CHAPTER 2.

THE STUDY AREA AND METHODS.

LOCATION.

Phinda is located in the Maputaland region of northern Kwa-Zulu Natal, South Africa at latitude 27 ° 40' to 27 ° 55 south and longitude 31°12' to 32°26' east. (Fig. 1). The region forms part of the almost flat low level coastal plain which runs from the Umfolozi River, north into Mozambique (Maud, 1980). Maputaland is bounded by the Indian ocean to the east and the Lebombo Mountains to the west.

Phinda is approximately 30km from the eastern coast of South Africa and covers an area of 170km^2. Over 95% of the reserve lies beneath 100m above sea level with a minimum altitude of 4m above sea level and a maximum of 201m above sea level where the southern tip of the Ubombo mountains run through the reserve in its south-west. Phinda has two rivers, the Mzinene which forms the boundary in the south and the Munyawana which bisects the reserve at approximately the mid-point between northern and southern tips. Both rivers are naturally seasonal though in the case of the Mzinene, an artificial weir has resulted in year-round water. Numerous small, shallow seasonal pans occur throughout the reserve as do a number of man-made dams which have water piped to them on an ad-hoc basis during the dry winter.

Surrounding land comprises privately owned farmland, rural Kwa-Zulu communities and state and privately-owned game reserves (Fig.1). Phinda itself is privately owned and was established as a conservation area in 1990. Prior to this, land-use was a mixture of private farming concerns (livestock, pineapples and cotton) and small game "farms" mostly devoid of large mammal species with the exception of some ungulates (see below). Phinda's mother company, the eco-tourism operation Conservation Corporation Africa (hereafter CCA) purchased or leased a number of these small properties to establish the reserve. During the study, the reserve's land was owned by a consortium comprising CCA and two private families from which CCA leased to permit traversing rights for game drives. Internal fences divided the reserve into two areas as illustrated in Fig.2 until February 1993. Prior to February 1993, re-introduced felids only occupied the northern portion of the reserve. After February 1993, the internal fence was removed and cats were free to traverse the whole area. The entire reserve formed the field site for this study. As is prescribed for reserves in South Africa reintoducing dangerous species, the entire perimeter of Phinda (115km) is fenced with electrified game fencing. Three entrance points to the reserve, the width of a single-lane carriage way, are unfenced and protected by electrified cattle grids.

