Andropogon virginicus. © *David J. Stang. CC BY-SA 4.0*

The management of broomsedge bluestem (*Andropogon virginicus*)

Measures and associated costs

Species (scientific name)	*Andropogon virginicus* L.
Species (common name)	Broomsedge bluestem
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Common names

BG	–
HR	Andropogon
CZ	–
DA	Virginsk kostegræs
NL	Amerikaans bezemgras
EN	Broomsedge bluestem
ET	Virgiinia habehein
FI	Oranssivarrasheinä
FR	Barbon de Virginie
DE	Blauständige Besensegge
EL	Ανδροπωγών
HU	–
IE	Gas gorm grúim
IT	Andropogon della Virginia
LV	–
LT	Virgininis barzdotis
MT	Il-barrum safrani
PL	–
PT	–
RO	Iarba bărboasă de Virginia
SK	Fúzatka virgínska
SL	Viržinski kršin
ES	Popotillo pajón
SV	Whiskygräs

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

Andropogon virginicus, broomsedge, is a wind-dispersed, perennial, densely tufted, C4 grass native to North (eastern and south-eastern North America), Central and South America. *A. virginicus* is well adapted to fire, has a high seed production and invades a wide variety of habitats from disturbed to relatively intact habitats including ruderal areas, wetlands, open pastures, grasslands, and open woodlands. The high production of seed and its tolerance for fire hinders control efforts once broomsedge is established.

PREVENTION

Presently there are few established populations of *A. virginicus* in Europe (it is reported only from France). Beyond wind dispersal, there is little evidence from its native range in the US about how it is dispersed over long distances, thus it is difficult to predict a likely mode of introduction or mechanism of dispersal in the EU. The best information suggests it could be introduced to the EU as an ornamental (plants for planting), as a contaminant of hay, or on machinery and equipment (current occurrences potentially linked to this pathway), or by tourists. Monitoring these pathways and vectors and implementing measures, such as equipment cleaning and a ban on sale, should help prevent further intentional and unintentional introductions of *A. virginicus* to the EU.

EARLY DETECTION

Early detection of established populations will require diligent surveillance by natural resource professionals, supported by citizen scientists. Training, or a high level of botanical field experience, is needed to identify *A. virginicus*. Smartphone and tablet applications can be effective for supporting citizen science reporting of new *A. virginicus* populations, but people would need to be aware of the species and educated on identification, and natural resource professionals, botanists, or ecologists would need to confirm identification.

RAPID ERADICATION

Multiple methods can be used to rapidly eradicate new *A. virginicus* populations, including hand weeding, broad-spectrum herbicides, and post-emergent grass-specific herbicides. Hand weeding is only practical for eradicating small populations of a few square meters, but the method requires no equipment or chemicals, and trained individuals can be selective, so there are relatively few non-target effects on native species. Broad-spectrum herbicides are highly effective for removing *A. virginicus*, but they are not selective as they eliminate all vegetation, which may allow other invasive species to colonize treated sites. Thus, they only should be used when total vegetation control is desired (such as heavily infested roadsides). Grass-specific herbicides could efficiently remove *A. virginicus* without harming native herbs and trees, resulting in greater diversity of native species following invader eradication. Both broad-spectrum and grass-specific herbicides can be used for management of *A. virginicus* but whenever possible, grass-specific herbicides should be used because they are equally as effective and allow native broadleaf species to return. The advantage of broad-spectrum herbicides is that they are more cost-effective and control all vegetation, while grass-specific herbicides are more expensive but promote native species recovery.

MANAGEMENT

Once established, a combination of chemical and physical measures should be applied to reduce the competitive strength of A. *virginicus.* This method has been applied in pastureland in the United States. However, the effectiveness of such methods in the presently invaded habitats in France needs to be proven.

In summary, further introduction and spread of *A. virginicus* can be prevented through monitoring of likely pathways, new populations can be detected with diligent surveillance, and populations can be rapidly eradicated or managed with herbicides and hand weeding. Proper application of appropriate measures can effectively remove invasive *A. virginicus* populations and allow native species recovery.

In view of the very limited species-specific information on management of *A. virginicus*, it is recommended to consult Brundu (2017) 'Information on measures and related costs in relation to species included on the Union list: *Pennisetum setaceum*', another perennial tuft-forming grass species.

