Pennisetum setaceum is native to open, scrubby habitats in East Africa, tropical Africa, the Middle East and south-western Asia..
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The management of fountain grass (*Pennisetum setaceum*)

Measures and associated costs

Scientific name(s)	*Pennisetum setaceum* (Forssk.) Chiov., Bull.Soc.Bot.Ital. 1923:113 (1923)
Common names (in English)	Fountain grass
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Common names

BG	фонтан трева
HR	Čekinjasta trava
CZ	Dochan setý
DA	Lampepudsergræs
NL	Fraai lampenpoetsergras
EN	Fountain grass
ET	Harjas hiidhirss
FI	Arabiansulkahirssi
FR	Herbe aux écouvillons rouge
DE	Afrikanisches Lampenputzergras
EL	Πενισέτο
HU	Rózsás tollborzfű
IE	–
IT	Penniseto allungato
LV	Purpurvioletā sarzāle
LT	Šeriuotoji soruolė
MT	Il-penniżetum
PL	Rozplenica szczecinkowata
PT	Penisetum
RO	–
SK	Perovec veľkokvetý
SL	Rdečelistna ščetinasta perjanka
ES	Plumero
SV	Fjäderborstgräs

Main features of the species

Densely clumped appearance, tufted, forming like a fountain from the base.

Size: Stems: 20 to 130 cm high. Inflorescence: a 8–32 cm long panicle, leaves: rolled 0.1–0.3 cm wide and 30–100 cm long.

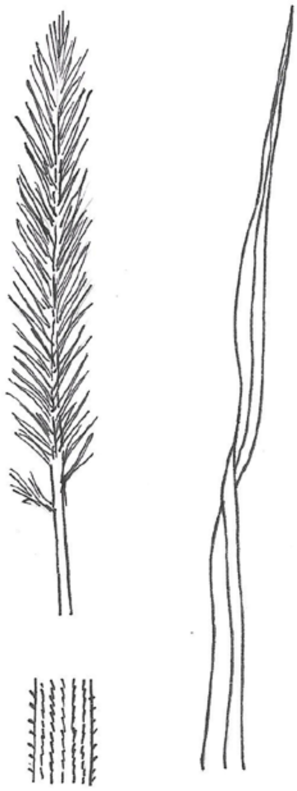
Inflorescence: an upright panicle 8–32 cm long and up to 5 cm wide, comprising grouped bristly spikelets placed on stalks. Peduncle glabrous below the panicle. Colour may vary from light green (for example in case of immature plants) to cream, tan or pinkish purple.

Green or brown, slender, involute leaves 1–3.7 mm wide and 30–100 cm long with a prominent central vein and edges rough to the touch.

Spikelet: about 6 mm long, with prominent bristles, in clusters of 1–3. Stipe relatively long, over 1.1 mm.

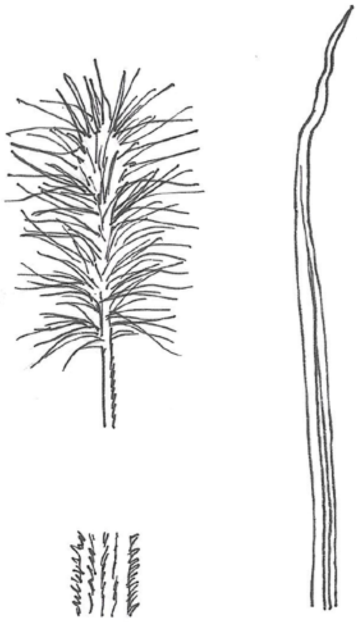
Similar species

Pennisetum advena



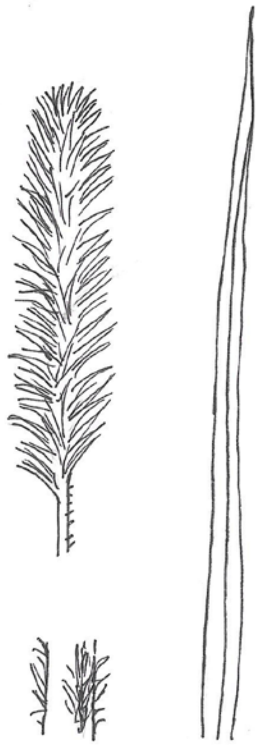
Differs from *P. setaceum* in the leaf blade being flatter, wider, and shorter (23–52 cm X 0.6–1.1 cm; see image below); peduncle rough to the touch below the panicle.

Pennisetum villosum

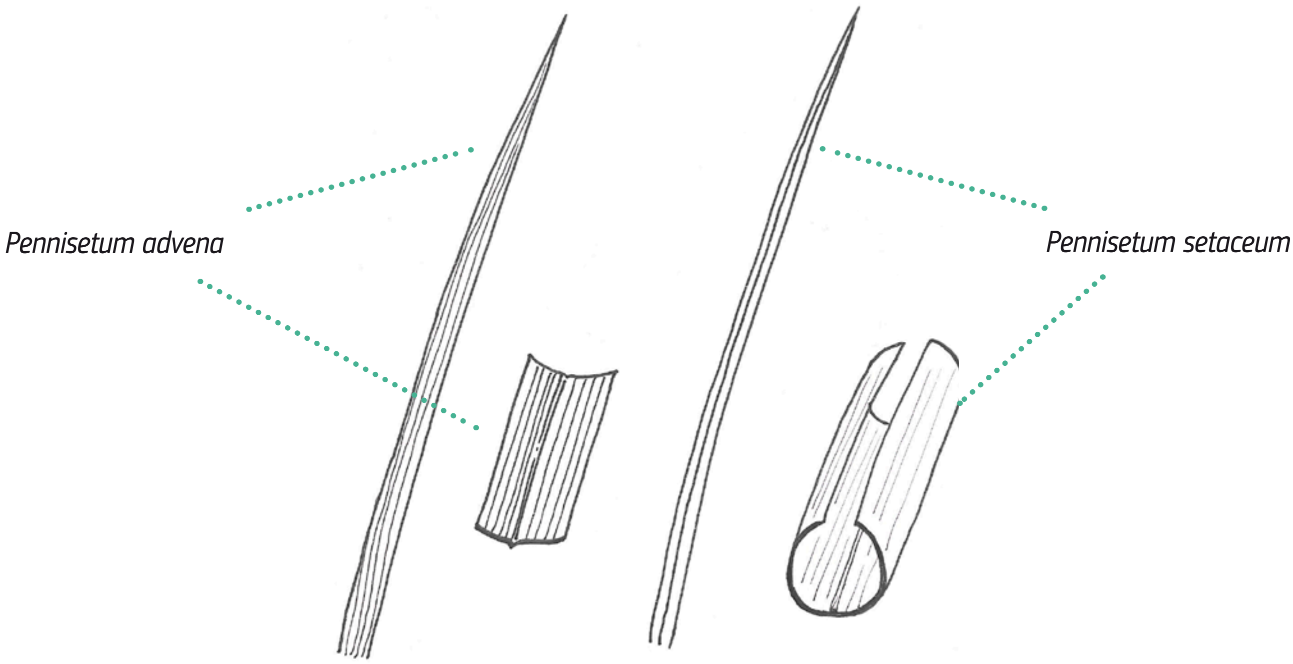


Differs in smaller dimensions of the plant, peduncle hairy below the panicle, spikelets single with bristles up to 50 mm. Inflorescence with a very different appearance.

Pennisetum alopecuroides



Differs in smaller dimensions of the plant, peduncle hairy below the panicle, bristles unequal as opposed to some bristles being distinctly longer than others in *P. setaceum*.