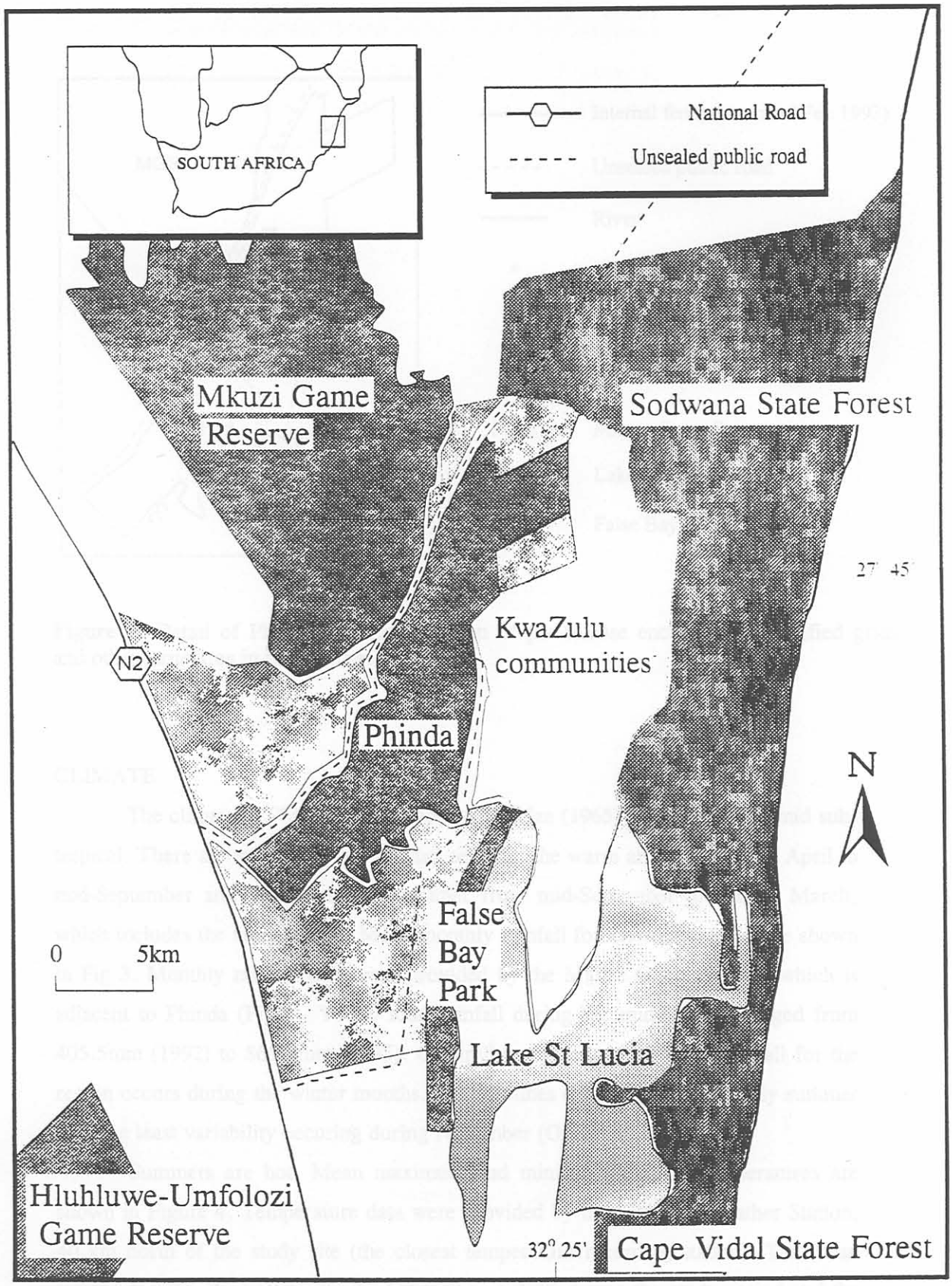

Figure 1. Location of Phinda showing proximity to surrounding conservation areas and land-use on the boundaries. Land-use types as follows:

Conservation areas

Primarily privately-owned land with mixed agriculture livestock and wildlife.

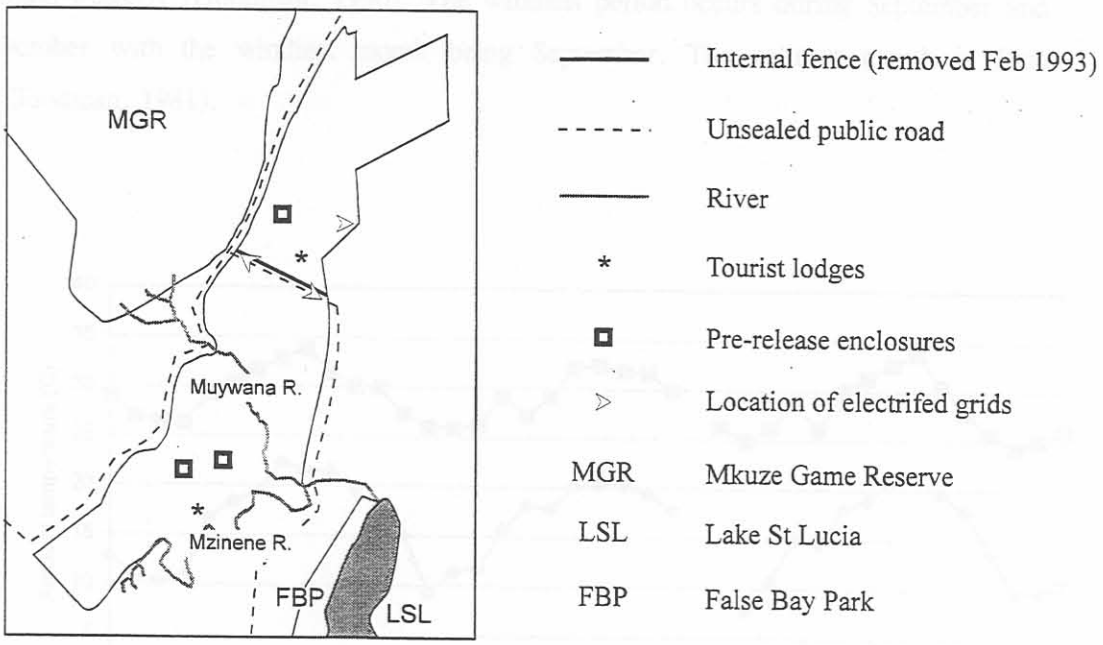

Figure 2. Detail of Phinda, showing location of pre-release enclosures, electrified grids and other structures in the reserve.

CLIMATE

The climate of Phinda is described by Schulze (1965) warm to hot, humid sub-tropical. There are essentially two distinct seasons: the warm arid winter from April to mid-September and the hot humid summer from mid-September to end of March, which includes the rainy period. Mean monthly rainfall for the study period are shown in Fig 3. Monthly rainfall data were provided by the Mkuze Game Reserve which is adjacent to Phinda (Fig.1). Yearly total rainfall during the study period ranged from 405.5mm (1992) to 865.9mm (1995). Generally, greatest variablity in rainfall for the region occurs during the winter months. This declines during spring and early summer with the least variability occuring during November (Goodman, 1981).

Summers are hot. Mean maximum and minimum monthly temperatures are shown in Figure 4. Temperature data were provided by the Makatini Weather Station, 40 km north of the study site (the closest temperature recording station). The mean temperature for the hottest month, January, was 33^{0}C during the study period and the absolute maximum recorded was 45.5^{0}C. Winters are warm with a mean maximum for the coldest month (July) of 25.5^{0}C. The mean monthly minimum for July was 9.9^{0}C and the absolute minimum recorded was 5.0^{0}C.

The prevailing winds for the Natal coastal strip are roughly north-easterly and south-westerly (Goodman, 1990). The windiest period occurs during September and October with the windiest month being September. The calmest month is June (Goodman, 1981).

