EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

16-21488

Pest Risk Analysis for

Microstegium vimineum

Microstegium vimineum in the USA. © Luke Flory

September 2015

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This risk assessment follows the EPPO Standard PM 5/3(5) Decision-support scheme for quarantine pests (available at http://archives.eppo.int/EPPOStandards/pra.htm) and uses the terminology defined in ISPM 5 *Glossary of Phytosanitary Terms* (available at https://www.ippc.int/index.php). This document was first elaborated by an Expert Working Group and then reviewed by the Panel on Invasive Alien Plants and if relevant other EPPO bodies. The PRA was reviewed by the EU IAS Scientific Forum in 2016.

Cite this document as:
EPPO (2014) Pest risk analysis for *Microstegium vimineum*. EPPO, Paris.
Available at http://www.eppo.int/QUARANTINE/Pest_Risk_Analysis/PRA_intro.htm

16-21488 (15-21051)

Pest Risk Analysis for *Microstegium vimineum*

This PRA follows the EPPO Decision-support scheme for quarantine pests PM 5/3 (5).
A preliminary draft was prepared by Ms Asuman Ergün (PPO of Turkey). This document has been reviewed by an Expert Working Group (EWG) that met at the EPPO Headquarters in Paris, France on the 2014-10-21/24.

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The PRA was reviewed by the Panel on Invasive Alien Plants on 2015-05-05/07

Content

Stage 1: Initiation

1.01 - Give the reason for performing the PRA

Identification of a single pest

Microstegium vimineum possesses characteristics typical of many invasive alien species: it grows quickly, fruits within a single season, produces abundant seed, and readily invades habitats that have been disturbed by natural (e.g., flood scouring) and anthropogenic (e.g., mowing, tilling) sources. It is also capable of invading wildland areas and swiftly replacing natural communities with nearly monospecific stands (Tu, 2000; Oswalt, 2007).

M. vimineum is an annual grass with a sprawling habit. It germinates in spring and grows slowly in early spring but very rapidly during the summer, ultimately reaching heights of 0.6 – 1 m with the reclining stems growing up to 1 metre long. Slender stalks of tiny flowers are produced in August through to September or early October. In late fall they fade to pale greenish-yellow or turn pale purple in colour (Mehrhoff, 2000).

M. vimineum is an annual C4 grass, that flowers under short day conditions, native to China, India, Japan and Nepal. It was introduced to North America from Asia. It was first identified in the United States in 1919 in Tennessee, and by 1960 had spread to Ohio and Pennsylvania, and to all Atlantic coastal states from Florida to New Jersey. Its dried leaves may have been used as a packing material for porcelain from China, and this was the putative means of its introduction into the U.S. (Fryer, 2011). *M. vimineum* occurs in riparian habitats, lawns, woodland thickets, damp fields, forest plantations and roadside ditches and partially and deeply shaded understories.

With the discovery of *M. vimineum* in Turkey and southern Caucasus, the European and Mediterranean Plant Protection Organization (EPPO) added the species to the EPPO Alert List in 2008 and transferred it to the List of Invasive Alien Plants in 2012 labelling it as an emerging invasive alien species considering the outputs of the EPPO Prioritization process for this species.

1.02a - Name of the pest

***Microstegium vimineum* (Trin.) A. Camus**

A description of this species can be found in the corresponding EPPO Datasheet.

1.02b - Indicate the type of the pest

Non parasitic plant

1.02d - Indicate the taxonomic position

Reign: Plantae; Family: Poaceae; Genus: *Microstegium*; Species: *Microstegium vimineum* (Trin.) A. Camus

1.03 - Clearly define the PRA area

EPPO region (see map at: http://www.eppo.int/ABOUT_EPPO/images/eppo_map.jpg).

1.04 - Does a relevant earlier PRA exist?

No. No relevant earlier PRA.

PRAs exist for Canada (Canada Food Inspection Agency, 2009) and for the USA (Gage *et. al*., 2010; UF/IFAS IPWG, 2013). However, these PRAs do not evaluate potential invasion pathways and are not valid for other areas than the PRA area.

1.06 - Specify all host plant species (for pests directly affecting plants) or suitable habitats (for non parasitic plants). Indicate the ones which are present in the PRA area.

Microstegium vimineum thrives in along mesic roadsides, ditches, woodlands, bottomland woodlands, and woodland borders, floodplains and streamsides, field margins and turfgrass (Fairbrothers & Gray, 1972; Hunt & Zaremba, 1992). It can also be found in mesic upland sites, and performs best in high light and high moisture conditions (Droste *et al.* 2010; Flory *et al.*, 2011c). It does not survive, however, in areas with periodic standing water (i.e., greater than one month).
These habitats are widely present in the EPPO region.

1.07 - Specify the pest distribution for a pest initiated PRA, or the distribution of the pests identified in 2b for pathway initiated PRA

As the genus *Microstegium* is poorly studied, the known range of *M. vimineum* could be incomplete, and the species could have been confused with other species. See Figures 1 and 2.

Native distribution:

Asia: Bhutan (Woods, 1989), China (Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hebei, Henan, Hubei, Hunana, Jiangsu, Jiangxi, Jilin, Shaanxi, Shandong, Shanxi, Sichuan, Yunnan, Zheijiang), India (Himachal Pradesh, Meghalaya, Nagaland, Sikkim, Uttarakhand, West Bengal), Iran, Japan (Hokkaido, Honshu, Kyushu, Ryukyu Islands, Shikoku), Myanmar, Nepal, Philippines, Taiwan, Thailand, Vietnam.

Note: the species is often recorded as native from Malaysia, though, there is no original source for this information and there are no herbarium records for this country. The species is also recorded in Armenia, but no original source could be retrieved for this record.

EPPO region: Russia (Primorye).

Exotic distribution:

EPPO region: Azerbaijan, Georgia, Russia (Northern Caucasus), Turkey.

Central America: Costa Rica, Puerto Rico.

North America: United States of America (Alabama, Arkansas, Connecticut, Delaware, District of Columbia, Florida, Georgia, Illinois, Indiana, Kentucky, Louisiana, Maryland, Massachusetts, Mississippi, Misouri, New Jersey, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Virginia, West Virginia). See appendix 2 for the distribution map in the USA.

Note: there is an Herbarium record of the species in the Democratic Republic of Congo from 1929. There is no additional record since that date, thus the record is then not interpreted as an established population in the absence of further information.
M. vimineum was first noted in North America around 1919 in Tennessee, where it was probably introduced accidentally (Barkworth *et al.*, 2003; Ehrenfeld, 2003, in Fryer, 2011).

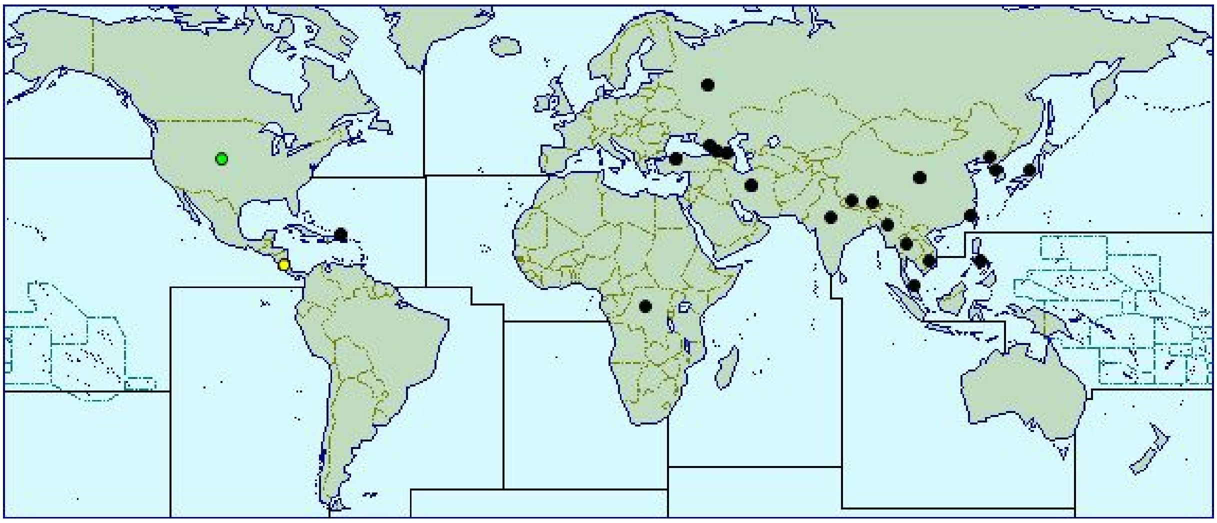


Fig.1. Worldwide Distribution map of *Microstegium vimineum* (CABI, 2014)

Present, no further details.

Occasional or few reports

See regional map for distribution within the country

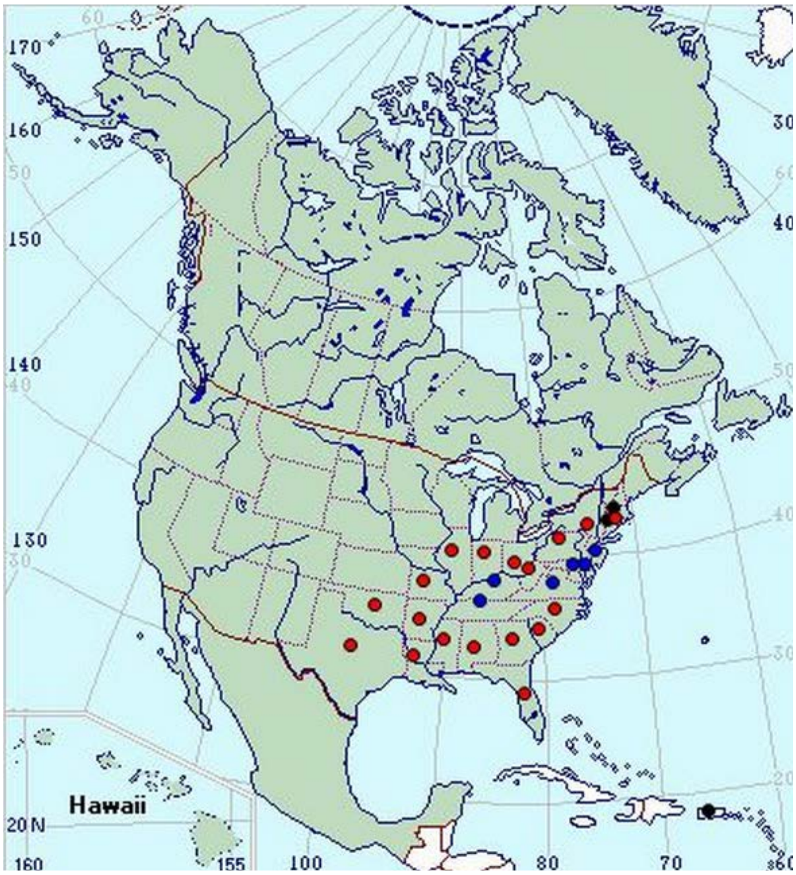


Fig. 2 Distribution map of *Microstegium vimineum* in North America (CABI, 2014)

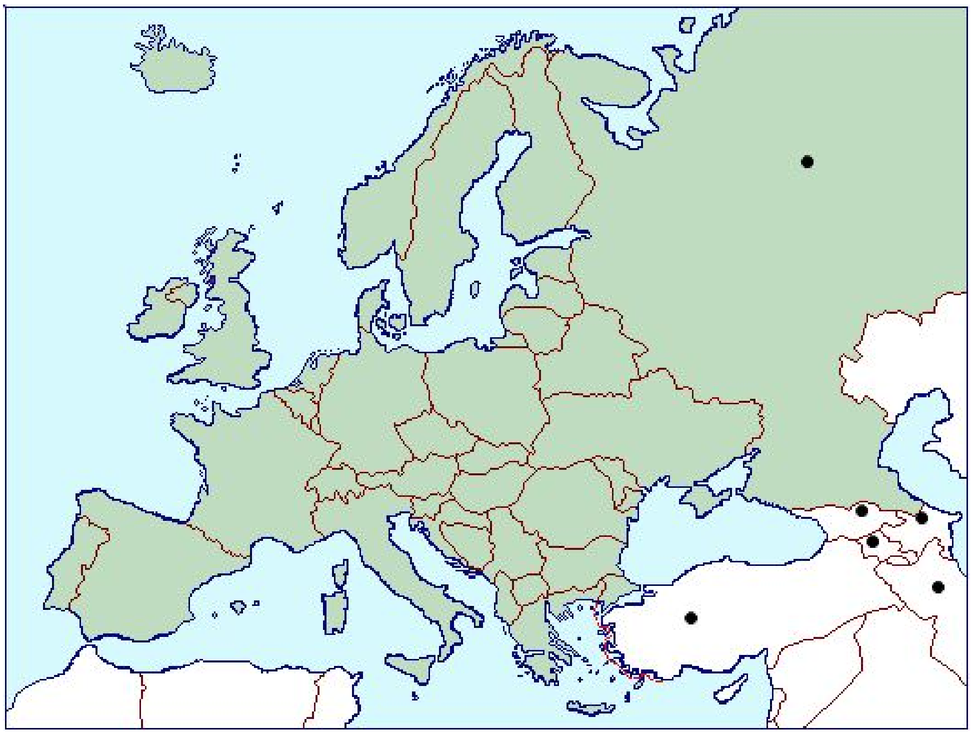


Fig.3. Distribution map of *Microstegium vimineum* in the EPPO region (CABI, 2014)

Stage 2: Pest Risk Assessment Section A: Pest categorization

Identity of the pest (or potential pest)

1.08 - Does the name you have given for the organism correspond to a single taxonomic entity which can be adequately distinguished from other entities of the same rank?

Yes

The scientific name of the species is *Microstegium vimineum* (Trin.) A. Camus (Poaceae), and it can be distinguished from other entities of the same rank.
Although in the Flora of China the species is distinguished from its congeners by the presence of a lower glume with transverse veinlets below the apex (Chen & Phillips, 2008), the taxonomy of the genus is incomplete or at least not fully circumscribed.

1.10 - Is the organism in its area of current distribution a known pest (or vector of a pest) of plants or plant products?

Yes (the organism is considered to be a pest)

In the USA, *M. vimineum* has established in 26 states and is listed in Alabama, Connecticut and Massachusetts as a weed (USDA, NRCS, 2014). *M. vimineum* has become a significant problem in forests in many eastern and midwestern states. It spreads rapidly due to high seed production and is able to out-compete native vegetation and is facilitated by deer herbivory (Baiser *et al*., 2008). It often establishes in locations where moist soils are scoured such as along streambanks, floodplains, ditches and trails. Typical habitats include river corridors, forested wetlands, moist woodlands, forest plantations, old fields and thickets, utility rights-of-way, roadsides and lawns (Warren, 2010). In addition, Touchette & Romanello (2010) found that *M. vimineum*'s capacity to tolerate a range of soil moisture conditions, including the ability to maintain stable water relations during flooding and waterlogging, may facilitate the species' invasion of mesic habitats and disturbed systems.

1.12 - Does the pest occur in the PRA area?

