Risk Assessment of *Carpobrotus edulis*

Name of Organism:	*Carpobrotus edulis* (L.) N.E.Br. 1926 – Hottentot-fig
Objective:	Assess the risks associated with this species in Ireland
Version:	Final 30/09/2014
Author(s)	Erin O'Rourke and Liam Lysaght
Expert reviewer	Matthew Jebb

Stage 1 - Organism Information

Stage 2 - Detailed Assessment
Section A - Entry
Section B - Establishment
Section C - Spread
Section D - Impact
Section E - Conclusion
Section F - Additional Questions

About the risk assessment
This risk assessment is based on the **N**on-native species **AP**plication based **R**isk **A**nalysis (NAPRA) tool (version 2.66). NAPRA is a computer based tool for undertaking risk assessment of any non-native species. It was developed by the European and Mediterranean Plant Protection Organisation (EPPO) and adapted for Ireland and Northern Ireland by Invasive Species Ireland. It is based on the Computer Aided Pest Risk Analysis (CAPRA) software package which is a similar tool used by EPPO for risk assessment.

Notes: Confidence is rated as low, medium, high or very high.
Likelihood is rated as very unlikely, unlikely, moderately likely, likely or very likely.
The percentage categories are 0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%.
N/A = not applicable.

DOCUMENT CONTROL SHEET

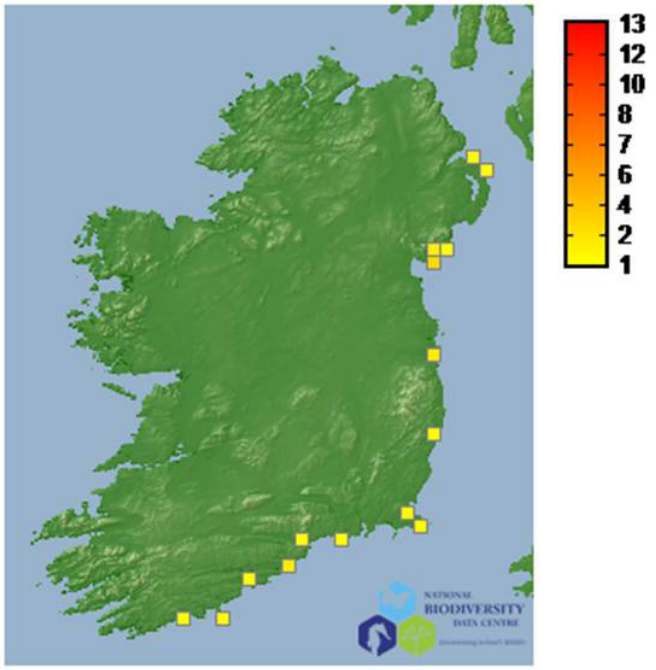
Name of Document:	Risk Assessment of *Carpobrotus edulis*				
Author (s):	Dr Erin O'Rourke and Dr Liam Lysaght				
Authorised Officer:	Dr Liam Lysaght				
Description of Content:	Non-native species risk assessment				
Approved by:	Dr Liam Lysaght				
Date of Approval:	30/09/2014				
Assigned review period:	n/a				
Date of next review:	n/a				
Document Code	n/a				
This documents comprises	TOC	Text	List of tables	List of Figures	No. Appendices
	n/a	YES	n/a	1	0

Version Control Table

Version No.	Status	Authors(s)	Reviewed by	Approved by	Date of issue
Draft 1	Complete	Dr Erin O'Rourke	Dr Liam Lysaght		17/06/2014
Expert review	Complete	Dr Erin O'Rourke	Dr Matthew Jebb	Dr Michael Millane	02/09/2014
Public Consultation	Complete	Dr Erin O'Rourke		Dr Liam Lysaght	03/09/2014
Final	Complete	Dr Erin O'Rourke		Dr Liam Lysaght	30/09/2014

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
1	What is the reason for performing the risk assessment?	-	A risk assessment is required as this species is listed as a "Non-native species subject to restrictions under Regulations 49 and 50" in the Third Schedule of the European Communities (Birds and Natural Habitats) Regulations 2011, SI 477/2011.
2	Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	YES	*Carpobrotus edulis* (L.) N.E.Br. 1926 – Hottentot-fig Taxonomy: Kingdom: Plantae Phylum: Spermatophyta Subphylum: Angiospermae Class: Dicotyledonae Order: Caryophyllales Family: Aizoaceae Genus: Carpobrotus Species: edulis Synonyms: *Carpobrotus edulis* (L.) L. Bolus 1927; Mesembryanthemum edule L. 1759. The original name for this species was *Mesembryanthemum edule* L; it was renamed *Carpobrotus edulis* by Brown in 1926 and by Bolus in 1927 (CABI, 2014). Common names (English): Ice plant; kaffir pig; freeway iceplant; cape fig; highway ice plant; sea fig; sour fig Varieties: *Carpobrotus edulis* var. *edulis*; *Carpobrotus edulis* var. *rubescens;* *Carpobrotus edulis* var. *Chrysophthalmus* (refer to Question 4; Stace, 1997) Similar species: *Carpobrotus glaucescens*; *Carpobrotus acinaciformis* (Stace, 1997).
3	If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	N/A	

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
4	Describe the organism.	-	*Carpobrotus edulis* is a robust, succulent, trailing perennial herb, which roots at nodes and forms dense flat mats (GISD, 2008; CABI, 2014). Stace (1997) describes the plant as "stems procumbent, woody, angled, to 3m; leaves 5-12cm, equally thick for most of length, c. as thick as wide; flowers mostly 4.5-10cm across; petals yellow (often but not always fading pinkish) (var. *edulis*), pinkish-purple (var. *rubescens* Druce) or pink with yellow bases (var. *chrysophthalmus* C.D. Preston & P.D. Sell); ovary flat to raised on top; receptacle gradually tapered into pedicel". *C. edulis* has a very dense fibrous root system concentrated in the upper 50cm of the soil, with new roots forming at each node as the plant spreads outward (D'Antonio and Mahall, 1991). The leaves arise in opposite pairs, are *c.*5cm in length and sharply 3-angled with a pointed, mucronate apex. Fruit is fleshy, indehiscent and edible, 35mm in diameter, shaped like a spinning top, on a winged stalk, becoming yellow and fragrant when ripe (GISD, 2008; Malan and Notten, 2006). The outer wall of the fruit becomes yellowish, wrinkled and leathery with age. The seeds are embedded in the sticky, sweet, jelly-like mucilage. The fruits can be eaten fresh and they have a strong, astringent, salty, sour taste. If they are not eaten they become very hard and dark reddish brown and decay slowly in place on the stems (Malan and Notten, 2006; GISD, 2008).
5	Does a relevant earlier risk assessment exist? (give details of any previous risk assessment for Ireland)	YES	In Ireland, a preliminary risk assessment was previously carried out. This was a prioritisation risk assessment as part of the Risk Analysis and Prioritisation for Invasive and Non-native Species in Ireland and Northern Ireland (ISI, 2012). It designated *Carpobrotus edulis* as a "high risk" invasive species.
6	If there is an earlier Risk Assessment is it still entirely valid, or only partly valid?	PARTIAL	Only a preliminary risk assessment was previously conducted in Ireland (refer to Question 5).
7	Where is the organism native?	-	*Carpobrotus edulis*, a sub-tropical species, is native to South Africa (Preston, 2002; Delipetrou, 2006; 2009; GISD, 2008; CABI, 2014). It can be found growing on coastal and inland slopes around the fringes of Cape Province, (GISD; 2008; Malan and Notten, 2006; CABI; 2014).
8	What is the current global distribution of the organism (excluding Ireland)?	-	Including its native range (refer to Question 6) the species has a current global distribution spanning Northern Europe (Great Britain, Ireland); Southwestern Europe (Balearic Islands, Gibraltar, Spain, Corsica, Sardinia, France); Southeastern Europe: (Italy, Sicily, Malta, Albania, Greece); West Temperate Asia: (Cyprus, Turkey, Lebanon-Syria, Israel-Jordan); Northern Africa (Algeria, Morocco, Libya, Macaronesia); Africa Middle Atlantic Ocean (St. Helena); Northern America (California, Florida); Southern America (Mexico, Chile, Argentina); South-Central Pacific (Pitcairn Is., French Polynesia); Australasia (Australia, New Zealand) (Delipetrou, 2006; 2009; GISD, 2008; CABI, 2014).

