NYIKA- VWAZA TRUST RESEARCH STUDY REPORT
(2021/22)

ASSESSING SPATIAL DISTRIBUTION, ABUNDANCE AND VEGETATION STRUCTURE OF *LANTANA CAMARA* IN VWAZA MARSH GAME RESERVE

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ABSTRACT

A study by Sichinga in 2018 on the vascular plants of Vwaza Marsh Wildlife Reserve (VMGR), Malawi, reported the presence of the alien invasive species *Lantana camara* there. The fact that *Lantana* is among the world top 10 worst invasive plant species listed by the IUCN, and recognising that VMGR is classified as an Important Bird Area that could facilitate the spread of this invasive plant once deforestation occurs, a study was carried out to assess the spatial distribution, abundance and vegetation structure of *Lantana camara* in VMGR before the situation becomes worrisome.

The study employed a cross-sectional survey with every colony found along the line transects constructed within sampled areas suspected to contain the invasive species recorded with coordinates. Plots in sampled areas were also constructed to measure and analyse the vegetation structure of the species. Data were analysed using QGIS version 3 and the spatial analysis tools used to determine the spatial distribution of *Lantana* within VMGR and compile distribution maps.

The results showed that *Lantana* only occupies 16.5 ha, or 0.0167% of the entire VMGR area and 0.0281% of the total sampled area. Just 69 colonies were counted inside the protected area and were found only in one old village named Lower Chalepweteka out of the 19 old villages and camps that were assessed in the reserve. The results indicate that *Lantana camara* is not invasive in the reserve at present. The study recommends that the species should be eradicated now as it will be cheap with low labour costs to manage and control the plant inside the protected area. The study also recommends further study on the ecological factors that have suppressed the invasion of *Lantana* since its introduction inside the protected area.

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PROJECT RATIONALE

Problem Statement

From a recent survey work of vascular plants and mopane species in Vwaza Marsh Game Reserve (VMGR), it was reported that there was dense contiguous thickets of the invasive *Lantana camara*[1] in the protected area (Sichinga, 2020). It was suggested that some of these were remnants of *Lantana camara* populations in areas previously occupied by people before they were resettled outside of the protected area, whilst others suggested to be self-established colonies emanating from these. Unfortunately, there were neither records on when the species was introduced in the game reserve, nor data on its spatial distribution and vegetation structure within the protected area. It was the researchers' understanding that ignoring this situation was worrisome considering two main facts regarding the invasion ecology of *L. camara* (Sundaram and Hiremath, 2012).

Firstly, was that whilst VMGR is classed as an Important Bird Area (Vwaza Marsh Game Reserve archived 2008-05-30 at the Wayback Machine, Southern Destinations), it is the very same species (i.e. birds) that are known active agents in facilitating the spread/invasion of *L. camara* by means of seed dispersal (Sastry & Kavathekar 1990). This was not to purport there was a high abundance of birds in VMGR aiding in *L. camara* seed dispersal, rather to suggest that it could have been a possibility. Secondly, was that whilst *L. camara* is known to aggressively invade newly deforested areas (Kodandapani et al. 2004), as is typical of most plant invaders (Day et al. 2003), there was deforestation activity that was currently happening in VMGR where (1) *Gmelina arborea* species populations were being removed for being considered alien-invasive, and (2) a large chunk of forest strips was being cleared for road construction (Sichinga, 2021; personal communication). Again, this was not to purport the inevitability of *L. camara* invasion after the disturbances (for we did not know its current distribution), but to highlight that it is known such actions often allow invasion of *L. camara* elsewhere (cf. CABI *Lantana* factsheet).

Seeing as both the dispersal agents and conditions for *L. camara* invasion were present in VMGR, management of the protected area could have been waiting on an invasion time-bomb and only realize the species were having multiple negative effects to biodiversity in the protected area while too late. Unfortunately, again, how exactly such activities and attributes of VMGR may have

[1] Information on the invasion ecology of *Lantana camara* can be found from the CABI Invasive Species Compendium through the following link; https://www.cabi.org/isc/datasheet/29771

actually been contributing to *L. camara* invasion could only be speculated upon, seeing as there was no baseline information on its invasion in the form of the current spatial distribution and vegetation structure of *L. camara* populations in VMGR. Consequently, the important question of whether this (i.e. *L. camara* invasion) was or may have been a cause for much concern to the conservation of biodiversity in VMGR sooner or later could not be answered.

