African Journal of Agricultural Research Vol. 8(4), pp. 386-397, 6 February, 2013
Available online at http://www.academicjournals.org/AJAR
DOI: 10.5897/AJAR12.1646
ISSN 1991-637X ©2013 Academic Journals

Full Length Research Paper

Distribution status and the impact of parthenium weed (*Parthenium hysterophorus* L.) at Gedeo Zone (Southern Ethiopia)

Talemos Seta*, Abreham Assefa, Fisseha Mesfin and Alemayehu Balcha

Department of Biology, Dilla University, Ethiopia.

Accepted 18 January, 2013

A study was conducted in Gedeo Zone, Southern Ethiopia to determine the impact and distribution status of Parthenium weed, *Parthenium hysterophorus* L. in the area. To collect data related with the impact of parthenium, 14 Peasant Association (PAs) were purposefully selected along the high way. A total of 140 quadrats (1 m^2 area each) from 14 PAs were selected by using stratified random sampling for herbaceous vegetation data associated with parthenium. The plant species found in each quadrat were counted, recorded and identified. The data collected from farmers' perception on the impact of parthenium weed were analyzed by using descriptive statistics. Shannon Diversity Index, evenness, species richness and Jaccards Similarity Index to determine parthenium impact on species diversity were calculated from the vegetation data. To see correlation of vegetation variables among and between sample PAs, R.2.14.0 Package was used. This study revealed that high infestation level of parthenium weed is confined to Dilla administrative town as supported by 73% of the respondents. A total of 45 plant species under 20 families were recorded from this study. The sampled PAs in Dilla town showed high infestation level with lower diversity index. Thus, it is an urgent task to draw the attention of relevant responsible bodies and public in general for managing and preventing further introduction and dissemination of the weed in this study area.

Key words: Diversity Index, Farmers' Perception, herbaceous vegetation, *Parthenium hysterophorus* L.

INTRODUCTION

Weed and undesirable woody plants encroachment have been threatening the agricultural system and pastoral production system in the Horn of Africa, particularly Ethiopia (Amaha, 2003; Gemedo et al., 2006). Moreover, population pressure, over-stocking, overgrazing and deforestation have facilitated the disturbance of the Ethiopian ecosystem and enhanced the effect of weed invasion by threatening biodiversity of the country (EARO, 2003). Herbaceous weedy species like *Xanthium* like *Prosopis juliflora* (Sw.) DC. (Fabaceae), *Acacia mellifera* (Vahl) Benth. (Fabaceae), *Acacia nubica* (Fabaceae), *Lantana camara L* (Verbenaceae) and succulents such as *Opuntia* spp. (Cactaceae) are nowadays increasing in different regions of the country. They are responsible for a significant reduction in production of the potential of the rangelands and arable lands (SERP, 1990). Among others, *Parthenium hysterophorus* L. (Asteraceae) is a Parthenium (both are Asteraceae), woody species aggressive invasive alien weed species (Kohli et al., 2006), native to the Americas but now widely spread in Asia, Africa and Australia (Evans, 1997).

Parthenium weed was first introduced accidentally into Ethiopia in the 1970s. It was first reported from Ethiopia in 1988 at Dire- Dawa and Harerge, Eastern Ethiopia (Seifu, 1990) and subsequently found near Desse, North-eastern Ethiopia as well. Both are major food-aid distribution centers and there is a strong assertion that parthenium weed seeds were imported from subtropical North America as a contaminant of grain food aid during

*Corresponding author. E-mail: talemos.seta@yahoo.com.

the 1980s famine and distributed with the grain (Tamado et al., 2002).

However, it has now emerged as one of the most aggressive weeds of both grazing land and cereal-based agriculture and crop lands (Tamado and Milberg, 2000). *P. hysterophorus* is considered as a noxious weed because of its prolific seed production and fast spreading ability (Haseler, 1976), allelopathic effect on other plants (Adkins, 1996), strong competitiveness with crops (Tamado et al., 2002) and health hazard to humans as well as animals (Chippendale and Panetta, 1994). Parthenium is so devastating that very little and sometimes no other plant species are seen in areas where it has gained dominance (Shabbir and Swhsana, 2005). In areas where the weed occurs, the productivity of forage is reduced by 90% and the weed make lands infertile and weakens the quality of grazing land, animal health, meat and milk products, agricultural production (Rezene et al., 2005). It also poses a serious threat to the environment and biodiversity owing to its high invasion and allelopathic effect which has the capacity to rapidly replace the native vegetation (Tamado and Milberg, 2000). Parthenium exerts strong allelopathic effect and reduces the growth and reproduction of associated crops. It does these by releasing phytotoxins from its decomposing biomass and root exudates in soil. Bioassay, pot culture and field studies have revealed that all plant parts (shoot, root, inflorescence and seed) are toxic to plants (Mulatu et al., 2009)

As mentioned earlier, *P. hysterophorus* was first observed in eastern part of Ethiopia, especially in Dire-Dawa and Hararghe, Eastern Ethiopia. Currently, the weed has been distributed to different regional states of ethiopia, eastern to southern including SNNPR (Southern Nations Nationalities and Peoples Region)

However, the local people have not yet noticed its effect on arable land, rangeland, animals and human health. The occurrence of *P. hysterophorus* is very frequent in urban, semi-urban and rural areas of Gedeo Zone, which is found in Southern Nations, Nationalities and peoples Region. However, no data of scientific studies have been documented regarding the diversity and abundance of plant species where there is *P. hysterophorus* infestation in both arable and non-arable lands. It is imperative to identify plant species that may have the ability to resist or overcome the challenges of the weed, which is increasingly reducing the quality and quantity of the composition and biomass of the herbaceous species. Thus, major objective of this present study was to determine the impact of *P. hysteroporus and* its distribution status in Gedeo Zone.

MATERIALS AND METHODS

Description of the study area

This study was conducted in Gedeo Zone which is found in the Southern Nations, Nationalities and Peoples Region (SNNPR). Gedeo Zone extends south as a narrow strip of land along the eastern escarpment of the Ethiopian Highlands into the Oromia Region, which borders the zone on the east, south and west. Gedeo zone shares its northern boundary with Sidama zone. Dilla is the zonal administrative town.

