WINTER FORAGE AS A LIMITING FACTOR FOR GUINEAFOWL IN PLANTATION FORESTRY LANDS

By

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Submitted in partial fulfilment of the academic requirements
for the degree of
Master of Environment and Development
In the
Centre for Environment and Development,
School of Applied Environmental Science,
University of Natal

Pietermaritzburg
2003

ABSTRACT

This research investigates the potential impacts that a change in land-use to plantation forestry from an area of extensive / intensive agriculture has on helmeted guineafowl *Numida meleagris* populations. A comprehensive literature review revealed that the likely limiting factors for guineafowl in plantation forestry areas include the age of plantation, proportion of home range planted to timber and the availability of winter forage species. Initially the process of planting creates a disturbance that encourages favourable weed and grass species for guineafowl that provide winter forage and suitable groundcover. Up to five years since planting, habitat conditions are favourable and guineafowl populations increase. After five years, the shading effects from the *Pinus* spp. results in a decrease in species richness of the understorey vegetation as well as a decrease in the abundance of crucial winter species such as *Cyperus esculentus.* As a result populations of guineafowl start to decline. Guineafowl populations that have plantations older than ten years within their home range need to have diets supplemented by grain maize, or a suitable grain substitute, unless there is adequate unplanted area to meet their nutritional needs.

The rationale for this study originates through a mixed response in growth rates of guineafowl flocks observed in the study area. The study-site for this research is North East Cape Forests, near the town of Ugie. Land-use in this area was an extensive beef and sheep grazing farmland. Up until recently, much of the area has been transformed into plantation forestry, planted to predominantly *Pinus* species. The effect of a change in land-use to plantation forestry on guineafowl populations is largely unknown and this research therefore presents the first attempt to gain an understanding of how plantation forestry can impact on guineafowl populations.

This research forms the final component to the degree of Master of Environment and Development: Protected Area Management. It is a mini-dissertation with an

expected duration of six months. The research has been written up as two separate components. Component A includes a study of the literature and methods used in the dissertation. Component B presents the findings of the research with conclusions and recommendations. Component B has been written and formatted for submission according to the standards required by the South African Journal of Wildlife Research.

PREFACE

The research described in this mini-dissertation was carried out at the Centre for Environment and Development, University of Natal, under supervision of Mr Jan Korrubel.

This mini-dissertation represents the original work of the author and has not otherwise been submitted in any form for any degree or diploma at any university. Where use has been made of the work of others it is duly acknowledged in the text.

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CHAPTER 1. GENERAL INTRODUCTION.

The transformation of landscape to suit human needs has been recognised globally as the primary reason for the demise of many of the world's species (Primack 2000). In South Africa, large-scale landscape transformation has occurred from natural grasslands and forests to sugarcane, maize monocultures and afforestation in order to meet the demands of human consumption. Generally this transformation has lead to the demise of many avian species (Allan *et. al.* 1997). However there are those species that benefit from habitat transformation. One such bird that has arguably benefited from the modification of landscape is the helmeted guineafowl *Numida meleagris* (Ratcliffe & Crowe 2001a). Associated with much of the transformed landscapes has been an increase in fragmented landscapes that provide a mosaic of agricultural and natural vegetation types, which provide good quality habitat for guineafowl.

Since most of the guineafowl habitat falls outside the jurisdiction of conservation authorities (Whittaker 1990), the success of the species lies in the conservation efforts of farmers and other land-owners. Since this species is extremely resilient to habitat transformation (Ratcliffe & Crowe 2001b), it may act as a reflector of the state of biodiversity within South Africa. Essentially the demise of the helmeted guineafowl across the region may be a reflection of improper and environmentally unfriendly management practices, (Pero & Crowe 1996).

The transformation from natural grassland and areas of intensive and extensive agriculture to plantation forestry represents a radical change in both vegetation structure and species composition. With such a change, elements of habitat quality are affected in both positive and negative ways allowing for an increase in abundance of populations if conditions are more favourable. The effect of a change in land use to plantation forestry on guineafowl populations is largely unknown. The purpose of this paper is to try and assess the potential impact that afforestation may have on the future of this species. By reviewing the available literature on guineafowl ecology, an attempt is made to identify those factors that may be limiting to populations of guineafowl in afforested areas. Limiting factors as defined by Crowe (1978a) are those factors that potentially inhibit the growth of a population of a species from reaching its maximum potential. Unpublished research by (Mc. Pott *pers. comm.*) found that *Cyperus esculentus* was the major constituent of the winter diet of the helmeted guineafowl in the area. Special emphasis will be placed on the availability of winter forage, particularly the availability of *Cyperus esculentus*. It is likely that the major limiting factor for guineafowl in plantation forestry areas is diet related.

At the beginning of each chapter of this component is a review of the relevant literature and past research pertaining to guineafowl.

1.1 Problem Statement.

With the transformation in land use from intensive / extensive agriculture to plantation forestry, it would appear that those flocks of guineafowl that have home ranges surrounded by forestry, no longer have access to grain crops in the winter as a food resource. Residual grain from cultivated crops along with bulbs and tubers of the Cyperaceae are known to provide guineafowl with crucial dietary requirements in the winter months when food reserves are considered scarce (Grafton 1970). It is therefore likely that guineafowl have a stronger dependency on weed species such as members of the Cyperaceae family particularly *Cyperus esculentus* in plantation forestry areas. With the growth of trees in a plantation area, understorey vegetation is changing in composition as a result of competition from the *Pinus* trees. It is not known if the vegetation includes those species that provide adequate food in the winter for guineafowl. A study of this nature should be able to predict the available winter forage within each of the forested stands and project them onto known home ranges of flocks. This is to ensure that managers that wish to increase populations of guineafowl can take precautionary decisions with regards to supplementing the diet of particular flocks with maize, or by creating disturbances to promote winter forage. e.g. by ploughing marginal lands to encourage *Cyperus* spp. in the winter. Information gained in this research will provide value in the conservation of other gamebirds that have similar dietary requirements. Recommendations may also provide useful information to land owners that wish to promote the species.

1.2 Research Purpose.

Aim: The purpose of this study is to determine the impact that plantation forestry has on the availability of weed species particularly *C. esculentus* as winter forage for guineafowl.

Objectives:

1. To show that the availability of winter forage is the limiting factor for guineafowl populations in plantation forestry areas.
2. To classify the compositional characteristics of the vegetation within the forested stands and identify those important guineafowl forage species.
3. To rate each of the forested stands and home ranges of flocks according to forage availability.
4. To see if there is a correlation between the availability of forage and flock growth rates.
5. To give recommendations for guineafowl management within plantation forestry.

CHAPTER 2. A CONCEPTUAL FRAMEWORK FOR GUINEAFOWL MANAGEMENT.

A conceptual framework of guineafowl management is provided in Figure 1. Identified factors that regulate guineafowl populations include the quality of their habitat, predation, harvesting, rainfall and the presence of agrochemicals within the area. Habitat quality is manipulated through the actions of management. Management actions directly related to guineafowl conservation include the burning regime, level of disturbance, past land-use, zoning of land-use and the stocking rates of grazing species within the system. Essentially, these activities all change the species composition and structure of the habitat. This in turn determines the quality of the food resources, nesting sites, roosting sites and cover suitability.

Other factors that affect habitat quality for guineafowl include macro features such as topography, geology and soil type. These macro features are excluded since there is little that management can change in this respect.

Monitoring the guineafowl population will give management an indication of the maximum numbers of birds to be harvested in the form of wing shooting. The state of the population will then feedback towards management influencing further actions to create a favourable environment for guineafowl.

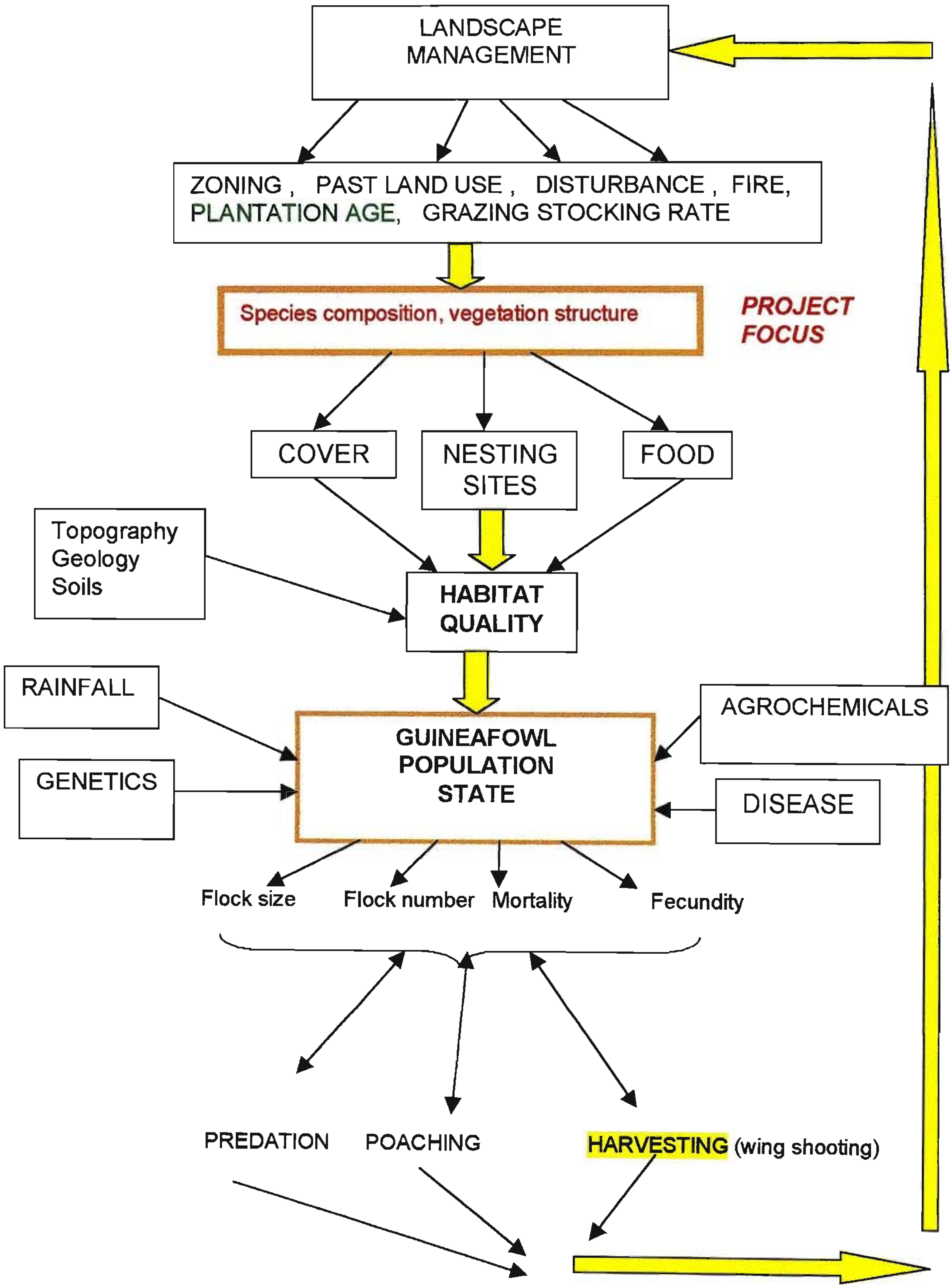

Figure 1. A conceptual framework for guineafowl management.

CHAPTER 3. THE ECOLOGY OF GUINEAFOWL.