Alien-invasive species management is usually considered expensive and therefore given less priority by managers of many protected areas (Veldtman et al., 2010). However, late detection of problematic invasive species (such as *L. camara*) in different protected areas (such as VMGR) has proved to be costlier in multifaceted ways to biodiversity conservation efforts in protected areas, with varying degrees in the magnitude of inevitable impacts on important ecosystem components, functions/processes and services of the landscape on a case-by-case basis (Sundaram & Hiremath, 2012). The extent of *L. camara* invasion in VMGR was not known, and therefore we could not rightly appraise the threat it was posing to the overall components, functions, and services offered by the Vwaza ecosystem. However, it was a known fact that the invasion of *L. camara* could have extensive impacts on plant community structure, functioning and composition, with differential effects on specific species, spanning from altered wildlife habitats, reduced food resources for both vertebrates and invertebrates, delayed seedling establishment and recruitment in natural forests, as well as increased competition with other plant species resulting in reduced species richness of native vegetation and community evenness (Day et al. 2013; Vardien et al. 2012; Dobhal et al. 2011; Sandham et al. 2010; Prasad 2009; Hiremath & Sundaram 2005; Kodandapani et al. 2004; Mack et al. 2000; Fensham et al. 1994; Hardin & Arena 1974; Morton 1971). With several studies that have been conducted on *L. camara* invasion researchers have found and introduced possible ways of managing and controlling the invasion of *Lantana*, (Fensham et al, 1994*),* these techniques were possible solutions that could overcome the posed threats by *Lantana camara* to the protected area in Vwaza. In light of the aforementioned, a feasibility assessment on the possible control of *L. camara* was essential after determining clearly the invasion status of the species in the protected area.

The study therefore proposed to investigate the current spatial distribution, abundance, vegetation structure, and potential control options for *L. camara* populations in VMGR.

Objectives

The specific objectives of the proposed study were:

1. Mapping the spatial distribution of *Lantana camara* invasion in VMGR.
2. Determining the abundance of *Lantana camara* populations in VMGR.
3. Assess the vegetation structure of *Lantana camara* colonies in VMGR.

Study Outputs and Significance

The study has helped shed light on *Lantana camara* invasion in VMGR by means of a distribution map of *L. camara* invasion across VMGR. Additionally, the study also provides an assessment of the population abundance and structure of *L. camara* populations within VMGR. This information, compiled in relevant research outputs (report/scientific manuscript, etc) has provided a sound basis from which to begin methodically deciding on whether *L. camara* invasion may be posing a threat to biodiversity in VMGR and whether the invasion warrants more attention from managers of VMGR in the Department of National Parks and Wildlife (DNPW). Furthermore, having filled the information gap on *L. camara* invasion in VMGR after the proposed study, the information itself will also be of value to the Environmental Affairs Department (EAD), which coordinates efforts in biodiversity conservation across the country, and is currently engaged in the management and control of alien-invasive species across the country's protected landscapes and ecosystems.

METHODOLOGY

The study employed a cross-sectional survey design, data was collected in October (2021) and March (2022), we sampled an area of about 58805.36 ha which represents 5% of the whole reserve with a perimeter of about 232.15 km. Most of the sampled area was in south west, south east, north with few areas in the western side of VMGR. We failed to reach to reach other areas in central and eastern side because of poor roads that connects these regions as these areas are rarely patrolled or visited, (Msukwa, personal communication, 2021).