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 *A. virginicus*.

MEASURE DESCRIPTION

Andropogon virginicus is available for commercial purposes (through the horticultural trade) and promoted for landscaping in the USA and within the EU[1].

There is no evidence that the species is commonly imported as seed into Europe, and the wider EPPO Euro-Mediterranean region[2], for horticultural purposes. 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. Importantly, trade is generally considered the major pathway for short- and long-distance movement of ornamental and landscaping plant species such as *A. virginicus*.

However, present populations within the EU (France only) cannot be linked to this pathway (EPPO, 2018).

EFFECTIVENESS OF THE MEASURE

Effective.

A ban on trade etc. would be effective in addressing future intentional introductions through the horticultural trade. However, such restrictions are most effective for addressing species that are neither present in the EU nor in the neighbouring countries, and this is not the case for *A. virginicus,* as it has been reported from France. Therefore, a ban on trade etc. will only address further intentional introductions in the already invaded Member States and new introductions in Member States where *A. virginicus* is presently absent.

Thus, in conclusion, legislation alone (for example, a trade ban) should prevent new intentional introductions of this species as an ornamental but will not prevent further spread of *A. virginicus*; nevertheless, it is likely to slow its progress.

SIDE EFFECTS

Environmental effects: Neutral or mixed
Social effects: Neutral or mixed
Economic effects: Neutral or mixed

Social effects are marginal in view of the limited presence of the species within the EU.

Economic effects, in view of the limited online availability and the absence of the species in garden centres, are assumed to be marginal.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

In the absence of evidence of imports into the EU and considering the very limited online availability, *A. virginicus* can be currently considered marginal from a commercial perspective.

ADDITIONAL COST INFORMATION

No species-specific information available. In general, this measure would require effective biosecurity and inspection facilities along with awareness raising activities for the horticulture sector, both of which would be used to address multiple species.

LEVEL OF CONFIDENCE*

Unresolved.

The information provided is limited as a result of the very limited availability and popularity of the species in trade within the EU. However, common sense can only lead to the answers as given above.

1 For example, see http://www.jelitto.com/de/Saatgut/Ziergraeser/ANDROPOGON+virginicus+Portion+en.html [accessed 01/11/18]
2 European and Mediterranean Plant Protection Organization (EPPO) region – see https://www.eppo.int/ABOUT_EPPO/about_eppo [accessed 01/11/18]
* See Appendix

A ban on the import of hay from outside EU.

MEASURE DESCRIPTION

Seeds of *A. virginicus* can be moved as a contaminant of hay (for example, incidents of the species being spread as a contaminant of hay in Australia), however there are no reported cases of this pathway for Europe even though hay is imported from the USA (EPPO, 2018). Furthermore, *A. virginicus* is considered low quality forage therefore it would be less likely to find the species in commercial export products. Apart from a total ban of import of this commodity, there are no realistic measures that can be applied to reduce this risk.

SCALE OF APPLICATION

The ban on hay imports from native and infested areas would need to be done EU wide.

EFFECTIVENESS OF THE MEASURE

Effective.

Banning the import of hay from native range and infested areas would be effective to address this unintentional pathway of introduction. However, occurrences in France cannot be linked to this pathway.

EFFORT REQUIRED

The restrictions would need to be put in place permanently.

RESOURCES REQUIRED

In general, this measure would require effective biosecurity and inspection facilities along with awareness raising activities for the agricultural sector which would be used to address multiple species.

SIDE EFFECTS

Environmental effects: Neutral or mixed
Social effects: Negative
Economic effects: Negative

According to the USDA Global Agricultural Trade System online[3] the total import value of hay from the US to the EU between 2013 and 2017 (5 years) is valued at just over US$ 8 million, therefore there would likely be economic and social effects to the agricultural sector.

ACCEPTABILITY TO STAKEHOLDERS

Unacceptable.

The species has so far not been intercepted on this pathway and present-day occurrences in France cannot be linked to the pathway. Therefore, this measure will probably be deemed disproportionate by many stakeholders, and both exporting countries and importers in the EU will likely not accept the measure.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Inconclusive.

