EVALUATION OF THE ADAPTATION PROCESS OF A REINTRODUCED ANATOLIAN MOUFLON (*Ovis gmelinii anatolica*) POPULATION THROUGH STUDYING ITS DEMOGRAPHY AND SPATIAL ECOLOGY

EVALUATION DU PROCESSUS D'ADAPTATION D'UNE POPULATION RÉ-INTRODUITE DE MOUFLON (*Ovis gmelinii anatolica*) PAR L'ÉTUDE DE SA DÉMOGRAPHIE ET DE SON ÉCOLOGIE SPATIALE

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY
AND
À L'ÉCOLE DOCTORALE SEVAB
DE
L'UNIVERSITÉ PAUL SABATIER - TOULOUSE III

BY

DENİZ ÖZÜT

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
BIOLOGICAL SCIENCES

NOVEMBER 2009

Approval of the thesis:

EVALUATION OF THE ADAPTATION PROCESS OF A REINTRODUCED ANATOLIAN MOUFLON (*Ovis gmelinii anatolica*) POPULATION THROUGH STUDYING ITS DEMOGRAPHY AND SPATIAL ECOLOGY

submitted by **DENİZ ÖZÜT** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in the Department of Biological Sciences, Middle East Technical University and to l'École Doctorale SEVAB de l'Université Paul Sabatier - Toulouse III** by,

Prof. Dr. Canan Özgen ________________
Dean, **Graduate School of Natural and Applied Sciences**

Prof. Dr. Zeki Kaya ________________
Head of Department, **Biological Sciences, METU**

Prof. Dr. Aykut Kence ________________
Supervisor, **Biological Sciences, METU**

Dr. A. J. Mark Hewison (France) ________________
Co-Supervisor, **INRA, Université Paul Sabatier**

Examining Committee Members:

Prof. Dr. Aykut Kence ________________
Supervisor, Biological Sciences Dept., METU

Prof. Dr. Yüksel Coşkun ________________
Dept. of Biology, Dicle University

Assoc. Prof. Dr. C. Can Bilgin ________________
Biological Sciences Dept., METU

Assoc. Prof. Dr. Ergi Deniz Özsoy ________________
Dept. of Biology, Hacettepe University

Dr. A. J. Mark Hewison (France) ________________
Co-Supervisor, INRA, Université Paul Sabatier

Prof. Dr. Stéphane Aulagnier (France) ________________
INRA, Université Paul Sabatier

Dr. Pierrick Blanchard (France) ________________
Evolution et Diversité Biologique, Uni. Paul Sabatier

Date: 25/11/2009

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name : Deniz Özüt

Signature :

ABSTRACT

EVALUATION OF THE ADAPTATION PROCESS OF A REINTRODUCED ANATOLIAN MOUFLON (*Ovis gmelinii anatolica*) POPULATION THROUGH STUDYING ITS DEMOGRAPHY AND SPATIAL ECOLOGY

Özüt, Deniz
Ph.D., Department of Biological Sciences
Supervisor: Prof. Dr. Aykut Kence
Co-Supervisor: Dr. A. J. Mark Hewison

November 2009, 156 pages

In this thesis the demography, home range and habitat selection of a reintroduced population of Anatolian mouflon (*Ovis gmelinii anatolica*), which had a single remaining population, was studied to evaluate the reintroduction success and determine the conservation management interventions.

For this purpose among 104 individuals reintroduced in Sarıyar Wildlife Protection Area (Ankara, Turkey), 40 adults were radio-collared and 28 juvenile were ear-tagged and monitored from 2005 to 2009. The survival of the population according to the age groups (females, 0: 0.5423, 1: 0.60, 2: 0.5316, 3: 0.6637, 3+: 0.6728) and the fecundity of adult females (2: 0.2260, 3: 0.2034, 3+: 0.2034) are estimated. A population viability analysis was performed and the persistence of the population within the next 20 years was estimated. Increasing the survival rate of adult female through conservation or restocking the population with at least six adult females every year decreased the risk of extinction in the near future considerably.

The year-round home ranges of the individuals ranged between 805 – 3435 ha. (Mean ± SE: 1934 ± 140 ha). The movements of the tracked individuals followed seasonal patterns: centers of activities changed according to seasons in 80% of the adult mouflon. Reintroduced mouflon selected southern aspects (p=0.001), increasing slopes – especially medium to high slope terrain – (slope > 30°, p=0.002), and distant locations to villages and roads.

Results indicate that appropriate protective measures should be implemented immediately to mitigate the causes of juvenile mortality. Restocking the population for the next 10 years with adult females would have a stabilizing effect on the declining population and will act as a buffering mechanism during the adaptation period to the new area.

Keywords: Anatolian mouflon, reintroduction, demography, home range, habitat selection, radiotelemetry, population viability analysis.

ÖZ

YENİDEN AŞILANAN BİR ANADOLU YABAN KOYUNU (*Ovis gmelinii anatolica*) TOPLUMUNUN DEMOGRAFİSİ VE UZAMSAL EKOLOJİSİ ARAŞTIRILARAK UYUM SÜRECİNİN DEĞERLENDİRİLMESİ

Özüt, Deniz
Doktora, Biyolojik Bilimler Bölümü
Tez Yöneticisi: Prof. Dr. Aykut Kence
Ortak Tez Yöneticisi: Dr. A. J. Mark Hewison

Kasım 2009, 156 sayfa

Bu çalışmada, insan kaynaklı baskılardan dolayı yaşayan tek bir toplumu kalan Anadolu yaban koyununun (*Ovis gmelinii anatolica*) eski yaşam alanlarından birine yeniden aşılama çalışmasının başarısını ölçmek ve gerekli koruma stratejilerini zamanlı bir şekilde belirlemek için, yaban koyunu toplumunun demografisi, yaşam alanı ve habitat seçimi çalışılarak, toplumun karşı karşıya kaldığı sorunlar ortaya çıkartılmıştır.

Bu amaçla, yeniden aşılamaların yapıldığı 2005 – 2009 yılları arasında 40 erişkin birey radyo-vericili tasmalar ve 28 yavru kulak

markalarıyla işaretlenmiş ve haftalık ilâ aylık sıklıklarda değişen aralıklarla takip edilmiştir. Çalışma sonunda toplum yaşama başarısı ve doğurganlık yaş gruplarına göre tahmin edilmiştir (Yaşama başarısı, dişiler üzerinden 0: 0,0873, 1: 0,1398, 2: 1,000, 3: 0,4131, 3+: 0,4442; doğurganlık, erişkin dişiler için, 2: 0,3750, 3: 0,2315, 3+: 0,3239). Yavru yaşama başarısının oldukça düşük olmasının nedenleri evcil sürü köpeklerinin saldırı ve hırpalamaları ile kurt gibi avcı türlerin verdiği zarardır. Bu zararın boyutunun bu derece yüksek olması ise bireylerin esaret altında yetişmiş bir toplumdan ve bu tehlikelere karşı tecrübesiz olmalarının yanı sıra kendilerine yabancı bir bölgede bulunmalarıdır. Yapılan toplum yaşayabilirlik analizi soncunda toplumun her yıl en az altı erişkin dişi birey ile desteklenmesi durumunda 30 civarında bir sayıda kalabileceği tahmin edilmiştir.

İzlenen bireylerin yaşam alanları büyüklükleri 805 – 3435 ha arasında değiştiği tahmin edilmiştir (Ortalama ± Standart Hata: 1934 ± 140). Habitat seçimi analizi sonuçlarında yaban koyunlarının güney bakıları ($p<0,001$), orta ve yüksek eğimleri (eğim>30°, $p<0,001$), ve yerleşim yerleri ile yollardan uzak alanları seçtiği görülmüştür.

Çalışmanın sonuçları, yavru ölümlerinin azaltılması için gerekli olan önlemlerin – evcil sürülerin doğum dönemi ve sonrasında alana girmesinin önlemesi gibi – bir an önce alınmasının gerekliliğini göstermiştir. Önümüzdeki 10 yıl boyunca her yıl, yeni erişkin dişi bireylerin yeniden aşılanan topluma katılmasının, nüfusu belirli bir seviyede tutarak uyum sürecindeki yok olma riskini azaltacağı söylenebilir.

Anahtar Kelimeler: Anadolu yaban koyunu, yeniden aşılama, demografi, yaşam alanı, habitat seçimi, radyo telemetri.

RÉSUMÉ

EVALUATION DU PROCESSUS D'ADAPTATION D'UNE POPULATION RÉ-INTRODUITE DE MOUFLON (*Ovis gmelinii anatolica*) PAR L'ÉTUDE DE SA DÉMOGRAPHIE ET DE SON ÉCOLOGIE SPATIALE

Özüt, Deniz
Doctorat, Département des Sciences Biologiques
Directeur: Prof. Dr. Aykut Kence
Co-Directeur: Dr. A. J. Mark Hewison

Novembre 2009, 156 pages

Dans cette thèse la démographie, domaine vital et la selection d'habitat d'une population réintroduite de mouflons Anatoliens (*Ovis gmelinii anatolica*), qui etait restraint a une seule population, a été étudiée pour évaluer le succès de réintroduction et pour déterminer les interventions de gestion opportunes.

