MAPPING OF DISTRIBUTION OF INVASIVE SPECIES IN RUHANDE ARBORETUM

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ABASTRACT

The biodiversity of Ruhande Arboretum is threatened by many alien invasive species. *Lantana camara*, *Thitonia diversifolia* and *Agave sisalana* as invasive species found within that forest, outcompete the established species in their plots and to date, there is no study demonstrating the areas covered by those invasive species. Using GPS and QGIS, skimming the whole forest in a walking census moving around each patch covered by each of those species, we aimed to map the distribution and land cover of *Lantana camara*, *Thitonia diversifolia and Agave sisalana* and identified the dominant species among the 3 invasive plant species within Ruhande Arboretum. Of latter, we used stratified random sampling method to determine the abundance of invasive plant species of our interest, determining the proportion of susceptibility of the vegetation types found in Ruhande Arboretum. The findings indicated that among those 3 invasive species, *Lantana camara* were more distributed followed by *Agave sisalana* in Ruhande Arboretum. *Lantana camara* covering 36.13% (74.70 ha) was more dominant than others followed by *Tithonia diversifolia* with 2.98% (6.16 ha) and *Agave sisalana* with 2.51% (5.18 ha) of the whole forest. The Eucalyptus species was the most attacked by invasive species of our species of interest, compared to other vegetation types of Ruhande Arboretum. For better management and conservation of Ruhande Arboretum, we recommend to Rwanda Water and Forestry Authority (RWFA) to remove those invasive species and to assess the distribution of other invasive species such as *Tecoma stans* and *Calliandra calothyrsus* that can outcompete the established species.

Keywords: *Agave sisalana*, invasion, *Lantana camara*, *Tithonia diversifolia* and QGIS

1. INTRODUCTION

The global extent and rapid increase in invasive species is homogenizing the world's flora and fauna diversity (Mooney & Hobbs, 2000), especially in developing countries. This issue has been elevated onto the international trade and environmental policy agendas through a variety of international agreements and by conspicuous incursions of non-indigenous pests (Andersen *et al*., 2004). In Rwanda, *Lantana camara* was recently ranked as the first invasive plant species (REMA, 2016). Ruhande Arboretum plant diversity is facing the problem of invasion for a time.

The biological invasion may cause irreversible changes to ecological communities by altering the composition and abundance of native species, in some cases, to the point of extinction via four phases namely entry, establishment, spread, and impact (Andersen *et al*., 2004). This is likely to alter the ecosystem functions such as regeneration and structural diversity of invaded communities (REMA, 2009).

Invasive species are a current focus of interest of ecologists, biological conservationists and natural resources managers due to their rapid spread, threat to biodiversity and damage to ecosystems (Joshi, *et al*, 2002). The government of Rwanda is committed for protecting the biodiversity against invasive species (REMA, 2016). In Ruhande Arboretum (RA), there is a variety of invasive species such as *Lantana camara, Thitonia diversifolia* and *Agave sisalana*, which outcompete the established species in their plots. However, there is no study demonstrating the areas covered by the invasive species within that forest. For its better management and protection, we carried a study to provide the baseline information about the distribution and abundance of three invasive plant species in Ruhande Arboretum.

2. MATERIALS AND METHODS

2.1. Study area

This study was conducted in Ruhande Arboretum (29°44´ E and 2° 36´ S) located near the University of Rwanda-Huye

Campus. It was established in 1934 with an area of 200ha, composed of over 207 native and exotic species (Nsabimana, 2013) (Figure 1).

