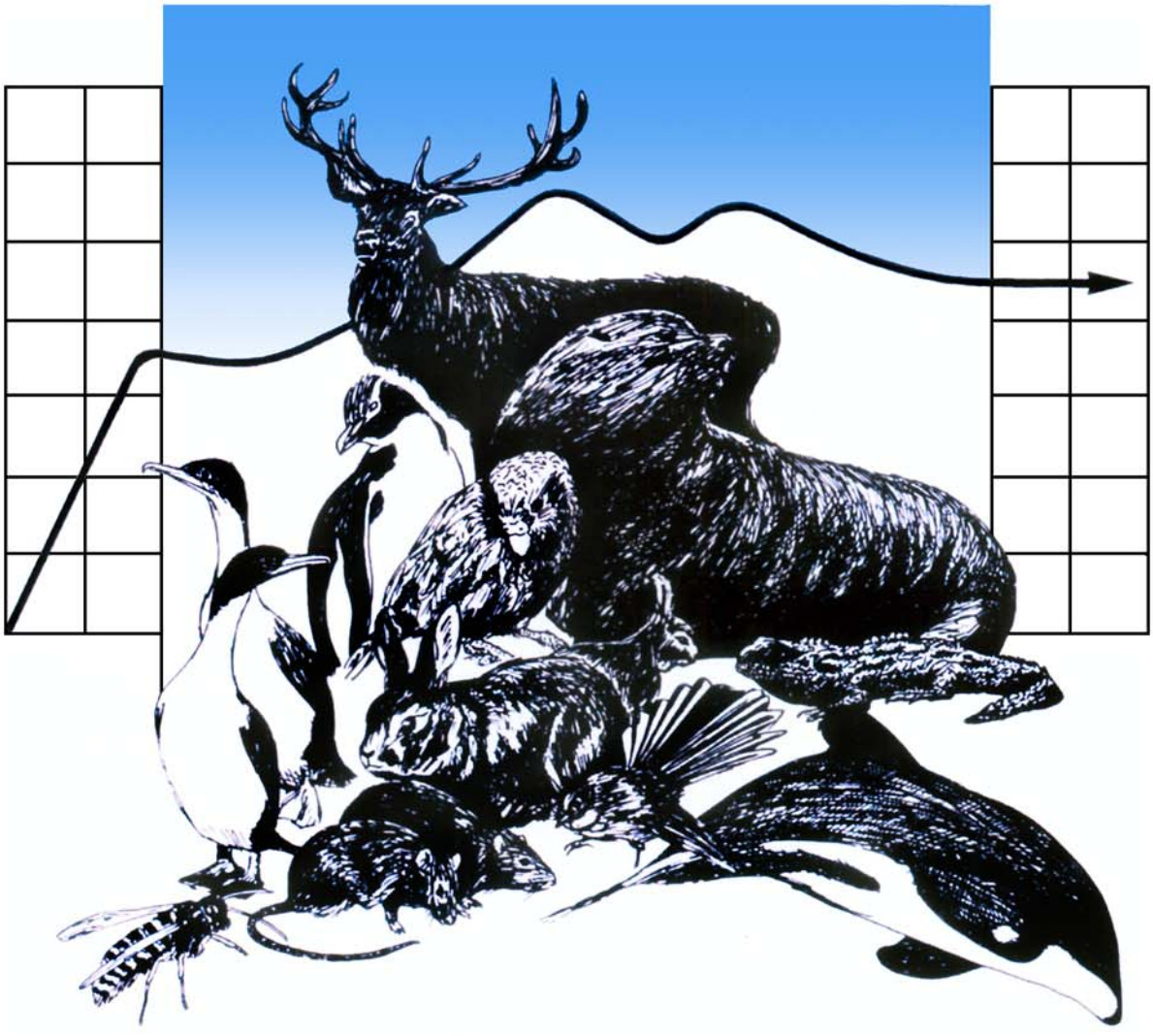
UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

NEW ZEALAND

DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Crop Raiding by Wild Vertebrates in the Illubabor Zone, Ethiopia

Courtney Quirin

A report submitted in partial fulfilment of the
Post-graduate Diploma in Wildlife Management

University of Otago

2005

University of Otago
Department of Zoology
P.O. Box 56, Dunedin
New Zealand

WLM Report Number: 206

Crop Raiding by Wild Vertebrates in the Illubabor Zone, Ethiopia

By
Courtney Quirin

May 4, 2005

Table of Contents

Executive Summary

Investigation Title

Crop Raiding by Wild Vertebrates in the Illubabor Zone, Ethiopia

Study Sites

Upland and wetland farming communities in the Wichi wetland catchment, Metu Wereda, Illubabor Zone, Ethiopia.

Investigator

Courtney Quirin

Aims

Short term:

1) To investigate the relationship between dominant pest raiding behaviours and patterns of crop loss.

2) To identify gaps, inefficiencies and strengths in methods used by farmers to protect their crops from loss to raiding (termed guarding strategies)

3) To provide information regarding dominant pest foraging behaviours and patterns of crop loss, in order to assist future guarding decisions and decrease the impact of guarding and crop loss on farmers' livelihoods.

Objectives

1) To determine patterns of cultivation and composition of wetland and upland farm plots

2) To identify what types of crops are being damaged by wild pests in both upland and wetland farm plots and quantify this loss.

3) To identify what animals are responsible for this reported damage and gather details on their foraging behaviours.

4) To identify what strategies farmers use to guard their crops against raiding animals.

Methods

Research was conducted over a two week period during March and April 2007 in Metu Wereda (district) of Illubabor zone, Western Ethiopia. Data was collected from three sites within the Wichi wetland catchment. Sites included Upper Wichi, Middle Wichi, and Didibe farming communities.

The objectives of the research were achieved through a program of Participatory Rural Appraisal (PRA) activities held with farmers from each site. Semi-structured discussion formed the core of each session. Within this framework, ranking, proportional piling, seasonal calendars, historical timelines, daily activity profiles and participatory mapping techniques were used. Sessions followed the outline below:

Session 1:

- Farm crop composition
- Amount of damage to each crop with and without guarding
- Seasonal and historical timelines of crop damage by pests (termed raiding intensity)

Session 2:

- Identification and ranking of wild pests perceived to be responsible for crop damage
- Foraging behaviour profile for each identified pest
- Loss to each crop attributed to individual pests
- Seasonal timeline of animal activity for the top four ranked pests

Session 3:

- Identification of methods used by farmers to protect their crops from foraging pests (termed guarding strategies)
- Problems encountered while guarding
- Division of guarding labour
- Prediction of the pest problem in five years if no action is taken
- Future management solutions that will alleviate the reported pest problem

Results

Farm Composition and Crop Loss

Maize was ranked as the most important crop in all sites, accounting for the most crops grown in both wetland and upland plots. In upland plots, more plants were lost closest to the forest edge, with decreasing loss progressing downhill towards lowlands. Within wetland plots, maize also comprises a significant portion of total

crops grown. Kale loss varied among sites but was reported to be less than potato loss at each site.

The likelihood of loss of upland maize with sorghum and wetland maize with potato and kale varied across sites. These differences in likelihood of loss between sites may reflect differences in guarding strategies (joint-area vs. individual), patterns of cultivation (wetland potato), and division of guarding labour.

Pest Profiles and Dominant Foragers

Within wetland and upland areas for all sites, the top 4 animals responsible for the most damage to crops were determined to be baboons, vervet monkeys, wild pigs, and porcupines. These results confirm the ranking of pests in Upper Wichi and Didibe, and refute rankings in Middle Wichi (top four ranked pests included vervet monkey, porcupine, fox and colobus monkey).

In wetland areas, the impact of the baboon is strongest in Middle Wichi and Didibe, while crop loss in Upper Wichi is distributed across the top four pests. The vervet monkey has a pronounced affect on wetland crop loss in Middle Wichi. In upland areas, the baboon is a dominant forager, taking the most amounts of crops from Middle Wichi and Didibe. In Middle Wichi, the vervet monkey is the dominant forager, having a similar impact on upland and wetland crops.

Guarding Strategies

Guarding in the field, hereafter called in-field guarding, was indicated to be the primary and most effective means of guarding against pests. All other strategies were described to be supplementary and minimally effective. Major differences in in-field guarding included organization and division of labour. In-field guarding is either organized and carried out by individual plot owners (individual guarding) or by many households within a similar area (joint-area guarding). Guarding is mainly carried out by men, however the Middle Wichi site divides guarding labour among men, women, and children.

Predictions and Future Management Solutions

All three sites indicated that if there is no action taken, then within the next 5 years the pest raiding problem will become much worse. Future management solutions offered by farmers include: 1) relocation of pests to other forested areas, 2)

holding another culling campaign for a longer period of time, and 3) legalization of hunting of certain pests.

Conclusions and Recommendations

Identifying the foraging behaviours of current pests and determining how and why dominant pest species and their behaviours change over time, may aid in future guarding decisions and decrease the impact of guarding and crop loss on farmers' livelihoods. Knowledge in pest foraging behaviours and patterns of crop loss may assist in identifying gaps and inefficiencies in guarding strategies. Further investigation of the efficacy and practice of guarding strategies across sites may also reveal variation in techniques used. Identifying these discrepancies and differences may initiate the critique and analysis of current methods in use, sparking ideas on ways to improve weaknesses. Communication between farmers from different sites provides an opportunity for farmers to share experiences and critiques of guarding strategies and how pests respond to them. Such discussion may lead to innovation, modification, or adoption of different guarding strategies.

Farmers in the Illubabor zone, Ethiopia, may benefit from future research which 1) maps changes in animal populations and pest composition, 2) observes actual pest raiding behaviour and human guarding practices; 3) measures actual crop damage attributed to each pest; and 4) maps actual patterns of crop loss within wetland and upland sites. Findings from future research may help farmers predict trends in foraging behaviours and crop loss, and allow for farmers to alter their guarding strategies accordingly. Changes in guarding strategies may enhance farmers' abilities to protect their crops from raiding pests, therefore reducing the impact of wildlife raiding on their livelihoods.

Acknowledgements

I would like to thank Dr. Alan Dixon of the University of Otago, Department of Geography, for introducing me to the issues that farmers face in Illubabor, Ethiopia, and for inviting me to participate in this on-going research project. Without Alan I would not have had the opportunity to conduct this research. I would also like to thank Dr. Alex Thornton of the University of Otago, Department of Geography. Alex assisted with the set up of Alan's research. It was a pleasure to work with both Alan and Alex.

Finally, I would like to extend a very special thanks to all of the employees of the Ethio-Wetlands Natural Resource Association. This research would not have been possible without the assistance and guidance of all members, especially Tilahun Semu and Afework Hailu.

List of Tables

List of Figures

1. INTRODUCTION

Ethiopian highlands account for over 80% of its human and livestock population and 90% of its arable land (McCann 1995). Intra-annual distribution of rainfall is one of the most important climatic variables of food production in Ethiopia with patterns of seasonal rainfall trigger the social and economic processes of labor, the renewal of resources, and the shortage or abundance of harvests (McCann 1995). Western Ethiopia is largely dominated by rural farming communities. The livelihoods and food security of these communities are not only threatened by drought, but are also severely impacted crop loss to wild vertebrates (A.B.Dixon pers.comm., September 28 2006; Dixon 2005; UNDP-EUE 1999).

Within the Illubabor Zone of Western Ethiopia (see Figure 1.1), pressure on land resources is sharply rising due to a rapid increase in population growth and recent government actions to increase coffee production within the region. This resource pressure has led to rapid deforestation, land clearing, and wetland draining for cropland areas, and led to the use of forest edge for coffee plantations. These actions reduce the area of core habitat for wild animals and eliminate corridors for migration. In addition, the expansion of farmland areas and the use of forest for coffee plantations increase the probability of contact, and possibly conflict, between farmers and wild animals. It is unknown within this area how wild animal populations are effected by changes in available habitat, however previous research by Dixon (2005) within the Illubabor zone confirms that many farmers consider wildlife to have a major impact on crop productivity, severely threatening their livelihoods. Despite the decline of core habitat, some wild animals may still be thriving due to the availability of new food resources, such as human crops, and Ethiopian government policy that forbids the killing of any wildlife.

Farmers in the Illubabor zone have been reporting increased populations of wild pests and consequently increasing loss of crops to raiding animals (A.B.Dixon, pers. comm., September 28, 2006, Dixon 2005). Primates, particularly the baboon and vervet monkey, and wild pigs were previously reported to be the primary pests responsible for crop damage (A.B.Dixon, pers.comm., September 28, 2006). Primates are particularly successful crop raiders due to their cooperative behaviors, opportunistic lifestyle, non-specialized and omnivorous diet, and their ability to learn rapidly and change their behavior accordingly (Hill 2000). In addition to these

behaviors, primates seem to be less effected by reduced forest than other wild animals as they have been observed to readily live beside humans in rural, urban and semi-urban environments (Hill 2000). After years of complaints by farmers to local government officials, such as Zonal and Regional Ministry of Agriculture agents, the government allowed a brief baboon culling campaign in the Illubabor zone in 2004. The details and effectiveness of this campaign are still under investigation.