Summary of the measures, emphasizing the most cost-effective options

Pennisetum setaceum is a wind-dispersed, perennial, C4, bunch grass native to arid regions in the Middle East and North Africa. *P. setaceum* is apomictic and although it reproduces mainly by seed, it can form pseudo-viviparous plantlets when the inflorescences are inundated. Apart from the biological characteristics of *P. setaceum*, many other factors need to be considered during the implementation of preventive measures, such as the pathways via which *P. setaceum* can enter new areas. Actually, the main pathway is the voluntary introduction in the EU and within EU countries mainly as an ornamental, but accidental pathways are possible as well. Preventive measures and biosecurity strategies could not be any longer effective to avoid the introduction in the EU, but of course they will reduce further spread within the EU and new introductions in the EU. Plenty of established populations have been detected in Portugal, in Spain (including Baleares and Canary Islands), France, Italy (including Sardinia, Sicily and small Sicilian islets), in Malta and Cyprus. In addition, *P. setaceum* is reported also for Greece in the island of Lesvos, and for Bulgaria and Slovenia.

Early Detection and Rapid Eradication (EDRE) of *P. setaceum* should be included in a general surveillance programme concerning a selected group of invasive alien plant species that might be introduced by the same pathways and in the same points of entry, which might invade similar habitats and corridors such as roadside verges and rivers or disturbed land. At the same time, it is very likely that new outbreaks will be found close to large towns, and large green areas in urbanised areas. In addition, due to its very high capacity to colonise bare soils, disturbed areas should be prioritised for monitoring. This has to include human disturbance (for example mining, urbanisation, fires etc.) and natural disturbance (fires, current volcanic eruptions). Mediterranean coastal areas in the EU have to be prioritised for monitoring.

The prolific production of long-lived seed hinders control efforts once fountain grass is established. Control strategies should be included in dedicated strategic management plan and focus on removing seed heads and reducing seed production. Treatment priority should be assigned to small or sporadic infestations upon otherwise healthy sites, followed by larger infestations. A combination of mechanical and chemical control (such as foliar spray) should be considered. Choice of control method for *P. setaceum* depends on the current land use and site conditions; accessibility, terrain, and climate; density and degree of infestation; non-target flora and fauna present and Member States legislation. Other considerations include treatment effectiveness, cost, and the number of years needed to achieve control.

Land managers, the local public, and road crews should be educated in identification of invasive species so they can help report all suspected infestations. Vehicles, humans, and domestic animals should be discouraged from traveling through infested areas; and a programme to check and remove seeds from vehicles, clothing, and domestic animals should be implemented to help stop dispersal. Since *P. setaceum* is currently promoted as an ornamental, coordination with local nurseries to withdraw it from the market is necessary. Management measures can be very effective in reducing further spread in the EU, and mitigating negative impacts in nature conservation areas invaded by *P. setaceum*. The measures would be quite costly, but effective.

Measures for preventing the species being introduced, intentionally and unintentionally.

This section assumes that the species is not currently present in a Member State, or part of a Member State's territory.

A ban on importing (pre-border measure), selling, breeding, growing, and cultivation, as required under Article 7 of the IAS Regulation, targeting intentional introduction of plants and propagules of *P. setaceum*.

MEASURE DESCRIPTION

P. setaceum has been frequently deliberately introduced as ornamental plant, for landscaping, soils stabilisation or for other uses. Actually, the main path is the voluntary introduction in the EU and within EU countries as an ornamental or for other purposes and, less frequently, accidentally due to misidentification with similar or congeneric species or as contaminant or stowaway.

Presently, nine *Pennisetum* taxa are commonly used as ornamental grasses, including four wild species [*Pennisetum alopecuroides* (L.) Sprengel, *P. setaceum*, *P. orientale* and *P. villosum*], one artificial hybrid (*P. glaucum* × *P. purpureum*) and four cultivars (*P. alopecuroides* 'Little Bunny', *P. alopecuroides* 'Moudry', *P. setaceum* 'Rubrum', and *P. purpureum* 'Prince'), all of which are cultivated widely in the tropical and subtropical regions (Zhang *et al.*, 2015 and references cited therein). In addition, many more cultivars exist both for *P. setaceum* and *P. alopecuroides*. Conflicting information does exist on the sterility of *P. setaceum* 'Rubrum'. This cultigen is listed as invasive by the University of Florida (http://edis.ifas.ufl.edu/fp464), but breeding for the production of sterile cultigens is of course an option.

The intentional introduction is addressed with a ban on keeping, importing, selling, breeding and growing as required under Article 7 of the IAS Regulation.

However, taking into account the information in the Risk Assessment (RA) for this species, plenty of established populations have been detected in Portugal, in Spain (including Baleares and Canary Islands), France, Italy (Italian mainland and islands, including Sardinia, Sicily and small Sicilian islets such as "Isola delle Femmine"; Caldarella *et al.*, 2010; Celesti-Grapow *et al.*, 2009), in Malta (for example Brunel *et al.*, 2010) and Cyprus. Actually, this distribution pattern is supported by a sound scientific literature and can be accepted with a high degree of confidence. In addition, *P. setaceum* is reported also for Greece in the island of Lesvos (Arhonditis *et al.*, 2000) and if we take into account also "grey literature", is reported also for Bulgaria and Slovenia (CoE, 2015). In addition, quite a lot of localities have been recorded for continental Spain since 2006 (Devesa and Arnelas, 2006).

Therefore, preventive measure and biosecurity strategy could not be any longer effective to avoid the introduction in the EU, but of course they will reduce further spread within the EU and new introductions in the EU.

EFFECTIVENESS OF MEASURE

The volume of human-facilitated movement of goods and organisms, and people travelling around the globe to the European Union and within Europe is huge and might be increasing every year. Importantly, trade is generally considered the major pathway for short- and long-distance movement of ornamental plant species such as *P. setaceum*. Preventive measure tackling voluntary pathways can be very effective for those species that are neither not present in the EU nor in the neighbouring countries and with a prevalent pathway of voluntary introduction. However, this is not the actual case for *P. setaceum* so that preventive measures can be effective only in limiting further spread within the EU, further introductions in the already invaded Member States and new introductions in Member States where *P. setaceum* is presently absent. New introductions may be often risky, as new (more invasive) genotypes could be introduced.

Importantly, other species of the genus *Pennisetum* have already been recorded in the EU in the casual or naturalisation or even invasive status, for example *Pennisetum cladestinum* in Spain (Romero and Amigo, 2010), or *Pennisetum villosum* in Italy (Celesti-Grapow *et al.*, 2009). As a result, a ban on a single species of *Pennisetum* may be effective on that species but, on the other side, may promote a shift of trade towards other species in the genus which can provide similar aesthetic or landscape values but that might be also invasive. In fact, four different species of

Pennisetum (*P. clandestinum*, *P. purpureum*, *P. setaceum*, and *P. villosum*) are already addressed by the Spanish legislation on invasive alien species (Real Decreto 630/2013, de 2 de agosto, por el que se regula el Catálogo español de especies exóticas invasoras. Ministerio de Agricultura, Alimentación y Medio Ambiente, BOE núm. 185, de 3 de agosto de 2013, Referencia: BOE-A-2013-8565).

Thus, in conclusion, legislation alone (for example, trade ban) might prevent new introductions and the use as an ornamental species, but will not prevent further spread of *P. setaceum*; nevertheless, it is likely to slow its progress. However, there is a danger that it will promote the spread of other potentially invasive species of *Pennisetum*.

EFFORT REQUIRED

The measures need to be maintained indefinitely.

Preventing *P. setaceum* spread entirely is probably beyond feasible effort, but slowing future spread by controls on imports and sale would slow the spread without considerable expenditure of resources.

