayata) Hayata; *Persea camphora* (L.) Spreng. (Tropicos.org. Missouri Botanical Garden. 19 Aug 2016 <http://www.tropicos.org/Name/17805257>

Common names:
zhāng Chinese; 樟Chinese; kamferboom Dutch; camphor English; camphor laurel English; camphor tree English; majestic beauty camphor English (US); camphrier French; laurier du Japon French; Kampferbaum German; albero della confora Italian; alloro canforato Italian; laurocanfora Italian; kusu-no-ki Japanese; クスノキ Japanese; alcanforeira Portuguese; камфорное дерево Russian; камфорный лавр Russian; коричник камфорный Russian; alcanforero Spanish; kamferträd Swedish (EPPO Global Database, 2016)

Plant type: Evergreen large tree (Flora of China Vol. 7 Page 102, 167, 175)

Related species in the EPPO region: (from Botanical gardens) *Cinnamomum glanduliferum* (Wall.) Meisn. *Cinnamomum verum* J.Presl, *Cinnamomum japonicum* Siebold, *Cinnamomum micranthum* (Hayata)

2. Pest overview

Introduction

Cinnamomum camphora is a large evergreen tree that is native to Southeast Asia (China and Japan), but due to its commercial applications and use as landscaping species, has been introduced to warmer climates on six continents. The species produces drupes that are readily dispersed, primarily by birds, but also by waterways (Jordan 2011; Firth and Ensbey 2014). *Cinnamomum camphora* is considered a noxious weed or invasive in several regions where it has naturalized, including Australia (Firth, 1980a), USA (Florida), and South Africa, mostly due to its tendency to dominate disturbed environments and exclude other species (Stubbs 2012; Firth and Ensbey 2014). Within the EPPO region, the species is sold as an ornamental plant and is present in France, Germany, Ireland, Italy, Netherlands, Portugal and Spain (GBIF 2016; Eaton 1912), primarily as individually planted specimens although some of these occurrences may not be outdoors. Currently, in the EPPO region, both the incidences of occurrence and their densities are apparently limited. Species distribution models conducted for this PRA suggest that there are no areas within the EPPO region that have high suitability for establishment given the current climate conditions, and that only limited areas in the Mediterranean and Black Sea biogeographical regions and have marginal suitability for the species (see Appendix 1 and Appendix 2). Given realistic climate change scenarios (i.e., RCP8.5) expanded areas of suitable establishment are predicted for large parts of the Atlantic, Continental, and Black Sea biogeographic regions. Thus, the future distribution of this potentially problematic species may increase under climate change scenarios, particularly due to increases in minimum annual temperatures. However, current documentation of species soil, habitat conditions, temperature, precipitation requirements is limited for *C. camphora.*

Environmental requirements

Relatively limited research has been conducted on the ecophysiological limits of *C. camphora*. The species is most often distributed in moist tropical and subtropical environments but tolerates a reported broad range of precipitation and temperature conditions. Once established, adult *C. camphora* are considered hardy (USDA hardiness zones 9B through to 11), and Firth (1981) noted that it grows well in a wide range of environments throughout the world. However, there are limits to the conditions where *C. camphora* can survive. Both Yan De-qi et al. (2007) and You Yang et al. (2008) demonstrated that seedlings are damaged at temperatures of -10 ^{o}C and lower. However, neither study determined the temperature limit of the species, and large trees in Japan are known to survive 70-80 days per year of temperatures as low as -11 ^{o}C (Kew 1899). The preferred mean annual temperatures are reported to be around 14-27 ^{o}C. One source indicates that *C. camphora* can survive at altitudes of up to 1350-1800 meters and Gupta (1982) observed the species thriving at 2000 m asl in Nilgris, India. There is some indication that the species can tolerate annual rainfall of 640-4030 mm (Agroforestree Database, 2009) but Firth (1981) reported that *C. camphora* in Australia exhibited lower colonization in areas subject to rainfall less than 1400 mm. Under natural forest canopy in the native range in China, experimental research showed low germination and seedling growth (Chen et al 2004). It occurs on a variety of soils, although the development of minor deficiencies on alkaline soils has been reported and the species will not grow on soils that are waterlogged for extended periods (Gilman 2016; Kew 1899). Firth (1979) observed that *C. camphora* was most often found on well-drained, red clay soils (these are the acidic, krasnozem soils of cleared rainforest regions) in Australia. In sum, while *C. camphora* is broadly distributed in some regions, it is limited by temperature (cold in particular) and soil moisture conditions.

Habitats

Cinnamomum camphora is native to broadleaved evergreen, mixed deciduous and moist rainforests with warm, moist climates. However, in its introduced ranges it is most often found in heavily disturbed areas, particularly where forests have been cleared, plantations (e.g., banana in Australia) have been abandoned, or in cases where pastures are overgrazed or abandoned. In South Africa, the species invades forest margins, coastal bush and river banks (Henderson 2001). See also the **environmental requirements** section above.

Identification

Cinnamomum camphora is a large evergreen tree reaching heights of 30 meters and diameter at breast height of 1.5-2.0 m (See Figure 1 and 2, Appendix 3). It is strongly camphor-scented, including bark, leaves, branches. The bark is yellow-brown, and irregularly and longitudinally fissured (see Figure 3, Appendix 3). Branchlets are brownish, terete, and glabrous. Terminal buds are broadly ovoid with bud scales broadly ovate or suborbicular and sparsely sericeous outside. Leaves waxy in appearance, alternate; petiole slender, 2-3 cm, concave-convex, and glabrous (See Figure 4, Appendix 3). The leaf blade is yellow-green or gray-green and glabrous on both surfaces or sparsely puberulent abaxially only when young. Flowers are bisexual, tiny, with a white membranaceous perianth, and are organised in panicules that are shorter than the leaves. The fruit is a purple-black, ovoid or subglobose drupe, 6-8 mm in diameter, subtended by a small cupule (See Figure 5, Appendix 3). The plant features bract-covered buds and long, slender petioles (Flora of China, n.d.). *Cinnamomum camphora* can be distinguished from *C. glanduliferum* for example by leaf nervation. The former species typically has three main nerves to its leaves whereas the latter is pinnately nerved.

Symptoms

The primary symptom of *C. camphora* establishment in introduced ranges is the tendency to displace native vegetation, often to the extent of creating near monotypic thicket (Firth and Ensbey 2014). However, it should be noted that in many cases the formation of dense stands has occurred after land has been cleared, poorly managed (e.g., overgrazing), or abandoned. Once a monospecific stand of *C. camphora* forms, the ecological and economic value of land is diminished, especially because the species is considered difficult and costly to remove. Adult trees are highly competitive and produce a large, shady canopy that can suppress native seedlings (Firth and Ensbey 2014). *Cinnamomum camphora* may contribute to soil erosion on steep slopes and stream banks due to its shallow root system (Scott 1999). Limited studies in Australia have linked the fallen leaves of *C. camphora* to die-offs of aquatic animals in stream ecosystems. One such study showed that the leaf litter of *C. camphora* has detrimental effects on the densities of some native shredding invertebrates and inhibited growth rates of a common shredding caddisfly (Davies 2009). Thus, there is some evidence that *C. camphora* invasions can result in altered community structures and ecological functions. However, the extent of ecological effects of invasions appears highly variable, and may also be a symptom of land degradation.

Existing PRAs

Hawaii: Pacific Island Ecosystems at Risk (PIER). This risk assessment predicts the likelihood of invasions of species in Australia, Hawaii, and the high islands of the Pacific. Results are also sometimes modified for the State of Florida. The risk assessment for Hawaii scored *C. camphora* as 7.5, indicating that the species poses a significant risk of becoming a problematic invader (PIER 2005).

Spain: Andreu & Vilà (2009) performed two different types of Weed Risk Assessments (WRAs) for 80 species for Spain, including *C. camphora*. For both the "Australian" WRA and "Weber and Gut" methodologies *C. camphora* scored an 11, indicating low risk of invasion (Andreu & Vilà, 2009).

Europe (overall): The current PRA is being conducted under the LIFE project (LIFE15 PRE FR 001) within the context of European Union regulation 1143/2014, which requires that a list of invasive alien species (IAS) be drawn up to support future early warning systems, control and eradication of IAS.

Socio-economic benefits

Cinnamomum camphora has a history of use as a landscaping, ornamental, shade, and timber tree. Mature trees are attractive and hardy, and provide dense shade, making them ideal for parks, greenways, and landscapes. The wood of *C. camphora* is traded around the world to be used for products such as furniture and mulch. Camphor oil, derived from *C. camphora*, was historically harvested in eastern Asia to be used for medicinal, insecticidal, insect repellent, sanitary, and religious/ceremonial purposes (Stubbs 2012). In the 1860s, camphor began to be harvested for the creation of the nitrocellulose-based plastic that would become known as celluloid. At one point in the early twentieth century, as much as 70% of all camphor production was used for celluloid (Eaton 1912), with a primary use being the production of film. In the early part of the 20th century, industrial use of *C. camphora* declined as alternatives and synthetics emerged (PlantUse 2016). Although naturally derived camphor oil has been largely replaced on the market by synthetic versions, there exists a niche market for the product sourced from *C. camphora* (Scott 1999). More recently, leaves of the species have been used in the biosynthesis of silver and gold nanoparticles (Huang 2007). In South Africa, *C. camphora* is used as a foraging plant in bee farming. *Cinnamomum camphora* leaves have been used as a phytoremediation for the effective removal of Pb(II) from aqueous solutions (Chen et al., 2010).

Camphor tree continues to be available at online nurseries, e.g., in the UK:
http://www.planfor.co.uk/buy,camphor-tree,9295,EN
http://www.jungleseeds.co.uk/contents/en-uk/d20.html (seeds online)

and in Italy:
http://www.gorinipiante.it/en/mediterranean-plants/cinnamomum-camphora-2-00-2-50-clt-30-35_1959997703_en_gb-detail

3. Is the pest a vector? **Yes**

Cinnamomum camphora is a host for *Xyleborus glabratus* (redbay ambrosia beetle), which carries the spores of *Rafaela lauricola*, the fungus that causes laurel wilt disease. Laurel wilt disease is a pathogen with the potential to devastate *Persea borbonia* (redbay), avocado (*Persea americana),* and other related species (Mayfield et al. 2008). Recently, the disease has led to mass redbay tree deaths in the southeastern USA (Mayfield et al 2008) and was first discovered on an avocado tree in Florida in 2007 (EPPO 2016). Both *X. glabratus* and *R. lauricola* are absent in the EPPO region, but *R. lauricola* can be transferred from diseased trees to insects other than *X. glabratus* and still lead to tree mortality. The PRA regions main area of risk are probably the laurel forests (including Lauraceae genera such as *Apollonias, Ocotea, Persea*) found in the Azores, Madeira (PT) and Islas Canarias (ES) – although, their susceptibility is unknown (EPPO 2016). EPPO also reports "avocado is not widely grown in the EPPO region but is of economic importance at least in Israel and Spain." Currently, there are no cultivars of avocado immune to laurel wilt disease. C. camphora has been reported as a host of *Phytophora ramorum* (Rooney et al., 2013).

4. Is a vector needed for pest entry or spread? **No**

No vector is necessary for *C. camphora* to enter into or spread within the PRA area.

5. Regulatory status of the pest

USA:
Category 1 (capable of "...altering native plant communities by displacing native species, changing community structures or ecological functions, or hybridizing with natives.") on the Florida Exotic Pest Plant Council's 2015 List of Invasive Plant Species (fleppc.org). Prohibited in Miami-Dade County, Florida, USA.