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
9	What is the current distribution of the organism in Ireland?	-	The first known record for *Carpobrotus edulis* in the wild in Ireland is from Howth Head with a Botanical Society of Britain and Ireland (BSBI) Atlas record for 1962 (Reynolds, 2002). The species has a relatively restricted and localised distribution along the east, and south coastline; often abundant on coastal cliffs, rocks and sand, where it competes with native vegetation (Kelly and Maguire, 2009; Parnell and Curtis, 2012; Reynolds, 2002, Stace, 1997). The National Biodiversity Data Centre hold 34 verified records of the species in 15 10km squares, at sites along the coast of counties Cork, Down, Dublin, Louth, Waterford, Wexford and Wicklow (Figure 1; National Biodiversity Data Centre, 2014).  **Figure 1.** Map showing the verified records for *Carpobrotus edulis* (Hottentot-fig) per 10km^2 in Ireland. Colour scale bar shows density of records per 10km (National Biodiversity Data Centre, 2014).

Stage 1 - Organism Information *The aim of this section is to gather basic information about the organism.*			
N	**QUESTION**	**RESPONSE**	**COMMENT**
10	Is the organism known to be invasive anywhere in the world?	YES	*Carpobrotus edulis* is an invader of coastal habitats in America, Australasia and Europe (Delipetrou, 2006; 2009; Kelly and Maguire, 2009; Smyth and Jebb, 2011; Squirrell, 2011; CABI, 2014). It can readily and rapidly spread to form deep, dense mats which smother other low-growing native vegetation (CABI, 2014; GISD, 2008). *Carpobrotus edulis* can also cause changes to soil pH and hybridise with other *Carpobrotus* species (CABI, 2014). It is widely naturalised and invasive in the Mediterranean-Atlantic regions of Europe, north to Germany, Britain and Ireland (Kelly and Maguire, 2009; Squirrell, 2011). In Britain *Carpobrotus edulis* is an invasive species on the Gower peninsula, Wales and along the Cornish and Devon coasts of England where it has formed extensive colonies smothering many kilometres of coastal cliffs (Smyth and Jebb, 2011; Squirrell, 2011). On the drier eastern coasts of Ireland, it poses a serious ecological threat to coastal cliffs and coastal grasslands (Smyth and Jebb, 2011). It has also been reported as a severe threat to native plant communities and ecosystems in the Mediterranean Basin because of the flexibility of its mating system and high seed production (CABI, 2014). In 2001, the European Commission approved the LIFE Nature proposal for the *Conservation of areas with threatened flora in the island of Minorca*; in achieving the objectives of this project a large proportion of resources were dedicated to the eradication of *C. edulis* as it posed the main threat to the islands endemic and threatened flora (Kelly and Maguire, 2009). In California, USA, the plant poses a threat to several rare and endangered plant species (CABI, 2014). It is a known invasive species in Australia where it fills the same niche and out competes and hybridises with the native *C. rossii* (Kelly and Maguire, 2009).

Stage 2 - Detailed assessment: Section A - Entry

This section evaluates the probability of entry of an organism into Ireland. For organisms which are already present, only complete the entry section for currently active pathways of entry and potential future pathways. The entry section need not be completed for pathways which have allowed an organism to enter in the past but are no longer active.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.01	How many active/future pathways are relevant to the potential entry of this organism (n/a, very few, few, moderate number, many or very many)?	VERY FEW	HIGH	There are few active/future pathways relevant to the entry of *Carpobrotus edulis*. The main pathway of introduction is the horticultural trade.
1.02	List significant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways.	1. Horticultural trade	HIGH	Potential for the species to be sourced through the horticultural trade, particularly via mail order seed companies and via the Internet, for use as an ornamental garden plant in coastal areas, stabilisation and landscaping of open sites in parks and along roadsides and erosion control on sandy habitats, particularly dunes, and loose rocks. From habitats to which it is introduced it may become invasive under suitable climatic and abiotic conditions (refer to Question 2.02 and 2.03).

Pathway 1 – Horticultural trade

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
1.03	Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (e.g. the organism is a contaminant of imported goods)?	INTENTIONAL	HIGH	Entry of the species along this pathway is deliberate.
1.04	How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year?	UNLIKELY	HIGH	There is no reliable data that exists to allow a reasonable assessment of the number of *Carpobrotus edulis* travelling along this pathway. Movement of the plant along this pathway would be dependent on the level of supply and demand. In Ireland the species was initially introduced via the horticultural trade as an ornamental garden plant and as a dune stabilisation plant (Kelly and Maguire, 2009). Today, planting of *C. edulis* directly into the wild for use in dune stabilisation or possibly as ground cover and stabilisation of roadside verges or slopes is extremely unlikely i.e. no demand. This is due to the developed appreciation for the invasiveness of the plant at existing sites of establishment, including actions to control/eradicate the species in Ireland (NBG, 2011; Smyth and Jebb, 2011).