RESOURCES REQUIRED

If the trade ban and the biosecurity/phytosanitary measures and biosecurity policy for *Pennisetum* will be part of general biosecurity policy and biosecurity strategy, resources and costs will be reduced. For example, if there will be a unique biosecurity strategy for all the invasive alien plants of Union concern this will of course produce general beneficial effects and economies of scale, for example for the training of staff and application of custom controls as some pathways (for example ornamental horticulture) are responsible for the introduction of more than one taxon. From a trade perspective, one of the most relevant aspects of phytosanitary measures, in general, is their potential distortionary effect. For example, SPS/WTO measures are generally applied in a nondiscriminatory manner, as they usually target products regardless of their origin. However, the costs of compliance with SPS measures are often asymmetrical because compliance depends on technical know-how, production facilities, vectors safety and an infrastructural base that, while usually available in developed and emerging markets, is often lacking in many low-income countries (Murina and Nicita, 2017). As a result, the cost of compliance and the resource required might be different across Member States, for example in relation to the existing organisational framework, the total number of points of entry (unpacking facilities, car import yards and industrial premises where machinery is unloaded), the size of the borders, the size of the country, the total number of islands, the biogeographical region, the trade routes.

In conclusion, the resources required are not necessarily large assuming that controls are incorporated into current biosecurity protocols.

SIDE EFFECTS

There will be very limited side effects in relation to preventive measures (trade ban) applied to tackle *P. setaceum*. In fact, limited negative side effect might be expected on trade and on ornamental horticulture industry. Ornamental grasses are quite popular in gardens but a plethora of species is available on the market, so that a trade ban on *P. setaceum* can be easily accepted. However, if there will be a unique biosecurity strategy for all the invasive alien plant of Union concern this will of course produce general beneficial effects as some pathways are responsible for the introduction of more than one taxon.

ACCEPTABILITY TO STAKEHOLDERS

The successful implementation of policies on invasive alien plants and phytosanitary measures is often dependent, at least in part, on their acceptability to a wide range of stakeholders. A ban on *P. setaceum* can be accepted by stakeholders if well communicated, however this might also cause a shift towards other species in the same genus, or for similar ornamental grasses, due to horticulturalists' and consumers' constant search for novelties in the area of ornamental plants and ornamental grasses. Although attention for the role of stakeholders' groups in relation to risk analysis (for example risk communication), management and impacts has increased in the past decade, only limited knowledge about public perception of non-native species exists (Verbrugge *et al.*, 2013).

Apart from the general public and the horticultural sector, a ban on *P. setaceum*, might be disliked by other stakeholders' groups. This is related to the fact that there are ongoing studies on the use of *Pennisetum* (for example, *P. setaceum* 'Rubrum' and *P. setaceum* 'Cupreum') due to the remediation capacity of the plants and their associated rhizosphere microbial communities, with special concern to storm water pollutants such as nitrogen (Hunt *et al.*, 2015). In addition, *P. setaceum* is one of the species being investigated in the framework of conversion of waste to energy via a biological process establishing microbial fuel cells (MFC) as a prominent source of sustainable energy (Chiranjeevi *et al.*, 2012).

ADDITIONAL COST INFORMATION

Prevention is the first and most cost-effective line of defence against invasive alien species. However, there is only very limited information (for example, Batabyal and Beladi, 2006) on cost of prevention for (single) invasive alien grasses, and practically no cost-benefit analyses. This cost is often calculated on an opposite basis, for example as the cost that have been borne for eradicating or controlling those invasive alien species that were not blocked with preventive measures or in the lacking of preventive measures. Another proxy for the cost of prevention could be the cost of the general biosecurity surveillance programmes, if available.

On the other side, If the trade ban and the biosecurity/ phytosanitary measures and biosecurity policy for *P. setaceum* will be part of general biosecurity policy and biosecurity strategy for a set of species, resources and costs will be reduced due to economies of scale.

LEVEL OF CONFIDENCE*

High.

There is plenty of literature on the presence and status of *P. setaceum* as an alien naturalised species in the EU. At the same time, pathways and uses of the species in the EU are well documented.

Pennisetum setaceum *thrives in warmer, drier areas.*
© Tim Adriaens, INBO

* See Appendix

Applying best management practice for the construction and maintenance of transport corridors (road, rail), waterways, and habitats and land uses that are at a high risk of invasion (for example limiting disturbance, movement of soil).

MEASURE DESCRIPTION

The measures to prevent the unintentional introduction, and secondary spread of *P. setaceum*, need to be identified through a comprehensive analysis of its pathways of unintentional introduction and spread within the territory of the European Union (as per Art. 13, EU Reg 1143/2014).

These measures will need to include applying best management practices for the construction and maintenance of transport corridors (road, rail), waterways, and habitats and land uses that are at a high risk of invasion (discussed in this section). In addition, awareness campaigns targeting key stakeholder groups will be needed (discussed in the following *Prevention* section). It is important to note that all measures need to be addressed within a single action plan, and incorporate targeting the highest priority populations of *P. setaceum* close to transport corridors and riparian networks for eradication (see *Early Detection* and *Rapid Eradication* sections below).

MEASURE DESCRIPTION

Pennisetum setaceum is a wind-dispersed, perennial, C4 species that can live for up to 20 years (CDFA 2001), although most specimens live for a shorter time. Many *Pennisetum* species are known to be apomictic (asexual production of seeds from mitotically derived eggs), a breeding system that results in progeny that are genetically identical to the maternal plant, and several studies indicate that *P. setaceum* is also apomictic (Poulin *et al.*, 2005). Although it reproduces mainly by seed, it has been reported for South Africa that it forms pseudo-viviparous plantlets when inflorescences are inundated, for example production of rootless plantlets in spikelets (Milton *et al.*, 2008). Flowering occurs over a prolonged period from spring through summer (Csurhes, 2011–2016). A single caryopsis is retained in the spikelet, therefore, hereafter, caryopsis as the seed will be used with the same meaning. Ornamental cultivars such as 'Rubrum' and 'Eaton Canyon' usually do not produce seeds according to CDFA (2001), but they are not 100% sterile.

Apart from the biological characteristics of *P. setaceum*, many other factors need to be considered during the implementation of preventive measures, these factors are usually included in standard risk analysis schemes, for example, in the EPPO PRA. In particular, are the pathways via which *P. setaceum* can enter new areas. There are three broad categories of pathways of introduction: (a) natural spread from invaded areas outside the EU but close to its borders, either passively by water or wind, including extreme events such as cyclones; (b) accidental introduction by hitch-hikers; or (c) via a vector, including commodities during trade; movement of material during emergency relief or conflicts; movement of people and their luggage; or the movement of plants, animals, soil; contaminated agricultural, military, or industrial equipment; and ships, including ballast water. For example, in South Africa, *P. setaceum* establishes on roadsides and river banks and benefits from habitat conditions prevailing at these interchanges (bridges) (Rahlao *et al.*, 2010).

There are many best practice guidelines available for road maintenance and construction that can help prevent the spread of invasive plants (for example on roadsides and into agricultural or natural areas). Importantly, activities such as mowing, grading, ditching, construction and planting on the roadverges can work to either exacerbate or prevent the spread of invasive plants, including *P. setaceum* (for example, Pennsylvania Department of Transportation, 2014; Graziano and Clayton, 2017; USDA Forest Service San Dimas Technology, 2017 and others)[1]. The movement of vehicles and machinery from known, or potentially, infested sites needs to be avoided, unless measures (check and cleaning) are strictly followed. In addition the identification of infested sites, will allow areas where soil should not be removed from.

Very simple measures, such as cleaning of agricultural machinery or ensure clothing and footwear is free of soil and plant material before stepping into vehicles cannot be considered as "stand alone" measures but must be integrated within a broader action plan including codes of conduct, and widely disseminated (see the *Prevention* section on awareness raising below).

