SPATIAL DISTRIBUTION OF *Argemone mexicana* IN NGORONGORO CONSERVATION AREA, IN TANZANIA

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Abstract

The study investigated the spatial distribution of *Argemone mexicana* in selected parts of Ngorongoro Conservation Area (NCA). Sites selected for the study includes Longuuko, Maranja Elerai, Crater, Limala, Empakai, and Endulen Primary School. Roaming surveys for exotic plant mapping was used with the aid of Garmin 76s Global Positioning System unit. Results revealed that 70 072 m^2 (64%) were infested with *A. mexicana* across the Ngorongoro conservation area out of 110 326 m^2 surveyed. Furthermore, results reveal that Maranja Elerai, Endulen primary school and Limala (57%, 24% and 10% respectively) were more affected than the rest. Human activities especiatially infruscture development and tourism activities are major sources which bring in *A. mexicana* in NCA. Construction materials especially sand imported from outside the park Karatu in particular and vehicles (tourist and management cehicles) brought and dispersed seeds of *A. mexicana* in NCA. The invasion of *A. mexicana* in NCA is at low level and mangeable. Therefore, it is recommended to effectively implement invasive alien plants strategic management plan based on thorough knowledge of its distributions and abundance.

Keywords: Invasive species, Global positioning system, Mapping

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Introduction

Ngorongoro Conservation Area (NCA) together with the Serengeti National Park (SNP) in Serengeti ecosystem forms an ecologically and economically important area. However, invasive alien plant species have been identified as one of the main known biological threats to biodiversity in the area (URT, 2011). *Argemone mexicana* is among of invasive species invading wildlife protected areas in Serengeti ecosystem. *A. mexicana* were noted growing sporadically along the roads of Ngorongoro conservation area and Ngorongoro crater floor in 1998 (URT, 2011). A possible means of introduction of alien species in Ngorongoro Conservation Area is through the importation of construction materials, especially sand from Karatu and development of gardens in lodges and residential areas (Foxcroft, 2006). Increase in human activities caused an increase in biological invasion in ecosystems and hence trade and travel patterns determine invasion pathways and the frequency with which alien species are introduced into vulnerable ecosystems (McNeely *et al.,* 2001; Perrings, 2002; Sharma *et al.,* 2010; Westphal *et al.,* 2008). According to Perrings (2002), the probability of establishment of intentionally introduced alien species is greater than that of unintentionally introduced species. Invasive species encounters heterogeneous landscape in new habitat range composed of mosaics of habitat types and environmental gradients. Hence, the spatial distribution of invasive species within such landscapes is often patchy, with some types of habitats and environmental conditions more invaded than others (Miller, 2006). To date, control of further spread of *A. mexicana* in Ngorongoro Conservation Area is carried out by uprooting and burning method (URT, 2011). Proper management actions to control invasive species in ecosystem require understanding and predicting the future patterns of how that invader will spread throughout the landscape (Voline *et al*., 2004). Predicting the future spread requires understanding of current patterns of distribution: what they are and how they have developed (Lambrinos, 2001). Hence, spatial distribution and historical spread of invasive species is required in order to put biological invasion in context. Historical reconstruction of spread patterns can explain how current patterns have developed, identify those regions and habitats where invasion has been most rapid, and identify areas at risk for future infestation (Lambrinos 2001; Brown and Carter 1998; Weber, 1998). Hence, for effective management of *A. Mexicana* in Ngorongoro conservation area, there is a need to determine their spatial distribution and possible future areas to be infested by the same. Results from this study will provide baseline information for better management and control of further spread of *A. mexicana* in Serengeti ecosystem.

Material and Methods

Study area location and description

Study was done at Ngorongoro Conservation Area, located at latitude and longitude 3° 12′ 32″ S, 35° 27′ 46″ E in Arusha region Tanzania. Ngorongoro Conservation is a protected area established in 1959 as a multiple land use area, with wildlife coexisting with semi-nomadic Maasai pastoralists practising traditional livestock grazing. The Ngorongoro Conservation Area (809 440 ha) experiences different vegetation types includes highland plains, savanna, savanna woodlands and forests, from the plains of the Serengeti National Park in the north-west, to the eastern arm of the Great Rift Valley.

