

WEEDS OF NATIONAL SIGNIFICANCE

POND APPLE

(Annona glabra)

Strategic Plan

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Supporting information about the National Weeds Strategy, Weeds of National Significance and progress to date may be found at www.weeds.org.au where links and downloads provide contact details for all species, their management committees and copies of the strategy.

This strategy was developed under the leadership of the Department of Natural Resources, Queensland with full cooperation of all the States, Territories and Commonwealth of Australia.

Comments and constructive criticism are welcomed as an aid to improving the process and future revisions of this strategy.

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For further information contact:

John R Thorp, Project Manager

For the National Weeds Strategy Executive Committee

16 Flowers Court LAUNCESTON Tas. 7250

Telephone: (03) 6344 9657 Mobile: 0419 323 400 Fax: (03) 6343 1877

Email: jthorp@jta.com.au Web: www.weeds.org.au

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Dept of Natural Resources, Qld

Land Protection

Locked Bag 40

COORPAROO DC QLD 4151

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A pond apple infested creek running along the edge of farmland north of Babinda

EXECUTIVE SUMMARY

Pond apple, *Annona glabra*, is an invasive weed, with the potential to have disastrous impact in Australia. It is a semi-deciduous woody tree that forms dense thickets capable of replacing whole ecosystems. It is the weed of greatest concern in the Wet Tropics Bioregion. It grows in fresh, brackish and salt water and so is able to impact on a wide range of disturbed and undisturbed coastal ecosystems. Although an adaptable plant, it thrives best in moist, sunlit positions. Establishing a dominant understorey.

A wide ranges of habitats are currently being invaded including stream and riverbanks, paperbark and pandanus wetlands, sedge lands, mangrove communities and high tide zones on beaches

Introduced to Australia as grafting stock for custard apple, pond apple now infests more than 2,000 hectares of north Queensland. The plant's fruits and seeds are readily dispersed by fresh or salt water as well as by animals, thereby allowing pond apple to spread within and between catchments. Without intervention, pond apple could spread throughout northern Australia, extending from the Mitchell Plateau in Western Australia to Casino in New South Wales. Implementation of the Pond Apple Strategic Plan will reduce the extent of pond apple, minimise the impact of any remaining infestations and ultimately result in its eradication.

The vision for pond apple is:

Pond apple is eradicated from Australia

Steps to achieving the vision

5 year: The community recognises pond apple as a significant environmental weed and active control is commenced across its range

10 year: Isolated and strategic pond apple infestations are eradicated so the species is contained and the infested area contracts

20 year: The plant is eradicated from Australia

The national strategy has four closely linked

goals that will be achieved through implementing a range of strategies:

1 Alert the community to the impact and seriousness of pond apple

- Identify the target community
- Develop and extend targeted education programs
- Nominate pond apple as a key threatening process
- Encourage community ownership of the issue
- Develop targeted awareness campaigns to raise community awareness of the threat

2 Contain the spread

- Map current distribution
- Identify the potential geographic area at risk from spread by water currents
- Educate the community on vectors of spread
- Develop procedures for early detection of new infestations
- Prevent cultivation

3 Infestations of pond apple are systematically controlled

- Develop best practice control methods
- Eradicate isolated infestations
- Document economic / environmental / social impacts of pond apple infestations
- Promote pond apple management as a component of landscape reclamation
- Contain well established infestations
- Ensure long term control programs
- Use enforcement to ensure compliance with management actions
- Review, document and distribute information on current and potential incentives/ disincentives to control
- Look at biocontrol.

4 Coordinate management

- Maximise the availability of resources and the efficiency of their use
- Monitor and evaluate implementation of the strategy and its impacts on the problem.

THE CHALLENGE

Pond apple is potentially one of Australia's most environmentally damaging weeds as it invades remote nationally significant sites, including endangered ecosystems in World Heritage properties of the Wet Tropics of Queensland. Unlike many weeds, pond apple can invade and destroy undisturbed ecosystems.

Invades undisturbed and hard to access sites: Pond apples is a very hardy tree. The impacts and survival of pond apples are aided by the development of dense thickets, tolerance to salt and inundation, effective seed dispersal and seed germination spread over several months. It continues to invade areas of northeast Australia spread by water and fruit eating animals. Many sites are remote and possibly dangerous (crocodile habitat) making pond apple plants hard to find and risky to control. Control staff must be dedicated to ensure effective control first time minimising the need for re-treatment but ongoing vigilance is also required due to possibility of re-invasion.

The challenge is to ensure early detection and control of all new infestations.

The impact is very high: Pond apple competes strongly in native wetlands and other natural ecosystems, reducing biodiversity, ecosystem function and conservation values. Management of pond apple in natural ecosystems can be extremely difficult. The mechanics of eradication illustrate how a significantly greater burden of labour must often be accepted in treating environmental weeds than for other weeds. Workers must be careful that the treatment does not create disturbance that will facilitate re-occupation by the weed or other exotic species.

The challenge is best practice management of pond apple thickets resulting in effective revegetation or sustainable land use.

Options for management are limited: Current management techniques are not always effective. A method to achieve management and rehabilitation of some pond apple infestations needs considerable development and extension. Opportunities exist in several areas including herbicide

technologies, fire, revegetation methods and possibly biological control. We can also learn from the management of other invasive trees.

The challenge is to come up with answers for effective control / management options.