À cette fin 40 individus adultes ont été radio-colletés et 28 juvéniles ont été étiquetés a l'oreille et dépistés de 2005 à 2009. La survie de la population selon les groupes d'âge (femelles, 0:0.5423, 1:0.60, 2: 0.5316, 3:0.6637, 3+ : 0.6728) et la fécondité des femelles adultes (2 : 0.2260, 3:0.2034, 3+ : 0.2034) est estimée. Une analyse de viabilité de population a été exécutée et on a estimé que la persistance de la population pendant 20 ans est réalisée en réapprovisionnant la population avec au moins six femelles adultes chaque année.

Les domaine vital des individus se sont étendues entre 805 - 3435 ha. (moyen de ±. : 1934 ± 140 ES). Les movements des individus tracés ont suivit des tendances saisonières. Les centres d'activités ont montrées des variances saisonières dans 80% des mouflons adultes.

Les résultats de choix d'habitat ont montré une préférence des aspects méridionaux ($p < 0.001$), de moyen à haut terrain de pente (pente > 15°, $p < 0.001$) et une distance de >1 kilomètre. à partir des établissements humains ($p < 0.05$).

Les résultats indiquent que des mesures de sauvegarde appropriées soient appliquées immédiatement afin d'atténuer les causes de la mortalité juvénile. Réapprovisionner les femelles adultes à la population pendant les 10 années suivantes aura un effet stabilisant sur la population actuellement en déclin et agira comme une mechanisme de tampon pendant la periode d'adaptation à la nouvelle région.

Mots-clés: Mouflon, réintroduction, démographie, domaine vital, choix d'habitat, radiotélémétrie.

To Hande, Güney, Leyla, Eser & Doğan

ACKNOWLEDGMENTS

The author wishes to express his deepest gratitude to his supervisors Prof. Dr. Aykut Kence and Dr. A. J. Mark Hewison for their guidance, advice, criticism, encouragements and insight throughout the research. The author would also like to thank Assoc. Prof. Dr. C. Can Bilgin and Prof. Dr. Stéphane Aulagnier for their suggestions and comments. The technical assistance of Dr. Ayşe Turak, is gratefully acknowledged.

I am grateful to many undergraduate and graduate students who helped me in the field and in other circumstances. To name a few of them, I thank to Lütfiye Özdirek, Alper Ertürk, Mustafa Durmuş, Emre Çobanoğlu, Tolga Kankılıç, Mert Elverici, Emel Durmaz, Aytaç Emecen, Cevza Altunkara, Teslime, Deniz Mengüllüoğlu, Damla Beton, Ayhan Altun and Rahşan İvgin Tunca. Without their help this study could not be realized.

The help and cooperation of the responsible officers in General Directorate of Nature Protection and National Parks are acknowledged. I thank a lot, to many National Park local officers who worked with me in the field day and night. Many thanks to the Director and all other personnel of Sarıyar Elektrik A.Ş. and Mayor of Sarıyar who provided us food and shelter during our field studies.My special thanks to Turist Turan and Hüseyin Kılıç from Sarıyar, Halis abi and Ahmet from Nallıhan for their help throughout the field study.

I find the energy and strength to work with their loving support and understanding, thank you very much Hande, Güney, Leyla, Esko and Dodo; and our always cheerful and most helpful friends Hüma and Uğur.

This study was supported by the TÜBİTAK Project No: 106T182, Turkish Directorate of Nature Protection and National Parks, French Embassy in Ankara and METU-BAP.

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CHAPTER I

INTRODUCTION

1.1. Anatolian mouflon

Anatolia is homeland of many endemic species and a center of biodiversity. From the perspective of man, this biodiversity of Anatolia has provided its inhabitants a multitude of agronomic opportunities such as cultivation of wheat and domestication of sheep (*Ovis aries*) and goats (*Capra hircus*). Recently, Naderi et al. (2008) indicated that one of the domestication centers of goats is Eastern Anatolia. Hiendleder et al. (2002) indicated that the mouflon subspecies found in Anatolia (*Ovis gmelinii anatolica* and *O. g. gmelinii*) are the most probable ancestors of domestic sheep. Not only being an endangered species and the only large herbivore found in low altitude of Anatolian steppes, but also being the ancestor of such an economically important species, Anatolian mouflon deserves a concentrated effort of research and conservation.

1.1.1. General Characteristics

Anatolian mouflon looks more like a deer than a domestic sheep. It is taller, owing to its longer fore and hind legs, longer neck and its more slender body. The males weigh 45 to 74 kg, while the females weigh 35 to 50 kg. The longevity of Anatolian mouflon is 15 to 18 years. The body length of Anatolian mouflon, from nose to end of tail, varies from 105 – 140 cm. The breast height of males is about 80-90 cm, while females' breast heights vary from 80 – 85 cm (Kaya, 1991). Their hind legs are longer thn the front legs, which make them very good runners, and so they prefer smoothly curved and open landscapes instead of steep slopes and rocky hills, which are preferred by wild goat (*Capra aegagrus*) in Anatolia. Males of *O. g. anatolica* and *O. g. gmelinii* have permanent horns that can reach up to 75 cm in total length. In males, horns are thick, large and stretch towards the sides and then loop towards the back of the animal. The age of the males can be determined by the annual rings on the horns. The horns of the females of *O. g. gmelinii* are short and blunt, and can grow up to 20 cm. (Arıhan, 2000). A minority of the females of *O. g. anatolica* also have horns with the longest recorded length of 15 cm (Deniz Özüt, unpublished data). Fur of Anatolian mouflon is tawny colored, which helps to its sort of camouflaging against the dominant coloration of its habitat. They shed their fur in May and June. The hair of summer coating is short, thick, sparse and light-colored, while the hair of winter coating is long, thin, dense and dark-colored (Kaya, 1989). Breeding occurs in November and December every year and adult males compete with each other. Except for the rutting season, adult males rarely form groups with females. The gestation period lasts five months and either one or two lambs are born per female.

1.1.2. Taxonomy of Anatolian Mouflon

There are five species of genus *Ovis* in the world. The four of them are as follows: *O. ammon* is known as Argali sheep and lives in Asia; *O. nivicola* is known as snow sheep and found in northeastern Russia; *O. canadensis*, the bighorn sheep, is found in North America; *O. dalli*, known as thinhorn sheep, is found in northern North America (Shackleton, 1997). The fifth species' taxonomy is not clarified yet. This fifth species comprises mouflon and urial sheep. In the last Status Survey and Conservation Action Plan for Caprinae (the subfamily containing *Capra*, *Ovis* and other ungulates), IUCN/SSC Caprinae specialist group includes both mouflon and urial sheep into a single species called *Ovis orientalis* (Table 1.1).

Table 1.1 Classification of mouflons and urials, taken from Shackleton (1997).

Species	Subspecies	Common name	Countries within range
Ovis orientalis Gmelin, 1774		Mouflons and urials	
	O. o. arkal Eversmann, 1850	Transcaspian urial	Iran, Kirgizistan, Uzbekistan, Turkmenistan
	O. o. bocharensis Nasonov, 1914	Bukhara urial	Tadjikistan, Uzbekistan, Turkmenistan
	O. o. cycloceros Hutton, 1842	Afgan urial	Afghanistan, Iran, Pakistan, Turkmenistan
	O. o. gmelinii Blyth, 1841	Armenian mouflon	Armenia, Azerbaijan, Nakhichevan, Iran, Iraq, Turkey
	O. o. isphahanica Nasonov, 1910	Esfahan mouflon	Iran
	O. o. laristanica Nasonov, 1909	Laristan mouflon	Iran
	O. o. musimon Schreber, 1782	European mouflon	France, Italy
	O. o. ophion Blyth, 1841	Cyprian mouflon	Cyprus
	O. o. orientalis Gmelin, 1774	Red sheep	Iran
	O. o. punjabiensis Lydekker, 1913	Punjab or Salt Range urial	Pakistan
	O. o. severtzovi Nasonov, 1994	Severtzov's urial	Uzbekistan
	O. o. vignei Blyth, 1841	Ladakh urial or Shapu	India

In the same book Shackleton and Lovari (1997) explains the conflict in classification in following words (Shackleton, 1997):

> "[Mouflon and urial sheep] are either classified as a single species (*Ovis orientalis*), or as separate species (mouflon (*O. gmelinii*) and urial (*O. vignei*)). Part of the problem revolves around the significance of diploid (2n) chromosome number (i.e. total number of chromosomes) for speciation. In *Ovis*, the number of diploid chromosomes varies from 2n = 54 in mouflon, to 2n = 58 in urial. However, populations with individuals carrying 2n = 55 and 2n = 56 chromosomes are known, and have been considered to be hybrid populations (Valdez et al., 1978). An additional factor is the presence (in urials) and absence (in mouflons) of throat bibs, which also vary in these "hybrid populations". Based on these two criteria, Valdez et al. (1978) suggest that the name *Ovis orientalis* (Blyth, 1841) be rejected because the description was based on a specimen from Sardinia from a hybrid population in the Albroz Mountains of northern Iran. … Hence they suggest that the oldest name, *gmelinii* (Blyth, 1841) should be applied to mouflons."