Australia:
New South Wales: Class 4 (locally controlled weed). The growth and spread of this species must be controlled according to the measures specified in a management plan published by the local control authority and the plant may not be sold, propagated, or knowingly distributed (in the Ballina, Bellingen, Blue Mountains, Byron, Clarence Valley, Hornsby, Ku-ring-gai, Kyogle, Lismore, Nambucca, Richmond Valley, Ryde, Tweed and Willoughby local authority areas).

Queensland: Class 3 (primarily an environmental weed). A pest control notice may be issued for land that is, or is adjacent to, an environmentally significant area (throughout the entire state). It is also illegal to sell a declared plant or its seed in this state.

South Africa:
Category 1 (i.e. requires compulsory control) species in 4 out of the 9 South African Provinces (KwaZulu-Natal, Limpopo, Eastern Cape and Mpumalanga), but not subject to legislation elsewhere. In the Western Cape Province listed as category 3 species meaning that a permit is required for transport and use.

6. Distribution

Continent	**Distribution** (list countries, or provide a general indication, e.g. present in West Africa)	**Provide comments on the pest status in the different countries where it occurs** (e.g. widespread, native, introduced)	**Reference**
Africa	Canary Islands, Madagascar, South Africa, Egypt, Ghana, Kenya, Togo, Tanzania, Zimbabwe	Introduced and established. Cultivated in Madagascar	Henderson (2007), Kew (1899), USDA (2016).
North America	United States: Florida, North Carolina, South Caroline, Georgia, Alabama, Mississippi, Louisiana, Texas, California	Introduced. Widespread primarily in parks and gardens and disturbed areas, often listed as invasive	USDA (2016), Langeland et al. (2008), Tropicis.org (2016).
South and Central America	Bolivia, Brazil, Costa Rica, El Salvador, Honduras, Puerto Rico, Trinidad and Tobago, Venezuela,	Introduced. Widespread primarily in landscaping and disturbed areas, often listed as invasive	Kew (1899), USDA (2016).
Asia	China, Japan, South Korea, Vietnam, Bangladesh, Hong Kong, Indonesia, India, Laos, Malaysia, Saudi Arabia, Taiwan, Sri Lanka	Native and widespread in SE Asia.	Eaton (1912), Stubbs (2012), USDA (2016), GBIF (2016).
Europe	France, Portugal, Spain.	Introduced, currently not invasive. In France, the species is regarded as casual. There is a single record of the plant on GBIF growing on a dune system at the Cap de Ferret, near Bordeaux. The species occurs in European countries (for example, the Netherlands, Italy and Germany) as a planted species in botanical gardens.	Eaton 1912, GBIF (2016) Personal Communication G. Fried (2016); Maniero (2000).
Oceania	Australia, French Polynesia, Hawaii, New Zealand	Invasive and problematic, primarily in Australia where it is under chemical and mechanical control.	GBIF (2016), Stubbs (2012), USDA (2016).

Introduction

Cinnamomum camphora is native to much of eastern, and primarily southeastern, Asia, including southern China, Indonesia, Vietnam, Korea, and southern Japan. It was introduced intentionally in many regions of the world for ornamental, landscaping, and maybe most often for commercial purposes to produce camphor oil. The species is most problematic and widespread in Australia and Florida, USA (See Figure 1, Appendix 4).

North America
Introduced to Florida as early as 1870 and one nursery alone was selling 15,000 trees annually in the early twentieth century (Eaton 1912). In 1880, the USDA distributed seed and young trees to be planted as windbreaks and ornamentals, resulting in rapid and widespread distribution in the southern and principally southeastern USA (Eaton 1912). In the 1900s, *C. camphora* was regularly planted as a street tree in California (McPherson 2003). The USDA currently reports *C. camphora* established in North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Texas, and California (USDA 2016).

Asia
Cinnamomum camphora is native to subtropical East Asia, specifically Japan, China, Vietnam, and Taiwan (Stubbs 2012). By 1912 it was being cultivated in Malaysia, Sri Lanka (Ceylon as detailed in Eaton, 1912), India, and Myanmar (Burma, as detailed in Eaton, 1912) (Eaton 1912). There are no available reports to indicate that *C. camphora* is problematic in its native range.

Europe
Prior to 1912, *C. camphora* was grown as an ornamental in Italy and other southern European countries near the Mediterranean (Eaton 1912). By 1899 the species was reported as 'thriving' in Southeastern France (Kew 1899). However, more recent evidence of *C. camphora* occurring outside cultivation in Europe is very limited. In France the species is regarded as casual. There is a single record of the plant on GBIF growing on a dune system at the Cap de Ferret, near Bordeaux. The majority of literature that mentions the species refers to a lone tree, specimens in botanical gardens, and urban ornamentals. In Switzerland, the is reference to the *C. camphora* but the species has not become naturalised (Walther, 2000).

Oceania
Cinnamomum camphora was introduced to Australia in the late 1820s, but the earliest planting outside of a botanical garden occurred in the 1870s (Stubbs 2012). By the late 1990s, it had become a major environmental problem in eastern Australia (Firth, 1980b; Stubbs 2012). In Queensland and New South Wales the species is prohibited from sale and propagation. In eastern Australia "extensive monospecific stands have developed along the banks of creeks and rivers preventing regeneration of native tree and shrub species. It is particularly well-adapted to areas formerly covered by rainforest (PIER 2012)."

Central and South America
By 1899, *C. camphora* was reported as flourishing in Buenos Aires, Argentina (Kew 1899). By 1912 it was under cultivation in Jamaica and the West Indies (Eaton 1912).

Africa
There have been various efforts to cultivate the species as an ornamental, agricultural, and silvicultural plant in Africa. In 1896, *C. camphora* was shipped from East Africa to the British Royal Gardens, Kew (Botanical Enterprise in East Africa 1896). Field records from 1979 to 2000 in South Africa, Lesotho, and Swaziland (consolidated by Henderson 2007) show *C. camphora* listed as invasive in forest habitats**,** savannah biome, and grassland biome. However, the "total weighted abundance" for the species is consistently rated very low within the same area (Henderson 2007). By 1899 the species was reported as 'thriving' in Egypt (Kew 1899).

7. Habitats and their distribution in the PRA area

EUNIS habitats from: European Environment Agency (2016)

Habitats	**EUNIS habitat types**	**Status of habitat (eg threatened or protected)**	**Present in PRA area (Yes/No)**	**Comments (e.g. *major/minor habitats* in the PRA area)**	***Reference***
Wooded areas	G: Woodland, forest and other wooded land	Protected *pro parte*: e.g. Annex 1 G: 41.181, 41.184, 41.6, 41.77, 41.85, 41.9, 41.1A X 42.17 41.1B, 42.A1 44.17 44.52, 44.7 44.8, 45.8, 41 .7C, 45.1, 45.2, 45.3, 45.5, 45.61 to 45.63, 45.7	Yes	Major habitats within PRA area.	EWG opinion
Heathland	F: Heathland and scrub	Protected *pro parte*: e.g. Annex 1 F: 32.216, 32.11	Yes	Major habitats within PRA area.	EWG opinion

Cinnamomum camphora is native to broadleaved evergreen, mixed deciduous and moist rainforests with warm, moist climates. However, in its introduced ranges it is most often found in heavily disturbed areas, particularly where forests have been cleared, plantations (e.g., banana in Australia) have been abandoned, or in cases where pastures are overgrazed or abandoned. In South Africa, the species invades forest margins, coastal bush and river banks (Henderson 2001). In the EPPO region, habitats include evergreen forests, cleared land, mixed forests and moist forests.

Woodland habitat is found throughout the PRA area. The abundance and diversity of heath and scrub habitats is uneven across the different regions of Europe, with a higher representation in the Mediterranean, the Macaronesian and in the Atlantic regions, where a substantial number of genera of legumes, ericaceous and other sub-shrubs are highly diversified

8. Pathways for entry

Possible pathways *(in order of importance)*	**Pathway: Plants for planting**
Short description explaining why it is considered as a pathway	*Cinnamomum camphora* has a history of deliberate planting for ornamental and other purposes at both urban (e.g., city streets) and rural (e.g., abandoned fields) sites (Stubbs 2012). The seeds and young plants are available on the internet informally and through nurseries. Seed of C. camphora is available for purchase from outside of the EPPO region. Websites often advertise that seeds are shipped worldwide (for example http://www.seedscollector.com/50-seeds-camphor-tree--cinnamomum-campho50.html). Many of the traders misidentify *Cinnamomum camphora* with other *Cinnamomum* spp, e.g. *C. glanduliferum*.
Is the pathway prohibited in the PRA area?	There is no evidence of regulation within the PRA area.
Has the pest already intercepted on the pathway?	Yes because it is the commodity itself.
What is the most likely stage associated with the pathway?	All growth forms except for large trees are associated with this pathway, including trade of seeds.
What are the important factors for association with the pathway?	Seed suppliers (http://www.seedscollector.com/50-seeds-camphor-tree--cinnamomum-campho50.html and online marketplaces (e.g., ebay.com)
Is the pest likely to survive transport and storage in this pathway?	Only through intentional introductions by humans. However, given the seeds can be dispersed by birds and waterways, any tree producing drupes within the EPPO region could be the origin of a new establishment, especially trees that are planted near watercourses and in non-urban habitats.
Can the pest transfer from this pathway to a suitable habitat?	Yes, through direct human actions. The species responds well to anthropogenic disturbances in rural (e.g. agriculture) areas. Planted individuals may have the potential to be spread via birds or water dispersed seeds.
Will the volume of movement along the pathway support entry?	Any volume of movement will support entry. However, there is no information on the amount the species is traded (imported) into the EPPO region from Asia or the USA.
Will the frequency of movement along the pathway support entry?	Yes, see question 'Will the volume of movement along the pathway support entry?'
Likelihood of entry	*Low* ☐ *Moderate* **X** *High* ☐

Rating of uncertainty	*Low* X	*Moderate*	*High* ☐

Do other pathways need to be considered?

No

9. Likelihood of establishment in the natural environment PRA area

In the native range the species is generally limited to approximately 10-36 °N and 105-130 °E and in warm, moist climatic zones (CABI 2016). In areas where minimum temperatures dip below -10 °C, C. *camphora* seedlings experience damage (Yan De-qi et al 2007; You Yang et al 2008). Therefore, establishment within the PRA area is less likely where such temperatures are common. The most likely area of establishment is the Mediterranean and Black Sea biogeographical region. Habitats within the endangered area include Mediterranean woodlands and scrublands where laurels are known to grow.

Habitats within the endangered area include evergreen forests, cleared land, mixed forests and moist forests that are widespread within the EPPO region.

Rating of the likelihood of establishment in the natural environment	*Low* X	*Moderate*	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

10. Likelihood of establishment in managed environment in the PRA area

Cinnamomum camphora has been planted regularly for more than 150 years as an ornamental and urban landscaping plant (McPherson 2003; Stubbs 2012, Firth and Ensbey 2014) and is found as single specimens in managed areas (i.e., parks and gardens) in the PRA area.

Relatively limited research has been conducted on the ecophysiological limits of *C. camphora*. The species is most often distributed in moist tropical and subtropical environments but tolerates a reported broad range of precipitation and temperature conditions. There are limits to the conditions where *C. camphora* can survive. Both Yan De-qi et al. (2007) and You Yang et al. (2008) demonstrated that seedlings are damaged at temperatures of -10 °C and lower and therefore this would limit its natural establishment within much of Europe. The preferred mean annual temperatures are reported to be around 14-27 °C.

