AES BIOFLUX

Advances in Environmental Sciences - International Journal of the Bioflux Society

Diversity, vegetation analysis and RCE inventory employed in assessing riverine channel of Malapatan, Sarangani Province, Philippines

Jeljie L. Dice, Jephte R. Ecot, Sarah P. Olegario, Sitti Ayesha P. Abdon, Luke Angelo A. Celeste, Lady May P. Tayong, Rome R. Podico, Christine J. Ferrer, Jibrolet Sabid, Jess H. Jumawan

Department of Science, College of Natural Sciences and Mathematics, Mindanao State University – General Santos City Campus, General Santos City, Philippines. Corresponding author: J. L. Dice, dicejeljie@gmail.com (mail to: mfitzpatrick@yahoo.com)

Abstract. Vegetation assemblage and distribution was assessed through plot-nested method across riparian habitat in Brgy. Lun Padidu, Malapatan, Sarangani, Philippines. A total of 1331 individuals were recorded and were classified into 56 genera and 61 species. Of the total species sampled, 79% (49) were shrubs/herbs. However, the most abundant species are grasses suggesting that riparian vegetation in the chosen study site was mainly made of grassland community. *Cyperus brevifolius* (pugo-pugo) was found to have the highest Importance Value (IV = 26.09%) followed by *Eleusine indica* (IV = 10.43%) and *Sterculia* sp. (IV = 8.78%). Most species sampled were Least Concerned (LC) or Not Evaluated (NE) according to IUCN 2013. However, the presence of two invasive species - *Chromoelana indica* (hagonoy) and *Saccharum spontaneum* (talahib) may potentially disrupt the native flora in the study area. Diversity index indicates that area 2 is the most diverse however Evenness (E) values show that area 3 being least diverse, has the highest evenness value (E = 0.65). As a whole, Riparian, Channel and Environmental (RCE) inventory values show that the river is in good condition (mean RCE = 154). Mean RCE value further indicated that Lun Padidu river was Class III stream. This classification of the stream was supported by the presence of only few tree stand and shrubs and the dominance of grass species.
Key Words: diversity index, importance value, riparian, invasive species, plot-nested method.

Introduction. Riparian areas provide services to the ecosystem by attenuating flood, cycling nutrients, sequestrating carbon dioxide, depositing sediments, producing timbers and serving as recreation and wildlife habitat (Alldredge & Moore 2014). Riparian ecosystems in fact support wetland species due to the fact that these species have been subjected to periodic inundation that is frequently substantial to restrict upland species dominance (Alldredge & Moore 2014). In addition, these water sources provide economic (fisheries, livestock, forestry) as well as social (water supply) functions (Bassi et al 2014).

Vegetation indicates the overall health of wetland ecosystems and at the same time even serves as the basis for classifying streams or rivers and may further indicate human led intervention (Fenessy et al 2002; Cowardin et al 1979; Petersen 1992; Kosuth et al 2010).

Thus, restoring riparian habitats requires the understanding of both regional and local patterns of plant species diversity wherein a full understanding of species distribution is essential in improving restoration planting success and enhancing sustainable ecosystem functioning (Viers et al 2011; Kosuth et al 2010). Moreover, exploring natural flora as a source for identifying gene bank in various plant groups require the assessment of regional plant diversity (Vipin & Madhuri 2014).

Another key component that may describe the current status of a riparian community is by assessing its overall Riparian, Channel and Environmental status. The Riparian, Channel and Environmental (RCE) Inventory (Petersen 1992) was formulated to analyze and understand the biotic as well as abiotic components of small streams found in the lowland, agricultural landscape. This analysis consists of sixteen characteristics which define the structure of the stream, morphology of the stream channel, and the overall ecological condition of the river. Ross (1963) was able to initially observe the impacts of riparian channel interaction: the evolution and distribution of the *Trichoptera* species were associated to the abundance of deciduous riparian vegetation. Furthermore, Cummins et al (1989) related the macroinvertebrate community functional structure to the structure of the riverine vegetation.