Identification and scope of problem: The pond apple problem is relatively new and so the species and its impacts are not known to many land managers. Awareness and identification products are required to raise the profile of this species. Some landholders are not concerned about pond apple. Only limited enforcement is currently possible through local government declaration.

The challenge is to have land managers aware of the pond apple problem.

Community, government and industry involvement: A small industry utilises this species but the whole community benefits from its removal in non-production areas. Appropriate government agencies have a public responsibility to reduce the impact of pond apple on public managed lands.

The challenge is to get whole community ownership of the problem.



A dense pond apple infestation in Warrina Lakes Environmental Park, Innisfail, Queensland

1 BACKGROUND

Pond apple is a weed of national significance; thickets of this woody weed are capable of replacing highly productive and biologically diverse ecosystems. It currently affects lands of agricultural, tourism and high environmental value and poses an enormous threat to coastal regions, particularly throughout northern Australia, some of which are endangered.

1.1 The biology of pond apple

Pond apple, *Annona glabra* (synonym: *Annona palustris*), is a semi-deciduous woody plant that grows to 15 metres and forms dense thickets. A member of the genus *Annona* (137 species) in the family Annonaceae, pond apple has no close native relatives in Australia. Other species in the genus are grown commercially in Australia: *A. cherimola* (cherimoya or custard apple), *A. reticulata* (bullock's heart) and *A. squamosa* (sweet apple or sweet sop). There are 30 dissimilar native species of the family growing in the rainforests of north Queensland. Pond apple may be confused with some native mangrove species due to the presence of lenticels and its occurrence in mangrove communities.

A lifecycle diagram (Figure 1) summarises key parts of the plant's biology, identifying control points. Leaves are alternate, oval shaped and aromatic when crushed. Dull green leaves of mature trees turn yellow and fall in the dry season, assisting in aerial detection. Plants are usually single trunked but multiple stemmed plants are also common since several seedlings may germinate together. The soft wooded stems have a grey bark with prominent lenticels (a pore which allows the gaseous diffusion between the interior of the plant and the environment). The wood and roots both float readily, whether fresh or dry.

Plants are believed to reach reproductive maturity in two years producing pale yellow to cream flowers 2-6cm in diameter containing three leathery outer petals and three smaller inner petals. The inner base of the flower is red. Fruit set is limited by floral biology; the flowers are hermaphroditic but do not self-pollinate and pollination is most probably brought about by beetles.



Green fruit 5-15cm in diameter form over summer and autumn and contain about 140 pumpkin-like seeds. The size and longevity of the seed bank is not yet known. Water is the main dispersal agent for the fruit and individual seeds. Floodwaters and ocean currents carry pond apple fruits and seeds appear to remain viable after prolonged periods in salt or fresh water. Animals, including fruit bats, cassowaries and feral pigs spread seeds within and between catchments. Fruit bats have been seen carrying whole fruit into the Innisfail swamp and seeds passing through pigs and cassowaries remain viable.



The plant tolerates some mutilation or damage. Cut stems may strike if they come into immediate contact with wet soil. The significance of this in the lifecycle is unknown.

Pond apple favours moist environments; replacing the understorey of wetland and riparian communities with dense seedling thickets becoming the sole canopy tree over time. Pond apple is versatile; it grows in fresh, brackish and even saline waters, where it acts very much like the mangroves it replaces. The plant will not survive, however, in areas that are permanently

inundated or too shady. Pond apple is adapted to a wide range of soils including moist sand depressions, steep hillsides on metamorphic soils and the high tide mark on rocky coastal shores.

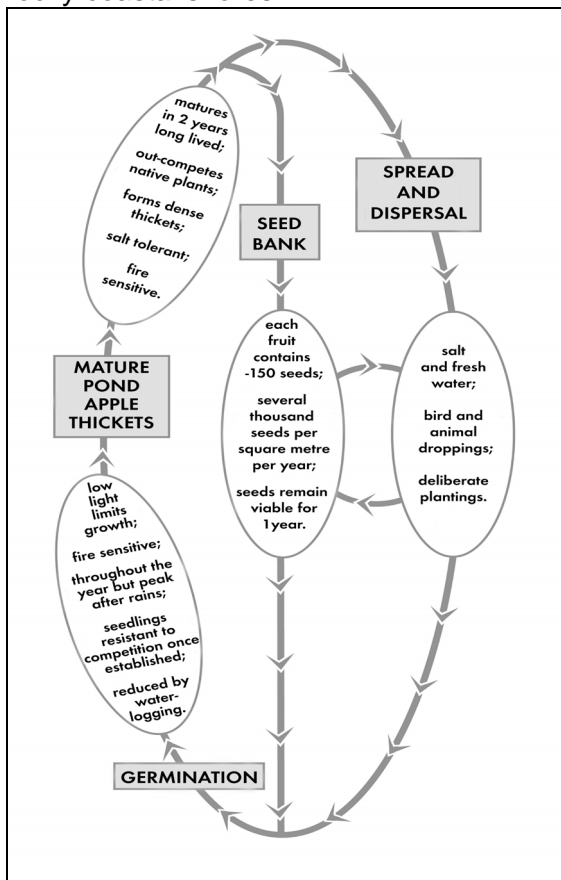


Figure 1. Lifecycle of pond apple

Disturbance can play an important part in encouraging infestations of pond apple. Seedlings require moist to wet, generally well lit conditions. This disturbance can be of a natural or human origin. For example, cyclones can create canopy gaps that allow light to penetrate rainforest environments allowing the growth of pond apple. A reduction in canopy cover after disturbances results in higher light intensity and soil temperature, factors which stimulate germination and growth. In a different case, excessive drainage of coastal land through land reclamation raises saline water tables killing paperbarks but allowing the growth of the more salt tolerant pond apple. Storm surges or high tides that result in increased salinity may also favour pond apple. The infestation in Mutchero Inlet may have resulted from such an event. Pond apple fruit is edible and is reportedly sold in north Queensland as “caramel custard apple” (Low 1999). Nurseries in New South Wales and the Northern Territory also sell plants of this species. Pond apple is still used

commercially as a salt and water tolerant rootstock for custard apple in north Queensland. Trade and any horticultural uses of the plant increase the risk of further spread.