Cinnamomum camphora occurs on a variety of soils, although the development of minor deficiencies on alkaline soils has been reported and the species will not grow on soils that are waterlogged for extended periods (Gilman 2016; Kew 1899). Firth (1979) observed that *C. camphora* was most often found on well-drained, red clay soils (these are the acidic, krasnozem soils of cleared rainforest regions) in Australia.

Currently, in the EPPO region, both the incidences of occurrence and their densities are apparently limited. Species distribution models conducted for this PRA suggest that there are no areas within the EPPO region that have high suitability for establishment given the current climate conditions, and that only limited areas in the Mediterranean and Black Sea biogeographical regions and have marginal suitability for the species (see Appendix 1 and Appendix 2).

Rating of the likelihood of establishment in the managed environment	*Low* ☐	*Moderate* X	*High*
Rating of uncertainty	*Low*	*Moderate* X	*High* ☐

11. Spread in the PRA area

Natural spread

The species spreads primarily through frugivorous birds that feed on the drupes and disperse seeds widely, with little effect on seed viability (Stubbs 2012, Jordan 2011, Firth and Ensbey 2014). Firth (1979), suggested other fauna also consume and spread the seeds, but he did not give the species names. He also indicated the possibility of spread by water due to the fact the seed can survive up to 40 days in water. It has been reported that seeds can remain viable for up to 3 years and germination can extend across a period of 4 to 20 weeks (Firth and Ensbey 2014). However, experimental work demonstrated that seed survival was less than 1 % after 12 months (Panetta 2001). Under natural forest canopy in the native range in China, experimental research showed low germination and seedling growth (Chen et al 2004), but establishment rates in the invaded range (eg. Australia) are high. Drupes also can be spread by flowing water, streams (Queensland Government 2016).

Human assisted spread

Cinnamomum camphora is planted for landscaping and was historically farmed for camphor oil and timber production (Stubbs 2012). After the mid-1940s, large plantations were established in Japan and China. It has been cultivated outside of its native range, including in Sri Lanka, southern India, eastern Africa, and the USA (Eaton 1912), but there are no documented sites of camphor production within the EPPO region. The plant is present in Europe primarily due to ornamental or landscaping plantings.

Camphor tree continues to be available at online nurseries, e.g., in the UK:
http://www.planfor.co.uk/buy,camphor-tree,9295,EN
http://www.jungleseeds.co.uk/contents/en-uk/d20.html (seeds online)

and in Italy:
http://www.gorinipiante.it/en/mediterranean-plants/cinnamomum-camphora-2-00-2-50-clt-30-35_1959997703_en_gb-detail

Deliberate planting of *C. camphora* seeds or young plants remains the most likely form of human assisted spread. The small inedible drupes that hold the seeds currently are unlikely to be accidentally spread via human operations.

A low rating for magnitude of spread has been given as even though the species has been reported to spread by water there is no evidence that the species grows near riparian systems in the EPPO region. In addition, it is unlikely that active frugivore fauna that is capable of spreading seeds of the plants dimensions are present in the EPPO region.

Rating of the magnitude of spread	*Low* X	*Moderate*	*High* ☐
Rating of uncertainty	*Low*	*Moderate* X	*High* ☐

12. Impact in the current area of distribution

12.01 Impacts on biodiversity and ecosystem patterns

Cinnamomum camphora can form apparently monotypic thickets and exclude native vegetation (Firth and Ensbey 2014). Its large shady canopy and dense shallow roots may suppress the establishment and growth of seedlings in the immediate vicinity of the tree (Firth and Ensbey 2014). However, a scientific review committee assembled by the Government of New South Wales, Australia found little evidence to support the claims of adverse impacts on native taxa from the toxic chemotypes found in *C. camphora's* leaf exudates (NSW Scientific Committee 2004). *Cinnamomum camphora* actually may be beneficial for bird populations in Australia by providing food and habitat on recently cleared land (Date 1991; Kanowski and Catterall, 2008). Experiments have found *C. camphora* has a detrimental effect on densities of native invertebrates and impairs growth rates of a common shredding caddisfly, possibly due to the chemicals in the leaf litter dropped into streams (Davies 2009). The root system of *C. camphora* is thought to poorly hold soil in place around streams and drainage ditches, resulting in bank destabilisation (Scott 1999; Firth and Ensbey 2014).

To-date there are no impacts recorded on red list species and species listed in the Birds and Habitats Directives.

Control measures

Mechanical control

Smaller trees can be cut down easily, but the stumps can rapidly resprout so they must be grinded out or treated chemically (Firth 1981). Bulldozing is effective at removing the entire tree and can be done without prior treatments, but is expensive (Firth and Ensbey 2014). However, care should be taken during the mechanical removal of entire trees as the resulting soil disturbance can encourage further invasions of *C. camphora* or other non-native species (Firth and Ensbey 2014). Continuous mowing will kill resprouting shoots, and burning can be effective, but larger trees often resprout (Queensland Government 2016).

Chemical control

This section lists chemicals that have been cited for use against the species. This does not mean the chemicals are available or legal to use and countries should check to ensure chemicals are licensed for use in their country. Depending on the type of herbicide and size of the tree, control can be achieved through cut stump, stem injection, basal bark, or foliar spray application techniques (Firth and Ensbey 2014). Firth (1981) recommends spraying young plants with a 0.3 % mixture of 2,4-D and 2,4,5-T in water. Basal bark and cut stump applications are recommended for larger trees, with a higher concentration; 3 to 5 % herbicide in oil. See table below for recent recommendations:

Adapted from: State of Queensland, Department of Agriculture and Fisheries, 2016. Camphor laurel Factsheet. (note: This section lists chemicals that have been cited for use against the species. This does not mean the chemicals are available or legal to use and countries should check to ensure chemicals are licensed for use in their country).

Herbicide	Rate	Comments
Triclopyr 300 g/L + picloram 100 g/L (e.g. Conqueror)	350–500 mL/100 L water	High-volume spray for trees up to 3 m tall; higher rate for trees > 2 m tall.
	500 mL/10 L water	High concentration/low volume application (gas gun or sprinkler sprayer). Trees less than 1.5 m high which are able to be sprayed from all sides. Use high volume application on larger bushes.
Triclopyr 300 g/L + picloram 100 g/L + aminopyralid 8 g/L (e.g. Grazon Extra)	350–500 mL/100 L water	High concentration/low volume application (gas gun or splatter gun). Trees less than 1.5 m high.
	500 mL/10 L water	High concentration/low volume application (gas gun or splatter gun). Trees less than 1.5 m high. Use high volume application on larger bushes.
Triclopyr 600 g/L (e.g. Garlon 600)	170 mL/100 L water	High-volume foliar spray for trees up to 3 m tall.
Triclopyr 600 g/L (e.g. Garlon 600)	1 L in 60 L diesel	Basal bark trees to 10 cm diameter or cut stump trees to basal bark size or greater.
Triclopyr 200 g/L + picloram 100 g/L (e.g. Slasher)	Mix 1 part herbicide with 4 parts water	Stem injection application. Consult label for detailed instructions.
Triclopyr 200 g/L + picloram 100 g/L + aminopyralid 25 g/L (e.g. Tordon RegrowthMaster)	Mix 1 part herbicide with 4 parts water	Stem injection application. Consult label for detailed instructions.
Glyphosate 360 g/L (e.g. Roundup Biactive)	2 mL of 1:1 mix with water	Stem injection for trees up to 25 cm in diameter.
	2 mL undiluted	Stem injection for trees 25−60 cm in diameter
Glyphosate 360 g/L (Roundup®)	Undiluted	4ml per drill hole / axe cut
Glyphosate 360 g/L (Roundup®)	1 part glyphosate to 50 parts water	Spray seedlings and coppice shoots.
Glyphosate 360 g/L (Roundup®)	1 part glyphosate to 1.5 parts water	Cut stump/scrape stem application for saplings. Stem injection application large trees and shrubs.
Picloram 100 g/L + Triclopyr 300 g/L + Aminopyralid 8 g/L (Grazon Extra®)	350 or 500 mL per 100 L water	Use higher rate on trees over 2 m tall. Apply as a thorough foliar spray.
Picloram 44.7 g/kg + Aminopyralid 4.47 g/L (Vigilant II ®)	Undiluted	Cut stump/stem injection application. Apply a 3–5 mm layer of gel for stems less than 20 mm. Apply 5 mm layer on stems above 20 mm.

Biological control

There are no known biological control agents for management of *C. camphora*, and no current efforts to develop agents.

A high rating for impact in the current area of distribution has been given due to the plants impact on invertebrate populations. The EWG hold the opinion that dense stands of *C.*

camphora can have a significant impact on native biodiversity. A moderate uncertainty is given to reflect that much of the information on impacts is currently unsupported by scientific studies.

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* X
Rating of uncertainty	*Low*	*Moderate* X	*High* ☐

12.02. Consider the negative impact the pest may have on categories of ecosystem services

Ecosystem service	**Does the IAS impact on this Ecosystem service?** Yes/No	**Short description of impact**	**Reference**
Provisioning	Yes	May inhibit growth of more desirable forest species.	Firth and Ensbey, 2014.
Regulating	Yes	Experiments have found *C. camphora* has a detrimental effect on densities of native invertebrates and impairs growth rates of a common shredding caddisfly, possibly due to the chemicals in the leaf litter dropped into streams. May suppress biodiversity of trees herbaceous plants and aquatic organisms.	Davies 2009; Firth and Ensbey, 2014; Victoria State, Australia 2016.
Supporting	Yes, but no documented effect.	Given the formation of apparently monotypic thickets and exclusion of native vegetation, it is expected there are effects on nutrient cycling and habitat stability.	EWG opinion
Cultural	Yes	Impacts on tourism through the poisonous qualities of all parts of the plant. In addition, the root structure may damage cultural sites.	Victoria State, Australia 2016.

Rating of the magnitude of impact in the current area of distribution	*Low* ☐	*Moderate* ☐	*High* X
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

12.03. Describe the adverse socio-economic impact of the species in the current area of distribution

Economic impacts

In heavily invaded areas of Australia, where *C. camphora* stands have established in former rainforest sites, restoration of native forest has been documented to be costly (Kanowski and Catterall, 2007).

Removal of large trees is expensive and *C. camphora* often regenerates after felling (Firth and Ensbey 2014). Other websites provide additional anecdotes of economic effects such as devaluation of grazing land (eg. Victoria State Australia, 2016), but many of these impacts are very general and non-specific to the invader. Kanowski and Catterall (2007) estimate costs of removing trees in rainforest habitats in New South Wales, Australia, vary from 5 000 – 30 000 $AUS/ha.

Human activities

There is little evidence of disruption to human activities due to the presence of *C. camphora*. It is often planted as a shade and timber tree, and its desirable qualities have been noted (Stubbs 2012). All parts of *C. camphora* are poisonous to humans and can cause allergies, nausea, vomiting, respiratory distress (Johnson, 2006). There have also been reported effects on leisure activities, but these are generally unsubstantiated.

Rating of the magnitude of impact in the current area of distribution	*Low*	*Moderate* X	*High*
Rating of uncertainty	*Low*	*Moderate* X	*High*

13. Potential impact in the PRA area

Potential impact on biodiversity and ecosystem services in the EPPO region are likely to be low with a moderate uncertainty. Considering the low likelihood of establishment and spread within the EPPO region, due to the lack of suitable climate, soils and habitat, it is perceived that the impacts of *C. camphora* under current climate conditions will be low compared to the current range of the species. No impacts are envisaged on red list species and species listed in the Birds and Habitats Directives in the near future though this could potentially change if the species establishes under future climate conditions.

