Distribution and abundance of *Datura stramonium* in Ngorongoro Conservation Area

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Abstract

Ngorongoro Conservation Area (NCA) is one of the protected areas located in Northern part of Tanzania. Among other problems that faces this protected area, invasion and rapid spread of invasive alien species has been the greatest challenge hindering conservation efforts. *D. stramonium* is among troublesome invasive alien species that poses great ecological problems in this protected area. It is an annual, strong-scented, poisonous invasive alien species, reproducing by seeds. The aim of this study was to map the distribution of *D. stramonium* and determine the possible causes of its spread within NCA which create ecological effects in an ecosystem. The results obtained from this study showed that Embaruai, Lerai, Lemara rangers post, Empakai, Ndian, Olbalbal, Oldupai and Malanja are areas which are highly invaded by *D. stramonium*. The species was more distributed in Lerai 205,244 m^2 (69.57%) and Olbalbal 53161 m^2 (18.02). The least infested area was Empakai camp site 1781 m^2 (0.60%) which is located at the rim of Empakai crater. Other areas with low infestation of *D. stramonium* included Lemara ranger post 1847 m^2 (0.63%) and Ndian 1916 m^2 (0.65%). Spread of *D. stramonium* in NCA has been contributed by many factors including construction of roads and view points; movement of vehicles; presence of tourist hotels, campsites and staff residences; presence of temporal and permanent Maasai residences "bomas"; and the climate change.

Keywords: Invasion, Invasive alien species, Mapping, Human activities

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Introduction

Ngorongoro Conservation Area (NCA) is one of the protected areas located in Northern part of Tanzania (2°30'-3°30'S, 34°50'-35°55'E). It borders Loliondo Game Controlled Area (LGCA) to the North, Serengeti National Park to the west, Lake Eyasi to the south and agricultural communities on south eastern border (Niboye, 2010). Recently, the management has declared that among other problems that faces this protected area, invasion and rapid spread of Invasive Alien Species (IAS) has been the greatest challenge hindering conservation efforts (NCAA, 2011). IAS has many ecological impacts in an ecosystem and they are usually irreversible if appropriate strategies will not be taken immediately after invasion (Cronk and Fuller, 1995). *D. stramonium* is an annual, strong-scented, poisonous invasive alien species, reproducing by seeds (Wilbur, 1987). It produces numerous small seeds encapsulated in apple-shaped fruit capsules (hence the name thorn apple) (Alexander *et al*., 2008). *D. stramonium* is a common weed generally found growing along roadsides, grazing land, waste areas, and agricultural fields and it falls under family Solanaceae (Binev *et al.*, 2006; Mahnaz *et al.*, 2011). It is commonly known as Angel's trumpet, Jimson weed, Devil's trumpet, Devil's weed, Thorn apple, Jamestown weed, Stinkweed, Locoweed, Devil's cucumber and Hell's Bells (Waseem, 1998; Mahnaz *et al.*, 2011). Thorn apple is also known as Devil's apple because of its dangerous qualities and the peculiar effects when ingested (Oseni *et al*., 2011). The invasion of Invasive alien species to the recipient ecosystem can be influenced by many factors and one of them being climate change. The increase in the number of alien plants in NCA between 2002 and 2007 is associated with variability in rainfall patterns whereby precipitation in years 2003, 2004, 2005 and 2006 was below long-term average followed by relatively heavy rains in 2007 (Runyoro *et al*., 2011). However, the variation of precipitation might be due to climate change (Higgins *et al*., 2007). Human activities also have great contribution to invasion and spread of invasive alien species in the ecosystem (Foxcroft *et al*., 2006; NCAA, 2011). Hoeck (2010) reported that amongst other areas in this protected areas, Lemuta, Angata Kiti, Angata Salei, Karian, Sanjan Gorges and Olduvai are highly invaded by *D. stramonium*. Therefore; there is need for mapping the distribution of *D. stramonium* so as to understand the extent of invasion in all areas in NCA. This will help to determine the rate of spread as well as predict future ecological impacts if appropriate measures to control this species will not be taken. Prevention of further invasion and removal of *D. stramonium* in infested areas require immediate response due to the fact that they

will continue to dominate the areas of NCA if not controlled. Through the release of allelochemicals to the environment, this invasive species will keep on suppressing the native plants which are palatable to wildlife and thus threaten the survival of biodiversity in the ecosystem. Therefore; this study is very important since its findings will be very useful to establish baseline information on distribution of *D. stramonium* in NCA.

Materials and Methods

Experimental site

Mapping of distribution of *D. stramonium* was carried out in NCA located in Arusha region, Tanzania. It is one of the protected areas in the country with large number of plants and wild animals. It is a part of Serengeti-Ngorongoro Biosphere Reserve. Field survey to map the distribution of *D. stramonium* in NCA was conducted in March and April, 2013.