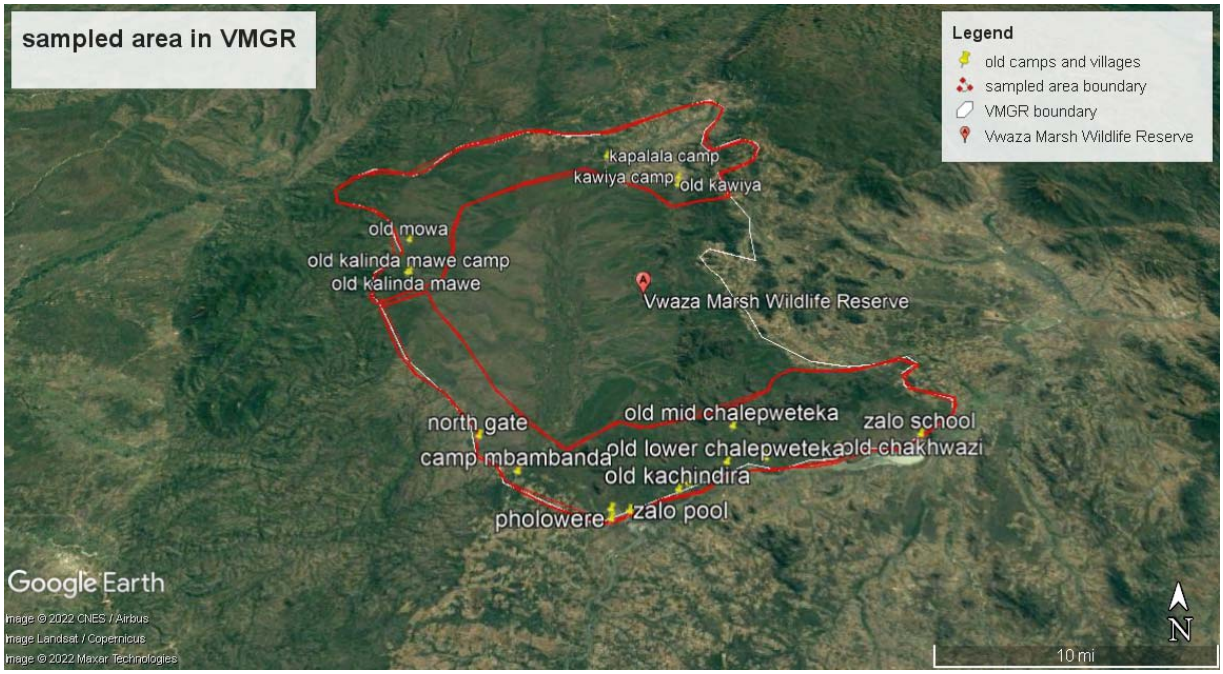

Figure 1. Map showing sampled areas in Vwaza during the study

Figure 2. An impassable road captured during collection of data

Assessing spatial distribution of Lantana camara

Upon obtaining secondary data from the management and staff of Vwaza Marsh Game Reserve, Lower Chalepweteka was pointed out as our suggested point of introduction for *L. camara*, so we constructed 4 line transects in all directions (to north, east, west and south side), 3 km each. We conducted transect walks towards each direction from the known point of introduction and recorded coordinates for each and every *Lantana* colony observed within the transect using handheld GPS, the coordinates were saved in form of Universal Transverse Mercator (UTM) Zone 36, based on the World Geodetic System of 1984 (WGS 84). The data was transferred from the record field book into Excel sheets for storage.

After sampling the Lower Chalepweteka area which was considered as our point of introduction, we travelled through each and every old village and camp within VMGR where people used to reside before being chased out of the protected area. The other sampled villages included *Old Kachindira, Old Kachindira 2, Old Nthunduwike, Old Mid Chalepweteka, Old Chankhwazi, Mpholowere, Kalinda Mawe Village, Old Mowa Village, Old Mowa Village, Old Kawiya Village* and the camps are *Kalinda Mawe Old Camp, Camp Kapalala, Kawiya Camp, North Gate, Camp Bambanda, Zalo Camp, Zalo School, Zalo Pool.*

Areas were chosen as sampling sites since *L. camara* is found in disturbed areas; it grows best in open, unshaded situations such as degraded land, pasture, edges of tropical and subtropical forests, warm temperate forests, beachfronts, and forests recovering from fire or logging (Day, 2003). At each old village and camp, we recorded its estimated area size, then we conducted transect walks of about 3 km towards each direction in each and every village or camp sampled and to record the coordinates of any *L. camara* colony if observed within the transects. Line transects emanating from the main road network within the protected area were also used. Transect walks from the road were carried out after every 3 km within the protected area, extending at least 3 km both sides of the road for a total cross strip of 6 km.

Lastly, we visited villages outside VMGR 2 km away from the wired fence boundary of the protected area, and check if *L. camara* was present or not in the villages, if yes we recorded the coordinate and name of the village and count the colonies observed and use of the invasive plant (*L. camara*) within each village, then we could check from the boundaries if the *L. camara* from the outside villages were being dispersed into the protected area.

Figure 3. Old Kachindira, one of the old villages

The data that was recorded, was stored in Microsoft Office Excel. Later, the data was manipulated accordingly and entered into Quantum GIS software, where it was used to produce a distribution map of *L. camara* in VMGR. Spatial statistics for the distribution was calculated using the research tools library and functions of QGIS version 3.0.

Measuring Abundance and assessing vegetation structure of *Lantana camara*

Figure 4. Construction of plots

Figure 5. Measuring height of L. camara colony

After collecting the coordinates for the colonies, we constructed plots on the areas where *L. camara* was present. Only 5 square plots were sampled in Lower Chalepweteka Old Village because this was the only area with *L. camara* colonies. The plots were 25 x 25 m, we counted and recorded the number of *L. camara* colonies within each plot. Length, width, height and estimated coverage area percentage of *L. camara* colonies inside each plot were measured. We observed and recorded the presence of flowers and fruits, the colours of fruits and flowers if present and the associate plants of *L. camara*. We used tape measures, ropes, pegs, clinometers for constructing the plots and measuring the vegetation structure of *L. camara* colonies. Additionally, we recorded the coordinates for each plot using GPS.

