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 Approved 2006-09 Version N°2

PEST RISK ANALYSIS FOR Cabomba caroliniana

The terms are used according to the IPPC Glossary of phytosanitary terms (ISPM n° 5

Pest risk analyst:
A.J.W.Rotteveel (NL), a.j.w.rotteveel@minlnv.nl
EPPO Secretariat

Acknowledgements: R Baker (UK), r.baker@csl.gov.uk; P Champion (NZ), p.champion@niwa.co.nz; I Dancza (HU), Dancza.Istvan@ntksz.ontsz.hu; M Julien (AU), mic.julien@csiro-europe.org; R Randall (AU), RPRandall@agric.wa.gov.au;; C Wilson (CA) wilsonce@inspection.gc.ca.

Stage 1: Initiation

1 What is the reason for performing the PRA?		Found in the Netherlands, with an invasive behaviour: *Cabomba* was found to invade a number of ditches and lesser canals near Loosdrecht area, a major area for water sport related recreation, and several important nature reserves. The species was reported to have been present for several years on a campsite,

		now clogging entrance canals and necessitating dredging. In the close vicinity some spread was found, but the major lakes still seem unaffected. The responsible local Water Board Amstel and Vecht surveyed the situation and is organising eradicative action. The plant is also recorded in England, Hungary, Belgium, but it is not widespread and not known as invasive. k
2 Enter the name of the pest		*Cabomba caroliniana* Gray.
2A Indicate the type of the pest		Aquatic plant. Intended habitats are aquariums.
2B Indicate the taxonomic position		Plantae - Cabombaceae
3 Clearly define the PRA area		The EPPO Region.
4 Does a relevant earlier PRA exist?		National PRA for the Netherlands made by A.J.W. Rotteveel. PRA for Australia made by Rod Randall: http://www.invasivespecies.net/database/species/ecology.asp?si=402&fr=1&sts=sss PRA for Canada made by Clare Wilson: http://www.fao.org/docrep/008/y5968e/y5968e0g.htm
5 Is the earlier PRA still entirely valid, or only partly valid (out of date, applied in different circumstances, for a similar but distinct pest, for another area with similar conditions)?		The PRAs apply for different areas.
Stage 2A: Pest Risk Assessment - Pest categorization		
6 Does the name you have given for the organism correspond to a single taxonomic entity which can be adequately distinguished from other entities of the same rank?	yes	The plant is *C. caroliniana* Gray. Other species of the genus are clearly more (sub) tropical and would be unexpected. (Wilson, Canadian PRA, 2000) Spermatophyta Angiospermae Magnoliopsida Magnolidae Nympheaeles Cabombaceae

		At least three varieties or subspecies exist: *pulcherrima* (purple flowers), *caroliniana* (white flowers) and *flavida* (yellow flowers). Several cultivars are grown and used in the aquarium trade.
8 Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?	yes (the organism is considered to be a pest)	
10 Does the pest occur in the PRA area?	Yes	The plant is recorded in Belgium, Hungary, The Netherlands, The United Kingdom (Introduced in England).
11. Is the pest widely distributed in the PRA area?	No	Very few findings are recorded in the Netherlands (3). It is the same in Hungary, the UK and Belgium.
12 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	*C. caroliniana* grows in the mud of slow flowing or stagnant freshwaters. It grows in streams, small rivers, ponds, lakes, reservoirs, sloughs, ditches and canals. These habitats are very common in the PRA area and are vulnerable, often protected for their environmental value.
13. 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 14)		Not relevant.
14 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	The plant is known to be invasive in Southern Canada, Northern USA, and Australia where the climatic conditions are comparable with the PRA area.

15 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) ?	Yes	The plant could have detrimental impacts on environments, public safety, recreation activities, water quality, etc. In fact, out-competing native aquatic vegetation, clogging of waterways, speeding up natural successions, and obstructing recreation activities (boating, fishing and swimming) has been described extensively for the US, Canada and Australia. Australia mentions also tainting of drinking water that is hard to redress. Impacts on environment and human activities are reported on one site in the Netherlands.
16 This pest could present a risk to the PRA area.	Yes	The plant may represent a risk and may cause environmental, social and economic impacts. Whether it can establish and become invasive needs further evaluation.
Section 2B: Pest Risk Assessment - Probability of introduction/spread and of potential economic consequences		
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		• Unintentional release in the wild The plant is an internationally grown and traded commodity valued and used in tropical aquarium. In Europe, the plant is very commonly traded for aquarium (see EPPO Reporting Service 2007 n°1). Red fishes eat it. The intended habitat is aquarium. The unintended habitats are freshwaters. *Cabomba* is a much-used tropical aquarium plant that easily produces surplus growth. Disposal of surplus vegetation in waterways may lead to the establishment of wild populations. Although the occurrence of disposal into surface water may be low, but has been documented in Europe and elsewhere. Moreover, the plant may be misused in exterior as a pond plant. • The plant has been found in USA as a contaminant of other ordered aquatic plants

		in 2% of the consignments studied (Maki *et al*., 2004). There is no such data for Europe. Moreover, the aquatic plants contaminated will mainly be dedicated to aquarium use. This pathway is not further studied, the risk of escape from this pathway will be considered more globally with the study of the unintentional release in the wild (previous pathway). • In Queensland (Australia), many infestations have been started, not by dumped plants, but by intentional plantings by the trade to "bulk up" for retail sail (Mackey & Swarbrick, 1997). There are at least two producers of aquatic plants in Europe: one in Germany (Dennerle, http://www.dennerle.de/), and one in Denmark (Tropica). There also may be producers in Hungary as some exports of the plants were recorded in 2003 (Paris Border Inspection point). This production may also be the cause of the occurrence of the plant in Hungary. Nevertheless, those are national pathways and are not further considered, but would deserve further investigation for national management. There are also some natural pathways of spread of the plant as it reproduces vegetatively. The spread of the plant can also be helped by human assistance (movement of boats, fish gears, etc.). Those pathways are not considered in this analysis.
1.2 Estimate the number of relevant pathways, of different commodities, from different origins, to different end uses.	Very few	The trade as such is not a pathway as the plant is not meant to be planted in nature, nevertheless, the amount of trade may give indication on the probability of escape of the plant, based on the assumption that popular species have more opportunities to be released (Rixon *et al*., 2005). The unintentional release in the wild is the pathway. The plant has been found in USA as a contaminant of other ordered aquatic plants in 2% of the consignments studied (Maki *et al*., 2004).
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		Unintentional release in the wild and misuse of the plant in exterior.

of questions on pathways is then considered for each relevant pathway in turn, as appropriate, starting with the most important.		
Pathway n°: 1		**Unintentional release in the wild: escape from aquaria dumping or misuse in exterior (while it is intended for aquarium use)**
1.4 How likely is the pest to be associated with the pathway at origin, taking into account factors like the prevalence of the pest at origin, the life stages of the pest, the period of the year?	(Very) likely	According to Wilson *et al.* (2001), the plant is recorded as imported in Canada. Moreover, in Canada it is also sold by some suppliers for use in outdoor water gardens and ponds, which is also highly possible in Europe. The plant is commonly sold in Europe for aquarium trade. Large numbers of plants are sent from Florida to the rest of the U.S. for commercial use. It is also grown commercially in Asia for export to Europe and other parts of the world. Small-scale, local cultivation occurs in some areas in Europe (Ørgaard, 1991). According to the French NPPO (Paris Border Inspection points), in Roissy, statistics show that in 2005 there have been two consignments per year of 125 lots of almost 1000 plants each from Singapore. Moreover, there are at least two producers of aquatic plants in Europe: one in Germany (Denerle), and one in Denmark (Tropica). There also may be producers in Hungary as some exports of the plants were recorded in 2003 (paris Border Inspection point). This production may also be the cause of the occurrence of the plant in Hungary. As long as the plant is contained in aquarium (and eventually ponds), it can be considered absent form the PRA natural area. While the risk of the plant being released in the wild by aquariophylists discattering aquarium contents seems low, but is highly suspected to be the cause of its introduction in England and in the Netherlands.
1.5 Is the concentration of the pest on the pathway at origin likely to be high, taking into account factors like cultivation practices, treatment of consignments	Likely	*C. caroliniana* is a very common aquarium plant traded in huge quantities.

1.6 How large is the volume of the movement along the pathway?	Major/Minor	According to RSE 2007/016, more than 8000 plants of *C. caroliniana* have been imported as aquatic plants in Paris airports on April 2006, mainly coming from Indonesia and Singapore. It can be considered major in this respect. Data from Dutch and Austrian NPPOs confirm that the plant is one of the most popular aquarium plant. Movement from aquaria to natural habitats by man is likely to be minor as it is considered accidental.
1.7 How frequent is the movement along the pathway?	Often/Not very often	The plant is imported every month all over the EPPO region: often. The scattering of aquarium waters into natural ecosystems is supposed to be very limited as it is considered accidental. Misuse of the plant in exterior ponds and lake is possible (not very often).
1.8 How likely is the pest to survive during transport /storage?	Not relevant	
1.9 How likely is the pest to multiply/increase in prevalence during transport /storage?	Not relevant	
1.10 How likely is the pest to survive or remain undetected during existing phytosanitary measures?	Very likely	The species has been included in the recent review of the Scottish legislation (done in June 2005). Schedule 9 of the Countryside and Wildlife Act 1981 lists plants that cannot be planted or caused to grow in the wild (Richard Baker, pers. com., 2006). There are no other existing measures. The plant can therefore be introduced as an aquarium plant without restriction. It can also be released in the wild without any restriction, nor indication.
1.11 How widely is the commodity to be distributed throughout the PRA area?	Very widely	*Cabomba* is a very common aquarium plant, and has been traded and used during many years.
1.12 Do consignments arrive at a suitable time of year for pest establishment?	yes	In tropical areas, growth and flowering are continuous. In temperate areas, flowering and maximum growth occur in summer. It dies back in winter and lies on the bottom of the water body, where the stems break up and provide dispersal material. New growth starts from these dislodged stem pieces (Australian Department of the Environment and Heritage, 2003). It therefore depends where and when it will be introduced in unintended habitats. There is a high probability for the plant to arrive at a suitable time for establishment as the plant is already recorded in unintended habitats.