Location of Ngorongoro Conservation Area

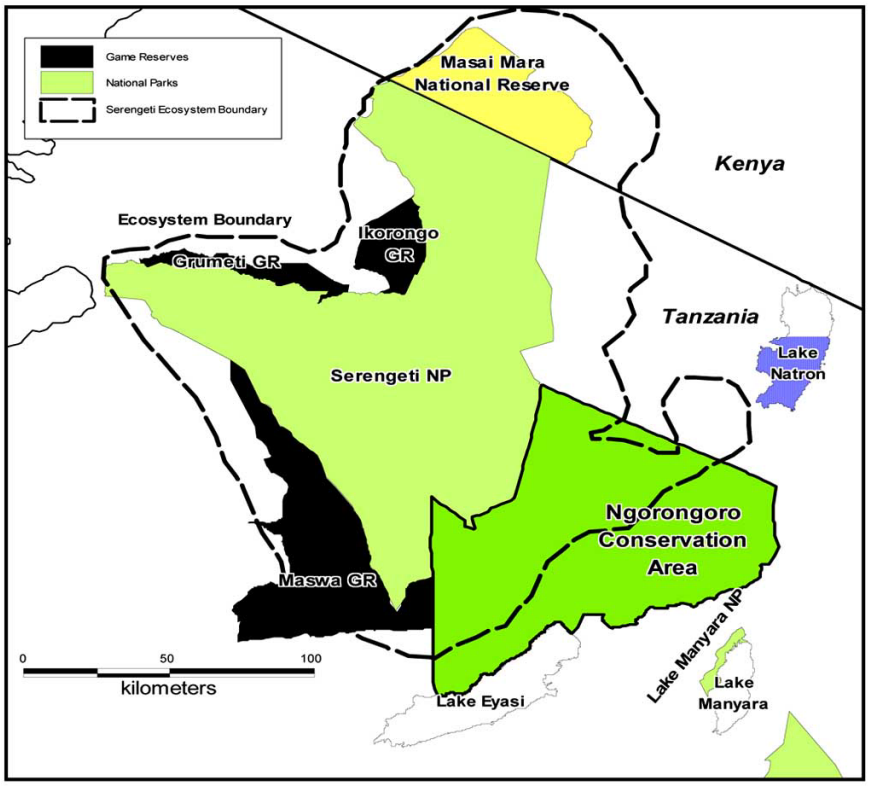

Figure 1: Ngorongoro Conservation Area in relation to Serengeti ecosystem (Source: Niboye, 2010).

Mapping of areas infested by *D. stramonium*

The areas infested by *D. stramonium* were marked in form of polygons using Hand-held Global Positioning System (GPS). The GPS was set to automatically record coordinates (points/waypoints) after every one second. The researcher was going around the peripheral of *D. stramonium* coverage to get the points/waypoints of the boundary each polygon. The waypoints of each polygon were recorded in notebook in order to verify if they were automatically saved by the GPS. The collected coordinates/points were downloaded from GPS to the computer using Garmin Map source software. The data were later exported in formats that were accepted by Arc Map 10 software. The coordinates/points obtained that make out the coverage of this invasive species were digitized to get polygons in Arc Map 10 software.

Data analysis

The Arc Map 10 software was employed to analyze data regarding spatial distribution of *D. stramonium* in NCA. The software was used to calculate the coverage area of *D. stramonium*, draw polygons and show location of the polygons on map to establish the overall distribution of *D. stramonium* in NCA.

Results

The results from field survey demonstrated that *D. stramonium* was highly distributed around Embaruai, Lerai, Lemara rangers post, Olbalbal, Empakai camp site, Ndian, Malanja and Oldupai. The species was more distributed in Lerai 205,244 m^2 (69.57%) and Olbalbal 53161 m^2 (18.02) (Table 1). The least infested area was Empakai camp site 1781 m^2 (0.60%) which is located at the rim of Empakai crater. Other areas with low infestation of *D. stramonium* include Lemara ranger post 1847 m^2 (0.63%) and Ndian 1916 m^2 (0.65%). Distribution of *D. stramonium* in other areas of NCA which were surveyed during field work in March and April, 2013 are shown in (Table 1) and (Figures 2-14).

Table 1: Distribution of *D. stramonium* in relation to surveyed and invaded areas.

Lacation	Surveyed area (m^2)	Invaded area (m^2)	Invaded area (%)
Ndian	3,214	1,916	0.65
Embaruai	11,865	7,005	2.37
Empakai camp site	2,678	1,781	0.60
Lemara ranger post	2,951	1,847	0.63
Lerai	315,294	205,244	69.57
Malanja	8,629	6,862	2.33
Olbalbal	102,738	53,161	18.02
Oldupai	24,118	17,215	5.83
Total	**471,487**	**295,031**	**100**