Figure 6. Research team at one of camps marking boundary between Malawi and Zambia

RESULTS AND DISCUSSION

Spatial distribution and abundance of Lantana camara in VMGR

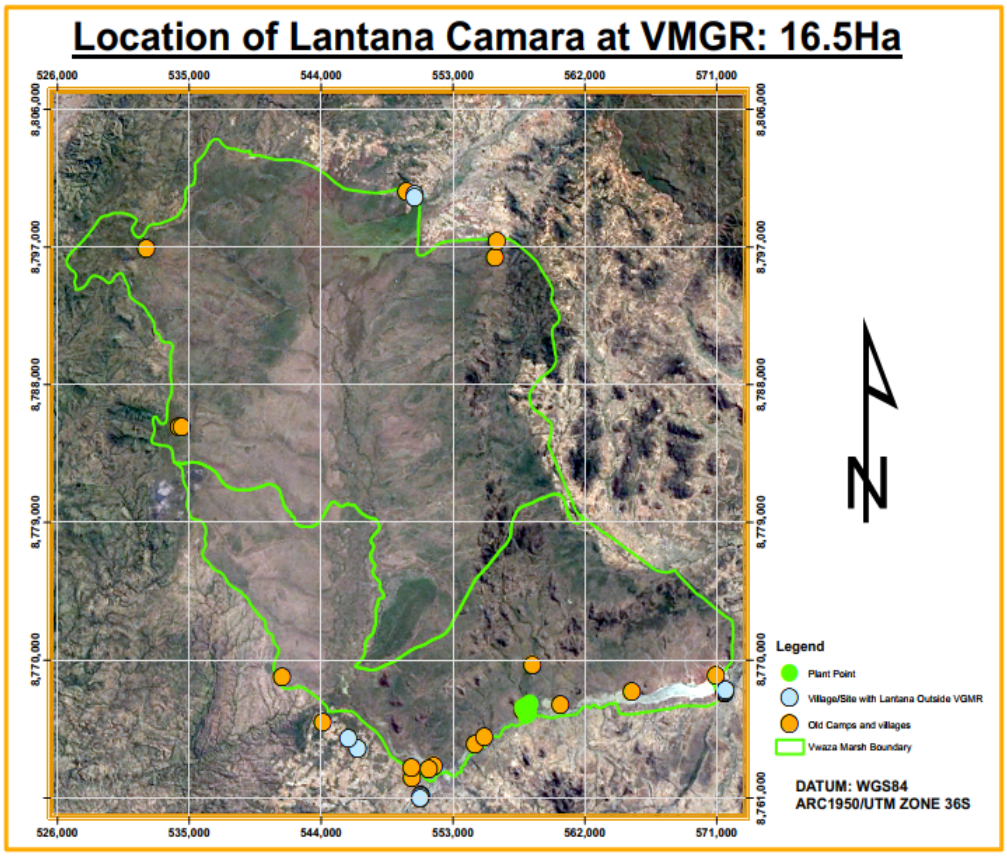

Figure 7. Map showing an overview of L. camara *location points in VMGR*

The study revealed that *L. camara* has occupied 16.5 ha of land in the reserve representing 0.0167% of the total 986,000 ha coverage area of VMGR, it also represents 0.0281% of the 58805.36 ha sampled area. Only 69 colonies of *L. camara* were counted through the transect walks during the study. These colonies had an average (mean) length and width of 4.81 ± 0.37 m and 3.36 ± 0.27 m respectively. A few belt strips were observed among the colonies in the affected area, the longest recorded length was 18 m and longest width recorded was 10.5 m while the lowest recorded length and width of the colonies were 1 m and 0.5 m. Different shapes of the *L. camara* colonies were observed with most of the colonies forming an irregular shape, few colonies had linear shapes and very few polygonal shaped colonies.

Through this intensive survey and field surveillance conducted within the protected area, the invasive plant was only detected in the southern part, close to the boundary of the reserve. In addition to the colonies inside the reserve we also observed the presence of *L. camara* within the surrounding villages along the boundary of VMGR. Some of the villages with *L. camara* included Nthala village approximately 1.2 km away from the boundary, Nyirenda Chipapika Village approximately 700 m from the boundary, Kapala Village 550 m approximately from the boundary and Ka Mlamba Village approximately 15 m away from the boundary. Other villages along the reserve boundary that we visited but had no *L. camara* included Nkanafulu and Tchuka on the Zambian side and Kanjenje Malawi side, just to mention a few. The plant was mostly used as fence for several houses in the villages, some used as ornamental plants and for drying clothes as hangers, few colonies were seen randomly scattered in fields within some villages. The leaves of the plant can be used as tea leaf when dried and the fruits are edible when matured.

