

Major Plant Invaders and Possible Management Options

Datasheets extracted from
**Guidelines on managing non-native plant invaders and restoring native plant communities in
terrestrial settings in the Maltese Islands**

Major Plant Invaders and Possible Management Options

Note: Choice of treatment methodology will depend on: the characteristics of the invasive species, the extent of the invasion, the identification of underlying causes or predisposing factors that facilitate the invasion, and the presence or absence of native plants in the area. It is thus recommended that chemical control (including when combined with mechanical control) is employed as a last resort when dealing with ecologically-susceptible areas and if the non-native species is in proximity to running water or threatened plants and animals. If the area in question is in a protected area then MEPA must be consulted beforehand. Moreover, it is important to carry field trials to see how each species in a particular area or habitat responds to control techniques, unless the species has already successfully been removed in a local context and hence the method is known to succeed and is suitable to the ecological context where it will be applied. Indiscriminate use of Plant Protection Products and senseless mechanical clearing is strictly prohibited.

The following species are considered:

Species (arranged in alphabetical order)	Flowering Time	Plant is deciduous	Species is dioecious	Species re- sprouts after cutting	Species exhibits vegetative propagation or spreads vegetatively	Species is a prolific seed producer
<i>Acacia cyclops</i>	Spring					•
<i>Vachellia karroo</i> (= <i>Acacia karroo</i>)	Late spring-Early summer					•
<i>Acacia saligna</i>	Spring			•		•
<i>Aeonium arboreum</i>	Winter-Spring				•	
<i>Agave americana</i>	Summer				•	
<i>Agave sisalana</i>	Summer-Winter				•	
<i>Ailanthus altissima</i>	Late Spring	•	•	•	•	•
<i>Aptenia</i> spp.	Late Spring-Summer				•	•
<i>Arundo donax</i>	Late Summer/Early Autumn			•	•	
<i>Symphotrichum squamatus</i> (= <i>Aster squamatus</i>)	Summer-Autumn					•
<i>Cardiospermum grandiflorum</i>	Summer-Early Autumn					•
<i>Carpobrotus edulis</i>	Spring				•	
<i>Casuarina equisetifolia</i>	Summer		•	•		•
<i>Eucalyptus</i> spp.	Summer			•		
<i>Lantana camara</i>	All Year Round			•	•	•
<i>Leucaena leucocephala</i>	Summer-Winter (All year round)			•		•
<i>Nicotiana glauca</i>	Spring-Autumn	(semi- evergreen)				•
<i>Nothoscordum borbonicum</i>	Spring					•
<i>Opuntia ficus-indica</i>	Late Spring-Summer				•	
<i>Oxalis pes-caprae</i>	Spring				•	
<i>Pennisetum setaceum</i>	Spring-Summer				•	•
<i>Pennisetum villosum</i>	Spring-Summer				•	•

Species (arranged in alphabetical order)	Flowering Time	Plant is deciduous	Species is dioecious	Species re- sprouts after cutting	Species exhibits vegetative propagation or spreads vegetatively	Species is a prolific seed producer
<i>Pittosporum tobira</i>	Summer		•			•
<i>Ricinus communis</i>	Spring-Autumn (All year round)			•		•
<i>Schinus terebinthifolius</i>	Autumn-Winter		•	•		•
<i>Tropaeolum majus</i>	Late Spring					•

Large Sized Trees

Eucalyptus spp.

Eucalyptus camaldulensis & *E. gomphocephala* (Maltese: *l-ewkaliptus*, *l-ewkaliptu*, *is-siġra tal-gamie*m; English: gum trees, eucalypts) - [Family Myrtaceae]

Management Options:

- **Manual/Mechanical for seedlings, saplings and small trees:** hand pulling or felling. Small individual trees can be hand-cut followed by digging up as much of the root system as possible in areas where native species would not be affected and where threatened and protected species such as *Tetraclinis articulata* are not found; where uprooting is not desirable then grind the stump to a depth a two feet followed by filling the hole with soil. Removal of *Eucalyptus* trees may be done in stages as documented by the US National Park Service by first removing the leaf litter and targeting the smaller trees as a form of 'stand thinning' and then removing the remaining larger trees as 'stand removal'. In ecologically sensitive areas, PPP should not be used for the management of this species. Instead, in order to address re-sprouting of cut stumps, 'tarping with heavy plastic' (*vide* the brochure by US National Park Service) will impede light reaching the trees and will also act as a physical barrier thereby preventing re-sprouting. Bossard, Randall & Hoshovsky (2000) who address *E. globulus* (pages 183-187) suggest that stump grinding can eliminate sprouting - all underground portions of stumps are ground to about a depth of 2 feet, followed by provisions to fill in holes in the ground with soil; for small infestations manual removal of sprouts from stumps can exhaust food resources. Since the bark sheds in long strips frilling may be adopted on small trees with trunks less than 2 feet in diameter, although this is not documented for this species.
- **Combination of Mechanical and Chemical for large mature trees** (only resorted to if tarping and stump grinding does not work, and where the area concerned is not ecologically sensitive):
 - Cut-stump method (e.g. see Tunison & Zimmer, 1992; Bossard, Randall & Hoshovsky, 2000) - Larger trees should be cut to the ground. If not treated with PPP the stumps will re-sprout and would need to be felled again. Repeated felling of the stump may exhaust the root system. Stumps may be treated by PPP if deemed necessary by painting the chemical on the cut stump. Treat any re-sprouts. Manually uproot young seedlings that emerge.
 - Frill or Hack and squirt treatment or Injection method - If the *Eucalyptus* tree is very large and felling might be a problem, either method may be applied instead, depending on available resources.

Comments: This long-lived species disperses by wind-blown and water-borne seeds. *Eucalyptus* trees abstract huge amounts of water from the ground. Burning is not recommended for *Eucalyptus* spp. which have highly volatile oil content and the aerodynamic leaves can disperse flaming material. Leaves have an allelopathic effect and the oil in the leaves alter the soil chemistry. Leaves should therefore be completely removed from the treatment area.