At the last meeting of IUCN/SSC Caprinae specialist group, which was held in Ankara, Turkey in June 2000, it has been stated that mouflons and urials should be given different species names as *O. gmelinii* and *Ovis vignei*, respectively.

Table 1.2. Diploid chromosome numbers of some of the mouflons and urials (Nadler et al, 1973; Bunch 1978, 1998)

Species / Subspecies name	Number of diploid chromosomes (2n)
Ovis orientalis anatolica	54
O. o. orientalis	54
O. o. musimon	54
O. o. vignei	58

Ovis gmelinii was first described by Gmelin in 1774 and named as *Ovis orientalis*. Then Blyth described the subspecies living in Turkey, Armenia and Iran as *Ovis orientalis gmelinii* in 1841, and the other subspecies living in Central Anatolia was described by Valenciennes as *Ovis orientalis anatolica* in 1856. Ellerman and Morrison-Scott (1966), Mursaloğlu (1964) and Kaya (1990) had reviewed their taxonomic status and accepted the Central Anatolian subspecies as *Ovis orientalis anatolica* (Valenciennes, 1856) as an endemic subspecies to Turkey and the Eastern Anatolian subspecies as *Ovis orientalis gmelinii*. Considering all of these information and also Arıhan (2000), we decided to use the name *Ovis gmelinii anatolica* for the Anatolian mouflon living in Central Anatolia and *Ovis gmelinii gmelinii* for the Eastern Anatolian subspecies, so-called Armenian mouflon. Therefore the taxonomy of the Anatolian mouflon in Central Anatolia is:

Class – *Mammalia*

Order – *Cetartiodactyla*

Suborder – *Ruminantia*

Family – *Bovidae*

Subfamily – *Caprinae*

Genus – *Ovis*

Species – *Ovis gmelinii*

Subspecies – *anatolica*

1.1.3. History of Distribution

In Turkey, there are two subspecies of Anatolian mouflon, *Ovis gmelinii*: *O. g. anatolica* and *O. g. gmelinii*. *O. g. anatolica* is found isolated in Central Anatolia, while *O. g. gmelinii* is found in Eastern Anatolia extending towards Armenia, Nakhichevan and Iran.

Until 2005, there was only one known population of *O. g. anatolica*, which is protected in a wildlife protection area since 1966, situated at the 50th km of Konya-Aksaray highway. The first studies of Central Anatolian populations were achieved by Turkish National Parks and Game-Wildlife Department (TNPGW) administrators in 1960'ies, about the sizes and distribution of the subspecies' populations

. They found that there are small and isolated populations that were spread to Nallıhan and Polatlı in Ankara, Sivrihisar-Eskişehir, Emirdağı-Afyon, and Ereğli, Karapınar, Karadağ and Bozdağ in Konya. All the populations except the one in Konya-Bozdağ vanished out by mid-1960's. The causes of extirpation of Central Anatolian populations can be fragmentation and destruction of the habitat by anthropogenic effects such as increasing human population and its accompanying constraints, increasing land use by domestic livestock, poaching etc. Bozdağ population was the lucky one of the three populations that was started to be protected in 1965, hence it existed until today while the two other populations got extinct.

There is almost no information about the past and current status (distribution, size, and major threats) of the eastern subspecies *O. g. gmelinii*. Its distribution is described as south of Mount Ağrı, east of Lake Van and northern and eastern territories of Hakkari (Turan, 1984) and anecdotal knowledge suggests a migratory behavior between Eastern Turkey and Iran. There is also a so-called protection area, Van-Özalp, which was established in 1971, covering a 5500 ha territory. A recent field study carried out at Eastern Anatolia by a group of researchers revealed that a very small number of animals were left in the previously mentioned parts of Eastern Anatolia and that the presence of Van-Özalp wildlife protection area exists only on paper (Weinberg and Özüt, 2007).

1.1.4. Conservation of Anatolian Mouflon

With the approval Land Hunting Law in 1937, Anatolian Mouflon was declared to be under protection and its hunting was prohibited. When the first surveys on the status and distribution of Anatolian mouflon were achieved in 1967 by Turkish National Parks and Game-Wildlife Department, it was revealed that the protection law alone had not been efficient for the conservation of mouflon and the range of distribution of the animal was restricted to Bozdağ region in Konya province. According to the population counts and observations in 1967, there were around 50-100 individuals of Anatolian mouflon in the Konya-Bozdağ area (Turan, 1967, 1981, 1990). Realizing that sound actions of conservation should be immediately taken, in 1967, Ministry of Agriculture (which later separated into Ministry of Forestry and Ministry of Agriculture) declared that the 42,000 ha area in Konya-Bozdağ be a Wildlife Protection Area and employed a warden for the protection of that area.

The degree of protection was improved over the years by increasing the number of wardens and motorization by land vehicles. With time, population size of Anatolian mouflon in Konya-Bozdağ has increased. In 1989 a ca. 4000 ha of the protection was fenced and then the fence further strengthened by setting up an additional electrified fence around it. After the introduction of the fence, all of the gray wolves (*Canis lupus*) inside fence were eliminated and throughout the later years, wardens forced the individuals outside the fence to move inside. The population inside the fenced area has been supplemented with water, salt licks and even with food in harsh winters. The studies of population abundance give a clear picture of how the size of the population increased dramatically after all these treatments (Figure 1.1).

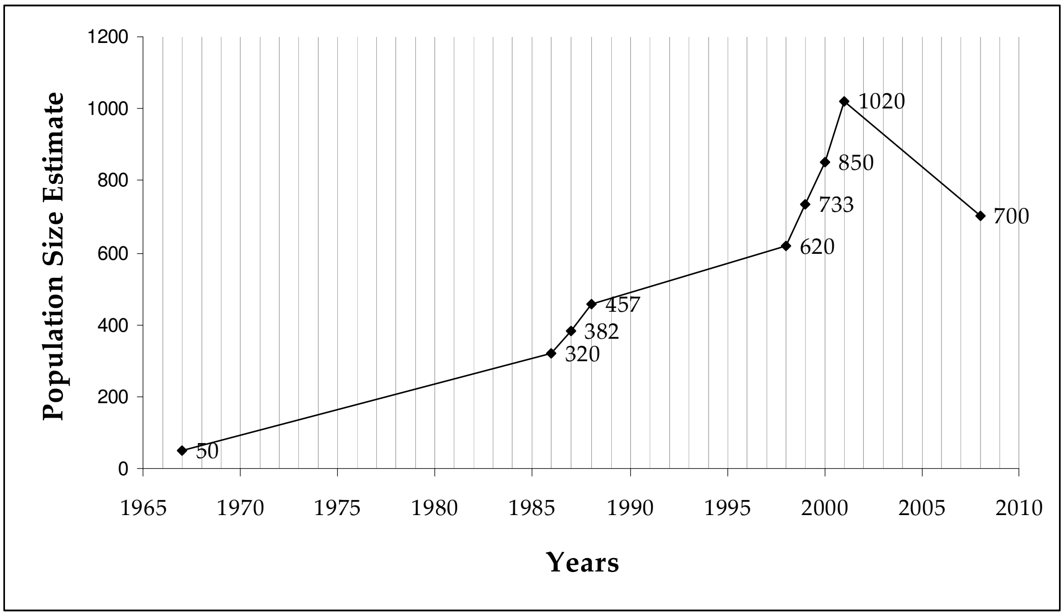


Figure 1.1. Population size change of Konya-Bozdağ Anatolian mouflon population from the start of conservation in 1967 to 2008. Population size estimates are: 1967 by Turan (1967); 1986-88 by Kaya (1989); 1999 by Arıhan (2000); 2000-2001 by Turkish Directorate of Nature Protection and Natural Parks-DNPNP (adjusted figures, see text); 2008 by Özdirek (2009).

The abundance estimates for the years before 2006 were made as total counts, while the ones after 2006 used distance sampling methodology (Özdirek, 2009). The population figures for 2000 and 2001 were estimated as 1000 and 1200, respectively, by the DNPNP. However due to the known reasons, such as double counts, these figures were overestimations and 15% of these estimates were subtracted to get conserved estimates of 850 and 1020, respectively.

The dramatic increase in the size of the population inside the fenced area gives hints about the possible causes of extirpation of Anatolian mouflon before such strict measures of protection were taken. Poaching is almost completely prevented, predators are absent, disturbance is lessened and most importantly, various adverse effects of – such as disease transmission, competition for food – domestic livestock (sheep) are no more affecting the population. In the surrounding villages, people mostly earn their salary by stockbreeding, and there are no less than 20.000 sheep using the Bozdağ area for grazing. Such a situation had been one of the most important factors decreasing the viability of Anatolian mouflon for years. Domestic sheep not only compete for food and cause rapid degradation of the productivity of the land by causing erosion due to their vast numbers, but also a notorious carrier of infectious diseases to the wild stock. These adverse effects are still influencing the Anatolian mouflon population outside the fences, whose population size was estimated to be 50-100 (Arıhan, 2000).