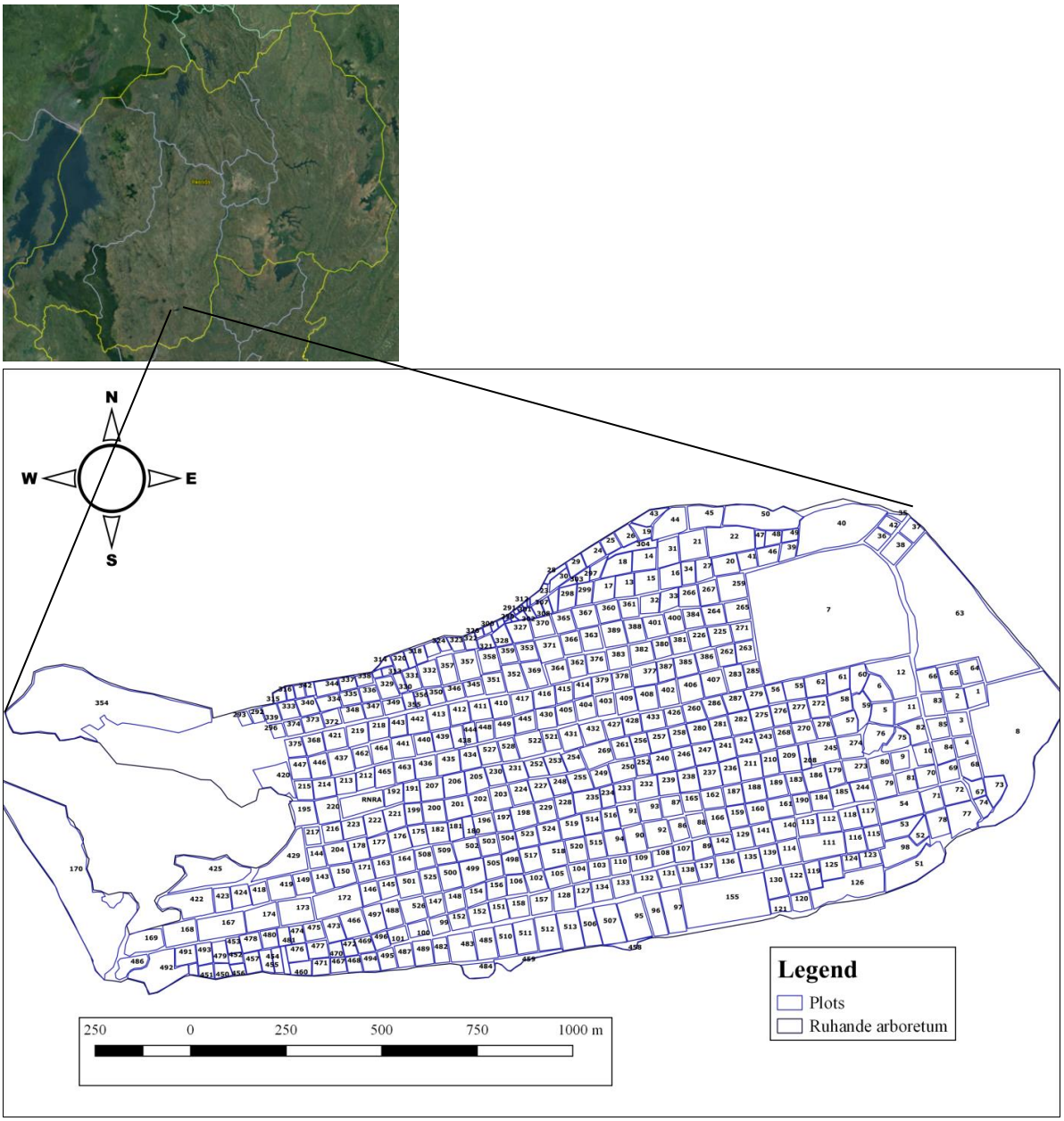

Figure 1: Map showing Ruhande Arboretum

2.2. Materials and Methods

We collected the data between March and May 2018, in a walking census of Ruhande Arboretum by recording different coordinates for the invasive species of our interest (*Lantana camara*, *Thitonia diversifolia* and *Agave sisalana*) using GPS. For mapping the complete distribution and coverage of invasive species of our interest,

we took the points by moving around each of their distribution's patches in the whole forest. Stratified random sampling method was used to determine the distribution abundance of invasive species of our interest, in Ruhande Arboretum (Maxwell *et al*, 2012), whereby stratum was chosen in order to yield more precise estimates of invasive species of our interest. The selection of first stratum was dependent on the presence of at least one of the three invasive species of our interest, and the next was taken after 100m; those strata were set not very close in each other in Ruhande Arboretum, with a total of 240 plots (10m x 10m each), set at interval of 20m from one another. Within each plot, we took the coordinates in the middle, and the focused invasive plant species were counted by using Braun- Blanquet method of visualizing the coverage in different vegetation of Ruhande Arboretum (Maarel , 2014). We used QGIS and Google earth to refine our data and produce maps.

3. RESULTS

Three most dominant invasive species identified include *Lantana camara, Agave sisalana and Tithonia diversifolia*, mostly distributed in the central and eastern part of the forest (Figure 2). *Lantana camara* covering 36.13% (74.70 ha) was more dominant than others followed by *Tithonia diversifolia* with 2.98% (6.16 ha) and *Agave sisalana* with 2.51% (5.18 ha) of the whole forest (Figure 3 - 7).