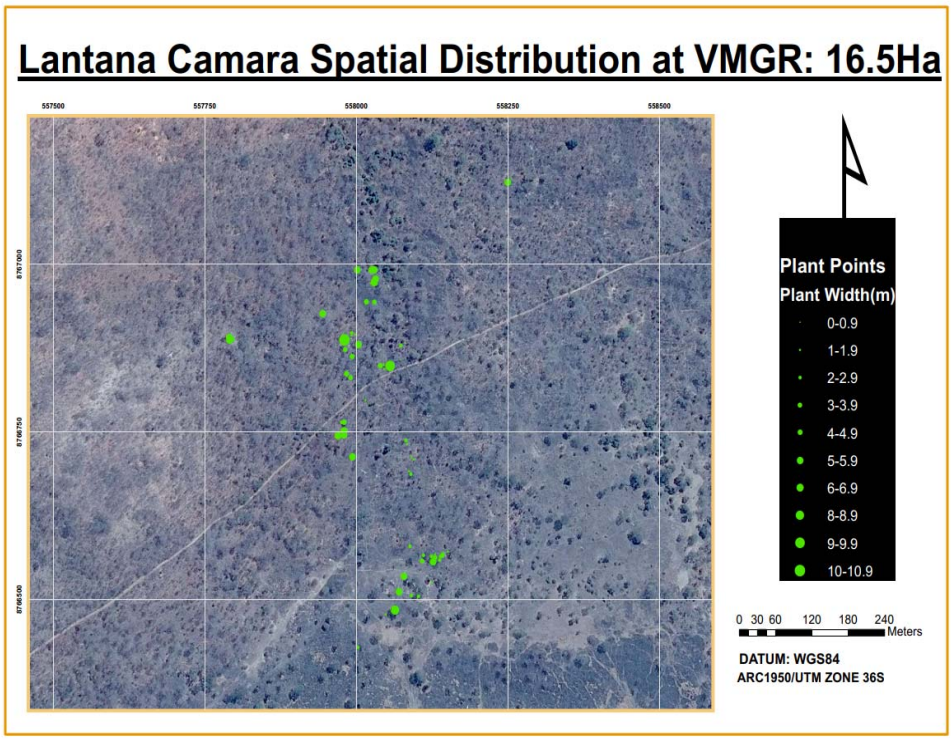

Figure 8. Spatial distribution of Lantana camara *in old village Lower Chalepweteka, VMGR.*

Lantana camara was only observed in 1 out of the 19 old camps and villages that were sampled. It has covered 16.5 ha out of 190 ha of the old village which represent 8.7% of this village giving a density of 0.36 colony/ha. This area was an old village, known by the name Lower Chalepweteka, located in the southern part of the reserve, approximately 500 m away from South Rukuru River which marks a boundary between the reserve and Kabila village which is the nearest village from the location where *L. camara* is found inside the protected area. Along South Rukuru people use the river for various activities such establishing and irrigating their nursery beds, washing clothes and utensils and fetching water for various domestic work in their respective villages. The old village is a dambo floodplain and pediment, it has short and intermittent valleys which connect up to the river within the boundary. A bear road also passes through the old village from the main camp gate towards Zalo Pool a significant site for birds. *L. camara* colonies were mostly found along this road, and approximately 30 m away from the valley in the old village. A number of large colonies were observed along the right side of the road, at the centre of the old village, the colonies were closely spaced around the area except only two colonies that were recorded approximately 200 m away from where the rest of the colonies dominated, approximately 20 m from the left of the valley and eastern side of the old village.

Figure 9. Lantana *being used as a fence in surrounding villages around VMGR*

Vegetation structure of *Lantana camara*

Description of Lantana camara

Figure 10. Lantana camara *with flower and buds*

Figure 11. L. camara *with flower and fruits*

Table 1. Vegetation structure of *L. camara* in dry and rainy eason

	Dry season	**Rainy season**
Flower	Absent	Present
Fruit	Absent	Present
Fruit colour	N/A	Green, dark purple
Flower colour	N/A	Pink, light yellow and cream
Twig colour	Brown	Green
Leaves	Very small or absent	Large and present
Leaf colour	Green	Green
Twig thorns	Present	Present

In the dry season *L. camara* had widely spread brown twigs with thorns, most had no leaves on the twigs while some had very small leaves. No flowers nor fruits were observed on any *L.*

camara plant inside the area. *L. camara* that we observed outside the protected within the surrounding villages was different from that inside the protected as it had brown twigs with thorns, green leaves, some had flowers and even fruits. This was so because *L. camara* in the outside villages have access to water such as the water used for domestic work (washing and mopping) which after use they pour unto the plant and as some use the plants as to dry clothes of which in the process provides water to the plant, as compared to *L. camara* inside the protected area which depend on the rains so as to have access to water.

During the rainy season, *L. camara* inside the VMGR had stems with widely spread green twigs which had thorns. The plant had deciduous leaves, arranged oppositely and superposed on the twigs, the leaves were simple and petiolate, with an ovate shape and serrate margins and were exstipulate. The leaf veins were conspicuous, reticulate and alternately arranged. An inflorescence of racemose type was observed on the floral system of the invasive plant. The flowers are pedicellate, with four tepals forming a polyphyllous (apotepalous) perianth which gives the flower an actinomorphic symmetry. Some of the flowers were pink in colour the whole parts whilst some flowers were cream whitish on the outside of perianth tube as well as the tepals, and yellow inside the perianth tube, the colours of the flower changes after pollination from yellow to pink as a signal to pollinators that the pre change colour contains a reward as well as being sexually viable and hence increasing pollination efficiency (Mohan Ram, 1984). The fruits were green and some were dark purple which could tell that the fruit has matured, the green fruits are inedible whilst the dark purple fruits can be eaten by human as they have a sweet taste.