General distribution of *D. stramonium* across the conservation area

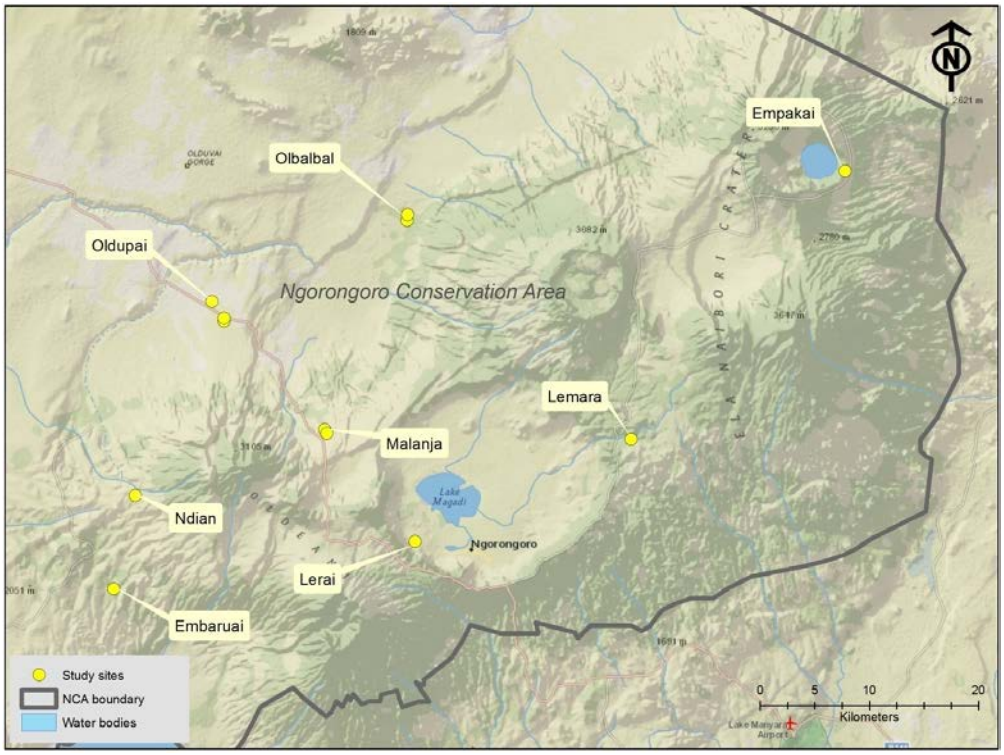

Figure 2: Distribution of *D. stramonium* in areas of Ngorongoro Conservation Area.

Locational distribution of *D. stramonium* in NCA

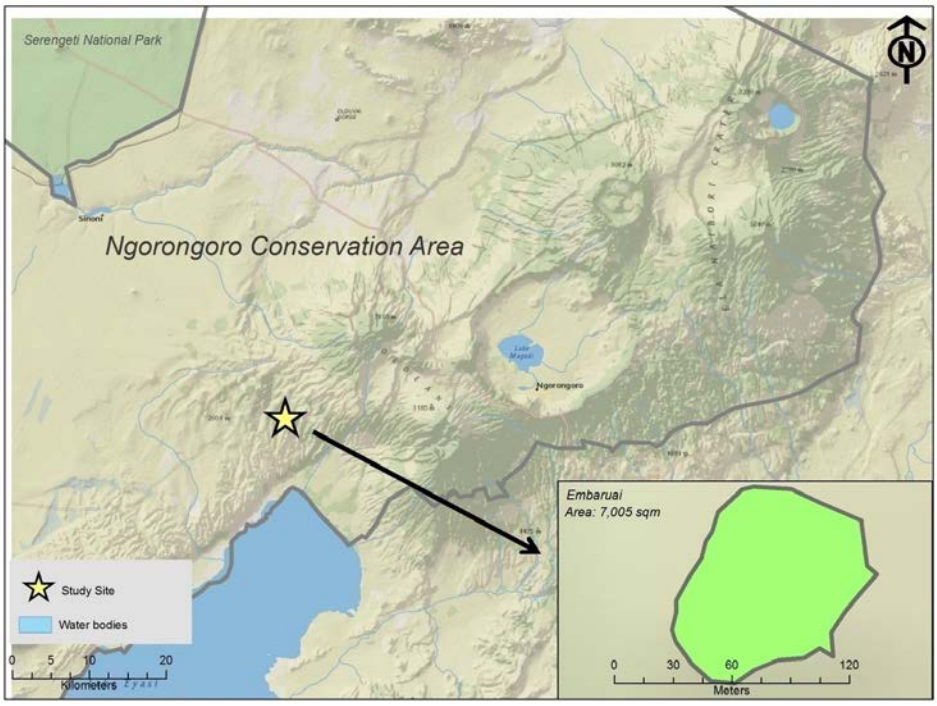

Figure 3: Distribution of *D. stramonium* at Embaruai. Source: Field data, 2013.

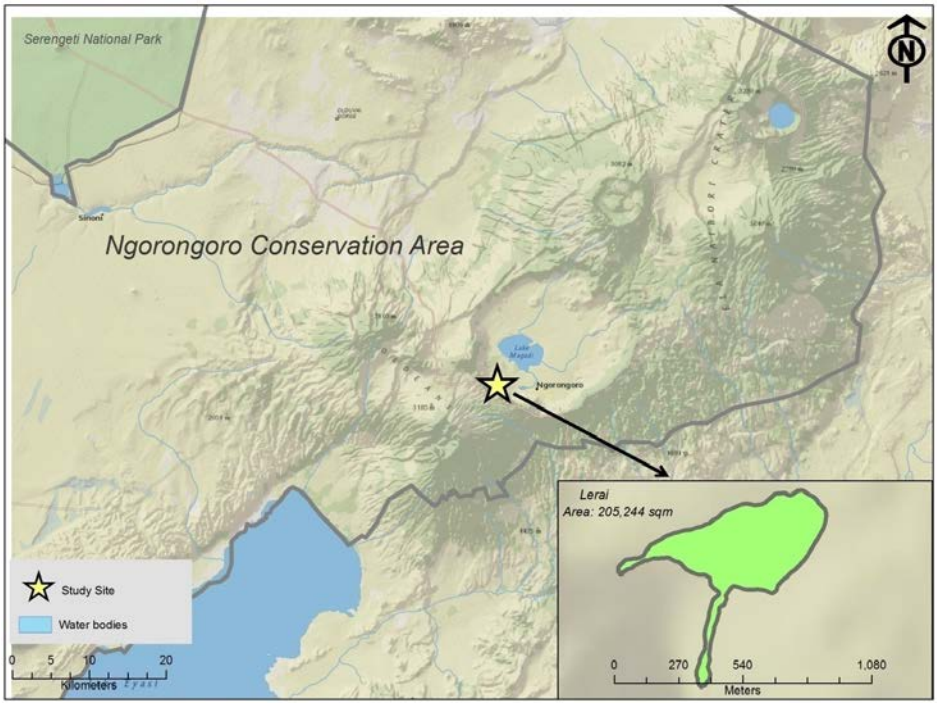

Figure 4: Distribution of *D. stramonium* at Lerai. Source: field survey, 2013.