Pathway 1 – Horticultural trade				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				Use of *C. edulis* as an ornamental, mostly in coastal or well-draining gardens, represents the only likely future demand for the plant. With a developing appreciation for the invasiveness of the species by gardeners, as reflected in online gardening blogs (see, for example, http://davesgarden.com/guides/pf/go/2024/#b), the plant may not often be deliberately cultivated i.e. little demand. However, for a viable population to develop only a small number of plants are needed.
1.05	How likely is the organism to enter Ireland undetected or without the knowledge of relevant competent authorities?	LIKELY	MEDIUM	It is likely that the species could enter Ireland undetected and without the knowledge of the relevant authority as seed via the Internet and/or mail order trade. It may be less likely for the species to go undetected as a plant, especially if it is labelled and checked at an entry point into the country.
1.06	How likely is the organism to survive during passage along the pathway?	LIKELY	HIGH	Likely for the species health requirements (i.e. nutrient and housing) to be catered for by the horticultural trader and subsequently by the garden centre and/or gardener. The species is known to have previously establishment via this pathway (refer to Question 1.04), substantiating that survival during passage in likely. The plant is highly resistant to drying out and is easily propagated by cuttings (M. Jebb pers. comm.).
1.07	How likely is the organism to arrive during the months of the year appropriate for establishment?	LIKELY	MEDIUM	Horticultural traders and gardeners are likely to stock and buy *C. edulis* at any time of the year. Its extreme drought-resistance and ease of rooting in well-drained soils makes it difficult to kill accidentally (M. Jebb, pers. comm.)
1.08	How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	LIKELY	HIGH	*C. edulis* is naturally a plant of coastal habitat. Typical coastal habitats where it is known to invade or naturalise include dunes, sands, shingles, rock cliffs, ledges, salt marshes, coastal scrub, coastal grassland, inland cliffs, rock pavements and outcrops (Delipetrou, 2006; 2009; GISD, 2008; Squirrell, 2011; CABI, 2014). It also inhabits roadsides and railway lines; it can be a pioneer in disturbed habitats with very sparse or no vegetation (GISD, 2008; Squirrell, 2011; CABI, 2014). The species is likely to be introduced to and/or encounter such suitable habitat within the Irish landscape (CORINE, 2006; Fossitt, 2000).

Pathway 1 – Horticultural trade				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.09	Estimate the overall likelihood of entry into Ireland based on this pathway?	MODERATELY LIKELY	MEDIUM	Use of *C. edulis* as an ornamental, mostly in coastal or well-draining gardens, represents the only likely future demand for the plant. With a developing appreciation for the invasiveness of the species by land managers and gardeners, the plant may not often be deliberately cultivated. However, for a viable population to develop only a small number of plants are needed. It is likely that the species could enter Ireland undetected and without the knowledge of the relevant authority as seed, or cuttings (which survive well in the post), via Internet exchange and/or mail order trade. It may be less likely for the species to go undetected as a plant, especially if it is labelled and checked at an entry point into the country.
1.10	Do other pathways need to be considered?	NO	HIGH	

Overall likelihood				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
1.11	Estimate the overall likelihood of entry into Ireland based on all pathways (comment on the key issues that lead to this conclusion).	MODERATELY LIKELY	MEDIUM	Refer to Question 1.09

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.01	Is the organism well established in Ireland (if there is any uncertainty answer 'unsure')	WELL ESTABLISHED	HIGH	The species is established at sites along the east and south coast (Stace, 1997; Reynolds, 2002; Kelly and Maguire, 2009; Parnell and Curtis, 2012). The National Biodiversity Data Centre hold 34 verified records of the species in 15 of the ~1018 10km squares which constitute the country (Figure 2; National Biodiversity Data Centre, 2014). Eradication of certain populations has now been successfully completed. However the plant is incipient in private gardens in many areas, such as Howth Head, and public understanding remains a difficulty.
2.02	How likely is it that the organism will be able to establish in Ireland based on the similarity between local climatic conditions and the organism's current global distribution?	LIKELY	HIGH	The establishment and spread of *C. edulis* is largely determined by climate. *C. edulis* prefers a warm temperate to dry climate, is sensitive to frost and resistant to drought and wind (Preston, 2002; Delipetrou, 2006; 2009; Squirrell, 2011). Ireland has a temperate oceanic climate which is mild, moist and changeable, with abundant rainfall and lack of temperature extremes (Keane and Collins, 2004). The milder, drier climate found along the east and south coast of Ireland has proved suitable for the establishment of the plant (Figure 1); and represents a climatic region which is most comparable to its native range, along coastal and inland slopes round the fringes of Cape Province, South Africa (CABI, 2014). Intolerant to frost, a milder, moister climate, as predicted for Ireland under global warming is likely to favour future establishment to new sites and further spread from existing sites (Kelly and Maguire, 2009; Squirrell, 2011).
2.03	How likely is it that the organism will be able to establish in Ireland based on the similarity between other local abiotic conditions and the organism's current global distribution?	LIKELY	HIGH	*C. edulis*, a lowland species, grows on well-drained acid to alkaline and also saline soils; it can grow on nutrient poor soils, but is N limited (Delipetrou, 2006; 2009). It usually prefers to grow in the sun, with room to spread but can also develop well in the shade and overgrow vegetation. It is an excellent evergreen drought, and wind resistant plant, that has inducible CAM metabolism when subjected to drought or salt-stress (Delipetrou, 2006; 2009).
2.04	How likely is the organism to encounter habitats necessary for the survival, development and multiplication of the organism in Ireland?	VERY LIKELY	HIGH	*C. edulis* is naturally a plant of coastal habitats, on dunes, sands, shingles, rock cliffs, ledges, salt marshes, coastal scrub, coastal grassland, inland cliffs, rock pavements and outcrops (Delipetrou, 2006; 2009; GISD, 2008; Squirrell, 2011; CABI, 2014). It also inhabits roadsides and railway lines; it can be a pioneer in disturbed habitats with very sparse or no vegetation (CABI, 2014; GISD, 2008; Squirrell, 2011). The

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				species is likely to be introduced to and/or encounter such suitable habitat within the Irish landscape (Fossitt, 2000; CORINE, 2006).
2.05	How likely is it that establishment will occur despite competition from existing species in Ireland?	VERY LIKELY	HIGH	*C. edulis* can readily and rapidly spread to form deep, dense mats which smother other low-growing native vegetation (GISD, 2008; CABI, 2014), as such any potential vegetative competition is not suspected to play a role in preventing growth. Once established the plants spread vigorously by prostrate stems which root at the nodes (CABI, 2014).
2.06	How likely is it that establishment will occur despite predators, parasites or pathogens already present in Ireland?	LIKELY	HIGH	Ice plant scale insects *Pulvinariella mesembryanthemi* and *Pulvinaria delottoi* were noted to be causing serious damage to the plant in California (Dahlsten and Hall, 1999). However, there is no knowledge of host-specific natural enemies of *C. edulis* in Ireland. Various insects and rodents may eat and/or damage the seed, acting as seed predators but also dispersers (Delipetrou, 2006; 2009). Seedlings eaten by mammals may result in high mortality, but once established they are not likely affected by herbivory or competition (Delipetrou, 2006; 2009; Squirrell, 2011).
2.07	How likely is it that establishment will occur despite existing management practices?	LIKELY	HIGH	There are best practice management guidelines in place to prevent the establishment of *C. edulis*. Invasive Species Ireland (ISI), a National Parks and Wildlife Service and the Northern Ireland Environment Agency funded project, produced the 'Hottentot Fig (*Carpobrotus edulis*) Invasive Species Action Plan'. The aim of the Action Plan is to prevent further spread of *C. edulis* in Ireland and put in place mechanisms to prevent new introductions to the island. This plan sets out actions required for successful implementation and guidance on methods for eradication/control of *C. edulis* populations in Ireland. Key priorities of the Action Plan are to be achieved through the implementation of control options, raising awareness of this species, developing policy and identifying actions needed to deal with further spread (Kelly and Maguire, 2009). The National Botanic Garden, Dublin have conducted a "Control of the invasive exotic Hottentot Fig (*Carpobrotus edulis*) in the Republic of Ireland" project. The project aimed to survey, locate and eradicate Hottentot fig from all recorded sites in the Republic of Ireland, using methods previously employed by this State body in the successful