These measures can be imposed by EU MSs making use of specific national legislation tools or can be included in more general biosecurity policy and biosecurity strategy for larger groups of invasive alien species. However, in addition to regulations MSs or single stakeholders' categories may consider and use a voluntary code of conduct as an effective

1 http://www.dot.ca.gov/dist05/planning/sys_plan_docs/chmp/vegetation_guidelines.pdf

alternative or complementary approach (for example, EPPO Phytosanitary Procedures, PP 3/74 (1); EPPO, 2009). Additional information can be found in the EPPO Guidelines for the management of plant health risks of bio-waste of plant origin (EPPO, 2008). Concerning the cleaning of machinery or of other vectors, useful information can be achieved, for example, from the Guidelines prepared by Biosecurity Queensland, part of the Department of Agriculture, Fisheries and Forestry, in Australia (Biosecurity Queensland, 2014) and similar documents[2].

Treating incipient populations of *P. setaceum* as soon as they are detected in these high risk areas is a very effective measure, in particular when they are located close to transport corridors and riparian networks, which could very likely promote unintentional spread of this alien species. The importance of these corridors is highlighted as well in the sections on *Early Detection* and *Rapid Eradication*, and in the section on *Management*.

EFFECTIVENESS OF MEASURE

To be effective, these preventive measures must be enforced addressing all possible unintentional pathways of introduction and secondary spread.

EFFORT REQUIRED

The measures need to be maintained indefinitely.

RESOURCES REQUIRED

No information available.

SIDE EFFECTS

These measures will help prevent the spread of other invasive alien plant species with similar pathways of accidental spread.

ACCEPTABILITY TO STAKEHOLDERS

Applying best construction and management practice for roads and railways, may incur costs for those sectors required to undertake the measures. However, these measures are expected to be accepted by most stakeholders as they will promote the presence of native plant communities and reduce the use of PPPs for controlling weeds.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

High.

Prevention is the first and most cost-effective line of defence against invasive alien species.

2 See also: http://dpipwe.tas.gov.au/Documents/Washdown-Guidelines-Edition-1.pdf https://www.boprc.govt.nz/media/395661/keepitclean.pdf

* See Appendix

Public awareness raising campaigns to reduce unintentional movement of seeds of the species.

MEASURE DESCRIPTION

Part of any action plan to address the accidental introduction of the species will need to incorporate awareness raising with key stakeholder groups that represent the pathways of introduction, such as tourism, horticulture, farming and construction sectors. This can also link to citizen science which can be a key aspect of any early detection scheme (see the relevant section below).

The arrival of international passengers by air has increased significantly in the past decade as well as internal tourism in the EU. Tourism as a pathway of introduction is relatively minor in comparison to commercial horticulture, however considering the existing large number of invaded sites, including many very famous Mediterranean and Macaronesia tourist destinations, this accidental pathway should not be underestimated and needs to be included in any strategy/action plan tackling *P. setaceum*.

One example of the involvement of stakeholders is the BASF 'Keep it Clean' campaign online[3], which top tips from other farmers, practical advice on arable weed control, weed fact sheets (https://basfrealresults.co.uk/awc/). The overall objective of the LIFE Alter IAS project[4] was to reduce the introduction of invasive plants at source by raising awareness about their environmental risks amongst the whole ornamental horticulture supply chain in Belgium. The project aimed to promote best practices for preventing the release and spread of invasive alien species through a voluntary Code of Conduct produced with the involvement of the horticultural sector (Halford *et al.*, 2014).

EFFECTIVENESS OF MEASURE

No information.

EFFORT REQUIRED

The measures need to be maintained indefinitely to prevent further spread of this alien plant within the EU.

RESOURCES REQUIRED

No information available. However, there are many LIFE projects that can provide information on awareness campaign concerning other invasive alien plants.

SIDE EFFECTS

No information available.

ACCEPTABILITY TO STAKEHOLDERS

These measures should be acceptable to all stakeholder groups.

ADDITIONAL COST INFORMATION

The costs will vary significantly depending on the engagement strategies used. No information available.

LEVEL OF CONFIDENCE*

High.

3 https://basfrealresults.co.uk/awc/keep-it-clean/
4 http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPageandn_proj_id=3501 and http://www.alterias.be/

* See Appendix

Measures for early detection of the species and to run an effective surveillance system to detect efficiently new occurrences.

Non-removal surveillance strategy.

MEASURE DESCRIPTION

Early Detection, followed by Rapid Eradication (EDRE), can detect and eradicate incipient populations of invasive species before they have a chance to become widely established, thus eliminating the need for costly and resource-intensive control programmes. If prevention fails, early detection and rapid eradication are the next and most cost-effective line of defence against invasive alien species. Early detection methods are based on terrestrial land surveys, but can be integrated with additional methods such as aerial survey, remote sensing, GIS modelling, and citizen science (for example, Wallace *et al.* 2016, in the USA for *P. ciliaris*).

Early detection measures for *P. setaceum* should be included in a general surveillance programme concerning a selected group of invasive alien plant species that might be introduced by the same pathways and in the same points of entry, which might invade similar habitats and spread along corridors such as roadside verges and rivers, or disturbed land. It is also very likely that new outbreaks might be found close to large towns, and large 'green areas' in urbanised areas (escaped individuals). In addition, due to *P. setaceum* very high capacity to colonise bare soils, priority areas for monitoring should include areas that have been disturbed by human actions (for example mining, urbanisation, fires etc.) and natural disturbance (fires, current volcanic eruptions).

In terms of within the EU, Mediterranean coastal areas and islands need to be prioritised for monitoring. It has been documented that in Sicily (Italy), *P. setaceum* (very likely introduced in the Botanical garden of Palermo, where the seeds imported from Eritrea and Ethiopia were planted in1938, as reported by Bella and D'Urso, 2012) has established and spread over many coastal areas up to 600 m a.s.l., especially on south-facing slopes within the thermo-Mediterranean belt (Corona *et al.*, 2016).

In the USA more than 3,000 km of roads, trails, and shorelines were chosen as survey areas because it was believed these areas would serve as establishment points and dispersal corridors (for a set of about 40 alien taxa, including *P. setaceum*). This systematic approach to surveying recorded both species presence and absence, which permitted distinguishing between unsurveyed area and true absences at the time of surveying. In road surveys by vehicle, both sides of the road were surveyed up to 10 m away from the road edge. Similar to road surveys, approximately 10 m of shoreline inland from the water's edge were surveyed by boat in shoreline surveys. This distance was chosen for practical reasons as approximately the greatest distance that surveyors could see and identify plant species, as was also determined by Shuster *et al.*, (2005). Driving speeds during roadside and boat surveys were approximately 5–15 km/h. Surveying 1.6 km (1 mile) by vehicle or boat required approximately 10–20 min on average for a crew of one to two people (Abella *et al.*, 2009).

Rahlao *et al.* (2010) describe the survey methodology used along 5,112 km of roads in South Africa, recording the presence and absence of *P. setaceum* at 10 km fixed interval (though no indication about total costs is reported).

The surveillance undertaken by the trained staff in the field could be supported by nongovernmental organisations and "citizen science" activities. In addition, remote sensing techniques, particularly the use of high geometrical resolution imagery and unmanned aerial vehicles (UAV), where their use is feasible, may greatly help surveillance. An application of remote sensing and GIS for mapping the distribution of *P. setaceum* was presented by Naranjo *et al.*, (2010) for Gran Canaria (Canary Islands).

Although not specifically planned for *P. setaceum*, Harris *et al.*, (2001) provide guidance and a model for New Zealand on time intervals for active weed and invasive alien plants surveillance and they distinguish active surveillance from fortuitous surveillance.

EFFECTIVENESS OF MEASURE

Several factors determine site invasiveness and probability of detection: rate of spread of the invasive alien plant, ability to find the new weed. The rate of arrival of an alien plant at a site varies with the proximity of the site to roads, towns and adjoining land use. Once an alien plant has arrived, its rate of spread depends on the habitat, the growth form, and its inherent biological capacity for spread. The visibility of an alien plant or small population, and hence the probability of finding it, varies with its growth stage, growth form and the location of the infestation. The ability to find an alien is also a function of our search effort (Harris *et al.*, 2001).