Yes

Within the EPPO region, *M. vimineum* is established in southern Caucasus including Azerbaijan, the Republic of Georgia, and Turkey (Valdés *et al.*, 2009). The species is also native to Russian Far East (Tsvelev, 1976) and introduced to Northern Caucasus (Valdés *et al.*, 2009).

1.13 - Is the pest widely distributed in the PRA area?

The pest is not widely distributed in the PRA area as it only has a limited distribution in a few countries.

1.14 - Does at least one host-plant species (for pests directly affecting plants) or one suitable habitat (for non parasitic plants) occur in the PRA area (outdoors, in protected cultivation or both)?

Yes

M. vimineum colonizes riparian habitats, lawns, woodland thickets, damp fields, managed forests, forest plantations and roadside ditches (Tu, 2000). These habitats are present in the EPPO region.

1.15a - Is transmission by a vector the only means by which the pest can spread naturally?

No

The plant may represent a threat on its own, without transmission by a vector.

1.16 - Does the known area of current distribution of the pest include ecoclimatic conditions comparable with those of the PRA area or sufficiently similar for the pest to survive and thrive (consider also protected conditions)?

Yes

Microstegium vimineum grows in temperate to warm continental climates. There is little available specific information about temperature ranges of the species. The coldest reported winter temperatures for a seed bank of *M. vimineum* are approximately -21 to -23 C (Redman, 1995). This low temperature would equate with USDA Plant Hardiness Zone of 6b. There also appear to be populations in zone 5 (Canadian Food Inspection Agency, 2009). Low soil moisture may affect performance (Droste *et al.*, 2010), but how precipitation patterns may affect its geographic distribution is unknown. However, the species can tolerate a wide range of soil moisture conditions (Touchette & Romanello, 2010). The species already occurs in the EPPO region (Azerbaijan, Georgia and Turkey). When considering ecoclimatic conditions of infested areas in the EPPO region, the climatic conditions are sufficiently similar fort the species to survive and thrive (see Fig.4.)

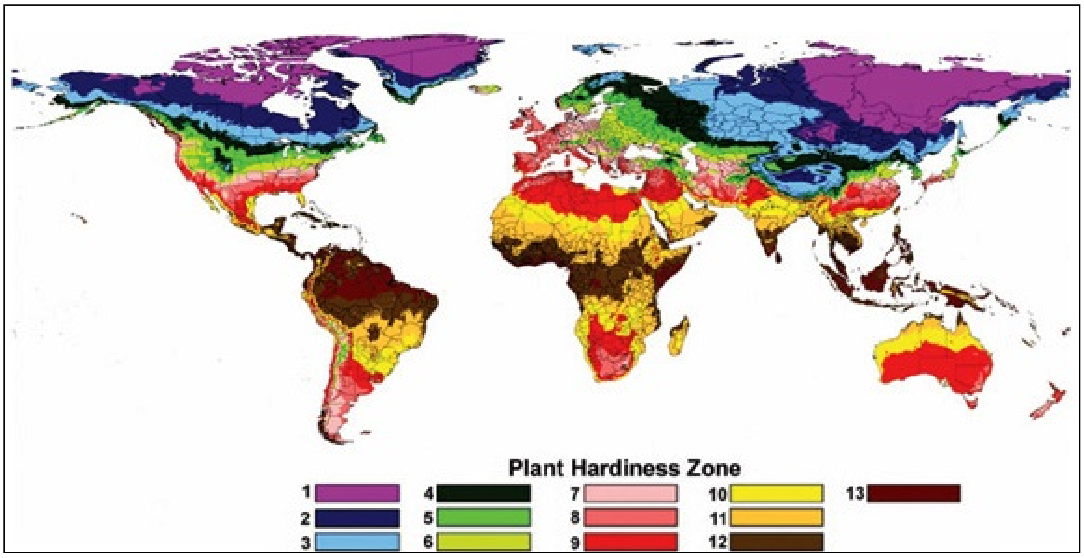


Fig. 4. Plant Hardiness Zone (Magarey *et. al.,* 2008)

1.17 - With specific reference to the plant(s) or habitats which occur(s) in the PRA area, and the damage or loss caused by the pest in its area of current distribution, could the pest by itself, or acting as a vector, cause significant damage or loss to plants or other negative economic impacts (on the environment, on society, on export markets) through the effect on plant health in the PRA area?

Yes

Microstegium vimineum (Poaceae) is a grass of Asian origin which is capable of invading, forming monocultures, and decreasing biodiversity in riparian zones, secondary hardwood forests, and areas of disturbance (Barden, 1987). The species could cause a range of detrimental environmental effects including decreasing plant biodiversity or increasing the intensity of ground fires (Robertson *et al,* 1994; Rubino *et al.* 2002; in Miller, 2011).

Recent experimental results in the USA demonstrate dramatic ecological effects of *M. vimineum* on native communities (see also (Kourtev *et al*., 2002, Adams & Engelhardt 2009, Flory & Clay, 2010b, c, Simao *et al*., 2010) (and others). Addition of *M. vimineum* to large, replicated field plots reduced native herbaceous biomass, richness and diversity (Flory & Clay, 2010b), and the establishment of tree seedlings (Flory & Clay, 2010c). Further, removing *M. vimineum* in natural populations with a grass-specific herbicide significantly increased native herbaceous biomass and diversity, and native tree regeneration (Flory & Clay, 2009, Flory 2010a). Invasions negatively affect arthropod abundance and diversity (Civitello *et al*., 2008, Simao *et al*., 2010) and can alter ecosystem processes such as nitrogen (Lee et al. 2012) and carbon cycling (Strickland *et al*., 2010), decomposition (Ehrenfeld, 2003), and fire regimes (Flory *et al.* 2012).

1.18 - Summarize the main elements leading to this conclusion.

Microstegium vimineum could present a risk to the EPPO region as eco-climatic conditions are similar to countries where the species occurs (Miller, 2011).

Stage 2: Pest Risk Assessment Section B: Probability of entry of a pest

2.01a - Describe the relevant pathways and make a note of any obvious pathways that are impossible and record the reasons. Explain your judgement

Entries as a contaminant of travellers, their clothes and shoes, machinery, hay, bird seed and soil have been important pathways for the introduction of *M. vimineum* in new regions. The following pathways are considered further in the assessment:

Identified pathways are the following:

As a contaminant of used machinery

Used machinery, vehicles, equipment are regulated articles frequently traded or otherwise moved between countries. They may have been used in agriculture, forestry and horticulture, as well as for construction, industrial purposes, mining and waste management. They can also be used military vehicles, machinery and equipment, although movement through such machinery has not been documented. Depending on their use before export, they may have become contaminated with pests. When moved internationally as either a traded commodity or an operational relocation (e.g., in the case of custom harvesters) the used vehicles, machinery and equipment can carry soil, pests, plant debris, and seeds and plants as pests, and they may therefore present a pest risk to the importing country. Depending on their use in the country of import, they may introduce quarantine pests to agricultural, forested, wilderness or other areas (IPPC, 2006).

Vehicles and machinery

M. vimineum have been observed being transported on automobiles in the USA (Mehrhoff, 2000). In addition, roads play an important role in plant invasions (Forman & Alexander 1998, Trombulak & Frissell, 2000, Mortensen *et al*., 2009). Road grading and construction equipment also represent a high risk (Mortensen *et al*., 2009).

Agricultural machinery

In the USA, occurances of *M. vimineum* are associated with vehicle movement (Shelton, 2010 in Gage *et al*., 2010). Movement of agricultural machinery is considered a possible pathway for the entry and spread of *M. vimineum*.

As a contaminant of bird seed

The import of foreign seed as foodstuffs for domestic and cage birds is a major source of introduction of aliens which has received little attention or detailed study. The most regular weeds are those whose seeds closely resemble the main bird food plants (Hanson & Mason, 1985). One of them is *Microstegium vimineum* which was introduced into Britain in birdseed. It was detected by the cultivation of samples of bird seed and the waste separated from commercial seed carried out by the authors (Hanson & Mason, 1985). In the British Isles, the plant is recorded to have been cultivated from bird seed (Ryves, Clement & Foster, 1996)

As a contaminant of soil

Man-made disturbances such as road construction create niches in the natural vegetation that can be rapidly colonized by *M. vimineum*. Transported soil can also spread seed.

As a contaminant of growing media adherent to plants for planting

An individual plant of *M. vimineum* can produce thousands of seeds (Wilson *et al*., 2014), and the seeds remain viable in the soil for three to five years (Barden, 1987; Gibson *et al*., 2002, Judge, 2006; Huebner, 2011). Seeds may be present in growing media adherent to plants for planting. Movement of plants for planting with adherent soil exists among EPPO countries.

<u>As a contaminant of travellers, their clothes and shoes</u>
M. vimineum attaches readily to human clothes and shoes. It has been observed to be spread by hikers in the USA (Mehrhoff, 2000 in CFIA, 2009). The species is also considered to be able to enter a new territory by 'hitchhiking' on human clothes (Cole & Weltzin, 2004; Mehrhoff, 2000; Woods, 1989). In addition, Camus (2009) indicates that for the plant one of the potential pathways into Canada is as a 'hitchhiker' on human (Camus, 2009).

<u>Spread pathway: as a contaminant of hay</u>
M. vimineum propagules (seeds) have been reported to be transported in hay in the USA (Tu, 2000), but this statement remains anecdotal.

<u>Unlikely pathways</u>
M. vimineum has not been documented as being intentionally planted as an ornamental, for erosion control or for forage (Howard, 2005).

In the past it may have been used as a packing material for porcelain from China which was considered to be its pathway of introduction into the USA (Tu, 2000), but is considered to be anecdotal. It is unlikely this pathway still exists (Canadian Food Inspection Agency, 2009) and it is expected that synthetic materials are nowadays used as packing material.

Unknown questions:

<u>As a contaminant of livestock or not?</u>
It is unknown whether livestock could be a pathway of entry of the species, though such matter should be considered in consultation with the animal health sector.

<u>As a contaminant of tea</u>
There is some speculation that *M. vimineum* was introduced into Turkey as a contaminant of tea. In Surmene-Camburnu (near Trabzon) in Turkey, *M. vimineum* is indeed found near a tea factory and the import of material for tea processing is expected to have been its pathway of introduction. Although *M. vimineum* has been observed growing as a weed in tea fields in China, tea processing is complex with multiple states that would reduce the probability of viable *M. vimineum* contamination. In Turkey, the presence of *M. vimineum* around a tea factory could most likely be likned to machinery.

<u>As a hitchhiker on logs</u>
M. vimineum can be a hitchhiker on logs of any forest tree originating from countries where *M. vimineum* occurs. Existing phytosanitary legislations that require debarking for some targeted pests could be efficient in preventing the contamination of logs, however the requirement only targets areas where these target pests occur. *M. vimineum* could be in fruit at the time of harvesting and be associated with the pathway, though, this is considered unlikely. The overall probability of this pathway is considered as unlikely.

2.01b - List the relevant pathways that will be considered for entry and/or management. Some pathways may not be considered in detail in the entry section due to lack of data but will be considered in the management part.

Pathway1: As a contaminant of used machinery

Pathway2: As a contaminant of bird seed
Pathway3: As a contaminant of soil
Pathway 4: As a contaminant of growing media adherent to plants for planting
Pathway 5: As a contaminant of travellers, their clothes and shoes

Pathway 1: As a contaminant of used machinery

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

Very likely

***Level of uncertainty*: low**

Movement of *M. vimineum* has been strongly associated with the transport of agricultural machinery. In a survey in the USA it was indicated that *M. vimineum* occurred more often close to roads, timber harvests, and streams. Within one year of establishment of a new log yard, there was 100% *M. vimineum* cover, and *M. vimineum* was present in every location where there was vehicle movement (Shelton, 2010 in Gage 2010).

Vehicles, machinery and equipment utilized in horticulture, earth moving, surface mining and waste management as well as used military vehicles, machinery and equipment are also considered relevant to the introduction of *M. vimineum* in the EPPO region even if there is no record about this.

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account current management conditions?

Likely

Level of uncertainty: low

There is legislation on the cleaning of machinery in Israel and in Norway. According to the Israeli legislation, machinery should come from an area free from *Striga* spp. The machines should be sprayed with sodium hypochlorite 2% and an insecticide. The machines should be treated with methyl bromide as follows:

- If the area is not free from *Striga* spp. or if there is no declaration in the Phytosanitary Certificate for freedom from *Striga* spp., machinery should be sprayed with methylbromide at160 g/m^3 at 16 c.d. or above for 24 hr (but this substance is subject to restricitions in some countries).
- In situation of positive evidence with phytosanitary declaration: 64 g/m^3 at 10 c.d. or above for 12 hrs.

In Norway, when used machinery and equipment intended to be used in agriculture, forestry or horticulture is imported, an official statement must accompany the consignment stating that it has been thoroughly cleaned and if necessary disinfected and that it is free from soil, plant remains and contamination from pests. The country of export’s plant inspection service, or an equivalent official agricultural authority shall issue this certification (Regulations of 1 December 2000 no. 1333 relating to plants and measures against pests).

These measures could prevent *M. vimineum* from entering Israel and Norway, but many other EPPO countries remain at risk.

There is no other known compulsory management practice for cleaning agricultural machinery, vehicles or military equipment in the EPPO region. However, a draft ISPM 'International movement of used vehicles, machinery and equipment' is under preparation (International Plant Protection Convention, 2006-004. Currently, no measures on machinery apply in the EPPO countries other than Norway and Israel.

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

Moderately likely

Level of uncertainty: high

The volumes of used machinery are difficult to estimate.

For what concerns harvesters, sale of second-hand vehicles may sometimes occur between EU or EPPO countries or other foreign countries, in particular through the internet, though the volume is unknown.

Vehicles circulate freely within European countries, and circulate as well among different EPPO countries, so the volume of vehicles to potentially spread *M. vimineum* would be high if the species would be present in a ground connected EPPO country.

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Moderately likely

Level of uncertainty: high

Vehicles and harvesters may circulate quite frequently across EPPO countries, though, that remains unknown as well.

2.07 - How likely is the pest to survive during transport or storage?

Very likely

Level of uncertainty: low

Seed is likely to survive all modes of transportation and extended periods of storage. Even at -21^{0}C, it does not loose germinability (Judge, 2005).There is no reason to suspect that survival would differ significantly at other temperatures, provided that seed is transported or stored dry.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Very unlikely

Level of uncertainty: low

M. vimineum is a plant and would be unable to complete its life cycle during transport or storage**.**

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Very likely

Level of uncertainty: low

2006-004: Draft ISPM: International movement of used vehicles, machinery and equipment is currently being drafted, so there is no known inspection of machinery in the EPPO countries except for Israel and Norway (see Q. 2.04).

In the absence of routine machinery inspection and cleaning procedures, it is very likely that *M. vimineum* would enter the PRA area undetected.

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Very likely

Level of uncertainty: low

Infested vehicles are expected to drive on roads, sometimes in nearby agricultural fields (in particular for agricultural equipment), or natural areas. In any case, the release of seeds of *M. vimineum* from the vehicles on road networks may facilitate its transfer to other unintended habitats connected by roads.

The primary vectors of long distance dispersal, such as road maintenance activities or vehicle traffic can play a profound role in the spread and growth of invasive alien species. For example, forest managers have reported that tens of kilometers of forest roads have been invaded by *M. vimineum* in a period of less than 10 years (Mortensen *et.al.*, 2009).

