Risk analysis for plants as pests for *Hydrocotyle batrachium*

COSAVE

STDF Standards and Trade Development Facility

IICA

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Cover design: Esteban Grille

Digital printing

Risk analysis for plants as pests for Hydrocotyle batrachium / Inter-American Institute for Cooperation on Agriculture, Comité Regional de Sanidad Vegetal del Cono Sur; Alec McClay. – Uruguay : IICA, 2018.

25 p.; A4 21 cm X 29,7 cm

ISBN: 978-92-9248-814-7

Published also in Spanish and Portuguese

1. Araliaceae 2. Hydrocotyle 3. Phytosanitary measures 4. Pests of plants 5. Risk management 6. Pest monitoring 7. Weeds I. IICA II. COSAVE III. Title

AGRIS	DEWEY
H10	632.5

Montevideo, Uruguay - 2018

ACKNOWLEDGMENTS

The *Guidelines of procedures for risk assessment of plants as pests (weeds)* has been applied for the development of two case studies: *Hydrocotyle batrachium* and *Ambrosia trífida.* This products was a result of the component aimed to build technical capacity in the region to use a Pest Risk Analysis process with emphasis on the assessment of Plants as Pests (weeds) in the framework of STDF / PG / 502 Project "COSAVE: Regional Strengthening of the Implementation of Phytosanitary Measures and Market Access".

The beneficiaries are COSAVE and the NPPOs of the seven countries that make up COSAVE. The Standards and Trade Development Facility (STDF) fund it, the Inter-American Institute for Cooperation on Agriculture (IICA) is the implementing organization and the International Plant Protection Convention (IPPC) Secretariat supports the project.

The editorial coordination was in charge of Maria de Lourdes Fonalleras and Florencia Sanz.

Maria de Lourdes Fonalleras, Florencia Sanz y Alec McClay, have defined the original structure of this Guide. The content development corresponds exclusively to Alec McClay expert contracted especially for the project.

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Víctor Manuel Lima y **Carla Roca Orellanos** from Servicio Nacional de Sanidad Agropecuaria e Inocuidad Alimentaria – SENASAG from Bolivia;

Adriana Araújo Costa Truta y **Clidenor Mendes Wolney Valente** from Secretaria de Defensa Agropecuaria – SDA/MAPA from Brasil;

Cecilia Niccoli y **Lilian Daisy Ibáñez** from Servicio Agrícola y Ganadero – SAG from Chile;

Maria Eugenia Villalba y **Mirta Zalazar** from Servicio Nacional de Calidad, Sanidad Vegetal y de Semillas – SENAVE from Paraguay;

Efraín Arango Ccente y **Cecilia Lévano Stella** from Servicio Nacional de Sanidad Agraria – SENASA from Perú;

Leticia Casanova y **María José Montelongo** from Dirección General de Servicios Agrícolas – DGSA/ MGAP from Uruguay.

We express special appreciation to all of them. We also thank the support received from the IPPC Secretariat for the implementation of this component of the project.

Finally, we thanks Esteban Grille by diagramming the document.

RISK ANALYSIS FOR PLANTS AS PESTS FOR *Hydrocotyle batrachium* Hance (Araliaceae)

Hydrocotyle batrachium Hance.
Image from Taiwan Biodiversity Information Facility, http://taibif.tw/zh/namecode/202318

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1. STAGE I. INITIATION

1.1. INITIATION POINT FOR THE PEST RISK ANALYSIS

This pest risk analysis was initiated in response to an application to import *Hydrocotyle batrachium* from Thailand and Singapore into Argentina as a plant for use in aquariums.

1.2. IDENTITY OF THE PLANT

Accepted scientific name:

Hydrocotyle batrachium Hance (The Plant List, 2013).

Synonyms:

Hydrocotyle rotundifolium var. *batrachium* (Hance) Cherm., *Hydrocotyle sibthorpioides* var. *batrachium* (Hance) Hand.-Mazz. ex Shan (The Plant List, 2013).

Hydrocotyle formosana Masamune (She et al., 2005)

Common names:

No common name was found to refer specifically to *H. batrachium*. *Hydrocotyle sibthorpioides* is known in English as "lawn marshpennywort" (USDA-NRCS, 2018). In Spanish, *H. ranunculoides* is known as " sombrerito de agua" (CABI, 2017), "chupana" and " paraguas" (EPPO, 2002) and "redondita de agua" (Wikipedia, 2017).

Taxonomic Position:

Family: Araliaceae

Formerly classified as Apiaceae (= Umbelliferae) (Nicolas and Plunkett, 2009)

The species is referred to as *H. batrachium* in the Flora of Taiwan (Flora of Taiwan Editorial Committee, 1993), as *H. sibthorpioides* Lam. var. *batrachium* (Hance) Hand.-Mazz. ex R.H. Shan in the Flora of China (She et al., 2005), and as *Hydrocotyle rotundifolia* Roxb. var. *batrachium* H. Cherm. by (Chermezon, 1921). *H. rotundifolia* is treated in most sources as synonymous with *H. sibthorpioides*.

The identifications of the *Hydrocotyle* species in this group are quite unreliable. There is no taxonomic monograph of the genus since Richard's original work (Richard, 1820) and a bibliographical and nomenclature review by (Eichler, 1987), which could not be consulted for the present study. In addition, the names used for species in the aquarium plant trade are not always accurate or reliable. The identification of *Hydrocotyle* species requires plants with flower and fruit, which are not always produced under aquarium conditions.

A species of *Hydrocotyle* that is reported as very popular in the aquatic plant market in Asia, and recently imported into Europe, is described as *Hydrocotyle* cf. *tripartita*, *Hydrocotyle* sp. "Australia" and *Hydrocotyle* sp. "Japan", but in the information available from a vendor the lack of certainty of this identification is recognized, and its similarity with *H. sibthorpioides* var. *batrachium* is noted[1].

Hydrocotyle tripartita R. Br. ex A. Rich. is an Australian species (Ralley, 2018).

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1 https://www.flowgrow.de/db/aquaticplants/hydrocotyle-cf-tripartita

Hydrocotyle sibthorpioides is also available in the aquarium plants market in the USA[2].

Given the lack of certainty of the identification of *H. batrachium* and the scarcity of information on this species, this PRA is partially based on information on *H. sibthorpioides*, *H. tripartita* and *H. ranunculoides*.

1.3. IDENTIFICATION OF THE PEST RISK ANALYSIS AREA

For the purpose of this case study the PRA area will be considered as the entire COSAVE region.