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				eradicate the plant at Howth Head, Dublin and the Murroughs, Co. Wicklow in 2010 (Smyth and Jebb, 2011). The project has been largely successful to date (http://www.botanicgardens.ie/herb/research/carpedul.htm). There are still populations on privately owned land adjacent to the Howth cliff walk and these present a problem for future re-invasion of the habitat.
2.08	How likely is it that management practices in Ireland will facilitate the establishment of the organism?	MODERATELY LIKELY	MEDIUM	It is a known pioneer of disturbed areas, growing well on bare or sparse vegetated ground (GISD, 2008). *C. edulis* is reported to tolerate, or benefit from, cultivation, browsing pressure, mutilation and fire (CABI, 2014). Any management practices or human induced events that result in the creation of such habitat are likely to facilitate the establishment of *C. edulis*. For example, *C. edulis* has been observed to invade new areas following fire events in California (D'Antonio *et al.* 1993). Perhaps in Ireland, the cultivation and livestocking of habitat, such as coastal grassland or scrub, invested with *C. edulis* has the potential to benefit establishment. The intentional use of *C. edulis* in the landscaping of open sites in parks and along roadsides and to stabilise sandy habitats, particularly dunes, and loose rocks would clearly facilitate establishment. In Ireland there is a developing appreciation for the invasiveness of *C. edulis*, and among land managers it is hoped that such employment of the plant is considered as any historic management practice (refer to Question 1.02 and 1.04).
2.09	How likely is it that the biological characteristics of the organism would allow it to survive eradication campaigns in Ireland?	LIKELY	HIGH	There are biological characteristics of *C. edulis* which make it likely to survive eradication campaigns. One of the most effective ways of dealing with this species is removal by hand (Kelly and Maguire, 2009). Often large mats can be simply rolled up but it is important that checks are made to ensure no fragments remain. It is important that all plant material is collected up and not allowed to remain on site or get moved to another site. This is because of the species high capacity to regenerate and the long term viability of seeds (Kelly and Maguire, 2009). Ungerminated seeds remain viable for at least 2 years, which allows for the formation of a soil seed bank (CABI, 2014; GISD, 2008). The uneaten fruits remain on the plants for several years,

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				constituting a type of canopy seed bank (Delipetrou, 2006; 2009; Squirrell, 2011). The composting of materials should be done carefully with composted material then only utilised in areas not vulnerable to invasion by this species (Kelly and Maguire, 2009). If possible, removed plants should be mulched off site. It may be appropriate to employ chemical control (broad spectrum herbicide such as glyphosate) after manual removal of the plant, to control any *C. edulis* seeds which have the potential to re-establish (Kelly and Maguire, 2009). *C. edulis* has shown itself to be particularly susceptible to the commercial herbicide mix of glyphosate and diquat [http://www.botanicgardens.ie/gspc/targets/news/carpobrotus2.htm]. Trials in Co Wicklow preceded extensive herbicide use on Howth Head and other sites across the country during 2010 and 2011 [http://www.botanicgardens.ie/gspc/targets/news/carpobrotus.htm] (Smyth *et al.*, 2013).
2.10	How likely is it that the biological characteristics of the organism will facilitate its establishment?	VERY LIKELY	HIGH	It is very likely that the biological characteristics of *C. edulis* will facilitate its establishment. With large flexibility in its mating system *C. edulis* has very high reproductive potential. It is slightly agamospermic (asexual reproduction in which seeds are produced from unfertilized ovules), completely self-fertile, slightly preferentially self-compatible (able to be fertilized by its own pollen), and experiences no inbreeding depression (Suehs *et al.* 2004). Flowers, which are present from May to July in western Europe and only open in the evening, are pollinated by a range of generalist pollinators including solitary bees, honey bees, carpenter bees and many beetle species (Malon and Notten, 2006). The plant has a high seed production (Suehs *et al.*, 2004). Numerous seeds are embedded in each fruit and may number over 1000 per m² (Weber, 2003). Mature fruit do not release the seeds for at least 3 years (D'Antonio, 1990). When seeds are eventually released to the soil through rotting of the fruit they may remain viable in the soil for two years (D'Antonio, 1990). Dispersal of the seed is depending on frugivorous (fruit eating) animals and germination of seeds is enhanced by passage through the gut of animals (D'Antonio, 1990 Malan and Notten, 2006).

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
				Although sexual reproduction occurs the role of seed is considered to be insignificant compared to that of asexual/vegetative reproduction (Preston, 2002; Squirrell, 2011). *C. edulis* is a fast growing plant. Once established the plants spread vigorously by prostrate stems which, in contact with the soil surface, root at the nodes (CABI, 2014). Active growth of *C. edulis* occurs primarily along the main axes, although lateral branches may also grow and an individual branch can elongate more than 1m in a year (D'Antonio, 1990). Branches tend to grow over each other, resulting in the accumulation of up to 40cm of live and dead plant material (D'Antonio, 1990). Stems exhibit vine like growth and can crawl over shrubs, fences and other obstacles (D'Antonio, 1990). The plant is readily cloned by rooting stem fragments that contain at least one node (GISD, 2008).
2.11	How likely is it that the organism's capacity to spread will facilitate its establishment?	VERY LIKELY	MEDIUM	Refer to Question 3.02 and 3.03.
2.12	How likely is it that the organism's adaptability will facilitate its establishment?	MODERATELY LIKELY	MEDIUM	*C. edulis* is not environmentally adaptive i.e. it does not occur over a range of climatic and abiotic conditions (refer to Question 2.02 and 2.03). The plant does have high reproductive adaptability which is very likely to facilitate its establishment (refer to Question 2.10).
2.13	How likely is it that the organism could establish despite low genetic diversity in the founder population?	UNLIKELY	HIGH	Given that the species is slightly agamospermic (asexual reproduction in which seeds are produced from unfertilized ovules), completely self-fertile, slightly preferentially self-compatible (able to be fertilised by its own pollen), and experiences no inbreeding depression (Suehs *et al.* 2004), low genetic diversity in the founder population is unlikely to prevent establishment.
2.14	Based on the history of invasion by this organism elsewhere in the world, how likely is it to establish in Ireland? If possible, specify the instances of invasion elsewhere in the justification box	VERY LIKELY	HIGH	*C. edulis* is already established in Ireland (refer to Question 9). The species has a relatively restricted and localised distribution along the east, and south coastline; often abundant on coastal cliffs, rocks and sand, where it competes with native vegetation ((Stace, 1997; Reynolds, 2002; Kelly and Maguire, 2009; Parnell and Curtis, 2012). Although a major eradication programme has been already been undertaken, the opportunity for re-establishment of these populations remains very likely.

