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Use of Telemetry Data to Investigate Home Range and Habitat Selection in Mammalian Carnivores

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1. Introduction

Management of mammalian carnivore populations, whether to conserve a threatened species or to control the abundance of a noxious one, requires a basic understanding of the ecology and behaviour of a given species. Habitat selection and home range are fundamental processes in the ecology and behaviour of most animals, explaining why most researchers generally investigate them when assessing a species' needs. Presumably, species should have a higher fitness in habitats that they select or allow them to accomplish basic activities such as foraging and reproduction. Once habitats can be ordered by their relative preference, they can be evaluated as to their relative importance in terms of fitness (Garshelis, 2000). Wildlife managers and conservation biologists can, then, make decisions regarding any habitat modification or population control requirement that may be needed to deal with the species in question.

The assessment of either habitat selection or home range requires the collection of data on the animals' use of space. In theory, different approaches can be used to obtain the data needed to assess habitat selection and home range patterns. One approach may be to obtain the data by following an animal in order to observe its movements and habits. However, this approach is likely to prove very difficult, particularly in areas with thick vegetation or where the animal is active at night or when dealing with a species with secretive habits. There is also the risk that the close proximity of humans could affect the animal's behaviour resulting in an unrealistic outcome of the study or possibly having a negative effect on the studied animal, like interfering with the hunting success in mammalian carnivores. Another approach may involve obtaining data from transect surveys (Buckland et al., 1993). These surveys record animals in the vicinity of a set of sampling lines or points and therefore tend to yield relatively few sightings, particularly for rare species living in inaccessible environments. Telemetry is without any doubt the most common method to quantify either habitat selection or home range patterns, especially in mammalian carnivore species. Telemetry is a tool or technique used to research wild animal species in the field in order to gain a thorough understanding of that population and its dynamics as well as to identify any potential threats to its survival (White & Garrott, 1990). It is typically used to gather data from distant, inaccessible locations, or when data collection would be dangerous or difficult for a variety of reasons. Wildlife telemetry concerns the use of telemetry techniques

to remotely locate wild species and obtain ecological, behavioural and physiological data. It was in the 1960s, when telemetry, specifically radio-telemetry, was first used to study terrestrial wildlife (Craighead, 1982; Hebblewhite & Haydon, 2010). Since then, wildlife telemetry has contributed significantly to our understanding of fundamental ecological and behavioural processes of many animal species (e.g., Johnson et al., 2006). Advances in wildlife telemetry have made it possible to acquire detailed data on animal' space use, including habitat selection, home-range size, movement metrics as well as migration timing and routes. Since many wildlife species are secretive and difficult to observe, telemetry has become a valuable tool to learn more about their respective life-histories.

Human attitudes vary worldwide towards mammalian carnivore species. The overlap in space-use with human populations results in competition for habitats and resources which is at the heart of most of the conflicts between mammalian carnivore species, especially canids, and humans (Sillero-Zubiri & Switzer, 2004). For instance, canids tend to prey upon a range of livestock, game stock and threatened wildlife, and some of the large-bodied size species may also attack, and on rare occasions, deadly harm humans. Human-carnivore conflicts are among the major causes of population decline in many species (Treves & Karanth, 2003) and can be particularly controversial when the resources concerned have economic value (e.g., livestock) and the carnivore species involved have a high conservation profile (Graham et al., 2005). This is usually the case of large-bodied size carnivore species that usually have extensive space requirements, low reproductive rates and are persecuted by humans (Matthiae & Stearns, 1981). But, while these carnivore species are declining globally, others have not only managed to survive, but to become abundant. Many medium-bodied size generalist carnivores have been able to expand their geographic ranges because they are capable of using human-use areas and anthropogenic resources (Harris & Smith, 1987; Prange et al., 2004). For instance, red foxes (*Vulpes vulpes*) and coyotes (*Canis latrans*) may occur not only in rural areas, but also in suburban and occasionally more densely populated urban areas (Atkinson & Shackleton, 1991; Gibeau, 1998; Grinder & Krausman, 2001; Lewis et al., 1999).

In this study, we will consider the use of telemetry data to investigate habitat selection and home-range patterns of two mammalian carnivore species. Although both species occur in human-dominated landscapes, their interactions with humans are very distinct, resulting in very different abundance levels and conservation status. However, in both cases, investigations of habitat selection and home-range patterns are fundamental initial steps in the management of their populations. In the following Section 2, we will briefly define key concepts that will be used in this chapter. In Case Study 1 (Section 3), we will use telemetry data to investigate habitat selection and home range of the red fox in Prince Edward Island, Canada. In this case, the species is benefiting from its interaction with human populations. Our objective for Case Study 1 is to show how telemetry data can be used to elucidate the effects of fox-feeding (anthropogenic food resources provided to foxes by humans) on habitat selection and home-range patterns. In Case Study 2 (Section 4), telemetry data will be used to investigate habitat selection and home range patterns of the African wild dog (*Lycaon pictus*) in Mkhuzi Game Reserve, South Africa. Contrary to the red fox, the interaction with humans has had detrimental effects on African wild-dog populations in South Africa and other parts of Africa. Our objective for Case Study 2 is to illustrate the use of telemetry data to assess the success of the establishment part of a reintroduction program of an endangered or threatened carnivore species. For purposes of comparison, we have tried to use the same approaches, methods and data-analysis procedures for both case studies

whenever possible. However, differences in abundance levels and current status of red foxes and African wild dogs, as well as data collection, needed sometimes the use of different approaches to achieve the objectives set out for each case study. Section 5 concludes the chapter and comments on the use of radio-telemetry and other similar technologies in ecology and wildlife management.

2. Basic concepts

Habitat refers to a distinctive set of physical environmental factors that a species uses for its survival and reproduction (Block & Brennan, 1993). The semantic and empirical distinctions between the terms *habitat use* and *habitat selection* are often unclear (Hall et al., 1997). *Habitat selection* carries a connotation of understanding complex behavioral and environmental processes that *habitat use* does not; *habitat-use* patterns are the end result of *habitat-selection* processes. *Use* of habitat is the way in which an individual or species exploits habitats to meet its life history needs (Block & Brennan, 1993). The study of *habitat-use* patterns describes the actual distribution of individuals across habitat types (Hutto, 1985). *Selection* of habitat is the process by which an animal actually chooses habitat (Johnston, 1980). In other words, *habitat selection* refers to a hierarchical process of behavioral responses that may result in the disproportionate *use* of habitats to influence survival and fitness of individuals (Block & Brennan, 1993; Hutto, 1985). *Use* is considered selective if habitat is used disproportionately compared with its *availability*, the latter being the amount of that habitat *accessible* to the animal. In field studies, however, where the *availability* of habitat is variable, *habitat selection* is the use of habitat relative to its availability in the environment and is conditional on the availability of all habitats to the animal. It is important to distinguish between the terms *accessible* and *available* because it may be possible that certain habitats, within a given landscape, are available to an animal (or species), but they may not be accessible. Use-availability studies inherently assume that study animals have free and equal access to all habitats considered to be available, implying that at any given moment each studied animal should be able to use any available habitat (Garshelis, 2000). This assumption may stand if use and availability are measured for each animal individually, but it may be violated when data from different animals are pooled together and the available habitat is considered to be same for all when it is not the case. For instance, use and availability may be considered to be the same when all animals move as a pack or in cases when there is significant overlap in their home ranges. However, differences between use and availability may occur when not all animals have the same habitat types within their home ranges (Garshelis, 2000). Differences between use and availability may also occur when not all animals have free or equal access to all areas within their home ranges.