No detailed information available.

Tourists entering the EU.

MEASURE DESCRIPTION

Measures in relation to the potential pathway 'tourists' as identified in the EPPO PRA are not realistic. Considering the species has not been intercepted on this pathway, that present populations in the EU are not linked to this pathway and considering the large volume of passengers from countries where *A. virginicus* is present, this measure is deemed to be disproportionate and is not further detailed.

Inspection and cleaning of used machinery and equipment.

MEASURE DESCRIPTION

There is a suspicion that the species has been associated with this pathway (contaminant of machinery and equipment) in the past (Granereau and Verloove, 2010). In France, it is believed that *A. virginicus* was introduced into the military camp 'Camp du Poteau' near Captieux with NATO munitions in the years 1950–1967 (EPPO, 2011; Granereau and Verloove, 2010).

3 USDA GATS https://apps.fas.usda.gov/gats/ExpressQuery1.aspx [accessed 01/11/2018]
* See Appendix

Andropogon virginicus. © *harum.koh. CC BY-SA 2.0.*

It is only recently, that an ISPM Standard, no. 41 (IPPC, 2017) has been drafted and adopted on 'International movement of used vehicles, machinery and equipment'. This focuses on reducing the risks of transporting contaminants (soil, seeds, plant debris, pests) associated with the international movement (either traded or for operational relocation) of vehicles, machinery and equipment (VME) that may have been used in agriculture, forestry, as well as for construction, industrial purposes, mining and waste management, and military.

For those VMEs that represent a contaminant risk the phytosanitary measures recommended are detailed in the ISPM, and cover cleaning, prevention and disposal requirements. These include cleaning using pressure washing or compressed air cleaning, chemical or temperature treatments, storing and handling VMEs that prevent contact with soil, keeping vegetation short around storage areas of ports.

SCALE OF APPLICATION

The measure would need to be applied across the EU, as once VMEs have been imported into the EU they could be moved to high risk areas.

EFFECTIVENESS OF THE MEASURE

Neutral.

It is difficult to assess whether VMEs present a risk, and therefore when to apply the relevant phytosanitary measure (IPPC, 2017). The ISPM provides a number of elements to consider when assessing risk; distance of movement (shorter distances are a lower risk), complexity of VME structure (more complex are a higher risk), origin and prior use (VME in close proximity to vegetation a higher risk), storage (VME stored outside near vegetation are a higher risk), intended location or use (VME for use in agriculture, forestry, or close proximity to vegetation are a higher risk).

In addition, the inspection, cleaning and treatment will normally take place in the exporting country, therefore these measures would need to be integrated in to import requirements.

EFFORT REQUIRED

The measure would need to be in place permanently.

RESOURCES REQUIRED

Facilities required for the inspection, cleaning, and treatment of VME may include: surfaces that prevent contact with soil, including soil traps and wastewater management systems;

temperature treatment facilities; fumigation or chemical treatment facilities (IPPC, 2017). In addition, trained staff are needed to undertake the inspections and phytosanitary measures, and suitable disposal facilities are required especially if implemented within the EU.

SIDE EFFECTS

Environmental effects: Neutral or mixed
Social effects: Neutral or mixed
Economic effects: Negative
There would likely be unintentional economic impacts to operators involved in moving VME into the EU, but there are no positive or negative social side effects expected with this measure. These measures would however, cover a broad variety of potential invasive alien species not just *A. virginicus*. Also, if suitable disposal facilities are not installed, there is a risk of environmental impacts (for example, to freshwater systems) in the local area from cleaning and treatment processes.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.
The cost of cleaning exported/imported equipment could be substantial, but it could be highly effective if they can be applied to all high risk VME being imported. Stakeholders may be resistant to implementing such measures depending on the associated costs and location of cleaning facilities, which might introduce transportation costs. Costs should not be prohibitive, although disposal of wash water may require construction of specialized facilities so water can be transported to wastewater treatment facilities or treated onsite.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Inconclusive.
Little detailed information available.

* See Appendix

Measures to prevent the species spreading once they have been introduced.

Inspection and cleaning of used machinery and equipment.