From 1967 until today, the best possible conservation action was taken. But today, the fenced area has already become small for the increased population of Anatolian mouflon. A population viability analysis on Konya-Bozdağ population has shown that re-introduction is an essential step in the conservation of Anatolian mouflon (Sezen, 2000).

In 2004, Turkish National Parks and Game-Wildlife Department administrators have initiated a reintroduction program. Two sites were chosen by the officials – partly supported by academic reports on site selection – for the reintroduction: Karaman-Karadağ and Ankara-Sarıyar. Starting from summer 2004 until autumn 2007 a total of 120 animals were translocated and released to Ankara-Sarıyar and 60 animals to Karaman-Karadağ sites. During this period a disease outbreak occured in source population of Konya-Bozdağ, causing a decrease in the population size. The estimate of population size in Konya-Bozdağ in 2004 was over 1000 (DNPNP, personal communication), but the size decreased to around 700 in 2007 (around 200 due to translocations). After various laboratory analyses on blood and fecal samples from the caught animals, the disease responsible for the decrease was determined to be paratuberculosis (*Mycobacterium avium*). Due to lack of an organized and systematic reintroduction plan, the disease was introduced to new areas by using paratuberculosis positive animals in reintroduction. National Parks authorities are now working on establishing a new captive breeding area where only paratuberculosis-negative animals will be used in the founding of new populations.

These reintroduction efforts were continued through collaborations with Middle East Technical University. The monitoring of the reintroduced populations started in 2005 through following of visually marked and radio-collared animals.

1.1.5. Scientific Research on the Anatolian mouflon

Anatolian mouflon was first described by Blyth in 1841, and later by Valenciennes in 1856. Until the middle of 20th century there was only one research made by Danford and Alston (1877). Then came along the above mentioned studies of Turkish National Parks and Game-Wildlife Department administrators, Nihat Turan and Sabit Tarhan mainly on the distribution and status of the species in Turkey.

Apart from earlier accounts on distribution and taxonomy (dating back to 19th century and beginning of 20th century), little research has been conducted on the Anatolian mouflon. But when compared to any other wild mammal taxon in Turkey, it can be said that more scientific studies have been carried out on the Anatolian mouflon. There are two PhD and four MSc studies, all on the Konya-Bozdağ population. The earlier PhD study defines the general morphology, diet, behavior and population size (Kaya, 1989). The first MSc study tried to reveal the seasonal grouping patterns and change in the population size (Arıhan, 2000). The second MSc study investigated the options of a reintroduction program using Population Viability Analysis (PVA) modeling (Sezen, 2000). The other two MSc theses were on conservation genetics of Anatolian mouflon. Özüt (2001) studied the genetic variability and possibility of genetic bottleneck using non-invasive genetic methods. Kayım (2008) also studied the genetic variability within the reintroduction framework, quantifying the amount of genetic variability transferred to the reintroduced populations and also investigating past genetic bottleneck through simulations. The last PhD study was on characterizing various behaviors, such as mating, grouping, and movement etc. of Anatolian mouflon (Çelik, 2006). Besides these studies, Schwartz (1993) determined the chromosome number of the subspecies.

1.2. Reintroduction Biology

1.2.1. Reintroduction Defined

Armstrong and Seddon (2007) defines reintroduction as "… attempts to return species to parts of their historical ranges where they were extirpated, and might involve release of either captive-bred or wild caught individuals." And they define reintroduction biology as "… research undertaken to improve the outcomes of reintroductions and other translocations carried out for conservation purposes." The terms used in literature that involves the movement of organisms by man are summarized in Box 1.1, some of whose definitions are given by IUCN/SSC Reintroduction Specialist Group (IUCN, 1998).

Box 1.1 Translocation terminology (IUCN, 1998).

Translocation: deliberate and mediated movement of wild individuals or populations from one part of their range to another.

Re-introduction: an attempt to establish a species/taxon in an area which was once part of its historical range, but from which it has been extirpated or become extinct

Re-establishment: a synonym for reintroduction, but implies that the reintroduction has been successful.

Re-inforcement/Supplementation/Restocking: addition of individuals to an existing population of conspecifics.

Conservation/Benign Introductions: an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and ecogeographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range.

Introduction: Deliberate or accidental movement of an organism/species outside its recorded distribution. The introduced species becomes an exotic species once established and can potentially become an invasive species, disrupting the local communities.

1.2.2. Reintroduction Guidelines

As explained in the IUCN guideline for reintroduction (IUCN, 1998) the aim of any reintroduction is "to establish a viable free-ranging population in the wild"; with an objective of enhancing the long term survival of an endangered taxon, among other objectives. The reintroduction program should be designed as a long-term management plan with a multidisciplinary approach, involving personnel from related governmental agencies, non-governmental organizations, universities, funding bodies, and such. The same document outlines the three main parts of a reintroduction program: i) pre-project activities, ii) planning, preparation and release, iii) post-release activities. A summary of specific steps within each main part is given in Box 1.2.

Box 1.2. Main parts of a reintroduction study (adapted from IUCN, 1998)

Pre-project Activities:

1. *The feasibility of the reintroduction program is made:*
   A suitable source population be found (same taxon as extirpated population); critical needs and properties – pertinent to adaptation – of the taxon be identified; release numbers and composition be determined and adaptation period modeled using population viability analysis; experiences from previous reintroduction studies be obtained
2. *Release site is determined:*
   A suitable release site should be within taxon's historic range, where the original plant and animal community, landscape and habitat is mostly retained; the identification and elimination/reduction of previous causes of decline (poaching, domestic herds, pollution etc.); habitat restoration be done if necessary.
3. *Source population(s) be determined:*
   Preferably wild animals are used; the populations with closer genetic and ecological characteristics be preferred; removal of individuals must not affect significantly the source population's viability; the genetic make-up of the founder population be maximized by various ways (mixing individuals from different source populations, randomly selecting individuals or selecting more genetically dissimilar individuals etc.); healthy populations and individuals be used.
4. *Socio-economic and legal arrangements/preparations be made:*
   Long term financial and political supports be secured; costs and benefits to local human populations be calculated; attitudes of local people be assessed and the program be fully understood, accepted and supported by local communities; protection of the

Box 1.2. (cont.)

reintroduction area must be established and measures be taken to minimize risks from human activities.

Planning, Preparation and Release

1. *Planning:*
   Getting approval from all relevant government agencies and landowners; a multidisciplinary team be formed; identifying short and long term success indicators along with clear aims and objectives; design of pre- and post-release monitoring program to obtain scientific data.
2. *Preparation*:
   Health screening of release stock and related taxa in reintroduction area, application of medication and vaccination and give enough time for gaining immunity, if necessary; transport plans, number and composition of release stock, appropriate catching plans and soft-release acclimatization sites be prepared; appropriate marking/monitoring tools be obtained.
3. *Release:*
   Timing of transport and release, release patterns be determined to ensure minimizing the stress on the individuals; soft release strategies are preferred; public relations through mass media and in local community be established.

Post-Release Activities

1. *Monitoring:*
   Direct monitoring of all individuals by tagging and radio-tracking; demographic, ecological and behavioral studies be undertaken; monitoring the adaptation process;
2. *Protection:*
   Interventions be made whenever required (supplemental feeding, veterinary aid, horticultural aid, reinforcing the population by new releases); active control and on-site protection measures be applied continuously to ensure following the reintroduction plan and make adaptive changes in a timely manner; habitat protection and restoration where necessary.
3. *Information Dissemination:*
   Continuing public relations activities; evaluation of reintroduction techniques; regular publications in scientific and popular literature.

IUCN-SSC Reintroduction Specialist Group's guideline intends to inform practitioners on how a reintroduction study should be planned and performed, in order to increase chance of success. Most reintroduction studies in Turkey and other developing countries however lack a coherent program which takes into account most aspects mentioned in the IUCN Guideline. But still there has been a significant increase in post-release monitoring of reintroduction programs (Armstrong and Seddon, 2007).

Griffith et al. (1989) identify seven statistically significant predictors of translocation success: (1) taxonomic class (bird vs. mammal), (2) legal status of the translocated species (native game vs. threatened, endangered, or sensitive species), (3) habitat quality of the release area (excellent, good, or fair/poor), (4) location of the release area relative to the historical range of the species (core vs. periphery or outside), (5) number – and sex/age composition – of animals released, (6) program's temporal length (number of years over which releases occurred), and (7) potential productivity of the translocated species (high vs. low). Upon this study, Wolf et al. (1998) reanalyzes the same data by taking into account the phylogenetic relatedness of the studied taxa. They conclude that "the habitat quality of the release location, the number of individuals released, and the range of the release area relative to the historical distribution of the species" (core vs. periphery or outside) are the most critical and general factors that determine the success of the translocation.