2.11 - The probability of entry for the pathway should be described.

Likely

Level of uncertainty: low

Considering uninspected movement of used vehicles, machinery and equipment into EPPO countries and adhesion capability of *M. vimineum* seeds, this pathway is assessed as likely.

Pathway 2: As a contaminant of bird seed

According to ISPM n°5, seeds are defined as 'a commodity class for seeds for planting or intended for planting and not for consumption or processing'.

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

Moderately likely

Level of uncertainty: high

Movement of *M. vimineum* has been associated with birdseed (Hanson & Manson, 1985).

Manufacturers and marketers of bird food prepare mixes which balance nutritional requirements of the birds with price. They can change between crops quite easily according to prices but the ingredients which distinguish the products are often the oilseeds such as Niger seed, sunflower seed, safflower seed or canary seed. These ingredients tend to be included regardless of price (Lin, 2005).

The various seeds first arrive in from foreign sources in containers which may contain a considerable proportion of unwanted material such as husks, stalks, straw, soil, stones, fragments of insects, pieces of newspaper and other rubbish. The imported seed also includes foreign seeds of the weeds which were harvested with the crop. The condition of seed on arrival depends on the type of crop and the country of origin (Hanson & Mason, 1985) and the price of the commodity. The opportunity to introduce foreign seeds varies with the type of plant, how it is harvested and which country it comes from. Some species can be harvested easily without gathering much foreign material, e.g. *Dipsacus sativus*, *Zea mays* and *Helianthus annuus*, while the low-growing cereals such as the millets cannot be easily separated from the weeds that grow. Therefore, individual seeds mix with another.

M. vimineum rarely occurs in cultivated fields in the United States. In China, the plant has been observed in close vicinity to agricultural production areas and is reported as a weed of crops (Zhirong, 1990).

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account current management conditions?

Moderately ikely

Level of uncertainty: high

M. vimineum rarely occurs in intensively cultivated fields.

The cleaning of bird seed and management in the field are management conditions to avoid weed invasion. There are a few processes for cleaning. In some cases the economic drivers of the seed industry dictates minimal cleaning (van Denderen *et al*., 2007). The few foreign seeds that escape the cleaning process are those that resemble the main seed most closely in size and shape. Studies have found that grass family seeds can contaminate commercial bird seed mixes (Hanson & Mason, 1985).

Certain species pass through the cleaning process more easily than others. There are a number of species whose seeds are introduced into EPPO country in large quantities as impurities, but which are very easily separated from the bird food and which therefore rarely have the opportunity to germinate. These include the very large fruits of plants such as *Scandix pecten-veneris, Tragopogon hybridus, Xanthium spinosum* and *Cenchrus incertus*. The tiny seeds of species of Chenopodium and Amaranthus are also relatively easily removed (Hanson and Mason, 1985), but this is not the case for *M. vimineum*.

Even if there are processes for the cleaning of bird seed, since the seeds of *M. vimineum* are of similar size as seeds of other Poaceae, it is still moderately likely that the plant would be associated with the pathway.

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

Likely

Level of uncertainty: low

The keeping of exotic and ornamental birds has become a major hobby in Europe (see fig 5), and there is also an increase in wild bird feeding.

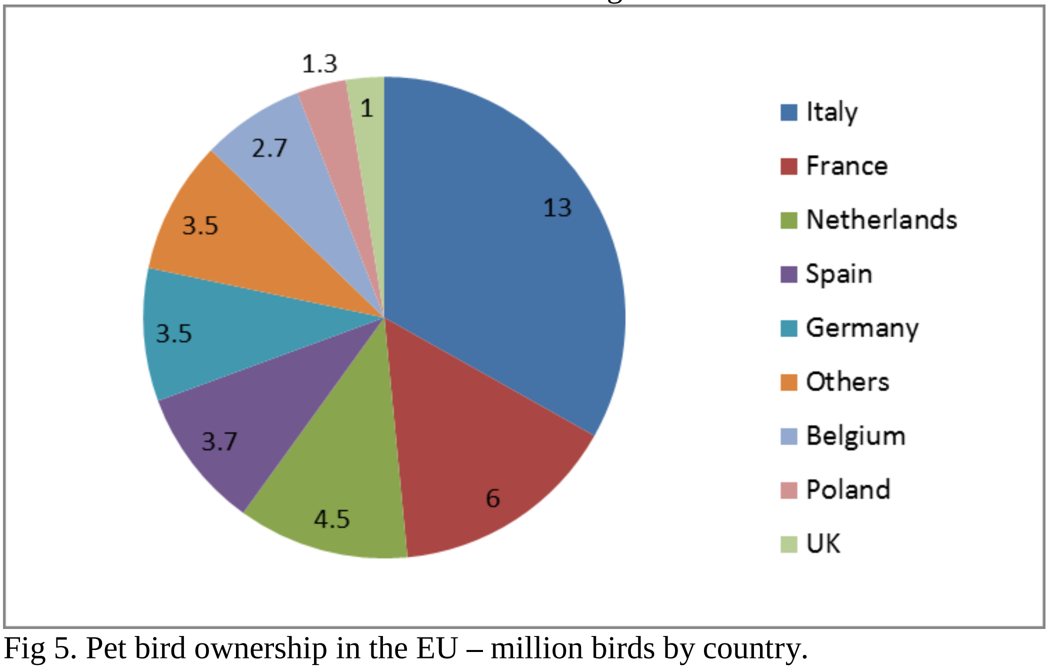


Fig 5. Pet bird ownership in the EU – million birds by country.

Statistics are difficult to evaluate as imports for bird food, although separately denominated by declaration at time of import, are not recorded under a separate tariff heading from 'oilseeds'.
The EU is a major importer of high value oilseeds which are used in many different products including bakery, snacks, pharmaceuticals, animal feed and paints as well as the primary use, cooking oil.
The United Kingdom market for companion bird food amounts to 1600 tonnes with a retail value of US$2.6 million (Lin, 2005). At the same time, the United Kingdom is one of the leading countries in outdoor feeding with an estimated expenditure of US$200 million (Lin, 2005).
The volume of movement is considered as likely to support entry.

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Likely

Level of uncertainty: low

There is trade on raw materials of bird seeds between EU countries in particular the Netherlands, Belgium and the UK frequently (CBI Market Information Database). There is a possible risk of entry from countries where *M. vimineum* occurs, in particular China.

2.07 - How likely is the pest to survive during transport or storage?

Very likely

Level of uncertainty: low

M. vimineum present as seed is likely to survive transport and extended periods of storage. Even if at -21^{0}C, it does not loose germinability (Judge, 2005).There is no reason to suspect that survival would differ significantly at other temperatures, provided that seed is transported or stored dry.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Very unlikely

Level of uncertainty: low

M. vimineum is a plant and would be unable to complete its life cycle during transport or storage

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Very likely

Level of uncertainty: low

The bird food market may serve as an outlet for products which are not well graded for size, which cannot be shelled at origin or which for reasons of appearance may not be valued for human consumption but are regarded as premium products in the bird food market. The bird food market can serve as an outlet for lower specification products with tolerances on contaminants and quality but cleanliness and low admixture are very important for sales to this sector as the product tends to go straight into the packing process without further processing.

In the EPPO region, there is no specific regulation on *M.vimineum* but there is legislation on the infestation of grain from *Ambrosia* species (Commission regulation No 574/2011), which requests that the grain be clean from *Ambrosia* spp. seeds. This regulation does not apply to *M. vimineum*, it is therefore vely likely that the plant would enter the EPPO region undetected.

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Moderately likely

Level of uncertainty: medium

Fediaf, the European pet food industry association estimates that there are 39 million pet and ornamental birds kept in the EU. Pet bird ownership are spread all around the EU, but are more numerous in Italy, France and the Netherlands (see Fig 5).

Most often, these birds are fed in cage away from suitable habitats. However, when cleaning the cages, owners may discard the content of the cage in their gardens, which would represent a suitable habitat for *M. vimineum*. A large proportion of the foreign plants that appear as casuals in town rubbish tips every summer originate from bird cage waste in domestic rubbish.

People may also feed wild birds. Birds could then spread the seed in the garden or in other suitable habitats by spilling. Mixtures sold as wild bird feed are often scattered in gardens or on waste ground where some of the seeds germinate.

There are also rare instances where waste from importers of grain is dumped or spilled on ruderal sites where some of the seeds may grow (CBI Market Information Database).

2.11 - The probability of entry for the pathway should be described.

Moderately likely

Level of uncertainty: high

Entry of *M. vimineum* is moderately likely to occur through bird seed, although there is high uncertainty on whether the plant could be a contaminant at the source of production of bird seed.

Pathway3: As a contaminant of soil

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

Likely

Level of uncertainty: low

M. vimineum is thought to be spread as a contaminant of soil for road construction and grading and could also be spread during other construction or agricultural activities (Mortensen *et al*., 2009). This could be one of the pathways for spread of *M. vimineum* from one place to the other within a country (spread pathway) or between countries (entry pathway).

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account current management conditions?

Likely

Level of uncertainty: low

There are no management practices for soil. Soil sterilization could kill the seeds, but this is neither required nor done and would not be economically feasible.

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

Unlikely

Level of uncertainty: high

Movement of soil from countries where *M. vimineum* occurs is expected to be low. However, there are no data available on this point.

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Unlikely

Level of uncertainty: high

The frequency of movement of soil is also expected to be low, but there is no information on this point.

2.07 - How likely is the pest to survive during transport or storage?

Very likely

Level of uncertainty: low

Seed is likely to survive transport and extended periods of storage. Even at -21^{0}C, it does not loose germinability (Judge, 2005). There is no reason to suspect that survival would differ significantly at other temperatures, provided that seed is transported or stored dry.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Unlikely

Level of uncertainty: low

M. vimineum is a plant and would be unable to complete its life cycle during transport or storage.

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Likely

Level of uncertainty: medium

The seeds of *M. vimineum* are light brown and very small (less than 5 mm) and are expected to remain undetected in soil.

However, according to the Directive 2000/29 (point 14 of annex III, part A), soil or growing media introduced from Turkey, Belarus, Moldavia, Russia, Ukraine and third countries not belonging to continental Europe, other than Cyprus, Israel, Libya, Morocco and Tunisia is prohibited of import in the EU. There are no specific requirements for soil or growing media coming from authorised countries (Cyprus, Israel, Libya, Morocco, Malta and Tunisia). Soil is unlikely to be imported from other continents (European Union, 2010, amended Council Directive 2000/29/EC of 8 May 2000). In other EPPO countries, import of soil is prohibited.

It is likely that *M. vimineum* would enter the PRA area undetected.

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Likely

Level of uncertainty: low

Seeds in soil will be able to germinate where the soil will be transported.

2.11 - The probability of entry for the pathway should be described.

Unlikely

Level of uncertainty: medium

Movement of soil from countries where *M. vimineum* occurs is expected to be low. This pathway is therefore considered as unlikely. However, where *M. vimineum* is present in the EPPO region, soil represents an important pathway for spread.

Pathway 4: As a contaminant of growing media adherent to plants for planting

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?

Likely

Level of uncertainty: medium

M. vimineum would be able to form large stands in and around production areas. Its numerous seeds could be spread by water or other vectors (e.g., machinery) to contaminate nursery stock and areas.

The probability of contamination is considered to be higher for trees and potted plants rather than for plants in glasshouses.

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account current management conditions?

Moderately likely

Level of uncertainty: medium

In nurseries, weeding could be done manually, mechanically or chemically. However, it is unlikely that *M. vimineum* is controlled in this way currently in its area of origin.

Other annual grass weeds have been found in bonzais imported from China to the Netherlands (Q-bank website, *Arthraxon hispidus* http://www.q-bank.eu/Plants/BioloMICS.aspx?Table=Plants%20-%20Species&Rec=75&Fields=All).

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?

Moderately likely

Level of uncertainty: medium

According to AIPH (2008), fruits trees and shrubs are imported into the EU, and these may have some growing media attached infested with seeds of *M. vimineum*.

AIPH provides values of import, but no figures of unit numbers of plants imported. In 2007, amounts of 906 000 € are imported in the EU from European countries (non EU), 1 046 000 € from Africa, 352 000 € from Asia (excluding the Middle East), 303 000 € from the Middle East, 636 000 € from North America and 738 000 € from Latin America.

Van Valkenburg *et al*. (2014) report that import value of plants for planting in 2010 in the European Union amounted to 285 million EUR, the Netherlands accounting for 60% of this. The import volume in Turkey for ornamental plants has increased since 2005 (Uludag & Erturk, 2012).

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Moderately likely

Level of uncertainty: high

The import of plants with growing media attached originating from East Asia is a year round activity with well over a million plants imported per year (van Valkenburg *et al*., 2014).

2.07 - How likely is the pest to survive during transport or storage?

Very likely

Level of uncertainty: low

Seed is likely to survive all modes of transport and extended periods of storage. Even at -21^{0}C, it does not loose germinability (Judge, 2005).There is no reason to suspect that survival would differ significantly at other temperatures, provided that seed is transported or stored dry.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Very unlikely

Level of uncertainty: low

*M. vimineum i*s a plant and would be unable to complete its life cycle during transport or storage.

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Likely

Level of uncertainty: low

The seeds of *M. vimineum* are light brown and less than 5 mm and are expected to remain undetected in growing media.

The current requirements of the EU Plant Health Directive do not cover specifically seeds in growing media. Though, the Directive 2000/29 (European Union, 2010) requires that plants for planting coming from Turkey, Belarus, Georgia,, Moldova, Russia, Ukraine, and other non European countries other than Algeria, Egypt, Israel, Libya, Malta, Morocco, and Tunisia are free from soil and organic matter or were subject to appropriate heat treatment or fumigation against pests (thermic treatment or fumigation, which may be efficient against seeds of *M. vimineum*).

In Turkey, although there are some checks for certain pests, plants and seeds are not explicitly mentioned. In Russia, introduction of plants with soil is restricted.

Little information is available from other EPPO countries.

Seeds (5 mm or less) are not visible in the growing media and they may remain undetected.

In the EU, as *M. vimineum* is not regulated, phytosanitary measures would not apply and seeds may be present in plants for planting with growing media attached coming from countries where it occurs.

In Turkey, although there are some checks for certain pests, plants and seeds are not explicitely mentioned. In Russia, introduction of plants with soil is restricted.

It is likely that *M. vimineum* would enter the PRA area undetected.

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Likely

Level of uncertainty: low

Plants for planting could be planted in suitable habitats for *M. vimineum*. Indeed, ornamental plants may be planted in gardens or on road sides and public areas.

All of these habitats are suitable for the plant to establish and to transfer to further suitable

habitats.
M. vimineum may germinate and produce seeds that could be spread by water, animals, machinery, etc.

2.11 - The probability of entry for the pathway should be described.
Moderately likely
Level of uncertainty: medium
Overall, the probability of entry of *M. vimineum* through growing media adherent to plants for planting is moderately likely.