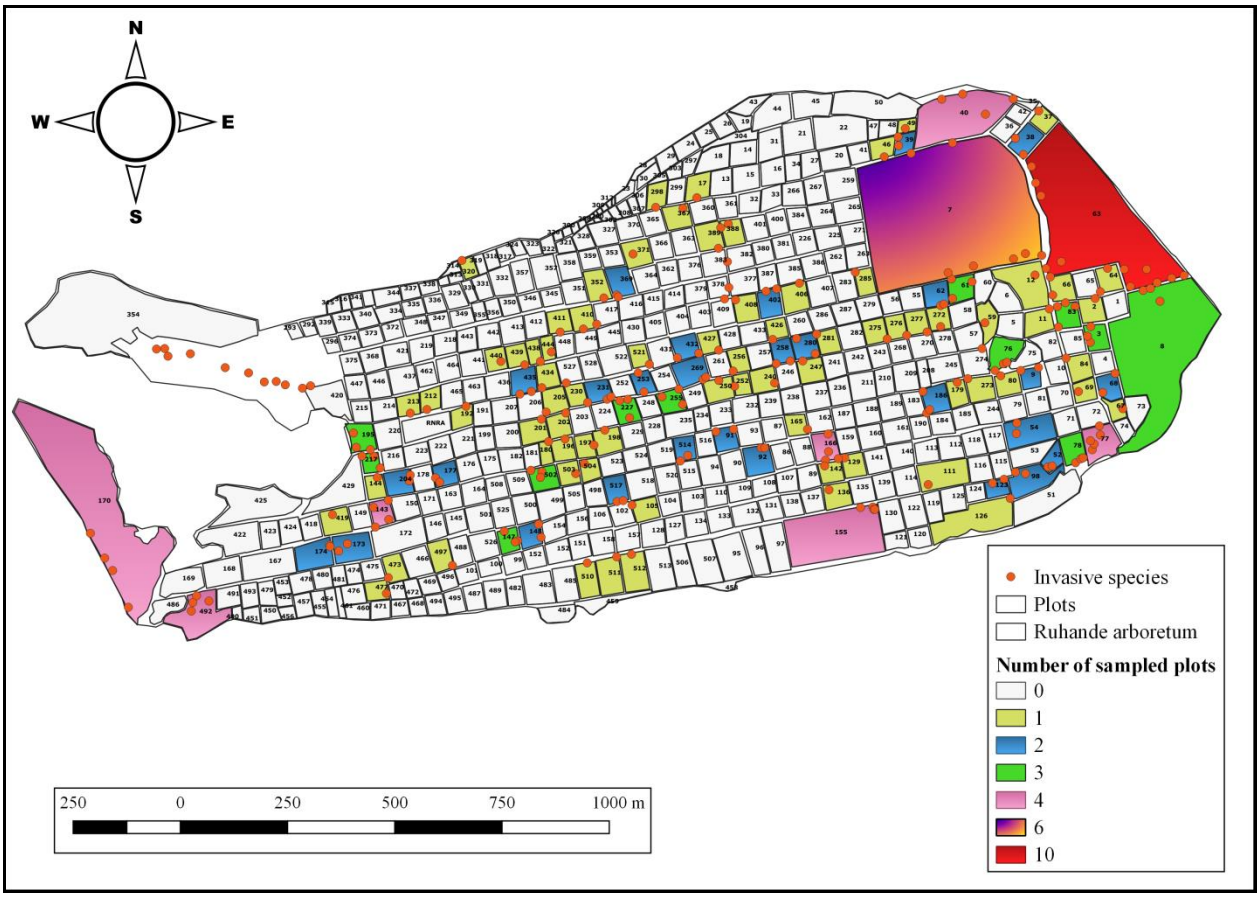

Figure 2: Overall map of distribution of invasive species in plots of Ruhande Arboretum.