The altitude of the zone ranges from 1268 m above sea level in the vicinity of Lake Abaya to an elevation of 2993 m at Haro Wolabu Pond (Tadesse, 2002). Among various zones of SNNPR, the Gedeo zone was given the major emphasis during this study (Figure 1). The Gedeo zone exhibits bimodal rainfall distribution, from March to May (Belg) and from July to October (Keremet) with an interval of 4 to 5 dry months. The source of rain from March to May is the monsoon wind from the Indian Ocean and from July to October from equator western region from the Atlantic Ocean. The mean annual rainfall ranges from 800 to 1400 mm with mean annual temperature of 11 to 29°C. The major proportion of the zone constituted from Weyena Dega (71%), Dega (21%) and Kola (8%). According to FAO classification, the soil type is farrsole and Nithosole; having greater depth. The traditional soil classification shows that the *zone* comprises brown soil (90%), red soil (5%) and black soil (5%).

Perception of local people on the impact of parthenium weeds

Data related to peoples' perception about the impact of this invasive weed from urban, semi-urban and rural areas (both arable and non-arable lands) were collected from *Gedeo Zone*. From three districts and Dilla administrative town of this zone, a total of 14 PAs were selected for this study. The researchers purposefully selected these PAs on the basis of the aggressive invasiveness of parthenium weed towards arable land following roadway. A single visit for an informal survey was conducted before the beginning of the actual research work. The survey was undertaken to observe the presence of weed, the impact of the weed on human health (if any) and to mark out the possible dispersal agents, cause of aggressiveness and the suitable seasons for the distribution of this weed in both arable and non arable lands. A total of 100 local people (farmers) and development agents at the age of above 30, unequal number of farmers from each PA were identified and selected by using purposive sampling procedure. This selection was based on the awareness of local farmers about the aggressive colonization of *P. hysterophorus* on arable land and non-arable land (road sides) and its impact on plant biodiversity, livestock and on themselves. In order to get adequate information on the overall impact of parthenium in the study area, semi-structured interview questions were prepared. Furthermore, observations, interview, and focus group discussions was made with development agents and agricultural experts of each district.

Sampling of herbaceous vegetation cover

The field study was undertaken between January and September 2011 to collect the vegetation data depending up on the ecology of *P. hysterophorus*. Where massive growth of the weed occurs, road transect survey method was employed (Wittenberg et al., 2004) in 50 m distance to lay a quadrat. Since the study area is well known in its agroforestry system other than grazing land, one hundred and forty (140) quadrats (10 from each kebele) around roadsides, gardens and the farmlands of 14 sampled kebeles/PAs each measuring 1 m × 1 m (1 m^2) were laid in order to collect herbaceous vegetation data and assess impact of parthenium on aboveground herbaceous vegetation cover in this study area. GPS readings to record altitude, latitude and longitude for each sample site was recorded using GPS reader in order to locate the global position of each quadrat as well as the study site.

The majority of the plant species collected from the quadrats was identified in the field. For species difficult to identify in the field, voucher specimen were collected, pressed and dried properly using plant presses and transported to the Addis Ababa University, National Herbarium for identification and proper naming. The nomenclature of the plant species followed the Flora of Ethiopia and Eriterea (Hedberg and Edwards, 1995). In order to investigate the relative abundance and composition of the herbaceous vegetation as impacted by parthenium, the proportion of individual species (cover and abundance of the plant species) encountered in each of the quadrats was recorded using the procedure documented by Wittenberg et al. (2004). This method involves a total estimate based on abundance and cover of the species where invasion is spatially patchy. The total estimate scale (abundance plus coverage) can be shown as follows. A plant species covers a very small area (+), cover small (1), less or equal to 5% area coverage (2), 6 to 25% area coverage (3), 26 to 50% area coverage (4), 51 to 75% area coverage (5) and 76 to 100% area coverage (6). Following the methods suggested by Chellamuthu et al. (2005), the sample sites were categorized into different groups based on parthenium infestation levels: None, very low (< 10%), low (11 to 25%), moderate (26 to 50%) and high (> 50%) of the total percent area coverage of parthenium weed.

Data analysis

Diversity of the species for the vegetation data from the sample sites in the study areas were compared using Shannon Diversity Index. This index accounts both for the abundance and the evenness of the species in natural environment as shown by the equation below (Shannon and Wiener, 1949). It is also used to assess the impact of parthenium on the diversity of herbaceous plant species. The higher value of index of diversity indicates the variability in the type of species and heterogeneity in the community where as the lesser values point to the homogeneity in the community.

$$H' = -\sum_{i=0}^{S} Pi \ln Pi$$

Where H' = Shannon diversity index; Pi = the importance value of the ith species; S = total number of species in the sample quadrat
The evenness of species will be calculated as proposed by (Hill, 1973):

$$E = \frac{H'}{\ln S}$$

Where E= evenness

This index explains how equally abundant each species would be in the plant community and high evenness is a sign of ecosystem health. This is because it does not have a single species dominating the ecosystem. The evenness or equitability assumes a value 0 and 1 with 1 being complete evenness and 0 a single species dominating the area. The similarity of the standing vegetation (herbaceous vegetation layer) among the sample sites in this study area was compared using Jaccard's coefficient of similarity (JCS**)** as shown by the equation below. This coefficient of similarity has been recognized robust and unbiased compared with other similarity indices, even with small sample size (Ludwing and Reyonlds, 1988).

$$JCS = \frac{a}{a+b+c}$$

Where, JSC **=** Jaccard's coefficient of similarity; a = species common to quadrat 1 and 2; b = species present in quadrant 1 but absent in quadrat 2; c= species present in quadrat 2 but absent in 1

The coefficient has a value from 0 to 1, where 1 reveals complete similarity and 0 complete dissimilarity. The data collected from the respondents on the impact of parthenium were arranged and analyzed by using 'Microsoft office excels' for descriptive statistics (frequency and percentage). Moreover, to analyze vegetation data obtained from the field on the impact of parthenium weed, R.2.14.0.package was used. The correlation of vegetation variables such as species composition, species richness, average parthenium density/sample, and average number of flower head/plant among sample sites were done to check if there is any association among and between sample sites.

RESULTS

Farmers' perceptions about parthenium weed

Information collected from the respondents with regards to their perception on the parthenium weed was analyzed and also interpreted as follows (Table 1).

