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Effects of Fires on the Invasiveness of *Lantana camara* in Forest Plantations

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Abstract

This study investigated the contribution of fires to the invasive potential of *Lantana camara* in a forest plantation. The objectives of the study were to (i) Compare the abundance and species richness of plants beneath the canopy of *Lantana camara* in the burned compartment and un-burned compartments and (ii) Compare the diversity of plant species in the burned and un- burned compartments. In each compartment, three transects were laid two meters apart underneath thick shrubs of *Lantana camara*. Plant species richness and abundance were assessed in quadrats systematically laid along each transect at an interval of two meters in the respective compartments. The findings indicated that *Lantana camara* was more invasive in the burned compartment than unburned compartment. Plant species diversity was higher in the unburned compartment compared to the burned compartment. Therefore *Lantana camara* has a high invasive potential in the burned compartment than in the unburned compartment. Burning as a method of control for *Lantana camara* should be greatly reduced because it enhances the ability of *Lantana camara* to out compete plant species in forest plantations. There is a need to study the relationship between *Lantana camara*, *Oplismenus hirtellus* and *Ageratum conyzoides* to determine the integrated loss these species impact on other plant species.

Key words: Forest fires, Invasive species, *Lantana camara*, Species abundance

1. Introduction

The Global Invasive Plant species Database of the IUCN contains a list of the worst one hundred invasive plant species of which *Lantana camara* is *among* the first twenty. *Lantana camara* is an indigenous plant species native to tropical and sub-tropical America that was introduced in most of the countries as an ornamental plant (Ghisalberti, 2000; Pimentel *et al*., 2001). The invasion of *Lantana camara* has social and economic impacts that need to be understood mostly in Africa. It invades cultivated land and releases chemicals that make it difficult for the growth of other plants hence reducing crop production in Africa (Vardien and Richardson et al., 2012). The tremendous success of this species in east Africa is associated with the tropical climatic conditions (Mulindwa *et al*., 2009). Methods such as fires and physical control for instance cutting the stems down and use of chemicals are used to control this plant species from spreading. Fires could be a cheaper method for controlling the spread of *Lantana camara*. However, fires allow its quick regeneration of *Lantana camara* (Sampson, 2012). Such quick regeneration of Lantana camara, allows it to colonize wider landscapes thus affecting plant diversity in such areas. Regeneration of *Lantana camara* in different environmental settings has been studied with no follow up on how the mature stand of *Lantana camara* competes with other plant species in such environmental conditions (Tierney, 2006).Therefore there is a need to compare the extent of invasiveness of the mature *Lantana camara* in such critical areas in order to understand the invasive behavior of *Lantana camara*. Frequent fires in the forest plantations aggravate the regeneration of *Lantana camara* colonizing other plant species. Although fires are important for regeneration of *Lantana camara* (Raghubanshi, 2006), studies to compare the invasiveness of *Lantana camara* growing in post fire

areas in tropical forest plantations have not been done. This study was conducted to compare the species richness, abundance and diversity under the mature *Lantana camara* crop in post fire affected and un affected forest plantation areas.

2. Study area and methods

2.1 Study area

The study was conducted in Nyabyeya Forestry College Pine (*Pinus spp*) forest plantation. The plantation of the College is situated in Masindi district in western Uganda, 32 km from Masindi Town on the Masindi –Butiaba road, and 240 km from Kampala, off the Kampala- Gulu highway. The college is found on the fringes of Budongo tropical high forest as presented below.

The forest plantation is located between latitude $1^0\,40^1$ and $1^0\,42^1$ and longitude $31^0\,32^1$ and $31^0\,33^1$ with a network of roads which are used as fire breaks, compartment boundaries and extraction routes. The forest covers a total area of 358.59ha and is divided into six blocks with different compartments. Other areas of the forest estate constitute 67.01ha including natural belts (14ha). About 10.55ha were destroyed by fire.

2.2 Methods

2.2.1 Selection of the Study Site

Plantation field records were used to identify the compartments where *Lantana camara* grows. Fire records were used to select the post fire compartment with the most recent fire history. Using the records, the most recently burned compartment and a control (the compartment that has not experienced fires) were selected for the study.