Mapping

Mapping for *A. mexicana* were carried out in March, 2013. Roaming surveys were used, which involved walking across to locate *A. mexicana* at Longuuko, Maranja Elerai, Crater, Limala, Empakai, and Endulen Primary School (Fig. 1). Sites were selected purposively based on invasion of *A. mexicana* in those areas as explained by staff from range and ecological monitoring unit of Ngorongoro Conservation Area Authority (NCAA). The invasive species polygons were collected using GPS. The GPS was set to automatically collect coordinates (points/waypoints) after every one second. The researcher went around the peripheral of the invasive species coverage to get the points/waypoints of the boundary of the invasive species in order to get a polygon. Occasionally, waypoints were recorded in a note book to verify with the one that were automatically collected by a GPS.

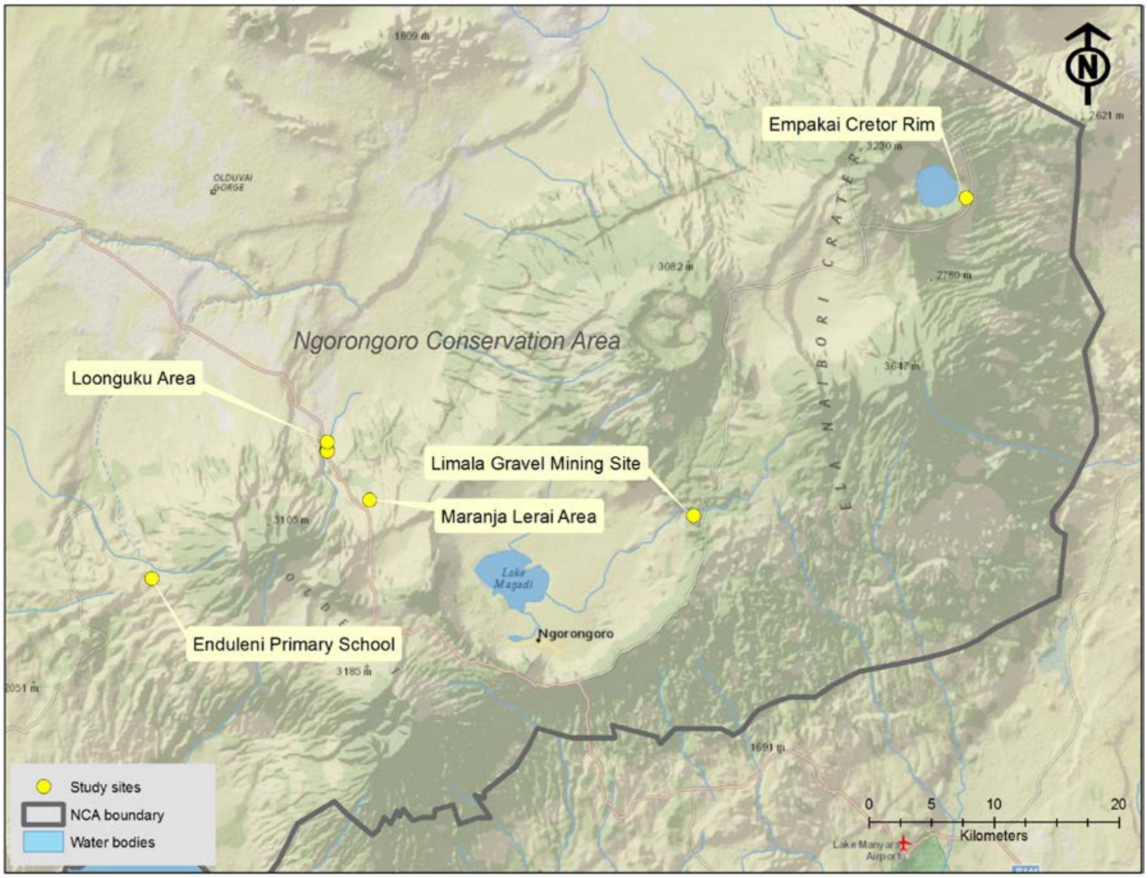

Figure 1: Map of Ngorongoro Conservation Area indicating sites where mapping of *A. mexicana* was conducted.