1.2.3. Reintroduction Studies in the World

As one of the earliest maybe the first example of contemporary reintroductions, 1907 release of 15 American bison (*Bison bison*) into a newly established reserve in Oklahoma, USA (Kleiman 1989) can be cited.

Between 1900 and 1992, a total of 126 reintroductions that used captive-bred stocks were documented (Beck et al., 1994). By 2005 a total of 489 reintroduction studies were accomplished (Seddon et al., 2005). The increase in the number of reintroduction studies can be attributed to one main factor – besides increase in documentation and man-power allocated to such studies –: a continuous disturbance and destruction of habitats and populations which leads to great contractions in the range of the species; even leading to a total extinction in the wild. Following this trend, the number of scientific research articles has increased as shown in Figure 1.2 (from Seddon et al., 2007).

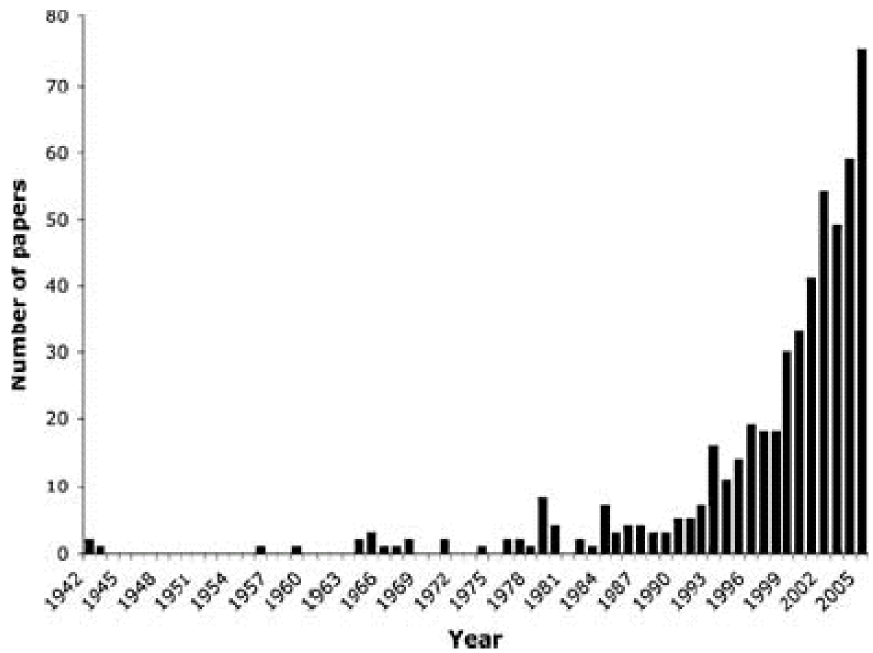


Figure 1.2 Number of reintroduction-related papers published in peer-reviewed journals by year since the first records located up to 2005 (Seddon et al., 2007)

Success of reintroductions worldwide was documented in several studies (Griffith et al., 1989; Beck et al., 1994). Griffith et al, (1989) defined success as a "… result in a self-sustaining population." And in their evaluation of near 200 studies that took place from 1973 to 1986, the reintroduction success was found to be 75% when wild-caught individuals are used while the success was 38% when captive-reared individuals are used. Beck et al.'s (1994) study considered 145 reintroduction projects and found only 11% of them to be truly successful (success measured as an unsupported wild population of at least 500 individuals). The criteria used to evaluate success of reintroduction studies are mostly straightforward and objective. There are several widely accepted criteria for success: i) breeding by the first wild-born generation (Sarrazin and Barbault, 1996), ii) a three-year breeding population with recruitment exceeding adult death rate (Sarrazin and Barbault, 1996), iii) an unsupported wild population of at least 500 individuals (Beck et al., 1994). But as Seddon (1999) puts it the definition of success is limited in time by any criteria. Therefore Seddon (1999) suggests that, "The ultimate objective of any reintroduction is population persistence without intervention, but this is a state, not a result, and is assessable only through long-term, post-release monitoring."

1.2.4. Reintroduction of Anatolian Mouflon

Reintroduction of Anatolian mouflon has been a major target and a challenge ever since the captive-breeding program in Konya-Bozdağ has reached its aim. Once the population in Konya-Bozdağ reached to a thousand individuals by the year 2000, it was thought that the fenced area has reached its carrying capacity and reintroduction studies should start.

But this could no be realized until 2004. During this period Directorate of Nature Protection and National Parks (DNPNP) conducted a site survey in Central Anatolia, working together with academicians, in search of suitable habitats for reintroduction. However, required scrutiny and concern was not spent either by DNPNP or by academicians. In the end two localities were determined: Sarıyar and its surroundings in Nallıhan-Ankara and Karadağ-Karaman. There are historical accounts (Turan 1981) and local evidence (horns hanging on houses in nearby villages, old people's eyewitness reports) in Sarıyar that Anatolian mouflon survived until 1960s. However Sarıyar is documented to be at the northwestern periphery of species distribution. On the other hand no evidence (neither documented nor eyewitness) was there to suggest that Anatolian mouflon once lived in Karaman-Karadağ. Selection of these localities were based on several expert reports formed by short visits to a limited number of potential sites. The attitude of local people in some of these potential sites were tried to be assessed by visits of National Park officials (DNPNP, personal communication). A comprehensive research, which should include the degree of domestic herd use, abundance of potential predators, protection and ownership status of the areas and habitat suitability, to determine the reintroduction sites was not made. By the year 2004 DNPNP have tried several ways of catching mouflon, on their own. Through a series of unsuccessful attempts, by trial and error, they have come up with trapping method to catch on average 20 animals in one time (Haluk Akgönüllü, pers. comm., 2006). This trapping method was improved and used exclusively throughout the rest of the reintroduction study (Figure 1.3).

Starting from 2004, until 2007 a total of 131 (51 ewes, 24 rams, 56 lambs) animals in four parties to Ankara-Sarıyar and 61 (21 ewes, 11 rams, 29 lambs) animals in three bouts to Karaman-Karadağ, were translocated. Once carried, animals were put in 5-10 ha fenced enclosures to stay for a couple of months for acclimatization purposes. Releases took place in

October 2005, December 2006 and lastly in October 2007. The first translocated groups in both localities stayed almost one year in the enclosure waiting for the radio-collars to arrive. During this period mortalities and births took place.

Figure 1.3 Photograph of one of the three traps in Konya-Bozdağ protection area, used for catching mouflon.

In the rest of the translocations and releases, the acclimatization period did not exceed one month. Eventually, in Ankara-Sarıyar 104 animals (43 ewes, 31 rams, 30 lambs) and in Karaman-Karadağ 57 animals (25 ewes, 15 rams, 17 lambs) were released in total. During the releases 40 individuals were radio-collared and 28 ear-tagged in Ankara-Sarıyar and 6 individuals radio-collared in Karaman-Karadağ for post-release monitoring. The radio-collared individuals all died by the end of 2006 in Karaman-Karadağ and post-release monitoring essentially halted, except for occasional surveys in the reintroduction site, which did not prove fruitful due to the very low density of released mouflon (40-50 animals in ca 25,000ha area). On the other hand due to higher number of marked individuals in Ankara-Sarıyar, the post-release monitoring continued as planned.

1.3. Use of Spatial Ecology in Wildlife Studies

Spatial ecology can be defined as the study of the interrelationship between organisms and their environment, especially the spatial nature of these interactions. A wide range of disciplines fall within spatial ecology from landscape scale to individual level. In wildlife scale, the relation of the animals with their surrounding environment includes procuring and securing feeding, hiding, sheltering grounds, mating, dispersal and migration decisions and opportunities. In wildlife ecology studies, at population and individual level, two widely used concepts utilized to study the spatial ecology of a species are home range and habitat selection. The use of the animals of their surrounding environment, their movements and spatial arrangements are directly linked to their population dynamics (Kernohan *et al.* 2001). Especially in reintroduced populations, the colonization process of the released individuals can be described through studying their movement patterns, home range selection and habitat use.

1.3.1. Home Range

One of the first and basic definitions of the general concept of home range was made by Burt (1943) as the area traversed by an individual for its usual activities such as feeding, mating and caring for young. This concept of home range have been criticized and redefined by many authors (i.e., Baker, 1978, White and Garrot, 1990; Hansteen et al., 1997) but a consensus could not be achieved. Kernohan et al., (2001) suggested a functional definition for home range mainly for heuristic purposes: "… extent of area with a defined probability of occurrence of an animal during a specified time period."

Knowledge about threatened animals' ecology, like home range, habitat selection, and behavior is crucial in formulizing management actions for their conservation. These kinds of data are especially important in reintroduction studies. They provide useful information in, for instance, selection of the suitable reintroduction sites, and determination of the size of protected area.

