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Current Status of *Mimosa pigra* L. Infestation in Peninsular Malaysia

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Abstrak: Status dan taburan *Mimosa pigra* L., spesis tumbuhan penceroboh separa-akuatik di Semenanjung Malaysia, telah dinilai secara berterusan antara tahun 2004 dan 2007. Penilaian ini bertujuan untuk menyiasat kepadatan dirian populasi tumbuhan ini dan kaitannya dengan aktiviti-aktiviti pengurusan rumpai. Secara keseluruhan, 106 tapak kajian bagi enam jenis habitat utama iaitu, tapak pembinaan (CS), empangan (DM), hutan simpan (FR), ladang (PL), tebing sungai (RB) dan sisi jalan (RD) telah dinilai, dan 55 tapak kajian telah direkodkan dengan populasi *M. pigra.* Tapak pembinaan adalah habitat yang paling mungkin akan diserang oleh *M. pigra* (16 daripada 18 tapak yang telah dinilai mempunyai rumpai ini), sedangkan tiada satu pun daripada hutan simpan yang telah dilawati mempunyai *M. pigra*. Dari segi kepadatan dirian populasi, 41 populasi adalah dalam julat kepadatan dirian rendah (tumbuhan individu sebanyak ≤5 m^{-2}), berbanding hanya 9 populasi yang berada dalam julat kepadatan dirian tinggi (tumbuhan individu sebanyak >10 m^{-2}). Secara amnya, kesan semasa serangan *M. pigra* terhadap habitat semula jadi adalah agak rendah, memandangkan taburannya hanya terbatas di kawasan-kawasan yang telah diganggu. Walau bagaimanapun, pengawasan berterusan bagi spesis rumpai ini adalah sangat disyorkan, terutamanya pada zon tebing sungai dan habitat-habitat tanah bencah.

Kata kunci: *Mimosa pigra*, Kepadatan Dirian, Spesies Penceroboh, Jenis Habitat

Abstract: The status and distribution of *Mimosa pigra* L., a semi-aquatic invasive species in Peninsular Malaysia, were continuously assessed between 2004 and 2007. This assessment investigated its population stand density and related weed management activities. In total, 106 sites of 6 main habitat types i.e*.,* construction site (CS), dam/reservoir (DM), forest reserve (FR), plantation (PL), river bank/waterway (RB) and roadside (RD) were assessed, and 55 sites were recorded with *M. pigra* populations. A CS is the most likely habitat to be infested with *M. pigra* (16 out of 18 assessed sites have this weed), whereas none of the FR visited were found to harbour *M. pigra.* In terms of population stand density, 41 populations were in the low range of stand density (individual plant of ≤5 m^{-2}), compared to only 9 populations in the high range of stand density (individual plant of >10 m^{-2}). In general, the current impact of *M. pigra* infestation on natural habitats is relatively low, as its distribution is only confined to disturbed areas. However, continuous monitoring of this weed species is highly recommended, especially in the riparian zone and wetland habitats.

Keywords: *Mimosa pigra*, Stand Density, Invasive Species, Habitat Type

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INTRODUCTION

The earliest report of *Mimosa pigra* L. (*Mimosa*) in Peninsular Malaysia was recorded in 1980 from a survey conducted by the Department of Agriculture (DOA), although farmers in the state of Kelantan claimed *Mimosa* had been found as early as the 1970s (Anwar & Sivapragasam 1999). The *Mimosa* population in Kelantan likely originated in Thailand, where it might have been brought across the border into Malaysia by humans and/or by water along the Golok River (Napompeth 1983). The plant has also been presumed to have been transported by soil contaminated with *Mimosa* seeds lodged in moving vehicles (Lonsdale & Lane 1994) as well as in the intestines of large herbivores such as cattle and water buffalo (Miller & Lonsdale 1987). However, this weed was more likely to have been brought from Thailand intentionally for medicinal purposes (Anwar & Sivapragasam 1999). A more comprehensive study of *Mimosa* invasion in the southern part of Peninsular Malaysia was conducted by Chan *et al.* (1981). The worst *Mimosa* infestation ever recorded in the west coast of Peninsular Malaysia was on the island of Pulau Pinang, where it was found to infest newly cleared lands and abandoned rice fields (Mansor 1987).