Given that this plant has been present in the EPPO region since at the turn 18th Century (Eaton 1912), it appears at least some of the factors that influenced the Australian invasion are not present in the EPPO region. The combination of climate, soils, and lack of cleared forest and abandoned land, which represents the main types of habitats affected by near monotypic camphor stands in Australia, is not common in the region. There may be limited areas susceptible to invasion that should be monitored for natural colonisation of this potential invader.

Impacts of *C. camphora* invasions in the EPPO area are likely attenuated by current climatic suitability. In areas suited to the spread and establishment of the species the main question is whether we can expect an invasion similar to what has occurred in parts of Australia.

C. camphora is poisonous to humans and can cause allergies, nausea, vomiting, respiratory distress (Johnson, 2006).

Will impacts be largely the same as in the current area of distribution? No

13.01. Negative environmental impacts with respect to biodiversity and ecosystem patterns and processes

If No

Rating of the magnitude of impact in the area of potential establishment	*Low* X	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

13.02. Negative impact the pest may have on categories of ecosystem services

If No

Rating of the magnitude of impact in the area of potential establishment	*Low* X	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

13.03 Socio-economic impact of the species

If No

Rating of the magnitude of impact in the area of potential establishment	*Low* X	*Moderate* ☐	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High* ☐

14. Identification of the endangered area

Currently, in the EPPO region, both the incidences of occurrence and their densities are apparently limited (See Appendix 1). Species distribution models conducted for this PRA suggest that there are no areas within the EPPO region that have high suitability for establishment given the current climate conditions, and that only limited areas in the Mediterranean and Black Sea biogeographical regions and have marginal suitability for the species (see Appendix 1.). Given realistic climate change scenarios (i.e., RCP8.5) expanded areas of suitable establishment are predicted for large parts of the Atlantic, Continental, and Black Sea biogeographic regions. Thus the future distribution of this potentially problematic species may increase under climate change scenarios, particularly due to increases in minimum annual temperatures. However, current documentation of species soil and habitat conditions, and temperature and precipitation requirements is limited for *C. camphora.*

Habitats within the endangered area include evergreen forests, cleared land, mixed forests and moist forests that are widespread within the EPPO region.

15. Climate change

15.01. Define which climate projection you are using from 2050 to 2100*

Climate projection **RCP 8.5 2070**

15.02 Which component of climate change do you think is most relevant for this organism?

Temperature ***(yes)*** *Precipitation* ***(yes)*** *C0*$_2$ *levels (****yes)***

Sea level rise ***(no)*** *Salinity* ***(no)*** *Nitrogen deposition* ***(yes)***

Acidification ***(no)*** *Land use change* ***(yes)***

Are the **introduction pathways** likely to change due to climate change? **(If yes, provide a new risk and uncertainty score)**	**Reference**
Import for ornamental planting may increase as the range of suitable area for cultivation is predicted to expand within the EPPO region. The score for risk under predicted future climate conditions will not change but the uncertainty score will increase. Risk = Moderate Uncertainty = Moderate	EWG opinion; Appendix 1
Is the **risk of establishment** likely to change due to climate change? **(If yes, provide a new risk and uncertainty score)**	**Reference**
The likelihood of establishment could increase with higher temperatures and greater rainfall in some areas. A primary concern would be fewer low temperature events, given that it is know that -10 °C has negative effects on *C. camphora*. Climate change predictions suggest the species will be capable of more readily establishing around the Atlantic, Western Continental, and the Black Sea biogeographic regions. Therefore, new scores for risk and uncertainty for predicted future climate conditions, based on changes in temperature and precipitation is: Risk = High Uncertainty = High Other important elements of change, including land-use change and $C0_2$ levels are not included in the above scoring.	(Yan De Qi et al. 2007; You Yan et al 2008).
Is the **risk of spread** likely to change due to climate change? **(If yes, provide a new risk and uncertainty score)**	**Reference**
The risk of spread is unlikely to change as a result of climate change.	EWG opinion
Will **impacts** change due to climate change? **(If yes, provide a new risk and uncertainty score)**	**Reference**
With increasing temperatures it is possible *C. camphora* may impact the EPPO region as the area of suitability increases. Higher temperatures could cause more rapid growth and biomass accumulation, resulting in greater impacts to native species. Therefore, new scores for impact on biodiversity is moderate with high uncertainty for predicted future climate conditions, based on changes in temperature and precipitation is: Impacts on ecosystem sercives and socio-economic impacts will remain the same. Other important elements of change, including land-use change and $C0_2$ levels are not included in the above scoring.	EWG opinion

16. Overall assessment of risk

The overall likelihood of *C. camphora* entering into the EPPO region is moderate with a low uncertainty. Within the EPPO region, the species is sold as an ornamental plant and is present in France, where the species is regarded as casual, growing at the Cap de Ferret, near Bordeaux and in other European countries (for example, the Netherlands, Italy and Germany) as a planted species in parks and gardens.

The overall likelihood of *C. camphora* establishing in the EPPO region is moderate with a moderate uncertainty - the species is already present in France within the EPPO region. The overall potential impact of the species is low with a moderate uncertainty.

Pathways for entry:

Plants for planting

Rating of the likelihood of entry for the pathway, plants or seeds for planting	*Low*	*Moderate* X	*High*
Rating of uncertainty	*Low* X	*Moderate*	*High*

Rating of the likelihood of establishment in the natural environment in the PRA area

Rating of the likelihood of establishment in the natural environment	*Low* X	*Moderate*	*High*
Rating of uncertainty	*Low*	*Moderate* X	*High*

Rating of the likelihood of establishment in the managed environment in the PRA area

Rating of the likelihood of establishment in the natural environment	*Low*	*Moderate* X	*High*
Rating of uncertainty	*Low*	*Moderate* X	*High*

Magnitude of spread

Rating of the magnitude of spread	*Low* X	*Moderate*	*High*
Rating of uncertainty	*Low*	*Moderate* X	*High*

Impact on biodiversity

Rating of the magnitude of impact in the current area of distribution (Biodiversity)	*Low*	*Moderate*	*High* X
Rating of uncertainty	*Low* X	*Moderate*	*High*

Impact on ecosystem services

Rating of the magnitude of impact in the current area of distribution (ecosystem services)	*Low*	*Moderate*	*High* X
Rating of uncertainty	*Low* X	*Moderate*	*High*

Impact on socio-economics

Rating of the magnitude of impact in the current area of distribution (ecosystem services)	*Low*	*Moderate* X	*High*
Rating of uncertainty	*Low*	*Moderate* X	*High*

Will impacts be largely the same as in the current area of distribution? No

Rating for impacts within the EPPO region:

Impact on biodiversity

Rating of the magnitude of impact in the current area of distribution (Biodiversity)	*Low* X	*Moderate*	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High*

Negative impact the pest may have on categories of ecosystem services

Rating of the magnitude of impact in the current area of distribution (ecosystem services)	*Low* X	*Moderate*	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High*

Socio-economic impact of the species

Rating of the magnitude of impact in the current area of distribution (ecosystem services)	*Low* X	*Moderate*	*High* ☐
Rating of uncertainty	*Low* ☐	*Moderate* X	*High*

Stage 3. Pest risk management

17. Phytosanitary measures

The results of this PRA show that *Cinnamomum camphora* poses a low risk to the endangered area (Mediterranean and Black Sea biogeographical regions) under current climatic projections with moderate uncertainty. In the EPPO region *Cinnamomum camphora* is recorded (but not invasive) in France, Portugal, and Spain. In France a single occurrence is recorded, apparently casual.

The Expert Working Group recommends limited phytosanitary measures for this species given the overall low phytosanitary risk within the endangered area:

- a thorough review of identity and establishment status of *Cinnamomum* species within the endangered area,
- *Cinnamomum camphora* should be monitored for establishment and spread. Casual occurrences should be eradicated,
- industry correctly labels species in trade, including hybrids,
- the PRA is reviewed every ten years or when significant new information (e.g. naturalisation in the environment of the endangered area or ecological data) becomes available.

17.01 Management measures for eradication, containment and control

None recommended under the pest risk management section but see section 12.01 for measures applied in other regions.

18. Uncertainty

Uncertainty should also be considered in the context of species distribution modelling (SDM). Here records for *C. camphora* and synonyms were retrieved from GBIF and other online sources, and were also digitised from occurrences that were either mapped or clearly georeferenced in published sources. This may mean that the realised climatic niche of *C. camphora* is under-characterised. In addition, georeferenced records used in our SDMs were usually without information on population persistence – if records within the EPPO area, or in climatically similar areas, are typically of 'casual' occurrences, rather than established populations, it may be that our SDMs over-emphasise the likelihood of establishment in climatically marginal habitats.

Level of uncertainty of assessment (current/future climate)

Pathway for entry

Plants for planting: Low/Moderate

Likelihood of establishment in natural areas: Moderate/High

Likelihood of establishment in managed areas: Moderate/High

Spread: Moderate/Moderate

Impacts (EPPO region)

Biodiversity: Low/high

Ecosystem services: Moderate/High

Socio-economic: Moderate/High

19. Remarks

None

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Appendix 1. Projection of climatic suitability for *Cinnamomum camphora* establishment

Projection of climatic suitability for *Cinnamomum camphora* establishment

Aim
To project the suitability for potential establishment of *Cinnamomum camphora* in the EPPO region, under current and predicted future climatic conditions.

Data for modelling
Climate data were taken from 'Bioclim' variables contained within the WorldClim database (http://www.worldclim.org/), originally at 5 arcminute resolution (0.083 x 0.083 degrees of longitude/latitude) but bilinearly interpolated to a 0.1 x 0.1 degree grid for use in the model. Based on the biology of the focal species, the following climate variables were used in the modelling:

- Mean temperature of the warmest quarter (Bio10 °C) reflecting the growing season thermal regime. *C. camphora* is reported to require annual mean temperatures between 14 and 27 °C (Orwa *et al.*, 2011).
- Mean minimum temperature of the coldest month (Bio6 °C) reflecting exposure to frost. Severe frost is known to damage *C. camphora* (You *et al.*, 2008).
- Mean annual precipitation (Bio12 ln+1 transformed mm). *C. camphora* is reported to require annual preciptatioon between 640 and 4030 mm (Orwa *et al.*, 2011).
- Precipitation of the driest quarter (Bio17 ln + 1 transformed) as a further measure of drought stress.

To estimate the effect of climate change on the potential distribution, equivalent modelled future climate conditions for the 2070s under the Representative Concentration Pathway (RCP) 8.5 were also obtained. This assumes an increase in atmospheric CO_2 concentrations to approximately 850 ppm by the 2070s. Climate models suggest this would result in an increase in global mean temperatures of 3.7 °C by the end of the 21st century. The above variables were obtained as averages of outputs of eight Global Climate Models (BCC-CSM1-1, CCSM4, GISS-E2-R, HadGEM2-AO, IPSL-CM5A-LR, MIROC-ESM, MRI-CGCM3, NorESM1-M), downscaled and calibrated against the WorldClim baseline (see http://www.worldclim.org/cmip5_5m). RCP8.5 is the most extreme of the RCP scenarios, and may therefore represent the worst case scenario for reasonably anticipated climate change.
As measures of habitat availability we included:

- Tree cover, which may affect habitability. *C. camphora* seedlings tolerate some shading, but require full overhead light once they reach 2-3 m in height (CABI, 2015). Tree cover was estimated from the MODerate-resolution Imaging Spectroradiometer (MODIS) satellite continuous tree cover raster product, produced by the Global Land Cover Facility (DiMiceli *et al.*, 2011). The raw product contains the percentage cover by trees in each 0.002083 x 0.002083 degree grid cell. We aggregated this to the mean cover in our 0.1 x 0.1 degree grid cells and applied a log+1 transformation to improve conformance to normality.
- Human influence index as many invasive species are known to associate with anthropogenic disturbance. We used the Global Human Influence Index Dataset of the Last of the Wild Project (Wildlife Conservation Society - WCS & Center for International Earth Science Information Network - CIESIN - Columbia University, 2005), which is developed from nine global data layers covering human population pressure (population density),

human land use and infrastructure (built-up areas, nighttime lights, land use/land cover) and human access (coastlines, roads, railroads, navigable rivers). The index ranges between 0 and 1 and was log+1 transformed for the modelling to improve normality.

