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Original Article

Results of Survey and Evaluation of Invasive Plants in Ba Vi National Park, Vietnam

Vu Anh Tai*, Ngo Thi Bich Hong, Tran Thi Thuy Van, Le Thi Kim Thoa

Institute of Geography, Vietnam Academy of Science and Technology,
18 Hoang Quoc Viet, Cau Giay, Hanoi, Vietnam

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Abstract: The biodiversity of Ba Vi National Park has been faced with some passive impacts, one of them is alien species, that habitats for the native species is narrowed by increasing of invasive population expanding, it is necessary to conducted a research on the impacts of the invasive plants there and then giving the basis for better management of the national park. After field surveys in recently years (2018-2022), 47 alliance species recorded at the National Park were evaluated according to guidance and data provided by Invasive Species Specialist Group (ISSG) and Centre for Agriculture and Biosciences International (CABI) developed Invasive Species Compendium (ISC) and also Circular 35/2018/TT-BTNMT. Result showed that 29 species were invaders and especially 11 species of them are detailly evaluated in 10 habitats. 2 species as Mexican sunflower (*Tithonia diversifolia*) and Lantana (*Lantana camara*) are evaluated as High risk for both areas while 3 other ones are evaluated as High risk for buffer zone only, including Giant sensitive tree), Leucaena (*Leucaena leucocephala*) and Giant sensitive plant (*Mimosa diplotricha*). The other ones have been evaluated as Medium risk (at buffer zone) to Low risk (at core area) are Blackjack (*Bidens pilosa*), Siam weed (*Chromolaena odorata*), Bay Biscayne creeping-oxeye (*Sphagneticola trilobata*), Jamaica cherry (*Muntingia calabura*), Jamaica vervain (*Stachytarpheta jamaicensis*) and Coast morning glory (*Ipomoea cairica*). By this evaluation, Mexican sunflower (*Tithonia diversifolia*), Blackjack (*Bidens pilosa*), Jamaica cherry (*Muntingia calabura*), Jamaica vervain (*Stachytarpheta jamaicensis*) and Coast morning glory (*Ipomoea cairica*) are suggested to include to the list of invasive organisms of the nation. Besides that, it is necessary to strengthen control of Mexican sunflower (*Tithonia diversifolia*) inside the core area of the NP in particular and in Ba Vi district in general, especially at the tourist place where the festival of Mexican sunflower has been yearly organized.

Keywords: Invasive, Ba Vi National Park, GISD, CABI-ISC, Circular No.35.

* Corresponding author.
E-mail address: vatai@ig.vast.vn

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1. Introduction

An invasive species is a plant, fungus, or animal species that is not native to a specific location, and which tends to spread to a degree believed to cause damage to the environment, human economy or human health. So that, the invasive species have been noted by a lot of specialists over the world and the common and biggest group of specialists is Invasive Species Specialist Group (ISSG) - a global network of scientific and policy experts on invasive species, organized under the auspices of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN) in 1994. The ISSG aims to reduce threats to natural ecosystems and the native species they contain by increasing awareness of invasive alien species, and of ways to prevent, control or eradicate them. Currently, the Global Invasive Species Data is managed and published by this group that have been using common of the world where an invasive has been shown for native distribution or alien/impacted range and experience to manage them somewhere [1]. Besides that, in 2001, the Centre for Agriculture and Biosciences International (CABI) developed Invasive Species Compendium (ISC) as an encyclopedic resource that draws together scientific information on all aspects of invasive species [2]. The ISC is an online, open access reference work covering recognition, biology, distribution, impact and management of the world's invasive plants and animals, together with GISD, people can identify any organism as an invader or not.

Vietnam is a tropical country with a rich biodiversity, including 2393 non-vascular plants and 11,373 vascular plants [3] and in which, 882 species are listed in the Vietnam Red Data Book [4], including 418 animal and 464 plant species. However, the nature habitats and threatened species in the country have been facing a lot of pressures and risks and one of them is invasive organisms.

In 2012, it was reported as invasive plants for national parks in Vietnam [5]. Therefore, 134 alien species were assessed and 25 ones of them were determined as invasive plants. The authors had assessment for 10 national parks but the field survey was conducted at 4 of them only and it did not include BVNP. In this study, the species were determined to be Invasive Alien Species (IAS), Likely Invasive (L.IAS) or Potentially Invasive (P.IAS) based on criteria described by the Massachusetts Invasive Plant Advisory Group [2].

On 28th December 2018, the Ministry of Natural Resources and Environment stipulated Circular No. 35/2018/TT-BTNMT (Circular No. 35), on providing criteria for determination of invasive exotic species and promulgating the list of invasive exotic species [6].

Ba Vi National Park (NP) is one of the important national parks of Vietnam, locates 15 communes of 2 districts of Hoa Binh province and 3 districts of Hanoi capital and is under direct management of the Ministry of Agriculture and Rural Development (MARD). According to the data of the NP's website, the total area is 9.702,41 ha. Besides, about 35,000 ha of those 15 communes is planned for the buffer zone area of the Ba Vi. According to most update of biodiversity of the NP [7], the vegetation were included subtypes in tropical zone, sub-tropical zone (or montane tropical zone) as closed tropical hot-medium rainy broadleaf evergreen forest; secondary tropical cool-medium rainy broadleaf evergreen forest (including bamboo forest); secondary tropical hots (or cool) rainy broad leaf scrubs; Secondary tropical hots rainy grasslands; seasonal wet grasslands; tropical closed cold moisture broad leaf montane forest; secondary tropical cool moisture (rainy) broad leaf montane forest; secondary tropical cool moisture montane scrubs, plantation forest and other artificial/ cultivated lands; the flora was recorded as 2235 species, 958 genera and 207 families and the fauna was recorded as 342 vertebrate species (65 mammals, 169 birds, 30 reptiles, 27 amphibian species), 552 insect species (364 genera, 65 families, 14 ordos) [8].