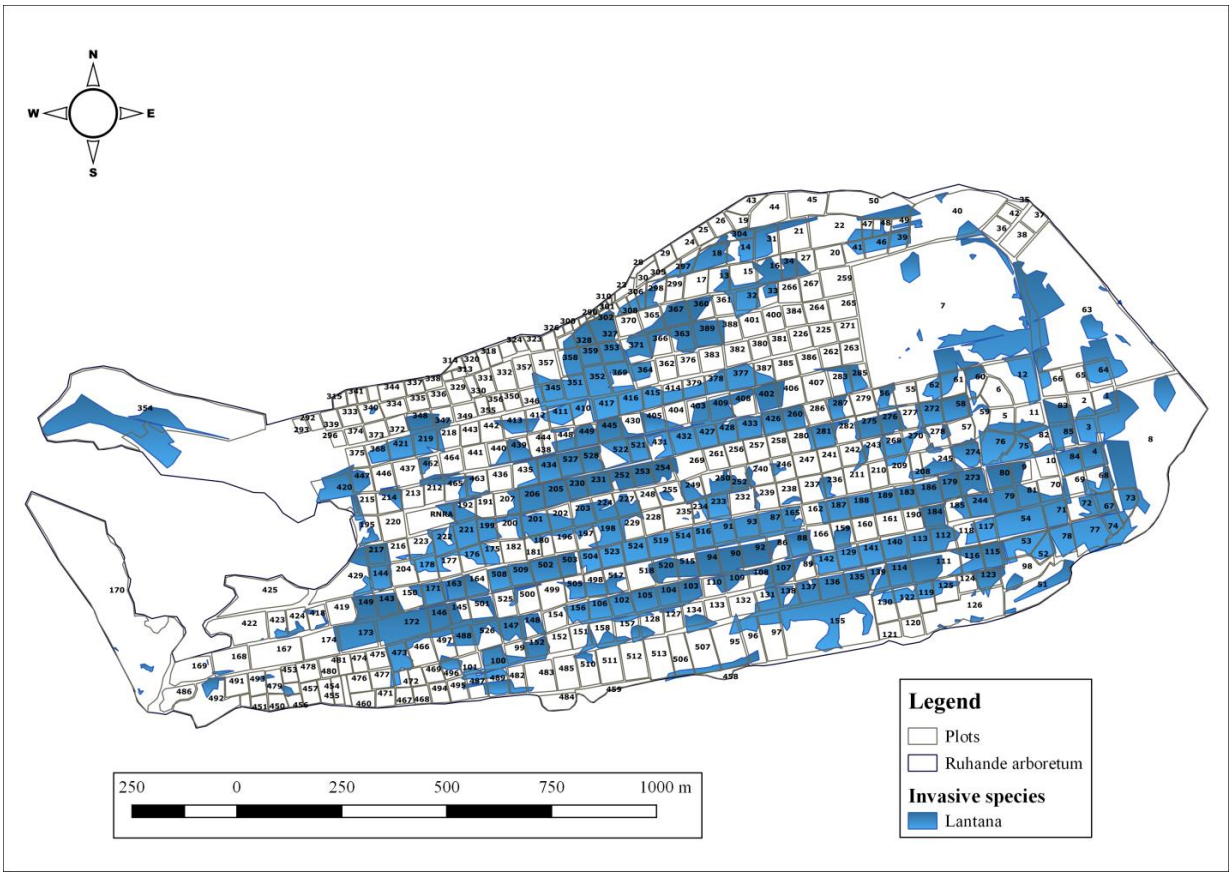

Figure 3: Coverage of *Lantana camara* in Ruhande arboretum.