This study is the first investigation into the reported crop-raiding problem within the Illubabor zone. The research discussed is the initial phase of a broader project which will 1) compare the actual and perceived impact of wild pests on the livelihoods of the rural farmers, and 2) identify the key environmental and societal factors that are influencing the proliferation of wild vertebrate crop damage in the area. This study investigates the relationship between changes in animal pest populations and raiding behaviors with changes in guarding strategies and farm composition. Over a daily, seasonal and historical timeline this research aims to identify 1) what types of crops are being damaged by wild pests in both upland and wetland farm plots and quantify this loss; 2) what animals are responsible for this reported damage and gather details on their foraging behaviors; and 3) what strategies farmers use to guard their crops against raiding animals. The results of this study will hopefully shed light on whether the foraging behaviors of wild pests are changing in response to changes in animal communities or farm composition and highlight any gaps or inefficiencies in current guarding practices. Knowledge of pest ecology, animal community composition, and seasonal pest activity may aid future guarding decisions and decrease the impact of guarding and crop loss on farmers' livelihoods.

Figure 1.1 Map of Illubabor Zone, Western Ethiopia

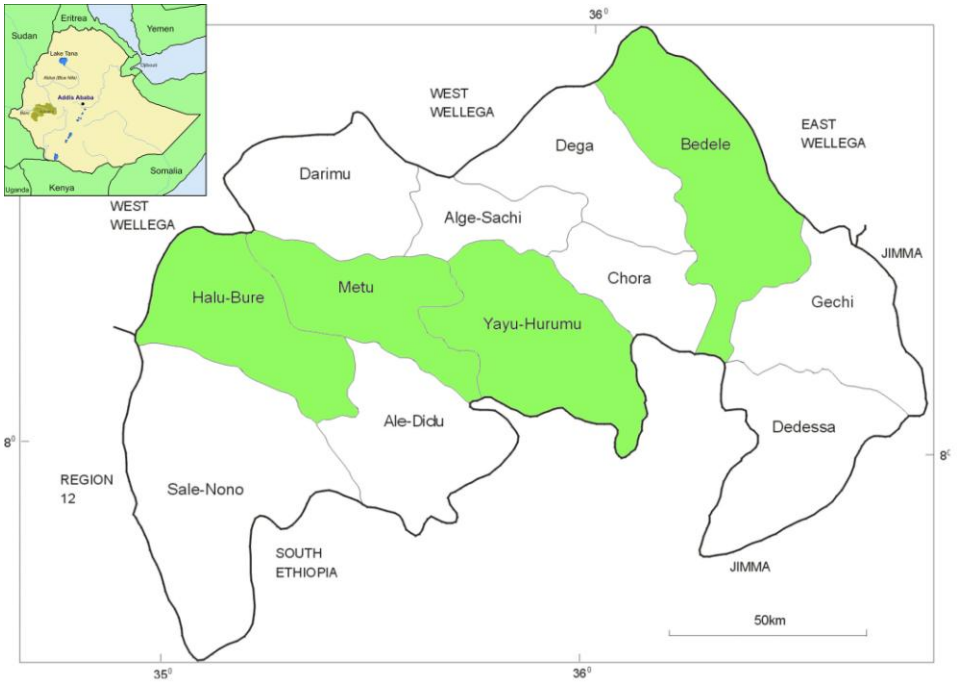


Figure 1.1 All sites are located within Metu Wereda.

2. METHODS

Research was conducted over a two week period during March and April 2007 in Metu Wereda (district) of Illubabor zone, Western Ethiopia (see Figure 1.1). The Illubabor area ranges between 1400 and 2000m a.s.l and is characterized by steep-sided river valleys and flat, waterlogged valley bottoms. The mean annual temperature is 20.7ºC and the rainfall is often in excess of 1800 mm per annum (Dixon 2005). The accumulation of runoff, poor drainage and a high groundwater table in these valley bottoms promotes the formation of both permanent and seasonal swamp-like wetlands, ranging from less than 10 ha to more than 300 ha. Both upland and wetland areas are utilized for subsistence farming.

Data was collected from three sites within the Wichi wetland catchment (see Figure 2.1). The total area of the Wichi catchment is 2800 ha, of which 364 ha are wetlands (Tilahun Semu, pers. comm., April 2, 2007). The total population is 13911 (7505 males; 6404 females) with 2881 households in the catchment (Tilahun Semu, pers. comm., April 2, 2007). The Upper Wichi site has a total population of 516 and 86 households. The Didibe site is similar in size with a total population of 358 and 96 households. Middle Wichi is the largest site, comprised of 853 people and 158 households. The area of each site has yet to be determined. Each site consists of

wetland and upland farm plots. Wetland and upland farms have different growing and harvesting seasons, however seasonal and site variation in growing seasons occur due to the timing of the rainy season, variation in crops grown, and differences in individual farming strategies.

The aims of the research were achieved through a program of Participatory Rural Appraisal (PRA) activities held with farmers from each site. Three sessions were arranged with four to six farmers from each site, however actual attendance ranged from six to thirty-four, of which the majority were middle-aged and elder men. PRA methods facilitate discussion among various community members, providing an opportunity for participants to share their experiences and to analyze and confirm aspects of the reported pest problem. Semi-structured discussion formed the core of each session. Within this framework, ranking, proportional piling, seasonal calendars, historical timelines, daily activity profiles and participatory mapping techniques were used. Three PRA sessions lasting 1 to 1.5 hours were held in Middle Wichi and Didibe. Due to time constraints, all three sessions were condensed into two sessions for Upper Wichi, each lasting 1.5 to 2 hours. Discussion addressed issues in both wetland and upland farming plots.

In session 1, farmers described farm crop composition and the amount of damage to each crop using proportional piling. Farmers were then asked to create seasonal and historical timelines of crop damage by pests (termed raiding intensity). Session 2 identified and ranked wild pests thought to be responsible for crop damage. A profile of foraging behaviors was built for each identified pest. For each crop, the amount of damage caused by each foraging pest was determined using proportional piling. A seasonal timeline of animal activity for the top four wild pests was created for both upland and wetland areas. Session 3 used only semi-structured discussion to identify the methods used by farmers to protect their crops from foraging pests (termed guarding strategies). Discussion addressed problems encountered whilst guarding, methods used to scare away raiding animals, division of guarding labor, and daily guarding activity profiles. Session 3 concluded by asking farmers their prediction of the pest problem in five years if no action is taken and what future management solutions they believe will alleviate this problem. .

Chi-square tests were used to compare the likelihood of loss of wetland maize with kale and potato, and upland maize with sorghum. Only loss due to mammals was included in this analysis. Birds and termites were excluded from analyses due to

reports that it is not possible to guard against these animals and therefore guarding strategies do not take these pests into consideration. Chi-square analyses tested the hypothesis that likelihood of loss is random, which is interpreted as crops having the same likelihood of loss to raiding pests. Expected values of all crops were equivalent to the observed maize loss to which crops were compared.

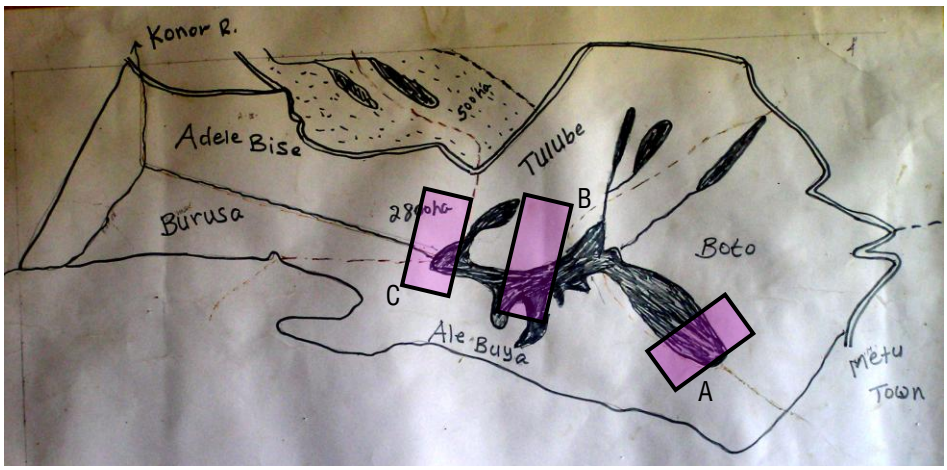
Figure 2.1 Location of sites within the Wichi Wetland Catchment

Key to Sites in Figure 2.1:

A- Upper Wichi

B- Middle Wichi

C- Didibe



3. RESULTS

Results were analyzed by wetland and upland areas for each site. All data regarding crop loss (total and per animal), animal behavior (preference, frequency, activity etc), and raiding intensity represents perceived data; this information was provided by farmers from each site, though no actual measurements have been collected.

3.1 Farm Composition and Crop Loss

Table 3.1.1 summarizes results of farm composition and loss of crops due to raiding by wild pests. All loss reported refers to loss in the presence of guarding. Without guarding, all farmers reported 100% loss to raiding pests.

Table 3.1.2 summarizes patterns of wetland cultivation by each crop for all sites. Patterns of cultivation in upland plots were less discrete and, at certain sites, depended upon the productivity of the land. However, a general trend of cultivation emerged; crops were grown from the homestead progressing downhill into the

lowland valley in the order of maize (grown closest to homestead), sorghum, teff/wheat/barley (inter-mixed), and legumes.

Table 3.1.2 Patterns of Cultivation in Wetland Plots

CROPS	UPPER WICHI	MIDDLE WICHI	DIDIBE
Maize	Mixed cropping	Mixed cropping	Mixed cropping
Potato	Well drained areas; anywhere within the plot	Center	Center
Kale	Mixed cropping	Mixed cropping	Mixed cropping
Tomato		Center	

3.2. Pest Profiles

Table 3.2.1 summarizes the profile given by each site for all pests ranked in the top four. Six animals are listed due to differences in top four rankings. Ranking considered the combined affect of each animal on crop loss in both wetland and upland areas. Ranking identifies pest severity with (1) indicating the worst pest. The type of fox species has yet to be identified. The common name for the bushpig, Potamochoerus *larvatus*, in Illubabor is wild pig. Therefore all reference to the wild pig refers to the bushpig, Potamocherus *larvatus.*

Table 3.1.1 Crops grown in Wetland and Upland Plots

WETLAND												
	UPPER WICHI				MIDDLE WICHI				DIDIBE			
RANK	CROP	% Comp-osition	% Lost	% Loss of Total Crops	CROP	% Comp-osition	% Lost	% Loss of Total Crops	CROP	% Comp-osition	% Lost	% Loss of Total Crops
1	Maize	61.67	43.24	26.67	Maize	49.18	73.33	36.07	Maize	75.41	50	37.70
2	Potato	15	44.44	6.67	Kale	26.23	62.5	16.39	Potato	16.39	50	8.20
3	Kale	23.33	14.29	3.33	Potato	14.75	66.67	9.84	Kale	8.20	40	3.28
4	x	0	0		Tomato	9.84	66.67	6.56	x	0	0	
UPLAND												
1	Maize	50.79	37.5	19.05	Maize	57.38	77.142	44.26	Maize	54.10	66.67	36.07
2	Sorghum	22.22	35.71	7.94	Sorghum	27.87	70.59	19.67	Sorghum	18.03	45.45	8.20
3	Teff	14.29	11.11	1.59	Teff	14.75	77.78	11.48	Teff	4.92	0	0
4	Wheat	4.76	33.33	1.59					Legume	11.48	42.86	4.92
5	Barley	4.76	33.33	1.59					Wheat	11.48	42.86	4.92
6	Legume	3.17	33.33	1.06								

Table 3.1.1 The data summarized in Table 3.1.1 was collected from proportional piling exercises for wetland and upland plots at each site. Percent composition refers to the percent of a crop grown out of all crops grown within a plot. Percent lost refers to the percent of a crop lost to raiding. The percent loss out of the total crops grown (% Loss of Total Crops) is determined for each crop by multiplying the % composition by % loss

Table 3.2.1 Animal Profiles of Listed Top 4 Worst Pests

ANIMAL	SITE	SITE RANK	UPLAND/ WETLAND	CROPS- age/part	TIME OF DAY	FREQUENCY
Baboon (Papio *cynocephalus Anubis)*	MIDDLE WICHI	5	Both	❖ non-selective ❖ eats every part of the crop: root, shoot, cob	4am/5am(before humans wake) to 7pm; present all day. After heavy rainfalls in the daytime/ late afternoon	3 times a week
	DIDIBE	1	Both, more of a problem upland*2	++ maize/sorg- seeds, shoots, above knee, stalk, cob/tassle; domestic animals		Everyday
	UPPER WICHI	1	Both, more of a problem upland*2	++ ❖ everything except teff ❖ maize- cob, stalk, root ❖ sorg/wheat/barley- tassel, flower, seed ❖ eats small domestic livestock (chickens, sheep) ❖ coffee- removes bark and eats central/inside part of stem		Depends on rain; comes everyday if rains b/c guarding is slow/less guards
Vervet Monkey (Cercopithecus *aethiops*)	MIDDLE WICHI	1	Both	❖ sorghum- tassel ❖ maize- cob, new shoots, planted seeds ❖ fruit- banana, mango, papaya ❖ kale- leaves ❖ barley seeds ❖ coffee berry- ripened	5am/6am to 6pm/7pm	Everyday/ opportunistic feeder; will raid as frequently as it can/every hour or several time in an hour
	DIDIBE	2	Both more of a problem upland*2	❖ sorghum- tassel ❖ maize- cob (new and mature), new/young shoots, stalks		
	UPPER WICHI	2	Both	❖ all crops except teff ❖ fruits ❖ sorg/maize- germinating plant, above knee stalk/shoot, tassle/young cob ❖ cereals- while flowering		