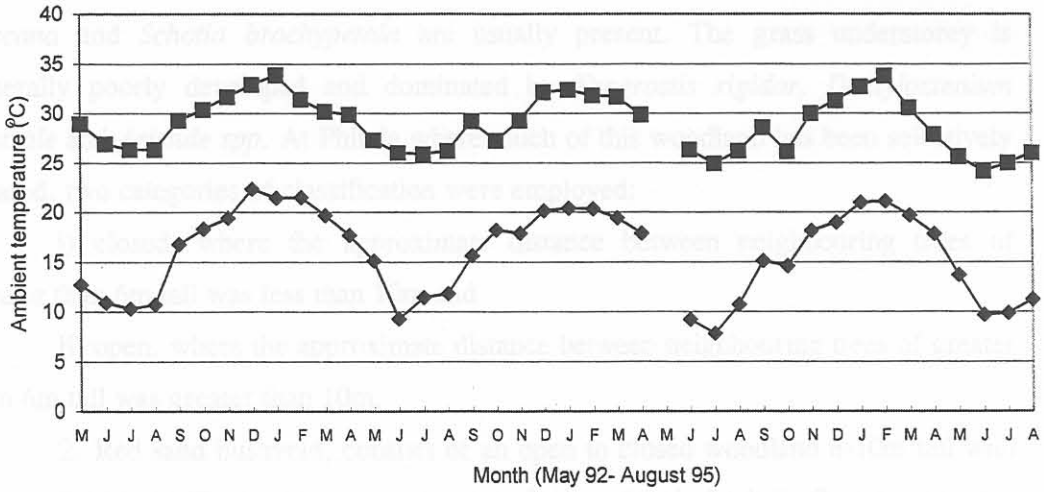

Figure 3. Monthly maximum and minimum temperatures for the study region, May 1992 to August 1995. Data unavailable for May 1994.

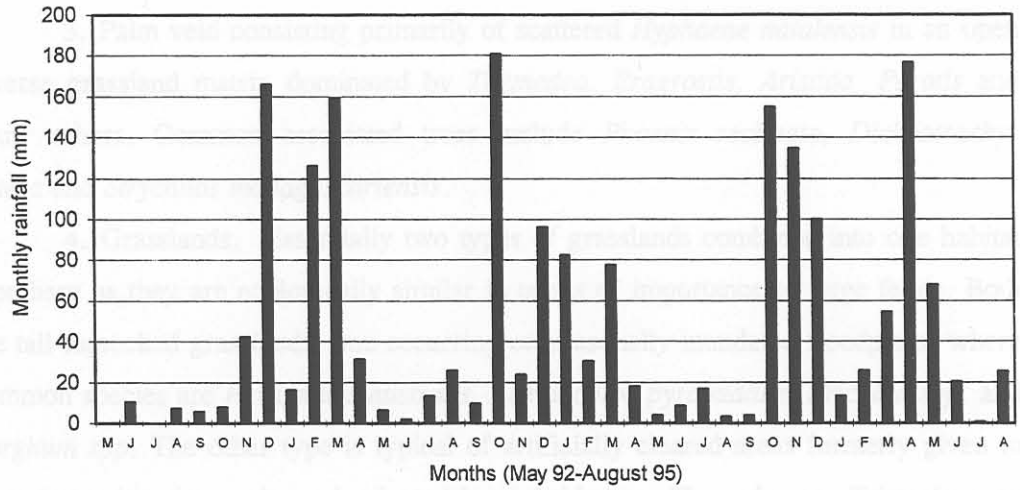

Figure 4. Monthly rainfall for the study period, May 1992 to August 1995. Data from Makatini weather station.

HABITAT TYPES.

Phinda is situated in Natal lowveld bushveld/coastal bushveld-grassland vegetation zones (Low & Rebelo, 1996). It may be divided into seven major vegetation types which in most cases overlap considerably and are not necessarily distinct. Terminology here follows Moll (1980) and Goodman (1990). The types are:

1. Mixed bushveld. *Acacia*-dominated woodland with commonly occurring species being *A. tortillis, A. nilotica, A. grandicornuta* and *A. senegal. Spirostachys africana* and *Schotia brachypetala* are usually present. The grass understorey is generally poorly developed and dominated by *Eragrostis rigidor, Dactyloctenium australe* and *Aristide spp*. At Phinda where much of this woodland has been selectively cleared, two categories of classification were employed:

i) closed, where the approximate distance between neighbouring trees of greater than 6m tall was less than 10m and

ii) open, where the approximate distance between neighbouring trees of greater than 6m tall was greater than 10m.

2. Red sand bushveld, consists of an open to closed woodland 6-10m tall with scattered thickets. The most common tree species are *Acacia burkeii, Combetum molle, Sclerocarya caffra, Ziziphus mucronata, Albizia versicolor* and *Terminalia sericea*. The herbaceous layer is generally sparse and is characterised by *Aristida spp. Panicum maximum, Eragrostis rigidior, Eragrostis pallens* and *Pogonarthria squarrosa*. I divided this habitat type into open and closed as for Mixed bushveld.

3. Palm veld consisting primarily of scattered *Hyphaene natalensis* in an open diverse grassland matrix dominated by *Themedea, Eragrostis, Aristida, Perotis* and many others. Common associated trees include *Phoenix reclinata, Dichrostachys cinera* and *Strychnos madagascariensis*.

4. Grasslands. Essentially two types of grasslands combined into one habitat type here as they are ecologically similar in terms of importance to large felids. Both are tall tussocked grasslands, one occurring on seasonally inundated floodplains where common species are *Phragmites australis, Echinochloa pyramidalis, Erichloa spp*. and *Sorghum spp*. The other type is typical of artificially cleared areas formerly given to intensive cultivation and are dominated by *Aristida spp, Themeda spp. Tristachya ssp* and *Paspalum ssp*.