2.2.2 Sampling design and data collection

Three parallel transects were laid, using 80m ropes, underneath a cluster of *Lantana camara* at a spacing of 2m respectively in the two compartments Within the compartments (i.e. the post fire

affected compartment and control – that has not experiences any fires) . Along each transect, 10 square plots of 1m x 1m were laid systematically at an interval of 2m down the length of each transect in the compartments respectively. The square quadrat method was used to collect data on plant species abundance and plant species richness for the plant communities in the respective compartments. Quadrats enable comparable samples to be obtained from areas of consistent size and shape and smaller quadrats are quicker to survey (Ecological sampling methods, 2004). They also enhance the ease of identifying the border of a given plot (Husch and Beer *et al.,* 2003). In each quadrat, plant species richness was obtained by counting each plant species observed in the plot. Plant species abundance was obtained by counting the number of individuals that represented each plant species in each plot in the respective compartments. Plant species that were not easily identified in the plots were collected, tagged with letter codes and stored in a press for identification at Makerere University herbarium.

2.3 Data Analysis

The plant species richness and plant species abundance obtained were used to determine the diversity of plants species growing underneath *Lantana camara* in two compartments. Shannon diversity index was used to measure the species diversity (Magurran, 1988) in the two compartments.

Shannon's diversity index was calculated using the formula;

$H' = - \Sigma\ pi \ln pi$

Where; ^{pi} is the proportion or relative abundance of each plant species and H' is Shannon's diversity index.

The Shannon diversity index was chosen because it takes into account both plant species abundance and plant species richness and is the most commonly used index (Nowak *et al.,* 2002).

3. Results and discussions

3.1 Plant species richness

Generally plant species richness was higher under *Lantana camara* canopy in the burned compartment compared to the control. The total number of plant species growing underneath *Lantana camara* in both compartments was 52 plant species with 25 and 27 of them occurring in the control and burned compartment respectively (Table 1). It is possible that the fire that occurred burned and created an open canopy in the clusters of *Lantana camara.* This probably resulted into the penetration of light on to the forest floor and enabled the seedlings and saplings of other plant species to make their own food. In the unburned compartment, low levels of light posed stress to plants. This is because irradiance limits photosynthesis, net carbon gain and plant growth (Lambers *et al.*, 2008), implying that perhaps the shady conditions in the unburned compartment led to insufficient light consequently reducing the plant species richness therein.

Table 3.1. Plant species richness in the burned and unburned compartments in Nyabyeya forest plantation

Unburned compartment	Burned compartment
Oplismenus hirtellus	*Ageratum conyzoides*
Acalypha bipartite	*Maricus cyperoides*
Ageratum conyzoides	*Oplismenus hirtellus*
Sida rhombifolia	*Acalypha bipartite*
Aristolochia elegans	*Digitaria spp*
Abutilon spp	*Cyphostemma adenocuala*
Commelina Africana	*Sida rhombifolia*
Asystasia gangitica	*Aerva lanata*
Acalypha brachystachya	*Aristolochia elegans*
Phyllanthus amarus	*Maesopsis eminii*
Cyphostemma adenocaule	*Plectranthus spp*
Desmodium repandum	*Stephania abyssinica*
Phyllanthus capillaries	*Albizia grandibracteata*
Achyranthus aspera	*Secamone Africana*
Triumfetta rhomboidea	*Urena lobata*
Brachiaria decubens	*Acalypha brachystachya*
Senna spectablis	*Phyllanthus amarus*
Cissus quadrangularis	*Cana indica*
Aneilema aequinoctiale	*Vernonia amygdalina*
Setaria kagerensis	*Conyza floribunda*
Maesopsis eminii	*Commelina Africana*
Momordica foetida	*Hilleria latifolia*
Secammone Africana	*Panicum maximum*
Albizia grandibracteata	*Manihot esculenta*
Impatiens spp	*Carica papaya*
	Aneilema aequinoctiale
	Mondia whitei
Total number of species= 25	Total number of species=27

3.2 Species abundance

The most abundant plant species in the unburned compartment was *Oplismenus hirtellus* (160 individuals) while other species such as *Momordica foetida; Seca*mm*one africana* and *Albizia grandibracteata* had the lowest abundances each with one individual. In the burned compartment, the most abundant plant species was *Ageratum conyzoides* with 150 individuals. *Carica Papaya, Aneile*m*a aequinoctial, Cana indica* and *Panicu*m m*axi*mu*m were among* the lowest abundant plant species in the burned compartment each with one individual (Figures 2 and 3).