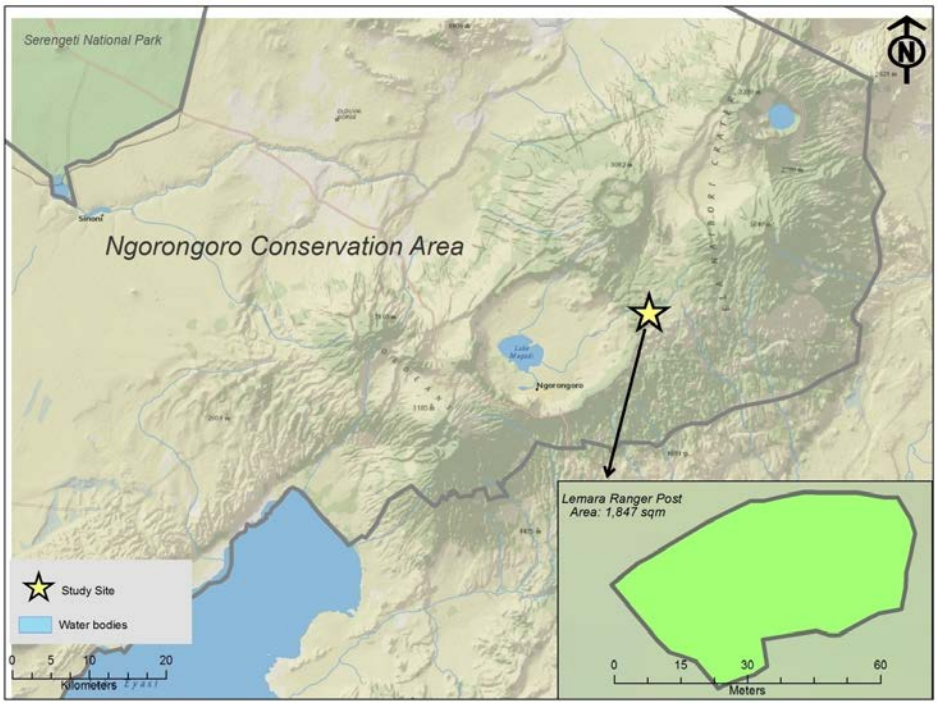

Figure 5: Distribution of *D. stramonium* at Lemara ranger post. Source: Field data, 2013.

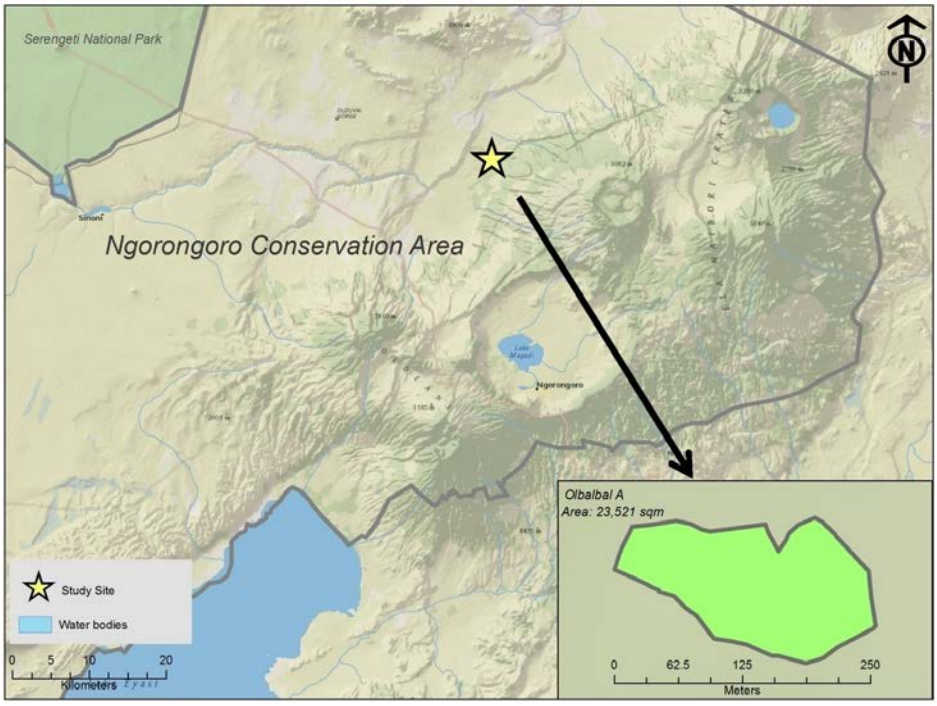

Figure 6: Distribution of *Datura stramonium* at Olbalbal A. Source: Field data.