MEASURE DESCRIPTION

The objective is to prevent spread from infested areas as a contaminant of vehicles and machinery. In France, in Landes and Gironde, most of the recent occurrences are assumed to be due to the movement of forest machinery. In fact, recently *A. virginicus* seems to be in expansion due to the management of pinewood with machinery (EPPO, 2018).

Therefore similar inspection, cleaning and treatment measures as described in the ISPM Standard, no. 41 (IPPC, 2017) 'International movement of used vehicles, machinery and equipment' (VME) which targets international movement could be applied to address secondary spread through the movement of VME from infested areas within Member States. See Inspection and cleaning of used machinery and equipment section above for details. There are also well-developed Best Management Practices that putatively prevent the spread of invader propagules (for example, "Equipment Cleaning to Minimize the Introduction and Spread of Invasive Species: Heavy Equipment used on Land" (Department of Natural Resources, 2018)[4])

SCALE OF APPLICATION

The measure would need to be applied at a local/site scale to prevent spread from infested areas.

EFFECTIVENESS OF THE MEASURE

Effective.

So far, the measure is not in place for *A. virginicus* within the EU.

Although little research has quantified the effectiveness of equipment cleaning procedures for preventing the spread of invasive species, it is believed they can be effective if correctly and consistently applied.

The key to effectiveness of equipment cleaning to prevent the spread of *A. virginicus* is diligent cleaning of equipment used in invaded areas. Currently, the distribution of *A. virginicus* is very restricted in Europe (it is only in France), thus this method is only needed on a limited basis for equipment coming from the infested sites in France.

EFFORT REQUIRED

All equipment coming from invaded areas should be inspected and cleaned before leaving the infested area. The measure would need to be implemented until populations of the invasive species have been confirmed to be eradicated.

RESOURCES REQUIRED

Pressure washing equipment in a quarantined area, staff to conduct inspections and cleanings, and preferably equipment and facilities for collecting material to test if the practice is preventing the introduction of seed. Collected material would need to be placed in a glasshouse under ideal growing conditions to germinate seed and identify and count species. Such data could be very useful for determining if the measure is cost-effective.

SIDE EFFECTS

Environmental effects: Neutral or mixed
Social effects: Neutral or mixed
Economic effects: Neutral or mixed

Equipment cleaning sites should be located where runoff would not enter streams or other waterways because

Andropogon virginicus. © *Harry Rose. CC BY 2.0.*

4 http://files.dnr.state.mn.us/natural_resources/invasives/terrestrialplants/equipment_cleaning_to_minimize.pdf

washing water could contain pollutants such as engine or hydraulic oil. Ideally, water would remain on site or would be directed into wastewater treatment facilities. These measures would however, cover a broad variety of potential invasive alien species not just *A. virginicus*.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

The cost of cleaning equipment could be substantial but may be highly effective. Stakeholders may be resistant to implementing such measures depending on the associated costs and location of cleaning facilities, which might introduce transportation costs. Costs should not be prohibitive, although disposal of wash water may require construction of specialized facilities so water can be transported to wastewater treatment facilities or treated onsite.

ADDITIONAL COST INFORMATION

No species-specific information available. The cost of cleaning and the environmental impact of the facility as such should outweigh the potential cost and environmental impact of potential new infestations.

LEVEL OF CONFIDENCE*

Unresolved.

Very little specific data is available on how much seed and how far seed is transported by equipment, so the effectiveness of this measure for prevention is difficult to quantify.

Inspection and cleaning of outdoor recreation equipment.

MEASURE DESCRIPTION

Although the measure is not documented specifically for *A. virginicus*, the pathway as such has been documented for other grass species (EPPO, 2018). Observations on another grass species of EU concern, *Microstegium vimineum,* can be taken as a proxy.

The transport of *Microstegium vimineum* seed by recreational activities has not been well researched but recent surveys demonstrate that populations in South Carolina, USA are associated with trail heads and near trails in forests used by hikers, bikers, and horseback riders. More generally, it is well-known that recreation and travel can result in movement of viable plant seeds, including invasive species (Flory, 2017).

Cleaning recreation equipment can be as simple as installation of boot brush stations at trail heads or more involved by installing bike washing stations or facilities for cleaning hooves of horses near camp sites or at trail heads.