Pathway 5: As a contaminant of travellers, their clothes and shoes

2.03 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account the biology of the pest?
Moderately likely
***Level of uncertainty*: high**
Material susceptible to be contaminated is: clothing, boot or shoe treads (Gage *et al.*, 2010). The fruit or caryopsis (grain) is yellowish to reddish, and ellipsoid in shape, less than 5 mm, it can attach to clothing and shoes. Adhesion of fruits to passing hikers is thought to explain the spread of *M. vimineum* through otherwise undisturbed natural areas in the USA (Corbit *et al.*, 1999 in Miller 2011). Furthermore, the plant forms near monospecific stands in habitats susceptibles for people to walk in (e.g. woodlands, roadsides, etc.)

Fig 6. Seed of *Microstegium vimineum* (http://www.inspection.gc.ca/plants/seeds/testing-grading/fact-sheets/microstegium-vimineum/eng/1397679674841/1397679719451).

2.04 - How likely is the pest to be associated with the pathway at the point(s) of origin taking into account current management conditions?
/
Level of uncertainty: /
Not relevant.

2.05 - Consider the volume of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this volume will support entry?
Likely

Level of uncertainty: low

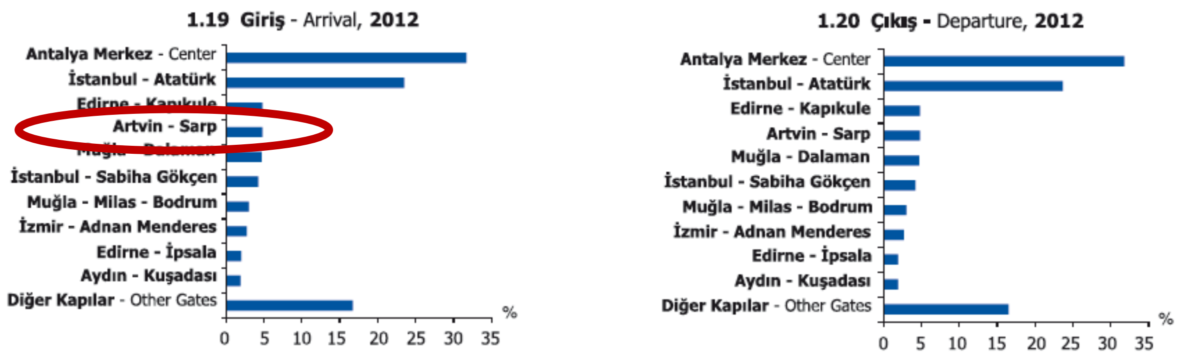
There is no data available, the volume of people travelling is considered to be high. There is an estimated 700 million people crossing international borders as tourists each year (McNeely, 2006). Millions of people visit the EPPO region every year from countries where *M. vimineum* occurs.

For example, within the EPPO region, the Artvin area in Turkey received more than 1,500,000 visitors in 2012 (see fig 7).

1.10 Giriş - çıkış kapısı ve ulaşım yoluna göre en çok giriş ve çıkış yapan yabancılar, 2012
Number of the most arriving and departing foreigners by the gate of arrival-departure and mode of transport , 2012
A. Hava yolu - Airway **B. Demir yolu** - Railway **C. Kara yolu** - Roadway **D. Deniz yolu** - Seaway

İlk on hudut kapısı The first ten border gate		Giriş - Arrival	(%)	İlk on hudut kapısı The first ten border gate		Çıkış - Departure	(%)
Toplam-Total		**31 782 832**	**100,0**	**Toplam**-Total		**31 655 188**	**100,0**
Antalya-Merkez-Center	A	10 075 506	31,7	**Antalya-Merkez**-Center	A	10 081 573	31,8
İstanbul-Atatürk	A	7 475 990	23,5	**İstanbul-Atatürk**	A	7 488 171	23,7
Edirne-Kapıkule	C	1 519 555	4,8	**Edirne-Kapıkule**	C	1 521 080	4,8
Artvin-Sarp	C	1 515 094	4,8	**Artvin-Sarp**	C	1 519 814	4,8
Muğla-Dalaman	A	1 506 133	4,7	**Muğla-Dalaman**	A	1 496 887	4,7
İstanbul-Sabiha Gökçen	A	1 346 496	4,2	**İstanbul-Sabiha Gökçen**	A	1 321 134	4,2
Muğla-Milas-Bodrum	A	963 707	3,0	**Muğla-Milas-Bodrum**	A	959 852	3,0
İzmir-Adnan Menderes	A	849 822	2,7	**İzmir-Adnan Menderes**	A	856 103	2,7
Edirne-İpsala	C	636 407	2,0	**Edirne-İpsala**	C	601 510	1,9
Aydın-Kuşadası	D	590 294	1,9	**Aydın-Kuşadası**	D	599 438	1,9
Diğer Kapılar- Other Gates		5 303 828	16,7	**Diğer Kapılar**- Other Gates		5 209 626	16,5

Kaynak: Emniyet Genel Müdürlüğü Source: General Directorate of Security



TÜİK, Turizm İstatistikleri, 2012
TurkStat, Tourism Statistics, 2012

Fig 7. Number of most arriving and departing travellers.

Artvin is the closest airpot from where Trabzon, where *M. vimineum* occurs in Turkey.

2.06 - Consider the frequency of movement along the pathway (for periods when the pest is likely to be associated with it): how likely is it that this frequency will support entry?

Likely

Level of uncertainty: low

Flights with travellers from all over the world arrive daily in the EPPO region.

2.07 - How likely is the pest to survive during transport or storage?

Very likely

Level of uncertainty: low

Seed is likely to survive all modes of transport and extended periods of storage. Even if at -21^{0}C, it does not loose germability (Judge, 2005).There is no reason to suspect that survival would differ significantly at other temperatures, provided that seed is transported or stored dry.

2.08 - How likely is the pest to multiply/increase in prevalence during transport or storage?

Very unlikely

Level of uncertainty: low

Seed can not multiply during transport because it needs to complete its lifecycle.

2.09 - Under current inspection procedures how likely is the pest to enter the PRA area undetected?

Very likely

Level of uncertainty: low

There are no phytosanitary measures in place to detect *M. vimineum*, the seed is small (less than 5 mm) and is very likely to remain undetected as passengers are not inspected.

2.10 - How likely is the pest to be able to transfer from the pathway to a suitable host or habitat?

Moderately Likely

Level of uncertainty: medium

Several studies have demonstrated that *M. vimineum* can establish in a variety of areas, and some authors have suggested human mediated transportation as likely explanation of dispersal (Barden, 1987, Gibson *et al*., 2002).

2.11 - The probability of entry for the pathway should be described.

Moderately likely

Level of uncertainty: medium

Considering the volume of travellers from countries where *M. vimineum* occurs, adhesion of *M. vimineum* fruits to passing hikers and surviving capability during transport, the probability of entry of *M. vimineum* as a contaminant of travellers, their clothes and shoes is considered as moderately likely. However, where *M. vimineum* is present in the EPPO region, travellers represent an important pathway for spread.

Stage 2: Pest Risk Assessment Section B: Probability of establishment

Select the factors that may influence the limits to the area of potential establishment and the suitability for establishment within this area.
For each question which was answered with a "yes", detailed information is provided after the table.

No.	Factor	Is the factor likely to have an influence on the limits to the area of potential establishment?	Is the factor likely to have an influence on the suitability of the area of potential establishment?	**Justification**
1	Suitable habitats (see note for Q3.01)	Yes (see 3.01)	Yes (see 3.09)	
2	Alternate hosts and other essential species	No	No	*M. vimineum* is a plant, so alternate hosts and essential species are not required for the species to complete its lifecycle and do not have influence on the limit/suitability of the area for the potential establishment of the pest.
3	Climatic suitability	Yes (see 3.03)	Yes (see 3.11)	
4	Other abiotic factors	Yes (see 3.04)	Yes (see 3.12)	
5	Competition and natural enemies	No	Yes (see 3.13)	Thirteen species of fungi and eight arthropod species are reported for the genus Microstegium in China (Zheng *et al.*, 2006). There is no report of these species in the PRA area, but other species may have an influecne on the suitability of the area of potential establishment (See table 1). Natural enemies have also been found on *M. vimineum* in North-America.
6	The managed environment	Yes (see 3.06)	Yes (see 3.14 / 3.15)	
7	Protected cultivation	No	No	Protected cultivation such as glasshouses do not have any influence on the limit/suitability of the area of potential establishment as *M. vimineum* is not a common weed of glasshouses.

Suitable habitats

3.01 - Identify and describe the area where the host plants or suitable habitats are present in the PRA area outside protected cultivation.

M. vimineum can colonize natural environments, transport corridors and wastelands.
Common habitats associated with *M. vimineum* are moist areas such as mesic roadsides, railroad right-of-way, ditches, utility right-of-way, logging roads, roadsides floodplain forest, forest wetland, herbaceous and shrub wetland, early and late successional forest, planted forest, forest edges and margins, woodland borders, floodplains, grassy areas, vacant lot, managed landscapes, and stream sides. The plant is also found in mesic upland sites, usually in moderate to dense shade.
M. vimineum can perform well in a wide range of environments with maximum productivity under high soil moisture and light conditions (see Q. 3.04).

The crops and habitats at risk from *M. vimineum* are the following (according to the Corine landcover classification):

- Green urban areas
- Roads and rail networks and associated land
- Water courses
- Forests

The habitats in which *M. vimineum* could occur according to the EUNIS classification are described in Appnedix 1, taking into account the first 2 levels of the classification.

These habitats are common and widespread all over the EPPO region.

Climatic suitability

3.03 - Does all the area identified as being suitable for establishment in previous question(s) have a suitable climate for establishment?

Partially (please provide justification)

Within the EPPO region, the Mediterranean Basin is particularly vulnerable because its climatic conditions potentially allowing the establishment of both sub-tropical and tropical species (Sala *et al*., 2000; Walther *et al*., 2009 in Brunel *et al*., 2010). *M. vimineum* grows in temperate to warm continental climates. There is little available specific information about temperature ranges for the species. The coldest reported winter temperatures for a seed bank of *M. vimineum* are approximately -21 to -23 °C (Redman, 1995).
In the context of climate change, the potential to establish and cause damages may increase (Sala *et al*., 2000; Walther *et al*., 2009). New places for possible invasion could develop with a changing climate that would be hospitable to the needs of the plant.

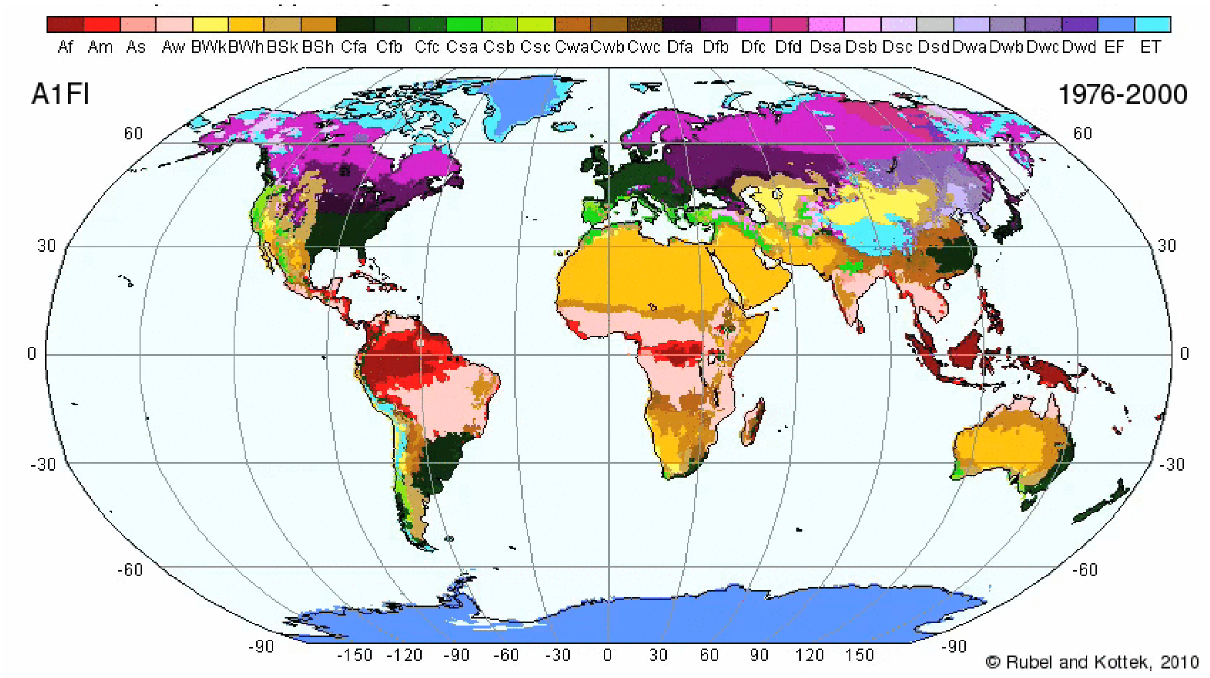


Fig. 8. World map of the Köppen Geiger climate classification. Source: ITIS, 2014.

Suitable climate categories

A Equatorial climates
Af Equatorial rainforest, fully humid: this corresponds to the distribution of the plant in the Philippines, Viet Nam.
Am Equatorial monsoon: this corresponds to its possible distribution in the Philippines.

C Warm temperate climates
Cs Warm temperate climate with dry summer would only be suitable with irrigation or in the vicinity of natural waterways.
Cw Warm temperate climate with dry winter: this corresponds to its distribution in China.
Cf Warm temperate climate, fully humid: this corresponds to its distribution in North-America, China, Japan, Taiwan.

There is a record of *M. vimineum* in the Kedrovaya pad area in Russia on the border of climate zone ‘warm temperate’a and ‘snow climates’.

Temperate to tropical climates are suitable provided there is adequate moisture. All EPPO countries are considered to be at risk. The Mediterranan countries are primarily at risk where soil moisture is not limiting, such as irrigated areas or in the vicinity of waterways.

Other abiotic factors

3.04 Does all the area identified as being suitable for establishment in previous questions have other suitable abiotic factors for establishment?

Yes

Water availability is a limiting factor for *M. vimineum* distribution (Touchette & Romanello, 2010), thus, well drained sandy soils, or other conditions that reduce soil moisture availability, may be less susceptible to *M. vimineum*.

Although *M. vimineum* is a C4 plant, it can perform well across a wide range of light conditions. While it performs best at high light intensities, seed production can occur at less than 5% light (Wilson *et al*., 2014). Thus, forest disturbances that result in more light reaching the ground may influence the spread of *M. vimineum* by creating a more favorable environment (Cole & Weltzin, 2004; Droste *et al*., 2010; Hull, 2010; Flory *et al*., 2011c; Wilson *et al*., 2014).
While early studies of *M. vimineum* in North America characterized its presence on acidic soils (e.g., Redman, 1995), subsequent expansion of its invasive range has occurred over a wide variety of soil types.

3.06 - Is all the area identified as being suitable for establishment in previous questions likely to remain unchanged despite the management of the environment?

Yes

Disturbances due to management such as grading, mowing, irrigation, fire and timber harvest may increase susceptibility of habitats to establishment but intensively cultivated areas will be less susceptible (Oswalt & Oswalt, 2007; Shelton, 2010). Although mowing can reduce the reproductive capacity of existing stands (Shelton, 2013), mowing can also spread seeds and encourage establishment of new populations if conducted during seed set.

