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

MEPA

Final Version

2013

Disclaimer

These guidelines are designed for use by practitioners of removal of invasive alien plants, practitioners of habitat restoration and management, as well as protected area/site managers, and are hereafter referred to as "Users of the Guidelines". Such users must comply with regulations in force at the time, and other relevant policies[1], prior to and during the carrying out of activities/interventions described in the guidelines. Users of the Guidelines should:

- be guided on the principles of the "precautionary approach" when faced with doubts as to whether any activities of removal of invasive alien plants may harm local biodiversity; and
- further follow the "ecosystem approach" when planning such activities, including native species reintroductions/reinforcements.

Any activity that involves alien plant removal and/or native plant conservation translocation (such as a reintroduction) within a Natura 2000 site or other protected area[2] requires prior authorisation from the Malta Environment and Planning Authority (MEPA)[3]. Land tenure/ownership/use considerations should also be addressed including any necessary third party consultations or consents prior to the carrying out of the intervention. It is the responsibility of the individual or entity, who is carrying out alien plant removal and/or habitat management, to ensure that the use of plant protection products (PPP) is in compliance with legislation in force at the time and label specifications. Application of PPP must be guided on the latest knowledge of environmental consequences of formulations, and, must be applied in a manner that does not in any way harm native biodiversity. The Malta Competition and Consumer Affairs Authority (MCCAA, the former Malta Standards Authority)[4] should be consulted for any queries on PPPs.

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1 A list of regulations and policies for which MEPA is the Competent Authority is available at: www.mepa.org.mt/lplegislationpolicymain. Legislation falling under the remit of other entities is available by accessing the Laws of Malta: www2.justice.gov.mt/lom/home.asp

2 An updated list of protected areas in Malta is available online at: http://cdr.eionet.europa.eu/mt/eea/cdda1

3 Contact Address: Nature Permitting, Ecosystems Management Unit, Malta Environment and Planning Authority, St. Francis Ravelin, Floriana, FRN 1230; Contact Email: nature.permitting@mepa.org.mt and invasive.species@mepa.org.mt; Contact Telephone Numbers: (+356) 2290 7102/7117

4 MCCAA Website: www.msa.org.mt/; Contact Details: www.msa.org.mt/contact_us.htm

Limitations of the Document

These Guidelines have been developed with the aim of ensuring that best practices are followed by practitioners of both the removal of invasive plants and in undertaking efforts aimed at reinstating or restoring native plant communities. The methodologies to mitigate the threats of invasive plants and described in these guidelines are mainly based on a literature review, taking into account current practices/experiences, where information is available. Hence the methodologies should not be seen as "recipes" which to follow to the letter (*i.e.* are not prescriptive), but rather should been seen as points to consider when making informed decisions. This statement is especially important when considering the different scenarios of invading species in varying ecological contexts, where they would have adapted to particular environmental cues (if the population is well established and naturalised), and hence would warrant decisions to be taken on a case-by-case approach.

These Guidelines are intended to be a living document, and in this respect should be periodically updated to reflect experiences in management and operational advancements. Practitioners of IAS remedial activities and habitat restoration, and managers of protected areas, are urged to report on experiences that can contribute towards refining these guidelines. In this respect, preliminary consultations took place in 2010, following by other consultations with stakeholders and the public between September and November of 2011. This revised and final version accordingly integrates feedback received during the consultation period.

Environment Protection Directorate
2013

MEPA

CONTENTS

List of Acronyms

CBD – Convention on Biological Diversity
EDPA – Environment and Development Planning Act
ESPC – European Strategy for Plant Conservation
GMO – Genetically Modified Organism
IAS – Invasive Alien Species
IUCN – International Union for Conservation of Nature
LN – Legal Notice
MCCAA - Malta Competition and Consumer Affairs Authority
MEA – Multilateral Environmental Agreement
MEPA – Malta Environment and Planning Authority
NBSAP – National Biodiversity Strategy and Action Plan
PHD – Plant Health Directorate
PPP – Plant Protection Product

Executive Summary

National legislation requires that measures are adopted to address invasive alien species (IAS) and to maintain or improve the conservation status of threatened and protected native species. Malta's National Biodiversity Strategy and Action Plan (2012-2020) adopts national targets and measures that address both issues. One NBSAP target states that "By 2020, measures are in place to prevent, in so far as practical, the introduction and establishment of new invasive non-native species, while those that are established are identified and prioritised for eradication or control, where feasible." Another target mentions that "By 2020, the risk of local extirpation of known threatened species has been reduced, with 30% of the species of European Community Importance in the Maltese territory having a favourable or improved conservation status".

Conservation endeavours involving alien plant eradications and native plant conservation translocations (such as plant reintroduction or reinforcement) are however inherently complex. This complexity can in turn be exacerbated by other factors such as climate change which would influence the abundance and distribution of both native and non-native species and depending on their ability to adapt to associated environmental changes. Both conservation endeavours are also complementary in that the removal of invasive plants and their associated impacts would contribute to reaching a favourable conservation status of native plant communities, whereas native plant conservation translocations (such as plant reintroductions and reinforcements) would contribute to the resilience and resistance of plant communities to biological invasions and other man-made pressures. Yet, such endeavours must be developed on a sound information basis so as to avoid undesirable effects, whilst maximising beneficial effects on local biodiversity in the most financially and ecologically viable manner. To this end, the present guidelines have been compiled with the following objectives in mind:

- To assist in the planning and implementation of management programmes, aimed at counteracting the spread of extant plant invaders in important natural and semi-natural areas (that is, areas of high conservation value including but not limited to protected areas) and rural areas, where the removal of alien plants is desired, since it would benefit neighbouring/adjacent natural and semi-natural habitats;
- To serve of assistance when designing and implementing native plant conservation translocations, aimed at reinstating native plant communities to a favourable conservation status or an ecological function in compliance with the relevant legislation in force at the time.

The guidelines will also support the implementation of Malta's NBSAP vis-à-vis invasive plants and improving the conservation status of native plant communities.

The main substance of the guidelines is provided by Part II and III of the document. These respectively detail the steps to follow when curtailing the spread of invasive plants, and when planning native species recovery programmes. Supporting material which adds to the informative value of the guidelines is annexed to the document (see Annex V), while technical terms are defined in Annex I.

The guidelines target managers of protected areas and entities involved in the removal of invasive plants and habitat management and/or restoration. The document also serves as guidance to be followed when implementing conditions on alien plant removal that may accompany development permits.

These guidelines address some of the major plant invaders in the Maltese Islands. Plant invasions are only considered in the context of terrestrial, riparian and coastal communities (aquatic species are not covered). Archaeophytes that require some form of management to control their encroachment are also addressed. The scope of the document also excludes ruderals, plant pests and diseases, and genetically modified organisms (GMOs).

The guidelines have been developed bearing in mind the guidance provided by Multilateral Environmental Agreements (MEAs) and other documents of best practice in invasive species management and habitat management/restoration of plant communities.

A number of paragraphs throughout the document are annotated with the following cautionary sign "**Note".** There are 30 such paragraphs and these confer information that is deemed to be of particular importance to the user of the guidelines.

PART I: *Objectives and Scope of the Guidelines*

The Maltese Islands support a plethora of native plant diversity with over 1000 higher plants[5] recorded, not to mention the hundreds of species of lower plants[6], and also fungi that characterise local ecosystems. The country's insularity, coupled with evolutionary forces, has led to the creation of some 25 species being endemic to the Maltese Islands. Such endemism imparts a degree of distinctiveness to the local natural heritage. In view of the island's high population density (1,300 persons per km^2) and the growing demand for natural resources, the survival and integrity of native plant communities, particularly those supporting endemic plants, is however increasingly being undermined. The conservation status of native and endemic flora is thwarted by an intricate suite of threats that act concurrently to the detriment of Maltese biodiversity. Such threats can be essentially traced to changes in land use and unsustainable use of natural resources. Ensuing pressures include those associated with pollution and nutrient overload, land fragmentation, degradation and deterioration, soil erosion, as well as anthropogenic climate change.

An environmental problem that is of growing global, regional and national concern is the threat posed to native biodiversity by invasive alien species (IAS). Insular ecosystems such as the ones found in the Maltese Islands are particularly susceptible to damage from biological invasions because of the endemic biological diversity present and the constrained size of such islands, whereby more often than not, local ecosystems are small-scale, coupled with the high extent of disturbed and fragmented land. Addressing in an effective manner, the various social, economic and environmental impacts associated with plant invasions, necessitates adequate planning, research, *in situ* restorative action, a high degree of committed time and effort, as well as the securing of long-term resources at an early stage, in order to achieve the desired end-results. *In situ* measures to curb biodiversity loss are varied and can range from threat mitigation, habitat and resource management, to restoration measures such as species reintroductions or reinforcements.

National legislation addressing non-native and invasive species has evolved over the years since the Environment Protection Act (EPA, Chapter 435: Act XX of 2001, as amended, and partly repealed by the Environment and Development Planning Act of 2010)[7] came into force. This led to the enactment of various pieces of subsidiary legislation incorporating provisions on non-native species. The establishment of guidelines to tackle plant invaders in a national context is also embedded in national legislation. Malta is also duty-bound, by a number of regional and global treaties to which it is a Party/Member, to address issues related to invasive species, to adopt *in situ* measures to safeguard biodiversity, and, to undertake activities aimed at species recovery, where this is deemed to benefit the conservation status of the species of concern. Moreover, Malta's National Biodiversity Strategy and Action Plan – Working hand-in-hand with Nature (2012-2020) establishes the following national targets which are of direct relevance to these guidelines:

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5 The majority are flowering plants, but also include ferns and conifers.
6 These include the non-vascular non-flowering plants *i.e.* algae, mosses, liverworts and lichens.
7 www.mepa.org.mt/file.aspx?f=1411

- **NBSAP Target 9** - By 2020, measures are in place to prevent, in so far as practical, the introduction and establishment of new invasive non-native species, while those that are established are identified and prioritised for eradication or control, where feasible.
- **NBSAP Target 11** - By 2020, the risk of local extirpation of known threatened species has been reduced, with 30% of the species of European Community Importance in the Maltese territory having a favourable or improved conservation status.
- **NBSAP Target 13** - By 2020, vulnerable ecosystems that provide essential services are safeguarded, with at least 15% of degraded ecosystems restored, while 20% of the habitats of European Community Importance in the Maltese territory have a favourable or improved conservation status.

The present guidelines have been compiled:

- To assist in the planning and implementation of management programmes aimed at counteracting the spread of extant plant invaders in important natural and semi-natural areas (that is, areas of high conservation value including by not limited to protected areas) and rural areas where the removal of alien plants from such habitats is desired as it would benefit neighbouring/adjacent natural and semi-natural habitats; and
- To serve of assistance when designing native plant conservation translocations, aiming at reinstating native plant communities to a favourable conservation status, or an ecological function, in compliance with the relevant legislation in force at the time.

The guidelines hence target managers of protected areas and entities involved in the removal of invasive plants and habitat restoration. The document also serves as guidance to be followed when implementing conditions for alien plant removal that may accompany planning permits.

These guidelines will also be of assistance when implementing the following NBSAP measures:

- **SH2:** Species and Habitats of European Community and National Importance are maintained across their natural range via the implementation of adequate conservation measures, which support the existing legal protection regime. Maintenance or improvement in the status of Maltese species and habitats of European Community Importance, when compared to current assessments, is achieved by 2020, in so far as feasible. (Timing for achieving measure 2018-2020)
- **SH3:** Opportunities for species reintroduction or reinforcement are explored and adopted, where feasible and where deemed of added value. Such endeavours should be designed following guidance issued by the IUCN and, should also be supported by secured resources and stakeholder engagement. (Timing for achieving measure 2012-2020 – ongoing)
- **BI2:** A systematic and coherent national strategy on invasive non-native species is in place by 2015 and is based on the CBD's three-stage hierarchical approach, which includes prevention, early detection of the species, and rapid action by eradication, containment and control (where feasible). This strategy is supported by other policy guidance on the removal of invasive species.(Timing for achieving measure 2015-2017)

- **BI3:** Endemic species and areas of conservation value at risk by invasive species are identified, and prioritised for targeted, well-planned, ecologically and financially feasible remedial action, with the goal of reinstating self-sustaining native communities and healthy ecosystems. (Timing for achieving measure 2012-2020 – ongoing)

Addressing invasive plants requires prevention of new introductions, through an early warning and rapid response system as a primary course of action, as well as remedial action for those invasive species that have inadvertently become established to the detriment of native biodiversity. These guidelines address the latter issue, while also acknowledging their usefulness in any required rapid response to remove potentially new invasive alien plant introductions before they become established. The Guidelines are not designed to address the prevention of the introduction of invasive alien plants into the country, since this issue is addressed by other existing or planned national policy (e.g. NBSAP Measure BI2 calls for a national strategy on invasive non-native species), EU policy[8] and the ongoing Better Regulation Initiative.

These guidelines address major plant invaders in the Maltese Islands (see Annex III) including species, such as *Symphyotrichum squamatus* (= *Aster squamatus*; Maltese: is-*settembrina s-selvaġġa*; English: sea aster) and *Oxalis pes-caprae* (Maltese: *il-ħaxixa Ingliża; l-Ingliża, il-qarsu*; English: Cape sorrel), which have become so ubiquitous that complete management is unfeasible, unless, control measures are desired in certain areas to minimise plant cover of these species. Plant invasions are only considered in the context of terrestrial, riparian and coastal communities (aquatic species are not covered). Archaeophytes that require some form of management to control their encroachment such as *Arundo donax* (Maltese: *il-qasba l-kbira*; English: great reed) are also addressed. The scope of the document excludes ruderals, plant pests and diseases, and genetically modified organisms (GMOs). The terms "alien species" or "non-native species" are used interchangeably in the guidelines but these terms do not include native species naturally extending their range in response to climate change[9].

Fifteen guiding principles, under the framework of the Convention on Biological Diversity (CBD)[10], lay down a global framework for governments and other organisations to develop strategies to prevent the introduction of, and promote the management of impacts of IAS[11]. In December 2003, the Standing Committee of the Bern Convention[12], to which Malta is a Party, endorsed and adopted the European Strategy on Invasive Alien Species[13]. This strategy provides guidance on several aspects of addressing IAS including in terms of impact mitigation (Genovesi & Shine, 2003; pp. 40-45) and restoration of native biodiversity (Genovesi & Shine, 2003; pp. 45-46).

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8 For updated information on EU policy on IAS refer to: http://ec.europa.eu/environment/nature/invasivealien/index_en.htm

9 This is in conformance to Recommendation No. 142 (2009) of the Standing Committee interpreting the CBD definition of invasive alien species to take into account climate change - https://wcd.coe.int/ViewDoc.jsp?id=1560527&Site=DG4-Nature&BackColorInternet=DBDCF2&BackColorIntranet=FDC864&BackColorLogged=FDC864

10 United National Convention on Biological Diversity - www.cbd.int/

11 CBD COP 6 Decision VI/23 - Alien species that threaten ecosystems, habitats or species - www.cbd.int/decisions/?dec=VI/23

12 Bern Convention on the Conservation of European Wildlife and Natural Habitats - www.coe.int/t/dg4/cultureheritage/nature/Bern/default_en.asp

13 *European Strategy on Invasive Alien Species* - Genovesi & Shine, 2003 - https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=1322677&SecMode=1&DocId=1440418&Usage=2

The present document has been compiled following guidance provided by the CBD and the European Strategy on Invasive Alien Species. These guidelines also contribute to the implementation of the European Strategy for Plant Conservation (ESPC 2008-2014)[14], which establishes the target 'Action Frameworks developed and implemented for controlling and monitoring 10[15] problematic invasive alien species in each country, with reference to information from other countries and regional initiatives' (Europa, 2008; p. 21). Activities aimed at the removal of invasive plan and reinstatement of native plant communities would also contribute towards the implementation of the CBD Strategic Plan 2011-2020 and Target 9 which *inter alia* calls for the control and eradication of priority invasive alien species by 2020. The present guidelines should be read in conjunction with these 15 CBD guiding principles, the European Strategy on IAS and other guidelines on best practice (Annexes II & V to this document). Moreover these guidelines further complement MEPA's "Guidelines on Trees, Shrubs and Plants for Planting & Landscaping in the Maltese Islands"[16], the booklet on "Common Species used for Landscaping in the Maltese Islands" as well as the information booklet[17] drawn up by MEPA to increase awareness on the Code of Conduct on Horticulture and Invasive Alien Plants issued jointly by the European Plant Protection Organisation (EPPO) and the Council of Europe.

[14] A Sustainable Future for Europe; the European Strategy for Plant Conservation 2008-2014 - Europa, 2008
[15] The ESPC indicates that this number may be less for the smallest countries in Europe, *i.e.* those countries with an area of less than 1,000 km^2.
[16] http://www.mepa.org.mt/file.aspx?f=3895
[17] http://www.mepa.org.mt/file.aspx?f=6839

PART II: Managing Plant Invaders

Plant Invasions – A Brief Overview

- Man-mediated transfer of plants, outside their past and present natural range, has occurred since historical times. Not being naturally part of the receiving environment, such introduced species are considered "non-native" or "alien"[18]. Natural shifts in the distribution range of a species (*e.g.* due to climate change) does not qualify a species as an alien.
- The efficiency and rate of transport, trade, travel and tourism observed over the last decades, as well as 'unprecedented accessibility of goods resulting from globalisation' as noted by Genovesi and Shine (2003; p. 7), has dramatically increased the associated entry and transfer of non-native plants by way of various vectors and pathways.
- Primary introduction can either be intentional (mainly for scientific, economic and commercial reasons - whether legal or illegal)[19] or unintentional (such as through contamination of cargo, or, pollutants of imported seed)[20]. Since 1492, intentional introductions of non-native plants into the Maltese Islands have occurred mainly for commercial reasons and in relation to horticultural and agricultural activities (*vide* MEPA, 2005[21]).
- The fate of the non-native species, upon introduction, into a new environment (hereafter the "receiving environment"), and whether or not it becomes established, will depend on the species' biology as well as on the compatibility with the conditions of the receiving environment (including lack of natural enemies). Natural expansion of a non-native species beyond the point of introduction indicates that the ecological conditions are suitable for the species to gain a foothold and become naturalised.
- The majority of non-native species provide benefits to human society such as when considering crop plants and forage species. Non-native plants are deemed harmful whence, upon establishment, they further become naturalised, and subsequently rapidly spread and colonise new areas where they threaten and impact native communities in some way. Such species are termed "invasive"[22]. Major plant invaders in Malta which were deliberately introduced mainly as ornamental plants include, amongst others, *Ailanthus altissima* (Maltese: *ix-xumakk il-falz*; English: tree-of-heaven) and *Carpobrotus edulis* (Maltese: *is-swaba' tal-Madonna, xuxet San Ġwann*; English: Hottentot fig). These species are also listed amongst 100 of the worst invaders[23] in Europe (DAISIE European Invasive Alien Species Gateway, 2008).