Data analysis

The collected data (coordinates/points) were downloaded from GPS to the computer using Garmin Map source software. The data were later exported in a format (dxf format) that can be accepted by ArcMap 10 software. The data (coordinates/points) that make coverage of a particular invasive species were digitized to get polygons in ArcMap 10 software. The ArcMap 10 software was used to calculate surveyed area, invasive species area coverage, draw polygons and show location of the polygons on the Ngorongoro Conservation Area map.

Results

Infestation in relation to surveyed area

The survey results shows that Maranja Lerai has the largest infested area (39 748 m^2), followed by Endulen primary school (16 622 m^2**)** and Limala (7 251 m^2), and the lowest infestation was recorded at Empakai (1648 m^2). The surveyed and infested area in square meter and percentage for the entire park are shown in Table 1.

Table 1: The surveyed and infested area in m^2 and percentage for the entire park

Location	Surveyed area (m^2)	Infested area (m^2)	Infested area percentage (%)
Loonguku	9 230	4 803	6.85
Endulen Primary school	25 241	16 622	23.72
Maranja Elerai	56 103	39 748	56.72
Limala	12 880	7 251	10.35
Empakai	6 872	1 648	2.35
Total	**110 326**	**70 072**	**100**

Spatial Distribution of *A. Mexicana*

(a) Loonguku

At Loonguku a total area of 9 230 m^2 were surveyed and found that 4 803 m^2 were infested (52%), which represents 6.85% of the total park area infested. Four polygons (Fig. 2- 5) were surveyed, and infestation size ranged from 149-3936 m^2.

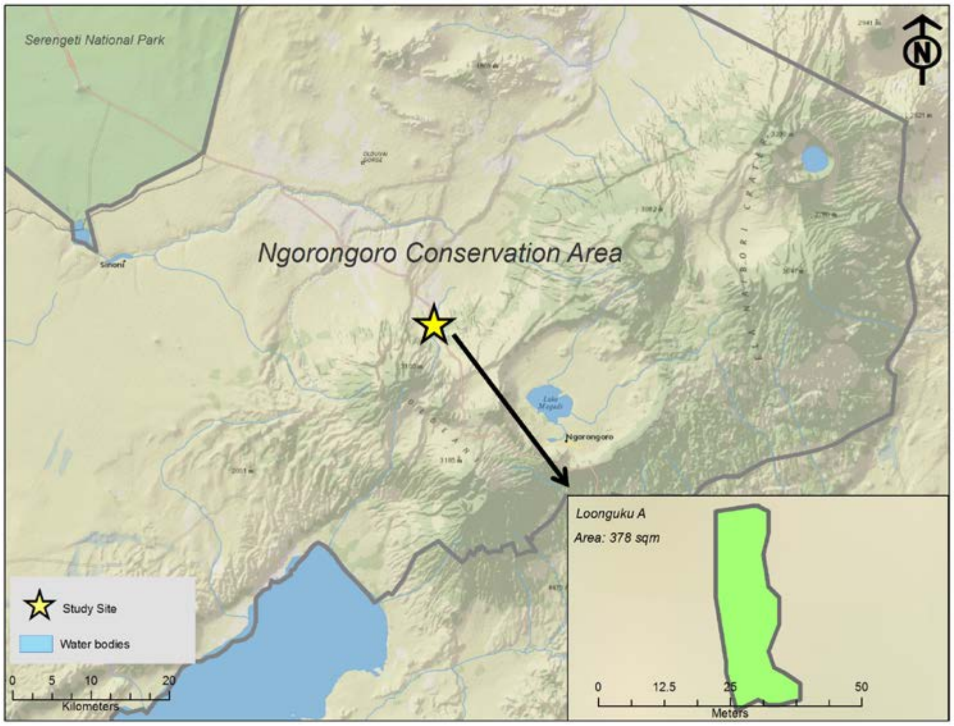

Figure 2: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Loonguku A.