1.2 History of spread

Native to the Central Americas: Puerto Rico, Columbia, Ecuador, Costa Rica, Nicaragua, Honduras, the Leeward islands, Mexico and Florida; pond apple has also spread naturally to coastal West Africa. Pond apple is naturalised in Sri Lanka, Thailand, Vietnam, mangrove communities in the Malay Peninsula and possibly China.

Pond apple is first recorded in Australia from the Cooktown Botanic Gardens in 1886. It was subsequently imported as grafting stock for commercial custard apple production. It has since invaded waterways and wetlands, mostly between Ingham and Cooktown, but also south to Mackay and north to some inhabited islands in the Torres Strait (Appendix 1). Pond apple is grown in home gardens in the Northern Territory but no infestations are known in the territory or for New South Wales.

The Russell River, south of Cairns, is central to the naturalised distribution of pond apple. More than 600 hectares are affected including most water bodies in the catchment.

The plant can be found in a wide range of climates and ecosystems from rainforest creeks such as Jumrum Creek near Kuranda with 2000-2500 millimetres rain per annum to open forest at Paddy's Creek with 750 millimetres per year.

Although areas such as the Upper Murray have been infested for 80+ years the pond apple problem has arisen quite quickly in some areas with infestations in Douglas Shire thought to be about 25 years old.

Areas at immediate risk from pond apple are the estuaries and floodplains of northeastern Cape York, due to the northward movement of currents from infested creeks. The finding of plants north of Cooktown, by NHT Cape York Weeds and Feral Animals Project staff, due to tidal flow from the Cooktown infestation, highlighted this risk.

Potentially, the species could spread throughout northern Australia, across the Northern Territory into Arnhem Land and the Daly and Victoria Rivers and along the coastline to the Mitchell Plateau of Western Australia (although the risk to the latter site is very low) (Figure 2). Infestations could establish as south as Casino in New South Wales. Establishment further south is unlikely, as seeds require a period of temperatures above 25°C for germination.

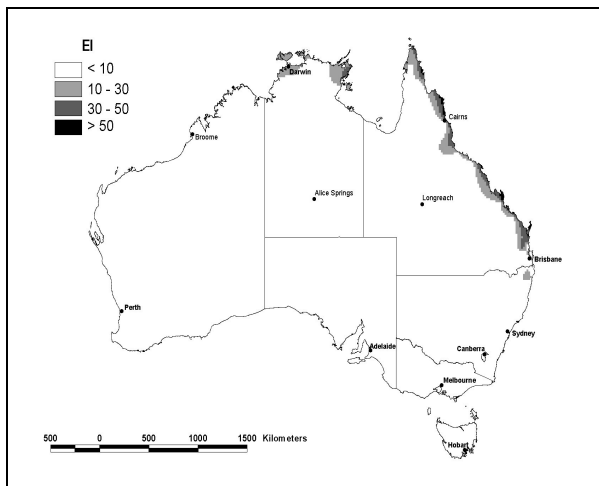


Figure 2. Potential distribution of Pond apple

(Data is splined from a CLIMEX prediction. EI = Ecoclimatic index. EI < 30, low potential for permanent population, EI > 50, potential for permanent population is very high.)

1.3 A weed of national significance

Environmental impacts:

- Pond apple is the weed of greatest concern in the Wet Tropics Bioregion
- A wide ranges of habitats are currently being invaded including stream and riverbanks, paperbark and pandanus wetlands, sedge lands, mangrove communities and high tide zones on beaches
- The tropical wetlands affected are of restricted distribution and of national and international importance including World Heritage areas
- Some affected wetlands are endangered or restricted bioregional ecosystems
- Pond apple forms a dense understorey/sub-canopy, replacing ferns, grasses, shrubs and sedges and prevents tree regeneration
- Seasonally inundated coastal habitats supporting paperbarks (*Melaleuca viridiflora*, *M. leucadendra*, *M. quinquenervia* and *M. cajuputi*) and mangroves are at risk

- Time between fires is lengthened due to the reduction in understorey in infested areas
- Many infested ecosystems are habitat for rare and threatened flora and fauna: infestations of paperbark swamps in Douglas Shire threaten; the vulnerable ant plants (*Myrmecodia beccarii*) that, in turn host the larval symbionts of the endangered apollo jewel butterfly (*Hypochrysops apollo*) and endangered orchids (*Dendrobium nindii*, *D. mirbelianum* and *Phaius tancarvilleae*)
- The fruit provide a food source for fruit eating animals including the endangered southern cassowary (*Casuarius casuarius ssp. johnsonii*). In Innisfail, however, pond apple along a main road significantly increases the risk of vehicular fatalities to these birds.
- Unlike many weeds, pond apple can invade and destroy undisturbed ecosystems e.g. infestation found in an undisturbed catchment within the Graham Range National Park
- Pond apple has invaded 14 protected areas and 10 Wetlands of National Significance
- It is worth noting that pond apple is threatened in the USA. In Florida, vast pond apple forests have been drained for farming and removed for other human activities. This loss has seen a commensal plant species *Cucurbita okeechobeensis* (the Okeechobee gourd) listed on the United States endangered plant list.