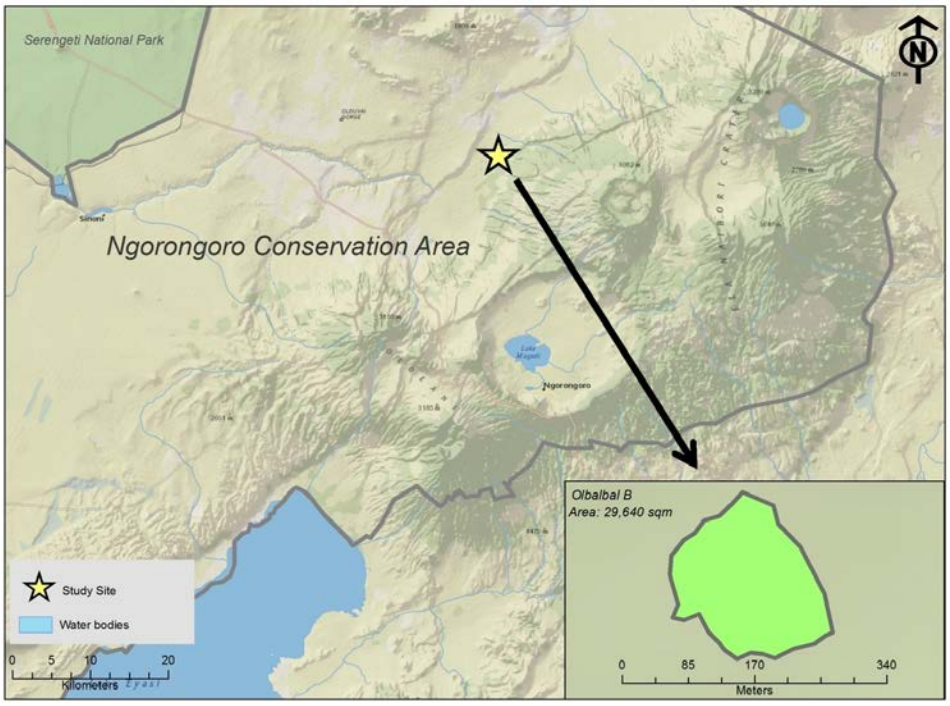

Figure 7: Distribution of *D. stramonium* at Olbalbal B. Source: field data, 2013.

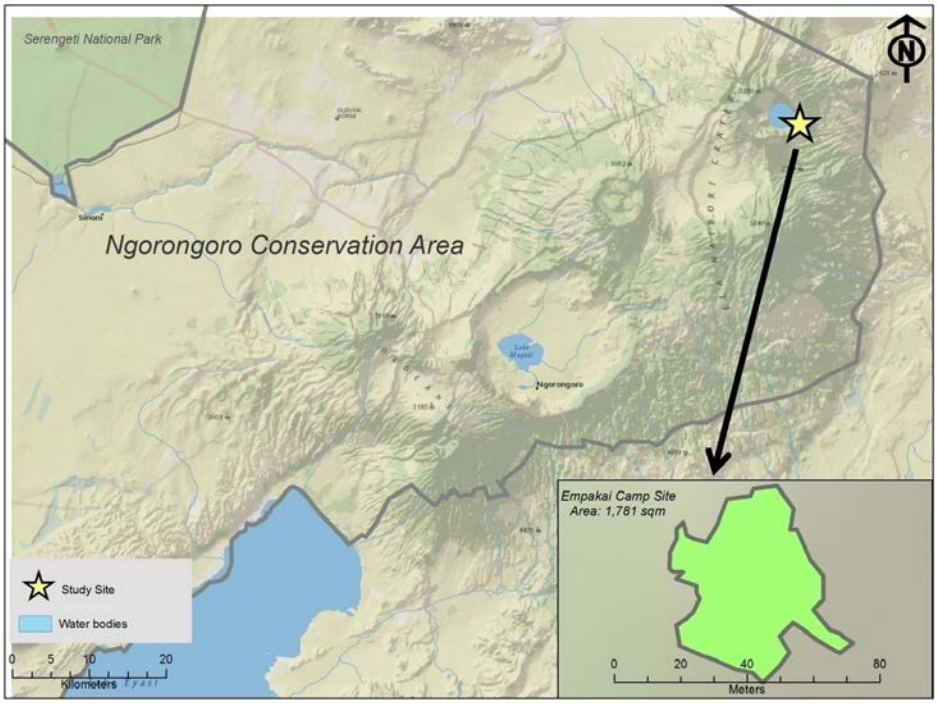

Figure 8: Distribution of *D. stramonium* at Empakai campsite. Source: field data, 2013.

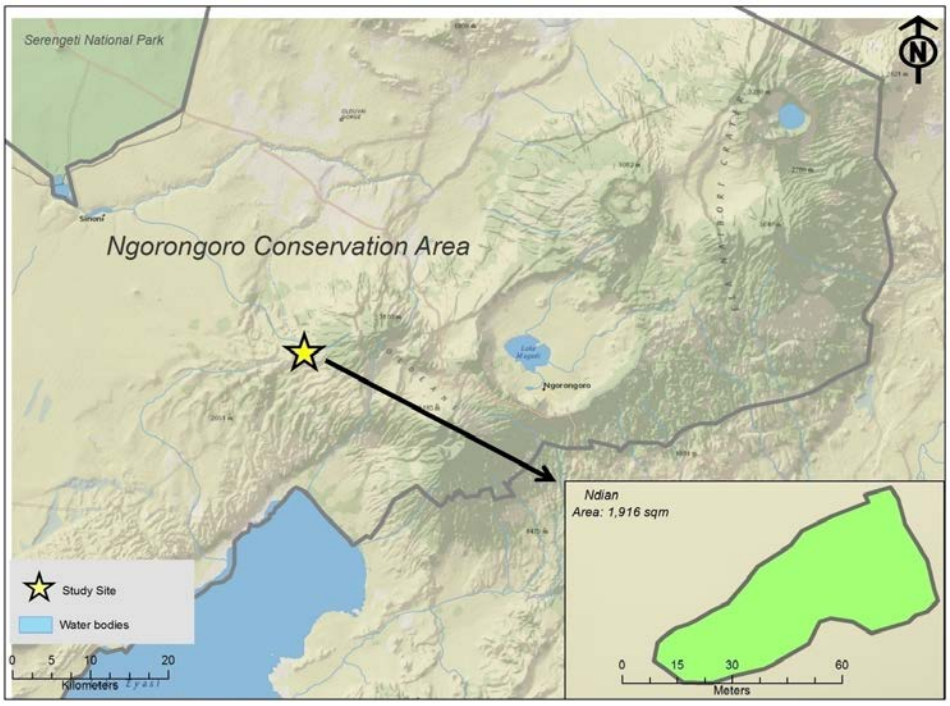

Figure 9: Distribution of *D. stramonium* at Ndian. Source: field data, 2013.