Vegetation along with RCE are two key components that would determine the total health of river ecosystems. However, published data on the vegetation in the riparian zones of Brgy. Lun Padidu, Malapatan, Sarangani, Philippines is presently insufficient. Thus, this research will embark on identifying the riparian vegetation in the said area so as to establish the possible anthropogenic impacts to the general ecology of the river. Water environment is influenced by human activities such as those from industries and the agriculture sector leading to serious degradation (Shi et al 2014; Wang & Pei 2012). Moreover, this research will analyze the RCE status of the said ecosystem. Vegetation assessment along with analysis of the RCE of the stream is important in properly establishing baseline data on the current ecological status of the said ecosystem. This information will serve as a guide for establishing proper conservation initiatives in the area. Moreover, it will be helpful in thoroughly understanding the dynamics of life that exists within the said ecosystem.

Material and Method

Study sites. The study was conducted for the period of June to August, 2014 in Malapatan, Sarangani Province (05^{o}58 N and 125^{o}17 E) (Figures 1 and 2). It is bounded on the west by Sarangani Bay, on the east by Davao del Sur, on the north by Alabel and on the south by Glan.

Three areas were identified and 10x10 plots where established across three transects for each area. The three sampling areas were located along the river with these coordinates: area 1 (A1) = 6^{o}3'56.94"N, 125^{o}18'22.48"E; area 2 (A2)= 6^{o}2'59.83"N, 125^{o}18'12.18"E; area 3 (A3) = 6^{o}2'12.73"N, 125^{o}16'50.53"E (Figures 3 and 4). All plants that fall within the plot were recorded.

Figure 1. Philippine Map.

Figure 2. Mindanao Map.

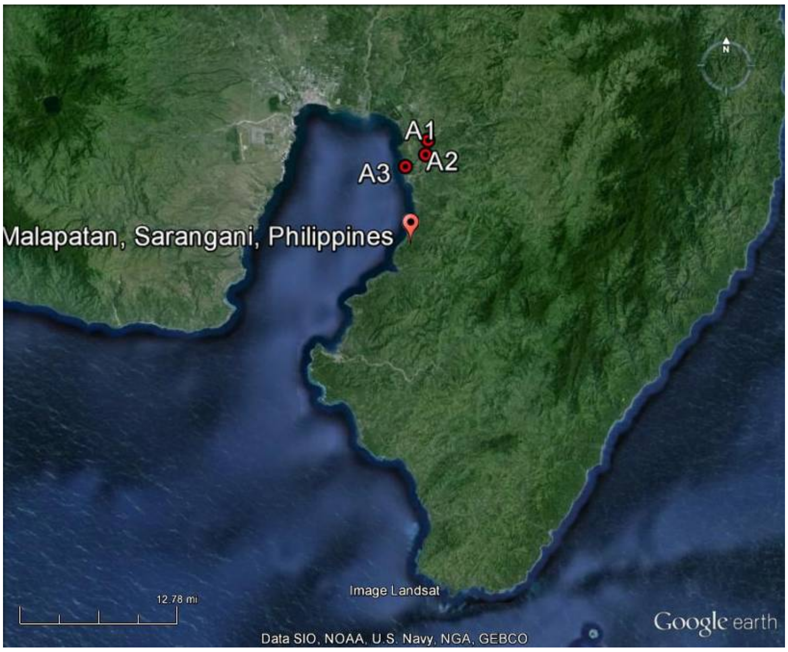

Figure 3. Map showing the relative location of study sites in Malapatan.

Figure 4. The three study sites in Malapatan.

Sampling method. Vegetation assessment was carried out through plot nested method. 10x10 plots were laid along each transect for each sites. Grasses, shrubs and trees that fall within the plot were recorded. Species recorded where identified down to species level. The data on the number of individuals was used to compute for biodiversity and importance values of each species.

Species composition. The species observed in the sampling area were identified and listed as species composition in the sampling area. Reliable identification guides and manuals were used (Moody et al 1984; Madulid 1995; Rojo 1999; Langenberger et al 2006; Madulid 2002).

Computation of diversity indices. The data on abundance was used to compute for diversity indices. The diversity indices include species richness, abundance, dominance, Shannon's diversity, Simpson's diversity, and evenness. The software Paleontological

Statistical (PAST) Software version 1.34 (Hammer et al 2001) was used in the computation of values. The values of biodiversity indices were assigned with rank from highest to lowest values in the three sampling areas.

Vegetation analysis. Communities are often described by the species or genera that are determined to be the most important in the community. This is quantified by calculating the statistics known as Importance Value (Schmidt 2005). Evaluation of ecological measurements of species composition and distribution was carried out by calculating species abundance, frequency and their relative measures. These values were derived using the formulas:

1. Abundance = total no. of individuals
2. Relative Abundance (RA) = (abundance/total no. of individuals of all species) x 100
3. Frequency = no. of transects the species appeared
4. Relative Frequency (RF) = (Frequency/Total frequency of all species) x 100
5. Importance Value (IV) = Relative Abundance + Relative frequency

Riparian, channel and environmental inventory. RCE inventory was done using the methods by Petersen (1992) where stream quality is identified using the scores from Table 1.