3.1 Past Research on guineafowl ecology.

Early research on guineafowl was conducted by Skead (1962); and Grafton (1970) who did studies on their behaviour. Further research by Crowe (1978a) who traced the phylogeny of the bird, initiated ecological studies on the species. Various research was undertaken on diet studies (Grafton 1970; Mentis *et al.* 1975; Winterbach & Oosthuizen 1992; Ayeni 1983) as well as attempts to explain the relationship between summer rainfall and breeding success (Berry & Crowe 1985; Crowe 1978a; Crowe 1978b). Work on specific aspects on the ecology of the species is limited. Most of our present understanding on guineafowl ecology originates from applied research that investigated reasons for the decline in populations in extensive / intensive agricultural areas, especially in the KwaZulu-Natal Midlands (Pero & Crowe 1996; Malan 1998; Malan & Benn 1999; Ratcliffe 2000; Ratcliffe & Crowe 2001a, b). This paper will therefore review a large portion of the research that investigated the possible reasons for the decline in the KwaZulu-Natal Midlands since this research will give an indication of the potential impact of plantation forestry on guineafowl. The chosen study site in the North Eastern Cape has a similar climate, topography and land use to that of the KwaZulu-Natal Midlands and hence make the habitat characteristics comparable.

3.2 Phylogeny and Distribution.

Guineafowl belong to the order Galliformes (Crowe 1978a). Of the nine recognised African subspecies, only three sub-species are found in southern Africa. *Numida meleagris damarensis* is confined to the drier western parts of Botswana and Namibia, with *N. meleagris coronata* occurring across the rest of South Africa (Crowe 1978a). A third subspecies *N. m. mitrata* is found in Mozambique, Zimbabwe and northern Botswana (Ratcliffe 2000). The South African form of the helmeted guineafowl *N. m. coronata* can be distinguished from other subspecies by its bony casque or 'helmet' on top of its head and long, pennant-shaped wattles which are blue with red tips and hang down from its jaw (Ratcliffe 2000). There is no obvious difference in appearance between the sexes although males are slightly larger in size. Differences exist in behaviour with males exhibiting the courtship displays (Ratcliffe 2000).

The helmeted guineafowl is endemic to Africa and is distributed throughout sub-Saharan Africa (Crowe *et al.* 1986). It is locally common to abundant in virtually all open-country terrain from near desert to the edges of forest and the bases of high mountains. Once predominantly a savanna species, the helmeted guineafowl has undergone range expansion, which has been associated with modern agricultural land-use practices. Humans have largely expanded this species range by adding the missing habitat requirements such as roosts, cover and watering points to the landscape. Range expansion has been further promoted by the capturing and subsequent releasing of wild birds into new areas (Crowe 2000, Ratcliffe 2000). Today, guineafowl are commonly associated with intensive/ extensive agricultural land-use practises. Helmeted guineafowl even occur in suburbia where they have interbred with domestic varieties of guineafowl. The helmeted guineafowl appears to be only constrained in distribution by low rainfall and severe human-induced habitat degradation (Little 1997). In southern Africa, it is absent from the deserts and sub-deserts of the Northern Cape and Namibia where it is speculated that there is shortage of drinking water and adequate roost sites (Ratcliffe 2000).

3.2 Population status.

In much of Africa, heavy hunting pressure and egg collecting has affected the population of the helmeted guineafowl (Crowe *et al.* 1986). Up until the 1970s, guineafowl were considered locally common to abundant. Since then, there has been a dramatic decline in populations in Gauteng, Mpumalanga and especially in KwaZulu-Natal (Crowe 2000). In some cases guineafowl populations have declined to local extinction (Pero & Crowe 1996). Much research has been conducted on investigating the reasons for the decline in KwaZulu-Natal (Malan 1998; Malan & Benn 1999; Ratcliffe & Crowe 2001a, b). The most apparent reason for the decline in KwaZulu-Natal has been associated with an intensification of agricultural land use practises (Johnson 1984; Pero & Crowe 1996; Malan & Benn 1999). This has led to an increase in the use of agricultural chemicals in crop production, and a loss of marginal habitat that is considered crucial for nesting and roosting sites. The application of herbicides and pesticides in crop production removes a high proportion of arthropods and weed species which are important for egg-production in females and the survival of their young (Malan & Benn 1999). Marginal habitat that provides the crucial habitat features for nesting has been transformed to large stands of monocultures. Large open stands of monoculture crops are considered unfavourable, where a landscape with a mosaic of land-uses over a small area is preferred. Helmeted guineafowl are often abundant in savannas mixed with cultivation (Malan & Benn 1999). In such cases, the savanna areas provide nesting-cover, roosts and refuge against predators (Crowe 1978b). The adjacent cultivated lands provide residual grain, weeds, tubers and arthropods, the bulk of the species' food. Guineafowl populations are also known to vary seasonally. Crowe and Siegfried (1978) showed that the populations of birds fluctuated quite dramatically, exploding in years when there was good rainfall prior to the breeding season.

3.4 Habits.

Guineafowl are gregarious in nature and tend to form large flocks over the non-breeding, winter period. Flocks are typically 15-40 birds but flocks of up to 150-200 birds are not uncommon (Crowe *et al.* 1986). During the non-breeding period, flocks typically descend off the roost in the early hours of the day and move to water to drink and socialise. Feeding takes place from the early hours up until mid-morning. Thereafter the birds tend to seek thick cover for the heat of the day. In the late afternoon, feeding re-commences after which they will return to their roost just prior to sunset. A potential reason for the formation of flocks in winter is that more protection is offered by being in a group, since vegetation cover is particularly low (Whitakker 1990).

As the breeding season approaches, flock size steadily drops and the first few days with heavy rainfall stimulate pairing (Ratcliffe 2000). It is at this time when males are seen courting females. A behaviour that typically involves males chasing one another in a contest of fitness. This chasing can sometimes lead to fighting with the beaks, wings and claws used as weapons.

3.5 Home ranges.

For the purposes of this paper, home ranges are defined as those areas where birds spend 95% of their lifetime. Guineafowl home ranges tend to be centred around roosting sites (Whittaker 1990) and their respective size is dependent upon the type of habitat (Crowe *et al.* 1986). Research on the size of home ranges by Ratcliffe & Crowe (2001a, b), found that the mean home range for stable flocks was 11.4 ha. Unstable, near extinct flocks had much larger home ranges and were calculated to be up to 252.7 ha. Large home ranges were associated with those arid areas where surface water was a limiting factor for guineafowl. A study in the KwaZulu-Natal Midlands found that the home ranges of flocks was between 8 and 18 ha (Malan & Benn 1999). Whittaker (1990) noticed that different flocks may share foraging habitat and thus their home ranges may overlap, but there was little emigration and immigration between flocks and birds always returned to their roosting sites. Guineafowl home ranges were observed to overlap in the non-breeding season where birds were less territorial (van Niekerk 2002).

3.6 Habitat requirements by guineafowl.

Rands (1988) defines an animal's habitat as *"the set of environmental characteristics or resources upon which it depends for its survival."* These resources and characteristics include food supplies, a suitable site for breeding, and some form protection against predators and harsh weather. Habitat selection is thus influenced by resource availability. In guineafowl, the use of habitat is strongly influenced by diet: In a habitat utilisation study, Ratcliffe and Crowe (2001a, b) found that guineafowl tended to avoid open grasslands, since food was limiting in these areas. Research by Whittaker (1990) on habitat preference, showed that guineafowl also tended to avoid residing in areas associated with high human activity.

3.6.1 Roosting.

Guineafowl require elevated areas for roosting. Often clumps of adjacent mature trees are selected. Skead (1962) found that some flocks used kloofs as roosting sites. In some areas, even telephone poles have been used as roosts (Crowe *et al.* 1986). Flocks of guineafowl were observed to rarely change or move roosting sites (Whitakker 1990).

3.6.2 Cover.

Cover is recognised as a critical habitat feature with respect to guineafowl (Crowe *et al.* 1986). Guineafowl require thick grass and trees to escape predators (Malan & Benn 1999). Common predators for guineafowl include raptors, and small carnivores such as caracal *Felis caracal* , serval *Felis serval* and African Wildcat *Felis lybica*. It has been reported that the increase in feral cats are also having a profound effect on guineafowl populations (Pero & Crowe 1996). Nesting sites tend be in thick grass as well. The density of the grass is likely to be a function of rainfall and this might explain the indirect relationship between the amount of rainfall prior to the breeding season and the success in reproductive rate (Crowe 1978a; Berry & Crowe 1985). Malan (1999) identified three critical factors that constitute suitable grassland cover for ground nesting gamebirds. These include the density of the vegetation, which may be critical to shield nesting birds from predators and the elements, secondly the height of the vegetation may be critical to hide birds and their young from aerial predators. The third factor is the annual frequency of burning and grazing. The typical grazing and burning regime for sourveld grasslands is that the grasslands are grazed heavily in the summer rain season and are burnt in the winter. Such practises may significantly reduce available cover at the onset of the breeding season and may thus affect the nesting success of guineafowl and other ground nesting birds (Malan 1999). Not only is the grazing pressure a likely influence on cover availability but also the type of grazers within the system. For example, by virtue of their feeding habits, both cattle and sheep can cause very different structural and compositional changes in the vegetation even at the same stocking rates. Therefore the type of grazers within the system would thus have a likely impact on the available cover for ground nesting birds. A reduction in available cover may thus lead to a reduction in suitable sites for nesting, increase in predation and increased exposure to the elements.

3.6.3 Food and feeding.

The helmeted guineafowl is a highly opportunistic feeder with a mixed diet, ranging from invertebrates to grass seeds, cereals and bulbs (Ratcliffe 2000; Little 1997). A study conducted on the diet of guineafowl by Winterbach and Oosthuizen (1992) showed that approximately 25 % of the diet, of both male and female birds combined, was composed of invertebrates, but the bulk of the diet (75 %) was from agricultural products and weeds. A categorisation of the diet of guineafowl is presented in Table 1. During the rainy season, evidence suggests that the species concentrates on invertebrates and grass seeds since this is when these forage resources are most abundant, and females require the higher protein diet for egg production (Crowe 1978b; Malan & Benn 1999; Ratcliffe 2000).

Table 1. A summary of diet categories by guineafowl from Mentis *et al.* (1975).

ANIMAL MATERIAL	PLANT MATERIAL
Beetles	Maize seed
Grasshoppers	Grass seed
Ants	Cyperaceae tubers
Larvae	Weeds

ANIMAL MATERIAL	PLANT MATERIAL
Arthropod pupae	
Spiders	

Winter is recognised as a critical time for guineafowl to obtain important food resources (Ratcliffe & Crowe 2001b; Grafton 1970). Especially important at this time, is the availability of maize, access to bulbous weeds in fallow lands and some winter greenery (e.g. lucerne), (Ratcliffe & Crowe 2001b).

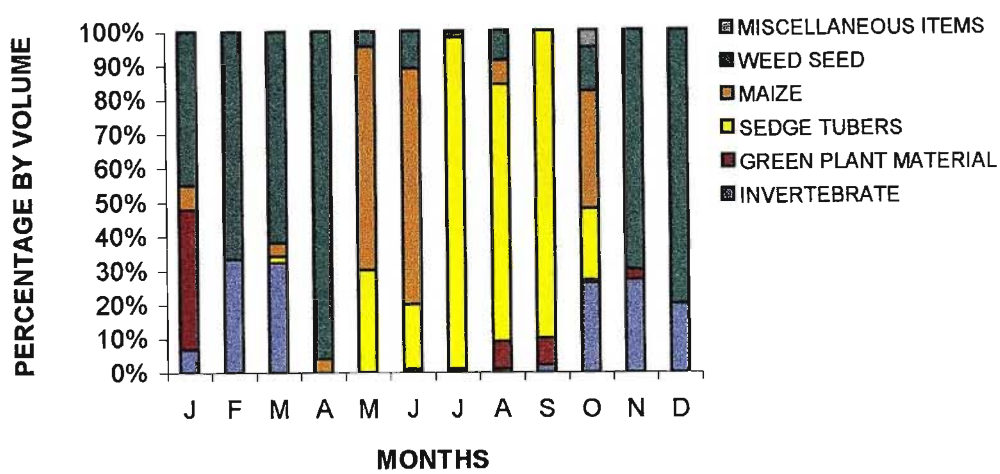

Figure 2. Monthly variation in food intake by guineafowl (from Mentis *et al.* 1975).