In the case of *P. setaceum*, there is a low probability of finding it during the flowering season (due to its visibility) in the EU. Also, while road corridors might be relatively easy to survey rivers are not, as well as coastal and rocky habitats where *P. setaceum* can thrive.

EFFORT REQUIRED

Early detection (ED) of *P. setaceum* will require large efforts in the EU. Therefore, ED of *P. setaceum* should be included in a general surveillance programme concerning a selected group of invasive alien plant species that might be introduced by the same pathways and in the same points of entry, which might invade similar habitats and spread along corridors such as roadside verges and rivers or disturbed land.

There is no specific information on the efforts and costs concerning the surveillance of *P. setaceum* in the EU. However, in the USA, more than 3,000 km of roadsides, trails, and shorelines were surveyed by vehicle, on foot, or by boat in a 35-month period from 2003–2006 (Abella *et al.*, 2009). An inventory carried out in Galapagos focused on the archipelago's inhabited areas, which are the sources of new introductions, and detected 257 new plant species. Six Ecuadorians were trained in botanical identification in the process. This exhaustive inventory required a total 17 person per year (carried out over five years by a four-person team), and cost an estimated USD 300,000. This corresponds to an average of USD 50 per property (Guézou *et al.*, 2010).

RESOURCES REQUIRED

Early detection of *P. setaceum* in the EU needs the availability of trained staff, to conduct surveillance by vehicle, on foot or by boat. A contingency plan is always needed to be ready for eradication. The surveillance needs to be undertaken by trained staff, and will need access to vehicles (including potentially boats) and they could be supported by non-governmental organisations and "citizen science" activities. Additional methods such as remote sensing techniques, will require additional resources (for example GIS software and imagery, unmanned aerial vehicles (UAV)).The cost for aerial and land survey are reported for Australia, for *Pennisetum ciliaris*, by Friedel *et al.* (2006). Some information is available for Hawaii (Tunison, 1992).

There are good examples of the involvement of volunteers for land survey for *P. setaceum* (and other alien species) at Hawaii Volcanoes National Park (USA), as reported

Pennisetum setaceum. © *Jean-Marc Dufour-Dror*

by Tunison and Misaki (1992). In 1992 volunteers cost approximately USD 7 per day in stipends for food and lodging.

SIDE EFFECTS

There are no known side effects in relation to early detection measures applied to tackle *P. setaceum*. However, if there were common biosecurity strategies for all the invasive alien plant of Union concern this will of course produce general beneficial effects as some vectors and corridors are responsible for the spread of more than one taxon, so that land surveillance in the same localities or along the same routes will tackle more than one alien taxon.

ACCEPTABILITY TO STAKEHOLDERS

As generally agreed, public participation in detecting invasive species can increase the available "eyes and ears" searching for identified targets. However, data collected through citizen science need to be carefully screened to avoid false-positives. In addition, surveillance will be facilitated whenever access to private properties will be necessary.

One example of voluntary monitoring of *P. setaceum* is provided, for example by the Asociación Pro Dunas Marbella (http://produnas.org/B/Home.htm).

ADDITIONAL COST INFORMATION

As *P. setaceum* is already present in many EU Member States, a lack of surveillance would certainly promote a further spread. Eradication of incipient populations of invasive plant species before they have a chance to become widely established, will eliminate the need for costly and resource intensive control programmes.

LEVEL OF CONFIDENCE*

High.

There is plenty of literature and practical cases supporting the fact that Early Detection, followed by Rapid Eradication (EDRE) would be a very effective strategy to limit further spread of *P. setaceum* within the EU. However, there is not enough information to calculate the total cost for the EU for such a strategic option, conducting surveillance (and management) programmes.

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* See Appendix

Pennisetum setaceum *tends to increase the risk of intense wildfires, to which it is well adapted. © Jean-Marc Dufour-Dror*

Measures to achieve rapid eradication after an early detection of a new occurrence.

Physical removal.

MEASURE DESCRIPTION

Rapid eradication is usually an inherent and substantial component of Early Detection and Rapid Eradication (EDRE) plans. Eradication of incipient populations of *P. setaceum* before they have a chance to become widely established, will eliminate the need for costly and resource-intensive control programmes. If prevention fails, early detection and rapid response are the next and most cost-effective line of defence against invasive alien species. In general, eradication efforts have been most successful in island situations, including `ecological islands' isolated by physical or ecological barriers, for example forest remnants surrounded by agricultural fields. However, the target species may survive in small populations outside an ecological island and, depending on the degree of isolation, could rapidly reinvade after an eradication campaign. The same may be true of real islands, especially coastal islands and archipelagos (Cock, 2003).

The measures to achieve rapid eradication of *P. setaceum* are the same as described in the section on *Management* (see below), for example rapid eradication should follow an integrated control methodology. In the very first phase of an invasion, where only few seedlings or very young individuals are present, hand pulling can be applied in combination with monitoring of the site and control follow-ups. In the case of larger infestations, presence of soil seed bank, risk of vegetative propagation from adult individuals, rapid eradication should be conducted according to an integrated control methodology in the framework of a dedicated plan (see *Management measures* section below). Any eradication campaign against alien plants must be carefully planned and should adequately address three components: delimitation or determining the known extent of the invasion (Panetta and Lawes, 2005), containment (no evidence of spread), and extirpation (Panetta, 2007). Delimitation methods include active and passive strategies (Dewey and Anderson, 2004), which involve roadside surveys, backyard searches in residential areas, and ground sweeps in rural or wildland areas. These have to be all conducted by a trained field crew at the initial detection site and surrounding areas.

Having in mind the present distribution of *P. setaceum* in the EU, any measure for rapid eradication would be feasible and effective only in case of new localised outbreaks in Member States / regions or sub-regions / islands of the EU (for example in the Mediterranean region) where this alien plant is still absent. Nature conservation areas, small populations and populations starting to colonise corridor networks should be considered as priorities for intervention. Treating incipient populations of *P. setaceum* as soon as they are detected is a very effective measure, in particular when they are located close to transport corridors and riparian network, which could very likely promote unintentional spread of this alien species.

According to Sanz Elorza *et al.*, (2004) hand pulling, to be effective, should include the removal of the entire root system of *P. setaceum* and must take place before the production of caryopsis (seed). Otherwise, it will be necessary to use plastic bags covering the spikes during removal to avoid any seed loss. After removal, fruiting plants will have to be destroyed (for example, by fire). However, the feasibility of using fire for destroying plant residuals might be considered case by case, in relation to the site, weather conditions and Member States legislation. In Hawaii, the spikes from flowering grasses were typically cut and bagged before treatment with herbicide (Penniman *et al.*, 2011).

According to Sanz Elorza *et al.*, (2004) hand pulling will have to be repeated for several years, along with monitoring, to ensure (local) eradication. However, visiting intervals have to be designed to ensure that plants did not set seed (see also the section on Management). The mechanical method used in Canary Islands consists in a two-steps removal. In a first step, all spikes are cut and removed, in a second step the whole plant is removed. Subsequently, the soil is cleaned up by the presence of seeds using a rake and finally all residuals are burned (Gobierno de Canarias, 2017).

In the case of massive infestations, an integrated control methodology in the framework of a dedicated plan is required. In the presence or large infestations, manual intervention alone might be inadequate and plant protection products (PPP) or a combination of chemical and mechanical control is recommended. Once the plants have been removed a pre-emergence herbicide can be applied. As in the case of the use of fire, the use of PPPs has to be carefully assessed case by case, in relation to the specific PPP, the site, weather conditions. EU/national/local legislation on the use of plant protection products and biocides needs to be respected.

EFFECTIVENESS OF MEASURE

Rapid eradication is expected to be very effective.