Literature Review:

Management:

- Brochure on Managing *Eucalyptus* by the US National Park Service (2006) - www.nps.gov/goga/parkmgmt/upload/firemanagement_eucalyptus_brochure.pdf
- Treatment options for *E. globulus* can be found in Chapter 6: The Plants: How to Remove Bay Area Weeds by MacKenzie, 2004, In: The Weed Worker's Handbook - A Guide to Techniques for Removing Bay Area Invasive plants (page 108)
- Weber (2005) addresses the following species which are however not present in the Maltese Islands: *E. cladocalyx* (p. 161); *E. diversicolor* (p. 162) and *E. globulus* (p. 163) - for *E. cladocalyx*: digging out seedlings and saplings along with removal of roots; cut stump method or drill-frill application of PPP for large trees; for *E. diversicolor* (which readily resprouts from stumps): cut stump herbicidal method; regular removal of sprouts; or grinding of stumps to prevent resprouting

***Casuarina* spp.**

(Maltese: *il-kazwarina*; English: Australian pine; she oak; beefwood) - [Family Casuarinaceae]

Management Options:

- **Manual** - In the case of small infestations, removal of seedlings and saplings. Cutting can induce sprouting, thereby requiring repeat treatment.
- **Chemical** - For heavier infestations and when dealing with mature trees, pesticide application would be more effective, using either by basal bark application or the cut-stump application.
- **Combination** - Hand pulling of seedlings and sapling combined with one of the chemical applications as above.

Comments: *Casuarina* species grow into medium to large trees. Several species are dioecious. The cone-like infructescence releases small samaras, which are wind dispersed. These samaras can then be secondarily dispersed by water and ants. Species of *Casuarina* form nitrogen-fixing root nodules. *Casuarina* species are quite similar and are hence difficult to separate without careful examination of the short branches and of the inflorescences and infructescences. Species such as *Casuarina equisetifolia* has invasive characteristics. *C. equisetifolia* is a prolific producer of wind-dispersed samaras and can resprout profusely after cutting. This particular species is fast-growing and is documented as a habitat generalist, and is tolerant to various environmental variables, including salt tolerance, and calcareous soils. It thus can form dense monospecific stands. It produces a lot of leaf litter which can impede germination and growth of native species. In Malta *Casuarina* spp. are widely used as ornamental or avenue trees. It currently invades disturbed areas. Potentially invadable natural habitats include coastal habitats and wetlands.

Literature Review:

Characteristics

- Cronk & Fuller (2001) on *C. equisetifolia* (p. 144)

Management:

- Information provided on the ISSG Database - www.issg.org/database/species/ecology.asp?fr=1&si=365
- Weber (2005) on *C. equisetifolia* (p. 88)

Small/Medium Sized Trees or Large/Dense Shrubs

Acacia spp.

including *Acacia cyclops* (Maltese: *l-akaċja tal-għajn/taċ-ċiklopi*; English: coastal wattle); *Acacia saligna* (Maltese: *l-akaċja*; English: blue-leaved wattle) and *Vachellia karroo* (= *Acacia karroo*, Maltese: *il-gažżija tax-xewk*, *ix-xewk ta' Kristu*, *l-akaċja tax-xewk*; English: Karroo thorn) - [Family Fabaceae]

Existing Practice in Malta: Management of *Acacia* species is carried out at *Għadira* where the tree/shrub is first hacked down with a chainsaw. Roots will re-sprout some growth shortly after the tree/shrub is cut; these are addressed using a small handsaw. The tree then weakens, will not re-grow and will die off. Mechanical control should be carried out before plant sets seed. Depending on the cover extent, gradual removal may be appropriate. The large spines of *A. karroo* may cause a hindrance to manual treatment (use heavy-duty gloves). Seedlings and saplings must be manually pulled (using gloves).

**Other Management Options:**

- **Manual/Mechanical for seedlings, saplings and small trees:** For *Acacia* spp. hand pulling of seedlings is to be applied once the mother plant is removed. Seedling removal can proceed once the soil is watered and upon seed germination (usually 1 to 2 weeks) Small individual trees can be hand cut. For small infestations and especially where heavy shade exists, repeated felling over time may exhaust the plants reserves and may be successful if continued for many years;
- **Combination of Mechanical and Chemical options:** for large infestations outside of ecologically-sensitive areas combined with planting of native species that fall within the ecological context of the area to shade off the soil and inhibit seed germination.

**Comments:**

- *A. cyclops* (Weber, 2005, p. 13) has a fissured bark; high litter production leading to increased soil nitrogen content; seed germination is enhanced after a fire; seedlings are intolerant of shade; tree rarely resprouts after fire damage or felling;
- *A. saligna* (Weber, 2005, p. 20) smooth bark becoming fissured with age; freely suckering, high litter production leading to increased soil nitrogen content; large seed bank; seeds are long lived and germinate rapidly after a fire; (Cronk & Fuller, 2001, pp. 62-67) fast growth rate, extensive root system;
- When dealing with *Acacia* spp. it is very difficult to exhaust the seed bank. *Acacia* species '... accumulate large quantities of viable but dormant seed in the soil' (Sabiiti & Wein, 1987). The level of management can be high where the species forms large seed banks under mature trees and where such seed banks can be persistent. However seeds can remain dormant until the hard outer casing is disrupted by for example heat, hence seed germination is enhanced after a fire.
- Some species are prone to re-sprouting after cutting (readily shown by *A. saligna*), whereas some species may show poor re-growth after cutting (*A. cyclops*).

- Seeds can be secondarily dispersed by water (*A. karroo*, *A. saligna*); birds (*A. cyclops*) or ants (*A. saligna*) (see e.g. Holmes, 1990).
- The large spines of *A. karroo* may cause a hindrance to manual treatment (use heavy-duty gloves).
- Uprooting will cause soil disturbance and will encourage seed germination, therefore it would be better to apply a combination of mechanical and chemical treatments depending on the environmental setting.
- Seed bank reduction should be the management goal for controlling *Acacia* sp. If the area in question is in a protected area then MEPA should be consulted beforehand.

Literature Review:

Management:

- Holmes, MacDonald & Juritz (1987) in their work on assessing the effects of clearing treatment on *A. saligna* and *A. cyclops*, noted the following:
'Seed banks of *A. cyclops*, but not of *A. saligna*, were reduced by shrub felling after 1 year, apparently because a high proportion of seeds do not have seed-coat induced dormancy, and thus germinate immediately'.
- Treatment options for other *Acacia* species is given in Chapter 6: The Plants: How to Remove Bay Area Weeds by MacKenzie, 2004, In: The Weed Worker's Handbook - A Guide to Techniques for Removing Bay Area Invasive plants (page 106)
- Weber (2005) - *A. cyclops*: mechanical control by cutting stems close to the ground; effort is needed to reduce soil seed bank; *A. saligna*: cut stump method; prescribed burning to stimulate seed germination followed by removal of emergent seedlings (not recommended in Malta)
- Cronk & Fuller (2001) - *A. saligna* (pp. 62 - 67) treatment needed to kill seedlings; cut-stump herbicidal method, every existing and potential seed producing individual must be removed;

***Leucaena leucocephala* (Lam.) de Wit**

(Maltese: *il-gazzija l-bajda*, *il-lewkena*; English: white lead tree, white popinac) - [Family Fabaceae]

Management Options:

- Manual/Mechanical for seedlings, saplings and small trees: hand pulling or felling. Seed pod removal should be done before ripening and before dehiscence and hence prior to dispersal. The canopy of the plant should be contained before any felling takes place to avoid dispersing the seeds.
- Hand pulling small individual plants with roots and all. Small individual trees can be hand cut followed by digging up as much of the root system as possible. Cutting will trigger vigorous resprouting, therefore when addressing small infestations, repeated treatment will be required over time in order to exhaust the plants reserves. This approach may be successful if continued for many years or where heavy shade exists.
- Chemical for saplings: basal bark method or cut-stump mode of application may be resorted to, though is not recommended for ecologically sensitive areas.
- Combination of Mechanical and Chemical options: for large infestations outside of ecologically-sensitive areas combined with planting of native species that fall within the ecological context of the area to shade off the soil and inhibit seed germination.