The 69 colonies gave out an average (mean) height of 3.4 m ± 0.22 m with a standard deviation of 1.82, with the maximum (highest) height measured of 8.4 m and minimum (least) height of 0.8 m. Typically, *L. camara* grows to 2 m high and under right conditions it grows up to 6 m high, (Sandham et al., 2010). These greater heights are as a result of the plant attaching and climbing through the trees to top hence attaining these maximum heights as those of the associated trees.

Habitat, associated plant and animal species of L. camara

Inside VMGR, *L. camara* was found in a dambo floodplain dominated by tall grasses which through my observation were invasive during the rainy season, they may reach a height of about 3 m on average, that they even block the road and, but they are destroyed through wild fires in dry season. The area has largely spaced trees such as *Acacia* which are common in the area, *Combretum fragrans*, *Ziziphus mucronata*, *Albizia harveyi* and some shrubs. The area has some small intermittent valleys that contains water during the rainy season and dry in dry season. The area has a diversity of bird species such as *Blacked eyed Boubou*, *Mourning*-D*ove*, *Guinea fowl*, *Frankolin* and *Blue Waxbill*, these are some of the birds that we could identify but there were some which we failed to through their calls, and we also observed *Elephants*, *Velvet monkeys* and *Hyena* (through scats) and *Hippopotamus* (through trails) within the location where *L. camara* is present. Few colonies were found at an open space during the dry season as most of the colonies were growing inside a shrub known as *Combretum mossambicense* (*Knobbly Bushwillow* as common name) which was identified by the experts at Mzuzu herbarium.

Figure 12. Feathers of Dove present inside a colony

Figure 13. Fresh Elephant scat

Ecology of Lantana in VMGR


Figure 14 & 15. Association L. camara *and* Combretum mossambicense

Almost at each and every point where *L. camara* was found it was growing inside a shrub known as *Combretum mossambicense,* native to Vwaza. This plant is usually a scrambling shrub with a long, trailing branches forming a dense thicket, but sometimes a small tree about 5 m high. It is found in low altitudes in hot dry areas, common along the edge of riverine fringe forest and thicket, along watercourses and jess-bush. Despite the presence of wildfires affecting the area during the dry season, making the area prone to disturbance, and the presence of poachers, birds and other animals such monkeys, elephants and hippopotamus of which could facilitate the transportation and spread of *L. camara* within the location and the entire reserve, we believe that this shrub *C. mossambicense* is suppressing *L. camara* to be invasive in the area, by providing shade which is an unconducive environment for *Lantana* to invade. We also observed the presence of birds roosting at this shrub, feathers were inside the thicket of this plant of which could also be another factor that maybe these birds carry seeds of *L. camara* and disperse them inside the thickets of *C. mossambicense* thus why most of the colonies of *L. camara* were growing inside this shrub hence the suppression as it is posed to a stiff competition for sunlight and other resources with the shrub. Literature states that *L. camara* is rarely found in natural areas of forest, as it is unable to compete with taller trees due to its lack of tolerance for shade of which instead it grows at the forest edge (Day, 2003).


Figure 16 & 17. Combretum mossambicense

CONCLUSION AND RECOMMENDATIONS

The results have shown that the status of *Lantana camara* in Vwaza Marsh Game Reserve is not worrisome as we thought it could by analysing that all the factors that help and increase the invasion of *L. camara* in various ecosystems were available in VMGR. This study has revealed that *L. camara* is not invasive at all and it is currently not affecting any ecological functions of Vwaza marsh ecosystem. However, there is still a threat to the protected area of an invasion of *L. camara* since it was found throughout all sides along the reserve boundary in the surrounding villages. Anytime if not careful, these colonies of *L. camara* found outside in the surrounding villages will soon spread into the protected area and throughout the reserve by birds that migrate through from the villages into the reserve, and since people in the villages are allowed to enter the protected area to collect non timber products such as fruits, i.e. palms and illegal access through poaching of which in the process may carry seeds and disperse them in the reserve.

In the case of management of *L. camara* inside VMGR, we recommend that the feasible control methods such as slashing, controlled burning and manual/mechanical budding should be applied now to remove the plant inside the reserve as keeping it may have severe consequences when this plant starts spreading. Controlling *L. camara* currently will be cheap and require less labour

force and will save the eradication cost that the management might spend once the plant invades the reserve.