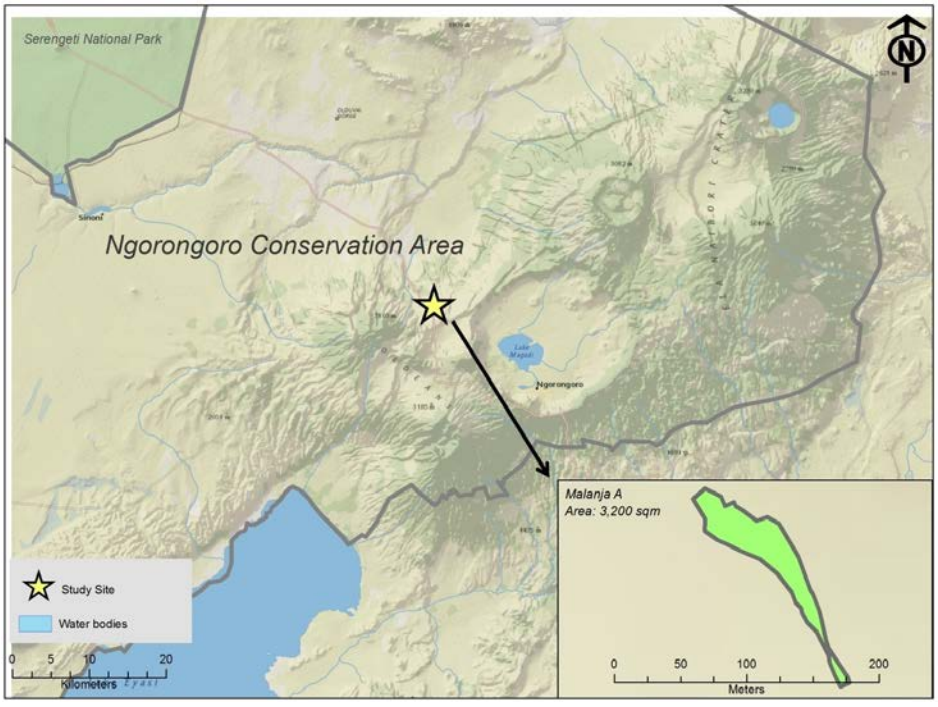

Figure 10: Distribution of *D. stramonium* at Malanja A. Source: field data, 2013.

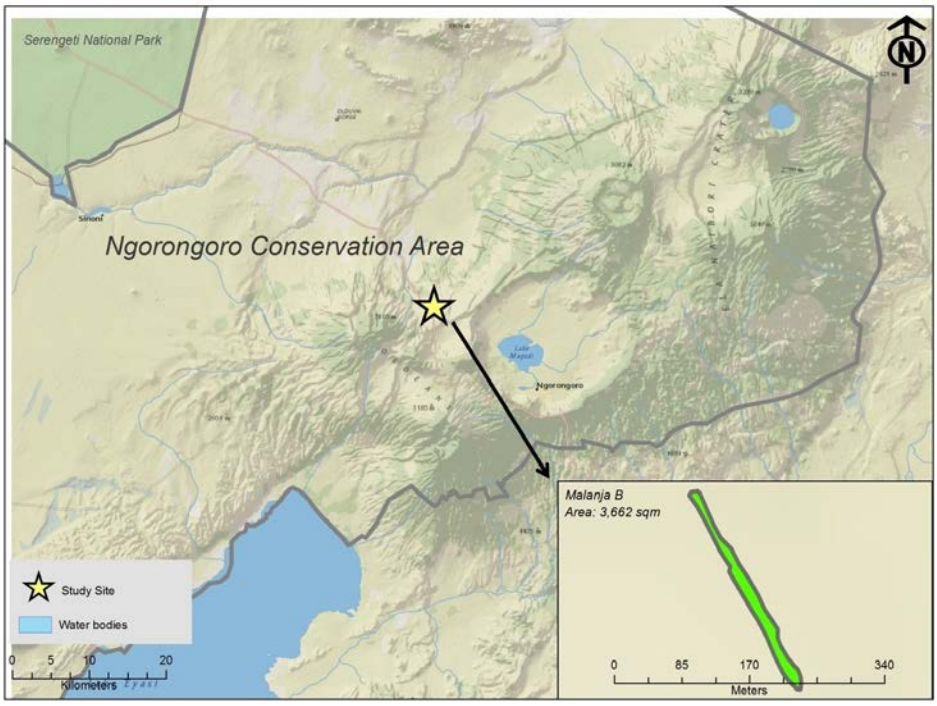

Figure 11: Distribution of *D. stramonium* at Malanja B. Source: field data, 2013.