Habitat-selection scales are often assumed to be a function of home-range sizes (e.g., Chamberlain et al., 2003; McLoughlin et al., 2002, 2004; Rettie & Messier, 2000). Thus, an important concept associated with habitat selection is home range. Burt (1943) first defined home range as the area traversed by an individual when performing normal activities such as foraging, mating and caring for young. However, this definition has been challenged because the word "normal" is difficult to interpret and lacks a temporal component (Cavallini, 1996; White & Garrott, 1990). A less ambiguous, and more popular, definition of the home range of an animal is the limited area within which it can be found during a specified time period (Harris et al., 1990; Kernohan et al., 2001). According to this definition,

a home range can be flexible, varying with season and overlapping with conspecifics (Harris et al., 1990), making the concept of home range particularly useful for habitat selection studies. In contrast, a territory, a term commonly used interchangeably with home range, is defined as an area that is occupied by an individual or group to the exclusion of other animals of the same species (Börger et al., 2008; Burt, 1943; Mech, 1970). Animals may or may not be territorial, but will still have a home range.

Quantifying an animal's home-range size and shape allows researchers to gain information on foraging behaviour and inter- and intraspecific interactions (Harris et al., 1990). It is also useful for investigating animal-habitat relationships such as habitat selection (e.g., Johnson, 1980). For instance, Johnson (1980) proposed a habitat selection classification system that involves the notion of home range. Johnson's (1980) classification system is based on a hierarchical order of selection: 1st-order selection of a species' geographic range from the global pool, 2nd-order selection of home ranges from the geographic range, 3rd-order selection of habitat within home ranges (e.g., *core areas*), and 4th-order selection of structures, variables or conditions within habitats. The term *core area* refers to those areas within the home range where individuals are found with greater probability (Börger et al., 2008; Kaufmann, 1962; White & Garrott, 1990). Thus, core areas are locations of concentrated use within home ranges (Kaufmann, 1962) that contain important resources such as den sites and quality foraging areas (Ewer, 1968). Although core areas may contain similar landscape elements as the whole home-range area, the importance of a given habitat type can vary between "core areas" and "home-range size". While home ranges of different animals have been found to overlap (e.g., Kolb, 1986; Lovari et al., 1994), overlap of the core areas does not commonly occur (Samuel et al., 1985). Thus, the identification of core areas is important when studying intraspecific interactions or when investigating animal-habitat relationships (Samuel et al., 1985).

Another important factor that must be taken into consideration when investigating habitat selection patterns is that many resources used by wild species occur heterogeneously across the landscape, linking the concept of habitat selection with the ideas of space-use and scale. For instance, the process of habitat selection in mammalian carnivores has increasingly been studied as a hierarchical, multi-scale process, in which selection of habitat features is accomplished at progressively smaller scales (Orians & Wittenberger, 1991; Rettie & Messier, 2000; Schaefer & Messier, 1995). An organism selects a home range in which to live, and then it makes decisions about the use of different habitats within this home range in which fundamental activities such as foraging will be performed (Johnson, 1980). Rettie & Messier (2000) proposed that animal selection patterns that are governed by an avoidance of factors that tend to limit individual fitness dominate at the larger spatial scales, while less important limiting factors influence habitat selection patterns at smaller spatial scales. If Rettie & Messier's (2000) hypothesis holds true, then processes occurring at the larger spatial scales exert the most influence on species habitat selection. One may then predict that habitat quantified at the largest spatial scales would explain or describe the most variability in species habitat selection.

3. Case study 1: The red fox

The red fox is a generalist species that can occur in a variety of habitats, including forest, tundra, agricultural land, desert and urban areas. Several studies, however, have shown that this species tends to be more abundant in mixed mosaic habitats such as those

characterizing human-altered landscapes (Ables, 2009; Catling & Burt, 1995; Lloyd, 1975). In Prince Edward Island (Canada), the red fox was the largest mammalian carnivore species until the arrival of coyotes during the early 80s. Although no studies have assessed the abundance of red foxes on Prince Edward Island, it is commonly known that they occur throughout the whole province, including urban areas. Regardless of its widespread distribution, little is known about the home range, habitat selection, behaviour and population dynamics of red foxes in Prince Edward Island.

The red fox is an opportunistic species with a diverse diet that has allowed it to survive in natural and human-altered landscapes (Dell'Arte et al., 2007). Eating habits of red foxes vary, but normally they include entire mice, voles, birds and rabbits. However, the importance of each prey varies depending on habitat type, regional prey availability and anti-predator behavior (Dell'Arte et al., 2007; MacDonald, 1977). Additionally, studies have found that anthropogenic food items can sometimes play an important role in the diet of red foxes (e.g., Contesse et al., 2004; Newsome et al., 2010). Another relevant characteristic of red foxes is that their interactions with humans can take different forms. In areas where they are potential carriers of the rabies virus, red foxes are considered nuisance animals and are usually subject to population control even though these operations are generally unsuccessful (Smith & Harris, 1991). In Prince Edward Island, especially within and near Prince Edward Island National Park, red foxes are considered charismatic animals and many residents and tourists feed them throughout the year. Red foxes are fed by humans inhabiting houses or cottages located near the park, as well as by tourists on roadsides. Little is known about the consequences of this activity on red fox population occurring within Prince Edward Island National Park. However, it has been postulated that because humans feed these animals in the park, red foxes tend to select road and human-use habitats, rather than natural habitats for foraging, thus increasing the probability of being accidentally killed by vehicles.

In this study, we determined habitat selection and home range of red foxes occurring in Prince Edward Island National Park using radio-telemetry data. Specifically, we examined the use of radio-telemetry data to elucidate the importance of human-use areas and fox-feeding in habitat selection and home range patterns of red foxes.

3.1 Study site

Prince Edward Island is situated in the Gulf of the St. Lawrence and encompasses an area of about 5,660 km² (Weighs, 1995). Prior to the 17th century, Prince Edward Island was covered by tree species characteristic of the Acadian Forest region, such as sugar maple (*Acer saccharum*), yellow birch (*Betula alleghaniensis*) and beech (*Fagus grandifolia*) (Round Table on Resource Land Use and Stewardship, 1997). Since the arrival of European colonizers about three centuries ago, anthropogenic activities such as urbanization, forestry, and agriculture have altered the natural habitats of the island. Although the peak of deforestation occurred in the early 1900s, it is the intensive exploitation for agriculture that have occurred during the last century that have resulted in most of the major transformation of the natural habitats of Prince Edward Island (Johnston, 2000). Currently, the forests of Prince Edward Island are composed of species such as white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), and trembling aspen (*Populus tremuloides*) (Round Table on Resource Land Use and Stewardship, 1997). It is possible to assume that these changes in the structure and composition of vegetation have been followed by significant alterations in the distribution and abundance of natural resources for mammalian species occurring in Prince Edward Island.

The study site selected for this study was located in Stanhope (543 ha; 46°25'E; 63°06'N), Prince Edward Island National Park (Fig. 1). Although situated within the park, Stanhope is surrounded by private houses and cottages, many of them inhabited throughout the whole year. It encompasses forest patches, marshes, shrubs, ponds, dunes, beaches, roads, agricultural fields, and human-use areas (about 0.30 human dwellings per ha). Although we do not possess quantitative data regarding fox-feeding intensity in Stanhope, anecdotal information and personal observations clearly indicate that fox-feeding is a common activity in Stanhope, with residents setting out food for foxes throughout the whole year and many tourists feeding these animals during the touristic season (i.e., summer).