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18 At a local level, a native species that does not naturally form part of a plant community, because it was planted there by man, would also be considered as alien. It may be desirable to remove such planted specimens that do not pertain to the ecological context of the area, especially if such specimens are detrimental to the biodiversity in the area.

19 The intentional introduction of non-native plants in the Maltese Islands is regulated by various policy instruments in the context of nature protection (see www.mepa.org.mt)

20 *Vide* Schembri & Lanfranco (1996) and the State of the Environment Report of 1998 for a review of non-native introductions in Malta

21 State of the Environment Report, Biodiversity Chapter - MEPA, 2005

22 Some native species exhibit invasive characteristics and encroach on other native species. Such species are considered as "opportunistic species" and would require some form of management. For instance, *Galactites tomentosa*, a native species shows invasive characteristics.

23 www.europe-aliens.org/speciesTheWorst.do

- The harmful status of a number of species has also been noted in domestic legislation. For instance, the "Trees and Woodland Protection Regulations, 2011" (LN 200 of 2011) lists a number of species of trees deemed to cause damage to biological diversity of trees or woodlands in Malta, or to the natural environment in general. The propagation, sowing, planting, import/export, transport and selling of these species[24] are hence prohibited.
- Spreading into other areas ("secondary introduction") beyond the initial point of introduction may occur via any one of the following dispersal modes:
  - seed dispersal by animals (birds, small mammals and insects, such as ants), water, soil movement and air;
  - vegetative or mechanical means;
  - migration mechanisms aided by other types of vectors (such as cars, farm machinery);
  - escape from cultivation (such as from agriculture, horticulture, forestation and plantations);
  - escape from ornamental planting (such as from botanic, public and private gardens, and other plantings such as along streets or from landscaped areas); or
  - natural (unaided) spread

  A species may exploit more than one mode of dispersal thereby increasing its range dispersal to the utmost resulting in "wide ranging invasion".
- Characteristics that confer invasive ability in non-native plants include: type of breeding system (sexual, vegetative or both), high reproduction rate (including propagule pressure), effective dispersal strategies, ability to live in a wide range of habitat types ("habitat generalists") including the ability to colonise barren areas or disturbed areas, together with the tendency of populations to persist following successful establishment. Some non-native plants also use toxic metabolites or "allelopathic substances" to keep away native flora, such as exhibited by *Ailanthus altissima*.
- Invasive alien species are those which become established in natural communities affecting, in various ways, the native species. Naturalised aliens may invade managed communities, such as agricultural land, gardens and roadsides. In such cases their impact on such communities is largely independent of their being non-native, similar impacts being also attributable to opportunistic native species.
- Not all introduced species turn out to be invasive within natural and semi-natural settings, as some may just be casual alien plants. However, those species that do become invasive and have associated environmental and socio-economic impacts[25], pose a major threat to local biodiversity, disrupt ecosystem services and can impinge on a number of sectors as well as human welfare.
- Plant invasion generally causes significant loss of characteristic native biodiversity[26] and irreversible impacts, unless addressed in a timely manner. In fact, bioinvasions have been documented as being one of main direct drivers of biodiversity change (MA, 2005)[27].

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[24] These species are: *Acacia cyclops*, *Acacia saligna*, *Acacia karroo*, *Ailanthus altissima*, *Eucalyptus camaldulensis*, *Eucalyptus gomphocephala*, *Leucaena leucocephala*, *Pittosporum tobira*, *Ricinus communis*, and *Schinus terebinthifolius*.

[25] More information on the impacts of invasive species in Europe can be obtained by referring to the EEA Technical Report No. 16/2012

[26] Biodiversity, both above and below ground, may be affected by plant invasions.

[27] *Ecosystems and Human Well-being: Biodiversity Synthesis* - Millennium Ecosystem Assessment, 2005

- Plant invasions can cause considerable damage to native flora by ways of hybridisation and associated genetic pollution, competition for resources, habitat alteration (soil, water, nutrient and fire regimes and other geomorphological processes) and degradation, displacement of native flora (and dependent fauna), homogenisation, ecosystem disruption and overall loss of native biodiversity. The worst case scenario is the extirpation of native species from an area or even extinction when considering very restricted species such as endemic plants.
- All semi-natural and natural ecosystems have succumbed to some degree of plant invasion in the Maltese Islands (*vide* Schembri *et al*. 1999)[28]. Disturbed and stressed ecosystems subject to human interference are readily invaded. Native species-rich communities are also vulnerable to biological invasions. Habitat management or restoration is important in preserving plant communities and in providing some degree of resilience to plant invasion.
- The CBD's three-stage hierarchical approach[29] is recommended in tackling invasive species and includes prevention, early detection of the species, and rapid action by eradication, containment and control (where feasible).

Planning and Implementing Management Programmes: Steps to follow

A number of steps should be considered and followed when embarking on the removal of non-native plant species from an area. These include the following steps:

- STEP 1 - Evaluating the target non-native plant species[30] and the area targeted for management *i.e.* from where the non-native plant(s) shall be removed (hereafter called the "treatment area");
- STEP 2 - Determining the management goal on the basis of likelihood of success, the biology/reproductive mode of the non-native plant, as well as the financial and ecological feasibility of the intended endeavour;
- STEP 3 - Choosing the right methodology for management which best suits the species and area in question, and exploring the possibility of habitat restoration, where desirable;
- STEP 4 - Developing and implementing an IAS management programme designed to achieve the stated and defined management goal(s) in specified timeframes, and with appropriate disposal of plant debris;
- STEP 5 - Monitoring throughout the endeavour and practising adaptive management where this is required; and
- STEP 6 - Post-removal monitoring and documenting results of the endeavour.

Activities on the ground will actually commence after having carried out an initial evaluation of the species and treatment area at hand (Step 1) and having decided on the management goal (Step 2) and the choice of the treatment methodology (Step 3). Along with these steps, several other important aspects will have to be borne in mind and as much as possible applied, as further detailed below for every step.

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[28] *State of the environment report for Malta 1998: Living resources, fisheries and agriculture* - Schembri *et al.*, 1999

[29] See Annex to *Decision VI/23 on Alien Species that threaten ecosystems, habitats and species* - http://www.cbd.int/decision/cop/?id=7197

[30] Such species may also include native species which are alien to the area targeted for management because they were wrongly planted there by man.

Note 1: MEPA should be alerted before embarking on alien plant removals from important natural areas. Such removals from Natura 2000 sites or other protected areas require prior authorisation by MEPA.

Step 1: Evaluating the target non-native plant species and the treatment area

Note 2: Reliable identification of the target species is essential before any intervention can take place. Moreover multiple species may be considered for removal in certain locations. As noted by Grice (2009; p. 69)[31] 'Attempts to address problems caused by a single invasive species in an environment in which there are multiple, functionally similar invasive species is likely to be an ineffective use of resources.'

(A) Evaluate the target non-native plant species taking note of:

- The extent of cover (and abundance) of the non-native species of concern, and urgency of the situation at hand in terms of, for instance, evaluating the degree and significance of current and potential impact(s) of the non-native species if left uncontrolled – such considerations will help to prioritise which species to target and where to focus efforts and resources. The latter is, more often than not, limiting, hence requiring that these are used in the most cost-effective manner;
- The biology of the non-native species (life cycle [annual, biennial or perennial], season of growth, time and method of reproduction, propagule pressure and mode of dispersal) as well as its ecology (germination and habitat requirements);
- Proximity of the non-native species to threatened and protected species;
- Assessment of potential impacts of removal of this non-native species;
- Level of difficulty of management and likelihood of success in curtailing the spread of the target non-native species;
- Presence of the non-native species in neighbouring areas and the possibility of re-invasion from these areas into the treatment area thereby undermining the management goal;
- Presence of other non-native plant species which may increase in number once the targeted non-native species is removed from the treatment area;

Note 3: Experience from past management efforts known to have taken place in other areas, locally, should be taken into account, so as to improve on future decisions. Where knowledge is imperfect at the start of the endeavour, additional knowledge can be acquired as the management programme proceeds, always ensuring to follow adaptive management where required.

(B) Define the treatment area (delimiting the site on a map plus photos) *and then take note of:*

- Description and extent of the area earmarked for management/removal of the non-native plant(s);
- Is the treatment area accessible?

[31] *Principles of containment and control of invasive species* – Grice, 2009

- Who is the owner of the area where the intervention is planned? (Any land users should also be liaised with);
- Ecological importance of the area and designations of the site, if any (that is, scheduling/protected area designations/Natura 2000 site);
- Presence of, and proximity to, flowing water bodies (these can act as "invasion corridors") in the treatment area;
- Abundance of the non-native species being targeted for management and extent of cover/distribution by carrying out an initial survey;
- Presence of protected and threatened species in the treatment area;
- Level of, and causes of, (physical and chemical) disturbance in the area and manageability of the disturbance factor (if not natural)[32];

Note 4: Delimiting the distribution and abundance of the target species is important because such information will serve as a basis on which to determine the management goal as well as to monitor progress towards achieving that goal.

Step 2: Determining the management goal[33]

Decide whether to:

- Eradicate *i.e.* successfully and permanently remove all individuals of the target non-native species in the treatment area;
- Control *i.e.* reduce the abundance of the non-native species (which is present as a large and extensive population) in the treatment area by mitigating its impact(s) to an acceptable level (requires recurring endeavours and associated resources);
- Contain *i.e.* prevent or retard the spread of the species to other areas by restricting the presence of the non-native species (which has not yet become widely spread) to a site in the treatment area (requires recurring endeavours and associated resources); or
- Decide on no action – this is the preferred option when management practices are deemed to further worsen the infestation. However, this option may be accompanied by mitigation such as translocating an endangered native species, if ecologically feasible and only adopted as a last resort as translocations can be rather contentious endeavours. Conservation translocation, which refers to the intentional movement and release of specimens of a native plant species where the primary objective is a conservation benefit, is considered in Part III of these guidelines. The latter will usually comprise improving the conservation status of that endangered/threatened plant species and/or restoring natural ecosystem functions or processes.

Eradication is usually the favoured approach to address and eliminate the impacts exerted by non-native species since it can be more a cost-effective option than control, containment and no action alternatives. However, it is noteworthy that this approach

[32] Factors that upset the natural disturbance regime in an area can create windows of opportunity for plant invasion. Such factors for instance include, chemical pollution, and, removal of natural vegetation cover. The element of man-made disturbance is also an important consideration since any management/restoration programme can only succeed if the underlying factors that lead to the disturbance in the first place (or subsequent disturbances) are appropriately addressed before and after the implementation of the programme.

[33] The primary management goal in a strategic approach to deal with biological invasions is prevention. This is however not addressed in these guidelines as these focus on providing guidance on how to go about addressing major plant invaders that are already present in the Maltese Islands and which warrant management in view of their adverse effects on local biodiversity. The element of prevention is however integrated in relevant provisions of domestic legislation.

tends to be more effective and successful if the species is at the early stages of invasion (*i.e.* prior to sustained populations having successfully become established and naturalised) and hence populations are small and localised. Effective eradication lies at the mercy of many factors including, amongst others:

- early detection of the non-native plant;
- timely response to destroy emergent seedlings and saplings by continual and rigorous surveying, monitoring and follow-up;
- commitment to continue eradication efforts until all individuals and propagules are completely removed (complete eradication can last many years); and
- secured human and financial resources for the duration of the programme. Resources must be secured before implementing the programme.

In heavily disturbed areas, the removal of IAS may create open patches that favour colonisation and expansion of other opportunistic species associated with such disturbance. In such cases, the best option would be to address the cause(s) of the disturbance rather than just the species itself, following with planting of native species as part of restoration of such areas. One must also bear in mind that disturbances may have altered the conditions required for native species to regenerate.

The choice of the management goal should therefore be taken based on information regarding:

- extent and significance of damage caused by the target species;
- the biology of the species and its mode of reproduction and dispersal;
- the plant's ability to re-sprout from cut plant parts and underground reproductive structures;
- seed ecology (rate of seed production – whether high or low, continuous or seasonal; longevity of seeds, and seed dormancy mechanisms – see Cronk and Fuller, 2001);
- extent of the plant's distribution;
- tolerance of the plant to fire, drought, shade and other environmental factors;
- impacts on native species and habitats assessed both individually and in conjunction with other threats posed by other activities, depending on the environmental settings;
- extent and degree of human disturbance within the site earmarked for management;
- possible undesired effects by the management goal on non-target species and also consequences of removal of the target species; and
- cost/benefit ratio considerations.

Likelihood of success in removal of the non-native plant(s) is dependent on the following factors:

- how early in the invasion process, action is being taken;
- accessibility to treatment area (landscape characteristics within the area), and ease of identifying, detecting and delimiting the species;
- the biology (life history & seed longevity) and susceptibility of the target species to the treatment method (*i.e.* efficacy of treatment method);

- re-invasion must be prevented, *i.e.* influx/immigration of individuals into the treatment area must be discontinued; this may involve removal of invasive species from neighbouring and connected areas;
- exploiting the time during the plant's life cycle when the population of the species is low or when a plant would be most susceptible to the treatment methodology (*e.g.* prior to reproductive episodes, prior to seed formation and dispersal; taking note of the direction of carbohydrate translocation by the plant[34]);
- the anthropogenic disturbance factor in the treatment area should be minimised or mitigated entirely;
- institutional and land user commitment and sufficient resources for funding the management programme to completion; and
- ensuring that the average rate of removal is greater than the annual rate of increase by the plant (see Parkes & Panetta, 2009)[35].

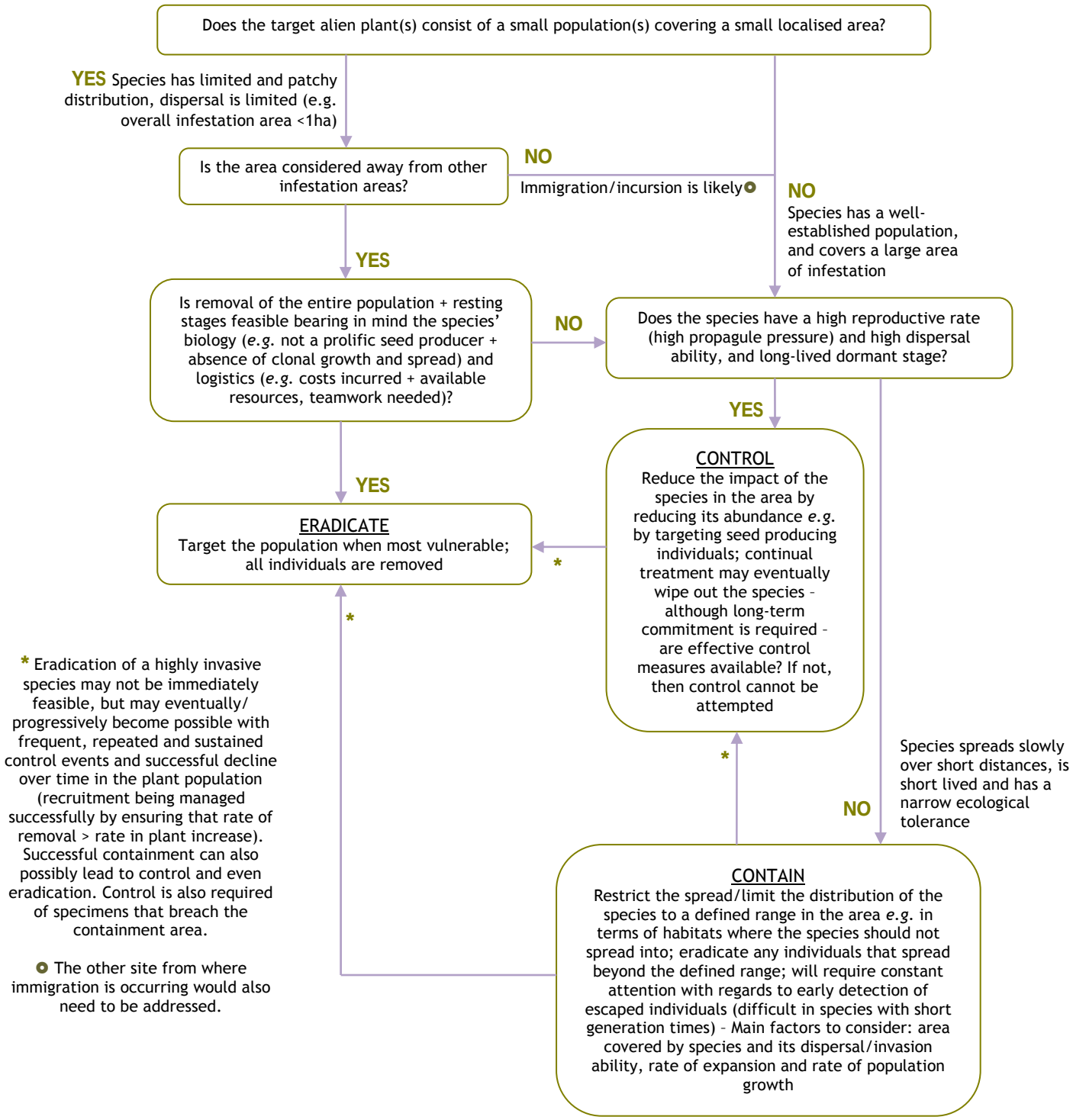
Eradication of plants having persistent seed banks (longevity covers a span of decades) will be difficult and will require commitment and resources until no viable seeds remain in the soil. The feasibility of eradication of such plants needs to be weighed against a number of factors including cost-effectiveness. Unless rate of removal is greater than rate of plant recharge from the seed bank, chances at successfully eradicating the species are unlikely.