In a study Oswalt & Oswalt (2007) suggests one mechanism facilitating rapid expansion of *M. vimineum* following site disturbance, and indicates that *M. vimineum* can experience rapid growth in response to site disturbance even in the absence of canopy removal.

Areas that have recently been naturally or anthropogenically disturbed (e.g. windthrows or timber harvests) are especially vulnerable to invasions (Marshall & Buckley, 2008). Subsequent disturbance events such as windthrow or timber harvest could result in a rapid increase in the local abundance of sparsely established invasive alien plants (Johnson *et al*., 2014). In addition, winter litter disturbance as a result of timber harvest activities, floodwater scour, or animal activities can drastically increase *M. vimineum* spread and may enhance potential ecological impacts of invasions by increasing *M. vimineum* percent cover (Oswalt *et al*., 2007). Multiple researchers anecdotally mention bare soil or disturbance of organic matter and leaf litter when describing optimal conditions for the establishment and spread of *M. vimineum* (e.g. Barden, 1987; Gibson *et al.*, 2002; Cole & Weltzin, 2004) and experimental data supports such observations (Oswalt and Oswalt 2007, Warren *et al*. 2013, Marshall & Buckley 2008)

3.08 - By combining the cumulative responses to previous questions with the response to question 3.07, identify the part of the PRA area where the presence of host plants or suitable habitats and other factors favour the establishment of the pest.

At least portions of all EPPO countries are considered suitable for the establishment of *M. vimineum*.
Uncertainty lies in the ability of the plant to adapt to shorter growing season at higher latitudes. However, such evolution has been documented in North-America when expanding its range northward (Novy *et al*., 2013).

Host plants and suitable habitats

3.09 - How likely is the distribution of hosts or suitable habitats in the area of potential establishment to favour establishment?

Very likely

Level of uncertainty: low

M. vimineum is most likely to first be found along roads, trails, riparian areas and other infrastructure networks. However, other areas such as forests and conservation lands are susceptible to invasion. These habitats are abundant, widely distributed across the whole EPPO region and the use of them is interconnected. Thus the distribution of suitable habitats is very likely to favour establishment.

For example, riparian zones and moist areas are both common habitats throughout the EPPO region and *M. vimineum* is expected to be able to establish in these habitats (see figure 9).

Fig 9. Pan European map of percentage of riparian areas in 1 km cells (Nicola *et. al.*, 2011).

Climatic suitability

3.11 - Based on the area of potential establishment already identified, how similar are the climatic conditions that would affect pest establishment to those in the current area

of distribution?

Largely similar

Level of uncertainty: low

M. vimineum grows in temperate to warm continental climates. These same climates are found throughout most of the EPPO region (see Q. 3.04).

There is little available specific information about temperature ranges for the species. *M. vimineum* grows in temperate to warm continental climates, so considering the Köppen-Geiger Climate Classification (see. Fig. 5) (Kottek *et. al.*, 2006), climatic conditions for the establishment of *M. vimineum* are largely similar to invaded countries such as the USA and Turkey as well as the native range.

Since the distribution range of M. vimineum is very similar to climates in the EPPO region, it is considered that the species could establish further and a detailed mapping is not necessary.

Where climate change is expected to decrease precipitation and soil moisture availability, *M. vimineum* invasion may become less likely, unless irrigation becomes more frequent. Where climate change is expected to raise temperatures without decreasing soil moisture, *M. vimineum* invasion may be facilitated. *M. vimineum* has invaded areas of the USA subject to frequent intense precipitation events such as hurricanes. Therefore increased precipitation intensity should not decrease likelihood of *M. vimineum* establishment, but may enhance the spread and establishment where flooding disturbance is becoming more common.

Other abiotic factors

3.12 - Based on the area suitable for establishment already identified, how similar are other abiotic factors that would affect pest establishment to those in the current area of distribution?

Largely similar

Level of uncertainty: low

M. vimineum occurs a wide variety of abiotic conditions but is limited at very low soil moisture and light conditions. Adequate abiotic conditions for *M. vimineum* establishment are present throughout most of the EPPO region. Abiotic factors are largely similar to invaded countries such as the USA and Turkey as well as the native range.

Competition and natural enemies

3.13 Based on the area of potential establishment, how likely is it that establishment will occur despite competition from existing species, and/or despite natural enemies already present?

Very likely

***Level of uncertainty*: low**

M. vimineum can co-occur with a diverse and abundant established native and alien plant (Flory *et al*., 2011c).

Although a wide variety of fungi and arthropod species are reported for the genus *Microstegium* (Zheng *et al.*, 2006; Farr & Rossman, 2014) (see Table 1 and 2), *Bipolaris* spp. have been found on *M. vimineum* in the USA (Klecweski *et al*., 2011, and some of these species occur in the EPPO region, the extent to which pathogens limit *M. vimineum* populations is unknown. While the ability of these organisms to suppress *M. vimineum* populations remains unknown, during invasion in North America, native fungi have switch host on *M. vimineum* and reduced fecundity (Flory *et al*., 2011a) and new species have been found, and the same could happen in the EPPO region.

Natural enemy	**Type**	**Life stages**	**Specificity**
Lethe confusa	Herbivore	*Adults*	*to genus*
Lethe europa	Herbivore	*Adults*	*to genus*
Melanitis phedima	Herbivore	*Adults*	*to genus*
Phyllachora ischaemi	Pathogen	Adults	to genus
Phyllachora leptotheca	Pathogen	Adults	to genus
Semiaphis montana	Herbivore	Adults	to genus
Ypthima baldus	Herbivore	Adults	to genus
Ypthima baldus zodina	Herbivore		

Table 1: Natural enemies reported on the genus *Microstegium* in China, with their type, the life stage at which *Microstegium* is under attack and the specificty of the ennemy. From Zheng *et al*., 2006.

Species

Balansia andropogonis: China and Taiwan
Bipolaris cynodontis: USA
Bipolaris microstegii: USA
Bipolaris sorokiniana: USA
Bipolaris sp.: USA
Cerebella paspali - (*Cerebella andropogonis*): China and Taiwan
Colletotrichum graminicola: Australia
Curvularia lunata: USA
Ephelis oryzae - (*Ephelis pallida*): India
Franzpetrakia microstegii: India, South Asia, Thailand
Meliola setariae: China
Phakopsora incompleta: China, Nepal, Papua New Guinea, Japan,
Phakopsora malloti: Taiwan
Phyllachora leptotheca: China, Japan
Phyllachora microstegii: China, Waiwan
Physopella clemensiae: Taiwan
Pleurovularia polliniae: Taiwan
Puccinia aestivalis: Taiwan, Japan, China, Papua New Guinea, Pakistan
Puccinia benguetensis: USSR, China, Taiwan
Puccinia microstegii: Taiwan
Puccinia neyraudiae: China
Puccinia polliniae: Taiwan, Pakistan, China
Puccinia polliniae-imberbis: China, Japan, Taiwan,
Puccinia polliniicola: China, Japan, Taiwan
Sphacelotheca microstegii - (Sporisorium microstegii): Pakistan
Sporisorium microstegii: South Asia, China
Sporisorium murreeanum: India, Pakistan, South Asia
Uredo microstegii: Taiwan
Uredo ogaoensis: Papua New Guinea
Uredo tonkinensis: Taiwan
Ustilaginoidea polliniae: China
Ustilago microstegii - (*Sporisorium microstegii*): Pakistan

Table 2: Recorded fungi for the genus *Microstegium* and location of records, source: Farr & Rossman (2014).

The managed environment

3.14 - How favourable for establishment is the managed environment in the area of potential establishment?

Highly favourable

Level of uncertainty: low

The management activities in Q. 3.06 are all present in the EPPO region. Particular attention may need to be paid on irrigation activities in EPPO countries which otherwise would be too dry to support *M. vimineum* invasion. The management environment in the EPPO region is highly similar to other areas where *M. vimineum* occurs.

3.15 - How likely is the pest to establish despite existing pest management practice?

Very likely

Level of uncertainty: low

No current existing management practices for other pests are likely to exclude *M. vimineum*, it is therefore very likely to establish.

<u>Other characteristics of the pest affecting the probability of establishment</u>

3.17 - How likely are the reproductive strategy of the pest and the duration of its life cycle to aid establishment?

Very likely

Level of uncertainty: low

Can the pest exhibit parthenogenesis (for invertebrates) /self-crossing or vegetative propagation (for plants)/ asexual reproduction (for pathogens) or self fertility?	● Yes ● No
Does the pest have a short life cycle (relative to other organisms in its niche) and more than one generation (or many generations per year)?	● Yes ● No
Does the pest have a "resting" stage during its life cycle that can be used to survive unsuitable environmental conditions? Or other conditions exist that enhance survival (survival in seeds)	● Yes ● No
Does the pest have a high intrinsic rate of increase?	● Yes ● No
Does the pest have prolific seed production?	● Yes ● No
Can the pest create a persistent seed bank or offspring bank?	● Yes

	● No
Could a relatively low number of individuals or low inoculums be able to start a population? For answering this question, also consider that Allee effects, competition and natural enemies may prevent the start of a population, if only a small number of individuals are present.	● Yes ● No

It has a high degree of phenotypic plasticity, self-fertilization, an annual life history with persistent seed bank and high seed production in dense stands (Claridge & Franklin, 2002; Droste *et al*., 2010; Gibson *et al.*, 2002; Horton & Neufeld, 1998). Individual plants can produce thousands of seeds (Wilson et al., 2014), resulting in an estimated 0.1–4 million seeds per m² (Barden, 1996; Cheplick, 2006; Gibson *et al.*, 2002; Judge *et al.*, 2005). However, flowering and seed production vary considerably, between years and across populations (Gibson *et al.* 2002).

Microstegium vimineum produces both cleistogamous (closed, self-fertilizing) and chasmogamous (open, outcrossing) flowers, and the proportion of chasmogamous seeds appear to increase with greater light (Cheplick, 2006). This provides the plant the ability to both reproduce when the gene pool is narrow and facultatively outcross. In the eastern USA, *M. vimineum* germinates in early-to-mid spring (depending on latitude) and reaches full growth potential until mid to late summer when it can reach 2 m in length and eventually produce numerous seeds in autumn (Barden, 1987; Hunt & Zaremba, 1992; Redman, 1995).

Seeds are dispersed by water, animals, and through human activities on clothing and vehicles. Seeds in the soil may remain viable for 5 years (Barden, 1987). Seeds require 90 days dormancy but not necessarily cold stratification (Judge, 2005). *M. vimineum* relies entirely on its seed bank for its annual recruitment.

M. vimineum is a short day flowering plant. It has tightly matched its critical day-length period to maximise its growing season at each latitude (Novy *et al*., 2013).

3.18 - Is the pest highly adaptable?
Yes, highly or very highly adaptable
Level of uncertainty: low

Microstegium vimineum exhibits adaptability through its biotypes, the environements and climates it thrives in and its seed production strategy.

Biotypes
It has been shown that *M. vimineum* has evolved specific critical day length periods (i.e. amount of time inducing flowering) which induce flowering during invasion in North-America (Novy *et al.*, 2013). This phenomenon demonstrates that the species posseses the ability, even under putative founder effects (Novy *et al.*, 2012), to create novel genotypes adapted to a new range in short times periods.

Adaptability to different environments
M. vimineum can occur in different environments (CABI, 2014). It can tolerate low-light environments with sufficient soil nutrients and moisture (Apsley & Smith, 2011). *M. vimineum* shows extreme plasticity in morphology, producing flowers and under a wide

range of habitat and light conditions (Fryer, 2011; Flory *et al*., 2011b, c).
M. vimineum is able to colonize a variety of habitats from mesic forests to managed utility right of ways.

Adaptability to climate
M. vimineum is present in at least 4 different Koppen-Geiger climate zones (Kottek *et al*., 2006), from equatorial climates to warm temperate climates (see Q 3.03).

Adaptability of the seed production
M. vimineum's mixed cleistogamous/chasmogamous mating system allows for the near fixation of fit genotypes at a given location while still promoting limited outcrossing, leading to opportunities for evolution and dispersal (Novy *et al*., 2013).

3.19 - How widely has the pest established in new areas outside its original area of distribution? (specify the instances, if possible; note that if the original area is not known, answer the question only based on the countries/continents where it is known to occur)
Widely
Level of uncertainty: low
M. vimineum established in Nearctic and Neotropic realms (see distribution).

3.20 - The overall probability of establishment should be described.
Very high
Level of uncertainty: low

Given access to suitable habitats via its most frequent pathways, it is highly likely that *M. vimineum* will establish and spread within the EPPO region (it already established and spread in Turkey since 1997).
Within the EPPO region, large areas exist where there is a confluence of suitable habitats, climate, abiotic factors and land management regimes (including transport infrastructure). Furthermore, *M. vimineum* has shown the ability to adapt rapidly to novel climates and increase its range (i.e. in the USA).

The countries considered most at risk are: Austria, Azerbaijan, Belgium, Bosnia & Herzegovina, Bulgaria, Czech Republic, Croatia, Denmark, Former Yugoslav Republic of Macedonia, France, Georgia, Germany, Hungary, Ireland, Italy (in particular northern and adriatic parts of the country), Kazakshtan, Moldova, Poland, Slovakia, Slovenia, Switzerland, the United Kingdom, Northern Spain, Northern Turkey, the Netherlands, Romania, Serbia, the coastal area of Norway, the coastal area of Sweden, southern areas in Ukraine, the Black Sea coast and southern in Russia.

Only irrigated or wet areas would be considered suitable in the following countries: Algeria, Cyprus, Jordan, Greece, Israel, Kyrgyzystan, Portugal, Morocco, Tunisia, Uzbekistan, southern Spain, southern Italy, southern and central parts of Turkey.

Other countries including Estonia, Finland, Latvia, Lithuania, Russia, Ukraine, the northern parts of Norway and Sweden may be too cold for the species to establish. Neverthelesss, the warmest parts of these countries may be suitable, considering that *M. vimineum* occurs in Kedrovaya pad (Siberia) in Russia.

Stage 2: Pest Risk Assessment Section B: Conclusion of introduction

c1 - Conclusion on the probability of introduction.

There are amples pathways and suitable habtiats and climates present in the EPPO region for the entry and establishment of *M. vimineum*.

The overall probability of entry is considered as likely:
Pathway1: As a contaminant of used machinery: likely
Pathway2: As a contaminant of bird seed: moderately likely
Pathway3: As a contaminant of soil: unlikely
Pathway 4: As a contaminant of growing media adherent to plants for planting: moderately likely
Pathway 5: As a contaminant of travellers, their clothes and shoes: moderately likely

Furthermore, it has established and spread in Turkey since 1997. Given the high volume of trade in between the EPPO countries and the USA and China (which both have abundant populations of *M. vimineum*), further introduction are likely with medium uncertainty.

Stage 2: Pest Risk Assessment Section B: Probability of spread

Spread is defined as the expansion of the geographical distribution of a pest within an area. Spread potential is an important element in determining how quickly impact is expressed and how readily a pest can be contained. In the case of intentionally imported plants, the assessment of spread concerns spread from the intended habitat or the intended use to an unintended habitat, where the pest may establish. Further spread may then occur to other unintended habitats. The nature and extent of the intended habitat and the nature and amount of the intended use in that habitat will also influence the probability of spread. Some pests may not have injurious effects on plants immediately after they establish, and in particular may only spread after a certain time. In assessing the probability of spread, this should be considered, based on evidence of such behaviour.