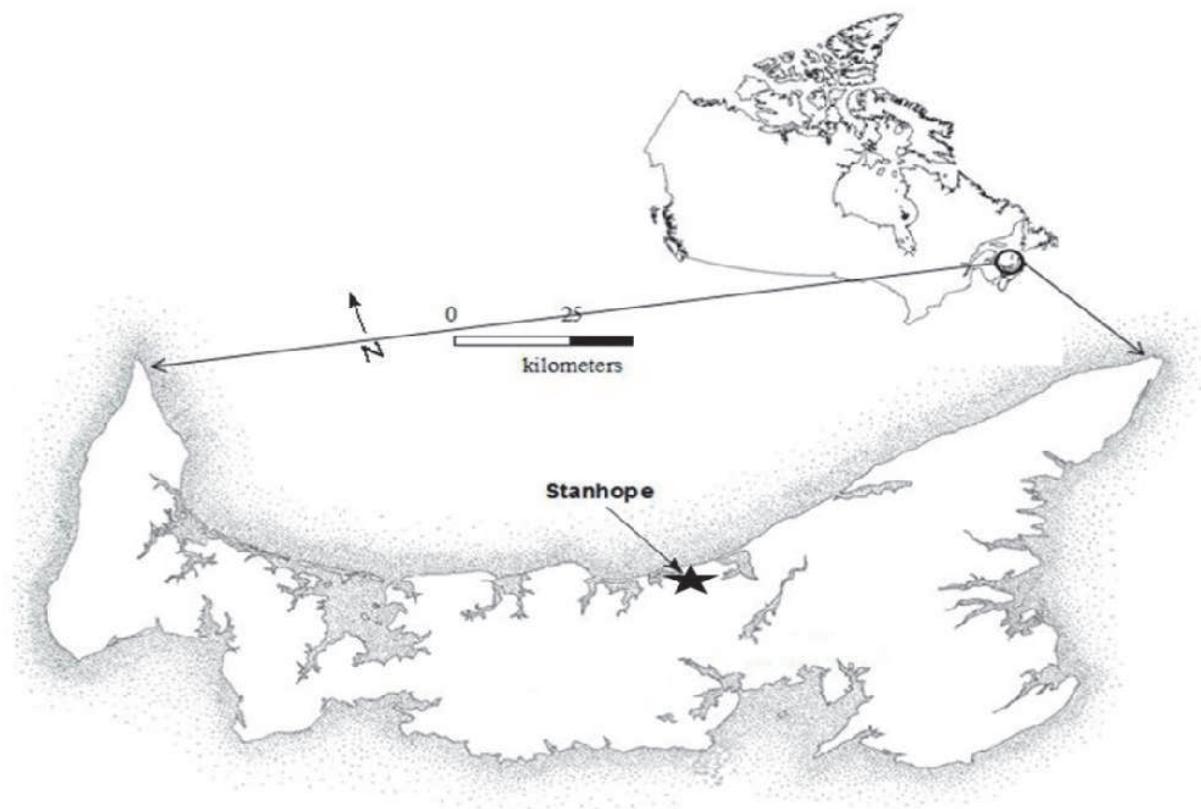


Fig. 1. Map of Prince Edward Island (Canada) in relation to Canada indicating the location of the study site (Stanhope) with a star. The scale-bar refers to Prince Edward Island only.

3.2 Data collection and analysis

Radio-telemetry data were obtained between April and September 2004. Trapping efforts were conducted from February to March 2004. Large Havahart single door box-traps (106.7 cm length x 38 cm width x 38 cm height) made from a combination of tensile wire mesh and steel were set within the study site in areas where red foxes or their tracks had been observed. Traps were baited with food for human consumption or wild meat and were checked every day. Captured foxes were anesthetized using Xylazine/Ketamine (1:10 mg/kg) and Atipamezole (1 mg per 10 mg of Xylazine; Animal Care Protocol, University of Prince Edward Island 03-043), and then radio-collared (TS-37 Telemetry Solutions; 50 g). The radio-telemetry procedure used in this study followed recommendations made by White & Garrott (1990). During the less active periods (morning and early afternoon), animal locations were estimated by one observer who

recorded 2-3 azimuths within 15-min intervals over a period of 1 hr. During the active periods (late afternoon and early evening), simultaneous triangulation was performed by 2-3 observers within 15-min intervals over a period of 1 hr. In addition, we also conducted 8-hr intensive (1 location every 15 min) telemetry sessions (sequential locations) twice per month (one in the afternoon: 13:00 to 21:00 and one during the night: 21:00 p.m. to 05:00 a.m.). These telemetry sessions were subjected to weather conditions, thus sometimes they were shorter than 8 hr. Tracking was done on foot using hand-held Yagi antennas and portable receivers (R-1000; Communications Specialists, Inc.). Triangulation angles were maintained between 30° and 150° (Gese, 2001). About 50% of radio-tracking locations were taken with the animal in view of the observers. Bearings were plotted immediately using LOAS 2.1 (Ecological Software Solutions 2003) to determine the accuracy of the locations. For the purposes of this study, we have not looked for statistical independence of locations (e.g., Swihart & Slade, 1985), but rather for their biological independence, using a minimum time interval between successive locations long enough to allow any radio-collared animal to cross entirely its home range. Repeated observations on the same individuals, as is the case with radio-telemetry locations, are often assumed to give rise to constant within-group correlation structures (i.e., lack of independence in the data). Although some ecologists and wildlife managers think that correlation structures represent a problem for the analysis and interpretation of wildlife telemetry data (Hansteen et al., 1997), others suggest that much can be learned by studying the causes and consequences of correlation structures in telemetry data. If a large time interval between successive locations is possible and/or the calculation of home-range size is the main goal of the study, strict adherence to the collection of non-autocorrelated data may be necessary. However, it may be difficult to translate autocorrelated data into an independent form and still retain a sample size that is adequate for the home-range size to reach an asymptote. Thus, the goals of most home-range or habitat selection studies require the collection of data which are dependent to some degree. This was the case in this study.

Habitat variables were determined using 2000 Prince Edward Island aerial photographs (1:17500; Prince Edward Island Department of Agriculture and Forestry) of the study site, and complemented with field observations to update any land-cover changes. ArcView GIS (version 3.3; Environmental Systems Research Institute, Inc., ESRI) was used to map animal locations obtained from radio-telemetry monitoring sessions and to assign to each location a habitat cover-type. Habitat was classified into 1 of 10 cover-types: agriculture (hay fields and pasture), forest (mature white spruce and hardwood forest), water or aquatic systems (frozen during winter; including ponds and saltwater bodies), dunes, beaches, roads (mostly paved), human-use areas (residential areas, recreational areas, parking lots), abandoned fields, marshes, and shrubs.

Habitat selection was examined by comparing use and availability of habitat types within the study area using the Neu Method (Neu et al., 1974). The Neu method is a straightforward application of the χ^2 goodness-of-fit test, and is usually used to compare observed counts of animals in each habitat with the counts expected if habitats were used in proportion to their availability. The method involves the calculation of confidence intervals (Bonferroni Z-statistic) around the expected proportions to determine whether the observed proportion of usage in each habitat is significantly different from expected. The usage of a particular habitat type was defined as the ratio between animal locations in each habitat type and the total number of locations recorded in the study area. Expected

usage of a habitat type was defined as the ratio of the area of the particular habitat type to the total area of the study site. The study-site area was defined at the home-range spatial scale using the smallest rectangle that included all 95% fixed-kernel home-ranges (see below for more information about the fixed-kernel home-range method), and at the core-area spatial scale using the smallest rectangle that included all the 50% fixed-kernel home ranges (*sensu* Kazmaier et al., 2001). This corresponds to a design-2 analysis of habitat selection according to Johnson (1980) because individuals could be identified using radio-telemetry data. ArcView GIS (version 3.3; ESRI) was used to calculate all the study site areas, as well as the availability of the different habitat types comprised within each study site.

Data on home-range size and core-areas were analyzed using the Animal Movement SA version 2.0 in ArcView (version 3.3; ESRI). The minimum number of locations required to accurately assess the home-range size of each animal was estimated by plotting cumulative home-range sizes against the number of locations (*i.e.* asymptotic home-range; Phillipps & Catling, 1991). The minimum convex polygon (MCP; Mohr, 1947) and the 95% fixed-kernel (Seaman & Powell, 1996) methods were used to determine home-range areas. The 100% MCP was utilized because it is the most commonly reported method in the literature (Harris et al., 1990), and therefore allows for some comparison with other studies. The 95% fixed-kernel method, while not without problems, has shown the best performance in simulation trials of home-range estimators that also included MCP. The 50% fixed-kernel method was used to estimate the size and shape of the core-areas or centers of activity within home-ranges. Fixed-kernel analyses were performed with a bandwidth calculated using least-squares cross validation (Powell, 2000; Seaman et al., 1999). The overlap area in home-ranges between two individuals was estimated using ArcView (version 3.3; ESRI).