Ba Vi is well-known place for tourism, especially in recently years when both of the district and the NP are opening a lot of tourism

places including Thuong Temple, President Ho Chi Minh Temple, Bao Thien Tower, Ngoc Hoa peak on the summits, core area of the NP in elevation over 1000m above sea level; relic church/French Summer Camps, French Military zone, code 400 resort area, at 400-800 m a.s.l., Trung Temple, Tan Vien Pagoda at 100-400 m. a.s.l. in the core area in Hanoi Capital area or some ecological Tourism areas in Hoa Binh province area [8]. The NP has one main gate to the summit but the tourists can access the NP from other entry ways such as Trung Temple areas or other ecological Tourism areas [8]. The average number of tourists visiting the NP each year is about 3 million, focusing on Tet holidays and other public holidays such as Hung Kings, Labour Day and Reunification Day, National Days and most of them are people from the Ha Noi Capital. Besides that, there are some infrastructures have been constructed in recently years, including some villas, pagoda, temples and special roads, even it is mostly in the buffer zone but not far from the core areas of the NP, that makes a lot considerable impacts to the natural habitats and habits of the wild animals and plants there. One of the impacts is invasive plants, which are often very competitive with native species, special at each entrance to the core area from the buffer zone area or packing area, surrounding the construction areas, because the invasive plants can very rapid and easily spread through the construction materials and tourists, it also follows by the surface water after every rain.

Therefore, in the purpose of conservation and sustainable development implementation on the Ba Vi NP, a survey and an assessment of invasive plants is necessary to conduct and suggest a suitable management or exploitation of those species.

2. Materials and Methods

The methodology of surveillance of alien species was based on the common species biodiversity survey methods. A list of alien species is prepared before a field survey is conducted. The list is according to the GISD [1] and CAB-ISC [2] with impacted/impacting species to Vietnam and other species is cited from the Circular No. 35 [6].

A field survey was planned based on the main ecological habitats of the site, and then, some transects as trails and roads were selected through almost all habitats and it was available to assess any site as a potential habitat of invasive species from the trail or road. In this study, 8 transects were selected for the survey include: main transect from entrance to the summits (King, Giant Temples); transect to Trung Temple; transect to Vien Nam mountain; transect to Mo stream in the core area and some transects in the buffer zone area (Da waterfall, Khoanh Xanh Suoi Tien tourist area, Da Chong Khanh Thuong). On each transect, to find out the invasive plants and evaluate their impact to the native habitat, we focus on open areas, including the construction area, tourism area and roadsides; the appearance of any alien was recorded by camera and GPS. Because of commonly, there is no need to collect specimens of the invasive plants but photos of each species at each surveyed point would be taken and name is identified based on An Illustrated Flora of Vietnam [9]. Field surveys were applied during the summers - autumns in years of 2018, 2019 and in the spring in 2022.

To evaluate level of impact to the native habitat of each species at each survey point, we use a record form according to the criteria stimulated in Circular No. 35 and guidelines of the GISD, ISC, focusing on: appearance as natural population, population size, risk as impacted levels to the native organism communities (low, medium or high). According to GISD, "*alien species*" is a species, subspecies, or lower taxon (non-native, non-indigenous, foreign, exotic) occurring outside of its natural range (past or present) and dispersal potential (i.e. outside the range it occupies naturally or could not occupy without direct or indirect introduction or care by humans) and includes

any part, gametes or propagule of such species that might survive and subsequently reproduce while "*alien invasive species*" means an alien species which becomes established in natural or semi-natural ecosystems or habitat, is an agent of change, and threatens native biological diversity. Based on that, we rank impact levels in the following table.

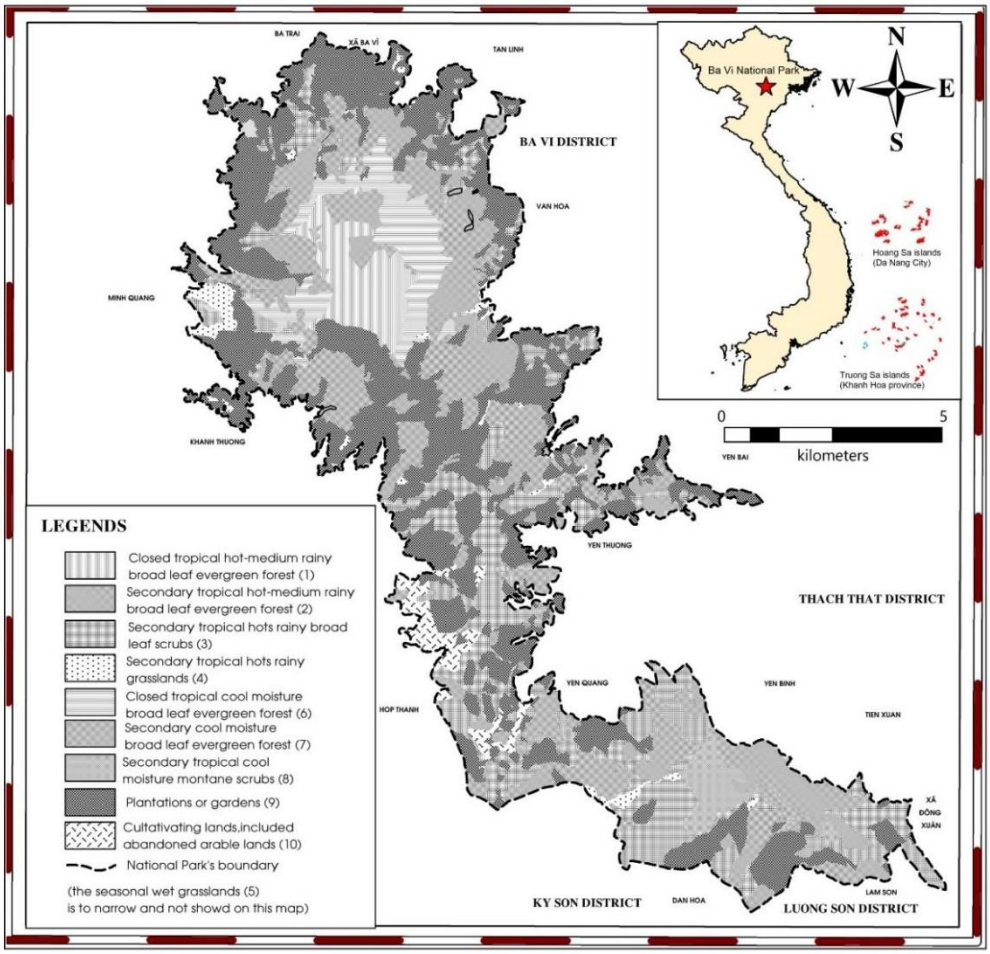


Figure 1. Map of habitats of Ba Vi National Park.

Table 1. Criteria for risk evaluation of invasive plant in Ba Vi area

Level of Risk	Population size (contiguously distribution; m^2)			
	Herb	Climber	Shrub	Tree
No risk (N)	Random	Random	Random	Random
Low (L)	0-1	0-1	0-1	1-10
Medium (M)	1-10	1-20	1-20	10-100
High (H)	>10	>20*	>20*	>100*

Note: * - or expanding, threatening to the other species habitat.