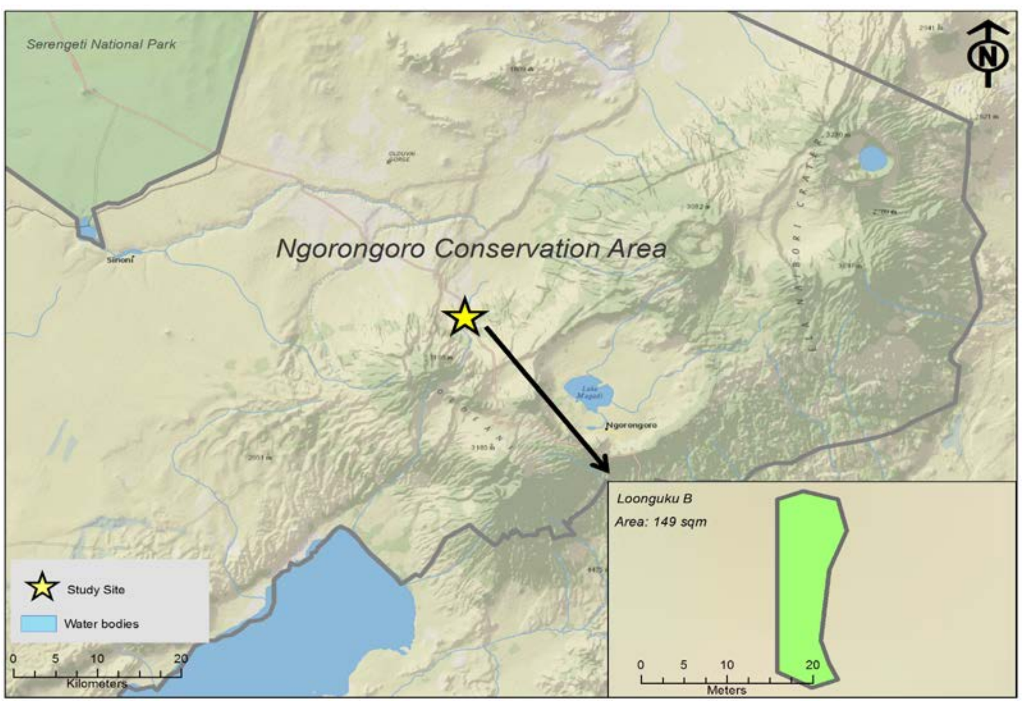

Figure 3: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Loonguku B.

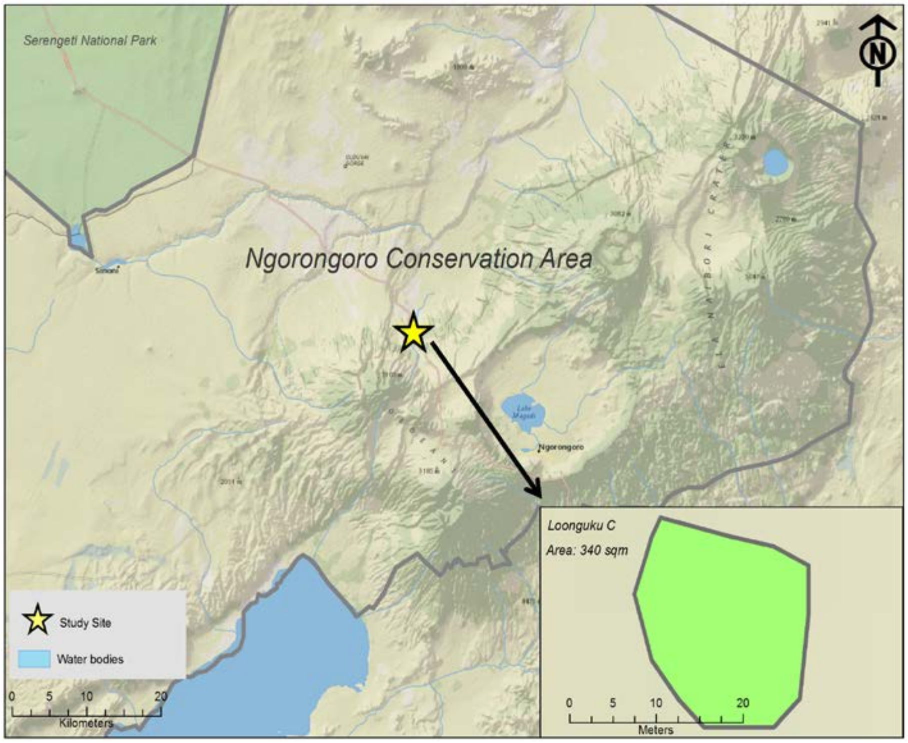

Figure 4: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Loonguku C.