A guineafowl crop content analysis by Mentis *et al.* (1975) showed how the diet of guineafowl varied over the months and seasons. Figure 2 illustrates the distinct variation between the winter and summer diet of the birds. The summer diet (October to March) indicates that invertebrates and weed seed (non-agricultural seed) made up the most of the diet. Over the winter period, (April to September) maize and sedge tubers (Cyperaceae) make up the bulk of the diet. Clearly these guineafowl had access to residual maize after harvesting (May to June). The sudden shift to sedge tubers in July might be explained by the depletion of residual maize (Mentis *et al.* 1975). A more likely explanation is that the tubers of sedge are only fully developed at this time making them an available resource to guineafowl.

Studies of the diets of guineafowl by Winterbach and Oosthuizen (1992) showed that tubers of the Cyperaceae made up 27.5 % of the total diets of the birds sampled. In a similar study in KwaZulu-Natal by Grafton (1970), tubers of the Cyperacae made up 12.5 % of the diet of birds. In both studies, maize and other agricultural cereal crops made up most of the diets, with tubers of Cyperaceae making up the next highest category. In such cultivated areas it would appear that weed species and bulbs have an important role in supplementing the diet with the residual cereals or grains. Research by Ayeni (1983) in Nigeria on the diet of guineafowl in the Kainji Lake Basin area, a savanna area, where there was an absence of grain crops, found that the bulbs of Cyperaceae were prevalent in most of the guineafowl crop contents. Cyperaceae tubers were also a dominant food source in the Waza district in Cameroon (Njiforti *et al.* 1998).

CHAPTER 4. OTHER THREATS AND LIMITATIONS IMPACTING ON GUINEAFOWL POPULATIONS.

In addition to the crucial habitat elements of cover, roosts, food resources, a number of other limiting factors could affect guineafowl populations in the study area.

4.1 The effect of agrochemicals on guineafowl populations.

Although guineafowl have expanded their range with the transformation of natural landscapes to agricultural monocrops, certain factors that are associated with agriculture have a negative impact on bird populations, especially guineafowl. The increase in the use of agrochemicals in crop production to sustain higher yields of food to meet the needs of an ever- increasing human population has had both a direct and indirect effect on guineafowl populations. The intensive use of herbicides and pesticides has been recognised as a potentially limiting factor for guineafowl populations (Grafton 1970; Ayeni 1981; Johnson 1984). Since more than 80 % of the guineafowl's diet can be attributed to agriculture in South Africa (Ratcliffe 2000), the application of agrochemicals can have a huge impact on guineafowl populations. The consumption of large quantities of agricultural grains in winter, and arthropods in summer (Grafton 1970; Mentis *et al.* 1975) results in guineafowl populations being exposed to a host of agrochemicals (Ratcliffe 2000). Pesticides will not only kill insect pests that are important constituents of the bird's diet but will also affect other non-harmful insects. In a similar fashion, herbicides may kill important weed species and Cyperaceae that are important in the winter diet of the birds (Mentis *et al.* 1975). Sub-lethal doses of 2,4-D, paraquat and monocrotophos, pesticides used within South Africa, are known to lower the reproductive success and survival of game bird chicks (Stromborg 1986; Potts 1986; Orians & Lack 1992 *in* Ratcliffe 2000).

Research on the potential of agrochemicals being a significant factor in to the decline of helmeted guineafowl was investigated by Crowe & Peall (2000). Their study did not find direct associations with guineafowl mortality and the presence of agrochemicals but more importantly it was the indirect effects of chemicals that were of interest. Their study concluded that the intensive crop agriculture and subsequent chemical use, may have resulted in a reduction in essential resources, notably food and cover, thus depressing guineafowl populations (Pero & Crowe 1996; Malan & Benn 1999; Ratcliffe & Crowe 1999; *in* Ratcliffe 2000).

4.2 The susceptibility of guineafowl to disease.

Guineafowl, along with pheasants (Phasianinae), partridges (Perdicini), quails (*Coturnix* spp.) and francolins (*Francolinus* spp.) are known to be vulnerable to certain diseases that are associated with the domestic chicken (*Gallus gallus*). Common diseases are the avian encephalomyelitis and Newcastle disease or avian influenza. Since the commercial chicken industry uses specifically designed vaccination programmes and various forms of biosecurity (fences, sanitation, quarantine facilities, etc.) it is likely that diseases get spread via rural domestic chickens (Walker *et al.* 2000). These chickens are often not vaccinated, mix freely with other chickens in free-ranging environments and are traded live, making them ideal agents for the transportation of diseases. A study by Horner *et al.* (2000) on the potential of disease to be a likely factor that contributed to the decline of guineafowl in KwaZulu-Natal yielded non-significant results. The potential for disease to transmitted from rural chickens to guineafowl remains fairly high and could certainly influence the survival of flocks.

4.3 Genetic contamination from interbreeding with domestic varieties.

For centuries guineafowl have been domesticated and bred for traits such that their appearance, anatomy and behaviour, and are quite distinct form wild varieties (Crowe 1978a). Domesticated guineafowl have been introduced to areas with wild varieties and have hybridised with wild stock. This interbreeding with domestic and wild stock may undermine the ability of their offspring to survive in the wild. The interbreeding between native and introduced taxa, even at a small scale, has the potential to cause genetic introgression, jeopardising a species' integrity (Ratcliffe 2000). The artificial selection in the breeding of domestic guineafowl could undermine the viability of wild populations if interbreeding did take place (Crowe 2000). Since Ratcliffe and Crowe (2001a, b) reported individuals with mixed traits of both domestic and wild stock, hybridisation must have occurred in some flocks in KwaZulu-Natal. It is thus likely that other populations outside of KwaZulu-Natal have also hybridised and thus may reduce the viability of certain flocks to increase to the best of their potential.

4.4 Rainfall and its influence on guineafowl populations.

Patterns have been detected with higher rainfall years and increased flock sizes and improved breeding success. Crowe (1978a, b) studied the influence of weather patterns, especially rainfall, on the shooting index of guineafowl populations. (The shooting index is an indirect estimate of the population since it assumes that there is a direct relationship between the number of birds shot and the total population for that year. Rainfall is likely to effect available cover for birds as well as the availability of certain food resources. During the higher rainfall period, adult female birds require a high protein diet for egg production. Young birds also require the high protein diet for growth and development. This may explain why both female and young consume a high proportion of arthropods at this time of year. Since the number of arthropods increase with rainfall and this might therefore explain the poor breeding success with the low rainfall since these birds are not attaining the critical protein resources for egg production and growth (Crowe 1978a, b). In drier more arid environments, rainfall may also play a substantial role in the availability of drinking water as well in the availability of sedge and weed species.

4.5 Hunting pressure as a limiting factor for guineafowl.

The helmeted guineafowl is Africa's most widespread and probably most well known gamebird (Little 1997). Recognised for its value in the wing-shooting industry, the helmeted guineafowl is a high profile species that has been hunted for recreational purposes since the beginning of the twentieth century (Grafton 1970). Guineafowl are recognised as gamebirds since they are, or have the potential to be shot on a regular basis for recreational purposes where populations are at harvestible sizes. Where it is economically feasible, economic incentives that result from such hunting can be used to promote careful management of species and their habitats and provide a means of conserving both habitats and birds (Potts 1986; McGowan *et al.* 1995). Harvesting of species in this manner requires regular monitoring to enable the determination of the sustainable yield of the population and thus avoid over-exploitation. Improving the quality of the species environment through appropriate habitat management can increase sustainable yields (Aebisher 1991). Wingshooting has been particularly well developed in the Northern Hemisphere where it has become a commercially viable industry (Ratcliffe 2000). In South Africa, the wingshooting industry is still developing. Research by Little & Crowe (1993) that shown that harvesting of the greywing francolin *Francolinus africanus* by wingshooting in the Eastern Cape is both biologically sustainable and economically feasible. However, a study on the sustainability of guineafowl hunting in KwaZulu-Natal by Pero & Crowe (1996) concluded that where the species populations are in threat, wingshooting of the species is not sustainable.

CHAPTER 5. THE IMPACT OF AFFORESTATION ON BIRDS AND BIODIVERSITY.

Commercial afforestation has long been criticised for its negative impact on bird species and biodiversity in general. The conversion of natural grassland to afforestation represents an extreme form of transformation because not only the species composition but also the macro-structure of the vegetation changes (Harrison & Underhill 1997). The response of bird species to the transformation of natural vegetation to afforestation is varied. Those birds that are disadvantaged by the transformation are mostly grassland species (Steyn 1977; Allan & Tarboton 1985; *in* Armstrong & van Hensbergen 1994). None the less there are some species that benefit from the transformation of natural grasslands to forested lands. A study by Allan *et al.* (1997) on the impact of commercial afforestation in bird populations in Mpumalanga showed that approximately 65 bird species present within Mpumalanga are considered to benefit from commercial afforestation to at least some degree. Amongst these species was the helmeted guineafowl. Whitaker (1990) speculated that commercial afforestation is having a negative impact on helmeted guineafowl owing to the fact that exotic timber plantations are reducing the amount of natural habitat. However there is a lack of empirical evidence to support the extent of the change in habitat and as such this research aims to gain further understanding on the change of natural habitat to plantation forestry and its effect on guineafowl populations.

5.1 Past Research on afforestation and its impact on birds.

Most of the research conducted on the impact of afforestation to bird species has been conducted at a macro landscape level over entire provinces and countries. Substantial work has been conducted in Australia on the impact of afforestation and avian diversity. In South Africa, Allan *et al.* (1997) investigated the impact of afforestation on bird distributions in Mpumalanga. On a more specific scale Armstrong and van Hensbergen (1994) compared avifaunas associated with the

Pinus radiata habitats and the different ages of trees. Malan (2001) researched the avifauna associated with riparian vs. *Pinus* habitat edges. It is apparent that there has been no work conducted on the impact of afforestation on gamebirds, particularly guineafowl, in South Africa.

5.2 The North East Cape Forests.

The North Eastern Cape region of South Africa has undergone a radical change in land use from what was originally an extensive beef / sheep farming with areas of intensive crop production to plantation forestry. In the Ugie district (which from here on is referred to as the NECF-*North East Cape Forests*), Mondi Forests have control of approximately 78 000 hectares of land of which they are permitted to utilise up to 75% under plantation. At present, approximately 30 % of the area is planted to predominantly *Pinus* species. The unplanted areas, which are mostly riparian areas and steep mountain slopes, are managed for the objectives of biodiversity conservation and for multiple resource use (MRU) projects. The helmeted guineafowl is common in the area and is recognised as a potential species that can be exploited within the MRU program in the form of sustainable hunting or wingshooting. Revenue generated from the hunting of guineafowl can be used to supplement their biodiversity conservation management program.

With the transformation in land use to plantation forestry, the flocks of guineafowl are exposed to different habitat characteristics. Initial observation would suggest that the timber plantations should provide adequate roosting sites and cover to escape predation. Similarly the unplanted areas and the marginal habitat between plantations should provide adequate nesting sites, since these areas are seldom burned and are lightly grazed by the resident wildlife. It is therefore assumed that with the change in land use, the habitat quality for guineafowl is largely constrained by the availability of food during the winter period. Figure 3 presents a framework for illustrating the limiting factors for guineafowl in the North Eastern Cape.

With respect to the NECF, predation is assumed to be constant across all flocks. This is because it is likely that there is an even spread of predators across the area since there are no natural barriers and the land is fairly uniform across the study site.