The success of an alien plant eradication programme is determined by an interplay between biological, operational, economic and socio-political factors (Panetta, 2009). Rejmánek and Pitcairn (2002)[4] report some of the numerous examples where small infestations of invasive plant species have been eradicated. According to the study the same authors conducted in California, professional eradication of exotic weed infestations smaller than one hectare are usually possible. Furthermore, about 1/3 of all infestations between 1 ha and 100 ha and 1/4 of infestations between 101 and 1,000 ha have been eradicated. Costs, however, increase dramatically (an approximate estimate of direct costs in USD was obtained by multiplying work hours by USD 96; this includes salaries, cost of transportation, and cost of herbicides and equipment). However, according to Rejmánek and Pitcairn (2002), with a realistic amount of resources, it is very unlikely that infestations larger than 1,000 ha can be eradicated.

In Sète (Languedoc-Roussillon region, south of France), the Park and Leisure service of the Municipality has been involved in removing invasive alien plants from its plantations and advising alternative plants for several years. Although not planted for ornamental purposes, 23 plants of *P. setaceum* and 26 plants of *P. villosum* have been discovered on a road side in the city of Sète (EPPO, 2017). It is hypothesised that they entered as contaminants of other ornamental plants. The municipality therefore decided to conduct an eradication programme against these 2 species, consisting in the following actions: (1) cutting plants and collecting all plant parts (including spikes) for incineration, (2) spraying of each cut plant with glyphosate (EPPO, 2017). The cost of eradication was estimated to be 187 euros. Since the seeds of these 2 species can remain viable for 6 years, a monitoring programme will be undertaken and any regrowth will be destroyed. While undertaking the eradication programme, the press was invited in order to raise awareness among the public on the topic of invasive alien plants and several articles were published in the local newspapers (EPPO, 2017)[5].

As reported in the RA on *P. setaceum*, this alien species has been subjected to eradication plans in Canary Islands. In Tenerife and Gran Canaria efforts to eradicate have failed but in La Palma it has been almost completely eliminated (Sanz Elorza *et al.*, 2004). Similarly, due to the large number of infested sites in the islands of Sicily (Italy) Pasta *et al.*, (2010) do not consider any longer the feasibility of a complete eradication from the island, while they suggest local eradications and management.

On the contrary, as reported by Penniman *et al.*, (2011), *P. setaceum* was eradicated from Moloka'I (Hawaii, USA; the total size of the island is 674 km^2).

EFFORT REQUIRED

Information about seed longevity is considered fundamental in determining the likelihood that a remaining seedbank had been exhausted. Although specific experimental data for the EU are missing, in Australia it has been documented that *P. setaceum* seed can remain viable in the soil for at least seven years (NSW, 2017).

As a result of the presence of a *P. setaceum* seed bank, the removal by hand may need to be repeated several times a year, at one to two-month intervals. Seedlings will need to be monitored and removed thereafter (Di Tomaso *et al.*, 2013).

RESOURCES REQUIRED

The resources required will be related to the number and extent of the invaded areas, the land accessibility, the need to repeat the interventions. When hand pulling is planned, inflorescences should first be removed using gloves to prevent skin irritation. A heavy tool such as a pick, shovel or mattock may be needed to uproot large plants with a basal diameter over 10 centimetres.

SIDE EFFECTS

Eradication actions need to be planned carefully and restoration actions are always necessary as disturbance during interventions might promote invasion by other generalist invasive alien plants. Restoration of undisturbed native vegetation might be a way to limit further spread of *P. setaceum*.

Badalamenti *et al.*, (2016) in one year-long experiment (Siciliy, Italy), compared the early life stages of *Ampelodesmos mauritanicus* (Poir.) Dur. and Schinz, a native perennial Mediterranean grass, and *P. setaceum*. The alien seedlings grew significantly faster and were approximately 2.5 times taller than the *A. mauritanicus* seedlings. *P. setaceum* showed a more rapid life cycle compared with *A. mauritanicus* and produced seeds 9 months after sowing while no spikelet was produced by *A. mauritanicus* until

4 Available at: http://issg.org/database/species/reference_files/eupesu/Rejmanek.pdf
5 EPPO Reporting Service no. 08 - 2009 Num. article: 2009/168, available at: https://gd.eppo.int/reporting/article-360

the end of the experiment. As a consequence, *P. setaceum* may gain a reproductive advantage due to rapid seed dissemination. Ultimately, a suite of peculiar early growth traits makes *P. setaceum* an aggressive competitor against *A. mauritanicus*, which is an important floristic element of native Mediterranean grasslands in Sicily. *P. setaceum* seems better suited than *A. mauritanicus* in colonizing frequently disturbed sites with fluctuating resource availability or irregular rainfall distribution and, as a result, it is gradually replacing *A. mauritanicus* in Sicily.

ACCEPTABILITY TO STAKEHOLDERS

It is worth mentioning that the programme to control expansion of *P. setaceum* in Cabo de Gata Natural Park (Canary Islands, Spain) was launched by scientific and policy entities to address the expansion of a set of invasive plant species. However, for *P. setaceum*, it was not possible to obtain the commitment of any social entity as was planned based on the prior diagnosis (López-Rodríguez *et al.*, 2015).

To promote acceptability, it can be useful to identify and promote replacement plant species for *P. setaceum* after its eradication from private or public gardens and urban green areas. Replacements need not to be limited to grasses, in fact, many low-growing plants produce flowers and grass-like leaves. See also above, the information on awareness raising campaigns (in the section on *Prevention measures*).

ADDITIONAL COST INFORMATION

Being that *P. setaceum* is already present in many EU Member States, a lack of intervention, in particular local eradication of new outbreaks, would certainly promote a further spread. Rapid eradication of incipient populations of invasive plant species before they have a chance to become widely established, will eliminate the need for costly and resource-intensive control programmes. In addition, it is generally agreed that "doing nothing" or waiting for more research violates precautionary principles (Underwood, 1997). Thus, local authorities and land managers should plan programmes to detect and facilitate the eradication of small, incipient *P. setaceum* populations to attempt, in accordance with precautionary principles, to preclude additional widespread infestations.

LEVEL OF CONFIDENCE*

High.

There is plenty of literature on the presence and status of *P. setaceum* as an alien naturalised species in the EU to support the soundness of this section on eradication.

Pennisetum setaceum *grows fast, reaches 1 metre in height, and has many purple, plumose flower spikes. © Tim Adriaens, INBO*

* See Appendix

Measures for the species' management.

Dedicated strategic management plan and general considerations on management measures.

MEASURE DESCRIPTION

Management measures (phytosanitary measures as defined in EPPO PRA or by IPPC, ISPM5) have to be included in a dedicated strategic management plan for *P. setaceum* and have to be coordinated with similar action plans for other species, as already recalled in the previous sections. Knowing in a detailed way *P. setaceum* presence, distribution, local abundance and the invasive status of its populations in an area is a key step for modelling, forestalling widespread infestations and for developing a long-term alien species management plan. A good example is provided, for example, by the Australian Strategic Plan for Buffel Grass (*Pennisetum ciliaris*), prepared by Biosecurity SA (2012).

In the strategic plan, management zone boundaries should be delineated broadly on the basis of current knowledge of *P. setaceum* extent, reflecting likely gradients of invasion and establishment and having implications for the cost and the feasibility of interventions. These boundaries can be reviewed in the future after a more thorough investigation of the extent of *P. setaceum* across the MS territory. Typically, 3 main types of management zones can be identified: (1) management zones; (2) containment zones; (3) local eradication zones. In the management zones management aims to reduce the overall impacts of *P. setaceum* through targeted management actions including protection of key sites/assets. In the containment zones management aims to prevent the ongoing spread of *P. setaceum* into new non-invaded or priority areas, for a significant reduction of the extension of the total invaded range. In local eradication zones the management aims to significantly reduce the invaded range of *P. setaceum*, locating and destroying all new infestations aiming for local eradication at feasible sites.

