FORMAT FOR A PRA RECORD (version 3 of the Decision support scheme for PRA for quarantine pests)

	European and Mediterranean Plant Protection Organisation		
	Organisation Européenne et Méditerranéenne pour la Protection des Plantes		
	Guidelines on Pest Risk Analysis		
	Lignes directrices pour l'analyse du risque phytosanitaire		
	Decision-support scheme for quarantine pests Version N°3		
PEST RISK ANALYSIS FOR *Eichhornia crassipes*			
Pest risk analyst:			
			The Expert Working Group on *Eichhornia crassipes* composed of: Jesús Cabezas Flores (Spain), Julie Coetzee (South-Africa), Martin Hill (South-Africa), Angel Hurtado (Spain), Célia Laranjeira (Portugal), Michael Nang'alelwa (Zambia), Trinidad Ruiz Téllez (Spain), Jorge Sanchez (Spain), Gritta Schrader (Germany), Uwe Starfinger (Germany) With the help of Mic Julien (Australia).
Stage 1: Initiation			
1 What is the reason for performing the PRA?			*E. crassipes* is considered one of the worst aquatic invasive plant worldwide (Harley *et al*., 1996). It is a threat in Spain and Portugal, but its distribution is currently limited in the EPPO region.
2 Enter the name of the pest			*Eichhornia crassipes* (Martius) Solms
2A Indicate the type of the pest			Floating freshwater plant (macrophyte)

2B Indicate the taxonomic position		Plantae - Pontederiaceae
3 Clearly define the PRA area		The EPPO Region.
4 Does a relevant earlier PRA exist?	Yes	National PRA for the UK (Mauremootoo, 2007) In New Zealand, the plant has been assessed and is considered one of the most problematic weeds (Champion & Clayton, 2001). A PRA has been performed for Victoria in Australia (Department of primary industries, 2008), stating high impacts for agriculture, fauna, and recreation. A Risk assessment of *E. crassipes* for the Pacific was prepared by Pacific Island Ecosystems at Risk (PIER). The result is that the species is likely to be a pest. This risk assessment is available on the PIER website (http://www.hear.org/pier/index.html).
5 Is the earlier PRA still entirely valid, or only partly valid (out of date, applied in different circumstances, for a similar but distinct pest, for another area with similar conditions)?	Partly valid	The PRAs apply for different areas, or for part of the EPPO region (UK PRA).
Stage 2A: Pest Risk Assessment - Pest categorization		
6 Specify the host plant species (for pests directly affecting plants) or suitable habitats (for non parasitic plants) present in the PRA area.		Freshwater bodies and ecosystems.
7. Specify the pest distribution		**EPPO region:** Israel, Italy, Jordan, Portugal, Spain **Asia:** Bangladesh, Cambodia, China, Brunei Darussalam, India, Indonesia, Lebanon, Japan, Laos, Malaysia, Maldives, Myanmar, Philippines, Singapore, South Korea, Sri

		Lanka, Syria, Taiwan, Thailand, Viet Nam, **North America:** Mexico, USA (Alabama, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, Texas). See the USGS/Florida Caribbean Science Center map from the "Protect your waters" website. **Central America**: Costa Rica, Guatemala, Honduras, Nicaragua, Panama, **South America:** Argentina, Bolivia, Brazil, Chile, Columbia, Ecuador, French Guiana, Guyana; Uruguay, Paraguay, Peru, Suriname; Venezuela. **Caribbean**: Bahamas, Cuba, Dominican Republic, Haiti, Jamaica, Puerto Rico. **Oceania:** American Samoa, Australia, Cook Islands, Fiji, French Polynesia, Guam, Marshall Islands, Federated States of Micronesia, Nauru, New Caledonia, New Zealand, Northern Mariana Islands, Palau, Papua New Guinea, Samoa, Solomon Islands, United States minor outlying islands, Vanuatu. **Africa:** Angola, Benin, Burkina Faso, Burundi, Cameroon, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of Congo, Egypt, Equatorial Guinea, Ethiopia, Gabon, Ghana, Guinea, Guinea Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Niger, Nigeria, Reunion, Rwanda, Senegal, Sierra Leone, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia and Zimbabwe.
8. Is the organism clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	Yes	The plant is *E. crassipes*. There are eight species in the genus *Eichhornia* (Cook, 1998), all of which originate in South America, except *E. natans* (P. Beauv.) which is native to tropical Africa (Gopal, 1987). *E. crassipes* can adequately be distinguished from the other species (Ruiz Téllez *et al.*, 2008a). Spermatophyta Angiospermae (Magnoliophyta) Monocotyledones (Liliopsida) Liliales Pontederiaceae There are no described subspecies or varieties.
9. Even if the causal agent of particular symptoms has not yet been fully identified, has it been shown to produce consistent symptoms and to be transmissible?	/	Not relevant

10. Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?	Yes	*E. crassipes* is considered a pest in most of its introduced range (Gopal, 1987), including Spain and Portugal (e.g. Ruiz Téllez *et al*., 2008b, Fernandes & Moreira, 1987, Moreira *et al*., 1999, Martins *et al*., 2006). Within its indigenous range (Amazonian area), there are some impacts reported and some control methods, but the species is not as invasive as in its introduced range (FAO, 1997).
11. Does the organism have intrinsic attributes that indicate that it could cause significant harm to plants?		
12 Does the pest occur in the PRA area?	Yes	The plant is established in Israel, Italy, Portugal, and Spain. The plant is casual (= transient) in France, the Netherlands, Belgium and the UK. The plant has recently been recorded in botanical gardens: cultivated in the Botanic Gardens of Amsterdam (The Netherlands) Colonia (Köln) (Germany) and in Brno (Czech Republic) (T. Ruiz Téllez, pers. com., 2008). It has been reported from Slovak Republic, cultivated during the summer in gardens (Prof. H. Otahelòvá Pers. com. 2008). It does not thrive in these countries and hardly flourishes, and is planted every year. It might be more widely spread as it is freely available in shops, markets and internet. *E. crassipes* is widely grown under glasshouse conditions in UK for horticulture (Mauremootoo, 2007).
13. Is the pest widely distributed in the PRA area?	No	
14. Does at least one host-plant species (for pests directly affecting plants) or one suitable habitat (for non parasitic plants) occur in the PRA area (outdoors, in protected cultivation or both)?	Yes	Freshwater bodies and ecosystems are very common in the EPPO region.
15. If a vector is the only means by which the pest can spread, is a vector present in the PRA area? (if a vector is not needed or is not the only means by which the pest can spread go to 16)	/	Not relevant

16. Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?	Yes	*E. crassipes* is regarded as highly invasive in most of its introduced range. This includes southern USA and Mexico, Oceania, southern Asia (India, Bangladesh, Sri Lanka) South East Asia, China, Japan, Taiwan, Africa and parts of South America, as well as in Spain and Portugal. These areas have ecoclimatic conditions at least moderately similar to the Mediterranean area of the EPPO region.
17. With specific reference to the plant(s) or habitats which occur(s) in the PRA area, and the damage or loss caused by the pest in its area of current distribution, could the pest by itself, or acting as a vector, cause significant damage or loss to plants or other negative economic impacts (on the environment, on society, on export markets) through the effect on plant health in the PRA area?	Yes	The plant has detrimental economic impacts: it is a threat to agriculture, plant health, environment, public safety, recreation activities, water quality and quantity, human health. The most important impacts of the plant on crop yield are caused by water loss. *E. crassipes* impacts agriculture production worldwide. Furthermore, there is a direct cost to irrigation infrastructure including irrigation canals and pumps (Gopal, 1987). *E. crassipes* impacts rice production in 3 ways: direct suppression of the crop and inhibition of its germination, water loss and increase in costs in harvesting since the plants get caught up in the mechanical harvester. It out-competes native aquatic vegetation, speeds up succession, negatively impacts the diversity of benthic invertebrates (Midgley *et al*. 2006), plankton (Masifwa *et al*., 2001, Ruiz Téllez, Pers. com. 2006 for evidence in Spain, Almeida, 2006 for Portugal), aquatic biodiversity (Toft *et al*., 2003), clogs waterways, and obstructs recreation activities (boating, fishing and swimming). Disruption of socioeconomic and subsistence activities by preventing access to fishing ground, gardens, schools and hospitals have been described extensively for the USA (Center *et al*. 2002), Australia (Wright & Purcell 1995), most countries in Africa (Cilliers *et al*. 2003) and South East Asia (Julien & Orapa 2001*). E. crassipes* provides suitable habitats for the vectors of insect borne diseases such as malaria and bilharzias (Harley *et al*. 1996). These impacts are reported in crops such as rice and in freshwater bodies and ecosystems, such habitats also occur in the PRA area, similar impacts are expected.
18. This pest could present a risk to the PRA area.	Yes	The plant may represent a risk and may cause economic, including environmental and social impacts. *E. crassipes* is already considered a pest in Spain and Portugal (see question 10).
19. The pest does not qualify as a quarantine pest for the PRA area and the assessment for this pest can stop.		