Table 1

Relative RCE score with the corresponding classification of stream quality

Class	*Score*	*Evaluation*
I	273-340	Excellent
II	204-272	Very good
III	134-203	Good
IV	66-133	Fair
V	15-65	Poor

Data analysis. In determining the comparison in the condition of three sites an arbitrary ranking of values were assigned from highest to lowest. In biodiversity values, vegetation analysis and RCE scores, ranks were assigned to the site with highest values. The mean numbers of ranks were computed and the resulting values were used to compare the condition of the three sites.

Results and Discussion

Species composition. Riparian vegetation in Lun Padidu, Malapatan, Sarangani Province is mostly made of grassland community. A total of 1331 individuals were recorded and were resolved into 54 genera and 60 species: of which, 48 are shrubs/herbs/vines, 10 are grasses and 2 are trees (Figure 5; Appendix A).

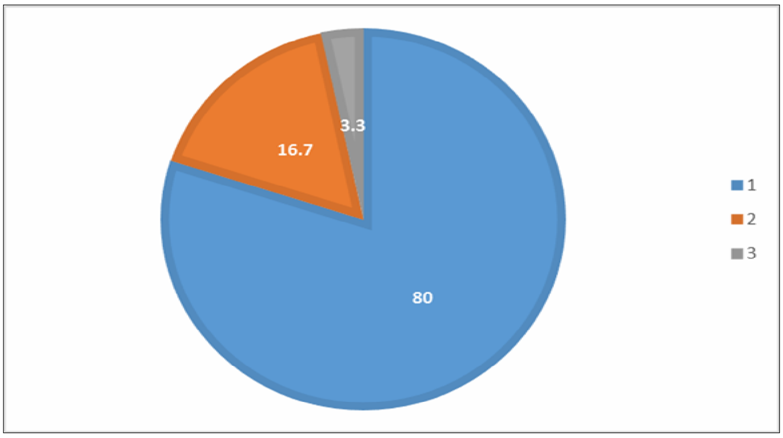

Figure 5. Percent composition by habit: 1). grasses; 2). shrubs; 3). trees.

In this study, based from the data collected, 80% of the total species identified is comprised of shrubs and herbs species. Only two tree species were recorded in the study site: *Leucaena leucocephala* (Ipil-Ipil) and *Cocos nucifera* (Coconut Palm) which are both recorded in area 3.

Moreover, the study site is characterized by the presence of the invasive species *Chromolaena odorata* (Hagonoy) and *Saccharum spontaneum* (Talahib) which have devastating ecological impacts and may be the primary cause of biodiversity loss (Schmidt 2005; Hejda et al 2009) due to their abilities to form dense populations; this may cause a debilitating impact on the native flora of the area (Schmidt 2005; Hejda et al 2009).

Vegetation analysis. Area 1 is dominated by the species *Cyperus brevifolius* (21.30%) followed by the species *Eleusine indica* (14.08%) and *Cyperus iria* (9.79%).

On the other hand, Area 2 is dominated by *C. brevifolius* (12.68) followed by *S. spontaneum* (8.61%) and *Euphorbia hirta* (10.17%)

Area 3 however, as compared to the former areas, is less diverse as only eight (8) plant species were recorded. This area which is found already in the mouth of the river is primarily dominated by the species *Sterculia* sp. (62.73%), *Portulaca oleracea* (29.09%) and *Physalis angulata* (25.45 %).

Overall, *C. brevifolius* was computed as the most important species in the study site with an IV of 26.10. This is followed by *E. indica* (IV= 10.44), *Sterculia* sp. (IV= 8.78), *E. hirta* (IV = 8.27) and *C. iria* (IV = 7.26) (Table 2).

C. brevifolius (Pugo-Pugo) is an annual herb that is found all throughout the Philippines at low to medium altitudes and is known to have decongestant, antipyretic, anti-inflamatory, analgesic and antimalarial properties.