The use of herbicides in the preparation of lands in the silviculture process, poses a huge threat since the guineafowl are likely to have a strong dependence upon weed species and Cyperaceae tubers in the planted lands. It is precisely these problematic plants that are targeted with herbicides owing to their strong competitive ability with *Pinus* species. However in comparison to crop production which was practised in the area prior to planting, the overall use of pesticides has decreased, since pesticides are used only in special cases in silviculture.

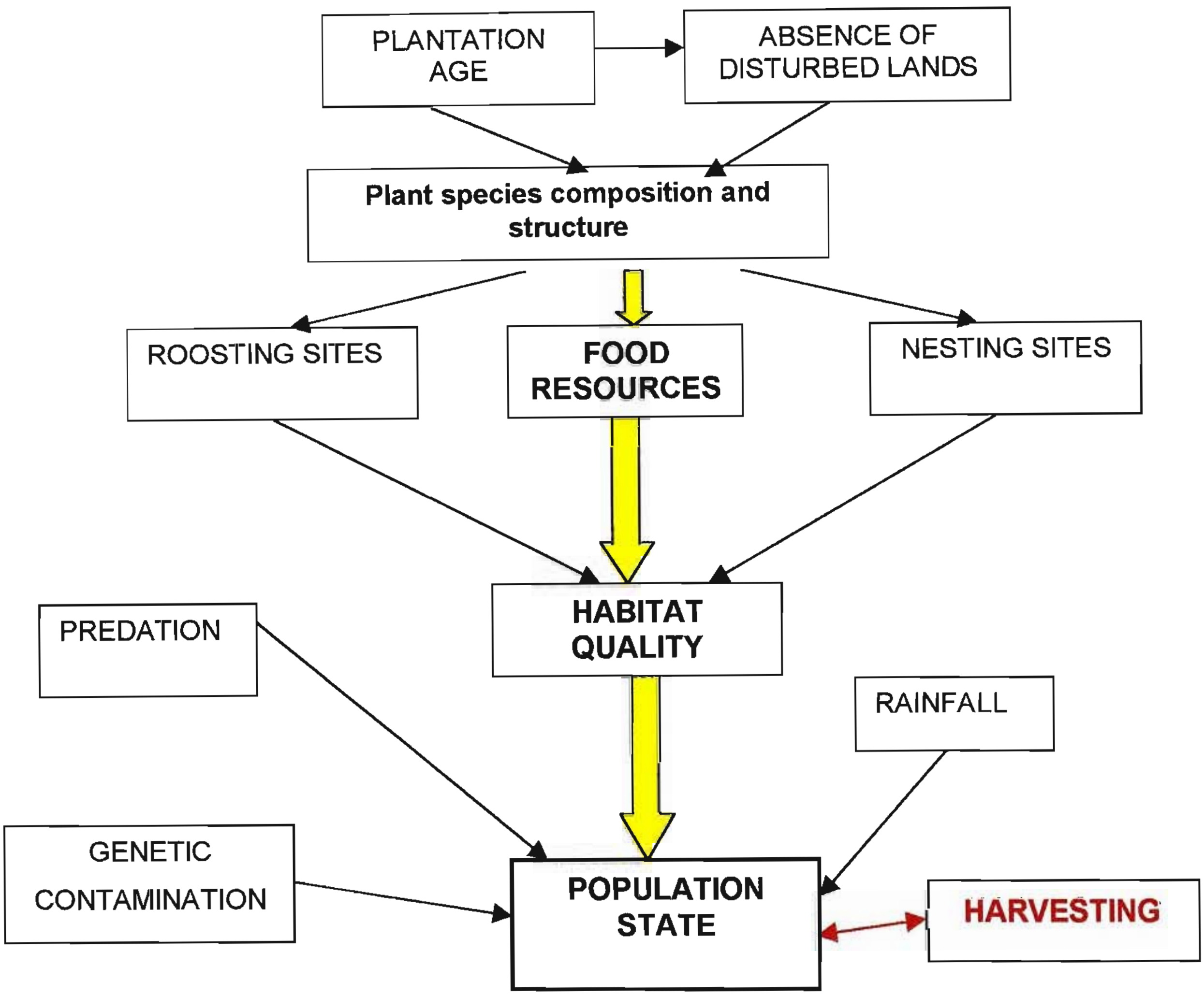

Figure 3. Illustration of the potential limiting factors for guineafowl in the NECF region.

Population censuses performed on guineafowl flocks within the NECF region over the last five years show varying trends. Some flocks are increasing in size, whereas others are decreasing. With the change to plantation forestry, it is unknown as to how the flocks are responding to the change in food resources. The guineafowl no longer have access to cereal and grain crops that were prevalent in the area and are considered crucial over the winter period. The growth of trees also implies that the majority of the understorey vegetation will change in both structure and composition as a response to competition induced from the growth of *Pinus* species for light, nutrients and water. This will therefore influence food availability within the plantations.

Owing to the poor cover offered by the unplanted area, which is a short *Themeda* and *Festuca* dominated grassland, guineafowl should seek cover and forage resources within the plantations.

With the change in land use in the NECF, guineafowl have a strong dependence upon Cyperaceae species for their winter diet. Members of the Cyperaceae that produce underground tubers, especially *Cyperus esculentus* and *C. rotundus,* are usually associated with disturbed sites such as old cultivated lands (Bromilow 1995). Since *C. rotundus* favours frost-free areas (Bromilow 1995), it is likely that *C. esculentus* is a high priority species within the winter diet of guineafowl in the NECF region. *C. esculentus* is indeed found on the old cultivated lands that were previous maize and potato crop lands. Both species are known as problem weed species in crop cultivation (Keeley & Thullen 1978).

It is expected that *C. esculentus* will be outcompeted with the growth of *Pinus* species. *C. esculentus* has a C_4- photosynthetic pathway which suggests that it requires high levels of irradiation and is thus sensitive to the effects of shading (Stoller & Sweet 1987). Research on the effects of shading by crop canopies found that the growth of *C. esculentus* is suppressed by a decrease in photosynthetic rates (Keeley & Thullen 1978). Research by Keeley and Thullen

(1978) indicated that not only did the densities of *C. esculentus* decline with increase shading, but so also did the number of tubers per plant and the number of shoots and flowers per plant. A study by Santos *et al.* (1997) found that at 80% shading, tuber production in *C. esculentus* had almost entirely ceased. This has relevance to guineafowl in that although *C. esculentus* may grow in those forest stands where there is 80% shading, there may in fact be no tubers for the guineafowl to feed on.

CHAPTER 6. METHODOLOGY.

The first priority is to investigate which limiting factor is responsible for the decline of certain populations of guineafowl. The second part of the methodology is to gain an understanding of how the understorey vegetation, particularly guineafowl winter forage species, changes with the growth of pine trees. This will be achieved by performing a vegetation composition analysis of the plantation understorey. Plantations will be categorised according to plantation age.

6.1 Description of Study site and the choice of guineafowl flocks.

Flocks have been chosen using the criteria that they are large, accessible and have home ranges that are unlikely to overlap. A total of four flocks have been chosen for this study. Three of the flocks are found along the Wilderbees River, on the Wilderbees Estate, an area of uniform altitude, climate and aspect and so it is likely that the unplanted areas are fairly similar in composition and structure. Population data was included for a fourth flock of birds, since this flock still has access to winter maize and green pastures as its home range overlaps into a commercial farmland. This flock has been included for control purposes.

For the purpose of comparison, a table of the crucial habitat characteristics of the home ranges of the three study flocks was generated.

Limiting factors that were assessed included the distance to, and availability of permanent water (i.e. a stream or dam), the proportion of home range planted to forestry, as well as the age of compartments within the home range.

6.2 Methods of data collection.

6.2.1 Comparison of study flocks.

In order to compare the limiting factors of the study flocks, an area with a 500m radius around the existing roost sites is to be analysed according to various habitat characteristics. Using GIS, areas will be calculated for the amount of unplanted and planted vegetation as well as the nearest distance to permanent water from the roosting site.

The age since planting of the forest compartments within each home range will be averaged to give a comparable figure.

6.2.2 Measuring the vegetation composition.

Within each of the identified plantation compartments a vegetation composition analysis will be conducted for the understorey vegetation within the plantation compartments. The understorey vegetation will be studied for both species composition and species abundance. Species composition and abundance will be determined from a frequency quadrat sampling technique. This method will be used to identify the availability of weed and grass species within the compartments, as well as to identify the amount of sedge (*Cyperus esculentus*) available to the respective flocks.

Measuring the vegetation within the plantation compartments.

Sample sites will be selected on the basis that they are fairly large and homogenous. Where possible, sites will have the same topography, elevation, slope, aspect and soil type. Areas that are likely to cause heterogeneity such as rocky outcrops, water features, roadside edges, firebreaks and any other unusual features will be avoided. Essentially, sites will be selected on the basis that they are similar for comparison such that site to site variation is natural and any other variation can be accounted for by the measurements in the study. Edge effects will be avoided by not sampling the edge of a compartment.

Vegetation sampling will be conducted in April and May since this is when most of the winter forage is already growing and flowering, which makes species identification considerably easier, and there will be negligible new recruitment of weed species due to frosts. Sampling the vegetation during this period presents a potential weakness since guineafowl are likely to be restricted in diet at the end of winter rather than at the onset of winter. However it is assumed that the composition of the vegetation will stay the same owing to the uniformity of vegetation within *Pinus* plantations.

Placement of samples.

There are three options available for the placement of samples. Sites may be selected on the basis that they are typical of the area as a whole, by placing samples randomly, or by placing samples in a systematic regular pattern (Greig-Smith 1983). The first option is considered inappropriate since there is preconceived bias in the placement of the sample by the observer and is therefore not suited to quantitative analysis. The alternatives of random and systematic sampling therefore have more merit. With systematic sampling, there is no measure of the precision of the mean and thus no possibility of assessing the significance of its difference from the mean in another area or plantation compartment (Greig-Smith 1983). In contrast, random placement of samples allows for an estimate of the precision of the mean and thus two different samples can be compared. Since this research will make comparisons of samples taken from different plantation compartments, a random placement of samples is the chosen approach.

A 30 x 30 m homogenous and representative sample plot (based on uniform slope, aspect and soil properties) will be randomly allocated within each of the plantation categories (see Table 2).

Table 2. Sample categories of plantation.

CATEGORY	AGE OF PLANTATION
I	Unplanted, disturbed site
II	0- 5 yrs old, disturbed site
III	5-10yrs old, disturbed site

The siting of each sample within a plantation category will be allocated through the random co-ordinate process. By standing in the corner of a compartment, one can walk co-ordinates in metres determined from random number tables. For example, if a random number is 84, then the observer will walk from the south-western corner 8 m north and then 4 m east and place the corner of the sample plot. For the purpose of replication, sampling will take place in two plantations per plantation category. The site selection of these samples will be determined from orthophotos taken over the region. Within each of the sample plots, 25 random quadrats will be allocated. Samples will then be ranked according to the age category of plantation.

Ideally, the best method for determining the abundance of a species is the density estimate measure (Greig-Smith 1983). Where frequency measurements compare species relative abundances, density measurements estimate the number of individuals per unit area. In such cases the number of individuals of each species are individually counted and expressed per unit area of the size of the quadrat. Although this method can be easily converted and expressed as a convenient measure of area such as number of individuals per hectare, the method does have its disadvantages. The frequency-quadrat method was therefore chosen over the density estimate measure due to the following reasons.

- The first major disadvantage with the density estimation method is that it requires that individual plants be counted. Often the growth form of plants is such that is very difficult to distinguish between individuals. This is especially true for rhizomatous or stoloniferous forms where there may be more than one shoot per plant. It is relatively easy to count stems but difficulties may still be experienced in distinguishing whether stems originate from different plants. The growth form of *C. esculentus* is such that it makes the density estimate extremely difficult (Up to 7000 tubers have been recorded for a single plant, (Bromilow 1995).