As detailed in the main text, *C. camphora* may have wide edaphic tolerances. Nevertheless, we included two soil variables, derived from the GIS layers available from SoilGrids (https://soilgrids.org). Each soil property is provided at depths of 0, 5, 15, 30, 60, 100 and 200 cm as 0.002083 x 0.002083 degree rasters. These were aggregated as the mean soil property across all depths on the 0.1 x 0.1 degree raster of the model. The soil variables obtained were:

- Soil pH in water as *C. camphora* may prefer acidic to neutral soils (CABI, 2015)
- Soil sand percentage as *C. camphora* may be affected by waterlogging.

Species occurrences were obtained from the Global Biodiversity Information Facility (www.gbif.org), supplemented with data from the literature and the Expert Working Group. Occurrence records with insufficient spatial precision, potential errors (e.g. a record georeferenced in Saudi Arabia that was labelled as originating in China) or that were outside of the coverage of the predictor layers (e.g. small island or coastal occurrences) were excluded. Six records from planted gardens in Sweden, Ireland, Germany and Netherlands were also excluded from the modelling. The remaining records were gridded at a 0.1 x 0.1 degree resolution (Figure 1).

In total, there were 1234 grid cells with recorded occurrence of *C. camphora* available for the modelling (Figure 1).

Figure 1. Occurrence records obtained for *Cinnamomum camphora* used in the model, after exclusion of planted records from the non-native range.

Species distribution model

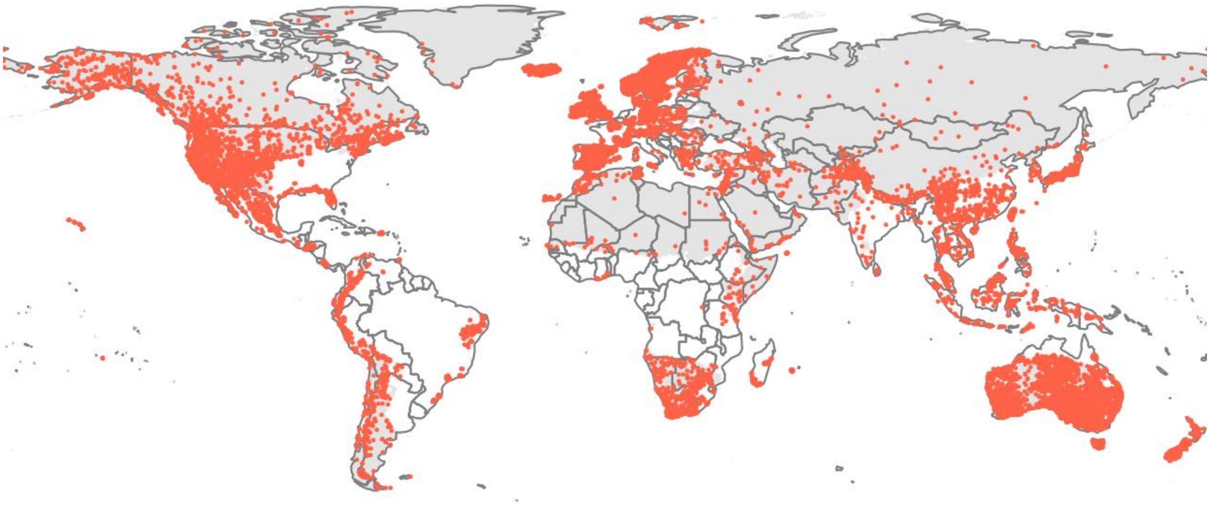
A presence-background (presence-only) ensemble modelling strategy was employed using the BIOMOD2 R package v3.3-7 (Thuiller *et al.*, 2014, Thuiller *et al.*, 2009). These models contrast the environment at the species' occurrence locations against a random sample of the global background environmental conditions (often termed 'pseudo-absences') in order to characterise and project suitability for occurrence. This approach has been developed for distributions that are in equilibrium with the environment. Because invasive species' distributions are not at equilibrium and subject to dispersal constraints at a global scale, we took care to minimise the inclusion of locations suitable for the species but where it has not been able to disperse to. Therefore the background sampling region included:

- The native continent of *C. camphora*, in which the species is likely to have had sufficient time to cross all biogeographical barriers. For the model we used the whole of Asia, even though the species has been reported as introduced to some parts of Asia; AND
- A relatively small 50 km buffer around all non-native occurrences, encompassing regions likely to have had high propagule pressure for introduction by humans and/or dispersal of the species; AND
- Regions where we have an *a priori* expectation of high unsuitability for the species (see Fig. 2). The following rules were applied to define the region expected to be highly unsuitable for *C. camphora*:
    - Mean minimum temperature of the coldest month (Bio6) < -10 °C. *C. camphora* experiences frost damage below -10 C (You *et al.*, 2008) and the coldest location with a presence in our dataset has Bio6 = -9.9 °C.
    - Mean temperature of the warmest quarter (Bio10) < 15 °C, which is consistent with reported low tolerances for the mean annual temperature (Orwa *et al.*, 2011). Only one occurrence is in a colder location than this.
    - Annual precipitation (Bio12) < 640 mm, which is consistent with reported minimum moisture requirements (Orwa *et al.*, 2011). In our database 29 occurrences (2.4%) are in drier locations than this. Since this is a small percentage of the records it was reasonable to assume that locations this dry are generally of low suitability.

Within this sampling region there will be substantial spatial biases in recording effort, which may interfere with the characterisation of habitat suitability. Specifically, areas with a large amount of recording effort will appear more suitable than those without much recording, regardless of the underlying suitability for occurrence. Therefore, a measure of vascular plant recording effort was made by querying the Global Biodiversity Information Facility application programming interface (API) for the number of phylum Tracheophyta records in each 0.1 x 0.1 degree grid cell. The sampling of background grid cells was then weighted in proportion to the Tracheophyte recording density. Assuming Tracheophyte recording density is proportional to recording effort for the focal species, this is an appropriate null model for the species' occurrence.

To sample as much of the background environment as possible, without overloading the models with too many pseudo-absences, five background samples of 10,000 randomly chosen grid cells were obtained (Figure 2).

Figure 2. Randomly selected background grid cells used in the modelling of *Cinnamomum camphora*, mapped as red points. Points are sampled from the native continent (Asia), a small buffer around non-native occurrences and from areas expected to be highly unsuitable for the species (grey background region), and weighted by a proxy for plant recording effort.



Each dataset (i.e. combination of the presences and the individual background samples) was randomly split into 80% for model training and 20% for model evaluation. With each training dataset, ten statistical algorithms were fitted with the default BIOMOD2 settings, except where specified below:

- Generalised linear model (GLM)
- Generalised boosting model (GBM)
- Generalised additive model (GAM) with a maximum of four degrees of freedom per smoothing spline.
- Classification tree algorithm (CTA)
- Artificial neural network (ANN)
- Flexible discriminant analysis (FDA)
- Multivariate adaptive regression splines (MARS)
- Random forest (RF)
- MaxEnt
- Maximum entropy multinomial logistic regression (MEMLR)

Since the background sample was much larger than the number of occurrences, prevalence fitting weights were applied to give equal overall importance to the occurrences and the background. Variable importances were assessed and variable response functions were produced using BIOMOD2's default procedure. Model predictive performance was assessed by calculating the Area Under the Receiver-Operator Curve (AUC) for model predictions on the evaluation data, that were reserved from model fitting. AUC can be interpreted as the probability that a randomly selected presence has a higher model-predicted suitability than a randomly selected absence. This information was used to combine the predictions of the different algorithms to produce ensemble projections of the model. For this, the three algorithms with the lowest AUC were first rejected and then predictions of the remaining seven algorithms were averaged, weighted by their AUC. Ensemble projections were made for each dataset and then averaged to give an overall suitability.

Results

The ensemble of the seven statistical algorithms suggested that suitability for *C. camphora* was most strongly determined by the mean temperature of the warmest quarter, soil pH, annual precipitation and the minimum temperature of the coldest month (Table 1). From Fig. 3, the ensemble model estimated the optimum conditions for occurrence at approximately:

- Mean temperature of the warmest quarter = 27.6 °C (>50% suitability with bio10 > 17.7 °C)
- Low soil pH (>50% suitability with pH < 7.5)
- Annual precipitation = 1521 mm
- Minimum temperature of the coldest month = 5.5 °C

These optima and ranges of high suitability described above are conditional on the other predictors being at their median value in the data used in model fitting.

The model also characterised slight habitat preferences for wet driest quarters, high human influence, low tree cover and sandy soils (Fig. 3).

There was substantial variation among modelling algorithms in the partial response plots, especially for precipitation (Fig. 3). In part this will reflect their different treatment of interactions among variables. Since partial plots are made with other variables held at their median, there may be values of a particular variable at which this does not provide a realistic combination of variables to predict from. It also demonstrates the value of an ensemble modelling approach in averaging out the uncertainty between algorithms.

Global projection of the model in current climatic conditions (Fig. 4) indicates that the native and known invaded records (Fig. 1) generally fell within regions predicted to have high suitability. In Europe and the Mediterranean region, there are no areas predicted to have very high suitability for invasion by *C. camphora* in the current climate (Fig. 5). However, marginal suitability is predicted around much of the coastline of southern Europe, from southwest France, round the Atlantic coast of Iberia and around the northern shores of the Mediterranean to the Middle East. Areas of marginal suitability are also predicted in western Iberia and the Azores.

By the 2070s, under climate change scenario RCP8.5, projected suitability for *C. camphora* in Europe increases substantially (Fig. 6). Much of Mediterranean and western Europe is predicted to become suitable for the species.

Table 1. Summary of the cross-validation predictive performance (AUC) and variable importances of the fitted model algorithms and the ensemble (AUC-weighted average of the best performing seven algorithms). Results are the average from models fitted to five different background samples of the data.

Algorithm	**Predictive AUC**	**Variable importance**							
		Minimum temperature of coldest month	**Mean temperature of warmest quarter**	**Annual precipitation**	**Precipitation of driest quarter**	**Tree cover**	**Human influence**	**Soil pH**	**Soil sand content**
GBM	0.9710	4.8%	49.6%	43.7%	0.7%	0.3%	0.7%	0.3%	0.0%
ANN	0.9690	10.8%	44.0%	6.0%	7.0%	2.6%	4.7%	24.7%	0.3%
GAM	0.9682	7.2%	55.1%	9.8%	0.8%	1.5%	3.3%	22.3%	0.1%
MARS	0.9660	7.7%	58.6%	16.0%	0.0%	0.6%	4.0%	13.1%	0.0%
GLM	0.9658	10.4%	50.9%	3.9%	0.4%	1.1%	3.4%	29.9%	0.1%
RF	0.9582	10.3%	44.8%	20.9%	12.9%	1.9%	2.4%	4.4%	2.3%
MEMLR	0.9514	0.1%	55.4%	0.2%	1.0%	2.5%	3.9%	36.7%	0.2%
FDA	0.9494	7.8%	69.2%	3.5%	4.3%	2.7%	1.5%	10.3%	0.6%
CTA	0.9328	6.6%	43.1%	48.4%	0.0%	1.4%	0.5%	0.0%	0.0%
MaxEnt	0.9262	8.6%	35.0%	22.1%	5.1%	5.2%	3.2%	9.3%	11.6%
Ensemble	0.9690	7.4%	51.2%	14.4%	3.2%	1.5%	3.2%	18.7%	0.4%

Figure 3. Partial response plots from the fitted models, ordered from most to least important. Thin coloured lines show responses from the seven algorithms, while the thick black line is their ensemble. In each plot, other model variables are held at their median value in the training data. Some of the divergence among algorithms is because of their different treatment of interactions among variables.