Porcupine (Hystrix *cristata*)	MIDDLE WICHI	2	Both	❖ maize- cob only ❖ all tubers ❖ roots of all crops bananas	Night	Every night
	DIDIBE	3	Both; more of a problem upland*3	❖ all crops except cereals (barley, wheat, millet, teff etc.)		
	UPPER WICHI	3	Both	❖ root and tuber crops ❖ maize ❖ haricot bean		
Colobus Monkey (Colobus *guereza*)	MIDDLE WICHI	4	Upland	❖ maize- cobs, seeds ❖ fava bean seeds ❖ sorghum tassle coffee berry- ripened	Day	❖ almost everyday ❖ moves around to unoccupied crops/ opportunistic difficult to track movement and frequency
	DIDIBE	6		❖ maize- green stage to mature stage ❖ recently feed on sorghum tassle		
	UPPER WICHI	5		❖ maize- young cob ❖ recently feed on sorghum tassle		
Fox	MIDDLE WICHI	3	Both	❖ maize- green cob ❖ rabies	Night	❖ stores cobs in burrow; freq. depends on success of raiding bout; successful in one raid- raid every 2 days; unsuccessful- raid every day
	DIDIBE	5		❖ maize- cob		
	UPPER WICHI	6		❖ maize- green cob		
Wild Pig*1 (Common name: Bushpig; Potamochoerus *larvatus*)	MIDDLE WICHI	8	Both	❖ maize- all parts sorghum- stalks	Night	1 time/week or once every 3 days; freq. depends on success of its first raiding bout
	DIDIBE	4		❖ maize- all parts ❖ root crops ❖ false banana	Night*4	Near Forest- every 3 days; Far from Forest- 1/week
	UPPER WICHI	4		❖ maize- cob ❖ *?(root crops)?* ❖ sorg- tassle	Night	Every 5 to 9 days

Key to Table 3.2.1

*1 most destructive but occurs at a low frequency; can destroy ¼ ha. of maize in 1 night

*2 wetland- joint-area/communal guarding/easy to guard against; upland- dispersed farms and forest cover/ difficult to guard

*3 Damage is most serious by the homestead and decreases in severity as move downhill towards lowlands

*4 depends- may start to come as early as 3pm or 5pm
++ in addition to crops listed above

Upper Wichi and Didibe ranked the baboon, vervet monkey, wild pig and porcupine in the same order as the top 4 worst pests in their sites. Middle Wichi listed a different combination of top four worst pests, ranking in the order of vervet monkey, porcupine, fox and colobus monkey. The colobus monkey ranked lower in both Didibe (6^{th}) and Upper Wichi (5^{th}) as did the fox (Didibe-5^{th}; Upper Wichi-6^{th}). Middle Wichi ranked the wild pig (8^{th}) and the baboon (5^{th}) much lower than the other two sites. Although Middle Wichi farmers recognized the wild pig as the most destructive animal, its low ranking is attributed to its low frequency of raiding. Upper Wichi farmers reported a lower frequency of wild pig foraging than did Middle Wichi, however the wild pig was still ranked highly by Upper Wichi farmers.

Fox is reported to forage on maize cob in upland and wetland plots for all sites. Middle Wichi farmers also stated that fox has infected several domestic dogs and livestock with rabies and predates on newborn sheep, goats and chickens. The colobus monkey has been recently observed to forage on sorghum tassel in all sites and on ripened coffee berry in Middle Wichi. Within the last three years, the colobus monkey has also been observed to begin foraging on maize. Farmers claim that the colobus monkey has learned these foraging behaviours from the vervet monkey.

The porcupine is listed as one of the top three pests in all sites, foraging on a variety of crops and at different stages of crop development. The vervet monkey appears to be a major pest at all three sites, occurring in both upland and wetland plots. The baboon is ranked 1^{st} in Didibe and Upper Wichi, having a high foraging frequency. In Middle Wichi the baboon, ranked 5^{th}, is reported to forage at a lower frequency of three times per week. Didibe and Upper Wichi farmers describe baboons to be more of a problem in upland sites due to difficulties in guarding upland plots.

Other Pests Listed

Other animals identified as responsible for crop loss in wetlands and uplands include birds, termites, duiker and antelope, aardvark, and the blue monkey. These pests were not ranked in the top four and were therefore excluded from Table 3.2.1. All farmers

lumped duikers and other antelopes into one category, duiker/antelope. Farmers did not distinguish between different types of foraging birds. Therefore, all crop loss due to birds falls into one category, birds.

Birds

Birds were also listed as pests in both Middle Wichi and Upper Wichi, though they were reported to forage on different crops. Upper Wichi reported birds to predate on sorghum (20.25% of damage), teff (49.4%), and wheat and barley (36.7%). Middle Wichi reported birds to forage on sorghum (10%) and Teff (100%). Didibe did not list birds as a pest in their site.

Termites

Middle Wichi identified termites as responsible for 13.8% of kale loss and 18.6% of potato and tomato loss. Termites were reported to forage on the roots of all crops.

*Duiker/Antelope (*Sylvivapra *grimmia)*

Middle Wichi reported 34.5% of kale loss to foraging by duiker, yet it was ranked last because it is easily detected and deterred. Duiker was reported to only forage in wetland areas in Middle Wichi. Upper Wichi ranked the duiker last, however farmers expressed difficulty in guarding against duiker stating that it is difficult to detect, making very little noise while foraging. Upper Wichi reports duiker to forage on teff (responsible for 26.6% of loss), sorghum (11.4%) and legumes (35.8%) in upland plots and on kale (responsible for 100% of loss) and potato (25.32%) in wetland plots. Didibe also ranked the duiker last, stating that it minimally foraged on kale and that it is easy to guard against and deter.

*Aardvark (*Orycteropus *afer)*

The aardvark is only mentioned as a pest in Middle Wichi, ranking 6th of 9 identified pests. It reportedly forages on upland maize cob (at any stage). It is also reported to predate on bees kept in traditional bee keeping hives. Bee predation reduces the production of honey, which is a major staple for most farmers in the Illubabor zone (Tilahun Semu, pers. comm., March 23, 2007).

*Blue Monkey (*Cercopithecus *mitis*/ C. *albogularis*)

The Blue Monkey is ranked 7th in all three sites, though its areas of foraging vary between sites. It is reported to forage on upland maize cobs in Middle Wichi and Didibe, sorghum tassel in Didibe and wetland maize cob in Upper Wichi. Its frequency (daily) and time of foraging (5/6am to 6/7pm) is similar in all sites. The Blue Monkey is described as being bold and does not scare easily by human presence.

3.3 Dominant Foragers by Crop

Data regarding pest foraging behaviours was collected from proportional piling exercises that identified the amount of specific crops lost to individual pests. Dominant foragers on each crop can be identified in Figures 3.3.1 and 3.3.2. Figure 3.3.1 summarizes the loss of maize, potato and kale in wetland plots for each site. Figure 3.3.2 summarizes the loss of maize, sorghum and teff in upland plots for each site.

In both upland and wetland areas for all sites, maize is primarily dominated by the baboon, followed by the vervet monkey. The top 4 foragers on upland and wetland maize include baboons, vervet monkeys, porcupines and wild pigs. The baboon clearly dominates wetland maize resources in Didibe, though use of this resource is more evenly foraged upon by baboons, vervet monkeys and wild pigs in Upper Wichi. The amount of maize taken by baboons and vervet monkeys in wetland areas are similar in Upper and Middle Wichi. Wetland potato resources are dominated by different animals in each site. The baboon is a clear dominant forager in Didibe, while the porcupine dominates potato crops in Middle Wichi and Upper Wichi. Didibe and Upper Wichi identified only one pest responsible for kale loss, while Middle Wichi attributed kale loss to the vervet monkey, duiker/antelope and termites. The vervet monkey dominates kale resources in both Didibe and Middle Wichi.

Upland maize is dominated by the baboon in both Didibe and Upper Wichi, while crop loss in Middle Wichi is distributed among the vervet monkey and baboon. Baboons and vervet monkeys also dominate sorghum resources at all sites, though sorghum loss is more evenly distributed across all pests in Upper Wichi. In both Upper Wichi and Middle

Wichi birds dominate teff resources. Duikers/antelopes and baboons also significantly contribute to teff loss in Upper Wichi.

Figure 3.3.1 Loss Attributed to Pests for Wetland Crops

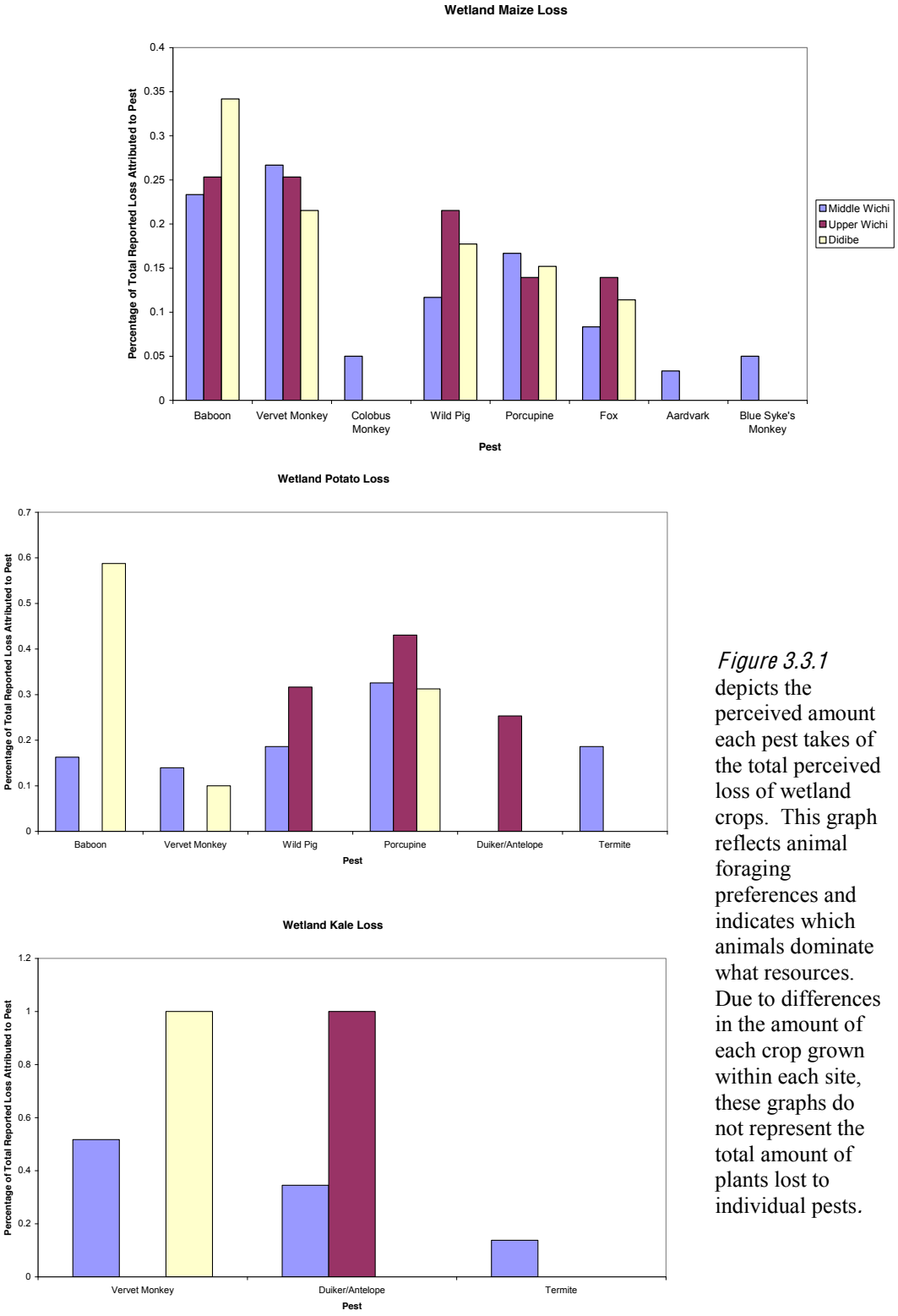
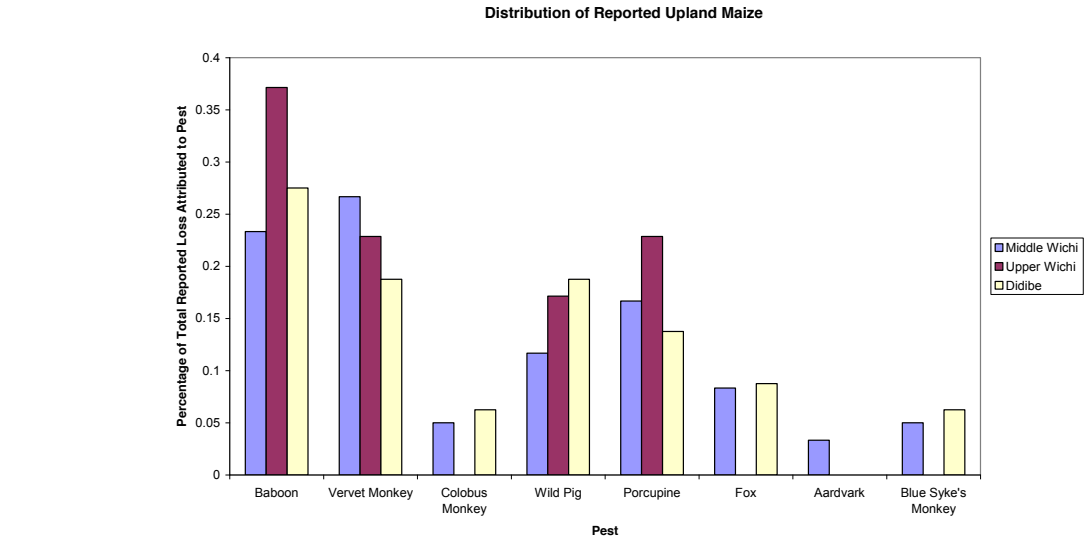
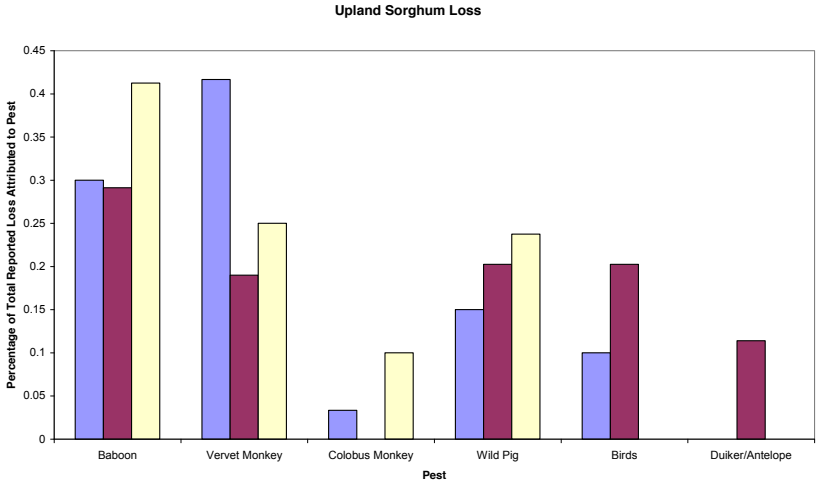