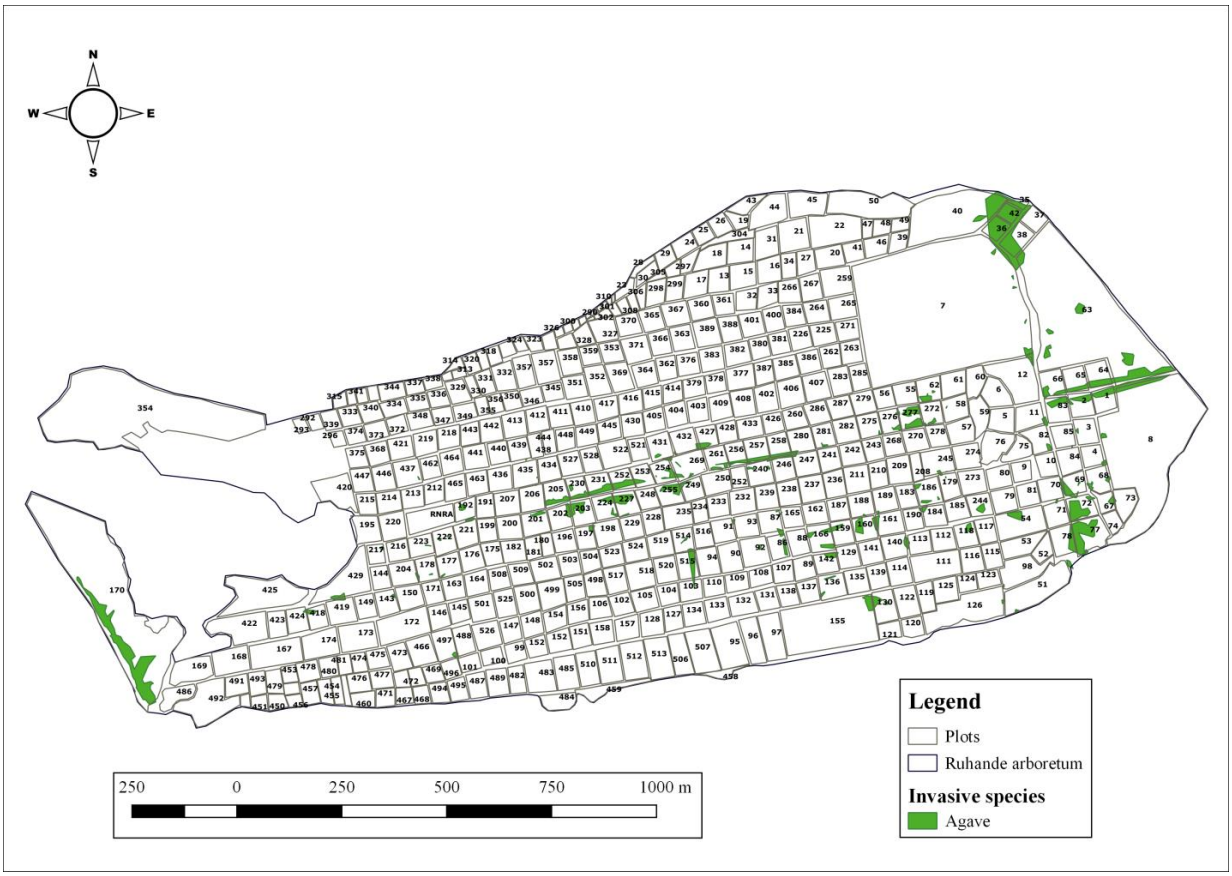

Figure 4: Coverage of *Agave sisalana* in Ruhande arboretum.