- A second difficulty with the density estimate measurement, is that difficulty may be experienced in determining whether an individual falls within the quadrat boundary and whether it should be counted or not. It is a common occurrence that the edge of the quadrat will fall over a proportion of plant and whether the plant should be included within the count remains questionable.
- A third major difficulty with the density estimate method is the time that it takes to count individuals within each quadrat. Where there are many categories of samples that the researcher is willing to compare, the density estimate measurement is severely limiting in this respect. Density measurements are also better suited for comparison of closely similar communities (Mueller-Dombois & Ellenberg 1974).

6.2.3 Estimation of species frequency.

Frequency can be estimated from either a quadrat or a line transect method. The quadrat method is chosen for this research since it is preferred for research and monitoring purposes over the line transect method (Hardy *et al.* 1999).
Frequency is defined as the number of times a species occurs in a given number of repeatedly placed small sample plots or sample points (Mueller-Dombois & Ellenberg 1974). It is expressed as a fraction of the total, usually as a percentage. No counting in the field is involved, just a record of the species' presence.

Frequency is calculated by the formula:

$$F = \frac{\text{(no. of quadrats with species } s\text{)}}{\text{no. of quadrats per sample}} \times 100$$

The frequency of species will be determined from a total of the 25 quadrats. i.e. if a species occurs in 5 of the 25 quadrats we can say that its frequency is 20%.

This method of estimating species frequencies has been known to be very successful in species-poor communities (where the total number of species is reasonably low). Mueller-Dombois and Ellenberg (1974) found that the frequency method is the most commonly applied quantitative parameter for the analysis of forest undergrowth and herbaceous communities. This was due to its simplicity and reliability.

Since frequency is dependent on the size and shape of the sample unit, it has to be kept constant if future research will use the results. The chosen sample unit will be a quadrat of 0.25 x 0.25 m which is a standard size.

The randomisation process for the placement of quadrats will be determined from walking distances on random number tables in a similar fashion to the placement of sample sites mentioned above. To gain an estimate of the species richness of the weed and grass species within the compartments, the type of species occurring within each quadrat will be recorded. Due to the fact that guineafowl use a variety of weed and grass species (Grafton 1970), it is assumed that they would benefit from those plantations with more weed and grass species present. Plantations planted on previously disturbed sites would therefore be more favoured than those plantations planted on virgin grassland.

In order to predict how the understorey vegetation will change with plantation age, plantations will be ranked according to their age. The availability of food resources will be determined by the total number of weed and grass species present. Table 2 presents the age categories of plantation that will be use in the statistical analysis of the compositional data.

It is likely that the guineafowl will have preference for those forested lands that are planted on previously disturbed areas owing to the presence of pioneer weed species caused by an over-turning of the soil. Disturbed sites are those areas that were previously subjected to disturbances such as ploughing for the cultivation of crops and pastures. This will be determined from aerial photographs that were taken over the study site prior to planting. A review of the pre-planting strategy (pre-planting preparation plan for each stand) will also lend useful information in the delineation of disturbed vs. undisturbed lands.

6.2.4 Photosynthetically active radiation.

In order to determine how the *Pinus* species are affecting the available light within the forested stands, a PAR (photosynthetically active radiation) reading will be taken within each of the sample categories. Since PAR is likely to be the major controlling factor with respect to species composition within the forested stands, it would be useful to rate the forage abundances against a PAR value. Due to the uniform structure of *Pinus* trees, we would expect similar PAR within similar age plantations. PAR is measured with a light ceptometer (Decagon Sunfleck Ceptometer) within each of the plantation categories as well as in the unplanted areas. The percentage of shade or shading effect can then be calculated by dividing the PAR value for the compartment by the value attained in full sunlight which is in the unplanted areas. Between 12.00 noon and 1.00 pm, a PAR reading will be taken in each sample category. Readings will only be taken on cloud-clear days and will be repeated ten times, and a mean value is attained for each sample category. PAR values will then be correlated with the age of plantation to identify if there is a relationship with PAR and age. A correlation analysis will be performed with PAR and the frequency of sedge in order to determine whether the amount of light is affecting the abundance of sedge and hence the availability of forage for guineafowl.

6.2.5 Determining the amount of forage within the home ranges of selected flocks.

An area within 500 m of the roost site will be taken as an estimate of the home range of guineafowl in the study area. This equates to an area of 78.5 ha. Although Ratcliffe & Crowe (2001a, b) found that home ranges can be up to 252 ha in total area, these flocks were confined to the drier western parts of the country where the availability of drinking water is a limiting factor. Home ranges will then be plotted on forestry stock maps using GIS (ARCVIEW version 3) and will be centred on known roosting sites (See Figure 4).

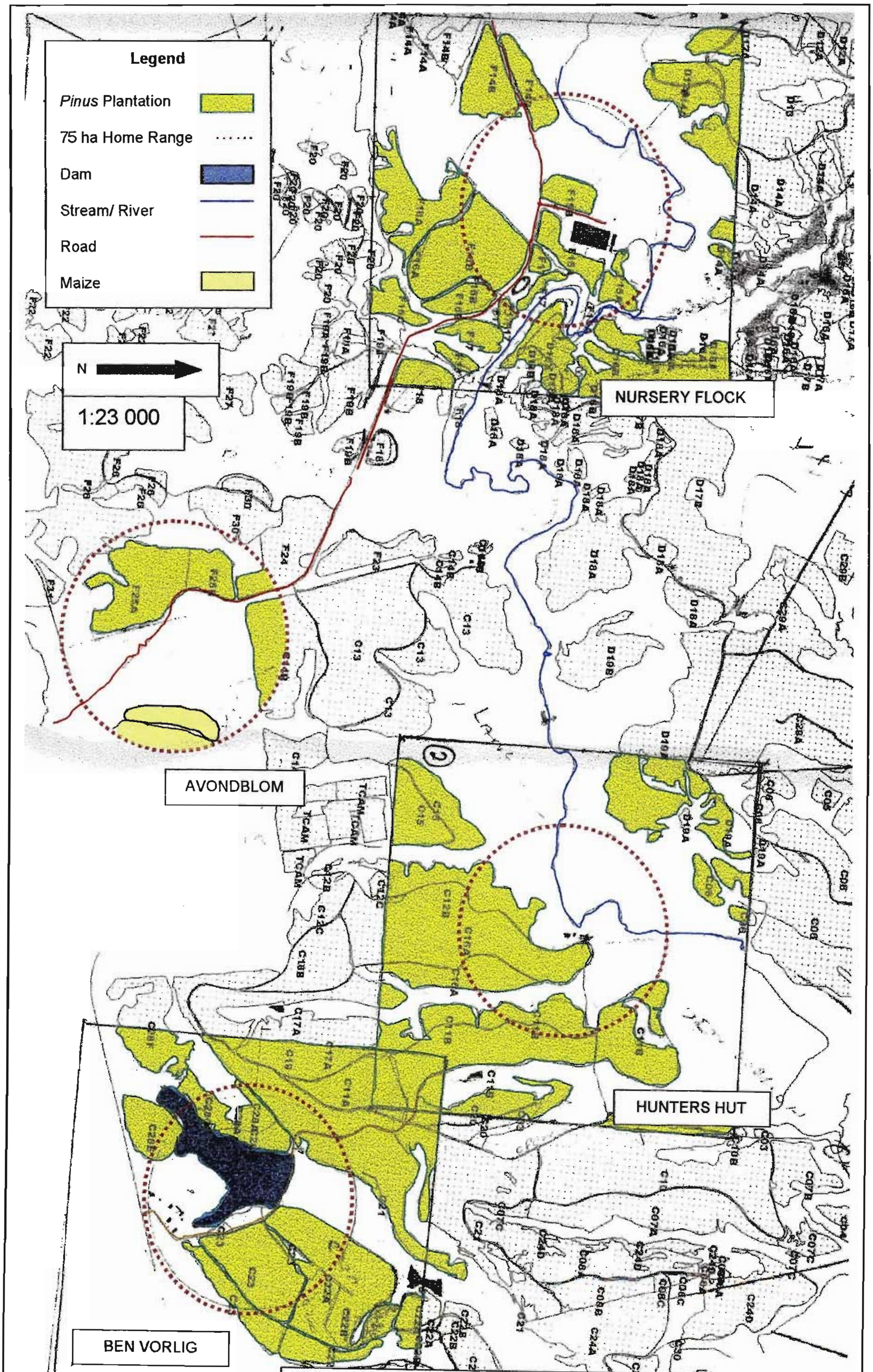

Figure 4: Map of study flocks.

With the use of GIS, the area of each individual plantation category within an identified home range will be calculated as well as the unplanted area.

6.2.6 Assigning Preference Weightings to the plantation categories.

Plantation compartments will be weighted according to a number of criteria. These include the species richness of weed and grass species as well as the relative abundance / frequency of *C. esculentus* and the shading effects induced by *Pinus* spp. The availability of *C. esculentus* was assumed to be the most influential factor and was thus given twice the weighting of the other criteria. Shading was included as a criterion because tuber production has been found to increase with light intensity (Keeley & Thullen 1978) and it has been found that tuber production in *C. esculentus* ceases where shading by the canopy exceeds 80% (Santos *et al.* 1997). Compartments have been divided into five age categories. The area within each home range of the study flocks that falls into the respective age categories will be multiplied by the category score to gain a quantitative estimate of the available forage within a home range. Calculations of the weightings and the forage scores are presented in Table 3.

Insert table 3.

6.3 Methods of data collation, synthesis and analysis.

Correlation analysis will be used to determine if there is a relationship between the availability of winter forage and the growth rate of flocks. If there is statistical significance, then it is possible to make conclusions on the impact of plantation forestry on the availability of winter forage. If results are insignificant, then there must be another factor that is causing fluctuations in the flock sizes of guineafowl; e.g. predation, or over-hunting.

Independent *t*-tests will be used to test for significant relationships in the species richness and that of plantation age.

Since frequency data are asymmetric and show a binomial distribution, and the fact that the mean and the variance are correlated, a *t*-test is not advisable to compare two frequencies (Greig-Smith 1983). The frequency of sedge was therefore tested for significant differences across the plantation categories using *chi*-square analysis which thus represents a better method of comparison (Greig-Smith 1983).

6.4 Methods process diagram.

Figure 5 represents the stages in methodology to be followed by this research.