1.13 How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?	Moderatly likely	Scattering of aquarium waters have been a source of introduction of the plant in many countries, even it is seem an accidental pathway of introduction. "Somebody dumps the contents of an aquarium in a suitable ditch at a suitable moment".
1.14 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?	unlikely	The intended use of *C. caroliniana* is to be used as an aquarium plant. This use theoretically does not aid to transfer to a suitable habitat. However, some aquarium waters are dumped in the wild. The plant may also be used as an aquatic plant for ponds, while it is not the usual use of it.
1.15 Do other pathways need to be considered?	No	
1.16 a Specify the host plant species (for pests directly affecting plants) or suitable habitats (for non parasitic plants) present in the PRA area.		*C. caroliniana* is a very hardy and persistent species that has established itself in a wide range of aquatic habitats. It grows in the mud of slow flowing or stagnant freshwaters. It grows in streams, small rivers, ponds, lakes, reservoirs, sloughs, ditches and canals. It can survive wide fluctuations in water depths. It is usually found in less than 3 metres deep, but can manage to survive in up to 10 metres deep.
1.16 b Estimate the number of host plant species or suitable habitats in the PRA area.	Many	All the habitats in which *C. caroliniana* can establish are present in the PRA area.
1.17 How widely distributed are the host plants or suitable habitats in the PRA area? (specify)	Very widely	Suitable fresh water habitats abound in the PRA area, and particularly in the Netherlands with all the canals. It cannot be excluded that the occurrence of warmer winters since the early nineties have created more possibilities for *Cabomba* to survive.
1.18 If an alternate host is needed to complete the life cycle, how widespread are alternate host plants in the PRA area?	Not relevant	No alternate host needed.
1.19 Does the pest require other species for critical stages in its life cycle such as transmission, (e.g. vectors), growth (e.g. root symbionts), reproduction (e.g. pollinators) or spread (e.g. seed dispersers) ?	No	The plant reproduces very efficiently vegetatively and does require any other species.

1.19A Specify the area where host plants (for pests directly affecting plants) or suitable habitats (for non parasitic plants) are present (cf. QQ 1.16-1.19). This is the area for which the environment is to be assessed in this section. If this area is much smaller than the PRA area, this fact will be used in defining the endangered area.		The Whole PRA area is the area assessed as freshwaters are present in the whole PRA area.
1.20 How similar are the climatic conditions that would affect pest establishment, in the PRA area and in the current area of distribution?	Moderately similar	It prefers a warm climate with a temperature range of 13-27°C but can survive when the surface of the water body is frozen. Rainfall is less important for aquatic species as long as water bodies exist. In Australia, prolonged snow cover is said to be detrimental to *Cabomba* (Australian Department of the Environment and Heritage, 2003), while in Canada, the plant overwinters under prolonged snow and ice cover and continues to thrive and spread (C Wilson, pers. com.). As it has spread in the US and in Canada, it has shown its ability to thrive well outside the range of the warm, humid climates it is said to prefer in the literature, to areas with "rain throughout the year and an average temperature of 15-18°C" (Mackey & Swarbrick, 1997; Wilson, 2001). See maps at the end of this document. The plant has shown to over winter and spread in Ontario, which is its northern limit. Considering this fact and the climate match with Ottawa, the plant should therefore be able to survive in the whole EPPO region, but this data is to taken with much care since climatic prediction is not very suited for aquatic plants. Some areas seem more at risk than others, considering the behaviour of the plant in the EPPO Region. In fact, the plant seems invasive in Queensland (tropical climate) but maybe not as bad in Victoria (more temperate climate) (P Champion, pers. comm., 2006). The countries which seem the most at risk are the freshwater ecosystems of the Mediterranean area, according to a Climex climate match with Sacramento in California, where the plant is an exotic invasive plant. These countries are: Algeria, France, Greece, Italy, Jordan, Morocco, Portugal, Spain, Tunisia, Turkey, Ukraine (Coast). The fact the plant is absent from there may be explained with aquariophiles hobbies

		which may be less developed in the Mediterranean area. The countries with aquatic ecosystems also may be at risk in the Western and Central Europe, according to a Climex climate match with Portland in Washington State (USA), where the plant is also an exotic invasive plant (information from the Washington State Department of Ecology). These countries are: Albania, Algeria, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Germany, Hungary, Israel, Montenegro, Moldova, The Netherlands, Northern Ireland, Poland, Republic of Macedonia, Romania, Serbia, Slovakia, Slovenia, and Switzerland. In England by now, the plant is naturalized but is not considered invasive. The Panel estimates that the plant may not grow in the United Kingdom because summers are not long enough. In fact, in England, the species has been present in the South-East since 1969 (definition: Kent, Sussex, Surrey, Hampshire, Isle of Wight, Berkshire, Oxfordshire, Buckinghamshire). It is considered an "established taxa reproducing vegetatively or sexually and thus present as self-sustaining" (Hill *et al*., 2005). *C. caroliniana* was found in the Forth and Clyde Canal in 1969 and has been introduced from discarded aquarium material, but is no longer present. In 1991 it was found in the Basingstoke Canal, and was still present there in 1995. It may be overlooked elsewhere (Preston *et al*., 2002). There is question mark on the northern part of the EPPO region, according to the situation of the plant in Ontario (Canada), which is the north limit of the plant known by now: Estonia, Belarus, Denmark, Finland, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Norway, Russia, Sweden, Uzbekistan. The interpretation of the Climex maps have to be used with care since the species is a submerged aquatic plant, the level of uncertainty is considered medium to high. Moreover, the Agriculture and Resource Management Council of Australia & New Zealand (2000) made a prediction of the potential distribution of the plant using a Climex model based on temperature tolerance found its native range. This prediction suggests that all Australian States and Territories have favourable climatic conditions for *C. caroliniana*, with excellent habitat conditions provided across southern and eastern Australia. This model over-estimates the potential distribution because it focuses only on

		temperature but not the avaibility of water. GARP is another prediction model that uses parameters based on the known existing distribution within Australia. This model predicts that the potential distribution is limited only to the east coast with optimal habitat from southern Queensland to west coast Tasmania. The potential distribution is probably somewhere between the two models but the key feature of the two predictions is how extensive the potential range is.
1.21 How similar are other abiotic factors that would affect pest establishment, in the PRA area and in the current area of distribution?	Similar	The plant is sensitive to drying out and requires permanent contact with water, although it can survive wide fluctuations in water depths. It is usually found is less than 3 metres deep, but can manage to survive in up to 10 metres deep. It grows well on a silty bed but not so well on hard surfaces. It grows better in nutrient-rich waters with low pH, and tends to loose its leaves in more alkaline waters. High calcium levels also inhibit growth. *C. caroliniana* has the unusual ability to grow in turbid or cloudy waters (Australian Department of the Environment and Heritage, 2003) and is said to do well both in cool and warm waters. Nevertheless in Hungary, *C. caroliniana* is a neophyte which is considered naturalized in the warmer waters as it overwinters, and casual in colder waters (I Dancza, pers. com., 2006). The plant has not naturalized in New Zealand. P Champion wondered about the sensibility of the plant to water chemistry as a condition to its establishment. New Zealand has soft waters with high available dissolved CO2 rather than other C forms like bicarbonate, which may not be suited for *C. caroliniana* (P Champion, pers. com., 2006).
1.22 If protected cultivation is important in the PRA area, how often has the pest been recorded on crops in protected cultivation elsewhere?	Not relevant	
1.23 How likely is that establishment will not be prevented by competition from existing species in the PRA area?	Moderatly likely	In the Netherlands, the plant has been recorded as likely to out-compete existing species near Loosdrecht. In Oranjekannal, patches of *C. caroliniana* have shown to out-compete the exotic *M. heterophyllum* (T. Rooteveel, pers. com., 2007).