As part of the Malaysian government's response to control the spread of *Mimosa*, it was gazetted as an A2 pest based on the 4^{th} Schedule of the Agriculture Pest and Noxious Plants (Import/Export) Regulation in March 1982 (Mislamah *et al.* 1991). By this classification, *Mimosa* is considered as already introduced and spreading throughout Malaysia. This status was further confirmed by a DOA survey in 1991. The survey revealed that 10 out of 11 states visited had *Mimosa* compared to only three states in 1981 (Anwar & Sivapragasam 1999).

In terms of controlling and managing the spread of *Mimosa,* the Malaysian government, through the Malaysian Agriculture and Research Development Institute (MARDI), initiated a collaborative effort to form a biological control program with neighbouring countries, including Australia [through Commonwealth Scientific and Industrial Research Organisation (CSIRO)] in the 1980s. Through this regional and international collaboration, two biological agents, *Carmenta mimosa* Eichlin & Passoa, *Mimosa* stem-boring moths, and *Acanthoscelides puniceus*, a seed bruchid, (see review on both species by Paynter 2005) were introduced into Malaysia between 1992 and 1994 (ACIAR 1998).

As control programs cost a significant amount of money, it is understandable that Malaysian authorities may be reluctant in committing substantial funding to manage *Mimosa*, which usually does not pose any real threat to economically important crops. However, *Mimosa* is considered as a very serious threat in other countries (e.g., Australia, America and Thailand) and thus could become a serious threat to the natural ecosystem in Malaysia.

Objectives

After 24 years since it was first reported, *Mimosa* has been reclassified as weed of waste land (Othman & Abu Hashim 2003), and little attention has been paid to monitoring its spread and any environmental impacts. However, the threat of its invasion into natural habitats, especially reservoirs and hydroelectric dams, is important and needs to be addressed. The specific objectives of this survey were as follows:

i. review current *Mimosa* infestation in Peninsular Malaysia to determine the current status of *Mimosa* distribution
ii. monitor *Mimosa* population and its distribution, especially in wetland habitats.

This survey was conducted with the intention of determining whether *Mimosa* has reached its distributional limit or whether it will continue to expand into new locations.

MATERIALS AND METHODS

The survey was conducted continuously between the months of May 2004 and December 2007. The propagule movement of *Mimosa* in terrestrial ecosystems is probably mostly effected by seeds in soil being moved among sites during construction activity. Thus, six habitat types, namely a construction site (CS), a dam/reservoir (DM), a forest reserve (FR), a plantation (PL), a riverbank/ waterway (RB) and a roadside (RD), were chosen to represent a range of habitats that can be invaded by *Mimosa*.

The selection of habitat type was based on the assumption that *Mimosa* spreads more successfully via seed movement by machinery from an infested site to a new location than by any other mechanism (e.g., water and animals). This survey was established to cover four regions:

i. Northern states: Perlis, Kedah and Pulau Pinang
ii. East-coast states: Kelantan, Terengganu and Pahang
iii. Southern states: Johor, Negeri Sembilan and Melaka
iv. West-coast states: Perak and Selangor.

The RD is an important habitat for invasive plant establishment, as it acts as a corridor of movement (Lugo & Gucinski 2000). In this survey, the federal main road linking all state capitals and major townships in Peninsular Malaysia was used as the main reference line, and 11 reference sampling points (RSP) were specifically chosen. These RSPs (see Table 1) were major population centers (cities or townships) on the main trunk road and were chosen due to logistical purposes (e.g., accommodation and transportation). A transect line, approximately 50 km in length, was then established each time the RSP was entered or exited. A total of 22 transect lines were generated. It should be noted however, that DM and FR sites were specifically chosen based on the sites' accessibility and location.

At each site, a sampling plot was established according to the following method: 4 lines of transect, each being 10 m long and 2 m from the next transect line, were constructed from the road edge inward, and 5 quadrats (1 x 1 m each) were then placed along the line transect at 1 m intervals. Data were gathered from 10 quadrats (i.e., 25 small-folded papers with each quadrat's number were placed in a hat, and 10 papers were then randomly chosen). The number of individual *Mimosa* plants in each quadrat was recorded. *Mimosa* stands, based upon the cumulative number of individual plants within the 10 quadrats, were grouped into the following 3 levels of density per 100 m^{-2}: low (0–50 plants; ≤5 plants m^{-2}), medium (51–100 plants; 6–10 plants m^{-2}) and high (>100 plants; >10 plants m^{-2}). Weed management on site was also rated based upon the following visual inspection: i) not managed; background vegetation and intact weeds, ii) partly managed; visual evidence of selected weed groups being cut, burned or sprayed with herbicide and iii) properly managed; all weeds being completely removed or cleared.