5. Dry Mountain Bushveld. Open woodland associated with rocky soils usually at altitudes greater than 100m above sea level. Representative species include *Combretum apiculatam, Acacia nigriscens, Themeda triandra, Heterropogon contortus*

and *Cymbopogon excavatus*. Where the soils are shallow, the herbaceous understorey is poor and *Aloe martlothii* is particularly common.

6. Sandforest, a unique vegetation type under threat in South Africa (Low & Rebelo, 1996). The forest is very dense and the canopy is high extending to 25m. Important tree species present include *Newtonia hilderbrandtii, Cleistanthus schlerteri, Hymanocardia ulmoides, Pteleopsis myrtifolia, Dialium schlerteri, Croton gratissimus* and *Strychnos henningsii*. *Salacia leptoclada, Croton pseudopluchellus* and *Hymenocardia ulmoides* form a well-developed sub-canopy of small trees and shrubs (Goodman, 1990). The herbaceous understory is almost non-existent.

7. Riparian woodland. Well-developed woodland occurring adjacent to the two main rivers, Munywana and Mzinene. Main woody species are *Acacia xanthophloea*, *A. robusta, Spriostachys africana, Rauvolfia caffra* and T*richilia emetica*. The subcanopy is dense, key species being *A. schweinfurthii*. *Azima tetracantha* and usually the alien *Eupatorium odoratum*.

No detailed vegetation map exists of Phinda, so I surveyed the entire reserve classifying habitat types into the above categories. I attempted to delimit edges of habitat types using two series of 1:30,000 aerial photographs of Phinda taken in 1975 and 1995. This is accurate for obvious habitat divisions such as the boundaries of grasslands and patches of sandforest. However, divisions between vegetation types are generally indistinct, so I usually assigned edges to vegetation groups after ground reconnaissance either by driving or walking and recording habitat types on a 100m x 100m grid overlaid on a 1:50,000 topographic map. Although this method is crude, it is considered acceptable for defining coarse differences in plant communities which are potentially ecologically significant to large mammals (Goodman, 1990:27). I drew the boundaries of vegetation types by hand on the aerial photographs and then digitized the data using ArcView™ Geographical Informations Systems (GIS) software to generate a habitat map of the reserve (Figure 5.)