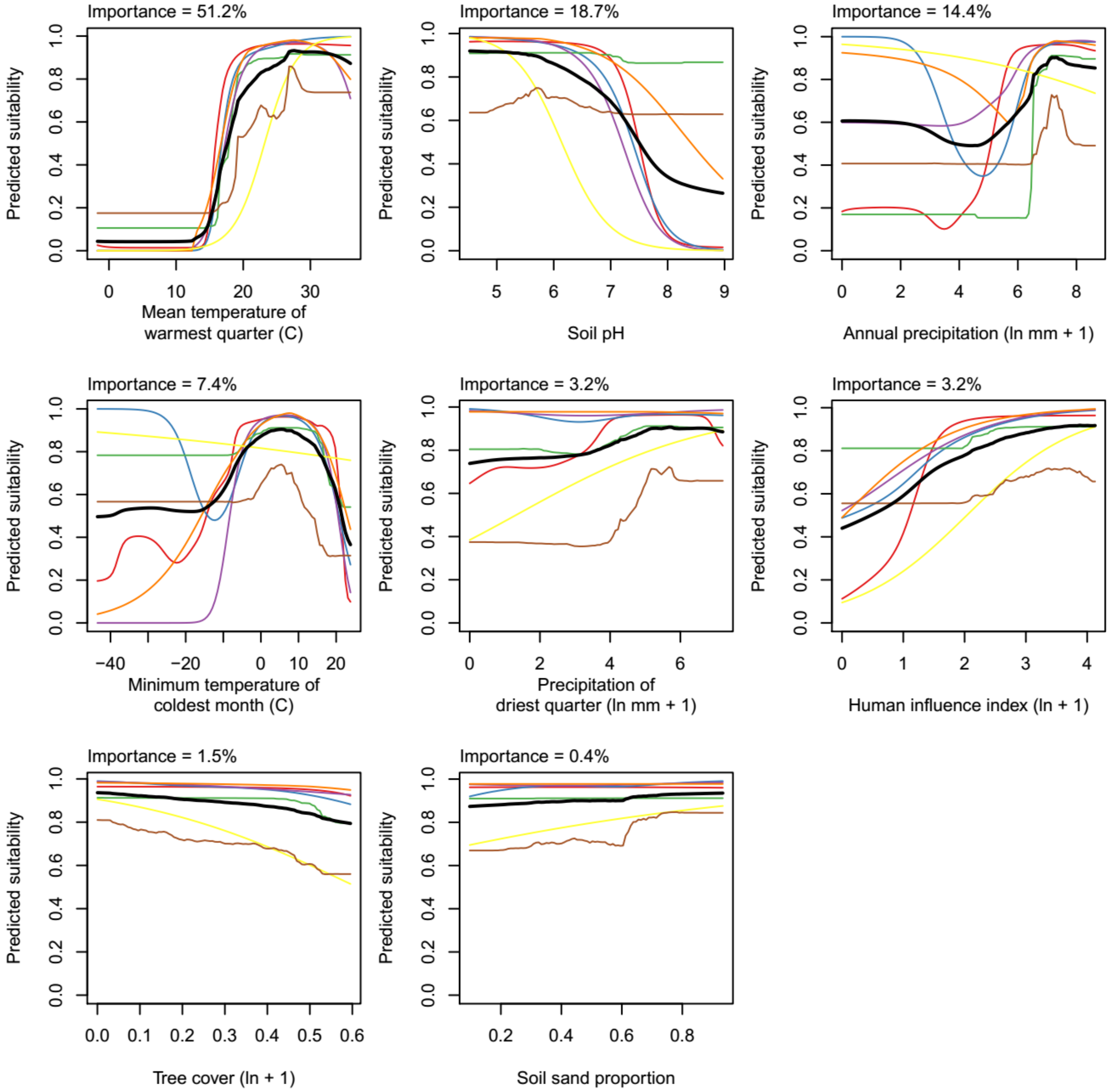


Figure 4. Projected global suitability for *Cinnamomum camphora* establishment in the current climate. For visualisation, the projection has been aggregated to a 0.5 x 0.5 degree resolution, by taking the maximum suitability of constituent higher resolution grid cells. Values > 0.5 may be suitable for the species. The white areas have climatic conditions outside the range of the training data so were excluded from the projection.

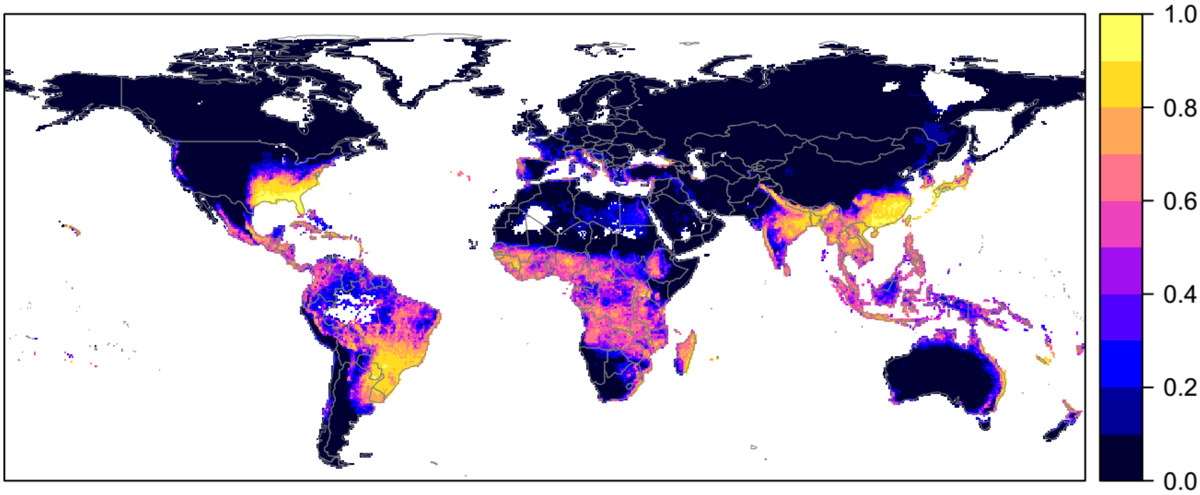


Figure 5. Projected current suitability for *Cinnamomum camphora* establishment in Europe and the Mediterranean region. For visualisation, the projected suitability has been smoothed with a Gaussian filter with standard deviation of 0.1 degrees longitude/latitude. The white areas have climatic conditions outside the range of the training data so were excluded from the projection.

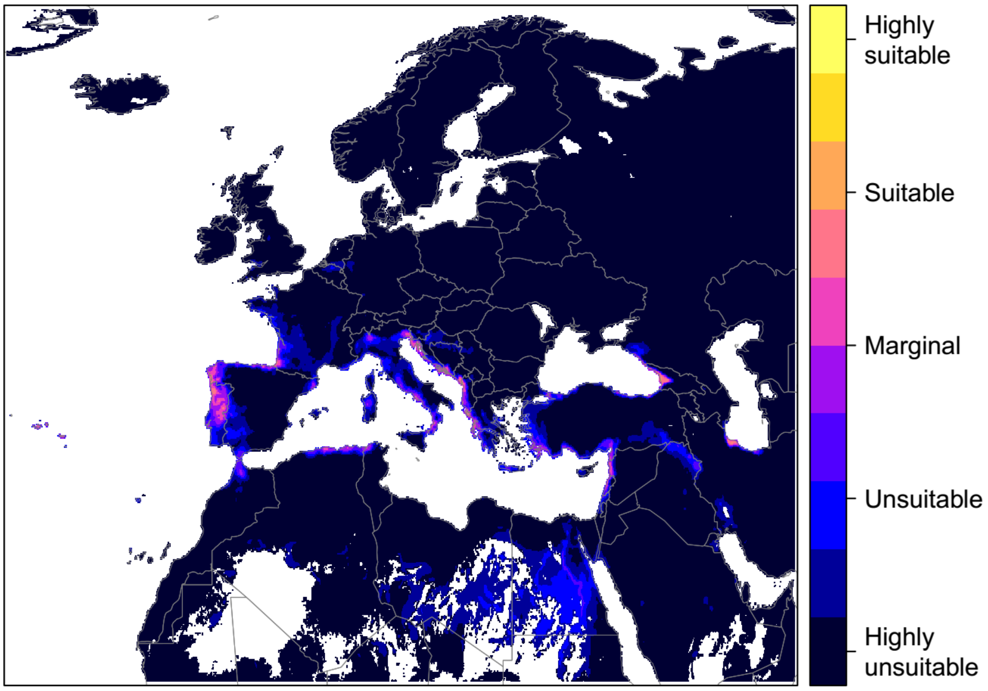
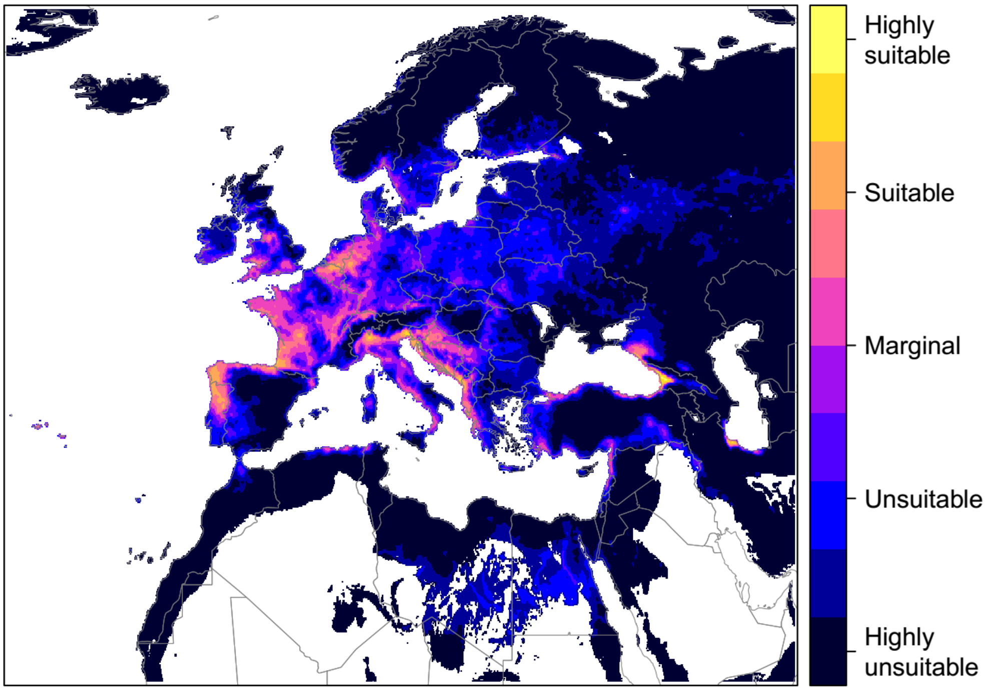


Figure 6. Projected suitability for *Cinnamomum camphora* establishment in Europe and the Mediterranean region in the 2070s under climate change scenario RCP8.5, equivalent to Fig. 5.