Comments: The species is a hermaphrodite and grows easily from seeds. Trees are generally short-lived (20-40 years), however once established, this species is difficult to eradicate being a prolific seed producer, and it can form dense monospecific thickets. The soil seed bank can remain viable for at least 10-20 years after seed dispersal (ISSG Database - Management info on the species). Seeds are secondarily dispersed by water and possibly ants. It also re-grows from cut stumps and it can be grown from cuttings. It can also regenerate after burning from its basal shoots (Cronk & Fuller, 2001). Grazing has also been used as a management approach to control the seedlings of this species (*vide* for instance, Walton, 2003 - page 40). The tree is 'deep-rooted' with a rapidly growing taproot; resprouts from cuttings, stumps and root collars (Weber,

2005);

Literature Review:

Characteristics:

- Information on *L. leucocephala* by PIER (Pacific Island Ecosystems at Risk) (2002) - www.hear.org/pier/species/leucaena_leucocephala.htm
- Information provided on the ISSG Database - www.issg.org/database/species/ecology.asp?si=23&fr=1&sts

Management:

- Management options explored by the work of Walton (2003) on a review of the plant's pest status in Queensland
- Weber (2005) on *L. leucocephala* (p. 234)

***Ailanthus altissima* (Miller) Swingle**

(Maltese: *ix-xumakk il-falz*; English: tree-of-heaven) - [Family Simaroubaceae]

Management Options:

Manual/Mechanical for seedlings, saplings and small trees: Removal is easily carried out by pulling the entire plant with roots and all when in the seedling stage and when the root system is shallow (use gloves as sap contact can result in dermatitis - DAISIE fact sheet) and when the soil is moist and loose. Once the plant establishes a tap root, manual removal then becomes very difficult. If small infestations are being tackled it may be feasible to dig out the rootstocks. For small infestations, repeated cutting of sprouts over time can exhaust the plants reserves and may be successful if continued for many years or where heavy shade exists.

The EEA Technical Report 16/2012 mentions that for this species "[to] avoid root suckers emerging from root fragments and stump sprouting after cutting, girdling of single trees is recommended. The following year the vitality of the tree is reduced and cutting without invoking much sprouting is possible."

Combination of Mechanical and Chemical: when the tree becomes too large for mechanical removal, then as a last resort employ one of the following method:

- Cut-stump method + PPP treatment (for young shoots) + manually remove emerging seedlings until the seed bank is exhausted. Dormant season applications may prevent re-sprouting from the stump itself, but will not inhibit root suckering.
- Injection method (for mature seed producing shoots) - This method can be used with trees of any size, though it is most productive with stems over 2 inches in diameter. Not to be used if there are neighbouring native trees/non-target plants in view of PPP translocation. See also Lewis (2007).

Comments:

- *A. altissima* is a fast growing, deciduous and dioecious tree that reproduces both sexually (prolific production of thousands of wind-borne seeds - samaras - which have a high germination rate and can be dispersed over long distances in open habitats) and asexually (suckering, root sprouts or ramets), in which case dense populations can be produced. Seed dispersal of this species is assessed in the work of Landenberger, Kota and Mc Graw (2007) whereas clonal growth in this species assessed by Ingo (1995). The EEA Technical Report 16/2012 documents for the species heights of 15 to 30 m and a life span of not more than 100 years.
- "Sprouts may emerge up to 15 m from the nearest existing stem" (DAISIE fact sheet).
- Although this species is a pioneer of disturbed ground it also invades natural habitats. It employs allelopathy, and releases ailanthone which inhibits seed germination and seedling growth of native plants in the vicinity (*vide* Heisey, 1990; Lawrence *et al.*, 1991).
- It is also able to withstand drought by employing some sort of water saving mechanism (*vide* Trifilò *et al.* 2004).



- Mature and established trees produce numerous suckers from the roots. Moreover, cutting triggers vigorous re-sprouting from stumps and root fragments and will also allow the germination of seeds in the soil once they are no longer shaded out. Unless rigorous follow-up monitoring and treatment with immediate uprooting of emergent seedlings before they are able to rebuild root reserves is carried out, the chance that infestation may be worsened is likely. Establishing a thick cover of indigenous trees will help shade out and discourage establishment of *Ailanthus* seedlings.
- Ring-barking is not appropriate for *Ailanthus altissima* as it causes intensified vegetative
- Controlled grazing can kill *Ailanthus* stems and weaken the roots, but does not resolve the problem of the continuous sprouting.
- This species is included in the EPPO list of invasive alien plants (EPPO Secretariat - <http://archives.eppo.org/EPPOReporting/2005/Rse-0509.pdf>). *A. altissima* is listed as one of the 100 of the Worst Invasive Species on the DAISIE database regeneration.

Literature Review:

Characteristics:

- *Ailanthus altissima* - Global Invasive Species Database - www.issg.org/database/species/ecology.asp?fr=1&si=319

Management:

- The effectiveness of manual control and PPP control (PPP tank mixes as low-volume basal applications) on *A. altissima* is reviewed by Burch & Zedaker (2003);
- Biological control of this species is reviewed by Ding *et al.* (2006) - this option should not be applied in the Maltese Islands unless native agents can be used;
- The effects of hand-pulling and mulching, cut stump and glyphosate application, cut stump alone, and the EZJect Capsule Injection System (using glyphosate) on the management of *A. altissima* are examined by Meloche & Murphy (2006);
- Management options reviewed by Swearingen & Pannill (1999) - Fact Sheet on *Ailanthus altissima* - www.nps.gov/plants/alien/fact/pdf/aial1.pdf
- Treatment options on *A. altissima* can also be found in Chapter 6: The Plants: How to Remove Bay Area Weeds by MacKenzie, 2004, In: The Weed Worker's Handbook - A Guide to Techniques for Removing Bay Area Invasive plants (page 110)
- DAISIE Fact sheet (Author: Corina Başnou and Montserrat Vilà; Last modified: 1/12/2006) - www.europe-aliens.org/pdf/Ailanthus_altissima.pdf - Mechanical followed up by chemical application (cut-stump)
- Bossard, Randall & Hoshovsky (2000) on *A. altissima* (pp. 32-36) - where soil is wet or loose hand pulling of seedlings when they are large enough to grasp but before they produce seeds; hand digging for small infestations taking care to remove every piece of root; cutting the above portion of the plant using manually operated tools where footing is certain - this will need to be repeated several times per year in view of resprouting; girdling and treating the cut with PPP; cut-stump method is documented as the most effective;
- Weber (2005) on *A. altissima* (p. 32) - hand pulling of seedlings and saplings taking care to remove root fragments; Cutting must be combined with PPP treatment;
- EEA Technical Report 16/2012 - Section on *A. altissima* (pp. 70-72)

***Nicotiana glauca* R.C. Graham**

(Maltese: *is-siġra tat-tabakk*; English: tree tobacco, mustard tree) - [Family Solanaceae]

Management Options:

- *Manual* - pulling or digging out of seedlings and saplings
- *Chemical* - cut-stump method

Comments: drought resistant growing either as a tree or a stunted shrub; exhibits vigorous growth (Weber 2005);

Literature Review

Management

- Weber (2005) on *N. glauca* (p. 286)
- Cronk & Fuller (2001) on *N. glauca* (p. 174)

***Pittosporum tobira* (Thunb.) W.T.Aiton**

(Maltese: *il-pittosporum*; English: Japanese pittosporum, Japanese cheesewood) - [Family Pittosporaceae]

Management Options:

- *Mechanical*: by cutting and where appropriate uprooting if dealing with single shrubs.

Comments: Seeds are bird-dispersed.

Literature Review:

Management:

- Chemical control methods documented for other *Pittosporum* species include the cut-stump, frill, and basal bark methods (vide Hawaiian Ecosystems at Risk project [HEAR] Reports on *P. pentrandum*, *P. undulatum*, and *P. viridiflorum* available from - www.hear.org/starr/hiplants/reports/)
- Weber (2005) on *P. undulatum* (p. 333) - cutting small trees, cutting or girdling larger trees, often in combination with PPP treatment; follow-up programmes are necessary to deal with re-growth and emergent seedlings

***Ricinus communis* L.**

(Maltese: *ir-riġnu*; English: castor oil tree, castor bean) - [Family Euphorbiaceae]

Management Options:

- *Manual/Mechanical*: involves hand pulling of young seedlings (using gloves) and pulling out of saplings with the use of tools and making sure that the bulk of the roots are also removed [this is easiest when soil is wet]. Seedling removal should be done upon seed germination with timing after first rain.
- For species which have oil-rich seeds such as in the case of *Ricinus communis*, seed harvesting can be employed as a control method. This involves making use of seed floatation following heavy rain to collect the seeds. Another method involves the removal of seed pods before ripening and before dehiscence and hence prior to dispersal.
- If small infestations are being tackled it may be feasible do as follows:
 - In areas where single plants and/or small clumps are located but are not in direct vicinity to the native trees, these can be felled and the stumps dug out manually + repeated hand pulling of emerging seedlings until seed bank is exhausted.



- In areas where the Castor Oil is present as dense clumps and is directly adjacent to the native trees these should only be felled (but not uprooted) + tarping or continued felling of re-sprouts, followed by rigorous uprooting of emerging seedlings.
- *Combination of Mechanical and Chemical for Mature Plants*: Cut-stump method for mature plants before fruit develops + hand pulling of seedlings until the seed bank is exhausted (*vide* Bossard, Randall & Hoshovsky 2000 pp. 269-273; Tunison & Zimmer 1992; Weber 2005 p. 360)

Comments: Herbaceous when young but becomes woody with age. The Castor Oil Plant produces large seeds discharged from capsules. The seeds may then be dispersed by birds, rodents and insects, planting by man, and through movement in the soil; though most frequently by water. It is fast growing and short lived (Weber, 2005). Seedlings grow rapidly. Cutting stems and girdling the cambial tissue on the stem will lead to heavy root and stump sprouting and increased stand density, unless immediately followed by PPP application as instructed. It is important to note that the whole of the seed with the outer coating (hull) is very toxic/poisonous both to animals and humans, if ingested and chewed. One must also be aware of the irritation and possible carcinogenic effect of waxes from *Ricinus communis*.

Existing Practice: Past experience in controlling the spread of this species includes efforts at removing clumps from *Bahrija* valley. This intervention consisted of uprooting small saplings and small trees by man power. At the time most specimens were still dormant with only a few specimens in leaves and buds (elsewhere in Malta specimens of *Ricinus* were observed to fruit earlier in April). Before uprooting these, the buds were trimmed off. Follow-up of the intervention took place to remove emerging seedlings.

Literature Review:

Characteristics:

- *Ricinus communis* - Global Invasive Species Database - www.issg.org/database/species/ecology.asp?si=1000&fr=1&sts=sss
- Information provided by PIER - www.hear.org/pier/species/ricinus_communis.htm

Health concerns:

- **INCHEM**: <http://www.inchem.org/documents/pims/plant/ricinus.htm>

***Schinus terebinthifolius* Raddi**

(Maltese: *is-siġra tal-bżar*; English: Brazilian pepper tree) - [Family Anacardiaceae]

N.B. Should not be confused with the related *Pistacia lentiscus*, *Pistacia terebinthus* and *Pistacia atlantica*.

Management Options:

- *Manual/Mechanical*: Hand-pulling seedlings and saplings with root and all. For small individual plants, hand cut and dig up as much of the root system as possible. Larger specimens may be felled. In view of resprouting, perseverance is needed in removing the sprouts and seedlings in order to control this species. Yearly monitoring up to three years is recommended by Bossard, Randall & Hoshovsky (2000) - lack of sprouting for 1 or 2 years does not necessarily imply that potential for sprouting of roots has been eliminated.
- *Combination of Mechanical and Chemical*: Larger trees may be cut to the ground and stumps treated immediately by applying for instance the cut-stump method. Use of the basal-bark application for this species is also documented.