1.4. PEST RISK ANALYSIS HISTORY

No previous PRA was found for H. *batrachium*. In an PRA by pathway of the importation of aquatic plants for aquariums, *H. sibthorpioides* was identified as a negligible risk species for the EPPO region (Brunel, 2009), based on its presence as a naturalized plant in the region without causing problems.

There are two PRAs for the American species *Hydrocotyle ranunculoides* L. f. carried out by EPPO (EPPO, 2009) and by the Royal Belgian Institute of Natural Sciences (Robert et al., 2013). *Hydrocotyle ranunculoides* has been established in some European countries since the 1980s. It forms dense floating mats in freshwater ecosystems and water bodies such as ponds, ditches, swamps, channels, etc., especially in static or slow-flowing water (EPPO, 2009).

1.5. CONCLUSION OF STAGE I

The PRA was carried out for the species *Hydrocotyle batrachium*, taking into account information obtained about the related species *H. sibthorpioides*, *H. tripartita*, and *H. ranunculoides*, and for the COSAVE region in its entirety as the area of risk analysis.

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2 See for example http://shop.plantedaquariumscentral.com/Dwarf-PennyWort-Mat-Hydrocotyle-sibthorpioides-3-x-5-inches_p_149.html

2. STAGE II. WEED RISK ASSESSMENT

2.1. CATEGORIZATION

2.1.1. PRESENCE OR ABSENCE OF THE PLANT IN THE PEST RISK ANALYSIS AREA

In the Missouri Botanic Garden collection there is a single record of *H. batrachium* in Peru, with the data "Aquatic, with *Ranunculus flagelliformis* Sm. Cordillera Blanca, Valley of the Rio Marcará, Vicos. Common plants around town (4284-4313). Altitude 2960 m. Department of Ancash, Province of Carhuas. 10 March 1964"[3]. In the image of this specimen it can be seen that it was initially identified as *Hydrocotyle ranunculoides* L.f. and that later a label was added (undated and with no name of the identifier) with the name *Hydrocotyle rotundifolia* var. *batrachium* (Hance) Cherm. This specimen was considered by León (1993), in her catalog of the aquatic plants of Peru, as *H. ranunculoides* L.f., a native species widely distributed in the Americas. Based on the image of the specimen, Dr. León commented that she considers that it is *Hydrocotyle ranunculoides* L.f., "because the length of the peduncle is less than half the length of the petiole, a morphological character that separates it from the Asian *H. rotundifolia* - *H. sibthorpioides*" (personal communication, Dr. Blanca León, University of Texas, February 12, 2018).

Considering this specimen as *H. ranunculoides*, and in the absence of other records of H. batrachium in the region, it was concluded that *H. batrachium* is absent from the COSAVE region.

2.1.2. REGULATORY STATUS

2.1.2.1. In the pest risk analysis area

Hydrocotyle batrachium is not under official control in any COSAVE member country.

2.1.2.2. Worldwide

No regulatory status was found for *H. batrachium*, *H. sibthorpioides* or *H. tripartita*. In Europe *H. ranunculoides* is listed in the EPPO A2 list of pests recommended for regulation as quarantine (EPPO, 2017) and in the list of invasive alien species of Union concern (Comisión Europea, 2016).

2.1.3. POTENTIAL FOR ESTABLISHMENT AND SPREAD IN THE PEST RISK ANALYSIS AREA

Based on the climatic and habitat data (see 2.2.2.4 and 2.2.2.5), it is likely that suitable conditions exist for the establishment and spread of *H. batrachium* in all countries of the COSAVE region.

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3 See http://www.tropicos.org/Specimen/2036143

2.1.4. POTENTIAL FOR ECONOMIC OR ENVIRONMENTAL IMPACT

Hydrocotyle batrachium is not reported as a weed with economic impact, with the exception of Taiwan, where it has been described as a weed of lawns. *Hydrocotyle sibthorpioides* is documented as a weed of several crops in Asia and Africa, although with no quantitative information on its effects. *Hydrocotyle ranunculoides* is recognized as a significant invasive species in Europe. For more details see section 2.4.

2.1.5. CONCLUSION OF CATEGORIZATION

Hydrocotyle batrachium is a species absent from the PRA area. Although there are few quantitative data, there are reports that this species and other species of the genus can behave as weeds in other regions of the world. It is likely that *H. batrachium* would be able to establish under the climatic and environmental conditions of the region. Therefore, it is concluded that *H. batrachium* can potentially meet the requirements to be considered as a quarantine pest.

2.2. INFORMATION ABOUT THE PLANT

2.2.1. GEOGRAPHIC DISTRIBUTION OF THE PLANT

Native distribution

H. batrachium is native to China (provinces of Anhui, Fujian, Guangdong, Guangxi, Hubei, Hunan, Jiangxi, Sichuan), Taiwan, the Philippines and Vietnam (She et al., 2005) (Figure 1).

H. sibthorpioides is native to China (provinces of Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hubei, Hunan, Jiangsu, Jiangxi, Shaanxi, Sichuan, Yunnan, Zhejiang) and Taiwan, Bhutan, India, Indonesia, Japan, Korea, Nepal, the Philippines, Thailand, Vietnam, tropical Africa (She et al., 2005), and Australia (Vicflora, 2018). In GBIF there are also records for Malaysia and Papua New Guinea. (Global Biodiversity Information Facility, 2018a) (Figure 2). In the Euro + Med PlantBase it is indicated as a native species in Italy, Israel and Syria (Hand, 2011).

H. tripartita R.Br. ex A. Rich is native to eastern Australia (Bean and Henwood, 2003) (Figure 3).

Naturalized distribution

H. batrachium was found in several places in New York State, USA, in 2014 and 2016 (Atha, 2017).

H. sibthorpioides is naturalized in the USA (Arkansas, California, District of Columbia, Delaware, Florida, Georgia, Hawaii, Indiana, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, New Jersey, Ohio, Pennsylvania, South Carolina, Tennessee, Virginia, West Virginia) (USDA-NRCS, 2018) and in New York (Atha, 2017). There are six records in GBIF for *H. sibthorpioides* in Europe (Spain, France and Holland) but they correspond to botanical gardens and urban areas and, therefore, probably do not indicate the presence of naturalized populations (Global Biodiversity Information Facility, 2018a). The Euro + Med PlantBase database shows *H. sibthorpioides* as naturalized in Great Britain and possibly in France (Hand, 2011).