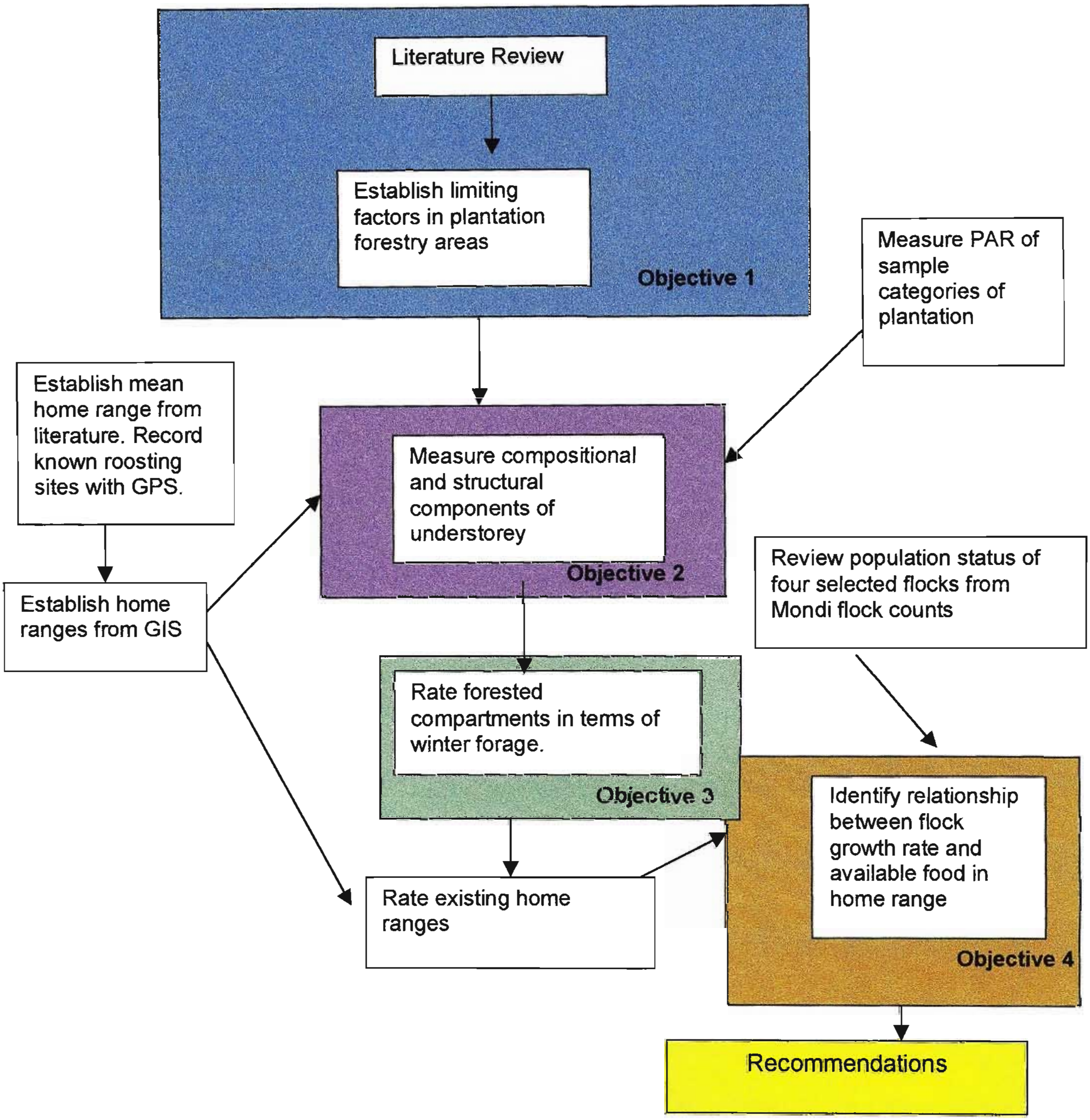

Figure 5. Proposed methodology for guineafowl research.

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Brendon Steytler

WINTER FORAGE AS A LIMITING FACTOR FOR GUINEAFOWL IN PLANTATION FORESTRY LANDS.

By

BRENDON MARK STEYTLER

Abstract

This research investigates the potential impacts that a change in land-use to plantation forestry from an area of extensive / intensive agriculture has on helmeted guineafowl *Numida meleagris* populations. A comprehensive literature review revealed that the likely limiting factors in plantation forestry areas include the age of plantation, proportion of home range planted to timber, and the availability of winter forage species. Initially the process of planting creates a disturbance that encourages favourable weed and grass species for guineafowl that provide winter forage and suitable groundcover. Up to five years after planting habitat conditions are favourable and guineafowl populations increase. After five years, the shading effects from the *Pinus* spp. results in a decrease in species richness of the understorey vegetation, as well as a decrease in the abundance of crucial winter species such as *Cyperus esculentus.* As a result populations of guineafowl start to decline. Guineafowl populations that have plantations older than ten years within their home range need to have diets supplemented by grain maize, or a suitable grain substitute, unless there is adequate unplanted area to meet their nutritional needs.

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Introduction

The helmeted guineafowl *Numida meleagris* was once a common species found in a wide variety of habitat types distributed throughout sub-Saharan Africa (Crowe, Keith & Brown 1986). Thriving in savannas mixed with cultivation (Crowe *et al.* 1986), this species has undergone severe range expansion that has been associated with the modification of natural landscapes to a mosaic of agricultural land-uses (Ratcliffe & Crowe 2001a). The resultant interface of agricultural and natural lands has provided the species with good quality habitat characteristics that include food, water, cover and roosting sites (Crowe *et al.* 1986; Ratcliffe & Crowe 2001a; Malan & Benn 1999). However, while once an abundant species, populations of helmeted guineafowl have recently declined (over the last 15-20 years) due to an intensification of farming methods to accommodate the needs of increased production for the growing demands of the human population (Pero & Crowe 1996; Ratcliffe & Crowe 2001b; Malan & Benn 1999). As a result marginal lands, which provided crucial cover and food resources have since been cultivated causing a decline in the habitat quality in these areas (Malan & Benn 1999).

The transformation from natural grassland and areas of intensive / extensive agriculture to plantation forestry represents a radical change in both vegetation structure and species composition. With such a change, elements of habitat quality are affected in both positive and negative ways, allowing for an increase in abundance in populations if conditions are more favourable. The effect of a change in land-use to plantation forestry on guineafowl populations is largely unknown. The purpose of this paper is to try and assess the potential impact that afforestation may have on the future of this species. Owing to the fact that the guineafowl is known to be extremely resilient to habitat change (Ratcliffe &

Crowe 2001b), its decrease across a region calls for strong concern regarding the state of biodiversity in that particular region. Essentially the decrease of guineafowl may thus be a reflector of improper and environmentally unfriendly management practices (Pero & Crowe 1996).

Not only is the helmeted guineafowl an important species from a biodiversity indicator perspective, it is becoming increasingly valued as a species that can be sustainably harvested in the form of wingshooting provided that populations are healthy and stable (Pero & Crowe 1996) thus providing landowners with an additional source of income.

Much of the expansion of range of guineafowl in agricultural areas is due to the presence of critical winter forage, especially the availability grain crops such as maize (*Zea* spp.) and winter greenery (i.e. fodder species) (Ratcliffe & Crowe 2001b). In the absence of maize, this research aims to investigate how plantation forestry impacts on those understorey plant species that are likely to make up the winter diet of the species. Previous research on guineafowl diets found that the species favours invertebrates in the summer months and residual grains, sedge tubers and winter greenery such as lucerne in the winter (Ratcliffe 2000; Little 1997; Winterbach & Oosthuizen 1992; Crowe 1978; Malan & Benn 1999; Mentis, Poggenpoel & Maguire 1975; Grafton 1970). In the absence of residual grain crops, species such as yellow nut-sedge *Cyperus esculentus* will have a crucial role in supplementing the diet of the guineafowl. *Cyperus esculentus* has been given special preference since this is likely to be the main constituent in the winter diet for guineafowl in afforested areas. Additional research on the diet of guineafowl in areas where birds had no access to winter grain crops was conducted by Ayeni (1983), who noticed that *Cyperus* bulbs where prevalent in most crop contents. A crop content investigation by R. McC. Pott (unpublished) on the guineafowl flocks in the study area found that *C. esculentus* bulbs were the main constituents of the diet in all birds studied.

Materials and Methods

Identification of limiting factors for guineafowl.

A comprehensive review of key literature pertaining to guineafowl and plantation forestry provided information on the likely limiting factors for guineafowl in plantation forestry areas. These included:

- Abundance of winter forage species i.e. weed species, grass species and especially nut-sedge species;
- Distance to drinking water;
- Proportion of home range planted to *Pinus* as well as the unplanted area;
- Age of plantation within home range;
- Annual rainfall.

Study site.

The chosen study site is the North East Cape Forests that surround the town of Ugie, Eastern Cape. The Ugie area falls at the southern extension of the Drakensburg range. Topography includes rolling sandstone hills and riparian valleys. This area was an extensive beef and sheep grazing area interspersed with maize and potato croplands with winter pastures. Much of this habitat has been transformed into plantation forestry in the last 15 years.

Choice of study flocks.

Four flocks of guineafowl were studied in this research. Three flocks were chosen on the basis that they had home ranges that included areas surrounded by plantations of different age classes, and a further fourth flock was included for control purposes, since this flock had access to winter maize. Flock counts collected over the last 7 years by Mondi Forest personnel provided information on the growth rates on the study flocks. Data for the year 2002 were missing and at the time of fieldwork for this project, flocks had not completely reformed after raising young to do accurate counts for 2003.

Individual flock home ranges could not be established by more conventional methods such as radio tracking. Informal discussion with Mondi Forest personnel suggested that the flocks were rarely observed further than 500 m from their respective roost site. A circular area within 500 m of each roost site was therefore considered as the home range of each flock. Home ranges therefore equated to an area of 78.5 ha. Hypothetical home ranges were plotted around the roosting sites of the study flocks. (Mean home ranges in the KwaZulu-Natal Midlands were found to be between 11 and 25 ha (Ratcliffe & Crowe 2001b; Malan & Benn 1996). In the drier western parts of the country home ranges were found to be up to 252 ha (Ratcliffe & Crowe 2001b).

Within this area, areas were calculated for the *Pinus* plantations as well as the unplanted riparian zones. The mean age of trees since planting was also calculated for each home range.

Vegetation analysis.

The compositional analysis of the understorey vegetation was rated against plantation age in order to determine how the understorey vegetation changed with time and hence how the availability of winter forage was affected with the growth of *Pinus* species. The quadrat-frequency method as described by Greig-Smith (1983) was used for determining the abundance and composition of species within the plantation compartments. Plantation compartments are defined as those units of land that are planted at the same time with the same species at the same age. Plantation compartments were divided into five age class categories, namely: 0 – 2 year-old, 2-4 year-old, 4-6 year-old, 6-8 year-old and 5 -10 year-old trees. A 30 x 30 m sample plot was allocated to those different plantation age categories that were found in the home ranges of the study flocks and a total of 25 quadrats were randomly allocated within each sample plot. Each plot was replicated twice. Within each quadrat, the species present were recorded.

Frequency is calculated by the formula:

$$F = \frac{\text{(no. of quadrats with species } s\text{)}}{\text{no. of quadrats per sample}} \times 100$$

The total number of species found in the sample of twenty-five quadrats was used as a measure of species richness. This included both grass and weed species. Data were then compared across the plantations using independent *t*-tests.

Research on weed control in timber plantations found that the degree of shading was deemed to be the most likely factor responsible for the change in species composition of the understorey vegetation within the *Pinus* plantation (K. Little *pers. comm.* March 2003). For this reason photosynthetically-active-radiation (PAR), a measure of light intensity, was recorded within each of the plantation compartments using a DECAGON Sunfleck light ceptometer. PAR was only recorded at noon on cloud-clear days. The degree of shading was then calculated by proportion of PAR recorded within the compartment to PAR recorded in direct sunlight.

Since frequency data are asymmetric and show a binomial distribution, and the fact that the mean and the variance are correlated, a *t*-test is not advisable to compare two frequencies (Greig-Smith 1983). The frequency of sedge was therefore tested for significant differences across the plantation categories using *chi*-square analysis which thus represents a better method of comparison (Greig-Smith 1983).

Rating the forest compartments in terms of available forage.

A method was developed whereby forest compartments were weighted according to a number of criteria in order to derive a forage score for a home range. Criteria used included the availability of *C. esculentus,* which was deemed to be the most important factor and was thus given twice the weighting; the percentage shading induced by *Pinus* species since it was found that *C. esculentus* tuber production increased with light intensity (Keeley & Thullen 1978); the availability of grass species; and the availability of weed species.

A weighting was calculated for each forest category. The area of that category of forest within each home range was multiplied by the weighting and then summed to give a final forage score for each respective home range. The methodology and the derivation of the weightings are described in Table 1.