1.24. How likely is that establishment will not be prevented by natural enemies already present in the PRA area?	Unlikely	In its native habitat, *C. caroliniana* is only eaten by waterfowl and some fish and provides cover for some small fish and plankton (Ørgaard, 1991). So far, no natural enemies have been reported in the PRA area. This makes the establishment unlikely to be prevented by natural enemies.
1.25 To what extent is the managed environment in the PRA area favourable for establishment?	Highly favourable	Existing practices of mechanical waterway maintenance tend to cut off plants and spread the fragments. These fragments root easily and form new plants, enabling new stands to establish.
1.26. How likely is it that existing control or husbandry measures will fail to prevent establishment of the pest?	Very likely	Existing maintenance practice will favour spread. Mechanical maintenance of waterways typically results in the formation of numerous stem fragments. These are dispersed easily by water (and machinery), and root easily and establish new stands. In Oranjekannal (NL), *C. caroliniana* grows in between a dense vegetation of *Myriophyllum heterophyllum*, another exotic species which covers several kilometers of canal. The local Water Board took action on *M. heterophyllum* and cut a strip of vegetation in the middle of the canal to improve drainage. This measure was quite successful on *M. heterophyllum*, but *C. caroliniana* re-colonized the open space very efficiently.
1.27. How likely is it that the pest could survive eradication programmes in the PRA area?	(Moderately) likely	The plant spreads very easily by vegetative means but does not reproduce by seeds. Current infestations may be demarcated in the PRA area. On the Loosdrecht site in the Netherlands, the Dutch board decided to eliminate the plant and started an eradication programme in 2006 which was pursued in 2007. Plants were uprooted with a laser jet and collected for destruction. Small starting infestations were taken out by hand. The Dutch board estimates that the infestation has been reduced by 75% (T Rooteveel, pers. com., 2007). On the other hand, the plant disappeared in England, and it has not spread from the places where it is present in Hungary, Belgium and other sites in the Netherlands.

1.28 How likely is the reproductive strategy of the pest and the duration of its life cycle to aid establishment?	Likely	*C. caroliniana* grows quickly and produces a large amount of plant material. In Lake Macdonald in Queensland, growth of 50 mm a day has been reported, allowing the plant to respond to wide fluctuations in water depth. The fibrous roots grow on the bottom of water and the stems can reach the surface. Floating parts of the plant can survive in water for 6 to 8 weeks (Australian Department of the Environment and Heritage, 2003). It spreads via rhizomes or from vegetative reproduction by stem fragments. A detached piece of the plant can regenerate into a full plant as long as it has at least one pair of leaves, and pieces as short as 10 mm may be viable. In late summer, *C. caroliniana* stems become brittle, and plants tend to break apart, creating opportunities for spread (University of Maine Cooperative Extension). According to Wilson *et al*. (2001), in colder climates the terminal ends that remain attached to the stem overwinter under snow and ice.
1.29 How likely are relatively small populations or populations of low genetic diversity to become established?	Likely	Many aquatic plants reproduce vegetatively and are sought to have populations of low genetic diversity but are very invasive (e.g. *Ludwigia* spp.). Low genetic diversity may however limit establishment adaptability. Nevertheless, considering the different origins of traded species, populations of *C. caroliniana* may be diverse genetically. A study will be undertaken in the Netherlands to study genetic differences between the populations found on the different sites (T Roteveel, pers.com., 2007).
1.30 How adaptable is the pest? Adaptability is:	High	The plant can establish in different habitats. Moreover, as it has spread in the US and in Canada, it has shown its ability of thriving well outside the range of the warm, humid climates it is said to prefer in the literature, with “rain throughout the year and an average temperature of 15-18°C”. (Mackey & Swarbrick, 1997; Wilson, 2001). Moreover 3 varieties exist, increasing adaptability.
1.31 How often has the pest been introduced into new areas outside its original area of distribution? (specify the instances, if possible)	Often	Known in South America (native), in North America (native and introduced), India, Malaysia, Japan, Europe, Australia, China, etc. It is therefore present in 5 continents and many countries.

1.32 Even if permanent establishment of the pest is 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) ?	Moderatly likely	Establishment of the pest seems already done. In Scotland a transient population existed and disappeared (Ton Rotteveel), as in England. It is not impossible that transient populations have existed elsewhere in the past, especially in more northern latitudes where the likelihood of winter extinction is much greater. Moreover, small founder populations are always subject to high risks of early disappearance by natural events.
1.33 How likely is the pest to spread rapidly in the PRA area by natural means?	Moderatly likely	In Ontario, the plant was present in 2001, no eradication or control measures have been undertaken. The plant has continued to spread in the watershed where it was present. It grows in very dense monocultures where it occurs, and has been shown to replace native species. So far, it has not been reported anywhere else in Ontario (or Canada) outside this watershed" (C Wilson, pers. comm., 2006). Even if the plant does not reproduce by seeds in some of its places of introduction, it reproduces very actively by vegetative reproduction by stem fragments or rhizomes dispersed by water. See question 1.28. However, the plant has not spread in England and Belgium, nor in the Maastricht site in the Netherlands. In England, in 1991, the plant was found in the Basingstoke Canal, and was still present there in 1995 as a naturalized plant, but is not considered invasive. In Belgium, the plant is naturalized in a pond containing indigenous species such as *Potamogeton spp., Myriophyllum spp*. It is present on a part of the pond, but has not shown invasive behaviour and did not reach the other ponds (F Verloove, pers. com., 2006). It has only spread from the Loosdrecht site in the Netherlands.
1.34 How likely is the pest to spread rapidly in the PRA area by human assistance?	Moderately likely	Once introduced in an unintended habitat, the plant can be accidentally dispersed by human activities attached to fish gear or to the hull, anchor line, engine, other part of a boat, across drainages and perhaps by waterfowl (Australian Department of the Environment and Heritage, 2003 ; Schooler *et al*., 2005). In the Loosdrecht in the Netherlands, the infestation reached approximately 1 km from the initial site and various water-types had been invaded (T Rooteveel, pers. com., 2007).

		But in the Maastricht site, although fragments have been floating away in the barge harbour, no other infestations were found nearby.
1.35. How likely is it that the spread of the pest will not be contained within the PRA area?	unlikely	In Australia, it seems that the plant has been managed and prohibited at an early stage so it did not have wide detrimental effects. In the PRA area, infestations are still limited and eradication or at least containment seems possible. Waterways are most often line-shaped elements that can be closed of at both ends. They normally belong to watersheds that either do not connect, or have very definite points of contact that may be closed. Contaminated machinery can be cleaned, the pest is visible (stem fragments). The public would need to be informed on this problem.
The overall probability of introduction and spread should be described. The probability of introduction and spread may be expressed by comparison with PRAs on other pests.		Even if the probability of introduction would have seem low as the plant is mainly accidentally introduced by aquarium waters dumped in the wild, the plant already entered the PRA area and colonized areas many times. The plant is naturalized in England and Belgium, its establishment is therefore lasting, but the plant is not considered a threat there. The species seems likely to establish in the Mediterranean area. For what concerns spread, the plant has extended its range only in the Loosdrecht in the Netherlands. In other sites in Europe, the plant is not reported as spreading. Factors that may influence the spread of the plant remain unknown, and spread in unlikely.
1.36 Based on the answers to questions 1.16 to 1.35 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.		Slow flowing or standing fresh water bodies in western, central and southern Europe. Is it uncertain if the plant could establish in the northern part of the EPPO region, although it is considered that the plant could not be invasive in England because of too short summers.

2.0 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.		The plant is present in different countries of the EPPO region, but is considered invasive only in 1 site over 3 in the Netherlands.
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?	Moderate	In Australia, conservative 1999 estimates place the national cost of *C. caroliniana* control at more than $500,000. According to Wilson *et al*. (2001), wild rice production (*Zizania palustris* L.) could be potentially affected by *C. caroliniana* in Canada. Moreover, plant extracts are allelopathic, inhibiting the germination of wheat and lettuce seed and vegetative growth in some aquatic species (Randall, 1997).
2.2 How great a negative effect is the pest likely to have on crop yield and/or quality in the PRA area?	Minor	Crop of *Zizania palustris* is not recorded in Europe. (not recorded neither in FAOSTAT, nor in Flora Europaea). Rice cultivations (*Oriza sativa*) in the EPPO region does not seem at risk as the plant needs permanent flooding.
2.3 How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area?	Moderate	Costs of management in natural and protected environments may exist, as well as in canals. Cost of one operation on one site for one year was EUR 350,000, near Loosdrecht in the Netherlands (T Rooteveel, pers. com., 2007).
2.4 How great a reduction in consumer demand is the pest likely to cause in the PRA area?	None	No reduction in consumer demand is expected.
2.5 How important is environmental damage caused by the pest?	Moderate	*C. caroliniana* is a highly competitive, densely growing and persistent plant. Upon introduction into a new water body it progressively colonizes near shore areas, where it intercepts sunlight to the exclusion of other submerged plants, crowds out native plants, clogs waterways, disrupting natural flow and hindering recreational activities such as fishing and boating. In Australia, the weed can smother native submerged plants such as pondweeds (*Potamogeton spp*.), stoneworts *(Chara spp*.), hornwort (*Ceratophyllum demersum*), and water nymph (*Najas tenuifolia*) (Mackey and Swarbrick, 1997). It may