Conceptually, the management of *P. setaceum* needs to include a range of technologies and tools rather than only plant protection products and/or mechanical interventions alone. In fact, quite different types of habitats and land uses are invaded in the European Union, and such a diversity is present as well at single country or single region level. The idea of an integrated control originates from the agricultural sector but can be very effectively applied to many of the environmental weeds. This is often referred as IPM 'integrated pest management', IWM 'integrated weed management', IVM 'integrated vegetation management' or also as best management practices (BMPs).

The dedicated strategic management plan has to framework the integrated control measures and to take into account that *P. setaceum* prolific production of long-lived seed hinders control efforts once fountain grass is established. Control strategies should focus on removing seed heads and reducing seed production. Treatment priority should be assigned to small or sporadic infestations upon otherwise healthy sites, close to transport corridors and riparian networks, followed by larger infestations. Treatment should be made along the perimeter of an infestation and then worked toward the centre. In most cases, multiple years of treatment is necessary to remove all seed producing plants, followed by 6–7 years of monitoring and implementing measures to control seed germination and emerging seedlings. An adaptive management approach can be included in the plan as well. It will allow for adjustments to be made as the plan is implemented. Combination of mechanical, chemical and other methods of control (such as foliar spray) should be considered and as described for rapid eradication, chemical control with pre-emergency product can be applied after plant removal. Choice of control method for *P. setaceum* depends on the current land use and site conditions; accessibility, terrain, and climate; density and degree of infestation; non-target flora and fauna and MSs legislation. Other considerations include treatment effectiveness, cost, and the number of years needed to achieve control (United States Department of Agriculture, 2014).

The dedicated strategic management plan has to include pathway management measures, which are similar to those described in the sections on *Prevention*. For example, land managers, the local public, and road crews should be educated in identification of *P. setaceum* (and other invasive species) so they can help report all suspected infestations. Vehicles, humans, and domestic animals should be discouraged from traveling through infested areas; and a programme to check and remove seeds from vehicles, clothing, and domestic animals should be implemented to help stop dispersal. Since *P. setaceum* is currently promoted as an ornamental, coordination with local nurseries to withdraw it for the market is necessary (in application of Article 7 of the IAS Regulation). Importantly, within the EU, there are few, if any, native species that could be confused with *P. setaceum* when it is flowering.

In addition to the methods discussed below, mowing is not an effective method for *P. setaceum* control. Tillage might not be practical in most areas where *P. setaceum* grows and is not likely to be successful as a control option (Di Tomaso *et al.*, 2013). Prescribed fire and burning are not recommended, except as a means to manage debris. *P. setaceum* rapidly regrows following fire, which often leads to an increase in its dominance (United States Department of Agriculture, 2014).

EFFECTIVENESS OF MEASURE

The control of *P. setaceum* by integrated control strategy within a dedicated strategic management plan is an effective measure. The management measures described in the following sections can be very effective in reducing further spread in the EU, and mitigating negative impacts in nature conservation areas invaded by *P. setaceum*.

EFFORT REQUIRED

The measures need to be maintained indefinitely.

In the Canary Islands, local administrations carried out control and eradication programmes with variable success (Pérez de Paz *et al.*, 1999; Gobierno de Canarias, 2008–2017). In the Canary Islands, *P. setaceum* spread started in the last 30 years and the invaded area ranges from sea level up to 1,000 m a.s.l., prevailing below 500 m a.s.l. (González-Rodríguez *et al.*, 2010). Nature conservation areas are prioritised for management. More information is included in the next section.

RESOURCES REQUIRED

Some information on resources required is available for Canary Islands. In the Canary Islands, there is not a plan to control or eradicate *P. setaceum* for the entire archipelago (Marcos Salas Pascual, pers. comm., 2017). Environmental competencies, in general, are in the hands of the local administrations (Island Council, Cabildo Insular), and each island may organise its activities differently. In addition, actions on the populations of *P. setaceum* can be related to several more general objectives, such as those related to the Protected Natural Areas of the Canary Islands, with genetic rescue plans for certain endangered species, and with ditch cleaning in roads. Hence it is practically impossible to know exactly how much money has been spent in recent years on this problem (Marcos Salas Pascual, pers. comm., 2017). The Island "Cabildos" do not have a budget or a template for the control of this plant. The interventions in protected areas are carried out by nonspecialized personnel who are subsidized with the so-called Social Employment Plans. This Employment Plan consists of contracting long-term unemployed and young people who are engaged in different tasks, including environmental ones, and sometimes to the eradication of *P. setaceum* (for example, http://invasionesbiologicas.blogspot.com.es/2015/02/se-han-iniciado-trabajospara-el.html). Hence, it is practically impossible to assess the specific cost borne for tackling *P. setaceum* in the Islands. However, some data exists on past activities and projects explicitly dedicated to the elimination of this alien grass (Marcos Salas Pascual, pers. comm., 2017). In Tenerife, from August 2008 to January 2009, the Technical Service for Environmental Territorial Management and INEM spent € 386,456.95 on control and eradication work . The Island Council of La Palma implemented a plan for the control and eradication of *P. setaceum*. This plan, written by the professors of the Botany Department of the University of La Laguna, Pedro Luís Pérez de Paz, Antonio García Gallo and Catalina León Arencibia (with a budget of 100 million of "pesetas"), began in September 1998 and It was necessary to hire three technicians, four foremen and 90 laborers who were distributed in 13 work crews. The aim was for each work group to perform its work in its usual municipality or, at least, one near its own (Marcos Salas Pascual, pers. comm., 2017). The budget allocated to the Eradication Plan of *P. setaceum* was equal to 34,875,276 "pesetas", of which 27,170,448 "pesetas" came from the Comprehensive Plan of Employment of the Canary Islands (PIEC) through INEM, and 7,704,828 pesetas from the Cabildo Insular de La Palma from its budget heading entitled "Conventions for the Promotion of Employment 1998". The project ended without obtaining positive final results, in spite of the expense made and the dedicated effort. A medium and long-term planning on the management and eradication of this plant in the Canary Islands seems not to exist, despite the serious problem that this plant represents (Marcos Salas Pascual, pers. comm., 2017).

In the Canary Islands the cleaning of ditches is not a specific intervention against *P. setaceum*, as it has also other purposes; although there are some official guidelines for the management of this plant (http://www.gobcan.es/boc/2014/120/006.html), mechanical brush-cutters are sometimes used. In the case of chemical control along roads in Canary Islands, on the average (Marcos Salas Pascual, pers. comm., 2017) an amount of 7 litres of herbicide (usually glyphosate) is used per hectare, including roads where *P. setaceum* is not present.

SIDE EFFECTS

No information available.

ACCEPTABILITY TO STAKEHOLDERS

The successful implementation of any management actions is dependent, at least in part, on their acceptability to a wide range of stakeholders. Management actions can be accepted by stakeholders if well communicated, however this cannot be easily predicted as there are always very diverse perceptions among stakeholders' groups.

For example, the programme to control expansion of *P. setaceum* in Cabo de Gata Natural Park (Canary Islands, Spain) was launched by scientific and policy entities to address the expansion of a set of invasive plant species. However, for *P. setaceum*, it was not possible to obtain the commitment of any social entity as it was planned based on the prior diagnosis (López-Rodríguez *et al.*, 2015). Between March and July 2012, in Canary Islands, 400 self-administered questionnaires were distributed amongst the principal villages proportional to the number of inhabitants. Of the respondents, 73.9% knew that invasive species were present on the island. Tourists showed the lowest knowledge (41%) about this issue. Ten species (seven animals and three plants) were cited in 73.7% of the total answers, and *P. setaceum* was the most cited plant species. Most respondents (77%) considered these invasive species to be a substantial problem for the conservation of native biodiversity. However, this concern changes significantly between groups, as more hunters thought that invasive species are not a substantial threat. Of 307 questionnaires, 141 respondents (45.9%) considered competition with native species as the main impact (Medina *et al.*, 2016).