Tourism, recreation and amenity impacts:

- Thickets of pond apple restrict access and impair outlooks and the general variety of the coastal recreational experience
- Creeks may become muddy monocultures which indirectly this affects local tourism and affiliated industries.

Primary production issues:

- Current impacts to primary industries are not large. Pond apple plantings may be used to stabilise creek and riverbanks and to suppress weeds in cane drains
- Pond apple's impacts are increasing however as these plants spread to affect the cattle and cane industries by growing in and along creeks, fence lines and farm drains

- Thickets result in restricted access and movement of animals, humans and vehicles and additional control costs
- Low lying cane land may be invaded after floods or after long ley periods or pond apple may spread out from infested drains.
- Replacement native species for the current industry use of pond apple are known e.g. creek cherry (*Syzygium australe*).

1.4 Legislative controls

Pond apple is not declared at the state level in Queensland at this time but it will be declared under the *Land Protection Act 2001*. Several local governments currently declare it, Cairns City, Douglas and Cardwell Shires. Pond apple has recently been declared as a "prohibited entrant" in the Northern Territory in the new *Territory Parks and Wildlife Act 2001*. It is not declared in other states. Although it has not been recorded as naturalised, it may currently be grown, traded or distributed from these states. Nationwide declaration is required to ensure that this does not occur.

1.5 Control to date

A number of control measures have been used for pond apple. The success and type used, however, will depend on each site. Very careful consideration of control methods is necessary as the weed mostly occurs in sensitive environments. Methods should be chosen that do not affect adversely on non-target plants or on the surrounding environment. Minimising disturbance of sites will assist in restoration of the natural environment.

Pulling and bulldozing have been used successfully in drains in Cairns (Babinda). However, disturbance of surrounding areas for access should be minimised. Sites must be monitored to ensure pond apple seedlings that emerge afterwards are removed. Where sites are prone to erosion or weed establishment after pond apple removal, areas should be revegetated using local native plant stock. Consideration of the requirements of native fauna, such as cassowaries, is important in revegetation. Naturally occurring cassowary food plants should be used where appropriate to replace pond apple.

Pond apple plants and possibly seed are destroyed by fire and it has been employed in areas with sufficient understorey to sustain a fire, such as the sedge/grass community in

Eubenangee Swamp National Park. The effects of fire, however, leading to habitat changes must be considered. For example, an understorey of sedges, grasses, ground orchids and a simple grass layer through inappropriate fire regimes can replace other herbaceous plants. In addition, caution is required in riparian and wetland areas to prevent destruction of rainforest or mangrove plants and to minimise effects on the area's ecology.

Herbicides available for woody weeds have proved effective. Trees have been controlled by stem injection using triclopyr plus picloram or by glyphosate. Triclopyr plus picloram can also be used for basal bark spraying and treatment of seedlings, provided dry conditions prevail. Although grasses are not affected in the latter case, native herbs and broad-leaved saplings can be killed by this method. Basal barking may not be as effective as stem frilling with some resprouting observed from the former method. Stem injection may be a slower, more laborious method but is an important consideration for avoiding chemical runoff and protecting existing native vegetation.

Biological control has not been investigated for pond apple. Researchers will need to find agents that do not affect commercial or native family members but this has been successful in the case of other WONS species such as blackberry so it is possible.

1.6 Principles underlying the plan

This Strategy is based on the recognition and acceptance of four principles outlined in the National Weeds Strategy:

1. Weed management is an essential and integral part of the sustainable management of natural resources and the environment, and requires an integrated, multidisciplinary approach.
2. Prevention and early intervention are the most cost-effective techniques that can be employed against weeds.
3. Successful weed management requires a coordinated national approach, which involves all levels of government in establishing appropriate legislative, educational funding and coordination frameworks in partnership with industry, landholders and the community.
4. The primary responsibility for weed management rests with the

landholders/land managers but collective action is necessary where the problem transcends the capacity of the individual landholder/land manager to address it adequately.

1.7 Process followed

Participation and consultation of all stakeholders is paramount in the development of a successful strategy. The national strategy for pond apple is a product of 4 months of planning and public consultation. It was developed through the Pond Apple National Strategy Workshop (held in South Johnstone on 16-17th August 2000), attended by eighteen local government, state government, community, industry and conservation representatives from across north Queensland. A questionnaire was given to all participants to capture the community's knowledge and current activities on this species.

The draft strategy was forwarded electronically to individuals and groups who expressed interest during the development process. The draft was also distributed at a symposium that was attended by over one hundred people working in resource management. Many of these individuals provide links to major stakeholder networks through their membership. The final document takes into account feedback from 15 stakeholders who commented on drafts.

1.8 Relevance to other strategies

The pond apple strategy has been created to provide a framework for coordinated management of pond apple across the country. Complementary linkages can be found in a range of existing resource management initiatives at all jurisdictional levels as shown in the table below.

