Queensland **the Smart State**

Pest plant risk assessment

Dense waterweed

Egeria densa

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The Department of Primary Industries and Fisheries (DPI&F) seeks to maximise the economic potential of Queensland's primary industries on a sustainable basis.

Contents

Summary

Egeria densa is a submerged, freshwater plant native to South America. It is very popular as an aquarium plant and has been transported across the world for this use. It has become a major pest in Japan, New Zealand and the United States, where it has escaped cultivation and now imposes multi-million dollar costs. Under favourable conditions, its prolific growth can preclude recreational activities in lakes and streams, and block irrigation equipment and hydro-electric power plant intakes.

E. densa is common and abundant in freshwater creeks, lakes and rivers in south-eastern Queensland and is currently being sold in substantial quantities by the Queensland aquarium trade. It appears to have already spread over much of its potential bioclimatic range, but might expand its range to some degree into cool-climate areas and perhaps upland areas in North Queensland (areas where water temperature does not exceed 30 °C).

Important note: This weed risk assessment is a working draft only and requires more information before firm recommendations can be made. Please send any additional information, or advice on errors, to the authors.

Identity and taxonomy

Taxa: *Egeria densa* Planch.

Synonyms: *Anacharis densa* (Planch.) Vict.
Elodea densa (Planch.) Casp.
Philotria densa (Planch.) Small and St. John.

Common names: Dense waterweed, anacharis, Brazilian elodea, egeria, leafy elodea (Shepard et al. 2001), Brazilian waterweed, waterpes (USDA, ARS, National Genetic Resources Program 2007), South American waterweed (USDA, Natural Resources Conservation Service 2007).

Description

E. densa is similar in appearance to 'elodea' (*Elodea canadensis*), another aquatic plant that is commonly used within home aquaria in Queensland and elsewhere. Retail aquarium shops in Queensland erroneously use both species' names interchangeably.

The leaves of *E. densa* are 1–3 cm long, up to 5 mm wide and are arranged along the stems in whorls of four to eight. The leaves are minutely serrated and linear. Short internodes tend to give the plant a 'leafy' appearance (more so than elodea). The lowest leaves on the stem are arranged in opposite pairs or in whorls of three, while the middle and upper leaves are arranged in whorls of four to eight. The stems are erect, cylindrical, simple or branched, and grow until they reach the water surface, where they can form dense mats. The flowers are white, 18–25 mm in diameter and have three petals. The flowers float or rise above the water's surface on thread-like hypanthiums produced from apical double nodes. Roots are freely produced from double nodes on the stem. *E. densa* is dioecious.

Reproduction and dispersal

Seeds and/or female flowers have never been reported on *E. densa* in Australia or the United States (Parsons & Cuthbertson 2001; Washington State Department of Ecology 2007). Male flowers are produced in November–December and flowering continues until late February (Parsons & Cuthbertson 2001). The absence of sexual reproduction in introduced populations of *E. densa* means that spread occurs via dispersal of plant stems and fragments only. Fragments break off the parent plant quite readily. Each fragment contains a double node and has the potential to develop into a new plant (Washington State Department of Ecology 2007).

Dispersal of *E. densa* over long distances is generally a consequence of transport by people, rather than via natural mechanisms. Moreover, dispersal can be quite rapid since *E. densa* is one of the most widely available aquarium plants (Cook & Urmi-Konig 1984).

Following initial establishment in a particular area, subsequent spread of *E. densa* occurs when crowns and buds on stem fragments move away from the parent colony in stream flow; a fact that highlights the danger of mechanical control measures (Parsons & Cuthbertson, 2001). This mode of dispersal is also assisted by human recreational activities as fragments of *E. densa* get caught in the propellers of boats, or to boat trailers and can start new populations when the boat is launched into another waterbody (Westerdahl & Getsinger 1988).

Seed longevity

Seed longevity is unknown, due in part to the fact that the plant rarely produces any seeds.