3.3 Results

Amongst the five adult red foxes captured in Stanhope, sufficient data to calculate home-range sizes were only obtained for three individuals (Table 1). Asymptotic home-range was achieved with 140 locations for both females, and with 40 locations for the male. Using the 100% MCP method, home-ranges varied between 105.7 ha and 168.8 ha while the 95% fixed-kernel method resulted in home-ranges that varied between 77.4 ha and 131.3 ha (Table 1; Fig. 2). The 50% fixed-kernel method resulted in core-area values that ranged between 7.4 ha and 13.2 ha, representing about 10% of each animal's home-range (Fig. 2). Home ranges of all three foxes overlapped to some extent, with the greatest overlap (63 ha) occurring between F3 and M2. The overlap in home ranges between F1 and M2 was 8.6 ha while between F3 and F1 was 3.2 ha.

	F1 (♀)	F3 (♀)	M2 (♂)
Telemetry locations recorded	172	368	63
100% Minimum convex polygon (ha)	121.6	168.8	105.7
95% Fixed-kernel (ha)	99.5	131.3	77.4
50% Fixed-kernel (ha)	13.2	10.5	7.4

Table 1. Radio-telemetry data collected from three red foxes captured in Stanhope, Prince Edward Island National Park (Prince Edward Island, Canada).

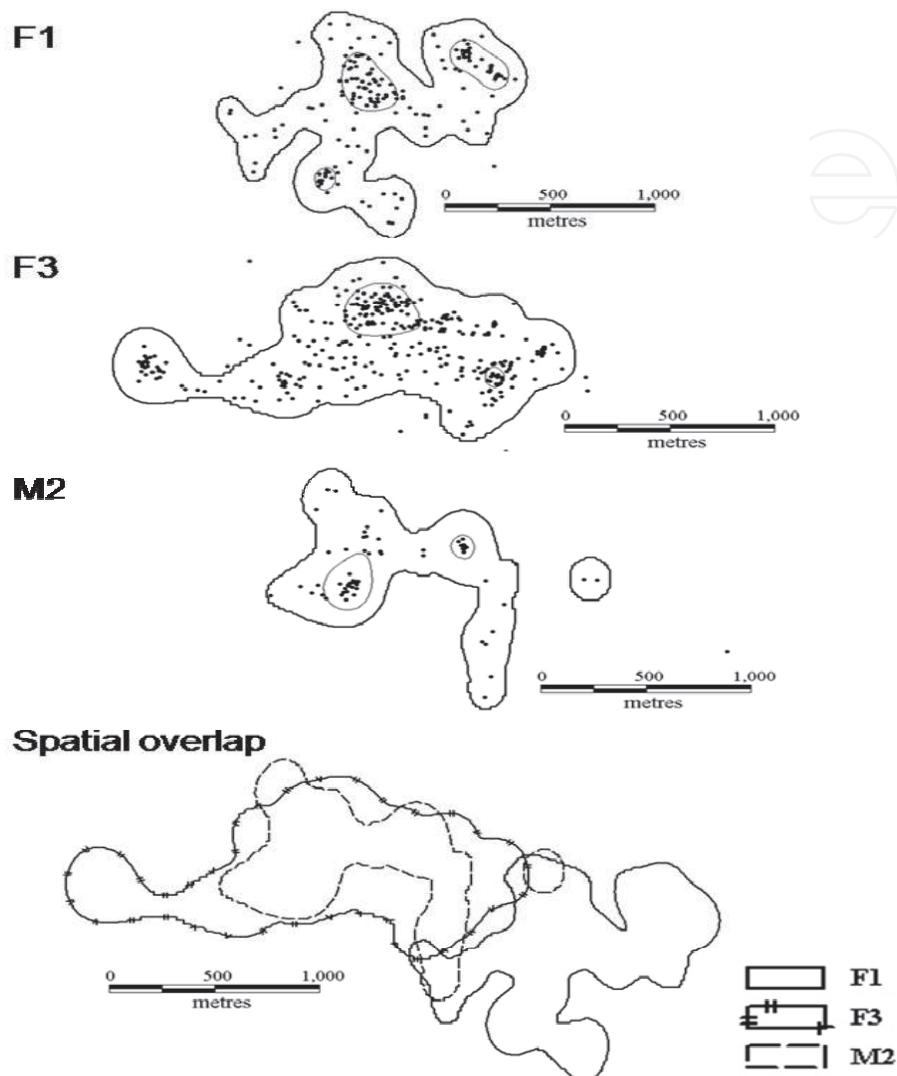


Fig. 2. Home range (95% fixed kernel analysis) and core areas (50% fixed kernel analysis) of F1, F3, and M2. Core areas are contained within the home range boundary. Animal locations are indicated by solid black circles. Spatial overlap of the home ranges of the radio-tracked red foxes in Stanhope is shown in the bottom panel.

All three red foxes used all available habitats in Stanhope, except for the abandoned field habitat. At the home-range spatial scale, red foxes selected for agricultural fields, dunes, roads, and human-use areas, while forest, marsh, and water habitat were used less than expected based on their availability (Table 2). No significant preference was observed for beach habitat. At the core-area spatial scale, red foxes selected only for dunes and roads, while beach, forest, marsh, and water habitats were used less than expected based on their availability. No significant preference was observed for human-use, agriculture and shrub habitats at this spatial scale.

Habitat	Observations (# locations)	Habitat Use proportion		Expected Use proportion	Preference
		Average	SD		
<i>Home-range Level</i>					
Human-use	300	0.517	0.077	0.114	+
Dune	86	0.148	0.054	0.053	+
Road	64	0.110	0.048	0.033	+
Agriculture	31	0.053	0.034	0.005	+
Beach	41	0.071	0.039	0.100	0
Shrub	15	0.026	0.024	0.003	0
Marsh	1	0.002	0.006	0.109	0
Forest	39	0.067	0.038	0.503	-
Water	3	0.005	0.011	0.060	-
Abandoned Field	0	0	0	0.019	-
<i>Core-Area Level</i>					
Dune	67	0.249	0.056	0.118	+
Road	16	0.172	0.036	0.084	+
Human-use	103	0.369	0.062	0.394	0
Shrub	8	0.035	0.026	0.028	0
Agriculture	11	0.012	0.007	0.008	0
Beach	18	0.089	0.048	0.161	-
Forest	27	0.067	0.028	0.142	-
Marsh	1	0.003	0.004	0.01	-
Water	1	0.003	0.008	0.054	-

Table 2. Comparisons of use and availability of various habitat types in Stanhope (Prince Edward Island National Park) based on telemetry data from three red foxes. Habitat types are shown in order of preference. Comparisons were made using the Neu Method and Bonferroni confidence intervals. Preference was determined with Bonferroni confidence intervals ($\alpha = 0.001$) placed on use. "+" indicates used more than expected; "-" indicates used less than expected; "0" use according to availability or non-significant difference between expected and available.

3.4 Discussion

Although home-ranges and core areas of red foxes inhabiting the study site were comparable to values observed in studies conducted in other parts of North America and Europe (e.g. Adkins & Stott, 1998; Voigt & Macdonald, 1984), they were at the lower end of the spectrum for this species. There are several possible explanations for these results. It is possible that our findings reflect the habitat requirements and movement patterns of foxes during the kit-rearing season when foxes are involved in cub rearing and lactation (especially females) and need to stay close to their dens (e.g. Saunders et al., 1995). If this is true, it is possible to assume that home ranges and core areas obtained during this study are underestimations of values at other times of the year. This hypothesis was supported by the fact that one of the females (F3) was observed rearing three pups and receiving help from the male (M2). This observation would also explain the considerable overlap in home range areas found between F3 and M2. Another possible explanation for our findings is that the small home ranges observed in this study are the result of the aggregated distribution of anthropogenic food sources. It has been shown that the distribution of non-territorial, solitary carnivores tend to become more aggregated when anthropogenic resources are concentrated into a few patches, resulting in smaller and

more stable home ranges (Joshi et al., 1995). Alternatively, it is possible that home ranges were small because Stanhope supports a high density of red foxes due to high fox-feeding levels. Small home ranges would allow foxes to cover their territories in a relatively short time to maintain exclusive rights to the areas and reduce intraspecific competition (Baker et al., 1998). Although this has not been investigated yet, anecdotal information suggests that there may be a correlation between fox numbers and the overabundance of anthropogenic resources within certain sectors of Prince Edward Island National Park. Observations made by wardens from the park suggest that red-fox abundance in Stanhope has actually increased during the last years. Although it is logical to expect that deaths caused by vehicles can reduce foxes abundance in the park, they can also incite an increase in the reproductive output or productivity of the fox population. Some predator species compensate for high mortality levels resulting from exploitation (e.g., trapping, hunting, etc.) by increasing their litter size or reproductive output (e.g., van Deelen & Gosselink, 2006). Although an accidental death caused by a vehicle is not the same than exploitation, it may contribute to the adverse effects that other human activities in the area or nearby (e.g., tourism, trapping, farming) may have on the red-fox population inhabiting the study site.

