# DETERMINING SPACE USE AND DEMOGRAPHY OF A REINTRODUCED FALLOW DEER (*Dama dama*) POPULATION USING GPS TELEMETRY IN DILEK PENINSULA NATIONAL PARK, TURKEY

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# ABSTRACT

## DETERMINING SPACE USE AND DEMOGRAPHY OF A REINTRODUCED FALLOW DEER (*Dama dama*) POPULATION USING GPS TELEMETRY IN DILEK PENINSULA NATIONAL PARK, TURKEY

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The Fallow Deer (*Dama dama*) population in Turkey is presumed to be one of the few autochthonous populations globally. Although the species has been under protection since the 1960s, it had become restricted to a single site in Düzlerçamı, Antalya.

Within the context of a reintroduction project, 21 deer were translocated into Dilek Peninsula National Park (Aydın, Turkey) in 2011 and 2012. Fifteen individuals were GPS-collared and monitored between 2011 and 2013 to understand their movements, habitat choice and social interactions.

Annual average home range size is estimated to be 587±321 ha for males and 564 ±297 ha for females. Habitat selection analyses revealed that males and females differ in habitat use, except during mating seasons. Habitat selection is stronger in females, and the abundance and quality of resources shape space use pattern in females. On the other hand, predation potential of the habitats likely determines habitat selection of males.

Significant sexual segregation occurs, except during mating seasons. Two hypotheses are tested to find out the underlying reason for sexual segregation. Forage selection hypothesis better explains observed spatial utilization differences between sexes. Males use both non-territorial and single territory strategies during mating.

Demographic variables were estimated using closed population mark-resight models and camera trap records. Population size has increased over the study period with an average growth rate of 0.24 ±0.10, and reached an estimated 48.17±3.29 in 2016.

Our results indicate that the reintroduced individuals have successfully adapted to the new environment and expanded their range into favourable habitats.

Keywords: reintroduction, home range, habitat selection, GPS telemetry, demography.

# ÖZ

## DİLEK YARIMADASI MİLLİ PARKI'NA AŞILANAN ALAGEYİK POPULASYONUNUN GPS TELEMETRİ KULLANILARAK ALAN KULLANIMI VE DEMOGRAFİK YAPISININ BELİRLENMESİ

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Türkiye'deki alageyik (*Dama dama*) populasyonu dünyada otokton olarak kabul edilen populasyonlar arasındadır. 1960'lardan beri koruma altında olsalar da, alageyik populasyonu Düzlerçamı, Antalya bölgesinde kısıtlı bir alanda yaşamaktadır.

Bu amaçla 2011 ve 2012 yılları içerisinde 21 birey Dilek Yarımadası Milli Parkı'na taşınmıştır (Aydın, Türkiye). Taşınan bireylerin 15 tanesine GPSli tasma takılmış ve 2011-2013 yılları içerisinde habitat tercihlerinin, hareketlerinin ve aralarındaki sosyal ilişkilerin anlaşılması için izlenmiştir.

Yıllık ortalama yaşam alanı büyüklüğü erkekler için 587 ±321 ha ve dişiler için de 564 ±297 ha olarak tahmin edilmiştir. Habitat tercihi analizleri, erkek ve dişilerin habitat kullanımlarının çiftleşme dönemi haricinde birbirinden farklılık gösterdiğini ortaya koymuştur. Dişilerde habitat tercihinin daha güçlü olduğu ve habitat tercihlerini etkileyen temel faktörlerin kaynak bolluğu ve kalitesi olduğu belirlenmiştir. Erkeklerin habitat kullanımının ise predasyon riskiyle ilişkili olduğu tahmin edilmiştir.

Çiftleşme dönemleri dışında önemli ölçüde cinsiyete bağlı mekansal ayrışma tespit edilmiştir. Bu ayrışmanın nedenlerini anlamak için iki hipotez test edilmiştir. Besin seçimi hipotezi, cinsiyete bağlı mekansal ayrışmanın açıklanması için daha yeterli bulunmuştur. Erkekler çiftleşme döneminde bölgesel olmayan ve tek bölgesel stratejileri kullanmıştır.

Demografik değişkenler, kapalı populasyon "işaretle-tekrar yakala" ve fotokapan kayıtları kullanılarak tahmin edilmiştir. Populasyon büyüklüğü çalışma süresince 0.24±0.10 oranında artmıştır. Alandaki birey sayısı 2016 yılı için 48.17±3.29 olarak tahmin edilmiştir.

Sonuçlar, aşılanan bireylerin başarılı bir şekilde yeni alana uyum sağladıklarını ve alan kullanımlarını kendileri için daha uygun habitatlara doğru genişlettiklerini göstermiştir.

Anahtar kelimeler: aşılama, yaşam alanı, habitat tercihi, GPS telemetrisi, demografi.

To Ayşe DURMUŞ

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## LIST OF ABBREVIATIONS

ABBREVIATIONS

CMR – Capture-mark-recapture
Dow – Distance to oak woodland
Drls – Distance to rocky low shrubland
Dtm – Distance to military stations
Dtpf – Distance to tall pine forest
Dtr – Distance to road
Dtss – Distance to tall sclerophyll shrubland
Dwrp – Distance to permanent water resources
Dwrr – Distance to water resources in the rainy period
Ele – Elevation
ENFA - Ecological Niche Factor Analysis
FK - Fixed Kernel
GIS - Geographical Information Systems
GPS - Global Positioning System
IUCN - International Union for Conservation of Nature
KBB - Kernel Brownian Bridge
MCP - Minimum Convex Polygon
NP - National Park
PDOP - Positional Dilution of Precision
SECR - Spatially Explicit Capture-Recapture
Slo – Slope
UD - Utilization Distribution

# CHAPTER 1

# INTRODUCTION

The world is being increasingly faced with anthropogenic threats since the industrial revolution. Natural habitats have been destroyed, fragmented or degraded so that many wild species have gone to extinct or are threatened (IPCC, 2014). Due to increasing human-mediated pressures on natural habitats and wild species, habitable places on Earth have become narrower for wild species (Thomas et al., 2004). As long as we do not change our human-centered view from *ex gratia* favors of natural resources for humanity to sustainable use, environmental crisis has kept growing (Schlosberg, 2007) and will reach to a point of no return in the near future (Hansen et al., 2008; IPCC, 2014). In this sense, stricter applications of current national and international regulations are one of the important steps. For the sake of biodiversity conservation, establishing more protected areas, allocating more funds for the management of protected areas, supporting employment for specialists in these areas should be more seriously considered.

Within this context, Turkey is one of the countries that should receive more emphasis since it not only contains 3 out of 36 global biodiversity hotspots but also high climatic and geographical diversity leading to high endemism rate, and habitat and species diversity (Şekercioğlu et al., 2011). Currently, 4000 out of 19000 known invertebrate species in Turkey, and of over 100 species out of 1500 recorded vertebrates, 70 of them are fish species, are endemic. Moreover, two major migratory routes of birds pass over the country while rich wetlands make Turkey one of the major resting and breeding sites for birds.

Additionally, Turkey is also home for 11000 plant taxa, out of which one third are endemic (Kahraman et al., 2012).

Fallow deer (*Dama dama*) is one of the large mammal species with high conservation concern, along with Mountain gazelle (*Gazella gazella*), Arabian sand gazelle (*Gazella marica*), and Anatolian mouflon (*Ovis gmelinii anatolica*) in Turkey. The Ministry of Agriculture and Forestry, universities and non-governmental organizations have carried out research about mentioned species; however, they are insufficient when the rich biodiversity of Turkey is considered. This thesis covers the most comprehensive conservation effort ever conducted for fallow deer protection in Turkey that aimed to establish a self-sustaining population within its former range by reintroduction and monitoring the first years of reintroduced populations.

## 1.1 Fallow Deer (*Dama dama*)

Fallow deer is a highly threatened species at the national level and needs special conservation efforts. Even though it is widespread over the world and many of the populations are strong in numbers, and its IUCN Red List status is “Least Concern”, the status of the Turkish population is critical, and requires immediate conservation implications. Furthermore, populations in other countries either were established by introduced individuals or have uncertain origins, but Turkish fallow deer population is certainly native over the world (Masseti and Mertzanidou, 2008). Therefore, it constitutes an indigenous genetic stock that makes the population even more special to conserve (Masseti and Mertzanidou, 2008; Baker et al., 2017).

### 1.1.1 Morphology

Fallow deer is a medium-sized deer species that is bigger than roe deer (*Capreolus capreolus*) but smaller than red deer (*Cervus elaphus*) (Figures 1-4; all photos were taken in Dilek Peninsula NP between 2011and 2014 unless otherwise stated). Body mass changes with age and nutritional status of individuals. Adult male body mass ranges between 70 kg to 125 kg while it changes between 40 kg to 80 kg in adult females (Sarıbaşak et al., 2005). Shoulder height is about 80-100 cm in males, and 70-80 cm in females. Fallow deer shows clear sexual dimorphism. Males have palmated antlers, which become evident after the age of 2-3. Antler length ranges between 50 to 70 cm and palm length between 7 to 20 cm. Antler formation starts in the newborn male fawns at 6 months old, followed by shedding in following May. In later ages, antlers are shed in April and are formed again in May with a velvet cover. This cover falls off in August when the complete growth of antler finishes (Riney, 1954; Chapman and Chapman, 1979; Turan, 1984). Pelage color varies with seasons of the year. In winter, darker colours are dominant and range from grey to silver. Summer pelage is yellowish, orange to brick red. Spots on their pelage are apparent in spring and summer. A black dorsal strip extends from nape to tail. They also have white ventral strips on both sides. Molting occurs twice in a year, in spring (April-May) and autumn (October-November) (Feldhammer et al., 1988).

**Figure 1.** Fallow deer buck with winter pelage and palmated antler

**Figure 2.** Fallow deer buck with summer pelage and antler development (Photo was taken in Köyceğiz Wildlife Reserve)

**Figure 3.** Mother and fawn with winter pelage

**Figure 4.** Adult female with summer pelage

### 1.1.2 Ecology, Social Organization, Ontogeny, and Behaviour

Fallow deer live in a variety of habitats but most often are found in older forests containing openings good for grass development. Some of the habitat types that they have been known to live are mixed forests, broad-leaved forests, subalpine vegetation, grassland, woodland, scrubland, and savannah. They can inhabit a wide range of climates from cool-humid to warm-dry (Chapman & Chapman, 1980).

The social organization of fallow deer shows sexual and seasonal differences. Fallow deer bucks are usually single in summer, and form bachelor groups with autumn. During the rut, mixed groups are observed. Does live in groups throughout the year and form mixed groups during the rut. Group sizes are smallest during the fawning season (Feldhammer et al., 1988; Sarıbaşak et al., 2005). Home ranges of males changes within a year. They occupy two home ranges, one in rut, and the other in bachelor times. Home ranges of bucks are larger than does (Chapman and Chapman, 1975 cited in Feldhammer et al., 1988).

Their peak activity is at dusk and dawn when they prefer to feed. They spend daytime at safer places like inner forest by resting and ruminating. Their diet changes with seasons. According to Sarıbaşak et al. (2005) (Table 1), grasses dominate their diet in spring, whereas they are replaced by shoots of broad-leaved trees and shrubs in summer after grasses have died out. Autumn and winter diets are composed of fruits, seeds, and leaves.

**Table 1.** Düzlerçamı/Antalya fallow deer population's diet (Sarıbaşak et al., 2005)

| **Plant family** | **Example species** |
|---|---|
| Fagaceae | *Quercus coccifera, Quercus infectoria, Quercus ithaburensis* |
| Oleaceae | *Olea europea, Phillyrea latifolia* |
| Fabacae | *Spartium junceum, Ceratonia siliqua, Vicia* sp., *Trifolium* sp., *Medicago* sp. |
| Rhamnaceae | *Paliurus spina-christii* |
| Rosaceae | *Rubus sancta, Crateagus monogyna, Rosa canina, Sarcopoterium spinosum* |
| Liliaceae | *Hedera helix* |
| Ericaceae | *Erica arborea, Arbutus andrachne* |
| Moraceae | *Morus alba, Ficus carica* |
| Anacardiaceae | *Pistacia lentiscus, Pistacia terebinthus* |
| Rutaceae | *Citrus sinensis* |
| Vitaceae | *Vitus vinifera* |
| Ephedraceae, Portulaceae, Polygonaceae, Malvaceae, Oxalidaceae | *Sytrax officinalis, Salix alba* |

Rutting takes place between October and November (Turan, 1984; Sarıbaşak, 2005). Even though copulation occurs in this interval, females can be ready for mating between September and January. The length of the oestrous cycle is 24-26 days. This cycle may repeat seven times during the breeding period in the absence of pregnancy

(Asher, 1985; Komers et al., 1999). They rarely give birth to twins (Asher, 1986). Peak fawning time is late May and early June. Birth weight of fawns is 4.0 kg for female fawns, and 4.3 kg for male fawns (Mulley et al., 1990). The lactation period lasts about 9 months. If female fawns are well developed, they can become pregnant when they are 6-7 months old. However, it generally takes place when they are 16 months old. Male fawns are capable of breeding at 14-17 months old, but generally, they do not get a chance to copulate before 3-4 years old. Their lifespan is between 12 to 18 years (Chapman & Chapman, 1970).

Mating period of fallow deer starts with establishing rutting ground by bucks in early autumn. They prepare the ground by leveling and clearing it for copulation. They also mark the area by urinating and depositing scent around. Adam's apple of bucks becomes more prominent at this time. Groaning and grunting vocalizations of bucks are also characteristics of this period. Males check the oestrus time in females by sniffing and licking their backside. Instead of establishing mating territory, young males may walk around the older males' territories. If they violate the territory border, they are chased away by older males. Fights between older bucks are also seen in this period (Chapman and Chapman, 1975 cited in Feldhammer et al., 1988; Buschhaus et al., 1990).

Pregnant does look for a safe hiding place for birth. Generally, inner parts of the forest with dense shrub cover are suitable for parturition. After giving birth, mothers stay away from the herd for 2 to 10 days. They move around their fawns and visit them for nursing throughout a day. Mother and fawns stay at the birth site for a week until the fawn develops its moving ability. Nursing frequency is every 4 hours until the fawn is 4 months old. Rumination does not begin until 2-3 weeks of age. After 20 days, weaning starts and fawns start to eat vegetation. Amount of nursing gradually decreases and complete weaning occurs at about 7 months of age. When 3-4 weeks old, the fawn follows its mother and joins the group (Chapman & Chapman, 1970).

### 1.1.3 Taxonomy and Distribution of Fallow Deer

Genus *Dama* is represented by two species, European Fallow Deer, *Dama dama* (Linnaeus, 1758), and Persian Fallow Deer, *Dama mesopotamica* (Broke, 1875). Some authors make their distinction on subspecies level but the current widely accepted classification considers them two separate species. In this thesis, fallow deer is accepted as European Fallow Deer. Smaller size of European Fallow Deer and colouring in antler and tail are their morphological differences (Haltenroth, 1959 cited in Arslangündoğdu et al., 2010; Ferguson et al., 1985). In addition, genetic studies of Pitra et al. (2004) by using mtDNA have shown that these two species are genetically different from each other. Taxonomic position of *Dama dama* is given in Table 2.

**Table 2.** Taxonomic place of *Dama dama*

| | |
|---|---|
| Order | Artiodactyla |
| Suborder | Ruminantia |
| Family | Cervidae |
| Subfamily | Cervinae |
| Tribe | Cervini |
| Genus | *Dama* |
| Species | *Dama dama* |

There are two known populations of Persian Fallow Deer in the world. One is a native, Iranian population, and the other is a reintroduced, Israeli population. This species is regionally extinct in Iraq, Jordan, Lebanon, Palestine, Syria, and south eastern Turkey (Werner et al., 2015). On the other hand, European Fallow Deer is found in many countries where they either are introduced or have an unknown origin. The only certainly native population in the world is the Turkish population. According to Masseti and Mertzanidou (2008), the countries inhabited by European Fallow Deer are given in Table 3.

**Table 3.** European Fallow Deer populations of the world

| | |
|---|---|
| **Native** | Turkey |
| **Introduced** | Argentina; Austria; Belarus; Belgium; Canada; Chile; Czechia; Denmark; Estonia; Fiji; Finland; France; Germany; Hungary; Ireland; Latvia; Lithuania; Luxembourg; Moldova; Netherlands; New Zealand; Norway; Peru; Poland; Portugal; Romania; Russian Federation; Slovakia; South Africa; Spain; Sweden; Switzerland; Ukraine; United Kingdom; United States; Uruguay; Italy (Sardegna and Sicilia) |
| **Present – uncertain origin** | Albania; Bosnia and Herzegovina; Bulgaria; Croatia; Cyprus; Greece; Italy (mainland); Macedonia, the former Yugoslav Republic of; Montenegro; Serbia; Slovenia |

The original range of European Fallow Deer is not clear. Most of the current populations in the world have been introduced. North European populations are known to have gone extinct during the last glacial period. Anatolia appears to have become a refuge for many species, including the fallow deer. Other known such ice age refuges in Europe are southern Italy, the Iberian Peninsula, and southern Balkan Peninsula. These regions also have fallow deer populations but it is unknown whether they are native or introduced (Chapman and Chapman, 1980; Masseti, 2008 cited in Baker et al., 2017; Masseti and Mertzanidou, 2008; Chapman and Chapman, 1997 cited in Arslangündoğdu et al., 2010). Baker et al. (2017) conducted a comprehensive genetical study by using microsatellite and mtDNA loci to show anthropogenic effects on the distribution of fallow deer. They used 364 samples collected from 11 different countries (10 European countries and Canada) and showed that at least two population are autochthonous, Turkish and Italian populations.

### 1.1.4 Conservation History in Turkey

According to Huş (1964) and Turan (1984), fallow deer range in Turkey has drastically decreased since the beginning of the 20th century to the 1960s due to illegal hunting. The species had lived in lowland forests of Marmara, Aegean and

Mediterranean regions at the beginning of the century. However, its distribution has become limited to Düzlerçamı, Manavgat, Serik, Taşağıl in Antalya, and Pos-Çatalan in Adana by the 1960s. Until the above-mentioned reintroduction project started in 2011, the only surviving population had been left in Düzlerçamı-Antalya (Figure 5).


**Figure 5.** Past distribution of fallow deer in Anatolia
(digitized from Turan 1984)

First conservation effort for fallow deer protection in Turkey was the implementation of a hunting ban in 1957. In addition to this measure, a 1750 ha area was designated as Fallow Deer Protection Area, 34 ha of it is used as a breeding area where 7 individuals (2 males, 2 females, 3 fawns) were introduced in 1966 (Turan, 1966 cited in Arslangündoğdu, 2010). The area was first expanded to 11432 ha then to 14300 ha in 1970. In 1987, the area attained wildlife protection status and was enlarged to 34000 ha (Sarıbaşak et al., 2005). A few reintroduction efforts were carried out to its former ranges, Gökova and Adaköy (Muğla), Ayvalık (Balıkesir) and Pos (Adana) in the 1980s but these attempts have failed (Turan, 1984). After deterioration of the enclosed area, 64 fallow deer were translocated to a new 430 ha fenced area in Düzlerçamı in 2002 (Sarıbaşak et al., 2005). Population size was estimated as 130 in 2010 (Arslangündoğdu (2010). The last significant attempt to conserve fallow deer in Turkey, by reintroducing them to former distribution areas and monitoring their adaptation period with GPS telemetry and camera traps, is the subject of this thesis.

## 1.2 Reintroduction and Post Release Monitoring

Reintroduction is a powerful tool for the conservation of threatened animals and there are many examples in the world (Fischer and Lindenmayer, 2000; Taylor et al., 2017). According to IUCN's "Guidelines for Reintroductions and Other Conservation Translocations" (IUCN/SSC, 2013), the aim of reintroduction should be to re-establish a viable population. Good planning is critically important for a successful reintroduction. The number and sex composition of released animals, genetic diversity, ecological knowledge about reintroduced species, reintroduction site choice, time of the year (Akçakaya et al., 1999) effective monitoring and financial opportunities (Fischer and Lindenmayer, 2000) should all be carefully assessed.

IUCN Guidelines for Reintroductions (2013) lists requirements of successful reintroductions. Reintroduction site should be within the historical range of the animal, and habitat suitability of reintroduction site should be assessed. In addition, causes of past extinction on reintroduction site should be searched by field surveys, meetings with local people and relevant local authorities to be sure that the same risks are not anymore present in the area (Souty-Grosset and Grandjean, 2009; IUCN/SSC, 2013). If possible, disturbance factors for the species at the release site should be eliminated. In case of failure risk, alternative reintroduction sites should be taken into account (IUCN/SSC, 2013).

One essential activity of the reintroduction process is monitoring since it may provide critical information for further efforts and an early indicator of progress (IUCN/SSC, 2013). Survival of reintroduced individuals depends on becoming familiar with the unknown environment (Frair et al., 2007; Bell, 2014; Berger-Tal and Saltz, 2014). There is a trade-off between exploring the unfamiliar environment for new resources and exploitation of already known resources (Eliassen et al., 2007; Berger-Tal et al., 2014). Behaviours of the reintroduced animals change with familiarity to the new environment (Berger-Tal and Saltz, 2014). Monitoring of these behavioural changes are indicators on the fate of the newly established population. Demographic parameters of the reintroduced population should be estimated, and if possible, input into a population viability analysis. Obtained data should shape adaptive management strategies and decision-making mechanisms (Canessa et al., 2014). Radiotelemetry, GPS telemetry, and camera trapping are widely used tools for monitoring individuals and populations to obtain vital data (such as home range size estimations, habitat preferences, behavioural changes, spatial interactions, and demographic parameters) for the future of reintroduced populations.

## 1.3 Home Range

Kernohan et al. (2001) define the home range as “the extent of an area with a defined probability of occurrence of an animal during a specified time period”. The area that a reintroduced species needs for surviving and establishing a viable population and environmental conditions required for success are among the most important information for conservation biologists and administrators for making decisions on where to choose as reintroduction site and determine the size of that area (Laver, 2005; Özüt, 2009).

Kernohan et al. (2001) also emphasize the factors affecting home range size calculations. Sampling scheme, seasonal and sexual differences affect estimates and should be considered before taking action. The time interval between two consecutive locations (Swihart and Slade, 1985), the number of observations (Seaman et al., 1999), or data collection technique (Adams and Davis, 1967) influence results so they should be properly designed. Sample size and time interval between successive locations are inversely correlated with each other. Increasing the time interval between consecutive locations decreases sample size while the opposite situation leads to autocorrelation. Presence of autocorrelation in data violates assumptions of many statistical tests that require independence of observations (Hansteen et al., 1997). Data reduction is one solution for eliminating autocorrelation (Ackerman et al., 1990). Another is using estimators less sensitive (or insensitive) estimators to autocorrelation (Horne et al., 2007). Data collection was labour intensive and time consuming before advances in GPS technologies. They involved triangulation and homing which required long-term fieldwork (Mech, 1983) and the result was small sample sizes and highly autocorrelated data.

Advances in GPS technology and decreasing the cost of tracking technologies provided a large set of data to researchers and this led to improvements in spatial data analysis in wildlife ecology (Walter et al., 2015; Dougherty et al., 2017). In parallel with these advances, home range estimation techniques have also become more complex and variable. Minimum convex polygon (MCP), cluster analysis, harmonic mean, and kernel density are widely used home range estimators. Kernohan et al. (2001) reviewed 12 such estimators (namely MCP, peeled polygon, concave polygon, cluster analysis, grid cell count, Jennrich-Turner, weighted bivariate normal, Dunn estimator, Fourier series smoothing, harmonic mean, fixed kernel, and adaptive kernel) and compared their advantages and disadvantages with one another. He concluded that adaptive and fixed kernel density estimations are superior over others.

Fixed and adaptive kernel methods differ from each other with their bandwidth selection techniques. Smoothing parameter (bandwidth) is quite an important variable in kernel density estimations. The value determines the width of individual kernels, and hence, the degree of data smoothing (Kernohan et al., 2001). The same bandwidth value is used for each observation in the fixed kernel method, while bandwidth changes for each observation in the adaptive kernel method (Laver and Kelly, 2008). There are many smoothing parameter techniques proposed in literature but its selection is strictly related with the aims of the study, sampling regime and spatiotemporal behaviours of studied species (Worton, 1995; Gitzen and Millspaugh, 2003; Gitzen et al., 2006). Reference bandwidth ($h_{ref}$) and least square cross-validation ($h_{lscv}$) are widely used in home range studies. Generally, $h_{lscv}$ is more suitable for bimodal and multimodal space use and $h_{ref}$ for unimodal distributions since its assumption of true distribution is bivariate normal. On the other hand, $h_{lscv}$ does not assume the true underlying distribution (Seaman and Powell, 1996; Seaman et al., 1999; Millspaugh et al., 2006).

Moreover, smoothing parameter has influence on utilization distribution (UD). UD is defined as relative frequency distribution for input spatial data over a defined time (Figure 6) (Van Winkle, 1975). It gives occurrence probability of animal for a point in the study area and provides a useful representation of space use patterns of animals (Millspaugh et al., 2000; Benhamou and Lambert, 2012). Estimates of utilization distribution will be composed of many local “peaks and valleys” with lower smoothing parameters, while oversmoothing will be the result when higher values are entered (Worton et al., 1995; Seaman et al., 1999; Hemson et al., 2005).

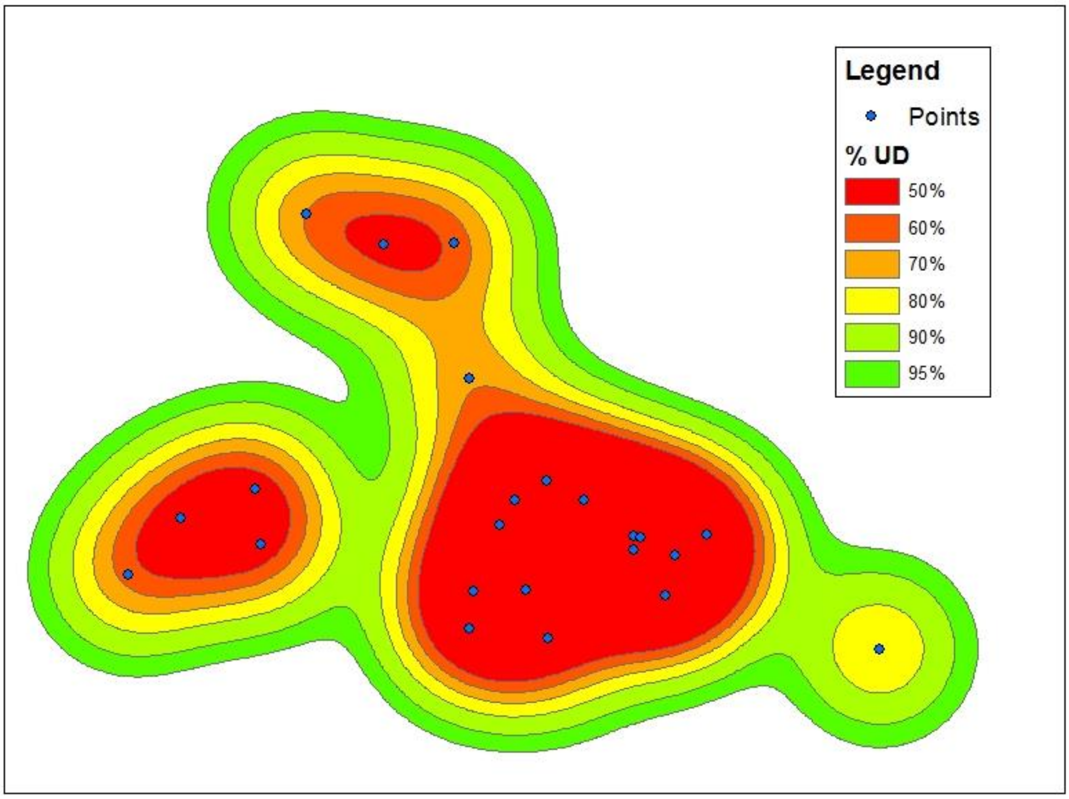



**Figure 6.** A sample visualization for different levels of utilization distributions

The fixed kernel is considered superior over adaptive kernel density estimator since the latter is more biased in estimating the periphery of utilization distribution. Most studies have concentrated on the core area of use. Since peripheral areas are considered to have less biological significance for a species, using fixed kernel is more reasonable for researchers (Seaman et al., 1999). Comparative studies of Seaman and Powel (1996) and Worton (1995) support the idea of superiority of the fixed kernel method.

Home range studies use the location data of an individual animal, and this discrete unit based analysis provides a mechanistic approach for the researcher. However, animals still move between consecutive fixes but its locations are unknown during that interval. More dynamic approaches have been developed recently for home range estimations which take into consideration of animals paths like kernel Brownian bridge estimation (Horne et al. 2007), autocorrelated kernel density estimation (Fleming et al., 2015) and possible path area home range estimation (Long and Nelson, 2015).

One of the most widely used home range estimator based on the movement of the individuals is kernel Brownian bridge home range estimator. Bullard (1991) defines Brownian motion as a two-dimensional random walk in an area. In order to understand and present animal movement based utilization distribution, missing data between available discrete locations should be estimated. Estimation process of missing data from available data is called Brownian Bridge (Horne et al., 2007). Home range estimation by using this approach is first proposed by Bullard (1991) and according to him; weakness of known home range estimators is the lack of temporal nature of locations. Calenge (2006) improved Bullard's ideas and developed a package for software R (R development core team, 2017) for Brownian bridge based home range estimation. The point making Brownian bridge home range estimation a powerful method is the inclusion of start and end points of motion, time interval and distance between two successive locations, the speed of animal, and relocation inaccuracy into the calculations (Horne et al., 2007).

## 1.4 Habitat Selection

There are many habitat definitions in the literature. One of the widely accepted one is Krebs' (2001) definition, which is "any part of biosphere where a particular species can live either temporarily or permanently". Resource distribution in a habitat is heterogeneous and the habitat selection concept is related to resource selection. The term 'resource' covers a broad range of objects, either physical or biological, whose presence affects the fitness of the animal positively, and its absence negatively (Buskirk and Millspaugh, 2006). The aim of habitat selection studies is to define environmental variables making a place habitable for a species (Calenge, 2011).

The selection process is hierarchical, and its direction is from the general to the specific. It could involve a home range within the geographical distribution of a species or a bed site within the home range of an individual (Manly et al., 2002). As habitats are composed of resources, the researcher should first define available and unavailable resources for the studied species, and then used and unused resources are identified through observations. Habitat selection studies are based on the disproportional use of available resources that indicates selection (Johnson, 1980).

In the literature, three types of design (namely Design I, Design II, and Design III) are defined for habitat selection studies according to the presence of individual identification, sampling unit and resource partitioning levels (Table 4) (Thomas and Taylor, 1990). Logistic regression and compositional analysis are among the widely used methods for evaluating habitat selection (Thomas and Taylor, 2006).

**Table 4.** Habitat selection study designs

| | **Individual identification** | **Sampling Unit** | **Levels of resource partitioning** |
|---|---|---|---|
| **Design I** | No | Locations | Used, unused, and available resource units are sampled in the study area at the population level. |
| **Design II** | Yes | Individual | Used resource units are measured for each marked animal, available resource units are measured at the population level. |
| **Design III** | Yes | Individual | At least two sets of used resource units (available, used, and unused) are sampled for each marked animal. |

However, relatively new methods like Ecological Niche Factor Analysis (ENFA, developed by Hirzel et al. 2002) have been proposed within the last two decades. Advances in GIS and GPS technology make obtaining or creating habitat variable layers or carrying out habitat selection analysis easier for researchers. ENFA is a multivariate analysis and exploratory method that is practical for making an inference of resource selection.

Hutchinson's (1957) concept of ecological niche is the basis of ENFA. Niche is an "n-dimensional hypervolume" according to Hutchinson and each "n" represent a habitat variable. ENFA is a derivative of principal component analysis based on eigenanalysis and it compares location data of species in ecogeographical variables with the study area and creates suitability functions. In other words, it makes a comparison between available space in the area and used space by individuals. The ideal environment is accepted as the average use of species in the analysis, and the connecting vector between the ideal environment and the average available environment is defined as the "marginality vector". In other words, connecting vector of available space centroid and used space centroid gives the marginality vector and its magnitude points out the strength of selection (Hirzel et al.,2002; Basille et al., 2008; Calenge, 2011). For the sake of clarity, Figure 7 is given below. In this figure, small grey dots represent available space for defined resources and dark grey dots on right with varying sizes represent the used space by an animal. Vector "m" is marginality vector extending from centroid of available space to centroid of used space that whose magnitude indicates the strength of selection. The closeness of the centroids points out the weakness of selection.

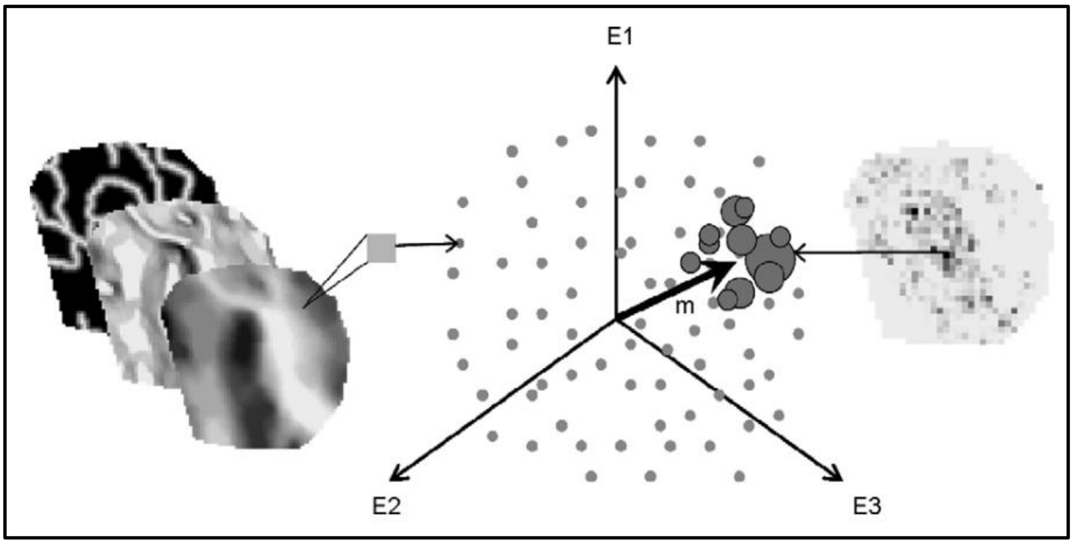



**Figure 7**. An example of marginality concept
(Visual is taken from Martin et al, 2008)

## 1.5 Spatial Segregation of Sexes in Ungulates

One of the central concepts in ecology is finding out factors affecting the distribution of the species. Dispersal ability and habitat requirements of species, presence of intraspecific and interspecific interactions in the area, and distribution of abiotic environmental parameters are limiting factors that shape the distribution of species (Krebs, 2001; Morris et al., 2016). Animals occupy some specific areas within their distribution that can be represented as “homerange” (Burt, 1943). Underlying reasons for specific space use patterns of animals can be related to distribution of resources, seasonal variations in availability of resources (Bergerud, 1974 cited in Horne et al., 2008; Powell, 2000), reproduction system of animals (Greenwood, 1980), presence and abundance of predators, competitors (Pimm and Rosenzweig, 1981; Morris, 1987; Brown, 1988), or combinations of them.

In conjunction with these species-species and species-habitat relationships, some space use patterns have evolved in time like sexual segregation observed in many herbivore species. Males and females occupy different territories except for the rut in sexually segregated ungulate species (Main and Coblentz, 1990; Main et al., 1996). Main (1998) stated that sexual segregation is so widespread among polygynous ungulates that there should be a common underlying cause of sexual segregation. This issue has attracted researchers for years and they have tried to find out reasonable explanations for sexual segregation. Many hypotheses have been developed in years (Geist and Petocz, 1977; McCullough, 1979 cited in Main and Coblentz, 1990; Morgantini and Hudson, 1981; Jakimchuk et al., 1987) but currently some of them have been popular among researchers (Meldrum and Ruckstuhl, 2009). As the predation risk - reproductive strategy hypothesis (Main and Coblentz, 1990) features ecological factors for explaining sexual segregation, two other hypotheses, the forage selection or sexual dimorphism-body size hypothesis (Main et al., 1996) and the activity budget or body size-predation hypothesis (Ruckstuhl, 1998) put emphasis on physiological factors for it. Ruckstuhl and Neuhaus (2002) summarized the main assumptions and key predictions of these three hypotheses presented in Table 4. Their review study covered 35 studies within the scopes of these hypotheses to find out a common underlying cause of sexual segregation suggested by Main (1998). Their results showed that the activity budget hypothesis was confirmed in most cases and can be considered as the driving force of sexual segregation among ungulates. The other two hypotheses can be additive factors.

On the other hand, the social-factors hypothesis (Villaret and Bon, 1995; Bon and Campan, 1996) is also highlighted idea receiving attention by researchers (Gerard & Richard-Hansen, 1992 cited in Calhim et al., 2006; Conradt, 1998; Cransac et al., 1998; Le Pendu et al., 2000; Biggerstaff et al., 2017). The suggestion of this hypothesis is learning important skills such as developing fighting skills, establishing hierarchical dominance relation before the rut, and learning potential mates to reach reproductive success leads to sexual segregation (Perez-Barberia and Yearsley, 2010; Gaudin et al., 2015). Finding resources and safe birthing places are also among the learned skills related to sexual segregation (Main et al., 1996; Ruckstuhl and Neuhaus, 2000; Gaudin et al., 2015).

**Table 5.** Main assumptions and key predictions of three hypotheses (the table is taken from Ruckstuhl and Neuhaus, 2002)

| *Summary of assumptions and key predictions of three hypotheses advanced to explain sexual segregation in ungulates* | | |
|---|---|---|
| | **Main assumptions** | **Key predictions** |
| **Predation-Risk Hypothesis** | Females and especially offspring are more vulnerable to predation than the larger males. | Females with offspring will choose predator-safe habitats of often inferior* food quality or quantity. |
| | Males need food of high quality to be fit competitors during the breeding season. | Males will choose habitat with abundant and high-quality food. |
| **Forage-Selection Hypothesis** | Smaller females are less efficient at forage digestion than the larger males, due to a small stomach size, and quicker passage rate of food, hence food quality is more important to females than food quantity. | Smaller females will use high quality* food habitats. |
| | Males are good at digesting even low-quality food and hence food quantity is more important for males than food quality. | Males will use lower quality but higher biomass habitat than females. |
| **Activity Budget Hypothesis** | Females are less efficient at digesting forage than males. | Females will compensate for their lower digestive efficiency by foraging for longer than males, while males will spend more time ruminating or lying than females to digest forage. |
| | Big differences in activity budgets make synchrony of behaviour difficult and potentially costly. | Animals with similar activity budgets will form groups. |

* Note that the forage-selection hypothesis predicts the opposite outcome to the predation-risk hypothesis, regarding sexual differences in forage selection. While the predation-risk and forage-selection hypotheses predict habitat segregation, the activity budget hypothesis predicts social segregation.

In addition to these hypotheses, the scramble competition hypothesis (Main et al., 1996) which has been derived from the forage selection hypothesis proposes that intersexual competition on resources gives rise to sexual segregation. Differences of allometry in sexes result in feeding habit variations. Larger males cannot consume plants as effective as smaller females due to smaller incisor arcade of males (Illius & Gordon, 1987). Since metabolic requirements of males are higher than females because of larger body sizes, feeding in the same area leads to poor nutrient intake for males (Clutton-Brock and Guinness, 1987). Being a weak competitor forces male to feed on different patches.