There are several approaches for estimating the home range of an animal. Among these methods minimum convex polygon, cluster analysis, harmonic mean and kernel are the most widely used ones. Kernohan et al. (2001) reviewed the literature and compared the advantages and disadvantages of 12 home range estimation methods (Table 1.2). Some estimators require higher sample sizes for home range estimation for example 200-300 fixes are necessary for a reliable home range estimate in minimum convex polygon and grid cell count (Bekoff and Mech 1984, Doncaster and Mcdonald 1991). Although absence of autocorrelation is one of the assumptions of the probabilistic statistics, it is theoretically and practically difficult for an animal's consecutive locations to be independent from each other. The intended use of home range and the question at hand should be determining the sampling design. The ability to calculate utilization distribution is a desired property for an estimator, since utilization distribution calculation means that the estimator uses the relative frequency of all data to calculate the occurrence probability of an animal at one location (Van Winkle 1975, Millspaugh and Marzluff, 2001). If an estimator does not assume a statistical distribution for the data, then it is a nonparametric estimator, and this is a desired probability for home range estimators since the area use of an animal hardly corresponds to a statistical distribution. Calculation of multiple centers of activity is useful for understanding the spatially heterogeneous structure of the home range (Hodder et al. 1998). Estimators not sensitive to outliers are more reliable than sensitive ones, since its effect of outliers on home range size can be dramatic (Ackerman et al. 1990). Some home range estimators can be relatively more comparable to other estimators when using the identical data set, and some can not. Comparability is a good property of an estimator but not as vital as i.e. sensitivity to outliers (Kernohan et al., 2001). According to Table 1.3 kernel-based methods (Worton, 1989) are superior to other methods. Other evaluative studies reached to similar conclusions on the preference of kernel estimators (Börger et al., 2006).

Table 1.3 Evaluation of 12 home range estimators relative to 7 criteria (taken from Kernohan et al., 2001)

Home range estimator	**Sample size**[b]	**Auto-correlation**[c]	**Utilization Distribution**[d]	**Non-parametric**[e]	**Center of activity**[f]	**Outliers**[g]	**Comparability**[h]	**Score**[a]
Min. convex poly.	0	1	0	1	0	0	1	**3**
Peeled polygon	1	1	0	1	0	0	1	**4**
Concave polygon	0	1	0	1	0	0	1	**3**
Cluster analysis	1	1	0	1	1	0	1	**5**
Grid cell count	0	1	0	1	1	0	1	**4**
Jennrich-Turner	0	0	1	0	0	0	1	**2**
Weighted bivariate normal	0	0	1	0	0	0	1	**2**
Dunn estimator	0	0	1	0	0	0	1	**2**
Fourier series smoothing	0	0	1	1	1	1	0	**4**
Harmonic mean	0	0	1	1	1	1	0	**4**
Fixed kernel	**1**	**1**	**1**	**1**	**1**	**1**	**0**	**6**
Adaptive kernel	1	1	1	1	1	1	0	**6**

[a]Each criterion could receive one (1) point, and score represents the sum of those points.
[b]Calculated home range extent often stabilizes with ≤ 50 location points.
[c]Estimator is less sensitive to autocorrelated data.
[d]Estimator calculates home range boundary based on the complete utilization distribution.
[e]Estimator is nonparametric.
[f]Estimator calculates multiple centers of activity.
[g]Estimator is less sensitive to outliers.
[h]Estimator reveals comparable results for different data sets

1.3.2. Habitat Selection

The word habitat has several definitions and which is the correct one to use in wildlife ecology is still an issue of debate (Garshelis, 2000; Hall *et al.* 1997). Like any other concept, habitat is not an existing reality but a man-made construct and it should be treated as one. More often than not, habitat is regarded as a species-specific concept and defined as the collection of resources and conditions necessary for the survival, reproduction and other needs of the organism; and in the ultimate sense, the ideal habitat of a species would be the one which maximizes the fitness of the individuals living in that habitat (Rosenzweig & Abramsky 1986). Therefore, the organisms are thought to select from a given/existing conditions and resources and the collection of these constitute the habitat of that organism. This selection can vary among individuals, sexes, age classes and among seasons or other biologically meaningful parts of the year for the specific species (i.e. rutting and parturition seasons for mouflon). Hence, the study of habitat selection should take into account these factors to account for the existing variation.

It was suggested that selection of habitat actually stems from the individual's innate preference (Peek, 1986) of certain resources. (Johnson 1980) defined selection as the process of choosing resources while he defined preference as the likelihood of a resource being chosen if offered on an equal basis with others. Therefore, determination of preference would enable us to evaluate the suitability of a habitat for a species. However, the resources in nature are not distributed in equal amounts. Additionally, there are various factors which affect the degree of availability of resources;

such as competitors, predators, geographic barriers etc. Hence, in most of the wildlife studies habitat selection approach is used to infer the habitat preference of a species (Erickson *et al.* 2001). Animals can actively select where they live or passively persist in certain habitats depending on their behavior. The specific behavior they perform ultimately plays a major role in their survival and reproduction. As a result, the patterns of their behavior which determine their patterns of resource use affect their fitness.

Depending on the questions, available resources, type of data, study species etc., one tends to choose among many approaches, the one that suits his/her study the best. The habitat or resource selection studies can be classified using three main characteristics, which a researcher should consider while making a decision about his/her approach. These three characteristics are: i) study approach: determining the type of inference for habitat quality, ii) study design: determining the sampling units, and iii) study scale: determining the spatial scale of the study.

The study approaches are grouped into three by Garshelis (2000): use-availability design, site-attribute design and demographic response design. The use-availability design has been the most widely used approach (Klar *et al.* 2008) and it basically compares the amount of specific habitat type used by the organism with the relative abundance of that habitat type: a significant deviation from proportional use to availability would mean a selection. In site-attribute design the same comparison is made between used (selected) habitat types and the unused or randomly chosen habitat types (i.e., (Hacker & Coblentz 1993; Ockenfels & Brooks 1994; Nadeau *et al.* 1995). A multitude of habitat-related variables at used sites are measured and used in a multivariate context to characterize the selection. Lastly, the demographic response design compares the demographic characteristics (survival, reproduction, density, etc.) of organisms selecting different habitat types (Loegering & Fraser 1995; Boyce & McDonald 1999). Since use results from selection, selection results from preference and preference results from resource-specific differential fitness (Garshelis, 2000), a habitat selection study should establish a link between selection and fitness. This link is much more direct in demographic-response studies than in use-availablity studies, which can only suggest a proximate relation between use and fitness. However, a demographic response design would require a much larger sample size (i.e. number of individuals radio-tracked) than use-availability studies, which can be one of the reasons of its less frequent utilization in habitat selection studies.

1.3.3. Use-Availability Approach

The use-availability approach has been used more extensively in wildlife studies than the other two approaches. The use-availability approach assumes that the amount of use of an habitat indicates the quality of that habitat, which in turn reflects the fitness in that habitat (Boyce & McDonald 1999). Four different types of designs have been recognized and utilized under this approach (Thomas & Taylor 2006). These designs differ from each other in determination of the sampling unit for quantifying use and in determination of scale for quantifying the availability. In design I, all individuals of a population assumed to have the same preference/selection and the sampling unit is the location of an individual. The availability is defined as the entire study area. In design II and III, individual animals are the sampling units; therefore variation among individuals is taken into account. In design II, availability is again defined as the entire study area, while in design III, availability is defined separately for each individual (i.e.

as their home ranges) (Manly *et al.* 2002). Erickson et al. (2001) added a fourth category as design IV, in which individual animals are the sampling units as design II and III, but availability is defined for each location of an individual. Although design I is still being used, its weaknesses have been recognized (Aebischer *et al.* 1993) due to violation of independence assumptions and causing to 'averaging out' of individual variations in selection patterns (Erickson et al., 2001).

The spatial scale used for the habitat selection affects the results of the analyses. As pointed out in different types of designs, the particular definition of 'what is available' to the animals, determines the particular type of selection of that animal at that scale (Levin 1992). A widely accepted classification of these scales was given by Johnson (1980) as a natural ordering of selection: first-order selection as the geographic range of the species, second-order selection as the selection of home range within the geographic range, third-order selection as the use of particular habitats within the home range, and fourth-order selection as the selection of particular items for specific use (feeding, reproducing, shelter etc.) within the selected habitats. Therefore, the chosen scale of availability in habitat selection analysis, determines the particular type of selection that takes place within these different scales.

There are various kinds of analyses which have been used in use-availability type habitat-selection studies. For design I, χ^2 analysis (Neu *et al.* 1974; Byers *et al.* 1984; Arthur *et al.* 1996), logistic regression (Smith *et al.* 1982; Arthur *et al.* 1996), log-linear modeling (Heisey 1985) and discrete choice models (Cooper & Millspaugh 2001) are applicable. For design II and III, besides the methods for design I, Johnson's method (Johnson, 1980), Friedman's test (Friedman 1937; Conover 1999) and compositional analysis

(Aebischer et al., 1993) have been widely used. White & Garrott (1990), Erickson et al. (2001), Manly et al. (2002) and Thomas and Taylor (2006) have described and compared these methods and reviewed the relevant literature for various applications of these methods for different species and habitats.