Data obtained from the responses given by local people (Table 1), show that 73% (73 in numbers) of the respondents from semi-urban and rural areas heard about parthenium weed and its presence in the area and they do have some information about the impact of parthenium on their surroundings and on themselves. Only 27% (27 in number) of the respondents did not hear and know about the presence of the weed in their surrounding and they did not have any information about the effect of the weed on animal, human health, and bio-diversity. As further evidence, the researchers observed the people cleaning the floor and front yard of their house with matured dried parthenium weed. From the total number of respondents who heard and knew about the weed before, 44% were from Dilla administrative town, which is a major town of Gedeo Zone, while residents are in and closer to the town and they observed dense parthenium growth in their surroundings. The highest numbers of respondents (46%, 46 in number) for this study were deliberately selected from Dilla town as the highest distribution of the weed has been observed.

From the table it can be seen that 88% (64 in numbers) of the respondents that heard and knew about parthenium weed before this study were able to identify it from other weeds by its morphology or physical form. As indicated in the Table 1, 85% respondents believed that the first appearance of parthenium was observed particularly in specific localities of Dilla town at the beginning of 2001 where donated food grain is stored (warehouse for grain storage) and temporary station for grain carrying trucks. According to the respondents (Table 1, item number 5), it is apparent that the weed seeds may have arrived with introduced grain and vehicles that carry them.

For the extent of parthenium weed distribution status in this study area (in item no.4), sixty eight percent of the respondents indicated that the weed have been highly distributed in Gedeo Zone specifically Dilla administrative town since the beginning of 2001 regardless of low

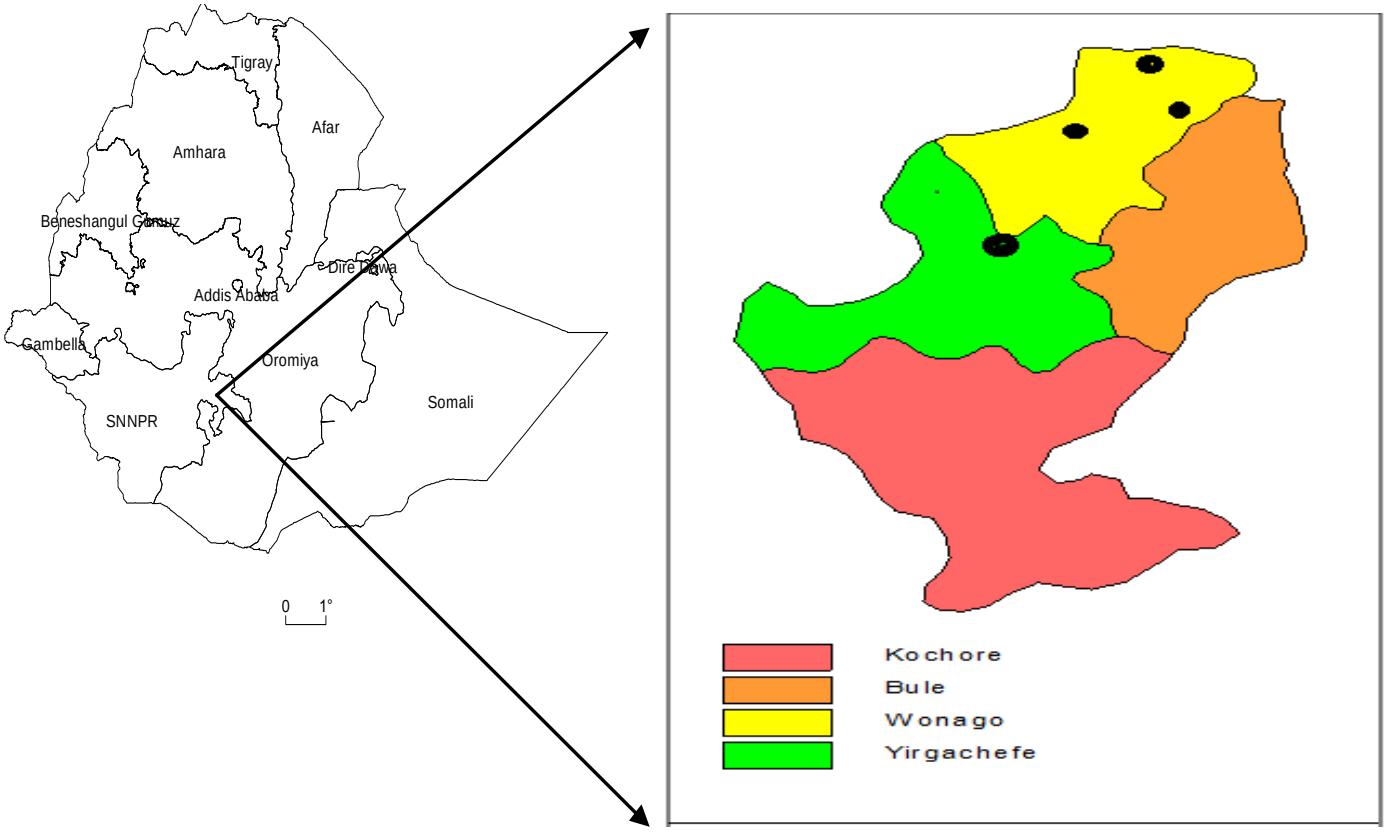

Figure 1. Map of the study area

distribution level of parthenium weed in *Yirga cheffe* and Wonago district.. As to the respondents in this study area, the agents for the wide spread dispersal of parthenium seed is mainly with the introduced grain donated for the food aid. This is supported by 72.6% of the respondents in this study area. The vehicle and farm implements as agents for the dispersal of the weed were supported by 17.8% of the respondents, flood (supported by 6.8%) and animal movement (supported by 2.7%).

However, 68.5% of the respondents explained that most parthenium invasion was observed along road sides of town (non-arable land) because of long distance dispersal of the seed by the vehicles and farm implements followed by crop field (16.4%) and wasteland (as supported by 15.0%). It was described by them that the road sides of Dilla administrative town are highly infested with parthenium weed unlike the other parts of Gedeo zone. Farmers perception on distribution and impact of parthenium weed From all the study sites, as mentioned by the respondents who knew parthenium weed (68.5%) ranked first because of its high spread and invasion on road sides and on the margin of farmland, *Lantana camara* ranked as first by 13.7% of the respondents, *Euphorbia pulcherrima* ranked as first by 8.2%, *Argemon mexicana* ranked as first by 5.5% of the respondents and *Cuscuta* spp. with 4.1% respondents ranked first well known distributed weeds in their surroundings with negative effects on native plants and human health. Based on the above first rank frequency researchers gave the general ranking from 1st to fifth (Table 2).