H. tripartita is naturalized in the North Island of New Zealand (Webb and Johnson, 1982), although there are also many records in GBIF for the South Island (Global Biodiversity Information Facility, 2018b).

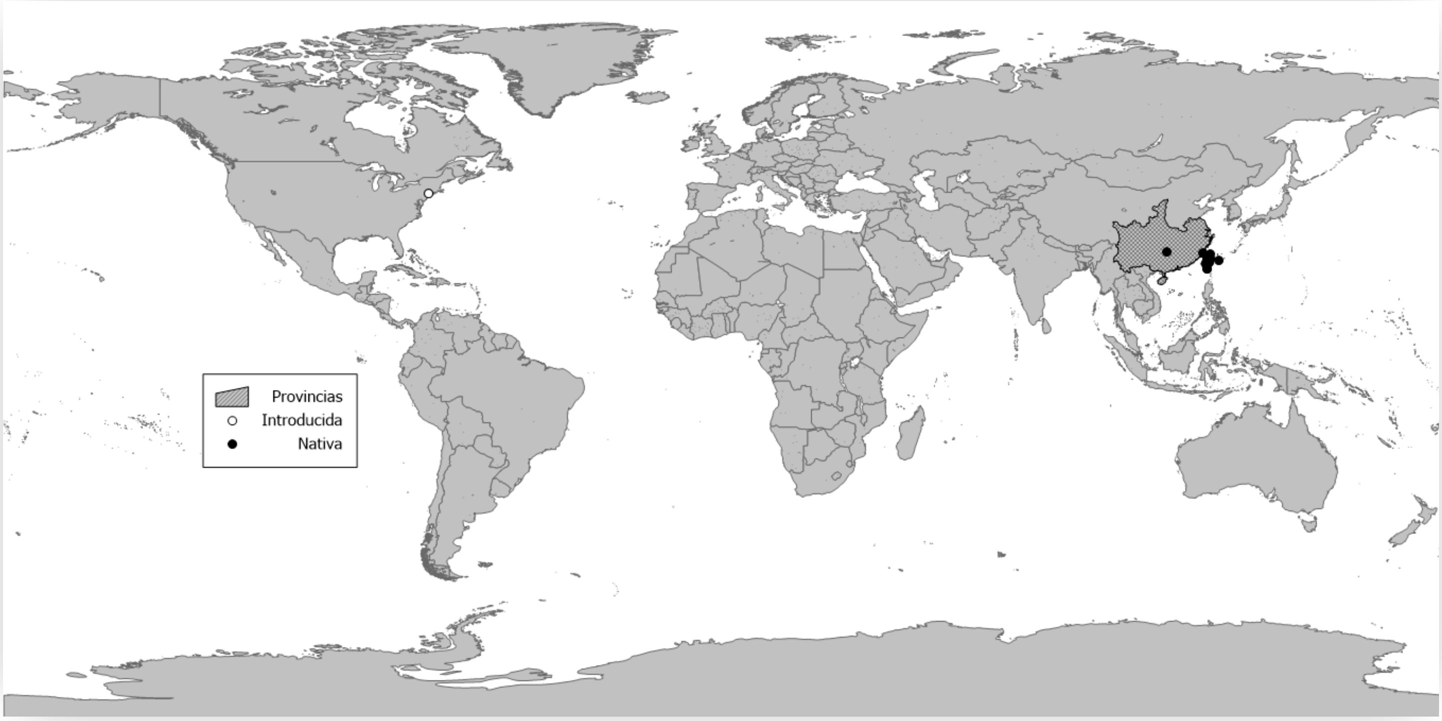

Figure 1. Worldwide distribution of *Hydrocotyle batrachium* according to She et al. (2005), who indicate the provinces of China where it is present, and Global Biodiversity Information Facility (GBIF 2018b).

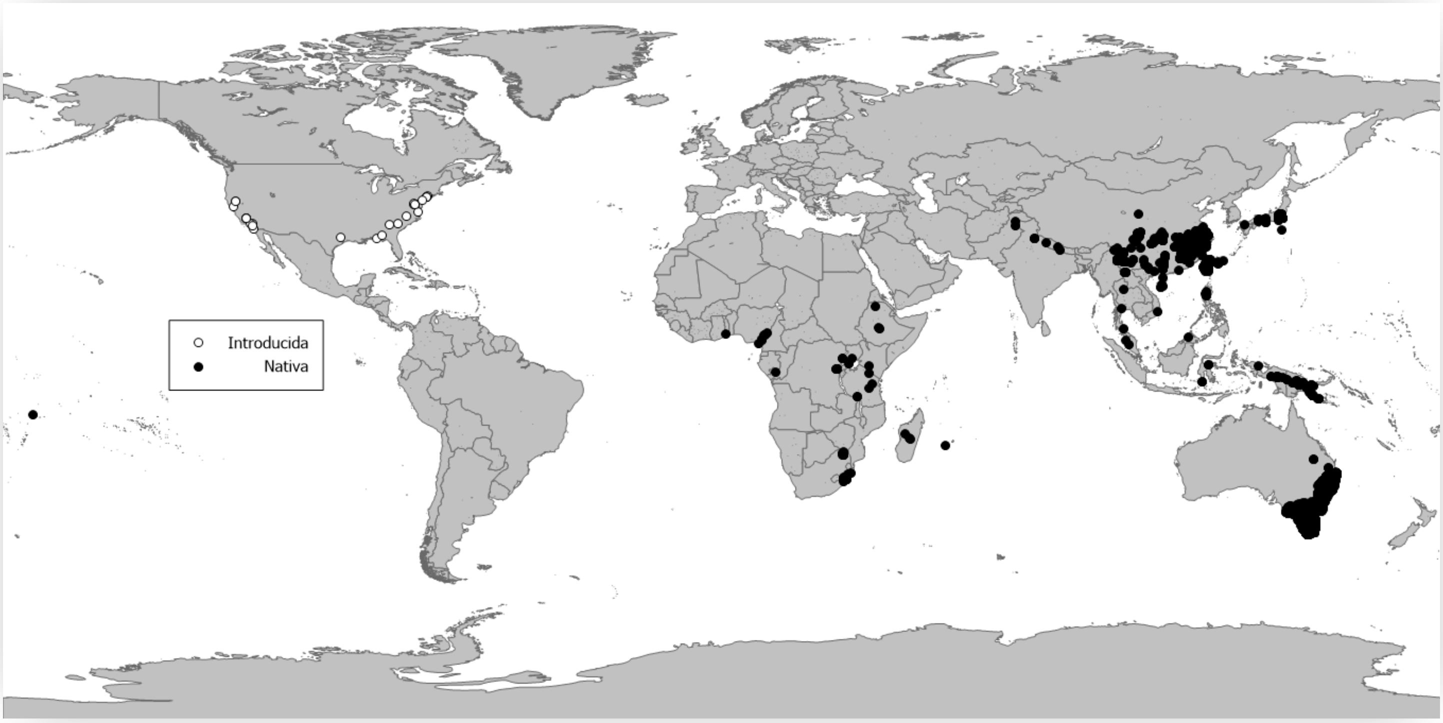

Figure 2. Worldwide distribution of *Hydrocotyle sibthorpioides* (Global Biodiversity Information Facility, 2018a).