		also reduce germination of desirable native emergent plants. It is likely that infestations of *C. caroliniana* affect light level in the water column, shading out other submerge plants (Wilson, 2001). In relatively shallow lakes and ponds, fanwort can colonize the entire water body. When dense mats of *C. caroliniana* decay, the available oxygen in the water may be depleted and cause foul-smelling water. The resulting low oxygen conditions can lead to fish kills and harm other aquatic organisms (Commonwealth of Massachusetts). In Northern Queensland, native animals' numbers such as platypus and water rat are lower in infested creeks (Australian Department of the Environment and Heritage, 2003). On the other hand, according to Champion *et al*. (2004), the plant is present in New-Zealand and has been traded for over 30 years, but has not naturalized and experimental studies showed that *C. caroliniana* had no significant impact on either native or other introduced plants under experimental conditions. In the PRA area, the plant has been sold for many years as an aquarium plant in the EPPO region and has not been widely found in the wild. When it is found in the wild, it is naturalized but not considered invasive (Belgium, England, Hungary). The plant is only considered invasive near Loosdrecht in the Netherlands and smothers native vegetation (T Rooteveel, pers. com., 2007).
2.6 How important is the environmental damage likely to be in the PRA area (see note for question 2.5)?	Minor to moderate	As stated in 2.5, the plant could have a negative impact on other aquatic plants and on the structure of aquatic ecosystems. American and Australian ecosystems are considered moreover more vulnerable than European and Mediterranean ones, although aquatic ecosystems are among the most fragile.
2.7 How important is social damage caused by the pest within its current area of distribution?	High	Near Loosdrecht in the Netherlands, total obstruction of the canal and its direct surroundings was noted and boating, fishing and swimming became impossible (T Rooteveel, pers. com., 2007). In addition, it is a potential danger to swimmers who may become entangled in the long stems (Schooler *et al*., 2005). Mackey and Swarbrick (1997) report the forced closure of fishing camps in the USA, resulting in significant losses of income. Dense infestations can degrade aesthetic and scenic quality, directly influencing tourism and real estate values (University of Maine Cooperative Extension). In case of severe

		infestation, it can raise water level to the point of overflow and cause heavy seepages (Preconic Estuary Program). It can also significantly reduce water storage capacity and taint drinking water supplies. Water treatment costs can be increased by up to $50 a megalitre (Australian Department of the Environment and Heritage, 2003).
2.8 How important is the social damage likely to be in the PRA area?	Moderate	However the same impacts could be expected, the plant only expressed the same social impacts in the Loosdrecht site in the Netherlands.
2.9 How likely is the presence of the pest in the PRA area to cause losses in export markets?	None	
2.9A As noted in the introduction to section 2, the evaluation of the following questions may not be necessary if any of the responses to questions 2.2, 2.3, 2.4, 2.6 or 2.8 is "major or massive" or "likely or very likely". In view of these responses, is a detailed study of impacts required?		
2.10. How easily can the pest be controlled in the PRA area?	With some difficulty	In the Netherlands, the area to be cleaned seems still to be small (but populations are largely submersed). Clearing is difficult, but seen the area, it may be still possible if done quickly and efficiently. Methods are damming and draining ditch sections and dredging. Results of action remove 75% of the invasive plants in one year.
2.11. How likely is it that natural enemies, already present in the PRA area, will not suppress populations of the pest if introduced?	Very likely	No natural enemies have been recorded in the PRA area and in the range of introduction of the species.
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?	Likely	Increased mechanical control would be needed, which would also increase the frequency of environmental disruption for all other species inhabitating the ecosystem.
2.13. How important would other costs resulting from introduction be?	Moderate	Waterways maintenance would be done at an increased frequency, monitoring also. In the Netherlands, dependant on the area involved this may cost several hundred thousand euros per year per water board, and several million euros per year if the species

		would spread over the whole country, extrapolating from the cost of 350,000 euros for managing the plant on one site over one year. This figure is also derived from existing experience with *Hydrocotyle ranunculoides* which presence also increases the need for more frequent waterway maintenance. There would also be communication costs to inform people not to release this plant in the wild and not to use it as an aquatic plant for ponds.
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?	Very unlikely	There are no other members of the *Cabomba* family in the Netherlands outside aquaria and sexual propagation seems absent.
2.15A Do you wish to consider the questions 2.1 to 2.15 again for further hosts/habitats?	No	
2.16 Referring back to the conclusion on endangered area (1.36), identify the parts of the PRA area where the pest can establish and which are economically most at risk.		The countries which seem the most at risk are the freshwater ecosystems of the Mediterranean area, according to a Climex climate match with Sacramento in California, where the plant is an exotic invasive plant: Algeria, France, Greece, Italy, Jordan, Morocco, Portugal, Spain, Tunisia, Turkey, Ukraine (Coast). The fact it is absent from there may be explained with aquariophiles hobbies which may be less developed in the Mediterranean area. The countries which aquatic ecosystems also may be at risk in the Western and Central Europe, according to a Climex climate match with Portland in Washington State, where the plant is also an exotic invasive plant. In England by now, the plant is naturalized but is not considered invasive. The Panel estimates that the plant may not grow in the United Kingdom because summers are not long enough. Albania, Algeria, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Germany, Hungary, Israel, Montenegro, Moldova, The Netherlands, Northern Ireland, Poland, Republic of Macedonia, Romania, Serbia, Slovakia, Slovenia, Switzerland, The United Kingdom, The level of uncertainty is medium to high.

2.16A 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 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.	Medium to high	The following uncertainties have been identified : - The reason why the plant have shown invasiveness in only one site over three in the Netherlands. Hypothesis are differences in genotypes on the 3 sites, differences in chemical water quality, *Cabomba* being possibly sensitive to CO2 levels in water, and the higher amount of nutrient load. - The reason why the plant is not recorded in Mediterranean countries which are countries supposed to be the most at risk. May this be explained with aquariophiles hobbies which may be less developed in the Mediterranean area? It is in fact mainly traded in anglo-saxon websites.
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.		**Unintentional release in the wild: escape from aquaria dumping or misuse in exterior (while it is intended for aquarium use)**: moderately likely The plant has already entered the PRA area. The plant is recorded as present in England, Belgium and Hungary and in the Netherlands. The only probable pathway is the trade of *C. caroliniana* as an aquarium plant, its accidental release in nature or misuse as a pond 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.		The plant has disappeared from Scotland (Ton Rotteveel, pers. com.) and England (Preston *et al*., 2002) and even if present in England since 1969, it did not spread or become invasive there, nor in Belgium and Hungary. In the Netherlands, it spread and became problematic in one site over three. One hypothesis is that it has maybe not yet expressed its potential behaviour in the EPPO region. It could also be a successful integration of an exotic plant in European and Mediterranean ecosystems. The Mediterranean area would be the one the most at risk. Though, it is surprising that the plant has not yet been recorded there. Experimental studies have shown that it did not naturalized in New-Zealand and is not a threat while natural ecosystems there are supposed to be more fragile than the European and Mediterranean ones. Invasive plants are a major threat when they are directly and widely planted in the intended habitats, which is not the case for *C. caroliniana*. There are many uncertainties on its ability to spread and become invasive in the EPPO region. On the other hand, if the plant has the potential to become invasive, it is a good time to act now as the plant is not widespread. Moreover, as the plant is present in the western and in the central part of Europe, it could naturally spread (waterways, water birds,…) and establish in the Mediterranean area.
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.		- colonization of ditches, clogging of canals and swimming, boating and fishing: moderately likely - threat to natural ecosystems: moderately likely - Dense infestations can degrade aesthetic and scenic quality, directly influencing tourism and real estate values: unlikely - Degradation of water supply: unlikely
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 pest risk associated.		The plant would really represent a threat if it released in huge quantities in the wild. As it is an aquarium plant, releases in the wild are just accidents, but they have proven to happen. It may have the potential to establish and to be a threat in the Mediterranean area.
This is the end of the Pest risk assessment		

Stage 3: Pest risk Management

3.1. Is the risk identified in the Pest Risk Assessment stage for all pest/pathway combination an acceptable risk?		No if the plant is misused and planted in the wild or accidentally released in the wild. When only used as an aquarium plant with good practice, the risk is very low. It has been traded and used as an aquarium plant for many years and have not been identified as a major invasive plant till now.

Pathway 1		**Unintentional release in the wild: escape from aquaria dumping or misuse in exterior (while it is intended for aquarium use)**:
3.28. Are there effective measures that could be taken in the importing country (surveillance, eradication) to prevent establishment and/or economic or other impacts?	yes	• publicity As a general recommendation, contacts could be taken with the International Organization dealing with the trade of aquarium plants to organize a campaign of information toward the aquariophilists, to inform them of the risks to dump aquarium waters in the wild. This is also true for other aquarium plants. Moreover, garden centres selling aquarium plants and aquatic plants should inform their clients that these plants should only be used for aquaria, and not as aquatic plants for ponds. Growers of aquatic plants should be informed through codes of conducts of good practices to avoid contaminations of wild ecosystems and other produced aquatic plants. • monitoring/surveillance Eradication and monitoring/surveillance should be organized where the plant is known to be invasive, as for instance in the Netherlands. It does not seem to be a problem in England, Hungary and Belgium and does therefore not need to be eradicated. Where it is known to be invasive, sites should be monitored regularly at intervals of 3-6 months for at least 3 years following an apparent elimination of *C. caroliniana*. Treated and adjacent areas must be carefully examined for small fragments of the plant. The places where it is present but not invasive have to be monitored to see the evolution of the situation. Monitoring of aquatic invasive plants in general is particularly necessary in the Mediterranean area which is the area considered the most at risk.