In contrast, those respondents who were unaware of parthenium weed before the study (27% of the respondents) ranked *Euphorbia pulcherima* as the first, *Cuscuta spp* as the second, *A. mexicana* third and *L. camara* as the fourth well known and highly distributed weed in their surroundings. Those respondents who did not know parthenium weed and ranked the other weeds as the above mentioned one were mainly from the Peasant associations/kebeles of Dilla Zuria Woreda, *Wonago, and* Yirga Cheffe district. Moreover, the farmers from Wonago and Yirga Cheffe emphasized mainly on *Cuscusta* sp which is a parasitic liana of coffee plant in their homegarden. According to them, this parasitic liana on coffee reduces the annual production of coffee cherries. Therefore, a research should be conducted on the ecology, biology and management system of this parasitic plant on the area to prevent the coffee plant from being attacked by it. The respondents (100% of the respondents who were unaware of the weed) also explained that the parthenium weed has an impact on the growth and development of different plant species that

Table 1. Farmers perception on the weed

Items	Alternatives	DT	DZ	W'go	Y/Cheffe	Total	%
1. Have you ever heard about parthenium weed	Yes	32	15	10	16	73	73
	No	14	5	2	6	27	27
	Total	46	20	12	22	100	
Interview questions following were forwarded to only those respondents who heard about the weed (73 Respondents)							
2. Can you identify parthenium among other weed	Yes	32	10	10	12	64	88
	No	0	5	0	4	9	12
	Total	32	15	10	16	73	
3. The first appearance of weed in the area	In 2001/02	32	13	7	10	62	85
	In 2005	0	2	3	6	11	15
	After 2005	0	0	0	0	0	-
	Total	32	15	10	16	73	
4. The extent of parthenium distribution status in your area	High	32	10	0	8	50	68.5
	medium	0	5	5	2	12	16.5
	Low	0	0	5	6	11	15.0
	Total	32	15	10	16	73	
5. Which dispersal agents would you expect for high spread of parthenium?	Fodder	0	0	0	0	0	0
	Human activity	0	0	0	0	0	0
	Animal movement	0	0	2	0	2	2.7
	Introduced grain	25	10	8	10	53	72.6
	Wind	0	0	0	0	0	0
	Vehicle and farm implements	5	5	0	3	13	17.8
	Flood	2	0	0	3	5	6.8
	Total	32	15	10	16	73	
6. In which land use type is parthenium infestation highest	Roadside	24	9	7	10	50	68.5
	Crop field	4	3	2	3	12	16.4
	Wasteland	4	3	1	3	11	15.0
	Rangeland	0	0	0	0	0	0
	Others	0	0	0	0	0	0
Total		32	15	10	16	73	100

DT, Dilla Town; DZ, Dilla Zuria district; W'go, Wonago district; Y/Cheffe, Yirga Cheffe district.

Table 2. Weed mentioned by farmers as first rank (N=73).

Weed type mentioned	Respondents	%	Preference rank
Argemone mexicana	4	5.5	4
Cuscuta spp.	3	4.1	5
Euphorbia pulcherrima	6	8.2	3
Lantana camara	10	13.7	2
Parthenium hysterophorus	50	68.5	1

have either medicinal value or no negative effect on other crops or plants. As to their explanation, those parthenium impacted plant species are *Cyanodon dactylon, Amaranthus*spp.,*Solanumincanum, Nicandraphysaloides, Oxalis corniculata and Solanum dasyphyllum* which are palatable and have various medicinal values. This was so because those plant species mentioned above have been decreasing from time to time in the highly infested area. According to the farmers and agricultural experts' observation, the plant species in their surrounding that outcompete parthenium weed for long period of time are mainly *Achyranthes aspera, Argemone mexicana Cynodon dactylon, Lantana camera, and Xanthium stumarium.*

Table 3. Sample sites of study area with infestation level and Land-use type.

Number	Kebele (PA)	Woreda	Number of sample	Infestation level *	Land use type
1	Aroresa	D.A. town	10	High	Cultivated land, garden, roadside
2	Ase Dela	D.A.town	10	High	Garden, road side
3	Buno	D.A.town	10	High	Roadside, wasteland, waterway
4	Haroke	D.A.town	10	High	Roadside, wasteland
5	Bareda	D.A.town	10	High	Roadside, wasteland, water way
6	Odaya	D.A.town	10	High	Garden, roadside, wasteland
7	Boyiti	D.A.town	10	High	Waterway, garden
8	Chicho	D.Zuria	10	Moderate	Road side, waterway
9	Andida	D.Zuria	10	Moderate	Roadside, waterway
10	Deko	Wonago	10	Low	Roadside, cultivated land
11	Tumata Chirecha	Wonago	10	Low	Roadside, closer to cropland
12	Bule Bukisa	Wonago	10	Low	Roadside, closer to cropland, wasteland
13	Konga	Cheffe	10	Low	Roadside
14	Cheffe town	Cheffe	10	Low	Roadside
Total	14		140		

D.A. town, Dilla Administrative town; D. Zuria, Dilla Zura woreda; *,Groups based on parthenium infestation levels: None, very low (< 10%); low (11-25%); moderate (26-50%) and high (> 50%) of the total percent area coverage of parthenium weed.

According to the respondents (100% who are aware of the weed), they did not recognize the impact of parthenium weed on the area but had heard about its impact on milk quality, cropland, human health and biodiversity. They described that if a cow feeds on grass mixed with parthenium weed the quality of milk would be reduced by saying that the “milk becomes bitter”. They also heard that allergy on the skin of man can be caused by Parthenium weed contact. As long as the management is concerned, hundred percent of the respondents who knew the weed before this study only mentioned hand hoeing/hand pulling/uprooting and burning of parthenium weed in its early period before it sets flowers.

Vegetation data associated with parthenium weed

The vegetation data associated with parthenium weed with different invasion levels and the respective land-use type in 14 different sample sites/Kebeles are presented below in Table 3.

As can be seen from the table, 70/140 (50%) of the samples are taken from Dilla town due to the fact that there is high level of parthenium infestation in the area as compared to other sample sites. The basis for this classification was based on the parthenium weed cover in all sample sites of the kebeles in the town. The states of infestation are high in *Aroresa, Ase Dela, Buno, Haroke, Odaya, Bareda* and *Boyti* which are small kebeles in Dilla Administrative town. Except *Aroresa, Ase Dela and Odaya* where the parthenium weed are observed in both arable land and roadsides, the other parthenium infestation are only observed in non-arable land containing road side and wasteland.