Because *A. virginicus* currently only occurs in a limited number of sites in France, such measures only need to be implemented when recreational users are leaving areas, where *A. virginicus* is present. Such measures would benefit from local awareness campaigns to increase public participation in required measures.

SCALE OF APPLICATION

Local/site scale to prevent spread from infested areas.

EFFECTIVENESS OF THE MEASURE

Neutral.

The use of boot brush stations is widespread in natural areas subjected to frequent recreation activities but little quantitative information is available on their effectiveness. Anecdotally, natural areas managers indicate that such practices often result in removal of many invasive plant seeds, but little is known about the proportion of seeds removed, and whether there are enough seeds removed to prevent the spread of invasions to other areas (Flory, 2017).

EFFORT REQUIRED

Boot brush stations and facilities to clean bikes and horse hooves would only need to be used for *A. virginicus* specifically when recreational users are coming from infested areas.

RESOURCES REQUIRED

Knowledge of travel patterns would be helpful for determining where and when boot brush cleaning stations, and bike and horse cleaning facilities are needed. Given the limited distribution of *A. virginicus* in Member States, such facilities would receive little use specifically for *A. virginicus* but would likely prevent the spread of other invaders. Staff would be needed to construct and maintain the facilities, and ideally to collect data on seeds removed by these measures.

SIDE EFFECTS

Environmental effects: Positive

* See Appendix

Social effects: Neutral or mixed
Economic effects: Neutral or mixed
The practices of cleaning would likely prevent the introduction of other non-native invasive plants, and effective communication material could provide a good opportunity for education about invasive plant species in general.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.
The public may be resistant or ambivalent about the use of boot brush stations and other cleaning facilities, however with effective communication materials the public should be positive about the measure.

ADDITIONAL COST INFORMATION

Boot brush stations and facilities to clean bikes and horse hooves are relatively inexpensive.

LEVEL OF CONFIDENCE*

Unresolved.
Few data exist on the effectiveness of boot brush stations and bike and horse cleaning stations for preventing the spread of invasive plants, although it is understood that people and horses often disperse grass species and other invaders with lightweight seed that easily adhere to people's clothes and animals. More information is needed on where *A. virginicus* occurs in member states and the likelihood that the species will be transported by recreational users of natural areas.

* See Appendix

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

Terrestrial land surveys, ensuring inclusion of high-risk areas.

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.

Early detection measures for *A. virginicus* should be included in a general surveillance programme concerning a selected group of invasive alien plant species that can be introduced by the same pathways, invade similar habitats and spread along corridors such as roadside verges and rivers, or disturbed land. Present infestations are stop-over sites on a major migratory route for common crane (*Grus grus*) and dispersal might be facilitated by seeds adhering to these birds. Monitoring of other stop-over sites on this migratory route would deserve priority. Citizen Science programmes, from general surveillance to species-specific 'alert' systems that incorporate both public and highly skilled amateurs, can be used to support such processes (Pescott, *et al.,* 2015; Roy *et al.* 2015).

Although not specifically planned for *A. virginicus*, 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.

SCALE OF APPLICATION

This is a site scale measure but would need to be applied across the high-risk areas as identified by EPPO (2018) in the species risk assessment.

EFFECTIVENESS OF THE MEASURE

Effective.

In the Netherlands there is anecdotal evidence that early detection, followed by rapid eradication has already prevented the establishment of *Bachharis halimifolia* (van Valkenburg, Meerman, Bollen and Zwart, 2017). Using citizen science/public participation in detecting invasive species can increase the available "eyes and ears" searching for identified targets and can provide relatively reliable data which are highly valued (Schmeller *et al.,* 2009; Pescot *et al.*, 2015). It is important to note that data collected through citizen science need to be carefully screened to avoid false positives, but this expertise can be provided by highly skilled citizen scientists.

EFFORT REQUIRED

Early detection (ED) of *A. virginicus* will require a long-term commitment in the EU as with any other IAS that has not yet widely established in the EU. The surveillance system would need to be carried out indefinitely.