Figure 3.3.1 depicts the perceived amount each pest takes of the total perceived loss of wetland crops. This graph reflects animal foraging preferences and indicates which animals dominate what resources. Due to differences in the amount of each crop grown within each site, these graphs do not represent the total amount of plants lost to individual pests.

Figure 3.3.2 Loss Attributed to Pests for Upland Crops





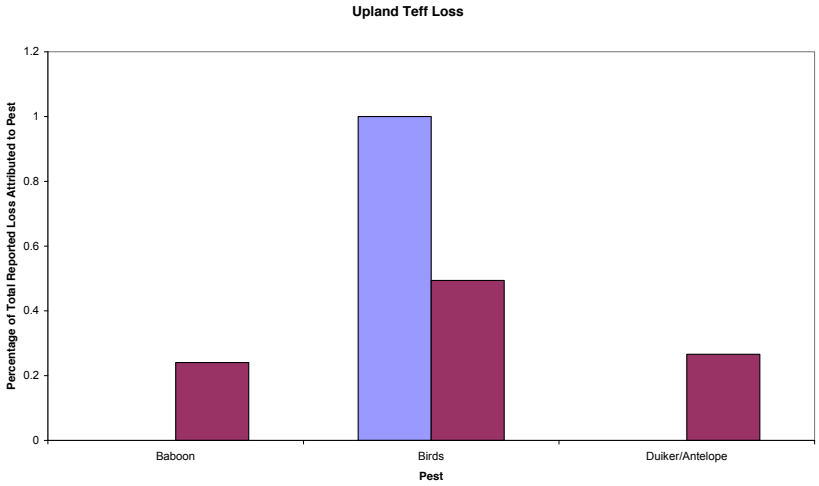


Figure 3.3.2 depicts the perceived amount each pest takes of the total perceived loss of upland crops. This graph reflects animal foraging preferences and indicates which animals dominate what resources. Due to differences in the amount of each crop grown within each site, these graphs do not represent the total amount of plants lost to individual pests.

3.4 Dominant Foragers by Area

Information in Table 3.4.1 validates or refutes the reported top 4 pests identified at each site. Table 3.4.1 identifies the top 4 pests by determining the percent that each pest takes of total crops grown in upland and wetland areas per site. This is determined by multiplying the (% of reported loss due to each animal)(% of total reported loss) to give the % of total crop grown lost to each animal. This value is multiplied by the composition percentage of each crop to calculate the percent lost of total crops grown. Bold numbers indicate the top four pests determined to take the most amounts of crops.

Table 3.4.1 Percent Loss of Total Crops Grown Attributed to Each Pest

UPLAND CROPS			
PEST	Middle Wichi	Upper Wichi	Didibe
Baboon	**0.162295**	**0.106513**	**0.1729502**
Vervet Monkey	**0.2**	**0.071946**	**0.1182372**
Colobus Monkey	0.028689	0	0.0307377
Wild Pig	**0.081148**	**0.050684**	**0.109221**
Porcupine	**0.07377**	**0.046277**	**0.0557375**
Fox	0.036885	0	0.0315574
Aardvark	0.014754	0	0
Blue Monkey	0.022131	0	0.022541
Birds	**0.134426**	0.035564	0
Duiker/Antelope	0	0.017044	0
Termite	0	0	0
TOTAL LOSS	**0.754098**	**0.328027**	**0.5409819**

WETLAND CROPS			
PEST	Middle Wichi	Upper Wichi	Didibe
Baboon	**0.11084**	**0.067511**	**0.177021**
Vervet Monkey	**0.203843**	**0.067511**	**0.122121**
Colobus Monkey	0.018033	0	0
Wild Pig	**0.072576**	**0.078481**	**0.066819**
Porcupine	**0.113483**	**0.065823**	**0.082888**
Fox	0.030055	0.037131	0.042955
Aardvark	0.012022	0	0
Blue Monkey	0.018033	0	0
Birds	0	0	0
Duiker/Antelope	0.056529	0.050211	0
Termite	0.053111	0	0
TOTAL LOSS	**0.688525**	**0.366667**	**0.491803**

Table 3.4.1 represents the overall damage to upland and wetland crops by each pest. The top pests, in terms of most damage caused to total crops grown, are identified by bold font. Total loss corresponds to the sum of %Loss of Total Crops (see Table 3.1.1) for wetland and upland plots per site.

The baboon, vervet monkey, wild pig and porcupine are determined to take the most amounts of total crops grown in wetland and upland areas for each site. In wetland areas, the impact of the baboon is strongest in Middle Wichi and Didibe, while crop loss in Upper Wichi is distributed across the top four pests. The vervet monkey has a pronounced affect on wetland crop loss in Middle Wichi.

In upland areas, the baboon is a dominant forager, taking the most amounts of crops from Middle Wichi and Didibe. In Middle Wichi, the vervet monkey is the dominant forager, having a similar impact on upland and wetland crops. The amount of crops taken in Upper Wichi upland sites is less evenly distributed as in wetland areas. In upland Middle Wichi, birds are responsible for the most amount of total crop loss, largely attributed to their dominance over teff resources and contribution towards sorghum loss.

Overall, Middle Wichi receives the most damage to both upland and wetland crops. Upper Wichi suffers least from crop raiding by wild pests. In Middle Wichi and Didibe more crops are lost to raiding pests in upland areas, while in Upper Wichi more crops are lost in Wetland areas.

3.5 Analysis of the Likelihood of Crop Loss

Chi-square tests compared the likelihood of loss of wetland maize with kale and potato, and upland maize with sorghum. Expected values for each test were equal to the observed loss of maize. Only loss due to mammals was included in this analysis, and therefore loss due to birds and termites was excluded. .

Table 3.5.1 Chi-Square Results Comparing the Likelihood of Crop Loss

	WETLAND		UPLAND
Site	Maize vs. Kale	Maize vs. Potato	Maize vs. Sorghum
Didibe	2.0/ not sig.	1.06/ not sig.	6.75/ sig.
Upper Wichi	19.38/ sig.	0.033/ not sig.	2.17/ not sig.
Middle Wichi*	5.16/ sig.	4.96/ sig.	2.40/ not sig.

Table 3.5.1. A summary of results of chi-Square tests comparing the likelihoods of loss to upland and wetland crops. Significance was assessed with chi-square value $x^2 = 3.84$ ($v=1$; at $p<0.05$). The reported percent lost to raiding vertebrate pests for wetland maize, kale and potato were compared; percent loss attributed to birds (sorghum for Upper and Middle Wichi) and to termites (kale and potato for Middle Wichi) were subtracted from the total reported loss of each crop.

3.6. Seasonal Calendars: Raiding Intensity, Animal Activity, and Human Cultivation Activity

Figures presented in this section represent the raiding intensity (RI) across wetland and upland seasons. The y-axis of each graph refers only to raiding intensity, which was determined by proportional piling. Raiding intensity values are derived from proportions and can only be compared within each upland and wetland seasonal calendar. Animal activity, indicated by different lines, is independent of RI proportion values on the y-axis. Animal activity refers only to month on the x-axis. Due to time constraints no data regarding animal activity was collected in Middle Wichi. Text boxes below each figure describe the human cultivation activity per month. Gaps in these text boxes indicate that no information regarding human activity was provide for that month.

In both Didibe and Upper Wichi porcupine activity in upland sites is discontinuous; there seems to be a consistent break in upland porcupine activity in June. There is a reported gap in all upland animal activity between December and February. Similar patterns of wetland raiding and animal activity are not found in Didibe and Upper Wichi.

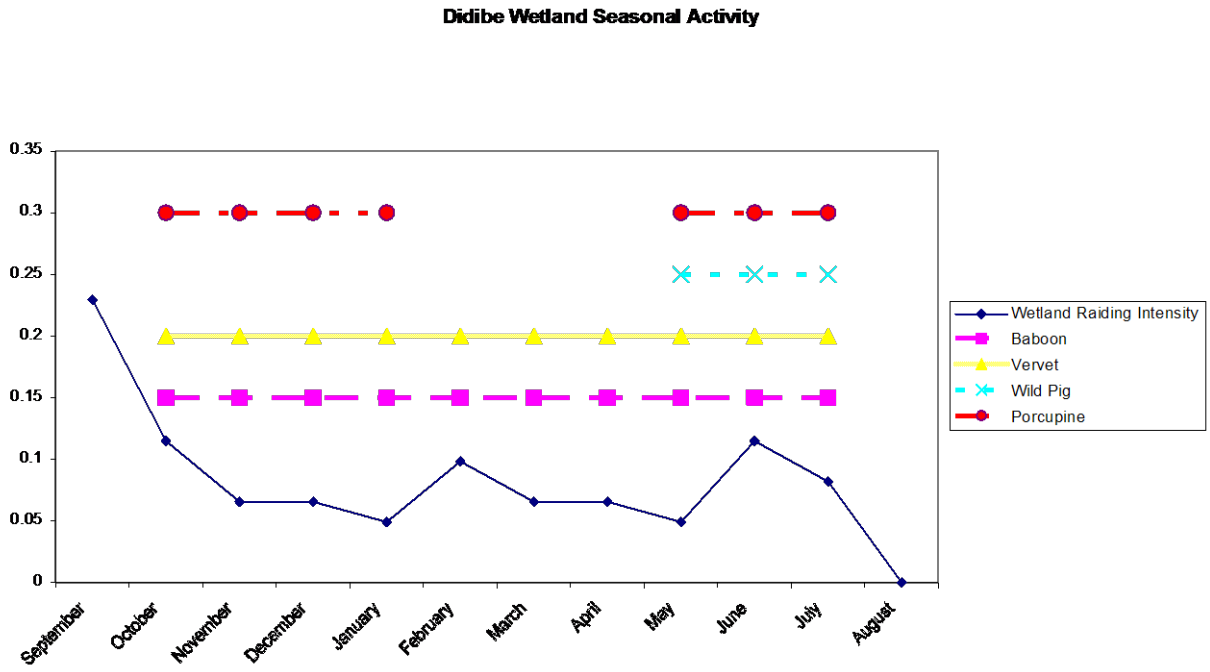
Didibe

Baboons and vervet monkeys have the same periods of activity for both upland and wetland areas. In wetland plots there is no reported animal activity in September when raiding intensity is highest. Wild pig is least active in wetland areas, while the porcupine is least active in upland areas. Both wild pig and porcupine have noticeably shorter periods of activity than baboons and vervet monkeys in both areas.