Note 5: It is of fundamental importance that the method chosen to remove the non-native species from the treatment area should be ecologically-feasible - in order words the situation must not be worsened and native biodiversity should not be harmed. It is important to plan out the most feasible option before actual action in the field so as to foresee, avoid or timely mitigate secondary impacts on native species and ecosystems that might arise due to insufficient planning. It is not easy to eradicate certain plants, especially those that are prolific seed producers and/or exhibit suckering or re-sprouting when cut. Eradication/control is best done when the species is in its seedling stage, in which case seedlings are removed manually (using gloves, and taking care to remove the root system).

[34] For instance, Holt (2009; p. 127) notes 'For example, shoot removal from a perennial plant in spring using physical or chemical means is unlikely to kill the plant since the majority of carbohydrates are being mobilised upwards to produce new shoots at the time.'

[35] *Eradication of invasive species: progress and emerging issues in the 21st century* – Parkes & Panetta, 2009

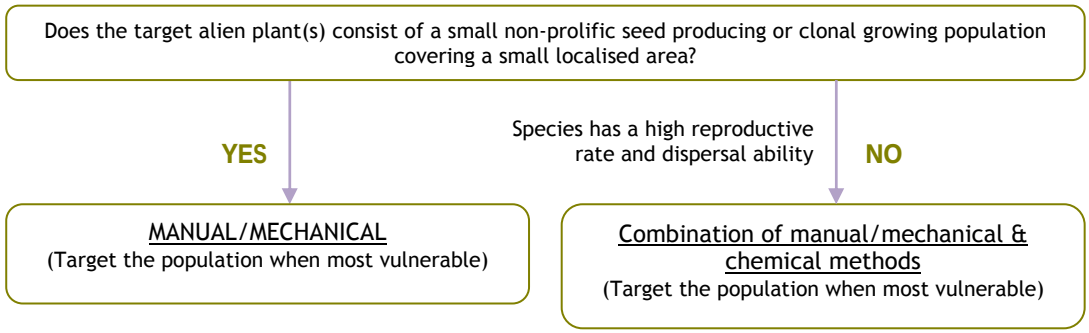
The flow chart below may be of assistance when deciding which of the management options to follow[36]:



[36] Grice (2009) reviews the choice between control and containment in more depth.

Step 3: Choosing the right methodology and exploring the possibility of concurrent habitat management or restoration, where desirable

Species can be controlled by manual/mechanical means, chemical means or a combination of the most appropriate methods in the context being dealt with. The flow chart below may be of assistance when deciding which of these options to follow:



Note 6: Biological/chemical control may be effective for certain species. The control agent may either be a native or an alien species (which should be host-specific; although there are occasional documented situations where non-target species have been affected), or, a poison/ growth inhibitor. Biological control is based on the theory that the biological control agent, as a host-specific natural enemy, can limit the distribution and abundance of its host. Factors that need to be considered when planning a biological control, include, the characteristics of the control agent and potential ecological risks. This would require research into the population ecology of the agent and its host range. What must definitely be avoided is that the alien control agent must not end up being itself invasive nor should it affect non-target species. The use of non-native biological control agents and chemical agents (these may pose a pollution risk to the ecosystem and to the wider environment) should undergo stringent risk assessment and authorisation from the Competent Authority(ies) before actual release.

In the case of clonal invasive species, where no seed is being set, introduction of the seed forming form might help to dilute clonal vigour. However this would require a risk assessment before pursuing any such endeavour in order to ensure that such introduction of the seed forming form does not in actual fact aggravate the invasion of the species in question. Hence this method is not recommended unless a rigorous risk assessment can take place and only in light of positive findings which do not in any way compromise Malta's biodiversity and subject to the necessary approvals from the Competent Authority.

The options for IAS management however should be determined on a case-by-case approach and this will depend on several factors including the alien species in question, as well as the susceptibility of any nearby threatened species to the management methodology. Elements of disturbance, including nutrient enrichment, have been scientifically documented as important contributing factors to plant invasions. For this reason when embarking on eradication/control efforts anthropogenic disturbance must be kept at a minimum (*e.g.* by minimising the use of heavy machinery).

Note 7: Whichever management option is chosen from the documented ones that shall be described herewith, it would be advisable to initially target the removal of seed-producing adults and seedlings. The best treatment method for an IAS is not always straightforward at the beginning of control efforts and is usually only gradually known by trial and error. Caution must therefore be exercised when deciding whether to employ either of the following techniques or a combination of these, as described in the following paragraphs. Consult MEPA before embarking on management efforts to address non-native plants especially when:

- in doubt whether the method you have chosen is adequate;
- in doubt whether the treatment area falls in a protected area;
- in doubt about the species' identity;
- in doubt about presence of native/endemic/threatened/protected species in the treatment area;

Examples of how particular species may be addressed according to documented experiences/guidelines are given in Appendix III. In the end, the choice of methods should be based on a case-by-case basis and considerations of effectiveness, target specificity, cost, practicality, regulation, occupational health and safety and environmental impact.

Manual/Mechanical Techniques[37] - either by hand or using tools and machinery.

As explained by Holloran (2004; p. 37)[38] various cutting tools exist and 'Choosing the right one often depends on biological considerations, safety issues, and efficacy'.

- The techniques described hereunder are:
  - specific in nature and therefore should minimise the likelihood of disturbing and/or damaging adjacent threatened and/or protected species;
  - effective for small infestations *i.e.* when the population being targeted for management is small; and
  - are labour-intensive and time-consuming.
- A regime of consistent and timely follow-up treatments may be necessary usually in the next growing season since seed banks may be present and re-sprouting/germination may occur. Soil seed banks or extensive underground root/vegetative systems may require a number of years to deplete. Frequency of visits to the treatment area is determined by plant maturation periods and seedling emergence.
- Mechanical techniques that involve cutting may cause suckering in certain trees, in which case they go into an emergency response mode by producing sprouts and root suckers such as observed in *Ailanthus altissima*. For this reason, it is not recommended to cut such species unless rigorous follow up is ensured by either continually cutting spouting parts from cut stumps or else by combining cutting with some form of chemical treatment.
- Repeated manual and mechanical operations may:
  - deplete seed banks or vegetative propagules provided there is timely and committed response to deal with escaped or surviving individuals;

[37] This section is adapted on a literature review based on published material by Tu, Hurd & Randall (2001) and Holloran (2004).

[38] Chapter 5 – Tools and Techniques: Manually Controlling Wildland Weeds - Holloran, 2004

- exhaust the carbohydrate reserves of perennial species thus suppressing their re-growth;

Note 8: Disturbance by machines can create conditions for re-invasion or even disperse plant debris, and so the use of heavy machinery should be done with caution and as a last resort. If the treatment area falls in a protected area, MEPA should be consulted before carrying out any activities unless these activities form part of a management plan approved by MEPA; Legislation in force at the time, must be complied with.

MANUAL/MECHANICAL MEANS
What are the plant characteristics of the target alien species?

Plant produces oil-rich seeds

SEED HARVESTING USING FLOATATION

Seed harvesting involves making use of seed floatation following heavy rain to collect the floating seeds; adequate disposal of collected seeds/seed pods is essential and should be incinerated;

Plant produces seed pods

SEED POD REMOVAL

Seed pods are removed before ripening and before dehiscence and hence prior to dispersal; adequate disposal of collected seed pods is essential and should be incinerated;

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MANUAL/MECHANICAL MEANS
What are the plant characteristics of the target alien species?

Small seedlings/plant with shallow root system in soft or sandy substrate (*e.g.* in a sand dune); annual or simple perennial plants, which are unable to sprout from roots or other vegetative organs

HAND PULLING, USING HEAVY DUTY GLOVES,
N.B. Some species may be toxic or cause allergic reactions

Loosen the roots of the plant with a manual implement, and then hold the soil at the base of the plant with one hand and pull the plant with the other, making sure to remove as much of the root as possible whilst maintaining minimal soil disturbance;

a) Small individual shrubs or trees with thin branches and shallow and narrow root systems
b) Rhizomatous species such as members of Convolvulaceae and Grasses

PULLING OR LIFTING WITH TOOLS

a) Tools are used to grasp the stem and create enough force to pull the entire plant along with roots from the ground; when dealing with a small shrub or tree, the plant may be dug out

Not recommended for prolific seed producers

b) Rhizomatous species can be removed by applying the digging fork technique to lift the entire soil block, when soil is dry, loosening the rhizome and lifting all pieces out of the soil. Rhizomes must then be destroyed by incineration or anaerobic immersion in water.

Plants with underground storage organs (*e.g.* roots, rhizomes, or taproot)

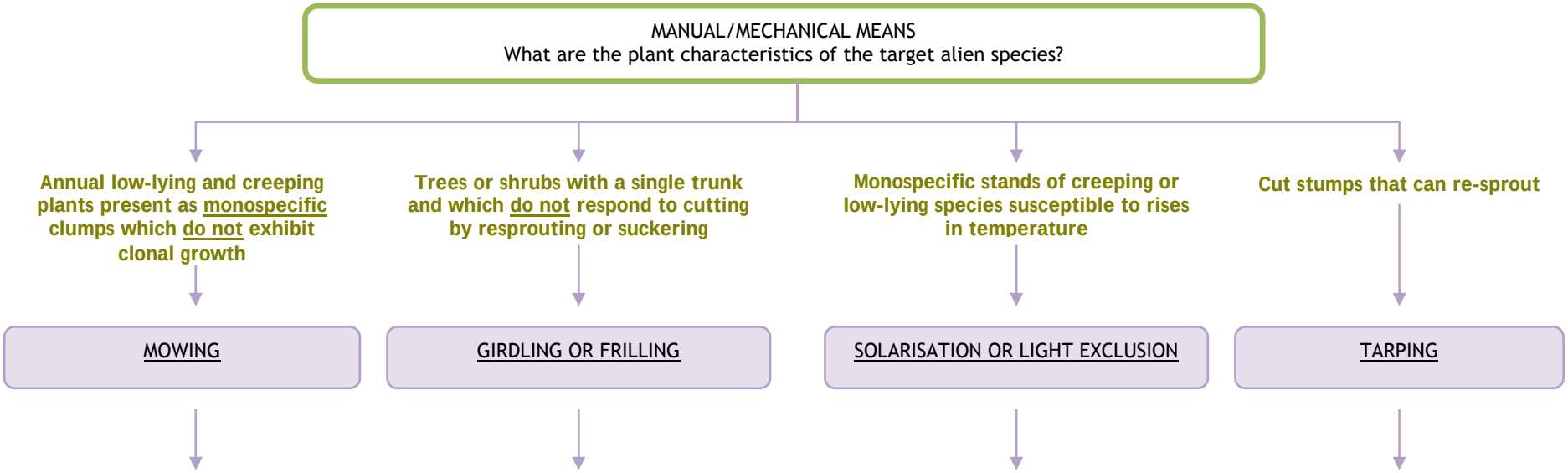
STABBING

Stabbing of the storage organ will injure it and will also impede the plant from obtaining access to its own nutrients in storage structures, thereby leading to plant starvation; to prevent re-sprouting from taproots, the root crown (where the stem becomes the root) should be severed;

Large trees which do not respond to cutting by re-sprouting or suckering

FELLING

Cutting at or near the ground leaving the stump, which may be grinded or macerated below the soil surface to prevent any possible re-sprouting; Uprooting small stumps may be considered when dealing with single trees or very small clumps, where manageable, and where threatened or protected species are not present in direct proximity. Although some form of soil disturbance is inevitable it should be kept minimal. Uprooting is not recommended when dealing with prolific seed producers.



Repeated and frequent mowing, *i.e.* cutting and shredding herbaceous foliage, must be done before plant sets seed, in order to prevent dispersing the seeds into the soil. Not recommended for succulents or plants which can re-grow from plant debris as mowing will mix the plant debris in the soil and hence is more likely to survive and re-grow.

In the case of monospecific stands of a perennial species, repeated mowing, will stimulate new shoot development, but will also result in carbohydrate starvation and eventual death of the plant. 'Mowing every few weeks for at least one to two growing seasons is usually necessary to suppress herbaceous perennial vegetation in this way.' (Holt, 2009; p. 134)

If the intention is to kill a standing tree without felling it then two options may be pursued:

Girdling by removing a band of bark from the entire outer circumference of woody stems or branches - this damages the cambium thereby interrupting the nutrient flow from the leaves to the roots, resulting in death of the plant.

Frilling by cutting downward long slices of the bark that can then be peeled off always in a downward movement. This option is not effective on trees larger than two feet in diameter because the bark will then be too thick for peeling (see Holloran, 2004; p. 39).

Frilling or Girdling should not be carried out on trees that re-sprout or respond by suckering when cut.

Covering the plant stands with clear polyethylene plastic film during the summer period will trap solar radiation (solarisation), causing an increase in soil temperatures up to levels that will kill the plants and seeds. If a black plastic film is used (light exclusion), it will also block the sun from reaching the plant thereby inhibiting photosynthesis from taking place. A drawback of these methods for dealing with monospecific stands is the possibility for initial biological, physical, and chemical changes to the soil, which may inhibit growth of desirable native species for the first few years or so. Success of this treatment is less likely for species adapted to higher temperatures. The higher the temperatures created, the more quickly the species is killed and hence is more effective during the summertime, and when soil is wet.

The stump is tightly covered with a seamless tarp. As noted by Holloran (2004) stumps need to be covered up to a year or more, and the covered stumps will need to be checked (2 to 3 times a year) to ascertain that sprouts have not pierced the tarp or emerged around the edge.

Chemical Techniques[39] – Selective methods of systemic application of plant protection products:

A. Choice of PPP

Note 9: Contact the Malta Competition and Consumer Affairs Authority (MCCAA) to obtain information on a suitable choice of registered plant protection products (PPP) for use in Malta[40].

- Before applying any PPP read the label and, where required, also check the material safety datasheet (MSDS) where more detailed information would be available. Information that one should be aware of is *inter alia* in terms of mode of activity[41], movement in plants, selectivity, environmental considerations, behaviour in soils, toxicity and product formulation.
- PPPs should be used in a manner consistent with the labelling of the product and used strictly in accordance with label precautionary statements and directions as well as national legislation. Also read product labels for appropriate dilutions.
- The chosen chemical for use should be:
  - selective;
  - rapidly degradable;
  - non-toxic to animals and humans;
  - compatible with the ecological context of the treatment area;
- Systemic chemicals should be used. These are absorbed from the point of application and are then translocated within the plant system to other remote tissues.

B. Appropriate use and handling of PPP

Note 10: Use, handling, disposal and storage of Plant Protection Products must be in compliance with the Pesticides Control Act (Act XI of 2001 - CAP 430)[42], the Principles of Good Plant Protection Practice in Malta[43], related domestic legislation (the Plant Protection Products Regulations) and relevant EU policy (including Council Directive 91/414/EEC)[44], as well as the Thematic Strategy on the Sustainable Use of Pesticides[45] and the Pesticides Framework Directive (2009/128/EC) and transposing national legislation thereto. PPP are also covered by the Prevention and Remedying of Environmental Damage Regulations, 2008 (LN 126 of 2008, as amended)[46]. Regulation 14 of the Trees and Woodland Protection Regulations, 2011 (LN 200 of 2011) should also be compiled with.

- PPPs should only be applied by recognised Professional Users.

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39 This section is based on literature review of published material by Everest & Patterson (1997) - Brush Control; Ferrell, Langeland & Sellers (2006) - Herbicide Application Techniques for Woody Plant Control and Tu, Hurd & Randall (2001) - Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas

40 MSA also publish a list of PPP which are approved for use in Malta. This list is regularly updated and can be obtained by accessing MSA's website: http://www.msa.org.mt/rad/pesticides/downloads/

41 how the chemical enters the plant – whether foliar active (enters through leaf and possible even stems), soil active (enters through the roots when plant transpires) or both. Soil active chemicals are not recommended in ecologically sensitive areas.

42 http://www.mrra.gov.mt/htdocs/docs/laws_chp430.pdf

43 COGAP – Section 5 – Good Plant Protection Practice - http://www.agric.gov.mt/file.aspx?f=8

44 Council Directive of 15 July 1991 concerning the placing of plant protection products on the market (91/414/EEC) (OJ L 230, 19.8.1991, p. 1) Available at: http://europa.eu/eur-lex/en/consleg/pdf/1991/en_1991L0414_do_001.pdf

45 http://ec.europa.eu/environment/ppps/strategy.htm

46 www.mepa.org.mt/file.aspx?f=1229

- When using and handling PPPs, every care should be taken by Professional Users to avoid adverse effects on the environment, non-target organisms and human health.
- Always wear recommended protective clothing and equipment when handling PPPs.
- When PPPs are to be used in the vicinity of water bodies or flowing water, only those products that are not dangerous to the aquatic environment and to human health should be employed using the most efficient application techniques, including the use of low-drift application equipment. Application methods that minimise off-site movement/translocation of PPP into the environment are preferred, especially if threatened species and water bodies are present in the vicinity.
- Some PPPs may need to be diluted before use such as when adopting foliar PPP applications. Match formulations of PPP with the application method *e.g.* water soluble PPP when applying the hack and squirt method, whilst using an oil-soluble PPP formulation for basal bark method; Caution should be taken when using PPPs applied by stem injection and cut-stump treatments as desirable woody plants can be damaged through transfer/translocation of PPPs by root exudates; Damage to surrounding native plants can be minimised by careful planning and assessing the likelihood of potential damage as well as proper application.
- Record keeping is important when using PPPs to evaluate the attainment of the management goal and, following adaptive management, in case of failure or detection of mistakes. Hence, it is important to take note of the plants treated and where this has been done; amounts and types of PPP used, and on what days the PPP was administered.
- The possibility of using sign posting to notify the general public that PPPs are being applied to a certain area, may be explored. This may sometimes be a requirement in the label for certain PPPs.
- After PPP use, adequately clean the equipment used and rinse thoroughly protective clothing; Left over PPPs that shall no longer be used should be treated as hazardous waste.