Researchers agree that there should be a common evolutionary cause of sexual segregation (Main, 1998) and most of them consider that the process is driven by a combination of different factors of following; predation, foraging efficiency, social factors, activity budgets and competition (Bon et al., 2001; Ruckstuhl and Kokko 2002; Ruckstuhl and Neuhaus, 2005). The mechanism underlying sexual segregation shows variation between populations (Bowyer 2004; Ruckstuhl, 2007). Driving factor and additional factors are linked with habitat characteristics, species, or population structure, the presence of predators and competitors.

## 1.6 Population Dynamics and Demography

Sociality is a known phenomenon existing in many different taxa in nature. Evolution of social behaviours is considered to increase the fitness of animals (Hamilton, 1964). Different forms of social behaviour are present in nature ranging from hunting strategies of predators and defense mechanisms of prey to cooperative breeding. It is considered that social behaviours have evolved in ungulates to decrease predation risk during resource consumption and to increase foraging efficiency (Hamilton, 1971; Jarman, 1974; Hirth, 1977; Berger, 1978; Gosling, 1986 cited in Molvar and Bowyer, 1994). Grouping behaviour is advantageous for early detection of predators and for confusing the predator in choosing its prey (predator dilution) (Alexander, 1974).

Stability or instability of groups is an indicator of habitat-species relationship. Highly stable groups mean that knowledge of predation risk areas and important resource sites increase the fitness of individuals by peer learning (Franklin et al., 1975; Cobb, 2010). Presence of less stable groups points out to unfavorable conditions for the population and to different resource needs of the individuals (Bender and Haufler, 1999). Grouping behaviour can show local temporal variations due to the specific time of species like the mating period, density-dependent variations related to an increase in population density, and limited resources (Rosenzweig, 1991). Group living is an evolutionarily advantageous strategy but increasing group size makes intraspecific competition more intense. At the point that profits of group living do not compensate for the loss of intraspecific competition, group sizes show variations and get less stable (Cobb, 2010).

Animals tend to use the most productive parts of the habitat (Charnov, 1976; Bailey et al., 1996). However, increasing population size leads to intraspecific competition and range of population is expected to increase toward less productive parts of the habitat (Rosenzweig, 1991). The Ideal Free Distribution Theorem is based on the idea that population growth leads to range expansion and individuals populate in productive parts of the new range with low densities. With the increase in population size, individual fitness declines due to intraspecific competition (Fretwell and Lucas, 1969). This distribution model is suggested for non-territorial animals that freely move. Fletwell (1972) theorized another distribution for territorial organisms, namely the “Ideal Despotic Distribution”. This theory predicts that if animals are not free to move elsewhere, an increase in population size leads to competition and weak individuals can be forced to occupy less productive, marginal habitats.

Another important concept for introduced herbivore populations is irruption (Caughley, 1970). Irruption is the name of the process that collapse of an herbivore population due to overuse of food plants after an initial increase in population size until carrying capacity in an introduced environment without any predator. Caughley (1970) and Laeder-Williams et al. (1987) documented irruptions in the Himalayan thar (*Hemitragus jemlahicus*) in New Zealand and reindeer (*Rangifer tarandus*) in South Georgia consecutively. There are other irruption cases exist in literature such as Sika deer population in Hokkaido Island, Japan (Uno et al., 2009) and mule deer (*Odocoileus hemiomus*) populations in USA (Gruell, 1986). Even though irruption cases have been reported for introduction of herbivores to new areas, it can be the fate of reintroduction studies as Hansen et al. (2007) showed an example for irruption in reindeer reintroduction to Norway.

In addition to intraspecific interactions and relationship with the environment, monitoring changes in demographic variables of reintroduced populations such as survival, mortality, fecundity, growth rate etc. has vital importance (Sarrazin, 2007; Converse et al., 2013). Camera traps can be an excellent tool for obtaining demographic parameters of populations. Capture-mark-recapture techniques (CMR) are widely used methods for monitoring populations, especially for density estimations (Ricker, 1975). Capturing, marking, releasing, and recapturing of animals are the basis of the technique allowing researchers to make estimations for the whole population by using the proportion of captured animals in following samplings. Petersen method, Schnabel method, and Cormack-Jolly-Seber method are the first methods built on this approach. Usages of these methods depend on the existence of the variations of population size throughout the study. If population size changes in the study period by immigration or birth and death events, studied population is an open population. Cormack-Jolly-Seber method is more suitable for open populations with multiple censuses. The assumptions of open population models are as following.

1- Probability of being caught is the same for all individuals,
2- Survival probability of every marked individuals is the same from n th to the (n+1) st sample,
3- Marks have not lost,
4- Sampling time is insignificant in relation to sampling intervals. (Krebs, 1989; Pollock et al., 1990)

Whereas population size is stable during the study, the population is closed and Petersen or Schnabel method is more suitable. Using the Petersen method is appropriate for a closed population with single marking and recapturing. On the other hand, multiple marks and recaptures events make Schnabel method more suitable for closed populations (Otis et al. 1978; Pollock et al., 1990; Amstrup et al., 2006). Using camera traps or observations instead of physical capture modifies the technique into capture-mark-resight but otherwise, the principles remain the same.

Advances in camera trap technology and CMR theory have recently led to the development of likelihood-based spatially explicit capture-recapture (SECR) models (Efford, 2004; Borchers and Efford, 2008; Gopalaswamy, 2010). The models are a combination of capture-recapture and distance sampling approaches that developed for estimating range of each animal, center of activity and create probability density functions by using known locations of animals (Borchers and Efford 2008; Borchers 2011). SECR analyses, according to the logic lying behind it, assume the following:

- Marks have not lost during the study,
- Marks are legible,
- All individuals have an activity center,
- Activity center has not changed during the study period,
- Population is closed,
- Capture probability is the same for all individuals,
- Detections are independent,
- Detectors are randomly placed,
- Records of capture coordinates are accurate. (Efford, 2012)

### 1.7 Objectives of Thesis

The main purpose of the study is to perform post-release monitoring by using GPS collars and camera traps to find out specific requirements of reintroduced fallow deer population listed below and suggest management implications for that particular study area.

- Seasonal and sexual space use dynamics
- Habitat use patterns
- Population dynamics of the translocated population.

# CHAPTER 2

# MATERIAL METHODS

## 2.1 Some Clarifications for Study

Full name of the national park where this study took place is “Dilek Peninsula and Büyük Menderes Delta National Park”. It is actually a combination of two former National Parks, namely “Dilek Peninsula” and “Büyük Menderes Delta”. Dilek Peninsula was declared as National park in 1966 and Büyük Menderes Delta was joined with it in 1994. The delta part of this protected area does not relate to this study, so the reintroduction site is mentioned as “Dilek Peninsula National Park” throughout this thesis.

The conservation project previously mentioned establishing two reintroduced populations of fallow deer. Captured animals have been translocated to both Dilek Peninsula National Park and Köyceğiz Wildlife Reserve area. However, the scope of the thesis only covers the Dilek Peninsula National Park reintroduction.

Study period differs with the type of data collected. Analyses are based on location data collected by GPS collars between 05.2011 and 06.2013 due to 2 years drop off arrangement of collars. While data collected by camera traps cover the period between 06.2011 and 10.2017 (about six years).

## 2.2 Study Area

The study area is the Dilek Peninsula National Park located in Güzelçamlı district in Kuşadası-Aydın, where fallow deer were reintroduced (Figure 8). It surrounded by Güzelçamlı and Söke districts to the east, Doğanbey, and Atburgazı to the south and the Aegean Sea in the west and north. The National Park covers a total of 108.95 $km^2$, but only a part of this area is available for reintroduced fallow deer, especially for the first reintroduced group. Therefore, by taking into consideration the available area for fallow deer, the study area is defined by linking the outer locations of all individuals throughout the study with 200 m buffer and is calculated as 37 $km^2$ (Figure 8). Translocated animals were first released into a fenced 650 $m^2$ acclimatization area (Figure 9-10).

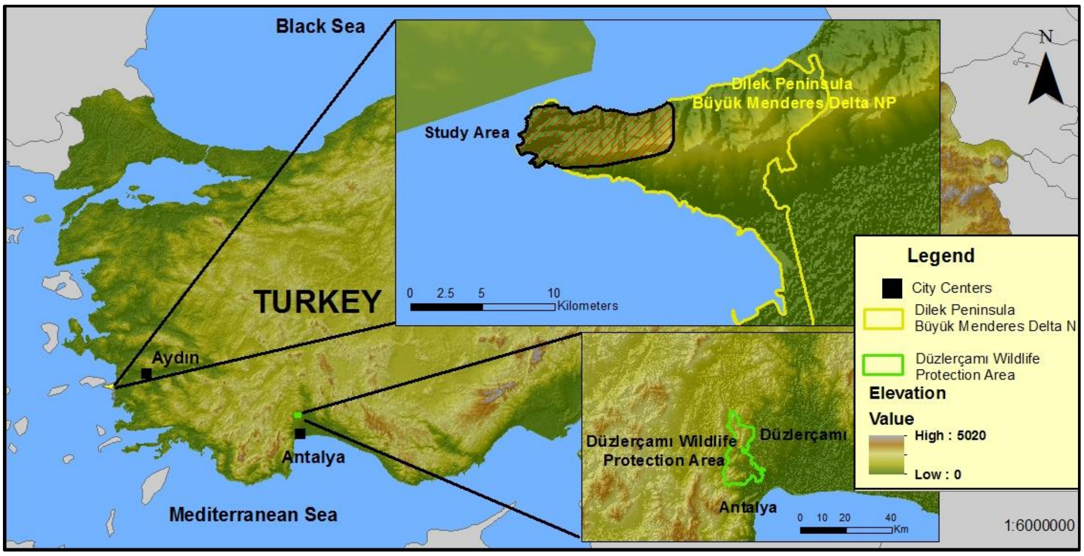



**Figure 8.** The areas of source population (Düzlerçamı, green bordered), reintroduced population (Dilek Peninsula, yellow-bordered) and study area (black bordered area in Dilek Peninsula NP).

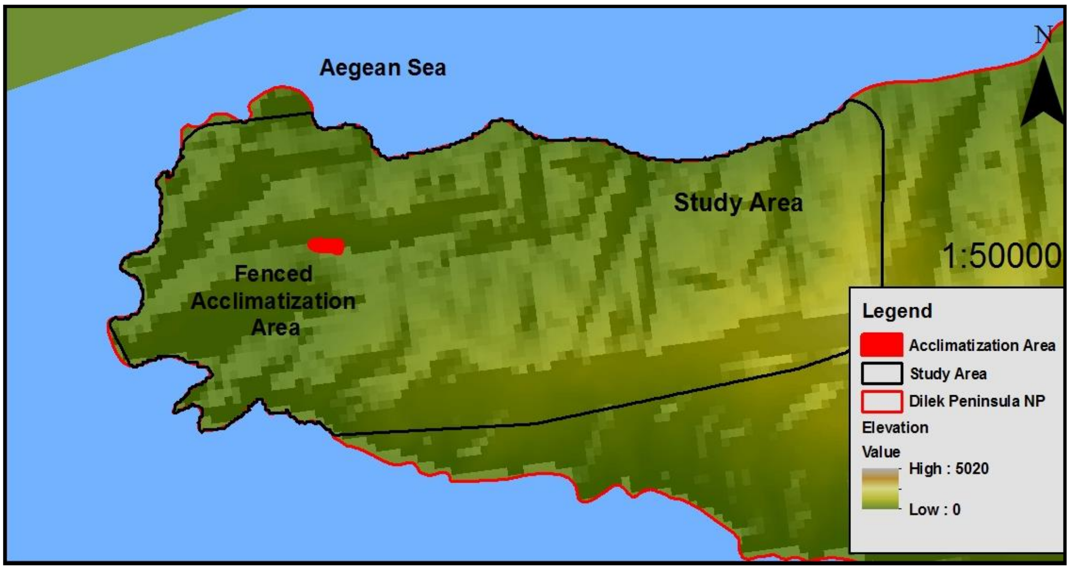



**Figure 9.** Location of fenced acclimatization area on Dilek Peninsula NP

**Figure 10.** Acclimatization paddock at the National Park

Topography of the park is heterogeneous. It contains deep valleys, rugged rocky terrain, and lowlands. However, the study area is dominated by lowlands and smooth hills. Elevation of the study area ranges between 0 m and 1198 m. The area shows the characteristic climate of Mediterranean regions, with hot-dry summers and cool-rainy winters. The annual mean temperature for nearest long term weather station (Aydın, 1940-2017) is 17.7 °C, and annual mean precipitation is 646.0 mm, with most of it received in winter (Meteoroloji İşleri Genel Müdürlüğü, 2018).

The richness of flora elements in Dilek Peninsula National Park due to local geographical and climatical variations make it one of the most striking protected areas of Turkey. The other reason of this richness is the removal of human disturbance since the declaration of the area as a national park. Floristic diversity of Dilek Peninsula includes both Europen-Siberian and the majority of Mediterranean flora components and because of this, Biogenetic Reserve Network of European Council has declared Dilek Peninsula National Park as "Biogenetic Reserve Area" (Bingöl, 2011). 804 plant species have been identified there, belonging to 95 families (Durmuşkahya, 2000 cited in Bingöl, 2011). The dominant vegetation is maquis and garrigue in lower elevations as well stands of Turkish pine (*Pinus brutia*), which is replaced with Black Pine (*P. nigra*) at higher elevations around 1000 m. The maquis is dominated by well developed sclerophyllous elements (due to lack of human disturbance since 1966) such as sandal trees (*Arbutus andrachne*), kermes oak (*Quercus coccifera*), holy oak (*Quercus ilex*), strawberry tree (*Arbutus unedo*), terebinth (*Pistacia terebinthus*), mastic (*Pistacia lentiscus*), mock privet (*Phillyrea latifolia*), Judas tree (*Cercis siliquastrum*), Phoenician juniper (*Juniperus phoenicea),* Oriental plane (*Platanus orientalis*), and olive tree (*Olea europea var. sylvesteris*) (Yaltırık, 1995; Aydınözü, 2008). In addition to these species, other typical maquis elements found in the area are Spanish broom (*Spartium junceum*), carob tree (*Ceratonia siliqua*), oleander (*Nerium oleander*), tree heath (*Erica arborea*), and myrtle (*Myrtus communis*) (Yaltırık, 1995).

Animal diversity is also high in the area. 210 birds, 27 reptiles, 5 amphibia, and 29 mammal species have been reported from the area (Doğa Koruma ve Milli Parklar Genel Müdürlüğü, 2018). One of the most important inhabitants of the National Park is the Mediterranean monk seal (*Monachus monachus*) which is accepted as one of the most threatened sea mammals (Panou et al., 1993). The area is also known as one of the last habitat of Anatolian leopard (*Panthera pardus tulliana)* habitat (Huş, 1978). In addition to this wild fauna, horses and cattle of former residents had been left behind before the national park declaration and increased in number within years (Bilgin, 2014).

## 2.3 Preparations of Study

Comprehensive preliminary research has been conducted before the decision for translocating the deer. Firstly, modeling was performed to find out suitable sites for fallow deer in Turkey. Suitable candidate sites have been visited by specialists and evaluated by using camera traps, and interviews with local people and authorities. The Dilek Peninsula National Park has been selected as the best suitable area for fallow deer reintroduction in Turkey especially due to limited human access as a result of the national park and military statuses (Bilgin, 2014). The next most suitable place was Köyceğiz Wildlife Reserve, which is outside the scope of this thesis.

A limited resource in the area was water availability, so seven artificial water sources were constructed before the reintroduction. Additionally, to make effective monitoring possible, GPS collars, receiver, antenna, ear tags, and camera traps were researched and purchased prior to the reintroduction.

## 2.4 Trapping Fallow Deer

All fallow deer have been captured in Düzlerçamı-Eşenadası Fallow Deer Breeding Center, Antalya between the years 2011-2014. The total number of captured animals is 42 in this period and they are presented in Table 5.

**Table 6.** Capture dates, number of animals caught and their treatment

| Date | Total Number of Animals | | | | | |
|---|---|---|---|---|---|---|
| | **Captured** | **Translocated** | **Females** | **Males** | **Released back** | **Dead** |
| **Apr 2011** | 7 | 6 | 0 | 6 | 0 | 1 |
| **Aug 2011-1** | 5 | 4 | 1 | 3 | 1 | 0 |
| **Aug 2011-2** | 12 | 8 | 8 | 0 | 4 | 0 |
| **Sept 2012** | 8 | 4 | 4 | 0 | 4 | 0 |
| **May 2013** | 2 | 2 | 0 | 2 | 0 | 0 |
| **Sept 2013** | 5 | 5 | 2 | 3 | 0 | 0 |
| **Mar 2014** | 3 | 3 | 3 | 0 | 0 | 0 |
| **Total** | **42** | **32** | **18** | **14** | **9** | **1** |

21 of captured animals, a total of 8 males, 3 of them fawn or young, and 13 females, 4 of them fawn or young, were translocated into Dilek Peninsula National Park between the years 2011 and September 2012. Table 6 shows the marking methods of individuals for monitoring and Table 7 gives Dilek Peninsula population details.

**Table 7.** Markings of founder population of Dilek Peninsula National Park

| **Stage** | **Sex** | **Total** | **GPS Collared** | **VHF Collared** | **Ear tagged** |
|---|---|---|---|---|---|
| Adults | Males | 5 | 5 | 0 | 5 |
| | Females | 9 | 9 | 0 | 9 |
| Fawns | Males | 3 | 0 | 1 | 3 |
| | Females | 4 | 1 | 0 | 4 |
| Total | | 21 | 15 | 1 | 21 |

**Table 8.** Details of individuals translocated to Dilek Peninsula National Park

| # | Eartag no | Sex | GPS code | Collar no | Capture period |
|---|---|---|---|---|---|
| 1 | 102 | Male | 30192 | 102 | April 2011 |
| 2 | 103 | Male | 30191 | 103 | April 2011 |
| 3 | 105 | Male | 31273 | 106 | April 2011 |
| 4 | 107 | Male | 31272 | 107 | April 2011 |
| 5 | 108 | Male | 30189 | 108 | April 2011 |
| 6 | 133 | Male | VHF | * | August 2011-1 |
| 7 | 136 | Male | * | * | August 2011-1 |
| 8 | 134 | Male | * | * | August 2011-1 |
| 9 | 135 | Female | 31448 | 114 | August 2011-1 |
| 10 | 142 | Female | 31271 | 111 | August 2011-2 |
| 11 | 112 | Female | 31449 | 112 | August 2011-2 |
| 12 | 113 | Female | 31447 | 113 | August 2011-2 |
| 13 | 117 | Female | * | * | August 2011-2 |
| 14 | 143 | Female | 2153 | 118 | August 2011-2 |
| 15 | 119 | Female | 2154 | 119 | August 2011-2 |
| 16 | 144 | Female | 31274 | 104 | August 2011-2 |
| 17 | 115 | Female | 31451 | 115 | August 2011-2 |
| 18 | 126 | Female | * | * | September 2012 |
| 19 | 127 | Female | * | * | September 2012 |
| 20 | 123 | Female | 2153a | 118 | September 2012 |
| 21 | 124 | Female | 30190 | 109 | September 2012 |

Two techniques were used for trapping fallow deer: boma type trap and drop-net. Baits were used to attract deer into the traps, which were observed from a suitable place at a safe distance, and when deer enter into the traps, a vertical drop mechanism was triggered immediately. The boma trap had been constructed in a circular area surrounded by 4 m height wooden walls and a guillotine gate controlled from outside by a wire linked to the gate (Figure 11). There is a compartmented corridor in the trap where each chamber has a sliding door mechanism opening to the next narrower chamber in the corridor. Closing each chamber door forces trapped deer into the next smaller chamber and the last chamber is big enough for only a single deer (Figure 12, 13, and 14). At this point, the individual has been trapped.

**Figure 11.** Boma type trap

**Figure 12.** Inside of the trap, chambered corridor

**Figure 13.** Sliding doors

**Figure 14.** A captured adult male inside the chambered corridor

The second method, drop-net, is also a remotely controlled system based on an electromagnetic release mechanism. The system is composed of a net sliding vertically through five poles, 4 at the corners and 1 in the center, and kept in place by magnets (Figure 15). If fallow deer enter into under the net, the circuit is cut off remotely and the net drops on the deer.

**Figure 15.** Drop-net

5-20 people have attended each capturing effort. Once the deer is trapped under the net, these people immediately moved nearby. Trapped fallow deer are immobilized by tying its legs immediately and their eyes are covered temporarily to minimize visual stimuli and calm down the animals as well as protect their eyes from dust and any particles that can cause damage. Sedatives were used only if the veterinarians saw it necessary. Then morphological measurements and, tissue and blood samples have been taken, and the animals were marked with GPS collars and/or ear tags (Figure 16).

**Figure 16.** A scene from applications after capture

## 2.5 Equipment

15 Lite Track Iridium model GPS-GSM collars (Lotek Wireless Inc, Ontario, Canada) were used in this study. Their frequencies ranged between 149.000 MHz to 151.000 MHz. The weight of a collar was 330 gr. corresponding to 1.83 % of the lightest collared animal (17 kg). Collars have drop-off mechanisms, which were adjusted to 2 years for this study. All recorded data were stored on board and sent to project participants via GPRS network. Each GPS fix contains longitude, latitude, date, and time of the location. Additional data such as temperature, altitude and positional dilution of precision (PDOP) were also recorded. Collars were set to send mortality message in case of motionless situation for 7 hours. The frequency of GPF fixes was arranged to be every 2 hours for females in fawning time, 2 hours for all collared animals during the breeding period, and every 7 hours at all other times. VHF signals were activated between the hours of 08:00-11:00 and 17:00-20:00 every day. These signals can be detected using a Yagi-antenna from a distance of a kilometer. In case

of mortality (i.e. no movement for 7 hours), the collars produce a continuous, different signal pattern.

Various numbers of camera traps have also been used throughout the study. Their numbers were increased especially during the fawning period. Individual identification has been provided in the study by written codes on collars and ear tags. Moreover, natural individual marks such as dot patterns, and shape and size of the antlers have also be used.

## 2.6 Data

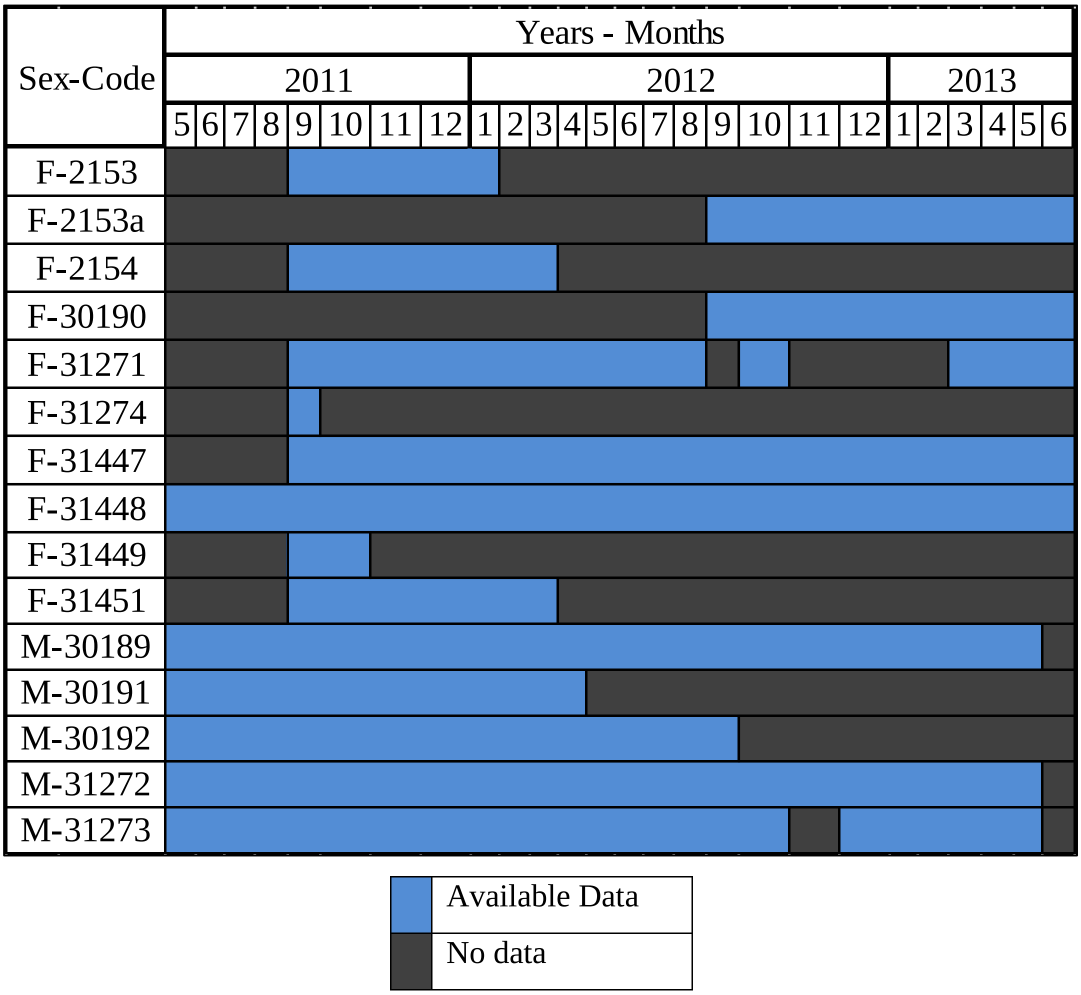
### 2.6.1 GPS Collar Data

Total number of GPS fixes that were obtained throughout the study is 29,526. Some fixes are not usable and needed to be excluded. Data excluded from the analyses are listed below:

- 4086 fixes, which were taken within the fenced acclimatization area,
- 2344 fixes, for which PDOP values were higher than 8 indicating higher inaccuracy of locations,
- 2205 fixes, which were mortality or pseudomortality data continuously taken from the same location within a very short time.

The total number of usable data is 20,891 after data reduction. Since animals have been released at different times, the data from 15 GPS collared individuals do not match completely in time. The number of individuals with usable data on this range is presented in Table 8. Two out of 10 females, 31274 and 31449 coded individuals are excluded from the analyses due to a short period of data collection time. Disconnections on the data are related to release time differences (2153, 2153a, 2154, 30190, 31271, 31274, 31447, 31449, 31451, death (31449), and technical reasons (2153, 2154, 31271, 31451, 30191, 30192).

**Table 9.** Available data of GPS collared individuals for the study period




A year is divided into 3 biologically meaningful periods of Mating, Dry, and Rainy seasons for home range and habitat selection analyses as specified below.

Rainy season – between 15 November and 14 May

Dry season – between 15 May and 14 September

Mating season – between 15 September and 14 November

Throughout the study, home range and habitat selection analyses were carried out for 3 dry, 2 mating and 2 rainy periods. Number of individuals with available data for these analyses is presented in Table 9-10. The 2011 dry season analyses were performed for males only since females had not been released in this period, while the

2013 dry season analyses were performed for females only since the collars of males had dropped off before this period.

The location data input for home range and habitat selection analyses are spatially autocorrelated to some extent in spite of the reduction of approximately one-third of data. Spatial autocorrelation is a major problem for this type of ecological analysis (Legendre, 1993) and generally, dilution of data till reaching complete autocorrelation free data is not possible (Hirzel et al., 2001). More reduction may cause to miss biologically important information.

**Table 10.** Home range and habitat selection study periods, and number of individuals by sexes

(Dark cells mean no data available and "+" indicates available data)

| Individuals | | 2011 Dry | 2011 Mating | 2011_12 Rainy | 2012 Dry | 2012 Mating | 2012_13 Rainy | 2013 Dry |
|---|---|---|---|---|---|---|---|---|
| F-2153 | | | + | + | | | | |
| F-2153a | | | | | | | + | + |
| F-2154 | | | + | + | | | | |
| F-30190 | | | | | | | + | + |
| F-31271 | | | + | + | + | | + | + |
| F-31447 | | | + | + | + | + | + | + |
| F-31448 | | | + | + | + | + | + | + |
| F-31451 | | | + | + | | | | |
| M-30189 | | + | + | + | + | + | + | |
| M-30191 | | + | + | + | | | | |
| M-30192 | | + | + | + | + | + | | |
| M-31272 | | + | + | + | + | + | + | |
| M-31273 | | + | + | + | + | + | + | |
| Number of individuals | Male | 5 | 5 | 5 | 4 | 4 | 3 | 0 |
| | Female | 0 | 6 | 6 | 3 | 2 | 5 | 5 |

**Table 11.** Home range and habitat selection analyses periods

(Blue and orange colored cells mean available data, black cells mean no data available)

| | 2011 dry | 2011 mating | 2011-12 rainy | 2012 dry | 2012 mating | 2012-13 rainy | 2013 dry |
|---|---|---|---|---|---|---|---|
| Males | | | | | | | |
| Females | | | | | | | |

### 2.6.2 Camera Trap Data

A total of 37,176 camera trap-days was achieved with a varying number of camera traps (minimum 7, maximum 36; Reconyx and Bushnell) throughout the study period (Figure 17). Camera traps were placed on tree trunks at 30-40 cm above from the ground (Kelly and Holub, 2008). In order to avoid the sunlight effect, the devices were installed on trunks in a north-south direction. Shell and cable locks were used for both protection of equipment and for providing stability. Consecutive three photos were taken for each trigger. The time interval between each trigger was arranged to be two minutes. 42 field surveys were carried out to collect camera trap data, relocate cameras, and renew batteries or SD cards.

**Figure 17.** Camera trap equipment and on-site use

GPS collar data and field observations were used to identify densely used areas by fallow deer, and camera traps were set to such sites to maximize capture events. Forest openings, used tracks, potential mating, or parturition sites were chosen as camera trap stations (Figure18).

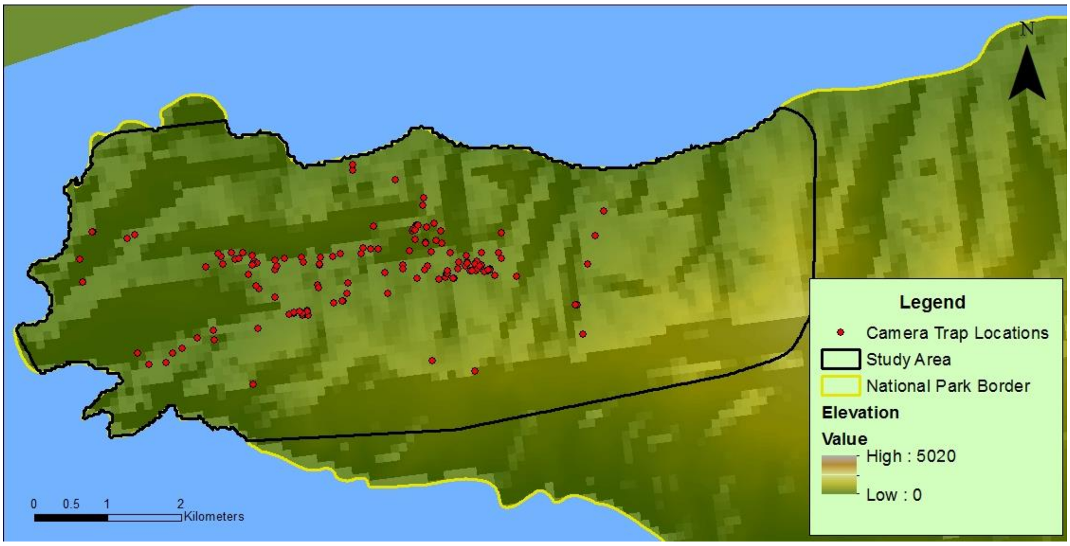



**Figure 18.** Camera trap locations throughout the study period

Individuals were identified mostly by distinctive marks on their collars and/or eartags. GPS collared individuals were named by their collar codes and eartag numbers were used for naming individuals without collars. Shape and size of the antlers and specific spot patterns of individuals have also been helpful for individual identification. Capturing the same animal on the same trap station within one hour is considered as the same event. Unidentified capture data of marked individuals and Dilek Peninsula born individuals without any mark have been included in the analyses.

## 2.7 Home Range Calculations

Home range is an important concept to infer specific needs of animals and to understand their behaviour by examining routinely used areas by them (Burt 1943; Powell 2012 cited in Fieberg and Börger, 2012). There are many estimating methods developed for home range estimations (some of them are mentioned in section 1.3). Three techniques have been used for seasonal home range estimates of males and females in this study: minimum convex polygon (MCP), fixed kernel, and kernel Brownian bridge (KBB). 50% and 95% utilization distributions have been calculated for both identifying the core area of space use and not to miss the biological importance of wider movements. Using different techniques provide both comparisons of different methods within the study and the same methods with different studies. MCP was calculated by using an ArcGIS (ESRI, 2009) extension, Hawth's Analysis Tools version (Hawthorne, 2006). Home Range Tool extension for ArcGIS (Rodgers et al., 2007) was used to estimate fixed kernel home range. Lastly, KBB home ranges were estimated by using AdehabitatHR package of R statistical software (Calenge, 2017a).

Due to restrictions of available data, home ranges are estimated only for males in the 2011 dry season, and only for females in 2013 dry season. The 2011 and 2012 mating, 2011-2012 and 2012-2013 rainy, and 2012 dry season home ranges were estimated for both sexes. Location data of individuals have not been pooled for estimating sex-based home ranges because individual variations can significantly affect the results (Aebischer et al., 1993; Rogers and White, 2007) and mislead conservation efforts. For instance, pooling location data of a group of individuals with small home range sizes and spatially segregated from each other will give overestimated results. Instead, individual home ranges were calculated and averages for each sex for each season were used.

Individual home ranges of completely matched seasons for two years are merged to obtain total range expansion of both sexes. The mentioned seasons are mating 2011 and rainy 2011-2012 seasons for the first year, and mating 2012 and rainy 2012-2013 seasons for the second year. Second year range is expected to be larger for both sexes.

In order to measure the seasonal space use differences of sexes, centroids of 50% fixed kernel home range polygons are found for each individual and distance between centroids of consecutive seasons are calculated. Additionally, seasonal spatial shifts in core area use of males and females are evaluated.

Results of home ranges are evaluated with habitat use patterns and population dynamics. For the sake of simplicity, statistical analyses of home range estimates have been carried out for only the fixed kernel method. Moreover, fixed kernel results provide comparable data for similar studies since the method has been widely-used by researchers. In order to obtain comparable results with similar studies, fixed kernel home range results are used in statistical analyses. The difference between the home range sizes of both methods was not statistically significant ($p=0.721$). However, kernel Brownian bridge home range estimations are better to represent space use dynamics of animals since fixes are not discrete units in this method, rather temporal nature of fixes is included in calculations.

A visual representation for three home range estimation methods is given in given in figure 19 for clarifying different outputs of three methods.

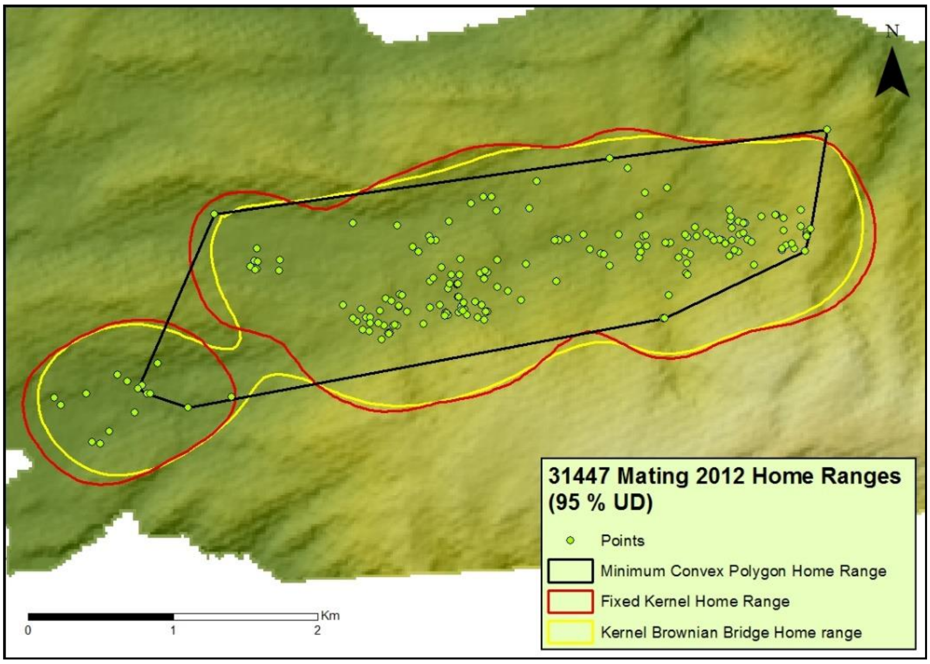



**Figure 19.** mating 2012 95% MCP, FK and KBB home range of an individual

In order to document the effect of different seasons and sexes and their interactions on home range sizes, two-way ANOVA is used. Additionally, home range sizes of some specific periods have been analyzed to test some predictions about the spatial behaviour of fallow deer that presented below.

*Prediction a: Home range sizes of males are larger than those of females.*

To test this hypothesis, the average annual home ranges for both sexes were compared. In addition to annual home range sizes of males and females, home range sizes within the same periods were also compared. Since home range sizes did not fit to normal distribution, log-transform was applied to data before the analyses, and then one-way ANOVA was carried out.

*Prediction b: Home ranges just after release are smaller than those in the following season due to initial unfamiliarity to the new environment for both sexes.*

The 2011 dry season and the 2011 mating season correspond to the period just after release for males and females, respectively. The following period to test is 2011 mating season for the males and the 2011-2012 rainy season for the females. Like in the first analysis, one-way ANOVA was used for comparisons after log-transform.

*Prediction c: Home range sizes of same periods for different years are not different except after release periods.*

Same periods in different years have been compared for each sex separately. Due to increasing familiarity with the reintroduction area, especially in the first season after release, it is not expected to obtain significant differences between home range sizes (of the same seasons) in different years. The exceptions are release periods, which are dry season 2011 and dry season 2012 for the males and, mating season 2011 and mating season 2012 for females. They are expected to be significantly different.

The SPSS statistical software is used for the above mentioned tests (SPSS Inc., 2009). Summary of statistical comparisons carried out in the home range analyses is presented in Table 11 below.

**Table 12.** Biologically and statistically meaningful home range size comparisons

| **Home Range Size Comparisons** | |
|---|---|
| **Within Sex Comparisons** | After release and following periods **(Prediction b)** |
| | First-year mating period and second-year mating period **(Prediction c)** |
| | First-year rainy period and second-year rainy period **(Prediction c)** |
| | First-year dry period and second-year dry period **(Prediction c)** |
| **Between Sex Comparisons** | Biannual averages of sexes **(Prediction a)** |
| | First-year mating period of sexes **(Prediction a)** |
| | First-year rainy period of sexes **(Prediction a)** |
| | 2012 dry period of sexes **(Prediction a)** |
| | Second-year mating period of sexes **(Prediction a)** |
| | Second-year rainy period of sexes **(Prediction a)** |

## 2.8 Habitat Selection

Habitat is the composition of different resources that are generally heterogeneously distributed. Habitat selection analyses are approaches trying to reveal species-habitat relationships. The concept is important since access to key resources is crucial for survival and reproduction of animals (Yaelle et al., 2015) and distribution of resources over habitat shapes the behaviour of individuals (Rhodes et al., 2005). Disproportional use of resources indicates selection or avoidance. There are plenty of methods developed for habitat selection analyses. Compositional analysis, logistic regression, log-linear modeling, and discrete choice modeling are among the most widely used and traditional ones. Recently, more user-friendly and easy to interpret methods have been developed like K-Select Analysis (Calenge et al., 2005) and Ecological Niche Factor Analysis (ENFA) (Hirzel, 2002). In this thesis, ENFA is used for habitat selection analyses. The major outputs of the ENFA are marginality values and vectors indicating whether the selection exists or not through a resource. Larger marginality values indicate stronger selection.