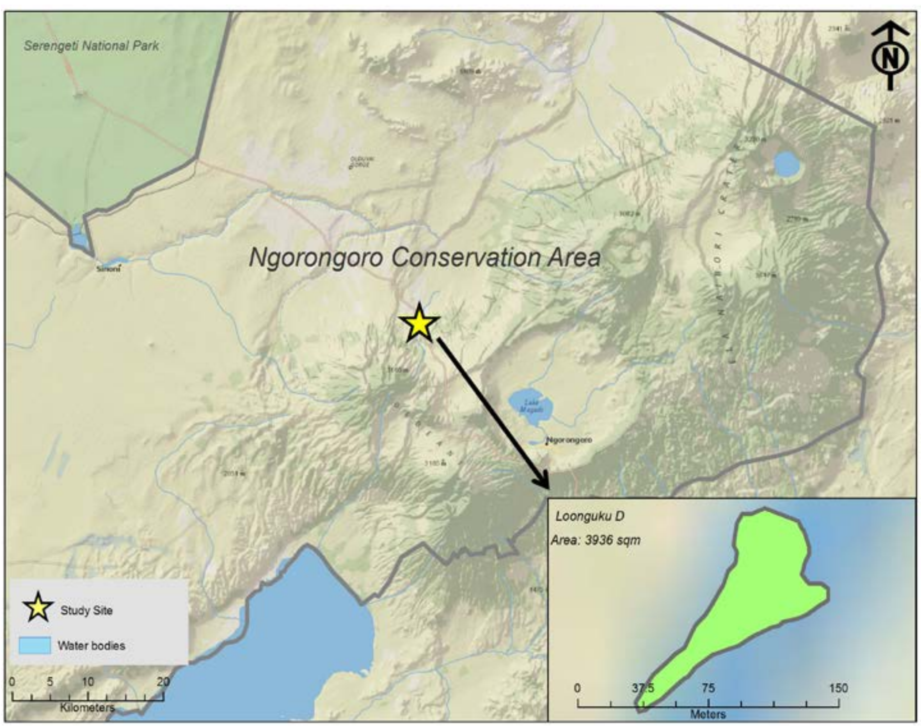

Figure 5: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Loonguku D.

(b) Endulen primary school

At Endulen primary school, a total area of 25241 m^2 were surveyed and found out that 16622 m^2 were infested (32%), which represents 24% of the total park area infested (Fig. 6).

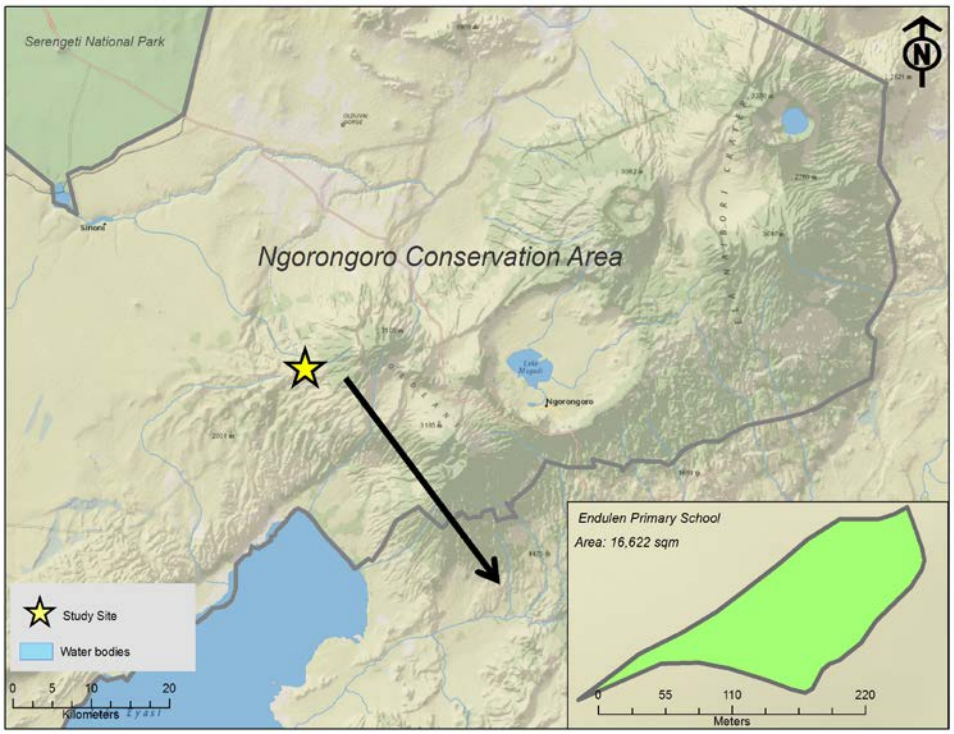

Figure 6: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Endulen primary school.