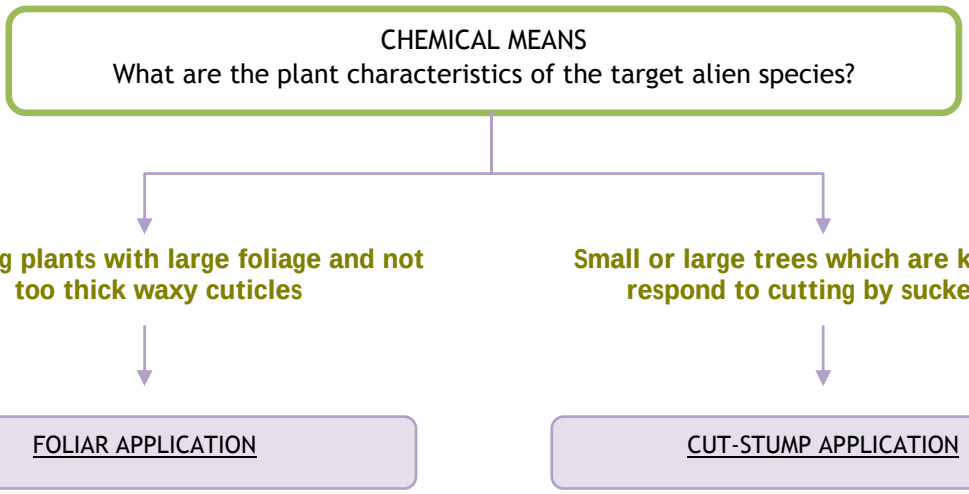
C. Appropriate timing for PPP administration

- The best period in the year for applying PPPs depends on the mode of action of the product and the species being specifically targeted. However, generally this is during the specific growing season of the plant[47] being treated, particularly before seed maturation and dispersal and, before the species enters into dormancy. This is because translocation of nutrients by the plant from the leaves and stems to underground storage organs can be made use of to carry PPPs to the root system.
- Do not apply PPPs to plants that are suffering from stressful conditions since during such periods the plant would have shut down its metabolic processes, included growth, and, most PPPs usually act by attacking these processes and the growing tissue.
- Allow enough time to elapse (even a month or so) for the PPP to show any evidence that it is actually affecting the plant as desired. Herbicidal activity may be detected in the form of yellowing of foliage or leaves with dead spots or margins. Follow-up treatment may be necessary usually in the next growing season (new vegetation most readily absorbs the chemical) depending on the type and extent of the infestation, effectiveness of the PPP, and proper technique selection and application.

Note 11: Chemical options to address invasive plants should be used as a last resort and only after careful consideration of other management options available. Use of PPPs in

[47] The growing season depends on the species being considered. However generally for annuals the growing season is from emergence until flowering; for perennials the growing season is spring-summer.

Natura 2000 sites should be avoided as much as possible. Aerial spraying by aircraft is prohibited in any part of the Maltese Territory.



PPP is applied directly onto living foliage:

(a) either by spraying using a hand-held spray bottle or pump sprayer (spot applicator),

(b) or by brushing with a sponge or wiping using a heavy cotton glove (onto which the PPP has been applied) worn over a thick rubber glove (wipe-on applicator), depending on the non-native plant targeted.

PPP should be applied in amounts just enough to wet the leaves. The spraying method is suitable for small trees, saplings and herbaceous plants. It is important to remember that when spraying PPP, this may aerially drift and harm or kill non-target plants. Spraying during strong windy spells, very hot temperatures or relatively low humidity will cause high losses through drift and volatilisation and should therefore be avoided. Drift control additives can be added (depending on the label) to reduce this problem and also by using low-pressure sprayers and spray shields. Foliar application should not be carried out during the rainy season not even on windy days, so as to minimise off-site movement due to drift, run-off or leaching. This treatment is not effective when plants are under drought stress. Use of a marker dye with foliar-applied PPPs (depending on the label) could aid in avoiding non-target vegetation and will facilitate better coverage on the target species.

Trees are felled leaving a stump of about 8 to 20 inches above ground. It is important to cut the stump as level as possible to prevent chemical run-off from the stump and on to the ground. PPP should be applied immediately (within an hour) after cutting the tree - directly to the exposed cambium next to the bark - by brushing onto the fresh cut stump taking care to having first removed sawdust from the stumps before treatment. Trees less than 3 inches in diameter should have the entire cut surface treated. Do not spray the PPP (although documented, this option of spraying PPP onto the cut stump should be avoided). A surfactant may be added to the PPP (depending on whether this is allowed by the label) to aid absorption of the chemical. The cut-stump method is effective for controlling root-suckering species and is also more appropriate for woody species that re-sprout after being cut or felled. This method should not be carried out when spring sap may flow to the surface of the cut as it would rinse the chemical off (depend on the species being considered). This treatment should be followed up every few months as treated stumps may still re-sprout.

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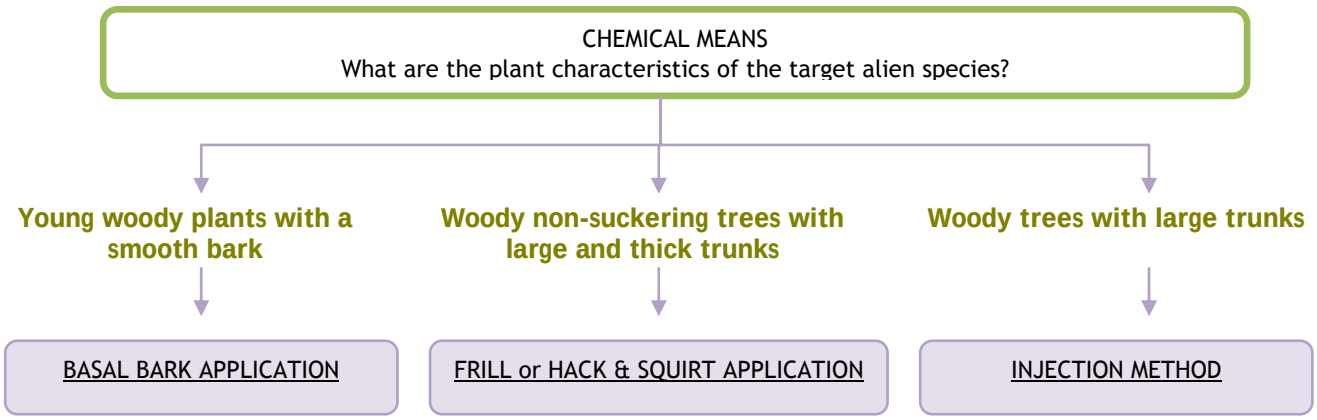

PPP is applied as a band around the circumference of the bark in amounts enough to wet the bark but not to the point of run-off. The band width depends on the size of the species being targeted. Not effective on trees with very thick bark. Wind drift is less of a problem when applying this method but should still be taken into account. This method is not effective against older plants with thick corky bark.
TYPE OF PPP: Oil-soluble PPP

Using a hatchet or axe, downward cuts are made to the bark around the circumference of the tree trunk without removing the chip from the trunk, thereby creating a sort of frill. The chemical is immediately applied to the cuts. A continuous line of cuts around the trunk can likely cause suckering trees to go into the emergency response mode and react by producing basal sprouts and root suckers. For this reason, frilling is not recommended for suckering trees unless long term follow-up treatment is possible.
TYPE OF PPP: Water or oil soluble systemic PPP

PPP is applied in downward incision cuts or injection cuts made into the trunk surface using special tree injectors. The PPP must penetrate the cambium. Seepage out of the cut should be prevented. This process should be carried out for every incision cuts spaced around every 2 to 6 inches around the woody stems.
Tree injection treatments should not be performed during the rainy season to avoid the PPP being washed out from the incision with the possibility of damaging nearby plants, nor performed during heavy spring sap flow.
TYPE OF PPP: Capsules made up of water soluble PPP paste

Habitat management and restoration

"Habitat management" includes activities designed to benefit either a native species or a group of native species (communities) deemed of high conservation value and which, for instance, depend on a particular stage of the successional process or on "germination gaps" (*i.e.* bare ground where germination can take place – see Ausden, 2007)[48]. Some species (such as annuals and biennials) may depend on some form of natural disturbance (*e.g.* grazing[49] or fires – see Sutherland, 1995)[50]. Where these are lacking, management needs to emulate the desired effects, ensuring however compliance with national legislation such as the Trees and Woodland Protection Regulations, 2011 (LN 200 of 2011), which includes provisions on fires and grazing (Regulations 17 and 18, respectively).

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[48] *Habitat Management for Conservation - A Handbook of Techniques* - Ausden, 2007

[49] Sutherland (1995; p. 9) notes the following:
' There has been a considerable body of research on the consequences of grazing on plant species diversity which has produced seemingly conflicting results. The actual underlying rule is very simple: if the dominant species is palatable then grazing will increase diversity, but if the dominant species is unpalatable then grazing will reduce diversity'. This author further comments on the fact that grazers differ in the degree of habitat disturbance they cause, which results in the fact that each grazer produces a different plant community. Although grazing may increase plant diversity, it may decrease the diversity of invertebrates especially insects – seeing that grazing affects plant flowering, standing crop, plant litter and microclimates. Considerable pre-planning is required before grazing is adopted as part of a management regime.

[50] *Introduction and principles of ecological management* - Sutherland, 1995

In the case of habitat management for higher plants, the goal would be to maintain or increase native species richness if desired, modify or reinstate the structural diversity of vegetation, and/or maintain/restore populations of endangered plants. A native species-rich habitat with high functional diversity can have natural defences and competitive superiority over plant invasion. Moreover, native species richness can succumb to aggressive invaders, in which case the objective would be not only to improve conservation status, but also to reinstate the lost species. Habitat management is desirable in situations where fragmentation has led to small, isolated patches of natural habitat and in which suitable natural processes no longer operate. Management activities comprise of controlling the spread or cover of invasive or unwanted species, mitigating anthropogenic impacts, and also employing methods to influence the physical structure of vegetation or some stage in the process of succession. The timing and frequency of such activities are important factors to consider. Timing and frequency of management must take into account of the characteristics of the plant community and dependent fauna. Moreover, plant characteristics such as life history, whether it is a good disperser, fast or slow growing, sensitivity to competition, and so forth, are important considerations. Inappropriate habitat management will result in the deterioration and destruction of biodiversity. This should be avoided at all costs. Management should be supported by monitoring, and any management experience should be documented. A step-by-step approach to habitat management is recommended so as to gain an understanding of how the site is responding to management.

Before embarking on habitat management, the following must be taken note of:

- List of species and classification of plant communities present, and especially the vegetation structure and relative abundance of the species seeing that management would alter these and would have consequences for animals, dependent on the plant communities being affected by management;
- Factors prevalent on the site that affects the plant communities (*e.g.* aspect, weather, water regime, underlying geology, pathogens/parasites, and human activities; in the latter case both on site and in surrounding areas);

Planting vegetation would on the other hand, be carried out as "habitat restoration" (see for instance Ausden, 2007). In the context of these guidelines restoration also means to rehabilitate an invaded ecosystem to a pre-invaded state where feasible following IAS removal, and to enhance the resilience of that ecosystem against future biological invasions. Restoration is generally costlier and more resource-demanding than the maintenance of healthy ecosystems. It is therefore crucial that the underlying factors that lead to the degradation of the habitat – which may be a combination of factors – are adequately addressed; otherwise any restoration initiative would be futile. The early involvement and participation of all stakeholders must be ensured throughout all stages of the programme/project. This should ensure the long-term success of any initiative.

- 'Tree planting is considered synonymous with conservation yet it is often unnecessary in semi-natural habitats, natural regeneration usually being preferable.' (Sutherland, 1995; p. 18).
- It would be desirable to couple environmentally sensitive eradication of invasive plants with management and restoration of the treatment area, as appropriate, especially if this area forms part of a semi-natural ecosystem or a protected area.
- The possibility of restoring the area by way of the reintroduction or augmentation of native species should be explored (guidelines provided in Part III of this document).

- Planting competitive native species in order to establish a thick cover of vegetation will help shade out and discourage the establishment of non-native plant seedlings after treatment is carried out.

Note 12: Planting of native specimens should be carried out only after adult non-native plants especially seed-producing individuals and already germinated seedlings are removed. Planting or other restoration endeavours should be compatible with the general vegetation structure in the area (*e.g.* vegetation types and age structure) as well as the physical structure of the ground (*e.g.* irregularities, depression), which is important as it sustains different microclimates and the diversity of groups of animals. The choice of which native species to plant (if at all required and depending on the possibility of natural regeneration) will depend on the ecological context of the area in question and the plant communities found within the area[51]. Habitat management and restoration should not result in the creation of an artificial area. "Obsessive tidiness" should be avoided at all costs (see Sutherland, 1995).

Step 4: Develop and implement a management programme designed to achieve the management goal

The management programme must indicate when, how and who will conduct the eradication/control/containment operations and how progress will be monitored. Before full-blown eradication/control efforts are embarked on, it is recommended to initially carry out a field trial when the chosen method is being practised for the first time in the local context with respect to the non-native plant being targeted. This will help to minimise undesired effects on a large scale. The area for a field trial should not host endemic/protected species and should not be in proximity of water bodies or structures that can act as "invasion corridors". If the field trial, coupled with monitoring throughout the endeavour, reveals any adverse effects, such as increased infestation or secondary impacts, and the ineffectiveness in reaching the management goal, then, the chosen treatment option should be discontinued and another option must be undertaken as a form of adaptive management. Eradication or removal of plants should be carried out in stages (when dealing for instance with areas of infestation > 1ha – See for instance Parkes & Panetta, 2009) without sudden obliteration of the non-native vegetation so as to avoid drastic changes to the environment and that would allow colonisation by opportunistic species.

Note 13: Important natural areas (protected areas) must not be used for field trials.

Adequate Disposal of Plant Debris

It is important to dispose of all plant debris properly, since plant parts that are in contact with the soil may continue to live and grow, especially when dealing with succulents or vegetative parts that can re-sprout a new plant. Disposal of aerial pars of the tree should be done at the time of the year when fruit production has not yet begun and should definitely not be carried out when seeds are ripe.

When dealing with invasive plants which are prolific seed producers and/or spread by vegetative growth, the plant debris should be incinerated. Other debris which is not able to grow into a new plant can be disposed of in a registered landfill. During the

[51] The species to be planted must already form part of the historic assemblage of the target area and must be of local provenance to maintain natural heterogeneity of habitat types and ecosystems.

removal process, the debris can be placed in a suitable covered recipient such as a skip. Depending on the amount of debris at hand, and also depending on proximity to the road, debris can be either, bagged up and loaded, or else, loaded directly into a registered waste carrier/truck/vehicle that can be securely covered. No plant fragments should be allowed to fall and disperse elsewhere. Controlled burning may not always be the remedy in view of certain species releasing noxious gases or else being dangerously flammable. Hence, extreme caution would need to be exercised, and that is why incineration is the most desirable option. Burning on-site is prohibited as this will cause other undesirable impacts on the site itself, by:

- introducing an additional ecological impact (as well as visual, and soil-related impacts);
- favouring colonisation by opportunistic species (possibly also by the invasive species itself);
- posing a fire hazard especially in wooded areas or near dry grass;
- burning of biomass contributes to the release of carbon dioxide into the atmosphere, exacerbating the causal effects of climate change

Considerations could be explored of leaving on site any vegetation material which would not propagate and only in cases that such debris could create a suitable habitat for a variety of fauna and fungi.

Note 14: Information on where the plant debris can be incinerated and also as regards to locations of registered landfills should be obtained by contacting WasteServ Malta Limited[52]. Propagules must be destroyed by incineration.

Cleaning Clothing and Equipment

Equipment and clothing must be cleaned before leaving the treatment area:

- identify appropriate sites where cleaning can be done such as non-vegetated areas where any falling debris can be easily collected;
- restrict movement of equipment from infested to non-infested areas;
- clean clothing and equipment by removing any soil, mud or dirt including any attached seeds and plant parts - collect into bags and appropriately dispose of;
- the area where cleaning of equipment has been carried out should also be monitored when carrying out follow-up of plant removal.

Step 5: Monitoring throughout endeavour and adopting adaptive management where required

Species and habitat monitoring throughout the endeavour will allow:

- assessment of the consequences and progress of the intervention;
- detection of changes in the distribution and abundance of the target species;
- detection of changes in the structure and composition of the plant communities especially native species that are directly impacted by the target species (are these native species exhibiting natural regeneration?);

[52] WasteServ Malta Ltd - Phoenix Building, Old Railway Track, Santa Venera SVR 9022; Office General Telephone Number: 2385 8000; Office General Fax Number: 2144 1930; FREEPHONE 8007 2200; General Email Address: info@wasteservmalta.com

- close examination of the extent of achievement of the management goal;
- the timely detection of undesired secondary impacts to the treatment area, thereby enabling the modification or abandonment of the treatment by way of adaptive management.