Section 2B: Pest Risk Assessment - Probability of introduction/spread and of potential economic consequences

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		Note: If the most important pathway is intentional import, do not consider entry, but go directly to establishment. Spread from the intended habitat to the unintended habitat, which is an important judgement for intentionally imported organisms, is covered by questions 1.33 and 1.35.
1.1. Consider all relevant pathways and list them		• Intentional import as an ornamental aquatic plant for use outdoors and in aquariums. Because of its attractive purple flowers, *E. crassipes* is a favorite amongst ornamental pond and garden enthusiasts. As a result humans have spread it widely and due to its fast growth rate it now flourishes in all continents except Antarctica (Gopal, 1987), including Europe (see question 7). Most spread can be attributed to deliberate planting of *E. crassipes* outdoors as an ornamental. The plant is also used as an aquarium plant. Owing to its large size, the plant is restricted to open aquariums, which are quite rare, the majority of aquariums being closed. Though the plant is traded as a small plant, it could be disposed of into the wild when it gets too large. • Intentional entry with passengers Tourists visiting countries where the species is present could bring it into the EPPO region. This is considered minor compared to trade. • Intentional import for non ornamental uses The use of *E. crassipes* as pig fodder has contributed to its spread in China, where it was distributed widely to 16 provinces in the 1950s and 1960s and 1970s (Ding *et al*. 2001). *E. crassipes* has a number of uses such as fodder (Gunnarsson and Petersen, 2007; Spain, Ruiz Téllez, pers. com. 2008), decontaminant of waste waters, biogas (as observed in Spain by Delgado Arroyo, 1989; Boillot *et al*., 1983), compost, and furniture (Lindsey & Hirt, 1999). The species is usually not introduced for these purposes (see question 1.33), but the use of the species as a decontaminant of used water, as a biogas, as a fodder or for

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		compost could become important. Nevertheless, there is no evidence and insufficient information for these pathways, and measures would be the same as for intentional import of the plant for ornamental purposes. *E. crassipes* is considered botanically interesting and has been introduced for research purposes, e.g. in Denmark (Chikwenhere & Phiri, 1999). The experts considered that import for research purposes could occur. As for the previous uses of the plant, measures would be the same as for intentional import of the plant for ornamental purposes. • Unintentional import as a contaminant No information is available on the plant being a contaminant of other commodities, such as traded aquatic plants. According to Maki and Galatowitsch (2004), *E. crassipes* has not been found as a contaminant of other traded aquatic plants. The experts considered that contaminants are usually vegetative parts of aquatic plants, which is very unlikely for *E. crassipes* since daughter plants are big, and seeds would have to be introduced through sediments.
1.2. Estimate the number of relevant pathways, of different commodities, from different origins, to different end uses.	Few	The pathway is intentional import of the plant for ornamental purposes. The commodity is exported from few countries such as Thailand, Singapore and Malaysia, into at least 4 importing countries (EPPO Secretariat, to be published)
1.3. Select from the relevant pathways, using expert judgement, those which appear most important. If these pathways involve different origins and end uses, it is sufficient to consider only the realistic worst-case pathways. The following group of questions on pathways is then considered for each relevant pathway in		Intentional import of the plant for ornamental purposes is the most important pathway. Intentional import for agricultural, energy, waste water treatment and research purposes could also be a potential pathway but this is currently considered to be minor. If the PRA is being conducted on a pest that is intentionally imported, e.g. a plant for planting or a biological control agent, and this is the only pathway of entry, an assessment of its entry potential is not required. However, it is still important to record the volume, frequency and distribution of imports, following the relevant questions of entry of the

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
turn, as appropriate, starting with the most important.		scheme.
Pathway n°: 1 This pathway analysis should be conducted for all relevant pathways		**Intentional import of the plant for ornamental purposes**
1.4. How likely is the pest to be associated with the pathway at origin taking into account factors such as the occurrence of suitable life stages of the pest, the period of the year?	Certain Low uncertainty	The plant is imported.
1.5. How likely is the concentration of the pest on the pathway at origin to be high, taking into account factors like cultivation practices, treatment of consignments?		
1.6. How large is the volume of the movement along the pathway?	Moderate Low uncertainty	From the study performed by EPPO on traded aquatic plants, for one month in 2005 or 2006 (depending on the countries), the following quantities of plants have been traded (EPPO Secretariat, to be published): - 3050 in France - 42 in the Netherlands (425 for one year) - 7200 in the Czech Republic - 220 in Hungary. These figures do not exclude that the species could be imported into other EPPO countries and are considered to be underestimated. The species is also traded on internet: http://www.aquaristic.net/eichhornia-crassipes-wasserhyazinthe-1-stportion.html?lang=1 http://www.redbubble.com/products/configure/910272 http://www.gartencenter-shop24.de/ http://www.zooplus.de/ http://www.barranco-watergarden.eu/ The plant is also available in catalogues of big companies: http://www.aquaproduction.be/fr/catalogue%20AQUA.pdf

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		http://www.moerings.nl/pagesfr/index.html Additionally, the plant is cultivated in huge volumes in the Netherlands (J van Valkenburg, pers. com., 2008). *E. crassipes* is widely grown under glasshouse conditions in UK for horticulture (Moremootoo, 2007). These plants could be traded within the EPPO region.
1.7. How frequent is the movement along the pathway?	Often Low uncertainty	As an extrapolation of the study on imported aquatic plants in the EPPO region (EPPO Secretariat, to be published), it is considered that the plant is imported all year round in the EPPO region.
1.8. How likely is the pest to survive during transport/storage?		
1.9. How likely is the pest to multiply/increase in prevalence during transport /storage?		
1.10. How likely is the pest to survive or remain undetected during existing management procedures (including phytosanitary measures)?		
1.11. In the case of a commodity pathway, how widely is the commodity to be distributed throughout the PRA area?	Widely Low uncertainty	The species is available for sale in many countries of the EPPO region. The experts reported sales in Germany (41 suppliers according to the PPP index), Spain, France, Slovakia. The species is also traded on internet and is available in catalogues of big companies (see question 1.6). Moreover, the plant has been both sold in local markets, and big supermarkets chains and garden shops in Badajoz in the last four years (Ruiz Téllez, pers.com. 2008). It is considered that it is likely to occur for the rest of Spain, as well as for other EPPO countries.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
1.12. In the case of a commodity pathway, do consignments arrive at a suitable time of year for pest establishment?		
1.13. How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?		
1.14. In the case of a commodity pathway, how likely is the intended use of the commodity (e.g. processing, consumption, planting, disposal of waste, by-products) to aid transfer to a suitable host or habitat?	Likely Low uncertainty	The intended habitats are: - confined waterbodies such as garden ponds, - aquariums. The species could be misused and introduced directly into freshwater bodies and ecosystems (e.g. stream, lakes, dams). The unintended habitats are freshwater bodies and ecosystems (semi-natural and natural waterbodies). Plants used in confined waterbodies could spread to unintended habitats very easily through human activities as well as through natural spread by floods downstream, and eventually over large distances via sediments containing seeds stuck to the feet and feathers of water fowl (Ruiz Téllez *et al*., 2008d) Dumpings of aquarium contents have been a source of introduction of aquatic plants in some countries, even if it is considered as an accidental pathway of introduction (e.g. *Cabomba caroliniana* in the Netherlands, see the EPPO PRAon the species; *Hydrilla verticillata* in the USA, Langeland, 1996). Though, it is less likely than when the plant is used as an outdoors ornamental plant.
Do other pathways need to be considered?	No	

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
Conclusion on the probability of entry. Risks presented by different pathways.	Very likely Low uncertainty	The plant has already entered the EPPO region. It is still entering the EPPO region for ornamental purposes.
1.16. Estimate the number of host plant species or suitable habitats in the PRA area (see question 6).	Few Low uncertainty	Ideal habitats for *E. crassipes* are slow moving or still freshwater bodies and ecosystems. According to the CORINE Land Cover nomenclature, the suitable habitats are: - Continental waters (water courses, water bodies) - Banks of continental water, Riverbanks / canal sides (dry river beds)
1.17. How widespread are the host plants or suitable habitats in the PRA area? (specify)	Very widely Low uncertainty	Freshwater bodies and ecosystems abound in the EPPO region.
1.18. If an alternate host or another species is needed to complete the life cycle or for a critical stage of the life cycle such as transmission (e.g. vectors), growth (e.g. root symbionts), reproduction (e.g. pollinators) or spread (e.g. seed dispersers), how likely is the pest to come in contact with such species?	No Low uncertainty	Another species is not needed to complete the life cycle of the plant. The plant is able to reproduce vegetatively. However, *Apis mellifera* is the agent responsible for cross-pollination, replacing the plant's natural pollinators, so the plant is able to produce seeds in Mediterranean climates (Ruiz Téllez *et al.*, 2008c, 2008d Barrett, 1980).
1.19. How similar are the climatic conditions that would affect pest establishment, in the PRA area and in the current area of distribution?	Moderately similar Medium uncertainty	Very similar in southern Europe to totally dissimilar in northern Europe. Optimal growth occurs at temperatures of 28-30^{o}C (air temperatures) while growth ceases when water temperatures drop below 10ºC (Gopal, 1987). During these times of stress, stored carbohydrates from the rhizome are used as energy reserves (Owens & Madsen 1995), but prolonged cold temperatures, below 5^{o}C, result in death of the plants, limiting *E. crassipes* distribution in high latitudes (Gopal 1987, Owens and Madsen 1995). See Appendix 1. Transient populations of the weed are likely to occur in the more temperate regions of Europe, where population expansion is likely through the summer months and retraction during winter, as it is the case in canals in the Netherlands for *E. crassipes* (Bruinsma,