Table 1: Plantation forage ratings

Rankings and weightings for forage abundance criteria

	Frequency category	Weighting	Compartment age	Plantation category
Cyperus esculentus	0-25	**2**	>8yrs	**5**
	>25-50	**4**	0-2.5yrs, 5-8yrs	**1,2,4**
	>50-75	**6**	2.5-5yrs	**3**
	>75-100	**8**		
	Percentage			
Shading	0-20	**4**	0-3	**1**
	>20-40	**3**	3-5yrs	**2**
	>40- 60	**2**	5-7yrs	**3**
	>60- 80	**1**	>7yrs	**4**
				5
Grass species	Number			
	0-5	**1**	>10yrs	**4.5**
	>5-10	**2**	>5-10yrs	**3**
	>10	**3**	0-5yrs	**1,2**
Weed species	0-5	**1**	>10yrs	**4,5**
	>5-10	**2**	>5-10yrs	**3**
	>10	**3**	0-5yrs	**1,2**

Score calculation example:

Category 1: = (weighting for *C.esculentus* + weighting for shading + weighting for number of grass species + weighting for number of weed species)
= (4+4+3+3)
= 15

Plantation categories

Plantation Category	Age of compartment	Category score
1	0-2 year old	15
2	>2-4 year old	14
3	>4-6 year old	13
4	>6-8 year old	7
5	>8 year old	4

Home range forage score calculation example:

Hunters Hut Flock: = area of each compartment category x category score
= (14x14+8x13+4x4)
= **316**

By comparing the forage scores calculated for the study flocks with their respective growth rates, associations could then be made with the response of flocks to forage availability.

Results

Flock growth rates.

Fig 1.

A review of the census counts indicated that the total population of those guineafowl flocks that are monitored in the NECF showed a positive increase (Figure 1). Mean annual rainfall also increased over the study period. However the annual rainfall in 1999 was below the Ugie mean of 1100 mm p.a. A review of the study flocks showed varying trends in population growth rates (Figure 2). The four flocks of guineafowl studied had population growth rates that were both increasing and decreasing. Over the period 1997 to 2001, the Avondblom flock, which had access to winter maize lands, has shown a positive growth rate. Flocks found solely in the forested areas showed differing responses. The Hunters Hut flock has increased, doubling in number in the five years. The Nursery flock has remained relatively stable, increasing only slightly, where as the Loch Vorlig flock has decreased from approximately 75 to 30 birds in five years.

Fig 2.

A review of the habitat characteristics of each of the study flocks has been summarised in Table 1. Within the hypothetical home range of 78.5 ha or area within 500 m of the roost, the identified key limiting factors showed that all flocks had sufficient access to permanent drinking water (within 500 m). The proportion of planted area and unplanted riparian zones within the home range also showed varying trends. The most striking difference in the home range comparison was with the mean age of compartments. Both the Hunters Hut and the Nursery Flock were surrounded by similar-age compartments within their home ranges. The Loch Vorlig Flock had much older compartments within its home range.

Table 2. Comparison of the home ranges and forage scores of study flocks (percentages in brackets reflect percentage of home range).

	Hunters Hut	**Nursery**	**Loch Vorlig**	**Avondblom**
Hypothetical size of home range	78.5 ha	78.5 ha	78.5 ha	78.5 ha
Distance to drinking water	80 m	340 m	40 m	50 m
Area under plantation	26 ha (33%)	25 ha (32%)	23 ha (29%)	16 ha (20%)
Area of available maize land	nil	nil	nil	6 ha
Mean Age of compartments within 500 m of roost	4.25 ± 0.29 yrs	4.95 ± 1.06 yrs	8.86 ± 0.81 yrs	2.75 ± 2.06 yrs
Calculated forage scores	316	361.75	116.25	236
Growth Rates	positive	positive	negative	positive

Species Composition of the understorey vegetation.

Figure 3 reflects the linear relationship between species richness and plantation age. From Figure 3, it can be seen that the number of weed and grass species present (species richness) in the understorey vegetation was strongly negatively correlated with plantation age (R = -0.798). The number of species for compartments that were ten years old was significantly less than those compartments that were five years old (t = 4.19**; 7 df).

Not only did those older plantations have fewer weed species, the species themselves in those older compartments were often very different. Table 3 presents the mean abundances of the species found in the compartments within those unplanted, five-year-old and ten-year-old plantations. Most notable was the decline in abundance of *Hypochoeris radicata,* which was very abundant in unplanted disturbed sites. *Pennisetum clandestinum* increased in abundance with plantation age.

Fig 3.

Initially, the abundance of *C. esculentus* increased with plantation age (Figure 4). Relative abundances increased marginally from 40 % to 50 % in those plantations that were five years old since planting. The relative abundance of sedge in plantations older than five years shows a different trend where the relative abundance of *C. esculentus* decreased with plantation age quite rapidly, and the species was almost non-existent in those plantations that are ten years and older (Figure 5). A *chi* square analysis revealed that the increase in relative abundance from planting to five year old compartments was non-significant. However between compartments that were five to ten years old, there was a significant decrease in *C. esculentus* abundance (χ^2= 6.186; $\chi^2_{0.05}$ 1df= 3.84).

Fig 4.

Fig 5.

Fig 6.

Figure 6 shows that more than eighty % shading occurred in those plantations older than eight years. The effects of shading are only evident in those plantations that are older than three years.

Table 3. Mean abundances for unplanted disturbed sites, 5-year-old plantations and 10-year-old plantations.

	unplanted disturbed site	5 yr old plantation	10 yr old plantation
mean PAR	1168	805.7	163.82
Species richness	15	16	7
no. of grass species	9	6	4
no. of weed species	6	9	3
Species	**Frequency**	**Frequency**	**Frequency**
Bidens pilosa	24%	34%	19%
Conyza albida	0%	5%	0%
Cymbopogon excavatus	0%	1%	0%
Cynodon dactylon	2%	0%	0%
Cyperus esculentus	40%	52%	13%
Digitaria sanguinalis	12%	12%	1%
Festuca arundinaceae	2%	0%	0%
Eragrostis curvula	8%	13%	4%
Bromus catharticus	2%	0%	1%
Hypochoeris radicata	92%	71%	9%
Oxalis spp.	8%	13%	0%
Paspalum dilitatum	14%	24%	0%
Paspalum notatum	0%	1%	0%
Paspalum urvillei	2%	0%	0%
Pennisetum clandestinum	0%	0%	9%
Setaria megaphylla	0%	0%	0%
Sporobolus africanus	8%	0%	0%
Setaria pallide-fusca	18%	8%	0%
Achyranthes aspera	8%	5%	0%
Tagetes minuta	8%	12%	0%
Trifolium repens	0%	8%	0%
Verbena bonariensis	0%	19%	0%

Forage abundance scores.

Scores calculated for the study flocks are presented in Table 1. Lower scores as displayed by the Loch Vorlig flock appear to be associated with those flocks that have negative growth rates.

Discussion

The overall increase in the guineafowl population since 1994, suggests that since then habitat management has been favourable. With the inception of plantation forestry there has been an increase in birds despite periods of intermittent rainfall, hunting pressures and most importantly a change in habitat. However, the variation in growth rates between flocks calls was apparent. A pattern was detected linking the age of plantation with the flock growth rate. The Loch Vorlig flock had 23 % of its home range occupied of plantations 8 years and older, and showed a population decline. In comparison, both Hunters Hut and the Nursery flock, which had positive growth rates, had 33 and 32 % of their home ranges respectively occupied by much younger plantations. In both the Nursery flock and the Hunters Hut flock, there is an increase in flock sizes with the inception of tree planting. It would thus appear that the disturbance created by the preparation of lands and planting of timber creates a favourable environment for guineafowl. However, with the growth of trees and time, habitat quality deteriorates with a loss in cover and a decrease in food availability, and as a result the guineafowl populations start to decline. The reasons for the decline may be two-fold. First, the species richness of the understorey vegetation decreases, and second the abundance of crucial species like *C. esculentus* also decreases. By comparing the forage scores calculated for the study flocks it can be seen that the highest scores were associated with the Hunters Hut and the Nursery flock's which had the highest population growth rates. In contrast, the Loch Vorlig flock, which had the lowest forage score, has shown a decline in population. The Avondblom flock, which had an intermediate score, displays a strong growth rate, suggesting the importance that maize has in supplementing the diet of the birds in winter.

Being habitat generalists, and having a widely mixed diet of weed and bulbous species in the winter (Grafton 1970; Mentis *et al.* 1975; Winterbach & Oosthuizen 1992;) we would expect guineafowl to become limited in those environments where there are fewer forage species, and where the abundance of those species is less. As plantations become older, the decrease in species richness of weed and grass species, as well as the decrease in abundance of *C. esculentus,* are having a vital role in the availability of winter forage for guineafowl. Other species known to be consumed by guineafowl, and which also declined with plantation age, included *Bidens pilosa, Oxalis* spp. tubers, *Paspalum* species and *Eragrostis* species. Not only is the decline in species richness of the understorey vegetation due to the shading and competing effects of the *Pinus* species, but herbicides may also be having a notable role in the reduction of weeds species such as *C. esculentus* are targeted weed species in silviculture because they compete strongly with *Pinus* species (Bromilow 1995).

Although the relationship between plantation age and the degree of shading was linear, there was a high variation in shading for samples around ages 4-5 years. This could be explained by the variation in pruning heights, where some trees were pruned at 1.5 m above the ground, and others as much 3 m. This would allow for varying light and shading effects in the younger compartments. Tuber production in *C. esculentus* has been known to decrease with increased effects of shading (Keeley & Thullen 1978).Research by Santos, Morales-Payan, Stall, Bewick and Shilling (1997) found that *C. esculentus* ceases to produce any tubers where more than 80% shading occurs making the species useless in the diet of guineafowl.

Conclusions and Recommendations

Initially the change from an extensive farming land-use to plantation forestry creates a more favourable environment for the establishment of weed species and thus favourable conditions for guineafowl. However, with the growth in trees, species composition in the understorey changes as a result of the competing effects of *Pinus* species. A decrease follows in those winter forage species considered crucial in the diet of guineafowl. Once *Pinus* plantations reach five years old, habitat conditions become unfavourable and flocks start to decline. In the long term it is thus apparent that plantation forestry is having a negative impact on populations of guineafowl. In those areas where flocks have home ranges including plantations that are five years and older, and have no access to winter grain crops, it is highly recommended that grain maize or a suitable alternative is made available to supplement the diet for helmeted guineafowl in late winter.

Acknowledgements

The author thanks Mondi Forests who sponsored this project especially Ricky McC. Pott for his support and valued expertise throughout the duration of the project. Special thanks to the staff and colleagues at Centre for Environment and Development, University of Natal who also remained supportive throughout the project. Dr Keith Little of the ICFR is also thanked for the use of the ceptometer.

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CAPTIONS FOR FIGURES

Figure 1. The state of the guineafowl population in the NECF Region.
Line chart indicating annual rainfall for Ugie. Data from the South African Weather Bureau.