The type of monitoring/surveying methodology to apply will depend on the target species and the community/habitat under consideration. Techniques for surveying and monitoring higher plants for acquiring data on presence-absence and population size estimates (frequency, cover, density – if required), are not described here as they are well-documented in literature.

Note 15: Persons undertaking monitoring/surveying must be familiar with the target species not only when in flower, but must also be able to identify vegetative growth. Presence-absence can be readily assessed when the species is in flower. However, in an alien plant management programme even non-flowering/vegetative individuals need to be taken into account.

When designing the monitoring activity, the following considerations need to be made:

- ease of detection of the species;
- period of dormancy of the species – although not present above-ground, the species is not necessarily absent from the treatment area;
- seasonal variation in appearance and abundance of the target species;
- frequency of monitoring;
- health and safety issues;

Step 6: Post-removal Monitoring and Documenting Findings of the Endeavour

When eradicating/controlling non-native plants, it is important to keep in mind that even in cases where all aerial and vegetative plants are destroyed, the species may still persist in the form of seeds or root/vegetative segments in the soil. Post-removal monitoring in the form of repeated surveying is a must so as to avoid re-invasion and will also allow the detection of remnant or newly emergent individuals. Moreover, it should be noted that by eliminating the presence of one non-native plant species, opportunities might be created for the emergence of suppressed non-native species. So caution should be employed in this respect. As stated by Grice (2009; p: 67) 'seed longevity and germination requirements are important in determining how long a site must be monitored after established individuals have been removed.'

Note 16: Unless rigorous post-removal monitoring is carried out, coupled with some form of management in the area, re-invasion will recur due to the seed bank and potential for re-sprouting, and in the end, the management goal would not be achieved.

It is important to document (and also inform MEPA on) attempts made to remove non-native plants as well as findings in order to serve as a learning tool and to keep track of actions taken within the Maltese Islands. It is therefore recommended to present results as case-studies by documenting the following:

- site location,
- the non-native species that has/have been targeted for removal (and its/their biology),

- a description of the ecosystem it invaded and any visible impacts,
- the options considered for mitigating the threats and reasons for selecting the action taken (early detection, eradication control, restoration, monitoring),
- ways how the species responded to different management goals and conditions under which these were applied;
- costs of actions and benefits achieved (expressed in monetary terms),
- time frame of operation, and lessons learned from the operation

PART III: Restoring Native Plant Populations/Communities

Plant Conservation Translocation Options – A Brief Overview[53]

- Options to improve the conservation status of an endangered species may involve *in situ* actions such as "conservation translocations", which involve the deliberate/human-mediated movement of live specimens of the species in question from one site for release, under natural conditions, in another site which may either be within the species' natural/native range (population restoration) or outside the species' natural/native range (conservation introduction). Such translocations comprise species reintroduction, reinforcement [54], ecological replacement and assisted colonisation. Information on each option for species recovery is provided in the flow chart shown overleaf.
- The ultimate goal of species recovery is to re-establish a population that:
  - is resilient and self-sustaining in its natural environment in the long-run,
  - maintains the genetic integrity needed for adaptive evolutionary change,
  - is viable in terms of demographic stability and growth, and
  - requires minimal management over the long-term (*vide* IUCN, 1998; Guerrant, 1996[55]).

Note 17: As mentioned by the Revised Guidelines for Reintroductions and Other Conservation Translocations (IUCN, 2012), such conservation translocations should result in a "quantifiable conservation benefit" at all biological levels (and not only benefit the conservation status of species'/taxon in question) and should not be implemented unless justified on the basis of the findings of a feasibility/risk assessment. If there are high risks (ecological, social and/or economic) and high costs with potential significant impacts associated with a particular conservation translocation (especially if involving a conservation introduction) then it should not be allowed to proceed and alternatives to translocation should be considered instead. Such alternatives may include management interventions that can curtail the threat or pressure (e.g. removal of invasive species, habitat management/restoration/connectivity). The crucial question to answer with reasonable confidence is "What will happen after release of the species in question to the new site both over the short and longer term and taking into account of the ecological, social and economic implications of such release and by weighing absolute risk with expected benefits?

- Conservation translocation may not always be the most viable or successful option to conserve a threatened species; and should certainly not be employed as a substitute to proper protection and conservation of existing populations *in situ*. There should be no population restoration, which involves a reintroduction, if a species became extinct because of habitat change which remains unresolved (unless restoration can reinstate

[53] This section is mainly based on the terminology applied in the IUCN's Revised Guidelines for Reintroductions and other Conservation Translocations (IUCN SSC Reintroduction Specialist Group and the Invasive Species Specialist Group, 2012), the user of these guidelines is strongly recommended to refer to this IUCN publication when adopting Part III of these national guidelines in order to procure more information. Other important references are also available such as by Falk *et al.* (1996) – Restoring Diversity – Strategies for Reintroduction on Endangered Plants

[54] In certain cases inter-population augmentation is desirable when dealing with an impoverished population. (Not recommended when dealing with co-adapted gene complexes and genetically distinct populations).

[55] Designing Populations: Demographic, Genetic and Horticultural Dimensions; In: Falk *et al.* 1996 – Restoring Diversity – Strategies for Reintroduction on Endangered Plants

the condition required to support the species in question), or where significant habitat deterioration and fragmentation has occurred since the extinction[56].

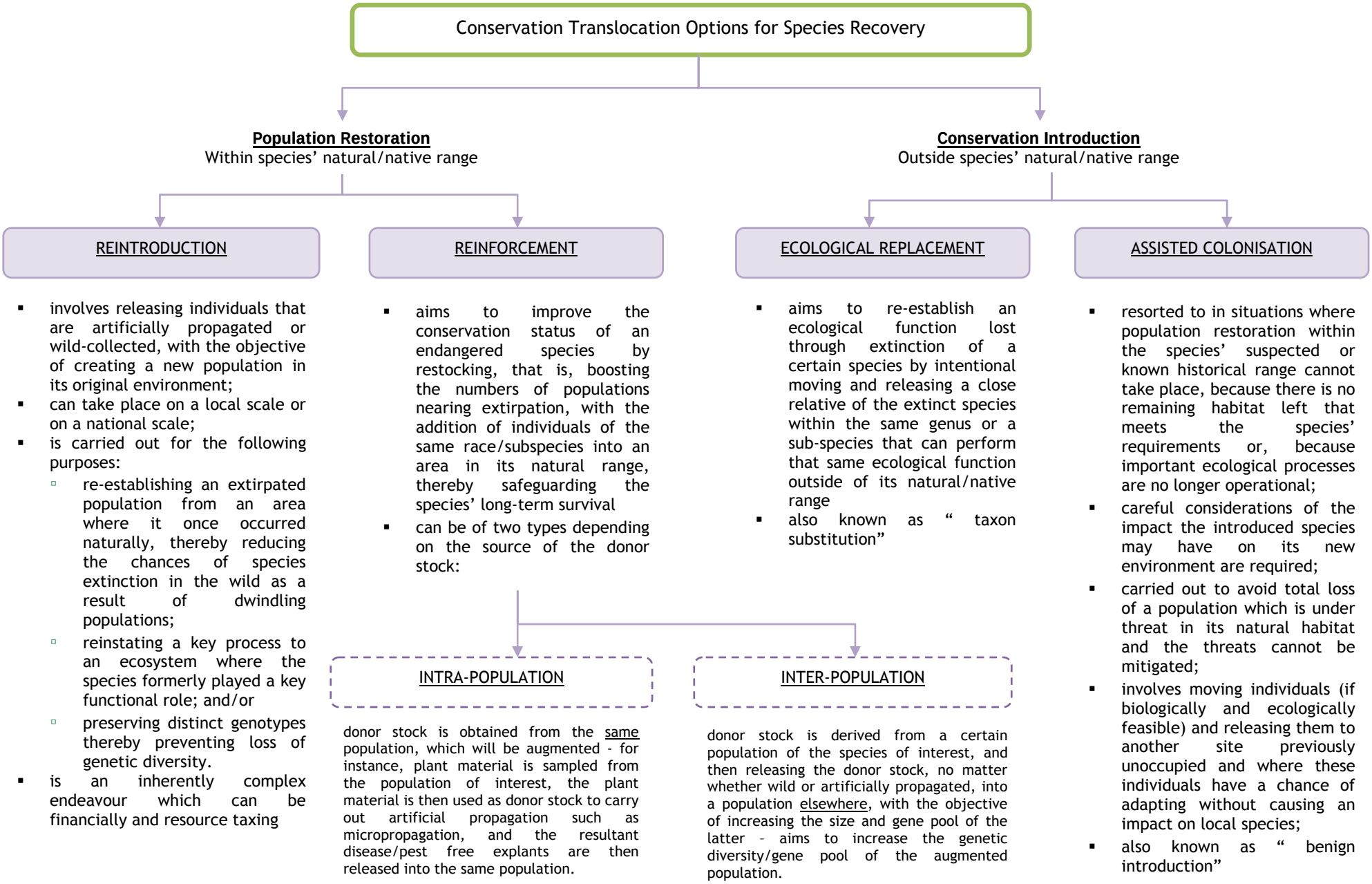
- A species reintroduction programme aims to re-establish new populations of a once common species within its natural range, but from where it has been completely extirpated. This differs from reinforcement programmes in which case populations of the species of interest are still in existence, however due to their small population sizes they are more susceptible to harmful factors that prevail in such circumstances. In this case, the remaining populations and their viability are augmented using individuals of the same race, so as to guarantee survival and overcome factors, such as loss of genetic diversity.
- In the case of population reinforcement, the impact of releases/donors on the residual population necessitates caution regarding the origin and genetic make-up of the donor stock. Care must be taken not to introduce contaminants/diseases within the area or, alter the genetic composition of the existing population (unless the intention is to introduce new genotypes/genes to address inbreeding depression or an impoverished gene pool).

Note 18: Intervention through planting of species must be led by the needs of the specific restoration exercise. The desired species must first be identified, and only then, followed by propagation in order to build the required planting stock. It is underscored that any planting intervention must fit the ecological context of the area.

- The intentional movement and release of an organism outside its natural range may be applied either to reinstate an ecological function which has been lost through extirpation of the taxon carrying out that function by replacing it with a similar species that can carry out that same function (this is called "Ecological Replacement") or to avoid the extinct/extirpation of a species by moving it to a safer site, if biologically feasible (this is referred to as "Assisted Colonisation").

Note 19: This part of these Guidelines adopts the terminology used by IUCN (2012). In this respect is it important to note that the removal of individuals of a species from a location due to land use change into another location would be termed "mitigation translocation". Case-specific conditions that accompany such mitigation translocation would be defined in the development permits issued by MEPA and hence mitigation translocation is not considered further in these guidelines.

[56] The IUCN Position Statement on Translocation of Living Organisms – Introductions, Reintroductions and Restocking


Conservation Translocation Options for Species Recovery
Population Restoration
Within species' natural/native range
Conservation Introduction
Outside species' natural/native range
REINTRODUCTION
REINFORCEMENT
ECOLOGICAL REPLACEMENT
ASSISTED COLONISATION
involves releasing individuals that are artificially propagated or wild-collected, with the objective of creating a new population in its original environment;
can take place on a local scale or on a national scale;
is carried out for the following purposes:
re-establishing an extirpated population from an area where it once occurred naturally, thereby reducing the chances of species extinction in the wild as a result of dwindling populations;
reinstating a key process to an ecosystem where the species formerly played a key functional role; and/or
preserving distinct genotypes thereby preventing loss of genetic diversity.
is an inherently complex endeavour which can be financially and resource taxing
aims to improve the conservation status of an endangered species by restocking, that is, boosting the numbers of populations nearing extirpation, with the addition of individuals of the same race/subspecies into an area in its natural range, thereby safeguarding the species' long-term survival
can be of two types depending on the source of the donor stock:
INTRA-POPULATION
donor stock is obtained from the same population, which will be augmented - for instance, plant material is sampled from the population of interest, the plant material is then used as donor stock to carry out artificial propagation such as micropropagation, and the resultant disease/pest free explants are then released into the same population.
INTER-POPULATION
donor stock is derived from a certain population of the species of interest, and then releasing the donor stock, no matter whether wild or artificially propagated, into a population elsewhere, with the objective of increasing the size and gene pool of the latter - aims to increase the genetic diversity/gene pool of the augmented population.
aims to re-establish an ecological function lost through extinction of a certain species by intentional moving and releasing a close relative of the extinct species within the same genus or a sub-species that can perform that same ecological function outside of its natural/native range
also known as " taxon substitution"
resorted to in situations where population restoration within the species' suspected or known historical range cannot take place, because there is no remaining habitat left that meets the species' requirements or, because important ecological processes are no longer operational;
careful considerations of the impact the introduced species may have on its new environment are required;
carried out to avoid total loss of a population which is under threat in its natural habitat and the threats cannot be mitigated;
involves moving individuals (if biologically and ecologically feasible) and releasing them to another site previously unoccupied and where these individuals have a chance of adapting without causing an impact on local species;
also known as " benign introduction"

Designing & Implementing Native Plant Conservation Translocations: Steps to follow

Species recovery programmes that involve any of the above-mentioned conservation options should essentially involve the following steps (adapted from IUCN, 1987; IUCN, 1998; and IUCN 2012) with progress reviews carried out after each step and adjusting accordingly:

- STEP 1 – Goal/Objective Definition and Feasibility and Risk Assessment
- STEP 2 - Planning Phase
- STEP 3 – Preparatory & Planting/Release Phase
- STEP 4 – Post-Planting Phase

The actual carrying out of the species recovery programme in the field will start at STEP 3. STEP 1 and 2 are 'pre-project activities'. Each phase shall be expanded more in detail below, with a focus on reintroductions and reinforcements, since each step entails a number of specific measures that must be taken into consideration in order to correctly design and carry out a programme that warrants the health and survival of the species of conservation concern within a suitable habitat(s). The substance of the following sections is based on guidelines provided by the International Union for Conservation of Nature (IUCN) and also Falk *et al* (1996 - especially Part V - Guidelines for Developing a Rare Plant Reintroduction Plan).

Note 20: Conservation translocations should only be carried out when they are compatible with the receiving environment/release site. In planning out and implementing conservation translocations, the best available information at the time should be applied. Conservation translocations should not be implemented with release occurring in areas where invasive species or some other threat can undermine efforts in restoring the conservation status of a species or plant community of conservation importance. Prior to actual implementation, the possibility of eradicating or controlling the invasive species or other threat mitigation should first be explored/assessed taking into account the information provided in Part II of these guidelines.

Step 1: What is the goal of conservation translocation and is it justifiable? – A Feasibility and Risk Assessment

The intent to apply conservation translocation to a certain species must be justified and must be accompanied by explicit goals (statements of intended quantified results of the chosen conservation translocation option) and detailed information on how such goals would be achieved within a specific timeframe. As documented by the IUCN (2012; p. 6)[57], 'The pivotal criteria for justifying any conservation translocation will be situation- and species-specific.'

Native (including endemic) species that are of high conservation concern and fall under any one of the following categories may be considered for population restoration (i.e. either reintroduction or reinforcement as applicable and subject to the findings of the feasibility study, see below):

- Plant species that are extinct in the wild from the Maltese Islands (in which case reintroduction would apply);
- Plant species constituted by few, small and dwindling populations, threatened by genetic impoverishment;
- Plant species that have, over the years, suffered severe range contraction and are facing imminent extirpation;
- Plant species constituted by very small populations with limited natural recruitment or dispersal;
- Plant species of EU community interest that have an unfavourable conservation status;
- Plant species being adversely affected by climate change; and/or
- Plant species is rare/endangered and is an important component of an ecosystem e.g. a keystone species.

Native (including endemic) species that are of high conservation concern and fall under any one of the following categories may be considered for conservation introduction (i.e. either assisted colonisation or ecological replacement as applicable and subject to the findings of the feasibility study, see below):

- Plant species can carry out the ecological function of an extinct species (in which case ecological replacement would apply);
- Plant species is unlikely to survive in its present location and no alternative exists to ensure the safeguard of that species in its current location (in which case assisted colonisation would apply); and/or
- Plant species being adversely affected by/unable to adapt to climate change in its current location.

A feasibility and risk assessment should be undertaken prior to embarking on a project that involves any of the four conservation options considered for the recovery of a species. The assessment would help in answering whether the conservation translocation would be feasible or not, and then which chosen or planned option would be the most appropriate and feasible as well as whether it would benefit both the species concerned and the site/habitat and other species therein where planting/release would be carried out

[57] Annex 3: Deciding when translocation is an acceptable option; In: Translocation Annexes accompanying the IUCN Guidelines for Reintroductions and other Conservation Translocations (IUCN, 2012)

(particularly important for conservation introductions so as to avoid adverse effects). Examples of questions to pose when undertaking a feasibility and risk assessment are presented in a question-based format in Annex IV to document.