Table 1: Allocation of survey sites among regions, states and RSPs.

Region	States	RSP	Habitat types allocation					
			CS	DM	FR	PL	RB	RD
East-coast	Kelantan	Kota Bharu	2	1	1	2	2	2
	Pahang	Rompin	2	0	1	2	2	2
	Terengganu	Kuala Terengganu	2	1	1	2	2	2
North	Kedah-Perlis	Alor Setar	2	1	2	2	2	2
	Pulau Pinang	Georgetown	2	1	1	2	2	2
South	Johor	Kluang	2	1	1	2	2	2
	Melaka-Negeri Sembilan	Bandar Melaka	2	1	2	2	2	2
West-coast	Perak	Pengkalan Hulu	2	1	0	2	2	2
	Perak	Taiping	2	0	1	2	2	2
	Selangor	Kajang	2	1	1	2	2	2
	Federal Territory	Kuala Lumpur	2	0	1	0	2	2
		Total	22	8	12	20	22	22

Notes: CS = construction site, DM = dam/reservoir, FR = forest reserve, PL = plantation, RB = river/waterways, RD = roadside. Numbers represent the number of sites for each habitat type. Peninsular Malaysia was divided into four geographical regions. The states were allocated one RSP each, except for 1) Kedah/Perlis and Melaka/Negeri Sembilan, which shared one RSP, and 2) Perak, which was allocated two RSPs.

RESULTS AND DISCUSSION

A total of 106 sites were surveyed, and 55 sites were recorded with *Mimosa* populations (Table 2). The habitat type with the highest number of recorded

Mimosa was CS (18 sites), and none of the FR sites were recorded to have *Mimosa* present (Fig. 1).

Table 2: Number of sites of each habitat types where *Mimosa* was recorded.

Region	States	RSP	Habitat types allocation					
			CS	DM	FR	PL	RB	RD
East-coast	Kelantan	Kota Bharu	2	1	0	2	1	2
	Pahang	Rompin	1	0	0	1	1	1
	Terengganu	Kuala Terengganu	2	1	0	1	0	2
North	Kedah-Perlis	Alor Setar	2	1	0	0	1	1
	Penang	Georgetown	2	0	0	1	2	2
South	Johor	Kluang	2	0	0	1	1	2
	Melaka-Negeri Sembilan	Bandar Melaka	2	0	0	1	2	2
West-coast	Federal Territory	Kuala Lumpur	1	0	0	0	0	0
	Perak	Pulau Banding	1	1	0	1	0	2
	Perak	Taiping	1	0	0	0	0	1
	Selangor	Kajang	2	0	0	0	0	2
		Total	18	4	0	8	8	17

Notes: CS = construction site, DM = dam/reservoir, FR = forest reserve, PL = plantation, RB = river/waterways, RD = roadside; *n* = 106.

Mimosa can survive in a wide range of ecosystems ranging from reclaimed sea front up to 1200 m above the sea level, as observed by Napompeth (1983). *Mimosa* has been recorded along the East-West Highway (RSP Pulau Banding), and it seems to thrive relatively well at this altitude. Because this highway is one of the main access roads between the east and the west coasts of Peninsula Malaysia, it is likely that *Mimosa* seeds are being transported unintentionally by vehicles and in soil.

Mimosa and its Population Density

In general, based on the three density levels for *Mimosa* populations, the general habitat conditions could be described as follows:

i. Low density: the individuals may be sparsely distributed (i.e., an individual ranging from 1–5 m^{-2}), and the undergrowth is abundant within the stand. This condition can be found in locations where disturbance is minimal. The surrounding area usually is well-maintained, and background vegetation has probably reached a stable condition.

Figure 1: High density *Mimosa* stands recorded from four habitat types (CS = ●, DM = △, RB = ◇ and RD = ■).