In the PRATIQUE project, spread modules have been investigated. To decide whether it is appropriate to try to use these modules, please follow this link "quantitative spread module" (only available when online)

4 .01 - What is the most likely rate of spread by natural means (in the PRA area)?

Medium rate of spread

Level of uncertainty: medium

M. vimineum can be dispersed by natural water flow event, floods events and potentially by animals, such as deer in the USA (Williams *et al*., 2008 in Gage *et al*., 2010). The fruits which may be contained in senesced *M. vimineum* can float and disperse throughout an entire wetland or alluvial floodplain during high-water events (Mehrhoff, 2000).
Riparian areas are found throught the EPPO region (see Q. 3.01) and flooding events are frequent in the EPPO region (see Figure 10).

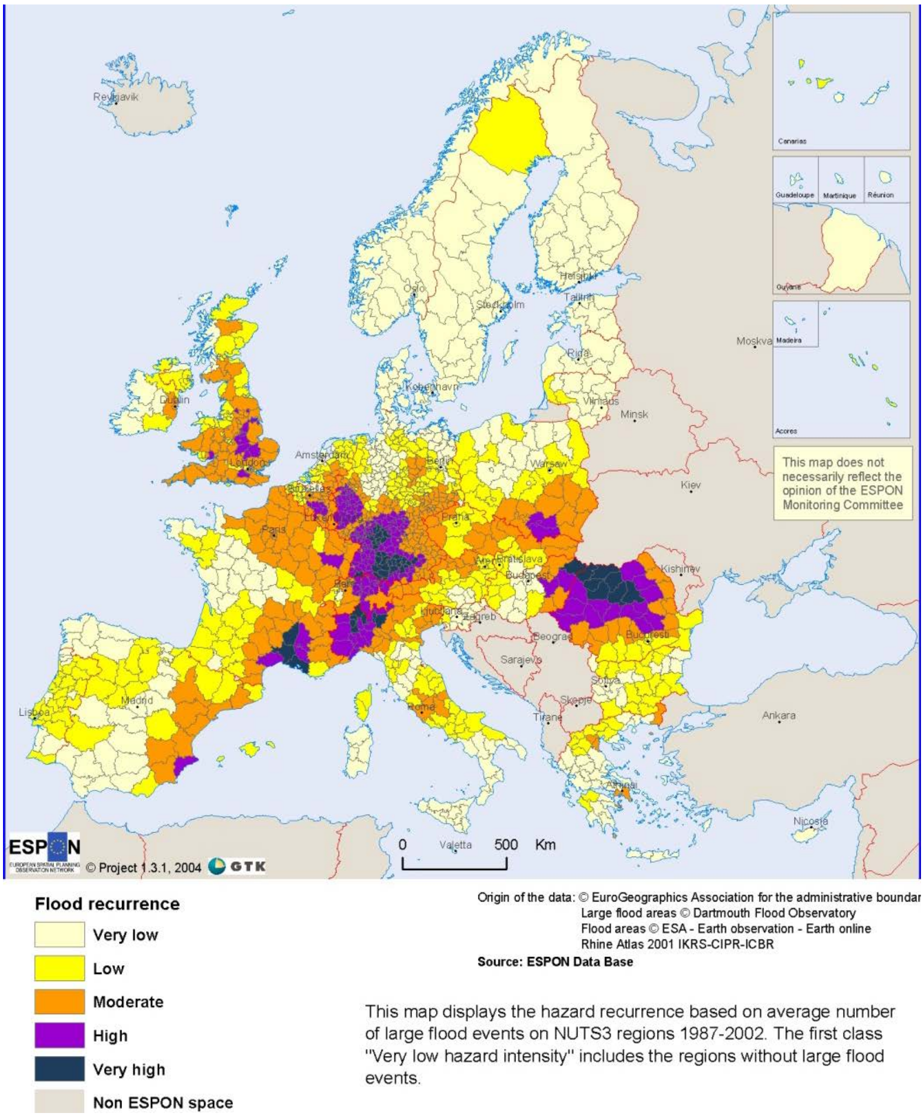


Figure 10. Flood occurences in Europe.

4.02 - What is the most likely rate of spread by human assistance (in the PRA area)?

High rate of spread

Level of uncertainty: low

Plants and seeds of *M. vimineum* may be carried by many different human-mediated vectors. Humans are the most important vector for long-distance dispersal and new introductions. Some human associated vectors are: clothing, boot or shoe treads, pets, horse hooves, car and bicycle tires, mowing equipment, canoes, logging or agricultural machinery, construction crews, road graders, soil or mulch transport and the creation of fire breaks (Evans, 2006; Mehrhoff, 2010 in Gage, 2010), but it does not appear to have any clear adaptations to assist in seed dispersal. Anecdotally, invasion in North America is thought to have begun due to human transport of seed in grass packing material in ceramics from China (Dorman, 2008).

Spread rates were also determined to be higher in roadsides than in forested and wetland patches, even in the absence of major disturbances. Roads therefore appear to be playing an important role in facilitating the movement of *M. vimineum* through forests, and this includes maintenance and water movement associated with forest roads (Mortensen *et al*. 2009).

4.03 - Describe the overall rate of spread

High rate of spread

Level of uncertainty: low

Given the many potential natural and human-mediated pathways of spread and the rapid rate of spread in the USA, the overall rate of spread of *M. vimineum* is assessed as high.

4.04 - What is your best estimate of the time needed for the pest to reach its maximum extent in the PRA area?

***Level of uncertainty*: high**

This estimate will depend largely upon the degree and effectiveness of intervention. However, some idea can be gained of unimpeded spread from the history of spread of *M. vimineum* elsewhere in its introduced range (see 4.02).

M. vimineum was introduced into the USA in between the end of the 19th century and beggining of the 20th century. By the 1970s it had naturalized in most of the eastern USA and then by 2000 it had become a serious invasive pest in more than 25 states. Its range in the USA continues to expand.

Considering that this species is already present in Turkey, it has the potential to be significantly present in the EPPO region on the order of decades and reach maximum extent on the order of one century or two.

4.05 - Based on your responses to questions 4.01, 4.02, and 4.04 while taking into account any current presence of the pest, what proportion of the area of potential establishment do you expect to have been invaded by the organism after 5 year-term?

Level of uncertainty: high

Considering the current distribution of *M. vimineum* in Turkey and the probability of further introductions from outside the EPPO region, the proportion of the area of potential establishment is expected to be less than 1% as spread follows an exponential pattern and is expected to be slow at the start of the invasion process.

Immediate eradication effort in Turkey and preventive measures to prevent further introduction should drastically reduce the rate of spread in the EPPO region.

Stage 2: Pest Risk Assessment Section B: Eradication, containment of the pest and transient populations

5.01 - Based on its biological characteristics, how likely is it that the pest could survive eradication programmes in the area of potential establishment?

Moderately likely

Level of uncertainty: low

M. vimineum is realtively easy to identify but in the USA, *M. vimineum* has been confused with *Leersia* species, *Dicanthelium* spp., *Elymus* spp., *Oplismenus* spp., *Panicum* spp. and *Polygonum* spp.. In Turkey, it has also been mistaken with *Oplismenus* species.

Identification of the species and monitoring is therefore a limiting factor in effective eradication.

M. vimineum is relatievely easy to manage on a per plant or peer area basis, especially early in the invasion process as it responds to herbicide and does not reproduce vegetatively. However, because invasions can spread rapidly and cover large areas and because a seed bank is present, management becomes more difficult as invasion progresses.

In order to locally control this annual, seed-banking plant, repeated annual efforts must be made to prevent flowering and seed set until the seed bank is exhausted. Most control methods will need to be repeated for at least a few growing seasons, since control is rarely 100% effective and the seed of *M. vimineum* may remain viable in the soil for up to 5 years (Barden, 1987).

Although many control techniques have been attempted with varying levels of success, there are few cost-effective control methods that have minimal impact on native plant populations. Grass specific herbicides are highly effective and cause minimal damage to native species – but they are expensive (Flory & Clay, 2009). Manual and mechanical, environmental/cultural, and chemical methods are all useful to varying degrees in controlling *M. vimineum*. Prescribed burns have not been successful in controlling this species so far and may in fact exacerbate invasion. *M. vimineum* produces a large number of viable seed that can remain in the soil seed bank for several years. If controlled during the early stages of invasion, the potential for successful management is high.

For example, in Florida (USA), a 7 hectare invasion was almost completely removed during a single year of management using post-emergent herbicide at a cost of approximately 430€/hectare (Brian Pelc, the Nature Conservancy, pers. comm., 2014).

5.02 - Based on its biological characteristics, how likely is it that the pest will not be contained in case of an outbreak within the PRA area?

Likely

Level of uncertainty: medium

Due to the difficulty of identifying *M. vimineum* in the field, the high propagule pressure and the numerous spread pathways, it is unlikely that it can be contained in case of an outbreak, despite the fact that small infestations are relatively easy to manage.

5.03 - Are transient populations likely to occur in the PRA area through natural migration or entry through man's activities (including intentional release into the environment) or spread from established populations?

Level of uncertainty: high

Because of the biological characteristics of *M. vimineum*, the majority of populations could be self-sustaining, although at the limits of the climatic range, some populations may be transient.

Stage 2: Pest Risk Assessment Section B: Assessment of potential economic consequences

6.01A – Are there any socio-economic benefits described for the organism in the PRA area?

No

There are no known socio-economic benefits associated with *M. vimineum* within the PRA area. The species is not traded within horticulture and has no economic benefits in any known sector.

6.01 - How great a negative effect does the pest have on crop yield and/or quality of cultivated plants or on control costs within its current area of distribution?

Moderate

Level of uncertainty: high

M. vimineum is not currently considered an agronomic weed. However, extensive invasion occur in economically managed hardwood and pine forests in the USA and there is evidence that invasions can reduce natural tree regeneration (Flory & Clay, 2010; Oswalt *et al*., 2007). Invasions may also increase fire intensivities and further reduce survival of tree seedlings (L Flory, pers. comm., 2014). It is unknown if documented reductions in tree seedlings survival are sufficient to affect stand-level dynamics.

In addition, there are reports of *M. vimineum* invasions in lawns and gardens, however control costs would be similar as for other minor weeds.

Differential effects on tree species may inhibit succession and cause a shift in forest community composition over time (Flory & Clay, 2010). The effect of invasion by *M. vimineum* on different tree life history stages was studied in a long-term experiment in Indiana. A subset of plots in a blocked design where either tree saplings were planted or tree seeds sown. Seeds were planted to simulate old-field succession, while planted saplings simulated later successional stages. Some tree saplings showed higher mortality in invaded plots, and recruitment was more than four times greater than in invaded plots. Greater impact was observed for early successional simulations, particularly for small seeded tree species. Invasion had no significant effect on large seeded tree species [oaks or hickories], although there was a trend for decreased survival of *Quercus palustris* (pin oak), *Quercus alba* (white oak), and *Quercus macrocarpa* (bur oak). The number of small seeded tree species, *Liquidambar styraciflua* (sweetgum), *Liriodendron tulipifera* (tulip poplar), and *Fraxinus pennsylvanica* (green ash) decreased in invaded plots (Flory, 2010). This effect was dramatic for *Liquidambar styraciflua*, in contrast with the results of Wright (Wright, 2010), where *M. vimineum* leaf-leachate increased germination of this species. Additionally, a survey of invaded areas found reduced natural regeneration for *Acer negundo* (boxelder), *Acer rubrum* (red maple) and *Lindera benoin* (spicebush) (Flory & Clay, 2010). However, removal of *M. vimineum* using grass specific heerbicides significantly increases natural tree recruitment, including species of economic important (Flory & Clay, 2009).

Though no reliable estimate exist, expanses associated with detection, monitoring and treatment of *M. vimineum* invasions are considerable.

6.02 - How great a negative effect is the pest likely to have on crop yield and/or quality of cultivated plants in the PRA area without any control measures?

Minimal

Level of uncertainty: high

M. vimineum has the potential to reduce tree recruitement in forest stands in the EPPO region, but its overall impact on commercial forestry is unknown. It is unlikely to affect timber volume.

6.03 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area without any additional control measures?

Minimal

Level of uncertainty: high

Current control measures are not likely to affect *M. vimineum*, so the impacts would be the same (see Q. 6.02).

6.04 - How great a negative effect is the pest likely to have on yield and/or quality of cultivated plants in the PRA area when all potential measures legally available to the producer are applied, without phytosanitary measures?

Moderate

Level of uncertainty: high

Detection, monitoring and treatment costs may be substantial, in particular in forestry systems that rely on natural recruitment. However there is no specific information available on economic impacts.

6.05 - How great an increase in production costs (including control costs) is likely to be caused by the pest in the PRA area in the absence of phytosanitary measures?

Moderate

Level of uncertainty: high

Detection, monitoring and treatment costs may be substantial, in particular in forestry systems that rely on natural recruitment. However there is no specific information available on economic impacts for this species.

Cost in mitigating the environmental impact in natural forests could be significant.

6.06 - Based on the total market, i.e. the size of the domestic market plus any export market, for the plants and plant product(s) at risk, what will be the likely impact of a loss in export markets, e.g. as a result of trading partners imposing export bans from the PRA area?

Minimal

Level of uncertainty: high

The only agricultural product that could be at risk is timber, which has not been identified as a pathway of entry for *M. vimineum*.

The other potential export market might be bird seed or plants for planting with adherent soil, but a potential ban is unlikely as it is currently unregulated.

The impact on the loss of export market is considered to be minimal.

6.07 - To what extent will direct impacts be borne by producers?

No judgement possible

Level of uncertainty: high

There are potential costs to producers for detection, monitoring and treatment and there might be impacts on tree regerenation but these costs are not currently available. The producer has no power to increase the cost of the timber and it is unlikely that such costs could be borne by the consumer.

Environmental impact

6.08.0A - Do you consider that the question on the environmental impact caused by the pest within its current area of invasion can be answered? (Read the note)

Yes

Data on environmental impacts are available from the USA.

6.08.01 - To what extent does the plant cause a decline in native species populations and changes in communities of native species?

High extent

Level of uncertainty: low

M. vimineum threatens native understory vegetation in full sun to deep shade. It readily invades disturbed shaded areas, like floodplains that are prone to natural scouring, and areas subject to mowing, tilling and other soil-disturbing activities including white-tailed deer traffic. It spreads opportunistically following disturbance to form dense patches, displacing native wetland and forest vegetation as the patch expands (Swearingen *et. al.*, 2010). Invasions of *Microstegium* can quickly crowd out native species resulting in significant reductions in herbaceous species productivity and diversity. Invasions can also reduce tree regeneration and alter the growth of trees.

<u>Impact on plant diversity</u>
M. vimineum changes plant community richness (number of species), plant diversity, and overall groundcover, out-competing other species (Flory & Clay 2010a, b; Adams & Engelhardt, 2009; Meiners, 2010). It may impact native species through multiple mechanisms including competitive exclusion, changing soil properties, reducing light availability, and increasing native consumer activity.