Therefore: No risk (N) - appearance in a control lance by the human; Low risk (L) - random appearance population of invasive species, population size is less than 1 m^2 (herb/shrub/climber habits) or 10 m^2 (tree habit); Medium Risk (M) - population of invasive species is expanding, threatening to the other species habitat and population size is 1-10 m^2 (herb), 20 m^2 (shrub/climber) or up to 100 m^2 (tree); High Risk (H) - population of invasive species size is more than 10 m^2 (herb), /20 m^2 (shrub/climber) or over 100 m^2 (tree) and threatening to the threatened/valued organism or local native habitat. The habitats in this survey based on the list of vegetation types and subtypes of the NP (Figure 1), including closed tropical hot-medium rainy broadleaf evergreen forest (1), secondary tropical hot-medium rainy broadleaf evergreen forest (including bamboo forest) (2), secondary tropical hot (or warm) rainy broad leaf scrubs (3), secondary tropical hot rainy grasslands (4), seasonal wet grasslands (5), closed tropical cold moisture broad leaf montane forest (6), secondary tropical cool moisture (rainy) broad leaf montane forest (7), secondary tropical cool moisture montane scrubs (8), plantation forest (9) and cultivated lands (10, included abandoned arable lands).

3. Results and Discussion

3.1. List of Invasive Plants in Ba Vi National Park

In the field survey, through 8 transects crossing 2 main areas of the NP, 47 alien plant species were recorded and all of them are flowering plants, including 40 genera, 19 families of 18 orders and 2 classes (Table 3). Among them, there are 7 species that are listed in the Circular No. 35 including 5 exotic alien species and 2 other species that would be exotic invasive species in Vietnam; 15 species are listed in the data of GISD and 46 species would be found in the data of the CABI-ISC.

The alien richness families there are aster (Asteraceae) with 11 alien species and bean (Fabaceae) with 8 alien species. Two of those alien rich families are also the most rich plant families in Vietnam that are easy to meet in the most habitats including forest, scrub, grassland, plantation and cultivated lands, from the tropical to the subtropical zone and from the lowland to the mountain. Those families also contain high potential invasive species in many ways such as by human activities, animal habits, water flow, infrastructure materials,…

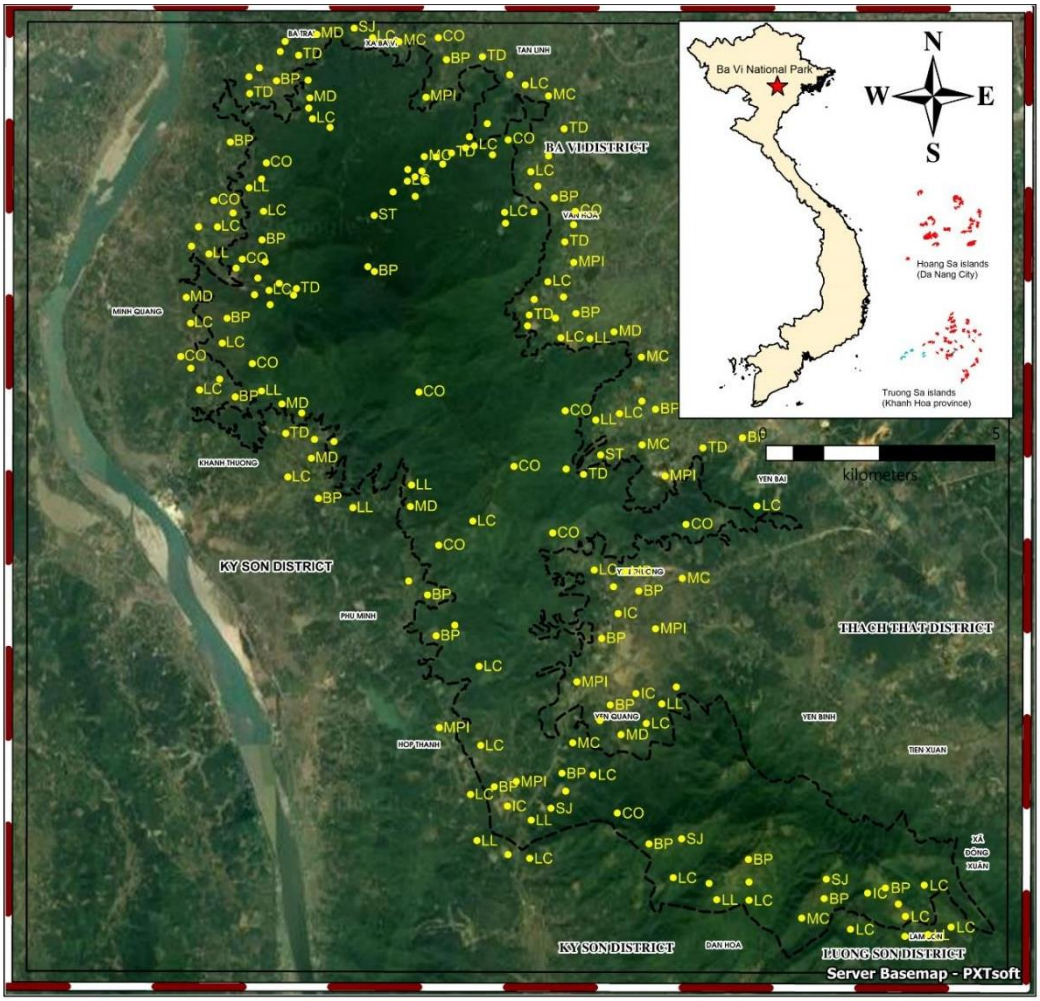
Those alien plants have originated mostly from the America with 34 species including the central and south Americas (11 species) and the tropical Americas (6 species), 4 species originated from Australia or Pacific regions, 2 others from temperature Eurasia (Europe) while there are 5 species that also originated from Asia (but not in Indochina region).

3.2. Habitat Impacting Evaluation

The results of impact evaluation of each species to the habitat at both the core area and buffer zone area of the NP is presented in Table 4. In the core area, there are 9 (from 1 to 9) habitats while the buffer zone area has 6 habitats (2,3,4,5,9,10), there is no species recorded appearance at all habitat in the core area or in the buffer zone area. Among 47 alien species, 15 species have been recorded at invasive at the core area while the buffer zone area has been recorded by 29 invasive species and total invasive plant species has been record for the NP is 29 and 18 other species appearance in the NP has been recorded at non-impact (N) at buffer zone area or sometimes it has been not recorded in the core area. There are 11 species that have been recorded as non-impact in the core area but were recorded at low impact in the buffer zone area.