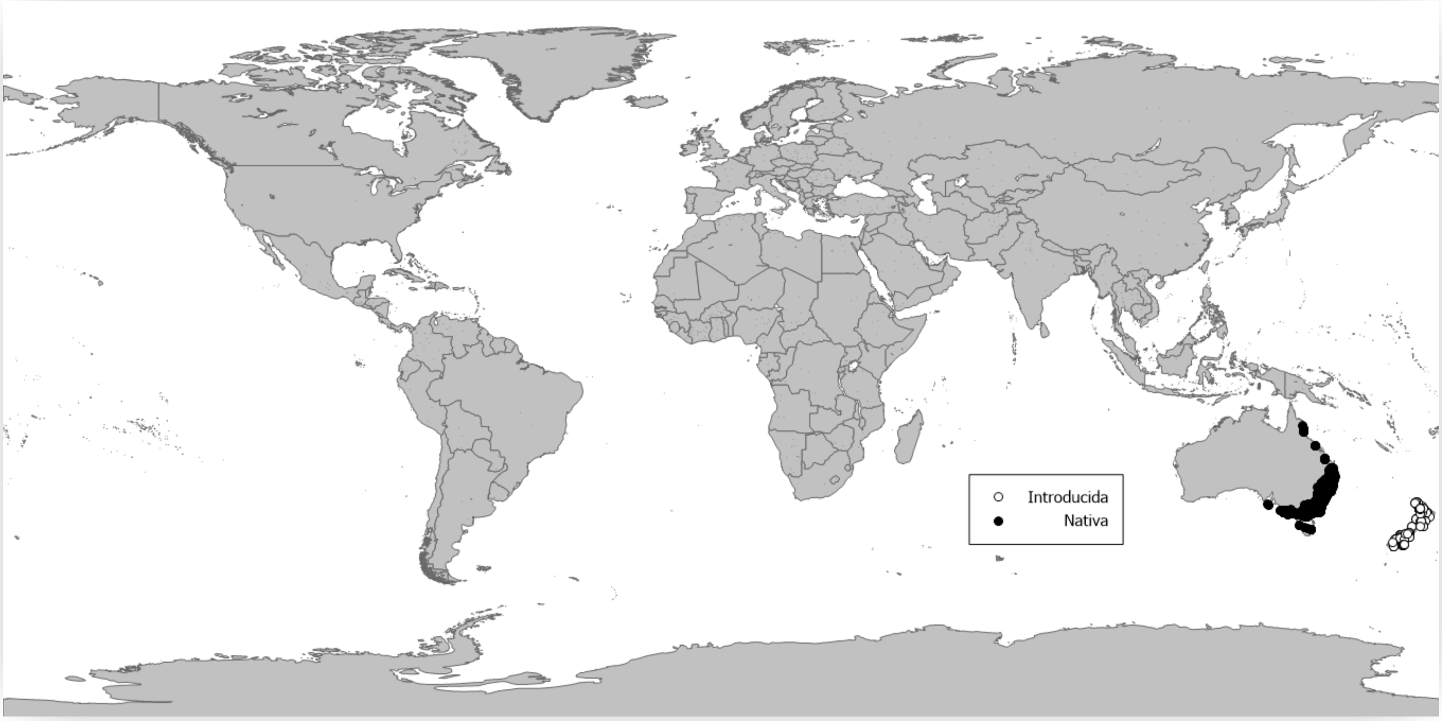

Figure 3. Worldwide distribution of *Hydrocotyle tripartita* (Global Biodiversity Information Facility, 2018b).

Cultivated distribution

As already mentioned, it is difficult to ascertain the identity of the *Hydrocotyle* species for commercial sale as aquarium plants. However, a plant called *Hydrocotyle* sp. "Japan", supposedly a variety of *H. tripartita* from Southeast Asia, is available from many vendors in Europe[4] and the USA[5] and on internet sites such as Amazon.com. It should be noted that in the botanical literature no records of *H. tripartita* were found as a native plant in Southeast Asia.

Gutiérrez et al. (1993) reported that an unidentified species of *Hydrocotyle* imported from Japan was available in the aquarium plant market in Lima, Peru, although rare at that time.

2.2.2. BIOLOGY OF THE PLANT

2.2.2.1. Morphology

Hydrocotyle batrachium is a strongly aromatic herb with slender, weak, branching, creeping stems, rooting at the nodes. The leaves are rounded with a diameter of 0.5 - 3 cm, divided almost to the base into 3 to 5 lobes, with petioles 0.7 - 9 cm long. The inflorescence is an umbel of approximately 5 to 8 bisexual flowers, with greenish-white petals 1.2 mm in length, the peduncle 0.5 - 3.5 cm in length and 1 - 1/3 as long as the petioles. The fruit is approximately 1.5 mm in diameter, green with purple blotches when ripe, rounded with prominent ribs, and contains two seeds (She et al., 2005).

4 See http://tropica.com/en/plants/plantdetails/Hydrocotyletripartita(039B)/4458

5 See https://www.azgardens.com/product/hydrocotyle-tripartita-mat/

2.2.2.2. Life cycle

Hydrocotyle batrachium is perennial. In China flowers and fruits are produced in the northern hemisphere summer, from April to September (She et al., 2005). It produces seeds, but no information was found on their quantity or viability, persistence in the seed bank, dormancy or conditions necessary for germination. No information was found on the method of pollination, nor the time required to reach reproductive maturity.

Since the stems are fragile and root at the nodes, it may be assumed that *H. batrachium* is capable of multiplying by vegetative fragmentation.