Table 1: Policy and strategy linkages

Scope Scale	Natural Resource Management	Weed Management	Weed Species Management
National	National Strategy for Conservation of Biodiversity National Strategy for NRM National Strategy for Ecological Sustainable Development	National Weeds Strategy; Weeds of National Significance	Weeds of National Significance Pond Apple Strategy
State	State Biodiversity and Natural Resource Management Strategies	State Weed Strategies	
Regional	FNQ 2010 - Regional plan for far north Queensland Wet Tropics Regional Strategy for Natural Resource Management	Regional Pest Management Strategies	
Catchment	Strategy for the Conservation and Management of Queensland Wetlands Strategic Management Plan for the major rivers and streams in Douglas Shire	ICM Pest Management Strategies	NQ Afforestation Catchment Rehabilitation Plans – Russell-Mulgrave, Tully-Murray, Barron
Local	Landcare plans, Conservation corridor plans, Riparian vegetation management plans and Bushcare plans	Local Government Pest Management Plans (Qld.)	Pond apple plans in Cairns City and Cook, Cardwell and Douglas Shire pest management plans
Property	Property Management Plans National Park Plans of Management	Property Pest Management Plans National Park Weed Management Strategies (Qld and NT)	Property species management plans

2 STRATEGIC PLAN

VISION

Pond apple is eradicated from Australia

2.1 Steps to achieving the vision

5 year: *The community recognises pond apple as a significant environmental weed and active control is commenced across its range*

10 year: *Isolated and strategic pond apple infestations are eradicated so the species is contained and the infested area contracts*

20 year: *The plant is eradicated from Australia*

2.2 Alert the community to the impact and seriousness of pond apple

Desired Outcome

The community becomes aware, committed and skilled to take action on pond apple.

Background

Coordinated regional, statewide and potentially nationwide awareness campaigns are essential to ensure that the whole community is aware of the significance of the pond apple threat. Many community members need to be skilled in its identification, including community rangers, parks and garden supervisors, fisheries inspectors, tree planting crews, sugar cane environmental officers and Landcare coordinators. Two specific target groups are; indigenous communities and isolated stations, both will require specific products.

Strategy	Actions	Responsibility	Rank
2.2.1 Identify the target community	Identify key stakeholder groups across the infested areas	PondMG	1
	Develop tools and appropriate strategies for reaching these groups including isolated communities	DNR Extension, local government	1
2.2.2 Develop and extend targeted education programs	Procure and train key staff to provide extension	DNR	1
	Establish best practice demonstration sites and conduct training in management techniques	DNR, EPA, Industry groups, WTTPS	1
	Develop effective identification tools and packages to ensure easier identification of plant/seeds (link to 2.4)	LG, DNR, WTMA, NT/NSW	2
2.2.3 Nominate pond apple as a key threatening process	Collate information required to nominate the impacts of pond apple invasions to Environment Australia as a key threatening process under Commonwealth legislation	DNR, EPA, PondMG	1
2.2.4 Encourage "community" ownership of the issue	Increase field officer awareness	DNR, LG, EPA, NT	1
	Raise awareness with politicians – local, state and national	All stakeholders	1
	Initiate action groups and target activities to Canegrowers, farm workers, national parks, the tropical fruit industry and schools	L G, Landcare, ICM, Coastcare, WTMA, NTDPIF, DNR	2
	Hold community control days	LG, DNR, WTTPS	2
	Use fishing groups and aboriginal groups for detection of remote infestations	DNR Extension, DPI (Fisheries), ATSIC	2
2.2.5 Develop targeted awareness campaigns to raise community awareness of the threat	Develop multifaceted mass media products (TV, radio and Internet) and print media	DNR, WTMA, EPA, NT/NSWAg	1
	Target local government through pest management process	LG, DNR	1
	Provide displays at community events such as Croc Eisteddfod, Bamaga Show and TI cultural festival and linkages with other existing field days	LG, DNR, Community councils, WTMA	1
	Develop postcards, leaflets, departmental envelopes	DNR Extension	2

2.3 Contain the spread

Desired outcome

The current distribution of pond apple is mapped and its potential spread is prevented.

Background

It is essential to map the full extent of the problem in Australia, including those areas susceptible to pond apple invasion in surveys outside the known infested areas including other states. This will include contacting all state herbaria, local, regional and state botanic gardens and land protection staff in other states and other regions of Queensland. Maps should be at a detailed level (1:25,000) and should include the best access route given that the species occurs in remote country. It will be very important that the person doing the mapping is in contact with land managers to ensure that both parties are aware of the presence of the plant to ensure that control actions are undertaken and follow up is observed.

Water is the major vector of pond apple so early detection of plants associated with water bodies, outside of known infested areas is critical. It is important that these areas are prioritised and regular surveys carried out, particularly following major rainfall events. Pond apple has a recognisable aerial signature, due to its leaf yellowing in the late dry season (September to November) that should help in surveys.

A high priority is to document the history of the use of pond apple in Australia. It is important to determine if and where the plant continues to be grown, either as a rootstock or as a fruit tree, and where across Australia it has been planted. Pond apple cuttings are currently available commercially from at least one "botanical garden" in northern New South Wales. It will be important to discuss the problems with this species with groups that may want to continue to trade or distribute this species.