RESOURCES REQUIRED

The surveillance needs to be undertaken by trained staff, and they could be supported by non-governmental organisations and "citizen science" activities which often benefit from the use of smartphone and tablet applications. Additional methods such as remote sensing techniques, will require additional resources (such as GIS software and imagery, as well as unmanned aerial vehicles (UAV)), but these are more effective for mapping existing areas of infestation and not for early detection.

SIDE EFFECTS

Environmental effects: Positive
Social effects: Neutral or mixed
Economic effects: Neutral or mixed

A potential positive environmental side effect might be the detection of other invasive alien species. No social and economic side effects are expected.

ACCEPTABILITY TO STAKEHOLDERS

Acceptable.

Such surveillance programmes are likely to be acceptable to most stakeholders.

ADDITIONAL COST INFORMATION

The cost for aerial and land survey are reported for Australia, for *Cenchrus ciliaris*, by Friedel *et al.* (2006). Some information is available for Hawaii (Tunison, 1992). Present infestations are stop-over sites on a major migratory route for grey cranes and dispersal might be facilitated by seeds adhering to these birds. Monitoring of other stop-over sites on this migratory route would deserve priority.

LEVEL OF CONFIDENCE*

Inconclusive.

No species-specific information available.

* See Appendix

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

Manual and mechanical control.

MEASURE DESCRIPTION
If prevention fails, early detection and rapid eradication are the next and most cost-effective line of defence against invasive alien species. To rapidly eradicate new introductions, plants can be uprooted manually or with some mechanical aid and, if flowering, subsequently bagged to avoid any potential spread of seed.

SCALE OF APPLICATION
No species-specific information available but is likely to be only for site scale application due to manual labour requirements.

EFFECTIVENESS OF THE MEASURE
Effective.
Uprooting all plants at an early infestation followed by control efforts over a 5-year span should be effective.

EFFORT REQUIRED
A five-year period is in general considered reasonable to declare a small scale infestation to be eradicated.

RESOURCES REQUIRED
Dedicated staff and volunteers, a spade and plastic bags.

SIDE EFFECTS
Environmental effects: Neutral or mixed
Social effects: Neutral or mixed
Economic effects: Neutral or mixed
Physically removing a small number of plants will result in a relatively limited level of disturbance.

ACCEPTABILITY TO STAKEHOLDERS
Acceptable.
This measure is likely to be accepted by all stakeholders.

ADDITIONAL COST INFORMATION
No information available.

LEVEL OF CONFIDENCE*
Unresolved.
Very little species-specific information is available.

Application of broad-spectrum plant protection products (PPP) or post-emergent grass-specific PPPs.

MEASURE DESCRIPTION
PPPs can be applied with hand pump sprayers, backpack sprayers, or CO_2 or gas-powered sprayers mounted on ATVs or trucks. Any PPP should be applied according to manufacturer's instructions and in accordance with EU and national regulations. Briefly, *A. virginicus* is highly sensitive to broad-spectrum herbicides such as glyphosate (EPPO, 2018). It is important to not over apply, and be as selective with applications as possible.

Also note that EU, national, and local legislation on the use of plant protection products and biocides needs to be respected and authorities should check to ensure chemicals are licensed for use in their respective countries/regions.

SCALE OF APPLICATION
No species-specific information is available.

EFFECTIVENESS OF THE MEASURE
Effective.
Given the very high effectiveness of broad-spectrum herbicides on *A. virginicus* and their ready availability they can be a good option for eradicating emerging, small invasive populations. Broad-spectrum herbicides (such as glyphosate) are known to be highly effective on *A. virginicus* (EPPO, 2018; Sandler *et al.,* 2015) if applied at the appropriate time of year. In Hawai'i, glyphosate (1% concentration in water) applied to new growth is reported to be effective in controlling *A. virginicus* (EPPO, 2018).

* See Appendix

For post-emergent grass-specific PPP (for example, fluazifop-p-butyl, fenoxaprop-P, imazapic, and sethoxydim) little species-specific information for *A. virginicus* is available. Sandler (2015) tested sethoxydim in demonstration style plots, and found that spraying directly into clumps in the fall (autumn) injured plants but did not reduce seed production.

EFFORT REQUIRED

No information available.

RESOURCES REQUIRED

Application of any type of herbicide requires staff who are trained in how to apply herbicides safely, equipment (such as backpack sprayers and ATV sprayers), herbicides, and potentially surfactants depending on the product being used and the specific formulation. Follow manufacturer and government regulations.