2.2.2.3. Dispersal

With regard to natural dispersal, it is likely that fragments of the plant can be transported by river flow, as was found for a *Hydrocotyle* sp. in the San Marcos River, Texas, USA (Owens et al., 2001). No specific information was found on mechanisms of dispersal of *H. batrachium* seeds. Viable seeds of *Hydrocotyle vulgaris* L. were found in the manure of cattle and horses in Belgium (Cosyns et al., 2005); seeds of an undetermined species of *Hydrocotyle* were found in horse manure in a national park in Australia, but their viability was not determined (Weaver and Adams, 1996). The seeds have no adaptation for aerial dispersal nor for external transport by animals.

2.2.2.4. Habitat and environmental factors affecting the plant

In China, *H. batrachium* and *H. sibthorpioides* grow in forests, slopes, wet valleys, and grasslands, and at the edges of streams and rice fields (Flora of Taiwan Editorial Committee, 1993; She et al., 2005). The introduced populations of *H. batrachium* in New York were found in a domestic garden and in the floodplain of a river; *H. sibthorpioides* was found in the same floodplain and also in planters, lawns and sidewalk cracks in an urban area of Manhattan (Atha, 2017).

In Australia *H. tripartita* grows in humid places in forests along watercourses (Ralley, 2018). It was classified by Casanova and Brock (2000) in a group of species that germinate in wet or flooded conditions, tolerate fluctuations in the water level, are short in stature and tolerate full immersion when the water level rises.

It is noteworthy that the botanical literature on *H. batrachium*, *H. sibthorpioides* and *H. tripartita* does not describe these species as fully aquatic plants, but rather that they grow in a wide range of habitats that tend to be humid. However, the documented use of "*H. tripartita* Japan" and the intended use of *H. batrachium* as aquarium plants indicate that they grow well under immersion conditions and that they may therefore have the ability to colonize natural or artificial bodies of water. According to Jacobsen (1979) and Kasselmann (2003) (cited in Chuah et al., 2007), *H. sibthorpioides* is an amphibious plant that grows both in dry and humid places, with a tendency to float on the surface of the water, and is sometimes fully submerged.

Under experimental conditions *H. sibthorpioides* showed the best growth under conditions equivalent to full sunlight (Chuah et al., 2007). However, the aforementioned data on the natural habitat indicate that all these *Hydrocotyle* species are capable of growing in partial shade conditions, such as forests or urban areas.

No data were found on soil or water conditions (pH, nutrients, etc.) necessary for *H. batrachium, H. sibthorpioides* and *H. tripartita.*

2.2.2.5. Climatic Adaptation

The world distributions of *H. batrachium*, *H. sibthorpioides* and *H. tripartita* do not show evidence of much differentiation between the climatic tolerances of the three species. Therefore, they were evaluated as a whole. The vast majority of their joint distribution is found in the climatic zones Cfa (subtropical without dry season, warm summer), Cfb (oceanic, mild summer) and Cfc (oceanic sub-polar) according to the modified Köppen and Geiger system (Kottek and Rubel, 2017). There are also some occurrences in zones Af, Am, Aw, BSh, BSk, Csa, Csb, Cwa, and Cwb (Figure 4). In terms of the NAPPFAST system (Magarey et al., 2008) the great majority of the world distribution of *H. batrachium, H. sibthorpioides* and *H. tripartita* is found in zones 7 to 10, corresponding to annual minimum temperatures of -17.8 ° C to 4.4 ° C (Figure 5).

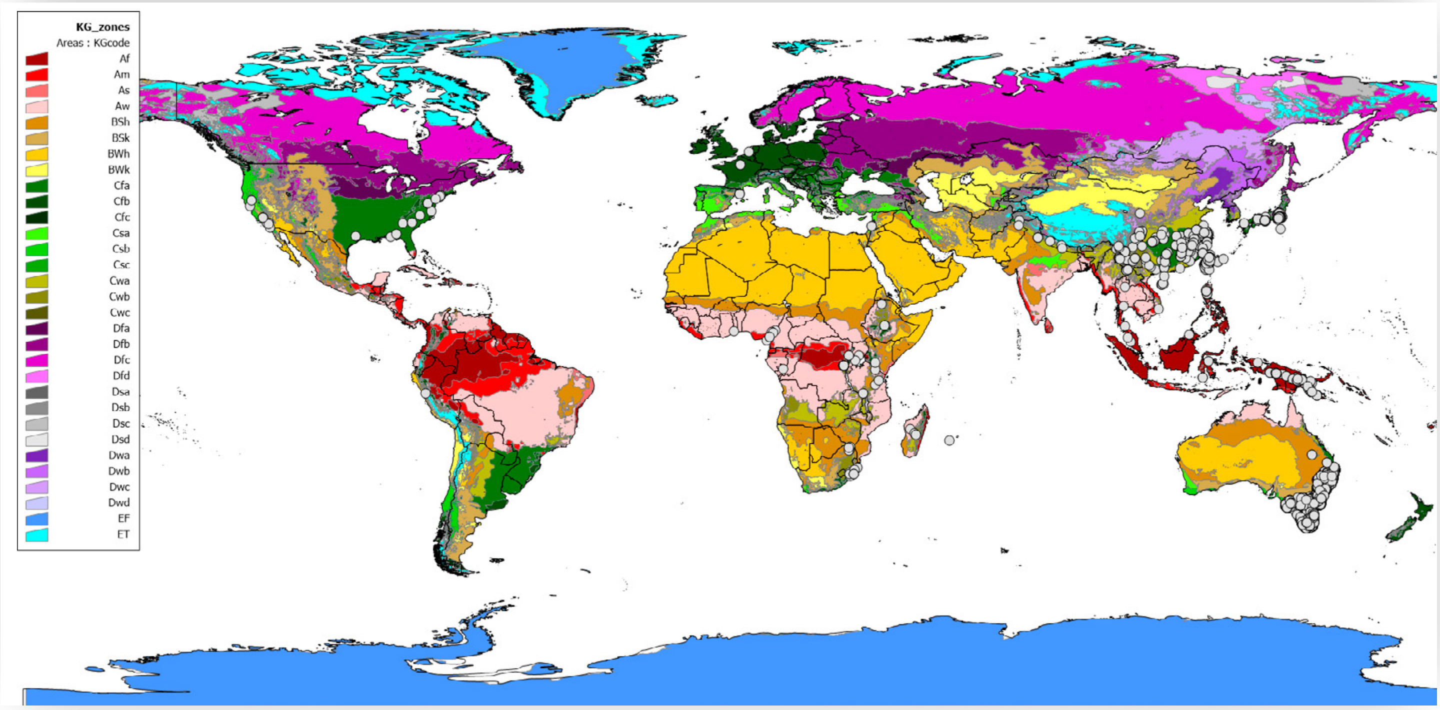

Figure 4. World distribution of *Hydrocotyle sibthorpioides* in relation to the modified Köppen-Geiger climate classification (Global Biodiversity Information Facility, 2018b).