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		2000). It is not known whether the plant could set seeds during summer in these areas, and whether the crown could survive, protected by dead parts of the plant.
1.20. How similar are other abiotic factors that would affect pest establishment, in the PRA area and in the current area of distribution?	Very Similar Low uncertainty	*E. crassipes* can tolerate pH levels from 4.0 to 10.0, ideally 6 to 8 (Martín de Rodrigo *et al.*, 2008). It grows best in water high in nutrients (for precise figures, see Ruiz Téllez *et al.*, 2008 e), Reddy *et al*. 1989 and 1990). Salinities of more than 25‰ kill the plants. With regards to luminance, the species is heliophilous and needs between 24.000 to 240.000 lux (François, 1969). *E. crassipes* can tolerate water level fluctuations, whereby plants stranded on the banks of the water body are capable of surviving for several months provided the banks are moist. Further, the plant is able to survive in ephemeral water bodies as the seeds are resistant to desiccation and germinate once the water body is re-inundated (Gopal, 1987). These abiotic conditions are very similar to the ones occurring in the EPPO region, e.g. in Spain and Portugal (Moreira *et al*., 2005; Ruiz Téllez *et al.* 2008b).
1.21. If protected cultivation is important in the PRA area, how often has the pest been recorded on crops in protected cultivation elsewhere?	Not relevant	
1.22. How likely is it that establishment will occur despite competition from existing species in the PRA area?	Very likely Low uncertainty	*E. crassipes* is a highly competitive floating macrophyte that is capable of outcompeting other species of invasive floating macrophytes throughout the world such as *Salvinia molesta*, *Pistia stratiotes*, *Myriophyllum aquaticum, Azolla filiculoides* (Coetzee *et al.* 2005). In Spain, all associated species both on banks (*Phragmites communis, Typha latifolia, T. angustifolia*, etc.) and in water (*Lemna minor, Azolla filliculoides*) were affected by the fast growth of *E. crassipes*. Initially, *E. crassipes* would coexist with other aquatic plants, but soon outcompetes these species (Ruiz Téllez *et al*., 2008b).
1.23. How likely is it that establishment will occur despite natural enemies already present in the PRA area?	Very likely Low	*E. crassipes* has a suite of specialised insects and pathogen species in its region of origin that control populations (Cordo, 1999). Besides generalist herbivory from water fowl the plant experiences enemy free space in its introduced range.

Question	**Rating + uncertainty**	**Explanatory text of rating and uncertainty**
	uncertainty	So far, no natural enemies have been reported on *E. crassipes* in the EPPO region.
1.24. To what extent is the managed environment in the PRA area favourable for establishment?	Highly favourable Low uncertainty	Two factors contribute to the establishment of *E. crassipes*: - increased nutrient status through agricultural, urban and industrial run-offs - and impoundment of waters by creating dams, altering hydrological regimes (Ruiz Téllez *et al*., 2008b, Hill & Olckers, 2001).
1.25. How likely is it that existing pest management practice will fail to prevent establishment of the pest?	Very likely Low uncertainty	There are no known specific management systems to deal with plant invasions of freshwater bodies and ecosystems in the Mediterranean part of the EPPO region. For Spain and Portugal there were no existing pest management practices to prevent establishment of the plant.
1.26. Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the PRA area?	Very likely Low uncertainty	Based on its reproductive strategy (see question 1.27), *E. crassipes* is a very successful invader. Gutiérriez *et al*. (1996) stated that considering reproductive abilities of the plant, its resistance to adverse conditions, it is impossible to eradicate it once established. There is no example of successful eradication of *E. crassipes* anywhere in the world once the plant has established.
1.27. How likely is the reproductive strategy of the pest and the duration of its life cycle to aid establishment?ated	Very likely Low uncertainty	Each flower of *E. crassipes* produces about 250 long-lived seeds (up to 20 years) (Barrett, 1980) that are resistant to the drying up of the water body. Germination occurs once the water body is re-inundated and the plants are then capable of rapid growth through the asexual production of daughter plants (Watson & Cook, 1987). In Spain (River Guadiana), *E. crassipes* reproduces both vegetatively and sexually and has floral cycles of about 1-2 days, and 1-2 months to produce mature dehiscent fruits and seeds (Ruiz Téllez *et al.*, 2008c, 2008d). Its doubling time can be as little as one week (Edwards & Musil, 1975), and depends on water nutrient content and temperature. In the Guadiana river in Spain, doubling time varied between 10 and 60 days (Ruiz Téllez *et al*., 2008e).

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
1.28 How likely are relatively small populations to become established?	Very likely Low uncertainty	The species is self-compatible and reproduces vegetatively. The lack of genetic diversity is no constraint to its invasiveness (Li *et al.*, 2006). Indeed, it is very likely that *E. crassipes* was introduced to a number of countries as a single plant from which infestations have arisen.
1.29. How adaptable is the pest?	High Low uncertainty	The plant has a broad environmental tolerance (see question 1.19) and broad geographical range (see question 7). The plant can establish in different freshwater bodies and ecosystems. It has a high phenotypic diversity. The growth form is plastic with short plants with inflated petioles occurring in new infestations and along the edge of infestations and taller plants with thinner petioles in more established stands. Furthermore, in the region of origin three style morphs are described (Barrett, 1979). However, in its introduced range, only the mid-style form is found. This has been confirmed in Spain by Ruiz Téllez *et al.*, 2008c. Based on this information, it is assumed that adaptability of the species is high.
1.30. How often has the pest been introduced into new areas outside its original area of distribution? (specify the instances, if possible)	Very often Low uncertainty	The plant has been introduced to all continents except Antarctica, and several countries on these continents. See question 7 for details on countries.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
1.31. If establishment of the pest is very unlikely, how likely are transient populations to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment) ?	/	Establishment of the pest has already occurred in some countries of the EPPO region.
Conclusion on the probability of establishment	**Very high** **Low uncertainty**	The species has already established in Spain and Portugal and the whole Mediterranean area would be suitable for its establishment. The species is also capable of developing transient populations in the more temperate part of the EPPO region.
1.32. How likely is the pest to spread rapidly in the PRA area by natural means?	Very likely within catchments/ unlikely between separate catchments Low uncertainty	*E. crassipes* is already present in a number of waterbodies in the Iberian Peninsula (Ruiz Téllez *et al.* 2008b; Marchante & Marchante, 2005), it can spread naturally downstream through seed and plant drift, and between catchments by water fowl, although this is less likely. The natural spread of the plant up to 100s of kms has been well documented in many of the large river systems in Africa (Navarro & Phiri, 2000) and in Spain (Ruiz Téllez *et al*., 2008b; Martín de Rodrigo *et al*., 2008). Studies in Spain highlighted that propagule dispersal was the highest in September, and reached an average of 4.5 propagules dispersed in 15 minutes (Ruiz Téllez *et al*. 2008b).
1.33. How likely is the pest to spread rapidly in the PRA area by human assistance?	Very likely Low uncertainty	Once introduced in an unintended habitat, *E. crassipes* can be accidentally dispersed by human activities during maintenance of swimming areas, attached to fishing gear or to the hulls, anchor lines, engines, or other parts of boats, across drainages. Moreover, existing practices of mechanical waterway maintenance tend to cut off plants and spread the fragments. These fragments thrive and form new plants, enabling new stands to establish. It can also be intentionally moved between water bodies for utilization, e. g. as a fodder plant, as a decontaminant of waste waters. In Spain, *E. crassipes* has been utilized as a fodder for sheep by farmers, especially during

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		drought when alternative fodder is in short supply (Ruiz Téllez, pers. com. 2008). The use of *E. crassipes* as a decontaminant of water has been reported in Spain and Italy for example (Delgado Arroyo, 1989). These uses and others listed in literature (e. g. growing the plant for use as compost, biogas, and furniture) can lead to the spread of the plant to new freshwater bodies and ecosystems.
1.34. Based on biological characteristics, how likely is it that the pest will not be contained within the PRA area?	Likely Low uncertainty	Reproduction is both vegetative via daughter plant production, and by seeds. Daughter plants are spread through wind and wave action. Seeds are produced in very large numbers, and persist in the seed bank for up to 20 years, germinating due to increased light penetration of the water column following removal of the parental population. Within a catchment, biological characteristics of the plant make it difficult to contain. However between unconnected catchments, the possibility of containment is high. It should be possible to contain the species to the Iberian Peninsula since there is no direct connection between Iberian and other European water bodies where the plant does not occur. If some new outbreaks are found in other EPPO countries at risk, containment would only be possible if the outbreak is managed at an early stage, due to its ability to spread via water courses.
Conclusion on the probability of spread	**High** **Low uncertainty**	The plant has high capacity of spread.
Conclusion on the probability of introduction and spread **The overall probability of introduction and spread should be described. The probability of introduction and spread may be expressed by comparison with**	**High** **Low uncertainty**	Entry, establishment and spread have already occurred within the EPPO region.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
PRAs on other pests.		
Conclusion regarding endangered areas 1.35. Based on the answers to questions 1.16 to 1.34 identify the part of the PRA area where presence of host plants or suitable habitats and ecological factors favour the establishment and spread of the pest to define the endangered area. **Strange to define before impacts**		The most endangered part of the PRA area is freshwater bodies and ecosystems in the southern parts of the EPPO region. The countries the most at risk are: Albania, Algeria, Bosnia and Herzegovina, Croatia, France (including Corsica), Greece, Israel, Italy (including Sardinia, Sicilia), Jordan, Montenegro, Morocco, Portugal (Azores, Madeira), Slovenia, Spain (Baleares, Canarias), Turkey, Tunisia. Freshwater bodies and ecosystems of more temperate areas are also susceptible to transient infestations. Countries of western and central Europe would be the more at risk (e.g. the UK, the Netherlands).
2. In any case, providing replies for all hosts (or all habitats) and all situations may be laborious, and it is desirable to focus the assessment as much as possible. The study of a single worst-case may be sufficient. Alternatively, it may be appropriate to consider all hosts/habitats together in answering the questions once. Only in certain circumstances will it be necessary to answer the questions separately for specific hosts/habitats.		
2.1. How great a negative effect does the pest have on crop yield and/or quality to cultivated plants or on control costs within its current area of distribution? **Control costs not necessarily linked to yield crop**	Major Low uncertainty	The most important impacts of the plant on crop yield are caused by water loss. *E. crassipes* increases water loss due to evapo-transpiration. Estimates of increased water loss vary from 2.67 times (Lallana *et al*, 1987) to 3.2 times (Penfound & Earl, 1948) more from a mat of *E. crassipes* in comparison to open water. Lallana *et al.* (1987) calculated that *E. crassipes* caused an increase in water loss of about 70 000 l/ha/d from a dam in Argentina.