One of the most important points is habitat selection analysis is the selection of environmental parameters to be used. Selected variables should influence the behaviour of animals, like distance to water resources, feeding areas, settlements, etc. In this study, ten parameters have been chosen for analyses specified below with their abbreviations used in the following sections.

Ele – Elevation

Slo – Slope

Dwrr – Distance to water resources in the rainy period

Dwrp – Distance to permanent water resources

Dtr – Distance to road

Dtm – Distance to military stations

Dow – Distance to oak woodland (Figure 20)

Dtpf – Distance to tall pine forest (Figure 21)

Drls – Distance to rocky low shrubland (Figure 22)

Dtss – Distance to tall sclerophyll shrubland (Figure 23)

**Figure 20.** Oak woodland

**Figure 21.** Tall pine forest

**Figure 22.** Rocky low shrubland

**Figure 23.** Tall sclerophyll shrubland

All layers were created by using Spatial Analyst tool of ArcGIS. Elevation range in the study area is between 0 and 1198 m while slopes change between 0 and 58 degrees. The number of permanent water resources (i.e. dry season water resources) in the area is 12, while the number is 15 in the rainy season. Human-caused disturbances are related to two environmental parameters in the area, “dtm”, and “dtr” (Figure 24). There are two military stations and one asphalt road used at least twice a day year round.

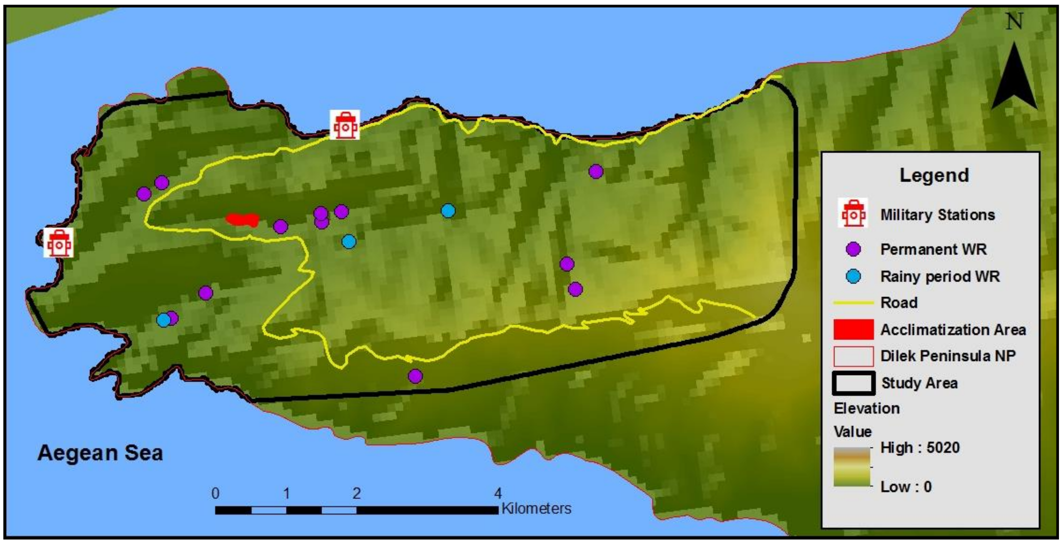



**Figure 24.** Water resources, military stations, and road in the study area

Distribution of habitat types on study area is given in figure 25. Seasonal habitat use percentages of fallow deer for each sex are also calculated by the formula given below. The percent cover of habitat types on study area is given in Table 12.

$$\% \text{ use of habitat x} = \frac{\text{\# of GPS fixes recorded on habitat x for season y}}{\text{total \# of GPS fix for that season y}}$$

**Table 13.** The percent cover of habitat types on the study area
(Pixel size is 42x42 m.)

| Habitat Type | Available Pixels | Percentage |
|---|---|---|
| Tall Sclerophyll Shrubland | 8001 | 38.94 |
| Tall Pine Forest | 7359 | 35.81 |
| Rocky Low Shrubland | 4398 | 21.40 |
| Oak Woodland | 791 | 3.85 |
| Total | 20549 | 100.00 |

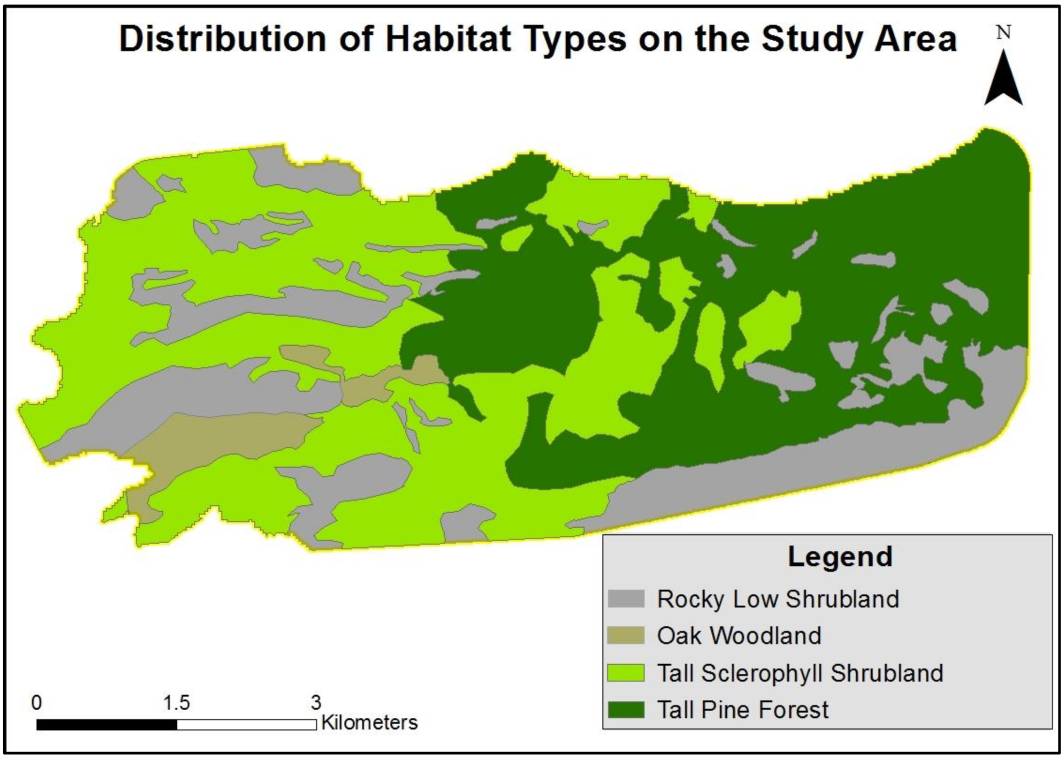



**Figure 25.** Distribution of habitat types on the study area

Since the national park is also a military area, access to civilians is forbidden. The roads and the landscape are only used by military or national park personnel. Human disturbance seems low in the area since the number of people actively using the area is limited. However, field observations and camera trap records show that there are occasional illegal entries. For instance, dogs associated with the military stations were often released free in the daytime in 2011 (one of the deer death cases was possibly due to dog attack). Camera traps have also detected these dogs in the area until the stations were closed down in summer 2012. In addition, it is claimed that due to the remoteness of the area to settlements, military personnel may have been performing target practise (local people, pers.comm.). Another important claim is that the area is used by poachers. According to local people, poachers approach beaches of the national park by boats at night and land in suitable places to hunt. A broken camera trap and the deaths of two deer might be related to such intrusions.

A significant number of horses and cattle, now feral, also live within the national park. They heavily use the patches close to water resources, oak woodlands, and tall sclerophyll shrublands. Therefore, interspecific competition for food and water resources can occur near those sites.

Habitat selection analyses were performed for the same periods as for home range analyses (see above under 2.7). The study design used is Design I (see Table 4). Availability of resources has been defined for the whole study area and utilized resources have been defined at the population level for each sex. AdehabitatHS package (Calenge, 2011, 2017b) of R statistical software (R Development Core Team, 2017) was used in habitat selection analyses.

## 2.9 Hypothesis Testing: Sexual Segregation

In order to document presence or absence of any sexual segregation, “kerneloverlap” function in “AdehabitatHR” (Calenge, 2017a) package of statistical software R (R Development Core Team, 2017) was used. This function can implement all kernel home-range overlap indices defined by Fieberg and Kochanny (2005). These indices are computed from location data of animals and allow making pairwise comparisons of UDs of animals. In this analysis, “PHR” index is used to compute the volume UD of an animal within the home range of another animal. In other words, it calculates the probability to find an animal in the home range of another animal. The output of the analysis was a matrix giving the index values of overlap for all pairs of animals. The matrix is used as an input for hierarchical clustering to determine the number of groups and compositions by using “classical clustering” tool of software

PAST (Hammer et al., 2001). The results show the presence or absence of spatial segregation of the two sexes.

The same location data of individuals used in home range and habitat selection analyses were used to determine the spatial and sexual associations of animals. The 2011 and 2013 dry season analyses cover only one sex.

However, temporal variations in space use may have been missed by this method. Home ranges of animals can overlap to some extent in an area but it may not indicate that the group is formed by those individuals. Figure 26 presents an example below. Individuals can use the same area in a period that is completely different from the other individuals. Therefore, a crosscheck was developed for group formation analyses. The study area was divided into 100x100 m grids and locations of each individual are matched with those grids for each defined period. Then, grids with location attributes were filtered by date and hour. Individuals found on the same grid at the same day and the same hours were evaluated as a group for that time. Obtained data were then converted into a co-occurrence matrix by calculating the encounter ratio of individuals. It was calculated by using the equation defined below.

$$\# \, of \; co - ocurence \; days \; by \; individual \; x \; and \; y \; in \; season \; z / \# \, days \; in \; season \; z$$

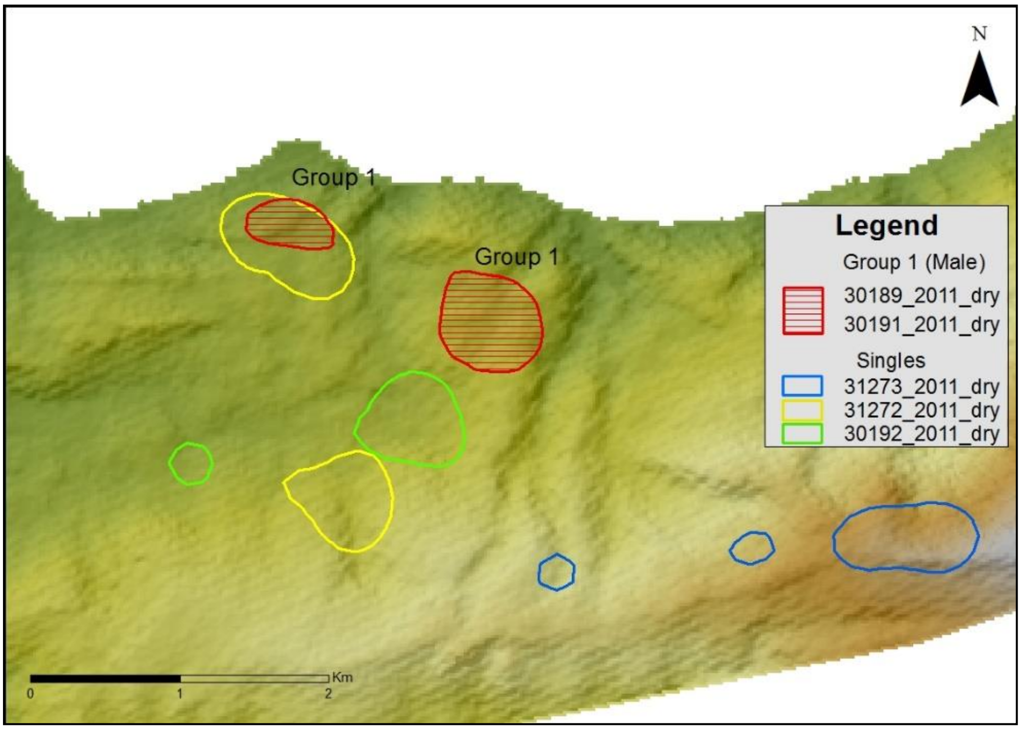



**Figure 26.** An example of potential misinterpretation case (Overlapping home range polygons of group 1 and individual 31272, overlapping area has been used by 31272 in different time independent from group 1 individuals.)

In case of spatial sexual segregation, environmental variables used in the habitat selection analysis are classified into two biologically meaningful groups as predation risk and resource quality to test the hypothesis of predation-risk, and forage-selection (Table 13).

**Table 14.** Tested hypotheses and their assumptions

| **Driving Force of Sexual Segregation** | **Predictions** |
|---|---|
| by Predation-Risk Hypothesis | Females occupy safer habitats with poor quality food. |
| | Males occupy insecure habitats with high quality food. |
| by Forage-Selection Hypothesis | Females use habitats with high-quality food. |
| | Males use habitats with lower food quality. |

Since there was no predator of the adult deer in the area, we used potential disturbance as a proxy for predation risk. The parameters related to disturbance in the study area are “distance to military stations (dms)” and “distance to road (dr)”. The parameters related to resource quality are “distance to water resources (dwr)”, “distance to oak woodlands (dow)”, and “distance to tall sclerophyll shrublands (dtss)”. Disturbance is assumed high in patches close to the military stations and roads. Quality and abundance of the resources are also assumed high near water sources, oak woodlands, and tall sclerophyll shrublands. Oak woodlands and tall sclerophyll shrublands contain openings allowing effective grazing opportunities for fallow deer due to presence of grasses. They also provide additional high-quality food resources like fruits and seeds. Tall pine forests are assumed as safe places with medium quality of resources. Water and food resources are poor when compared to oak woodlands and tall sclerophyll shrublands. Rocky low shrublands are accepted as high disturbance areas with low resource quality. Therefore, the study area has been divided into four with respect to disturbance probability and resource availability as following:

1- High disturbance areas (with variable resource quality)
2- High disturbance areas with high-quality resources
3- High disturbance areas with low resource quality
4- Safer places with medium resource quality

Mating season data of 2011 and 2012 years are excluded from the analyses since the hypotheses are related to spatial segregation of males and females. Space use patterns of both sexes were similar during the mating season.

Design I habitat selection was used for testing these hypotheses. Available and utilized habitats are defined at the population level. ENFA is carried out for habitat selection analyses using AdehabitatHS package (Calenge, 2011, 2017b) of R statistical software (R Development Core Team, 2017).

## 2.10 Demography, Population Dynamics

The main goal of camera trap data is monitoring population dynamics by demonstrating the demographic parameters of the reintroduced population. Use of camera traps is particularly useful for obtaining data that GPS collars were not able to provide like number of pregnant females, reproductive success, population growth etc. In addition, not all the animals were collared by GPS collars and camera traps are only data collection method for them. Moreover, camera traps give information about other species that can affect the fallow deer population by competition or predation. All the demographic analyses were carried out by using camera trap data.

Program “MARK” is one of the widely used software for demographical parameters of populations (White and Burnham, 1999). In order to avoid violating the closed population assumption, a year is represented by two months, October and November. These months are mating period of the fallow deer that all of the individuals occupy areas close to each other. The choice of these months is also meet the requirement of another CMR assumption of stability of individual activity centers during the study. Population sizes of the years were estimated by “mark-resight” model in software MARK. Input data for the model requires an encounter history file for the study period. It contains total recapture events of individuals for defined periods. Analyses have also required total number of marked alive individuals, total number of marked but unidentified individuals, and total number of unmarked individuals for each analyze period. The input data is given in Table 14.

**Table 15.** Input data for mark-resight model

| Year | # of Detected Unmarked Individuals | # of Detected Marked, Unidentified Individuals | # of Marked Individuals |
|---|---|---|---|
| **2011** | 0 | 21 | 17 |
| **2012** | 11 | 154 | 22 |
| **2013** | 20 | 101 | 24 |
| **2014** | 37 | 247 | 29 |
| **2015** | 70 | 308 | 34 |
| **2016** | 53 | 100 | 34 |

Some clarifications about column headings are given below.

*The number of detected unmarked individuals:* All unmarked individuals are Dilek Peninsula born fawns. The numbers in the column indicate total number of individuals detected in different events.

*The number of detected marked, unidentified individuals:* It shows the number of reintroduced, marked individuals detected in different events. Their marks could not be read due to low light conditions at nights, motion effect on legibility or wrong angle etc..

*The number of marked individuals:* The numbers show the total number of marked individuals detected for the related year. The individuals having a clear dot pattern is also evaluated as "marked individual".

Direct camera trap capture records for different individuals were counted to obtain a range of minimum population sizes for the study period. Post-breeding censuses were used for those calculations. Minimum range of density was also calculated by dividing the minimum and maximum number of individuals to study area, 37 $km^2$, for respective years. The growth rate of the population was also evaluated for the study period by subtracting the first population estimate from the last population estimate and dividing the result into the first population size value.

# CHAPTER 3

# RESULTS

## 3.1 Home range

Range expansion is an expected result for fallow deer space use. This behaviour is common for animals translocated into an unfamiliar environment. Merged home ranges of individuals for both sexes are presented in Figure 27 and Figure 28. Total area of space use in the second year has increased from 1786 ha to 2182 ha in males and from 967 ha to 1444 ha in females. Males have explored more area than females (Figure 29-30).

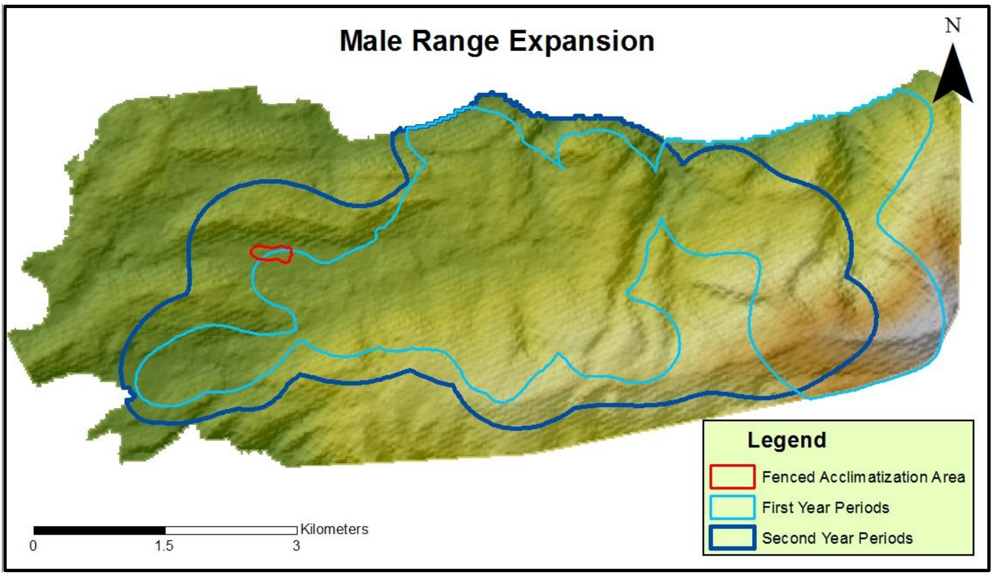



**Figure 27.** Range expansion of males

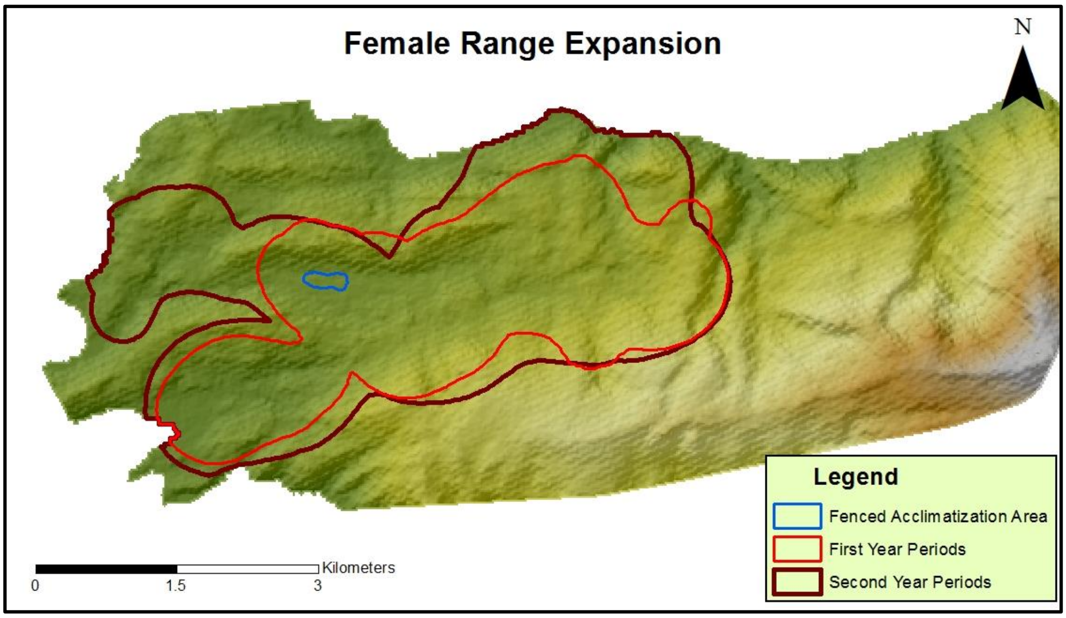



**Figure 28.** Range expansion of females

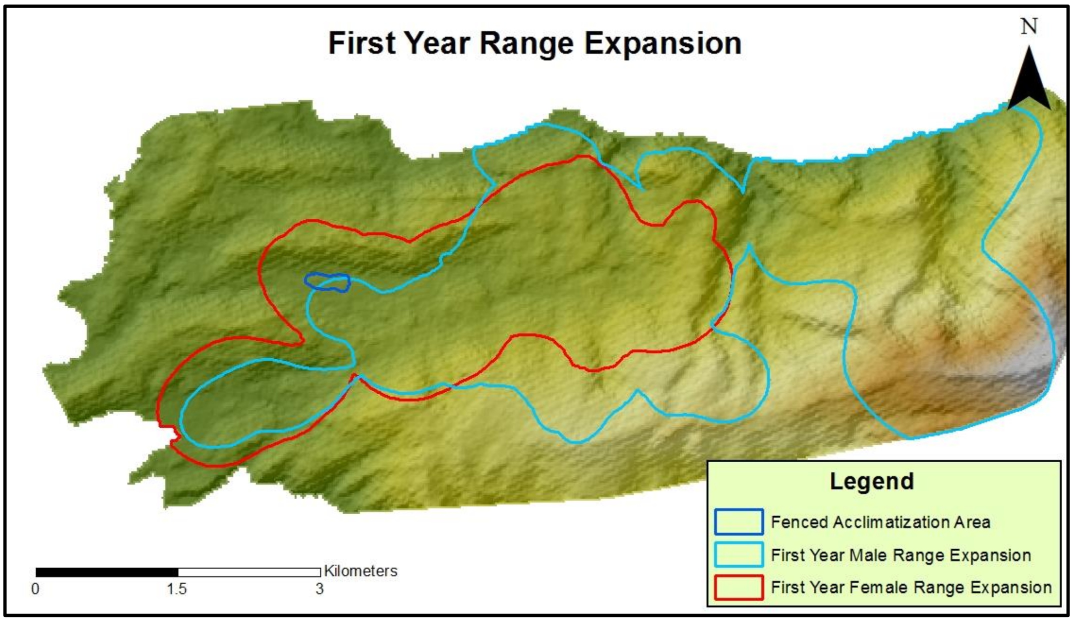



**Figure 29.** First year range expansions of males and females

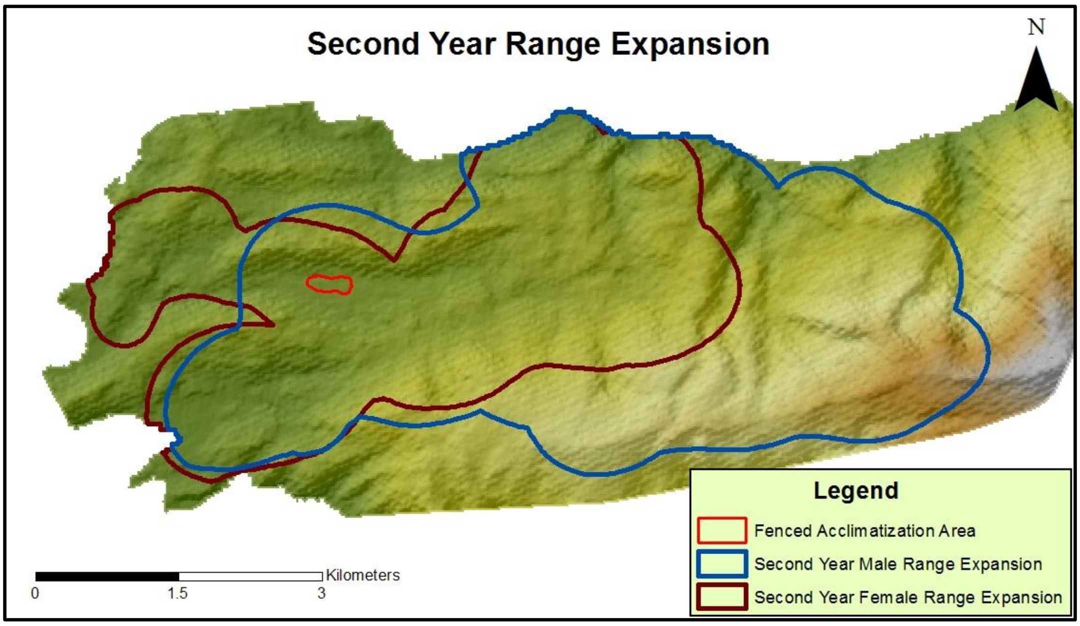



**Figure 30.** Second year range expansions of males and females

Space use patterns of both sexes are evaluated by using centroid distances of 50% fixed kernel home ranges. Mean distances covered just after release season is 3394.4 ± 1009.9 m for males (n=5, dry season 2011), 2959.3 ± 188.6 m (n=6, mating 2011) for the first release group females, and 1054.5 ± 69.5 m (n=2, rainy season 2012-13) for the second release group females. Mean distance covered by males are higher than females but not statistically significant (p=0.169, one-way ANOVA). However, it differs between two female release groups. First release group moves further than the second release group of females (p=0.000, one-way ANOVA). Space use patterns show the social interactions between males are weaker than females. When male space use pattern is more dispersed, the pattern of females is more compact. The minimum mean distance covered by reintroduced animals belongs to the second release group of females (Figure 31-32-33-34).

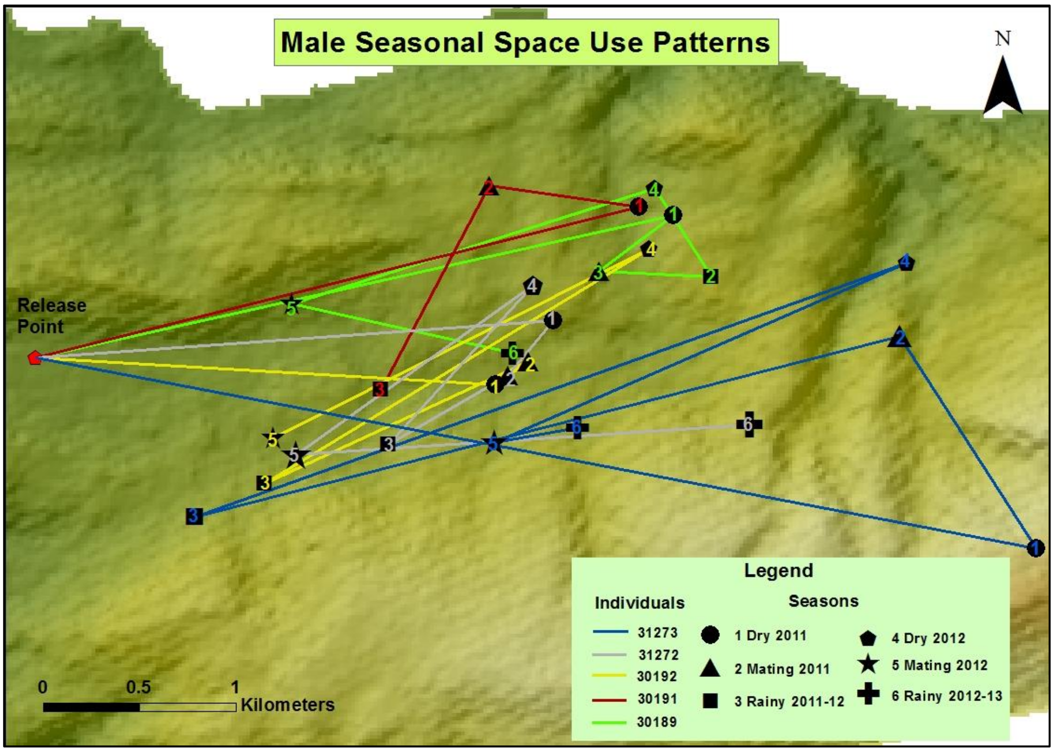
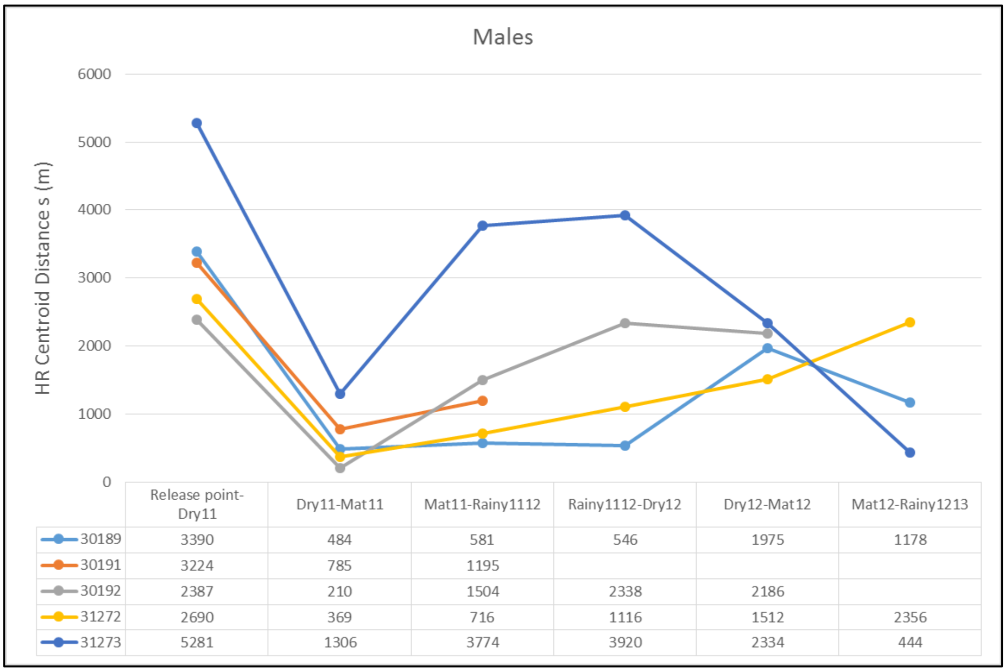



**Figure 31.** Seasonal space use pattern of males

(50% fixed kernel centroids)




| | Release point-Dry11 | Dry11-Mat11 | Mat11-Rainy1112 | Rainy1112-Dry12 | Dry12-Mat12 | Mat12-Rainy1213 |
|---|---|---|---|---|---|---|
| 30189 | 3390 | 484 | 581 | 546 | 1975 | 1178 |
| 30191 | 3224 | 785 | 1195 | | | |
| 30192 | 2387 | 210 | 1504 | 2338 | 2186 | |
| 31272 | 2690 | 369 | 716 | 1116 | 1512 | 2356 |
| 31273 | 5281 | 1306 | 3774 | 3920 | 2334 | 444 |

**Figure 32.** Seasonal 50% fixed kernel home range centroid distances of males

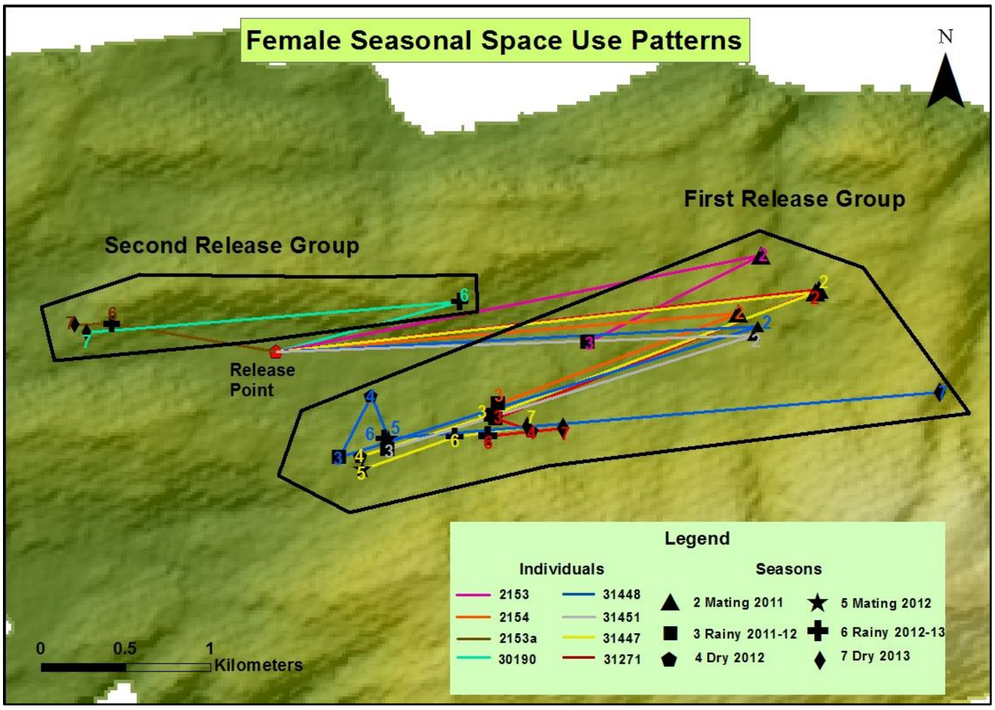
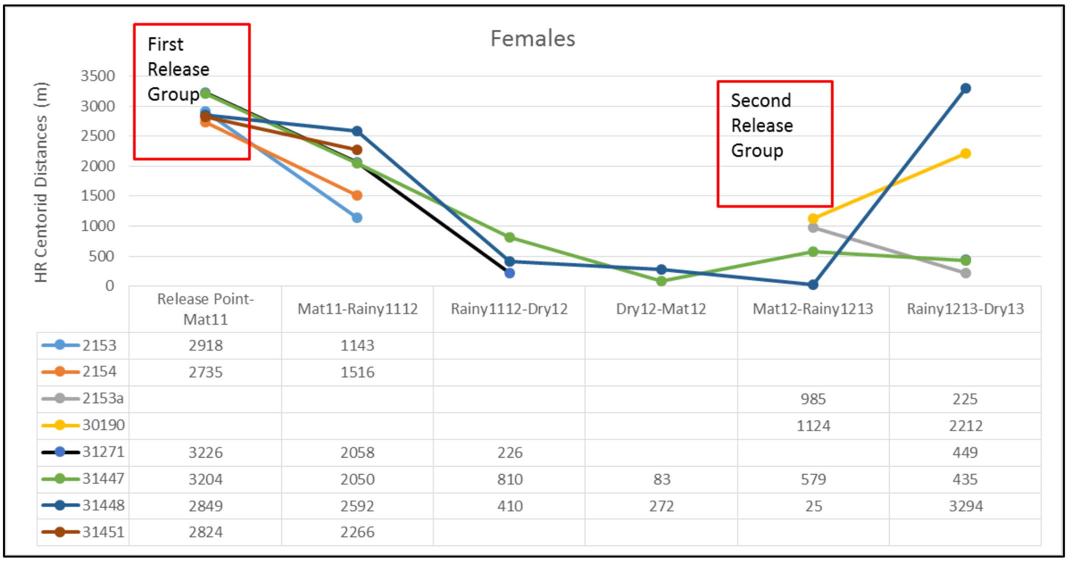



**Figure 33.** Seasonal space use patterns of females
(50% fixed kernel centroids)




| | Release Point-Mat11 | Mat11-Rainy1112 | Rainy1112-Dry12 | Dry12-Mat12 | Mat12-Rainy1213 | Rainy1213-Dry13 |
|---|---|---|---|---|---|---|
| 2153 | 2918 | 1143 | | | | |
| 2154 | 2735 | 1516 | | | | |
| 2153a | | | | | 985 | 225 |
| 30190 | | | | | 1124 | 2212 |
| 31271 | 3226 | 2058 | 226 | | | 449 |
| 31447 | 3204 | 2050 | 810 | 83 | 579 | 435 |
| 31448 | 2849 | 2592 | 410 | 272 | 25 | 3294 |
| 31451 | 2824 | 2266 | | | | |

**Figure 34.** Seasonal 50% fixed kernel home range centroid distances of females

Home ranges of GPS collared individuals are estimated for 50% and 95% utilization distribution contours by using three methods, namely Minimum Convex Polygon, Fixed Kernel and Kernel Brownian Bridge (denoted as MCP, FK, and KBB) for different seasons defined in section 2.6.1. Average 95% fixed kernel home range size of females is 435.0 ± 228.1 ha for the first year, 502.4 ± 97.4 ha for the second year, and the first and the second year averages for males are 481.0 ± 188.5 ha and 732.4 ± 399.4 ha respectively. Biannual average home range size is 493.2 ± 252.7 ha for females and 587.4 ± 321.6 ha for males. Table15, 16, 17 and 18 give the results and Figure 35 is a visual summary of the tables.