The feasibility and risk assessment should be based on best available knowledge and should address *inter alia* the following issues:

- The species' status according to the IUCN Red List Categories and Criteria[58] *i.e.* whether extinct in the wild from the Maltese Islands; critically endangered, endangered, vulnerable, near threatened, least concern, or data deficient; if the species is of European Community Importance then conservation status should be specified i.e. Favourable (FV), Unfavourable-Inadequate (U1), Unfavourable-Bad (U2) or Unknown. Species' status should be evaluated together with causes that led to the current status;
- If ecological replacement is being considered, reasons should be defined why that particular species/sub-species was chosen and why that particular ecological function is important to the release site;
- Extinction/mortality/threat factors (alone and in concert, direct and indirect, and considered through all seasons and life stages of the species), their severity and the species' sensitivity to these factors and whether such factors can be controlled, managed or eliminated, indicating the degree of effort needed;
- Is the species really extinct or extirpated from the area of interest where population restoration is to be carried out? This can be determined by the species' lack of presence in the context of its biology (such as dormant underground structures – bulbs, seeds etc.);
- How well documented the species' historical range is (excellent, good, poor, not known), with available knowledge of the preferred habitat type and well-defined range limits, distribution maps and abundance [Available documented ecological information should be reviewed];
- Availability and quality of source of genetic material/germplasm/donor stock (is it genetically diverse, disease/pest free, easily propagated; is it of local provenance if species is not extinct from Malta?);
- Availability of historical and/or suitable habitat (considering both biotic and abiotic habitat requirements for all the plant's life stages), presence of critical components and the assessment of the likelihood that such habitat is not in jeopardy of being degraded or altered by anthropogenic disturbance and land use conflicts;
- Legal and regulatory considerations and whether the release of the species would conflict with present land uses on the site in question;
- Restoration potential of the planting/release site and habitat conditions amenable for proper planting [Are essential ecological processes such as dispersal and pollination operating in the planting site?]
- Possibility of competition and/or interaction arising between non-native or other native species with the species of conservation concern, in the planting site – This problem can be addressed by first embarking on alien plant removal (Part II of guidelines);
- The native species' potential to expand and inhabit areas around the planting site(s);
- The ecological role of the species at the planting/release site and impacts;
- What are the risks associated with the proposed conservation translocation;

[58] http://www.iucnredlist.org/static/categories_criteria

In order to properly design species recovery programmes, information is needed both on the species and the site earmarked for planting/release.

(A) Species Selection

Information required on the candidate plant species	
▪ Natural life history characteristics & biotic and abiotic habitat requirements:	
▫ Phenology and seasonality	☐
▫ Pollination biology (whether wind, water, or animal mediated) and whether pollinators are present within the potential planting site;	☐
▫ Reproduction mode (e.g. asexual whether vegetatively or by apomixis; sexual whether by self-fertilisation or cross-fertilisation);	☐
▫ Dispersal mechanisms (insects, birds, human, mammals, water, wind, mechanical, passive, vegetative, or any other mechanism);	☐
▫ Symbiotic relations, host plants and mycorrhizal associations that assist in the plant for instance in nutrient uptake; and other interspecific relationships	☐
▫ Microsite requirements for establishment and long-term persistence including proper planting/sowing depth; sun/shade position; soil moisture requirements, etc.	☐
▫ Climate requirements and whether they will be met also in the foreseeable future vis-à-vis the taxon's tolerance limits to climate change;	☐
▪ Impacts of grazing by small ruminants (goats and sheep), rats and rabbits;	☐
▪ Evidence of insect pests and diseases present at the planting site which might jeopardise the recovery;	☐
▪ Source of donor(s)stock/donors/founders (propagated source or wild source; if the latter implications of sourcing from the wild should be explained);	☐
▪ Ideal stage for planting (seed, seedlings, juveniles, mature plants, or a combination of these) and age classes of the donor(s);	☐
▪ Method of propagation ensuring that throughout the process the effective population size (*i.e.* the number of reproducing individuals) is maintained;	☐
▪ The effective population size is large enough to maintain genetic integrity;	☐
▪ Ideal sex ratio if the species is dioecious;	☐
▪ Spatial design of planted populations bearing in mind possible changes in distribution in the face of climate change;	☐
▪ Acclimatisation of the species to the planting site;	☐
▪ Post-planting maintenance such as curtailing mortality caused by abiotic stresses (such as drought) and biotic stresses (such as competition by opportunistic species);	☐

Note 21: The use of donor/founder stock of local provenance is stressed because native species have, through evolutionary processes, adapted to prevailing environmental cues.

(B) Site Selection and Suitability

As a first step, the site proposed for a species recovery programme should be precisely mapped. Maps should include the historical range and present distribution of the species and the locations of known populations, where possible. Next, the physical and environmental characteristics and location/s of the planting site should be studied to evaluate whether the proposed site is suitable to the critical needs of the species to be

translocated (e.g. reintroduced) and amenable to planting. This is especially important when dealing with species having extremely specialised habitat requirements. It is also important to ensure that the planting site has sufficient carrying capacity that will allow the population to grow and become self-sustaining in the long-run. When assessing the quality of the site, mortality factors should be identified and assessed individually and in concert. This might require scientific endeavour in order to explore the most effective means of abating such threats.

Information required when carrying out the site selection process[59]	
Potential sites for release/outplanting should be evaluated for their physical and ecological characteristics. Information should be collated and provided on *inter alia* the following items:	
▪ Name of release/planting site;	☐
▪ Site location (map + photos) – does the site fall within the known or suspected past and present range of the species?	☐
▪ Area (m^2) of the site – is it deemed large enough to maintain a viable population?	☐
▪ Access to the site;	☐
▪ Land use history if known;	☐
▪ Land tenure;	☐
▪ Degree of protection (is the area scheduled or is it a protected area?);	☐
▪ Biotic community type and structure - habitats present and quality in terms of structure and function;	☐
▪ Ecological process (pollination, dispersal, important natural disturbance processes) – Are these essential? Are they operating in the site?	☐
▪ Physical site/microsite characteristics (also those important for the plant e.g. slope, soil characteristics *etc*.)	☐
▪ Microsite characteristics and variation – these will influence establishment of the new population or planted specimens;	☐
▪ Current management, if present;	☐
▪ Restoration potential and any requirement to enhance ecological connectivity to establish metapopulations, if required;	☐
▪ Landscape context of the site (nearby habitats, proximity to rural and urban settings, potential future development of the site);	☐
▪ Appropriate buffers to minimise edge effects;	☐
▪ Ecological conditions of donor site (*i.e.* from where the plant stock will be obtained) – does the donor site geographically and ecologically resemble the release/planting site?	☐

Note 22: Plant translocations (e.g. reintroductions and reinforcements) follow a different approach to translocations involving animals. This is because plants are sedentary thereby requiring specialised microclimate (solar radiation, shade, dry or wet conditions) and microsite requirements, making site selection critical in plant translocations in order to enable plants to survive and reproduce. When considering a potential planting site, any alteration to the habitat that may have occurred over time (by for instance non-native species altering soil, fire and moisture regimes or man-driven changes), should be taken into account. The reason for this is that such changes might have rendered the site unsuitable for the species in question.

[59] More information on site selection may be obtained by referring to 'Selecting Reintroduction Sites' by Fiedler & Laven, 1996; In: Falk *et al*. 1996 – Restoring diversity: strategies for reintroduction of endangered plants.

(C) Legal Requirements – Permitting

The requirement to carry out a study/assessment prior to conservation translocations so as to assess whether such a measure would contribute to the conservation of the concerned species is embedded in EU (Habitats Directive), regional (Bern Convention) and national legislation enacted under the Environment Protection Act and the Environment and Development Planning Act. An additional requirement is that of consulting the public concerned prior to implementing a reintroduction/reinforcement programme.

Note 23: Before a project involving a conservation translocation can proceed, the proponent of such project must have prior consent from the Competent Authority, i.e. MEPA. Land tenure/ownership/use considerations should also be addressed including any necessary consultations or consents prior to the carrying out of the intervention. Legislation also requires that the experiences of EU Member states and Parties to the Bern Convention are also taken into account. In the case of the Competent Authority, a permit would be issued authorising the implementation of such project if deemed to favourably restore the conservation status of the species in question in conformity with legislation in force at the time.

Submission of a project proposal and application for a nature permit to undertake the reintroduction/reinforcement in natural and semi-natural settings should present *inter alia* the following information:

- Scientific name of the candidate species for recovery;
- Status of the species in the Maltese Islands, including any data on cover/abundance estimates, trends, present and past distribution, if available and where possible;
- Statement of intent/purpose of project and quantified objectives;
- Justification for the recovery programme;
- Threats to the species (actual and potential, short- and long-term);
- Name of proposed site for planting, general information on the site (location, description, area, land tenure *etc*.); designations (if any) and management needs of the site, and any limiting factors - any relevant photos and maps should be included;
- Reasons for choosing the site and if critical needs of the species are catered for in the proposed site;
- Source and origin of plant germplasm and target effective population size [germplasm of unknown origin should not be used];
- Methodology for collection as well as propagation and planting strategies with justification given of the approach chosen;
- Will the species recovery programme involve a series of plantings over a number of years?
- Monitoring plan;
- Research opportunities;
- Criteria for evaluating recovery success;
- List of resources required and indication as to whether they are readily available and for how long (the latter is crucial in determining the overall success of the project);
- List of relevant stakeholders and whether they are interested/committed to being involved;
- Work schedule with detailed milestones, deliverables and timeframes (using Gantt Chart);
- Follow-up to the species recovery programme including duration;

- Breakdown of costs and indication that resources required for carrying out such project to completion, are at hand;
- List of bibliographic references consulted to supply the above information.

The above points essentially build the structure of a species recovery programme or method statement and aid in following a "logical decision-making process".

On consideration of the information provided on the above-mentioned points, a permit may be granted or refused in line with national legislation in force at the time. Any species recovery programme carried out without a permit or in violation of the permit conditions will be in breach of legislation and penalties will be applied as stipulated by national legislation that applies at the time.

Step 2: Planning Stage

This step should delve into how species recovery will be carried out, monitored and evaluated. Planning out a species recovery programme is a crucial step. The potential effects of the implementation of such a programme should be foreseen so as to avoid any undesired consequences. For instance, the potential negative consequences of reintroduction are described in the work of Caplow (2004; p. 12) [60] as follows:

'… a) a focus on reintroduction could supersede or dilute emphasis on the protection and habitat management of existing populations, b) reintroduction attempts could result in populations that appear stable after five years but are not stable or viable over longer time periods, and this could lead to premature delisting or downlisting of the species, or c) hasty reintroductions or augmentations without a thorough understanding of the genetics of the species could result in genetically depauperate new populations or genetically contaminated natural populations. … These potential negative consequences, if anticipated, can be controlled or diminished.'

(A) Preparation of the Planting/Release Site

The chosen planting site can be located either within the species' natural range (preferable) or in a site outside the known range (i.e. for benign introductions and only if the former is not an option and only after careful consideration of any potential adverse effects of such a benign introduction on the receiving environment). Only those sites that have maintained biotic and abiotic elements that are critical for successful establishment of the planted specimens, and which can support a distinct population over the long-term, should be considered as potential sites for reintroduction/reinforcement.

In order to secure and stabilise the planting site, species recovery programmes should be supported by habitat restoration and any other necessary management to reinstate certain components of the habitat where these have been degraded or altered, in order to enable successful natural establishment by the species of interest. Any site management carried out to mitigate the identified threats should be conducted with care so that the habitat is not degraded further. The planting site is prepared by securing habitats whereby the original cause/s for decline or extinctions have been removed, thereby allowing planting to proceed.

[60] Reintroduction Plan for Golden Paintbrush. Caplow (2004). (http://www.dnr.wa.gov/Publications/amp_nh_cale_reintroduction.pdf)

(B) The Candidate Species for Conservation Translocation - Biological, Ecological and Technical Considerations for Plant Species

The best available scientific information/advice on the species of interest is required when planning out species recovery. This is because the biological characteristics, critical needs and taxonomic status of the concerned species must be known. If a species is being reintroduced in order to re-instate a certain process into the ecosystem, it is essential to evaluate the suitability of the proposed area to achieve the intended objective. Where baseline data is lacking, any information on congener/similar species may prove useful.

Molecular genetic studies, where required, may be desirable, to shed light on:

- the taxonomic status of the individuals to be reintroduced,
- genetic structure of existing populations and any signs of inbreeding depression,
- genetic distances between the donor stock, and the population into which individuals are to be released for inter-population augmentation so as to prevent the break-up of co-adapted gene complexes and avoid consequent outbreeding depression,

The individuals to be reintroduced should 'preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available'[61].

Genetic diversity can be elucidated qualitatively by for instance noting connected heterogeneous habitats versus small fragmented parcels of land with impaired gene flow (this would negatively affect those species based on metapopulations), demographic considerations (reproductive rates, sex ratios *etc.*) and environmental stochasticity. Genetic studies however should be carried out when the candidate species is an endemic species.

Important aspects to be looked at when dealing with plant reintroductions, are the application of an ecological understanding to the re-establishment of the species of interest, methods of sampling genetic variation for seed/donor stock, and, the proper matching of genotypes to the receiving environment. Knapp and Dyer (1998)[62] delve into these aspects in terms of ecological restoration, strategies for reintroducing genetically appropriate populations, and consequences of non-local introductions on existing native populations. They note the following:

- 'Genetic provenance of the source material - In the absence of data, it is prudent to assume that local populations are the best adapted to the receiving environment than a commercially bred variety or other non-local population, which may provide a poor genetic match to the environment and result in failure of restoration efforts;'
- 'Recommendations for obtaining germplasm with the best chance of being well-adapted include collecting propagules within a certain distance of the restoration [planting] site, and from natural environments as similar as possible to the one being restored;'
- 'In the context of the restored plant community, where conditions of intense inter-specific as well as intra-specific competition often prevail, a faster growth rate could make the difference between success or failure in a restoration planting;'

[61] IUCN/SSC Guidelines for Reintroduction.
[62] Chapter 14: When do genetic considerations require special approaches to ecological restoration? Knapp and Dyer (1998).

- 'Mixtures of seed collected from different populations within a region could maximise the amount of available genetic variation and allow a composite population to adapt, over time, to many possible environments. When following this approach however, it is important to gain knowledge on the genetic distance between the different populations so as to curtail outbreeding depression (*i.e.* the reduction in vigour of progeny from matings between divergent populations) and instead promote heterosis (*i.e.* hybrid vigour). While maintaining the genetic integrity of source populations will however still be the goal in most cases, the use of population mixes (containing both local and non-local genotypes) may produce superior results, particularly when restoring landscapes that have undergone recent dramatic environmental changes. This approach would require some form of controlled field trials or experimentations;'
- 'Care should be taken when introducing non-local genes into regions containing native local populations, but the potential negative consequences of genetic contamination are greatest when the amount of introduced non-local genetic material is high, relative to the local source'. The same cautionary approach should be adopted for genetic diversity between two or more populations of the same species if found to be genetically distinct.

Additional information may be obtained by referring to Section 5.5 on Founders in Annex 5 on Feasibility and Design in the Translocation Annexes that accompany the IUCN Guidelines for Reintroductions and other Conservation Translocations (IUCN, 2012).

(C) The Plant Donor/Founder Stock and Methods of Propagation

Ex situ techniques may be used for the reintroduction or reinforcement of particular species if this will lead to its favourable conservation status, and allow for propagation of individuals to be used as the planting/release stock. If the founder stock is wild sourced, the source population should not be adversely affected via the removal of propagules. If the species in question is legally protected, then a nature permit is required prior to undertaking wild sourcing.

Note 24: In the planning stage, plant nurseries should be approached well in advance in order to propagate the species and hence build the required planting stock for bringing the species recovery programme successfully to completion. If the species is legally protected, a permit is required from MEPA for taking and possession of specimens of the protected plant as well as for introducing/reintroducing into the wild. Plant stocks of foreign provenance should only be allowed when the species is no longer found in the Maltese Islands (i.e. it is extinct) and hence no local plant stock is available. In cases where the species is still present in the Maltese Islands, then the species recovery programme shall use plant stock of local provenance in order to prevent genetic pollution which would arise if the plant stock is from an alien/foreign or unknown/unconfirmed source.

Before implementing this step, decisions should be taken on what stage and age classes will be used and what is the desired population structure (taking into account of growth rates, persistence over time) – Is using a diversity of stage classes combined with several introductions to create a "multiple age class population", a desired, effective and feasible approach? Falk *et al*. (1996; p. 483) also recommend: 'For perennial species, the stage and size structure of comparable natural populations should be observed closely in designing the reintroduction programme'. The availability of the right germplasm and also time constraints are other considerations to make.

Note 25: A suitable planting stock of the species should be available on a regular basis or throughout the endeavour and subsequently as follow-up, using propagules of local provenance in order to prevent genetic pollution. Inappropriate genetic material should not be used as stock. Native plant stock should be "geographically close" and "ecologically similar" to the site intended for outplanting. A mixture of several native populations can also be considered as donors depending on the goal of the species recovery programme. 'The source population should ideally be closely related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preferences) to the original sub-population'[63]. The proponent of a species recovery programme must provide evidence that planting stock is available, is of local provenance and is free of any plant pest/diseases. Adherence to regulations on phytosanitation is of essence. The Plant Health Directorate should be consulted for information on plant health regulations.

Plant stock can either be in the form of seeds that can be sown, cuttings from the donor population or any other material raised in nurseries, or micropropagated material. Stocking can be done by conventional methods of propagation (seeds, cuttings or transplants for plants), or micropropagation. Controlled propagation of plant species should only be used when other methods of obtaining viable propagules from the wild have failed or have been shown to be ineffective in achieving the recovery of the species. Obtaining viable propagules from wild stock should not in any way harm the native population from where sampling occurs. High effective population sizes should be maintained throughout the propagation process. It must also be borne in mind that small populations are susceptible to founder events and demographic stochasticity (*e.g.* see Primack 1998 – Chapter 11). Falk *et al*. (1996; p. 479) provide the following guidance to minimise inbreeding[64] in the new population and thereby maintain the potential for the natural genetic structure to evolve:

- 'plant diverse genotypes scattered systematically over the planting site'
- 'plant with high stocking density to promote abundant cross-fertilization'

Management techniques must be developed to control predation by animals, disturbances especially during seedling establishment, and competition by non-native species. In this respect, survival success might be increased by using artificially grown plants whereby seeds are germinated in controlled environments (either by sexual propagation using seeds or else by asexual propagation *i.e.* using vegetative parts such as shoots, roots or leaves, whereby all characteristics of the parent occur in the new offspring). The young plants can then be transplanted into the appropriate habitat. Issues of growth rate and persistence should be considered.

Note 26: Micropropagation should be considered for species that are native or endemic and require special conservation efforts to prevent their extinction in the wild. However, micropropagation should only be used for those species that cannot be propagated by conventional methods. This is because although this technique aids in boosting numbers of individuals, it does not increase the genetic diversity of the overall population and species since micropropagated specimens will be genetically identical to the donor/mother stock.