Among 15 invasive species recorded at the core area, there are 2 species are evaluated as High risk as Mexican sunflower (*Tithonia diversifolia*) and Lantana (*Lantana camara*); 2 others are evaluated at Medium risk as Leucaena (*Leucaena leucocephala*) and Giant sensitive plant (*Mimosa diplotricha*). There are 11 species are evaluated as Low impact, including Giant sensitive tree (*Mimosa pigra*), Bay Biscayne

creeping-oxeye (*Sphagneticola trilobata*), Siam weed (*Chromolaena odorata*), Billy goat weed (*Ageratum conyzoides*), Blackjack (*Bidens pilosa*),… and the most high risk invasive plant in Vietnam as Giant sensitive tree has been limiting recorded because of aquatic habitat (streams, rivers and ponds) of the NP, it is recorded at river banks, stream banks only.



ID	Latin	English_name	Vietnamese_name
BP	Bidens pilosa L., 1753	Beggar-ticks	Đơn buốt
CO	Chromolaena odorata (L.) R.M. King & H.Rob., 1970*	Siam weed	Cỏ lào
IC	Ipomoea cairica (L.) Sweet, 1827	Coast morning glory	Bìm ai cập
LC	Lantana camara L., 1753 *	Wild-sage	Bông ổi, Ngũ sắc
LL	Leucaena leucocephala (Lam.) de Wit, 1763*	White lead tree	Keo dậu
MC	Muntingia calabura L.	Jamaica cherry	Trứng cá
MD	Mimosa diplotricha C. Wright ex Sauvalle	Giant sensitive plant	Trinh nữ móc
MP	Mimosa pigra L., 1759*	Giant sensitive tree	Mai dơng, Trinh nữ gỗ
SJ	Stachytarpheta jamaicensis (L.) Vahl, 1804	Billy goat-weed	Cỏ đuôi chuột
ST	Sphagneticola trilobata (L.) Pruski, 1996	Bay Biscayne creeping-oxeye	Sài ba thùy
TD	Tithonia diversifolia (Hemsl.) A.Gray	Mexican sunflower	Hoa dã quỳ

Figure 2. Map of main recorded invasive plants for Ba Vi National Park.

At the buffer zone area, there are 5 species are evaluated at High risk, it includes Mexican sunflower (*Tithonia diversifolia*) and Lantana (*Lantana camara*), Giant sensitive tree (*Mimosa pigra*), Leucaena (*Leucaena leucocephala*) and Giant sensitive plant (*Mimosa diplotricha*). Both of 5 those species are very common invasive of the tropical areas now (CABI; GISD), 3 of them are listed in the toxic list of the Circular 35 (Lantana, Giant sensitive tree, Giant sensitive plant) while Leucaena is also introduced to invasive by this Circular. However, Mexican sunflower is very high risk for the area even it has been not mentioned by the official document of the authorities such as the Circular 35 but it has been recorded as invasive in the data both of CABI and GISD, this species has been rapidly introduced, expanding to the area in supporting for tourism purpose, even the Mexican sunflower flowering festival has been yearly organized at the NP and there are a lot of checking point around the NP (at the buffer zone area) where this species is commonly planted. There are 6 species recorded as Medium risk for the buffer zone's habitat, including Blackjack (*Bidens pilosa*), Siam weed (*Chromolaena odorata*), Bay Biscayne creeping-oxeye (*Sphagneticola trilobata*), Jamaica cherry (*Muntingia calabura*), Jamaica vervain (*Stachytarpheta jamaicensis*) and Coast morning glory (*Ipomoea cairica*). Those species are impacting the open habitat, mostly in the cultivated land, plantation and secondary forest where it is closed to the traffic road, construction area and especially at the entrance to the tourism areas. There are 18 other species recorded at low risk at the buffer zone habitat and there is not much chance for them to be higher risk.

According to the above evaluation of each species for each habitat, it can be evaluated that the most high-risk habitat at the NP impacted by the invasive plants are Secondary tropical hots rainy grasslands and plantation forest at both of the core area and buffer zone area and together with cultivated land at the buffer zone area and next to the secondary tropical hots rainy broad leaf scrubs. Those habitats have been recorded at least 15 invasive species (scrubs) to 29-30 (grassland) and the highest number of invasive species if found in cultivated lands (33 species), for more detail, see Table 2 below.

Table 2. Number of alien plant species record for each habitat at Ba Vi National Park

Habitat	Core area					Buffer zone area				
	N	L	M	H	O	N	L	M	H	O
1	5	1			1					
2	27	9	1		10	24	10	3		13
3	26	10	5		15	18	16	5	1	22
4	9	25	3	1	29	8	22	5	2	29
5		1	1		2		2		1	3
6	1				0					
7	1				0					
8	27	11			11					
9	11	21	6	2	29	10	19	7	4	30
10					0	8	20	7	6	33

Note: N - Non-risk; L -Low risk, M - Medium Risk, H - High Risk, O - Overall evaluated as invasive.

The most seriously impacted habitats are resulted from selected logging, infrastructure construction building (road, tourism area and other support facilities), so scrubs and grasslands is appeared with many sources of invasive attached, mostly from the building materials such as Leucaena, Jamaica vervain, Siam weed, Giant sensitive plant,… The tourism activities are also a considerable reason for the invasive plant's expanding, there is a lot of species that

can expand through attachment to the tourist's clothes such as Blackjack, and some others have been positive planted to support for the tourism area, mostly are ornamental plants such as Lantana, Mexican sunflower, Bay Biscayne creeping-oxeye. Final reason for the appearance of invasive species in the NP is from cultivation activities, many species from the aster family such as Blackjack, Bay Biscayne creeping-oxeye, Billy goat weed and Giant sensitive plant, Leucaena are resulting from cultivated lands. The natural expansion would be presented by the appearance of Jamaica cherry (*Muntingia calabura*). The fruit of this plant is sweet, delicious for man also, then it is easy to expand by animals such as birds, squirrels, and even by man.

3.2. Assessment of Main Alien Species

The identification of all invasive species with medium or high risk to the core or buffer zone areas is important in conservation of the NP, so in this paper, 11 significantly invasive species to the NP are described and evaluated.