Origin

E. densa is considered native to south-east Brazil, from Minas Gerais and Espirito Santo following the coast southwards through Uruguay to Buenos Aires. In Argentina, it occurs along a plain between the Parana and Uruguay rivers almost up to the boarder of Paraguay. It also occupies a region around Cordoba (Cook & Urmi-Konig 1984).

History of introduction

This study was unable to determine when *E. densa* was first introduced into Australia. However, it was probably many decades ago. The first specimen recorded by the Queensland Herbarium was dated 1969. *E. densa* was almost certainly introduced into Australia by the aquarium trade and is now one of the most common ornamental species in aquaria and small garden ponds (Parsons & Cuthbertson 2001). *E. densa* is currently being sold in most pet shops in Queensland.

In the United States, *E. densa* was offered for sale in 1915 when it was promoted as an oxygenator for raising fish used to control mosquito larvae (Cook & Urmi-Konig 1984). However, *E. densa* was probably grown as an aquarium plant prior to this. For example, there are records of its existence in 1893 in Long Island, US, in 1903 in Europe and in 1910 in Germany (Cook & Urmi-Konig, 1984). *E. densa* was introduced into Japan from the US in the 1920s to provide material for physiological experiments and has now naturalised in many waterways of Japan (Haramotoa & Ikusima 1988).

Worldwide distribution

Native range: Brazil, Argentina, Uruguay (USDA, ARS, National Genetic Resources Program 2007).

Introduced range: The naturalised range of *E. densa* is extensive. Cook and Urmi-Konig (1984) outlined the distribution of *E. densa* in 20 countries, as follow:

Country	Date of first record	Location
Italy	1947	Lombardia, Toscana and Piemonte
Switzerland	1948	Lago Maggiore
The Netherlands	1944	Dordrecht, Bussum and Doorn
British Isles	1953	Canals in Failsworth, Chadderton and Droylsden—Lancashire
France	1919	Manche and then in Loire Atlantique
Germany	1910	Leipzig, River Niers, Karlsruhe, Pfalz
USSR	1939	Caucasus
Azores	1980	
USA	1893	New Hampshire, Vermont, Florida, Nebraska, Kansas, Oklahoma, Texas, Oregon, California, Arizona, New Mexico, Utah, North Carolina, Hawaii
Canada	Not known	Vancouver, Duncan on Vancouver Island
Mexico	1941	
El Salvador	1940	San Salvador
Cuba	1950	Pinar del Rio
Jamaica	Not known	Altitudes between 200 and 400 m
Guadeloupe	1940	
Martinique	1940	
Australia	1950	Victoria, Queensland and New South Wales
New Zealand	1946	Elbow, North Auckland, Hawkes Bay, Napier, Wellington, South Canterbury
Republic of South Africa	1915	Natal
Japan	1958	Tokyo

Distribution in Australia

The table below provides a list of locations within Queensland where specimens of *E. densa* have been sent to the Queensland Herbarium for identification (source: Queensland Herbarium HERBRECS database). Figure 1 provides an indication of the distribution of *E. densa* in Australia.