1.3.4. Compositional Analysis

The compositional analysis method utilizes multivariate analysis of variance (MANOVA) models to analyze log-ratios for comparison of utilization and availability of habitats (Aebischer et al. 1993). In compositional analysis setup, n categories of a habitat variable (i.e. vegetation) can be available and an individual animal's proportional use can be represented by the composition U_1, U_2, ..., U_n where U_i is the proportion of the category i used by the individual for i = 1, 2, ..., *n*. The sum of the U_is is 1. Similarly, the available proportions for the same animal are represented by the composition A_1, A_2, ..., A_n. For any component U_j of a composition, the log-ratio transformation $y_i = \log (U_i / U_j)$ for $i \neq j$ results in new variables that are linearly independent. The n - 1 differences $d_i = \log (U_i / U_n) - \log (A_i / A_n)$ for i = 1, 2, ..., n-1 are calculated for each individual animal. If no selection (i.e., random use) occurs, the mean value of d_i over all animals should be zero for all i. Testing of whether the vector of mean values of d_i is significantly different from the zero vector is then performed by multivariate analysis of variance (MANOVA) to determine if a selection exists. A significant value of the test is interpreted as indicating that selection has occurred (Aebischer *et al.* 1993; Bingham & Brennan 2004).

Among the methods used to evaluate the habitat selection of a population, logistic regression (40%) and compositional analysis (25%) are the most widely used ones (Thomas & Taylor 2006). For use-availability studies, Keating & Cherry (2004) do not recommend in general the utilization of logistic regression analyses on the grounds that unless the sampling design, underlying probability models and associated assumptions are meticulously revised, erroneous results can easily be obtained. On the other hand Thomas & Taylor (2006) do not recommend compositional analysis when use of one or more resources is low and/or the number of relocations per animal are not equal among all analyzed animals. In such cases the type I error rate is reported to be high (Pendleton *et al.* 1998; Dasgupta & Alldredge 2002; Bingham & Brennan 2004).

Despite these suggested pitfalls of compositional analysis, it has the advantages of using animals as the sampling units, circumventing the unit-sum problem (i.e. since the sum of all categories of a variable sums to one, avoidance of one category invariably leads to selection of another) and enabling the differential use by groups of animals (Aebischer et al., 1993). In their review, Thomas and Taylor (2006) mentioned that compositional analysis was used in literature for design II and III studies: comparison of habitats in home ranges (used) with study area (available) (Dees *et al.* 2001; Bond *et al.* 2002; Chamberlain *et al.* 2003), comparison of animal relocations (used) with home ranges (available) (Chamberlain *et al.* 2000; Gabor *et al.* 2001; Dickson & Beier 2002), and comparison of animal locations (used) with study area (available) (Dickson & Beier 2002; Hartke & Hepp 2004).

1.3.5. K-Select Analysis

Besides "hypothesis testing" based approaches - whether habitat type A is selected over B or not - summarized in the previous section, there are other approaches which are rather of an exploratory nature. Morrison *et* *al.* (2006) makes another distinction between hindcasting and forecasting studies of habitat selection. Hindcasting identifies key environmental variables that account for observed variation in species variables, while forecasting studies attempt to predict future or potential species habitat use. Therefore hindcasting approach is an exploratory one. All the variables that potentially characterize the habitat of a species, from which the selection takes place, can be included in a hindcasting type exploratory analysis. The aim of such an analysis is to evaluate these potential variables and determine the ones that play a role in the selection process, rather than a hypothesis testing of resource selection. One of these exploratory methods is the K-select analysis developed by Calenge *et al.* (2005). K-select analysis relies on the concept of ecological niche (Hutchinson 1957) and focuses on the marginality criterion (Doledec *et al.* 2000; Hirzel *et al.* 2002) which is a measure of distance (Euclidean distance) between the average habitat conditions used by an organism and the average habitat conditions available to it. As Calenge et al. (2005) puts it:

> "… the niche of a species is viewed as a multivariate probability density function which gives the density of probability of the species presence according to the position in the ecological space. If the niche can be assumed to be multivariate normal, the mean vector of this distribution is the optimum location for the species and defines the point where the probability density of use is the highest. The squared distance of this optimum from the point located at the average of available habitat conditions on the study area is called

'marginality' and measures the strength of habitat selection, i.e. the mean difference between habitat use and availability."

Therefore the marginality vector is defined as the difference between the vector of average available habitat conditions and the vector of average used conditions. The size of the marginality vector is proportional to the degree of habitat selection, and its direction indicates which variables are selected. A principal component analysis (PCA) of the table containing the coordinates of the marginality vectors of each animal (row) on the habitat variables (column) is performed, upon which the K-select analysis returns a linear combination of habitat variables for which the average marginality is greatest. The synthesis of variables in PCA axes indicates which variables contribute the most to the habitat selection and the biological significance of the factorial axes of the PCA is deduced from the loading of variables.

The data to quantify the availability for the K-select analysis, consists of one value for each of J number of different habitat variables, in each discrete "resource unit". A resource unit (RU) can be a pixel – of i.e., a raster map – of determined size (eg. 2500 m^2), depending on the extent of the study area; and the study area is covered by these pixels (Manly et al., 2002). The data to quantify the use, on the other hand, is obtained by the radio-tracking of K number of animals. The number of relocations of the animal k in a RU gives an estimate of the use of that particular RU. As a result, information on available and used resource units are gathered in the manner classified as "sampling protocol A" by Manly et al. (2002). In Figure 1.4, the K-select analysis is schematically summarized.

Both design II and III use-availability analysis approaches can be performed by K-select analysis through setting the availabilities for each animal separately (i.e. assigning individual home ranges as available) or using the same availability for each animal (i.e. assigning the whole study area as available). The variables used in K-select analysis can be continuous and/or categorical.

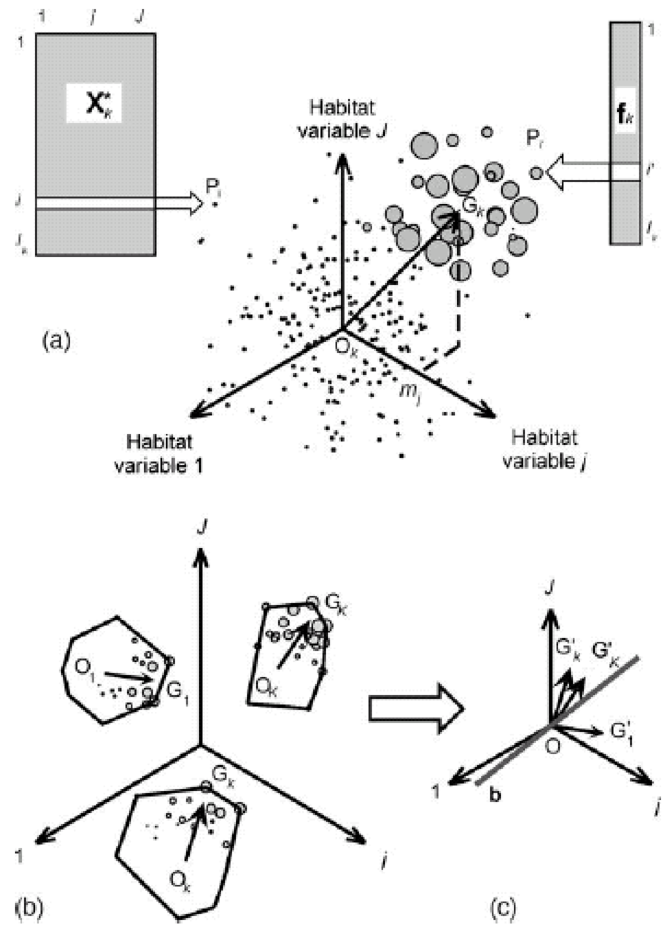


Figure 1.4 Steps in analysis of marginality (a) Case of one animal: the X_k table contains values of *J* habitat variables on the I_k resource units available to the animal *k*. Each row of the X_k table defines a point in the J-dimensional space of habitat variables. The origin O_k of the space is located at the average of available habitat conditions. The vector f_k contains the relative frequencies of use of each unit by the animal. The diameter of the circles is proportional to these frequencies. The average m_j of the habitat variable *j* is weighted by the relative frequencies of use. The *mj*s are the coordinates of the point G_k, which is located at the average used habitat conditions. The vector *OkGk* is the marginality vector of the animal *k*. (b) Case of K animals (design III): For each animal *k*, the average available habitat conditions define a point O_k and the average used conditions define a point G_k. The vector O_kG_k is the marginality vector for animal k. (c) The K-select analysis proceeds in two steps: first, a translation is applied to each vector O_kG_k, so that they all have a common origin *O* (the origin of space); second, an eigenanalysis is performed on the table of coordinates of the translated vectors O_{gk} on habitat variables, so that the mean marginality projected on the first axis b is maximized (taken from Calenge et al., 2005).