Plant diversity, species composition and evenness

The herbaceous vegetation data associated with parthenium had shown 45 plant species recorded and classified under 20 families. Of 20 plant families, *Poaceae* accounts the largest (17.8%), Asteraceae accounts 15.6%, Amaranthaceae, Solanaceae and Euphorbiaceae accounts 8.9% each holding the third place among the plant species recorded in this study area.

The biodiversity impact of parthenium weed on highly infested areas was more visible than the moderate and low infested areas. The sampled sites in Dilla town starting from Aroresa to Boyti have lower diversity index (H) (highly infested area) as compared to other sites where the calculated Shannon Diversity Index is high (where invasion was low) (Table 4). Aroresa and Buno showed the lowest Shannon Diversity Index value of 1.6 and 1.37 respectively due to the fact that their species diversity was highly affected by the high infestation of parthenium. Comparatively, the Tumata Chirecha, Bule Bukisa, Andida Konga and Cheffe have a diversity Index of greater than 3.0 showing low parthenium infestation in the area and the impact of it on species diversity is low. Similarly, the evenness index was found to be higher in uninfested areas which indicated that the species are evenly distributed. This is true in this present study sites such as Chicho, Andida, Tumata Chirecha, Bule Bukissa, Konga and Cheffe where the evenness index were above

Table 4. Shannon Diversity index (H), Species richness (S) and evenness (E).

Study sites	H	S	E
Aroresa	1.6	32	0.46
Odaya	2.08	39	0.57
Ase Dela	1.66	40	0.45
Buno	1.37	33	0.39
Haroke	1.73	38	0.48
Bareda	1.76	37	0.49
Boyti	1.72	32	0.50
Tumata Chirecha	3.04	32	0.88
Bule Bukisa	3.13	34	0.89
Deko	2.98	29	0.88
Chicho	2.74	30	0.81
Andida	3.2	34	0.91
Konga	3.3	36	0.92
Cheffe town	3.41	39	0.93

0.80 which shows the sampled area were uninfested by the weed. In contrast, the fact that it was lesser in the weed-infested area indicated patchiness in distribution where a few species dominate the area.

This current study showed that the number of desirable species declined in the high parthenium infested sites of the study areas. Such a reduction could be attributed to the increasing abundance of the weed in the sites.

The result of this study goes in line with the study of Sakai et al. (2001) and Kohli et al. (2004) where invasive plants are known to exert significant impact on the natural communities as they cause their displacement and hence exert imbalance in the natural and agricultural ecosystem.

This imbalance causes the formation of large monoculture of invasive plants in the alien environment. The weed affects not only the species diversity of the native areas, but also their ecological integrity. Moreover, environmental degradation and disturbance favours the invader species such as parthenium weed. Under such circumstances the weeds easily establish themselves in the sites and start interfering with other native species by suppressing their potential growth and biomass production. Parthenium was known to suppress the associated species through the release of allelochemicals from decomposing biomass and root exudates into the soil environment (Pandey et al., 1993).

There is a high negative correlation between mean parthenium density and Shannon diversity index with $R^2 = 0.89$, $p<0.001$. The equation for the regression line is $y = 398.6 - 126x$ indicated in the Figure 2. High negative correlation means that as the mean parthenium density increases, the Shannon Diversity Index decreases. This in turn shows the parthenium effect on the biodiversity of plants.

Jaccards similarity coefficients (JSC) of herbaceous vegetation

The standing herbaceous vegetation associated with parthenium among 14 sampled PAs were recorded and Jaccards Similarity coefficients were calculated (Table 5). The values in Table 5 are calculated by using Jaccards Coefficient of Similarity. This coefficient of similarity has values from 0 to 1, where 1 reveals complete similarity and 0 complete dissimilarity. Thus, the standing herbaceous vegetation from the sample sites of the Dilla town where there is high parthenium infestation level showed higher Jaccards Similarity coefficient (greater or equal to 0.683). This may be due to the complete dominance of parthenium weed over other palatable herbaceous plant species in both arable and non-arable lands of the study area. The high similarity value between parthenium invaded areas of Dilla town indicated that there is no radical change on species composition within the area. In contrast, other kebeles from Dilla zuria, Wonago, and Yirga Cheffe woreda showed relatively lower similarity coefficient than Kebeles from Dilla town revealing low impact of the weed in the area.

Comparison and correlation of mean parthenium density

For 14 PAs, the mean parthenium density and species richness were compared (Table 6). Aroresa Site in Dilla town has the first highest mean parthenium density (Table 6) which accounts $267/m^2$ but with relatively low species richness. Buno accounts the second highest mean parthenium density which is 235.5 with the species richness value of 33 and Ase Dela accounts the third highest with its mean parthenium density comprising species richness of the same value as of Buno. In general, the table shows the trend of decrease of species richness as the mean parthenium density is increasing in sites/kebeles. This is particularly true in Dilla town where the distribution of parthenium weed is highest as compared to other study sites. In contrast, species richness increases as mean parthenium density decreases as in the case of sample sites such as Chicho, Andida, Tumata Chirecha, Bule Bukisa, Deko, Konga and Chefe town. This definitely shows the impact of parthenium weed on species diversity and hence in species richness of the study area.

Mean of parthenium height, branches and flower head (capitula)

The mean of parthenium height, number of branches and number of flower heads counted in three different times (at the beginning of February, April, and June) in 14 sample sites are shown in the (Table 7).