Red foxes are typically considered habitat generalists, and their adaptability to marginal or degraded ecological conditions has been a key factor in allowing them to survive in fragmented landscapes and human-dominated areas. However, this does not necessarily mean that they do not have preferences for certain habitat types. For instance, red foxes did not show much preference for habitats such as forests, abandoned fields, and shrubs, in which they would normally have to hunt for prey such as small mammals. In this study, we found that red foxes used both human-use areas and dune habitats during the study period which corresponds to the kit-rearing season for this species. Our analyses also indicate that in Prince Edward Island, red foxes seem to avoid forests even though this habitat is the most available habitat type. Red foxes showed a preference for dune habitats in the study site at both large (home range) and small (core area) spatial scales, providing support for anecdotal information that suggest that it is in the dunes where their dens are located. The granular and sandy composition of dune habitats likely provides suitable habitat for excavation of dens. In addition, dune habitats are protected within the national park, thus limiting their access to humans.

Our analyses also showed that the value of certain habitat cover types to red foxes varies with the spatial scale at which habitat-selection is investigated. For instance, even though red foxes used human-use areas at the large spatial scale (home range), they did not significantly select for this habitat at the small spatial scale (core area). At the small spatial scale, our results indicated that foxes selected for dunes and roads. In our study site, foxes use roads to move between different habitat cover-types and to obtain food. Fox-feeding along roads is a common human activity during the kit-rearing season. Indeed, it is very common to see many red foxes of all ages sitting along the roads waiting for humans to feed them. During the kit-rearing season, although humans inhabiting cottages and houses still set out food for foxes, these animals must find "foraging" along the roads more efficient. During this season, it is not only easy to obtain food along the roads without too much effort, but roads are situated very close to the dunes where it is suspected that their dens are located. Parental care is particularly demanding in terms of food resources, so it may be more energetically efficient to stay close to the dens. Thus, our findings provide evidence suggesting that anthropogenic food resources are

important for foxes at both small and large spatial scales. It is, thus, possible to use our findings as indirect evidence supporting the idea that fox-feeding is altering the way that red foxes use habitats in the study site, and possibly other areas of Prince Edward Island National Park where fox-feeding is common.

4. Case study 2: The African wild dog

The African wild dog is a highly endangered carnivore (IUCN 2006) that has showed significant declines in population numbers over the last century, especially during the last 35-45 years (Woodroffe et al., 1997). Like much of Africa, the agricultural and economic development of South Africa led to the local extinction or extirpation of large predators in all but the most uninhabitable areas (e.g., Kruger National Park and north-east KwaZulu-Natal). Apart from rainforest areas and deserts, African wild dogs (herein called wild dogs) were historically distributed throughout much of sub-Saharan Africa (Fanshawe et al., 1991; Monod, 1928; Schaller, 1972). Now, however, they have been extirpated from most of their range, being confined to a few areas in southern Africa where human population density remains low. According to Fanshawe et al. (1997), there is about 3,000-5,500 wild dogs left in 600-1,000 packs, more than half of which are found in southern Africa. Unfortunately, most of these populations are too small to be considered viable in the long-term. For instance, it is commonly accepted that the only viable population of wild dogs in South Africa occurs in Kruger National Park (Fanshawe et al., 1991).

The principal threats to wild dogs are pressures resulting from human activities and infectious diseases. Both of these are mediated by habitat fragmentation, which increases contact between wild dogs, humans and domestic dogs. Wild dogs are intensely social animals, spending almost all of their time in close association with one other. Hunting in packs, each member achieves a higher foraging success than it would if it hunted alone (Creel & Creel, 1995). Packs may be as small as a pair, or number as many as 49 adults, yearlings and pups. Studies have shown that wild dogs live at very low densities, and are rare even when they live in large well-protected habitats where prey may be abundant, making these animals unusually susceptible to the loss and fragmentation of natural habitats (Woodroffe & Ginsberg, 1997). Growing human populations have caused wild-dog habitat to become increasingly fragmented or discontinuous, as large tracts of land have been taken over for livestock grazing and cultivation. In addition, wild dogs have been persecuted and their prey has been depleted. Like other large- and medium-bodied size mammalian carnivore species, wild dogs do kill livestock under some circumstances, and have therefore been shot, snared and poisoned in most livestock areas. Overall, the combination of all these factors has resulted in wild dog populations to become increasingly isolated in fragments of habitats with low human population densities.

Species reintroduction is a tool for conservation and wildlife management (Griffith et al., 1989) that may sometimes offer the only chance of survival for highly endangered or threatened species (Hayward et al., 2007a, 2007b). In the interest of improving the current status of the African wild dog, efforts are underway to reintroduce wild-dog packs into several parks and reserves of South Africa, including Mkhuzi Game Reserve (IUCN Wild Dog Advisory Group, 2005; Lindsey et al., 2004; Lines, 2006; Mills et al., 1998; Wells & Richmond, 1995). Mkhuzi Game Reserve (~ 360 km²) was established in 1912 and forms part of iSimangaliso Wetland Park (World Heritage Site formerly called the Greater St.

Lucia Wetland Park) which is approximately 3,320 km². Regardless of its small size, Mkhuze Game Reserve supports a very diverse mammalian community that includes four of the five big-game animals expected to occur in the area: leopard (*Panthera pardus*), African elephant (*Loxodonta africana*), black rhinoceros (*Diceros bicornis*), and buffalo (*Syncerus caffer*). Wild dogs were present in Mkhuze Game Reserve until the 1930s. In this game reserve, the reintroduction of wild dogs began in 2005 as part of the Priority Species Monitoring Project. In 2004, thirteen wild dogs originating from two other South African conservation areas (Marakele National Park and Madikwe Game Reserve) were placed together in two adjoining bomas in Mkhuze Game Reserve with the purpose of bonding all the animals into one pack. Boma construction was fundamental to ensure animals were exposed to electrified fencing (Mkhuze Game Reserve is surrounded by electric fencing), habituated to game vehicles, allowed to settle, become accustomed to radio-collars and other conspecifics within a new social group, and finally ensure that territorial bonds were relaxed so they remained at the release location (Hayward et al., 2007a, 2007b).

Although a variety of methods are used to assess the success of a species reintroduction program, a common recommended first step in most of these methods is to demonstrate that the species is adapting well to its new habitat during the establishment phase of the reintroduction (Hayward et al., 2007a, 2007b). Researchers generally accomplish this first step by examining habitat selection and home-range patterns, as the reestablishment of species in areas where they formerly occurred is often influenced by the suitability of habitats at proposed release sites (IUCN, 1998; Wolf et al., 1998). Without high quality habitats that provide adequate food, water and suitable places to forage and breed, reintroduction programmes have a low chance of success (Griffith et al., 1989; Hayward et al., 2007a, 2007b).

The main objective of this study was to examine how telemetry data can be used to quantify habitat selection and home-range patterns of a wild-dog pack during the establishment phase of a reintroduction program. We also expected that a better knowledge of the home range and habitat-selection patterns of reintroduced animals will help identify what resources and habitats are essential for the survival of wild dogs in small reserves or parks such as Mkhuze Game Reserve.