District name	Date	Label	Latitude	Longitude	Depth
Darling Downs	28.02.69	Toowoomba. Growing in ornamental lake.	S27 34 30	E151 57 30	
Darling Downs	26.03.69	Lake Annand, Toowoomba. The weed was introduced naturally to the lake and is now overgrowing about 0.5 acre of it and thus warrants control.	S27 33 30	E151 55 30	
Moreton	18.04.78	Brisbane, in Stable Swamp Creek, Rocklea. Large amounts in creek. It has grown and become a pest since the council dredged the creek in January 1978. Water ca. 10–60 cm deep.	S27 35	E153 05	
Moreton	21.01.81	Stable Swamp Creek next to Ipswich Road Bridge at Rocklea. Freshwater ca. 1 m deep. Growing in open water with *Hydrilla verticillata* and *Potamogeton crispus*.	S27 35	E153 05	
Moreton	17.04.85	Moggill Creek at Rafting Ground Road Crossing, 1 km west of Moggill Road, Brookfield, Brisbane. In flowing water. Gravelly sand.	S27 35	E152 55	
Moreton	16.11.93	Moggill Creek.	S27 35	E152 55	
Moreton	15.10.97	c. 500 m upstream of the Fernvale Bridge, Brisbane River, 3.5 km (by road) to Fernvale Grid Ref: 9443-639654. Aquatic plant growing in 90 cm of water. Flow: 0.02m/sec. Overhead cover: low (ca. 30–50%). Growing with *Hydrilla verticillata*.	S27 26 1.76	E152 38 6.87	0.9
Moreton	9.04.00	Hamon Cove, Wivenhoe Dam, north of Fernvale. Margins of lake. Adjacent land is cleared, with occasional remnant trees of *Eucalyptus tereticornis*. Water plant, floating on surface. Leaves bright green, flowers white, emergent. Common at site.	S27 18 1	E152 30 51	
Moreton	22.09.00	Petrie Creek, Maroochy catchment, near Nambour. Margin of weir pool.	S26 37 32	E152 57 46	
Moreton	28.10.00	Cannon Hill College, Cannon Hill, 7 km east of Brisbane. Remnant open forest of *Melaleuca quinquenervia* and adjacent water-filled drainage canal. Submerged water plant; flowers white, emergent. Common at site.	S27 27 42.52	E153 05 6.05	
Moreton	19.10.01	Oxley Creek—Stable Swamp Creek at Keats Street footbridge. In freshwater stream, alluvial soil, fringing open-forest, alluvium. Submerged aquatic.	S27 34 50.42	E153 02 45.48	

District name	Date	Label	Latitude	Longitude	Depth
Moreton	20.02.02	Cedar Creek, Mount Tamborine. Dense waterweed.	S27 55	E153 15	
Moreton	19.04.02	Witton Creek, Aaron Place, Indooroopilly. In slow moving, pools of creek—up to 60 cm deep. Submerged aquatic microphyte.	S27 30 25.45	E152 57 57.20	
Moreton	27.07.03	Brisbane River, Colleges Crossing. River bed, 1–2 m water depth, submergent herbland dominated by Eelweed, Vallisneria. Naturalised submerged perennial herb. Occasional.	S27 33 47.50	E152 48 27.20	

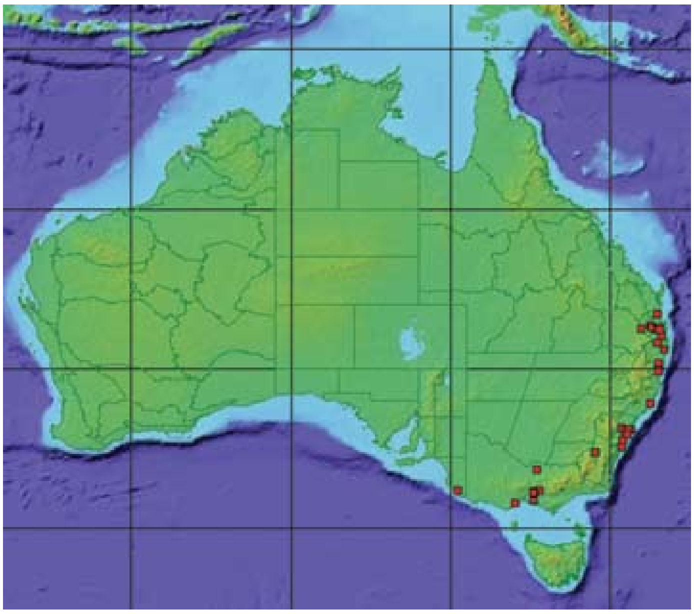

Figure 1. Distribution of *E. densa* in Australia (Australian Virtual Herbarium map 2007).