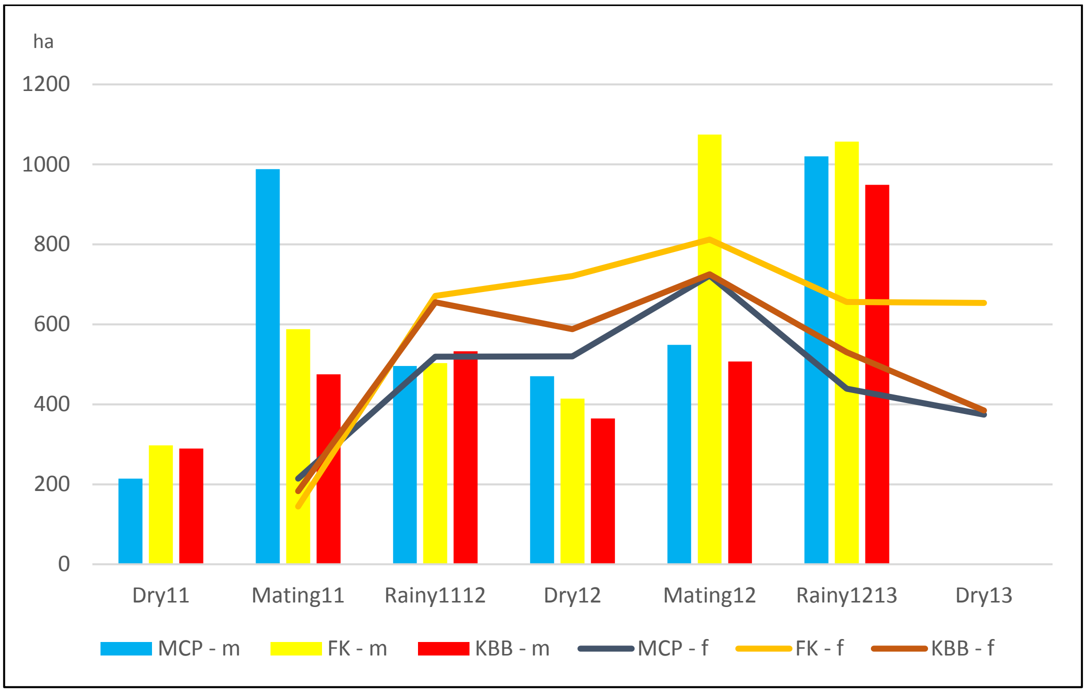



**Figure 35.** Graphical representation of average home range size estimates of sexes **(**Columns – males (m), lines – females (f))

**Table 16.** 50% and 95% dry season home range sizes of both sexes
*Area unit is ha.

| Period | Sex | Animal ID | MCP %50 | MCP 95% | FK 50% | FK 95% | KBB 50% | KBB 95% |
|---|---|---|---|---|---|---|---|---|
| Dry 2011 | Male | 30189 | 38.03 | 265.22 | 62.07 | 320.78 | 54.03 | 309.73 |
| | | 30191 | 54.91 | 216.68 | 65.9 | 366.64 | 82.78 | 371.07 |
| | | 30192 | 17.64 | 136.72 | 39.78 | 220.68 | 93.3 | 374.73 |
| | | 31272 | 67.85 | 320.64 | 75.52 | 358.07 | 38.18 | 274.12 |
| | | 31273 | 23.98 | 131.64 | 45.11 | 221.96 | 24.36 | 118.56 |
| | | **Avr.** | 40.48 | 214.18 | 57.68 | 297.63 | 58.53 | 289.64 |
| | | **Std. Dv.** | 18.75 | 73.15 | 13.3 | 64.18 | 26.07 | 93.58 |
| Dry 2012 | Female | 31271 | 73.32 | 475.04 | 163.88 | 740.35 | 140.48 | 488.52 |
| | | 31447 | 175.88 | 407.39 | 135.81 | 630.58 | 130.26 | 605.07 |
| | | 31448 | 152.49 | 676.43 | 176.92 | 792.31 | 146.34 | 670.87 |
| | | **Avr.** | 133.9 | 519.62 | 158.87 | 721.08 | 139.03 | 588.15 |
| | | **Std. Dv.** | 43.88 | 114.27 | 17.15 | 67.42 | 6.64 | 75.40 |
| | Male | 30189 | 53.96 | 258.32 | 62.24 | 266.65 | 52.17 | 216.53 |
| | | 30192 | 98.89 | 440.49 | 121.38 | 485.4 | 101.96 | 422.06 |
| | | 31272 | 74.34 | 400.08 | 77.5 | 364.26 | 81.06 | 488.90 |
| | | 31273 | 19.89 | 781.46 | 65.63 | 540.7 | 34.49 | 332.32 |
| | | **Avr.** | 61.77 | 470.09 | 81.69 | 414.25 | 67.42 | 364.95 |
| | | **Std. Dv.** | 28.94 | 192.08 | 23.61 | 106.46 | 25.96 | 102.13 |
| Dry 2013 | Female | 2153a | 52.83 | 171.43 | 71.75 | 289.83 | 238.13 | 250.39 |
| | | 30190 | 52.9 | 271.61 | 60.06 | 281.77 | 49.58 | 231.38 |
| | | 31271 | 40.39 | 312.23 | 207.36 | 965.36 | 374.43 | 537.09 |
| | | 31447 | 132.78 | 615.32 | 226.85 | 993.33 | 161.01 | 748.85 |
| | | 31448 | 164.14 | 498.63 | 165.28 | 739.28 | 142.46 | 156.39 |
| | | **Avr.** | 88.61 | 373.85 | 146.26 | 653.91 | 193.12 | 384.82 |
| | | **Std. Dv.** | 50.07 | 160.69 | 68.66 | 313.22 | 108.72 | 223.38 |

**Table 17.** 50% and 95% mating period home range sizes of both sexes

*Area unit is ha.

| Period | Sex | Animal ID | MCP %50 | MCP 95% | FK 50% | FK 95% | KBB 50% | KBB 95% |
|---|---|---|---|---|---|---|---|---|
| Mating 2011 | Female | 2153 | 21.69 | 153.91 | 37.25 | 192.49 | 43.61 | 206.13 |
| | | 2154 | 14.43 | 120.60 | 25.16 | 152.35 | 27.18 | 245.97 |
| | | 31271 | 10.79 | 70.50 | 16.03 | 78.59 | 21.01 | 139.25 |
| | | 31447 | 13.93 | 53.36 | 15.77 | 75.90 | 21.79 | 123.13 |
| | | 31448 | 35.17 | 124.18 | 43.66 | 184.12 | 50.66 | 202.44 |
| | | 31451 | 39.79 | 115.16 | 42.72 | 183.55 | 42.44 | 180.61 |
| | | **Avr.** | 22.64 | 106.29 | 30.10 | 144.50 | 34.45 | 182.92 |
| | | **Std.Dv.** | 11.07 | 34.04 | 11.70 | 49.18 | 11.58 | 41.60 |
| | Male | 30189 | 98.93 | 353.87 | 106.39 | 455.82 | 115.64 | 489.29 |
| | | 30191 | 68.49 | 270.22 | 75.64 | 385.30 | 116.15 | 462.86 |
| | | 30192 | 23.71 | 264.34 | 48.85 | 325.82 | 75.96 | 294.81 |
| | | 31272 | 83.56 | 389.79 | 96.85 | 440.69 | 115.67 | 533.66 |
| | | 31273 | 344.01 | 988.31 | 211.04 | 1333.7 | 70.35 | 593.82 |
| | | **Avr.** | 123.74 | 453.31 | 107.76 | 588.26 | 98.75 | 474.89 |
| | | **Std.Dv.** | 112.96 | 271.80 | 55.30 | 375.51 | 20.98 | 100.38 |
| Mating 2012 | Female | 31447 | 130.31 | 523.97 | 165.49 | 752.47 | 160.18 | 715.54 |
| | | 31448 | 154.71 | 573.73 | 189.46 | 871.72 | 148.71 | 734.89 |
| | | **Avr.** | 142.51 | 548.85 | 177.48 | 812.10 | 154.45 | 725.21 |
| | | **Std.Dv.** | 12.20 | 24.88 | 11.99 | 59.63 | 5.74 | 9.68 |
| | Male | 30189 | 169.47 | 537.77 | 158.55 | 624.34 | 197.54 | 457.32 |
| | | 30192 | 32.43 | 303.90 | 195.15 | 942.92 | 61.15 | 351.13 |
| | | 31272 | 319.50 | 848.57 | 337.65 | 1135.2 | 408.67 | 550.24 |
| | | 31273 | 338.45 | 1197.75 | 376.44 | 1596.5 | 341.99 | 670.84 |
| | | **Avr.** | 214.96 | 722.00 | 266.95 | 1074.7 | 252.34 | 507.38 |
| | | **Std.Dv.** | 124.06 | 335.82 | 92.05 | 352.17 | 134.19 | 117.77 |

**Table 18.** 50% and 95% rainy period home range sizes of both sexes

*Area unit is ha.

| Period | Sex | Animal ID | MCP %50 | MCP 95% | FK 50% | FK 95% | KBB 50% | KBB 95% |
|---|---|---|---|---|---|---|---|---|
| **Rainy 2011-2012** | **Female** | 2153 | 118.67 | 397.12 | 132.72 | 573.05 | 90.91 | 451.41 |
| | | 2154 | 194.93 | 673.33 | 191.45 | 759.32 | 142.18 | 654.95 |
| | | 31271 | 96.95 | 614.11 | 194.07 | 794.14 | 175.47 | 747.32 |
| | | 31447 | 116.65 | 588.07 | 186.25 | 778.95 | 173.02 | 727.47 |
| | | 31448 | 107.98 | 550.11 | 137.65 | 678.62 | 129.96 | 694.19 |
| | | 31451 | 85.43 | 290.45 | 97.87 | 443.54 | 197.65 | 387.18 |
| | | **Avr.** | 120.10 | 518.86 | 156.67 | 671.27 | 151.53 | 655.07 |
| | | **Std. Dv.** | 35.35 | 132.72 | 36.23 | 126.50 | 35.09 | 106.55 |
| | **Male** | 30189 | 34.95 | 185.84 | 39.78 | 211.29 | 49.63 | 222.31 |
| | | 30191 | 89.97 | 319.24 | 86.51 | 402.73 | 115.26 | 459.07 |
| | | 30192 | 78.74 | 371.15 | 88.23 | 398.28 | 100.55 | 518.97 |
| | | 31272 | 78.82 | 806.72 | 108.40 | 667.39 | 106.38 | 669.91 |
| | | 31273 | 194.24 | 794.49 | 185.62 | 837.29 | 159.03 | 792.14 |
| | | **Avr.** | 95.34 | 495.49 | 101.71 | 503.40 | 106.17 | 532.48 |
| | | **Std. Dv.** | 52.92 | 256.39 | 47.61 | 221.31 | 34.94 | 193.95 |
| **Rainy 2012-2013** | **Female** | 2153a | 21.93 | 136.26 | 75.06 | 294.61 | 38.65 | 182.86 |
| | | 30190 | 17.59 | 157.01 | 49.35 | 352.87 | 45.64 | 253.18 |
| | | 31271 | 167.46 | 416.42 | 226.21 | 859.07 | 141.91 | 573.19 |
| | | 31447 | 198.81 | 606.43 | 242.51 | 856.05 | 196.13 | 816.15 |
| | | 31448 | 151.01 | 879.54 | 180.99 | 915.39 | 157.49 | 827.19 |
| | | **Avr.** | 111.36 | 439.13 | 154.82 | 655.60 | 115.96 | 530.51 |
| | | **Std. Dv.** | 76.36 | 280.64 | 78.69 | 272.41 | 62.84 | 271.74 |
| | **Male** | 30189 | 73.97 | 369.60 | 82.91 | 463.57 | 84.62 | 459.86 |
| | | 31272 | 155.36 | 1339.37 | 214.83 | 1145.08 | 197.10 | 1109.23 |
| | | 31273 | 381.97 | 1350.41 | 407.39 | 1562.17 | 306.04 | 1278.75 |
| | | **Avr.** | 203.76 | 1019.80 | 235.04 | 1056.94 | 195.92 | 949.28 |
| | | **Std. Dv.** | 130.32 | 459.78 | 133.24 | 452.81 | 90.40 | 352.92 |

**Table 19.** 50% and 95% annual and biannual average home range sizes of GPS males and females for three methods MCP, FK, and KBB

*Area unit is ha.

| Sex and UD Contour | Method | Seasonal Range of Year Cover | Annual Average | Biannual Average |
|---|---|---|---|---|
| Males 95% | MCP | 2011 dry-2011 rainy | 387.66 ± 252.32 | 524.72±360.16 |
| | | 2012 dry-2012 rainy | 711.61 ± 399.04 | |
| | FK | 2011 dry-2011 rainy | 463.10 ± 282.12 | 618.20±406.15 |
| | | 2012 dry-2012 rainy | 829.71 ± 451.46 | |
| | KBB | 2011 dry-2011 rainy | 481.00 ± 188.50 | 587.38±321.61 |
| | | 2012 dry-2012 rainy | 732.43 ± 399.44 | |
| Females 95% | MCP | 2011 mating-2012 dry | 353.98 ± 225.89 | 387.86±225.48 |
| | | 2012 mating-2013 dry | 430.21 ± 217.67 | |
| | FK | 2011 mating-2012 dry | 470.53 ±281.90 | 564.06±297.97 |
| | | 2012 mating-2013 dry | 680.98 ± 275.37 | |
| | KBB | 2011 mating-2012 dry | 434.97 ± 228.07 | 493.16± 52.70 |
| | | 2012 mating-2013 dry | 502.41±97.350 | |
| Males 50% | MCP | 2011 dry-2011 rainy | 86.52 ± 80.62 | 121.36±102.86 |
| | | 2012 dry-2012 rainy | 156.20 ± 125.09 | |
| | FK | 2011 dry-2011 rainy | 89.05 ± 48.29 | 139.97±85.58 |
| | | 2012 dry-2012 rainy | 190.88 ± 122.87 | |
| | KBB | 2011 dry-2011 rainy | 87.82 ± 34.90 | 128.77±79.70 |
| | | 2012 dry-2012 rainy | 169.71 ± 124.49 | |
| Females 50% | MCP | 2011 mating-2012 dry | 71.37 ± 55.33 | 91.91±57.61 |
| | | 2012 mating-2013 dry | 112.44 ± 59.89 | |
| | FK | 2011 mating-2012 dry | 93.38 ± 68.77 | 124.59±65.24 |
| | | 2012 mating-2013 dry | 155.80 ± 61.71 | |
| | KBB | 2011 mating-2012 dry | 92.99 ± 64.11 | 122.21±71.74 |
| | | 2012 mating-2013 dry | 151.43 ± 79.37 | |

Two-way ANOVA results show that home range sizes were not influenced by sexual differences (p=0.148), but seasons and season-sex interactions (p=0.000 for both) have statistically significant effect on home range sizes.

The results of statistical analyses to test predictions are given in Table 19.

**Table 20.** Within and between sex home range size comparisons (by one-way ANOVA)

| **Home Range Size Comparisons** | | **P Values** | |
|---|---|---|---|
| | | Males | Females |
| **Within Sex Comparisons** | After release and following periods **(Prediction b)** | 0.075 | 0.000 |
| | First-year mating season vs second-year mating season **(Prediction c)** | 0.074 | 0.003 |
| | First-year rainy season vs second-year rainy season **(Prediction c)** | 0.125 | 0.645 |
| | First-year dry season vs second-year dry season **(Prediction c)** | 0.127 | 0.551 |
| **Between Sex Comparisons** | Biannual averages **(Prediction a)** | 0.681 | |
| | First-year mating season **(Prediction a)** | 0.002 | |
| | First-year rainy season **(Prediction a)** | 0.146 | |
| | 2012 dry season **(Prediction a)** | 0.029 | |
| | Second-year mating season **(Prediction a)** | 0.486 | |
| | Second-year rainy season **(Prediction a)** | 0.302 | |

*Prediction a:*

Average biannual home range sizes of males are bigger than females, but the difference is not statistically significant (p = 0.681). There are 5 overlapping seasons that home range sizes have been compared between males and females; mating 2011, rainy 2011-12, dry 2012, mating 2012, and rainy 2012-13. The difference between home range sizes of both sexes are only statistically different in 2011 mating season and 2012-2013 rainy season but only mating 2011 results statistically support the prediction a (p = 0.002). Home range sizes of females are bigger than males for the 2012-2013 rainy season.

*Prediction b:*

Just after the release, home ranges of females are significantly smaller than in the following season (p =0.000). Male home range sizes do not support the prediction (p=0.075). In other words, male home ranges in mating season 2011 are not significantly larger than home ranges just after release (2011 dry season) while female home ranges in rainy season 2011-2012 are significantly larger than those just after release (mating season 2011). The results of females support prediction b.

*Prediction c:*

There is no significant difference between the same period home range sizes of different years for both sexes except mating period home ranges of females. The results support the prediction c.

## 3.2 Habitat Selection

### 3.2.1 ENFA Results Summary

Habitat selection analyses are based on the marginality concept in ENFA as explained before. Marginality value is a measure of selection in ENFA and indicates the magnitude of the connecting vector, marginality vector, of used and available space centroids. The higher its value, the stronger is the selection. The strength of habitat selection seems to be stronger in females, but the difference is not statistically significant (p=0.109) (Figure 36).

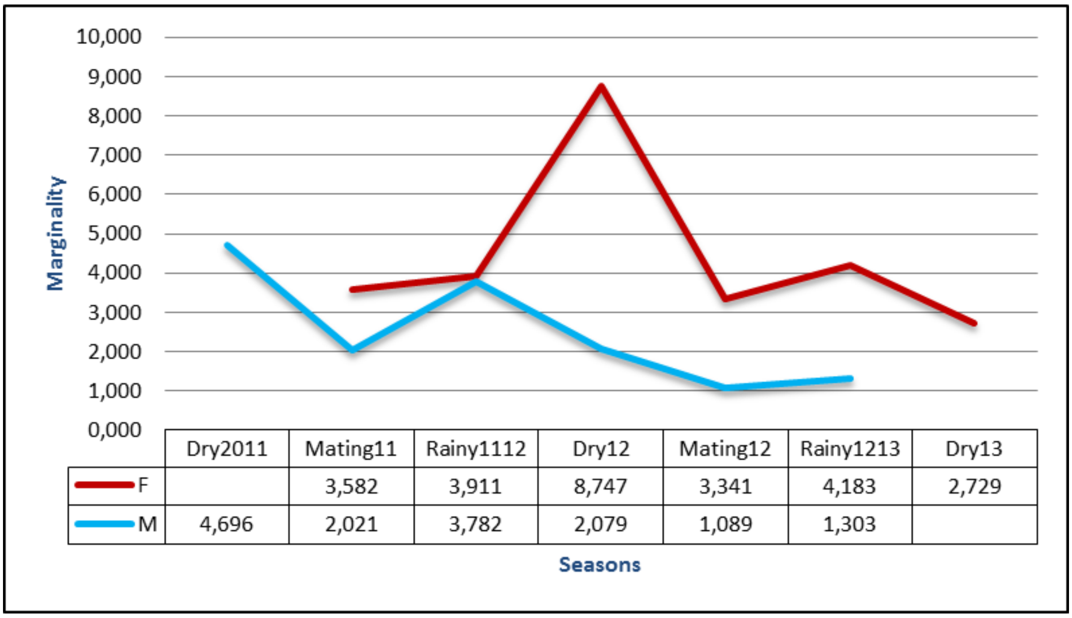



**Figure 36.** Marginality values of males and females for seasons

Summary table of ENFA findings for all environmental parameters are given below (Table 20) and seasonal changes in vegetation cover preference of sexes are given in Figure 37.

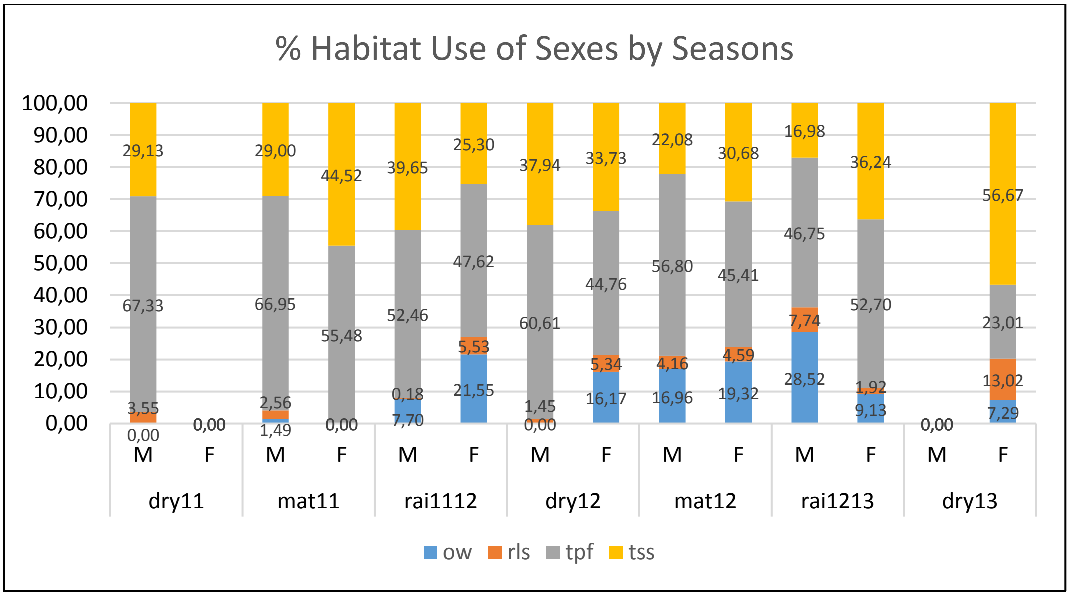



**Figure 37.** Seasonal changes in vegetation cover of sexes as percentages

**Table 21.** Habitat use pattern of males and females within the study period

| | ele | | slo | | dr | | dms | | dwr | | dtpf | | dtss | | drls | | dow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| **Dry 2011** | H | NA | L | NA | 0 | NA | 0 | NA | 0 | NA | + | NA | 0 | NA | - | NA | - | NA |
| **Mating 2011** | M | M | M | L | - | - | 0 | 0 | 0 | + | + | + | 0 | 0 | - | - | - | - |
| **Rainy 2011-12** | M | L | M | L | - | - | 0 | + | + | + | + | + | 0 | 0 | - | - | 0 | + |
| **Dry 2012** | H | L | M | L | 0 | - | 0 | 0 | 0 | + | + | + | 0 | 0 | - | - | - | + |
| **Mating 2012** | M | L | H | L | 0 | - | + | + | + | + | + | + | 0 | 0 | - | - | + | + |
| **Rainy 2012-13** | M | L | M | L | - | - | 0 | + | + | + | + | 0 | 0 | 0 | - | - | 0 | + |
| **Dry 2013** | NA | L | NA | L | NA | - | NA | + | NA | + | NA | - | NA | + | NA | - | NA | + |
| M - Male, F -Female, NA - Not Available | | | | | | | | | | | | | | | | | | |
| H-High, M-Medium, L - Low, - Avoidance, + Preference, 0 Neutral | | | | | | | | | | | | | | | | | | |

ENFA results showed that habitat use patterns of males and females are not similar except for the mating seasons (Table21, Figure 39, and Figure 62). None of the nine environmental parameters is apparently shared by males and females throughout the year, even though there are some seasonal similarities in resource use. On the other hand, both sexes have common avoidances of rocky low shrublands and the road. Moreover, they display neutral behaviour towards presence of tall sclerophyll shrubland. The sex-based resource use patterns of reintroduced fallow deer population can be summarized as follows: Females always prefer to stay at low elevations with mild slopes, close to water resources and oak woodlands but away from the road and rocky low shrubland. Characteristics of areas for male occupancy are tall pine forests away from rocky low shrublands. Higher elevations and steeper slopes are also not preferred by the males but their avoidance behaviour is not as strong as the females. In terms of vegetation cover preferences, tall pine forest is heavily used by males while oak woodland by females all year round. Another remarkable result is the sexual difference in the dependency on water resources. Females prefer to stay close to water resources throughout the year (Table 21).

**Table 22.** Habitat use pattern of males and females

(Same seasons of different years)

| | ele | | slo | | dr | | dms | | dwr | | dtpf | | dtss | | drls | | dow | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Dry 2011 | H | NA | L | NA | 0 | NA | 0 | NA | 0 | NA | + | NA | 0 | NA | - | NA | 0 | NA |
| Dry 2012 | H | L | M | L | 0 | - | 0 | 0 | 0 | + | + | 0 | + | 0 | - | - | 0 | + |
| Dry 2013 | NA | L | NA | L | NA | - | NA | + | NA | + | NA | - | NA | + | NA | - | NA | + |
| | | | | | | | | | | | | | | | | | | |
| | ele | | slo | | dr | | dms | | dwr | | dtpf | | dtss | | drls | | dow | |
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Mating 2011 | M | M | M | L | - | - | 0 | 0 | 0 | + | + | 0 | 0 | 0 | - | - | 0 | 0 |
| Mating 2012 | M | L | H | L | 0 | - | + | + | + | + | + | + | 0 | 0 | - | - | + | + |
| | | | | | | | | | | | | | | | | | | |
| | ele | | slo | | dr | | dms | | dwr | | dtpf | | dtss | | drls | | dow | |
| | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F | M | F |
| Rainy2011-12 | M | L | M | L | - | - | 0 | + | + | + | + | 0 | 0 | 0 | - | - | 0 | + |
| Rainy 2012-13 | M | L | M | L | - | - | 0 | + | + | + | + | 0 | + | 0 | - | - | 0 | + |

Seasonal evaluation of ENFA results shows that within-sex variation of resource selection is lowest between rainy seasons but highest between mating seasons. Between sex variations are lowest in mating seasons and highest in dry seasons (Table 21, Figure 38-73).

### 3.2.2 ENFA Outputs

Three ENFA outputs are presented in this section. First, a histogram view of resource use and availability pattern is presented (eg. Figure 38). Used and available spaces are represented as bar diagrams in this output. White bars show the distribution of available resources in the study area for the defined period while grey bars indicate the used resource distribution. The differences between used and available proportions point out the selection or avoidance by the deer for respective resources. A second type of output is the mean plot. Like a histogram, a mean plot shows the available and used resources along with the means of used and available space (Figure eg. 39). It is useful since the histogram view is a categorical representation of resource use, where the number of divisions may mislead the researcher. The last type of output of ENFA is a biplot. Here the x-axis represents marginality and the y-axis is the first specialization axis. The used (dark grey) and available spaces (light grey) are represented as polygons on a biplot (Figure eg. 40). ENFA rotates the input data on a plane in a way that sets the centroid of available space as zero (the origin) point. The magnitude of selection depends on the distance between the origin, the centroid of available space, and the centroid of used space, which is displayed as a white dot in the dark grey polygon. Environmental variables are showed in biplot as arrows, and their length and direction identify their contribution to each axis. All three outputs are evaluated together to avoid missing any significant result and better interpretation.

Respective class intervals for each variable shown as histograms Figures 38-73 are given below in Table 22. Each variable was classified into 19 classes.

**Table 23.** Class intervals of environmental variables used in the analyses

| | |
|---|---|
| Elevation | 63 m |
| Slope | 3 |
| Distance to Roads | 114 m |
| Distance to Military Stations | 349 m |
| Distance to Water Resources | 162 m |
| Distance to Tall Pine Forest | 36 m |
| Distance to Tall Sclerophyll Shrubland | 146 m |
| Distance to Rocky Low Shrubland | 89 m |
| Distance to Oak Woodland | 349 m |