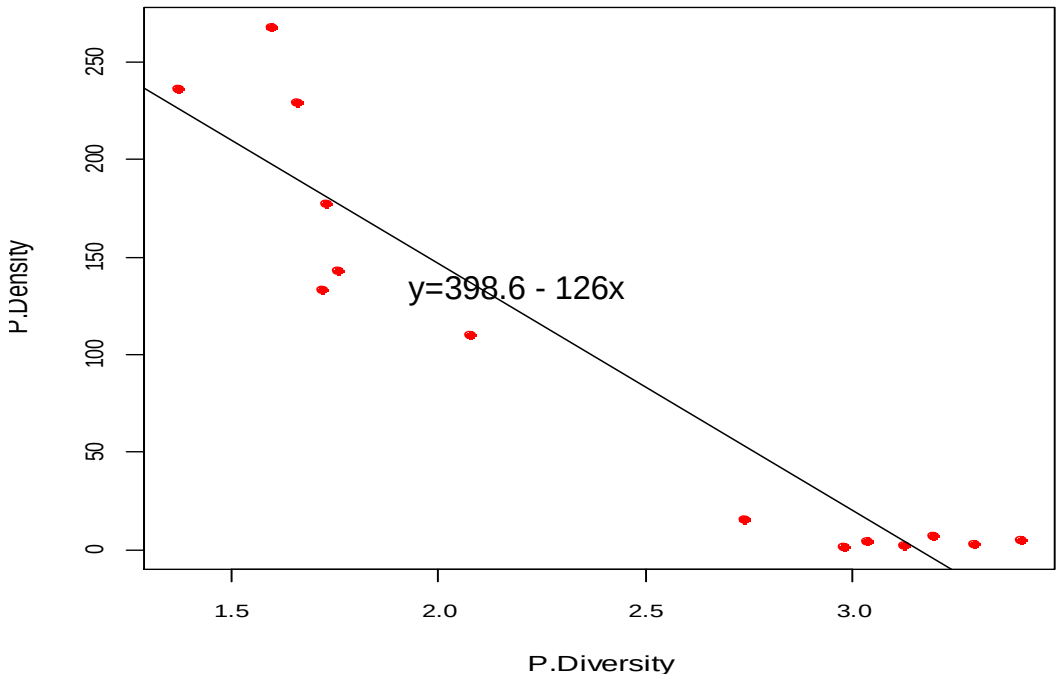

Figure 2. Correlation between parthenium density and Shannon Diversity index.

Table 5. The JSC of the standing herbaceous vegetation among 14 kebeles.

	Aroresa	Odaya	Ase Dela	Buno	Haroke	Bareda	Boyti	Tumata Chirecha	Bule Bukisa	Deko	Chicho	Andida	Konga	Yirga Cheffe
Aroresa														
Odaya	0.77													
Ase Dela	0.85	0.86												
Buno	0.73	0.76	0.76											
Haroke	0.88	0.83	0.93	0.73										
Bareda	0.85	0.81	0.90	0.71	0.88									
Boyti	0.68	0.73	0.73	0.97	0.71	0.68								
Tumata Chirecha	0.62	0.55	0.58	0.55	0.60	0.65	0.48							
Bule Bukisa	0.64	0.61	0.65	0.63	0.67	0.73	0.55	0.91						
Deko	0.57	0.55	0.58	0.51	0.60	0.61	0.45	0.81	0.85					
Chicho	0.52	0.60	0.57	0.58	0.55	0.60	0.52	0.60	0.68	0.74				
Andida	0.61	0.66	0.66	0.56	0.64	0.69	0.50	0.62	0.69	0.70	0.88			
Konga	0.66	0.71	0.71	0.61	0.68	0.70	0.48	0.57	0.64	0.67	0.74	0.84		
Yirga Cheffe	0.75	0.80	0.80	0.66	0.77	0.56	0.55	0.64	0.71	0.75	0.75	0.85	0.90	

From the table, the highest mean height (1.6 m) of parthenium was recorded in Aroresa kebele. The specific localities where this height recorded were along the way to Dilla University, main Campus, Dilla. The average number of branches counted in the same localities was 16 followed by Odaya where number of branches per plant was 11 with an average height of 1.2 m. Generally, the findings of this research shows a decreasing trend of mean height, number of branches, and flower head/plant from Aroresa to Cheffe town (that is, from sample sites along the way from Dilla town, Dilla Zuria wereda, wonago to Yirga Cheffe wereda).

Table 6. Comparison of mean parthenium density and species richness.

Sample sites	Mean parthenium density	Species Richness (R)
Aroresa	267	32
Odaya	110.2	39
Ase Dela	229	40
Buno	235.5	33
Haroke	177.2	38
Bareda	143	37
Boyti	132.8	32
Chicho	15.6	30
Andida	7.1	34
Tumata Chirecha	4	32
Bule Bukisa	2	34
Deko	1	29
Konga	3	36
Cheffe town	5	39

Table 7. Comparison of mean height, stem branches and number of flower heads.

Sites/Kebele	Mean height (cm)	Number basal branches/plant	Flower heads/plant
Aroresa	160	16	4751.0
Odya	130	11	4171.0
Ase Della	110	8	3663.3
Buno	100	9	3476.7
Haroke	80	12	2132.3
Bareda	82	10	1681.0
Boyti	78	7	1598.0
Chicho	50	5	114.0
Andida	30	6	112.0
Tumata Chirecha	35	5	56.0
Bule Bukisa	40	6	52.3
Deko	35	5	49.7
Konga	25	6	51.7
Cheffe	30	6	46.7

The mean number of flower head/plant in sample sites

The mean number of flower head counted per plant showed a considerable increase from February, April to June particularly in highly infested sites of Dilla town. The increased number of flower head/plant counted in June may be because of small rain that the area has got during the time of data collection. From this study, it is found that the average number of flower heads/capitulla counted in June was greater than that of the remaining two rounds for all the sites in the Dilla town where the level of infestation was higher. In comparison, Aroresa kebele has the highest average number of flower head/capitula counted (4751) in three rounds followed by Odaya (4171). The average numbers of flower heads counted for the sample sites other than Dilla Town are very low as its level of infestation was also moderate and low.

The competitive ability of plant species

Even though the experiment on the competitive ability of plants was not done in this present study, it is feasible to list down plant species that frequently occurred in the sampled sites of infested areas tolerating the ill effects of the weed. Thus, the plant species that can tolerate the effect of parthenium weed have the highest relative frequency indicating its frequent occurrence in both highly infested and low infested areas (Table 8).

It is obvious that the occurrence of parthenium weed was in all 140 sampled sites (100% relative frequency) even though their abundance varies. Accordingly, *Cyanodon dactylon* was the second frequently occurred

Table 8. The relative frequency of ten plant species in the sample sites**.**

Plant species	Frequency	Relative frequency
Achranthus aspera L.	130	93
Ageratum conyzoides L.	132	94.3
Amaranthus caudatus	120	85.7
Cyanodon dactylon	135	96.4
Datura stramonium L.	56	40
Eragrostis spp	115	82.14
Euphorbia hirta	50	35.7
Lantana camara L.	78	55.7
Parthenium hysterophorus	140	100
Xanthium strumarium	100	71.4

plant species with the relative frequency of 96.45 in this study area and thirdly *Ageratum conyzoides* which occurred in 132 sampled sites out of 140 (94.3%). This is so because *P. hysterophorus***,** *Ageratum conyzoides* and also *Lantana camara,* are tropical in origin and they possess similar growth strategies. They grow fast, have short life cycle and except *Lantana camara,* they have greater reproductive potential, competitive ability, and allelopathy that make them successful invaders of non native habitat (Grice, 2006). Due to its high growth rate, *Parthenium* becomes competitive and develops the ability to exclude the growth of other species.