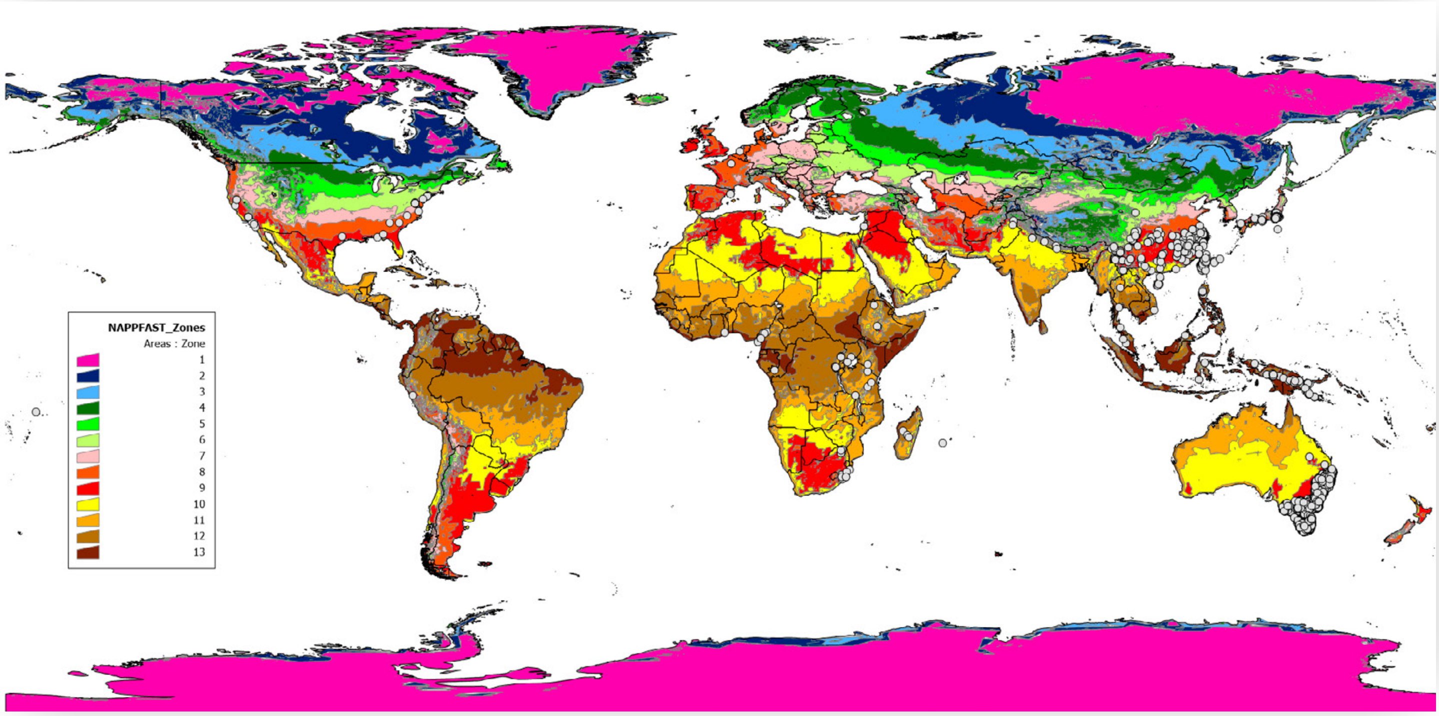

Figure 5. World distribution of ***Hydrocotyle sibthorpioides*** **in relation to the NAPPFAST system (Global Biodiversity Information Facility, 2018b).**

2.2.2.6. Methods of control

No information was found on control methods specifically for *H. batrachium* or *H. sibthorpioides*. In New Zealand triclopyr is one of the most effective herbicides for the control of *H. tripartita* in grasses and lawns, while MCPA, 2,4-D, mecoprop, ioxynil and dicamba are partially effective (Harrington, 2016).

In the United Kingdom, mechanical or manual cutting of *H. ranunculoides* is effective only in the short term and requires repeated treatments throughout the summer. Chemical treatment with glyphosate may give good results but total control is difficult and eradication may be impossible (Newman and Dueñas, 2010).

2.3. RISK EVALUATION

2.3.1. PROBABILITY OF INTRODUCTION AND SPREAD

2.3.1.1. Probability of entry

Given that the reason for the PRA is an application for the importation of *H. batrachium*, the probability of entry is automatically rated as high, with negligible uncertainty.

It should be noted that *Hydrocotyle* species, including *H. batrachium*, have uses in traditional Chinese medicine (She et al., 2005) and that it is therefore possible that they would also be imported for this reason.

2.3.1.2. Probability of establishment

Taking into account the Köppen-Geiger climatic zones Cfa, Cfb and Cfc, which include most of the world distribution of *H. batrachium, H. sibthorpioides* and *H. tripartita*, the percentage of the territory of each member country of COSAVE with climatic conditions favorable for these species varies between 2.4% for Bolivia and 100% for Uruguay (Table 1). Adding the other climatic zones in which there are records of these species (Af, Am, Aw, BSh, BSk, Csb, Cwa, and Cwb), it can be seen that there are potentially favorable climatic conditions for *H. batrachium, H. sibthorpioides* and / or *H. tripartita* in large portions of the territories of all countries, between 45% for Chile and 100% for Paraguay and Uruguay (Table 1).

The presence of *H. batrachium*, *H. sibthorpioides* and *H. tripartita* in NAPPFAST zones from 7 to 10 indicates that it can tolerate minimum annual temperatures above -17.8 ° C (see 2.2.2.5). Based on this tolerance, it is calculated that the percentage of the territory of the COSAVE countries within the thermal limits of *H. batrachium, H. sibthorpioides* and *H. tripartita* varies between 92.9% for Argentina and 100% for Brazil, Paraguay and Uruguay (Table 1), and that therefore the sensitivity to cold is not a significant factor that limits its potential to establish in the region.

Within the climatically favorable areas, these *Hydrocotyle* spp. would need suitable habitats to establish. According to the data in 2.2.2.4 these could include freshwater bodies, river banks, lakes, and rice fields, floodplains, forests and wet valleys, and urban areas (lawns, parks, and sidewalks). These habitats exist in all COSAVE countries.