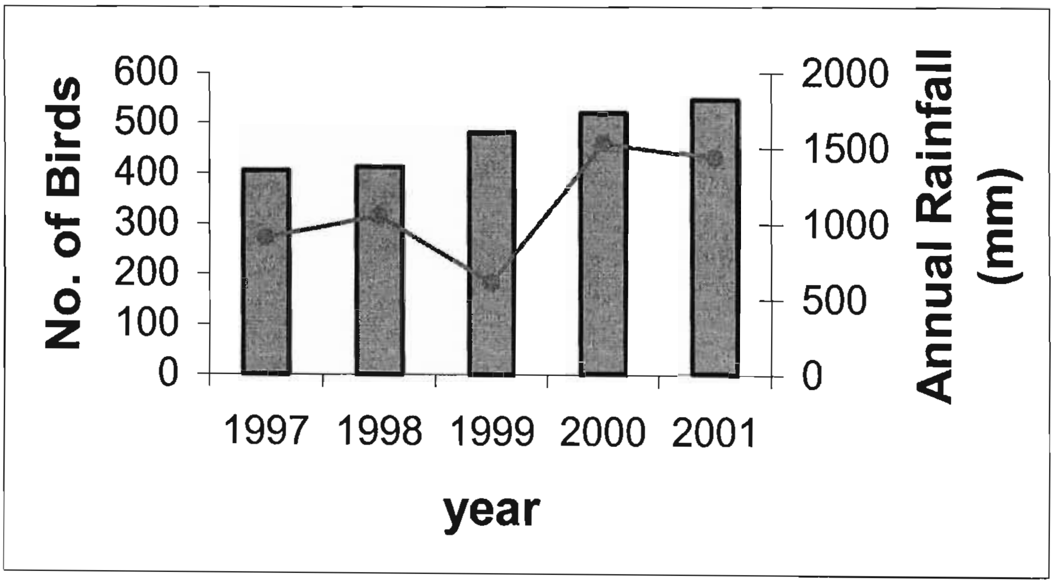
Figure 2. Flock size of guineafowl in the study site. Data from Mondi Forest census counts.

Figure 3. The number of weed and grass species combined in relation to the age of plantation.

Figure 4. The frequency of *C. esculentus* in plantations up to five years old.

Figure 5. The frequency of *C. esculentus* in plantations between five and ten years old.

Figure 6. The curvi-linear relationship between the shading induced by *Pinus* and the age of the plantation.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1500
1000
500
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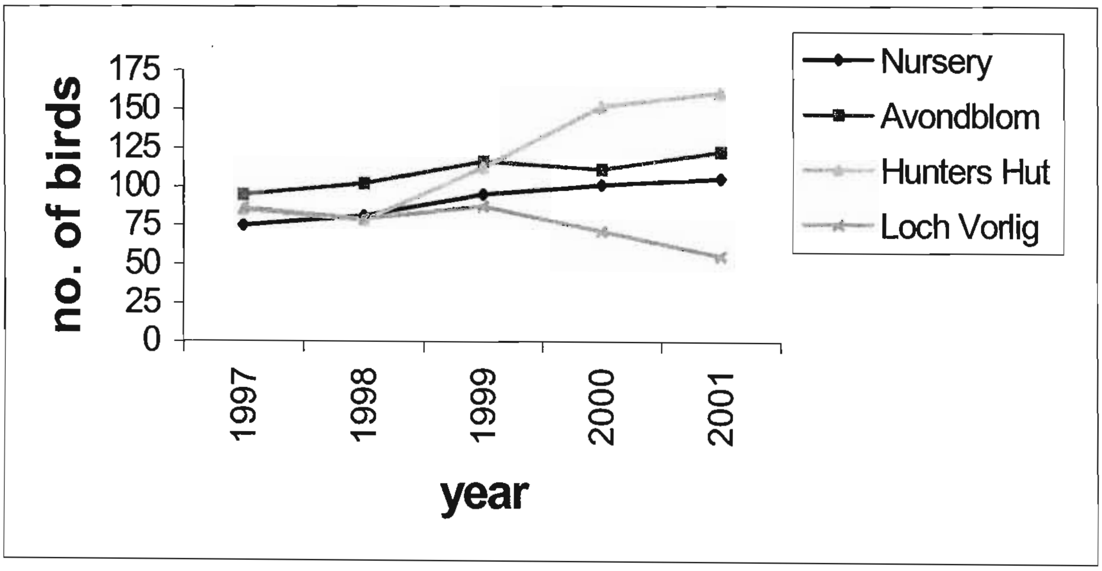
1998
1999
2000
2001
year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year
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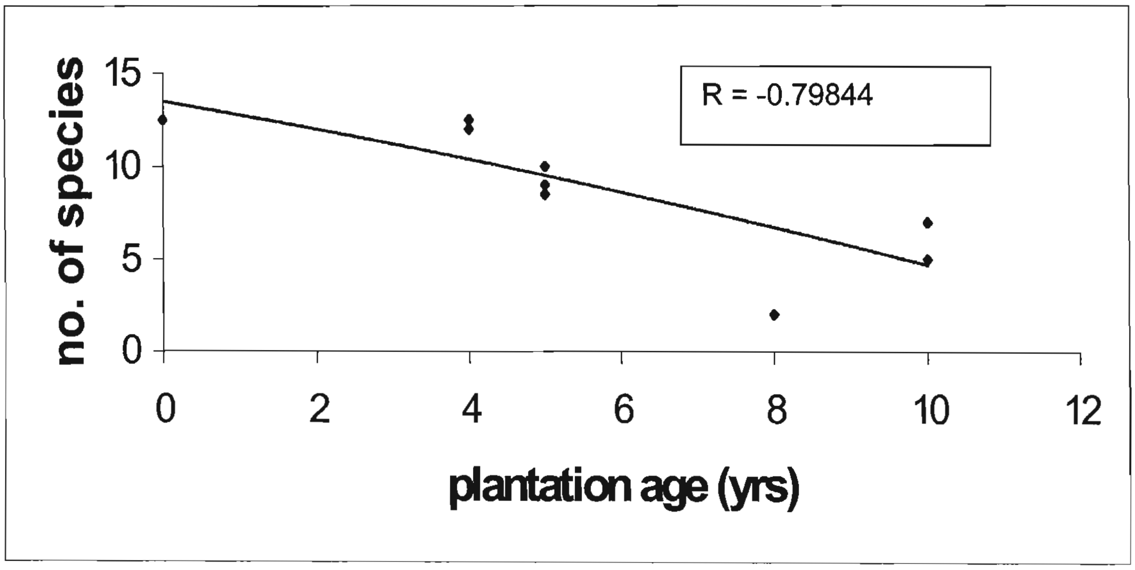
Hunters Hut
Loch Vorlig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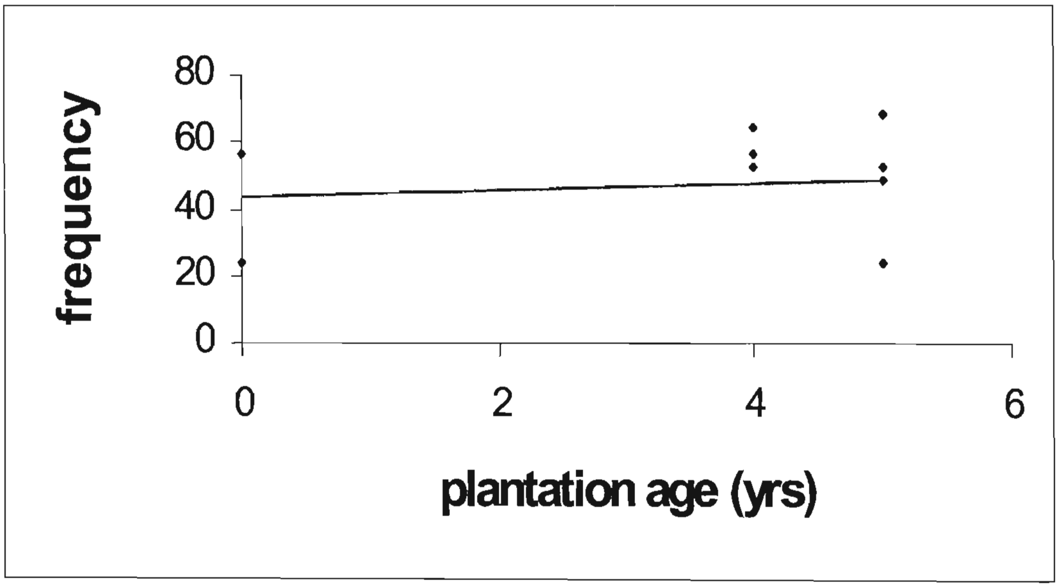
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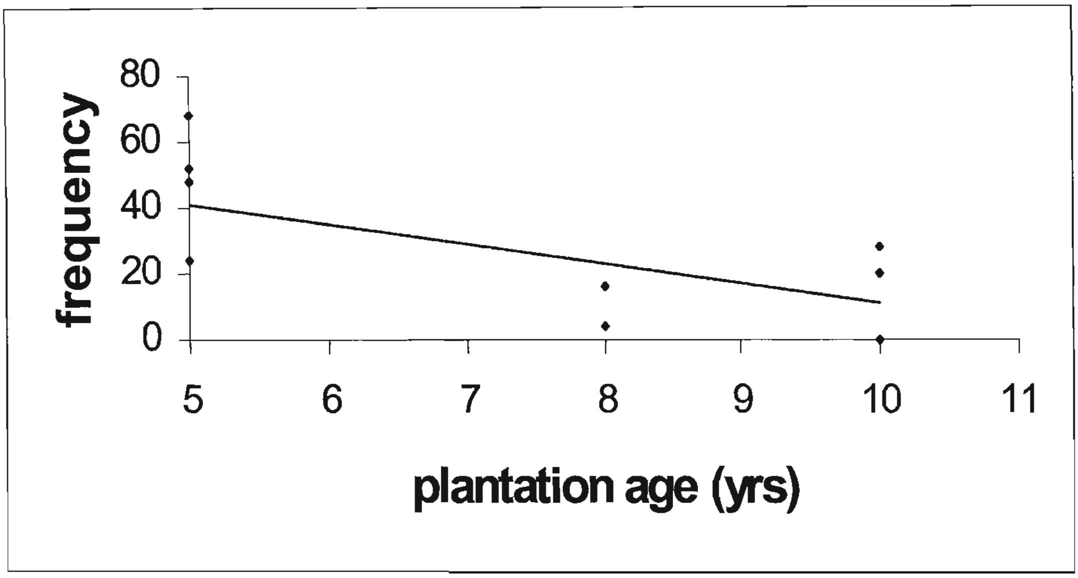

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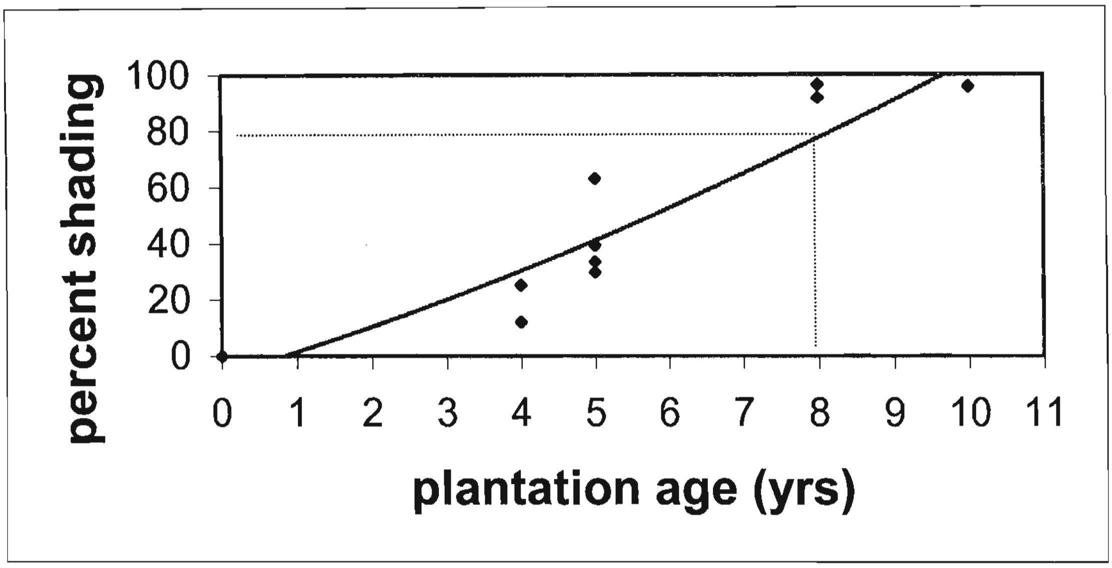
plantation age (yrs)



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plantation age (yrs)