Importantly, a recently funded project titled "Valorización ecosostenible de especies vegetales invasoras de la Macaronesia para la obtención de fibras de uso industrial, MAC/4.6d/040", promotes the use of plant fibres from invasive alien plants present in the Macaronesia biogeographic region, such as *Arundo donax* and *P. setaceum* (https://www.ulpgc.es/noticia/sepone-marcha-proyecto-obtencion-fibras-uso-industrial-partir-especies-vegetales-invasoras). This project is led by the Universidad de Las Palmas de Gran Canaria (ULPGC), in partnership with the Universidade da Madeira (Centro Químico da Madeira), el Cabildo de Gran Canaria (Jardín Botánico Canario Viera y Clavijo), the Universidade dos Açores and the Fundaçao Gaspar Frutuoso. The project will last for 3 years and will be supported by FEDER for the amount of 800,000€.

Providing beneficial effects from invasive alien plants may be the source of conflicting interests and controversial issues. However, one of the unique aspects of invasive plant control programmes in South Africa has been the ability to leverage further benefits (mainly through employment) for the expensive control programmes from the government's poverty relief budget. This has made it possible to allocate substantial funding to programmes such as "Working for Water" that would otherwise have struggled to obtain significant support (van Wilgen *et al.*, 2001).

ADDITIONAL COST INFORMATION

Please see above (section on *Resources required*).

LEVEL OF CONFIDENCE*

High.

There is enough scientific literature and practical evidence to support the content of this section with concern to the types of measure that can be applied and their effectiveness. Several management options do exist and would be very effective if included in a dedicated strategic management plan. However, such a dedicated management plan should be based on the knowledge of the actual distribution and abundance at MS level, at least with the resolution of a 10 x 10 km grid map (or even lower for some priority sites). Such important baseline mapping dataset is presently not available, so that the precise evaluation of efforts and resources required for managing *P. setaceum* in the EU is not possible

* See Appendix

Chemical control.

MEASURE DESCRIPTION

P. setaceum mortality rates of at least 90 percent have been attained by the Lake Mead Exotic Plant Management Team of the National Park Service through the use of glyphosate spot treatments performed annually to actively growing plants. Other herbicides can also effectively control fountain grass when properly applied, although some may negatively impact non-target species. Caution should always be taken if non-target plants, including woody species, need protection. Dry foliage may shield green leaves from herbicide spray and seasonal variations may reduce the effectiveness of treatment. Each PPP product has unique requirements and restrictions; therefore, it is important to read the label carefully and to follow all instructions and guidelines when mixing and applying the chemical in fully accordance with MSs legislation on PPP (United States Department of Agriculture, 2014). When spraying *P. setaceum* with a foliar active herbicide (such as glyphosate, imazapyr, or fluazifop-p-butyl), the foliage should be at least 50% green; however, better control is obtained when plants are more than 80 percent green. Hexazinone is active mainly through the roots so this herbicide should be applied before anticipated rainfall. A backpack sprayer should be used for smaller, less dense infestations. For areas with larger, denser infestations, it may be more practical to use an ATV or UTV sprayer or a conventional boom sprayer that is pulled or mounted to a truck or tractor (United States Department of Agriculture, 2014).

EFFECTIVENESS OF MEASURE

Chemical control alone is not effective.

Conceptually, the management of *P. setaceum* needs to include a range of technologies and tools rather than only plant protection products and/or mechanical interventions alone. In fact, quite different types of habitats and land uses are invaded in the European Union, and such a diversity is present as well at single country or single region level. Only the control of *P. setaceum* by integrated control strategy within a dedicated strategic management plan is an effective measure.

EFFORT REQUIRED

No information available.

RESOURCES REQUIRED

No information available.

SIDE EFFECTS

When chemical control is planned a careful assessment should be done on a case by case basis and according to MSs legislation, with special concern to National Action Plans for the Sustainable Use of Plant Protection Products. National Plans usually include systems of compulsory certified training for professional users, distributors and advisors. These systems cover both initial and continuing training. The law regulating plant protection products (PPP) in the European Union (EU) was fundamentally revised through the introduction of Regulation (EC) No. 1107/2009 which entered into force on 14 June 2011.

ACCEPTABILITY TO STAKEHOLDERS

In regards to the application of PPP's it is important to note that EU/national/local legislation on the use of plant protection products and biocides needs to be respected.

Importantly, the European Commission has decided on the 10th January 2017 to register a European Citizens Initiative (ECI) inviting the Commission "to propose to Member States a ban on glyphosate, to reform the pesticide approval procedure, and to set EU-wide mandatory reduction targets for pesticide use" (http://europa.eu/rapid/press-release_IP-17-28_en.htm).

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

High.

Conceptually, the management of *P. setaceum* needs to include a range of technologies and tools rather than only plant protection products and/or mechanical interventions alone.

* See Appendix

Biological control and other methods.

MEASURE DESCRIPTION

So far there is no relevant information on the possibility to apply biological control techniques.

Importantly, Bella and D'Urso (2012), during a survey on the insect pests of ornamental plants in Sicilian cities found *Balclutha brevis* Lindberg (a leafhopper, Rhynchota Cicadellidae). This species, probably native to Macaronesia, was recorded there for the first time to the Italian fauna in the Mediterranean basin. In Sicily, adults and immature stages of *B. brevis* have been found associated with the spike of *P. setaceum* practically all the year round. However, the species belonging to the genus *Balclutha* live on various grass species and some are vectors of plant diseases.

Grazing: Due to the presence of hard fibrous leaves, *P. setaceum* is generally regarded as not very palatable and little grazed. Therefore, susceptibility to grazing/browsing damage and biological control by cattle is typically low. However, in Hawaii, cattle were shown to eat *P. setaceum* when no other grasses were available (Di Tomaso *et al.*, 2013). It may be grazed intensively by sheep or cattle in early spring while shoots are tender and succulent. However, also in spring, livestock will usually graze other desirable species first and avoid *P. setaceum* when given a preference (United States Department of Agriculture, 2014).

EFFECTIVENESS OF MEASURE

Biological control alone is not effective.

Conceptually, the management of *P. setaceum* needs to include a range of technologies and tools rather than only plant protection products and/or mechanical interventions and/or biological control alone. In fact, quite different types of habitats and land uses are invaded in the European Union, and such a diversity is present as well at single country or single region level. Only the control of *P. setaceum* by integrated control strategy within a dedicated strategic management plan is an effective measure.

EFFORT REQUIRED

No information available.

RESOURCES REQUIRED

No information available.

SIDE EFFECTS

No information available.

ACCEPTABILITY TO STAKEHOLDERS

It should be borne in mind that the release of macro-organisms as biological control agents is currently not regulated at EU level. Nevertheless national/regional laws are to be respected. Before any release of an alien species as a biological control agent an appropriate risk assessment should be made.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

High.

Conceptually, the management of *P. setaceum* needs to include a range of technologies and tools rather than only plant protection products and/or mechanical interventions and/or biological control alone.

* See Appendix

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Appendix

Level of confidence provides an overall assessment of the confidence that can be applied to the information provided for the measure.

- **High:** Information comes from published material, or current practices based on expert experience applied in one of the EU countries or third country with similar environmental, economic and social conditions.

- **Medium:** Information comes from published data or expert opinion, but it is not commonly applied, or it is applied in regions that may be too different from Europe (for example tropical regions) to guarantee that the results will be transposable.

- **Low:** data are not published in reliable information sources and methods are not commonly practiced or are based solely on opinion. This is for example the case of a novel situation where there is little evidence on which to base an assessment.

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