Caveats to the modelling

To remove spatial recording biases, the selection of the background sample was weighted by the density of Tracheophyte records on the Global Biodiversity Information Facility (GBIF). While this is preferable to not accounting for recording bias at all, a number of factors mean this may not be the perfect null model for species occurrence:

- The GBIF API query used to did not appear to give completely accurate results. For example, in a small number of cases, GBIF indicated no Tracheophyte records in grid cells in which it also yielded records of the focal species.
- We located additional data sources to GBIF, which may have been from regions without GBIF records.

Some variables potentially affecting the distribution of the species, such as soil nutrients, were not included directly in the model.

The climate change scenario used is the most extreme of the four RCPs. However, it is also the most consistent with recent emissions trends and could be seen as worst case scenario for informing risk assessment.

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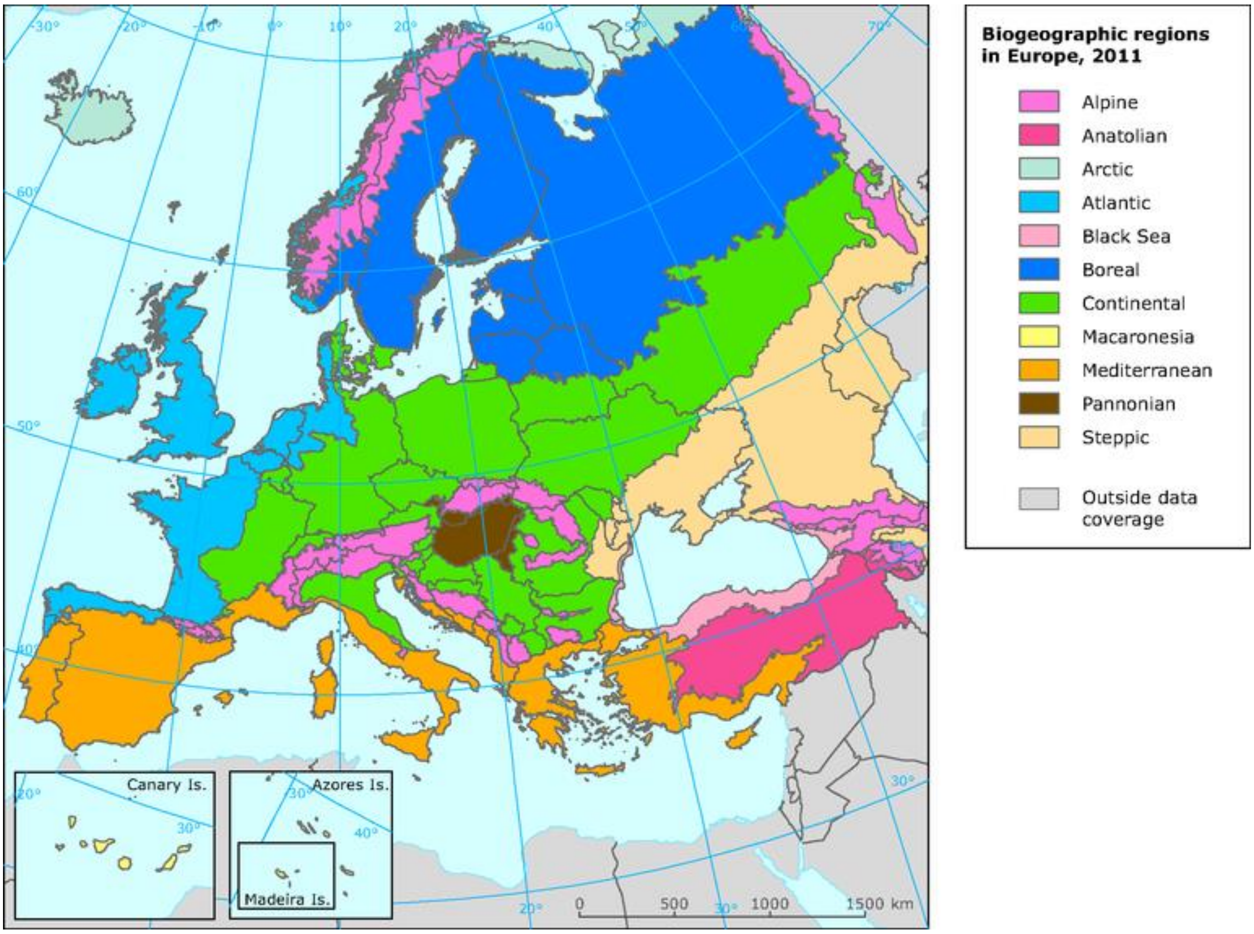
Appendix 2 Biogeographical regions in Europe



Appendix 3. Relevant illustrative pictures (for information)

Figure 1. *Cinnamomum camphora* (Forest and Kim Starr, Starr Environmental, Bugwood.org)

Figure 2. *Cinnamomum camphora* (Forest and Kim Starr, Starr Environmental, Bugwood.org)

Figure 3. *Cinnamomum camphora* (Forest and Kim Starr, Starr Environmental, Bugwood.org)

Figure 4. *Cinnamomum camphora* (Forest and Kim Starr, Starr Environmental, Bugwood.org)

Figure 5. *Cinnamomum camphora* (Forest and Kim Starr, Starr Environmental, Bugwood.org)

Appendix 4. Distribution maps of *Cinnamomum camphora*

Figure 1. World distribution (GBIF data)

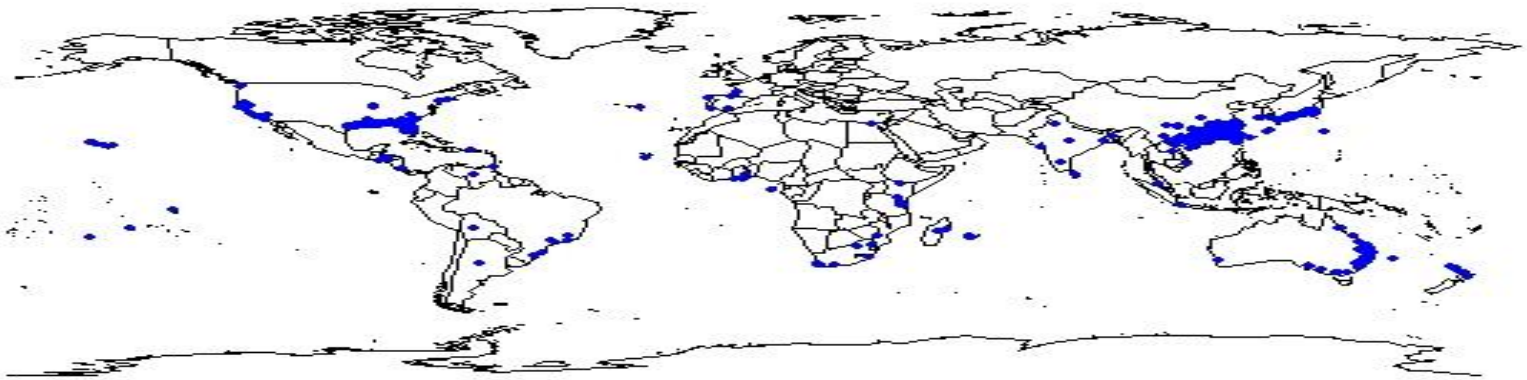


Figure 2. Distribution map of *Cinnamomum camphora* in North America (GBIF data)

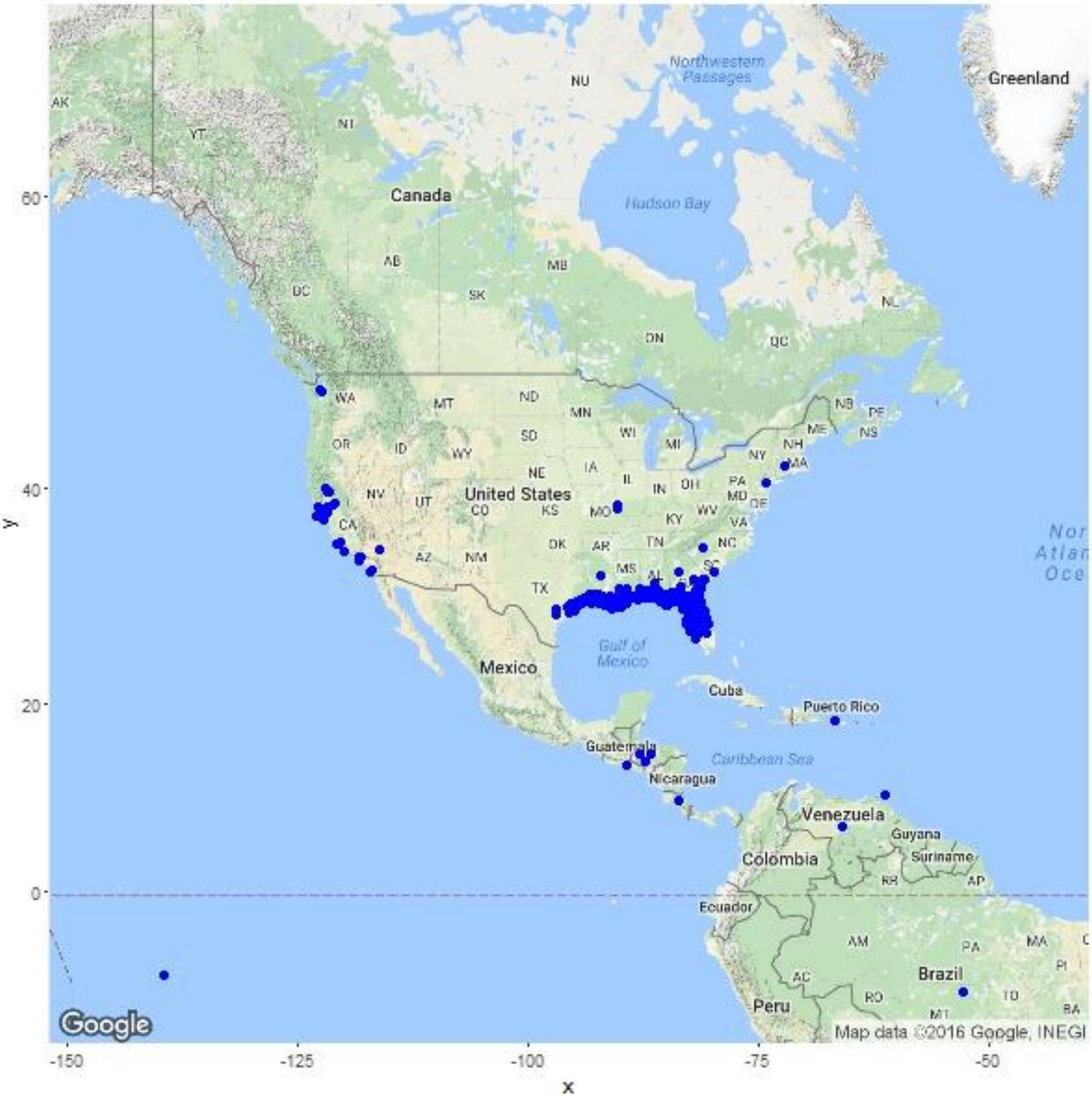


Figure 3. Distribution map of *Cinnamomum camphora* in Europe (GBIF data)