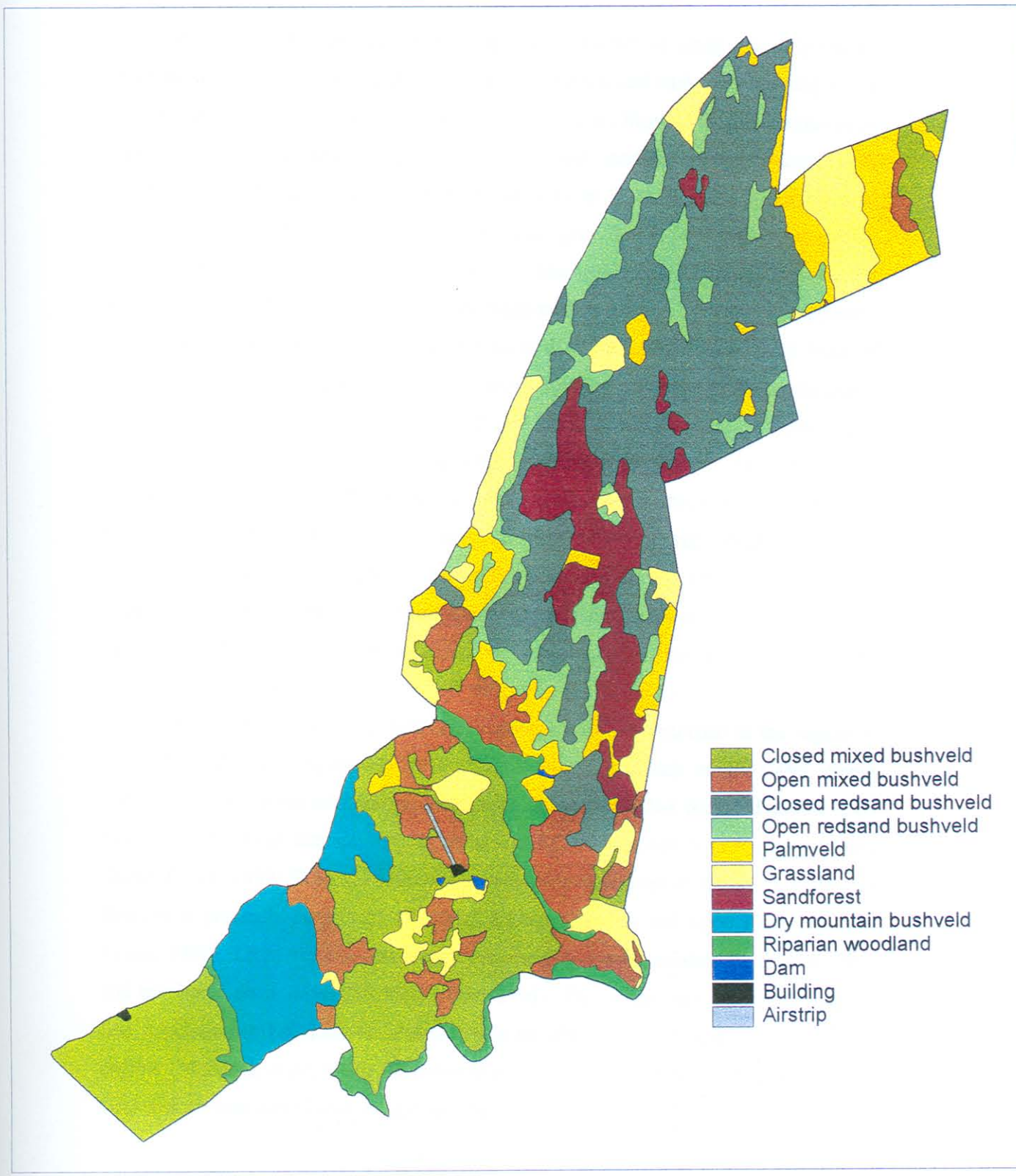

Figure 5. Distribution of vegetation types at Phinda. See text for description of habitat types.

MAMMALIAN FAUNA.

Prior to 1990, the study site comprised a number of small privately owned concerns with a mixture of land uses such as livestock and cash crop farming while also utilising the wildlife mostly for recreational hunting. Most of the indigenous large mammal fauna had been extirpated but small and medium-sized ungulates were common when Phinda assumed control of the area in 1990. Species present include nyala, impala, southern reedbuck, greater kudu, grey duiker, red duiker, steenbok, suni, warthog, bushpig and small numbers of blue wildebeest, Burchell's zebra and waterbuck (scientific names of all species mentioned in the text are listed in Appendix I). Between 1990 and 1993, Phinda translocated to the reserve over 1000 head of ungulates, supplementing numbers of the above species, particularly those anticipated to be important prey items for re-introduced felids (nyala, impala, wildebeest and zebra). Most of these ungulates originated from small ($<50km^2$) 'game farms' in northern KwaZulu/Natal. During this period, giraffe, white rhinoceros and elephant were also re-introduced. All species released by Phinda were once indigenous to the area, with the possible exception of giraffe (Goodman & Tomkinson, 1987). Very small (<20) populations of two non-indigenous ungulates, blesbok and red hartebeest, occured in the reserve at its inception but were largely removed prior to felid reintroduction in 1992.

Resident populations of lions and cheetahs were last recorded in the region in the 1938 and 1941 respectively (Rowe-Rowe, 1992; Maddock *et al,* 1996). Since 1966, attempted re-introduction of cheetahs to the province has occurred at five sites (Table 1). All these attempts appear to have failed to establish breeding populations (Rowe-Rowe, 1992: Table1). A second re-introduction attempt at Hluhluwe-Umfolozi Reserve is presently underway: 22 cheetahs have been released since 1995 (Marker-Kraus, 1996). Lions were re-introduced into the Hluhluwe-Umfolozi Reserve in 1965 and numbered 64 in 1996 (Maddock *et al*, 1996). This is the only other free-ranging lion population in KwaZulu-Natal aside from the Phinda animals and is apparently in decline (Maddock *et al*, 1996). Between March 1992- April 1994, Phinda released 13 lions and 15 cheetahs (Table 2, next section.)

Site	Number released	When released	Estimated population 1992*
Hluhluwe-Umfolozi Reserve	64	1966 -1969	13
Itala Game Reserve	13	1979	< 10
Lake St Lucia Reserve	18	1978 -1981	rare
Mkuzi Game Reserve	33	1966	< 10
Ndumu Game Reserve	14	1971	unknown

Table 1: Past attempts to re-introduce cheetahs in KwaZulu-Natal province, South Africa.
* Source: Rowe-Rowe 1992.

In addition to re-introduced carnivores, Phinda has low numbers of leopards and spotted hyaenas which had been heavily persecuted prior to Phinda's establishment. Both species are numerous in the adjacent Mkuze Game Reserve (Rowe-Rowe, 1992) and individuals freely migrate across reserve boundaries. African wild dogs are not resident in Phinda though transient animals occasionally pass through the area, most likely from the Hluhluwe-Umfolozi population. A group of five dogs was seen at Phinda during the study period (April, 1993). A single brown hyaena was killed on a district road along Phinda's western boundary in 1995, the only record of this species for the reserve. Small carnivores present include serval, caracal, two species of jackals, three mustelids and five viverrids. Other common mammals at Phinda include chacma baboon, vervet monkey, greater bushbaby, African porcupine and aardvark (full list of mammals present at Phinda in Appendix I).

THE REINTRODUCTIONS: Historical framework and methodology.

Socio-political considerations.

Increasingly practitioners of re-introduction are realising that socio-political elements have a fundamental influence on the success of reintroduction projects (Peek *et al*, 1991; Reading & Clark, 1996). While biological and technical aspects are typically given substantial attention, failure to address factors such as competing human values and socio-economic pressures have doomed some reintroduction efforts (Reading & Clark, 1996). Phinda management had initiated considerable involvement by surrounding communities in the reintroduction process prior to my arrival. Although my study is not directly concerned with the human dimension of reintroductions, one of my roles at Phinda was to interact with local communities regarding the reintroduced

felids. I have included here the historical background and details of this relationship to illustrate this important aspect of reintroduction projects.