Stage 2 - Detailed assessment: Section B - Establishment

This section evaluates the probability of establishment of an organism within Ireland. For organisms which are already well established in Ireland there is no need to complete this section - move straight to the Spread section.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
2.15	If the organism does not establish, then how likely is it that transient populations will continue to occur?	VERY UNLIKELY	MEDIUM	*C.edulis* is incredible persistent and populations are clearly long-lived. Fragmentation of the plant may allow small populations to escape notice for many years.
2.16	Estimate the overall likelihood of establishment. Mention any key issues in the comments box	VERY LIKELY	MEDIUM	*C. edulis* prefers a warm temperate to dry climate, is sensitive to frost and resistant to drought and wind (Preston, 2002; Delipetrou, 2006; 2009; Squirrell, 2011). As such the establishment of *C. edulis* is largely determined by climate. It is naturally a plant of coastal habitats, preferring well drained soil in sun, with room to spread. In Ireland the species is established at sites along the east and south coast (Stace, 1997; Reynolds, 2002; Kelly and Maguire, 2009; Parnell and Curtis, 2012), a climatic region which is most comparable to its native range along coastal and inland slopes round the fringes of Cape Province, South Africa (CABI, 2014). Vegetative competition and predation by natural enemies is not likely to prevent establishment. There are best practice management guidelines in place to prevent the establishment of *C. edulis*. The National Botanic Gardens has been the lead agency in the control of *C. edulis* in Ireland and successful eradication of the plant as some sites has already been achieved. *C. edulis* has very high reproductive potential, high seed production and fast growth will very likely aid establishment and possible hamper sustained control of the plant.

Stage 2 - Detailed assessment: Section C – Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.01	What area (given in % or 10km squares) in Ireland could the organism establish (0% - 10%, 11% - 33%, 34% - 67%, 68% - 90% or 91% - 100%)?	0%-10%	HIGH	Coastal habitats where *C. edulis* is known to inhabit include dunes, sands, shingles, rock cliffs, ledges, salt marshes, coastal scrub, coastal grassland, inland cliffs, rock pavements and outcrops (Delipetrou, 2006; 2009; GISD, 2008; Squirrell, 2011; CABI, 2014). It also inhabits roadsides and railway lines; it can be a pioneer in disturbed habitats with very sparse or no vegetation (CABI, 2014; GISD, 2008; Squirrell, 2011). With references to the CORINE land cover data *C. edulis* has the potential to inhabit ~1% of the Irish land surface: road and rail networks – 0.06%, beaches, dunes and sand – 0.15%, bare rocks – 0.20%, sparsely vegetated land – 0.29%, salt marshes – 0.07% (CORINE, 2006). *C. edulis* has the potential to establish and spread in any habitat where suitable climate (mild with no frost) and abiotic conditions (well drained soil on open ground) exist. It is of note that CORINE land cover data does not define the size of coastal gardens, scrub or grassland, which represent important habitat for the species. However, it is suspected that even if these habitat features of coastal regions where accounted for, the area in Ireland that the species has the potential to establish would still lie between 0%-10%.
3.02	How important is the expected spread of this organism in Ireland by natural means (minimal, minor, moderate, major or massive)?	MAJOR	MEDIUM	*C. edulis* is a fast-growing plant and natural vegetative spread occurs via the fragmentation and dispersal of stems (Squirrell, 2011). Once established the plants spread vigorously by prostrate stems which, in contact with the soil surface, root at the nodes (CABI, 2014). Active growth of *C. edulis* occurs primarily along the main axes, although lateral branches may also grow and an individual branch can elongate more than 1m in a year (D'Antonio, 1990). Branches tend to grow over each other, resulting in the accumulation of up to 40cm of live and dead plant material (D'Antonio, 1990). Stems exhibit vine like growth and can crawl over shrubs, fences and other obstacles (D'Antonio, 1990). The plant is readily cloned by rooting stem fragments that contain at least one node (GISD, 2008). Natural vegetative spread is facilitated by the activities of frugivorous animals e.g. deer, rats, and rabbits and nesting birds e.g. gulls (Preston, 2002). Fruit can me dispersed and consumed and excreted by animals such as deer, rats and rabbits and seed germination is enhanced by the ingestion of fruits (Delipetrou, 2006; 2009). Gulls, Cormorants and Shags can assist spread by taking vegetative fragments as nesting material (Preston and Sell, 1988; Kelly and Maguire, 2009).

Stage 2 - Detailed assessment: Section C – Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.03	How important is the expected spread of this organism in Ireland by human assistance (minimal, minor, moderate, major or massive)?	MODERATE	MEDIUM	Human assisted spread occurs with the inappropriate dumping of garden discards into the wild (Delipetrou, 2006; 2009; Preston 2002; Squirrell, 2011).
3.04	Within Ireland, how difficult would it be to contain the organism (minimal, minor, moderate, major or massive)?	MINOR	MEDIUM	Difficulties encountered in relation to containment of the plant, relative to other invasive plant species, would be minor. *C. edulis* has a localised distribution along the east, and south coastline of Ireland (Stace, 1997; Reynolds, 2002; Kelly and Maguire, 2009; Parnell and Curtis, 2012). It is currently geographically contained by climate, requiring mild temperatures with no frost and abiotic conditions, requiring well drained soil on open ground. Where the species does locally occur it is often abundant (Stace, 1997; Reynolds, 2002; Parnell and Curtis, 2012). However, the relative ease of containment may be best reflected in the ability of the 'Control of the invasive exotic Hottentot Fig (*Carpobrotus edulis*) in the Republic of Ireland' project to aim to locate, survey and eradicate the plant from all recorded sites (Smyth and Jebb, 2011; Smyth *et al*., 2013).
3.05	What proportion (%) of the area in Ireland suitable for establishment, if any, has already been colonised by the organism?	0%-10%	HIGH	As covered in Question 3.01 the preferred habitat to which the plant has the potential to invade accounts for ~1% of total land cover in Ireland. There are 34 verified records of the species in 15 10km squares, at sites along the coast of counties Cork, Down, Dublin, Louth, Waterford, Wexford and Wicklow (Figure 2; NBDC, 2014). The proportion of the area in Ireland suitable for establishment which has already been colonised by *C. edulis* is minimal (*c*. 6.66 Ha Smyth *et al*., 2013).
3.06	What proportion of the area in Ireland suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0%-10%	MEDIUM	Rate of growth of naturalised populations in Ireland is up to 1 m per year (Jebb *et al*., 2009). Growth and dispersal of this species is rapid (CABI, 2014). Although, however fast potential dispersal is, the plant is restricted by climatic and abiotic factors. It would therefore not be expected for the species to spread to more than 0%-10% of land cover in the next five years. Aiding the prevention of spread is the concentrated control of the plant by the NBG.