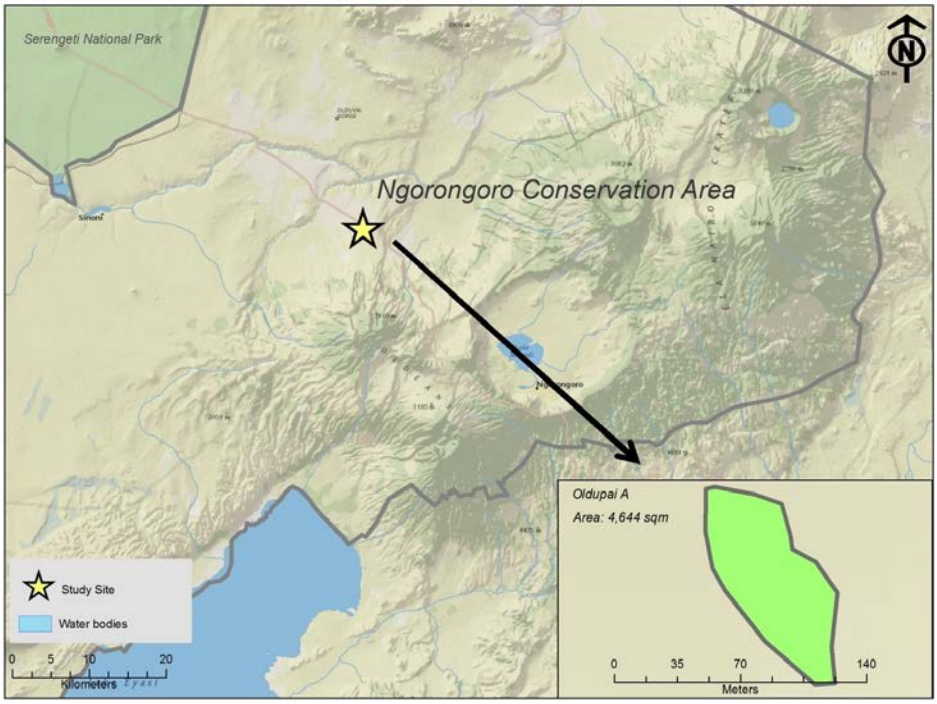

Figure 12: Distribution of *D. stramonium* at Oldupai A. Source: field data, 2013.

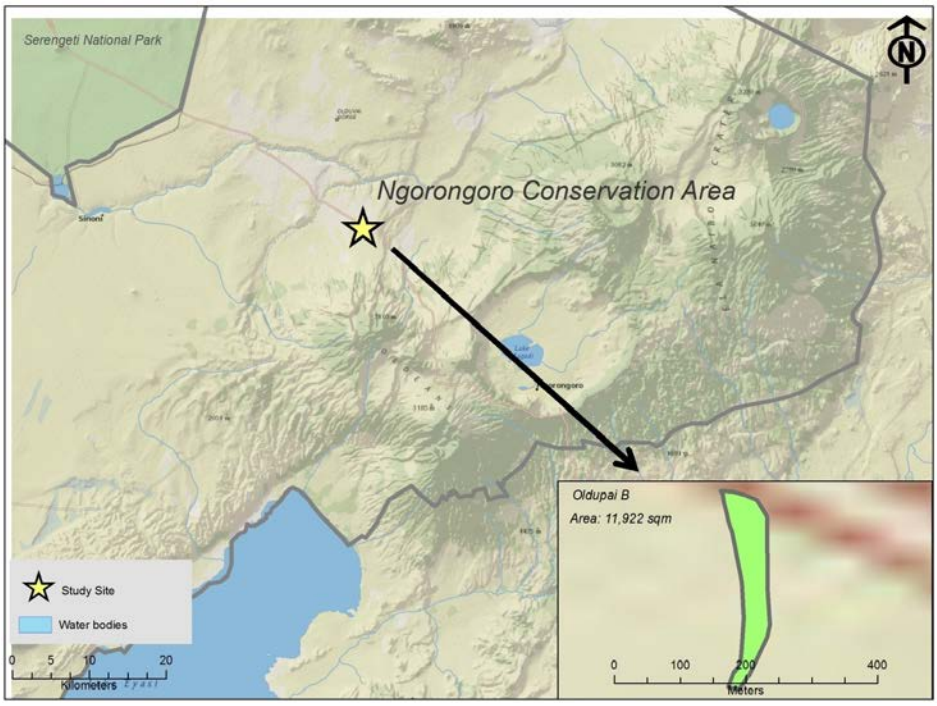

Figure 13: Distribution of D. stramonium at Oldupai B. Source: field data, 2013.