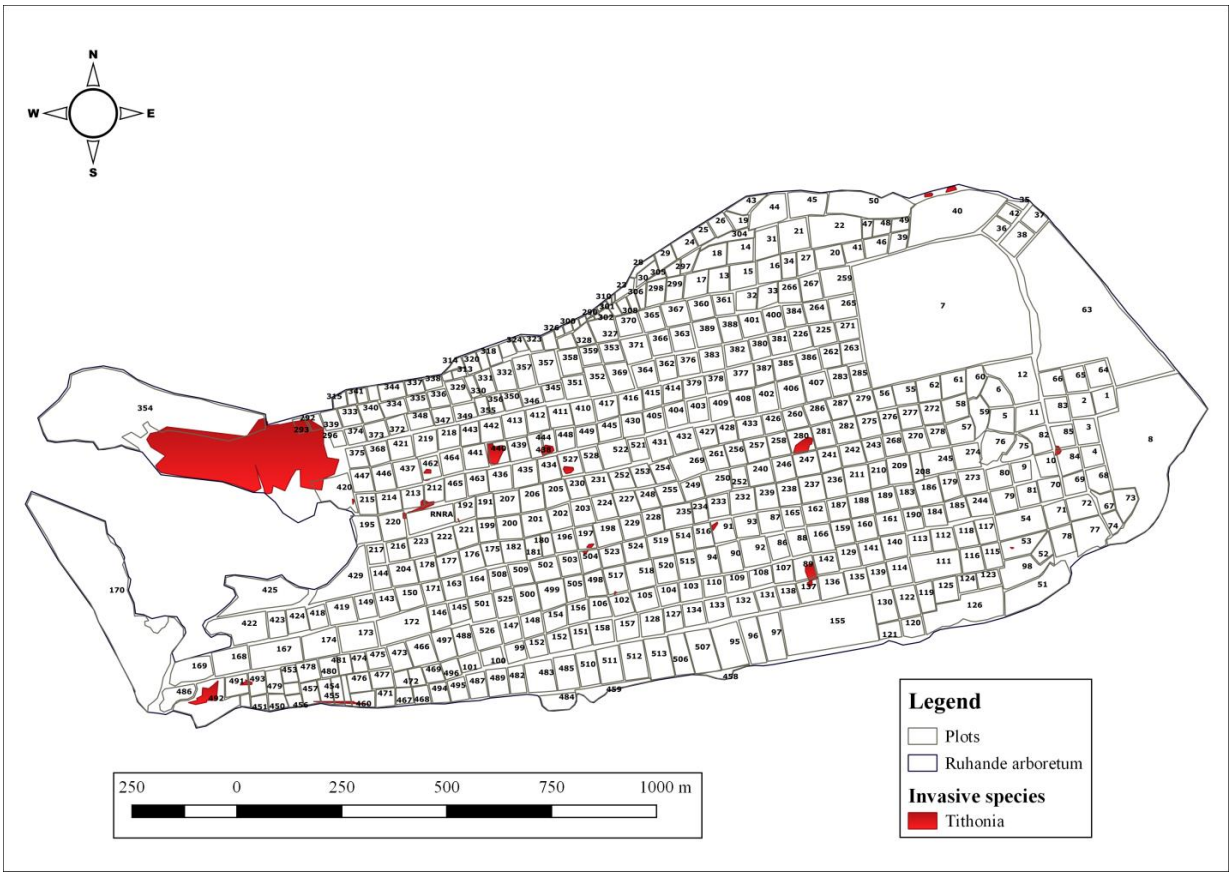

Figure 5: Coverage of *Tithonia diversifolia* in Ruhande Arboretum.

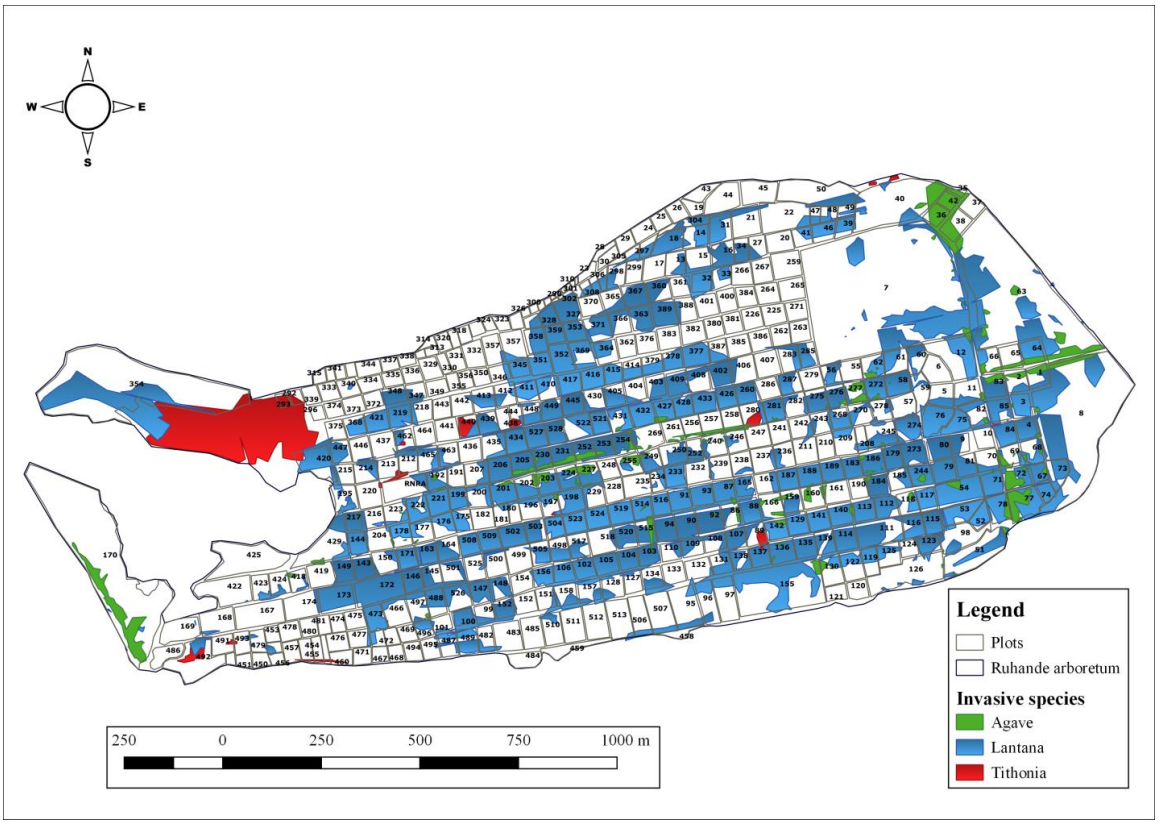

Figure 6: Map showing the distribution of *Lantana camara*, *Agave sisalana and Tithonia diversifolia* in Ruhande Arboretum