Strategy	Actions	Responsibility	Rank
2.3.1 Map current distribution	Collate existing maps	DNR, PondMG	1
	Produce a state/national map and distribute	DNR	1
	Hold mapping information in central system (PestInfo)	DNR	1
	Survey areas not currently mapped, including interstate, and records of plants from herbaria	DNR, LG, NT/NSWAg	1
	Collect voucher specimens from outlier infestations	DNR, LG, EPA, NAQS	2
	Ground truth information including areas subject to control	DNR, LG, EPA	2
	Trial aerial coastal surveys to supplement ground mapping	DNR, EPA, WTMA	2
2.3.2 Identify the potential geographic area at risk from spread by water currents	Identify high risk coastal infestations for early control	DNR	1
	Collate information on coastal currents in Queensland	DNR, EPA, GBRMPA	1
	Target high risk coastal sites for surveys	LG, DNR	1
	Determine the viability of seeds in water to better define the risk posed by this mode of spread	DNR (TWRC)	1
2.3.3 Educate the community on vectors of spread	Collect and collate information on vectors (see Goal 3.1)	DNR (TWRC), EPA	1
	Disseminate this information to target specific community groups eg. friends of cassowaries groups, fishermen, agriculture and backpackers	PondMG members	1
2.3.4 Develop procedures for early detection of new infestations	Develop a survey procedure that maximises returns for time and effort expended	DNR, LG	1/2
	Encourage vigilance within the community to report to appropriate authorities eg. fisherman, pig hunters and indigenous communities	DNR, LG, NAQS	2
2.3.5 Prevent cultivation and trade	Stop the sale and use of pond apple as a rootstock for custard apple	Nursery industry, NT/NSWAg/DNR	1
	Discuss the issue of invasiveness of this species with groups which may cultivate pond apple (see also Goal 3.8)	Nursery industry, DNR/NT/NSWAg, LG	1
	Investigate the current use and distribution in gardens, including indigenous communities, and commercial sales	DNR, LG, DPI, nursery industry, NT/NSWAg	1/2
	Recommend species for cultivation instead of pond apple	NR, DPI, EPA, WTTPS	2
	Prevent importation of pond apple into Australia	AQIS	2

2.4 Infestations of pond apple are systematically controlled

Desired Outcome

Pond apple infestations are removed using environmentally safe best practices resulting in restored sustainable ecosystems.

Background

Large information gaps still exist in our understanding of the biology, ecology and impacts of pond apple. Research is needed on both the ecology of pond apple and ways to control the species. Recommendations on best practice management must acknowledge the variety of locations and situations in which pond apple occurs. For example some pond apple infestations are very public (along the reaches of the North and South Johnstone Rivers) and so removal must be managed in a manner acceptable to the local community. These methods may be slower than those that would be used in less public sites. At the same time, many of the northern infestations of pond apple occur on the uninhabited coastlines and along mangrove creeks and streams. These sites require surveys by small boat and the staff carrying out the control actions is at risk from saltwater crocodiles.

The present scarcity of pond apple, combined with the enormous potential impacts of infestations, is reason to eradicate all infestations of pond apple in Australia. A systematic approach and planning is necessary to achieve this aim. This involves immediate treatment of strategic and isolated infestations and coordinated control of large infestations including the development of buffer zones. Effective buffer zones require research on the distance of spread by animal and water vectors. Community groups will be encouraged and provided resources to ensure that pond apple management is included in projects.

Control programs are expensive and require on-going land manager commitment to follow-up, especially if eradication is to be achieved. Some disincentives to control of pond apple include; bank stability post-removal, current small economic impact, poor access to sites, costs of control and safety concerns. Alternative species are available to replace the species from both WTTPS and commercial growers but the cost of purchasing, planting and maintaining the treated areas may be an obstacle as is supply of seeds from local provenances. The primary emphasis is on encouraging landholders, through involvement in weed management, to offer ownership of the issues and consequent outcomes. Once this species becomes declared at a state level enforcement should be considered as an option to ensure actions are undertaken.

Pond apple eradication should not be considered in isolation from other property or catchment management activities. Attention should be given to the total requirements of landscape restoration rather than only weed control. Furthermore, weed management should be considered as part of property management planning and coordinated with other management activities to maximise the benefits of control and seasonal fluctuations.

The vision of this strategy is eradication and so biological control has been listed as a low priority but it is a fall back option. An initial survey of agents is proposed. The commercial use of the genus will prohibit the release of biocontrol agents unless species-specific agents can be found but this has been successful for blackberry.