Phinda shares boundaries with rural Zulu communities and commercial farmers, both groups relying on their subsistence primarily from livestock. During 1989, communication was initiated with representatives from all surrounding communities. The focus of these early meetings was to discuss the planned development of Phinda as a wildlife reserve and to negotiate the placement of boundaries (which had been historically disputed). During these discussions, the concept of re-introducing 'dangerous game' was first introduced. The local provincial wildlife authority, the Natal Parks Board, controls translocation and introduction of "dangerous game" which includes the large felids. Initial negotiations focused on white rhinoceros, elephant and buffalo which were to be re-introduced before cats. In particular, the discussions emphasised insurance taken by Phinda to cover against any potential damage incurred by dangerous species should they leave Phinda's boundaries. By the time the release of lions and cheetahs was approaching, an extensive communication system between Phinda and local authorities was in place. Involvement and education of these communities regarding the large felids began nine months before the first release of cats. A series of meetings was held with representatives from the Biyala Farmers Association (commercial farmers), the three neighbouring tribal communities Mnqobogazi, Nibela and Mkasa, and the then KwaZulu Department of Veterinary Services. Additionally, the representatives were taken to areas within South Africa where lions and cheetahs exist to illustrate the role large predators play in ecological communities as well as emphasising the tourism appeal of these species and the role of post-release monitoring as a security safeguard. The activities culminated in the signing of a legally binding document in which the authorities representing all local communities gave Phinda the permission to introduce lions and cheetahs.

Part of this agreement was that no predators would be re-introduced without first informing all local communities and that representatives would be present for all releases. At the first lion re-introduction, as many people as possible were invited to witness the arrival of the lions. The local chiefs of the three tribal communities and all of the tribal elders were present along with the Biyala Farmers Association and any other interested members of the surrounding communities. The concept of radio-monitoring the cats and the transponder system of marking animals was explained and demonstrated during procedures in which sedated cats were fitted with radio-collars and transponders prior to their release. This was an interactive process in which people were encouraged to examine the sedated lions and the equipment used to monitor them.

This was the first time many of those present had seen wild felids and certainly, had been given the opportunity to interact at such an intimate level and the process generated enormous excitement. For subsequent re-introductions, all the relevant authorities expressed satisfaction with the process so long as they were informed and one of their representatives was present: evidently the excitement and uncertainty apparent during the first release was much reduced later on. To ensure on-going confidence with the felid re-introduction project, Phinda has a yearly inspection in which local authorities are invited to the reserve for a day in which they examine the integrity of boundary fences, and the efficacy of monitoring re-introduced cats is illustrated with radio-collared animals in the field. Additionally Phinda has an on-going undertaking with the communities to mark with transponders all offspring born to re-introduced felids before they are a year of age, an agreement which also assists in the monitoring and management of populations.

Communication with the surrounding communities regarding re-introduced felids is excellent and indicates that the general public is largely supportive or at least, tolerant of the project. On seven occasions when lions or cheetahs moved out of the reserve (see Chapter 3 for details), members of the farming public informed Phinda who recovered the cats, often assisted by farmers. In one case, lions killed R18,000 worth of wild and domestic stock on one farm before being sighted by the land-owner who called Phinda: the lions were recovered and the farmer was compensated for his losses.

This marks a significant change in attitude of the farming public to felids. Historical persecution of predators by farmers in this region is widespread and land-owners are legally permitted to shoot carnivores if they are a threat to life or livelihood. Many farmers express a wish to avoid shooting cats if an alternative exists. I believe the process of education and involvement initiated by Phinda management provides that mechanism for re-introduced species. Interestingly, indigenous carnivores such as leopards and spotted hyaenas (which were not reintroduced and therefore not perceived as Phinda's responsibility) are still heavily persecuted on farms in the region.

Techniques

Between March 1992-April 1994, Phinda released 13 lions and 15 cheetahs, (Table 2). The lions originated from the eastern Transvaal, South Africa approximately 400km north of Phinda. Most cheetahs originated from Namibia, largely within the Otjiwarongo-Otavi region 1900km north-west of Phinda. Two cheetahs were captured within South Africa, a transient female darted just outside Phinda's north-west

boundary and a male caught 915km km north-west of Phinda on the Botswana border. The re-introduction programme took place in seven separate releases (Table 2). Each release was a separate event and all the individuals of each group were held together prior to release. Release events were staggered and took place from different locations within Phinda (see Fig. 2.) in the hope that individuals had sufficient time and space to establish home ranges before other animals were released and conversely, that the chance of newly released individuals encountering established animals was reduced in early post-release stages.

Release	Species	Group composition	Relatedness among group members*	Date released
1	cheetah	2 adult males 4 adult females	All unrelated.	03/92
2	lion	2 adult females 2 subadult males 3 subadult females	Adults unrelated to all (& each other). Subadults all from same pride.	05/92
3	cheetah	3 adult males	2 brothers, other ♂ unrelated.	11/92
4	lion	1 adult female 3 subadult males 2 subadult females	Unrelated to all. 2 brothers, one ♂ unrelated to all. Unrelated to all.	02/93
5	cheetah	3 subadult females	All from same litter.	06/93
6	cheetah	1 adult female		04/94
7	cheetah	2 adult males	Unrelated.	06/94

Table 2: Details of lions and cheetahs released, arranged chronologically. *No animals from different groups were related. "Unrelated to all" means those individuals were not related to any other animal in the group.

As Reading and Clark (1996) have stressed, much of the methodology involved in translocation is experimental. Manipulations quantifying the results of techniques are beyond the scope of most re-introduction projects and in any case, would be impractical in the majority of situations, particularly those involving large carnivores. In this section, I present the techniques employed. I discuss the implications of some of these techniques in following chapter dealing with post-release behaviour.