4.1 Study site

Mkhuze Game Reserve is located between 32°06'25" to 32°56'46" E and 26°51'26" to 28°29'07" S in the subtropical zone (Fig. 3). The game reserve receives about 1,200 mm of rain annually, 60% of which falls in the summer. Mkhuze Game Reserve comprises a diverse array of habitat types, including grasslands, lakes and pans, wetlands, savannahs, thickets, woodlands and forests (van Rooyen, 2004). Two types of grasslands characterize the game reserve: lebombo-wooded grasslands and floodplains. Lebombo-wooded grasslands are mostly found on sandy soils near the bordering Lebombo Mountains but can also be present on soils composed of clay. The game reserve also includes several freshwater pans that although are mostly permanent bodies of water, may also undergo seasonal changes such as regular flooding and inundation (Van Rooyen, 2004). Although thickets and savannahs occur in various parts of the game reserve, most of the area is occupied by woodlands and forests. Woodlands have a discontinuous canopy while forests, also known as closed-woodlands, have a continuous canopy that commences at an elevation of 5 m or greater above the ground (Hockey et al., 2005).

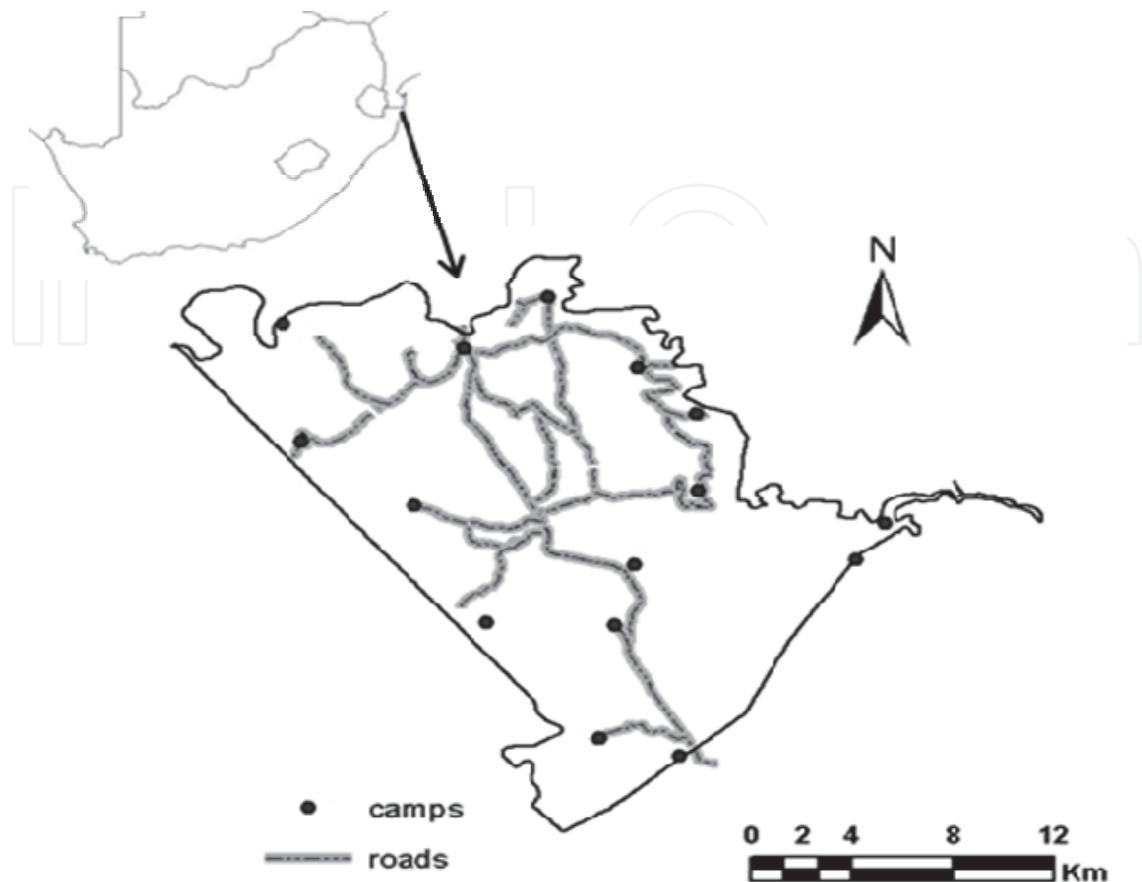


Fig. 3. Map of Mkhuze Game Reserve in relation to South Africa showing the main camps (solid dots) and roads (dashed lines) traversing the game reserve. The scale-bar refers to Mkhuze Game Reserve only.

4.2 Data collection and analysis

Radio-telemetry data of wild dogs were obtained from the Priority Species Monitoring Project of the Mkhuze Game Reserve. As part of this monitoring project, two African wild dogs belonging to a pack reintroduced in 2005 were radio-collared and tracked from December 2006 to June 2008. Although only one animal usually needs to be tracked when following a wild-dog pack, two animals were tracked in this case to ensure data collection success in case of death or malfunctioning of a collar. For the purpose of this study, we only used the radio-tracking data from the animal for which more data were collected. The Animal Care Protocol used in this study followed the guidelines of the American Society of Mammalogists (Gannon et al., 2007) and was approved by both Ezemvelo KwaZulu-Natal Wildlife Conservation and iSimangaliso Wetland Park Authority. Animals were darted with a combination of fentanyl and xylazine to minimize capture and handling stress. Once animals were immobilized, radio-collars (with activity and mortality signals as well as anti-snare plates; Model V5C181; width = 40 mm, circumference = 420 mm, weight ~ 420 g; Sirtrack radio-collars) were attached to them. The radio-telemetry procedure used in this study followed White & Garrott (1990). Radio-collared animals were tracked as a pack using Telonics aerials (Telonics, Arizona, USA) and Sirtrack receivers (Sirtrack, Hastings, New

Zealand). In order to reduce disturbance during the early stages of this wild-dog reintroduction program, the pack was located only twice daily (once at dawn and once at dusk). Geographic coordinates (latitude, longitude) of radio-tracking locations were recorded using a Garmin-GPS unit (± 0.30 m). Three types of radio-tracking locations or sightings were recorded in this study: A-sightings consisted of a close and accurate radio-tracking location where the pack was seen directly; B-sightings represented the presumed location of the close, but elusive, pack where a strong signal was recorded but the landscape prevented direct viewing; and C-sightings resulted from three compass bearings and a computer-tabulated triangulation. Triangulation angles were maintained between 40° and 150° . About 80% of radio-tracking locations were taken with the animal in view of the observers (i.e., 80% of locations were A-sightings). The software LOAS 2.1 (Ecological Software Solution 2003) was used to estimate the actual locations. Statistical independence of radio-telemetry data was not an issue for this study since only two sightings were recorded per day. Data on home-range size and core-areas were analyzed using the Animal Movement SA version 2.0 in ArcView (version 3.3; ESRI). The minimum number of locations required to accurately assess the home-range size of the pack was estimated by plotting cumulative home-range sizes against the number of locations (i.e., asymptotic home-range; Philipps & Catling, 1991). Similar to Case Study 1, home-range values were calculated using the 100% minimum convex polygon (MCP) and the 95% fixed Kernel method while the 50% fixed-kernel method was used to estimate size and shape of the core-areas or centers of activity within home-ranges.

Habitat variables were determined using a digitized map (aerial photographs of the study area were not available) of the habitat types comprised within Mkuze Game Reserve. ArcView GIS (version 9.3 and 3.3; Environmental Systems Research Institute, Inc., ESRI) was used to map animal locations obtained from radio-telemetry monitoring sessions and to assign to each location a habitat type. Two habitat classification systems were used to examine habitat selection patterns. First, we used a broad classification system that separated the habitats encompassed within Mkuze Game Reserve into six types: woodland, forest, thicket, river floodplain (includes seasonal stream habitats), *Terminalia sericea* savannah and other habitats (includes human-use areas, roads, etc). Most mammal species move throughout their home range and as they encounter different components and combination of features of their habitats they also make different selections. Thus, our second classification system involved a more refined classification that attempted to separate certain habitats (i.e., woodlands and forests) in categories that were perhaps a little bit more relevant to wild dogs inhabiting southern South Africa (Woodroffe & Ginsberg, 1997). Eleven habitat types were used for this second classification system: *Acacia nilotica* low-closed woodland, *Acacia* tall-open woodland, *Acacia tortillis* low-open woodland, dry-closed woodland, Lebombo wooded-grassland, low-thicket, open-woodland, river floodplain (includes seasonal stream habitats), riverine forest, *Terminalia sericea* savannah and other habitats (includes human-use areas, roads, etc). Similar to Case Study 1, habitat selection was examined by comparing use and availability of habitat types (using both habitats classification systems) within Mkuze Game Reserve using the Neu Method (see Section 3.2.2).