Upper Wichi

Baboons and wild pigs have the shortest, and similar, periods of activity in wetland plots. Porcupines have the longest period of activity in wetland areas, and all four pests are active from April to June. In upland plots, porcupines and wild pigs have the shortest period of activity. Baboons and vervet monkeys have the longest, and similar, period of activity in upland areas. No raiding or animal activity is reported between December, January and February.

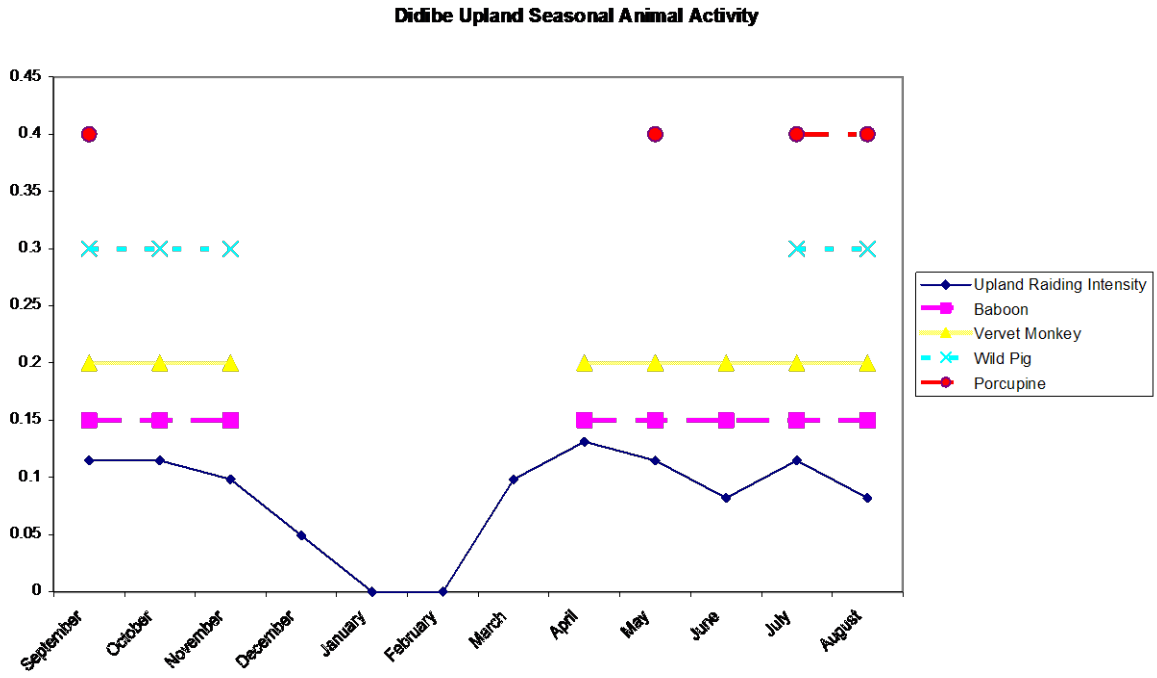
Figure 3.6.1 Seasonal Activity in Didibe Wetlands



September	Clear land
October	Clear land
November	Plow, plant potato
December	Harrowing for potato, prepare maize land
January	Completion of maize land cultivation
February	Plant maize
March	Harrowing, disking
April	Clear land, cultivate maize
May	Guarding only
June	Clear ditches for coming season
July	Clear ditches for coming season
August	

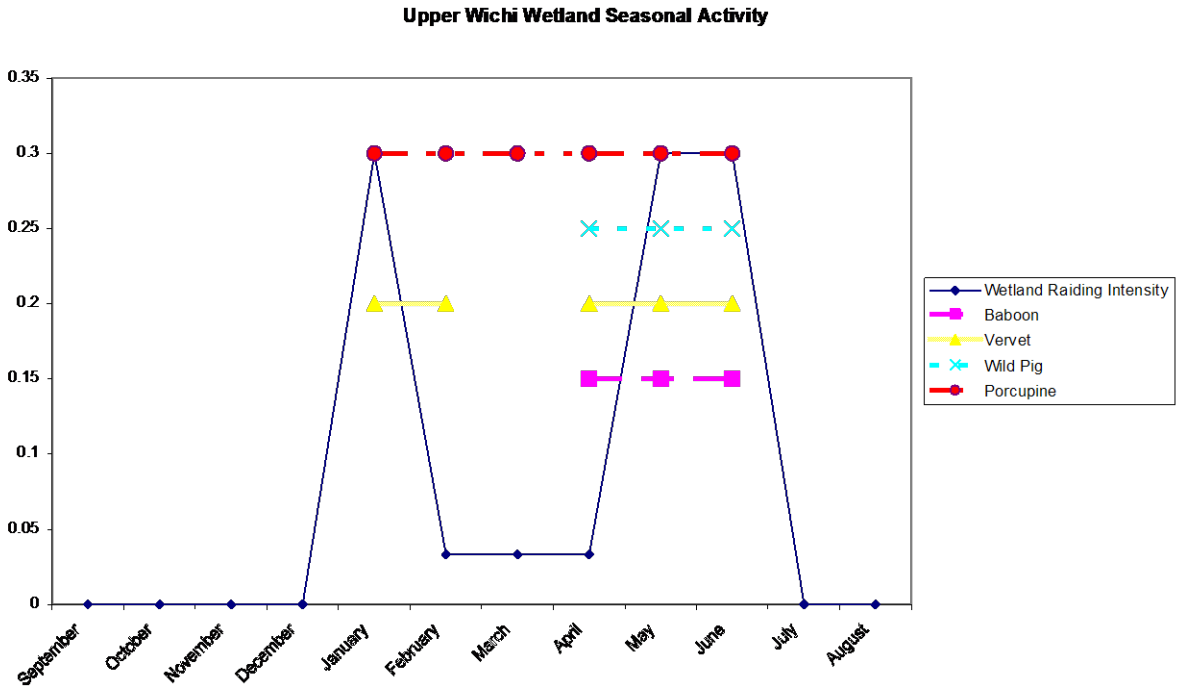
Guarding is continuous from September until the first week in June. No activity was listed for August. There is double cropping of maize and potato is wetland crops.

Figure 3.6.2 Seasonal Activity in Didibe Uplands



March	Clear land, initial plowing
April	First planting, first weeding
May	Late planting, weeding
June	Weeding only
July	Weeding, plowing for cereal crops
August	Late plowing for teff
September	Early harvesting, clearing for coffee
October	Clear land, coffee harvesting
November	Harvest maize, coffee, sorghum
December	Store harvested crops
January	
February	

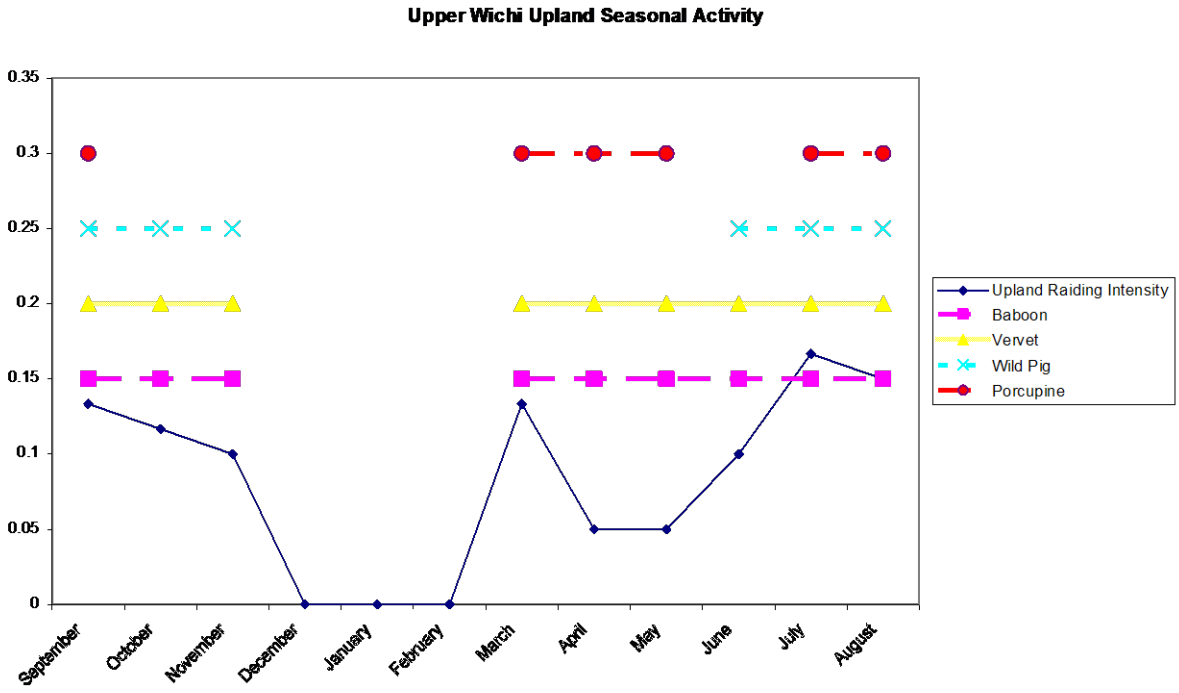
Figure 3.6.3 Seasonal Activity in Upper Wichi Wetlands



September	Clear land
October	Clear land
November	
December	prepare land for cultivation
January	Plant maize, potato
February	Guarding is low due to immature stage of crops
March	Guarding is low due to immature stage of crops
April	Guarding is low due to immature stage of crops
May	Green stage of crops
June	Green stage of crops
July	Green stage of crops
August	

No specified harvest period; Crops can be harvested at any time during the green stage in wetland cropping strategies. All wetland crops are harvested before the heavy rains in August.

Figure 3.6.4 Seasonal Activity in Upper Wichi Uplands



March	Clear land, initial plowing and planting
April	Planting
May	
June	Planting, sowing
July	Planting, sowing
August	Planting, sowing
September	Waiting for crops to mature, guarding
October	Waiting for crops to mature, guarding
November	End of November, after heavy rains, harvest crops
December	
January	
February	

Guarding is continuous. Details given on cropping activity were minimal compared to Didibe and Middle Wichi.

3.7 Guarding Strategies

Table 3.7.1 summarizes descriptions of guarding strategies used in all three sites. Efficacy within site is a ranking value, with (1) being the most effective strategy. Guarding in field, hereafter called in-field guarding, was indicated to be the primary and most effective means of guarding against pests. All other strategies were described to be supplementary and minimally effective. The remainder of semi-structure discussion is specific to in-field guarding.

Table 3.7.1 Profile of Guarding Strategies

METHOD	DESCRIPTION	TARGET ANIMAL	WHY CHOSEN	UPLAND OR LOWLAND	SITES USED	EFFICACY WITHIN SITE
Guarding in Field	At least one person is in the field guarding for 24 hours (day/night)	Any	No selection	Both	Upper Wichi Didibe Middle Wichi	1 1 1
	Evening: Sleep by farm area. When hear sound, stand up and scare away the pest by yelling/making noise			Night animals: pig, porcupine		
	Morning/ Daytime: Through farming in the am and day. Stand by crops and scare away when animal enters plot			Any animal		
Dogs- Type 1	Dog is with farmer and not tied to a post Daytime	Any	No selection	Both	Upper Wichi Didibe	2 Supplementary
Dogs- Type 2	Dog is tied to post in and around plot	Any	No selection	Both	Middle Wichi	3
Perfume/ soaps	Place perfume and soaps in a plastic bag and hang from a stick.	Porcupine, Pig, night pests	Scent may deter animal because it smells like humans*	Both	Didibe	Supplementary
Scarecrow with soaps/ perfumes in pockets	.	Any	Scent may deter animal because it smells like humans*		Upper Wichi	Not effective- *actually attracted animal*
Scarecrow with and without Gun	Polish wood with charcoal and make a fake machine gun. Put gun in hands of scarecrow	Vervet monkey, baboon	No selection	Both	Didibe Middle Wichi	Not effective 4
Wildcat Skin Scarecrow	Kill a wild cat (any species but usually leopard) and stretch skin onto posts by crops.	Vervet monkey	Thought to look like a wild cat and serve to scare away pests	In the direction of highest forest	Didibe	2 Very effective/ Haile Sallasie Period only/ *illegal & no more big wild cats in the area*
Shooting	Shoot any raiding animals	Any	No selection	Both	Didibe	N/A- Haile Sallasie Period only/ *illegal*
Trapping	Trap types: metal leg trap, wooden tie trap. Check every day and night: Night check-set at night and check in am; Day check-DAY- set at am and check in pm. Any trapped animal is killed.	Any; especially for Pig, Porcupine, Vervet monkey*, Baboon*, Colobus monkey	No selection	Both	Upper Wichi Didibe Middle Wichi	Not effective Not effective 2; Not effective over long term

Key to Table 3.7.1:
W indicates women
C indicates children
hh indicates total households
pp indicates total population
* indicates primary
+W/C indicates rare/supplemental guarding of women and children by homestead crops only

Guarding in the Field

Scare Tactic

In all sites, a daytime pest is scared away from the plot by silently approaching the foraging animal and, when in close proximity, throwing objects, such as stones, sticks, and spears, at the pest. This "approach and scare" method used in all sites and only by men. Women and children scare away an invading pest by shouting at the animal or by alerting men, who will then use the "approach and scare" method to deter the pest. In Didibe, guarding also occurs between the forest and plot. Evening in-field guarding is only carried out by men in all sites. Evening raiding pests are detected by sounds made while foraging. Shouting is mainly used to deter evening raiders due to poor visibility.