Mexican sunflower (Tithonia diversifolia)

About 10 years ago, Mexican sunflower was introduced as an ornamental to the district then it has escaped from cultivation to become invasive, mostly in disturbed sites, along roadsides and in rural areas near cultivation.

At Ba Vi NP, it has been planted widely in the Code 400 area, expanding to the plantation surrounding. It is also growing outside the NP, including on abandoned arable lands, roadside, boundary of plantation, shrubbery, somewhere the population is hundred m^2 and rapidly expanding to the surrounding that is why this species is evaluated at High risk in both core area and buffer zone area. It is necessary to control this species as soon as possible, especially at the core area of the NP in particular and in general it is necessary to add this species into the list of invasive plants of the nation.

Lantana (Lantana camara)

This is listed in the 100 of the World's Worst Invasive Alien Species [10]. Of course, it has been listed in the Circular 35's appendix of invasive alien species [6].

At Ba Vi NP, Wild-sage appears in many places, including gardens, uncultivated land, scrubs and roadsides, even the road through the core area and some tourist places. Within the core area, it is mostly planted but in the buffer zone area, their population is often dozen m^2 and this invader is impacting the native habitats including secondary forest and scrub, grassland. In this survey, this species is ranked as Hight Risk at both of the core area buffer zone areas. It is necessary to control this species as soon as possible, especially at the core area of the NP.

Leucaena (Leucaena leucocephala)

Leucaena appears mostly in secondary forest or scrubs (with small standing trees), including some just construction areas in the core area and common plantation forest or secondary forest at the buffer zone. Within the core area, it is mostly planted but in the buffer zone area, their population is often dozen m^2 and this invader is impacting the native habitats including secondary forest and scrub, grassland. In this survey, this species is ranked as Hight Risk at both of the core area buffer zone areas. It is necessary to control this species as soon as possible, especially at the core area of the NP. This species appears in most secondary habitats including the scrubs, abandoned arable lands, plantation and even in the understory layer of the open secondary forest, so that, in it is very common in the buffer zone area, where its population was found of dozens of m^2 as scrubs and is evaluated as high risk. In the core area, this species is limited in some places after construction at the elevation under 700m above sea level, mixed with the native species in the scrubs or plantation and it is evaluated as Medium risk.

Giant sensitive plant (Mimosa diplotricha)

This species appears in most secondary habitats including the scrubs, abandoned arable lands, plantation and even in the understory layer of the open secondary forest, so that, in it is very common in the buffer zone area, where its

population was found of dozens of m^2 as scrubs and is evaluated as high risk. In the core area, this species is limited in some places after construction at the elevation under 600m above sea level, mixed with the native species in the scrubs and is evaluated as Medium risk.

Giant sensitive tree (Mimosa pigra)

In the Mekong Delta, it was found that the average number of seeds in the topsoil was 100 seeds per meter squared [1]. This species has been listed in the Circular 35 as an appendix of invasive alien species. *Mimosa pigra* has heavily invaded some national parks and agricultural land in Vietnam recently [11].

In Ba Vi, this species appears in most wet habitats including the scrubs, abandoned arable lands, plantation and even in the understory layer of the open secondary forest which is close to the banks of the rivers or streams, even on the edge of the wet rice fields.

In the buffer zone area, it is very common, sometimes, it grows in hundreds of m^2 on the bank river, stream rivers, field banks, and it is evaluated as high risk. In the core area, because of the limit of wet habitat, it was found mostly in the stream banks and narrower population and is evaluated as Low risk for the native species and habitat.

Blackjack (Bidens pilosa)

This species is a hardy weed capable of invading a vast range of habitats ranging from moist soil, sand, lime rock, or dry, infertile soil and low to high altitudes and it was first record as alien species for Vietnam in 1993 [1] when it was found as very common in most secondary habitats such as abandoned arable lands, roadsides, scrubs and grasslands but it has been not mentioned in any alien species official assessment of the nation. Blackjack is very common in the buffer zone area, where its population was found of dozens of m^2 as scrubs, roadsides, grasslands, under plantation forest and even within opened secondary forest. However, it has not been recorded for its serious impact to the native species or habitat, it can not grow under forest canopy or other shared places, it is evaluated as Medium risk. In the core area, *Bidens piloba* appears mostly at the roadsides and it was not found in the forest, so this is evaluated as Low risk.

Siam weed (Chromolaena odorata)

Siam weed is recorded in the list of 100 of the World's Worst Invasive Alien Species [10] and was introduced as an alien species in Vietnam in 1992 [1]. In Ba Vi, the Siam weed is found mostly in the forestry lands, including secondary forest, scrub and plantation; it is occasionally to find some individuals growing independently at the other lands. At the buffer zone, their population in nature is strongly holding the habitat, expanding to the surroundings even at the roadsides close to the forest, scrub and grassland on the core area of the NP. The population was formed on the uncultivated lands after strong disturbance from human activities in the past, including forest cutting, road construction, infrastructure constructing and gardening support for tourism, or after natural landslides in some places of the islands. The side of its population is diverse, from several to hundreds m^2, it makes a Medium Risk to the habitat of the local species and habitat of the buffer zone, but in the core area, because of limiting of secondary forest together with very limit growing capacity of this species under forest canopy, the distribution of this species is limited and evaluating as Low risk.

Bay Biscayne creeping-oxeye (Sphagneticola trilobata)

This species is recorded in the list of 100 of the World's Worst Invasive Alien Species [10] but in Vietnam, it has been recorded as an alien species posing invasion risk [6]. Bay Biscayne creeping-oxeye is common, from the gardens, uncultivated lands, infrastructure constructing land to the roadsides. At the garden scale, it often covered several to hundred m^2 but in nature, the population size is limited at several m^2 only (in buffer zone only). Because of this spreading capacity, so even the population size in the nature is limited, the appearance of this at the core area is evaluated as Low Medium but it is

evaluated as Medium risk for the buffer zone areas because it has been using for ornamental very common in recently years, including in the gardens of household scale, park and also at gardens of some tourism areas.

Jamaica cherry (Muntingia calabura)

By field survey, this species was introduced as fruit tree at household scale many years ago and nowadays, it can be found in many places, mostly in the buffer zone areas, including in roadsides, open secondary forest, scrubs, especially at some wild places close to the residential areas. Surrounding some tourist areas, this plant is also common. However, the population in the wild of this species is limited to dozens of m^2. Therefore, for the buffer zone area, the appearance of this species is evaluated at medium risk while for the core area, because it was found as some individuals mixed growing with the native species at some places of constructed areas, it was evaluated as Low risk.