4.3 Results

When all the radio-telemetry locations ($n = 847$) were plotted on the map of the Mkuze Game Reserve, they appeared scattered throughout the entire reserve, although the

number of radio-telemetry observations were higher near the southern border of the reserve (Fig. 4). A 100% MCP yielded a home range of 383.9 km² while the 95% fixed-kernel method resulted in a home-range of 377.8 km². Thus, both 100% MCP and 95% fixed-kernel methods resulted in home-range sizes that were larger than the game reserve (~360 km²). In terms of centers of activity, the 50% fixed-kernel method resulted in a core-area of 103.6 km², representing about 29% of the total area covered by the game reserve.

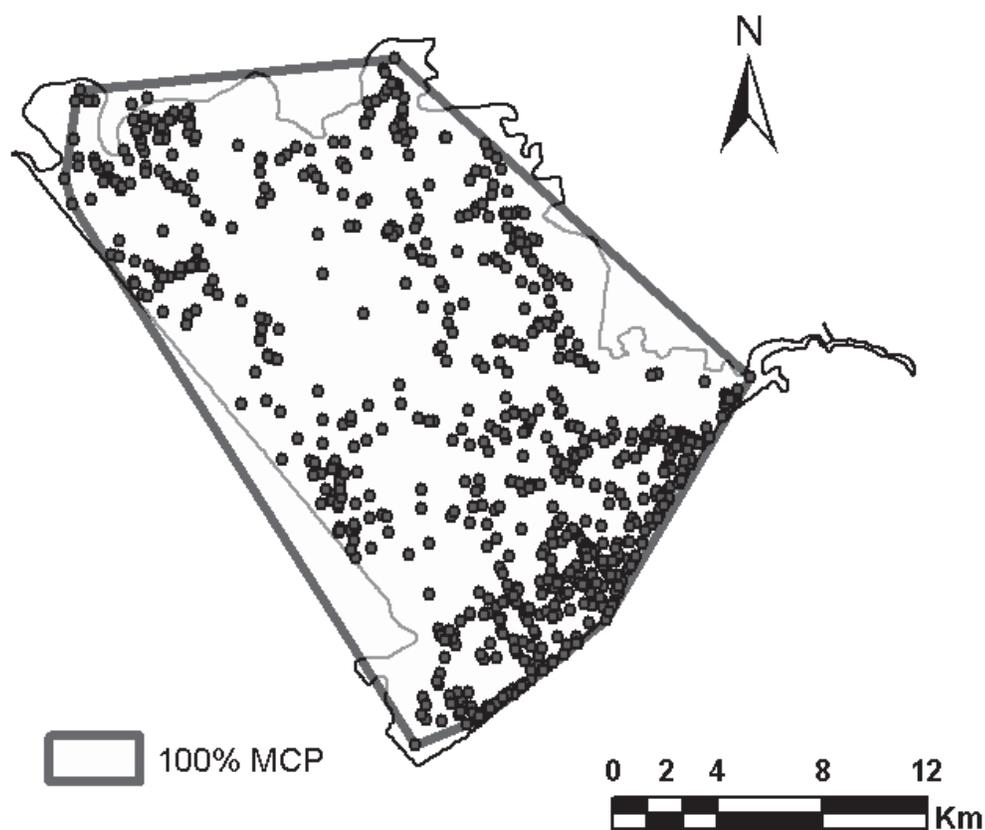


Fig. 4. Map of the Mkuze Game Reserve showing 847 radio-tracking locations collected from a wild-dog pack. The solid line represents the 100% MCP home-range of the wild-dog pack calculated in this study.

Using the broad habitat classification system, wild dogs selected only for one habitat, *Terminalia sericea* savannah habitats while thicket habitat types and river floodplains were used less than expected based on their availability (Table 3). Using the most refined habitat classification system, our analyses indicated that out all woodland habitat types, *Acacia nilotica* low-closed woodland was the most important for wild dogs. Using this same classification system, it was also found that wild dogs clearly selected for *Terminalia sericea* savannah habitats (Table 3). These analyses also showed that the habitats that were used less than expected based on their availability were thicket habitat types, river floodplains and riverine forest. No significant preference was observed for any of the other habitat types.

Habitat	Observations (# locations)	Habitat Use proportion		Expected Use proportion	Preference
		Average	SD		
Broad Habitat Classification System					
<i>Terminalia sericea</i> savannah	155	0.187	0.048	0.093	+
Woodland habitat types	279	0.336	0.058	0.379	0
Forest habitat types	269	0.324	0.056	0.291	0
Other habitats	10	0.012	0.013	0.014	0
Low-thicket habitat	49	0.059	0.029	0.096	-
River floodplains & streams	68	0.082	0.034	0.127	-
Refined Habitat Classification System					
<i>Terminalia sericea</i> savannah	155	0.187	0.039	0.093	+
<i>Acacia nilotica</i> low-closed woodland	134	0.161	0.037	0.049	+
<i>Acacia tall</i> -open woodland	106	0.128	0.033	0.160	0
<i>Acacia tortillis</i> low-open woodland	49	0.059	0.024	0.064	0
Dry-closed woodland	122	0.147	0.035	0.167	0
Lebombo-wooded grassland	52	0.063	0.024	0.071	0
Open-woodland	72	0.087	0.028	0.084	0
Other habitats	10	0.014	0.013	0.014	0
Low-thicket habitat	49	0.059	0.024	0.096	-
River floodplains & streams	68	0.082	0.027	0.127	-
Riverine forest	13	0.016	0.013	0.076	-

Table 3. Comparisons of use and availability of various habitat types of an African wild dog pack reintroduced to Mkhuzze Game Reserve based on telemetry data. Habitat types are shown in order of preference. Comparisons were made using the Neu Method and Bonferroni confidence intervals. Preference was determined with Bonferroni confidence intervals ($\alpha = 0.001$) placed on use. "+" indicates used more than expected; "-" indicates used less than expected; "0" use according to availability or non-significant difference between expected and available.

4.4 Discussion

An important requisite for the success of any reintroduction program of mammalian carnivores is the elimination of the factors that initially caused the decline of the species. As previously mentioned the main factors explaining the decline of wild dogs in Africa include killing by humans, reduced prey availability, competition with other carnivores, loss and fragmentation of habitats, as well as infectious diseases. The wild-dog pack reintroduced into Mkhuzze Game Reserve in 2005 was seen in this game reserve only until June 2008. Although it is suspected that some pack members moved out of the reserve onto neighbouring conservation parks or reserves, other individuals were found dead within or nearby Mkhuzze Game Reserve. Possible causes for the deaths of these animals include snares, predation, hunting injuries and infectious diseases that are still occurring in the study area (personal communication, Mkhuzze Game Reserve staff and veterinarians). Thus, the analyses discussed below contribute to a forensic-like study that we hope can provide some insights into the factors that may have played a role in the failure of this wild-dog reintroduction program.