		• emergency plan ○ quick eradication response when the plant is found (as in the Netherlands). • obligations to report findings, in the whole EPPO region, especially in the the Mediterranean area. • Prohibitions: High level of protection Prohibition of the introduction, trade, transport and possession of the plant. Nevertheless, the plant is intended for aquarium use, and release in nature is accidental. Moreover, very large amounts of the plants are traded. Lower level of protection Prohibition of planting and causing to grow it in the wild (For aquatic plant producers, there should also be an interdiction of producing these plants in the wild or in a place from where these species could escape in the wild), mainly in the Mediterranean area.
3.29. Have any measures been identified during the present analysis that will reduce the risk of introduction of the pest?	yes	see measures cited in 3.28
3.30. Taking each of the measures identified individually, does any measure on its own reduce the risk to an acceptable level?	no	
3.31. 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?	no	
3.33. Estimate to what extent the measures (or combination of measures) being considered interfere with trade.		High level of protection: Prohibition of the introduction, trade, transport and possession of the plant. It greatly interferes with trade as the plant is very popular. Lower level of protection: Prohibition of planting or causing to grow the plant in the wild (national measure). It does not interfere with trade but requests good practices from aquariophilists, aquatic plant growers and advices to clients from sellers.

3.34. Estimate to what extent the measures (or combination of measures) being considered are cost-effective, or have undesirable social or environmental consequences.		High level of protection: Prohibition of the introduction, trade, transport and possession of the plant. Aquariophilists and sellers of aquatic plants may not understand such legislation and may consequently not respect it. Lower level of protection: Prohibition of planting or causing to grow the plant in the wild (national measure). The trade of the plant will not be limited, the measure consists in good practices for aquariophilists and aquatic plant producers, it establishes dialogues and is a positive solution to the problem.
3.35. Have measures (or combination of measures) been identified that reduce the risk for this pathway, and do not unduly interfere with trade, are cost-effective and have no undesirable social or environmental consequences?	yes	High level of protection: Prohibition of the introduction, trade, transport and possession of the plant may have undesirable effects on trade. This measure shall be combined with publicity, eradication and monitoring/surveillance in the countries where it is invasive (the Netherlands), surveillance in the countries where it occurs but is not invasive (England, Belgium, Hungary) and surveillance of wet ecosystems in the countries the most at risk where it is absent (Mediterranean countries). The option recommended is the Lower level of protection by prohibition of planting or causing to grow the plant in the wild (national measure) combined with publicity, eradication and monitoring/surveillance in the countries where it is invasive (the Netherlands), surveillance in the countries where it occurs but is not invasive (England, Belgium, Hungary) and surveillance of wet ecosystems in the countries the most at risk where it is absent (Mediterranean countries). (The pest only qualifies to be included on the EPPO List of pest recommended for regulation if the higher level of protection is chosen, otherwise, national measures may be sufficient to prevent invasion.)
3.36. Envisage prohibiting the pathway	yes	Only if the higher level of protection is chosen
3.37. Have all major pathways been analyzed (for a pest-initiated analysis)?	yes	
3.40 Consider the relative importance of the pathways identified in the conclusion to the entry section of the pest risk assessment		**Unintentional release in the wild: escape from aquaria dumping or misuse in exterior (while it is intended for aquarium use)**: low to moderate

3.41 l 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.		
3.42. 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)		
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.**		**Unintentional release in the wild: escape from aquaria dumping or misuse in exterior (while it is intended for aquarium use)**: - Eradication and monitoring/surveillance in the countries where it is invasive (the Netherlands), surveillance in the countries where it occurs but is not invasive (England, Belgium, Hungary) and surveillance of wet ecosystems in the countries the most at risk where it is absent (Mediterranean countries). -- Publicity: International Organization(s) of aquariophilists and aquatic plants producers shall be informed of the problem and work should be undertaken with them on codes of conduct to use appropriately these plants, to avoid their release in the wild, and inform consumers. - Prohibition High level of protection: Prohibition of the introduction, trade, transport and possession of the plant. Lower level of protection: Prohibition of planting or causing to grow the plant in the wild.

Annexe 1

Cabomba caroliniana climatic prediction

Document prepared by the EPPO Secretariat

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.

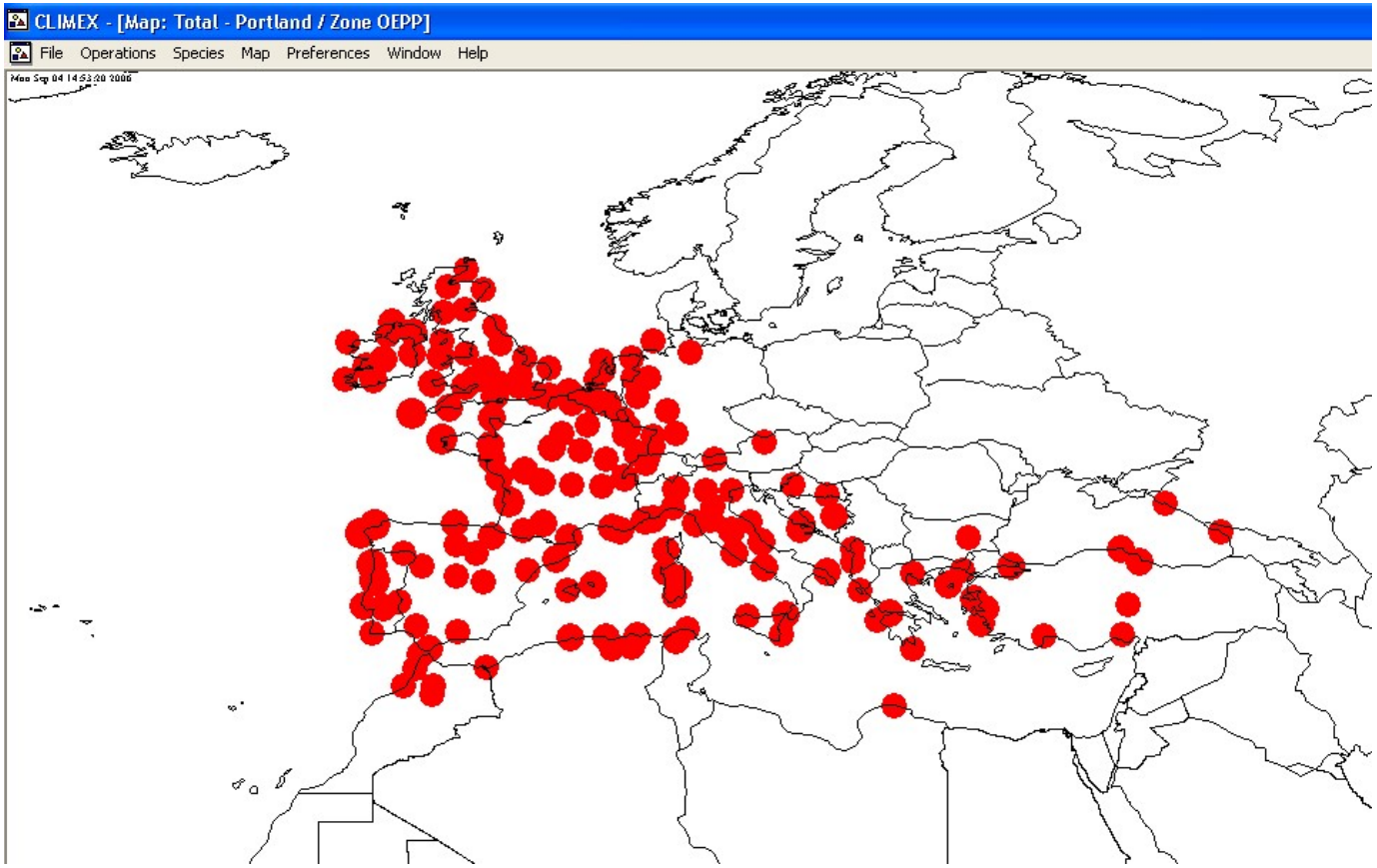
CLIMEX provides tools for predicting and mapping the potential distribution of an organism based on:

(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).

Only match Climate studies have been undertaken for this plant. Being an aquatic plant, a climatic prediction is quite difficult to perform.