Costs for applying herbicides vary widely based on region, habitat, and terrain.

SIDE EFFECTS

Environmental effects: Neutral or mixed
Social effects: Neutral or mixed
Economic effects: Neutral or mixed
By definition, broad-spectrum herbicides can kill most types of vegetation and should be applied with care so sensitive and desirable vegetation is not damaged. Non-target effects on other species, including via herbicide drift and runoff may also be of concern.

Compared to broad-spectrum herbicides, post-emergent grass-specific herbicides will affect fewer native plant species and probably have fewer side effects on native species. However, the chemicals in grass-specific herbicides (for example, fluazifop-p-butyl, fenoxaprop-P, imazapic, and sethoxydim) are less commonly applied, therefore less data is available on their side effects and environmental impacts, and they may be more environmentally damaging.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.
Due the effectiveness stakeholders may find them acceptable, especially if they can be applied selectively. However, because of the many potential side effects (for example, non-target effects on desirable vegetation), the stigma surrounding the use of herbicides, and the "scorched earth" appearance of treated areas, they may not be acceptable, particularly in natural areas used for recreation or those containing threatened or endangered species.

The relatively small side effects of grass-specific herbicides should make it an attractive rapid eradication method for stakeholders.

ADDITIONAL COST INFORMATION

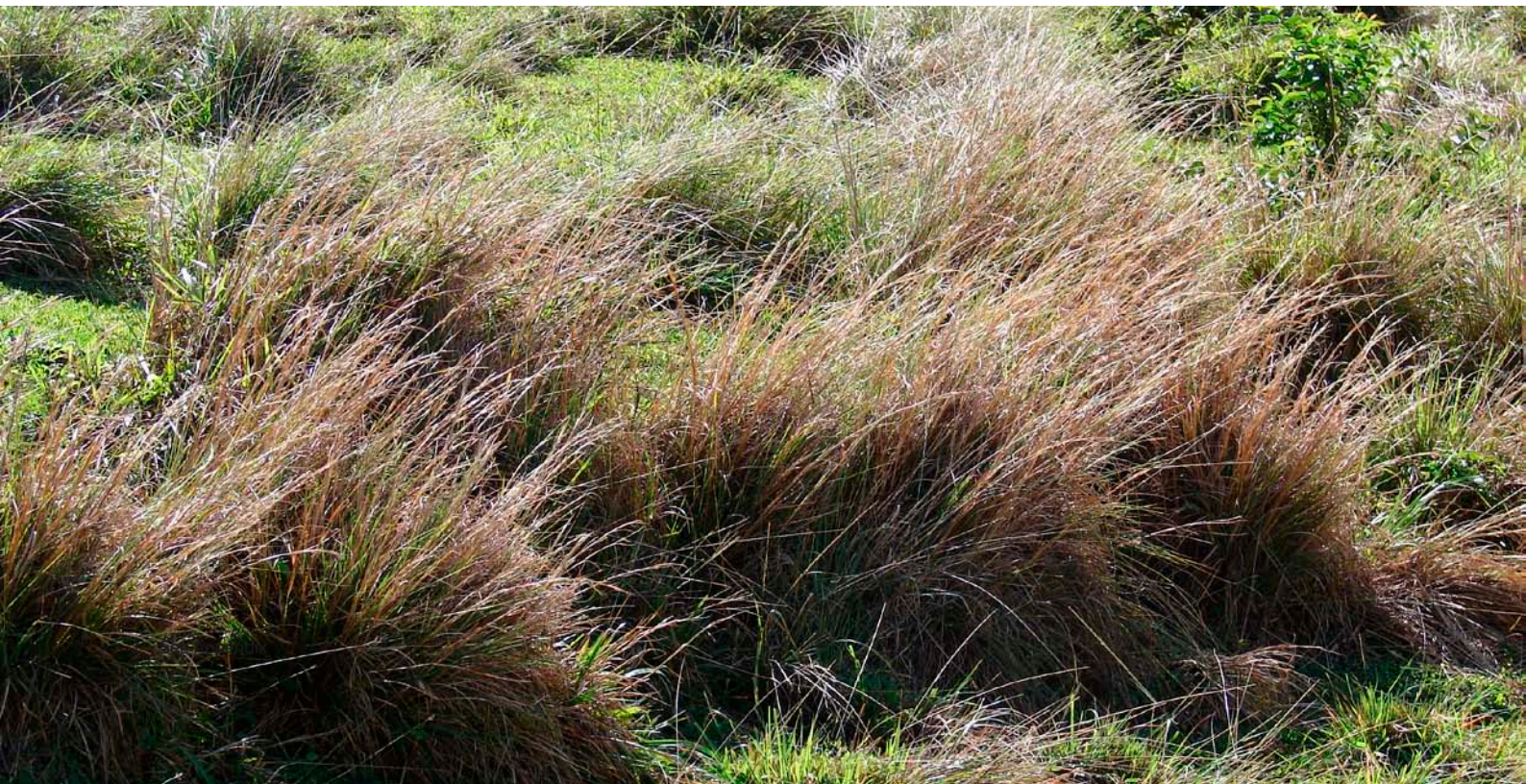
No information available.