Note: None of FR sites were invaded by *Mimosa* (✸) despite some of the sites located in close proximity with high density stands.

ii. Medium density: individuals are more closely distributed than for low density (individuals ranging from 6–10 m^{-2}), and the undergrowth is usually a combination of grasses and sedges.
iii. High density: individuals are usually packed together in a relatively small space (11 or more individuals m^{-2}), and generally undergrowth is very limited. This situation is normally observed when the area has been recently cleared; seedlings are the dominant life-stage observed.

The six sites recorded (CS = 3, RB = 2 and RD = 1) to have high *Mimosa* densities did not show proper weed management activities (Table 3). Additionally, however, high *Mimosa* densities were recorded in sites with some weed management activity (DM = 1 and RB = 2). This result might suggest that the weed management was not targeting woody weed species, with resources being concentrated on dealing with grasses, herbs and other non-woody species. Controlling woody weeds is laborious and time consuming (personal observation). *Mimosa* at high density seems to survive on sites with some weed management activity (three sites), sites without any weed management activity (six sites) and on sites with comparatively good weed management activity (Fig. 2). Weed management however, may vary between each local authority, especially in rural areas. This may not sufficiently reflect the real *Mimosa* infestation status within each sampling site.

Table 3: Number of sites visited, with the weed management status of the site and the *Mimosa* stand density.

Habitat types	Weed management status on site	Site without *Mimosa*	*Mimosa* stand density		
			Low (0–50)	Medium (51–100)	High (>100)
CS	NM		5		3
	SM		2	1	
	GM	4	6	1	
DM	NM				
	SM		2		1
	GM	4	1		
FR	NM	1			
	SM	6			
	GM	5			
PL	NM	1	6	1	
	SM	6			
	GM	5	1		
RB	NM	5		1	2
	SM	4			2
	GM	5	2	1	
RD	NM		5		1
	SM	2	4		
	GM	3	7		

Notes: CS = construction site, DM = dam/reservoir, FR = forest, PL = plantation, RB = river/waterways, RD = roadside. NM = no maintenance, SM = some maintenance, GM = good maintenance; n = 106.

As *Mimosa* is able to survive in all weed management statuses, perhaps it is important to establish whether an absence of seedlings is due to seed-limitation or to microsite-limitation. It is possible that no propagule had yet reached the sites that were recorded to be lacking *Mimosa*; thus, perhaps these results were not directly related to the habitat types. It is also possible that *Mimosa* would survive in most open and disturbed habitat types provided seeds were able to reach those habitats.

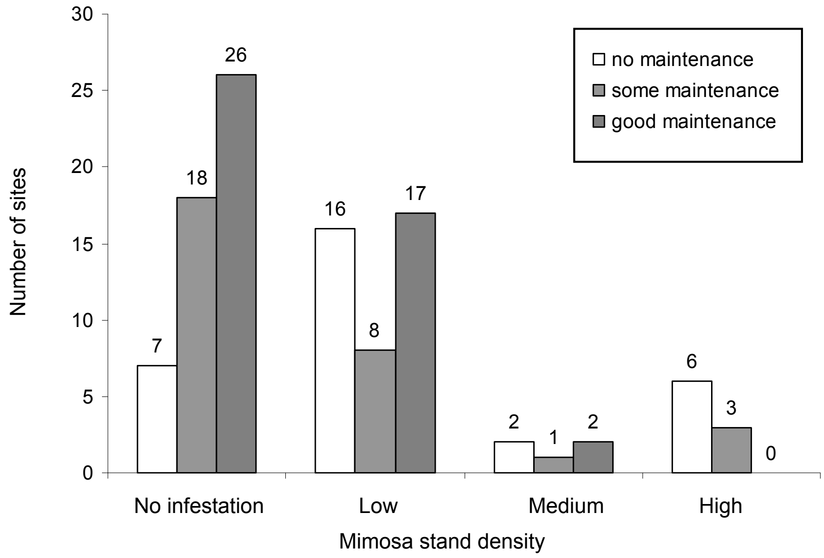

Figure 2: *Mimosa pigra* stand density.

Notes: A total of 55 sites (52.8%) were recorded with *Mimosa* (out of 106 sites). *Mimosa* stand's density is as follows: 0, not recorded; low, 1–50; medium, 51–100 and high, >100 number of individuals. Weed management program observed during the survey was categorised into: i) *No maintenance;* there is no evidence of surrounding vegetation (i.e., weeds) being managed; ii) *Some maintenance;* weeds were infrequently managed (i.e., some weeds were being left to grow uncontrolled) and iii) *Good maintenance;* all types of weeds (e.g., shrubs, creepers and woody plants) were constantly managed.