Daily Guarding Activity Profile

In-field guarding is carried out 24 hours per day, with the exception of one to two hours depending on the site. Due to interpretation difficulties in the Middle Wichi site details on daily guarding activity were unable to be collected. A daytime in-field guarding shift begins at 5:00am and ends at 6:30pm or 7:00pm in Upper Wichi and Didibe. In both sites there is a 90 minute gap between the daytime and evening guarding shift. This gap occurs from 6:30pm to 8:00pm in Didibe and 7:00pm to 8:30pm in Upper Wichi. This recess in guarding is reported to coincide with the return of vervet monkeys and baboons to the forest for the remainder of the night. Nighttime guarding begins at 8:00/8:30pm and ends with the start of the daytime guarding shift (5:00am). In Didibe, nighttime guarders were reported to nap from 4:00am to 5:00am when there is believed to be a break in nighttime and daytime pest raiding activity. Upper Wichi reported that occasionally farmers must guard in the field from 8:30 pm to 7:00pm the following day, taking all meals in the field.

Organization of Guarding

In Middle Wichi and Didibe, no distinction is made between wetland and upland daytime in-field guarding strategies. In both sites, guarding is organized and carried out individually by each plot owner and no system of communal guarding is used. In Middle Wichi, the number of people guarding a plot varies per farm and depends on the availability of farmers, however on average three people guard one plot. In Didibe one to four people guard depending on the size of the plot: one person guards if the plot is less than 1 ha, and three or four people guard if the plot is more than 1 ha or near the forest.

Upper Wichi has a different system of organization for wetland and upland daytime guarding. Joint-area or communal guarding is arranged among households for wetland plots. Farmers from participating households (approximately 50 to 70) form a rotating guarding roster based on area rather than individual plots. For areas 16 to 17 ha in size, seven to fourteen people will guard at a time. When pest populations are low, five to eight people will guard the area. Due to the scattering of upland plots, guarding cannot be organized by the "joint-area" method and must be carried out by individual plot owners. One to four people guard at a time depending upon the plot size and proximity to forest.

Nighttime guarding in all sites is organized by individual plot owners. Usually one person guards his own plot each night. Comments on night raiding severity are mixed, with farmers in Didibe stating that nighttime raiding pests are easier to detect due to lack of extraneous noise. Upper Wichi farmers, however, expressed concerns with nighttime raiding, stating that the lack of visibility (and silent feeding characteristic) of certain pests, such as the duiker and other antelopes, made it difficult to detect raiding animals.

Labor Divisions of in-Field Guarding

In Middle Wichi, the division of labor of daytime in-field guarding is a result of the availability of people. More men are stated to guard because they are already in the farm plot working. Women guard less because they spend a majority of their time working inside the. Children guard the least because they are students, however they do guard on weekends and in the mornings before school. In Middle Wichi, men, women

and children are thought to be equivalent in guarding abilities, with the exception of baboons not being deterred by women and children. Therefore, labor divisions are not a product of safety or efficacy, but rather reflect availability and convenience. In response to this information provided, a proportional piling exercise was carried out at Middle Wichi to determine the division of labor among men, women and children. Men are responsible for 46.6% of daytime in-field guarding, women responsible for 31.8% and children for 21.6%.

Proportional piling exercises were not carried out for Upper Wichi and Didibe, as almost 100% of in-field daytime guarding was reportedly carried out by well-aged men. Women, and sometimes children, guard minimally and usually only under certain circumstances. In Didibe, children under the age of 15 do not guard. In both sites, women and children will only guard crops close to the homestead.

Problems Encountered and Difficulties with In-Field Guarding

In all three sites guarding against baboons was listed as a problem encountered while guarding. Each site reported that guarding against baboons was unmanageable for women and children because the baboons are not afraid of them and therefore continue to raid. Upper Wichi expressed that this difficulty for women and children also occurs with other, unspecified pests. Upper Wichi described baboons as being "just as active as people and therefore difficult to guard against." Farmers described accounts of baboons dispersing themselves around plots or the forest edge, followed by one or two baboons darting through the field to attract the farmers' attention. While the farmers are busy chasing the invading baboon, the other baboons dispersed around the border raid the crops. Upper Wichi farmers expressed a sense of helplessness when guarding against such numbers of baboons. Other difficulties listed include: 1) difficulty to guard during heavy rainfall and during illness; 2) pests adapt to new strategies in guarding within one week; 3) almost all of the strategies used (supplemental and primary) are ineffective in deterring pests; 4) when an animal is scared away with the "approach and scare" method, it merely moves to another spot in the same plot and continues to forage; and 5) in-field guarding is dangerous due to threats of being attacked by large carnivores, such as leopards or wild dogs.

3.8 Predictions and Future Management Solutions

All three sites indicated that if no action is taken, then within the next 5 years the pest raiding problem will become much worse. Upper Wichi expressed concern that in the future people will be unable to cultivate the land due to pest raiding. Didibe attributed this future rise in raiding intensity to increased coffee cultivation and changes in animal behaviors rather than increases in animal populations. Government pressures to increase coffee production will reportedly exacerbate the current raiding problem by 1) suppressing the production of other livelihood crops, and by 2) facilitating the regeneration of forest, which will increase animal habitat and the likelihood of conflict between farmers and pests. Didibe (and Upper Wichi) farmers have reported that baboons have started eating coffee berries and flowers in addition to crops. With the addition of foraging on coffee berry, Didibe farmers believe that in the future even more time spent guarding will be required to protect crops against raiding pests. However, coffee guarding is described to be difficult because plants are grown inter-mixed with the forest trees. As a result, Didibe farmers believe that switching the primary crop to coffee will increase raiding intensity due to the difficulties of guarding coffee.

In contrast to Didibe, Upper and Middle Wichi explained this future rise in RI to be a result of increased animal populations. Didibe stated that animal population numbers are currently less than in the past, however raiding is still a rapidly growing problem because the wild animals are less afraid of and more aggressive towards humans, and have also adapted their diets to new crop grown.

Didibe and Upper Wichi farmers offered similar management solutions to alleviate the pest problem. These include: 1) relocation of pests to other forested areas, 2) conducting another culling campaign for a longer period of time, or 3) legalization of hunting of certain pests.

4. SUMMARY OF RESULTS

Results summarized in this section include 1) total crop loss by daytime and nighttime foragers (Table 4.1.1), and 2) summary of sites (Table 4.1.2).

Table 4.1.1 Total crop loss by daytime and nighttime foragers

Site	DAYTIME FORAGERS		NIGHTTIME FORAGERS	
	Wetlands	Uplands	Wetlands	Uplands
Middle Wichi	0.350749	0.413115	0.284665	0.206557
Upper Wichi	0.135022	0.178459	0.231646	0.114005
Didibe	0.299142	0.344466	0.192662	0.196516

Table 4.1.1 summarizes the total loss of crops due to nighttime and daytime mammal pests; loss due to termites and birds are excluded from this table. Nighttime foragers include the wild pig, porcupine, fox, aardvark, and duiker/antelopes. Daytime foragers include the baboon, colobus monkey, vervet monkey, and blue monkey.

Table 4.1.2 Summary of Sites

WETLAND								
	Percent Total Loss			Site Description		In-Field Guarding Organization		
SITE; hh; pp	Of Crops Grown	To Top 4 Pests (reported rank)		Plot Location	Cropping Strategy	Type	No. of People	Labor Division
Didibe hh: 96 pp: 538	49.18	Baboon (1) Vervet (2) Pig (4) Porcupine (3)	17.70 12.21 6.68 8.29	Close proximity	Double cropping	By Individual Plot	<1ha: 1; >1ha/ near forest: 3-4	Men* +W/C
Upper Wichi hh: 86 pp: 516	36.67	Baboon (1) Vervet (2) Pig (4) Porcupine (3)	6.75 6.75 7.85 6.58	Close proximity	Single cropping	Joint-Area	16/17ha: 7-14	Men* +W/C
Middle Wichi	68.85	Baboon (5) Vervet (1) Pig (8)	11.10 20.38 7.26	Close proximity	Single cropping	By Individual Plot	Avg. 3	Men (46.6); W

hh: 158 pp: 853		Porcupine (2)	11.35					(31.8); C (21.6)
UPLAND								
	Percent Total Loss			Site Description		In-Field Guarding Organization		
SITE; hh; pp	Of Crops Grown	To Top 4 Pests		Plot Location	Cropping Strategy	Type	No. of People	Labor Divis-ion
Didibe hh: 96 pp: 538	54.10	Baboon (1)	17.30	Scattered	Single cropping	By Individual Plot	<1ha: 1; >1ha/ near forest: 3-4	Men* +W/C
		Vervet (2)	11.82					
		Pig (4)	10.92					
		Porcupine (3)	5.57					
Upper Wichi hh: 86 pp: 516	32.80	Baboon (1)	10.65	Scattered	Single cropping	By Individual Plot	1-4	Men* +W/C
		Vervet (2)	7.19					
		Pig (4)	5.07					
		Porcupine (3)	4.63					
Middle Wichi hh: 158 pp: 853	75.41	Baboon (5)	16.23	Scattered	Single cropping	By Individual Plot	Avg. 3	Men (46.6); W (31.8); C (21.6)
		Vervet (1)	20.00					
		Pig (8)	8.11					
		Porcupine (2)	7.38					
		Birds	13.44					

5. DISCUSSION

5.1 Objectives and Site Overview

This research sought to identify the nature and factors contributing to the reported pest problem in Illubabor, Ethiopia. Research addressed 1) crop loss; 2) foraging behaviour of animals responsible for crop loss; and 3) guarding strategies used by farmers to protect their crops from raiding pests. Information was collected from farmers using participatory rural appraisal (PRA) and therefore represents perceived data, influenced by farmers' observations and indigenous knowledge.

All three sites are located within the Wichi wetland catchment west of Metu, Ethiopia (See Figure 2.1). The Middle Wichi site is located in the least forested area and

reports the most upland and wetland crop loss to pests. Farmers also reported that Middle Wichi was the site of most killing during the 2004 baboon culling. Upper Wichi, which is located closest to Metu and surrounded by the most forest, reported the least amount of crop loss, however, farmers stated that pest raiding is a severe problem that affects their livelihoods and future ability to cultivate the land. Didibe is located within a forest belt farthest from Metu and reported approximately half of all crops to be lost to raiding. Table 3.1.1 summarizes crop loss in upland and wetland areas for each site.

5.2 Top Four Pests and Ranking

Identifying the top pests and their preferences in wetland and upland plots may guide and enhance future guarding techniques, making them more efficient and specific towards dominant pests' ecology. Within wetland and upland areas for all sites, the top 4 animals responsible for the most damage to crops were determined to be baboons, vervet monkeys, wild pigs, and porcupines. These results confirm the ranking of pests in Upper Wichi and Didibe, and refute rankings in Middle Wichi. Middle Wichi ranked the top pests in the order of vervet monkey, porcupine, colobus monkey and fox. Only the vervet monkey and the porcupine were determined to make a significant contribution towards crop loss in both Middle Wichi wetland and upland plots. The baboon (ranked 8th in Middle Wichi) is the second most dominant forager in upland and wetland crops. This low ranking may be influenced by the reported low frequency of baboon visitation (3 times a week) when compared to the daily visitation of the top four ranked pests. The high ranking of the fox in Middle Wichi may result from the threat of rabies transmission and predation upon domestic livestock rather than its actual contribution to crop loss. Middle Wichi was the only site to express concern over fox transmitting rabies, however Didibe also did report fox predation newborn livestock.

The high ranking of the colobus monkey in Middle Wichi is unusual considering the reported low crop loss attributed to its foraging. This high ranking may reflect farmers' growing concern towards the newly observed behaviour of the colobus monkey to forage on subsistence crops. In all sites, the colobus monkey has been recently observed to begin foraging on sorghum tassel and maize. Middle Wichi also reported recent foraging on ripened coffee berry, a behaviour not observed in Upper Wichi and

Didibe. This recent foraging on coffee berry in conjunction with the current government pressures on Illubabor farmers to cultivate more coffee may be partially responsible for the raised threat of the colobus monkey in Middle Wichi. In addition to exhibiting new foraging behaviors, which some farmers believe to be learned from the vervet monkey, the colobus monkey demonstrates behavioural traits similar to other dominant pest. These behaviors include its reported capacity to learn, its high frequency and length of daily foraging periods, its agility and quickness, and its aggressiveness towards humans and guard dogs. Thus, the ranking of the colobus monkey in Middle Wichi may reflect its threat to become a future dominant pest, rather than its current and actual impact.