Comments: Females can be prioritised for management to prevent further spread. Brazilian pepper tree is propagated from both seeds and cuttings. Water availability (especially rapid changes in water level) determines to a great extent seedling success. It is a prolific seed producer. Granivorous birds disperse some seeds. The plant is capable of re-sprouting from above-ground stems and root crowns. It re-sprouts rapidly following cutting. Treatments for this species should be scheduled before berries are produced so as to avoid spreading the seed-laden berries when managing this species. The species has an intermediate tolerance of shade and can survive and grow slowly when shaded by other trees however it grows rapidly in open habitat forming a dense growth of low limbs and basal sprouts. This species can re-sprout from the base after burning (Cronk and Fuller, 2001). When cutting is involved in the management of this species care should be taken to avoid getting into contact with the plant's sap as it may induce rashes or other allergic reactions. The production of allelopathic chemicals by this species is

documented. Weber (2005) notes that spread is promoted by disturbance.

Literature Review:

Characteristics:

- Information on *S. terebinthifolius* by PIER - www.hear.org/pier/species/schinus_terebinthifolius.htm
- *S. terebinthifolius* - GISD - Information compiled by ISSG (2006) - www.issg.org/database/species/ecology.asp?si=22&fr=1&sts=sss

Management:

- Recommendations for management of this Species in Florida are documented by the Florida Exotic Pest Plant Council's Brazilian Pepper Task Force (1997) - Ferriter (1997)
- Brazilian pepper Tree Control - Gioeli & Langeland (2006) - http://plants.ifas.ufl.edu/education/misc_pdfs/SSAGR17.pdf
- Bossard, Randall & Hoshovsky (2000) on *S. terebinthifolius* (pp. 282-286) - Randall states (p. 285) 'The severity of the problem is an important consideration when designing a control strategy for Brazilian pepper tree.' - chemical options explore cut-stump; frill-cut method, and basal spot applications.
- Weber (2005) on *S. terebinthifolius* (p. 389) - hand pulling seedlings and saplings; basal-bark application; removal of female trees

***Lantana camara* L. (*sensu lato*)**

(Maltese: *il-lantana*; English: yellow sage; shrub verbena) - [Family Verbenaceae]

Management Options:

- *Mechanical* (can be labour intensive): by repeated cutting and where appropriate uprooting if dealing with single shrubs or small infestations. Individual plants can be pulled out ensuring the complete removal of the root system. Follow up with hand pulling (using gloves) of seedlings, and repeated control of any re-growth.

Comments: *Lantana camara* grows into a branched and erect, or straggling (in shading areas) medium to large aromatic shrub. Stems are often armed with recurved prickles. It exists in many forms or varieties. The colour of its compact and flat flowerheads ranges from white/pale pink, pink, yellow, to orange and red. It flowers profusely (setting copious seed) and is insect pollinated. Its fleshy purplish black drupes are dispersed by birds and hence aid in long distance dispersal. Its branches are easily broken and it can reproduce vegetatively from branch fragments (see Cronk & Fuller, 2001). It exhibits allelopathic characteristics and is tolerant to a wide range of environmental variables and its ability to invade a wide range of environments is documented. In Malta potentially invadable habitats include maquis and watercourses. It easily regenerates from the base after damage. It is commonly cultivated in Malta and its naturalisation in natural habitats is recently being observed, and success in its further establishment and spread can be aided by climate change. This species has been identified as one of the 100 world's worst invaders. Leaves and seeds are toxic to certain mammals (including small ruminants).

Literature Review:

Management:

- Cronk & Fuller (2001) on *L. camara* (pp. 82-86)
- Weber (2005) on *L. camara* (p. 228) - physical removal
- Information provided on the ISSG Database - <http://www.issg.org/database/species/ecology.asp?fr=1&si=56>

Perennial Succulent Shrubs/Rosettes

***Aeonium arboreum* (L.) Webb & Berth.**

(Maltese: *widnet il-Kalli*; English: tree house-leek) - [Family Crassulaceae]

Management Options:

- **Manual** removal taking care to remove all debris, as segments may take root and re-sprout.

Comments: Seed is wind dispersed.

***Agave* spp.**

Agave americana L. (Maltese: *l-agave*; *is-sabbara tal-Amerka*; English: century plant); and *Agave sisalana* Perrine ex Engelm. (Maltese: *is-sizal*; *l-agave s-sizalana*; *is-sabbara tal-Amerka* ; English: sisal; sisal hemp, hemp plant) - [Family Agavaceae]

Management options:

- **Existing Practice in Malta:** Trials aimed at the removal of *A. americana* were undertaken at ir-Ramla tat-Torri/Rdum tal-Madonna as part of the EU LIFE-funded Yelkouan Shearwater Project. The method employed, combined with follow-up (every couple of months) comprised of:
 - manual removal (by hand or via use of a trowel/hoe) of juvenile plants with roots and all with soil disturbance being kept as low as possible;
 - in the case of larger specimens, the management goal was to minimise further proliferation by removing young shoots and preventing vegetative propagation from older shoots; removal involved cutting off sharp spines on the ends of the leaves, followed by pruning of the plant down to the ground and then removal of the roots by digging around and under the base to facilitate root removal.



- **Mechanical (labour intensive):** (more appropriate for small rosettes and small patches) Control may be achieved by removing the flower stalk (before seed production), as well as removing young shoots from the adult plants, combined with carefully uprooting small rosettes (juvenile/young plants) of *Agave* by hand (using heavy duty gloves) or using a hand tool ensuring the removal of all debris - roots and rhizomes to prevent re-growth. When dealing with adult plants the removal of the above-ground structure of the plant using chainsaws with repeated cutting below the root crown (*i.e.* the area where the stem becomes the root) until no regeneration is visible, could be explored.
- **Chemical:** Foliar application of a systemic PPP applied directly onto the leaves of the plant using wipe-applicators, or wiping onto cut plants. When carrying out the foliar application, complete cover foliage is necessary. Over-application should be avoided especially spray run-off; this method should **not** be applied next to watercourses and in ecologically-sensitive areas; it is important to control spray drift and therefore should not be employed on windy and rainy days; multiple follow-up treatment might be required; a tracer dye could be applied so as not to leave any individuals untreated; areas with frequent public use may need to be closed off until PPP has dried, this approach should first start as a field trial.

Comments: *Agave* is monocarpic and is a freely-suckering plant (production of lateral shoots). Although the rosette, after flowering, will die, it will then produce basal side shoots. A specimen can take up to 10 years or more to reach flowering size as reported by Blamey & Grey-Wilson, 2008 (wildflowers of the Mediterranean, 2nd Edition). Reproduces sexually (in which case seeds are dispersed by water and soil movement) and vegetatively by offsets and bulbils - freely suckering. Eradication may be difficult, and hence control may be the best option bearing in mind that it will however require a lot of human commitment in order to follow up its spread with ongoing management and post-removal monitoring.