Mimosa on CS and RD

Two major areas that show *Mimosa* infestation are CS (18 sites, 63.6%) and RD (17 sites, 77.3%). Movement of soil contaminated with *Mimosa* seeds is most likely the reason many CS are infested by *Mimosa*. This seed movement would satisfy the two important stages required for successful species invasion: transporting a new organism to a new location (Williamson & Fitter 1996; Mack *et al.* 2000) and increasing the number of individuals of the invading species within the site (Veltman *et al.* 1996). The bare soil at the CS would provide optimal conditions for low inter-specific competition.

Weed management programs on CSs are not usually implemented until the project had been completed. This lapse in time often allows *Mimosa* to reach the reproductive stage. As for RD, weed maintenance can vary between local authorities, as such management schemes normally depend on its available resources and budget. Woody weeds are usually hard to manage and treating for them is time consuming; thus, most woody weeds will be left to grow in rural areas (personal observation).

Mimosa in Wetlands

In any tropical country that has been invaded by *Mimosa,* wetland habitats, especially river corridors, flood plains, lakes and reservoirs, are likely to be invaded by *Mimosa* (Marambe *et al.* 2004; Samouth 2004; Triet *et al.* 2004).

Dams and reservoirs

Of the eight sites surveyed, four dams were infested by *Mimosa*, namely: Pedu in Kedah, Temenggor in Perak, Pergau in Kelantan and Kenyir in Terengganu. However, due to high water levels in Temenggor and Kenyir, which left most of the stands partially submerged during the time of this survey, *Mimosa* populations were only observed in Pedu and Pergau.

In Pergau, the undergrowth of *Mimosa* stands consist mainly of a single grass species, *Zoysia matrella* (Siglap grass), which is common on sandy beaches and open, dry places. The population stands in Pergau are less dense than stands in Pedu, which were found to be denser and shorter in height. *Mimosa* populations in Pedu were the only high-density stands recorded for DM. Both inter- and intra-specific competitions were probably intense for this stand, as the individual plants were comparatively closer to each other than at other less dense stands.

Infestations at all sites are likely due to soil containing *Mimosa* seeds brought into these areas during construction. Infestation spread is limited to the open flood plain and has not been observed to establish in the dense forest bordering the dams. High water levels seem to have a significant negative effect on the plant, and most of the submerged stands in Kenyir died after approximately six months (personal observation).

Riverbanks and waterways

Newly constructed water canals and riverbanks used as soil dumping sites are highly prone to *Mimosa* infestation. This survey also revealed that waterways located within the vicinity of newly developed roads and highways are likely to be infested by *Mimosa.* Of the 12 sites visited, there were 8 RB (57.1%) infested with *Mimosa*.

Weed management is usually ignored for riverbanks and waterways (Table 3), especially in rural areas, suggesting a plausible reason for *Mimosa*'s successful establishment in these areas. However, *Mimosa* was probably overlooked during weed management activities in other areas, as four sites (i.e., one each for RSP Georgetown and Kota Bharu and two in RSP Bandar Melaka) recorded with *Mimosa* high density stands were in urban areas with good weed maintenance activity. It may be that due to its size, woody and thorny stems and branches, *Mimosa* is ignored and left to establish.

***Mimosa* in Agricultural Land**

Although Anwar and Sivapragasam (1999) mentioned that this species has not caused any losses in crop yield (*Mimosa* infestation is mainly limited to abandoned and un-maintained crop land), it might affect the development of newly planted crops. This phenomenon was observed in one plantation, north of Perak. In this case, a newly completed project of the North-East highway prompted a rapid establishment of *Mimosa* seedlings in a one-year-old palm oil plantation adjacent to the highway. Inter-specific competition is likely to be very intense at this stage of growth. Although it might have no detrimental impact on the development of young palm oil trees over long periods of time, overgrown

Mimosa populations could generate other problems such as restricting access to the palm trees during harvest.