Preferred habitat and climate

E. densa can survive as a submerged aquatic in a variety of freshwater habitats, such as ponds, lakes, reservoirs, pools, ditches and slow-flowing streams (Parsons and Cuthbertson 2001). It generally grows rooted to the substrate in depths of up to 7 m but can survive when drifting unattached in still or flowing water.

E. densa prefers warm-temperate and cool subtropical climates where the water temperature rarely exceeds 30 °C (Pierini & Thomaz 2004). Within subtropical and tropical areas, it is limited to high altitudes or cold-water springs (Cook & Urmi-Konig 1984). It is well adapted to cold climates and can survive freezing conditions over winter by storing starch in its leaves and stem and by using these supplies for growth once temperatures rise above 10 °C. Optimum growth occurs at a temperature of around 24 °C (Haramoto & Ikusima 1998). High water temperatures (greater than 30 °C) and high light intensities can cause senescence (Washington State Department of Ecology 2007).

History as a weed overseas and interstate

E. densa is a declared noxious weed in the US states of Alabama, Connecticut, Maine, Massachusetts, Oregon, South Carolina, Vermont, Washington (USDA, Natural Resources Conservation Service 2007).

E. densa growth in Japan is described as 'explosive' and the species now dominates many waterbodies (Les & Mehrhoff 1999). Similarly, in the Sacramento Delta, populations of *E. densa* have been found to double in size every four to five weeks during summer. Such rapid growth results in waterways becoming clogged and precludes recreational activities such as boating, swimming and fishing (Senft 1995).

In Australia, *E. densa* is a declared weed in South Australia (proclaimed plant), Northern Territory (Class C), Western Australia (P1, P2, whole state) and Tasmania (declared weed).

Impact

Under favourable conditions, *E. densa* can grow rapidly, covering water surfaces and blocking light to lower levels of the waterbody. This can cause a decline in populations of native plant species and thereby reduce populations of fish and other aquatic wildlife (Westerdahl & Getsinger 1988).

In south-east Brazil, *E. densa* and *E. najas* cause significant losses to hydro-electric companies. Interruptions of electricity generation and damage to grids and equipment are common in reservoirs belonging to hydro-electric companies in São Paulo (Barreto et al. 2000). The Washington State Department of Ecology (2007) states that, '*E. densa* forms dense, mono-specific stands that restrict water movement, trap sediment, and cause fluctuations in water quality. Dense beds interfere with recreational uses of a water body by interfering with navigation, fishing, swimming, and water skiing'. Growns et al. (2003) state that '*E. densa* is likely to harbour a different fish assemblage than beds of native macrophyte species'. Hamabata and Kobayashi (2002) state that '*E. densa* appeared in Lake Biwa in 1969 and its distribution peaked during the 1970s when the submerged plant zone in the southern basin was covered exclusively by this species'.

An estimated 1850 ML was lost annually in Lake Marion, South Carolina, due to sedimentation caused by *E. densa*. In Washington State, local and state governments and lake residents spend substantial amounts of money every year to manage infestations of *E. densa*. For example, the cost of a single control project in Silver Lake, Cowlitz Country is over $1 million (Washington State Department of Ecology 2007).

On the Waikato River in New Zealand, electricity generating plants have, at times, been shut down after fragments of *E. densa* have clogged intake structures. In New Zealand, *E. densa* has become widespread and, in some places, displaces assemblages of native aquatic plants (Champion & Tanner 2000).

In south-eastern Australia, *E. densa* can block water flow and interfere with irrigation projects, hydro-electric output and urban water supplies. It can also interfere with river traffic as well as recreational activities such as boating, swimming and fishing (Parsons & Cuthbertson 2001). In the Hawkesbury–Nepean River, from 1994–96, *E. densa* comprised more than 70% of the total biomass of aquatic macrophytes and displaced native ribbon weed, vallisneria (*Vallinseria americana*). It also restricted navigation and boating, clogged irrigation and water supply systems and slowed river flow. Dense beds of *E. densa* can alter the distribution and abundance of native macrophyte and invertebrate assemblages, block the migration of fish and support different fish assemblages (Growns et al. 2003).