Strategy	Actions	Responsibility	Rank
2.4.1 Develop best practice control methods	Collate current information on all control methods	DNR (TWRC)	1
	Register herbicides for seedlings, saplings and trees	DNR	1
	Continue research on mechanical control, flower biology, seed ecology and dispersal, aerial spraying, revegetation and use of fire both broad scale and for individual trees	DNR (TWRC)	1
	Develop best practice methods for public sites	DNR, WTMA, EPA	1
	Train control staff in best practice methods	DNR, LG	1
	Develop extension material on the use of chemicals	DNR, industry groups	2
2.4.2 Eradicate isolated infestations	Develop a prioritisation system for control programs	DNR	1
	Develop control plans for isolated or strategic sites, e.g. controls of upstream sections of larger infestations	DNR, LG, QPWS	1
	Treat infestations and ensure follow up	Land managers, LG	1
2.4.3 Contain well established infestations	Undertake control on riparian areas and irrigation drains as a high priority, starting in the south	All groups	1
	Establish buffer zones around heavy infestations eg. at property level by clearing scattered plants and upstream	LG, land managers	2
2.4.4 Ensure long term control programs	Develop eradication plans for each heavy infestation according to risk of spread	DNR, LG, QPWS, land managers	1
	Ensure follow-up for at least three years at all sites	LG	1
	Carry out control works on prioritised heavy infestations with available resources over time	LG, QPWS, DNR, land managers	1
2.4.5 Document economic/ environmental/ social impacts of pond apple infestations	Collect data on impact of pond apple (production, biodiversity/ amenity/ hydrology)	DNR, LG	1
	Highlight the cost of infestations to uninfested areas	DNR, LG, WTMA, EPA	1
	Ground truth environmental range and impacts	DNR, EPA, LG	1/2
2.4.6 Promote pond apple management as a component of landscape reclamation	Ensure a holistic approach to site restoration	All groups	1
	Research methods of revegetation to minimise weed re-establishment focusing on pond apple	DNR, EPA (CNC), WTTTPS	2
	Determine species/ quantities of species native to the area for revegetation, including replacement food plants	DNR, Landcare, EPA (CNC), WTTTPS	2
	Control all exotic species if more than pond apple is found at the site	DNR, LG, land managers	2
2.4.7 Use enforcement to ensure compliance in Queensland	Declare pond apple in Queensland to invoke landholder responsibility for control	DNR	1
	Promote the legislative responsibilities of all landholders	DNR, LG	1
	Ensure enforcement is used when required	LG, DNR	1
	Determine land tenure of affected lands	DNR, LG	2
2.4.8 Review, document and distribute information on current & potential disincentives / incentives to control	Document forms of assistance available	DNR, LG	1/2
	Investigate an environmental levy to fund control programs to ensure that the whole community pays	LG	2
	Use labour market schemes or volunteer crews for control or follow-up work on treated infestations where possible	LG, EPA	2
2.4.9 Look at bio-control	Investigate possible agents in the America's	DNR (Research)	3

2.5 Coordinate management

Desired outcome

Pond apple management is coordinated and maintained nationally

Background

The resources required to prevent the spread of pond apple and eradicate it are large. There is a need to ensure that all available resources are utilised and that all achievements and actions are documented as a measure of progress and success. This is also part of accountability requirements on government and private industry managers to ensure efficient use of resources. Approaches for funding should be co-ordinated to maximise potential success. This includes ensuring that WONS with similar growth forms, impacts and distributions are managed together.

As an environmental weed pond apple poses the problem that there are little incentives for private landholders to manage this species,

other than the long-term prospect that the environment in which the landholder lives will be irreversibly affected if the actions are not taken. This must be recognised and is best addressed by ensuring that all members of the community appreciate the long-term impact if these actions are not taken and support landholders who undertake this altruistic action.

Management on government land is required, as this species occurs in National Parks, reserves and unallocated State land. Many community groups in north Queensland are involved in revegetation projects and although they are not able to carry out all control actions (those using chemicals or involving dangerous situations) they will be very important in working with professional groups to carry out initial treatment programs or follow up revegetation works if resources are made available.

Strategy	Actions	Responsibility	Rank
2.5.1 Maximise the availability of resources and the efficiency of their use	Seek and maintain adequate resources for ongoing research to improve understanding of pond apple and increase management options	DNR	1
	Encourage and support on-ground control of infestations by community groups	DNR, LG, all groups	1
	Determine criteria for assistance or incentive programs	DNR, LG, PondMG	2
2.5.2 Monitor and evaluate implementation of the strategy and its impacts on the problem	Establish and maintain a Pond Apple Management Group (PondMG), with close links to the Far North Queensland Pest Advisory Forum	DNR	1
	Establish linkages and joint action with WONS strategies	DNR	1
	Ensure pond apple management in all coastal local government area pest management plans	PondMG	1
	Ensure the Queensland State Land Management Committee addresses pond apple management	PondMG	1
	Collate strategic plan milestones and report on progress annually to NWSEC and stakeholders	Pond MG	1
	Market the strategy and coordinate a planned approach to funding sources	DNR	1

3 MONITORING AND EVALUATION

This Strategy is subject to a 5-year review. The Pond Apple Management Group will monitor the implementation of the plan as a component of its quarterly meetings. Annual reports will be forwarded to the National Weeds Strategy Executive Committee and made available to interest groups in the most cost effective way. Monitoring will include a review of actions outlined and undertaken in:

- State weed management strategies
- Catchment management plans
- Local government pest management plans,
- Project plans developed from this strategy
- State of the Environment reporting processes.

A set of key performance milestones include the:

- Establishment of the Pond Apple Management Group,
- Provision of adequate resources to implement the strategy,
- Establishment of a reporting process,
- Identification and documentation of best practice,
- Specific awareness products delivered to aboriginal communities and isolated communities,
- Completion of research on biology, seed ecology and control methods,
- Registration of chemicals for various control situations,
- Surveys completed and action taken on high priority areas within 5 years,
- Completion of the study of the economic impacts of pond apple,
- Introduction of national legislation restricting the trade and distribution of pond apple,
- Identification and promotion of appropriate replacement species,
- Removal of pond apple plantings from public gardens and spaces,
- Implementation of a national promotion campaign,
- Completion of mapping,
- Increased delivery of extension material specific to target groups and sites,
- Increased survey of the conservation status and health of riparian and floodplain areas,
- Recognition of pond apple impacts and management in planning initiatives at all management levels,
- Decrease in distribution of scattered pond apple infestations within 10 years and
- National eradication of pond apple in 20 years.

4 STAKEHOLDER ROLES AND RESPONSIBILITIES

Agencies and individuals share responsibilities for the strategies and actions listed in Section 2 and rely on the development and maintenance of partnerships between community, industry and government.