- Plant stock for carrying out reintroduction/reinforcement of a species of concern should be of local provenance and should have a broad genetic base.

[63] IUCN/SSC Guidelines for Reintroduction.
[64] Not applicable in the case of natural inbreeders *i.e.* species that are self-pollinating as opposed to cross-pollinating

- *Ex situ* propagation should be applied as a supportive tool to *in situ* plant conservation, with the ultimate intention of strengthening or re-establishing wild populations as part of conservation efforts.

Step 3: Preparatory & Planting Phase

Once the programme for conservation translocation is approved by the Competent Authority, permits have been acquired, the plant stock is available, and the release area has been cleared of any potential threats (*e.g.* invasive species), then planting/release can proceed. The planting strategy must consider the appropriate season when to carry out planting, spatial and depth considerations, as well as acclimatisation and any management needs in the early establishment phase. The population structure needs to favour demographic stability and persistence. The planting pattern adopted must emulate the natural structure and composition of the community into which the stock will be planted. Multiple planting/release events may be required across more than one year and also by planting in more than one site within the planting/release area.

Before carrying out full-scale conservation translocation, it may be desirable to undertake a field trial using a small fraction of the entire release stock (the "experimental population") so as not to sacrifice the entire stock in case of failure of establishment, reproduction and dispersal. Consideration of such a field trial is particularly crucial if and when employing conservation introduction.

Field/Release trials aid in answering questions that involve a degree of uncertainty and which can help refine the conservation translocation, such as:

- What is the appropriate propagule/founder population size required for greater chances of establishment, recruitment, survivorship and maintenance of genetic integrity/diversity within populations?
- What is the appropriate spatial distribution/planting density and planting/sowing depth to be achieved?
- What is the appropriate stage and age class to use? Is a combination of seeds, juvenile and adult plants more likely to succeed?
- Are there other threats at the release site previously not considered?

In cases where the field trial shows that establishment in the wild is unlikely, the "experimental population" can be transplanted to another appropriate site, if feasible. On the other hand, where the field trial has shown positive results, the experimental population may then be used as a partial founder population in the full-scale planting/release.

The plant site needs to be delimited. Moreover, when carrying out the full-scale planting/release, it is crucial to document all placements of plants into the natural habitat; this can be done by recording GPS values and plotting on a map. This will help in future monitoring of the planted individuals.

Note 27: Apart from the need to undertake field trials, prior to release, it is also important to establish an agreement between the entities responsible for the conservation translocation and the landowner/user to ensure that the latter will not remove or damage in any way the planted specimens. Outreach activities to inform the public of an ongoing

project would also be desired to avoid any impacts such as trampling, any form of disturbance or waste disposal.

Step 4: Post-Planting Phase

(A) Maintenance and Management

Required maintenance may involve horticultural aid, while management might involve continuing habitat protection, suppressing cover of competing species (*e.g.* ruderals such as *Galactites tomentosa* and *Rubus ulmifolius*) or restoration as required. Management that favours natural regeneration of plant communities is preferred.

Note 28: Maintenance should be limited to the initial stages of post-planting and until the species or plant community is exhibiting evidence of re-establishment and self-regeneration. Maintenance and management:

- should not create an artificial system;
- should not proceed indefinitely;
- should be low-impact and in keeping with the wider conservation of the area;
- should be seen as a conservation tool and not as an end in itself.

Maintenance and management requirements should be developed/adjusted on the basis of monitoring results (see below).

(B) Monitoring – Duration, Objectives and Methods

An integral monitoring regime (against a pre-release/pre-planting baseline) is required both during and following the implementation of the conservation translocation with the purpose of taking stock of, *inter alia*, demographical changes (including health and mortality) and ecological changes , and in particular with respect to:

- assessing progress towards meeting the stated goals;
- indicating what other type of management is required to increase the success of the conservation translocation;
- assessing the health, early establishment, recruitment (especially important when dealing with annuals), population dynamics, survival and persistence of the species in the release/planting site;
- identifying factors that contribute to the success or failure (e.g. emerging threats) of the conservation translocation;
- enabling the early detection of any problems or unforeseen threats so as to timely address them before the target species or the release/planting site can be adversely affected; and
- in the case of ecological replacement, elucidating the ecological impacts arising from release of the species

For instance, monitoring might indicate that decisions are needed - either revision of the conservation translocation programme (adaptive management) or else discontinuation - if the conservation translocation does not proceed as intended or according to plan (e.g. lack of success or unacceptable consequences). In cases where discontinuation is required and justified, an exit strategy may be desirable (see IUCN, 2012).

A person responsible for overseeing such monitoring should be appointed before carrying out the actual conservation translocation. The methodology adopted for monitoring should integrate issues of precision, repeatability and efficiency. Monitoring must also be carried out over a duration that allows recording responses to the release, environmental changes, natural processes and management and in proportion to the scale and any uncertainties/risks of the project. Short-term monitoring will shed light on the early establishment, and basic life history/demography processes. Monitoring may need to be carried out over a number of years because what might seem a successful conservation translocation, might eventually fail. Hence, long-term monitoring is also required to determine the need for future releases, to document responses to management, occurrences of recruitment, population growth trends and variations both spatially and temporally (*e.g.* in response to the dynamics of succession, disturbance events, climate change) as well as population performance and ecological roles after translocation. Once monitoring reveals that the intended goals have been achieved (species successfully thriving in the release site, ecological role of the species being met at the release site, etc.), the monitoring frequency and intensity can be reduced.

The monitoring programme can be devised into two phases. Phase one would assess the acclimatisation and early establishment of the planted specimens to the new environment and thereby evaluate the success of the techniques used. Phase two, on the other hand, would involve recording the fate of the species and of communities at the release site and determining the impact of the translocated species on the receiving environment. The success of monitoring necessitates the adoption of an adaptive management approach so that any problems are identified at an early stage and rectified in a timely manner. The results of monitoring should be used to inform future efforts at conservation translocations in the country (see below – Section D).

(C) Success Indicators

Progress can be assessed both on the short-term and long-term by means of monitoring using a set of success indicators that are linked to the goals of the conservation translocation, such as population abundance/performance, extent, resilience and persistence of the translocated species. Success on the short-term is therefore revealed by:

- Evidence of establishment/re-establishment into the release site (in particular establishment of subsequent generations);
- Evidence of reproduction occurring on the site;
- Evidence of increase in the population size;
- Evidence of population expansion beyond the planting site therefore indicating natural dispersal;
- Evidence of the ecological function being successfully reinstated (in the case of ecological replacement);

On the other hand, long-term success is determined in terms of persistence and resilience to both natural and anthropogenic perturbations. Success of a conservation translocation will depend on how well the planted specimens adapt to the release site (inter-relationships with biotic and abiotic elements) and overall on how the species integrates within the ecosystem.

(D) Research Opportunities & Documentation/Dissemination of Experiences

Prior to contemplating a species conservation translocation, research may be required to shed light into the factors causing mortality/decline (if not known) and to test methods to mitigate such factors. For instance, Sarrazin and Barbault (1996; p. 477)[65] maintain that '… reintroductions offer a unique opportunity for experimental studies on ecological processes.' These authors also mention that since both the source of origin of individuals of the reintroduced species, as well as the size of the original population would be known, predicted models of population dynamics can thus be obtained while genetics can also be studied. Population modelling would be required to foretell population expansion of the reintroduction species.

Information on progress of the project should be presented in the form of an interim report(s) at key stages during the project and, a final report upon conclusion of the project documenting/communicating its results. Other means of dissemination may be considered tailored to the target audience (e.g. online newsletter, articles in peer-reviewed journals, social media etc.) The final report would serve as a record of the conservation translocation to guide any subsequent similar projects.

Note 29: It is imperative that progress and outcomes (both positive and negative) are documented in order to guide future conservation translocations.

[65] Reintroduction; challenges and lessons for basic ecology - Sarrazin and Barbault,1996

PART IV: *References*

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PART V: *Annexes*

Annex I: Terminology

Alien	See definition for "non-native" below
Allelopathic	Plant releases secondary metabolites that act as a toxin by influencing/suppressing the growth and development of neighbouring vegetation
Annual Plant	Plant completes life cycle in 1 year or less; '... generally species of disturbed ground of which a given area may be suitable for germination, growth and seed production in some years but not others; seed dormancy is the device annual plants use to overcome poor years' (Surtherland, 1995, p. 12) [Compare 'Biennial' and 'Perennial']
Assisted Colonisation	'The intentional movement and release of an organism outside its indigenous range to avoid extinction of populations of the focal species' (IUCN, 2012)
Bark	The bark comprises the outer plant tissues, which include the periderm, and also incorporates the phloem and the cambium. Stripping the bark may starve the roots from nutrients carried by the phloem.
Biennial Plant	Plant lives longer than 1 year but less than two years; Compare 'Annual' and 'Perennial'
Cambium	This is the meristematic (undifferentiated) plant tissue, which gives rise to the conducting tissues of the plant (that is the phloem and the xylem).
Casual alien plants	'Alien plants that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions for their persistence' (Richardson *et. al.*, 2000)
Co-adapted gene complex	'A concept in which particular gene combinations, presumable acting in concert through a long association, function particularly well together' (Meffe and Carroll, 1997)
Competent Authority	This is the Malta Environment and Planning Authority, unless otherwise stated
Conservation Introduction	'The intentional movement and release of an organism outside its indigenous range' (IUCN, 2012)
Conservation Status	Degree of threat a species faces and the related chance of its extinction
Conservation Translocation	'The intentional movement and release of a living organism where the primary objective is a conservation benefit: this will usually comprise improving the conservation status of the focal species locally or globally, and/or restoring natural ecosystem functions or processes' (IUCN, 2012)
Deciduous	Plant sheds its leaves at the end of its growing season
Dioecious	Plant species in which male and female organs appear on separate individuals [Compare 'Monoecious']
Ecological Replacement	'The intentional movement and release of an organism outside its indigenous range to perform a specific ecological function' (IUCN, 2012)
Ecosystem	'A dynamic complexity of plant, animal, and microorganism communities and their non-living environment interacting as a functional unit' (CBD Convention Text – Article 2 on Use of Terms)

Ecosystem Approach	'A strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way' (www.cbd.int/ecosystem/ and www.cbd.int/ecosystem/sourcebook/)
Effective Population Size	The number of breeding individuals; this number tends to be smaller than the actual population size
Eradication	'The permanent removal of entire discreet populations' (Parkes & Panetta, 2009)
Establishment (established)	The process of an alien species in a new habitat successfully producing viable offspring with the likelihood of continued survival (Decision VI/23 of the Conference of the Parties to the CBD, Annex, footnote to the Introduction; Genovesi & Shine, 2003)
Ex situ conservation	'The conservation of components of biological diversity outside their natural habitats' (CBD Convention Text – Article 2 on Use of Terms)
Formulation	'The final composition of a pesticide as provided to the user consisting in the combination of active and other substances, and the proportion thereof, in such pesticide, designed to render the product effective for the purpose claimed' (Pesticides Control Act – Cap. 430)
Germplasm	Sample of plant *i.e.* seed, pollen as well as entire plant
Habitat	'The place or type of site where an organism or population naturally occurs' (CBD Convention Text – Article 2 on Use of Terms)
Homogenisation	Replacement of diverse communities with plant stands of a single species
Impacts	Effects or influences that invasive alien species have on various ecological or socio-economic components of island ecosystems and/or the human communities that depend on island resources (UNEP, 2003)
Inbreeding depression	The result of breeding between closely related members of a species leading to loss of fitness, general vigour and fertility
Infructescence	Fruiting stage of an inflorescence; the group of fruit is arranged in a characteristic pattern
In situ conservation	'The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings …' (CBD Convention Text – Article 2 on Use of Terms)
Intentional Introduction	'The deliberate movement and/or release by humans of an alien species outside its natural range' (Genovesi & Shine, 2003)
Introduction	The movement by human agency, indirect or direct, of a non-native plant species outside of its natural range (past or present); This movement can be either within the Maltese Island or between the Maltese Islands and other countries
Invasive Alien species	'An alien species whose introduction and/or spread threaten biological diversity' (CBD)
Invasive Plant (plant invader)	'An alien plant spreading naturally (without the direct assistance of people) in natural or semi-natural habitats, to produce a significant change in terms of composition, structure or ecosystem processes' (Cronk & Fuller, 2001)
Label	'The written, graphic or printed matter, on or attached to, the pesticide or the immediate container thereof and the outside container or wrapper of the retail package of the pesticide;' (Pesticides Control Act – Cap. 430)
Life History	Events that make up the plant's life cycle
Micropropagation	*In vitro* vegetative/clonal propagation of plants from shoot tips or nodal explants under aseptic and controlled environmental conditions on specially prepared media that contain substances necessary for growth
Minimum Viable Population	A minimum viable population for a given species in any given habitat is 'the smallest population size that can be predicted to have a very high chance of persisting for the foreseeable future' (Chapter 11 – Problems of Small

	Populations; In: Primack – Essentials of Conservation Biology (p. 280).
Mode of Activity (of Plant Protection Product)	How the chemical enters the plant – whether foliar active (enters through leaf and possible even stems), soil active (enters through the roots when plant transpires) or both; Soil active chemicals are not recommended in ecologically sensitive areas
Monoecious	A plant having unisexual reproductive organs or flowers, with the organs or flowers of both sexes carried on a single plant [Compare 'Dioecious']
Native Species	A species, which occurs naturally in the Maltese Islands
Natural or semi-natural	Plant communities/habitats with some degree of conservation importance including those habitats that have historically adapted to some natural disturbance regime (*e.g.* habitats pertaining to a successional series)
Naturalised Plants	Alien plants that reproduce consistently and sustain populations over many life cycles without direct intervention by humans (or in spite of human intervention); they often recruit offspring freely, usually close to adult plants, and do not necessarily invade natural, semi-natural or human-made ecosystems (Richardson *et. al.*, 2000)
Non-native (alien; introduced, non-indigenous) plant	'A non-indigenous organism that has never been a native of Malta or which has been introduced therein during the past 500 years' (LN 311 of 2006) 'Plant taxa in a given area whose presence there is due to intentional or accidental introduction as a result of human activity' (synonyms: exotic plants; non-indigenous plants) (Richardson *et. al.* 2000) 'A species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.' (Convention on Biological Diversity)
Pathway	Means as applicable: 1. the geographic route by which a species moves outside its natural range (past or present), 2. the corridor of introduction (*e.g.* road, canal, tunnel), and/or 3. the human activity that gives rise to an intentional or unintentional introduction (Genovesi & Shine, 2003)
Perennial Plant	Plant lives longer than 2 years [Compare 'Annual' and 'Biennial']
Planting	Any operation whereby plants are placed in such a way as to ensure their growth, reproduction or propagation
Plants	Live plants and parts of live plants, including fruit and seeds (ACT No XI of 2001 - Pesticides Control Act 2001; Cap. 430)
Plant Protection Product	In the context of these guidelines - active substances and preparations containing one or more active substances, put up in the form in which they are supplied to the user, intended to: destroy undesired plants; or destroy parts of plants, check or prevent undesired growth of plants; (adapted from Council Directive 91/414/EEC)
Population Restoration	'Any conservation translocation to within indigenous range' (May comprise reintroduction or reinforcement) (IUCN, 2012)
Precautionary Approach	No definition available - 'The precautionary approach is that set forth in principle 15 of the 1992 Rio Declaration on Environment and Development and in the preamble of the Convention on Biological Diversity. The precautionary approach should also be applied when considering eradication, containment and control measures in relation to alien species that have become established. Lack of scientific certainty about the various implications of an invasion should not be used as a reason for postponing or failing to take appropriate eradication, containment and control measures. (See Principle 1 in CBD Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that threaten Ecosystems, Habitats or Species)

Propagule Pressure	Number of individuals of a species released into an area
Protected Area	Any area protected through the Environment Protection Act or scheduled for ecological and scientific reasons under the Development Planning Act, including Tree Protection Areas, or under the Environment and Development Planning Act
Reinforcement	'The intentional movement and release of an organism into an existing population of conspecifics' (IUCN, 2012)
Reintroduction	'The intentional movement and release of an organism inside its indigenous range from which it has disappeared' (IUCN, 2012)
Re-stocking	The movement of numbers of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat (IUCN, 1987)
Ruderal	Plant associated with disturbed land; Also considered as opportunistic species
Translocation	'The human-mediated movement of living organisms from one area, with release in another' (IUCN, 2012)
Unintentional Introduction	A species spread via humans themselves or human delivery systems *e.g.* trade, tourism, travel and transport
Vector	The physical means or agent (*i.e.* aeroplane, ship) in or on which a species moves outside its natural range (past or present) (Genovesi & Shine, 2003)
Viable population	A population that is able to maintain its capacity to survive and breed as well as its potential for evolutionary change and adaptation in its ecosystem

Annex II: Relevant Global & Regional Provisions

N.B. Relevant national legislation is available for viewing at www.mepa.org.mt

Global	
Legal Instrument:	UN Convention on Biological Diversity (CBD) (Rio de Janeiro, 1992)
Relevant Provisions:	Provisions on non-native species: Article 8(h) - "Each Contracting Party shall, as far as possible and as appropriate (…) *Prevent the introduction of, control or eradicate those alien species, which threaten ecosystems, habitats, or species*". Provisions on species reintroduction: Article 9(c) on *Ex situ* Conservation - "Each Contracting Party shall as far as possible and as appropriate, (…) *Adopt measures for the recovery and rehabilitation of threatened species and for their reintroduction into their natural habitats under appropriate conditions*."
Comments:	Invasive alien species is a cross-cutting theme under the CBD CBD Guiding Principles on IAS (Decision VI/23) that are relevant to the context of these guidelines are reproduced below: ▪ Guiding Principle 1 – Precautionary Approach "Given the unpredictability of the pathways and impacts on biological diversity of invasive alien species, efforts to identify and prevent unintentional introductions as well as decisions concerning intentional introductions should be based on the precautionary approach, in particular with reference to risk analysis, in accordance with the guiding principles below. The precautionary approach is that set forth in principle 15 of the 1992 Rio Declaration on Environment and Development and in the preamble of the Convention on Biological Diversity. The precautionary approach should also be applied when considering eradication, containment and control measures in relation to alien species that have become established. Lack of scientific certainty about the various implications of an invasion should not be used as a reason for postponing or failing to take appropriate eradication, containment and control measures." ▪ Guiding Principle 2 – Three-stage Hierarchical Approach "1. Prevention is generally far more cost-effective and environmentally desirable than measures taken following introduction and establishment of an invasive alien species. 2. Priority should be given to preventing the introduction of invasive alien species, between and within States. If an invasive alien species has been introduced, early detection and rapid action are crucial to prevent its establishment. The preferred response is often to eradicate the organism as soon as possible (principle 13). In the event that eradication is not feasible or resources are not available for its eradication, containment (principle 14) and long-term control measures (principle 15) should be implemented. Any examination of benefits and costs (environmental, economic and social) should be done on a long-term basis." ▪ Guiding Principle 3 – Ecosystem Approach "Measures to deal with invasive alien species should, as appropriate, be based on the ecosystem approach, as described in decision V/6 of the Conference of the Parties."