Jamaica vervain (Stachytarpheta jamaicensis)

This species is very common at both core and buffer zone areas, but it is found at roadsides in the core area while in the buffer zone, its population would be found as hundreds of m^2 on the abandoned arable lands, dozens of m^2 at roadsides. In the southern part of the NP, in Hoa Binh province, it is growing mixed in the secondary forest. Finally, this species is evaluated as medium risk for the buffer zone area and low risk for the core area.

Coast morning glory (Ipomoea cairica)

This species has not been mentioned in any alien species official assessment of the nation but it was mentioned as an invasive plant for Cu Lao Cham islands (Tai et al., 2017) and by the field survey of this research, the species is still recorded as invasive for Vietnam. In many place of the buffer zone, this species has been planting for many purpose, including for ornamental, natural defense, green roofs (to avoid the sun),… after many years of using this species to decorate for the local houses, the plant is very common at the buffer zone's habitat, including scrubs, plantation and also natural secondary forest, sometimes, it covered for dozens of m^2 and it is evaluated as Medium risk. However, in the core area, this species has been limited found in some tourist places at the elevation lower 400 m above sea level and it is evaluated as Low risk.

Conclusion

Results from field surveys in both the core area and buffer zone area of Ba Vi National Park shows that 47 alien plant species were recorded, including 29 invasive species found in the buffer zone area and 15 species found in the core area. The cultivated lands (abandoned arable lands), scrubs and grassland is the most high risk habitat under impact of alien invasive plants. The level of risk by the invasive plants at the buffer zone is always higher than that in the core area. Finally, 11 invasive plant species have been assessed for both the core area and buffer zone area. 2 species as Mexican sunflower (*Tithonia diversifolia*) and Lantana (*Lantana camara*) are evaluated as High risk for both areas while 3 other ones are evaluated as High risk for buffer zone only, including Giant sensitive tree (*Mimosa pigra*), Leucaena (*Leucaena leucocephala*) and Giant sensitive plant (*Mimosa diplotricha*). The other ones have been evaluated as Medium risk (at buffer zone) to Low risk (at core area) are Blackjack (*Bidens pilosa*), Siam weed (*Chromolaena odorata*), Bay Biscayne creeping-oxeye (*Sphagneticola trilobata*), Jamaica cherry (*Muntingia calabura*), Jamaica vervain (*Stachytarpheta jamaicensis*) and Coast morning glory (*Ipomoea cairica*). By this evaluation, Mexican sunflower (*Tithonia diversifolia*), Blackjack (*Bidens pilosa*), Jamaica cherry (*Muntingia calabura*), Jamaica vervain (*Stachytarpheta jamaicensis*) and Coast morning glory (*Ipomoea cairica*) are suggested to include to the list of invasive organisms of the nation. Besides that, it is necessary to more strict control of Mexican sunflower (*Tithonia diversifolia*) inside the core area of the NP in particular and in Ba Vi district in general, especially at the

tourisms place where the festival of Mexican sunflower have been yearly organized.

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Table 3. List of alien plants species appearing in Ba Vi National Park

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	CA	BZ
Division: Magnoliophyta. *I. Magnoliopsida*									
O.01. Asterales: f.01.Asteraceae									
1.	*Ageratum conyzoides* L., 1753*	Cỏ cứt lợn	Billy goat-weed	Tropical America	America, Asia, Australia, Europe	1979 (CABI-I)	(2), (3), (4), (8), (9), (10)	L	L
2.	*Ageratum houstonianum* Mill, 1768	Cỏ mịch	Blue billygoat weed	C. America	Large parts of the tropics & S. USA	1971 (CABI-I)	(1), (2), (3), (4), (6), (7), (8), (9), (10)	N	L
3.	*Bidens pilosa* L., 1753	Đơn buốt	Beggar-ticks	America	Global	1993 (CABI-I)	(2), (3), (4), (8), (9), (10)	L	M
4.	*Chromolaena odorata* (L.) R.M. King & H.Rob., 1970*	Cỏ lào	Siam weed	America	Global	1992 (CABI-I)	(2), (3), (4), (8), (9), (10)	L	M
5.	*Conyza canadensis* L. 1753	Hổ nhĩ thảo	Canadian fleabane	N. America and Central America	Temperate of Asia, Europe & Australia	1979 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L
6.	*Crassocephalum crepidioides* (Benth.) S.Moore, 1912	Rau tàu bay	Redflower ragleaf	New Caledonia	Tropical climate	2012 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L
7.	*Eclipta prostrata* (L.) L.	Cúc dùi trống	Eclipta	Warm temperate	India, Nepal, China, Thailand, and Brazil.	1979 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L
8.	*Elephantopus mollis* Kunth, 1820	Lưỡng sắc lá nguyên	Elephant's foot	S.&C. America	Tropical area	2013 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	CA	BZ
9.	*Sphagneticola trilobata* (L.) Pruski, 1996	Cỏ xuyến chi	Bay Biscayne creeping-oxeye	Mexico, C.America, Caribbean	Tropical areas	2011 (MONRE)	(2), (3), (4), (8), (9), (10)	L	M
10.	*Synedrella nodiflora* (L.) Gaertn., 1791	Cúc áo hoa vàng	Synedrella	S.&C. America	Tropical areas	1991 (CABI)	(2), (3), (4), (8), (9), (10)	N	L
11.	*Tithonia diversifolia (Hemsl.)* A.Gray	Hoa dã quỳ	Mexican sunflower	Mexico and C. America	Pantropical	2018 (CABI-I)	(2), (3), (4), (8), (9), (10)	H	H
O.02. Lamiales: f.02. Acanthaceae									
12.	*Thunbergia grandiflora* (Roxb. ex Rottler) Roxb	Cát đằng đứng	Bengal trumpet	Central of Asia temperature	Tropical Asia	2012 (CABI-I)	(3), (8)	N	N
O.03. Caryophyllales: f.03.Amaranthaceae									
13.	*Alternanthera philoxeroides (Mart.) Griseb. 1879*	Dệu	Alligator weed	Temperate regions of S. America	Parana River region of South America	1993 (CABI-I)	(3), (8)	N	N
14.	*Amaranthus dubius* Mart. ex Thell. 1912	Dền gai	Spleen amaranth	S.&C. America	Tropical and Subtropical areas	2014 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	N
15.	*Amaranthus spinosus* L. 1753	Dền lai	Spiny amaranth	Tropical Americas	Global	1991 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L
O.04. Gentianales: f.04. Apocynaceae									
16.	*Catharanthus roseus* (L.) G.Don	Dừa cạn	Madagascar periwinkle	Madagascar	Tropical and tropical regions	2015 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	N
O.05. Ericales: f.05. Balsaminaceae									
17.	*Impatiens balsamina* L.	Bóng nước harmand	Garden balsam	India, Myanmar	India, China and Southeast Asia	2001 (CABI-N)	(2), (3), (4), (8), (9), (10)	N	N