DISCUSSION

Studies by Taye (2007), show heavy and widespread infestation mostly on roadsides, wastelands, towns, villages and gardens in the central farmlands of east Shewa: Dukem, Bishoftu, Modjo, and Koka areas. One can also see parthenium infestation on field borders and in some fields; parthenium grew in crop field during fallow period. In Ziway, Awassa and Wolkite, the weed has been observed only in the town along the road and near dwelling sites indicating its recent introduction into the area. This report is in agreement with the present finding which shows us that roadside of Dilla town and surrounddings are highly infested with the weed. Moreover, this was also observed by the researchers during the period of data collection and some authors (Haseler, 1976) who reported the initial occurrence of *P. hysterophorus* in a new area usually occurs along roadsides and it is from this foothold that it spreads extensively into agricultural land.

Tamado and Milberg (2000) during his research in Eastern Ethiopia found that 90% of the interviewed farmers rank parthenium as the first and most serious problem both in the rangeland and croplands. Similarly, parthenium has a great impact on palatable plant species in this study area as mentioned previously in the result from the respondents of this present study. Moreover, this is evidenced by Oudhia (2000) who reported as because of its efficient biological activity and adaptability to varying soils and microenvironments, *Parthenium* weed has a tendency to replace the dominant flora in wide range of habitats cutting across state boundaries and agro-climatic regions. Very little or sometimes no other vegetation can be seen in *P. hysterophorus* dominated areas. Wherever it invades, it forms a territory of its own by replacing the indigenous natural flora including medicinal herbs utilized by man as a source of medicine. Its allelopathic properties, which cause inhibition of germination and suppression of the natural vegetation including many medicinal herbs, pose a strong threat to biodiversity.

The study conducted by Shabbir and Bajwa (2007) showed that impact of *P. hysterophorus* on livestock production is significant, both directly and indirectly, and affects grazing lands, animal health, and milk and meat quality, and the marketing of pasture seed and grain. The initial symptoms of allergy caused through Parthenium contact are described as itching, redness, swelling and blisters on eyelids, face and neck, which then spread to the elbows and knees. In the later stages, the skin thickens and darkens. The allergic reactions include hay fever, asthma or dermatitis and can be caused by the dust, debris or volatile fumes from the plant as well as its pollen (Kohli et al., 2004). However, from this present study, the interviewed people explained that they did not recognize the impact in the study area but heard about the impact of the weed on milk quality, cropland, human health and biodiversity.

The study done by Mohammed (2010) showed that some of the preventive methods that restrict the entrance of weed seed into a non-infested area are uprooting of the weed before flowering and seed setting. They indicated it as the most effective and less costly strategy to manage parthenium (and it is to be practiced only in small areas like in gardens, flower beds, intensively cultivated fields or high value crops). This present study reveals that there was a sharp decline of diversity index as the density of parthenium increased. This finding is similar with Kohli et al. (2004) findings where the Shannon index showed great plant diversity in uninfested area whereas the index was reduced by 36 to 51% in the weed infested areas. Therefore, the higher value of the diversity index indicates the variation in the type of species and the heterogeneity in the community, whereas the lesser value points the homogeneity in the community. In areas of high parthenium weed infestation there was also a high mean parthenium density per m^2 as depicted in Figure 2. This is probably due to high viability of the parthenium weed seed banks in soil. Thus parthenium weed density per m^2 is often increasing in every generation, unless intervention is taken to control its spread (Tamado, 2001).

The number of flower head/capitula for this present study is much higher than the number studied by Labrada (1988) where a single plant producing an average of 810

flower heads. This might be because of the fact that the season for data collection was more suitable for parthenium growth and development. In the Caribbean area parthenium flowers 30 to 45 days after germination and the whole plant cycle is completed within about 5 months. A photoperiod of 13 h and warm conditions are conducive to flowering (Tamado et al., 2002). Moreover, the above data showed certain similarity with the study done in North-Western Indian Himalia by Dogra et al. (2011). They described that the inflorescence bearing flowers started appearing in late April or early May. The flowering stage in some plants lasted till June and then seed setting started. In the rainy season (July, August and September), some new seedlings emerged and they also flowered in August. In September, the seed setting was observed in most of the plants. The seeds fully ripened in the month of October and November or it completed its life cycle by that time.

The plant species that were identified from this present study which have parthenium competitive ability include *Cyanodon dactylon, Ageratum conyzoides, Xanthium strumarium, Lantana camara and others mentioned in the result section.* They grow fast, have short life cycle and except *Lantana camara,* they have greater reproductive potential, competitive ability, and allelopathy that make them successful invaders of non native habitat (Grice, 2006). Due to its high growth rate, parthenium becomes competitive and develops the ability to exclude the growth of other species. The inhibitory allelopathic effect of parthenium on the germination and seedling development of *Ageratum conyzoides* (Singh et al., 2002), *Eragrostis tef* (Tadele, 2002), *Brassica* spp.*, Cicer arietinum* and *Raphanus sativus* (Batish et al., 2005) were studied.

ACKNOWLEDGEMENTS

We thank Dilla University Research and Dissemination Office for financial support and Agricultural and Development Offices of *Gedeo Zone,* Dilla Zuria Woreda, Wonago Woreda, Yirga Cheffe Woreda and Urban Agriculture offices of Dilla Administrative town for providing invaluable information.

REFERENCES

Adkins SW (1996). The allelopathic potential of parthenium weed (*Parthenium hysterophorus* L.). Australia Plant Prot. Q. 11:20-23.

Amaha K (2003). Pastoralism and the need for the future intervention in pastoral areas of Ethiopia. Annual Review on National Dry land Agriculture Research System, Addis Ababa, Ethiopia.

Batish DR, Sing HP, Pandher JK, Kohli RK (2005). Phytotoxic effect of *Parthenium hysterophorus* L. residues on three *Brassica* species. Weed Biol. Manage. 5: 105-109.