Table 2

Top ten species across all areas based on computed Importance Values (IV)

Species	*RA*	*RF*	*IV*
Cyperus brevifolius	15.40	10.70	26.09775
Eleusine indica	6.16	4.28	10.4391
Sterculia spp.	5.18	3.60	8.784122
Euphorbia hirta	4.88	3.39	8.274898
Cyperus iria	4.28	2.97	7.256449
Cyperus compactus	4.21	2.92	7.129143
Saccharum spontaneum	4.13	2.87	7.001837
Imperata cylindrica	2.70	1.88	4.58302
Portulaca oleracea	2.40	1.67	4.073796
Paspalum distichum	2.33	1.62	3.94649

Observed number of species with highest Importance Value. Overall, Area 2 has the highest number of species with the highest computed IV (Table 3). This is followed by Area 1. Both aforementioned areas have the highest number of species in the top ten list with highest IV since these areas have greater species abundance compared to Area 3 which has only a total of 8 identified species (Tables 3 and 6). Reviews on the conservation status of the species in the study site reveal that almost all species are found to have been listed as Least Concerned (LC) or Not Evaluated (NE). This current investigation on riparian habitats in Lun Padidu, Malapatan, Sarangani Province, Philippines revealed that it is typically composed of grassland community.

Table 3

Number of species with highest IV per area with ranking (R)

	A1	*A2*	*A3*
No. of species with highest IV	5 species (rank 2)	7 species (rank 1)	2 species (rank 3)

1 = highest; 2 = middle; 3 = lowest.

Diversity indices. Computed Simpson's diversity index in the study site has an average value of 0.868 suggesting a relatively high diverse ecosystem. From the three areas sampled, area 2 has the highest value (0.94) followed by area 1 (0.91). Area 3 has the lowest value of 0.76. This result can be accounted to the fact that more plant species comprise the area 2 and area 1 which has a total of 43 and 36 identified taxa respectively contrary to area 3 which has only 8 identified plant species (Tables 4 and 6).

Overall, the study area has high diversity (0.868). High diversity in an ecosystem enhances its ability to withstand disturbances such as pollution, maintain soil fertility and micro-climates, cleanse water and provide other invaluable services (Schmidt 2005). However, with the observed occurrence of invasive species, such high diversity may in the long run be put at risk if no sustainable measures for long-term conservation are undertaken.

Table 4

Data on diversity of the study site

Ecological measurements	*A1*	*A2*	*A3*
Species richness	35 (rank 2)	44 (rank 1)	8 (rank 3)
Abundance	582 (rank 2)	639 (rank 1)	175 (rank 3)
Dominance	0.09109 (rank 2)	0.06406 (rank 3)	0.2408 (rank 1)
Shannon diversity	2.887 (rank 2)	3.063 (rank 1)	1.643 (rank 3)
Evenness	0.5125 (rank 2)	0.4863 (rank 3)	0.6465 (rank 1)

Riparian, Channel and Environmental Inventory. RCE mean value (mean RCE = ΣRCE/total no. of areas) of 154 ([202+196+66]/3) suggests that Lun Padidu River is Class III stream suggesting that overall, the river is in good condition to support the biotic components of its ecosystem (Table 5). In this evaluation, it was observed that RCE values are decreasing (Table 6). Area 1 has a total RCE of 202; area 2 has 196 and area 3 has a total RCE of 66 (Table 5). This decreasing trend can be because of the fact that area 1 has less human-led intervention as compared to area 2 which is near road system and area 3 which is already in the river mouth which is already near to human dwellings.

Table 5

Data on diversity of the study site

Area	*RCE*	*Rank*	*Class*	*Condition*	*Remarks*
1	202	1	III	Good	Low plant density
2	196	2	III	Good	Low plant density
3	66	3	IV	Fair	Low plant density

Based on the present study, relative RCE results can support the abundance of observed species as well as the diversity of species in the study areas as evaluation of the land-use pattern across three sites reveal that it is mostly undisturbed. Disturbance in the study areas is minimal. However, despite of the fact that the river ecosystem appears to be undisturbed as there is minimal human led intervention in the area, low scores for the RCE analysis for the three identified sites is conferred by the fact that the vegetation is mostly of grasses. In this current investigation, only a few trees and shrubs were identified. The presence of small amount of detritus may support the abundance of graminoids in the area. Moreover, RCE analysis in the three areas reveal the presence of rocks and logs along with other woody debris contributed by these riparian vegetation which may serve as retention devices to retain nutrients and water that will be added to the floodplain at regular intervals (Petersen 1992).