Stage 2 - Detailed assessment: Section C – Spread

This section evaluates the probability of spread of an organism within Ireland. Spread is defined as the expansion of the geographical distribution of an organism within the risk assessment area.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
3.07	What other timeframe would be appropriate to estimate any significant further spread of the organism (10, 20, 40, 80 or 160 years)? Please comment on why this timeframe is chosen.	1-5	MEDIUM	Stems in Irish populations of *C, edulis* elongate by up to 1m per year (http://www.botanicgardens.ie/herb/research/carpedul.htm) Intolerant to frost, a milder, moister climate, as predicted for Ireland under global warming is likely to favour future establishment to new sites and further spread from existing sites (Kelly and Maguire, 2009; Squirrell, 2011). Any timeframe during which the Irish climate experiences warming effects as a result of climate change may be significant to the further spread of the species. In view of the recent eradication programme there is a need to regularly survey former sites over the next few years to determine if re-generation is a problem.
3.08	In this timeframe, what proportion of the area (including any currently occupied areas) is likely to have been invaded by this organism?	0%-10%	MEDIUM	The eradication programme already undertaken will have reduced current populations by 95-100%. Seven major sites have been treated, and five other sites were visited, but the plant was not seen [http://www.botanicgardens.ie/gspc/targets/news/carpobrotus.htm]. A number of sites remain to be treated, notably in Northern Ireland, where restrictions on herbicide use may prevent this control method.
3.09	Based on the answers to questions on the potential for establishment and spread in Ireland, define the area endangered by the organism. Be as specific as possible. If available, provide a map showing the area most likely to be endangered.	-	HIGH	Coastal dunes, sands, shingles, rock cliffs, ledges, salt marshes, coastal scrub, coastal grassland, inland cliffs, rock pavements, outcrops, roadsides, railway lines and disturbed habitats with very sparse or no vegetation are most at risk to invasion by the species (Delipetrou, 2006; 2009; GISD, 2008; Squirrell, 2011; CABI, 2014).
3.10	Estimate the overall potential for future spread for this organism in (very slowly, slowly, moderately, rapidly or very rapidly). Use the justification box to indicate any key issues.	MODERATELY RAPIDLY	MEDIUM	There will always remain the potential for the species to re-establish from garden populations or private land where control has not proved possible. After extensive control of *C. edulis* on Howth Head one landowner forbade control of an extensive population adjacent to the cliff footpath, but on private property.

Stage 2 - Detailed assessment: Section D - Impact
This section evaluates the probability of impact of an organism within Ireland.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
4.01	How great is the economic loss caused by the organism within its global distribution (excluding Ireland), including the cost of any current management?	MODERATE	MEDIUM	Unlike other invasive plant species, there are no reports of *C. edulis* directly causing losses to human enterprises e.g. agriculture, forestry, tourism. The losses caused by *C. edulis* invasion are due to control costs of the species, losses to biodiversity and losses to ecosystem function (refer to Question 4.06). Johnston (1989) reports that cliff subsidence is brought about by the weight of *C. edulis* rooted into cliff edges in the Channel Islands. As of yet only the control costs have some momentary value in Ireland (refer to Question 4.04). No figure is available for the cost of control of *C. edulis* throughout its global distribution.
4.02	How great has the economic cost of the organism been in Ireland from the time of introduction to the present? Exclude any costs associated with managing the organism from your answer.	N/A	N/A	As of yet only economic management costs have a momentary value.
4.03	How great is the economic cost of the organism likely to be in the future in Ireland? Exclude any costs associated with managing the organism from your answer.	N/A	N/A	There is no value on the economic cost of *C. edulis* excluding management to allow projections of future costs to be made.
4.04	How great have the economic costs of managing this organism been in Ireland from the time of introduction to the present?	MINOR	MEDIUM	In 2007 the National Botanic Gardens (NBG) started a project to control *C. edulis* from Howth, Co. Dublin, which was supported by the Heritage Council. This project was a success, with 97% reduction in the plants presence in Howth and the recovery of native flora (NBG, 2014). Using methods of control employed at Howth, the NBG is endeavouring to eradicate the species from all known sites in Ireland and received a grant from the Heritage Council of €25,000 (Kelly et al., 2013). Treating ca. 6.66 Ha, the cost, to date, works out at c. 37 cents per m^2 (Smyth *et al.* 2013).
4.05	How great is the economic cost of managing this organism likely to be in the future in Ireland?	MINIMAL	MEDIUM	The cost of control is minimal so long as herbicide can be used in the particular site and at the appropriate time of year. Mechanical control may be far less efficient if stricter controls on the use of glyphosate or diquat are introduced by the European Union.
4.06	How important is environmental harm caused by the organism within its global distribution?	MAJOR	MEDIUM	*C. edulis* forms impenetrable mats and competes aggressively with native species diversity, threatening rare and endangered species (D'Antonio and Mahall 1991, D'Antonio *et a.l*, 1993; Delipetrou, 2006; 2009). These mats can be over 50cm deep (D'Antonio and Mahall 1991, D'Antonio *et al*., 1993). Once it becomes established, it shows a high vegetative reproductive rate, and its growth does not appear to be