Question	**Rating + uncertainty**	**Explanatory text of rating and uncertainty**
		Furthermore, there is a direct cost to irrigation infrastructure including irrigation canals and pumps (Gopal, 1987). *E. crassipes* impacts agriculture production worldwide. As an example, in Portugal, negative impacts have caused big economic losses to rice fields and local farmers of the Sado River Basin (Guerreiro, 1976; Moreira *et al*., 1999). *E. crassipes* impacts rice production in 3 ways: direct suppression of the crop and inhibition of its germination, water loss and increase in costs in harvesting since the plants get caught up in the mechanical harvester. Globally, Gopal (1987) reported impacts on rice production with inhibition of the seed germination in India, Sri Lanka, Bangladesh (cost of 15 millions dollars according to Gopal (1987)), Burma, Malaysia, Indonesia, Thailand, Philippines, Japan, and Portugal. According to Parson & Cuthbertson (2001), losses are staggering, for example, in the Indian State of West Bengal, it causes an annual loss of paddy rice valued at 110 million rupees. Impacts are also reported on rape seed in Japan (Gopal 1987). *E. crassipes* has been reported to be an alternative host for the Asian corn borer, *Ostrinia furnacalis* Guenee and the rice root nematode, *Hirschmanniella oryzae* (van Breda de Haan) Luc & Goody (Grove *et al.*, 1995). Figures on general costs of control are available throughout the world, though, a separation between costs for agricultural purposes and other purposes cannot be made. Between 1980 and 1991, Florida spent over $43 million to suppress *E. crassipes* and *Pistia stratiotes* (Schmitz *et al*. 1993). Currently, annual costs for *E. crassipes* management range from $500,000 in California to $3 million in Florida (Mullin *et al*. 2000). The largest infestations of *E. crassipes* in the USA occur in Louisiana where the Department of Fisheries treats about 25,000 acres of *E. crassipes* with herbicides per year, mostly at boat ramps, at an annual cost of $2 million. Within its present range within the PRA area, the management cost to remove nearly 200,000 tonnes of the plant was 14,680,000 euros for 2005 to 2008 in the Guadiana river (for around 75 km of river) (Cifuentes *et al*. 2007). It represents 65,723 working days and

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		necessitates the use of crane trucks equipped with a grapple, backhoes with bucket, and 35 meters boom cranes (Ruiz Téllez *et al*., 2008b). In Portugal, the management in the Municipality of Agueda cost 278,000 euros from December 2006 to May 2008, including the purchase of the mechanical harvester and its monthly running costs, as well as almost 1 800 labour hours. Three persons where employed for this purpose in 2006 and 2007, and one during 2008 (Laranjeira, 2008). A water harvester and a truck were used. Moreira *et al*. (2005) and Santos (2003) report that 470,000 euros were spent during 1999 to 2004 near Leziria Grande de Vila Franca de Xira (Portugal) for an integrated management programme.
2.2. How great a negative effect is the pest likely to have on crop yield and/or quality in the PRA area without any control measures?	Major Low uncertainty	Impacts within the EPPO region would be as described in question 2.1, and would be exacerbated without any control measures.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.3. How easily can the pest be controlled in the PRA area without phytosanitary measures?	With much difficulty Low uncertainty	Without phytosanitary measures, *E. crassipes* will not be controlled.
2.4. How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area?	High Low uncertainty	Similar increase in control costs than those noted in Spain and Portugal (see question 2.1) are likely to occur in other EPPO countries.
2.5. How great a reduction in consumer demand is the pest likely to cause in the PRA area? **Related to agricultural impacts**	/	Not relevant.
2.6. How important is environmental damage caused by the pest within its current area of distribution?	Major Low uncertainty	Dense mats of *E. crassipes* reduce light to submerged plants, thus depleting oxygen in aquatic communities (Ultsch, 1973). The resultant lack of phytoplankton (McVea & Boyd, 1975) alters the composition of invertebrate communities (Hansen *et al*., 1971; O'Hara, 1967), ultimately affecting fisheries. Drifting mats scour vegetation, destroying native plants and wildlife habitat. *E. crassipes* also competes with other plants, often displacing wildlife forage and habitats (Center *et al.*, 1999). Higher sediment loading occurs under *E. crassipes* mats due to increased detritus production and siltation. Annual fish and wildlife losses associated with *E. crassipes* infestations in six South-Eastern states of the USA exceeded $4 million per year in 1947 (Tabita & Woods, 1962). Midgley *et al*. (2006) investigated the impact of *E. crassipes* on abundance and diversity of benthic invertebrates and chlorophyll *a* at a site in the Eastern Cape Province of South Africa. They showed that species richness, diversity and abundance and the concentration of chlorophyll *a* were significantly negatively affected by a cover of *E. crassipes*. The

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		plant has also been linked to a reduction in the diversity of water fowl on the Nseleni River, KwaZulu-Natal, South Africa (Jones, 2001).
2.7. How important is the environmental damage likely to be in the PRA area (see note for question 2.6)?	Major Low uncertainty	*E. crassipes* will have a major negative impact on aquatic biodiversity (see above) where it is able to establish. Spanish researchers (Ruiz Téllez, Pers. com. 2008) have reported losses of plankton diversity in the Guadiana River in 2005. Because the invasive turtle *Trachemys scripta* feeds on *E. crassipes*, it can increase its populations. This invasive turtle is already present in the Guadiana in Spain (Mesén, 1993), as well as in other parts of Spain, France, Italy, Poland (Global Invasive Species Database b).

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.8. How important is social damage caused by the pest within its current area of distribution?	Very high Low uncertainty	Recreation and tourism In some areas of the world, *E. crassipes* infestations have had a negative effect on waterfront real estate values and consumer driven recreational use of water bodies (Martins *et al.*, 2006). Water quality *E. crassipes* has a negative effect on the quality and quantity of potable water. *E. crassipes* blocks light penetration to the water column and leads to a reduction in oxygenation of the water and a build-up of sulphur dioxide, causing the water to smell and taste bad. The water treatment plant for Lusaka in Zambia was forced to retain the water in the plant for further treatment due to a reduction in the water quality drawn from the Kafue River that was infested with *E. crassipes* (Hill *et al*., 1999). Hydroelectric power production *E. crassipes* threatens the production of electricity through hydropower generation throughout Africa. A few examples have been noted in the literature. The hydropower station at the Kafue Gorge Dam in Zambia is responsible for supplying 900MW of power to the country. At the height of the *E. crassipes* problem on the dam, at least one of the 5 turbines was forced to be shut down for a day per week. This was due to the increased concentration of nitrous oxides in the water that caused a certain amount of corrosion on the turbines. The hydropower dams on the Shire River in Malawi and the Owen Falls Dam at Jinga in Uganda on the Nile River are also frequently forced to stop production due to *E. crassipes* clogging the intakes for the water cooling system. No estimates of costs of this are available, but it must amount to several million USD per year (Wise *et al*., 2007). The impact of the plant in 2007/2008 on the Victoria Falls Power Station amounted to USD 946,822 (Nang'alelwa, 2008). Case study Lake Victoria is the world's largest fresh water tropical lake and has been heavily impacted by *E. crassipes*. The weed was first recorded on the lake in around 1990 but by 1998 covered some 20,000 ha of the lake (Albright *et al*. 2004). The lake basin supports

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
		some 25 million people and has an estimated value of some USD 4 billion annually, with fishing benefiting the livelihood of at least 500,000 people and having a potential sustainable fishery export value of USD 288 million (Albright *et al*., 2004). *E. crassipes* severely threatened the economic activities on the lake and the development of the region. Economic impacts in Uganda in 1995 were estimated by Mailu (2001) at: • Maintaining a clear passage for ships to dock at Port Bell in Uganda were USD 3-5 million • Clearing the intake screens at Owen Falls hydroelectric plant were USD 1 million • Losses in fisheries were about USD 0.2 million • Losses in beaches, water supply for domestic, stock and agricultural purposes were USD 0.35 million Sociological impacts such as lack of clean water, increase in vector-borne diseases, migration of communities, social conflict and biodiversity losses were not calculated. Human health *E. crassipes* infestations intensify mosquito problems by hindering insecticide application, interfering with predators such as fish, increasing habitat for species that attach to plants, and impeding runoff and water circulation (Seabrook, 1962). Despite there being numerous references attributing an increase in malaria to *E. crassipes* infestations, in one of the quantified surveys, Mailu (2001) was unable to show a correlation between the explosion of *E. crassipes* on Lake Victoria and an increase in the disease. *E. crassipes* provides the ideal habitat for the snail vectors (*Biomphalaria* spp. and *Bulinus* spp.) of the bilharzia schistosome and there is some evidence from Ghana that increased infestations of *E. crassipes* are linked to an increase in the prevalence of this disease. It also blocks access to water points and, as such, has been linked to an increase in cholera and typhoid (Navarro and Phiri, 2000). Furthermore, *E. crassipes* harbours venomous snakes, crocodiles and hippos making the collection of water dangerous, sometimes fatal (Gopal, 1987; Navarro & Phiri, 2000).