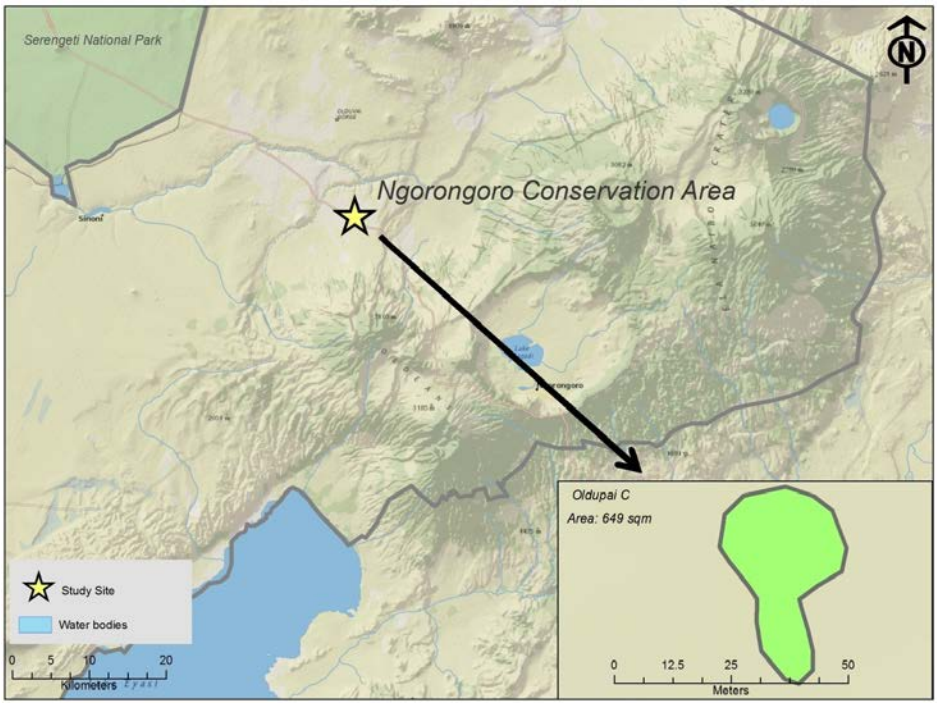

Figure 14: Distribution of D. stramonium at Oldupai C. Source: field data, 2013.

Discussion

Our study observed that the distribution of *D. stramonium* has been favored by many factors. In this study, the large polygons were recorded in Lerai and Olbalbal areas which receive relatively high water flowing from highlands and these areas seem to be very fertile. Lerai area is located within the crater and the distribution *D. stramonium* follows the gully which starts from the slope to the base of the crater. The spread of *D. stramonium* in this area might be contributed by tourism activities in and around Sopa lodge which is located at the rim of the crater. Seeds are transported by run-off flowing from the rim to the base of the crater. In Olbalbal, large fields of *D. stramonium* were observed along river banks and in flat areas where the soil is deep and fertile due to accumulation of eroded soil from highlands of Olbalbal village. The spread of this invasive species might be influenced by human activities in Olbalbal village.

Low abundance of *D. stramonium* in Empakai camp site might be due to less tourism activities because the number of tourists visiting this area is not big. According to local informants, there is less movement of people and vehicles to this area which are amongst factors influencing the spread of this species. The information obtained from key informants revealed that the increase in rate of spread of this species have been contributed by many other factors. Transportation of crops such as maize from Karatu and other neighboring areas might have contributed to the spread of this invasive alien species in NCA. Our observations also concur with Foxcroft *et al.* (2006), who reported that the spread of invasive alien species is influenced by human activities. Movement of animals both livestock and wild into and outside NCA is another possible causes of spread of *D. stramonium* as they can carry seeds of this plant species from one area to another. Wallowing animals like buffaloes, elephants and others can carry matured seeds from one area to another. Several patches of *D. stramonium* were found growing along animal trails within NCA.

Road and viewpoints construction within and across the protected area have influenced the spread of this species. Patches of *D. stramonium* were seen growing around gravel and sand ores. On the rim of Empakai crater, both individual plants and patches of *D. stramonium* have been growing around viewpoints and along the road on the rim of the crater. Although patches of *D. stramonium* are still few in this area, it is anticipated that they might continue to reproduce and increase in number if efforts to remove them will not be taken by the management of NCAA.

Not only that but also several patches of this species were seen growing along the road from Karatu town to the main gate of NCAA. Similar observations were reported by Mattay and Lotter (2005) which showed that the spread of *D. stramonium* may have been influenced by construction materials that were brought in NCA from Karatu. This indicates that movement of vehicles that enters and leave NCA can influence the spread of *D. stramonium*. Existences of several tourist hotels and many campsites in NCA have large impact on spread of *D. stramonium* within conservation area. Patches of *D. stramonium* as well as other IAS were found growing around and along the road to these hotels and campsites. They are also growing around conservation quarters. This is due to the fact that there is movement of people around, from and to these areas for tourism purposes and other social activities within NCA. Movement of livestock and wild animals around these areas increase the rate of spread of *D. stramonium* by moving seeds from one place to another. Availability of people in these areas means that there is also movement of vehicles, crops, domestic animals that might favor transportation of *D. stramonium* seeds from within and outside of NCA.

Moreover, the field survey also revealed patches of *D. stramonium* grown in areas where there were Maasai residences (bomas) before. Individual plants and small sized patches of this species were also found growing around Maasai residences for example at Ndian, Olbalbal and Embaruai. Climate change is now a hot topic all over the world because of its long term effects to the environment. Study carried out by Runyoro *et al*. (2011) also found that the increase in the number of alien plants in NCA between 2002 and 2007 is associated with variability in rainfall patterns whereby precipitation in years 2003, 2004, 2005 and 2006 was below long-term average followed by relatively heavy rains in 2007. The rainfall fluctuation in NCA might be due to changes in climate. A study carried out by Higgins *et al*. (2007) also postulated out that there is relationship between climate change and fluctuation of precipitation.

Conclusion

This study revealed that the distribution of *D. stramonium* within NCA have been influenced by many factors including natural and human factors. Information regarding the extent of invasion of *D. stramonium* in all potential areas is necessary so as to identify critical threats of this species

on survival of other plant species in an ecosystem. Studies should also include the element of genetic diversity to find out the origin of this invasive alien species. The use of remote sensing technology will be helpful to identify and determine invasion rate and distribution of other invasive alien species growing in NCA.

Acknowledgments

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