*2011 Dry Season:*

*Males:*

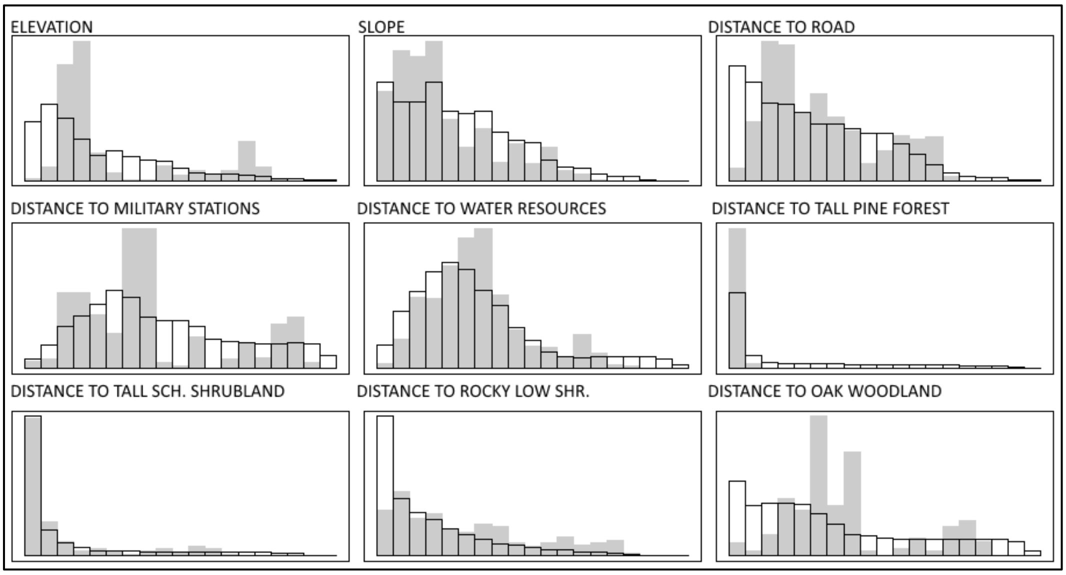



**Figure 38.** Male 2011 Dry season histogram view of habitat selection

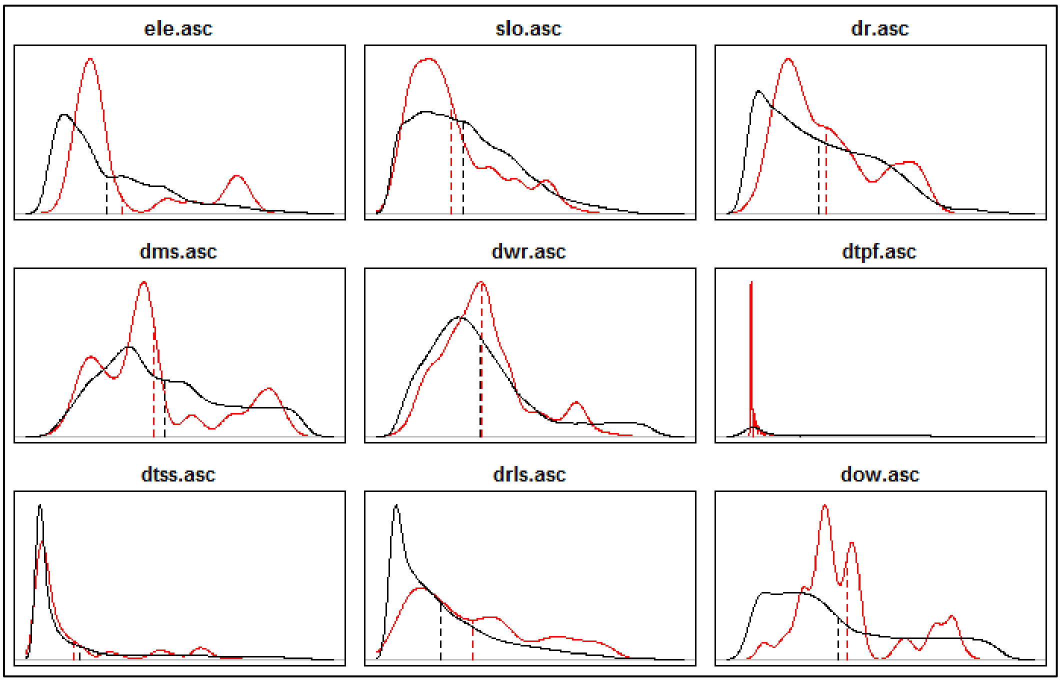



**Figure 39.** Male 2011 Dry season mean plots of habitat selection

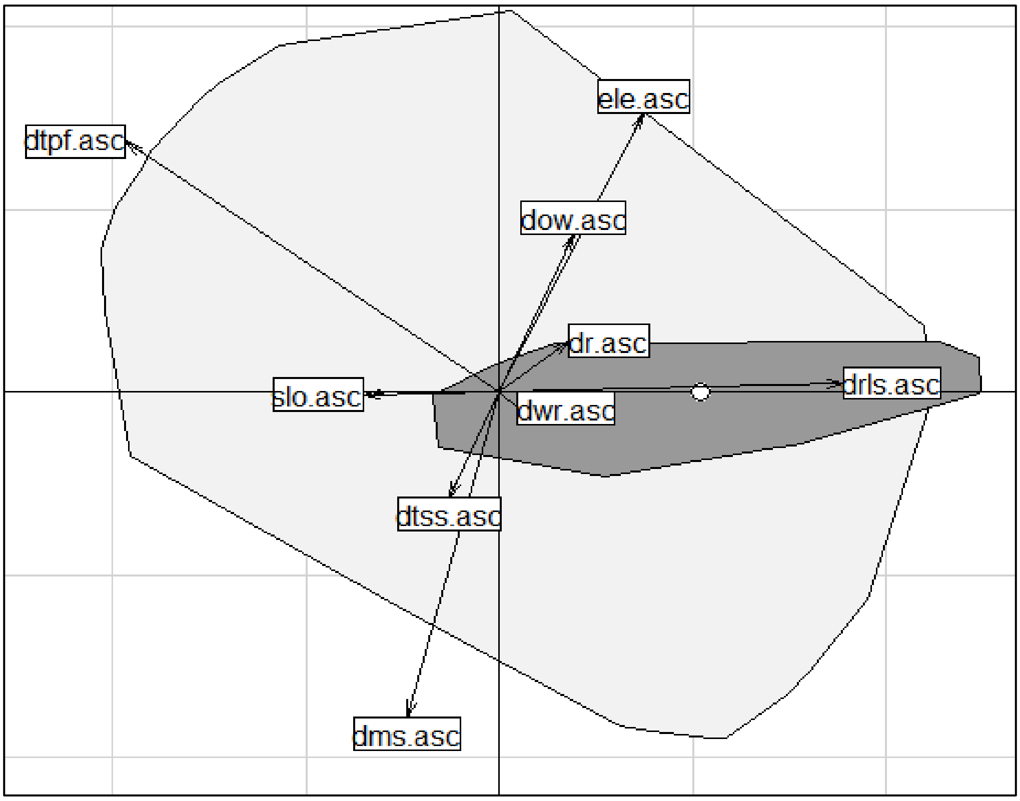



**Figure 40.** Male 2011 Dry season biplot representation of habitat selection

*2011 Mating Season:*

*Females:*

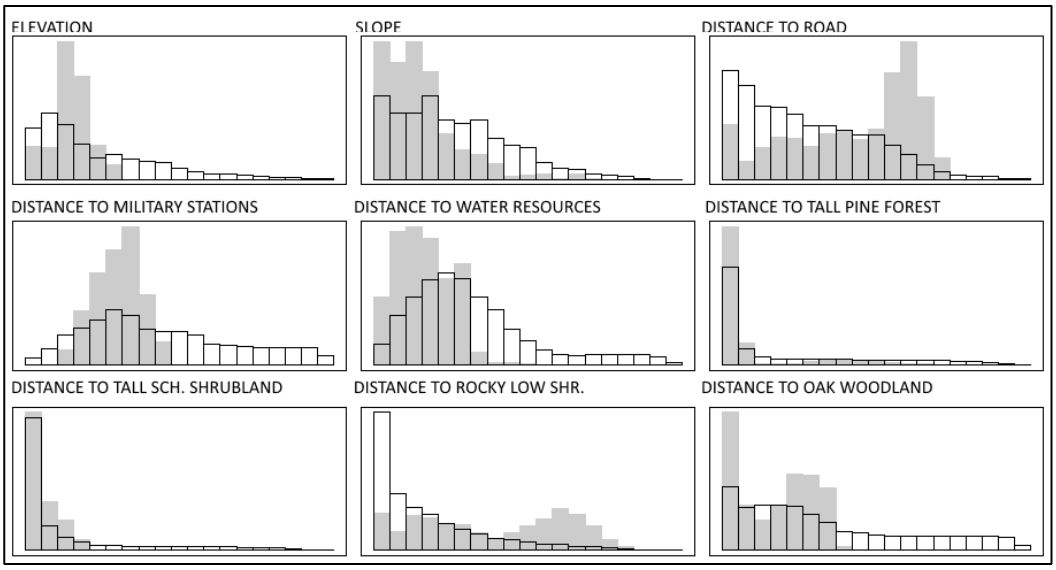



**Figure 41.** Female 2011 mating season histogram view of habitat selection

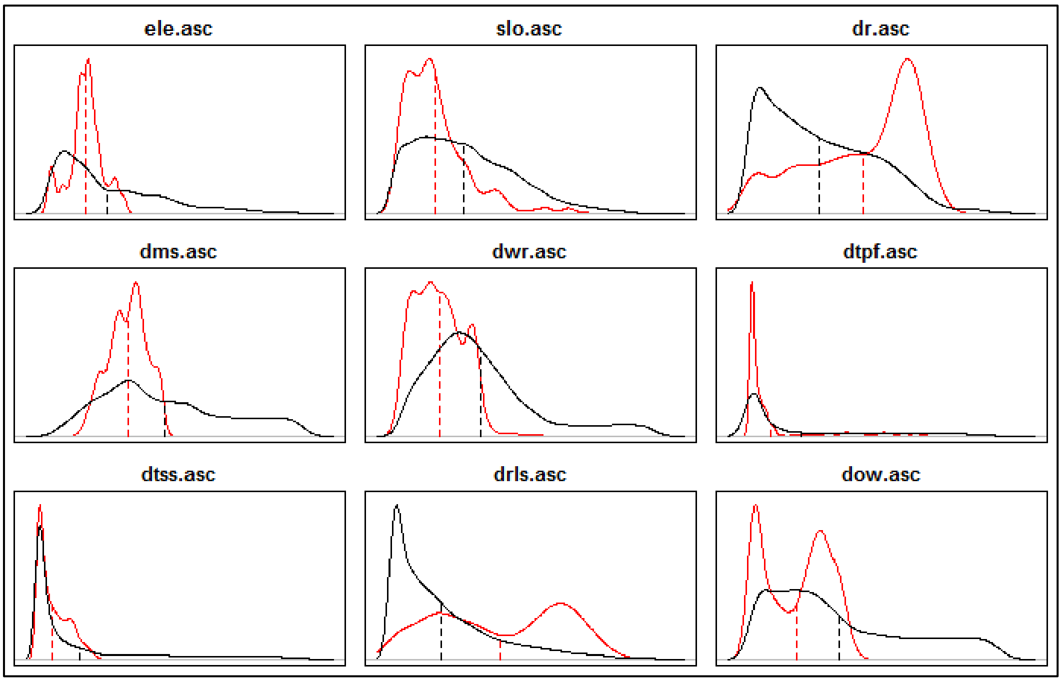



**Figure 42.** Female 2011 mating season mean plots view of habitat selection

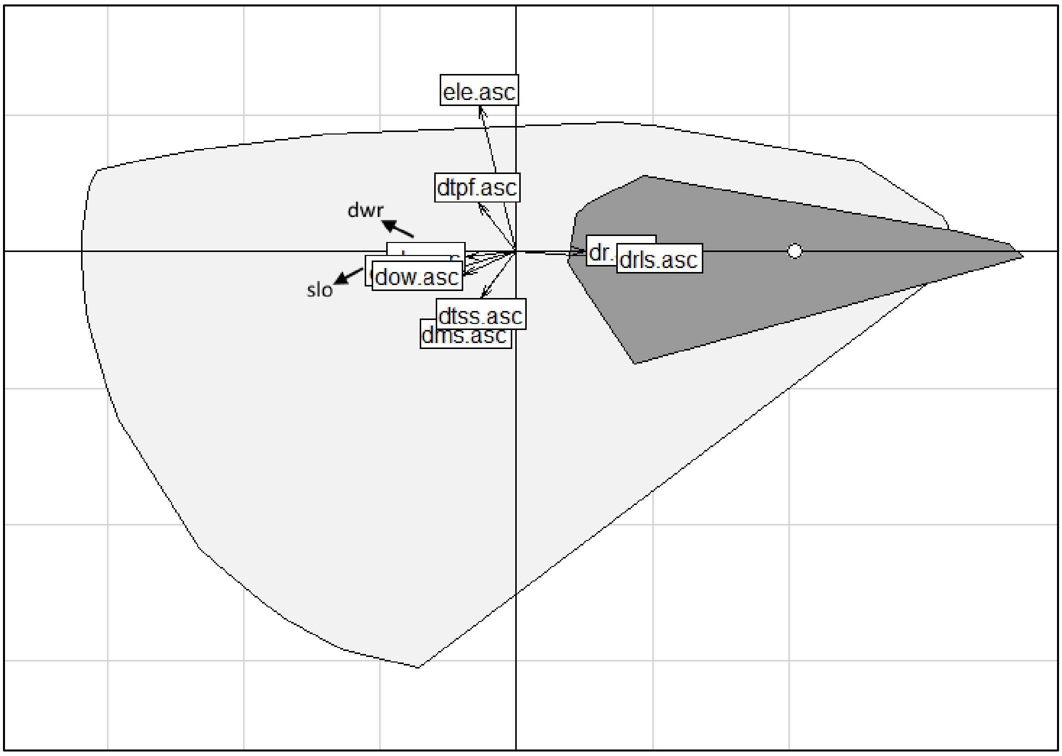



**Figure 43.** Female 2011 mating season biplot view of habitat selection

*Males:*

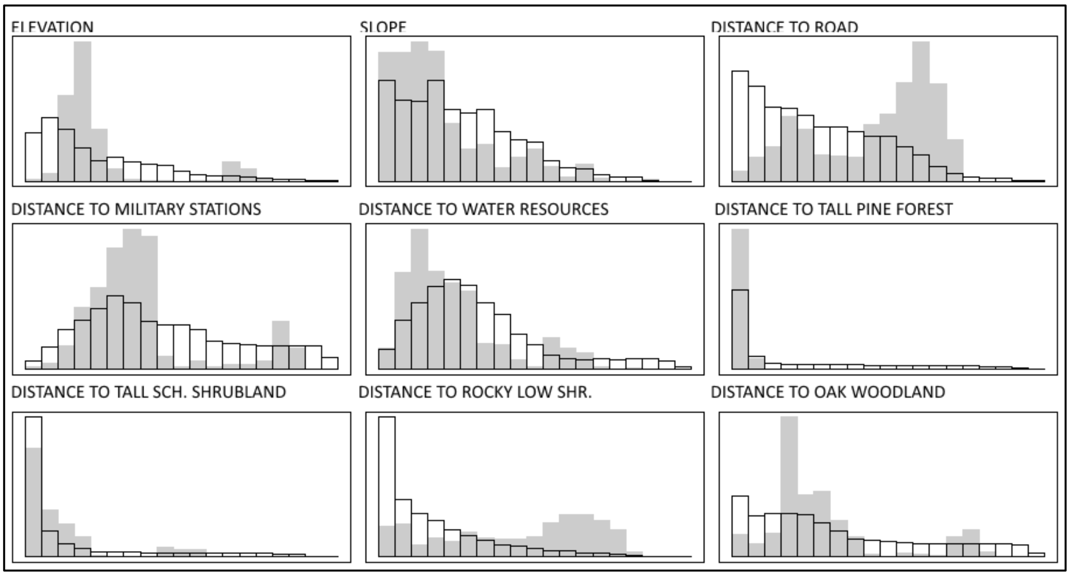



**Figure 44.** Male 2011 mating season histogram view of habitat selection

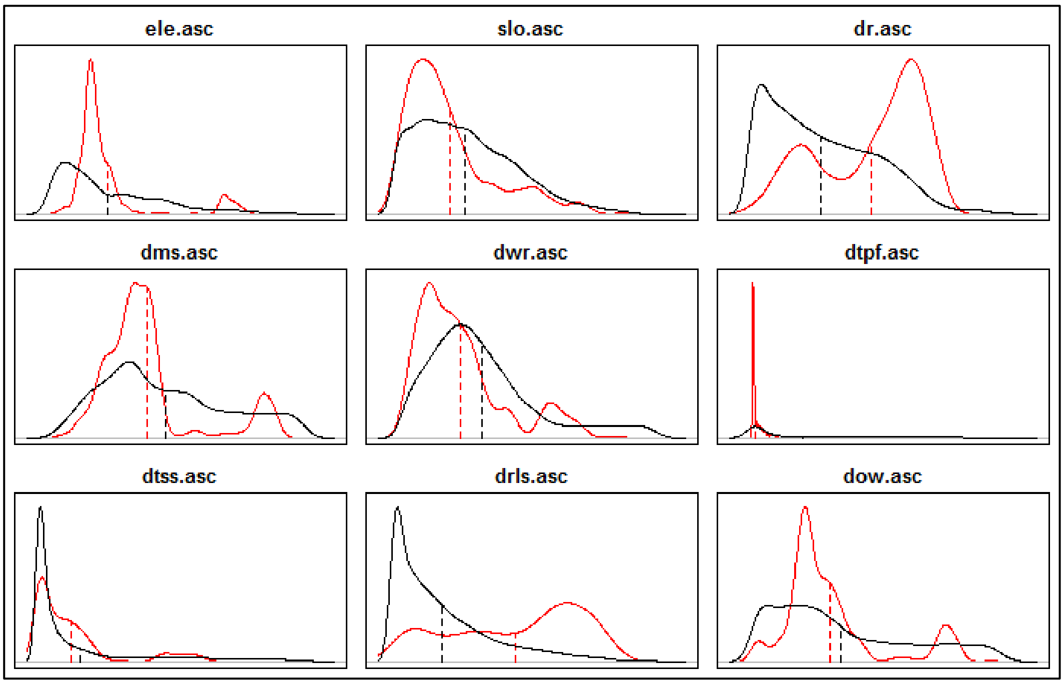



**Figure 45.** Male 2011 mating season mean plots view of habitat selection

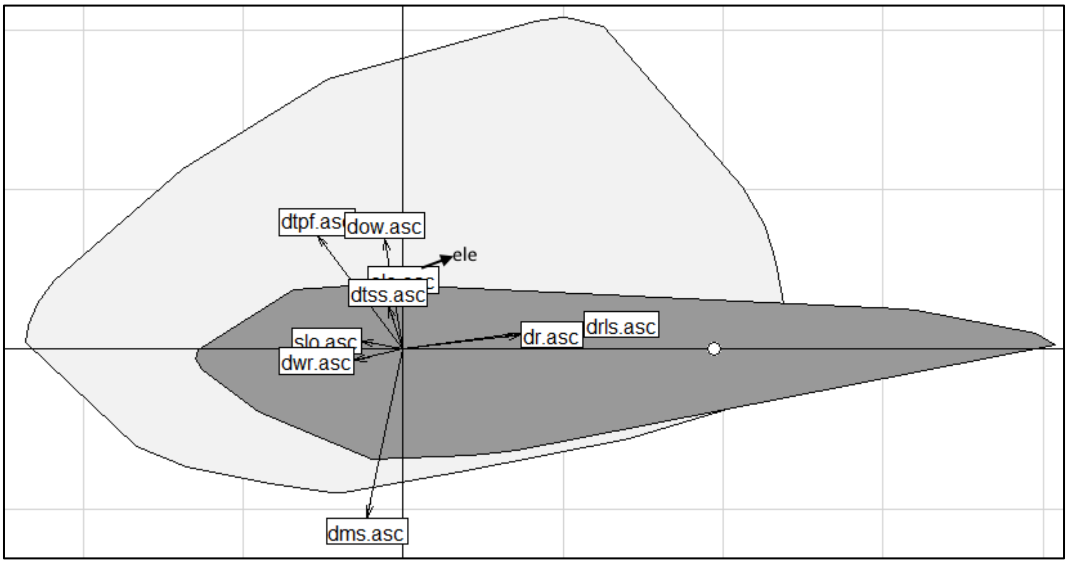



**Figure 46.** Male 2011 mating season biplot view of habitat selection

*2011-2012 Rainy Season:*

*Females:*

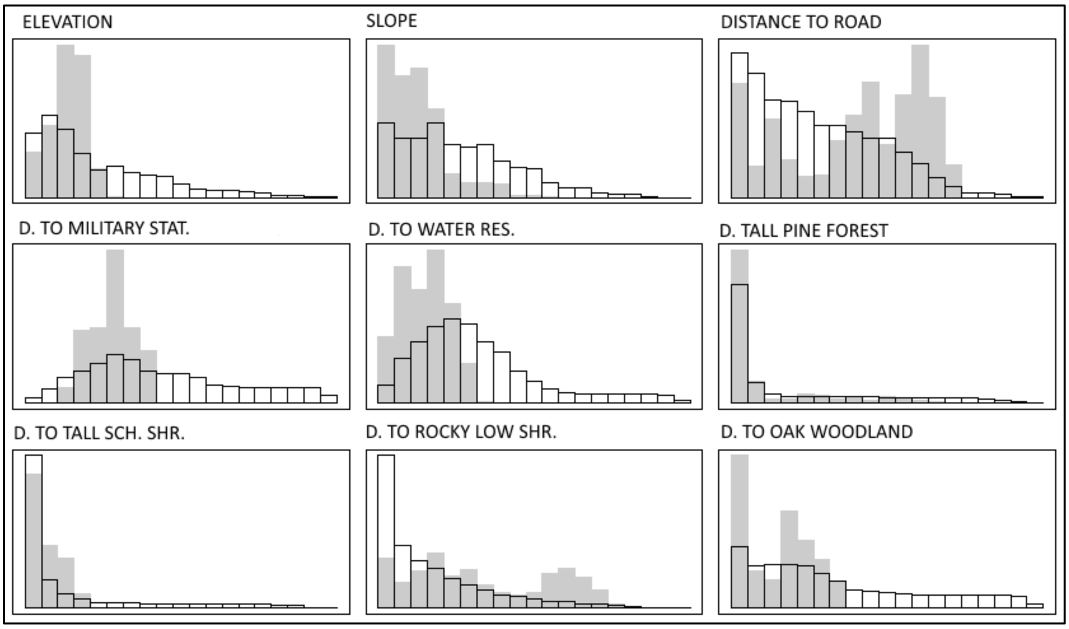



**Figure 47.** Female 2011-2012 rainy season histogram view of habitat selection

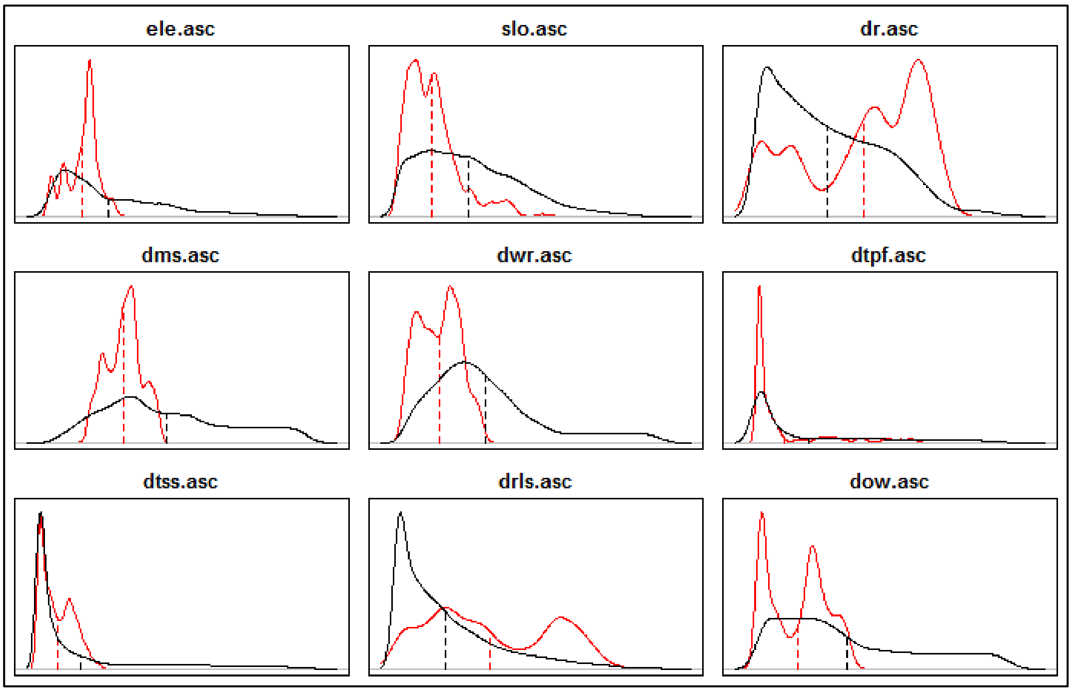



**Figure 48.** Female 2011-2012 rainy season mean plots view of habitat selection

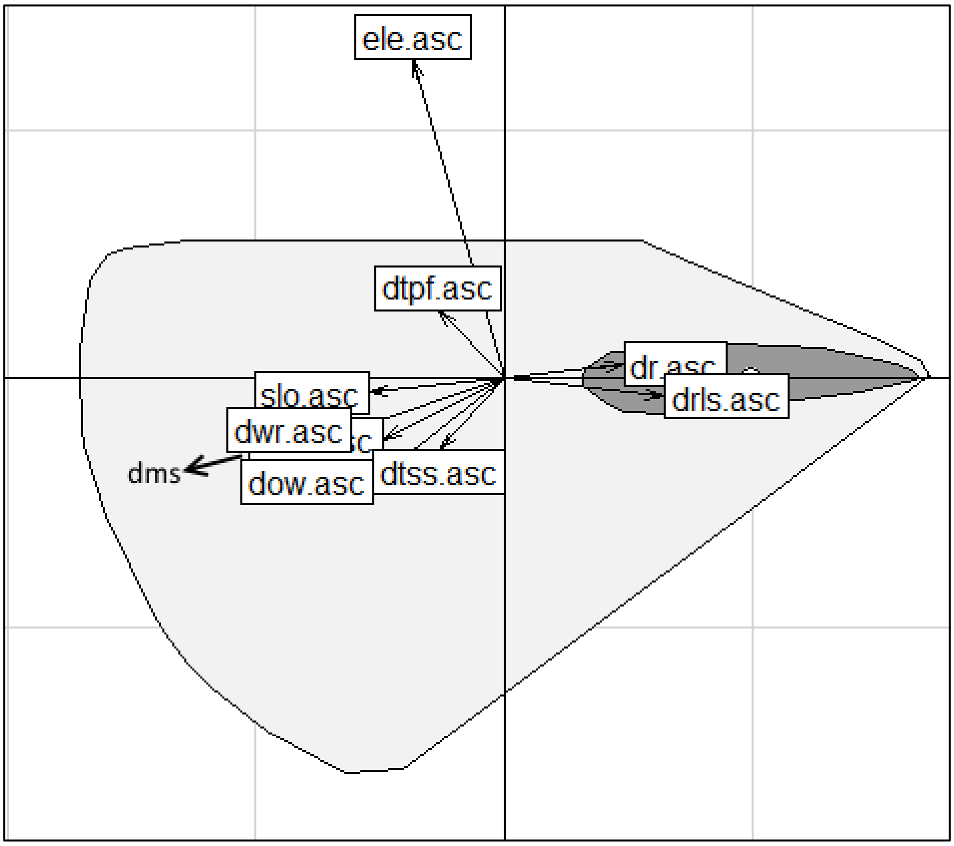



**Figure 49.** Female 2011-2012 rainy season biplot view of habitat selection

*Males:*

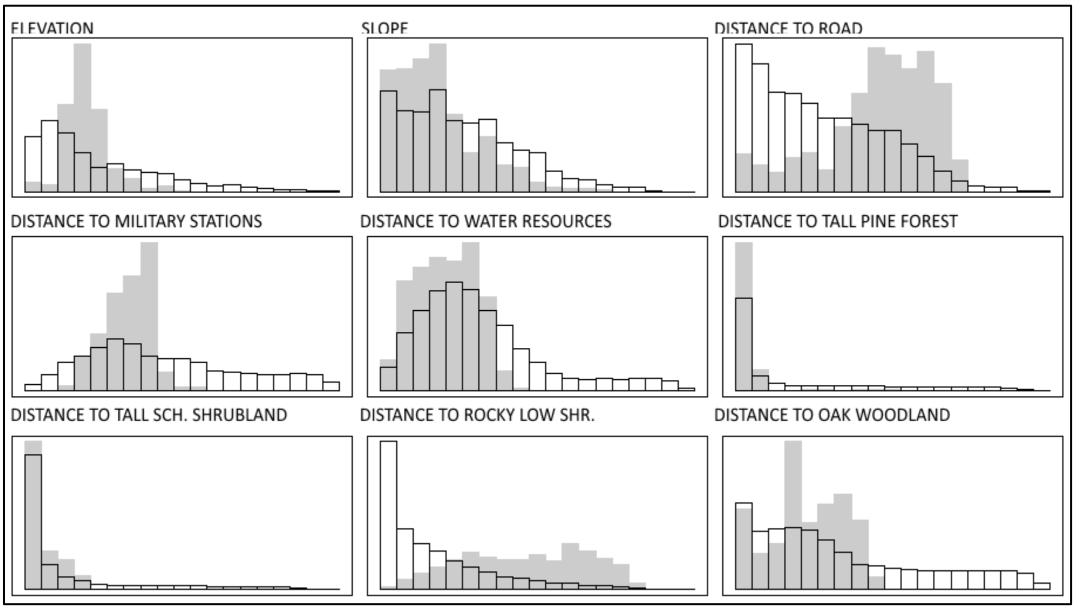



**Figure 50.** Male 2011-2012 rainy season histogram view of habitat selection

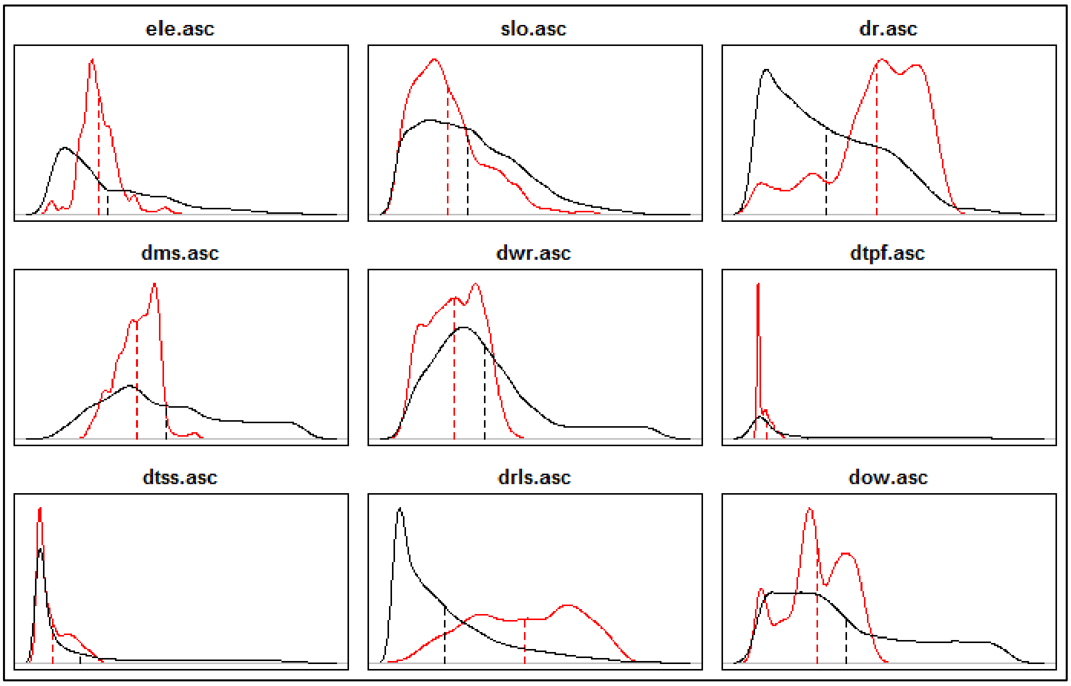



**Figure 51.** Male 2011-2012 rainy season mean plots view of habitat selection

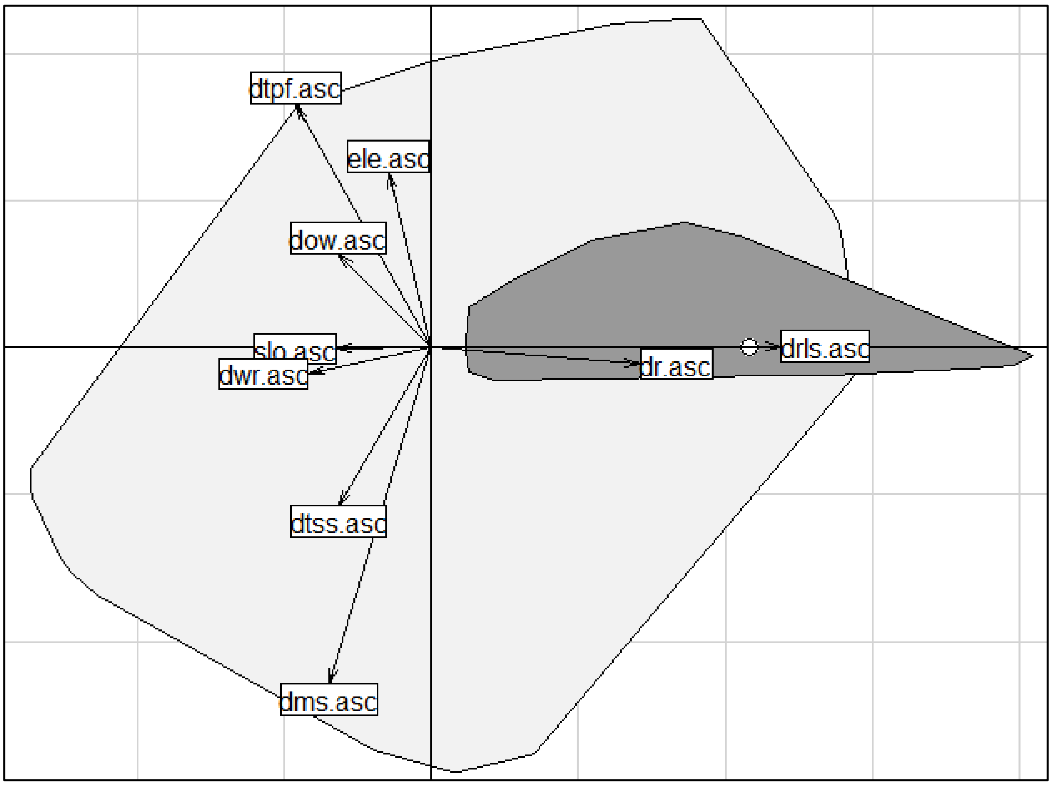



**Figure 52.** Male 2011-2012 rainy season biplot view of habitat selection

*2012 Dry Season:*

*Females:*

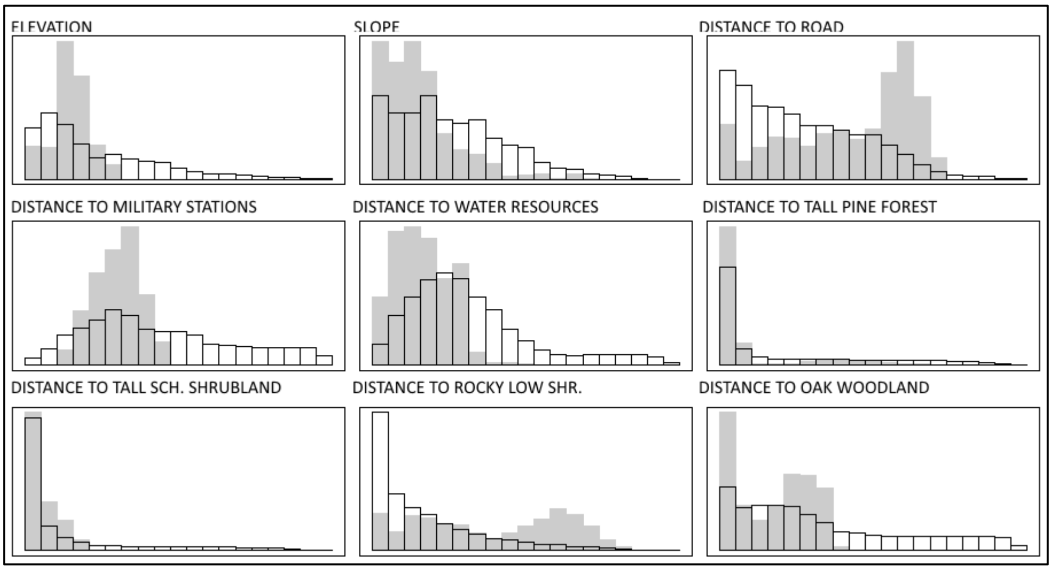



**Figure 53.** Female 2012 dry season histogram view of habitat selection

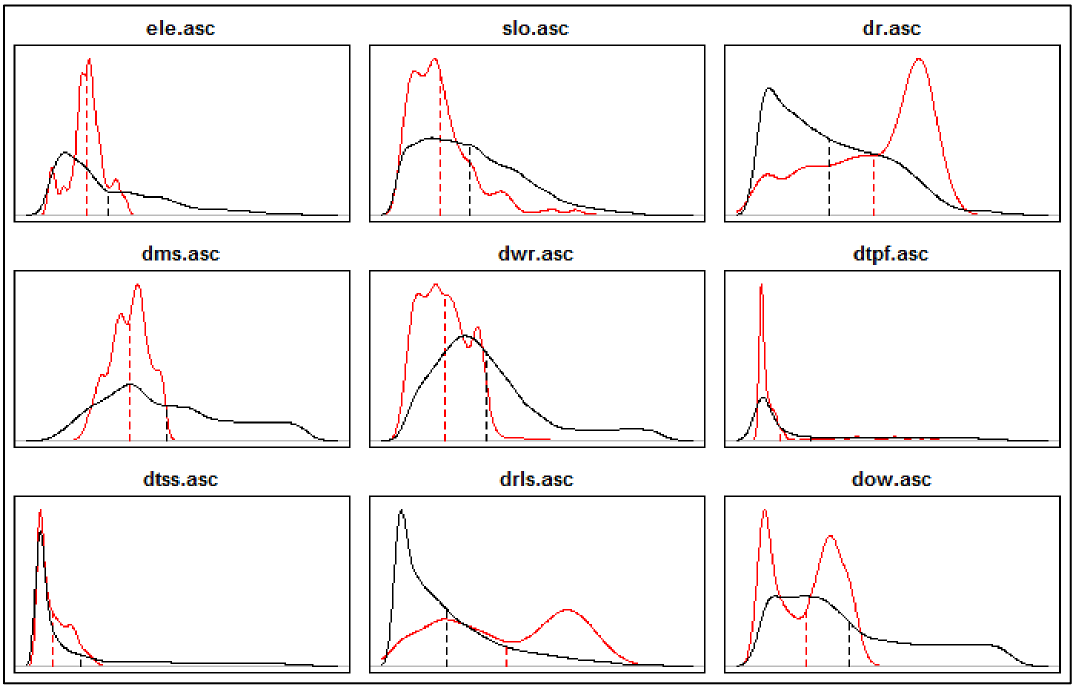



**Figure 54.** Female 2012 dry season mean plots view of habitat selection

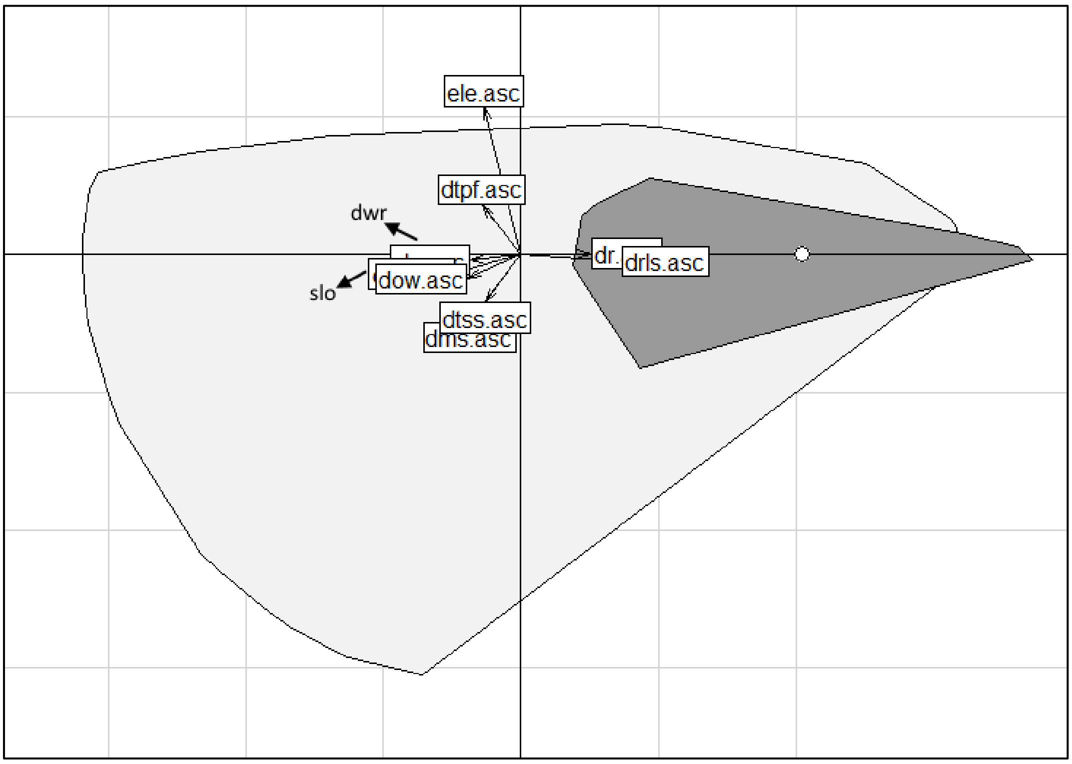



**Figure 55.** Female 2012 dry season biplot view of habitat selection

*Males:*

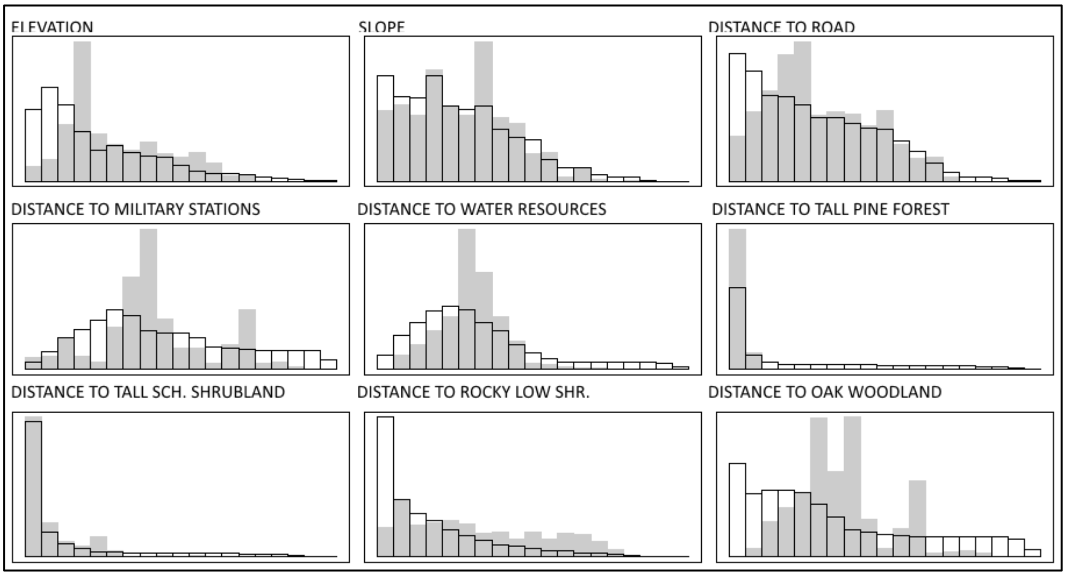



**Figure 56.** Male 2012 dry season histogram view of habitat selection

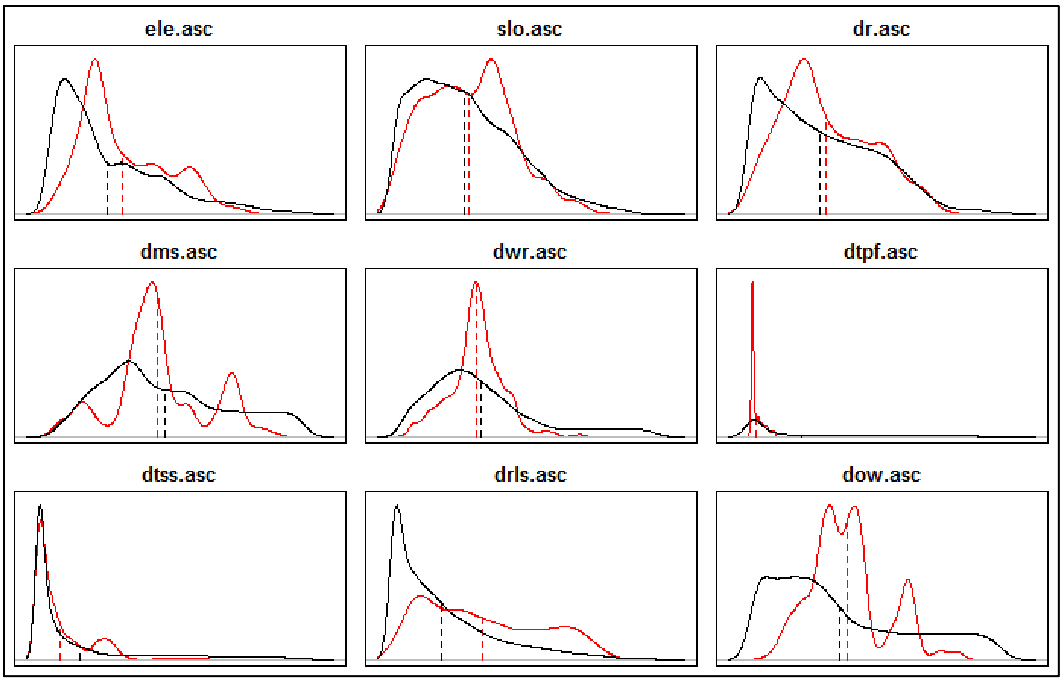



**Figure 57.** Male 2012 dry season mean plots view of habitat selection

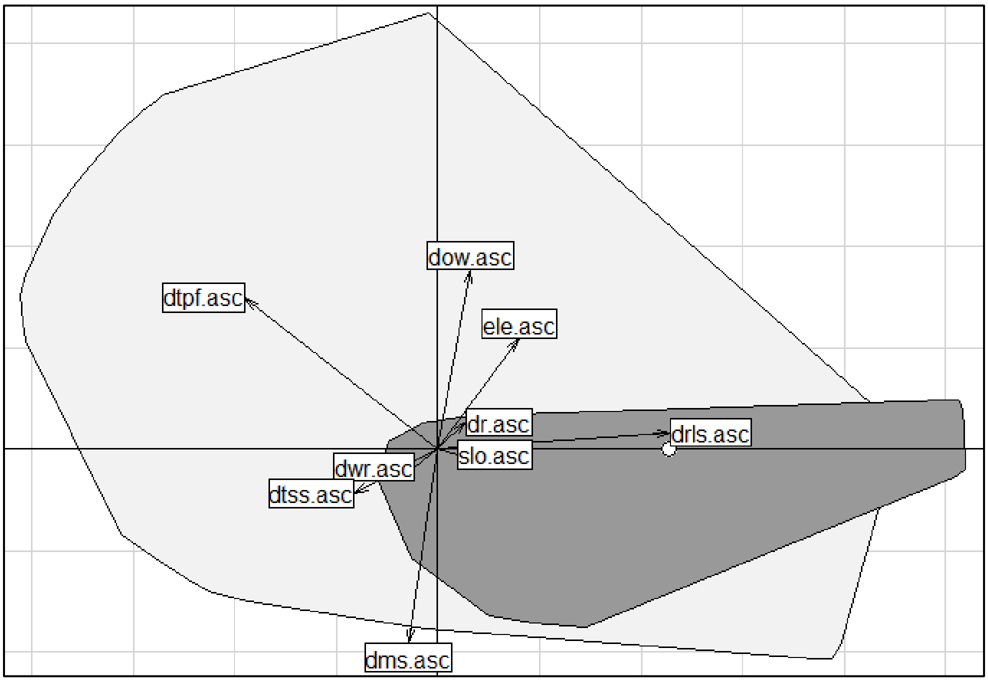



**Figure 58.** Male 2012 dry season biplot view of habitat selection

*2012 Mating Season:*

*Females:*

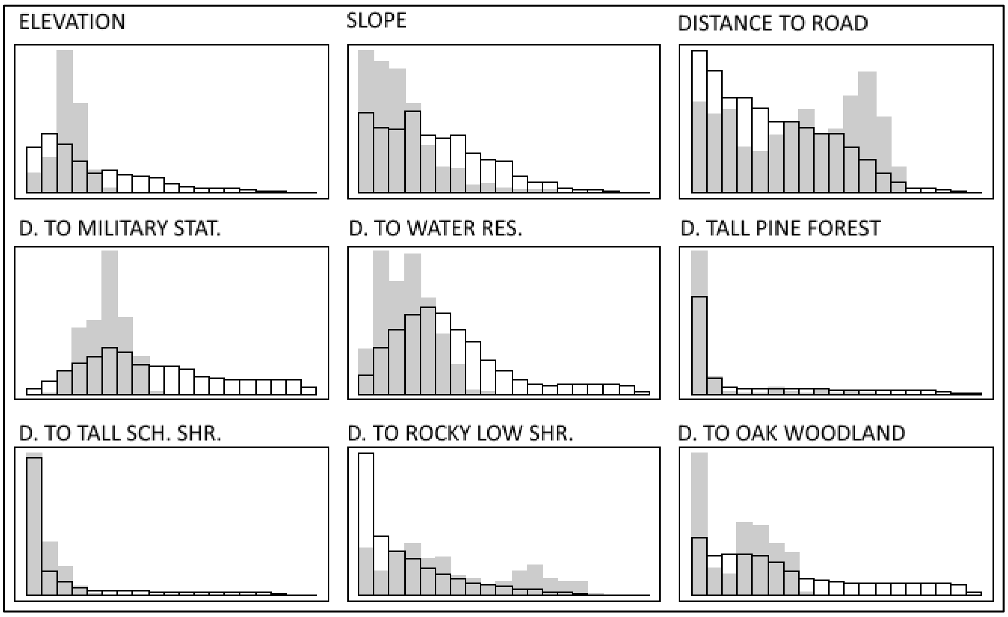



**Figure 59.** Female 2012 mating season histogram view of habitat selection

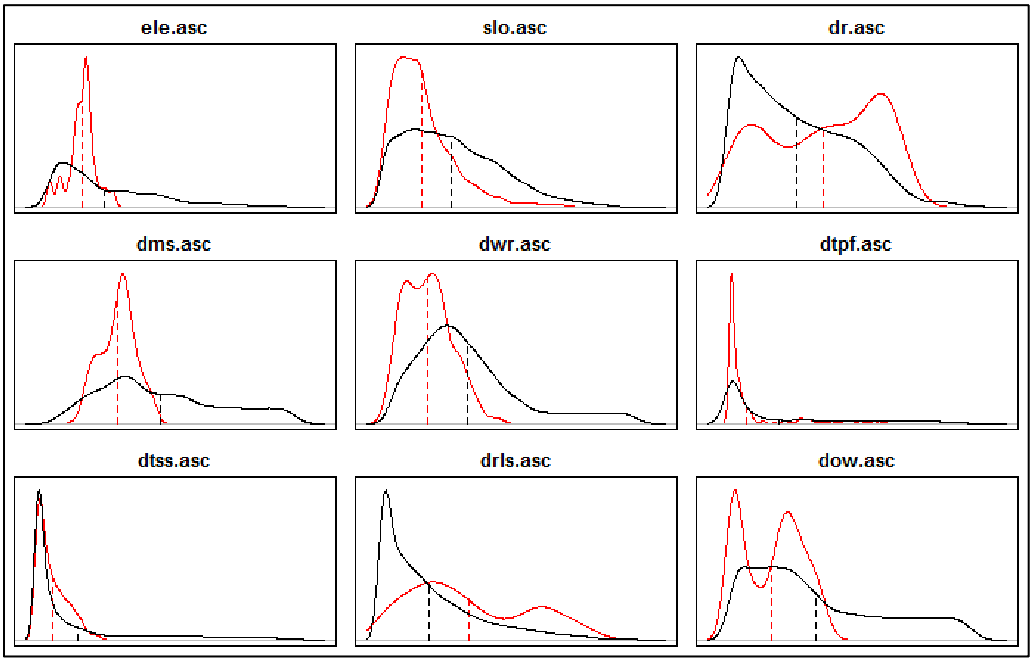



**Figure 60.** Female 2012 mating season mean plots view of habitat selection

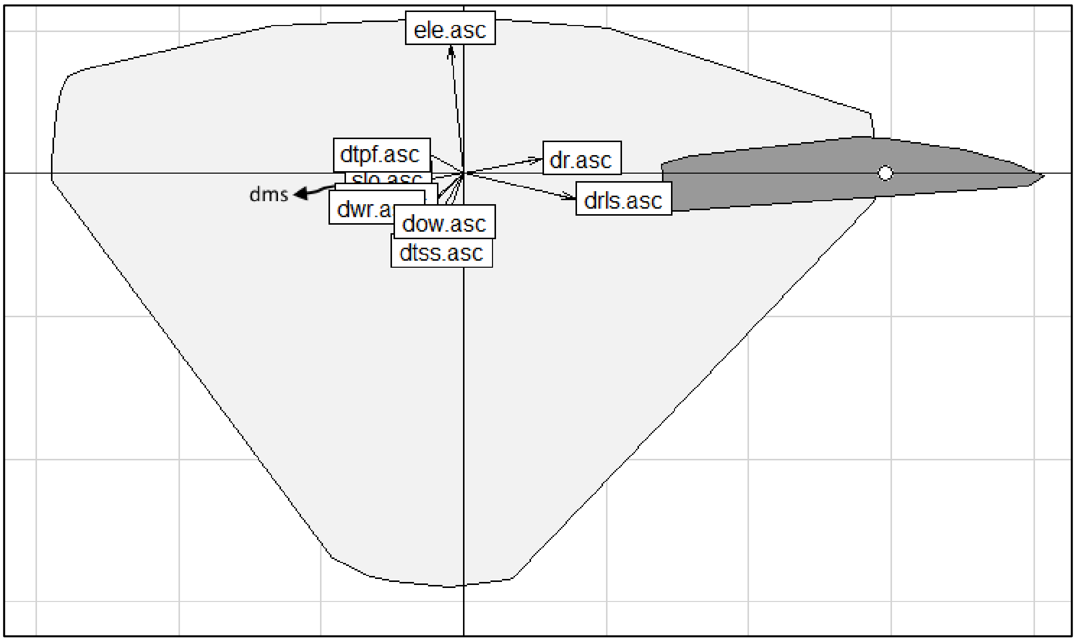



**Figure 61.** Female 2012 mating season biplot view of habitat selection

*Males:*

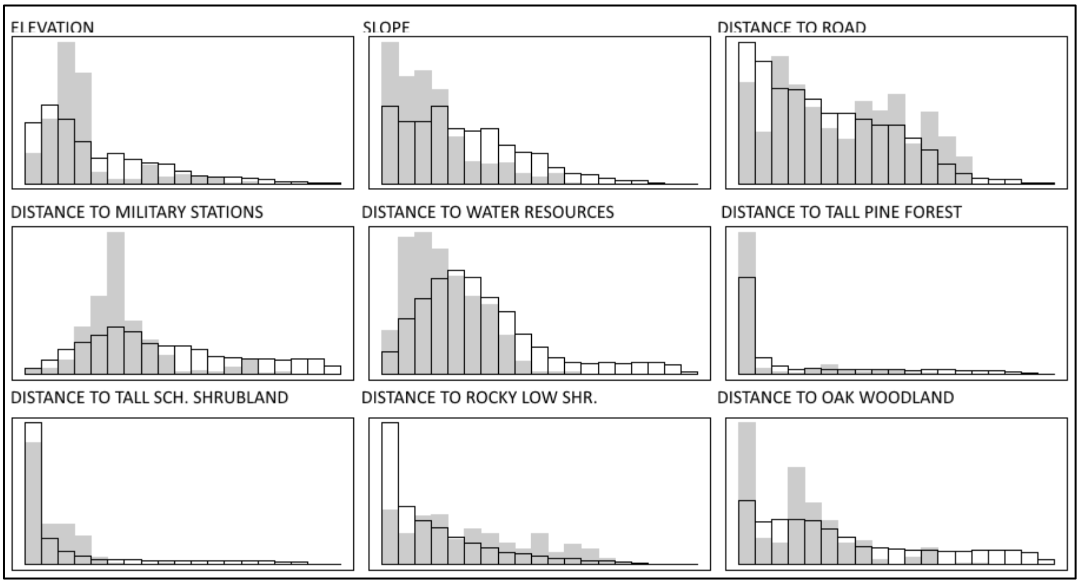



**Figure 62.** Male 2012 mating season histogram view of habitat selection

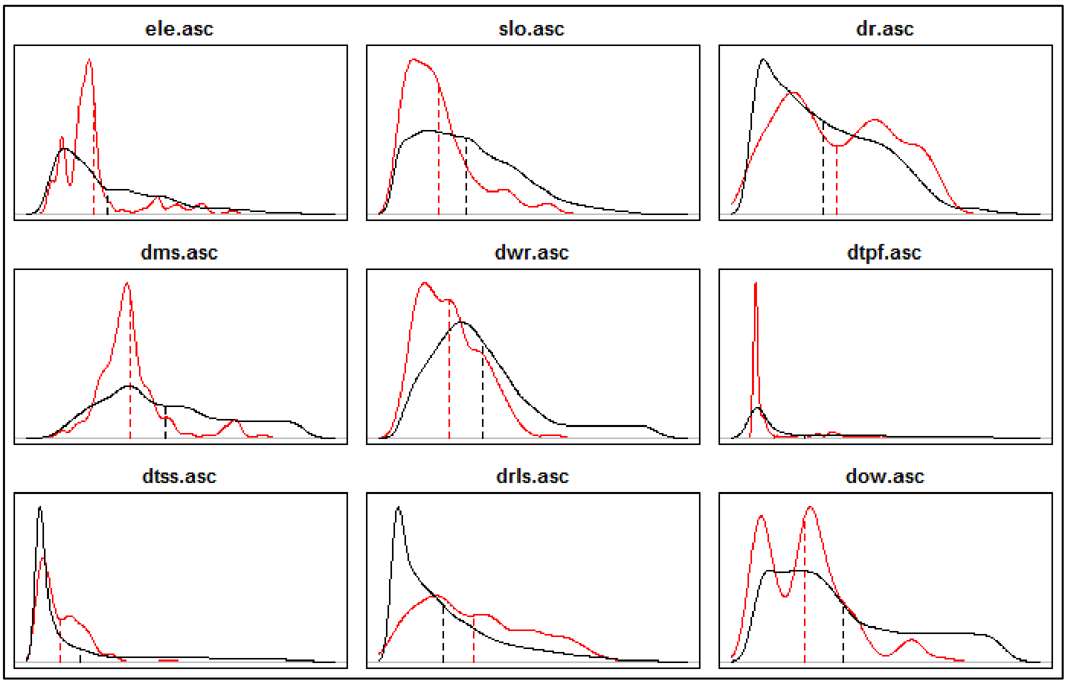