The recent observation of the colobus monkey to forage on subsistence crops may be in response to newly freed resource rather than a result of learned behaviours. Changes or declines in dominant forager populations may free up resources and renew foraging opportunities for lower foragers, or mesoforagers. Therefore, decline in top foragers, such as the baboon, may lead to a "mesoforager release." This hypothesis explaining newly exhibited foraging behaviours of the colobus monkey is an adaptation of the mesopredator release hypothesis (Yahner 1988; Litvaitis & Villafuerte 1996).

Large foragers require larger homeranges, and therefore, as landscapes are altered and core forest habitat is reduce by the spread of agriculture, it is likely that populations of megafauna will decline and, consequently, mesoforager populations will increase (Saether 1998, Yahner 1988). It is unknown how the 2004 baboon culling campaign affected baboon populations and the animal community composition. However, if baboon populations in Middle Wichi were actually reduced by the 2004 culling campaign, as was reported by Middle Wichi farmers, then this decline in top foragers may have led to rises in daytime mesoforager populations, such as the vervet monkey and colobus monkey. Other daytime foragers would no longer have to compete with baboons for crop resources, giving rise to more foraging opportunities and, consequently, more observations by farmers of foraging by different daytime pests.

Mapping changes in animal community composition and top forager populations and behaviours may provide insight into how human activities, such as modification of landscape design and use and large-scale culling, are likely to affect future trends in the distribution and abundance of wildlife communities and top forager composition (Yahner 1988).

5.3 Habitat Restrictions and Ecology of Pests

Broad knowledge of pest ecology, overall foraging strategies, and habitat restrictions may help farmers predict pest crop-raiding behaviours. This knowledge may help to minimize crop-raiding by allowing for farmers to modify their guarding strategies in response to patterns of crop loss and pest foraging behaviours. This study if the first to document crop raiding behaviours of pests within Illubabor. However, such accounts rest on farmers' observations and have yet to be confirmed by outside observations. The general ecology of ranked pests is discussed below, which serves to direct the analysis of guarding strategies specific to pest ecology.

The homerange of duiker, wild pig, and colobus monkey are restricted by vegetation cover (Stuart 1998). The duiker requires habitat consisting of woodland, thickets, and bush, completely avoiding open country, and homerange is not restricted by water. Dense vegetation cover is a habitat requirement of wild pig (Stuart 1998). Porcupine habitat consists of burrows, caves, rocks or dense vegetation, with several animals using the same burrow system (Stuart 1998). Baboon homerange is not necessarily restricted by forest, as it is found in savanna, montane areas, dense forest fringes and coastal habitats, however, restrictions include water accessibility, and large trees or cliffs for sleeping out of reach of predators (Stuart 1998). Vervet monkeys are found in savanna and riverine woodland, and coastal scrub forest. Similar to the baboon, habitat restrictions include sufficient sleeping sites, such as in trees or occasionally cliffs when suitable trees are not available (Stuart 1998).

The porcupine, duiker and wild pig are mainly active at night and foraging is primarily a solitary activity (Stuart 1998). When duikers feed, they may maintain close proximity to other species, including savanna baboons and larger antelope. Baboons, colobus monkeys and vervet monkeys are diurnal, sleeping at night and foraging during the day. All three primates are social animals traveling in large troops ranging in size (Stuart 1998).

5.4 Impact of Top Four Pests in Wetland and Upland Areas

Upland

At all sites baboons and vervet monkeys are responsible for the most crop loss in upland plots. Damage by wild pig is not similar to that of baboon and vervet monkey, likely due to differences in frequency of foraging and social behaviour. Baboons and vervet monkeys forage more frequently throughout the week and day than do wild pigs. In addition, the social behaviour of baboons and vervet monkeys may be responsible for their elevated raiding impact, i.e. larger number of individuals foraging in one bout compared to solitary foraging by nocturnal pests. Baboons have also been described to "strategically forage" by directing farmers' attention towards one raiding individual while other members of the troop raid an unoccupied section of the plot. Strategic crop raiding of this nature has also been observed in Kenya (Maples et al. 1976).

The dispersal of upland plots also complicates guarding; scattered plots are not buffered by crops from neighbouring farms, and therefore the entire perimeter of an upland plot may be exposed and vulnerable to incoming pests. Naughton-Treves' (1997) investigation of crop raiding in Kibale National Park, Uganda, supports this observation of increased vulnerability of scattered, upland plots. Naughton-Treves deduced that an individual's best defense against losing crops to wildlife is to have a neighbor's crops between his or her plot and the forest. Due to reduced visibility caused by dense vegetation cover, the direction and number of individuals approaching for a raid may be difficult to detect in upland plots bordering the forest, additionally complicating guarding. Plot dispersal also diffuses farmers throughout a large area, increasing the amount of area each farmer must guard.

Wetland

The same top four foragers were determined for all wetland plots, with more loss attributed to porcupines than in upland areas. Overall loss is more distributed across the top four pests in the wetland areas, though vervet monkeys and baboons are still responsible for the largest portion of crop loss. Both Didibe and Middle Wichi report a decrease in overall wetland loss due to raiding. Regardless of fewer crops lost in Didibe wetlands, loss to dominant foragers (baboon and vervet monkey) is actually reported to be slightly higher; only wild pig activity is reported to be less in Didibe wetlands. Most of this reduced wetland loss in Didibe can be accounted for the loss of other foragers,

such as the blue monkey and the colobus monkey. In Middle Wichi wetlands, the impact of baboon raiding is approximately 5% less than in upland plots. This difference in wetland loss is primarily a result of reduced loss to baboons and termites.

In contrast to these sites, Upper Wichi experiences an increase in wetland crop loss, despite reporting a 4% decrease in baboon raiding and a minimal decline of vervet monkey raiding. In addition, the same pests are found in both wetland and upland plots, with the exception of bird foraging in upland plots and fox foraging in wetland plots. However, the loss attributed to birds and foxes are approximately the same. This suggests that an overall increase of raiding by nocturnal pests in wetland plots is responsible for increased loss in wetlands. Such a difference may reflect inefficiencies in wetland night-time guarding in Upper Wichi.

5.5 Dominant Foragers by Crop Type

Identifying the dominant forager for each resource indicates foraging preferences for each pest and may provide insight into ways to best guard certain crops against specific animals with consideration to pest foraging behaviour. Figures 3.3.1 and 3.3.2 depict the crop preferences for each pest. In all wetland sites, there is a clear divide of dominant foragers dictated by crop type. The primary foragers on wetland potato are porcupines in Middle and Upper Wichi, and baboons in Didibe. The secondary forager is wild pig in Middle and Upper Wichi.

In Middle and Upper Wichi, similar differences in the likelihood of potato and maize loss were expected since both sites reported potato loss to the same top foragers (porcupine and wild pig) and described a similar wetland composition (UW-15% potato; MW-14.75% potato). However, differences in potato and maize loss are not significant in Upper Wichi, while significant in Middle Wichi. This random loss of potato in Upper Wichi could reflect differences in planting regime; Upper Wichi farmers plant potato anywhere in the plot as long as the area is well drained, whereas Middle Wichi farmers grow potato in the center of the plot. Differences suggest that potato crops may be less vulnerable to raiding by porcupine and wild pig if planted in the center of the plot. These differences in likelihood of loss also correlate with expressed difficulties in night-time guarding. Upper Wichi farmers reported difficulty in detecting evening raiding pests,

while other sites noted that nocturnal foragers were easier to audibly detect due to the lack of extraneous noise in the evening. Differences in the likelihood of potato and maize loss in Didibe are not significant. This similarity in frequency of potato and maize loss is expected since baboons are the reported dominant forager on both maize and potato in Didibe wetlands.

Dominant foragers on kale vary between sites. Pests of completely different pests ecology are reported to dominate this crop in Didibe (vervet monkey) and Upper Wichi (duiker/antelope). Damage to kale is attributed to both pests in Middle Wichi. Differences in the likelihood of loss of wetland maize and kale are not significant in Didibe, suggesting these inter-mixed crops share the same likelihood of damage to raiding pests. Since the vervet monkey is a dominant forager on both maize and kale in Didibe, this similarity in likelihood of loss is expected. However, in Upper and Middle Wichi, differences in the likelihood of maize and kale loss are significant. The differences in foraging behaviours and frequencies of visitation of dominant kale pests are likely to account for the large difference in the percent of kale lost in Upper Wichi (14.29%) and in Didibe (40%). Kale loss to vervet monkeys is likely to be higher due to the frequency of vervet monkey foraging (multiple times within an hour/day), the length of foraging period (5am to 7pm), and their social behaviour. Duikers tend to forage only in the evening, traveling either in pairs or alone, and are reported to be easily scared away by human presence. These characteristics may to reduce the impact of duiker per raiding bout compared to the vervet monkey. Kale is subject to foraging by both duikers/antelopes and vervet monkeys in Middle Wichi, which could account for the increased percent loss of kale (62.5%).

In upland areas, all major crops (maize and sorghum) are dominated by baboons and vervet monkeys. Considering that all sites reported similar top foragers and patterns of upland cultivation and farm composition, the same differences in likelihood of maize and sorghum loss are expected. Despite these similarities, sorghum loss is significantly different from maize loss in Didibe, but not significantly different in Middle and Upper Wichi. These different likelihoods may be a result of differences in upland daytime guarding strategies, the dispersal of upland plots (distance between plots), and the proximity of plots to the forest edge.

5.6 Guarding Strategies

Nighttime In-field Guarding

Nighttime in-field guarding is the only somewhat effective means to guard against nocturnal pests. This method was loosely defined as sleeping by the plot, detecting a pest by the noises it makes while foraging, and scaring away the intruder by yelling. There is no indication that guarding is targeted towards specific areas within a plot. Wild pigs and porcupines demonstrate a preference towards potato in wetland crops. In addition to these nocturnal pests, duikers and antelopes exhibit a preference towards kale and potato in Upper Wichi wetlands. With consideration to dominant potato foragers being nocturnal, potato loss at Upper and Middle Wichi may be reduced by modifying night guarding strategies to target specific areas of the plot that are more vulnerable to dominant potato foragers. Upper Wichi farmers may benefit from concentrating potato cultivation in the center of wetland plots, which could reduce loss by 1) having inter-mixed maize and kale serve as a buffer, and 2) increase the ability to detect nocturnal pests by concentrating potato in a specific, easily identifiable location within the plot.

Preferences of nocturnal pests in upland plots are more distributed across resources, with wild pig foraging the most on sorghum (and somewhat less on maize) and porcupine foraging only on maize. Duiker and antelopes are present in Upper Wichi and demonstrate a preference towards sorghum. Determining the direction from which these wild pests are approaching the upland plots may enhance the efficacy of upland nighttime guarding by allowing farmers to concentrate efforts in one direction or area. Taking into account duiker and wild pig habitat requirements, both pests are likely to approach upland plots from forested areas. Maize sections of upland plots are closest to the forest edge, being grown at the top of the plot. However, both pests demonstrate a preference towards sorghum, which is grown below maize, farther from the forest. Though maize may serve as a buffer to sorghum, damage to maize by wild pigs may also result from this large and heavy animal traversing through maize to reach sorghum. This same sort of destructive path is not expected from the light and agile duiker. The direction from which porcupines approach maize may be more difficult to determine since its habitat is unrestricted by forest cover.

Daytime In-field Guarding

Daytime in-field guarding is ranked as the most effective means of deterring daytime raiding pests. Invading pests are only temporarily scared away using the "approach and scare" method, with many pests merely moving to another, unoccupied area of the plot after the "scare." Only in Didibe is daytime guarding also reported to occur between the plot and forest boundary, while other sites described guarding only within a plot. Daytime guarding is almost entirely against foraging primates, with dominant foraging by baboons and vervet monkeys in upland and wetland plots and minimal raiding by colobus and blue monkeys in upland plots. Though colobus and blue monkey raiding is low, farmers reported that both are very difficult to guard against. The colobus monkey was described to be very dangerous, exhibiting an aggressive behaviour much different than other primates in the area. It is unresponsive to and aggressive towards women and children and can only be deterred by men. The blue monkey was also described to exhibit bold behaviour, scaring away guard dogs and not easily deterred by either men or women. The total loss attributed to daytime foragers is higher than nighttime foragers in all wetland and upland sites except at Upper Wichi, in which there is a higher loss of wetland crops due to nocturnal foragers (See Table 4.1.1.).

As discussed earlier, increases in total wetland crop loss in Upper Wichi are due to increased raiding activity of nocturnal pests, with the fox, porcupine, wild pig and duiker/antelope accounting for 63.18% of the reported loss (23.26% of total crops grown). Loss to baboon and vervet monkey raiding is actually less in Upper Wichi wetlands despite the overall increase in crop loss. Upper Wichi is also the only site that reports less activity of both baboons and vervet monkeys in wetland plots. Despite this higher loss of wetland crops in Upper Wichi, farmers reported that overall raiding is more of an issue in upland areas due to the increased difficulty of guarding against baboons in scattered, upland plots. This perception of overall raiding intensity compared to actual reported loss may reflect a lack of perceived threat of nocturnal pests to significantly contribute to crop loss. This discrepancy between perceived threat and loss may result in less emphasis placed upon the necessity for efficient, night-time guarding.