(c) Limala gravel mining site

Fig. 7 presents infested area at Limala gravel mining site. Total area of 12880 m^2 was surveyed and 7251 m^2 were found infested (56%) which represents 10% of the total park area infested.

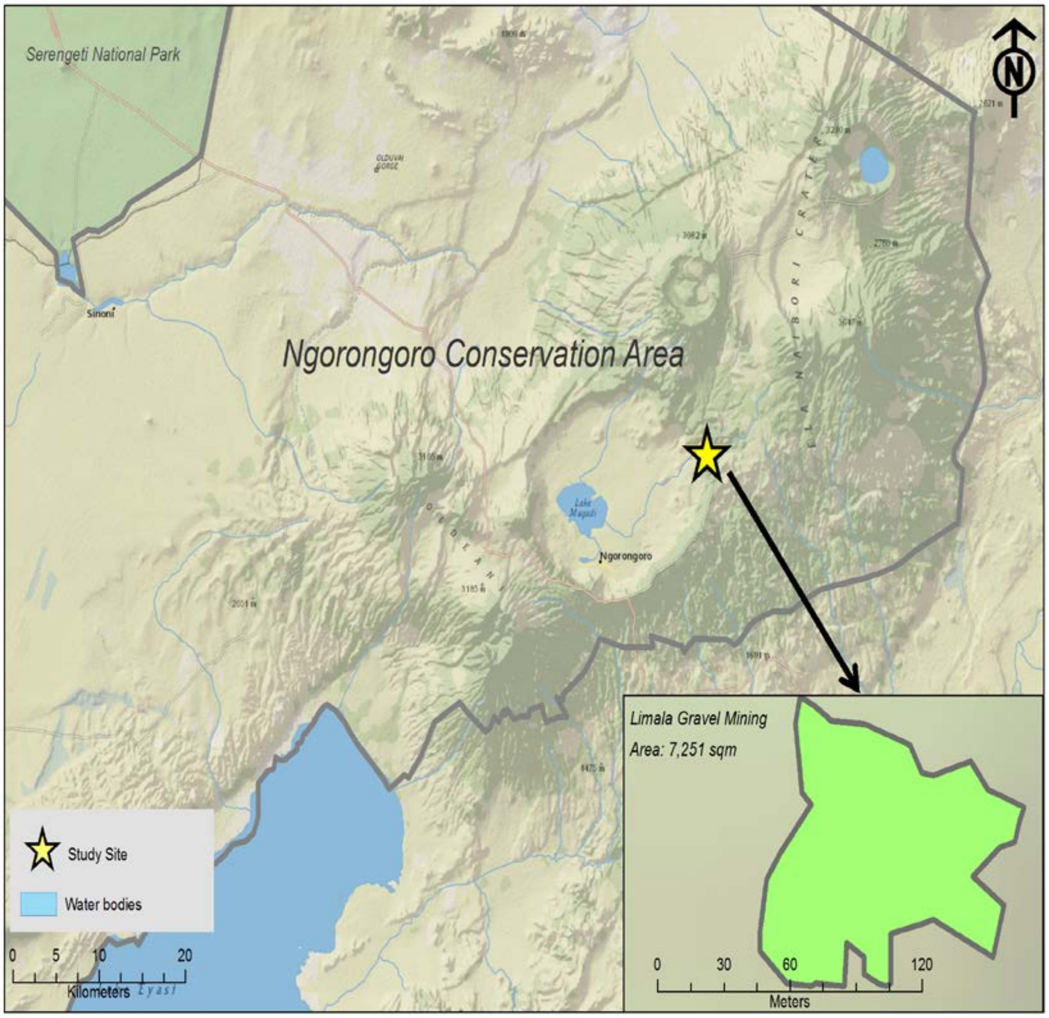

Figure 7: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Limala gravel mining site.