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.9. How important is the social damage likely to be in the PRA area?	Major Low uncertainty	Recreation and tourism In Spain and Portugal, impacts have been noted in fisheries, recreation water sport, boat navigation, aesthetic impacts (Ruiz Téllez *et a*l, 2008b ; Laranjeira, 2008, Cifuentes *et al*., 2007). This has also affected tourism. These impacts would be considered to be similar in other EPPO countries at risk. Quality of potable water EPPO countries relying on surface water supply could be impacted by *E. crassipes*. Hydroelectrical power stations As described in 2.8, hydroelectrical power stations could be impacted in EPPO countries at risk. Human health At present, malaria continues to pose a challenge in 8 out of the 52 Member States of the WHO European region, namely Armenia, Azerbaijan, Georgia, Kyrgyzstan, Tajikistan, Turkey, Turkmenistan and Uzbekistan (World Health Organization Regional Office for Europe, 2006). The WHO regional Committee for Europe has in its orientation programme 2006-2007 targeted Schistosomiasis for intensified control (World Health Organization Regional Committee for Europe, 2004). The control of the vectors of this disease would be more difficult due to the presence of *E. crassipes* in these countries.
2.10. How likely is the presence of the pest in the PRA area to cause losses in export markets? **Relevant when impact to crop yield and crop quality**		Not relevant.

Question	**Rating + uncertainty**	**Explanatory text of rating and uncertainty**
As noted in the introduction to section 2, the evaluation of the following questions may not be necessary if the responses to question 2.2 is "major" or "massive" and the answer to 2.3 is "with much difficulty" or "impossible" or any of the responses to questions 2.4, 2.5, 2.7, 2.9 and 2.10 is "major" or "massive" or "very likely" or "certain". You may go directly to point 2.16 unless a detailed study of impacts is required or the answers given to these questions have a high level of uncertainty.		
2.11. How likely is it that natural enemies, already present in the PRA area, will not reduce populations of the pest below the economic threshold?		
2.12. How likely are control measures to disrupt existing biological or integrated systems for control of other pests or to have negative effects on the environment?		
2.13. How important would other costs resulting from introduction be?		

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
2.14. How likely is it that genetic traits can be carried to other species, modifying their genetic nature and making them more serious plant pests?		
2.15. How likely is the pest to cause a significant increase in the economic impact of other pests by acting as a vector or host for these pests?		
2.16. Referring back to the conclusion on endangered area (1.35), identify the parts of the PRA area where the pest can establish and which are economically most at risk.		Any freshwater body and ecosystem within the Mediterranean part of the EPPO region that is utilized for irrigation, water abstraction, navigation, recreation and fisheries, but also natural / semi-natural water bodies having a high conservation value are the most at risk. In the more temperate countries, transient populations can be a threat during summer.
Degree of uncertainty **Estimation of the probability of introduction of a pest and of its economic consequences involves many uncertainties. In particular, this estimation is an extrapolation from the situation where the pest occurs to the hypothetical situation in the PRA area. It is important to document the areas of uncertainty (including**	Low	There is very little uncertainty since extensive literature is available for this species. *E. crassipes* has a wide distribution throughout the world and has major economic impacts. The weed is already problematic in the EPPO region although there are not yet quantified impacts on biodiversity. The main uncertainty are the climatic requirements of the species, especially the capacity of the species to be cold tolerant, influencing its ability to establish in more temperate countries, e.g. on the Atlantic coast in France and England. It is not known whether the plant could set seeds during summer in these areas, and

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
identifying and prioritizing of additional data to be collected and research to be conducted) and the degree of uncertainty in the assessment, and to indicate where expert judgement has been used. This is necessary for transparency and may also be useful for identifying and prioritizing research needs. It should be noted that the assessment of the probability and consequences of environmental hazards of pests of uncultivated plants often involves greater uncertainty than for pests of cultivated plants. This is due to the lack of information, additional complexity associated with ecosystems, and variability associated with pests, hosts or habitats.		whether the crown could survive, protected by dead parts of the plant. The EWG discussed the possible reasons for the plant only being invasive in the XX1st century in Europe, while it has been a threat in other parts of the world since the 1960s. Possible reasons are: - a change in climate - eutrophication of waters - trend in the selling of the plant in Europe - social and cultural habits on gardening, agriculture, treatment of waste waters.
Evaluate the probability of entry and indicate the elements which make entry most likely or those that make it least likely. Identify the pathways in order of risk and compare their importance in practice.	**Very likely** **low uncertainty**	*E. crassipes* has already entered and is traded within the EPPO region. The most important pathway is intentional import as an ornamental plant.
Evaluate the probability of establishment, and indicate the elements which make establishment most likely or those that make it least likely. Specify which part of the PRA area presents the greatest risk of establishment.	**Very likely** **low uncertainty**	- *E. crassipes* is already established in some countries of the EPPO region - Greatest risk of establishment: Mediterranean EPPO region - Medium risk: Western and Central Europe, where transient populations occur, e.g. the Netherlands, the UK, Belgium. - Least likely: establishment in Northern and Eastern EPPO countries.

Question	Rating + uncertainty	Explanatory text of rating and uncertainty
List the most important potential economic impacts, and estimate how likely they are to arise in the PRA area. Specify which part of the PRA area is economically most at risk. **Repetition**		Impacts will occur in freshwater bodies and ecosystems (see previous answer) and are described as follows: - Agricultural impacts: irrigation, abstraction, impacts on some crops (e.g. rice), high costs of control - Environmental impacts: loss of biodiversity, modification of habitats - Social impacts: hydropower generation, recreation, quality of water, human diseases.
The risk assessor should give an overall conclusion on the pest risk assessment and an opinion as to whether the pest or pathway assessed is an appropriate candidate for stage 3 of the PRA: the selection of risk management options, and an estimation of the associated pest risk.		*E. crassipes* is the most damaging aquatic weed in the world (Holm *et al*., 1969; Global Invasive Species Database a). It has impacted freshwater systems on most continents. At this stage the plant is relatively localized within Europe. Every effort should be made to control the weed. The risk of establishment, spread and impact is extremely high. The plant is an appropriate candidate for stage 3.

This is the end of the Pest risk assessment	

Stage 3: Pest risk Management

Question	Y/N	Explanatory text
3.1. Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combinations an acceptable risk?	**No**	The risks posed by *E. crassipes* are not acceptable.
Pathway 1		**Intentional import of the plant for ornamental purposes**
3.2. Is the pathway that is being considered a commodity of plants and plant products? **If yes, go to 3.11,** **If no, go to 3.3**	**Yes**	
3.3. Is the pathway that is being considered the natural spread of the pest? (see answer to question 1.32) **If yes, go to 3.4,** **If no, go to 3.9**		
3.4. Is the pest already entering the PRA area by natural spread or likely to enter in the immediate future? (see answer to question 1.32)		

3.5. Is natural spread the major pathway? **If yes, go to 3.29,** **If no, go to 3.6**		
3.6. Could entry by natural spread be reduced or eliminated by control measures applied in the area of origin? **If yes, possible measures: control measures in the area of origin, go to 3.7**		
3.7. Could the pest be effectively contained or eradicated after entry? (see answer to question 1.26, 1.34) **If yes, possible measures: internal containment and/or eradication campaign, Go to 3.8**		
3.8. Was the answer "yes" to either question 3.6 or question 3.7? **If yes, go to 3.38,** **If no, go to 3.44**		

3.9. Is the pathway that is being considered the entry with human travellers? **If yes, possible measures: inspection of human travellers, their luggage, publicity to enhance public awareness on pest risks, fines or incentives. Treatments may also be possible, Go to 3.29** **If no, go to 3.10**		
3.10. Is the pathway being considered contaminated machinery or means of transport? **If yes, possible measures: cleaning or disinfection of machinery/vehicles**		
3.11. If the pest is a plant, is it the commodity itself? **If yes, go to 3.29,** **If no (the pest is not a plant or the pest is a plant but is not the commodity itself), go to 3.12**	**Yes**	

3.12. Are there any existing phytosanitary measures applied on the pathway that could prevent the introduction of the pest? **if appropriate, list the measures and identify their efficacy against the pest of concern, Go to 3.13**		
3.13. Can the pest be reliably detected by a visual inspection of a consignment at the time of export, during transport/storage or at import? **If yes, possible measure: visual inspection, go to 3.14**		
3.14. Can the pest be reliably detected by testing (e.g. for pest plant, seeds in a consignment)? **If yes, possible measure: specified testing, go to 3.15**		
3.15. Can the pest be reliably detected during post-entry quarantine? **If yes, possible measure: import under special licence/permit and post-entry quarantine, go to 3.16**		