Example 1: changes of vegetation over time
Experimental plots were located in the Piedmont region of New Jersey, and plots encompassed 1 m^2 of young forest habitat. The plot with the longest history of invasion (6 years) had 70 % *M. vimineum* cover, while other, later invasions are quickly expanding at 20 – 40 % cover. High levels of invasion caused the loss of two species, on average, while low levels of invasion caused the loss of approximately one species in experimental plots, when comparing invaded to uninvaded plots. The loss of natives represents a significant impact at such a small scale of measurement. Plant diversity follows the same patterns (Meiners, 2010).

Example 2: impact on diversity and species richness
A long-term Indiana study showed similar decreases in native plant diversity and productivity, where *M. vimineum* was randomly applied to a subset of plots after establishment of 9 tree species and 12 herbaceous species. After three years, native biomass was still lower in invaded plots, with up to 64 % reduction. Diversity was 38 % lower and richness 43 % lower in invaded plots. Community divergence in invaded vs. uninvaded plots was shown using non metric multidimensional scaling ordination (Flory & Clay, 2010a).

Example 3: experimental removal
To evaluate the response of native species to *M. vimineum* invasion, multiple methods (pre and post emergent herbicide and hand weeding) were used to experimentally remove *M. vimineum* from replicated plots across eight sites in southern Indiana that varied in habitat and environmental conditions (Flory & Clay, 2009). Native plant communities responded positively to invasive removal; native community diversity was 24% greater when the invasion was removed with handweeding and 21% greater with post-emergent herbicide compared to reference plots, suggesting the invasion had been suppressing native species.

For information on effects on tree regeneration and succession, see Q 6.08.05.

<u>Impact on growth performance of individual species</u>
An experiment has been conducted in glasshouse to determine whether *M. vimineum* would have effects on planted plots of *Senna hebecarpa*. It appeared that *M. vimineum* invaded plots had 74% fewer *S. hebecarpa* plants, and *S hebecarpa* growing in invaded plots were 21% shorter and weighted 64% less than in control plots. The proportion of *S. hebecarpa* plants

that reproduced was 67% lower and plants produced 78% fewer seeds on average in invaded than in control plots (Bauer & Flory, 2011).

Change in vegetation structure
The amount of vole damage to trees is more than 125% greater in invaded than uninvaded areas. In addition, senesced *M. vimineum* is slow to decompose, resulting in a dense mat that can inhibit native species.
Established populations of *M. vimineum* usurp quality nesting habitat from quail and other wildlife. In addition, it creates excellent habitat for rats, especially cotton rats (*Sigmodon* spp.), that often prey on the nests of native bobwhite quail and attract other predators as well (A. Houston, pers. comm.) (Tu, 2000).

Impacts on arthropods and animal communities
Microstegium invasion has cascading ecological effects on the arthropod community. The arthropod community was sampled in invaded and uninvaded plots on two dates, June and September. Invaded plots showed a 19 % decrease in arthropod richness and a 39 % decrease in arthropod abundance. Abundance and diversity of carnivores and herbivores arthropods was reduced, although the effect was much larger on carnivores (Flory, 2010; Simao *et al.*, 2010).

Baiser *et al*. (2008) found that the species altered forest food webs in New Jersey forests during the period of 1980-2005, specifically via reduction of breeding woodland birds, due to the plant invasion's alteration of sub-canopy community structure. Interestingly, this food web effect resulted from an interaction with white-tailed deer (*Odocoileus virginianus*) after predator release led to deer overbrowsing and thus habitat creation for *M. vimineum*.

On the other hand, in a study which was conducted by Marshal (2007) in areas with *M. vimineum*, there were significantly more insects collected than in areas without *M. vimineum*. These increases in abundance likely resulted from 2.5 times greater plant cover due to the addition of *M. vimineum* to the plant communities. However, it should be noted that focusing on a single taxonomic group, such as insects, might not provide an adequate measure of exotic species impacts.

See Appendix 3 for pictures.

6.08.02 - To what extent does the plant hybridize with native species?

Low extent

Level of uncertainty: low

There is no evidence of hybridisation of *M. vimineum* with any native species in its exotic range.

Alteration of ecosystem patterns and processes

6.08.03 - To what extent does the plant cause physical modifications of habitats (e.g. changes to the hydrology, significant increase of water turbidity, light interception, alteration of river banks, changes in fire regime, etc.)?

Medium extent

Level of uncertainty: low

M. vimineum invasion poses a serious threat to ecosystems through changes in light availability, decomposition rates, and alteration of fire behavior and carbon storage.

Light availability

M. vimineum may affect native plant and animal species by altering environmental conditions such as light availability. In an experimental field study, thatch biomass was over 120% greater in invaded plots than in control plots when measured in early spring. In addition, significantly more light reached ground level in the invaded plots than in control plots in June, but this pattern was reversed in September with more light reaching ground level in control plots than in invaded plots (Flory and Clay, 2010b)

Decomposition

Multiple studies have shown that *M. vimineum* decomposes at slower rates than co-occurring native species. Demeester & Richter (2010) showed that *M. vimineum*-invaded plots accumulated approximately half the annual N biomass of the diverse community where *M. vimineum* had been removed. In addition, decomposition and release of N from *M. vimineum* detritus was much less than in the uninvaded community. In another study, in contrast, *M. vimineum* litter decomposed more slowly than the native species' litter, and it immobilized N (Ehrenfeld *et al.* 2001).

Fire intensity and effects

Flory *et al.* (2012) showed that maximum fire temperatures were on average 57% greater in *M. vimineum* invaded sites compared to uninvaded control areas. In addition, fires burned at temperatures over 300 °C for nearly twice as long and flame heights were 98% higher in invaded compared to uninvaded habitats. *M. vimineum* invasion reduced survival of experimental trees by 37% in areas exposed to prescribed fire compared to uninvaded areas and tree survival in invaded, burned plots was 53% lower than invaded, unburned plots. Exposure to prescribed fire increased natural tree regeneration overall but there were 60% and 57% fewer tree seedlings in burned and unburned invaded plots, respectively, compared to control plots with the same treatments. Prescribed fire increased *M. vimineum* biomass by five-fold the following growing season.

Soil carbon

Multiple studies have shown that *M. vimineum* can alter soil carbon cycling. For example, Strickland *et al.* (2011) evaluated soil carbon at *M. vimineum* invaded and nearby uninvaded areas across eight sites in the southeast US. They found significant declines in mass of faster-cycling particulate organic matter carbon pools, which resulted in an 11% decline in native derived carbon in the top 10cm of the soil profile. Carbon added by *M. vimineum* partially offset those effects, resulting in a net carbon loss of about 6%. Their results suggest that invasions of *M. vimineum* may cause faster carbon cycling in invaded forests and result in an overall loss of soil carbon. Also see Strickland *et al.* 2010.

6.08.04 - To what extent does the plant cause changes to nutrient cycling and availability (e.g. significant changes in nutrient pools in topsoils or in water)?

Medium extent

Level of uncertainty: medium

M. vimineum has been shown to cause changes to nutrient cycling and availability, however the ultimate ecosystem impact remains unknown.

Changes in nitrogen cycling

M. vimineum alters soil conditions to benefit itself by increasing pH, nitrifiction and nitrates, which also prevents the original natives from re-establishing (Lee *et al*., 2012; Fraterrigo *et al*., 2011). In a study, Lee *et. al.* (2012) proved that *M. vimineum* promotes nitrification rates in invaded soil, and suggest that monocultures of invasions are maintained by high soil nitrate concentrations. Such positive plant–soil feedbacks due to microbially mediated nutrient transformations and nutrient availability may be an underappreciated mechanism supporting the persistence of plant invasions. Ehrenfeld *et al.* (2001) found that *M. vimineum* invasion increased nitrogen mineralization rates and higher nitrification rates in northern New Jersey.

Changes in soil properties

M. vimineum may be responsible for altering natural soil conditions, creating an inhospitable environment for many native species. Kourtev *et al*. (1998) reported that in areas that have been invaded by *M. vimineum*, both litter and organic soil horizons were thinner than in uninvaded areas, and that the pH of soils in invaded sites was significantly higher than in uninvaded sites (Ehrenfeld *et al*., 2001).

6.08.05 - To what extent does the plant cause modifications of natural successions (e.g. acceleration or temporary freezing of successions)?

Medium extent

Level of uncertainty: medium

Once established, *M. vimineum* is able to crowd out native herbaceous vegetation in wetlands and forests within three to five years (Hunt, 1992; Barden, 1987). Oswalt *et al*. (2007) hypothesized that *M. vimineum* competes with regeneration of native woody plants. In a post-disturbance Tennessee forest understory, they determined that total native woody species stems per hectare declined with increasing *M. vimineum* cover ($p < 0.001$, r2 = 0.80), as did simple species richness of native woody species ($p = 0.0023$, r2 = 0.47).

Flory & Clay (2010b) tested the effects of *M. vimineum* on planted and naturally regenerating trees in a multi-year field experiment. *M. vimineum* invasion had an overall negative effect on small-seeded species driven primarily by the effect on *Liquidambar* spp., the most abundant small-seeded species, but did not affect large-seeded species such as *Carya* spp. and *Quercus* spp., which have more stored seed resources. Natural regeneration was over 400% greater in control than invaded plots for *Acer negundo*, *Acer rubrum*, and *Lindera benzoin*, and *Acer negundo* seedlings were 58% smaller in invaded plots. In contrast to the effects on tree seedlings, invasion did not affect tree sapling survival or growth. *M. vimineum* may be directly reducing tree regeneration through competition.

In a removal study, the density of native tree seedlings was 123% greater in post-emergent herbicide treated plots than in untreated plots, indicating that the invasion was inhibiting tree recruitment (Flory & Clay, 2009).

Marshall & Buckley (2009) evaluated the growth and survival of *Acer rubrum*, *Liriodendron tulipifera*, and *Quercus rubra* first-year seedlings in plots with and without *M. vimineum* in three planting beds under 50 percent shade. The tree species studied are abundant and of particular interest in the Central Hardwood Region of the US. *A. rubrum* and *L. tulipifera* seedlings experienced reduced growth due to the invasion. *Q. rubra* did not exhibit any differences between plots with and without *M. vimineum*, however there was a reduction in *Q. rubra* performance as a result of the presence of *M. vimineum*. The differential responses of *A. rubrum*, *L. tulipifera*, and *Q. rubra* to the presence of *M. vimineum* support the hypothesis that effects of this invasion will vary across tree species. As a result of *M. vimineum* effects on the growth of *A. rubrum* and *L. tulipifera* the rate at which seedlings of these species are recruited into larger size classes may be reduced.

6.08.06 - To what extent does the plant disrupt trophic and mutualistic interactions (e.g. through the alteration of pollinator visitations - leading to a decrease in the reproductive success of native species-, allelopathic interactions, strong reduction of phytophagous or saprophagous communities, etc.)?

Medium extent

Level of uncertainty: high

There are few studies specifically examining *M. vimineum* in trophic and mutualistic processes. However it was studied, changes in arthropod communities were observed (Simar *et al*., 200X). While impacts on pollinators has not been studied, in its invasive range in North America *M. vimineum* displaces large amounts of vegetation. Such impacts could indirectly decrease food sources for pollinators.

M. vimineum leaf-leachate has phytotoxic effects. Allelopathic potential (general inhibitory effects on growth of other plants) of *M. vimineum* was tested on radish seeds using tea made from known amounts of plant tissue. Germination decreases with increasing concentration of extract. Plants with previously known allelopathic effects, *Alliara petiolata* (garlic mustard), *Ailanthus altissima* (tree of heaven), and *Solidago* spp. (goldenrod), had similar effects on germination, although *M. vimineum* was less toxic than *Solidago* spp. (Meiners, 2010; Pisula & Meiners, 2010). However, other studies have found no effect of *M. vimineum* leaf infusion on black radish germination (Woods, 1989).

Allelopathy of *Microstegium* may reduce density of some species of tree seedlings. Studies have shown lower tree seedling densities in invaded plots (DeMeester & Richter, 2010; Flory & Clay, 2009), though tree species begin to emerge following *M. vimineum* removal. The mechanisms behind the suggested inhibition then documented re-emergence may be difficult to discern, possibly related to increased light levels, exposure of mineral soils, or removal of chemical inhibition due to plant secondary compounds. Allelopathy of *M. vimineum* leaf-leachate, was tested on the germination of *Liquidambar styraciflua* (sweetgum), *Ailanthus altissima* (tree of heaven), and *Acer negundo* (boxelder). Treated seeds of *Ailanthus altissima* showed decreased germination, while germination of *Liquidambar styraciflua* increased (Gage *et. al*., 2010). However, no record of field studies was found.

Conservation impacts

6.08.07 - To what extent does the plant occur in habitats of high conservation value (includes all officially protected nature conservation habitats)?

High extent

Level of uncertainty: low

M. vimineum occurs in national parks, national wildlife refugees and management areas, national forests, state forests and state parks, Nature Conservancy properties and nature preserves in the USA. For example, it has been observed Great Swamp National Wildlife Management Area (New Jersey), Shenandoah National Park (Virginia), Brendan Byrne State Forest (New Jersey), Torreya State Park (Florida), New Jersey Pinelands National Reserve (New Jersey), Great Smokey Mountain National Park (Tennessee), Rock Creek National Park (Washington, DC), Bear Mountain State Park (New York), Blue Ridge Parkway National

Park (North Carolina and Virginia), Patapsco Valley State Park (Maryland), in Chapman State Park (Pensylvania), etc. Also a detailed investigation of seed production was conducted at one of these populations in a secondary oak-hickory forest in Dixon Springs State Park, Illinois, USA (Gibson *et al*., 2002).

Within these protected areas, *M. vimineum* occurs in a wide variety of habitats including important conservation areas such as riparian wetland and forest habitats.

6.08.08 - To what extent does the plant threaten rare or vulnerable species (includes all species classified as rare, vulnerable or endangered in official national or regional lists within the PRA area)?

Medium extent

Level of uncertainty: high

Since M. vimineum occurs extensively in natural areas where species of conservation concern are also located, there is potential for impacts on rare or vulnerable species although there are no published studies.

As an example, *M. vimineum* has invaded vital habitat for *Trifolium stoloniferum* which is a federaly endangered species (highest level of protection in the USA) (see Figure 8).

Figure 8: *M. vimineum* encroaching on habitat of the federally endangered *Trifolium stoloniferum* in Ohio, USA. Courtesy Marjie Becus.

6.08 How important is the environmental impact by the pest within it current area of invasions?

Massive

Level of uncertainty: low

M. vimineum is listed by the US Forest Service as one of only 26 Category 1 invasive plants in the Eastern Region of the US, which are described as "Highly invasive plants which invade natural habitats and replace native species" (fs.fed.us). Furthermore, *M. vimineum* was recently ranked as the n°1 invasive plant of concern by researchers and land managers in the eastern USA (CWMA; mipn.org/cwma).

6.09.0a - Taking into account the responses to the relevant questions (on hosts and habitats, climatic conditions, abiotic factors, management methods) in the establishment section, are the conditions in the PRA area sufficiently similar to those in the area of invasion to expect a similar level of impact?

Yes

Level of uncertainty: medium

Most impacts would appear in riparian zones and temperate forests which are available in the EPPO countries at risk and therefore. Climate, spread pathways including road and trail networks, management methods (except for fires) are similar in the eastern USA and the EPPO region.