Literature Review:

Management:

- Management of *A. sisalana* and *A. americana* using foliar application and uprooting seedling of *A. americana* - vide Tunison & Zimmer (1992)
- Weber (2005) on *A. americana* (p. 26) - specific control methods not available; digging out of small rosettes taking care to remove all roots to prevent re-growth; *A. sisalana* (p. 27) - small plants dug out with complete removal of roots and rhizomes; PPP application to cut plants;

***Opuntia ficus-indica* (L.) Mill.**

(Maltese: *il-bajtar tax-xewk*; English: prickly pear) - [Family Cactaceae]

Management Options:

- *Mechanical control* - is difficult (same methods as described for *Agave* may help - *i.e.* removal of the above-ground structure of the plant using chainsaws with repeated cutting below the root crown until no regeneration is visible, accompanied by rigorous follow up of re-sprouts)
- *Chemical - stem injection with follow-up to address re-growth and seedlings*

Comments: Detached pads can root; *O. ficus-indica* is listed as one of the 100 of the Worst Invasive Species on the DAISIE database; seeds can remain viable for several years in the soil; rodents can disperse the seeds of the prickly pear; exhibits vigorous sprouting; Commercial uses in Malta - edible fruit is harvested and sold; use in farming - as a hedge in peripheral field boundaries, commonly along rubble walls; as a screening to protect seedlings; production of liqueurs, pharmaceutical research.



In Malta other *Opuntia* species have become naturalised, with some even on the increase such as *Opuntia macrorrhiza*.

Literature Review

Characteristics:

- DAISIE Fact sheet (Author: Montserrat Vilà; Last Modified: 4/10/2006) - www.europe-alien.org/pdf/Opuntia_ficus-indica.pdf
- PIER Database - www.hear.org/pier/species/opuntia_ficus_indica.htm

Management:

- DAISIE Fact sheet (Author: Montserrat Vilà; Last Modified: 4/10/2006) - www.europe-alien.org/pdf/Opuntia_ficus-indica.pdf - injection of PPPs into the cladodes
- Weber (2005) on *O. ficus-indica* (p. 290) - specific control methods not available; *O. dillenii* (p. 289) - specific control methods not available

Grasses

***Arundo donax* L.**

(Maltese: *il-qasba l-kbira*; English: great reed) - [Family Poaceae]

N.B. Reed habitats can act as an important habitat type for particular fauna including those which are threatened, depending on the location where they are found in Malta. Therefore before embarking on control efforts targeting this species, MEPA should be consulted beforehand.

Current Practice in Malta: Removal of *Arundo* from *ir-Ramla* area involves cutting when flowering starts (but before seed production) as this is the time when reserve food in the roots is close to being exhausted, coupled with removal of stalks to minimise further spread + constant follow-up to address re-growth from the roots. In the agricultural area, regular cutting + covering with a black plastic impedes photosynthesis + removal of any re-sprouts.

Management Options: The management goal can either be control of encroachment when dealing with a large infestation of dense, homogenous stands, or, complete eradication from the treatment area if the non-native plant is present as a small manageable clump of reeds and is not desired where found because for instance there is evidence that it is out-competing native species. Management options include both mechanical and chemical, and will require rigorous follow-up.

- **Mechanical:** involves cutting the canes at the base of the plant during the growth period; disposing of the cane debris and either:
 - digging up the roots (only feasible for a very small infestation and where harm cannot be done to any native species), or
 - flooding with at least three feet of water covering the rhizomes for an extended period during the growing season (may not be feasible, depends on the ecological context); or
 - employing soil solarisation (depends on the ecological context).

Mechanical methods described are appropriate for small infestations and where there is concern to use PPPs. It is important to remove all cane and root debris to prevent re-invasion. Cutting only the canes will not stop its growth but will only limit its spread downstream if present near running water. The reason is that although it propagates from its stems, it will re-sprout new growth from its roots. Cutting above-ground only stimulates additional growth from its massive root system; however, repeated cutting of the shoots can lead to depleting the carbohydrate storage in the rhizomes and, therefore, reducing the vigour of the plant. Fresh cut stems and canes can be still viable and capable of re-sprouting and re-rooting, which means extreme care must be taken when removing stems and canes after cutting. A drawback of this method if not carefully carried out, can lead to dispersal of plant propagules because of masses of root and rhizome which may be overlooked and accidentally moved to new locations. The mechanical method (cut of canes and root removal) can lead to soil disturbance and erosion if soil is washed away. To prevent this it would be appropriate to plant the native Common Reed (*Phragmites australis*) and/or *Arundo planiana* [*Arundo plinii*].

- **Chemical:** (not to be used in ecologically sensitive areas and when found inter-mixed with the native Common Reed):
 - Foliar method of application of a selective systemic PPP that is labelled as an aquatic-approved PPP: This method is documented as being most effective during the growing season and is optimal after the flowering season before the plant enters dormancy. It has been documented that within two to three weeks after the foliar treatment the leaves will turn brown and will soften making it easier to dispose of the biomass. The side-effects of this method are dependent upon the proper use of the PPP. The greatest risk in spraying PPPs is spraying also native vegetation. Foliar application of PPP, although documented as one of the more effective means for the control of this species, is not recommended in the Maltese context.

▪ *Combination of Mechanical & Chemical Methods:*

- Cut-stump PPP application method: involves cutting of the *Arundo* stalks 1 to 2 feet from the base and remove the cuttings; re-cut the stalks down to 2 to 3 inches and immediately apply an aquatic-approved PPP directly to the stump. The side effects of the cut-stump method include the risk of spillage of the PPP and a slight risk of soil damage, disturbance and erosion when removing the cane.
- Cut-stalk-re-sprout-spray method (after Bell, 1997): *Arundo* stalks are first cut and then the biomass is removed. Then, allow 3-6 weeks to pass so that the plant can grow one meter tall and then the foliar application of the PPP should be sprayed on the new growth. The advantage of this method is that there is less PPP applied to treat the new growth. The disadvantage is that cutting the stalks results in the plant returning to the growth phase. This means it is drawing nutrients from the root mass and there is less translocation of the PPP to the roots and therefore less root kill. Another disadvantage of this method is that it requires many follow-up treatments, which means more manpower and PPP application and desirable vegetation may be affected by the spraying technique.

Comments: This species is a hydrophyte (“water loving”) and can absorb profuse amounts of water in order to sustain its high rate of growth (*vide* Bell, 1997). Spreads by stem and rhizome fragments which can form new plants. Difficult to eradicate because of clonal root masses, which may reach up to more than a metre in thickness. Its rhizomes tolerate both seawater and periods of desiccation and, an ‘established plant may expand by rhizome extension roughly one-half metre per year’ (Dudley, 2006 - GISD). Apart from vegetative means of spread by rhizomes and fragments, Boland (2006) documents a new mode of spread termed as “layering”, which the author describes as ‘ the adventitious sprouting of stem tips in contact with the ground’.