Through observations during the study, there is a need to for sensitization and civic awareness in the surrounding villages on the negative impacts of keeping invasive plants like *L. camara* in their residences to the protected area. This will help in management of the invasive plants in the reserve as it will reduce the introduction and spread of the invasive plant within the protected area by the people in the villages. We also recommend further studies on possible related ecological factors that have led to the suppression of *L. camara* in VMGR, such assessing the ecological role of *Combretum mossambicense* to invasion of *L. camara*, i.e. analysing their phytochemicals if they might play a role in suppressing the invasion of *L. camara*, the results might be a breakthrough in control and management of this invasive plant in other areas that it invading such as in West Africa.

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APPENDICES

Appendix .1 Data Collection Forms

MAPPING SPATIAL DISTRIBUTION DATA SHEET (OBJECTIVE 1)

SURVEY AREA……

DATE……...**TEAM NUMBER** …….
TEAM LEADER……**SITE NUMBER**……

Site GPS LOCATION----------GPS SERIAL NUMBER ……

SITE LOCATION AND DESCRIPTION (brief description using landmarks, photograph number, etc. so site can be located again)

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GPS COORDINATE FOR LANTANA COLONY

	start of colony	Midpoint of colony	End point of colony
EASTING			
NORTHING			
ELEVATION			
	SIZE OF COLONY		
LENTGH (in metres)			
WIDTH (in metres)			
Distance from starting point(metres)			
	TRANSECT SIZE		
LENGTH(in kilometres)			

ABUNDANCE AND VEGETATION STRUCTURE OF *LANTANA CAMARA* (OBJECTIVE 3 (OBJECTIVE 2)

SURVEY AREA……**DATE**…….....

TEAM NUMBER…… **TEAM LEADER**…….

SITE NUMBER……..

SITE LOCATION AND DESCRIPTION (brief description using landmarks, photograph number, etc. so site can be located again)

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Appendix 2. Data Collected

These coordinates collected and used for making spatial distribution map are in UTM zone 36, WGS 84, and the length, width, height measurements used for abundance and vegetation structure of *Lantana* are in metres.

Lantana colonies inside VMGR

WAYPOINT	LATITUDE	LONGITUDE	ELEVATION	LENGTH (m)	WIDTH (m)	HEIGHT (m)
C1	558256	8767128	1094	1	0.6	0.8
CE1	558081	8766884	1096	1.2	0.8	2
CE2	558074	8766879	1095	2.7	2.3	3.04
CE3	558073	8766858	1096	1.1	0.8	4.41
CE4	558058	8766849	1094	6.4	4.86	4.92
CE5	558056	8766848	1097	10.4	9.04	6.68
CE5B	558046	8766844	1096	1.4	1	1
CE5C	558045	8766850	1096	1.9	1.3	1.1
CE6	558040	8766849	1097	9.3	4.3	4.75
CE7	558004	8766880	10	5.7	5	5.16
CE8	557991	8766831	1089	6.2	3.9	5.16

CE9	557984	8766836	1089	4.83	4.8	2.82
CE10	557994	8766713	1091	7.25	5.2	4.02
CEPQA	557970	8766745	1090	7.9	6.8	4.1
CEPQB	557980	8766751	1092	8.2	6.2	7.91
CEPQC	557980	8766746	1092	12.1	5.3	5.86
CE11	557976	8766765	1092	3	2	2
CE12	557980	8766765	1091	4.6	4.1	4.8
CE13	558021	8766792	1094	1	0.5	1
CE14	558015	8766797	1097	1.5	1	2
CEPQa	557993	8766862	1094	7.2	4.2	3.88
CEPQb	557982	8766873	1098	9.5	3.8	2.9
CEPQc	557981	8766887	1097	18	10.5	6.03
CE15	557992	8766894	1098	2	1	2.59
CE16	557993	8766898	1097	3.1	2.6	2.3
CE17	557999	8766895	1098	2.2	1.9	2.62
CE18	558017	8766944	1093	5.4	4.8	3.5
CE19	558030	8766944	1096	4.8	3.3	3
CE20	557945	8766926	1097	8.2	5.1	7.58
CE21	557796	8766888	1106	4.7	3.3	5.27
CE22	557791	8766891	1108	9.6	5.3	3.62
CE23	557791	8766887	1110	8.6	6.5	3.12
CE24	558002	8766991	1098	6.2	5.4	4.5
CE25	558026	8766991	1095	5.8	5	4.1
CE26	558030	8766991	1095	7.3	5	4.2
CE27	558032	8766978	1091	6.8	5.6	4.6
CE28	558030	8766973	1091	7.3	6.7	8.4
CE29	558025	8766972	1093	2.4	1.7	1.7
CE30	558250	8767122	1096	5.2	5	4.8
CE1	558151	8766572	1081	1.4	1	0.9
CE2	558143	8766567	1084	3.5	3	3.4
CE3	558139	8766565	1084	3.2	2.1	1.4
CE4	558142	8766565	1085	2.4	2.2	2
CE5	558130	8766567	1087	2	1.2	1.1
CE6	558130	8766563	1087	5	3.2	2.2
CE7	558124	8766564	1088	4	2.1	1.8
CE8	558123	8766563	1089	1	0.6	1
CE9	558127	8766560	1088	1	0.7	1.5
CE10	558124	8766555	1089	1.3	1	1
CE11	558138	8766559	1089	2.5	2	1.8
CE12	558127	8766557	1096	5.6	5.2	4.7
CE13	558109	8766558	1098	5	3.1	2.1