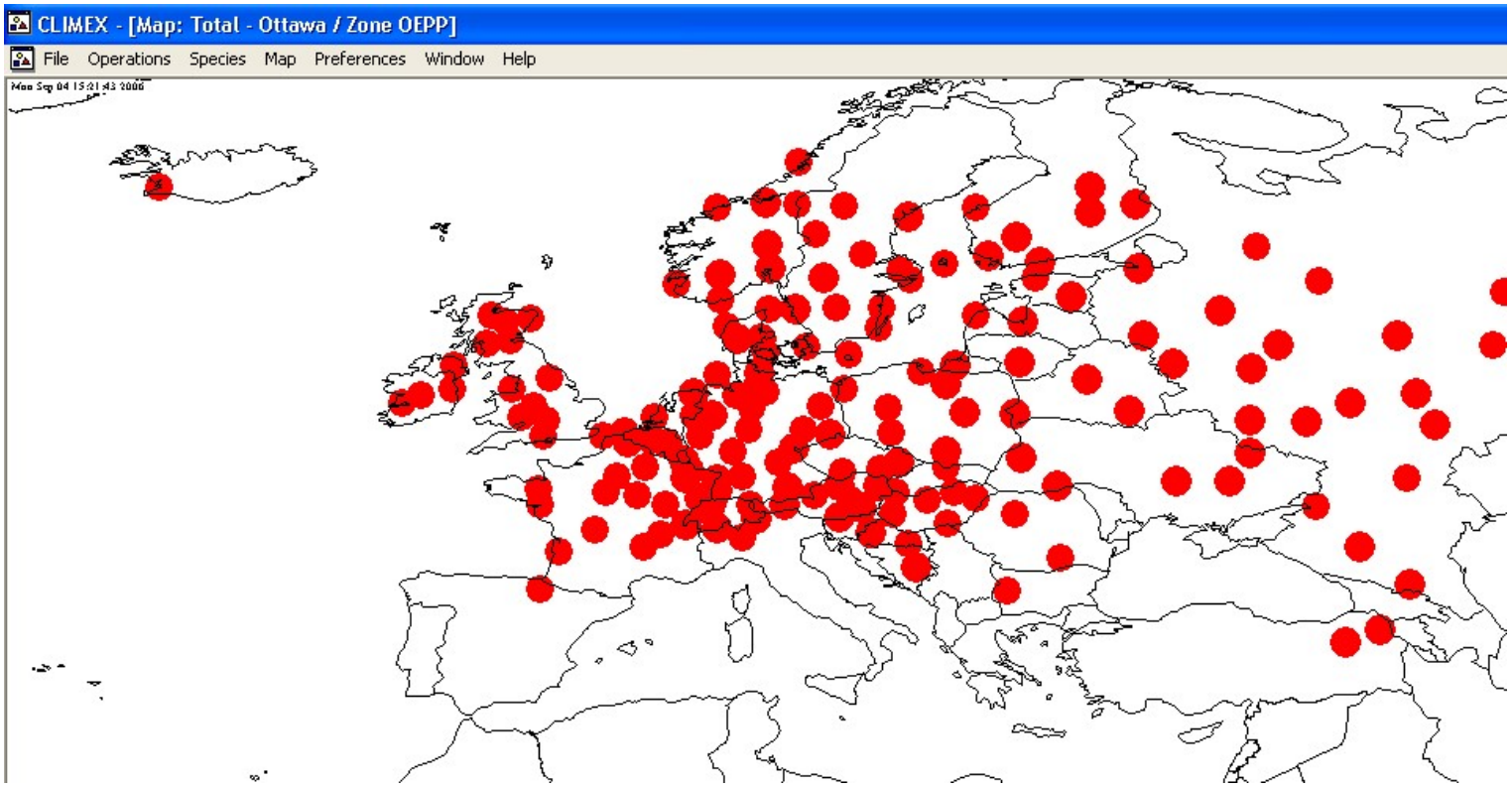
Match Climate with Portland

Cabomba caroliniana is recorded in Longview, in Washington State. Portland is a close place to Longview. This is the only place where the plant is recorded in Washington, but it is not considered a problematic aquatic plant.



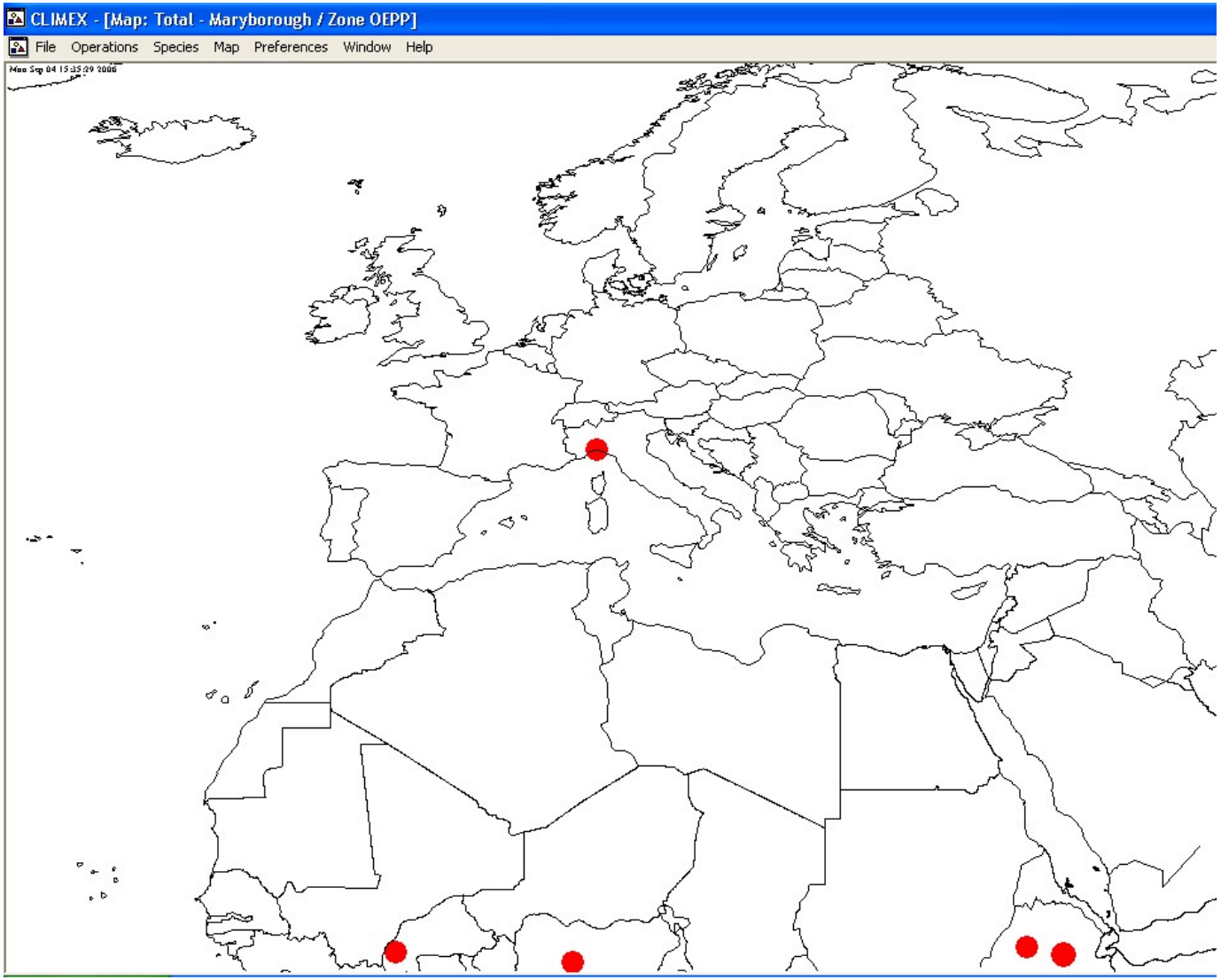
Match climate with Ottawa

In Canada, the plant is present in Kasshabog Lake, in the Kawartha Lakes of southern Ontario and has spread since the record of 2001. This appears to be the most northern site colonized by *C. caroliniana* to date in North America, and possibly in the world (exact localisation in Japan is unknown) (Wilson *et al*., 2001). It has been reported from several bays in Kasshabog Lake (occupying approximately 16% of the lake's surface area), and has also spread south out of Kasshabog Lake, down the North River into South Lake (about 8 km) and south out of South Lake and into Big Bass Bay (about 3 km). It spreads by fragments that are carried on the currents down the river. It grows in very dense monocultures where it occurs, and has been shown to replace native species. Ottawa is a close location of Kasshabog Lake.