3.16. Can the pest be effectively destroyed in the consignment by treatment (chemical, thermal, irradiation, physical)? **If yes, possible measure: specified treatment, go to 3.17**		
3.17. Does the pest occur only on certain parts of the plant or plant products (e.g. bark, flowers), which can be removed without reducing the value of the consignment? (This question is not relevant for pest plants) **If yes, possible measure: removal of parts of plants from the consignment, go to 3.18**		
3.18. Can infestation of the consignment be reliably prevented by handling and packing methods? **If yes, possible measure: specific handling/packing methods, go to 3.19**		

3.19. Could consignments that may be infested be accepted without risk for certain end uses, limited distribution in the PRA area, or limited periods of entry, and can such limitations be applied in practice? **If yes, possible measure: import under special licence/permit and specified restrictions, go to 3.20**		
3.20. Can infestation of the commodity be reliably prevented by treatment of the crop? **If yes, possible measure: specified treatment and/or period of treatment, go to 3.21**		
3.21. Can infestation of the commodity be reliably prevented by growing resistant cultivars? (This question is not relevant for pest plants) **If yes, possible measure: consignment should be composed of specified cultivars, go to 3.22**		

3.22. Can infestation of the commodity be reliably prevented by growing the crop in specified conditions (e.g. protected conditions such as screened greenhouses, physical isolation, sterilized growing medium, exclusion of running water, etc.)? **If yes, possible measure: specified growing conditions, go to 3.23**		
3.23. Can infestation of the commodity be reliably prevented by harvesting only at certain times of the year, at specific crop ages or growth stages? **If yes, possible measure: specified age of plant, growth stage or time of year of harvest, go to 3.24**		
3.24. Can infestation of the commodity be reliably prevented by production in a certification scheme (i.e. official scheme for the production of healthy plants for planting)? **If yes, possible measure: certification scheme, go to 3.25**		

3.25. Is the pest of very low capacity for natural spread? **If yes, possible measures: pest freedom of the crop, or pest-free place of production or pest-free area, Go to 3.28** **If no, go to 3.26**		
3.26. Is the pest of low to medium capacity for natural spread? **If yes, possible measures: pest-free place of production or pest free area, Go to 3.28** **If no, go to 3.27**		
3.27. The pest is of medium to high capacity for natural spread **Possible measure: pest-free area, go to 3.28**		
3.28. Can pest freedom of the crop, place of production or an area be reliably guaranteed? **If no, possible measure identified in questions 3.25-3.27 would not be suitable, go to 3.29**		

3.29. Are there effective measures that could be taken in the importing country (surveillance, eradication) to prevent establishment and/or economic or other impacts? **If yes, possible measures: internal surveillance and/or eradication campaign, go to 3.30**	**Yes**	Prohibition of selling, transport, planting and causing to grow in the wild, possession of the plant. The species is listed in the UK legislation. Schedule 9 of the Countryside and Wildlife Act 1981 lists plants that cannot be planted or caused to grow in the wild (Wildlife & Countryside act 1981). Several legislations exist to prevent the introduction of exotic species into the wild, but they are poorly implemented. Management measures are also recommended: - Integrated management plan for the control of existing infestations - Monitoring/surveillance: Early detection in the countries at risk - Emergency plan: rapid response to new infestations The main control options are: mechanical control, herbicide application and biological control. Possibly the most sustainable option is to integrate these methods with a reduction in nutrient input. Nevertheless, herbicides are usually prohibited in aquatic ecosystems. In Europe, the release of biological control agents may be subjected to specific procedures nationally and has to be in accordance with EU regulations. This implies that mechanical control is currently the only option. However, it is labour intensive and requires repeated follow ups. - Obligations to report findings, in the whole EPPO region, especially in the Mediterranean area - Proposal of alternative non invasive aquatic species for use - Publicity: public awareness campaigns about the impacts of the plant with the information not to use it as an ornamental, fodder, or decontaminant of waste waters. See the EPPO Standard PM 3/67 'Guidelines for the management of invasive alien plants or potentially invasive alien plants which are intended for import or have been intentionally imported'. See the EPPO PM9 on *Eichhornia crassipes* as well as the Code of conduct on horticulture and invasive alien plants developed by the Council of Europe (Heywood & Brunel, to be published).

3.30. Have any measures been identified during the present analysis that will reduce the risk of entry? of the pest? List them. **If yes, go to 3.31** **If no, go to 3.38**	Yes	Prohibition of the import, selling, transport, planting and causing to grow in the wild, possession of the plant is the most efficient measure. In Portugal, the Decreto - Lei n° 565/99 prohibits the release and spread of exotic invasive plants in Nature, *E. crassipes* is on this list. Penalties will be applied to those using any listed invasive species. Additionally, the D.L n° 165/74 of 22 of April also prohibits the trade, transportation and possession of *E. crassipes*. Cultivation of the plant is forbidden and any stock should be destroyed (PT, 1974; PT, 1999).
3.31. **Does each of the individual measures identified reduce the risk to an acceptable level?** Good interpretation? **If yes, go to 3.34** **If no, go to 3.32**	**No**	Control measures of infestations within countries are not efficient if the plant is frequently reintroduced. Prohibition of selling is therefore necessary.
3.32. For those measures that do not reduce the risk to an acceptable level, can two or more measures be combined to reduce the risk to an acceptable level? **If yes, go to 3.34** **If no, go to 3.33**	**Yes**	National measures Prohibition of selling, planting, holding and movement of the plant in the EPPO region is necessary. Moreover, the plant has to be controlled where it occurs. If these measures are not implemented by all countries, they will not be efficient since the species would spread. In addition, it has to be combined with international measures. International measures Prohibition of import into the EPPO region and within the countries.

3.33. If the only measures available reduce the risk but not down to an acceptable level, such measures may still be applied, as they may at least delay the introduction or spread of the pest. In this case, a combination of phytosanitary measures at or before export and internal measures (see question 3.29) should be considered. **Go to 3.34**		
3.34. Estimate to what extent the measures (or combination of measures) being considered interfere with trade. **Go to 3.35**		Prohibition of the import, selling, transport and possession of the plant interferes with trade as the plant is very popular.
3.35. Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences. **Go to 3.36**		Considering the high cost of the control of the plant, compared to the benefit its trade generates, the measures are very cost-effective. Aquarium enthusiasts and sellers of aquatic plants are not familiar with such legislation, nor is the public, but this case could raise awareness. Non invasive substitution plants could be proposed.

3.36. Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with international trade, are cost-effective and have no undesirable social or environmental consequences? **If yes, For pathway-initiated analysis, g** **For pest-initiated analysis, go to 3.38** **If no, go to 3.37**	**Yes**	Prohibition of import, trade, planting, holding and movement of the plant.
3.37. Envisage prohibiting the pathway **For pathway-initiated analysis, go to 3.43 (or 3.39),** **For pest-initiated analysis go to 3.38**		
3.38. Have all major pathways been analyzed (for a pest-initiated analysis)? **If yes, go to 3.41,** **If no, Go to 3.1 to analyze the next major pathway**	**Yes**	

3.39. Have all the pests been analyzed (for a pathway-initiated analysis)? **If yes, go to 3.40,** **If no, go to 3.1 (to analyze next pest)**		
3.40. For a pathway-initiated analysis, compare the measures appropriate for all the pests identified for the pathway that would qualify as quarantine pests, and select only those that provide phytosanitary security against all the pests. **Go to 3.41**		
3.41. Consider the relative importance of the pathways identified in the conclusion to the entry section of the pest risk assessment **Go to 3.42**		**Intentional import of the plant for ornamental purposes**: Very high

3.42. All the measures or combination of measures identified as being appropriate for each pathway or for the commodity can be considered for inclusion in phytosanitary regulations in order to offer a choice of different measures to trading partners. **Go to 3.43**		Importation of *E. crassipes* to the EPPO region and its distribution within it should be prohibited.
3.43. In addition to the measure(s) selected to be applied by the exporting country, a phytosanitary certificate (PC) may be required for certain commodities. The PC is an attestation by the exporting country that the requirements of the importing country have been fulfilled. In certain circumstances, an additional declaration on the PC may be needed (see EPPO Standard PM 1/1(2): Use of phytosanitary certificates) **Go to 3.44**		

3.44. If there are no measures that reduce the risk for a pathway, or if the only effective measures unduly interfere with international trade (e.g. prohibition), are not cost-effective or have undesirable social or environmental consequences, the conclusion of the pest risk management stage may be that introduction cannot be prevented. In the case of pest with a high natural spread capacity, regional communication and collaboration is important.		

Conclusion of Pest Risk Management. **Summarize the conclusions of the Pest Risk Management stage. List all potential management options and indicate their effectiveness. Uncertainties should be identified.**		**Major pathway is intentional import of the plant for ornamental purposes** <u>International measures</u> Prohibition of import in the EPPO region and within the countries will effectively prevent further introduction into the EPPO region. <u>National measures</u> Prohibition of trade, planting, holding and movement of the plant in the EPPO countries will effectively prevent further establishment and spread within the EPPO region. <u>Integrated management plan for the control of existing infestations</u> It is potentially highly effective if coupled with prohibition measures. Uncertainty concerns commitment to long-term implementation. This would require: - Accurate identification of the species - Monitoring/surveillance in the countries where it is invasive (Spain and Portugal), surveillance in the countries at risk. - Early warning consisting of exchanging information with other countries, and rapid response - Control of existing populations. A draft Standard on national regulatory control system is being prepared for *Eichhornia crassipes*. - Publicity: aquatic plants producers and sellers and aquarium enthusiasts shall be informed of the problem and work should be undertaken with them to explain the prohibition of the species, and inform consumers. Farmers and administration should also be warned that the plant shall not be used as a fodder or as a decontaminant of waste waters.