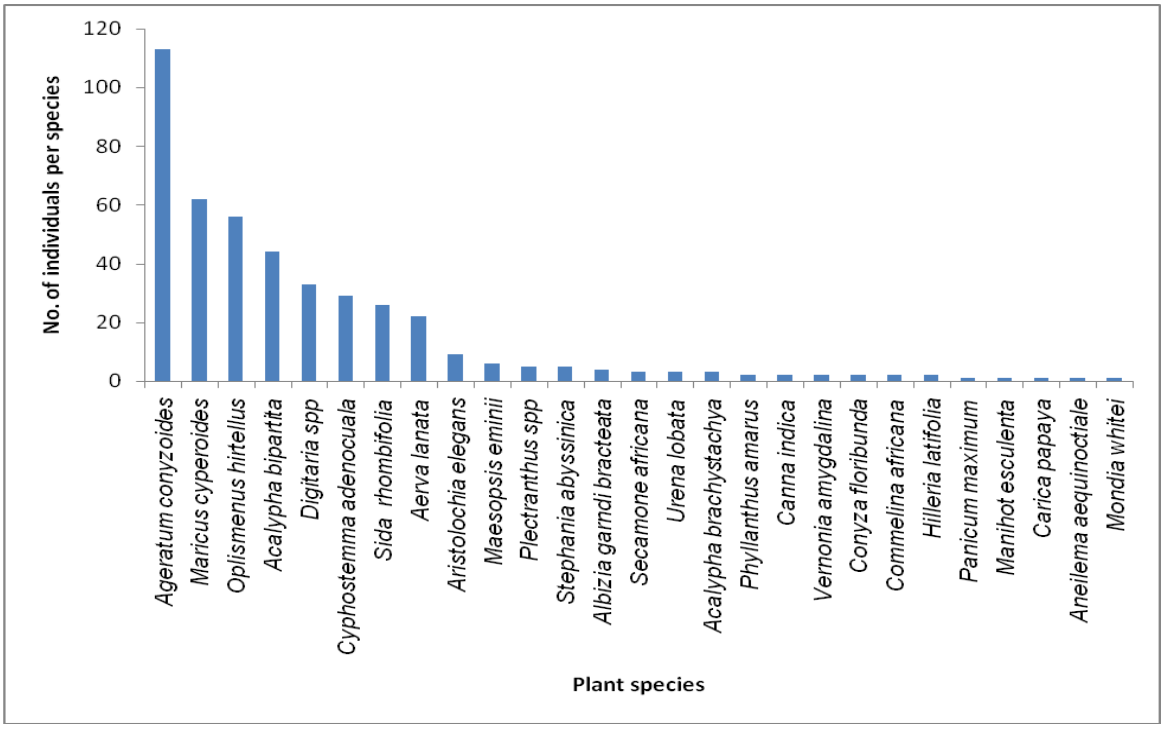

Figure 3.1. Rank abundance plot for plant species in the burned compartment

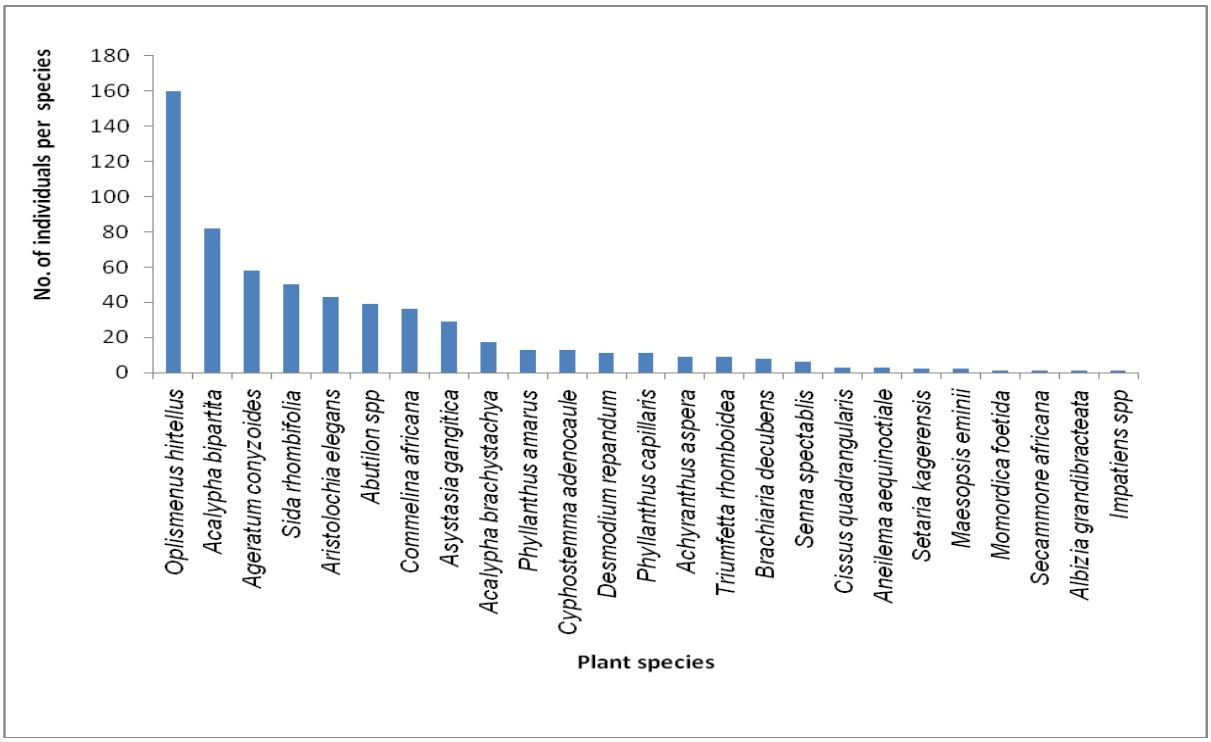

Figure 3.2. Number of individuals per plant species in the unburned compartment

These findings concur with Debano's (1990) studies on effects of fires on soil properties. The low abundance was perhaps due to the influence of fires on soil properties. Fire affects nutrient cycling, the physical, chemical, and biological properties of soils (DeBano, 1990).According to Verma and Jayakumar (2012), forest fires increase both soil PH levels and the amount of organic matter into the soil when the burned plant and half burned matter falls to the ground. Whereas this modification in soil PH greatly affects the dynamism of the growth of other plant species, it does not seem to cause significant alterations to the development of *Lantana camara. Lantana camara* performs well in several soils conditions (Gentle and Duggin, 1997). Therefore given the allelopathic nature of *Lantana camara* coupled with its ability to survive in different soil conditions and under fire, it possibly competed favorably with the already vulnerable plant species with ease (Cronc and Fuller, 1995). The high abundance of *Ageratum conyzoides* is mostly found in cultivated areas and plantations. It is an invasive plant species which produces allelopathic chemicals, has high regeneration capacity, aggressive stolon formation and fast growing (Bhatt *et al.,* 2012). These characteristics may have given it more edge over other plant species in the burned compartment. In the unburned compartment *Oplismenus hirtellus* was the most abundant plant species (160 