6.09.0b - Does the same native species or community, or the same threatened ecosystem services, occur in the PRA area and, if not, is it known whether the native species or communities, or ecosystem service in the PRA area are similarly and significantly susceptible?

Yes

Level of uncertainty: medium

Habitats are not the same but similar vicariant such as *Quercus* spp., *Acer* spp., *Fagus* spp. dominated temperate mesic forests and riparian and wetland habitats. Anthropogenic habitats which often serve as initial establishment points are similar in character and abundance between the eastern USA and the EPPO region.

6.09 - How important is the environmental impact likely to be in the PRA area?

Massive

Level of uncertainty: medium

In the EPPO region under suitable climatic conditions, *M. vimineum* is likely to attain high densities and to have massive impacts as observed in the eastern USA.

6.10 - How important is social damage caused by the pest within its current area of distribution?

Minor

Level of uncertainty: high

There is no record whether the plant is allergenic or toxic to animals or not. Social damage can affect workers at timber industry because of unemployment, though there is no record on this point and the EWG considered that the level of impact on forests is unlikely to reach the level to cause unemployment.

In the USA, environmental associations are paying close attention to this species and recommending changes in forestry management practices to avoid the spread of the species.

In eastern USA, aesthetic impact is reported in many natural forested areas, although unstudied this has the potential to alter people’s perception and uses of these areas.

6.11 - How important is the social damage likely to be in the PRA area?

Minor

Level of uncertainty: high

Timber industry and workers within this industry could be damaged but this remains hypothetical.

The aesthetic and ecological aspects of forest could also be impacted, as in eastern USA.

As your responses to question 6.04 and 6.05 were "major" or "massive" or any of the responses to questions 6.06, 6.09 and 6.11 is "major" or "massive" or "very likely" or

"certain", and the answers given to these questions do not have a high level of uncertainty, questions 6.12 to 6.14 are skiped.

6.15a - Describe the overall economic impact

Massive

Level of uncertainty: medium

The direct economic impacts through timber loss or loss of recreational use have not been quantified.

The environenmtal impacts in the eastern USA are massive thus the location, eradication and management of established *M. vimineum* in the EPPO region would be similarly massive.

Table 3 provides a summary of ecosystem services that may be affected by *M. vimineum.* This assessment is made for the endangered area (see Q 3.11). The different categories of ecosystem services have been taken from the Economics of Ecosystems & Biodiversity website, and from the EFSA guidance on the environmental risk assessment of plant pests (EFSA, 2011). For each ecosystem service, an assessment on a 5 grid scale (minimal, minor, moderate, major, massive) is provided, with an assessment of uncertainty (low, medium, high) and a justification. The overall impacts of *M. vimineum* on ecosystem services are considered to be massive.

Provisioning services		
Food	Minor Medium uncertainty	No report of the species being a serious agronomic weed. Though, *M. vimineum* may impact edible mushroom abundance.
Raw materials (fibres, wood, biofuels, ornamental resources).	Moderate Medium uncertainty	*M. vimineum* can impact wood production (see Q 6.01).
Biochemical, natural medicines, etc.	Minor High uncertainty	In West Virginia, *M. vimineum* had to be managed for the intercropping production in forests of ginseng (*Panax quinquefolius*) and black cohosh (*Cimicifuga racemosa*).
Fresh water	Minimal Medium uncertainty	No impacts have been reported on global hydrological cycle.
Regulating services		
Air quality regulation	Minimal Low uncertainty	No impacts have been reported on air quality regulation.
Climate regulation	Minor High uncertainty	Alteration of carbon cycling may ultimately affect the soil carbon pool. Studies have been conducted by Strickland *et al.* (2010, 2011).
Water regulation and cycling	Minimal High uncertainty	No impacts on water regulation are reported.
Soil formation	Minimal High	Soil structure may be altered but the large scale consequences are unknown (see Q. 6.08.04).

	uncertainty	
Erosion regulation	Minimal High uncertainty	This is a very weak rooted annual that may displace species more able to stabilize soils.
Nutrient cycling	Moderate Medium uncertainty	*M. vimineum* changes nutrient cycling (see Q 6.08.04).
Photosynthesis and primary production	Minor High uncertainty	There is evidence that M. vimineum can suppress native species but the consequences on net primary productivity are unknown.
Pest and disease regulation	Minimal High uncertainty	*M. vimineum* hosts pests and diseases which can be problematic on agronomic species however it is usually not the exclusive host (see Q. 6.01). It has been shown to suppress adult tick survival in the USA but with unknown consequences for tick borne illnesses (Civitello *et al*., 2008).
Pollination	Moderate High uncertainty	Invasion of *M. vimineum* would result in decrease in antive species which provide services to pollinators (see Q. 6.01 and 6.08.06).
Habitat or supporting services		
Habitats for species	Massive Low uncertainty	*M. vimineum* has the capacity to massively alter native plant communities adundance and composition with potential conseqeuces for small mammals, birds and arthropods (see Q 6.08.01 and Q 6.08.07).
Maintenance of genetic diversity	Moderate High uncertainty	Genetic diversity of any species displaced by *M. vimineum* may be altered or reduced (see Q 6.08.08).
Cultural services		
Recreation and mental and physical health	Moderate High uncertainty	*M. vimineum* has the ability to drastically alter the appearance of recreational areas including forests and parks (see Q. 6.10).
Tourism	Minor High uncertainty	If it affects on the appearance of recreational areas, tourism may be affected (see Q. 6.10).
Aesthetic appreciation and inspiration for culture, art and design	Minimal High uncertainty	There are no expected affects of *M. vimineum* on culture, art and design.
Spiritual experience and sense of place	Moderate Medium uncertainty	As *M. vimineum* changes habitats and species presence, this may affect the sense of place.

Table 3: summary table of the impacts of *M. vimineum* on ecosystem services.

The overall impacts on ecosystem services is assessed as massive, primarily because of the ability to alter the abundance, diversity and composition of plant communities, including herbaceous plants and trees. There are additional known effects on nitrogen and carbon cycling, fires, decomposition and other trophic levels (e.g. arthropods and birds).

6.15b - With reference to the area of potential establishment identified in Q3.08, identify the area which at highest risk from economic, environmental and social impacts. Summarize the impact and indicate how these may change in future.
Level of uncertainty: medium

Since the suitable habitats (i.e., forests and riparian zones) are common in the potential area of establishment, all the countries previously identified are considered at risk. Uncertainty lies on where the highest impacts will occur.

The countries considered most at risk are: Austria, Azerbaijan, Belgium, Bosnia & Herzegovina, Bulgaria, Czech Republic, Croatia, Denmark, Former Yugoslav Republic of Macedonia, France, Georgia, Germany, Hungary, Ireland, Italy (in particular northern and adriatic parts of the country), Kazakshtan, Moldova, Poland, Slovakia, Slovenia, Switzerland, the United Kingdom, Northern Spain, Northern Turkey, the Netherlands, Romania, Serbia, the coastal area of Norway, the coastal area of Sweden, southern areas in Ukraine, the Black Sea coast and southern in Russia.

Only irrigated or wet areas would be considered suitable in the following countries: Algeria, Cyprus, Jordan, Greece, Israel, Kyrgyzystan, Portugal, Morocco, Tunisia, Uzbekistan, southern Spain, southern Italy, southern and central parts of Turkey.

Other countries including Estonia, Finland, Latvia, Lithuania, Russia, Ukraine, the northern parts of Norway and Sweden may be too cold for the species to establish. Neverthelesss, the warmest parts of these countries may be suitable, considering that *M. vimineum* occurs in Kedrovaya pad (Siberia) in Russia.

Climate projection suggests that the potential area of establishment of the species may increase in northern parts in the EPPO region. However areas that are expected to experience more severe drought may be at lower risk.

Stage 3: PEST RISK MANAGEMENT

Identification of the pathways

Following consideration of the pathways and potential measures, the EWG decided it would not be appropriate to recommend detailed measures for these pathways as it would not be feasible to implement measures just for this species alone. General considerations should be taken into account for the pathways under consideration where these measures should involve awareness raising, monitoring, containment and eradication measures. For most of these pathways regulation by means of horizontal measures would be more appropriate and for some, International Standards for phytosanitary measures are in preparation (Movement of growing media in association with plants for planting in international trade and International movement of used vehicles, machinery and equipment (see below)).

The Expert Working Group considered the following pathways for the introduction of *M. vimineum*:

1) Contaminant of bird seed
2) Contaminant of growing media adherent to plants for planting
3) Contaminant of used machinery
4) Contaminant of travellers, their clothes and shoes

For 1: Confirmation that the consignment is free from *Microstegium vimineum* seed should be provided by the country of origin. Surveillance and monitoring methods adopted should be specified by the exporting country.

For 2: In addition to the existing requirement for a phytosanitary certificate (PC) by the exporting country, confirmation of pest free production from country of origin should be provided. Surveillance and monitoring methods adopted should be specified by the exporting country. In certain circumstances, an additional declaration on the PC may be needed (see EPPO Standard PM 1/1(2) Use of phytosanitary certificates).

Also see:
Draft ISPM Standard: Movement of growing media in association with plants for planting in international trade (2005-004)
Standard PP 3/74(1) 'EPPO guidelines on the development of a code of conduct on horticulture and invasive alien plants' (EPPO, 2009).

For 3: Decontaminate machinery that has come into contact with populations of the plant. Raise awareness on the species, including publicity regarding its identification and its impacts to the sector in question.
Also see: Draft ISPM: International movement of used vehicles, machinery and equipment (IPPC, 2006-004).

For 4: Raise awareness in general on the movement and impacts of invasive alien plants into the EPPO region.

Existing populations within the EPPO region

Management measure would be recommended to include an integrated management plan to control existing populations. Monitoring and surveillance including early detection for countries most prone to risk.

NPPO's should facilitate collaboration with all sectors to enable early identification including education measures to promote citizen science and linking with universities, land managers and government departments.

Eradication measures should be promoted where feasible with a planned strategy to include surveillance, containment, treatment and follow-up measures to assess the success of such actions. Regional cooperation is essential to promote phytosanitary measures and information exchange in identification and management methods. Eradication may only be feasible in the initial stages of infestation. Coordination of all stakeholders is required and should be easy to achieve, especially since the distribution is limited.

Natural spread (method of spread within the EPPO region): Increase surveillance in protected areas where there is a high risk the species may invade. Monitor existing populations. NPPO's to provide land managers and stakeholders with identification guides and facilitate regional cooperation, including information on site specific studies of the plant, control techniques and management.

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Appendix 1 - EUNIS Habitat where *Microstegium vimineum* could establish

The following list summarizes the main habitats in which *M. vimineum* could occur in the EPPO region, according to the EUNIS habitats classification: http://eunis.eea.europa.eu/habitats-code-browser.jsp?

C: Inland surface waters
C3: Littoral zone of inland surface waterbodies

D: Mires, bogs and fens

E: Grasslands and lands dominated by forbs, mosses or lichens
E2: Mesic grasslands
E3: Seasonally wet and wet grasslands
E5: Woodland fringes and clearings and tall forb stands
E7: Sparsely wooded grasslands

Woodland, forest and other wooded land
G1: Broadleaved deciduous woodland
G2: Broadleaved evergreen woodland
G3: Coniferous woodland
G4: Mixed deciduous and coniferous woodland
G5: Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice

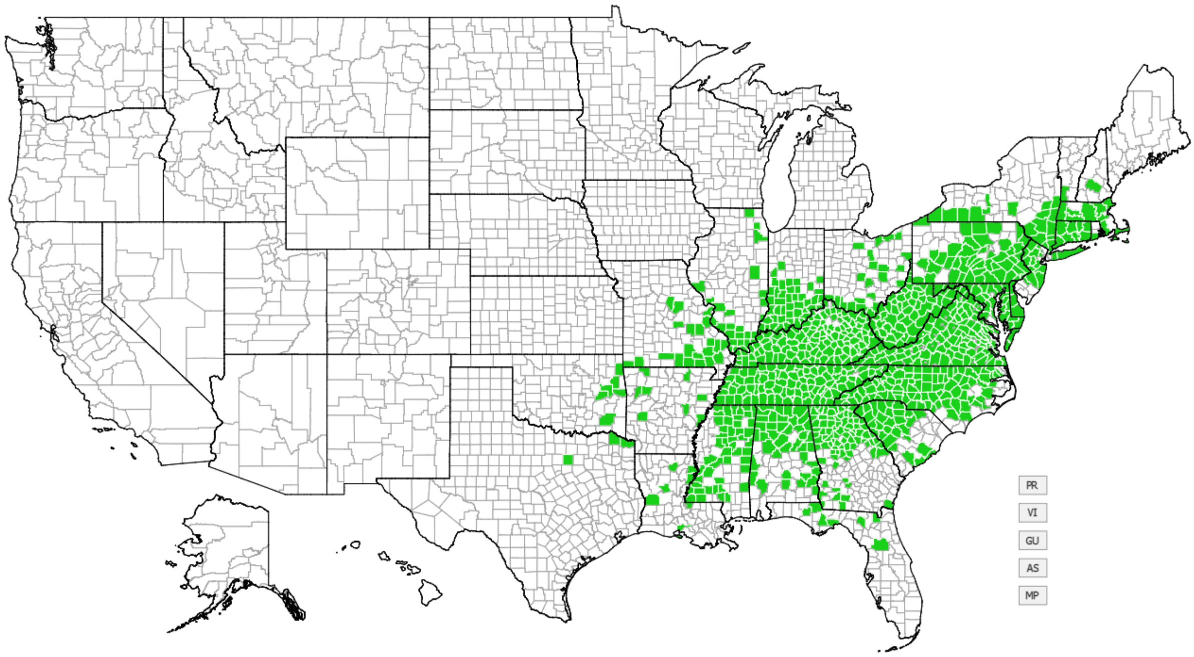
H5: Miscellaneous inland habitats with very sparse or no vegetation
H5.5: Burnt areas with very sparse or no vegetation

I: Regularly or recently cultivated agricultural, horticultural and domestic habitats
I1: Arable land and market gardens
I2: Cultivated areas of gardens and parks

J: Constructed, industrial and other artificial habitats
J4: Transport networks and other constructed hard-surfaced areas
J5: Highly artificial man-made waters and associated structures
J6: Waste deposits

X: Habitat complexes
X06: Crops shaded by trees
X07: Intensively-farmed crops interspersed with strips of natural and/or semi-natural vegetation
X09: Pasture woods (with a tree layer overlying pasture)
X10: Mosaic landscapes with a woodland element (bocages)
X11: Large parks
X13: Land sparsely wooded with broadleaved deciduous trees
X14: Land sparsely wooded with broadleaved evergreen trees
X15: Land sparsely wooded with coniferous trees
X16: Land sparsely wooded with mixed broadleaved and coniferous trees
X20: Treeline ecotones
X22: Small city centre non-domestic gardens
X23: Large non-domestic gardens
X24: Domestic gardens of city and town centres
X25: Domestic gardens of villages and urban peripheries

Appendix 2 Existing distribution map of *Microstegium vimineum*



Distribution of *Microstegium vimineum* in the United States by county, 2014.
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Appendix 3 Picture of *Microstegium vimineum*

M. vimineum invading a forest in the USA. © Luke Flory

Burnt *M. vimineum* in a forest after a fire in the USA. © Luke Flory