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Appendix 1

Climatic prediction for *Eichhornia crassipes*

Document prepared by the EPPO Secretariat and Darren Kriticos (CSIRO-ENSIS)

The CLIMEX model is a computer programme aiming at predicting the potential geographical distribution of an organism considering its climatic requirements. It is based on the hypothesis that climate is an essential factor for the establishment of a species in a country.

CLIMEX provides tools for predicting and mapping the potential distribution of an organism based on:

(a) climatic similarities between areas where the organism occurs and the areas under investigation (Match Index),

(b) a combination of the climate in the area where the organism occurs and the organism's climatic responses, obtained either by practical experimentation and research or through iterative use of CLIMEX (Ecoclimatic Index).

For *Eichhornia crassipes,* a compare location analysis has been undertaken.

1. Geographical distribution of the species

The global distribution of E. crassipes was assembled from a number of sources. *Eichhornia crassipes* is distributed throughout the world, flourishing in tropical and subtropical regions, and it seems to tend to extend to Mediterranean climatic areas (see question 10 and the datasheet for the enumeration of countries where the species is naturalized).
Data have both been provided at the country level (in pink), and at the location level, when data was available.

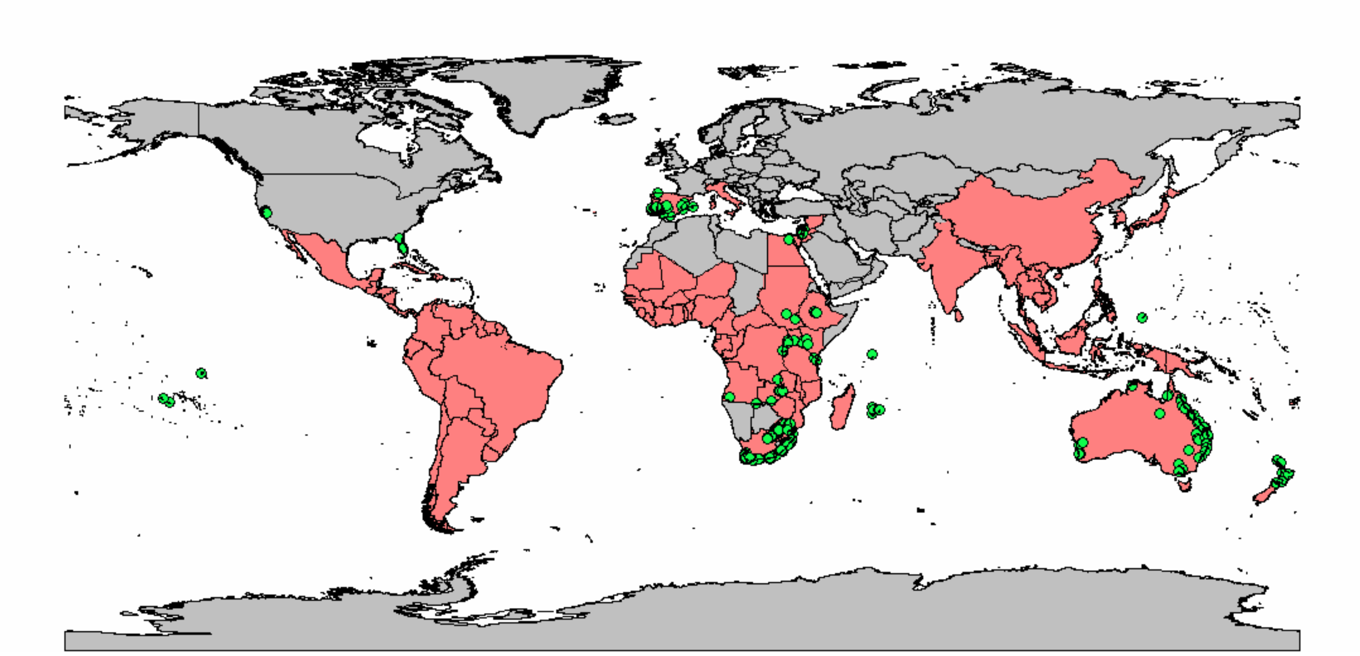

Figure 1: distribution of *Eichhornia crassipes* in the world

Phenology and Environment

Eichhornia crassipes flowers year-round in mild climates, producing abundant amounts of long-lived seeds. However it has been reported that sexual reproduction is limited, and although the plant flowers profusely, few observers have seen seeds or seedlings in the field (Gopal, 1987).

Influence of climatic factors on distribution

Rainfall
Being aquatic, the plant is highly dependent upon the presence of standing water. As this is a function of precipitation, evaporation, meso-topography and human practices, we decided to treat the presence of standing water separately from the other climatic factors.

Temperature
Eichornia crassipes is reported to be winter hardy, but sensitive to frost. Frosts kill the leaves and upper petioles which protect the rhizome, but prolonged cold temperatures, below 5 ^{o}C, may kill the rhizome resulting in death of the plants (Owens & Madsen, 1995).

Kasselmann (1995) reported that its minimum growth temperature is 12 °C, its optimum growth temperature is 25-30 °C, and its maximum growth temperature is 33-35 ° C. Owens & Madsen (1995) report that optimal growth occurs at temperatures of 28 to 30^{o}C, while growth ceases when water temperatures drop below 10ºC and it is retarded above 34ºC. It is assumed that these reported temperatures are air temperatures.

FITTING PARAMETERS
The parameters used in the CLIMEX model for *E. crassipes* are summarized in Table 1. The role and meaning of these parameters are fully described in Sutherst *et al*. (2004), and their values are discussed below. It should be noted that the meteorological data used in this model represent long-term monthly averages, not daily values. This means that it is not possible to compare directly values derived using the model with instantaneous values derived through direct observations. This applies mostly to parameters relating to maximum and minimum temperatures.
The climatic requirements of *E. crassipes* were derived by fitting the predicted distribution to the known distribution outside Europe, and then comparing the predicted and known distributions within Europe.

☐ Moisture Index					
☑ Temperature Index					
DV0	DV1	DV2	DV3		
12	25	30	34		
☐ Light Index					
☐ Diapause Index					
☑ Cold Stress					
TTCS	THCS	DTCS	DHCS	TTCSA	THCSA
2.5	-0.01	10	-0.0003	0	0
☑ Heat Stress					
TTHS	THHS	DTHS	DHHS		
37	0.001	0	0		
☐ Dry Stress					
☐ Wet Stress					
☐ Cold-Dry Stress					
☐ Cold-Wet Stress					
☐ Hot-Dry Stress					
☐ Hot-Wet Stress					
Day-degree accumulation above DV0					
DV0	DV3	MTS			
12	34	7			
Day-degree accumulation above DVCS					
DVCS	*DV4	MTS			
12	100	7			
Day-degree accumulation above DVHS					
DVHS	*DV4	MTS			
34	100	7			
Degree-days per Generation					
PDD					
0					

Fig 2: parameters used for *Eichhornia crassipes*
Stresses indices

In CLIMEX, stress indices indicate negative population growth potential and vary between 0 and ∞, where a value of 100 or greater indicates lethal conditions. When threshold conditions are exceeded, stresses accumulate on a compounding weekly basis. The thresholds and accumulation rates are user-defined parameters. Wet stress is not considered since the species is aquatic.

Dry stress
It is considered that the plant do not suffer from drought since it is aquatic. Moreover, the plant is present in Egypt which is a very dry country.

Heat stress
According to Kasselmann (1995), the species has a maximum growth temperature (DV3) of 33-35, according to Owens & Madsen (1995), growth is retarded by 34°C. The heat stress threshold is therefore set to 38°C. It is assumed that the stress accumulates quite rapidly, and the rate is set to -0.002 (THHS). The plant is present in Mali and Niger where temperature are very high (need precise station).

Cold stress. The reported frost sensitivity of *E. crassipes* suggested that a cold stress temperature model might be appropriate. TTCS is set to 2.5 °C, this is to say that the species begins to accumulate when weekly temperatures drop below 2.5 °C, as the species is reported to suffer from the frost. A monthly average daily minimum temperature of 2.6 °C coincides with the 14^{th} percentile, which means that on average that station would receive about one frost event per week. Since the species has been reported to remain alive at -5°C for a time but then dies, it is supposed that the cold stress accumulates moderately slowly and the rate (THCS) is set at -0.01. Cold stress appears to be the most limiting factor.

It therefore appears that records in New England in Maryland and Connecticut correspond to observations where the species is casual, and frequently introduced, as found while performing a more detailed analysis on this location (see IPANE website http://nbii-nin.ciesin.columbia.edu/ipane/icat/browse.do?specieId=124). The same phenomenon is observed in Seattle in Washington State and in Moscow, where the species is recorded as casual and dying because of cold temperature during winter. Additionally, the species is recorded in botanic gardens in Amsterdam (The Netherlands), Colonia (Germany), Brno (Czech Republic) and Slovak Republic, but does not thrive there.

According to Wilson (2002), the species is native to Argentina. It is reported as absent from Formosa and Salta, but present in la Rioja. The CLIMEX prediction shows that the species could be present in both Formosa and Salta. According to a match climate analysis, the climate in these two cities is the same as in South Africa and the eastern coast of Australia where the species is present and invasive. There is therefore no climatic reason why the species would be absent in this area of its indigenous range. It is assumed that this is missing information from Argentina.