Table 1. Percentage of the territory of each COSAVE member country included within the indicated Köppen-Geiger and NAPPFAST climate zones (see Annex 1).

Country	Köppen-Geiger Zones		NAPPFAST Zones
	Cfa, Cfb and Cfc	Af, Am, Aw, BSh, BSk, Cfa, Cfb, Cfc, Csb, Cwa, Cwb	≥ 7
Argentina	29.3%	85.0%	92.9%
Bolivia	2.4%	88.6%	98.2%
Brazil	7.7%	97.4%	100.0%
Chile	23.9%	45.0%	93.9%
Paraguay	36.2%	100.0%	100.0%
Peru	6.7%	70.9%	99.1%
Uruguay	100.0%	100.0%	100.0%

Based on the above, the probability of establishment of *H. batrachium* is rated as high. The uncertainty is considered medium, due to the use of information about other species of the same genus.

2.3.1.3. Probability of spread

Natural spread

Potential pathways of natural dispersal of *H. batrachium* within the PRA area include the transport of plant fragments by river currents, and potentially the dispersion in the manure of animals such as horses and cattle that feed on the plant (see 2.2.2.3). In Europe, consumption of *H. ranunculoides* by coypu (*Myocastor coypus*) and by cattle has been observed (EPPO, 2009).

Unintentional spread

There is not much information available to estimate the probability of unintentional dispersion. It can be assumed that fragments or seeds of the plant can be dispersed by the movement of boats or machinery that have been used in infested habitats.

Intentional spread

Given the intended use of the plant in aquariums, it seems likely that it will be transported in trade within the PRA area, either for commercial sale or in informal exchanges between amateurs. There is also the possibility that plants may be discarded in suitable habitats for their establishment when aquariums are emptied. In Europe it is considered that almost all the established populations of *H. ranunculoides* are derived from human activity, either by direct planting, the discarding of unwanted plants, or the cleaning of tropical aquariums or garden ponds with the result that fragments of plants enter water bodies (EPPO, 2009).

Based on the above, the probability of spread of *H. batrachium* is rated as high, with low uncertainty.

2.3.2. CONCLUSION ON THE PROBABILITY OF INTRODUCTION AND SPREAD

Combining the probabilities according to the method of Annex 2, it is concluded that the overall probability of introduction and spread of *H. batrachium* is rated as high, with low uncertainty.

2.3.3. EVALUATION OF POTENTIAL ECONOMIC AND ENVIRONMENTAL CONSEQUENCES

2.3.3.1. Economic effects

Effects on crop yield or quality

According to Chiang and Shi (2000) *H. batrachium* is a lawn weed in Taiwan (cited in Randall, 2017).

Hydrocotyle sibthorpioides is reported as a weed of transplanted rice in Indonesia, of dryland rice in Vietnam, and of rice (in unspecified cropping systems) in Bangladesh and India (Moody, 1989). It is reported as a weed of rice in China (Zhang et al., 2014) and of wheat in Nepal, where it was one of the most abundant weeds in experimental plots under certain conditions (Shah, 2011; Shah et al., 2011). It is a frequent weed in unspecified winter crops in Assam (India) (Bhattacharjya and Sarma, 2009) and is present as a weed in pineapple crops in West Bengal, India (Sarkar et al., 2017). In wetlands used in Kenya and Tanzania for agricultural production, for example of taro (*Colocasia esculenta*), it is a typical component of some plant communities (Alvarez et al., 2012).

In China, *H. sibthorpioides* is reported as a weed of *Zoysia tenuifolia* Thiele and *Paspalum vaginatum* Sw. turf (Lin et al., 2005; Xie et al., 2009). In New Zealand *H. tripartita* is a frequent weed of lawns and pastures (Harrington, 2016).

No quantitative information on the effects of *H. sibthorpioides* as a weed of crops, beyond its simple presence, was found in the cited sources.

Effects on production costs

No information was found to indicate any effect of these *Hydrocotyle* species on the costs of agricultural production.

Commercial effects

No information on commercial effects of these Hydrocotyle species was found. Since they are not classified as quarantine pests, it does not seem likely that they will be grounds for the rejection of exports.

Social effects

The fact of being considered as turf weeds implies that these *Hydrocotyle* species are undesirable from the aesthetic point of view for people who take pride in keeping their lawns in good condition.

2.3.3.2. Environmental effects

Effects on plant species

No information was found on the effects of *H. batrachium*, *H. sibthorpioides* and *H. tripartita* on populations of native or wild plants. In Belgium it was observed that H. ranunculoides is able to reduce the amount of native species of aquatic plants by 50% (up to 100% in the case of submerged species) (EPPO, 2009).

Effects on ecological systems or processes

No information was found about the effects of *H. batrachium*, *H. sibthorpioides* or *H. tripartita* on ecological systems or processes. In Europe it was concluded that *H. ranunculoides* causes significant changes in ecological processes and structures, causing reductions in water flow, increased sedimentation which accelerates ecological succession, changes in oxygen concentration, loss of accessible open water at the margins for wildlife (e.g. birds), loss of light, and increased flood risk (EPPO, 2009).

2.3.3.3. Non-phytosanitary effects

No non-phytosanitary effects of *H. batrachium*, *H. sibthorpioides* or *H. tripartita* were identified.

2.3.4. CONCLUSIONS ON POTENTIAL ECONOMIC AND ENVIRONMENTAL CONSEQUENCES

There is very little evidence that *H. batrachium* behaves as a weed of economic importance. Although the related species *H. sibthorpioides* appears in some lists of weeds, no information on its economic impact was found, suggesting that this impact is low. Regarding environmental effects, they are not documented for *H. batrachium*, *H. sibthorpioides* or *H. tripartita*. The only *Hydrocotyle* species reported with significant environmental consequences is *H. ranunculoides* in Europe; this species, however, is native to the COSAVE region, where it does not behave as a weed. Thus, any similarity between *H. ranunculoides* and *H. batrachium* can not be used to argue that the latter will have environmental impacts in the COSAVE region.

Summing up all the potential consequences identified, they are classified as low, but with high uncertainty due to the scarcity of information and the need to use information from other related species.

2.4. SUMMARY OF THE POTENTIAL RISK OF *HYDROCOTYLE BATRACHIUM*

The potential risk of H. batrachium is summarized in Table 2, which presents the ratings of the probabilities of entry, establishment and spread, and the potential economic and environmental consequences, with their corresponding degrees of uncertainty.