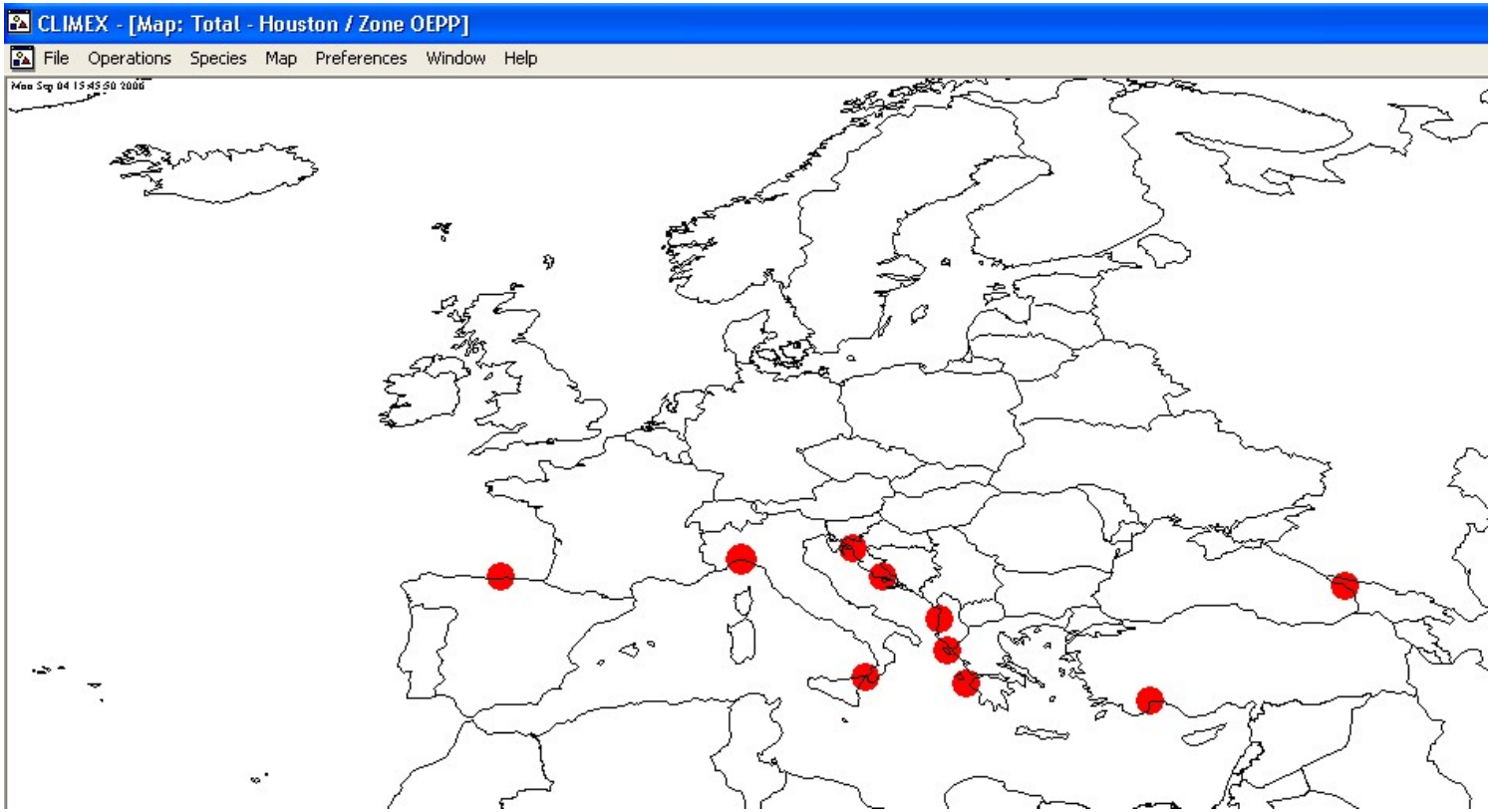
Match climate with Maryborough (Queensland)

C. caroliniana has been found naturalized and threatening natural ecosystems in Lake Mac Donald, near Maryborough.



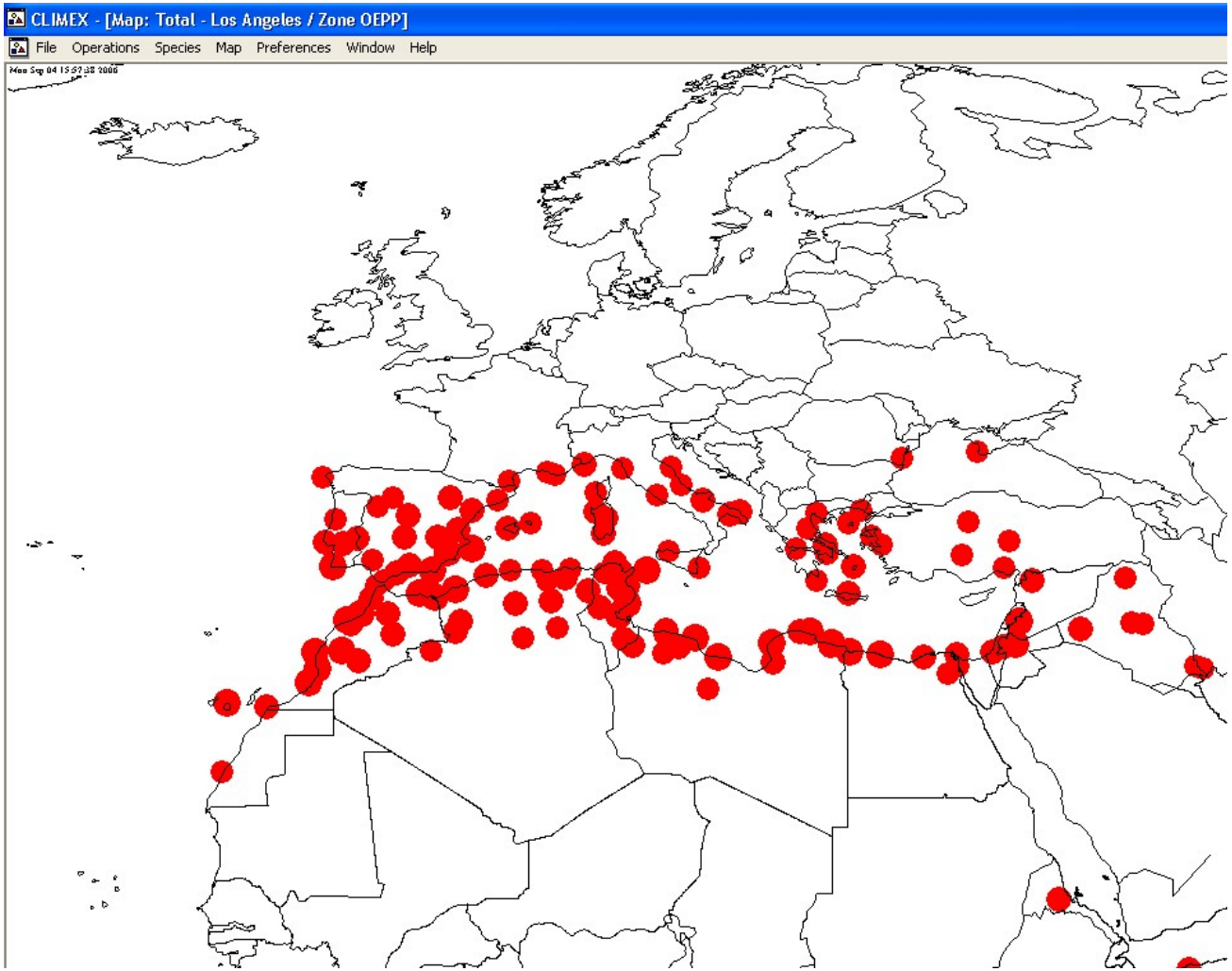
Match climate with Houston (Texas)

The plant is indigenous in Texas (see http://plants.usda.gov/java/county?state_name=Texas&statefips=48&symbol=CACA)



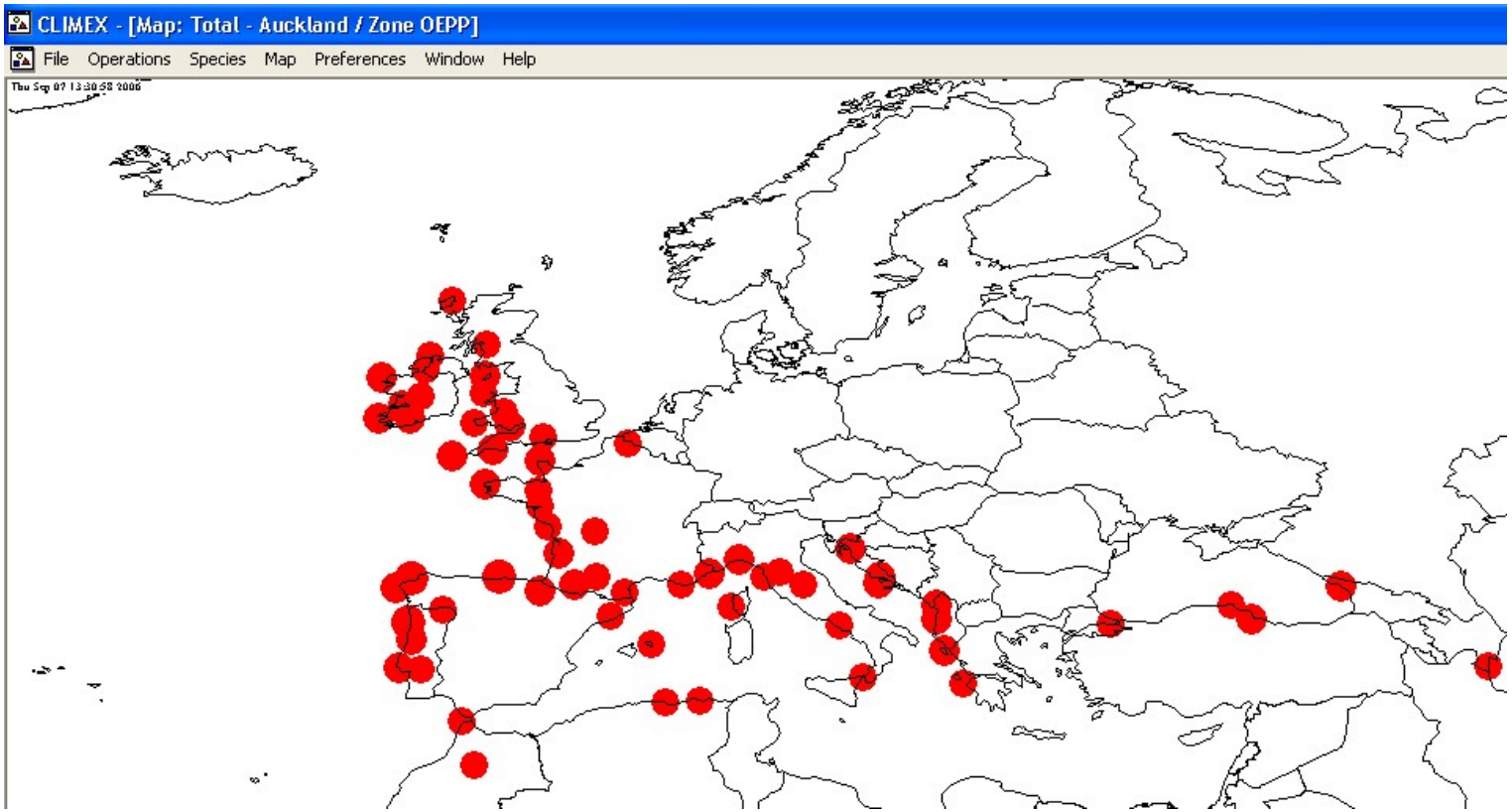
Match climate with Sacramento (California)