Upon their arrival to Phinda, each release group was introduced into one of three acclimation pens located in the reserve, shown in Figure 2. The pens measured 80m x 80m and were constructed of 3.5m high game fencing with an inner overhang and reinforced to a height of 1.5 m with diamond mesh cyclone fencing. The fence was

buried to a depth of 1m to discourage animals digging out of the pen. Thick existing vegetation inside the enclosure provided animals with refuges. The inner perimeter of the pen had three electrified wires discharging an average of 7000 volts at heights of 30cm, 1m and 2.5m. During the holding period, the animals were provided with a complete ungulate carcase every 2-5 days depending on the number of animals housed together, providing approximately 5kgs of meat per day per individual. All carcases were of wild prey species rather than domestic breeds to avoid any possible 'imprinting' on livestock.

In all release groups, the irregular availability of animals during the capture stage resulted in varying familiarity (and relatedness: see table 2) among individuals. Cheetahs of each group had been progressively introduced to one another in a holding facility in Namibia, and had gradually become accustomed to each other with low levels of aggression and no injury. However, in the case of the lions, the aggression between newly unfamiliar individuals posed a greater chance of injury to animals. Therefore, 100mg of long-acting perphenazine enanthate (trade name; Trilafon®, Schering-Plough, Isando, RSA: hereafter perphenazine) tranquilliser was administered intramuscularly to the adult individuals of each group in an effort to reduce aggression directed to unfamiliar, sub-adult animals (refer Table 2). Long-acting tranquillisers including perphenazine have been widely used in newly-captured African herbivores to overcome problems such as aggressive behaviour, panic and intra-specific conflicts in confined areas for up to 10 days (Ebedes, 1993). Lions on perphenazine were apparently fully aware of their surroundings but were noticeably affected (slower movements than undrugged animals, indifference to their captivity) 10-12h after injection and appeared unwilling to engage in aggressive encounters with unfamiliar cage-mates. Drugged animals displayed affiliative behaviour such as cheek-rubbing and mutual grooming to unfamiliar cage-mates after approximately 72h on perphenazine. The danger of mixing unfamiliar, undrugged lions precluded establishing a control group not treated with perphenazine so one needs to be cautious when drawing conclusions. However, unfamiliar individuals of large carnivores, particularly lions, are notoriously difficult to mix in captivity typically resulting in high levels of aggression, injury and death (Burroughs, 1993). The lack of such problems in the study animals suggests that perphenazine is useful in reducing aggression in lions (and may promote the establishment of lasting affiliative relationships between unfamiliar individuals; see Chapter 3). This is the first study where long-acting tranquillisers were used with this aim in large carnivores but it has been widely employed with similar results during pre-

release captivity periods in subsequent translocation efforts of carnivores in South Africa (Van Dyk, 1997).

Each release group was held for 6-8 weeks in the enclosure before release, an arbitrary duration established by the level of habituation of animals to vehicles. Monitoring and tourism requirements at Phinda demanded that re-introduced cats were accustomed to vehicles and it was also felt this period would assist newly-translocated felids in recovering from any agitation or disorientation resulting from capture and transportation. When lions and cheetahs showed indifference to vehicles, they were released by simply opening the feeding gates which led into the reserve proper. The animals were allowed to move out of their own accord, usually to a carcase which had been provided outside the enclosure. This was the last time animals were provisioned: supplemental feeding after their release did not occur, except where animals were darted, a procedure facilitated by the presence of a bait.

GENERAL METHODOLOGY

The general methodology used throughout the study is detailed in this section. More specific techniques are described in detail in the relevant chapters. The field work for the study was conducted over 40 months from May 1992 to September 1995 during which time I lived at Phinda and gathered field data daily during this period. Apart from occasional days off, periods I was absent from the reserve for longer than 3 days were: December 1992-January 1993 (4 weeks), October 1993 (12 days), December 1993 (10 days), March 1994 (10 days), April 1994 (4 weeks), October 1994 (10 days) November 1994 (5 days), December 1994 (6 days), April 1995 (18 days), May 1995 (9 days) July 1995 (6 days) and August 1995 (8 days). Total time of field work amounted to over 6000 hours. I made a total of 12 brief (up to 3 weeks) visits to the reserve between September 1995 and June 1998 to collect episodic data (sexes of new litters, deaths of animals etc) which are included in this study. All radio-tracking and observations were conducted from a Toyota Hi-Lux 4wheel-drive. I was in constant 2-way radio contact with tourist guides in the reserve which assisted in gathering data on some parameters (see Observation of Felids).

Immobilisation and telemetering of felids.

Certain individuals in each re-introduced group were immobilised and radio-collared prior to their release. Efforts were made to minimize the number of radio-collars present to reduce the aesthetic impact on the tourism experience (see Appendix II). Non-essential collars were removed post-release after a 'settling-in' period, so that

each pride (lions) or male coalition (lions and cheetahs) was represented by a single collar. Collars were replaced when their battery life expired and, where possible, were fitted to individuals temporarily not accompanying monitored animals (for example, when lionesses left the pride to give birth).