(d) Maranja Lerai gravel mining site

Maranja Lerai gravel mining site (Fig. 8) had a total area of 56103 m^2 which were surveyed, and 39748 m^2 were found infested (71%), of which represent 57% of the total infestation in the park. This was the biggest polygon recorded during the study with big area infested when compared with other areas.

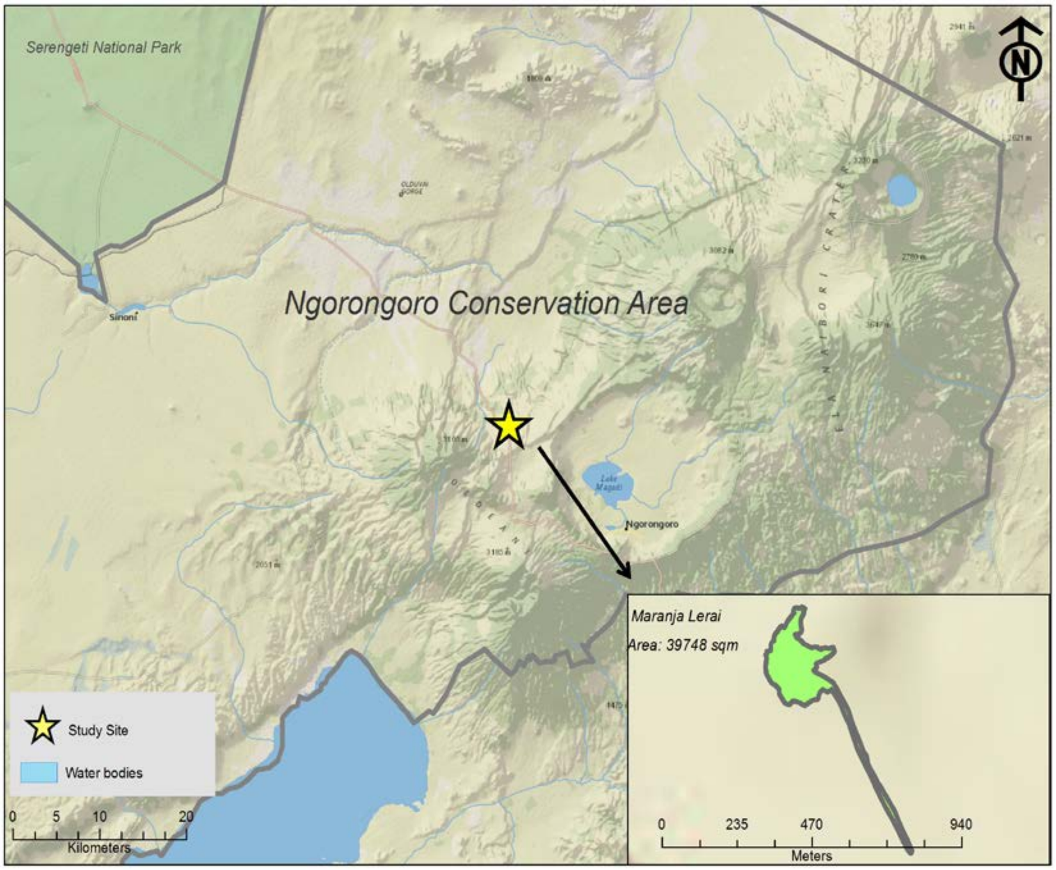

Figure 8: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Maranja Lerai gravel mining site.

(e) Empakai crater rim

One polygon with area of 6872 m^2 was surveyed and 1648 m^2 were infested (24%) with *A. mexicana*. Infested area accounts for 2 % total area infested by *A. mexicana* in the park (Fig. 9).