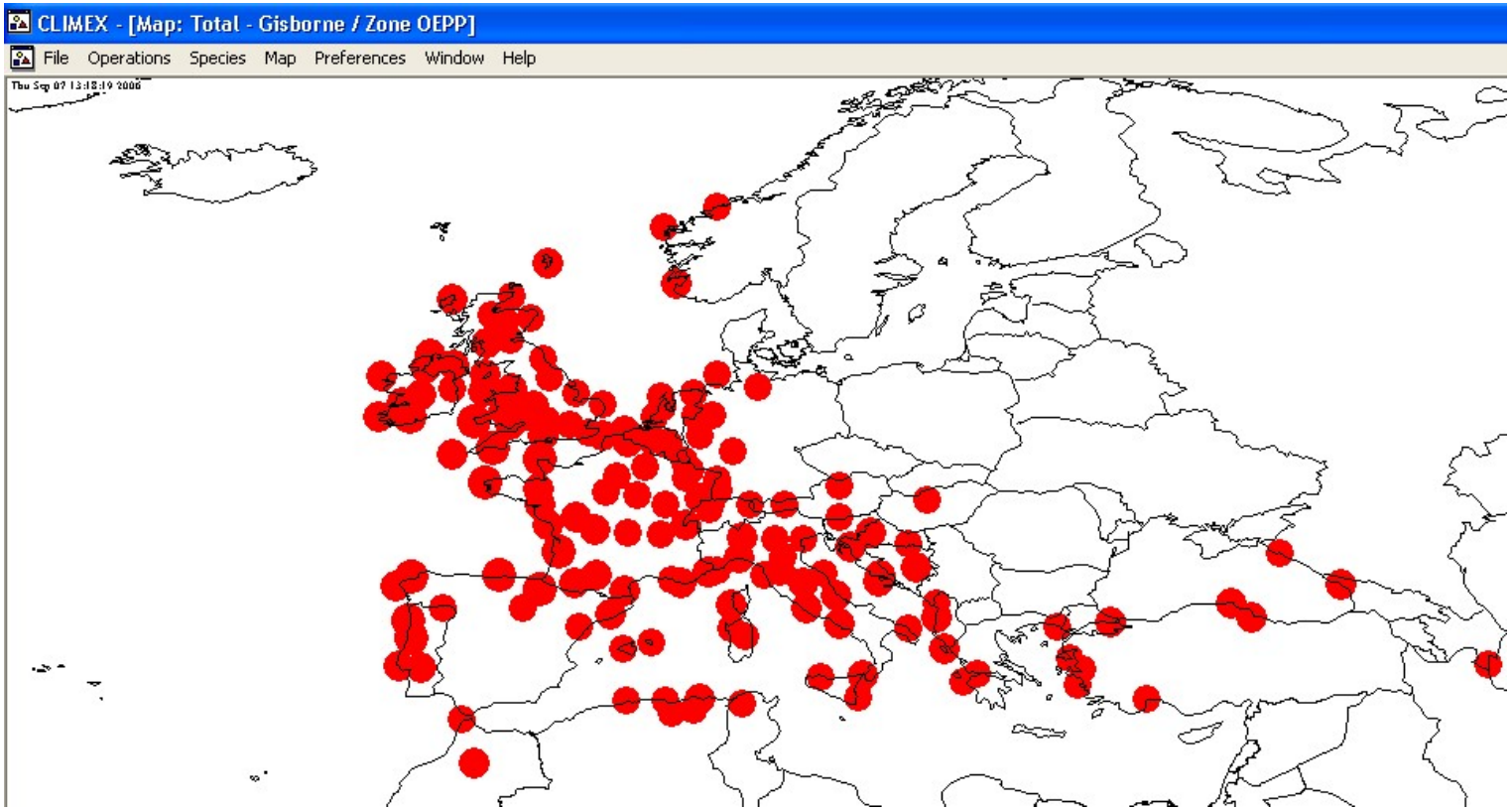
The plant is recorded as invasive in the Sacramento River delta



Match climate with Auckland and Rotorua (New Zealand)

In New Zealand, there is just one known outside pond site (Karangahape Gorge, 38° latitude) where the plant grows in cool spring-fed water; this is not a tropical site (P Champion, personal communication, 2006). The plant is not naturalized there although it has been traded for over 30 years.
This site is close between Rotorua and Auckland. The Match Climate with these locations shows that if climate was the major element for establishment, *C. caroliniana* would not establish in Europe, while the results from the location in Ontario and the current situation of the plant in the EPPO region shows it can. The fact the plant did not succeed in establishing may be linked to water chemistry (P Champion, personal communication, 2006).




CLIMEX - [Map: Total - Gisborne / Zone OEPP]
File Operations Species Map Preferences Window Help

References

See the EPPO Datasheet on *Cabomba caroliniana*

Agriculture & resource Management Council of Australia & New Zealand, Australian & New Zealand Environment & Conservation Council and Forestry Ministers (2000) Weeds of National Significance Cabomba (*Cabomba caroliniana*) Strategic Plan. National Weeds Strategy Executive Committee, Launceston.

Australian Department of the Environment and Heritage, (2003) Cabomba (*Cabomba caroliniana*). Weeds of National Significance: Weed Management Guide Department of the Environment and Heritage and the CRC for Australian Weed Management, 2003.
http://www.deh.gov.au/biodiversity/invasive/publications/c-caroliniana.html

Champion PD, Hostra DE, Clayton JS (2004) Border control for potential aquatic weeds. Stage 3. Weed risk management. Department of Conservation. National Institut of Water & Atmospheric Research Ltd.
Information at: http://www.niwascience.co.nz/pubs/wa/12-3/weed

Commonwealth of Massachusetts ~ Department of Conservation and Recreation ~ Office of Water Resources ~ Lakes and Ponds Program - Fanwort: An Invasive Aquatic Plant. *Cabomba caroliniana* http://www.mass.gov/dcr/waterSupply/lakepond/factsheet/fanwort.doc

EPPO Reporting Service n°1 (2007) Pathway analysis: aquatic plants imported in France. 2007/016
http://archives.eppo.org/EPPOReporting/2007/Rse-0701.pdf

Hill M, Baker R, Broad G, Chandler P J, Copp G H, Ellis J, Jones D, Hoyland C, Laing I, Longshaw M, Moore N, Parrott D, Pearman D, Preston C, Smith R M, Waters R (2005) Audit of non-native species in England. English Nature Research Reports n° 662. 81 p.
http://www.english-nature.org.uk/pubs/publication/pdf/662.pdf

Mackey AP (1996) *Cabomba spp*. in Queensland. Pest Status Review Series - Land Protection Branch, Department of Natural Resources and Mines, Qld, Australia

Mackey AP, Swarbrick JT (1997) The biology of Australian Weeds, 32. *Cabomba caroliniana* Gray. *Plant Protection Quarterly* **12**(4): 154-165.

Maki C, Galatowitsch (2004) Movement of invasive aquatic plants into Minnesota (USA) through horticultural trade. *Biological conservation* **118,** 389-396

Ørgaard M (1991) The genus *Cabomba* (Cabombaceae) - a taxonomic study. *Nordic Journal of Botany,* **11**:179-203.

Preconic Estuary Program (Undated) Fanwort, *Cabomba caroliniana*
http://www.peconicestuary.org/InvCabomba.html

Preston C D, Pearman D A, Dines T D. 2002. New Atlas of the British and Irish Flora. Oxford: Oxford University Press.

Randall R (1997) Weed potential of Cabomba, *Cabomba caroliniana* A. Gray (Family: Cabombaceae). Agriculture Western Australia.

Rixon CAM, Duggan IC, Bergeron NMN, Ricciardi A, Macisaac HJ (2005) Invasion risks posed by the aquarium trade and live fish markets on the Laurentian Great Lakes. *Biodiversity and Conservation* **14**, 1365-1381.

Schooler SS, Williams DG, Stokes K, Julien M (2005) Invasive Plants: Impacts and Management in Rivers and Catchments. Riversymposium.
http://www.riversymposium.com/index.php?element=46#search=%22mackey%20swarbrick%22

University of Maine Cooperative Extension, Bulletin n°2522 (Undated) Maine Invasive Plants, Fanwort, Cabomba –
http://www.umext.maine.edu/onlinepubs/htmpubs/2522.htm

Wilson C, Watler D (2001) Weed Risk Assessment, Fanwort, *Cabomba caroliniana* Gray. Canadian Food Inspection Agency. Plant Health Assessment Unit, Science Division, Nepean, Ontario. December 20, 2001.32 p.