Table 6

Summary of the areas with assigned ranks

Ecological measurements	*A1*	*A2*	*A3*
Diversity	2	1	3
Vegetation	2	1	3
RCE	1	2	3

1 = highest; 2 = middle; 3 = lowest.

Conclusions. Overall data on Lun Padidu River ecosystem show that A2 is the most abundant and the most diverse from among the three areas. A3 on the other hand ranks the least from among the three major aspects being studied in the said ecosystem. Meanwhile, A1 ranks first in terms of RCE value as it is the least inaccessible area in the study site.

Collectively, the computed RCE mean value of 154 suggests Lun Padidu river exhibited good quality of riparian ecosystem with its riparian vegetation being slightly altered by human-led intervention. This study shows that riverine vegetation mostly contains species that belong to native vegetation but only with the dominance of graminoids.

Furthermore, the presence of invasive species *C. odorata* (Hagonoy) and *S. spontaneum* (Talahib) would require protection and restoration measures in order to eliminate or prevent potential new impacts as much as possible and to further achieve the full integrity of riparian functions. There is a strong link between biodiversity and ecosystem functioning that biodiversity losses will induce modification of the natural ecosystem functioning and services.

Acknowledgements. The researchers would like to thank the support extended by the local government of Malapatan, Sarangani Province for allowing them to conduct the study in the said area.

References

Alldredge B., Moore G., 2014 Assessment of riparian vegetation sensitivity to river hydrology downstream of a major Texas dam. River Research and Applications 30(2):230-244.

Bassi N., Kumar M. D., Sharma A., Pardha-Saradhi P., 2014 Status of wetlands in India: a review of extent, ecosystem benefits, threats and management strategies. Journal of Hydrology: Regional Studies 2:1-19.

Cowardin L., Carter V., Golet F., Laroe E., 1979 Classification of wetlands and deepwater habitats of the United States. Washington D.C., U.S. Fish and Wildlife Service, 103 pp.

Cummins K. W., Wilzbach M. A., Gates D. M., Perry J. B., Taliaferro W. B., 1989 Shredders and riparian vegetation. Bioscience 39:24-30.

Fenessy S., Gernes M., Mack J., Wardrop D. H., 2002 Methods for evaluating wetland condition: using vegetation to assess environmental conditions in wetlands. Washington D.C., U.S. EPA, 38 pp.

Hammer Ø., Harper D. A. T., Ryan P. D., 2001 PAST: Paleontological statistics software package for education and data analysis. Palaeontologia Electronica 4:1-9.

Hejda M., Pysek P., Sarosik V., 2009 Impact of invasive plants on the species richness, diversity and composition of invaded communities. Journal of Ecology 97:393-403.

Kosuth P., Tormos T., Cernesson F., Lalande N., Villeneuve B., 2010 Assessing the role of riparian vegetation and land use on river ecological status using remote sensing and spatial modelling. Proceedings 7th European Conference on Ecological Restoration, 23-27.08.2010, Avignon, France, 4 pp.

Langenberger G., Martin K., Sauerborn J., 2006 Vascular plant species inventory of a Philippine lowland rain forest and its conservation value. Biodiversity and Conservation 15:1271-1301.

Madulid D. A., 1995 A pictorial cyclopedia of Philippine ornamental plants. Bookmark, Inc., Manila, Philippines, 388 pp.
Madulid D. A., 2002 A pictorial guide to the noteworthy plants of Palawan. PTFPP-PCSDS, Palawan, Philippines, 129 pp.
Moody K., Munroe C., Lubigan R., Paller E. J., 1984 Major weeds of the Philippines. University of the Philippines, Los Banos, Lacuna, Philippines, 328 pp.
Petersen R. C. Jr., 1992 The RCE: a Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. Freshwater Biology 27:295-306.
Rojo J. P., 1999 Revised lexicon of Philippine trees. Forest Products Research and Development Institute, DOST, UPLB, Philippines, 484 pp.
Ross H. H., 1963 Stream communities and terrestrial biomes. Archive for Hydrobiology 59:235-242.
Schmidt W., 2005 Herb layer species as indicators of biodiversity of managed and unmanaged beech forests. For Snow Landsc Res 79:111-125.
Shi P., Xu S., Zhan G., Liu W., Tan D., Huang P., 2014 Appling plankton-index of biology integrity to assess aquatic ecosystem health of river network in Hangzhou Bay New District, Ningbo. International Journal of Fisheries and Aquatic Sciences 3(2):19-25.
Viers J. H., Fremier A. K., Hutchinson R. A., Quinn J. F., Thorne J. H., Vaghti M. G., 2011 Multiscale patterns of riparian plant diversity and implications for restoration. Restoration Ecology, pp. 1-10. DOI: 10.1111/j.1526-100X.2011.00787.x.
Vipin S., Madhuri M., 2014 Tree diversity assessment and conservation of Singhori Wildlife Sanctuary, Madhya Pradesh, India. International Research Journal of Biological Sciences 3(3):14-18.
Wang Z., Pei Y., 2012 Ecological risk resulting from invasive species: a lesson from riparian wetland rehabilitation. Procedia Environmental Sciences 13:1798-1808.