The ability of *E. densa* to thrive in slow-flowing waters containing high nutrients is well documented (Roberts et al. 1999). *E. densa* tolerates a wide range of environments and nutrient levels, particularly phosphorus. It has a low light requirement and cannot tolerate high light intensities. As a result, the turbidity of Australian waters is likely to favour rather than hinder growth (Parsons & Cuthbertson 2001). In the Hawkesbury–Nepean River system of New South Wales, over the course of two years, increasing restriction of navigation and the loss of native macrophyte habitats have become evident because of *E. densa* (Roberts et al. 1999).

The Washington State Department of Ecology (2007) states that '*E. densa* forms dense beds that interfere with recreational uses of a waterbody by interfering with navigation, fishing, swimming, and water skiing'. This statement is supported throughout the literature, which states that widespread growth of this aquatic plant seriously impairs the multiple uses of surface water and promotes eutrophication. *E. densa* promotes eutrophication because it has very little fibrous material and starts to decompose when temperatures exceed 30 °C and/or water level decreases allowing high light penetration. When this occurs, the plant releases high levels of phosphorus into the water (Cook & Urmi-Konig 1984).

Economic benefits

E. densa has been spread worldwide through the aquarium trade and is easily cultivated in indoor aquaria. It is also used for biochemical and physiological investigations such as uptake and internal transport of various substances, metabolism of photosynthesis, movement of chloroplasts, hydraulic conductivity, bio-electric potentials, function and structure of phloem and the geometry of cell division (Cook & Urmi-Konig 1984).

Lara et al. (2002) state that 'among the higher aquatic plants, *E. densa* has been the preferred material for a number of different studies in plant physiology. One of the main reasons for its use in such studies is that its leaves contain a single longitudinal vascular bundle and the blade consists of two layers of cells only, allowing studies of the whole undamaged organ in a natural environment. In this plant, heterogeneity is reduced to a minimum; all leaf cells are in direct contact with the external medium and at the same developmental stage and thus in similar physiological condition. These properties, together with the leaf polarity displayed by *E. densa*, represent an advantage for different kinds of research and make this species one of the model organisms of the plant kingdom for experiments, such as electro-physiology'.

Pest potential in Queensland

E. densa is currently widespread and abundant in South East Queensland. *E. densa* prefers cool climates and this study predicts that it has already spread over much of its bioclimatic range in Queensland. However, *E. densa* may expand its range to some degree into cool-climate areas and perhaps upland areas of North Queensland, such as eastern parts of the Atherton Tablelands (wherever water temperatures rarely exceed 30 °C). Downstream of these areas, *E. densa* has the potential to establish in winter and then cause problems in summer when it quickly decomposes once temperatures exceed 30 °C, perhaps causing water quality problems and eutrophication (Cook & Urmi-Konig 1984).

E. densa is widely available and sold in aquarium or water garden dealerships. It is commonly promoted on commercial websites as a desirable aquarium plant. It also occurs as a contaminant among other plant species that are offered for sale (Kay & Hoyle 2001). There is a risk that continued sale and cultivation of this species in Queensland could accelerate its spread into additional areas.

Control options

Once *E.densa* has become established, eradication is generally impossible. Therefore, prevention is vital (Westerdahl & Getsinger, 1988). Localised control (in swimming areas and around docks) can be achieved by covering the sediment with an opaque fabric that blocks sunlight. Managers of reservoirs and some lake systems can lower the water level as a method of managing aquatic plants. Goldsby and Sanders (1977) reported that consecutive draw-downs in Black Lake, Louisiana eradicated *E. densa*. They noted that consecutive draw-downs may be more effective than an individual draw-down. The success of a draw-down is dependent on several factors such as degree of desiccation (draw-downs in rainy western Washington are often ineffective), the composition of substrate (sand versus clay), air temperature (the exposed sediments need to freeze down to a depth of 30 cm) and the presence of snow.