CE14	558111	8766566	1099	3.1	2	1.6
CE15	558089	8766580	1098	4.2	2.5	3
CE16	558079	8766535	1102	7.6	5.6	3.6
CE17	558003	8766428	1106	4.1	2.5	2.2
CE18	558049	8766478	1092	3.2	1.7	1.8
CE19	558064	8766484	1093	9.3	8.9	5.7
CE20	558071	8766512	1105	5.4	5.3	6.7
CE21	558091	8766506	1094	3.2	2.4	1.9
CE22	558103	8766505	1094	2.9	2	3.2
CE23	558125	8766526	1094	2.1	1.2	1.2
CE28	558087	8766691	1101	4.2	1.7	2.4
CE29	558090	8766687	1101	5.2	2.2	3.68
CE30	558091	8766713	1102	3	1.3	4.3
CE31	558095	8766709	1101	3.3	1	2.2
CE32	558082	8766737	1101	4.2	2.1	4.7
CE33	558084	8766732	1102	2.5	1.5	3
			MIN	1	0.5	0.8
			MAX	18	10.5	8.4
			MEAN	4.814	3.35	3.358

Villages sampled outside VMGR

WAYPOINT	LATITUDE	LONGITUDE	ELEVATION	DISTANCE from boundary	VILLAGE NAME
VGO1	571558	8767878	1113	0.03km	Ka Mlamba
VGO2	571570	8767882	1115		Ka mlamba
VGO3	571612	8767898	1110		Ka mlamba
VGO4	571632	8767993	1106		Ka mlamba
VGO5	550791	8761146	1102	1.2km	NTHALA
VGO6	550812	8761123	1105	1.2km	NTHALA
VGO7	550810	8761089	1103	1.2km	NTHALA
VGO8	550766	8761010	1095	1.2km	NTHALA
VGO9	546502	8764175	1116	2km	NTHALA
VGO10	545865	8764862	1110	700m	Nyirenda Chipapika
VGO14	550407	8800406	1182	580m	Kapalala
VGO15	550385	8800225	1182		Kapalala
VGO1	571584	8768430	1094		Ka Mlamba
VGO2	571548	8768188	1093		Ka Mlamba
VGO3	571546	8768284	1101		Ka Mlamba
VGO4	550991	8761378	1113	1km	NTHALA

VG011	532612	8796106	1211	Nkanafulu (Zambia)
VG012	538950	8802895	1168	Tchuka (Zambia)
VGO13	545498	8802657	1155	Kanjenjere

Camps and old villages in VMGR

WAYPOINT	LATITUDE	LONGITUDE	ELEVATION	SIZE	VILLAGE NAME
VG1	557774	8766700	1098	200 x 200	Old Lower Chalepweteka
VG2	554516	8764484	1104	100 x 150	Old Kachindira
VG3	555152	8764996	1104	300 x 200	Old Kachindira 2
VG4	560353	8767070	1100	200 x 300	Old Nthunduwike
VG5	558412	8769706	1124	300 x 400	Old Mid Chalepweteka
VG6	565236	8767903	1097	200 x 100	Old Chankhwazi
VG7	551701	8763114	1091	150 x 100	unknown
VG8	550184	8762273	1099		MPHOLOWERE
VG9	534313	8785215	1189	100 x 100	Kalinda Mawe village
VG10	533948	8789159			Old Mowa village
VG10b	532069	8796859	1218	500 x 200	Old Mowa village
VG11	555868	8796300	1230	100 x 100	Old Kawiya village
OTHER SITES					
POOL	551344	8762863	1081		Zalo Pool
Zalo School	570970	8769032	1066	100 x 100	Zalo school
Zalo Camp	550178	8762990	1071		Zalo Camp
Camp Bambanda	544099	8765952	1118		Camp Bambanda
Vwaza northgate	541332	8768915	1102		north gate
Wildlife Camp	534500	8785262	1196		Kalinda Mawe old camp
Camp Kapalala	549807	8800582	1195		Camp Kapalala
Kawiya Camp	555997	8797359	1246		Kawiya Camp

NB: VMGR - Vwaza Marsh Game Reserve;
ha - hectares; m - metres; km - kilometres