	▪ Guiding Principle 12 – Mitigation of Impacts "Once the establishment of an invasive alien species has been detected, States, individually and cooperatively, should take appropriate steps such as eradication, containment and control, to mitigate adverse effects. Techniques used for eradication, containment or control should be safe to humans, the environment and agriculture as well as ethically acceptable to stakeholders in the areas affected by the invasive alien species. Mitigation measures should take place in the earliest possible stage of invasion, on the basis of the precautionary approach. Consistent with national policy or legislation, an individual or entity responsible for the introduction of invasive alien species should bear the costs of control measures and biological diversity restoration where it is established that they failed to comply with the national laws and regulations. Hence, early detection of new introductions of potentially or known invasive alien species is important, and needs to be combined with the capacity to take rapid follow-up action." ▪ Guiding Principle 13 – Eradication "Where it is feasible, eradication is often the best course of action to deal with the introduction and establishment of invasive alien species. The best opportunity for eradicating invasive alien species is in the early stages of invasion, when populations are small and localized; hence, early detection systems focused on high-risk entry points can be critically useful while post-eradication monitoring may be necessary. Community support is often essential to achieve success in eradication work, and is particularly effective when developed through consultation. Consideration should also be given to secondary effects on biological diversity." ▪ Guiding Principle 14 – Containment "When eradication is not appropriate, limiting the spread (containment) of invasive alien species is often an appropriate strategy in cases where the range of the organisms or of a population is small enough to make such efforts feasible. Regular monitoring is essential and needs to be linked with quick action to eradicate any new outbreaks." ▪ Guiding Principle 15 – Control "Control measures should focus on reducing the damage caused as well as reducing the number of the invasive alien species. Effective control will often rely on a range of integrated management techniques, including mechanical control, chemical control, biological control and habitat management, implemented according to existing national regulations and international codes."
Reference:	Convention Text - http://www.cbd.int/convention/convention.shtml Information on Invasive Alien Species as a cross-cutting issue under the CBD - http://www.cbd.int/invasive/ CBD COP Decision VI/23 - http://www.cbd.int/programmes/cross-cutting/alien/decision-v8.shtml?dec=VI/23&menu=cross-cutting&filter=alien

Regional	
Legal Instrument:	*Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)* (Bern, 1979)
Relevant Provisions:	Provisions on non-native species: Article 11 paragraph 2(b) of the Bern Convention calls on its Contracting Parties to 'strictly control the introduction of non-native species'. Provisions on species reintroduction: Article 11 paragraph 2(a) - 'Each Contracting Party undertakes: to encourage the reintroduction of native species of wild flora and fauna when this would contribute to the conservation of an endangered species, provided that a study is first made in the light of the experiences of other Contracting Parties to establish that such reintroduction would be effective and acceptable;'
Comments:	The Bern Convention is managed by a Standing Committee, which has issued a number of technical reports, assessments, and guidelines, action plans and so forth on invasive alien species and has also established an IAS experts group in collaboration with the IUCN Invasive Species Specialist Group. This working group has developed a European Strategy on Invasive Alien Species presented at the 22nd meeting of the Standing Committee in 2002. The final version of this strategy (T-PVS (2003) 7 revised) was presented at the 23rd meeting of the Standing Committee. The strategy addresses the constraints that many European States face in their common efforts to address IAS.
Reference:	Bern Convention [Official Website]: http://www.coe.int/t/dg4/cultureheritage/nature/bern/default_en.asp

Regional	
Legal Instrument:	Council Directive 92/43/EEC on the Conservation of Natural Habitats and of Wild Fauna and Flora - Habitats Directive (EEC Directive 92/43/EEC)
Relevant Provisions:	Provisions on non-native species: Article 22 – 'In implementing the provisions of this Directive, Member States shall:… (b) ensure that the deliberate introduction into the wild of any species which is not native to their territory is regulated so as not to prejudice natural habitats within their natural range or the wild native fauna and flora and, if they consider it necessary, prohibit such introduction. The results of the assessment undertaken shall be forwarded to the committee for information…' Provisions on species reintroduction: Article 22 – 'In implementing the provisions of this Directive, Member States shall:… (a) study the desirability, of re-introducing species in Annex IV that are native to their territory where this might contribute to their conservation, provided that an investigation, also taking into account experience in other Member States or elsewhere, has established that such reintroduction contributes effectively to re-establishing these species at a favourable conservation status and that it takes place only after proper consultation of the public concerned…'
Comments:	In 2006 a study called "Scope options for EU action on invasive alien species" was financed by the EU Commission. This study carried out a gap analysis of the current legislative and put forward a suite of recommendations for action to address IAS at the EU level. Report Available at: http://ec.europa.eu/environment/nature/invasivealien/docs/2006_06_ias_scope_options.pdf Annex of the Report: http://ec.europa.eu/environment/nature/invasivealien/docs/2006_06_ias_scope_options_annexes.pdf Addendum: http://ec.europa.eu/environment/nature/invasivealien/docs/2006_06_ias_scope_options_addendum.pdf An EU Legislative Proposal on IAS is forthcoming in 2013.
Reference:	Information on the EC Habitats Directive: http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm Information on Invasive Alien Species on EU Website: http://ec.europa.eu/environment/nature/invasivealien/index_en.htm

Annex III: Major Plant Invaders and Possible Management Options

Note 30: 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 Productions 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
Acacia cyclops	Spring					•
Vachellia karroo (= *Acacia karroo*)	Late spring-Early summer					•
Acacia saligna	Spring			•		•
Aeonium arboreum	Winter-Spring				•	
Agave americana	Summer				•	
Agave sisalana	Summer-Winter				•	
Ailanthus altissima	Late Spring	•	•	•	•	•
Aptenia spp.	Late Spring-Summer				•	•
Arundo donax	Late Summer/Early Autumn			•	•	
Symphyotrichum squamatus (= *Aster squamatus*)	Summer-Autumn					•
Cardiospermum grandiflorum	Summer-Early Autumn					•
Carpobrotus edulis	Spring				•	
Casuarina equisetifolia	Summer		•	•		•
Eucalyptus spp.	Summer			•		
Lantana camara	All Year Round			•	•	•
Leucaena leucocephala	Summer-Winter (All year round)			•		•
Nicotiana glauca	Spring-Autumn	(semi-evergreen)				•
Nothoscordum borbonicum	Spring					•
Opuntia ficus-indica	Late Spring-Summer				•	
Oxalis pes-caprae	Spring				•	
Pennisetum setaceum	Spring-Summer				•	•
Pennisetum villosum	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
Pittosporum tobira	Summer		•			•
Ricinus communis	Spring-Autumn (All year round)			•		•
Schinus terebinthifolius	Autumn-Winter		•	•		•
Tropaeolum majus	Late Spring					•

Large Sized Trees

Eucalyptus spp.

Eucalyptus camaldulensis & *E. gomphocephala* (Maltese: *l-ewkaliptus, l-ewkaliptu, is-siġra tal-gamiem*; 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-każwarina*; 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-gażżija 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-gażżija 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 Bașnou 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 were 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 *Baħrija* valley. This interventionconsisted 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 latu*)

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

Management Options:

- *Mechanical* (can be labour intensive): by repeated cutting and were 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-siżal; l-agave s-siżalana; 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-aliens.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-aliens.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-penniżetum, 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-ħanżir, widnet il-ġurdien*; English: heart-leaved ice-plant)
Aptenia lancifolia L. Bolus (Maltese: *qrun il-baqra*, English: lance-leaved ice-plant) – [Family Aizooaceae]

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 on 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-aliens.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=&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)

Symphyotrichum 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

Oxalis pes-caprae **L.**

(Maltese: *il-ħaxixa Ingliża; l-Ingliża, 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-qsari*; 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.

Annex IV: Carrying out a Feasibility and Risk Assessment for Assessing the Desirability of Plant Conservation Translocations – Examples of Questions to Consider

SPECIES CONSIDERATIONS			
Is the species endemic/sub-endemic to the Maltese Islands?	Yes ☐	No ☐	(Specify)
Is the species of EU community importance?	Yes ☐	No ☐	(Specify Directive and Annex)
Is the species listed in the Red Data Book of the Maltese Islands?	Yes ☐	No ☐	(Specify)
Is the current conservation status of the species known?	Yes ☐	No ☐	(Specify the status)
Is the species afforded legal protection in the Maltese Islands?	Yes ☐	No ☐	(Mention relevant legislation)
Is the species' historical range and distribution in the Maltese Islands known?	Yes ☐	No ☐	(Specify including with maps)
Are there extant/existing populations of this species remaining in the Maltese Islands?	Yes ☐	No ☐	(Mention remaining localities)
Are the species' critical needs known?	Yes ☐	No ☐	(Specify)
Does the species play an important role in the ecosystem it typically inhabits?	Yes ☐	No ☐	(Describe role)
Are the mortality factors known? Can they be controlled or eliminated?	Yes ☐	No ☐	(Specify)
Is there a reliable stock of this species available locally?	Yes ☐	No ☐	(Mention source, technique used and available numbers)
Will the conservation action planned for the recovery of the target species affect other species in the planting site?	Yes ☐	No ☐	(Specify both positive and negative impacts)
HABITAT CONSIDERATIONS			
Does suitable habitat fall within the boundaries of a protected area?	Yes ☐	No ☐	(Give details)
Are there several suitable locations where the species can be planted so as to increase the changes of long-term survival?	Yes ☐	No ☐	(Specify)
Is there suitable habitat available locally within the species' natural range?	Yes ☐	No ☐	(Specify)
Is there suitable habitat left outside the species' natural range?	Yes ☐	No ☐	(Specify)
Are there any activities occurring in the intended planting site which can damage or wipe-out the planted specimens?	Yes ☐	No ☐	(Give details)
LOGISTIC CONSIDERATIONS			
Is there local expertise to adequately plan the species recovery?	Yes ☐	No ☐	(Give details)
Are resources available to cater for the duration of the species recovery and monitoring (to ensure the successful establishment of the planted population) as well as to deal with any problems that might emerge (contingency planning)	Yes ☐	No ☐	(Specify)
Is EU funding being sought for the species recovery as a conservation project?	Yes ☐	No ☐	(Specify)

OVERALL FEASIBILITY ASSESSMENT	
Based on the above considerations, what are the chances of success of *in situ* and *ex situ* efforts for this species?	☐ Excellent, with minimal management effort needed ☐ Very Good, but with significant management effort needed ☐ Bad and with considerable management effort needed ☐ Very bad, unlikely to succeed
RISK ASSESSMENT	
What risks are associated with the conservation translocation option under consideration? (Give details)	☐ Risk to source populations through removal of propagules including on associated/dependent species (especially if wild sourced) ☐ Ecological risk on other species, on the release site and on ecosystem functioning ☐ Disease/Pathogen Transmission risk ☐ Associated invasion risk of translocated specimens in the release site ☐ Risk of gene exchange between translocated individuals and residents (intra- and interspecific hybridization) ☐ Socio-economic risk ☐ Financial risk ☐ Any potentially unknown risks
OVERALL RISK ASSESSMENT	
Based on the above considerations, what are the overall risks associated with the proposed conservation translocation vis-à-vis not achieving its objectives and/or causing unintended damage?	☐ High ☐ Medium ☐ Low
CERTAINTY LEVELS OF PREDICTIONS	
Based on the above considerations, what is the level of certainty/confidence of the assessment findings/predictions?	☐ High ☐ Medium ☐ Low
OVERALL RECOMMENDATION	
Should the proposed conservation translocation proceed?	☐ Yes ☐ No

Annex V: Bibliography – Examples of Supporting Material

LIFE Projects Database - Projects on Invasive Alien Species

http://ec.europa.eu/environment/life/themes/animalandplants/lists/alienspecies.htm

Guidelines and Toolkits on IAS Management

- IUCN Guidelines for the Prevention of Biodiversity Loss caused by Alien Invasive Species – (May, 2000) – [Online] Available from: http://intranet.iucn.org/webfiles/doc/SSC/SSCwebsite/Policy_statements/IUCN_Guidelines_for_the_Prevention_of_Biodiversity_Loss_caused_by_Alien_Invasive_Species.pdf
- Invasive Alien Species: A Toolkit for Best Prevention and Management Practices – (Ed. By Wittenberg and Cock, 2001) – [Online] Available from: http://siteresources.worldbank.org/INTBIODIVERSITY/214584-1110958891157/20522670/toolkiteng.pdf
- CBD Series No. 1 – Assessment and Management of alien species that threaten ecosystems, habitats, and species – 2001 – [Online] Available from: www.cbd.int/doc/publications/cbd-ts-01.pdf
- CBD (2002). Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species [Online] Available from: www.cbd.int/programmes/cross-cutting/alien/decision-v8.shtml?dec=VI/23&menu=cross-cutting&filter=alien
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Codes of Conduct

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- European Code of Conduct for Botanic Gardens on Invasive Alien Species – prepared by Prof. Vernon Heywood with contributions by Suzanne Sharrock, Botanic Gardens Conservation International, and members of the European Botanic Gardens Consortium – Council of Europe - T-PVS/Inf (2012) 1 [Online] Available from: https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=2169478&SecMode=1&DocId=1943644&Usage=2

Dealing with Biowaste

- EPPO Guidelines for the management of plant health risks of biowaste of plant origin (EPPO PM 3/66(1) 2006) [Online] Available from: www3.interscience.wiley.com/cgi-bin/fulltext/118562480/PDFSTART

IAS in a Wetland Context

- RAMSAR Resolution VII.14 on Invasive Species and Wetlands and RAMSAR Resolution VIII.18 on Invasive Species and Wetlands – [Online] Available from: http://www.ramsar.org/cda/en/ramsar-documents-resol/main/ramsar/1-31-107_4000_0__

IAS Databases & IAS Alert Lists

- Global Invasive Species Database (GISD) – [Online] Available from: www.issg.org/database/welcome/
- Delivering Alien Invasive Species Inventories for Europe (DAISIE) – [Online] Available from: www.daisie.se/
- European Plant Protection Organisation (EPPO) – Portal on Invasive Plants [Online] Available from: http://www.eppo.int/INVASIVE_PLANTS/ias_lists.htm
- http://www.issg.org/database/species/search.asp?st=100ss

Global & Regional Policy on IAS

- Global Strategy on Invasive Alien Species (Ed. By McNeely, Mooney, Neville, Schei and Waage, 2001 - Published in collaboration with IUCN) – [Online] Available from: http://data.iucn.org/dbtw-wpd/edocs/2001-011.pdf

- T-PVS / Inf (2002) 44 - European and Mediterranean Plant Protection Organization (EPPO) work and policy on Invasive Alien Species: www.coe.int/t/e/cultural_co-operation/environment/nature_and_biological_diversity/nature_protection/sc22_inf44e.pdf
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Legal Issues related to IAS

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Biological Control

- FAO Code of Conduct for the Import and Release of Exotic Biological Control Agents [Online] Available from: www.fao.org/docrep/x5585E/x5585e0i.htm
- International Plant Protection Convention (IPPC) Guidelines for the export, shipment, import and release of biological control agents and other beneficial organisms. [Online] Available from: https://www.ippc.int/file_uploaded/1323944456_ISPM_03_2003_En_2011-12-01_Refor.pdf

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- CITES COP 10 adopted Decisions 10.54, 10.76 and 10.86 – Trade in Alien Species – [Online] Available from: www.cites.org/eng/dec/valid12/10-54more.shtml
- CITES COP 13 adopted Conf. 13.10 - Trade in alien invasive species – [Online] Available from: www.cites.org/eng/res/all/13/E13-10.pdf
- Bern Convention T-PVS/Inf (2006) 8 - Overview of existing international/regional mechanisms to ban or restrict trade in potentially invasive alien species - https://wcd.coe.int/com.instranet.InstraServlet?command=com.instranet.CmdBlobGet&InstranetImage=1344943&SecMode=1&DocId=1436876&Usage=2
- Bern Convention Rec. No. 125 (2007) on trade in invasive and potentially invasive alien species in Europe [Online] Available from: http://www.coe.int/t/dg4/cultureheritage/nature/bern/IAS/default_en.asp

Addressing IAS in an insular context

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- MEPA (2011). *Information Booklet on the European Code of Conduct on Horticulture and Invasive Alien Plants* [Online] Available from: www.mepa.org.mt/file.aspx?f=6832

Miscellaneous

- 100 of the World's Invasive Species – (Lowe, Browne and Boudjelas, 2000) – Available from: http://www.issg.org/database/species/reference_files/100English.pdf
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