Industry (including wholesale and retail nursery associations, gardening clubs, television, print media, landscape architects and designers)

- Promote best practice management of pond apple,
- Contribute to extension and education on impacts of pond apple,
- Stop promoting and planting pond apple in new areas,
- Promote alternative species to the community.

State agencies (agricultural and horticultural sections of Department's of Agriculture, Forests, Environment, Natural Resources and Water Conservation)

- Introduce and enforce legislation covering sale and distribution of pond apple,
- Investigate alternative control methods and integrated management systems,
- Document and promote best practice,
- Develop long term extension and education program for specific regions and audiences highlighting the impacts of pond apple,
- Control pond apple on all State managed lands,
- Identify strategic management areas and
- Map and monitor distribution of pond apple.

Local governments (including Shire, City and Community Councils)

- Remove pond apple and ensure it is not used in public plantings,
- Enforce legislation,
- Develop and use long term extension and education strategies to highlight impacts,
- Ensure pond apple strategy goals are recognised in appropriate management plans covering the area,
- Identify priority management areas and
- Monitor and evaluate Strategy implementation.

Federal government

- Ensure uptake by Departmental staff to restrict movement of weeds (agencies that manage land and travel on non-government land),
- Ensure pond apple control is undertaken on all Federally managed lands (Defence, EA and other Commonwealth departments / corporations that manage land),
- Oversee federal funds e.g. NHT and NWP (EA, Agriculture, Forestry and Fisheries – Australia) and
- Prevent further imports (AQIS).

National Weed Strategy Executive Committee

- Identify a national weed mapping system and,
- Promote goals and objectives of National Weed Strategy to industry professional bodies, local governments (users of pond apple).

Pond Apple Management Group

- Implement and monitor the Strategy,
- Access and coordinate resources and
- Develop the Communication Committee.

Community groups (including Landcare, ICM, Greening Australia)

- Assist or offer to assist in management of pond apple,
- Assist in development and promotion of best practice,
- Canvas support for National Weed Strategy goals,
- Assist in programs to replace pond apple with native species and
- Map and monitor the distribution.

Individual land managers

- Identify and manage priority infested areas,
- Include pond apple in property management plans and
- Use replacement native or non-invasive exotic species in revegetated areas.

5 ADDITIONAL READING

Anderson PA & Richardson AC 1995. *Pollination of cherimoya in New Zealand*. NZ Plant Protection Society.

Anon. 1999. *Pond apple. Pest Fact PP58*. Queensland Department of Natural Resources.

Goosem, S., Morgan, G. & Kemp, J. 1999. *Wet Tropics*. In Sattler and Williams (eds) *The Conservation Status of Queensland's Bioregional Ecosystems*. Queensland Environmental Protection Agency.

Humphries, S. & Stanton, J. 1992. *Weed Assessment in the Wet Tropics World Heritage Area of North Queensland*. Report to the Wet Tropics Management Authority.

Lindsay, A. 19** . *Comparative Study of the Germination Requirements of Pond Apple and the dominant Melaleuca Species occurring in Broad Leaf Paperbark Forests in the Wet Tropics Area of Northern Queensland*. Queensland Department of Natural Resources.

Low, T. 1999. *Feral Future*. Viking Penguin, Victoria.

Swarbrick, J. 1993. *The biology, distribution, impact and control of five weeds of the Wet Tropics World Heritage Area*. Weed Science Consultancy. Report to Wet Tropics Management Authority.

Swarbrick, J. and Skarratt, D. 1994. *The Ecological Requirements and Potential Australian Distribution of Pond Apple (Annona glabra)*. Weed Science Consultancy.

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Workshop participants:

Department of Natural Resources: Peter van Haaren, Vic Little, Paul Davis, Peter James, Simon O'Donnell and Joe Vitelli

Cape York Weeds and Feral animals project: Alice Beilby, Russell Graham, Lex Grant, Chad Lewis:

Rainforest Cooperative Research Centre / James Cook University: Garry Werren

Northern Australian Quarantine Strategy: Barbara Waterhouse

CSIRO Tropical Forest Research Centre: Chris Margules

EPA Innisfail: John Connolly

Cardwell Shire Council: Eric Higgins

Cairns City Council: Greg Cooper

Douglas Shire Council: Mick Jeffery

Johnstone Shire Council: Albert Holder

QPWS, Mossman: Rupert Russell

7 GLOSSARY

AQIS	Australian Quarantine and Inspection Service
ATSIC	Aboriginal and Torres Strait Islander Commission
CLIMEX	A simulation modelling system developed by CSIRO
CNC	Community Nature Conservation Program of the Queensland EPA
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DNR	Queensland Department of Natural Resources
DPI	Queensland Department of Primary Industries
EPA	Queensland Environmental Protection Agency
GBRMPA	Great Barrier Reef Marine Park Authority
ICM	Integrated Catchment Management
LG	Local Government
PondMG	Pond Apple Management Group
QPWS	Queensland Parks and Wildlife Service
NAQS	Northern Australian Quarantine Strategy
NWSEC	National Weed Strategy Executive Committee
NSWAg	New South Wales Agriculture
NT	Government agencies in the Northern Territory
WONS	Weeds of National Significance
WTMA	Wet Tropics Management Authority
WTTPS	Wet Tropics Tree Planting Scheme
TWRC	Tropical Weeds Research Centre (Department of Natural Resources)

APPENDIX 1. DISTRIBUTION OF POND APPLE IN QUEENSLAND

(from Swarbrick 1993 and workshop participants)