LEVEL OF CONFIDENCE*

Established but incomplete.
Several studies have shown the effectiveness of glyphosate, applied at the appropriate time, on *A. vriginicus* (Butler *et al.,* 2002)

* See Appendix

Andropogon virginicus. © *Forest and Kim Starr. CC BY 3.0.*



Measures for the species' management.

Integrated management, combining prescribed burning, chemicals, fertility, grazing and tillage regimes.

MEASURE DESCRIPTION

For effective control of established populations an integrated approach is needed. In the United States where *A. virginicus* can be a problem in poorly managed pastures, a combination of physical measures to remove above ground biomass (through prescribed burn) followed by herbicide application (glyphosate) are applied to reduce the competitive strength of *A. virginicus.* This needs to be combined with proper fertility and grazing management (Butler *et al.,* 2006). However, this approach may not apply to the vegetation types the species has invaded in France.

It is important to note that EU, national, and local legislation on the use of plant protection products and biocides needs to be respected and authorities should check to ensure chemicals are licensed for use in their respective countries and regions.

SCALE OF APPLICATION

This measure has been applied at the experimental field scale only.

EFFECTIVENESS OF THE MEASURE

Effective.

The work on pastures in the United States has shown that the competitive strength of *A. virginicus* can be altered (Butler *et al.,* 2002, 2006; Griffin, Watson and Strachan, 1988). Control efforts solely using combinations of prescribed burning and herbicides have only short-lived results because of the establishment of new seedlings. However, when combined with proper fertility and grazing management satisfactory control of *A. virginicus* can be achieved (Butler *et al.,* 2006).

However, this may not apply to the vegetation types the species has invaded in France.

EFFORT REQUIRED

This measure requires a combination of methods, which requires significant effort and the process of management might take several years.

RESOURCES REQUIRED

No data available.

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SIDE EFFECTS

Environmental effects: Negative
Social effects: Neutral or mixed
Economic effects: Neutral or mixed

The application of fertilizers, introducing prescribed burning, a tillage and grazing regime and the application of herbicides will most certainly affect all other species co-occurring in the area.

ACCEPTABILITY TO STAKEHOLDERS

Neutral or mixed.

The application of fertilizers, introducing prescribed burning, a tillage and grazing regime and the application of herbicides are probably controversial, particularly in natural areas.

ADDITIONAL COST INFORMATION

No information available.

LEVEL OF CONFIDENCE*

Unresolved.

The measures as described apply to a different vegetation type than the habitat where the species at present occurs in France.

* See Appendix

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Appendix

- **Well established:** comprehensive meta-analysis or other synthesis or multiple independent studies that agree. Note: a meta-analysis is a statistical method for combining results from different studies which aims to identify patterns among study results, sources of disagreement among those results, or other relationships that may come to light in the context of multiple studies.
- **Established but incomplete:** general agreement although only a limited number of studies exist but no comprehensive synthesis and/or the studies that exist imprecisely address the question.
- **Unresolved:** multiple independent studies exist but conclusions do not agree.
- **Inconclusive:** limited evidence, recognising major knowledge gaps.

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