individuals). Studies conducted by Global Invasive Plant species Database in 2010, revealed that *Oplismenus hirtellus* grows well in shady conditions. The species growth is influenced by cool temperatures and indirect sunlight. It is fairly adapted to a wide range of PH. This could be one of the reasons why it was abundant in the unburned compartment.

3.3 Diversity of plant species

There was high plant species diversity in the unburned compartment (H'= 12.23) than in the burned compartment (H'=10.56). Fires may have enhanced the regeneration of *Lantana camara* resulting in its thick clusters. Such thick clusters could have aggravated the allelopathic effects of *Lantana camara* because more allelopathic leaves of *Lantana camara* fell to the ground thus increasing the toxic effects in the soil. This probably led to more plant species being impeded from regenerating hence the little diversity recorded in the burned compartment.

4. Conclusion

In conclusion, although plant species abundance was generally higher in un burned forest plantation areas, species richness and diversity were higher in burned areas of the forest plantation compared to the controls. Hence fires have a positive effect on the regeneration of *Lantana camara* and enhance its invasiveness. Burning as a method of control for *Lantana camara* should be greatly reduced because it enhances the ability of *Lantana camara* to out compete other plant species in forest plantations. Studies on the relationship between *Lantana camara* and *Oplismenus hirtellus* and *Ageratum conyzoides* are needed to determine the integrated effects these species have on other plant species.

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