Table 2. Summary of the potential risk of *Hydrocotyle batrachium* for the COSAVE region.

	Risk rating	Uncertainty
Probabilities of entry		
Probability of entry	high	negligible
Probability of establishment and spread		
Probability of establishment	high	medium
Probability of spread	high	low
Overall probability of introduction and spread	high	low
Consequences		
Potential economic and environmental consequences	low	high

3. STAGE III: PEST RISK MANAGEMENT

Based on the above, the classification of *Hydrocotyle batrachium* as a quarantine pest for the COSAVE region cannot be justified. However, if an application is made to import *H. batrachium*, shipments should be accompanied by a Phytosanitary Certificate given that it is a regulated article.

It is also suggested that a voluntary code of conduct be developed for the aquarium plant industry, to warn sellers and buyers that they should not allow the disposal of live plants in natural waters.

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ANNEX 1: CLIMATIC TABLES

Table A1. Percentage of the territory of each COSAVE member country corresponding to each of the climatic zones of the Köppen-Geiger system. Calculated using the March 2017 updated version with data from 1986-2010 and with a resolution of 5 minutes, according to Kottek and Rubel[6].

'		Country						
		Argentina	Bolivia	Brazil	Chile	Paraguay	Peru	Uruguay
Af	Equatorial rainforest, fully humid		2.24	16.07		0.69	41.38	
Am	Equatorial monsoon		13.39	20.48		4.94	9.62	
As	Equatorial savannah with dry summer			2.56				
Aw	Equatorial savannah with dry winter		46.43	46.06		37.00	4.98	
BSh	Steppe climate, hot	7.13	6.62	5.76		18.26	1.67	
BSk	Steppe climate, cold	25.02	8.98		3.05		1.95	
BWh	Desert climate, hot	2.08	0.02	<0.01	0.67		7.73	
BWk	Desert climate, cold	6.06	5.52		25.52		4.08	
Cfa	Warm temperate, fully humid, hot summer	23.76	0.52	6.89		36.21		99.17
Cfb	Warm temperate, fully humid, warm summer	4.36	1.85	0.82	11.23		6.48	0.83
Cfc	Warm temperate, fully humid, cool summer and cold winter	1.22	0.05		12.65		0.18	
Csb	Warm temperate with dry, warm summer and cold winter	5.67			18.11			
Csc	Warm temperate with dry, cool summer and cold winter	0.74			1.07			
Cwa	Warm temperate with dry winter, hot summer	15.85	2.51	1.15		2.90		
Cwb	Warm temperate with dry winter, warm summer	1.98	6.01	0.21			4.66	
Cwc	Warm temperate with dry winter, cool summer and cold winter	0.45	0.60				0.73	
Dfb	Snow climate, fully humid, warm summer	<0.01						
Dfc	Snow climate, fully humid, cool summer and cold winter	0.02						
Dsc	Snow climate with dry, cool summer and cold winter	0.07			0.02			
Dwb	Snow climate with dry winter, warm summer	0.01						
Dwc	Snow climate with cool summer and cold, dry winter	0.02						
EF	Polar climate	0.01			0.02		0.01	
ET	Tundra climate	5.55	5.25		27.64		16.51	

6 Kottek, M. and F. Rubel. 2017. *World Maps of Köppen-Geiger Climate Classification*. Accessed online January 10 2018. http://koeppen-geiger.vu-wien.ac.at/present.htm.

Table 2. Percentage of the territory of each COSAVE member country corresponding to each of the NAPPFAST cold hardiness zones7.

NAPPFAST Zone	Mean annual extreme minimum temperature (°C)	Country						
		Argentina	Bolivia	Brazil	Chile	Paraguay	Peru	Uruguay
1	< -45.6	<0.01	0.00	0.00	0.00	0.00	0.00	0.00
2	-45.9 — -40.0	0.01	0.00	0.00	0.02	0.00	0.00	0.00
3	-40.0 — -34.4	0.07	0.00	0.00	0.01	0.00	0.00	0.00
4	-34.4 — -28.9	0.67	0.00	0.00	0.25	0.00	0.00	0.00
5	-28.9 — -23.3	2.09	0.15	0.00	1.07	0.00	0.00	0.00
6	-23.3 — -17.8	4.22	1.70	0.00	4.78	0.00	0.93	0.00
7	-17.8 — -12.2	7.45	9.74	0.00	11.47	0.00	5.31	0.00
8	-12.2 — -6.7	17.25	12.07	0.07	16.17	0.00	7.87	0.00
9	-6.7 — -1.1	46.69	10.64	3.69	26.29	4.46	9.35	80.22
10	-1.1 — 4.4	21.55	15.11	8.43	21.67	95.46	8.91	18.74
11	4.4 — 10.0	0.00	38.51	18.52	14.30	0.08	19.59	1.03
12	10.0 — 15.6	0.00	12.08	44.55	3.93	0.00	42.89	0.00
13	> 15.6	0.00	0.00	24.73	0.04	0.00	5.14	0.00

7 Calculated with data courtesy of Dr. R. Magarey, see Magarey, R.D., D.M. Borchert and J.W. Schlegel. 2008. Global plant hardiness zones for phytosanitary risk analysis. Scientia Agricola 65: 54-59.

ANNEX 2: METHOD OF COMBINING PROBABILITIES AND UNCERTAINTIES

To rate the overall risk of establishment and spread, each probability is converted into a numerical score (negligible = 0, low = 1, medium = 2, high = 3), and the numerical scores are multiplied as follows:

Probability of establishment and spread
=
Probability of establishment x Probability of spread

This product is used to rate the overall probability of introduction and spread as follows:

Product (probability of establishment × probability of spread)	Overall rating for probability of establishment and spread
0	Negligible
1 – 3	Low
4 – 6	Medium
>6	High

Similarly, the uncertainty levels of the probabilities of establishment and spread are combined to arrive at an uncertainty score for the overall probability of establishment and spread. As before, the levels of uncertainty are converted into numerical scores (negligible = 0, low = 1, medium = 2, high = 3). Unlike the probabilities, the uncertainties are added:

Uncertainty of the probability of establishment and spread = Uncertainty of the probability of establishment + Uncertainty of the probability of spread

This sum is used to rate the uncertainty of the overall probability of introduction and spread as follows:

Sum of uncertainty scores for the overall probability of establishment and spread	Overall uncertainty rating for the probability of establishment and spread
0	Negligible
1	Low
2 – 3	Medium
4 – 6	High