DISCUSSION AND RECOMMENDATIONS

Generally, the spread of *Mimosa* infestation in Peninsular Malaysia appears to be due to soil contaminated with *Mimosa* seeds being moved from an infested site to an un-infested site. This kind of movement was also reported in Australia (Miller 1983) and Thailand (Napompeth 1983). Other seed vectors (e.g., water, wind and animals) might also minimally contribute to *Mimosa*'s distribution in terrestrial ecosystems. The existence of persistent *Mimosa* stands in DM proved that wetlands are highly susceptible to *Mimosa* invasion. Flooding and water flow are two important and efficient agents in seed dispersal (Cronk & Fuller 1995), particularly for *Mimosa*'s, as its pods are adapted for water dispersal. The thriving populations within these man-made wetland systems could be a source of propagule, in which river systems (through the outflow) colonise riverbanks further downstream.

To date, agricultural land, including rice fields in the northern region of Peninsular Malaysia, have been free of *Mimosa*. Abandoned agricultural land however, seems to be prone to *Mimosa* infestation, probably because landowners are not likely to carry out weed maintenance activities within these areas. In addition, due to its low economic impact, *Mimosa* has been considered a non-threatening weed species (thus the reclassification). This status correlates with its abundance in abandoned rice-fields, non-cultivated vacant land, roadsides in rural area and in the riparian zone in wetland ecosystems where its stands were probably ignored.

New infestations were observed in zones with active developmental projects and may last as long as the constructions are in progress. *Mimosa* has never been considered a serious problem at such sites because any established population can be cleared by the local authority using heavy machinery.

Nonetheless, the full threat of *Mimosa* to wetlands and agricultural lands still needs further assessment. The populations of *Mimosa* in Temenggor, Pergau and Kenyir dams need to be closely monitored. Although it has not reached the alarming state faced by other Southeast Asian countries like Cambodia (Samouth 2004) and Vietnam (Triet *et al.* 2004), preventing a possible major outbreak should be assessed in future management plans. Some of the important economical activities and ecological processes that might be affected by uncontrolled *Mimosa* outbreaks are a decline in fish catch due to restricted access to the riparian zone and the displacement of local plant species (see Suwignyo & Waroatmodjo 1982).

As for intact forest areas, further, thorough inspections should be conducted to assess possible *Mimosa* invasions into forest edges, especially in areas with a close proximity to CS and PL. Jungle trails and open canopy areas within FR should also be frequently surveyed for *Mimosa*, as visitors might unintentionally introduce seeds lodged in their walking boots. Preventing a new invasion should be the first priority for landowners and relevant government agencies.

In terms of a *Mimosa* management scheme, despite the possible effectiveness of biological control programs for the long term, mechanical and chemical control are the most effective and immediate means of preventing or slowing *Mimosa* spread. Mechanical and chemical control should be used until the biological control agents have been widely established and have proven to be effective in field conditions (Cook *et al.* 1996). Integrated pest management (IPM) combines several control methods that should be considered for good control of *Mimosa* (Paynter & Flanagan 2004). This combinatory approach may increase the success rate of controlling weeds and reduce the burden of cost faced by land owners for long-term weed management plans (see also Buckley *et al.* 2004 on their study of using IPM in controlling *Mimosa*).

Results of this survey should be interpreted cautiously because only a limited number of habitat types and sites were surveyed. There is always a possibility that *Mimosa* populations are established in areas and habitats that were not covered in this survey. However, the survey achieved its objectives by showing that *Mimosa* can now be found throughout Peninsular Malaysia occupying a wide range of habitats. The population distribution suggested that most stands were established from soil contaminated with *Mimosa* seeds rather than other from vectors.

Controlling a species with a large seed bank takes a great deal of effort and is time consuming. To minimise seed movement from infested sites, a strict regulation of topsoil movement needs to be implemented. In practice, it is extremely unlikely that such a regulation could be effectively policed. The best possible way is to continue to monitor sensitive areas (e.g., conservation hot spots) for *Mimosa* invasion is to use mechanical intervention coupled with targeted herbicide application in cases that look likely to become serious if ignored.

Based on this survey, it is suggested that the current impact of *Mimosa* infestation on natural ecosystems is low because its distribution is mainly restricted to disturbed areas and abandoned land. In addition, *Mimosa* stands were mostly present at low density, where complete removal by mechanical methods and targeted herbicide application is possible. However, further surveys and *Mimosa* population assessments are recommended, including in habitats that were not covered in this survey. Thus, peat swamps and mangrove swamps, excluded (due to logistic constraints) in this survey, should be included in future surveys.

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