Mechanical

Hand pulling, cutting and digging with machines are costly, provide only temporary relief and, simultaneously, encourage spread by fragmentation (Parsons & Cuthbertson 2001). Therefore, mechanical control should only be used when the extent of the infestation is such that all available niches have been filled. In these circumstances, harvesting can remove surface mats and create open areas of water. Harvesting has been used extensively on Long Lake, Kitsap County to control *E. densa* (Goldsby & Sanders 1977).

Herbicide

Numerous, largely unsuccessful, attempts have been made to control *E. densa* using herbicides (Dillon et al. 1988). Diquat is recommended in Western Australia (Parsons & Cuthbertson 2001). There are no current permits or registered chemicals for use on *E. densa* in Australia (AVPMA 2007). In the United States, Westerdahl and Getsinger (1988) report control of *E. densa* using diquat and complexed copper, endothall dipotassium salt, endothall and complexed copper. California reports good control achieved using complexed copper alone.

In one case, fluridone (Sonar®) was used to treat *E. densa* in Lake Limerick in 1995 with good results. A year after treatment *E. densa* biomass had declined by 95% throughout the lake. However, some surviving stems initiated new growth. *Egeria densa* continues to regrow in Lake Limerick. However, the 2000 spring survey showed that the mean biomass of *E. densa* in the lake was still only 11% of the biomass present in the lake before treatment and five years after the whole lake Sonar® treatment (Washington State Department of Ecology 2007).

Biological control

Recent research in Brazil has identified a fungus (*Fusarium* sp.) that damages *Egeria densa* when growing in the laboratory (Barreto et al. 2000). This may have potential as a biological control agent.

Triploid grass carp find *E. densa* highly palatable and have been used to manage *E. densa* in Devil's Lake, Oregon and Silver Lake, Cowlitz County, US (Washington State Department of Ecology 2007). However, grass carp often remove the entire submerged plant community and should be used with great care. Grass carp are also not suitable for use in water bodies where inlets and outlets cannot be screened and are included in the Queensland noxious fish list. As such, they cannot be released into Queensland waterways.

Australian aquatic weed risk assessment model score

	Egerial densa	*Elodea canadensis*
Ecological adaptation		
water level fluctuation 0–3	2	2
salinity 0–2	0	0
water/substrate 1–2	1	2
clarity 0–3	1	0
habitat range 1–3	1	1
lentic 0–3	3	2
lotic 0–3	3	1
wetland 0–3	0	0
Competition		
within 0–15	10	5
between 0–5	0	0
Reproduction/dispersal		
Dispersal		
bird/wind 0–5	0	0
accidental 0–3	3	3
deliberate 0–1	1	1
within 0–1	1	1
Seeding		
quantity 0–3	0	0
viability 0–2	0	0
cloning 0–5	5	5
Impact		
water use 0–2	2	1
access 0–1	0	0

	Egerial densa	*Elodea canadensis*
flow 0–1	1	0
irrigation 0–5	2	1
aesthetic 0–1	1	1
Natural areas		
biodiversity 0–5	5	2
water quality 0–3	3	1
physical 0–2	2	0
Other		
health 0–2	0	0
terrestrial weed 0–1	0	0
potential distribution 0–10	5	1
Resistance to management		
implementation 0–2	1	1
recognition 0–1	1	1
scope 0–2	0	0
suitability 0–1	1	1
effectiveness 0–2	1	0
duration 0–2	1	1
Weed history		
countries other than Australia 0–5	5	1
history in Australia -5–+5	5	5
Cultivation history		
use 1–10	10	2
volume -5–+5	5	0
TOTAL SCORE	**82**	**42**

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