Several studies have suggested that a major reason why very few wild-dog reintroduction programs have succeeded to produce viable populations is because the game reserves were too small to include the whole home range of this species. Our findings provide support for this argument. In this study, the reintroduced wild-dog pack had a home range that was larger than the boundaries of the game reserve, indicating that these animals needed to use not only the entire reserve but also adjacent areas. Moreover, the center of activities (i.e., core areas) of the reintroduced wild-dog pack represented ~29% of the whole game reserve. Interestingly, most of the telemetry locations recorded in this study were situated in the southern region of the game reserve (Fig. 3). Different factors may be attracting wild dogs to this part of the game reserve and its neighbouring habitats. First, there is a private-game reserve (Phinda Game Reserve) that presents a similar wildlife diversity (including wild dogs) than that of Mkhuzi Game Reserve, with the addition of lions. Wild dogs are social animals, so it is possible that they were interacting with conspecific animals occurring in the private game reserve. Second, the habitats preferred by wild dogs are more abundant in the southern border of the game reserve. In this study, we found that the wild-dog pack selected for *Terminalia sericea* savannah (3,334 ha) and *Acacia nilotica* low closed woodland (1,742 ha) habitats. These two habitats only represent ~14% of the whole game reserve, with most of the *Terminalia sericea* savannah habitat being located at the southern border of the reserve. Conservation efforts and future wild-dog reintroduction programs should consider the protection and restoration of these two habitat types in other parts of the Mkhuzi Game Reserve.

Another factor that may have contributed to the failure of this wild-dog reintroduction may be competition for prey with other mammalian predators. Several studies have shown that wild dogs will avoid areas with high prey density if competition (or mortality due to) with predators such as hyaenas and lions is high (Creel & Creel, 1996; Mills & Gorman, 1997). In Mkhuzi Game Reserve, there are no lions, but hyaenas are abundant. Thus, it is possible that although some habitats were available to wild-dogs, in practical terms, they were not accessible to them. For example, we found that one of the habitat types that wild dogs preferred was low closed woodlands dominated by *Acacia nilotica*, small bushes and deciduous tree species. This type of habitat is ideal for antelope species such as impala and nyala, but it may be sometimes too dense to prevent wild-dogs pack hunting coordination to be effective. However, *Terminalia sericea* savannah, the other habitat type preferred by wild dogs, is characterized by dense vegetation. Although hunting should theoretically be more efficient in this habitat type because the ability of other competitor species (e.g., hyaena) to locate and steal prey from wild-dog packs is reduced, *Terminalia sericea* savannah only represents ~9% of the total game reserve. Other studies have found that wild dogs preferred deciduous and thorn woodlands (Creel & Creel, 2002) as well as forest and open-woodland (Andreka, 1996). In this study, we found that river floodplain, riverine forest and woodland habitats dominated by tall *Acacia* trees were avoided by wild dogs. Low-thicket habitats can be dense in many areas of Mkhuzi Game Reserve. Although many avian and small-bodied mammalian species may benefit from dense vegetation, large-bodied herbivores (common prey of wild dogs) are usually not able to find sufficient grazing area in this type of habitat. This may explain why wild-dogs tended to avoid low-thicket habitats in the game reserve.

Two decades ago, a successful reintroduction of a mammalian carnivore species in Africa was considerable unfeasible. Today, however, sufficient evidence exists suggesting that planned and well-documented reintroductions of mammalian carnivores are possible (Hayward et al., 2007a, 2007b). In part, this is because the results of other reintroductions

(successful and unsuccessful) are being published and peer-reviewed at more frequent intervals, so other reintroduction attempts can benefit from these experiences. In this case study, we analyzed telemetry data from an unsuccessful wild-dog pack reintroduction and learned a few key issues regarding the species' needs that must be considered in future reintroductions, especially in small game reserves.

5. Conclusions and future directions

The examination of habitat selection and home range patterns is an essential first step in the management of any wildlife species whether they are abundant, rare or endangered. The main goal of this chapter was to demonstrate how radio-telemetry data could be used to provide previously unavailable insights into the habitat selection and home range patterns of two mammalian carnivore species inhabiting human-dominated landscapes. In Case 1, the use of radio-telemetry data helped us to show that the presence of anthropogenic food sources in human-use areas and along roads is altering home range and habitat-selection patterns of red foxes inhabiting Prince Edward Island National Park (Prince Edward Island, Canada). In Case 2, radio-telemetry data were used to quantify home range and habitat-selection patterns of a wild-dog pack reintroduced in Mkhuzi Game Reserve, South Africa. In this case, our analyses not only helped us to quantify these patterns, but also to provide some insights into the reasons why this wild-dog reintroduction program failed. Radio-telemetry data clearly showed that the game reserve was smaller than the home-range of the wild dog pack and that the two habitat types that are preferred by the wild dogs only represent 9% of the total area of the reserve.

The advent of satellite technology, such as global positioning systems (GPS), has allowed wildlife researchers to collect telemetry data on a temporal scale that was not previously practical. Observations can now be obtained many times per day for many months with GPS devices. Although GPS applications have certainly transformed wildlife telemetry, they are not without problems. GPS-collars can be very expensive and experience failures in the field during data collection and trade-offs between GPS location collection intervals and unit longevity lead generally to fewer monitored individuals and shorter study durations compared with radio-telemetry (Frair et al., 2010; Gau et al., 2004; Hebblewhite et al., 2007). Another problem associated with GPS-telemetry is that a decreased interval between recorded locations results in an increased level of autocorrelation in the resulting data. Although some researchers consider that autocorrelation in telemetry data is not a problem, others still disagree with this statement and argue that it is really necessary to account for GPS errors in wildlife telemetry studies (Frair et al., 2010). In contrast with GPS-telemetry, radio-telemetry is inexpensive, accuracy is adequate for many types of investigations and it is possible to carry out studies for a relatively long time period. For instance, if the budget for the investigation is low, the use of radio-telemetry technology may be the only choice. This is the case of many developing areas of the world where ecologically-sensitive issues are present and is often very difficult for researchers or wildlife managers to acquire GPS-collars. Another important advantage of radio-telemetry technology is that radio-collars can be implemented on almost all animals for which GPS telemetry devices are too heavy. Having said this, it is important to mention that radio-telemetry technology can be time-consuming and limited by weather conditions. Thus, interpretations should be constrained within the accuracy and precision of the equipment and personnel involved in collecting the radio-telemetry data.

It is clear that emerging technologies such as GPS-telemetry open new avenues in wildlife telemetry and ecological research because they can provide more detailed information regarding fine-grain movement patterns. Ultimately, however, technologies are just tools in the hands of researchers. The choice of a given telemetry technology should be based on the kind of questions that one is trying to answer or investigate. In this chapter, the key focal points of our case studies were very specific, have clear conservation/management applications and dealt with medium-bodied size carnivore species. Additionally, in both case studies, the study areas were small which facilitated field work and our ability to track all collared animals daily without much effort. Therefore, in both case studies examined here, radio-telemetry technology was more than adequate to identify the habitat types that were avoided or preferred by the carnivore species under investigation. Clearly, the advent of GPS technology will allow ecologists and wildlife managers to develop more sophisticated and rigorous methods to assess home range and habitat-selection patterns. However, what is really needed at this point is to develop new methods or approaches to extract a maximal amount of information from data obtained from less-sophisticated technology such as radio-telemetry.

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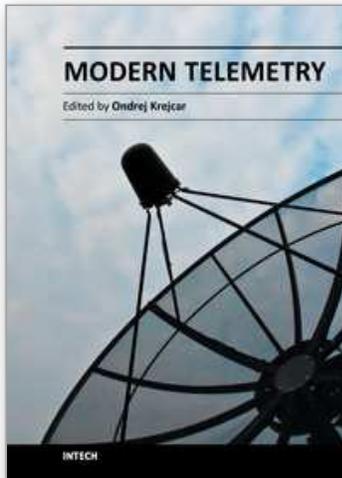
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Telemetry is based on knowledge of various disciplines like Electronics, Measurement, Control and Communication along with their combination. This fact leads to a need of studying and understanding of these principles before the usage of Telemetry on selected problem solving. Spending time is however many times returned in form of obtained data or knowledge which telemetry system can provide. Usage of telemetry can be found in many areas from military through biomedical to real medical applications. Modern way to create a wireless sensors remotely connected to central system with artificial intelligence provide many new, sometimes unusual ways to get a knowledge about remote objects behaviour. This book is intended to present some new up to date accesses to telemetry problems solving by use of new sensors conceptions, new wireless transfer or communication techniques, data collection or processing techniques as well as several real use case scenarios describing model examples. Most of book chapters deals with many real cases of telemetry issues which can be used as a cookbooks for your own telemetry related problems.

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