**Figure 63.** Male 2012 mating season mean plots view of habitat selection

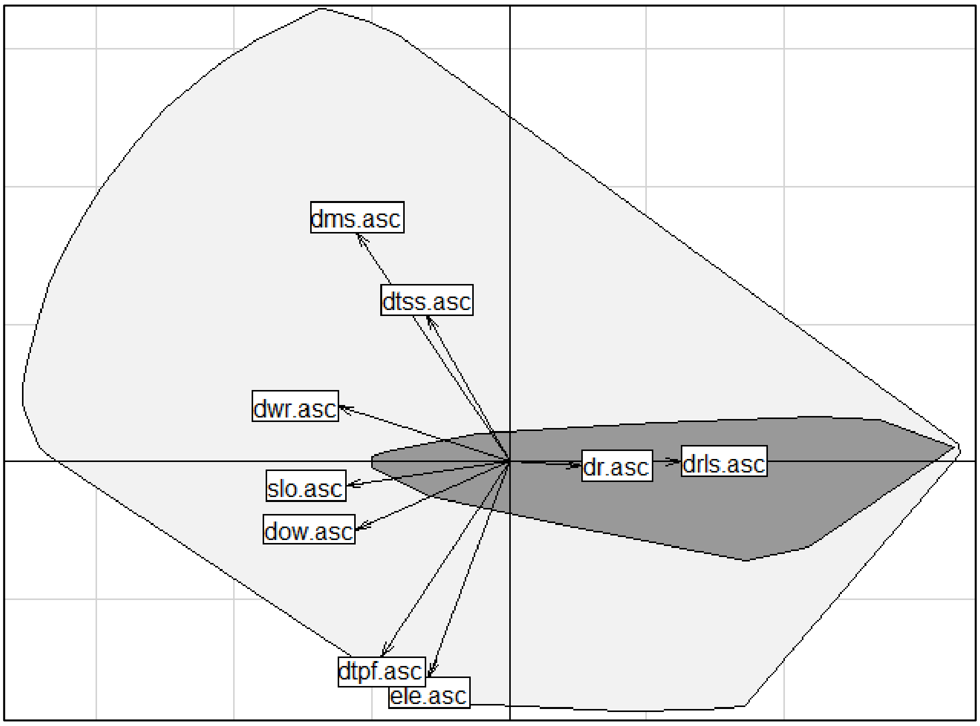



**Figure 64.** Male 2012 mating season biplot view of habitat selection

*2012-2013 Rainy Season:*

*Females:*

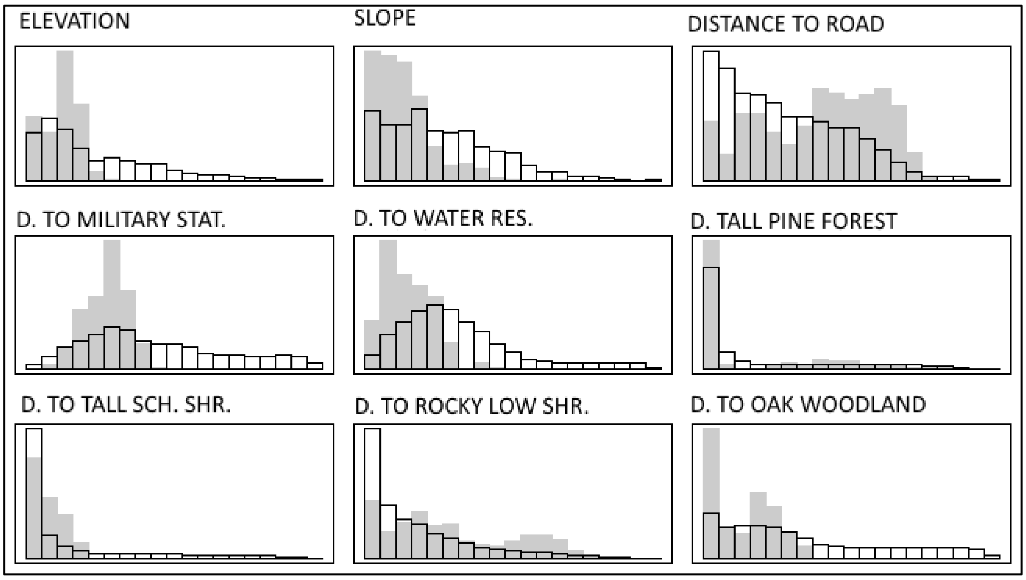



**Figure 65.** Female 2012-2013 rainy season histogram view of habitat selection

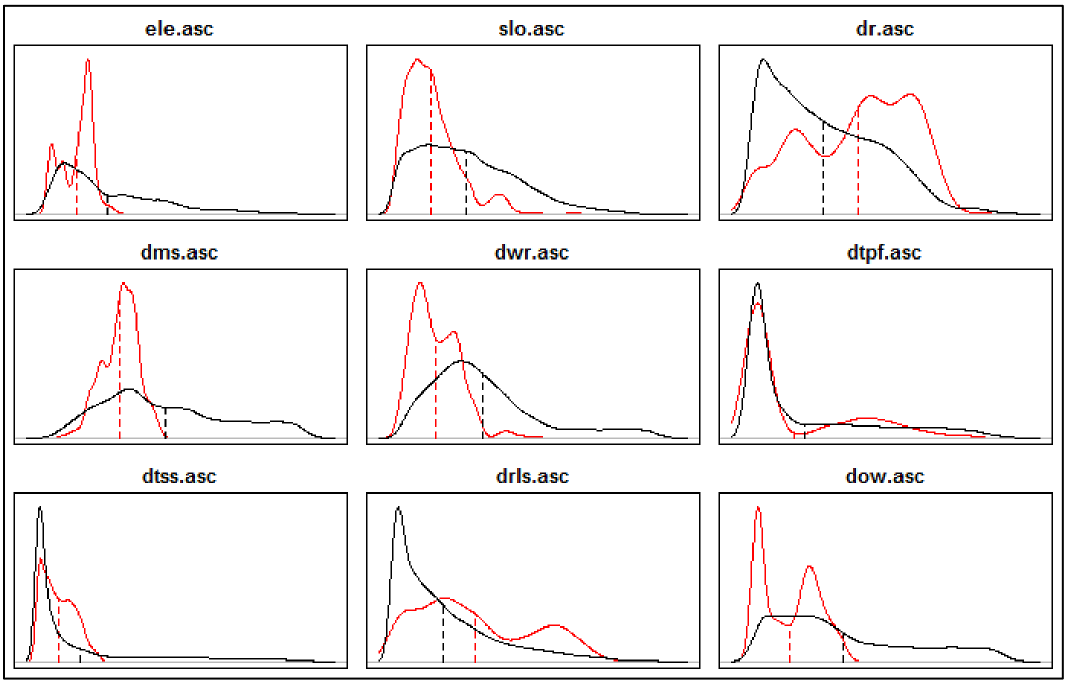



**Figure 66.** Female 2012-2013 rainy season mean plots view of habitat selection

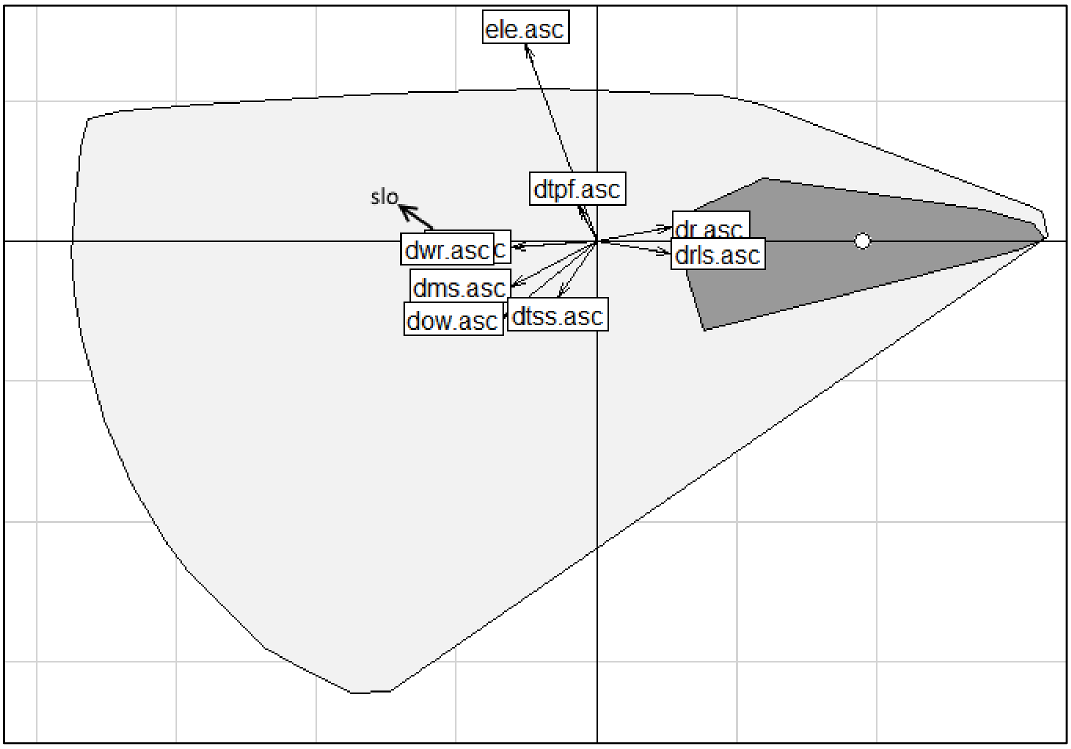



**Figure 67.** Female 2012-2013 rainy season biplot view of habitat selection

*Males:*

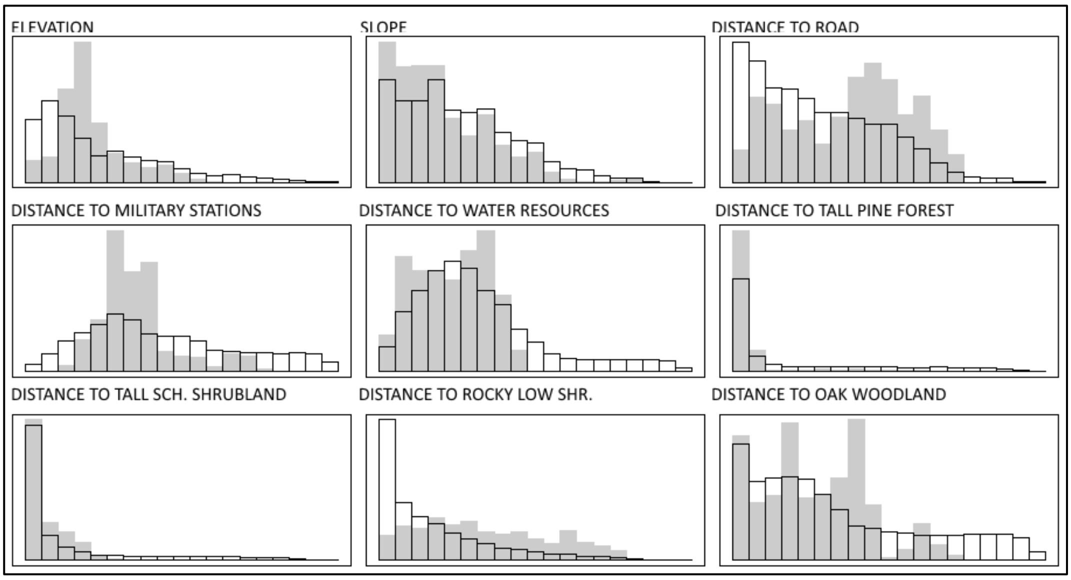



**Figure 68.** Male 2012-2013 rainy season histogram view of habitat selection

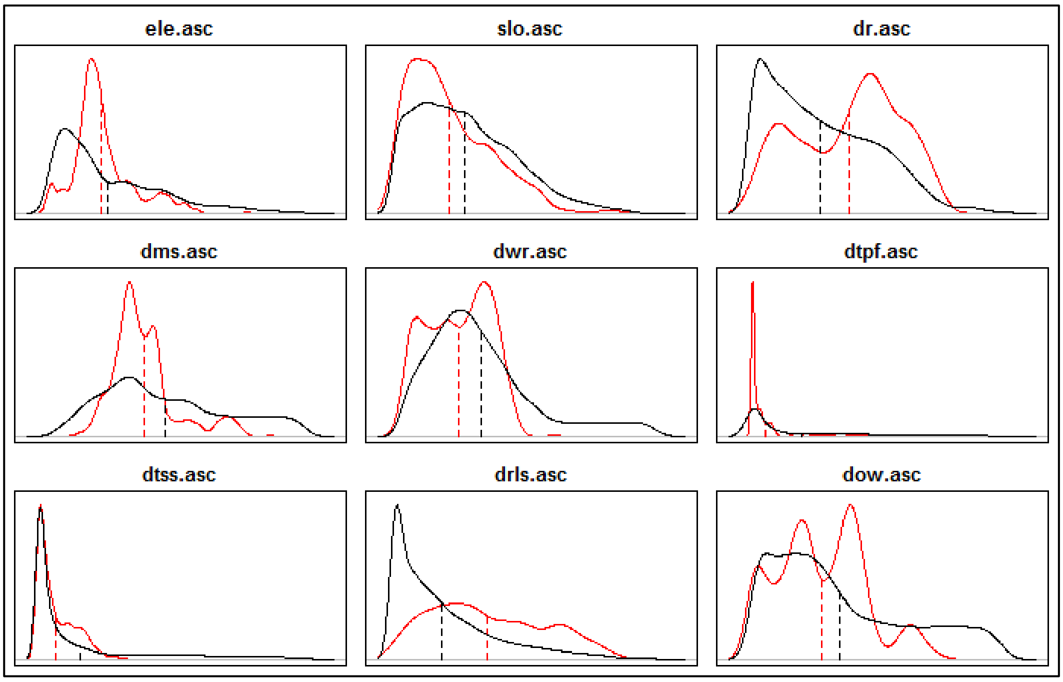



**Figure 69.** Male 2012-2013 rainy season mean plots view of habitat selection

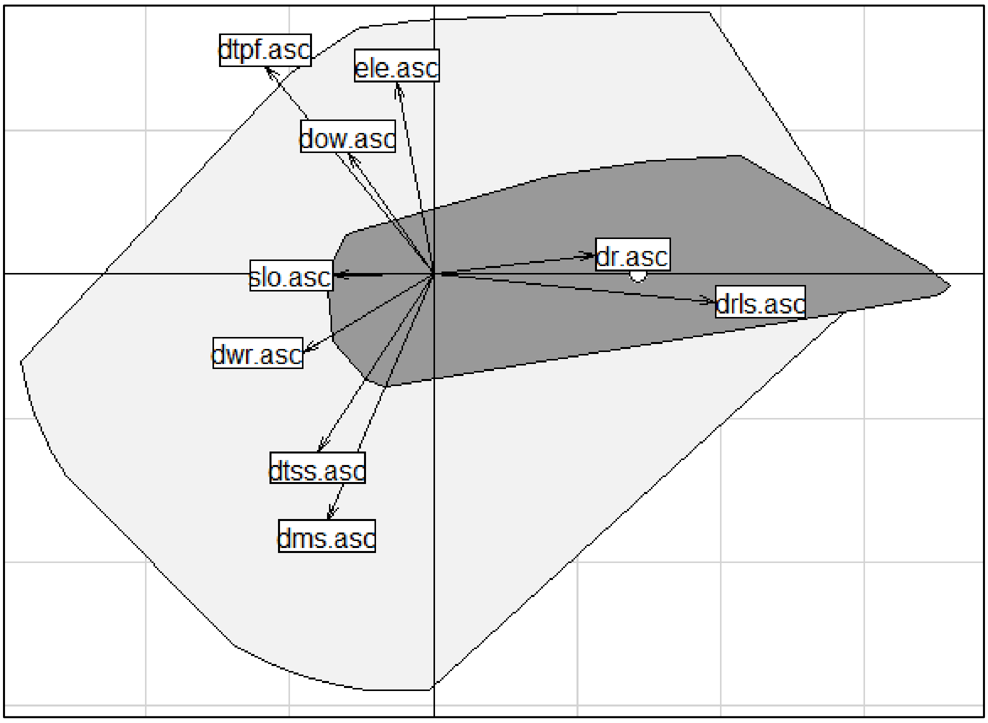



**Figure 70.** Male 2012-2013 rainy season biplot view of habitat selection

*2013 Dry Season:*

*Females:*

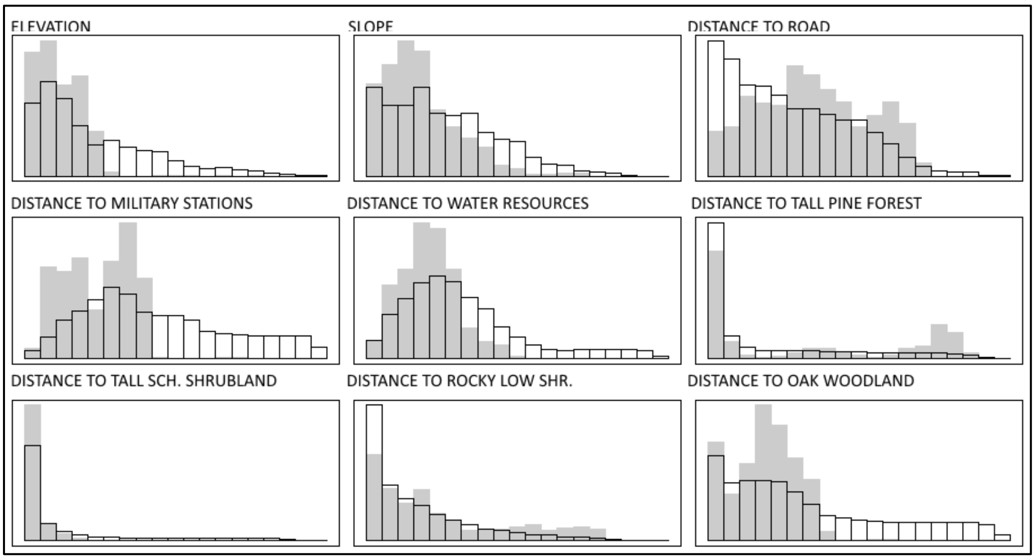



**Figure 71.** Female 2013 dry season histogram view of habitat selection

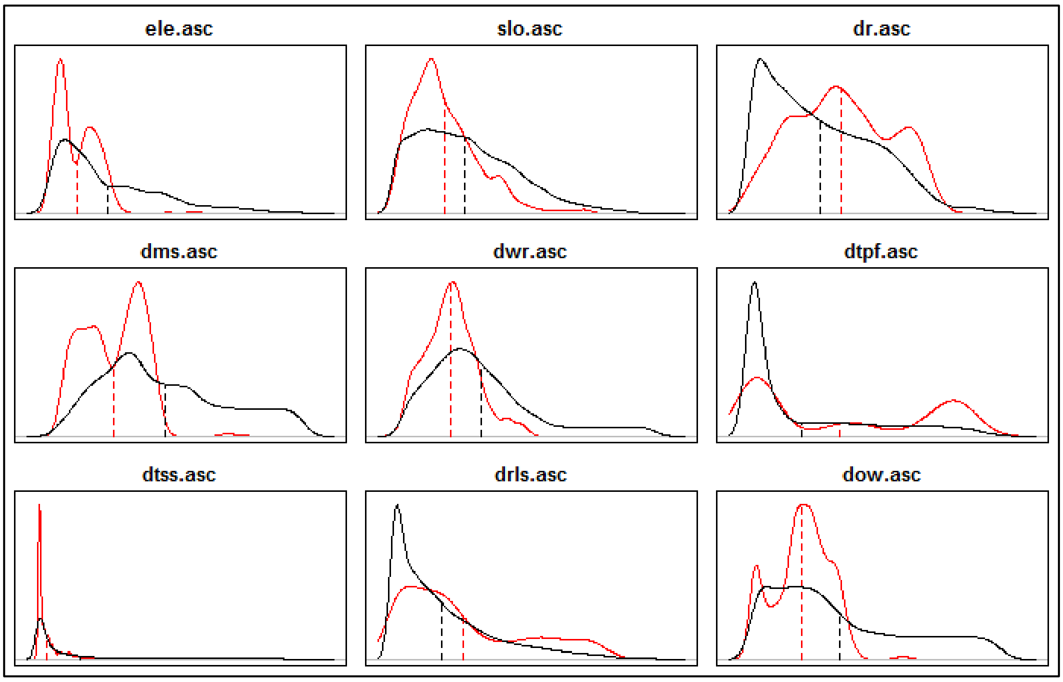



**Figure 72.** Female 2013 dry season mean plots view of habitat selection

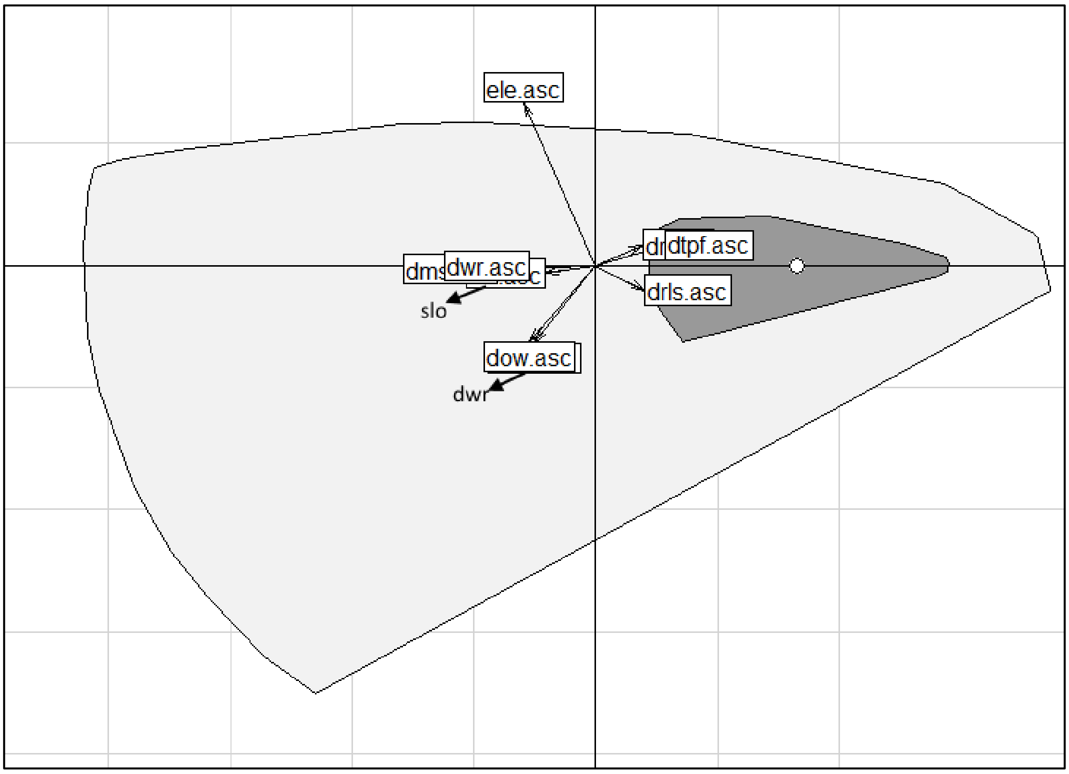



**Figure 73.** Female 2013 dry season biplot view of habitat selection

### 3.3 Spatial Segregation of Sexes

The common phenomenon of ungulate species, spatial segregation of sexes is clearly shown in the results except for mating seasons as expected (Table 23). Females stay close to each other throughout the year. Males are either single or form small groups within the year. The group compositions are not strict, as they can change within a season, and two groups can form a bigger group for a short period. Individuals showing close spatial affinity to each other are evaluated as a "group" and presented as such here. Mixed groups are expected be formed in mating seasons but 2011 mating season seems different (Figure74-80).

**Table 24.** Group information by seasons
(M - Mating Season, R - Rainy Season, D - Dry Season, MG - Male Group, FG - Female Group, MxG - Mixed Group)

| Season | Total # of individuals by Sex | # of Groups | Group Code* | Size of Groups | Individuals |
|---|---|---|---|---|---|
| Dry11 | 5M | 1 | D11MG 1 | 2 | 30189, 30191 |
| Mating11 | 5M, 6F | 3 | M11MG 1 | 2 | 30189, 30191 |
| | | | M11FG 1 | 2 | 31271, 31447 |
| | | | M11FG 2 | 2 | 31448, 31451 |
| Rainy1112 | 5M, 6F | 3 | R1112MG 1 | 3 | 30191, 30192, 31272 |
| | | | R1112FG 1 | 3 | 2154, 31448, 31451 |
| | | | R1112FG 2 | 2 | 31271, 31447 |
| Dry12 | 4M, 3F | 2 | D12MG 1 | 3 | 31271, 31447, 31448 |
| | | | D12FG 1 | 3 | 30189, 30192, 31272 |
| Mating12 | 4M, 2F | 2 | M12MxG 1 | 3 (2 M, 1 F) | 31272, 31273, 31447 |
| | | | M12MxG 2 | 2 (1M, 1F) | 30189, 31448 |
| Rainy1213 | 3M,5F | 3 | R1213MG 1 | 3 | 30189, 31272, 31273 |
| | | | R1213FG 1 | 3 | 31271, 31447, 31448 |
| | | | R1213FG 2 | 2 | 2153a, 30190 |
| Dry13 | 5F | 2 | D13FG 1 | 2 | 31271, 31447, 31448 |
| | | | D13FG 2 | 2 | 2153a, 30190 |

* D11MG 1: **D**ry Season 20**11** **M**ale **G**roup **1**
M - Mating Season, R - Rainy Season, D - Dry Season, MG - Male Group, FG - Female Group, MxG - Mixed Group