Although Middle Wichi also reports a decline in baboon activity in wetland areas, the reported total amount of crops taken by both baboons and vervet monkeys is much higher than in Upper Wichi. Other daytime foragers, such as the colobus monkey and blue monkey, are reported to be active raiders in Middle Wichi upland and wetland areas. Despite a reported decrease in total crops lost in Middle Wichi wetlands, there is much more raiding activity and loss attributed to daytime pests than in Upper Wichi. In Didibe wetlands, there are fewer types of raiding daytime pests than in uplands plots (loss of colobus and blue monkey activity in wetlands). However, regardless of less daytime pests being active, baboon and vervet monkey raiding is actually higher in Didibe wetlands. This variation in wetland daytime pest activity exists between all sites regardless of each reporting the same dominant daytime pests (baboon and vervet monkey) foraging primarily on maize (wetland and upland) and sorghum (upland), in addition to reporting the same patterns of farm composition and cultivation of the crops targeted by these pests (maize, kale, sorghum). Thus, this variation may reflect differences in the organization, and consequently efficacy, of daytime guarding.

In Middle Wichi and Didibe, daytime in-field guarding is organized and carried out individually by each plot owner and no system of communal guarding is used. Upper Wichi organizes wetland daytime guarding by joined areas, arranging rotating guarding rosters among households. This system of "joint-area" guarding may increase the efficiency of daytime guarding and reduce overall primate foraging impacts. If this were true, then joint-area guarding could be responsible for the lower amounts of total crops lost in Upper Wichi compared to other sites. Future research could test the efficacy of "joint-area" guarding by measuring the actual total loss and loss due to primates at each site.

In addition, the organization of guarding among many households may facilitate the transfer of indigenous knowledge of guarding techniques. Such collaboration on guarding strategies may promote the critique of various methods used, and lead to the innovation and acquiring of new, or the modification and adaptation of old, guarding strategies.

Although Middle Wichi and Didibe farmers utilize the same organization of daytime in-field guarding, the impact of vervet monkeys is much higher in Middle Wichi

than in Didibe. When comparing the total loss to daytime foragers in Didibe and Middle Wichi, Middle Wichi reports a higher loss of crops in both upland and wetland areas than does Didibe. The only major reported difference between Middle Wichi and Didibe daytime in-field guarding is in the reported division of guarding labour. In Didibe, guarding is conducted mainly by men, whereas in Middle Wichi guarding is distributed across the sexes with men responsible for 46.6%, women 31.8% and children 21.6% of the labour. In both Didibe and Upper Wichi, all primates are reported to be not easily deterred by women and children. In addition, baboons and colobus monkeys are reported to be aggressive towards women and, in some instances, men. Middle Wichi farmers have only observed these differences in guarding for baboons, while all other primates are believed to be equally deterred by men, women and children. Observations of primate behaviour towards men, women and children have yet to conducted, and therefore no data exists on the efficacy of guarding by gender. However, it is likely that in Middle Wichi primates other than baboons may act similar to those in Didibe and Upper Wichi and exhibit bold and aggressive behavior towards women and children. If this were true, then the effectiveness of guarding efforts by women and children would be less than that of men.

The division of labor in Middle Wichi could also reflect the perceived low threat of raiding by baboons. Farmers ranked baboons 8th of all pests, stating that after the 2004 culling campaign the baboon populations have declined and therefore raiding is much less of a problem. However, as previously discussed, baboons are responsible for a significant amount of crop loss in Middle Wichi. This gap between perceived threat of baboons and reported loss may lead to less precautions of baboon raiding in daytime guarding strategies. As a result, more women and children may be scheduled to guard despite raiding by baboons. In summary, if primates are not deterred by women and children, it is possible that the larger contribution of women and children to guarding may reduce the overall effectiveness of daytime guarding. If this primate behaviour is exhibited, then division of guarding labor in Middle Wichi may be responsible for the reported increased loss to daytime foragers.

5.7 Raiding Intensity, Seasonal Animal Activity and Cultivation Activity

The seasonal calendars provide insight into what time of the year raiding is most intense and how this intensity may correspond with the activity of certain animals or the activity of farmers. Differences between perceived animal activity and reported crop loss may be responsible for the gaps or weaknesses in guarding efforts. Knowledge of seasonal activity not only adds to the current analysis, but also serves to direct the timing of future research to occur at critical periods of raiding.

In upland and wetland plots, the planting of maize and the green stage of crops appear to coincide with high raiding intensity (RI). Activity of all four pests corresponds with early stages of crop maturity in both upland and wetland plots. In addition to this trend, high RI in upland plots and the presence of all four pests coincide with periods of heavy rainfall (July to September). Farmers expressed difficulties with In-field guarding during periods of heavy rainfall, and therefore it is unclear whether high RI during this period is due to reduced guarding efficiency or increased raiding activity.

Periods of high RI also coincide with labour and time intensive cultivation activities such as land clearing, coffee harvesting, sowing, harrowing and ditch clearing. Such labour intensive jobs carried out within a plot may reduce a farmer's vigilance in guarding. Coffee is cultivated within the forest edge separate from upland and wetland plots. Consequently, coffee cultivation requires time away from plots. This is likely to either reduce the amount of farmers available for in-field guarding or, if guarding efforts are maintained, increase the amount of people needed to work in-field at one time. Coffee cultivation places a high time- and work-demand on farmers, requiring in-field activities to be further allocated among uplands, wetlands, and agroforestry.

In uplands, all four pests are active from July to September which is a time associated with heavy rainfall. Crops are at an early stage of maturity in September, reaching full maturity in November. High RI at this early stage of maturity indicates that maize and sorghum are edible resources when immature. Coffee clearing also occurs during September, which may reduce farmers' abilities to adequately protect their crops, resulting in increased crop raiding. Wetland activities during periods of high upland RI include ditch clearing (July- Didibe only) and land clearing (September).

In wetlands, all four pests are active in May and June, which is associated with the green stage of crops. As in uplands, pests display a tendency to forage on crops at an

early stage of maturity. A peak in RI (January) in Upper Wichi coincides with planting of maize, although only vervet monkeys and porcupines are reported to be present. In Didibe, a peak in RI during the planting of maize (February) also occurs, with only baboons and vervet monkeys active. Upland activities during other periods of high RI include planting and weeding (May and June), and early harvesting and land clearing for coffee (September- Didibe only).

5.8 Predictions and Future Management Solutions

Farmers' responses to questions regarding the progression of the current pest problem and future management solutions reveal the desires, wishes and expectations of those affected by raiding. Answers identify factors that farmers perceive to influence raiding intensity. Solutions offered for the future management of pests also identify the level at which farmers believe management should be carried out, i.e. whether management should be bottom up, initiated at the grassroots level, or top down, initiated by the government.

All three sites identified a top down approach to pest management, expressing a sense of helplessness and inability to protect their crops due to government control of firearms and the illegalization of hunting. All sites described "action" being taken on the behalf of the government with no mention of grassroots efforts and capabilities. Of the three solutions offered, two suggest reducing animal populations by either holding another large-scale, extended culling campaign or by legalizing hunting. The third solution, described as being unlikely, called for the relocation of pests to other forested areas.

Upper and Middle Wichi attributed an increase in raiding intensity an overpopulation of pests. Middle Wichi also accredited rises in raiding to decreases in forest cover in the upland areas. Farmers explained that a loss in forest has caused more monkeys and other wildlife to travel farther from the forest in order to forage. These claims are supported by Yahner (1983), who suggested that as deforestation increases, vegetation in croplands provides better foraging than sparse, forest vegetation.

Middle Wichi farmers also recognized that wetlands provide a critical water source for wildlife and that during the dry season, wetlands crops are the only available

food resource in the area. Farmers and residents within Metu have reported drastic declines in the duration of the rainy season within the past few years. With consideration to climate change, drought, and animal water requirements, it is possible that a relationship exists between wetland raiding intensity, duration of the rainy season, and periods of drought. If a relationship does exist, then the high raiding intensity that reportedly coincides with the green stages of wetland crops may be exacerbated by shorter rainy seasons, resulting in fewer available food and water resources. Therefore, changes in climate to more arid conditions may also be a factor contributing to the growing pest problem.

In contrast to Upper and Middle Wichi claims, Didibe farmers stated that pest populations were lower than in the past, and that increases in raiding were not due to overpopulation, but rather due to changes in pest behaviours and government coffee cultivation objectives in Illubabor. Though Didibe recognized declines in forest cover and increases in human population, farmers did not relate this loss of core habitat, and the corresponding loss of forest food resources, to increases in raiding. In fact, Didibe farmers expressed concern that increased coffee cultivation will regenerate the forest and consequently this increase in core habitat will lead to an increase in pest populations.

No data on animal populations in Illubabor exists, and therefore it is not possible to determine if increases in raiding are due increases in pest populations, changes in the animal community composition, or changes in pest behaviour. Data on the past and current population sizes of the presently dominant pests may indicate what animals are (and were) responsible for the most crop loss. This data will also identify how the culling of specific animals, such as the 2004 baboon cull, affects the animal community and pest composition within an affected area. Currently, it is unknown whether the 2004 baboon culling alleviated raiding, and how changes in baboon populations, if any, affected the population sizes of other pests. If baboon populations were reduced by culling, it may be possible that this decline in top foragers led to a release of mesoforagers. Such a release would result in the population explosion of multiple, though less dominant, foragers. A sharp rise in mesoforager populations would likely complicate guarding strategies by either deeming strategies no longer adequate to guard against new pests or by requiring the quick adaptation or modification of strategies to new foraging behaviours and patterns

of crop loss. In addition, multiple foragers of moderate impact may cause more overall damage to crops or be more difficult to guard against than fewer foragers of high impact. Thus, data on changes in animal populations and dominant foragers are absolutely critical when considering future management solutions.

6. CONCLUSION

Identifying the foraging behaviours of current pests and determining how and why dominant pest species and their behaviours change over time, may aid in future guarding decisions and decrease the impact of guarding and crop loss on farmers' livelihoods. Knowledge in pest foraging behaviours and patterns of crop loss may assist in identifying gaps and inefficiencies in guarding strategies. Further investigation of the efficacy and practice of guarding strategies across sites may also reveal variation in techniques used. Identifying these discrepancies and differences may initiate the critique and analysis of current methods in use, sparking ideas on ways to improve weaknesses. Communication between farmers from different sites provides an opportunity for farmers to share experiences and critiques of guarding strategies and how pests respond to them. Such discussion may lead to innovation, modification, or adoption of different guarding strategies.

With the steady rise of demand on land resources, the spread of agriculture and increase in human populations, the forest cover in Western Ethiopia is likely to continually decline, increasing the amount of forest edge and decreasing secure habitat for wildlife. With this increase in deforestation, vegetation in croplands will presumably become a major food resource for foraging animals. In addition, modifications in landscape design and use may affect future trends in the distribution and abundance of wildlife communities (Yahner 1988). This may alter top forager composition and result in changes in the patterns, timing, and intensity of crop loss to wildlife. Farmers in the Illubabor zone, Ethiopia, may benefit from future research which 1) maps changes in animal populations and pest composition, 2) observes actual pest raiding behaviour and human guarding practices; 3) measures actual crop damage attributed to each pest; and 4) maps actual patterns of crop loss within wetland and upland sites. Findings from future

research may help farmers predict trends in foraging behaviours and crop loss, and allow for them to alter their guarding strategies accordingly. Changes in guarding strategies may enhance farmers' abilities to protect their crops from raiding pests, therefore reducing the impact of wildlife raiding on their livelihoods.

7. REFERENCES

Dixon, A.B. 2005. Wetland sustainability and the evolution of indigenous knowledge in Ethiopia. The Geographical Journal 171(4): 306-323.

Hill, C.M. 2000. Conflict of interest between people and baboons: Crop raiding in Uganda. International Journal of Primatology 21(2): 299-315

Litvaitis, J.A. and R. Villafuerte. 1996. Intraguild predation, mesopredator release and prey stability. Conservation Biology 10 (2): 676-677.

Maples, W.R, Maples, M.K, Greenhood, W.F., and M.L. Walek. 1976. Adaptations of crop-raiding baboons in Kenya. American Journal of Physical Anthropology 45: 309-316.

McCann, J.C. 1995. People of the Plow: An Agricultural History of Ethiopia. University of Wisconsin Press, Madison. pp. 23-38

Naughton-Treves, L. 1997. Farming the forest edge: Vulnerable places and people around Kibale National Park, Uganda. Geographical Review 87 (1): 27-47

Saether, B. 1998. Conservation biology top dogs maintain diversity. Nature 400: 510-511

Stuart, C. and T. Stuart. 1998. Field Guide to the Larger Mammals of Africa. Ralf Curtis Books, Sanibel Island Florida.

UNDP-EUE. 1999. Prosperity fades: Jimma and Illubabor zones of Oromia region. Emergency Unit for Ethiopia- assessment mission. EUE, Addis Ababa.

Yahner, R.H. 1988. Changes in wildlife communities near edges. Conservation Biology 2: 333-339

Yahner, R.H. 1983. Seasonal dynamics, habitat relationships, and management of avifauna in farmstead shelterbelts. Journal of Wildlife Management 47: 74-84