Comparing the distribution of the species in Spain, it appears that the species has been recorded in Yelbes (Center of Spain near Ciudad Real) and in the Laguna de Amao. It appears that Yelbes is 230 m in altitude, while Ciudad Real is at 630 m high, explaining why the CLIMEX map does not show *E. crassipes* as occurring in Ciudad Real. Additionally, Ruiz Tellez (2008) reported that the site in Laguna de Amao (North of Spain), was protected, explaining why the CLIMEX indicates that it should not occur there due to cold stress.

Additionally to be sensitive to a cold stress, the species might be sensitive to the fact that temperatures are not high enough to allow it to photosynthesise enough to offset minimum respiration demands. The parameters are therefore set (separately from the cold stress index) to 10 for DTCS. This parameter is set upon with an accumulation rate of -0.0003 (DHCS) since the species is supposed to accumulate this stress slowly.

Growth index.
The growth indices simulate how favourable each location is for population growth, and are scaled from 0 to 100. The weekly temperature index values are integrated to give the growth index GIa, which is re-scaled from 0 to 100. The growth index for a site is set to 0 if the minimum requirement for thermal accumulation is not met.

Temperature index.
The minimum threshold for population growth, DV0, was set to 12°C, as reported by Kasselmann (1995). The minimum temperature for maximum growth rates (DV1) was set to 25°C and the upper temperature threshold for maximum growth rates (DV2) was set to 30°C, following Kasselmann (1995) observations. The maximum threshold for population growth (DV3) was set to 34°C, following the same source, and lower than the heat stress threshold.

A minimum annual heat-sum for survival was not used in this model since the plant can produce seeds and reproductive vegetative parts within 12 weeks from germination (Julien, 2008). There was nowhere within its potential range where the distribution appeared to need this requirement to constrain it.

Results

The areas estimated to be climatically suitable for *E. crassipes* under current climatic conditions are illustrated for the world (see Fig 3), and for the European and Mediterranean area (see Fig 4). The potential distribution of this species includes many countries of the Mediterranean basin: Albania, Algeria, Bosnia and Herzegovina, Croatia, France (including Corsica), Greece, Israel, Italy (including Sardinia, Sicilia), Jordan, Montenegro, Morocco, Portugal (Azores, Madeira), Slovenia, Spain (Baleares, Canarias), Turkey, Tunisia. The current distribution of *E. crassipes* is fully consistent with the projected Ecoclimatic index.
The northern boundary of the potential distribution in Europe is defined by cold stress, since this is the most limiting factor. Heat stress limits the species in Central Africa such as in Mali (Araouane), south of Algeria (Oualen Bordj), Sudan (Merowe, Dongola).

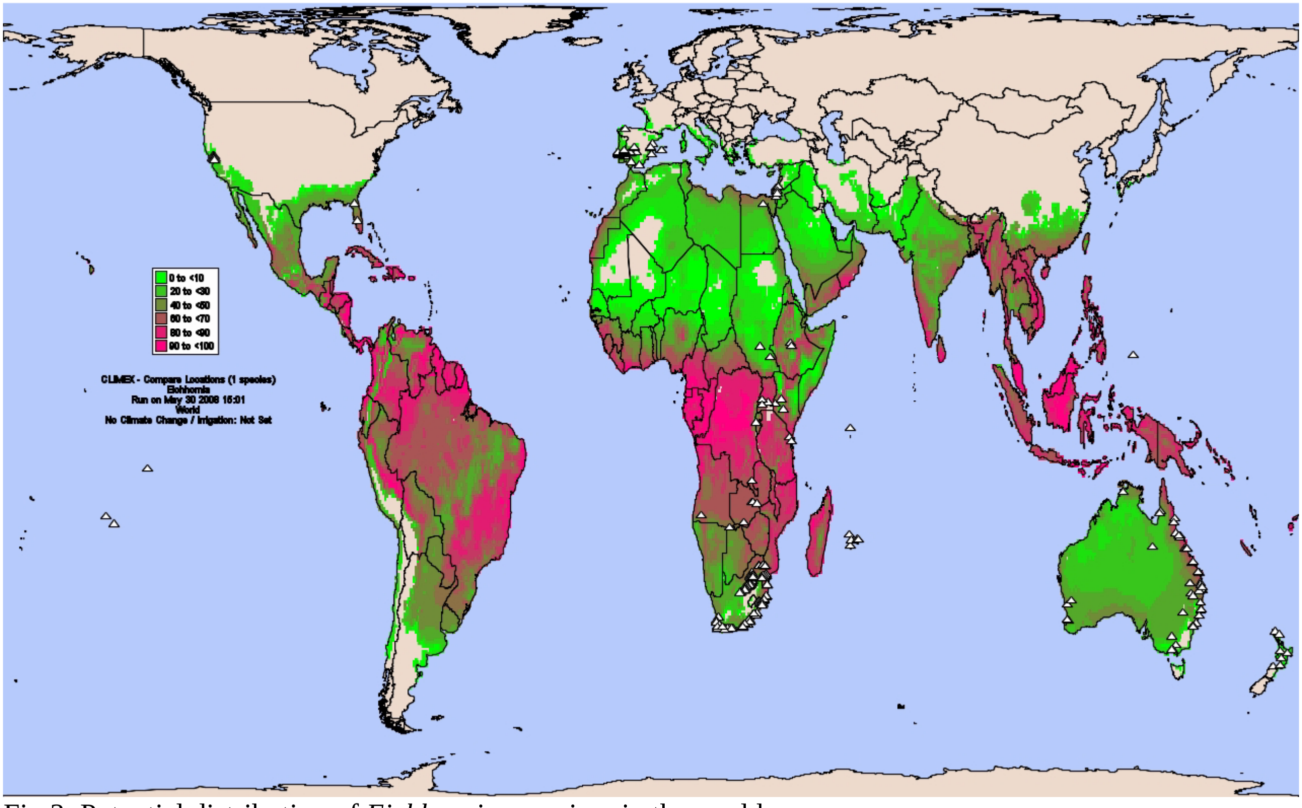

Fig 3: Potential distribution of *Eichhornia crassipes* in the world.

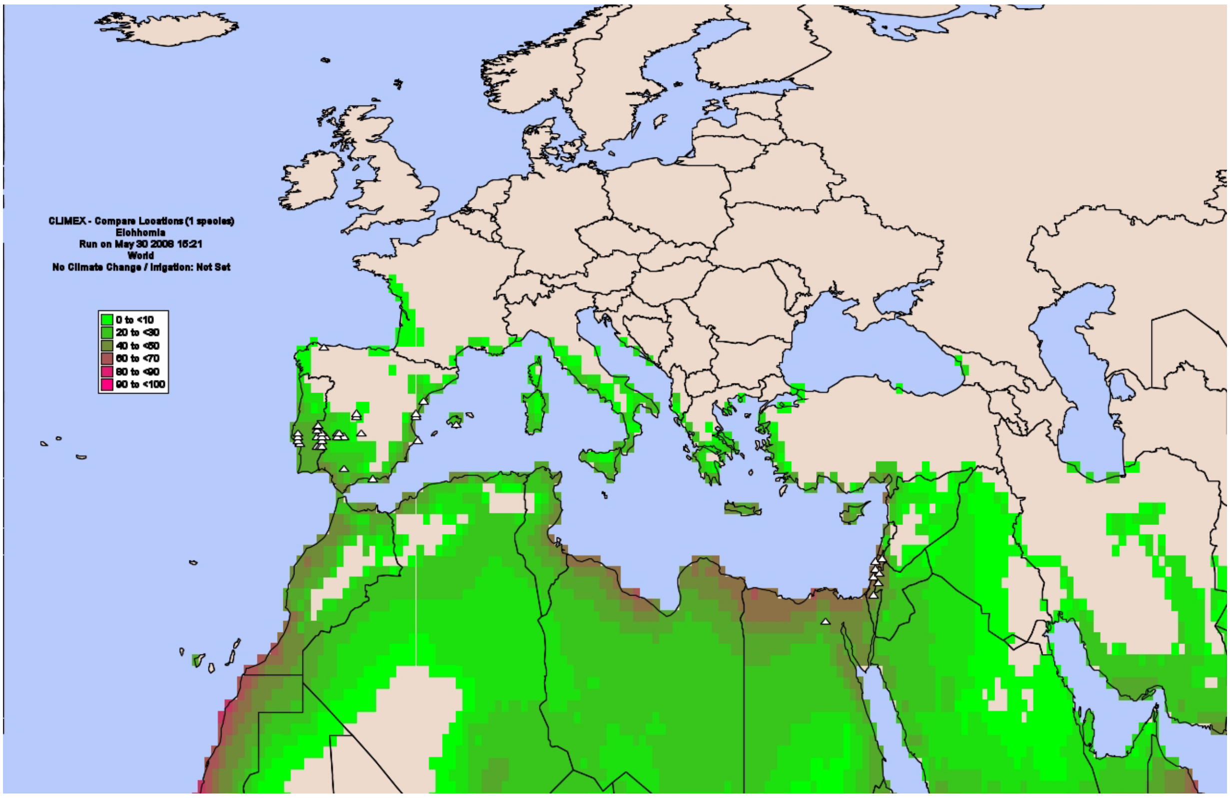

Fig 4: Potential distribution of *Eichhornia crassipes* in the EPPO region.

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