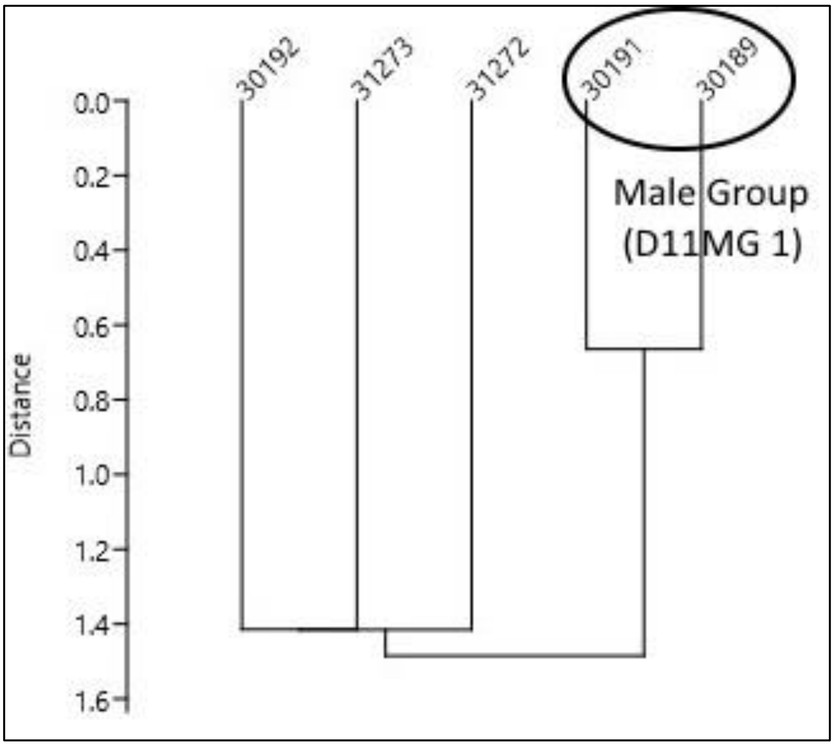



**Figure 74.** Dry season 2011 groups

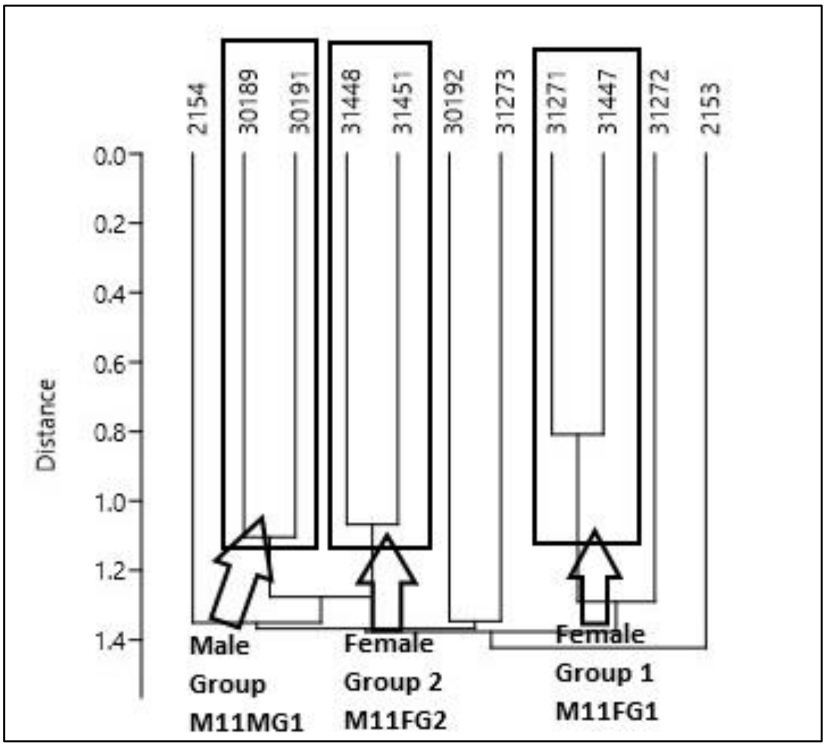



**Figure 75.** Mating season 2011 groups

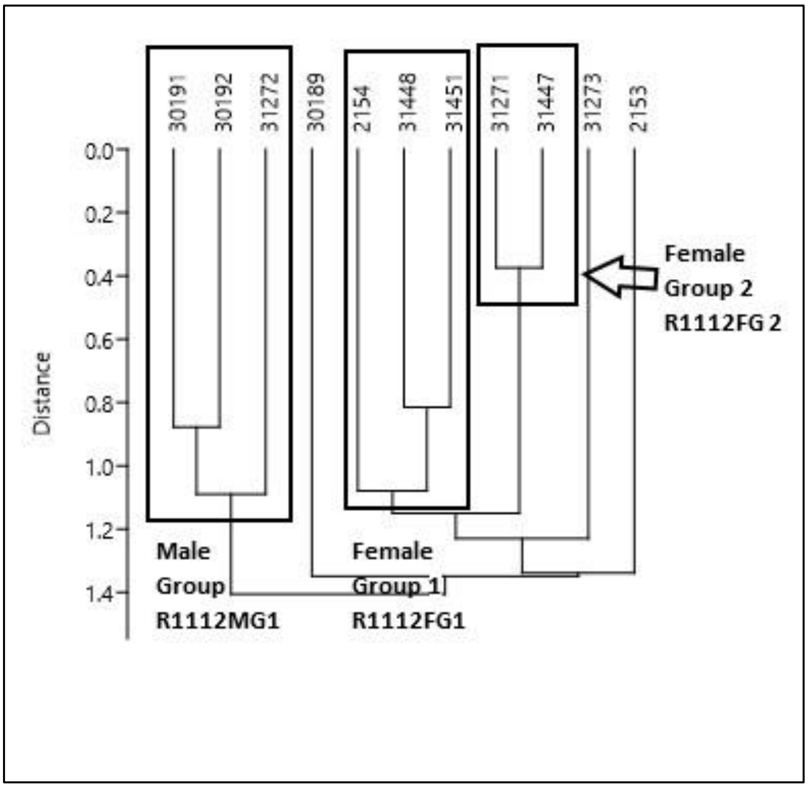



**Figure 76.** Rainy season 2011-12 groups

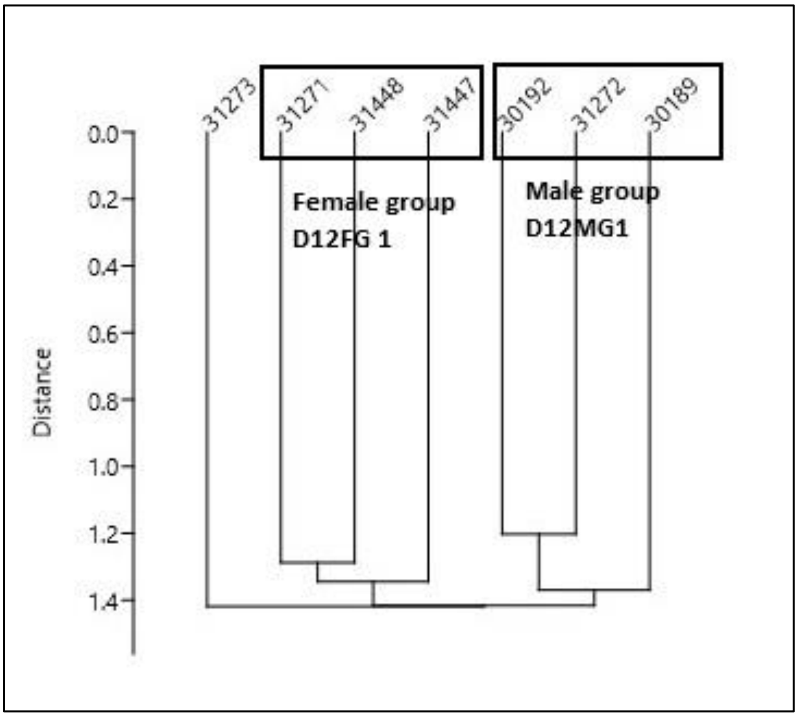



**Figure 77.** Dry season 2012 groups

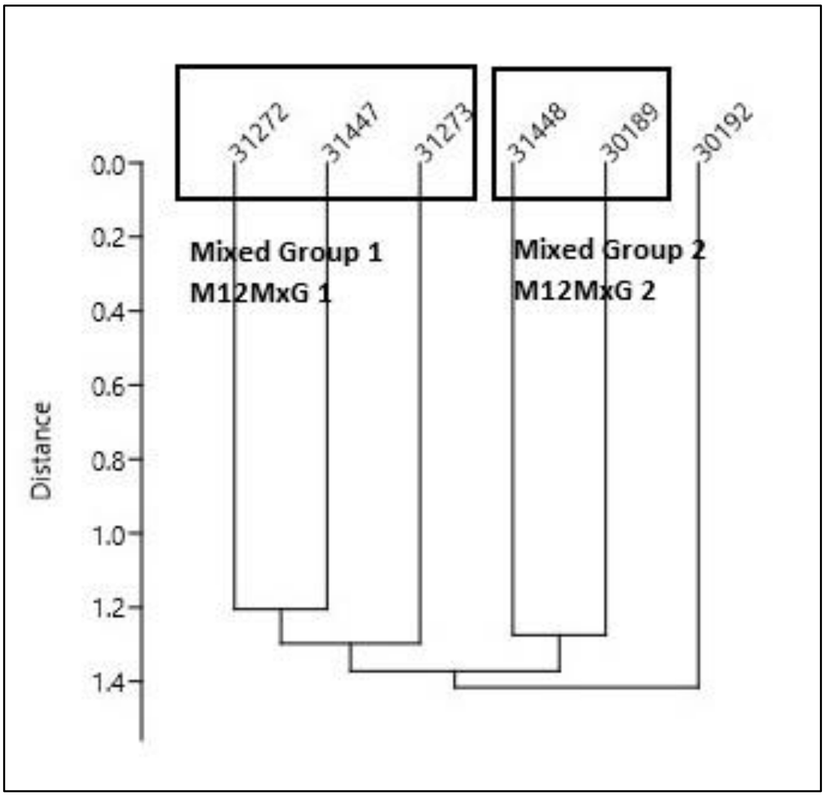



**Figure 78.** Mating season 2012 groups

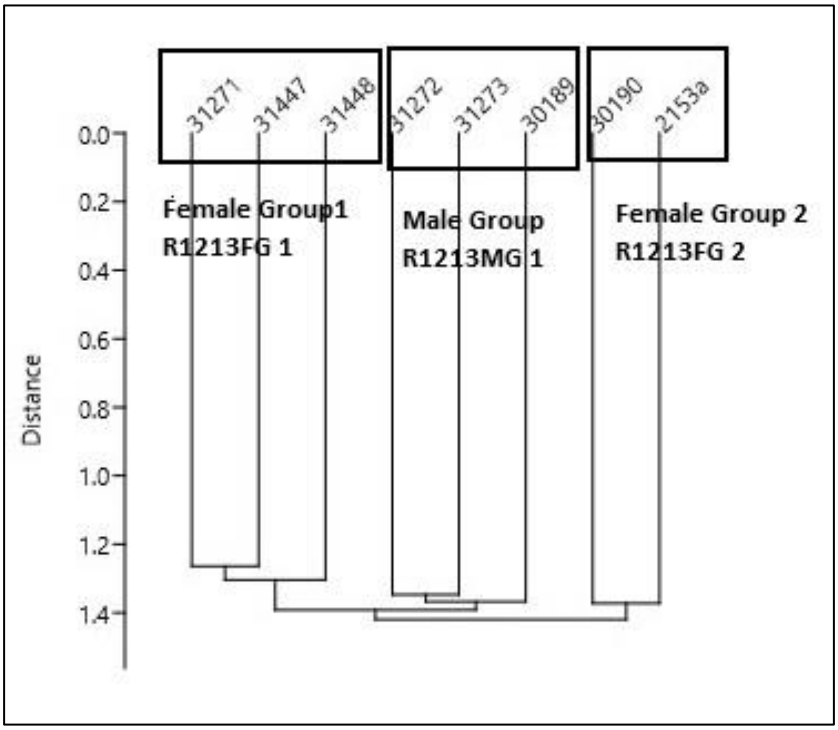



**Figure 79.** Rainy season 2012-13 groups

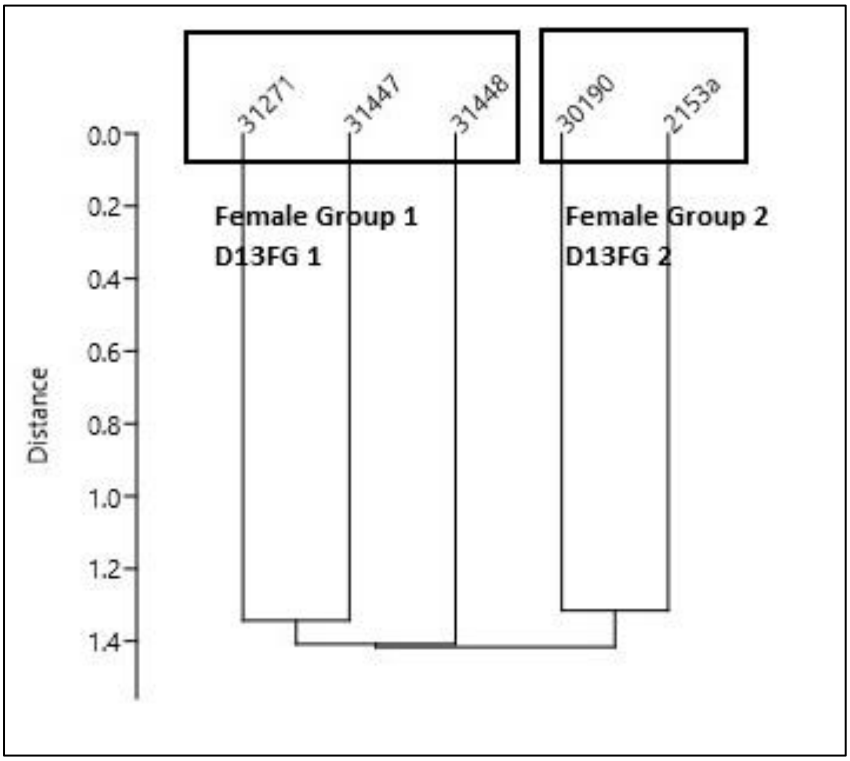



**Figure 80.** Dry season 2013 groups

Spatial segregation between males and females except during the mating season has been shown by hierarchical cluster analyses. In order to find out the driving force of spatial segregation between sexes in this study, ENFA was run for testing predictions of two common hypotheses, "Predation-Risk Hypothesis" and "Forage-Selection Hypothesis". The predation-risk hypothesis predicts that females use safer but lower quality habitats, and males prefer to inhabit risky areas with high quality of food. On the other hand, Forage-Selection Hypothesis predicts the opposite space use pattern, expecting females to use high-quality habitats and males to occupy low-quality habitats. According to results, predation risk hypothesis fails to explain spatial segregation of sexes. Forage selection hypothesis does better in explaining space use differences between males and females. Risky areas with higher resource quality are preferred by females while the males choose safer places with poorer resource quality (Figure 81-86). As explained before, the term disturbance is used instead of predation.

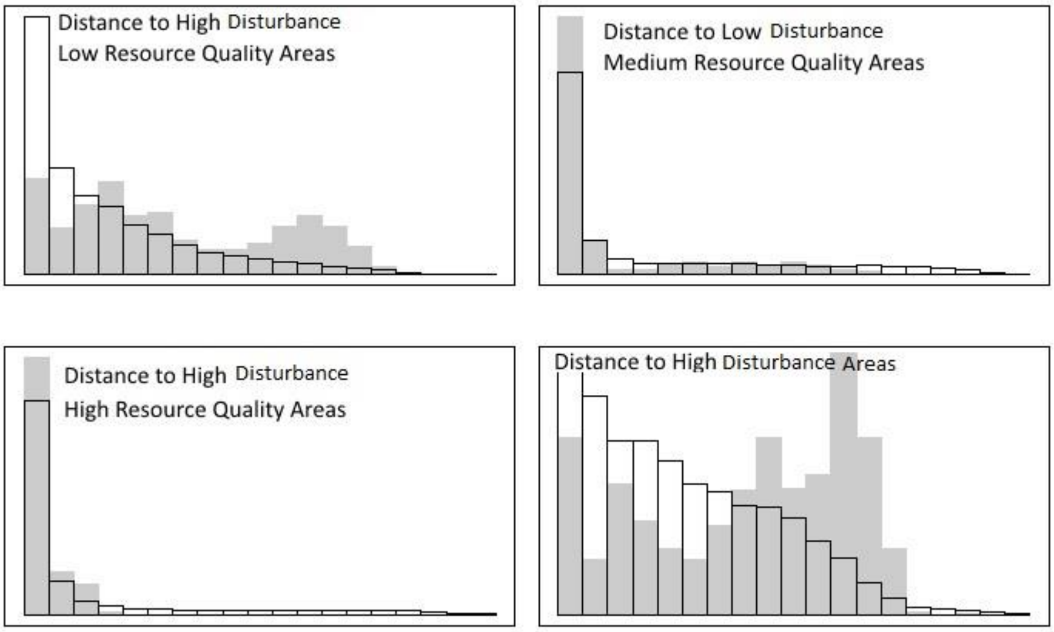



**Figure 81.** Histogram view of female habitat selection in terms of environmental variables related to disturbance and resource quality

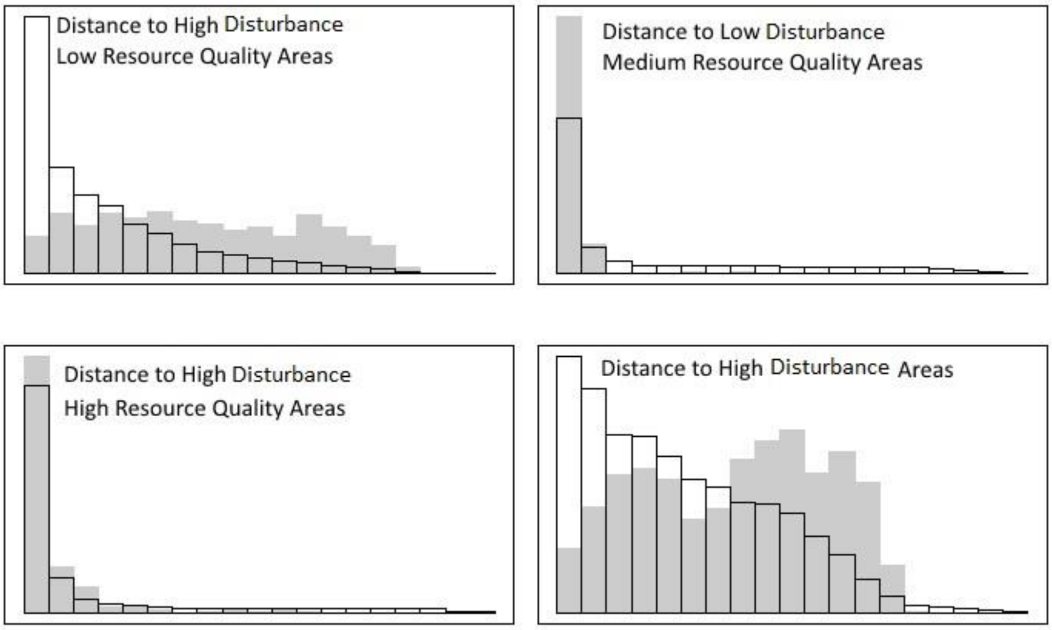



**Figure 82.** Histogram view of male habitat selection in terms of environmental variables related to disturbance and resource quality

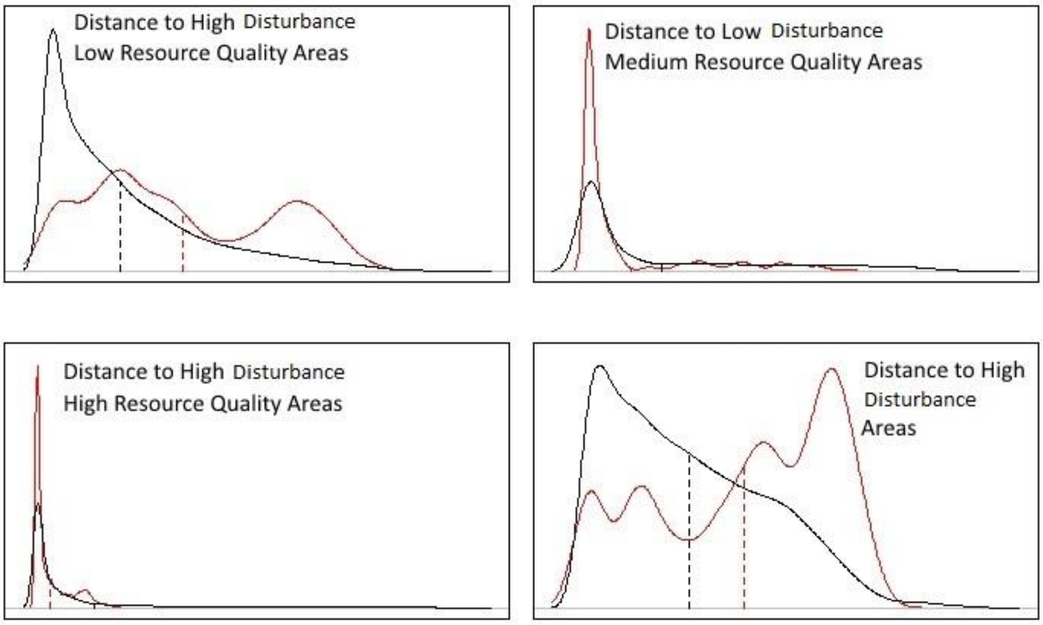



**Figure 83.** Mean plot diagram view of female habitat selection in terms of environmental variables related to disturbance and resource quality

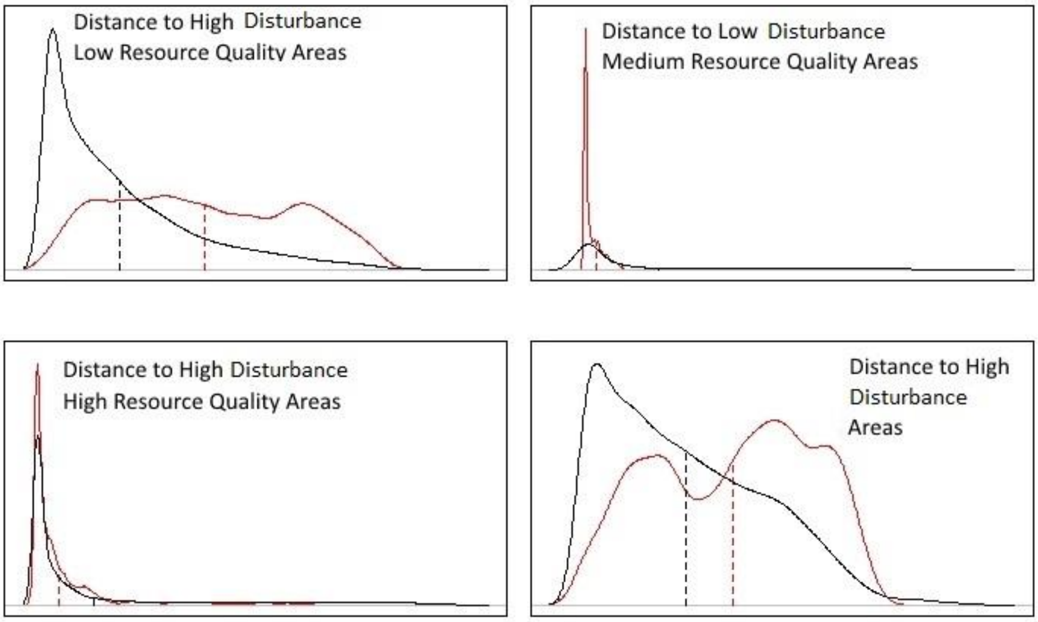



**Figure 84.** Mean plot diagram view of male habitat selection in terms of environmental variables related to disturbance and resource quality

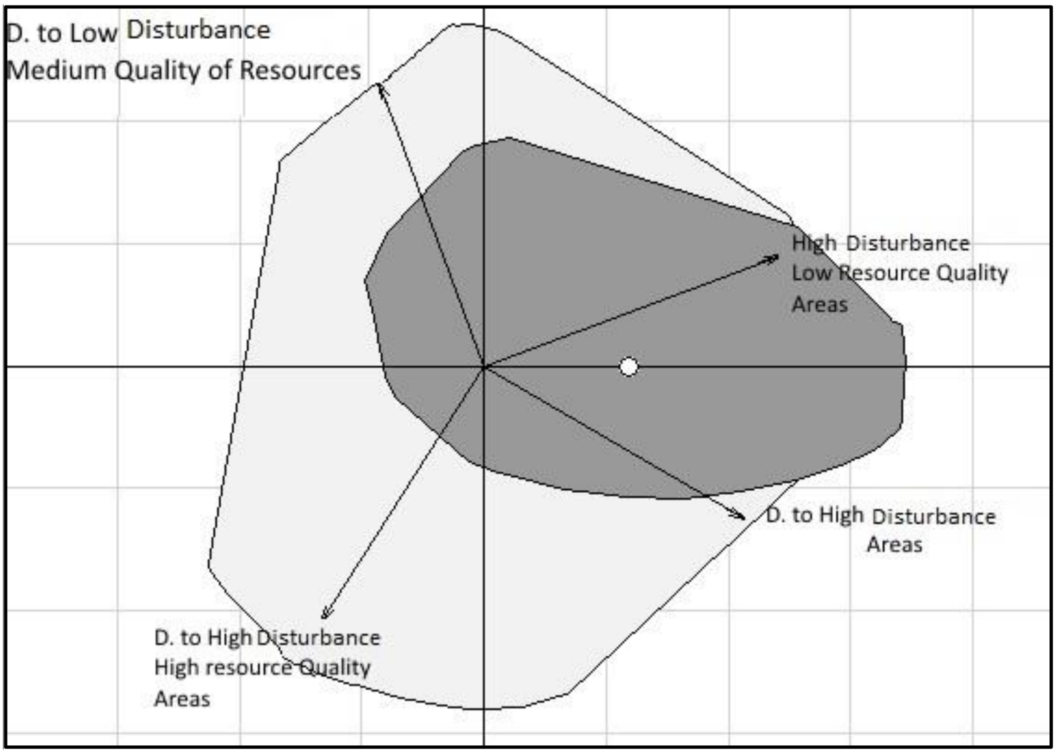



**Figure 85.** Biplot view of female habitat selection in terms of environmental variables related to disturbance and resource quality

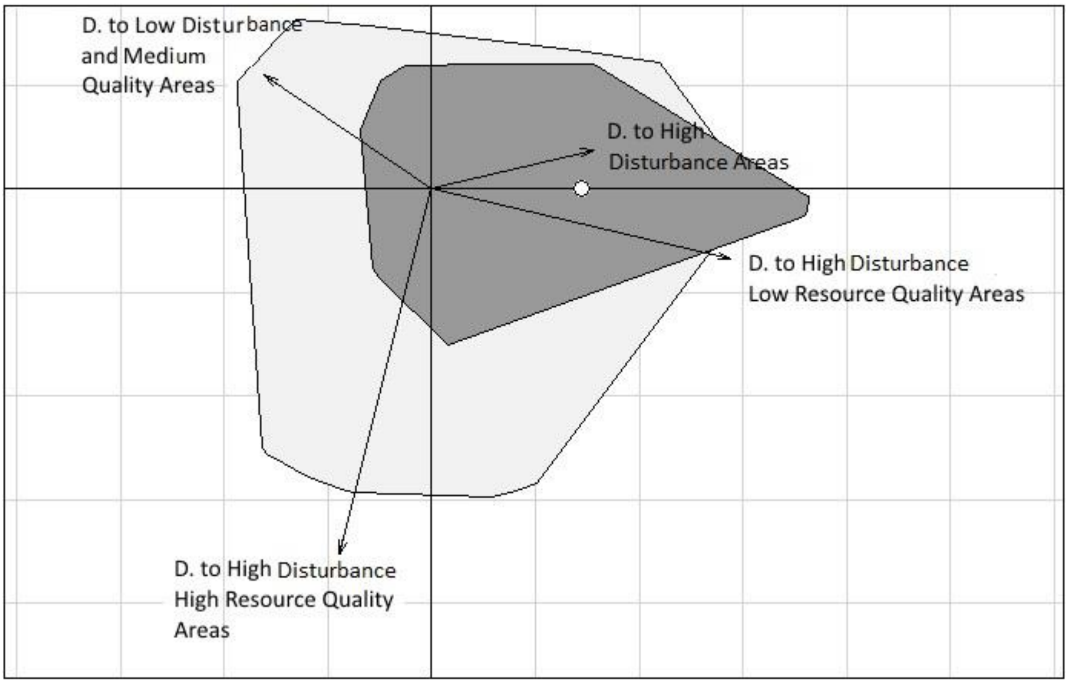



**Figure 86.** Biplot view of male habitat selection in terms of environmental variables related to disturbance and resource quality

### 3.4 Population Dynamics and Demography

The results of mark-resight analyses are given in Table 24. Increase in population size after 2014 is apparent. There are around 50 individuals in the area at the end of 2016 June.

**Table 25.** Population size estimations of mark-resight analysis

| Years | Population Size | SE | Lower | Upper |
|---|---|---|---|---|
| **2011** | 17.00 | 0.00 | 17.00 | 17.00 |
| **2012** | 22.17 | 0.18 | 21.82 | 22.54 |
| **2013** | 24.06 | 0.15 | 23.76 | 24.37 |
| **2014** | 29.05 | 0.18 | 28.70 | 29.40 |
| **2015** | 40.43 | 1.29 | 37.98 | 43.05 |
| **2016** | 48.17 | 3.29 | 42.14 | 55.07 |

Camera trap capture records show that the reintroduced fallow deer population has increased in size. Table 25 is the summary of changes in population size, number of male and female individuals, deaths, and newborns throughout the study period. The table includes minimum and maximum numbers for years since it is not always possible to identify newborns from each other. For the sake of simplicity, Table 26 shows the results of mark-resight population size estimations and camera trap calculations together.

**Table 26.** Yearly changes of demographic parameters

| Minimum Numbers | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | Pre-breeding Census (January to June) | | | | | Post-breeding Census (June to December) | | | | | Death | | | | |
| | F | M | FF | MF | Total | F | M | FF | MF | Total | F | M | FF | MF | Total |
| 2011 | NA | NA | NA | NA | NA | 8 | 9 | 1 | 0 | 18 | 1 | 1 | 1 | 0 | 3 |
| 2012 | 7 | 8 | 0 | 0 | 15 | 9 | 8 | 2 | 3 | 22* | 0 | 0 | 0 | 0 | 0 |
| 2013 | 9 | 8 | 2 | 3 | 22 | 11 | 11 | 0 | 2 | 24 | 0 | 1 | 0 | 1 | 2 |
| 2014 | 11 | 10 | 0 | 1 | 22 | 11 | 11 | 1 | 6 | 29 | 2 | 0 | 0 | 0 | 2 |
| 2015 | 9 | 11 | 1 | 6 | 27 | 10 | 17 | 2 | 5 | 34 | 3 | 2 | 0 | 0 | 5 |
| 2016 | 7 | 15 | 2 | 5 | 29 | 9 | 20 | 2 | 3 | 34 | 2 | 6 | 0 | 0 | 8 |
| 2017 | 7 | 14 | 2 | 3 | 26 | 9 | 17 | 0 | 3 | 29 | ND | ND | ND | ND | ND |
| Maximum Numbers | | | | | | | | | | | | | | | |
| Year | Pre-breeding Census (January to June) | | | | | Post-breeding Census (June to December) | | | | | Death | | | | |
| | F | M | FF | MF | Total | F | M | FF | MF | Total | F | M | FF | MF | Total |
| 2011 | NA | NA | NA | NA | NA | 8 | 9 | 1 | 0 | 18 | 1 | 1 | 1 | 0 | 3 |
| 2012 | 7 | 8 | 0 | 0 | 15 | 9 | 8 | 2 | 3 | 22* | 0 | 0 | 0 | 0 | 0 |
| 2013 | 9 | 8 | 2 | 3 | 22 | 11 | 11 | 0 | 3 | 25 | 0 | 1 | 0 | 1 | 2 |
| 2014 | 11 | 10 | 0 | 2 | 23 | 11 | 12 | 1 | 7 | 31 | 2 | 0 | 0 | 0 | 2 |
| 2015 | 9 | 12 | 1 | 7 | 29 | 10 | 19 | 2 | 7 | 38 | 3 | 2 | 0 | 0 | 5 |
| 2016 | 7 | 17 | 2 | 7 | 33 | 9 | 24 | 2 | 7 | 42 | 2 | 6 | 0 | 0 | 8 |
| 2017 | 7 | 18 | 2 | 7 | 34 | 9 | 25 | 0 | 3 | 37 | ND | ND | ND | ND | ND |

NA-Not Applicable
ND-No data
F-Number of females
M-Number of males
FF-Number of female fawns
MF-Number of male fawns
*4 individuals were transferred

Camera trap observations and estimations are in concordance with each other for all years (Table 26). Rate of increase in population size after 2013 is higher than previous years (Table 27, Figure 87). The population seems to be doubled in 2015, 5th years of release.

**Table 27.** Population size estimations and observations

| | Camera trap observation | | Mark-Resight Model | | | |
|---|---|---|---|---|---|---|
| **Years** | **Observed Min.** | **Observed Max.** | **Population Size** | **SE** | **Lower** | **Upper** |
| **2011** | 17 | 17 | 17.00 | 0.00 | 17.00 | 17.00 |
| **2012** | 22 | 22 | 22.17 | 0.18 | 21.82 | 22.54 |
| **2013** | 24 | 25 | 24.06 | 0.15 | 23.76 | 24.37 |
| **2014** | 29 | 31 | 29.05 | 0.18 | 28.70 | 29.40 |
| **2015** | 34 | 38 | 40.43 | 1.29 | 37.98 | 43.05 |
| **2016** | 34 | 42 | 48.17 | 3.29 | 42.14 | 55.07 |

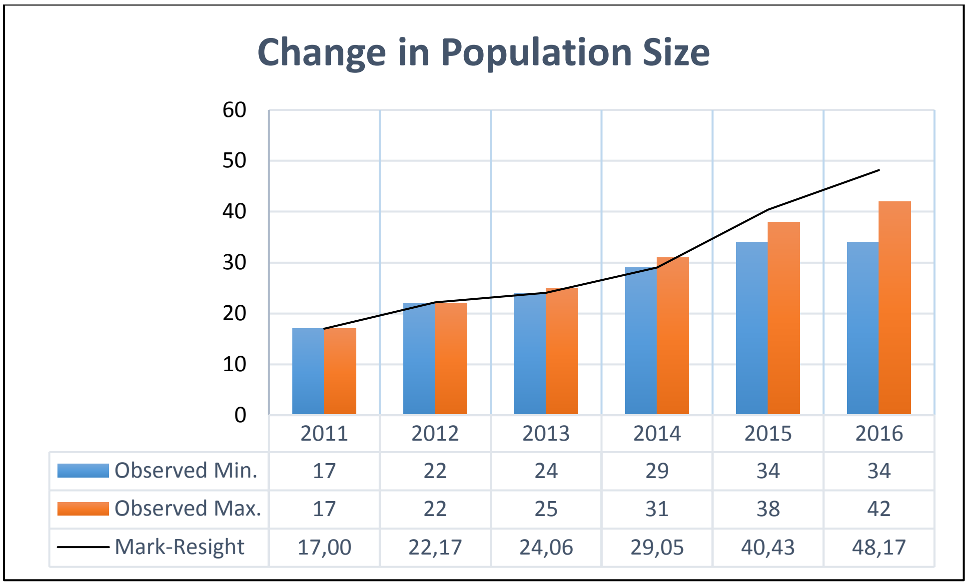



**Figure 87.** Changes in population size estimations and observations

**Table 28.** Changes in density and growth rate of the population

| | **Density (individual/km²)** | | | **Growth Rate** | | |
|---|---|---|---|---|---|---|
| | **Observed Min.** | **Observed Max.** | **Mark-Resight** | **Observed Min.** | **Observed Max.** | **Mark-Resight** |
| **2011** | 0.46 | 0.46 | 0.46 | NA | NA | NA |
| **2012** | 0.59 | 0.59 | 0.60 | 0.29 | 0.29 | 0.30 |
| **2013** | 0.65 | 0.68 | 0.65 | 0.09 | 0.14 | 0.09 |
| **2014** | 0.78 | 0.84 | 0.79 | 0.21 | 0.24 | 0.21 |
| **2015** | 0.92 | 1.03 | 1.09 | 0.17 | 0.23 | 0.39 |
| **2016** | 0.92 | 1.14 | 1.30 | 0.00 | 0.11 | 0.19 |
| **Average** | NA | NA | NA | 0.15 | 0.20 | 0.24 |
| **Std** | NA | NA | NA | 0.10 | 0.07 | 0.10 |

# CHAPTER 4

# DISCUSSION

## 4.1 Reintroduction effort

Reintroduction has always been a risky option for the conservation of a threatened species. Many parameters have to be taken into consideration for the success of reintroduction. Management implications need to be carefully assessed to minimise the risks. Following the guideline “Guidelines for Reintroductions and Other Conservation Translocations” prepared by IUCN Species Survival Commission (2013) as far as possible throughout the whole process has vital importance.

Reintroduction is an acceptable option for fallow deer in Turkey. The current population in Düzlerçamı/Antalya was restricted to a small area and had a potential risk of extinction due to poaching, epidemics, and forest fires. Increasing the number of populations by translocating animals to suitable new sites is a notable option for the conservation of the species. All the reintroduction process has been planned and conducted together with the related department of the General Directorate of Nature Protection and National Parks. Comprehensive prior assessments were conducted to find out suitable places for reintroduction (Bilgin, 2014). A habitat model was built by using parameters known to effect on fallow deer population viability to identify suitable areas. Candidate sites were visited by specialists to evaluate their suitability on site. Camera traps were used to detect any risks and interviews with local authorities and local people were utilized for better evaluation of potential risks. The site with the highest suitability score within the historical former range of the species was Dilek Peninsula National Park, and hence, was chosen for the first reintroduction. Access to this protected area is restricted since the National park is also a military area. Additionally, there are no human settlements in the area and motorized access is regulated. These factors minimise the main problem of wildlife populations of the earth, the human-caused disturbances. It means that the causes of previous regional extinction are not present anymore. Moreover, there is no natural predator of fallow deer in the selected site, except golden jackals (*Canis aureus*), whose presence is a potential threat for fawns. The main unwanted feature of Dilek Peninsula NP is the presence of potential competitors in the form of feral cattle and horses.

In line with the principle of “soft release”, a fenced acclimatization area was built for translocated animals to gain familiarity with the location. Overall, this was the first comprehensive reintroduction effort conducted in Turkey and had been a success (Bilgin, 2014). The post-release monitoring of the reintroduced population through GPS tracking and camera traps has provided the main bulk of data for this thesis.

## 4.2 Home range

Movements of reintroduced animals are important to understand the ecological process of range establishment (Meagher, 1989; Carden et al. 2011; Jung, 2017). Range expansion is apparent in both males and females throughout the monitoring period. Males expanded their range through all directions except the eastern side. This extension during the first year is the result of one individual’s discovery attempts of these parts. In the second year, no animals visited the eastern extension. It possibly means that there is nothing attractive for fallow deer there. Similarly, the second year range of females is larger than for the first year. The expansion appeared to have occurred in all directions except for the eastern and south-eastern sides. West side expansion, occurred through the military station, is related to the second release of female group. The military station had been removed when they released.

When considering distances between home range centroids of consecutive seasons, sparse distribution of males over the area and occasional closeness between individuals are apparent. Rather in females, space use patterns of individuals are similar and closeness of home range centroids indicates stronger relationship between individuals than males. Space use difference between two female release groups is possibly due to change in environmental conditions in the study area. Military stations had been removed from the area when the second female release group was released. Therefore, military station related disturbances were not present during the second female group release. Similarly, the distance covered by the second release group of females is lower than the first release group of females, and males due to the same reason.

Seasonal and biannual home range sizes of male and female fallow deer are evaluated within the context of three predictions. The first one is a widely observed situation in ungulates, that home range sizes of males are larger than females. The condition is observed and documented by many authors (Cederlund, 1983; Weckerly, 1993; Nugent, 1994; Borkowski and Pudelko, 2007; Morse et al., 2009). However, each study has its own dynamics where different mechanisms can drive spatial behaviours of individuals, sexes, and populations. Ciuti et al. (2004) showed that female fallow deer home ranges are larger than males in the San Rossoro population in Italy. Human disturbance is high there, so predation risk (or the perception of risk) is considerable during daytime. Space use of females is different during the day and night, so home range sizes are larger. At Dilek Peninsula NP, even though it is not statistically significant, the average biannual home range sizes of males are larger than females, as reported for most other fallow deer populations.

Home range size of males are also larger in 3 out of 5 overlapping seasons but only during the 2011 mating season home range size difference was statistically significant. That particular season coincided with the release period of female individuals and not surprisingly, just after acclimatization their home ranges were small. A similar result is reported by Dolev et al. (2002) from Israeli Persian fallow deer (*Dama mesopotomica*) population where reintroduced individuals gradually increased the size of their main activity area. Moreover, males may restrict female movements for reproduction due to single territory mating strategies of males, which include territorial defence. On the other hand, 2012 dry season home ranges of females were larger than those of males. The difference is statistically significant. The reason for this difference is that during the dry season females give birth and may search for safe sites far from their normal area of utilization. Therefore, more dispersed fixes in dry seasons may lead to increases in female home range sizes.

The results also showed that the period during acclimatization, in other words just after the release season home range sizes are smaller than in the following season. The prediction is verified for both sexes. In relation with this behaviour, home range sizes in the second-year are estimated to be larger than in the first year for both males and females.

In addition, the individuals are expected to prefer staying close to the fenced area in after release season until they discovered the new environment, learning the locations of key resources as well as risky areas. However, the first release group females and males prefer to stay away from the release site. The reason for this behaviour is possibly due to dog disturbance in the area where they had faced just after release. Space use patterns of second release group females support this idea. The mean distance covered by second-release females in after release season is significantly lower than the other releases because military stations and dogs had been removed from the area when they released.

Same season home range sizes of different years are expected to be close to each other, except if acclimatization took place in one of those years. This prediction is also supported statistically, except for mating season home ranges of females. When reproductive behaviour differences between females during the two years (2011 and 2012) are considered, the difference can be explained by interactions between individuals. In the first year, females were dominated by one male, 30189, and their movements were restricted. In the second year, none of the males could dominate all females, so they are free to move compared to the first year. A higher dispersion of locations results in larger home ranges.

In order to avoid overestimation of home range sizes, averages individuals were used. Since pooling fixes by sex results in overestimation of home ranges for species that show intrasexual and intersexual spatial segregation. Borkowski and Pudelko's (2007) study on fallow deer home range and habitat selection showed this kind of overestimation. Seasonal male home ranges changed between 172 and 660 ha, but the annual home range was 975 ha. Similarly, female home ranges varied between 55 and 144 ha, but the annual female home range was 210 ha.

The 95% minimum convex polygon (MCP) home range sizes in this study (524.72 ± 360.16 for males and 564.06 ± 297.97 ha for females) show both similarities and differences with other studies. Davini et al. (2004) found similar results with our study for San Rossore population in Italy. They estimated 95% MCP annual home range size of males as 588.9 ± 278.9 ha and calculated 95% kernel home range size of males as 337.5 ± 178.9 ha, which is considerably lower than our findings (618.20 ± 406.15 ha).

Fixed kernel and minimum convex polygon estimates were calculated to make comparisons possible with similar studies. The other method, Kernel Brownian Bridge home range estimation includes the temporal nature of fixes and is less sensitive to autocorrelation. Therefore, movement of individuals is included in the analyses and it can be considered as better to represent the natural behaviour of individuals compared to the other two estimators.

## 4.3 Habitat Selection

Space use patterns of animals are shaped by the distribution of resources in the area. Seasonal marginality values of males and females, which are obtained by ENFA, point out the differences in habitat use between sexes. Sexual differences in habitat selection of fallow deer are documented by some other studies conducted in Italy (Apollonio et al., 1998) and England (Putman et al., 1993). Contrary to sexual differences in habitat use, Thirgood (1995) found no difference between habitat use by sexes in England possibly due to lack of male location data or coarse habitat partitioning. Habitat selection is found to be stronger in females in our study. They are probably more dependent on key environmental variables than males, especially if with young. Females always preferred locations to close patches where water and food resources were available. Braza and Alvarez (1987) found similar results that showed fallow deer preferred to be near sites where better grazing opportunities are present.

Female habitat selection of water and food resources is especially strong in dry periods, which include the fawning time. The growth of fawns is an energy-requiring process for mothers so the availability of water and food resources is vital particularly around parturition. The females particularly preferred to stay in safer places far from the road or the military stations during fawning. They move through the closed habitats for reducing the predation risk by decreasing the visibility of fawns. The common antipredator behaviour of fallow deer mothers in the fawning season is shown in other studies (San Jose and Braza, 1992; Ciuti et al., 2006).

Habitat use differences between sexes are related to differential needs of sexes and support the general rule of spatial segregation of sexes in ungulate species. There are little shared selected resources for both sexes throughout the year except for some seasonal selections, especially during mating seasons. Similar resource use pattern of males and females during mating seasons is expected since they use the same patches for mating. Roads and rocky low shrubland were commonly avoided by both sexes. Staying close to road increases predation risk (as probably perceived due to disturbance caused by passing vehicles), therefore avoidance behaviour is expected. Similarly, visibility of animals is high in rocky low shrublands and deer are exposed. In addition, rocky low shrublands are poor habitats for feeding. Therefore, there is nothing attractive for fallow deer in rocky low shrublands.

Males and females are differentiated with respect to vegetation cover preferences. Oak woodlands are used mostly by females and tall pine forests by males. Quality, quantity, and variation of food resources are higher in oak woodlands (e.g. acorns) than tall pine forests but human access to oak woodlands are easy since they occupy a relatively flat area, so predation risk might be perceived as higher there.

## 4.4 Sexual Segregation, Social Interactions, and Mating Strategies

### 4.4.1 Social Interactions and Sexual Segregation

Grouping behaviour is common in social ungulates. Living in groups is advantageous for group members. It reduces the disturbance during resource consumption and increases foraging efficiency (Hamilton, 1971; Jarman, 1974; Hirth, 1977; Berger, 1978). Due to low population size, number and sizes of groups are small in Dilek Peninsula fallow deer population. Female groups are more stable than male groups. Presence of group stability is the indicator of the favourable conditions for the population. Knowledge of risky areas and resource areas are effectively passed through the next generations by peer learning (Franklin et al., 1975; Bender and Haufler, 1999).