Fire should not be used as a control method since the Great Reed is not only highly flammable but also regenerates more quickly due to its rhizomes which respond quickly after fire and rapidly outgrows native species that take much longer to recover. As stated by Bell (1997), ‘ A suite of methods is needed to control *A. donax* depending upon the presence or absence of native plants, the size of the stand, the amount of biomass which must be dealt with, the terrain, and the season.’ According to Bell, 1997 PPP use is more effective when applied in the post-flowering stage. The reason is that the plant would be sequestering nutrients to the rhizomes at the time thereby its own translocation system can be used the transport PPP to the rhizomes, requiring less PPP administration. If tackling the species along a watercourse it should be noted that the species has the ability to break off and transplant itself downstream. Therefore, the best control approach is to start upstream and work downward (*vide* GISD - Dudley, 2006; Lawson, Vartanian & Else, 1996). Full control requires decades of follow-up treatment.

Literature Review:

Characteristics: Information on *Arundo donax* provided on the Global Invasive Species Database (GISD, Compiled by Dudley, 2006) - www.issg.org/database/species/ecology.asp?si=112&fr=1&sts=sss

Management:

- Teamwork Kills *Arundo* in Cost-effective Manner - Lawson, Vartanian & Else, 1996
- Bell, G.P. (1997): *Ecology and management of Arundo donax, and approaches to riparian habitat restoration in Southern California*
- Southern California Integrated watershed Programme - *Arundo* Removal Protocol - 2002: Section 4 of this publication looks into the general methods for the removal of this species.
- Giant Reed in Chapter 6: The Plants: How to Remove Bay Area Weeds by MacKenzie, 2004, In: The Weed Worker’s Handbook - A Guide to Techniques for Removing Bay Area Invasive plants (page 92)
- Bossard, Randall & Hoshovsky (2000) on *A donax* (pp. 53-58) - manual methods for minor infestations; hand pulling for plants less than 2m in height; or dug up using hand tools in combination with stem cutting near the base; post flowering and pre-dormancy application of PPP - direct treatment to cut culms to avoid PPP drift - cut-stem application
- Weber (2005) on *A. donax* (p. 57) - hand pulling or digging out of smaller plants with removal of all rhizomes; just cutting the stems will not kill off the rhizome system; PPP application after flowering by cut stem treatment or applied as foliar spray.

***Pennisetum setaceum* (Forssk.) Chiov.**

(Maltese: *il-pennizetum*, *il-pjuma*; English: fountain grass) - [Family Poaceae]

Management Options:

- **Manual** - eradication can be achieved by hand-pulling and uprooting all individual plants in small infestations, taking care to remove all emergent seedlings. Control and containment can be done by destroying the inflorescences to prevent seed dispersal. Before hand pulling, any present inflorescences should be cut and placed in plastic bags and then destroyed to prevent seed dispersal.
- Rhizomatous species such as grasses like *Pennisetum* species can also be removed by applying the digging fork technique to lift entire soil block, when soil is dry, loosening the rhizome and lifting all pieces out of the soil. Rhizomes must be destroyed by incineration or anaerobic immersion in water.
- **Chemical** - for large infestations using a systemic post-emergent and pre-emergent herbicide if the infestation is away from protected species, trees and watercourses. Not all herbicides are effective for the control of this species.
- **Combination** - deemed more effective than either mechanical or chemical control alone.

Comments: perennial grass with clumped growth form; exhibits rapid growth and can live up to 20 years; thick growth form interferes with the regeneration of native species and result in displacement; seeds are formed by apomixis and are primarily dispersed by wind, but can also disperse by water and vehicles; seed bank in the soil is long-lived making control difficult; large quantities of dead biomass can promote fire hazards and the species also rapidly establishes itself after burning; planting with native species after removal of *Pennisetum*, can impede its re-establishment; while it thrives in disturbed areas with full sun (in fact it is drought resistant) and is aggressive in dry habitats where it can form monospecific stands, it can be outcompeted in wet habitats by other grass species.

Manual removal of *Pennisetum villosum* R. Brown, commonly known as feathertop, can be undertaken as above. The latter species is also a tussock-forming perennial grass, producing dense clumps. It is wind pollinated, but reproduces mainly vegetatively by rhizomes.

Literature Review:

Characteristics:

- EPPO information on *Pennisetum*: http://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm

Management:

- Bossard, Randall & Hoshovsky (2000) on *Pennisetum setaceum* (pp. 258-262)
- ISSG Database: www.issg.org/database/species/ecology.asp?si=309&fr=&sts=tss
- Weber (2005) on *Pennisetum setaceum* (p. 314)

Prostrate Creeping or Trailing Succulent Perennials

***Aptenia* spp.**

Aptenia cordifolia (L. f.) Schwant. (Maltese: *widnet il-ħanzir*, *widnet il-ġurdien*; English: heart-leaved ice-plant)

Aptenia lancifolia L. Bolus (Maltese: *qrun il-baqra*, English: lance-leaved ice-plant) - [Family Aizoaceae]

Management Options:

- **Manual** hand-pulling and uprooting individual plants, taking care to remove all live plant segments including buried stems as they may re-sprout if left in contact with soil. Large mats can be removed by rolling them up like a carpet (rolling mat technique). The mats can then be compressed and allowed to compost under plastic with ammonium sulphate or urea to accelerate the process.



Comments: able to grow roots and shoots from any node that is in contact with soil; This succulent is seed dispersed mainly by water. In order to prevent re-invasion, it would be ideal to plant native species that fall part of the ecological context of the area. In any case follow-up and monitoring should be done to detect any overlooked segments which might have sprouted.

Literature Review:

Characteristics:

- Information provided by PIER: www.hear.org/pier/species/aptenia_cordifolia.htm

Management:

- Bossard, Randall & Hoshovsky (2000) on *A. cordifolia* (pp. 46-48)

***Carpobrotus edulis* (L.) N.E. Br.**

(Maltese: *is-swaba' tal-Madonna*, *xuxet San Ġwann*; English: Hottentot fig) - [Family Aizoaceae]

[N.B. Information is also relevant for *Carpobrotus acinaciformis*]

Management Options:

- **Manual** uprooting individual plants, taking care to remove all debris including buried stems as segments may re-sprout, coupled with monitoring and any required follow-up in case re-sprouting has occurred. Large dense clonal mats can be removed by rolling them up like a carpet (rolling mat technique) (Weber, 2005 on *C. edulis*; p. 86). The mats can then be compressed and allowed to compost under plastic with ammonium sulphate or urea to accelerate the process. Considerations of minimum site/soil disturbance are important.