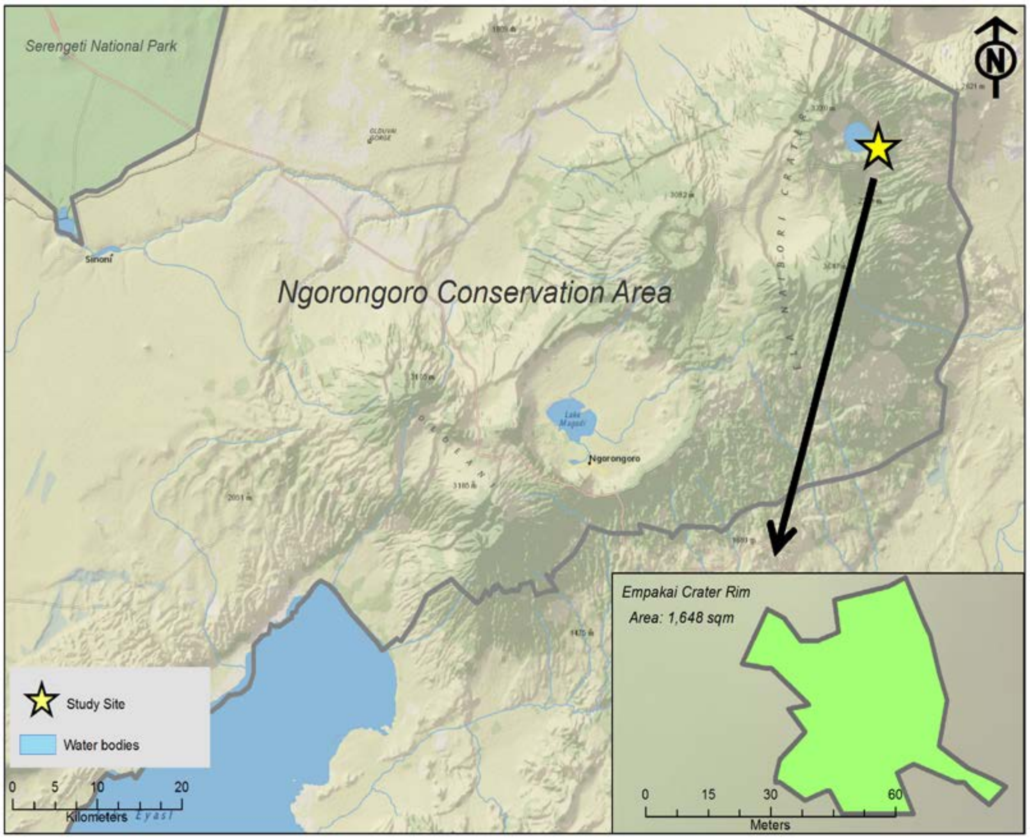

Figure 9: Map of Ngorongoro Conservation Area showing locational distribution of *A. mexicana* at Empakai crater rim.

Discussion

The study showed that the distribution of *A. mexicana* has been favored by land use history. In most cases, *A. mexicana* were spotted along the roads, in gravel mining sites and residential areas. This shows that the dispersal of *A. mexicana* in Ngorongoro has been caused by human activities like travel, tourism and infrastructures development. In gravel mining sites, there were large patches of *A. mexicana* compare with other areas. This indicated that the frequency of heavy vehicles carrying gravels brought more seeds to the site and spread around. The seeds of *A. mexicana* germinating along the roads were mostly brought in gravels by tipper and also dispersed by cars used by tourists and protection activities. In hotels and residential areas, *A. mexicana* were germinating from seeds brought by building and gardening materials especially sand. *A. mexicana* seeds are also dispersed by water and this was evident as *A. mexicana* plants found along the river, road side ditches and mitre drain. Wild animals and livestock may also disperse seeds of *A. mexicana* through mud adhering to their body (Parsons and Cuthbertson, 2001). Findings from our study correlates to a study by Foxcroft (2006) who reported that importation of construction materials, especially sand from Karatu and development of gardens in lodges and residential areas are possible means of introduction of alien species in Ngorongoro Conservation Area. Elsewhere, McNeely *et al.* (2001); Perrings (2002); Sharma *et al. (*2010); Westphal *et al. (*2008) reported that an increase in human activities such as trade and travel caused an increase in biological invasion in ecosystems. During the study *A. mexicana* plants were not found in the crater floor because the program to control invasive plants by NCAA put the crater floor as priority site and hence the activities of uprooting and burning *A. mexicana* was just completed before mapping. *A. mexicana* is an annual weed therefore, during March when study was done, most of them withered and in some places like Maranja lerai were germinating and new seedlings were observed.

Conclusion

Results from this study provide relative information on spatial distribution of *A. mexicana* and thus call for further mapping studies to take into consideration the seasonality, control program and combine mapping methodologies including use of remote sensing. *A. mexicana* has effects on other forms of life in plants and animals; including allelopathic potential that may suppress native plants and thus reduce the carrying capacity of the park.

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