Stability in female groups is expected in this study since the new environment is considered favourable for fallow deer. Dilek Peninsula National Park contains abundant and high-quality resources for them. Favourable conditions are expected to have a positive effect on the growth rate of the population until the population size reaches carrying capacity. Since the animals are not free to move due to peninsula geography and unsuitable inland extension of the area that is crossed by a heavily used road and human settlements, "ideal despotic distribution" conditions (Fletwell, 1972) will probably drive the population dynamics in following years. Increase in population size in island-like closed habitats brings with it more intense intraspecific competition for resources, where weaker individuals have to live in marginal habitats with poor quality resources.

It is unlikely but a worst-case scenario for the population in the future may be irruption. Caughley (1970) defined the irruption process as the collapse of an introduced herbivore population into a predator-free environment following overutilization of food plants. Irruption is not a frequently observed process but there are a few introduction and reintroduction examples in literature (Caughley, 1970; Gruell, 1986; Laeder-Williams et al., 1987; Hansen et al., 2007; Uno et al., 2009). However, it is yet early to predict whether such a risk is relevant to the Dilek Peninsula population.

Sexual segregation is a common phenomenon observed in ungulate species reported by many authors for different ungulate species (Miller and Litvaitis 1992; Bleich et al., 1997; Bleich, 199; Kie and Bowyer, 1999; Bowyer, 2004). Thirgood (1990) showed the sexual segregation in England and Buschhaus et al. (1990) in Illinois, the USA for fallow deer populations. The topic has attracted to researchers for years and they focused on three hypotheses, predation risk hypothesis, forage selection hypothesis, and activity budget hypothesis, to explain this behavioural difference. Predation risk hypothesis states that females with fawns are more prone to predation, so they prefer safer habitats (Main and Coblentz, 1990). Contrary to predation risk hypothesis, forage selection hypothesis predicts that quality of food is more important for females than males since smaller body size requires better quality food to gain sufficient energy especially for parturition (Main et al., 1996). The activity budget hypothesis emphasizes body size difference of sexes, relying on the fact that energy requirements of sexes are different due to body size differences (Ruckstuhl, 1998). Females spend more time to forage since they have a less efficient digestive system than males. Unlike forage selection hypothesis, which predicts habitat selection as the cause of sexual segregation, the activity budget hypotheses focus on the activity budget of sexes as the driving force (Ciuti et al., 2004). All proposed hypotheses have been tested by researchers, and it seems there is no single explanation lying behind this specific behavioural difference between the sexes. Main (1998) stated that the differences in space use pattern between sexes are so common in polygynous ungulates that there should be a common evolutionary cause. However, the mechanism underlying sexual segregation shows variation between populations (Bon, 2001; Ruckstuhl and Kokko 2002; Bowyer 2004; Ruckstuhl and Neuhaus, 2005; Ruckstuhl, 2007). Combination of all or some of the factors like intraspecific interactions, interspecific interactions, habitat structure, social and physiological factors, and their intensity can be the reason.

Sexual segregation is expected in space use pattern in this study, and it is confirmed by group composition results. In accordance with the expectations, mixed groups have not been observed in the study area except during mating seasons. Sexual segregation was observed in all remaining seasons.

Sexual segregation in Dilek Peninsula NP fallow deer population is better explained by forage selection hypothesis. Although the area is well protected, there are still threats related to human presence. The existence of two military stations in the area creates disturbances for fallow deer. It means that soldiers could freely walk around with their guns. In additions, dogs belonging to military stations were observed in the area freely moving through the area. Effects of free dogs on wild populations are documented by Manor and Saltz (2003). They showed the negative correlation between feral dog presence and fawn/female ratio of gazelles (*Gazella gazella*) in Israel. Dunham (2001) reported similar findings in mountain gazelle (*Gazella gazella*) population in Saudi Arabia. Moreover, Dolev et al. (2002) stated dog predation for Persian fallow deer (*Dama mesopotomica*) population in Israel. One of the death events in the area is possibly related to a dog attack. Moreover, poachers apparently have illegally entered the protected area by sea at night occasionally. One destroyed camera trap and the death of two animals, one GPS collared, are possibly related to poachers. The carcasses of those animals have not been found and the recovered collar was untypically clean for a natural predation event. When all these data are considered, the areas near beaches, military stations, and the road are evaluated to be high predation risk or disturbance areas. In relation with this evaluation, inner parts of the park, composed of mostly by tall pine forests, are considered to be safer places. No natural predator of fallow deer lives in the area, except the golden jackal (*Canis aureus*) in the fawning period. On the other hand, high predation risk-disturbance areas are rich places for feeding and contain both natural and artificial water resources. Grazing opportunities are high there due to openings (i.e. meadows). In addition, many tree and shrub species are also found there providing seeds and fruits like oak (*Quercus*), olive (*Olea*), locust (*Ceratonia*) and mock privet (*Phillyrea*). The safer tall pine forest, on the other hand, does not contain much feeding resources, unlike the high predation risk-disturbance areas. If predation risk hypothesis would be the driving force of sexual segregation, female groups would have used the safer tall pine forest habitats more than males. However, the results show the opposite situation, and therefore, support the forage selection hypothesis as the underlying mechanism for sexual segregation. Energy requirements of sexes are different in relation to body sizes. Rumen of larger herbivores, such as male deer, is larger, and males are considered more effective at gaining energy from fibre than females since the passing of food through rumen is slower (Robbins et al., 1995; Barboza and Bowyer, 2000). As a result, males gain more energy from low-quality forage than females (Main et al., 1996). In addition to forage selection hypothesis, scramble competition hypothesis (Main et al., 1996) may also explain to some extent spatial segregation of sexes in Dilek Peninsula population. Physical differences between sexes may lead to differential space use due to competition for food. Bite-size differences and smaller incisor arcade of males decrease their efficiency of food consumption (Illius & Gordon, 1987). Therefore, they are weak competitors compared to females. In addition to the intrasexual competition, the presence of potential interspecific competition with cattle and horses in high-quality food locations may increase the intensity of competition.

### 4.4.2 Mating Strategy

Fallow deer is a species that shows great variation in mating systems (Clutton-Brock et al., 1988; Langbein and Thirgood, 1989). The mating system of a population is formed through individual mating strategies of males (Langbein and Thirgood, 1989). These authors defined seven mating strategies of males based mainly on their degree of territoriality: harems, following, dominance groups, stands, temporary stands, multiple stands, and leks. The first group is non-territorial strategies that are following, harems, and dominance groups. In the ‘following’ strategy, bucks follow groups including receptive females. The second non-territorial strategy is the harem where a male holds a female group and defends it against other males. The last defined non-territorial mating strategy is dominance groups, which forms a mixed group of both sexes. Subordinate males are tolerated in such groups but most of the copulation events are achieved by the dominant male. The second degree of territoriality comprises single territories, which include stands and temporary stands. The stand is defined as a reproductive territory defended by a single male. The difference between the stand and the temporary stand is the duration of defencing the reproductive territory. The area is defended for a short period in temporary stands, and males search for other receptive females after defending the stand. The last type is the multiple territory strategy, including multiple stands and leks. Multiple stands strategy contains non-overlapping but neighbour reproductive territories of bucks. On the other hand in lekking systems, males aggregate in an area called “lek”, where females visit for copulation only. The difference between a lek and stand is that lek is considered as just courtship display and mating areas but stands additionally include resources and larger than leks (Putman and Flueck, 2011).

One or a combination of those strategies may occur simultaneously in fallow deer populations (Langbein and Thirgood, 1989). Thirgood (1990) showed that three mating strategies, namely following, single territory, and lekking are found simultaneously in New Forest fallow deer population in England. He also observed that adult males could change mating strategies within a single rutting period. Braza et al. (1986) documented the harem strategy of Spanish fallow deer population at Donana Reserve evolving into dominance groups in 10 years (San Jose and Braza, 1997). Lek systems are also reported from Denmark (Schaal and Bradbury, 1987 cited in Thirgood, 1990), Italy (Apollonio et al., 1989), and Texas, USA (Hirth, 1997). Multiple stands strategy is reported by Moore et al. (1995) from Ireland. Buschhaus et al. (1990) found following and harem systems together in an Illinois fallow deer population in the USA.

Mostly male density, then number of females and habitat type determines the reproductive strategy (Langbein and Thirgood, 1989). Non-territorial mating systems are linked with low density of males and females in the population. Single territory systems have been observed mostly when the density of males is higher than females, and high density of both sexes promote the multiple territory mating systems. Difficulties in finding receptive females living in unstable groups in large populations and defending the group by males promote territorial mating systems, multiple stands, and leks. The strategy provides females with protection from predation and harassment by other males (Clutton-Brock et al., 1988; Clutton-Brock et al., 1989; Clutton-Brock et al., 1993).

### 4.4.3 Mating Strategy in Dilek Peninsula Fallow Deer Population

Mating strategies of males are interpreted as dominance groups, stands, or temporary stands in this study. When considering low densities for both sexes, non-territorial and single territory mating strategies in the studied population are expected. The number of receptive females is low in the population and they live in two stable groups. The oldest buck has competed with four subordinate males for access to females. Defending one group has made the other female group accessible to subordinates. Younger males appear to have searched for opportunities around these female groups. The oldest male dominating a mixed large group indicates the presence of a "dominance group mating strategy". In addition, when they find the chance, all other males spend short or long periods nearby females, depending on the location of the oldest male. Therefore, it is possible to state that stands and temporary stands are secondary mating strategies during the rut.

According to hierarchical cluster analyses, there are no mixed groups during the 2011 mating season (Table21, Figure 75). Females capable of breeding stayed near rutting stands and their mobility is low in this period. Two rutting stands were formed in the study area. The oldest male, 30189, defended these stands against younger males to increase its reproductive success. It had to be more mobile in this period to defend both areas at the same time. Visual representation of 2011 mating season illustrates this behaviour (Figure 88). The 2011 mating season home range of 30189 covers all female home ranges that were capable of breeding at the time. None of the other males was able to dominate females. As a result and contrary to hierarchical clustering result for 2011 mating season, there is actually a single mixed group in this period composed of the oldest male and two female groups. Two of the subordinate males (30191, 30192) apparently tried to reach females around rutting stand 1 while two other young males (31272, 31273) did the same thing for rutting stand 2. Youngest male 30191 stayed relatively close to 30189 in this period, perhaps somewhat tolerated by the old buck. It has possibly succeeded to mate as it formed mixed groups with females for short periods in the season.

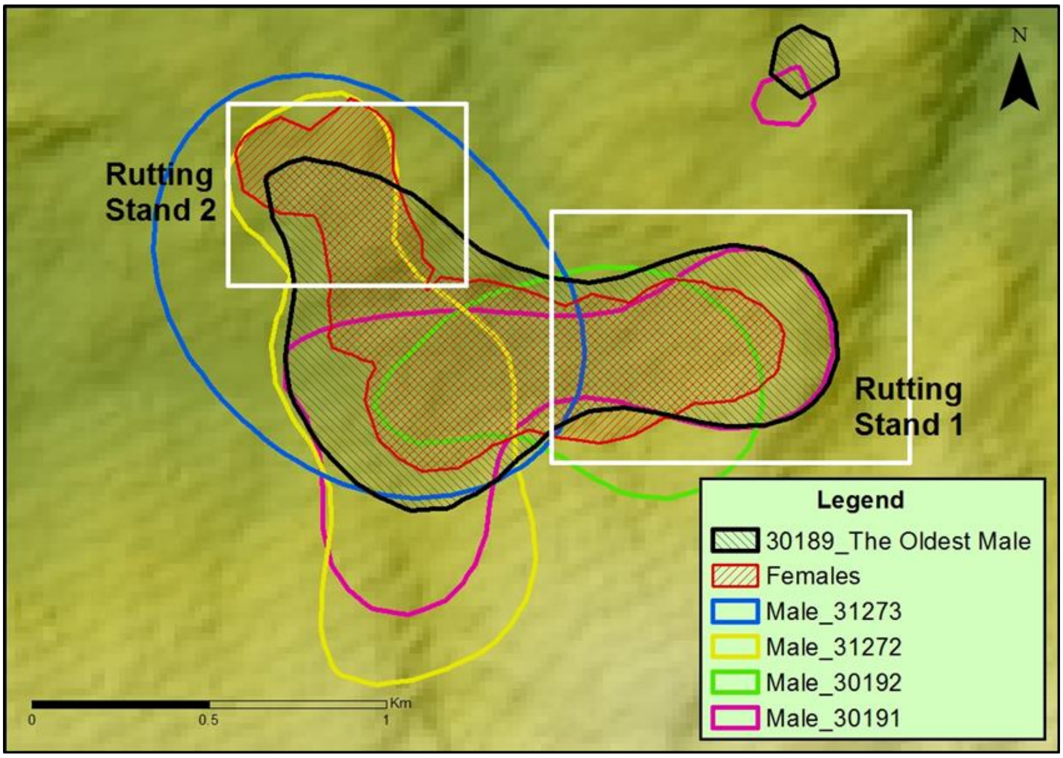



**Figure 88.** 2011 mating season rutting stands and male positions
(50 % Fixed kernel)

Behaviours during the 2012 mating season are different than in 2011. The oldest male, 30189, has not been as successful to defend the females as in 2011 mating period. The location data of females is limited for this season but the acquired data is sufficient to point out the difference between these two periods. Females have not kept in a limited area as in 2011; instead, two breeding groups were formed by 30189 and by two younger males, 31272 and 31273, in different locations (Figure 78, 89). Females first aggregated in the area defined as “rutting stand 1” in 2011, and then spatial segregation by males took place. The second year mating strategy seems to be single territory strategy “stand” or “temporary stands”.

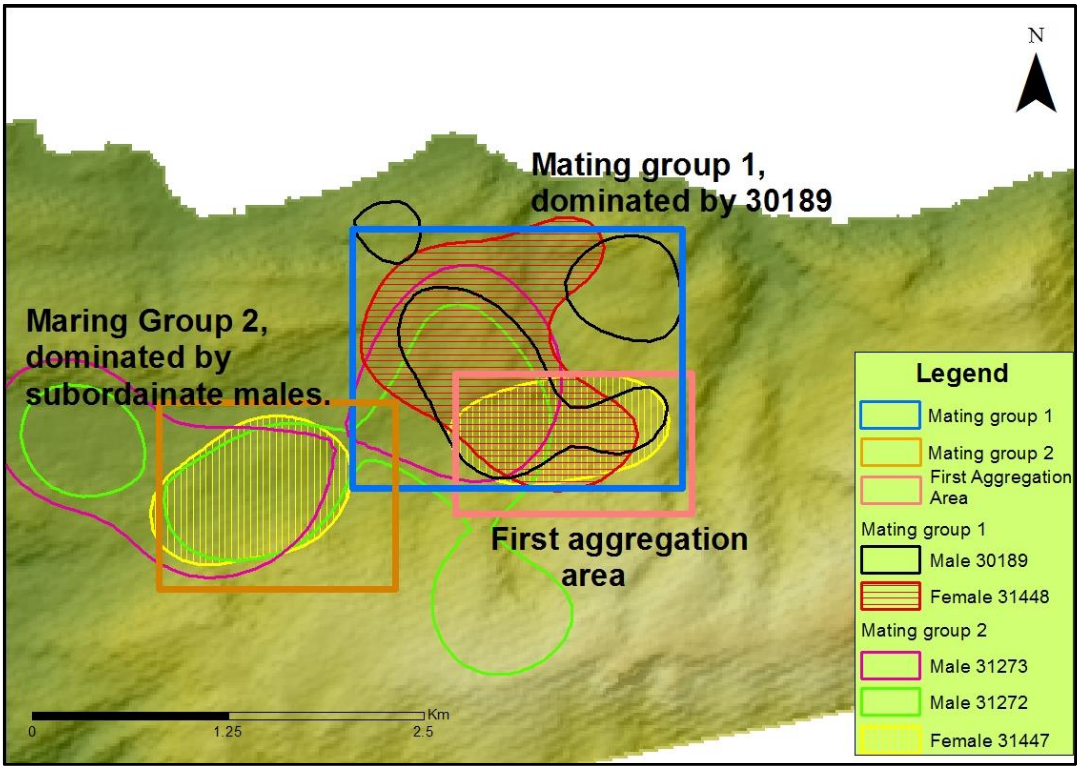



**Figure 89.** 2012 mating season rutting stands and male positions
(50 % Fixed kernel)

These findings suggest that as the reintroduced population increases in size and spatial coverage, it will become more difficult for a few males to dominate matings, and natural groupings of females will probably develop spontaneously at separate localities, each accompanied by different male individuals. From a genetic viewpoint, this would be a welcome development since inbreeding depression will become a less likely outcome of the limited population at Dilek Peninsula NP.

## 4.5 Population Dynamics, Demography

Mark-resight model and camera trap observations results show that reintroduced fallow deer population in Dilek Peninsula has an increasing trend. All the results, population size, density, and growth rate show this pattern as expected. 2014 seems to be a critical year about population dynamics. After 2014, the rate of increase is higher than in previous years. The explanation of this increase is most probably related to high fawn survival success. The number of Dilek Peninsula born fawns is 4 for 2012 and 2013, 22 for the next four years. Average number of fawns is 2 for the first period, and 5.5 for the second one.

Low rate of population size increase for the first two years is probably related to female fallow deer developing antipredator behaviour against golden jackals. There are two common antipredator strategies developed in ungulates, “hiding” and “following”. Following is a better strategy for open habitats and hiding is more advantageous for closed habitats (Lent, 1974; Ralls et al., 1986). Fallow deer strategy is hiding (Gilbert, 1968; San Jose and Braza, 1991). Gaining familiarity of females to the new environment may give rise to an increase in fawn survival. They have learned the safer places to give birth to protect their fawns against predators. A golden jackal predation was recorded by a camera trap in 2013 (Figure 90). Weak and defenseless fawns are easy prey for predators. Therefore, parturition site choice is crucially important for fawn survival. It is better to select a site where it will be hard to be detected or reached by predators. This is quite a striking point to show the dramatic effects of golden jackal predation on fawn survival and on population growth.


**Figure 90.** Golden jackal predation on 2013

When considering the suitability of a reintroduction site with no natural predators, abundant food and water resources, and restricted human impact, the population is expected to increase in years after the release. When considering the whole study period, population size has increased from 17 to 48 with an average annual growth rate of 0.24±0.10. The low numbers in 2017 can be related to both decreasing efficiency of individual identification and to incomplete data for the whole year. There is only 5 months' worth of camera trap records for 2017. The growth rate of Dilek Peninsula fallow deer population is better than Spanish fallow deer population at Donana National Park, which is 0.06 (Gaona et al., 1996) due to favourable conditions and lack of serious intraspecific or interspecific competition in Dilek Peninsula.

Male-biased maternal investment is another remarkable result for the reintroduced fallow deer population. Most of the fawns were males during the six fawning periods throughout the study. The ratio of female fawns was 0.19 (5 out of 27). This condition fits the Trivers-Willard model, which predicts that male fawns are favored in polygynous ungulate species when mothers are in good body condition (Trivers and Williard, 1973). Reproductive success of male individuals depends on their body size in sexually dimorphic polygynous ungulate species. Variance in mating success among males is higher than females and male reproductive success is related to early growth and maternal investment (Trivers and Williard, 1973; Clutton-Brock, 1991; Hewison and Gaillard, 1999). Hewison and Gaillard (1999) have reviewed studies related to this hypothesis for 16 ungulate species including fallow deer. They summarize the requirements of the model in addition to sexual dimorphism and polygyny as following.

- At the end of maternal investment, mothers in good physical condition have high-quality offspring,
- During adulthood, high-quality offspring are still in good condition,
- Being in good physical condition affects the reproductive success of males more than females.

Birgersson and Ekvall (1997) show the first two assumptions are valid for fallow deer by measuring body weights of a Swedish population. There is no data for the last assumption for fallow deer. When considering all of these assumptions and observations, the Trivers-Williard model can be considered valid for the Dilek

Peninsula fallow deer population. Abundant and varied food resources in the area have led to phenotypically high-quality individuals as supported by camera trap records. Females are in a good physical condition most of the time and male-biased investment is expected.

The density of the population also shows a similar trend with the growth rate and population size. It has increased from 0.46 to 1.30 individual per $km^2$ throughout the study period. 15 individual/$km^2$ is considered optimal fallow deer density in favorable habitats (Hoffman and Heidemann, personal comm.). Ünal and Çulhacı (2018) have recently conducted a study for estimating density and population size of the enclosed source population in Eşenadası Breeding Station (Düzlerçamı) and found population size to be $105 \pm 6.25$ and density as 20.7 individual/$km^2$. The findings of Ünal and Çulhacı (2018) and this study show that translocation of animals from Düzlerçamı population to Dilek Peninsula population should continue, considering the low density of sink population and high density of source population.

In conclusion, the reintroduced population size has an increasing trend, individuals successfully reproduce in the new site, and their fawns are able to survive there. These are positive indicators for establishing a self-sustaining population.

# CHAPTER 5

# CONCLUSION

This study is the first most comprehensive reintroduction monitoring study conducted in Turkey and may provide a model for similar research. As the Turkish fallow deer are probably one of the autochthonous population in the world (Baker et al., 2017; Arslangündoğdu et al. 2010), their reintroduction to new sites and a study of their spatial behaviour are important for the viability of the species.

The success of this reintroduction will lower the extinction risk of fallow deer in Turkey. In order to improve management of reintroduced fallow deer population, knowledge about the species has been enhanced by documenting important parameters such as home range sizes and resource use of reintroduced fallow deer. This study has provided the first-ever data on the spatial ecology of fallow deer in Turkey. Seasonal and sex-related differences in home range sizes and habitat selections, and changes in their social structure over seasons and years help us better understand the population's future and provide clues to its management.

It appears that within a year, or even within a few months, the translocated deer adapted to their environment, expanding their range further into suitable habitat, finding food and water resources and avoiding perceived danger by settling down into stable home ranges and/or social groups. A mix of habitats with both tall forest (for safety) and tall shrubland and/or open oak woodland are preferred by both sexes, although there are differences between sexes, probably driven by the greater nutritional needs of females. Mating strategies show flexibility but are in general agreement with expectations.

Several conservation and management implications can be derived from the results of this study:

- Monitoring with camera traps, especially during the fawning season, is necessary to obtain demographic parameters of the population, particularly population size, reproduction success, rates of survival, and causes of mortality. It will also inform managers about the possible expansion of deer into new areas. Camera traps can also show poaching activity if placed at strategic paths.

- The importance of (artificial) water sources, especially for females and their fawns during the dry season, is evident. Regular visits for timely detection of any unexpected situation, like clogging of water flow at artificial water sources, are recommended.

- Genetic variation of the study population should be closely monitored against the possibility of increased inbreeding. It may be necessary to augment the population with newly captured individuals, especially females, from outside the fenced breeding center in Düzlerçamı to increase genetic diversity.

- The number of cattle and horses inside the Dilek Peninsula NP are an ongoing problem. They are not only competitors with the deer but may also transfer diseases. Therefore, their numbers should be reduced, or better still, they should be completely removed from the protected area using appropriate methods.

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# CURRICULUM VITAE

**1. Family Name:** Durmuş

**2. Name:** Mustafa

**3. Date of Birth:** 23.09.1981

**4. Nationality:** Turkish

**5. Civil Status:** Single

**6. Education:**

| **Institution [Date from - Date to]** | **Degree(s) or Diploma(s) obtained:** |
|---|---|
| Middle East Technical University<br>2010-2019 | Ph.D. in *Biology* |
| Middle East Technical University<br>2008-2009 | M.Sc. in *Biology* |
| Middle East Technical University<br>2003-2007 | B.S. in *Biology* |

**7. Language skills:** Indicate competence on a scale of 1 to 5 (1 - excellent; 5 - basic)

| Language | Reading | Speaking | Writing |
|---|---|---|---|
| Turkish (mother tongue) | 1 | 1 | 1 |
| English | 1 | 1 | 1 |

**8. Membership of professional bodies:**

- The Society for Conservation Biology
- Nature Research Society

**9. Other skills: (e.g. Computer literacy, etc.)**

- Full computer literacy (Microsoft Office Word, Excel, Power Point..)
- GIS analysis (software - ArcGIS, TntMips, QGIS, Idrisi)
- Remote sensing analysis (software - ERDAS, Monteverdi)
- Ecological analysis (software – Distance (software for the design and analysis of distance sampling surveys of wildlife populations); RAMAS EcoLab (Software for the applied population ecology))
- Statistical analysis (R statistical software, SPSS, Minitab)
- Home range and Habitat selection analysis (Kernel, minimum convex polygon, Kernel Brownian Bridge, K-Select, Ecological Niche Factor Analysis)

**10. Present position:** Environmental Advisor at TEKFEN Construction

**11. Years within the firm:** 4 years

**12. Key qualifications:**

Qualification and skills:

- Master of Science in Ecology
- Project Specialist
- Conservation Biologist & Ecologist & Wildlife Biologist
- Large mammal expert
- Mapping and GIS specialist

General professional experience:

- 10 years of professional experience with conservation biology projects supported by TUBİTAK
- Experience in database management, GIS analysis, mapping in conservation biology projects
- Field techniques (Radiotelemetry, GPS telemetry, camera trapping)
- Habitat, biodiversity and endangered species conservation

Specific professional experience:

- Reintroduction Studies
- Gap Analysis and Systematic Conservation Planning
- Monitoring large mammals and large mammal population census techniques
- Environmental advisory for pipeline projects

## 13.Specific experience in the region:

| Country | Date from - Date to |
|---|---|
| Turkey | 2005-2016 |

## 14.Professional experience

| | | |
|---|---|---|
| **1** | **Date from- to** | 05.2005-10.2009 |
| | **Location** | Ankara, Karaman-Turkey |
| | **Position** | Research assistant (Volunteer) |
| | **Description** | **Developing new techniques in conservation strategies of reintroduced Anatolian mouflon (*Ovis gmelinii anatolica*) population with environmental and genetic data by radiotelemetry and genetic sampling methods**<br><br>The project is focused on reintroduction and monitoring of Anatolian mouflon (Ovis gmelinii anatolica) population to its past distribution sites; Nallıhan – Ankara and Karadağ – Karaman. The species is endemic to Turkey and considered as ancestor of domestic sheep. Throughout the project, home range, habitat selection and demographic parameters of reintroduced population were searched by using radiotelemetry and census techniques. |
| | **Company& reference person (name & contact details)** | Middle East Technical University<br>TUBITAK<br>Turkish General Directorate of Nature Protection and National Parks<br>Dr. Deniz Özüt- denizozut@gmail.com<br>Dr. Hasan Emir – hemir@ormansu.gov.tr |
| **2** | **Date from- to** | 06.2007-06.2009 |
| | **Location** | Konya-Turkey |
| | **Position** | Research assistant (Volunteer) |

| | | |
|---|---|---|
| | **Description** | **Estimation Of Demography And Seasonal Habitat Use Patterns Of Anatolian Mouflon (*Ovis gmelinii anatolica*) In Konya Bozdag Protection Area Using Distance Sampling**<br><br>The goals of the project are to clarify demographic parameters and sexual and seasonal differences in habitat use of Anatolian mouflon (Ovis gmelinii Anatolia). In order to achieve these aims, Bozdağ Anatolian mouflon population census were organised regularly and data collected in the census were analysed for estimating, population parameters like growth rate, sex ratio, reproductive success, birth and death rate etc. |
| | **Company& reference person (name & contact details)** | Middle East Technical University<br>TUBITAK<br>Turkish General Directorate of Nature Protection and National Parks<br>Expert biologist Lütfiye Özdirek- lutfiyeozdirek@gmail.com<br>Dr. Hasan Emir – hemir@ormansu.gov.tr |
| 3 | **Date from- to** | 07.2007-09.2007 |
| | **Location** | Antalya-Turkey |
| | **Position** | Intern (Summer practice) |
| | **Description** | **Sea Turtle (*Caretta caretta*) Conservation and Research Project**<br><br>The project aims to find out hatching census and statistical analysis of hatching success for the nests during hatching emergence season. To do this, the beaches were surveyed regularly to detect nests and monitor the detected nests till hatching time. |
| | **Company& reference person (name & contact details)** | Ecological Research Society<br>Dr. Ali Fuat Canbolat-canbolat@hacettepe.edu.tr |
| 4 | **Date from- to** | 11.2007-11.2010 |
| | **Location** | Şanlıurfa-Turkey |
| | **Position** | Project assistant |

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| | **Description** | **Evaluation of the adaptation process of the re-introduced Gazelle (*Gazella subgutturosa*) genetically by microsatellite analysis and ecologically by radio-telemetry and GPS-telemetry**<br><br>Within the scope of this project, gazelles which were captured in breeding center were released into sites that their past distribution covers. Captured gazelles were tagged with GPS collars, VHF collars and ear tags and monitored throughout 2 years. Seasonal and sexual space use of animals, their home ranges and demographic parameters were estimated by using collected location data. |
| | **Company& reference person (name & contact details)** | Middle East Technical University<br>Harran University<br>TUBITAK<br>Turkish General Directorate of Nature Protection and National Parks<br>Assoc. Prof. Meral Kence- mkence@metu.edu.tr |
| **5** | **Date from- to** | 01.2012-02.2014 |
| | **Location** | Aydın, Muğla, Antalya-Turkey |
| | **Position** | Project assistant |
| | **Description** | **Planning the reintroduction of the only global autochthonous population of Fallow Deer (*Dama dama*) to suitable new sites through habitat modelling, site assessment and population viability analysis and the monitoring of release with telemetry**<br><br>Suitable places for fallow deer in Turkey were obtained by using a preliminary modelling study and the most suitable ones, Dilek Peninsula National Park in Aydın and Köyceğiz Wildlife Reserve Area in Muğla were selected for reintroduction. GPS collared and tagged deer were transferred to these sites. Post-release monitoring was performed by using GPS telemetry, radiotelemetry and camera trapping techniques. Obtained location data were used to assess their adaptive success to those places. To achieve these, their movement patterns were analyzed by using GIS software and demographic parameters |

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| | | of reintroduced populations, seasonal and sexual differences in habitat selection and home range sizes were estimated. |
| | **Company& reference person (name & contact details)** | Middle East Technical University<br>TUBITAK<br>Turkish General Directorate of Nature Protection and National Parks<br>Prof. Dr. Can Bilgin-cbilgin@metu.edu.tr |
| **6** | **Date from- to** | 01.2011-12.2011 |
| | **Location** | Turkey |
| | **Position** | GIS expert |
| | **Description** | **Systematic Conservation Planning of Black Sea Region**<br><br>Within the scope of this project, prior conservation sites in the Black Sea region were identified. Monitoring and management guidelines for these sites according to Systematic Conservation Planning methods were developed. |
| | **Company& reference person (name & contact details)** | General Directorate of Forestry<br>World Wildlife Fund Turkey<br>Nature Conservation Center<br>Dr. Uğur Zeydanlı-ugur.zeydanli@dkm.org.tr |
| **7** | **Date from- to** | 01.2011-12.2011 |
| | **Location** | Turkey |
| | **Position** | GIS expert, Data officer |
| | **Description** | **Red Book of Butterflies in Turkey**<br><br>Identifying the butterfly species that are needed to be conserved in Turkey is the aim of this study. This group is quite vulnerable to environmental changes and a good indicator of the health of an ecosystem. Within the scope of this project, a database was created by using all the data in literature published and field surveys. These data were assessed by specialists to designate the threat status of butterfly species. |
| | **Company& reference person (name & contact details)** | Nature Conservation Center<br>Dr. Uğur Zeydanlı-ugur.zeydanli@dkm.org.tr |
| **8** | **Date from- to** | 01.2011-12.2011 |

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| | **Location** | Turkey |
| | **Position** | GIS expert, Data officer |
| | **Description** | **Integrating of Biodiversity into Forest Management**<br><br>To present applicable and cost-effective forest management strategies is the aim of this project. Key biodiversity elements were determined for each forest management directorate for this purpose and forest management strategies were proposed to them by taking key biodiversity components into consideration. |
| | **Company& reference person (name & contact details)** | Nature Conservation Center<br>Dr. Uğur Zeydanlı-ugur.zeydanli@dkm.org.tr |
| **9** | **Date from- to** | 08.2012-03.2013 |
| | **Location** | Turkey |
| | **Position** | GIS expert |
| | **Description** | **Mapping of Bird Mobility in Turkey**<br><br>The aim of this project is to identify major and minor migration routes of migratory birds in Turkey. In order to achieve this, literature data and "www.kusbank.org.tr" data were collected and all the bird species were classified by their migratory status. All species' Turkey distribution and their migratory routes were visualized by using their records in GIS environment. |
| | **Company& reference person (name & contact details)** | Ondokuzmayıs University<br>Ministry of Forestry and Water Affairs<br>Assist. Prof. Dr. Kiraz Erciyas-kiraze@omu.edu.tr |
| **10** | **Date from- to** | 02.2013-01.2014 |
| | **Location** | İzmir-Turkey |
| | **Position** | GIS expert |
| | **Description** | **Seferihisar Natural Heritage Project**<br><br>Seferihisar is accepted as "Natural Heritage Area" in "Key Biodiversity Areas of Turkey" project. Within the scope of this project, flora and fauna specialists recorded data during field surveys. Records of each |

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| | | species and their distribution were processed in GIS environment and visualized. |
| | **Company& reference person (name & contact details)** | Ecological Solutions<br>Özgür Koç-ozgur.koc@ekolojikcozumler.com |
| **11** | **Date from- to** | 03.2014-11.2014 |
| | **Location** | Sinop-Turkey |
| | **Position** | Assistant Mammal Specialist |
| | **Description** | **Inventory and Monitoring Biodiversity of Terrestrial and Inland Water Ecosystems in Sinop**<br><br>The project covers the biodiversity of Sinop province. Within this context, mammal species of Sinop were detected by both searching literature and field surveys. Detection of mammal species was performed by identifying animal tracks and feces, any other signs remaining in nature and camera traps. The records of mammal species were used to define their distribution in Sinop. Important mammal species for biodiversity of Sinop were determined and conservation and monitoring strategies were developed. |
| | **Company& reference person (name & contact details)** | Turunç Peyzaj<br>Seda Yıldız turuncpeyzaj@gmail.com |
| **12** | **Date from- to** | 07.2013-11.2014 |
| | **Location** | Adana-Turkey |
| | **Position** | Mammal specialist |

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| | **Description** | **Inventory and Monitoring Biodiversity of Terrestrial and Inland Water Ecosystems in Adana**<br><br>Biological diversity of Adana was documented within the scope of this project. Major species groups; mammals, birds, amphibians, reptiles, inland water fishes, invertebrates and plants were studied for this goal. Data were collected by both present literature records and field surveys.<br><br>In the field, animal species were recorded by identifying their tracks and feces and any other signs remaining in nature. Camera traps were also used for detection. By using these data, distribution of mammal species in Adana province were determined. Important mammal species for biodiversity of Adana were determined and conservation and monitoring strategies were developed. |
| | **Company& reference person (name & contact details)** | Nature Research Society<br>Osman Erdem-osman.erdem@dogaarastirmalari.org |
| **13** | **Date from- to** | 10.2014-03.2015 |
| | **Location** | Muğla, Adana-Turkey |
| | **Position** | Large mammal specialist |
| | **Description** | **Integrated Approach to Management of Forests, with Demonstration in High Conservation Value Forests in the Mediterranean Region (2014:P37-GEF-5) Biodiversity Assessment of Köyceğiz and Pos Forestry Operation Directorate**<br><br>Target large mammal species of Köyceğiz and Pos Forestry Operation Directorate dependent upon forest for their life were determined. Field surveys and literature reviews have conducted to handle location data of these species. Obtained records are going to use modelling distribution of these species. After these studies, important forest parts would be presented and forestry application for conserving these species will be recommended. |

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| | **Company& reference person (name & contact details)** | Nature Conservation Center<br>Dr. Uğur Zeydanlı-ugur.zeydanli@dkm.org.tr |
| **14** | **Date from- to** | 03.2015-present |
| | **Location** | Yozgat, Kırşehir, Kırıkkale, Ankara, Eskişehir - Turkey |
| | **Position** | Environmental Advisor |
| | **Description** | **Trans Anatolian Natural Gas Pipeline Project (TANAP)**<br><br>The project aims to transfer Azerbaijan natural gas to Europe by passing through Turkey. Minimizing the effect of construction works on sensitive environmental and ecological receptors along the route is one of the main purposes of the project in terms of environment. Protecting freshwater sources and topsoil during construction works, taking appropriate actions for this purpose and supervising their efficiency are among the standardized works for nature conservation in this project. Endemic species, narrowly distributed species and species of conservation concern are determined and construction team is informed about their sensitivities by trainings and warned about possible disturbances on these species and mitigation measures. |
| | **Company& reference person (name & contact details)** | TEKFEN Construction<br>TANAP A. Ş.<br>İpek Gülkaya Taşgın-itasgin@tekfen.com.tr<br>Mutlu Erdem-mutlu.erdem@tanap.com<br>Yücel Suat Güngör-yucel.gungor@tanap.com |

## 15. Other relevant information (e.g., Publications)

### MS. Thesis

- Determination of Home Range Size and Habitat Selection of Gazelles (*Gazella subgutturosa*) By GPS Telemetry in Şanlıurfa

**PhD. Thesis**

- Determining Space Use and Demography of a Reintroduced Fallow Deer (*Dama dama*) Population by Using GPS Telemetry in Dilek Peninsula National Park, Turkey

**Publications at International Peer-review journals**

- Zeydanlı, U.S., Turak, A.S., Balkız, Ö., Özüt, D., Ertürk, A., Welch, H., Karaçetin, E., Ambarlı, D., **Durmuş, M**., Bilgin, C., Identification of Prime Butterfly Areas in Turkey using systematic conservation planning: Challenges and Opportunities, 2012. Biological Conservation, 150:86-93
- Gürler Ş., Bozkaya F., Özüt D., **Durmuş M**., Some morphological characteristics and neonatal weights of re-introduced gazelle (*Gazella subgutturosa*) in Turkey, 2015. Turkish Journal of Zoology, 39:

**Poster Presentations at International Conferences**

- **Durmuş, M.**, Çobanoglu, A.E., Özut, D., Gürler, Ş., and Toprak Ş., Kence, M., – Second European Congress of Conservation Biology 1-5.09.2009
- Özdirek, L., Özut D., **Durmuş M**., Kence A., Demography and Habitat Selection of Anatolian Mouflon in Konya Bozdağ Protection Area., 2nd European Congress of Conservation Biology, Czech University of Life Sciences p: 199, 1-5.09.2009

**Oral Presentations at National Conferences**

- Reintroduction of Fallow deer (*Dama dama*) from Düzlerçamı-Antalya to Dilek Peninsula National Park in Aydın, Conservation and Monitoring by GPS GSM collars and Camera Traps, 21. National Biology Congress, İzmir, Türkiye

**Attended International and National Congress, Meetings**

- Second European Congress of Conservation Biology, Prague, Czech Republic, 1-5 Eylül 2009
- Third European Youth Perspective Conference on Biodiversity, Geel, Antwerp, Belgium, 1-6 Temmuz 2010

- 21. National Biology Congress, İzmir, Türkiye, 3-7 Eylül 2012

**Published Book Chapters, Reports etc.**

- Turak, A., Balkız, Ö., Ambarlı, D., **Durmuş, M**., Özkil, A., Yalçın, S., Özüt, D., Kınıkoğlu, Y., Meydan Kocaman, T., Cengiz, S., Albayrak, F., Kurt, B., Zeydanlı, U., Bilgin C. 2011. Black Sea Region Systematic Conservation Planning, Ankara. Nature Conservation Center.
- Özdirek, L., **Durmuş, M.,** Chapter 32: Animal Kingdom, Schaum's Outline of Biology, pp:413-429.