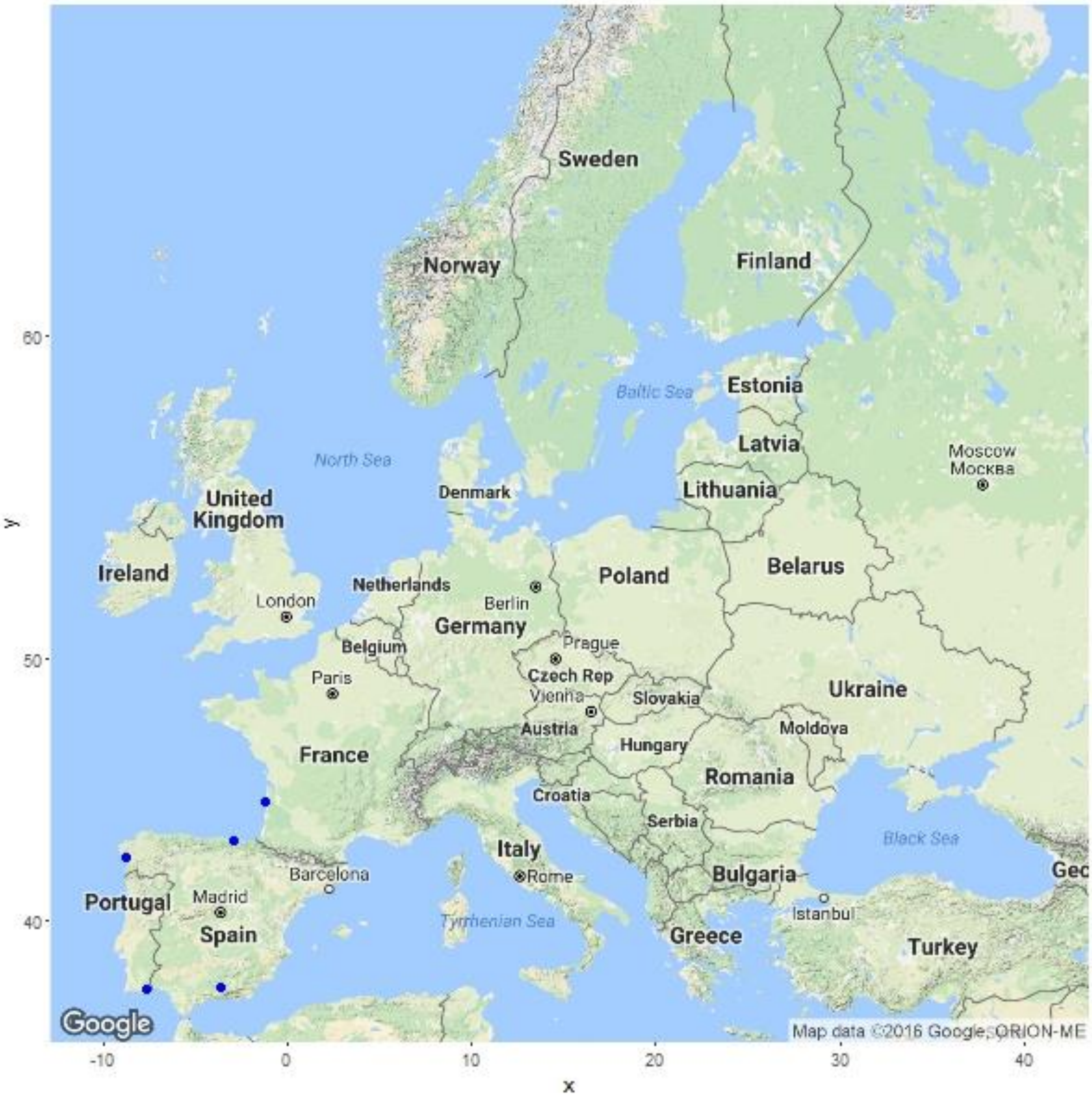


Figure 4. Distribution map of *Cinnamomum camphora* in Asia (GBIF data)

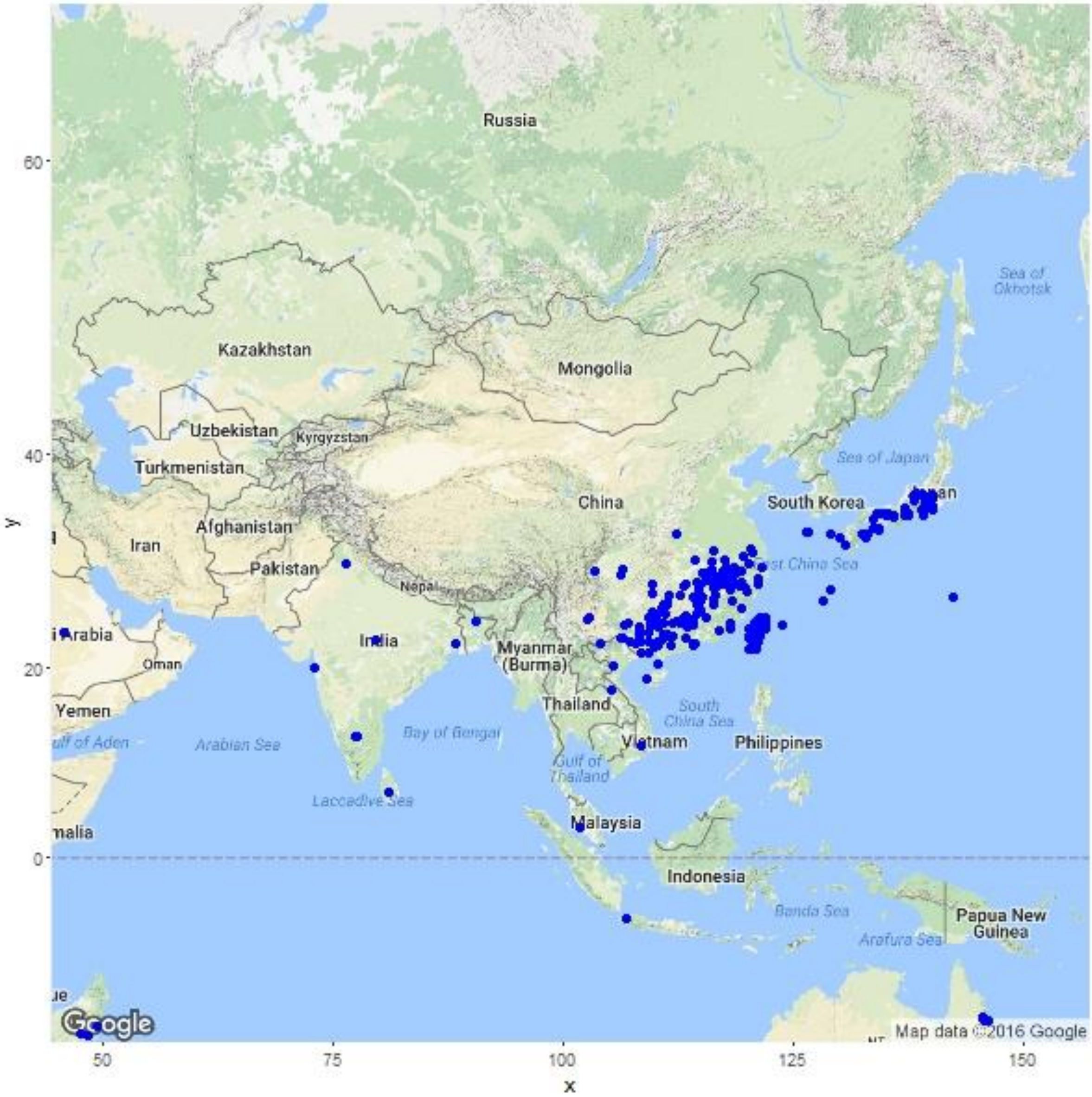


Figure 5. Distribution map of *Cinnamomum camphora* in Australia (GBIF data)

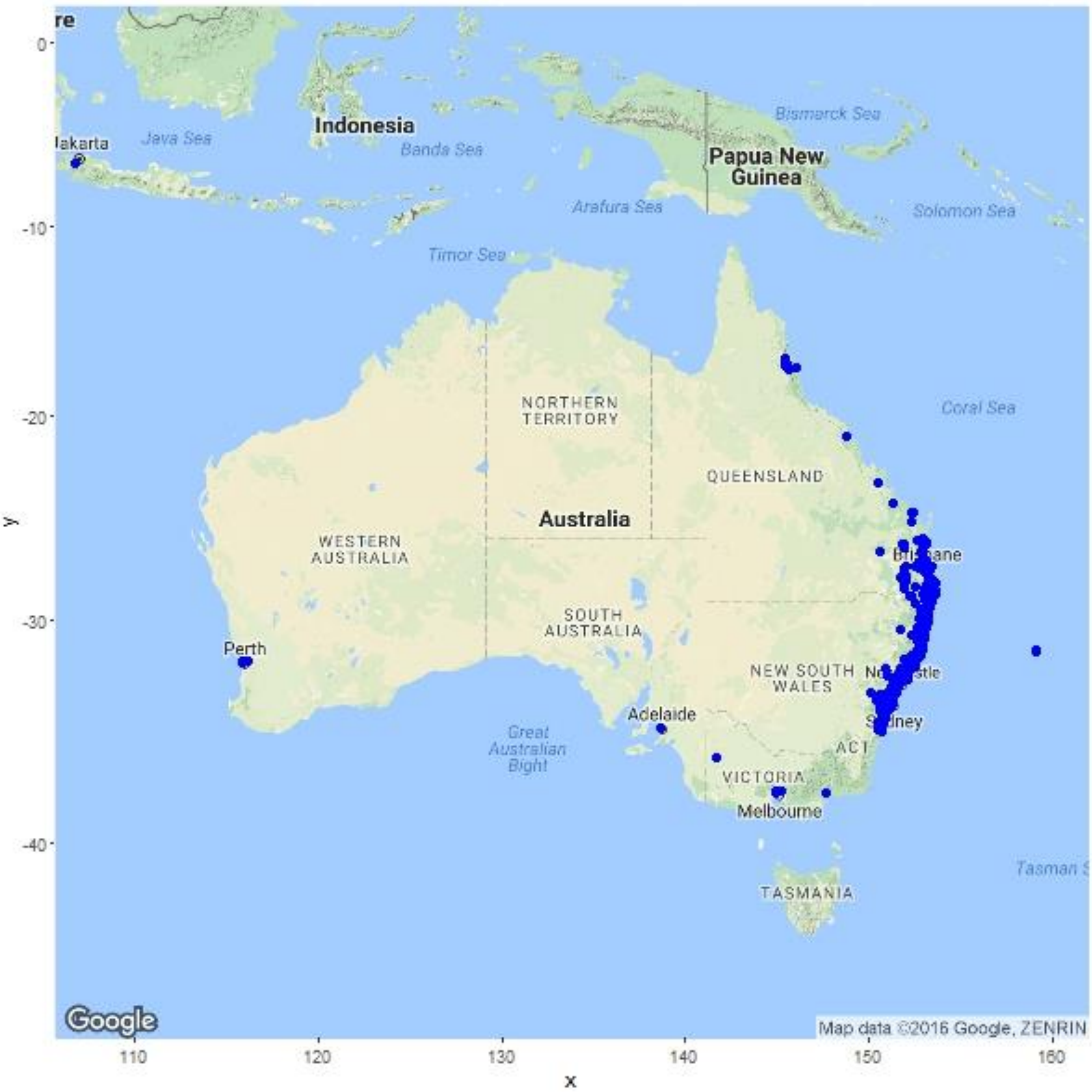


Figure 6. Distribution map of *Cinnamomum camphora* in South America (GBIF data)

Figure 7. Distribution map of *Cinnamomum camphora* in Africa (GBIF data)