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	CA	BZ
O.06. Brassicales: f.06. Cleomaceae									
18.	*Cleome viscosa* L.	Màn màn trắng	Asian spiderflower	Australia	Americas, Africa and Asia, Australia	2015	(2), (3), (4), (8), (9), (10)	N	N
O.07. Malpighiales: f.07. Euphorbiaceae									
19.	*Euphorbia hirta* L.		Garden spurge	Tropical Americas	Tropical area	1979 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	N
20.	*Jatropha curcas* L.	Dầu mè	Jatropha	The American tropics	Tropical and subtropical	2008 (CABI-I)	(3), (10)	N	N
O.08. Fabales: f.08. Fabaceae									
21.	*Calopogonium mucunoides* Desv	Kê huyết đằng	Calopo	Tropical Americas	Humid tropical areas	2012 (CABI-I)	(3), (8)	N	N
22.	*Leucaena leucocephala* (Lam.) de Wit, 1763*	Keo dậu	White lead tree	Mexico, Belize	America and other Tropics	2007	(2), (4), (9), (10)	M	H
23.	*Mimosa pigra* L., *1759**	Mai dương, Trinh nữ gỗ	Giant sensitive tree	C.&S. America	Wetland Tropics	1990	(2), (4), (5), (9), (10)	M	H
24.	*Mimosa diplotricha* C. Wright ex Sauvalle	Trinh nữ móc	Giant sensitive plant	Neotropics	Tropics	1977 (CABI-I)	(2), (3), (4), (8), (9), (10)	L	H
25.	*Mimosa pudica* L.,1753	Trinh nữ	Sleepy plant	C.&S. America	America and other Tropics	1977	(2), (3), (4), (8), (9), (10)	L	L
26.	*Senna hirsuta* (L.) H.S.Irwin & Barneby	Muồng me, Muồng hai nang, me rừng	Hairy senna	S. America	Tropical areas	2005 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	CA	BZ
27.	*Senna occidentalis* (L.) Link, 1829	Muồng chét, Mó hàn	coffee senna	Tropical America	Tropics	1979 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	N
O.09. Malvales: f.09. Malvaceae									
28.	*Sida acuta* Burm.f	Bụp hoa tai	Sida	C. America	Pantropica	1977 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L
f.10. Muntingiaceae									
29.	*Muntingia calabura* L.	Trứng cá	Jamaica cherry	Mexico S. to Bolivia,	Tropics	1989 (CABI-I)	(2), (4), (9), (10)	L	M
O.10. Caryophyllales: f.11. Portulacaceae (26)									
30.	*Portulaca pilosa* L.	Mười giờ	Kiss-me-quick	Tropical S. SE. Americas	Global	2015 (CABI-I)		N	N
O.11. Solanales: f.12. Solanaceae									
31.	*Physalis angulata* L.	Thù lù cạnh, tầm bóp, lồng đèn, bôm bốp	Cutleaf groundcherry	S. & C. Americas	Tropical and subtropical regions	1993 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	N
32.	*Physalis peruviana* L.	Ttầm bóp Nam Mỹ	Cape gooseberry	S. Americas	Global	2012 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	N
O.12. Lamiales: f.13. Verbenaceae									
33.	*Lantana camara* L., 1753*	Bông ổi, Ngũ sắc	Wild-sage	C.&S. America	America and other Tropics	1979	(2), (3), (4), (8), (9), (10)	H	H
34.	*Stachytarpheta jamaicensis* (L.) Vahl, 1804(¥)	Đuôi chuột	Blue porter weed	Caribbean	Tropics	1991	(2), (3), (4), (8), (9), (10)	L	M

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	CA	BZ
O.13. Malpighiales: f.14. Passifloraceae									
35.	*Passiflora foetida* L., 1753	Lạc tiên	Wild maracuja	America	Global	1991	(2), (3), (4), (8), (9), (10)	L	L
O.14. Myrtales: f.15. Myrtaceae									
36.	*Eucalyptus camaldulensis* Dehnh	Bạch đàn trắng	Red gum	Australia		2019 (CABI-I)	(9)	N	N
37.	*Eucalyptus paniculata* Sm. 1797	Bạch đàn	Grey ironbark	New South Wales	Global		(9)	N	N
38.	*Psidium guajava* L., 1753	Ổi	Guava	C. & S. America	Global (tropical & sub-tropical)	2002	(2), (3), (4), (8), (9), (10)	N	L
39.	*Rhodomyrtus tomentosa* (Aiton) Hassk., 1842	Sim	Rose myrtle	Himalayas, Malaysia, Philippines	S. E. Asia, E. US, Australia	2012	(2), (3), (4), (8), (9), (10)	L	L
O.15. Oxalidales: f.16. Oxalidaceae									
40.	*Oxalis corniculata* L., 1753	Chua me hoa vàng	Creeping wood sorrel	Oceania, Pacific America	Global	1977	(10)	N	N
O.16. Solanales: f.17. Convovulaceae									
41.	*Ipomoea cairica* (L.) Sweet, 1827*	Bìm ai cập	Coast morning glory	Uncertain	Africa, New South Wale, S.E. Asia, US	None	(2), (4), (9), (10),	L	M
II. Liliopsida									
O.17. Commelinales: f.18. Commelinaceae									

No.	Latin name	Vietnamese name	English common name	Nativity/ origin place	Geographic distribution	Alien first time record in Vietnam	Impact situation		
							Habitat(s)	CA	BZ
42.	*Callisia fragrans* (Lindl.) Woodson, 1942*(¥)	Cây lược vàng	Basket plant	Mexico	S. E Asia, C. Ameria, Caribbean, Oceania	2013		N	N
O.18. Cyperales: f.19. Poaceae									
43.	*Cynodon dactylon* (L.) Pers., 1805	Cỏ gà	Vilfa stellata	Middle East	America, Oceania, Pacific islands, S. E. Asia	1979	(2), (3), (4), (8), (9), (10)	N	L
44.	*Panicum repens* L. 1762	Cỏ cựa gà, Cỏ ống	Torpedograss	Eurasia	Global	1979	(2), (3), (4), (8), (9), (10)	N	L
45.	*Paspalum conjugatum* P. J. Bergius	Kê tóc, Cỏ gừng nam, Cỏ công viên	Buffalo grass	American tropics and sub-tropics	S. Asia & Pacific Islands, N. Africa & N. and E. Australia	2018 (CABI-I)	(2), (3), (4), (8), (9), (10)	N	L
46.	*Pennisetum purpureum* Schumach., 1827	Cỏ voi, cỏ đuôi voi	Elephant grass	Tropica Africa	Tropical & subtropical regions	1993 (CABI-I)	(3), (8), (10)	N	L
47.	*Saccharum spontaneum* L. 1771	Lách	Wild sugarcane	India	Asian tropics and subtropics	1997	(3), (8)	N	N

Note: CA: Core area; BZ: Buffer Zone; Note: N-Non risk; L - Low risk, M - Medium Risk, H - High Risk,
(*) - Circular No. 35; (¥) - CABI-ISC; E.-East; N.-North; S.-South; C.-Central.