After release, lions and cheetahs were immobilised from the vehicle at distances up to 30m with a Telinject G.U.T. 50 dartgun (Telinject SA, Randburg, RSA). Darting was often greatly assisted by drawing animals to a bait, a method which anchors them to a location and is particularly useful when more than one individual in a group needs to be caught. Animals were usually darted early morning before the hottest part of the day and, night-time was avoided because of the risk of harassment to drugged cats by spotted hyaenas. The drug used was a tiletamine-zolazepam combination (Trade name; Zoletil®, Logos Agvet, Halfway House, RSA) at 3-5mg/kg body mass for lions and 2-3 mg/kg body mass for cheetahs. Induction time was usually 7-8 minutes and they remained anaesthetised for 45-60 minutes. Zoletil® does not have a widely available antagonist (reversing agent) and complete recovery can take up to 4 hours. All darted cats were observed until they were mobile and showed negligible effects of the drug.

Radio-collars consisted of a MMK4 transmitter (Telonics™, Mesa, Arizona) in the 148-151 Mhz band powered by a 3.6v D-sized lithium battery and encased in dental acrylic. The collar was made of four cm wide industrial conveyer belting, which was fitted on animals by pop-rivetting. The whole unit weighed approximately 400g. Collars transmitted for over two years at ranges up to 2.8 km (on level ground). One male lion was fitted with an implantable transmitter unit (IMP 400/L, Telonics™, Mesa, Arizona) which was surgically sewn to the omentum membrane inside the abdominal cavity. However, signal range never exceeded 850m (see Appendix II) and no further implants were used. The receiver used to locate animals was a Yaesu FT 290RII (Yaesu Musen Co., Tokyo, Japan) and an aluminium four-element Yagi antenna.

Individual recognition of lions and cheetahs.

All reintroduced felids and their offspring were recognisable by individual facial features. Cats had both sides of their faces photographed so that the unique arrangement of whisker spots (lions) or cheek markings (cheetahs) could be used to identify animals. In the case of cheetahs, both sides of the tail were also photographed, as the bands at the end of the tail are unique to individuals (Caro, 1994). All cats were injected sub-cutaneously with passive identification transponders (Trovan™, AEG/Unidata, Rosebank, RSA: one chip each in the neck and the flank) and were tattooed with the letter "P" on the gum above an upper canine tooth to assist identification of sedated or dead animals. Theoretically,

transponders have an unlimited lifespan barring loss or damage. They functioned without any drawbacks for the duration of this study and enabled identification of decomposed animals which otherwise would have been impossible. Occasionally, transponders 'migrated' under the skin up to 20cm from the point of insertion but could always be detected after some searching. Conversely, gum tattoos, though still present after a year, were barely recognisable.

I assigned each animal a unique alpha-numeric identification following the form, species/sex/number. So, for example, CM2 refers to cheetah male two, LF5 refers to lion female five and so on. Numbering was sequential in each species (lions and cheetahs), regardless of sex e.g. CM1, CM2, CF3, CF4, CF5 etc, so that each individual (within a species) could be identified by the unique number alone. Cubs born in the reserve were numbered sequentially according to this system and if an animal died, its number was not used again. I refer here to all study animals by this nomenclature.

Observation of felids

Lions and cheetahs habituate to vehicles very quickly if not persecuted and largely ignored my vehicle, occasionally resting beneath it for shade or sitting on the bonnet to observe the surroundings. Observations were usually made from 20m-50m away but was often far greater, particularly during hunts. An attempt was made to locate all telemetred felids once daily between sunrise and 12:00am. Perhaps the most effective method of studying the feeding ecology of large carnivores is to follow them for long-term continuous sessions (Mills, 1992, 1996; Packer, 1995). This was possible on a limited basis at Phinda due to dense vegetation where I could not travel. Where possible, I followed active individuals from their afternoon active period (sunset $\pm$ 2-3 hours) until they became inactive or killed. For cheetahs this period rarely persisted after 20:00hrs but for lions it frequently extended until sunrise the following morning. As a tourism operation, Phinda has guided game-drives operating in the early morning and late afternoon-early evening on a daily basis. The large felids are highly sought after by the drives and very often I directed vehicles to cats that I was not observing (though I regularly remained at a sighting while game drives were present). In this way, I gathered data on some parameters from more than a single animal or group at the same time and the rangers were invaluable in providing information. I have included here only those observations of rangers not open to interpretation e.g. species killed by cats, the time it was killed and so on. As I was in constant radio-contact with rangers, I could collect this information as it happened and so avoided any loss of accuracy in reporting that may have occurred with time. Where possible, I confirmed ranger reports by visiting the site of kills.

Basic data such as animal's location, group composition, presence of a kill and so on were recorded in notebooks at the site, whereas more involved observations such as continuous sampling of behaviour were recorded on a pocket dictaphone and later transcribed. I recorded locations on a 100m x 100m grid overlaid on a 1:50,000 topographic map or with the use of a Garmin 12 GPS unit. Depending on distance between myself and the animals, I watched them with the naked eye or a pair of 10x40 binoculars and used a 500,000 candle-power spotlight at night. When animals were active and mobile such as when hunting, I attempted to remain as far as possible from them and avoided the use of the spotlight so as not to influence behaviour or the outcome of hunts.

Statistical analysis of data.

Where data sets satisfied the assumptions of parametric statistics, these were applied. Transformations were applied to some data before parametric statistics could be used. Failing that, non-parametric analyses were used. Details of all analyses and transformations are given in each chapter.

Data were analysed using Statistica and SAS software packages. Details of other software specific to particular analyses are provided in the relevant sections.