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
				affected by herbivory or competition (D'Antonio *et al.*, 1993; Campelo *et al.* 1999). *C. edulis* can also decrease species diversity by preventing sand movement, which hinders the natural processes of disturbance and change in dune environments (Delipetrou, 2006; 2009). Infestations on sand dunes can stabilise the sand to such an extent that the natural dynamics of the dunes can become affected and species that require sand disturbance could be lost from such sites (Squirrell, 2011). It is known to modify soil properties and nutrient dynamics by increasing soil N and organic C and by reducing soil pH (Delipetrou, 2006; 2009).
4.07	How important has the impact of the organism on biodiversity* been in Ireland from the time of introduction to the present? *e.g. decline in native species, changes in community structure, hybridisation	MAJOR	MEDIUM	In Ireland, *C. edulis* has a dramatic effect on habitat structure and native biodiversity in the coastal areas which it has invaded. Whilst the negative impacts of *C. edulis* on the floristics of coastal sites can be readily seen, there are possible positive impacts on faunistic diversity where mats of *C. edulis* have developed. The control of *C. edulis* on Howth head, Dublin not only resulted in hugely reduced numbers of the plant (a 97% kill rate); but the native flora of the cliffs also reappeared in large numbers and some 20% of the areas previously dominated by Hottentot Fig are now covered by regenerating Sea beet, Rock Samphire and Golden Samphire (Smyth *et al.* 2013; NBG, 2014)
4.08	How important is the impact of the organism on biodiversity likely to be in the future in Ireland?	MAJOR	MEDIUM	*C. edulis* is already impacting upon native biodiversity and the ecosystem functioning of sites where it has invaded. If the species further establishes and spreads the threat to biodiversity is likely to increase.
4.09	How important has alteration of ecosystem function* caused by the organism been in Ireland from the time of introduction to the present? *e.g. habitat change, nutrient cycling, trophic interactions	MAJOR	MEDIUM	Refer to Question 4.07.
4.10	How important is alteration of ecosystem function caused by the organism likely to be in Ireland in the future?	MAJOR	MEDIUM	*C. edulis* is already impacting upon native biodiversity and the ecosystem functioning of sites where it has invaded. If the species further establishes and spreads the threat to ecosystem functioning is likely to increase.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.11	How important has decline in conservation status* caused by the organism been in Ireland from the time of introduction to the present? *e.g. sites of nature conservation value, WFD classification, etc.	MAJOR	MEDIUM	The risk assessment undertaken as part of the Invasive Species Ireland project prioritised *Carpobrotus edulis* for preparation of an Invasive Species Action Plan. *C. edulis* has negative impacts on native flora and fauna and biodiversity of protected habitats (Kelly and Maguire, 2009). The Invasive Species Ireland project prioritised *Carpobrotus edulis* for preparation of an Invasive Species Action Plan, owing, in part, to its potential impact on protected habitats and species leading to non-compliance with EU legislative obligations under the Habitats Directive (Kelly and Maguire, 2009). The National Biodiversity Data Centre hold 34 verified records of the species in 15 10km squares, at sites along the coast of counties Cork, Down, Dublin, Louth, Waterford, Wexford and Wicklow (Figure 1; National Biodiversity Data Centre, 2014). Fourteen of these fifteen 10km squares contain or constitute protected areas (National Biodiversity Data Centre, 2014).
4.12	How important is decline in conservation status caused by the organism likely to be in the future in Ireland?	MAJOR	MEDIUM	*C. edulis* is already impacting upon the conservation status of sites where it has invaded by simply displacing vegetation. If the species further establishes and spreads the threat to conservation status is likely to increase.
4.13	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within its global distribution?	N/A	N/A	No knowledge of any social or human health harm to-date.
4.14	How important is social or human health harm (not directly included in economic and environmental categories) caused by the organism within Ireland?	N/A	N/A	No knowledge of any social or human health harm to-date.
4.15	How important is it that genetic traits of the organism could be carried to other organisms / species, modifying their genetic nature and making their economic, environmental or social effects more serious?	MAJOR	MEDIUM	*C. edulis* hybridises with its related species (native, naturalised and alien) in many parts of its introduced range (Suehs *et al.* 2004b). Hybrids are very vigorous and may intensify the invasion process (Suehs *et al.* 2004b). To date these other species have not been recorded from the wild in Ireland, but may be growing in private coastal gardens with *C. edulis*, presenting the future risk of such hybrids appearing.

Stage 2 - Detailed assessment: Section D - Impact *This section evaluates the probability of impact of an organism within Ireland.*				
N	**QUESTION**	**RESPONSE**	**CONFIDENCE**	**JUSTIFICATION**
4.16	How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	N/A	N/A	There are no reports of *C. edulis* as a host, a symbiont or a vector for other damaging organisms.
4.17	How important might other impacts not already covered by previous questions be resulting from introduction of the organism? Specify in the justification box.	N/A	N/A	We are not aware of any other impacts the introduction of this species would have.
4.18	How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in Ireland?	MAJOR	MEDIUM	Refer to Question 2.06
4.19	Indicate any parts of where economic, environmental and social impacts are particularly likely to occur. Provide as much detail as possible, where possible include a map showing vulnerable areas.	-	MEDIUM	Currently any potential economic and environmental impacts will occur in the species strong hold, along the east and south coastline. The sites of impact are more likely than not areas of conservation interest (refer to Question 4.11). Social impacts are likely to be negligible (refer to Question 4.13).
4.20	Estimate the overall potential impact of this organism in Ireland. Use the justification box to indicate any key issues.	MAJOR	MEDIUM	The potential impact of this species in Ireland has hopefully been averted. *C.edulis* was growing with great vigour on Howth head, with patches extending by up to 1m per year (http://www.botanicgardens.ie/gspc/targets/news/carpobrotushowth.pdf). Whilst there are no threatened plant species at risk from *C. edulis* at this time in Ireland, it has been implicated as a major threat to wild asparagus (*Asparagus prostratus*) in the UK. At present the five extant sites for this latter species in Ireland have not been impacted by *C. edulis*.

Stage 2 - Detailed assessment: Section E - Conclusion

This section requires the assessor to provide a score for the overall risk posed by an organism, taking into account previous answers to entry, establishment, spread and impact questions.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
5.01	Estimate the overall risk of this organism in Ireland. Noting answers given in 1.11, 2.16, 3.10 & 4.20	MAJOR	MEDIUM	Use of *C. edulis* as an ornamental, mostly commonly in coastal or well draining gardens, represents the only likely future demand for the plant. With a developing appreciation for the invasiveness of the species by land managers and gardeners, the plant may not often be deliberately cultivated. However, for a viable population to develop only a small number of plants are needed. It is likely that the species could enter Ireland undetected and without the knowledge of the relevant authority as seed *via* the internet and/or mail order trade. It may be less likely for the species to go undetected as a plant, especially if it is labelled and checked at an entry point into the country. *C. edulis* prefers a warm temperate to dry climate, is sensitive to frost and resistant to drought and wind (Preston, 2002; Delipetrou, 2006; 2009; Squirrell, 2011). As such the establishment of *C. edulis* is largely determined by climate. It is naturally a plant of coastal habitats, preferring well drained soil in sun, with room to spread. In Ireland the species is established at sites along the east and south coast (Reynolds, 2002; Stace, 1997; Kelly and Maguire, 2009; Parnell and Curtis, 2012) a climatic region which is most comparable to its native range along coastal and inland slopes round the fringes of Cape Province, South Africa (CABI, 2014). Vegetative competition and predation by natural enemies is not likely to prevent establishment. There are best practice management guidelines in place to prevent the establishment of *C. edulis*. The National Botanic Gardens of Ireland has been the lead agency in the control of *C. edulis* in Ireland and successful eradication of the plant at some sites has already been achieved. *C. edulis* has very high reproductive potential, high seed production and fast growth will very likely aid establishment and possible hamper sustained control of the plant. The timely management of this species in Ireland before it has had any appreciable impact on threatened plant taxa prevents a clear understanding of its potential impact in Ireland. That said, there is no doubt that the comparable situation in the south-west of Britain (Lizard Peninsula) has long passed the point at which an eradication programme, even though desirable, is now feasible.

Stage 2 - Detailed assessment: Section F – Additional questions

This section is used to gather information about the potential effects of climate change on the risk posed by an organism. It is also an opportunity for the risk assessor to highlight high priority research that could help improve the risk assessment.