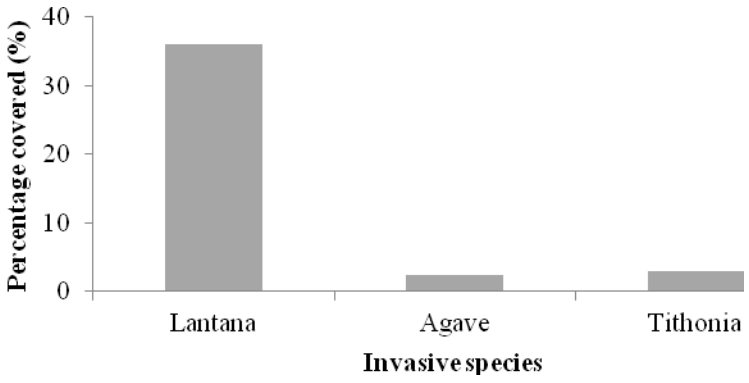

Figure 7: Percentages of area covered by invasive species in Ruhande Arboretum.

Based on different sampled vegetation types in Ruhande Arboretum, the three invasive plant species of our interest were not equally abundant. Eucalyptus, exotic coniferous, natural forest (non-introduced species) and exotic hardwood indicated more invasive

alien plant species (Figure 8). The proportions of locations of *Lantana camara*, *Agave sisalana*, and *Tithonia diversifolia* are shown separately in sampling vegetation types in Ruhande Arboretum (Figure 9).

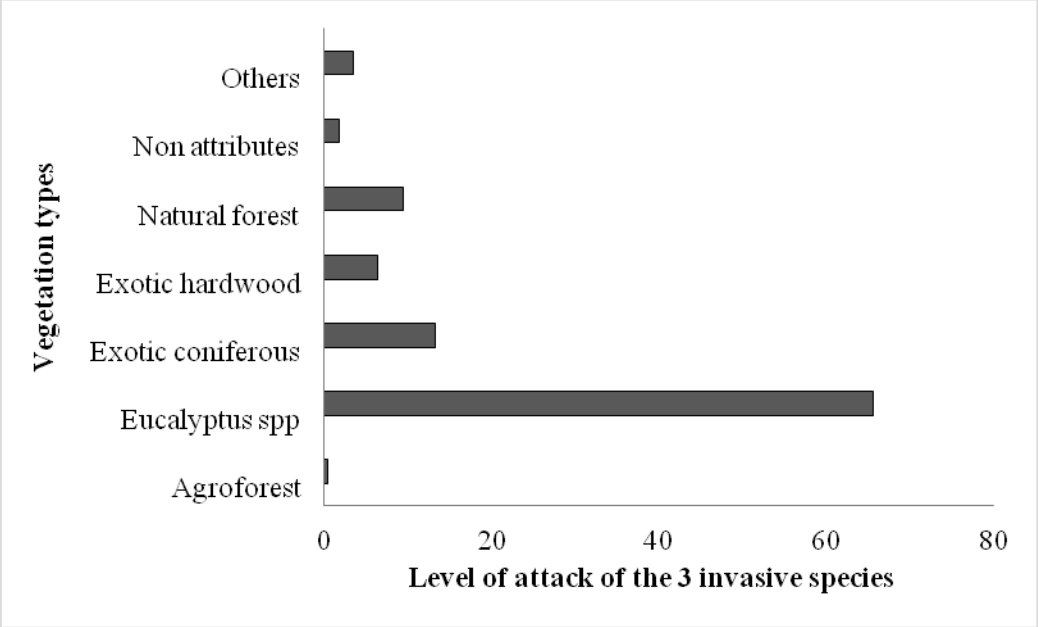

Figure 8: Proportion abundance of three invasive plant species of our interest in different sampling units of RA.