Table 4. Evaluation results for alliance plant species at Ba Vi National Park

No.	Species		Habitats at core areas											Habitats at buffer zone araea					
	Latin name	*English name*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*O*	*2*	*3*	*4*	*5*	*9*	*10*	*O*
1	*Ageratum conyzoides*	Billy goat weed		N	N	L				L	L	L	N	L	L		L	M	L
2	*Ageratum houstonianum*	Blue billygoatweed	N	N	N	L		N	N	N	L	N	N	L	L		L	L	L
3	*Bidens pilosa*	Blackjack		N	L	M				L	L	L	L	M	M		M	H	M
4	*Chromolaena odorata*	Siam weed	L	L	L	L				L	M	L	L	M	M		M	L	M
5	*Conyza canadensis*	Canadian fleabane		N	N	L				N	L	N	N	L	L		L	L	L
6	*Crassocephalum crepidioides*	Redflower ragleaf	N	N	L	L				N	L	N	N	L	L		L	L	L
7	*Eclipta prostrata*	Eclipta		N	N	L				N	L	N	N	N	L		L	M	L
8	*Elephantopus mollis*	Elephant's foot	N	N	N	L				N	L	N	N	N	L		L	L	L
9	*Sphagneticola trilobata*	Bay Biscayne creeping-oxeye	N	L	L	L				L	M	L	N	L	L		M	M	M
10	*Synedrella nodiflora*	Synedrella	N	N	N	L				N	L	N	N	N	L		L	L	L
11	*Tithonia diversifolia*	Mexican sunflower		L	M	M				L	H	H	L	M	M		M	H	H
12	*Thunbergia grandiflora*	Bengal trumpet			N					N		N		N					N
13	*Alternanthera philoxeroides*	Alligator weed			N					N		N		N					N
14	*Amaranthus dubius*	Spleen amaranth		N	N	L				N	N	N	N	N	L		N	L	N
15	*Amaranthus spinosus*	Spiny amaranth		N	N	L				N	N	N	N	N	L		L	L	L
16	*Catharanthus roseus*	Madagascar periwinkle		N	N	N				N	L	N	N	N	N		L	L	N
17	*Impatiens balsamina*	Garden balsam		N	N	N				N	N	N	N	N	N		N	N	N
18	*Cleome viscosa*	Asian spiderflower		N	N	N				N	N	N	N	N	N		N	N	N
19	*Euphorbia hirta*	Garden spurge		N	N	N				N	N	N	N	N	N		N	L	N
20	*Jatropha curcas*	Jatropha		N	N	N				N	N	N	N	N	N		N	N	N
21	*Calopogonium mucunoides*	Calopo			N					N		N		N					N
22	*Leucaena leucocephala*	Leucaena		M	M	L					M	M	M		H		H	H	H
23	*Mimosa diplotricha*	Giant sensitive plant		L	L	M	L				M	M	L	L	M	L	H	H	H
24	*Mimosa pigra*	Giant sensitive plant		L	L	L	M			L	L	L	L	L	L	H	H	H	H
25	*Mimosa pudica*	Sensitive plant		L	L	L				L	L	L	L	L	L	L	L	L	L

26	*Senna hirsuta*	Hairy senna		N	N	L					L	N	N	N	L		L	L	L
27	*Senna occidentalis*	Coffee senna		N	N	N				N	N	N	N	N	N		N	N	N
28	*Muntingia calabura*	Jamaica cherry		L	M	L				L	M	L	M	M	L		M	M	M
29	*Sida acuta*	Sida		N	N	L				N	L	N	N	N	L		L	L	L
30	*Portulaca pilosa*	Kiss-me-quick				N					N	N					N	N	N
31	*Physalis angulata*	Cutleaf groundcherry		N	N	L				N	L	L	N	N	L		L	L	N
32	*Physalis peruviana*	Cape gooseberry		N	N	N				N	N	N	N	N	N		N	N	N
33	*Lantana camara*	Lantana		L	M	H				N	H	H	M	H	H		H	H	H
34	*Stachytarpheta jamaicensis*	Jamaica vervain		L	M	L				L	M	L	L	M	M		M	M	M
35	*Passiflora foetida*	Red fruit passion flower		N	L	L				L	L	L	L	L	L		L	L	L
36	*Eucalyptus camaldulensis*	Red gum									N	N					N		N
37	*Eucalyptus paniculata*	Grey ironbark									N	N					N		N
38	*Psidium guajava*	Guava		N	N	N				N	L	N	N	L	N		L	L	L
39	*Rhodomyrtus tomentosa*	Rose myrtle		N	L	L				N	L	L	L	L	L		L	L	L
40	*Oxalis corniculata*	Creeping woodsorrel																N	N
41	*Ipomoea cairica*	Coast morning glory		N		L					L	L	L		L		M	M	M
42	*Callisia fragrans*	Basket plant																N	N
43	*Cynodon dactylon*	Bermuda grass		N	N	L				N	L	N	N	L	L		L	L	L
44	*Panicum repens*	Torpedo grass		N	N	L				N	L	N	N	L	L		L	L	L
45	*Paspalum conjugatum*	Buffalo grass		N	N	L				N	L	N	N	L	L		L	L	L
46	*Pennisetum purpureum*	Elephant grass			L					L		N		L				M	L
47	*Saccharum spontaneum*	Wild sugarcane			N					N		N		L					N
Total			6	37	41	38	2	1	1	38	40	44	37	40	37	3	40	41	47

Note: N-Non risk; L -Low risk, M – Medium Risk, H – High Risk, O – Overall evaluated.