N	QUESTION	RESPONSE	CONFIDENCE	JUSTIFICATION
6.01	What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	LIKELY	MEDIUM	Intolerant to frost, a milder, moister climate, as predicted for Ireland under global warming is likely to favour future establishment to new sites and further spread from existing sites (Kelly and Maguire, 2009; Squirrell, 2011).
6.02	What is the likely timeframe for such changes (5, 10, 15, 20, 50 or 100 years)?	5-100	MEDIUM	Any timeframe during which the Irish climate experiences warming effects as a result of climate change may be significant to the further spread of the species.
6.03	What aspects of the risk assessment are most likely to change as a result of climate change	-	MEDIUM	The increasingly favourable climatic conditions as a result of climate change would require for the risk assessment on the invasiveness of *A. triquetrum* to reconsider establishment and spread and their associated potential impacts to the Irish economy, environment and society.
6.04	If there is any research that would significantly strengthen confidence in the risk assessment, please note this here. If more than one research area is provided, please list in order of priority.	-		At present we have no clear understanding of seed dynamics in Irish populations. No discernable seedlings were identified during the recent project undertaken by the National Botanic Gardens. It would be valuable to determine if a viable seed bank exists in areas where the plant has been removed. Genetic studies may also shed light on whether sub-populations in areas such as Howth head are entirely clonal or demonstrate genetic diversity suggestive of seedling recruitment.

References

CABI. 2014. *Carpobrotus edulis (hottentot fig) [original text by Chris Parker]* [Online]. Invasive Species Compendium: Wallingford, UK: CAB International. Available: www.cabi.org/isc [Accessed 21st March 2014].

CAMPELO, F., MARCHANTE, H. & FREITAS, H. Ecology and population dynamics of the invasive exotic species *Carpobrotus edulis* in the Portuguese sandy coast. Proceedings 5th International Conference on the Ecology of Invasive Alien Plants, 1999 La Maddalena, Sardinia, Italy.

CORINE 2006. Environmental Protection Agency, (2008); CORINE Landcover 2006 update (Ireland). Final Report.

D'ANTONIO, C. M. & MAHALL, B. E. 1991. Root profiles and competition between the invasive, exotic perennial, Carpobrotus edulis, and two native shrub species in California coastal scrub. *American Journal of Botany,* 78**,** 885-894.

D'ANTONIO, C. M., ODION, D. C. & TYLER, C. M. 1993. Invasion of maritime chaparral by the introduced succulent Carpobrotus edulis. *Oecologia,* 95**,** 14-21.

D'ANTONIO, C. M. 1990. *Invasion of coastal plant communities by the introduced succulent, Carpobrotus edulis (Aizoaceae).* PhD, University of California.

DAHLSTEN, D. L. & HALL, R. W. 1999. *Handbook of Biological Control: Principles and Applications,* San Diego, New York, Academic Press.

DELIPETROU, P. 2006. *Species Factsheet: Carpobrotus edulis* [Online]. Delivering Alien Invasive Species Inventories for Europe. Available: http://www.europe-aliens.org/speciesFactsheet.do?speciesId=7190# [Accessed 21st March 2014].

DELIPETROU, P. 2009. *Carpobrotus edulis (L.) N.E.Br., freeway iceplant (Aizoaceae Magnoliophyta).* *In:* DAISIE (ed.) *The Handbook of European Alien Species.* Springer, Dordrecht.

FOSSITT, J. A. 2000. *A guide to habitats in Ireland*, Heritage Council/An Chomhairle Oidhreachta.

GISD. 2008. *Carpobrotus edulis (succulent)* [Online]. Global Invasive Species Database. Available: http://www.issg.org/database/species/ecology.asp?fr=1&si=1010 [Accessed 21st March 2014].

ISI 2012. *Carpobrotus edulis.* Risk analysis and prioritisation access database: Invasive Species Ireland.

JEBB, M., SMYTH, N. & ARMSTROING, C. 2009. Pilot survey of the invasive alien *Carpobrotus edulis* on Howth Head, Co Dublin, and options for its control.. National Botanic Gardens, Glasnevin Report http://www.botanicgardens.ie/gspc/targets/news/carpobrotushowth.pdf [accessed 1st July 2014].

JOHNSTON, P. 1989. Carpobrotus in Guernsey Excelsa No.14: 109-114.

KELLY, J. & MAGUIRE, C. M. 2009. Hottentot Fig (Carpobrotus edulis) Invasive Species Action Plan. Prepared for NIEA and NPWS as part of Invasive Species Ireland.

KELLY, J., TOSH, D., DALE, K. & JACKSON, A. 2013. The economic cost of invasive and non-native species in Ireland and Northern Ireland. The Northern Ireland Environment Agency and the National Parks and Wildlife Service: Invasive Species Ireland.

MALAN, C. & NOTTEN, A. 2006. *Carpobrotus edulis (L.) L.Bolus* [Online]. Kirstenbosch National Botanical Garden Available: http://www.plantzafrica.com/plantcd/carpobed.htm [Accessed 21st April 2014].

NATIONAL BIODIVERSITY DATA CENTRE. 2014. *Carpobrotus edulis interactive distribution map* [Online]. National Biodiversity Data Centre. Available: http://maps.biodiversityireland.ie/#/Species/40413 [Accessed 10th April 2014].

NBG. 2011. *Return of the Natives* [Online]. National Botanic Gardens. Available: http://www.botanicgardens.ie/news/20110915.htm [Accessed 21st April 2014].

PARNEL, J. & CURTIS, T. 2012. *Webb's An Irish Flora*, Cork University Press.

PRESTON, C. & SELL, P. 1989. The Aizoaceae naturalized in the British Isles. *Watsonia,* 17**,** 217-245.

PRESTON, C. D. 2002. Carpobrotus edulis Hottentot-fig. *In:* PRESTON, C. D., PEARMAN, D. A. & DINES, T. D. (eds.) *New atlas of the British and Irish flora.* Oxford University Press.

REYNOLDS, S. C. 2002. *A catalogue of alien plants in Ireland,* National Botanic Gardens, Glasnevin, Dublin, Ireland.

SMYTH, N. & JEBB, M. 2011. Control of the invasive exotic Hottentot Fig (Carpobrotus edulis) in the Republic of Ireland: Heritage Council Project Number M01247. An Chomhairle Oidhreachta - The Heritage Council.

SMYTH, N., ARMSTRONG, C., JEBB M. AND BOOTH, A. 2013. Implementing target 10 of the Global Strategy for Plant Conservation at the National Botanic Gardens of Ireland: Managing two invasive non-native species for plant diversity in Ireland. *Sibbaldia* 11: 125-141.

SQUIRRELL, J. 2011. *Hottentot-Fig, Carpobrotus edulis* [Online]. GB Non-Native Species Secretariat. Available: http://www.nonnativespecies.org//factsheet/factsheet.cfm?speciesId=669 [Accessed 21st March 2014].

STACE, C. 1997. *New flora of the British Isles*, Cambridge University Press.

SUEHS, C., AFFRE, L. & MÉDAIL, F. 2004a. Invasion dynamics of two alien Carpobrotus (Aizoaceae) taxa on a Mediterranean island: I. Genetic diversity and introgression. *Heredity,* 92**,** 31-40.

SUEHS, C., AFFRE, L. & MÉDAIL, F. 2004b. Invasion dynamics of two alien Carpobrotus (Aizoaceae) taxa on a Mediterranean island: II. Reproductive strategies. *Heredity,* 92**,** 550-556.

WEBER, E. 2003. *Invasive plant species of the world: A reference guide to environmental weeds,* Wallingford, UK, CAB International.