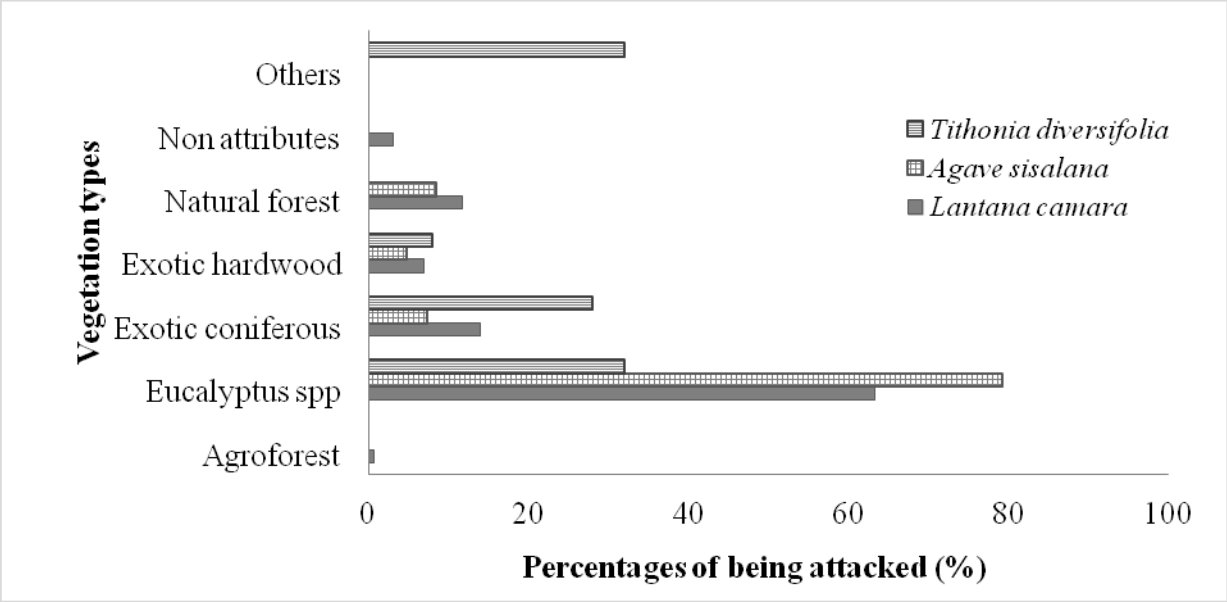

Figure 9: Proportion abundance of *Lantana camara*, *Agave sisalana*, and *Tithonia diversifolia* in different sampling units of RA.

4. DISCUSSION

Our findings confirm that *Lantana camara* is more distributed than *Agave sisalana* and *Tithonia diversifolia* in Ruhande Arboretum. This may be due to the highest seed dispersal of *Lantana camara* by different agents such as birds and mammals (Prasad, 2007; Ramaswami & Sukumar, 2011). For instance, in Ruhande Arboretum we have birds and monkeys which feed on the fruits of *Lantana camara* and their seeds are hard to be digested which favor their distribution through feces of those animals with the help of water. Not only those agents but also disturbance and edge effect created by humans travelling in that forest can disperse the fruits of *Lantana camara* easily from one place to another (Sundaram *et al.*, 2015). This mechanical dispersal of *Lantana camara* is high compared to the 2 remaining invasive species since its fruits are easily detached from hanging branches. *Lantana camara* have short germination period and high adaptability to low soil nutrients and water contents (Prasad, 2007) which can lead to its presence in different areas of the forest compared to *Agave sisalana* and *Tithonia diversifolia*.

The *L. camara* also covers a large area in Ruhande Arboretum compared to *Agave sisalana* and *Tithonia diversifolia* which may be due to its ability to form many branches and high growth rate compared to the two remaining species (REMA, 2016; Prasad, 2007). Although *Agave sisalana* have a higher distribution than *Tithonia diversifolia*; *Tithonia diversifolia* follows *Lantana camara* in covering large area in the forest because *Agave sisalana* is patchier than *Tithonia diversifolia.*

Even though *L. camara* is more sensible, the two others also act according to the edge effect created by different trails in that forest. These invasive species have attacked both established exotic and indigenous species within their plots, with Eucalyptus plots showing high level of being attacked. This might be related to the largest area that Eucalyptus species occupy in Ruhande Arboretum. In protected native species (natives protegé) found within Arboretum, these invasive species are distributed near its edges and rarely inside of that part due to the lowest level of human disturbance compared to other plots. Through disturbing the regeneration processes and reducing the biodiversity, *Lantana camara* can outcompete and suppress the established species within their plots in Ruhande Arboretum. *Agave sisalana* can prevent the

regeneration of trees; exclude understory species and reduce species diversity. *Agave sisalana* may cause also the economic loss for tree plantations mainly *Eucalyptus sp*. *Tithonia diversifolia* has rapid vegetative reproduction and forms dense thickets leading to mono-dominant stands (REMA, 2016).

5. CONCLUSION

This study found that *Lantana camara* is more distributed, covering a large area in Ruhande arboretum, compared to the two-remaining species. For better management and conservation of that forest, we recommend to RWFA to remove those invasive species and to assess the distribution of other invasive species such as *Tecoma stans* and *Calliandra calothyrsus* that can outcompete the established species. We also recommend to RWFA to set the rules and regulations to be followed by the local people and students especially those who can enter in that forest without the authorization as much as this can help in controlling and reducing the role of humans in seed dispersal of the invasive species.

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