Received: 03 October 2014. Accepted: 27 November 2014. Published online: 15 December 2014.
Authors:
Jeljie L. Dice, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: dicejeljie@gmail.com
Jephte R. Ecot, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: jephte_ecot@yahoo.com.ph
Sarah P. Olegario, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: Saraholegario20@gmail.com
Sitti Ayesha P. Abdon, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: Sitti.awesome68@gmail.com
Luke Angelo A. Celeste, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: antiskill5036@gmail.com
Lady May P. Tayong, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: tayong@yahoo.com
Rome Rafael Podico, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: rr-_spike_podix21@yahoo.com
Christine Jean Ferrer, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: xtinejeanferrer@gmail.com
Jibrolet Sabid, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: jibrolet23@yahoo.com
Jess H. Jumawan, Department of Science, College of Natural Sciences and Mathematics, Mindanao State University-General Santos City, Fatima, General Santos City 9500, Philippines, e-mail: jehoju78@yahoo.com
This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution and reproduction in any medium, provided the original author and source are credited.
How to cite this article:
Dice J. L., Ecot J. R., Olegario S. P., Abdon S. A. P., Celeste L. A. A., Tayong L. M. P., Podico R. R., Ferrer C. J., Sabid J., Jumawan J. H., 2014 Diversity, vegetation analysis and RCE inventory employed in assessing riverine channel of Malapatan, Sarangani Province, Philippines. AES Bioflux 6(3):267-275.

Appendix A

The occurrence of plant species for each area from the study site

Species	*A1*	*A2*	*A3*
Ageratum conyzoides	X		
Alternanthera sessilis		X	X
Amaranthus spinosus	X	X	
Borreria laevis		X	
Cassia tora	X		
Celosia argentea	X	X	
Chromolaena odorata	X	X	
Cocos nucifera			X
Corchorus olitorius	X	X	
Crotalaria incana		X	
Crotalaria mucronata	X		
Cyperus brevifolius	X	X	
Cyperus compactus	X	X	
Cyperus iria	X	X	
Desmodium triflorum	X		
Dodonaea angustifolia	X	X	
Echinochloa oryzoides	X		
Eclipta alba		X	
Elaeagnus umbellata		X	X
Elephantopus tomentosus	X		
Eleusine indica	X		
Euphorbia hirta		X	X
Hedera helix		X	
Hedyotis biflora		X	
Helianthus annuus	X	X	
Imperata cylindrica	X	X	
Ipomoea triloba	X	X	
Lantana camara	X		
Leucaena leucocephala			X
Ligustrum vulgare	X	X	
Lonicera japonica		X	
Ludwigia perennis	X	X	
Lythrum salicaria		X	
Melochia concatenata	X		
Microstegium vimineum		X	
Mimosa pudica	X	X	
Musa sp.		X	
Mussaenda sp.		X	
Paspalum conjugatum	X		
Paspalum distichum	X	X	
Phalaris arundinacea		X	
Phyllanthus amarus	X	X	
Phyllocladus hypophyllus	X		
Physalis angulata	X	X	X
Polygonum barbatum	X	X	
Polygonum cuspidatum		X	
Polygonum perfoliatum		X	
Portulaca oleracea	X	X	X
Ranunculus ficaria		X	
Rhamnus frangula		X	
Ricinus communis		X	
Rosa multiflora	X		
Rottboellia exaltata	X		
Saccharum spontaneum	X	X	
Scirpus grossus		X	
Stachytarpheta jamaicensis		X	
Sterculia sp.	X		X
Synedrella nodiflora	X	X	
Ternstroemia urdanatensis		X	
Vernonia cinerea	X		

(X) - present in the area.