Chellamuthu A, Nadanassababady P, Rammohan J (2005). Present status of *Parthenium hysterophorus* L. in the coastal regions of Pondicherry and Karaikal. In: Proceeding of the Second International Conference on Parthenium Management 5-7 December2005. University of Agricultural Science Bangalore, India, pp. 44-47.

Chippendale JF, Panetta J (1994). The costs of parthenium weed in Queensland cattle industry. Plant Prot. Q. 9:73-76.

Dogra KS, Sood SK, Sharma R (2011). Distribution, Biology and Ecology of *Parthenium hysterophorus* L. (Congress Grass) an invasive species in the North-Western Indian Himalaya (Himachal Pradesh). Afr. J. Plant Sci. 5(11):682-687.

EARO (2003). Ethiopian Agricultural Research Organization. National dry land research strategic planning pastoral and agro pastoral research program. Addis Abeba, Ethiopia. p. 60.

Evans HC (1997). *Parthenium hysterophorus*: A review of its weed status and the possibilities for biological control. Biocon. N. Info. 18:89-98.

Gemedo D, Maass BL, Isselstein J (2006). Rangeland condition and trend in the semiarid Borena low lands, Southern Oromia Ethiopia. Afr. J. Range. Forage Sci. 23:49-58.

Grice AC (2006). The impacts of invasive plant species on the biodiversity of Australian rangelands. Rangeland J. *28:1*-27.

Haseler WH (1976). *Parthenium hysterophorus* L. in Australia. PANS 22:515-517.

Hedberg I, Edwards S (1995). Flora of Ethiopia and Eritrea. Vol. 7. The National Herbarium, Addis Ababa, Ethiopia. 660 pp.

Hill MO (1973). Diversity and its evenness, a unifying notation and its consequences. J. Ecol. 54:427–432.

Kohli RK, Batish DR, Singh HP, Dogra K (2006).Status, invasiveness and environmental threats of three tropical American invasive Weeds (Parthenium hysterophorus L., *Ageratum conyzoides* L., *Lantana camara* L.). Biological Invasions 8:1501-1510.

Kohli RK, Dogra K, Daizy J, Singh, RB (2004). Impact of invasive plants on the structure and composition of natural vegetation of Northwestern India, Himalayas. Weed Technol. 18:1296-1300.

Labrada R (1988). Complemento al estudio biológico de Parthenium hysterophorus L. Resumenes IX Congreso ALAM, julio 26-30, Maracaibo, Venezuela.

Ludwing JA, Reyonlds JF (1988). Statistical Ecology. Wiley inter Science, New York. p. 111.

Mohammed W (2010). Prevalence and distribution survey of an invasive alien weed (*Parthenium hysterophorus* L.) in Sheka zone, Southwestern Ethiopia. Afr. J. Agric. Res. 5(9): 922-927.

Mulatu W, Gezahegn B, Solomon T (2009). Allelopathic effects of an invasive alien weed *Parthenium hysterophorus* L. compost on lettuce germination and growth. Afr. J. Agric. Res. 4(11):1325-1330.

Oudhia P (2000). Medicinal Herbs and Insects of Chhattisgarh India. Insect Environ. 6:138.

Pandey DK, Kauraw LP, Bhan, WM (1993). Inhibitory effect of *Parthenium* (*Parthenium hysterophorus*) residue on growth of water hyacanth (*Eizhhornia crassipes* Mart Solms.II): Effect of leaf residue. J. Chem. Ecol. 19:2651-2662.

Rezene F, Meckasha C, Mengistu H (2005). Spread and Ecological consequences of *Parthenium hysterophorus,* in Ethiopia. Arem 6:11-23.

Sakai AK, Allendorf FW, Holt JS, Lodge DM, Molofsky J, Baughman KA, Cabin S, Cohen, RJ, Allstrand JE, McCauley NC, O'Neil DE, Parker IM, Thompson JN, Waller SG (2001). "The population biology of invasive species" Ann. Rev. Ecol. Syst. 32:305-332.

Seifu W (1990). *Parthenium hysterophorus* L. A recently introduced weed to Ethiopia.Preliminary reconnaissance survey report on Eastern Ethiopia, East Harargae, Ministry of Agriculture, Ethiopia.

SERP. (1990). South Eastern Rangelands Development Project. Assessment of drought impact in Eastern Ethiopia, Jijiga. SERP Technical Report (Draft). p. 112.

Shabbir A, Bajwa R (2007). Parthenium Invasion in Pakistan – A Threat Still unrecognized. Pak. J. Bot. 39(7):2519-2526**.**

Shabbir A, Swhsana RB (2005). *Parthenium hysterophorus* spread and status on its management in Pakistan. pp. 28-35. In: Proceeding of the Second International Conference on Parthenium Management. 5-7 December. 2005. University of Agricultural Science, Bangalore, India.

Shannon CE, Wiener W (1949).The Mathematical Theory of Communication. University of Illinois Press, Urbana, Illinois.

Singh HP, Batish DR, Kohli RK, Saxena DB, Arora V (2002). Effect of pathenin - A sesquiterpene lactone from *Parthenium hysterophorus* L. – on early growth and physiology of *Ageratum conyzoides*. J.

Chem. Ecol. 28(11):2169-2179.
Tadele T (2002). Allelopathic effects of *Parthenium hysterophorus.* L. extracts on seed germination and seedling growth of *Eragrostis tef.* J. Agron. Crop Sci. 188:306-310.
Tadesse K (2002). Five thousand years sustainability. A case study in Gedeo Land Use (Southern Ethiopia). Treemail publishers, Heelsum, The Netherlands. p. 296.
Tamado T, Milberg P (2000). Weed flora in arable fields of Eastern Ethiopia with emphasis on the occurrence of *Parthenium hysterophorus L.* J. Weed Res. 40:507-521.
Tamado T, Schutz W, Milberg P (2002). Germination ecology of the weed *Parthenium hysterophorus* L. in eastern Ethopia. Ann. Appl. Biol. 140:263-270.
Taye T (2007). The prospects of biological control of weeds in Ethiopia. Ethiopian J. Weed Manage. 1(1):63-78.
Wittenberg R, Simons SA, Mauremootoo JR (2004). Instrument and tools for assessing the impact of invasive alien species in Africa. Report Procedures under the PDF-B phase of UNEP GEF Project-Removing Barriers to invasive plant Management in Africa. CAB. International. Nairobi, Kenya.