Comments: This perennial succulent generally spreads both by seed and vegetatively, however in Malta it does not seem to spread by seed. As documents in the EEA Technical Report 16/2012 "... stems are up to 3 m long, shoot segments can grow 0.5-1 m per year with individual clones reaching 50 m in diameter". Its fruit, which provides a water/energy-rich food source (see DAISIE fact sheet) can be dispersed by mammals including rodents. Ingestion by mammals increases seed germination. Reproduces mainly vegetatively by means of trailing stems/runners which root at the nodes and broken-off segments. Shallow, fibrous roots, and also shoots, form/grow at the nodes which are in contact with soil. This succulent can be easily eradicated. In order to prevent re-invasion, it would be ideal to plant native species that fall part of the ecological context of the area. In any case, follow-up and monitoring should be done to detect any overlooked segments which might have sprouted. *C. edulis* is listed as one of the 100 of the Worst Invasive Species on the DAISIE database; seeds that have not germinated can remain viable in the soil for at least 2 years (DAISIE). This species impacts local biodiversity by way of direct competition for space, nutrients, water and light and by suppressing the growth of native vegetation. It also disrupts

supporting ecosystem services by altering soil carbon and nitrogen content and pH. Although used to control erosion in dune communities, this species can alter the natural succession processes of this specialised habitat type by way of organic matter build-up from the plant's vegetation litter.

Literature Review:

Characteristics:

- Seed production and dispersal reviewed by D'Antonio (1990)
- *Carpobrotus edulis* - Global Invasive Species Database
www.issg.org/database/species/ecology.asp?fr=1&si=1010

Management:

- Eradication - Fraga *et al.* (2006)
- DAISIE Fact sheet by DAISIE (Author: P. Delipetrou; Last Modified 21/11/2006): www.europe-alien.org/pdf/Carpobrotus_edulis.pdf
- Bossard, Randall & Hoshovsky (2000) on *C. edulis* (pp. 90-94)
- EEA Technical Report 16/2012 - Section on *C. edulis* (pp. 52-54)

Creeping or Climbing Herbaceous Plants

***Cardiospermum grandiflorum* Sw.**

(Maltese: none known for this species; English: balloon vine) - [Family Sapindaceae]

Management options:

- *Manual* - for small infestations, manual pulling out of seedlings and smaller plants with complete removal of the taproot, or else if this remains in the soil, re-growth can occur; larger vines can be cut, combined with digging out of the tap root + rigorous follow-up to remove seedlings that emerge until the seed bank is exhausted.

Comments: Liana exhibits vigorous growth; a prolific seed producer; the large bladdery capsules carrying the seeds can float on water, the seeds equipped with a wing like septum are also dispersed by wind; its dense, heavy curtains of tangled stems can smother native species impeding them for photosynthesising; can tolerate occasional flooding/inundation (see Weber 2005; p. 82); plant prefers damp conditions

Literature Review:

Characteristics:

- Information provided by Global Invasive Species Database:
www.issg.org/database/species/ecology.asp?si=1346&fr=1&sts=f&lang=EN

Management:

- Cut-stump method (Weber 2005; p. 82) - use only if species is not present in an ecologically sensitive area and not in proximity to water, seeing that the mechanical option + rigorous follow-up is feasible for removing the plant.

***Tropaeolum majus* L.**

(Maltese: *il-kaboċċinella*; English: garden nasturtium; tall nasturtium; Indian cress) - [Family Tropaeolaceae]

Management options:

- *Mechanical:* cutting, taking care to remove all debris;
- *Chemical:* (used as a last resort and not to be used in ecologically sensitive areas and if the non-native tree is in proximity to running water or threatened plants): Foliar application of a systemic PPP applied directly onto the leaves of the plant.



Comments: Fruit (mericarp) is secondarily dispersed by water and other agents; Has a high rate of fruiting and ease of germination which hurdle eradication;

Literature Review:

Management:

- Management of *T. majus* using foliar application to reduce coverage - vide Tunison & Zimmer (1992)

Erect Herbaceous Plants***Symphotrichum squamatus* (Sprengel) Hieron. [= *Aster squamatus*]**

(Maltese: *is-settembrina s-selvaġġa*; English: sea aster) - [Family Asteraceae]

Management Options:

- *Manual* - hand-pulling and uprooting individual plants before flowering and taking care to remove all live plant segments

Comments: Plant is short-lived; Achenes dispersed by wind

Herbaceous Geophytes

***Oxalis pes-caprae* L.**(Maltese: *il-ħaxixa Inglīza*; *l-Inglīza*, *il-qarsu*; English: Cape sorrel) - [Family Oxalidaceae]**Management Options:**

- *Manual* - digging out individual scattered plants with complete removal of all underground structures; Weber (2005; p. 294) states that 'Constant weeding before bulblet formation may weaken the plant'.

Comments: This stemless species spreads vegetatively by underground bulbil/bulblet formation (dormant in summer; sprouts in autumn); flowers are sterile in Malta. Underground vegetative spread occurs by a combination of shoot elongation and root contraction so as to disperse renewal bulbs (Pütz, 1993). Bulbils/bulblets easily break off and then spread through soil disturbance, wind and water (bulbils float), vehicles and agricultural activities, and birds. In Malta, *Oxalis pes-caprae* is parasitized by *Orobanche muteli*. The plant dies after spring time. *O. pes-caprae* is listed as one of the 100 of the Worst Invasive Species on the DAISIE database.

Literature Review:**Characteristics:**

- Pütz, N. (1994). Vegetative Spread of *Oxalis pes-caprae* (Oxalidaceae). *Plant Systematics and Evolution*, 191: 57-67.

Management:

- Lambdon, P. (2006) *Oxalis pes-caprae*. In: DAISIE European Invasive Alien Species Gateway (2008). Available from: www.europe-aliens.org/speciesFactsheet.do?speciesId=10959

***Nothoscordum gracile* (Aiton) Stearn s.l.**(Maltese: *it-tewm tal-qšari*; English: fragrant false garlic) - [Family Liliaceae]**Management Options:**

- *Manual* - Removal of flowers before they go to seed. Plant can be dug out taking care that the bulb and all bulblets (easily break off if plant is disturbed) are removed, followed by adequate disposal.

Comments: Perennial bulbous herb which is hermaphrodite. Capsules open to release seed which is dispersed mainly by water and soil movements. It also reproduces and spreads vegetatively. This species has escaped from cultivation as an ornamental, and is now naturalised and frequent. It can be quite competitive when it invades natural habitats such as garigue and steppe.