Using a randomization method proposed by Calenge et al. (2005), the observed results of K-select analysis can be compared to the 'random habitat use', which is obtained by repeating the same procedure many times using random points as used and performing K-select analysis for each repeat. Eventually the first eigenvalue of the observed data set is compared with distribution of the first eigenvalues of the randomized data sets. Results of test of marginality and test of the effects of variables on the marginality of each animal can be obtained using the Bonferroni correction (Bland & Altman 1995). However, Calenge et al. (2005) indicates that these Bonferroni-corrected randomization tests are rarely significant due to the fact that Bonferroni inequality becomes highly conservative when a large number of tests are carried out (Bland & Altman 1995; Faraway 2002).

1.4. Objectives of the Thesis

One of the phases of a reintroduction programme as mentioned in the IUCN guideline (IUCN, 1998) is the post-release monitoring study. Unfortunately this phase, which should follow reintroductions, often remains neglected or is documented only in 'grey' literature (Sarrazin & Barbault 1996). The main purpose of this study is therefore to include the monitoring of the reintroduction of Anatolian mouflon in literature and meanwhile make suggestions on conservation management with the data and the results obtained from this study.

The specific objectives of the study are:

1. Quantifying the area use of the reintroduced Anatolian mouflon population to evaluate the resource needs.

2. Determining the demographic properties of the reintroduced population to evaluate the trend of the population.
3. Monitoring and evaluating the adaptation period of the reintroduced population with quantitative tools to suggest conservation management actions.

CHAPTER II

MATERIALS AND METHODS

2.1. Study Area

Study area is the Sarıyar Wildlife Protection Area, which is situated at 170 km. west of Ankara, and 30 km. southeast of Nallıhan province of Ankara. The southern border of the reintroduction site is bordered by the Sarıyar Dam Lake, built in 1950s (Figure 2.1). The altitude ranges between 400m – 900m. The total area of the potential reintroduction zone is 8000 – 15000 ha large. The hilly portions of the area have steppe vegetation with patches of black pine (*Pinus nigra*) forest. Other tree species found in the area are wild almond, wild pistachio, oak species and juniper species. The flora of the area was studied by Pazarcıkçı (1998) and included many steppe endemics. The climate is typical continental climate with dry and hot summers and cold and wet winters. For the 2006-2009 period the highest temperature has been 40.3°C and lowest temperature -13.7°C, maximum depth of snow has been 25 cm, mean number days with snow cover has been 7 days. Mean annual rainfall in the area is 290 mm (General Directorate of Meteorology data from Nallıhan station).

The fenced acclimatization area is around 5 ha and situated at the peninsula at west end of the area (Fig 2.1). It is separated from rest of the reintroduction area with a road connecting the Sarıyar village to the dam. The west and central portions of the area are closed to herding and farming activities almost totally. However the rest of the area is being used by herds totaling in number around 10000 domestic sheep and goats, along with around 25 shepherd dogs. In addition, abandoned and/or released hunting dogs use the whole area.

Other species of wildlife observed during the field studies in the reintoduction area are red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), brown hare (*Lepus europeaus*), wolf (*Canis lupus*), jackal (*Canis aureus*), and otter (L*utra lutra*). Lynx (*Felis lynx*) and brown bear (*Ursus arctos*) were not observed but are known to be living in the near vicinity of the reintroduction area, where forests are more abundant, in the north, west and south of the area. Jungle cat (*Felis chaus*) also occurs in lowlands with dense cover. There are also many species of birds of prey, some of which potentially poses a threat to mouflon, especially the newborns. These birds observed frequently in the area include Egyptian vulture (*Neophron percnopterus*) from spring to autumn, lammergeier (*Gypaetus barbatus*), black vulture (*Aegypius monachus*), sparrow hawk (*Accipiter nisus*), long-legged buzzard (*Buteo rufinus*), golden eagle (*Aquila chrysaetos*), white-tailed eagle (*Haliaetus albicilla*), black kite (*Milvus migrans*) and *Falco* spp.

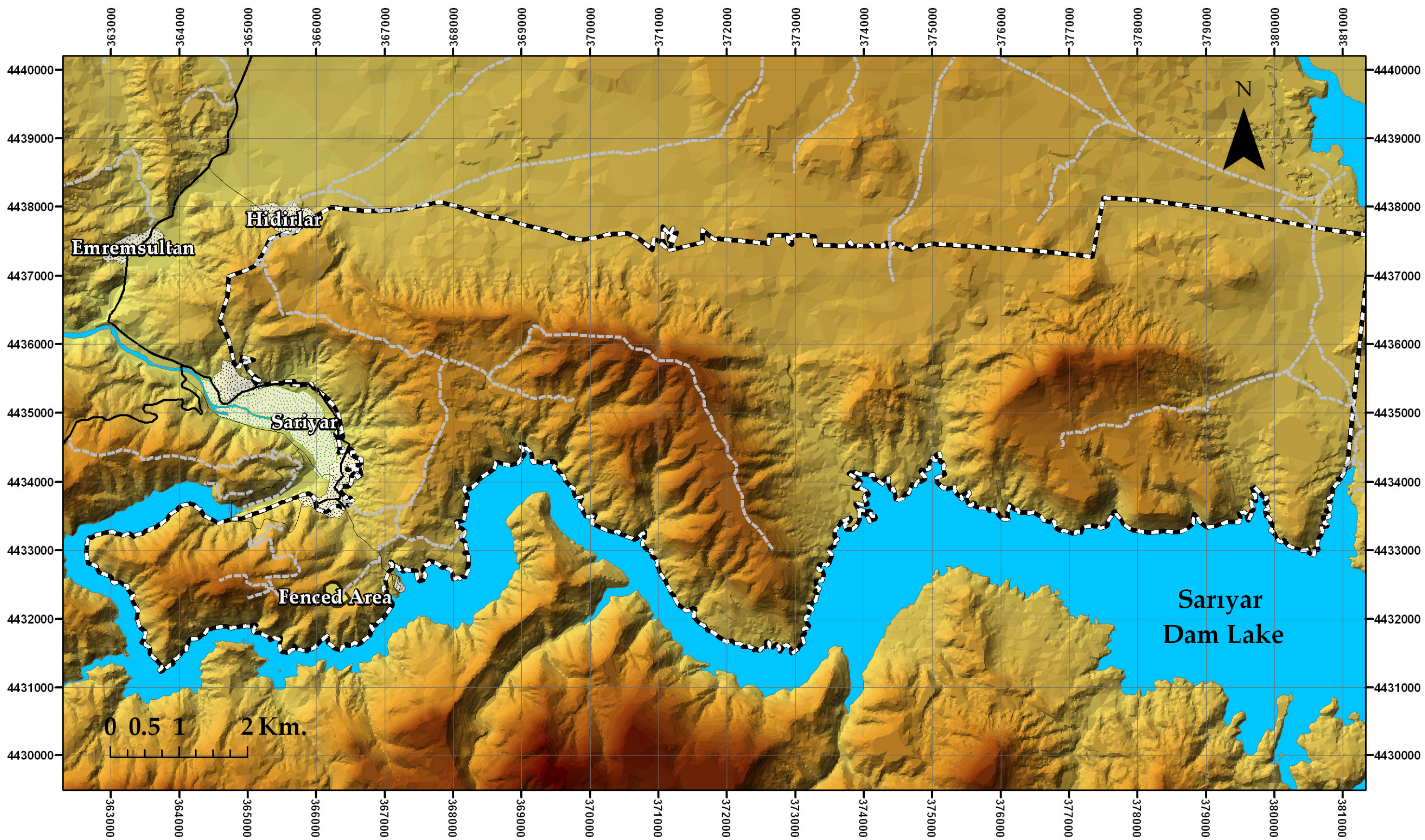


Figure 2.1 Topographic map of the study area surrounded by the dam lake form west, south and east (not seen). Black and white strip is the study area boundary. Grey dotted and black lines are roads. Three villages and the fenced area are shown (UTM coordinates are also given).

2.2. Radiotelemetry

Radiotelemetry is a technique that utilizes radio signals emitted from a transmitter, which is then received by a receiver connected to a directional antenna (i.e. Yagi antenna), to determine the direction of the transmitter relative to the receiver. When this transmitter is attached to an animal – as a collar or a harness for instance – depending on the strength of the signal produced and the topography and vegetation of the area, its emitted signal can be received from long distances with the receiver. Such a system greatly enhances data collection on various aspects of animal's ecology. The first studies that utilized radiotelemetry dates back to 1960s (Le Munyan *et al.* 1959). Kenward (1987) gives a concise history of the development of the technique and the literature. The main areas where radiotelemetry has been used are physiology (Budinger 2003; Letourneau & Praud 2003), behavior (Owen-Smith 1994; Cooper & Millspaugh 2001) and demography(Adams *et al.* 2008; Salvador & Fernandez 2008).

There are three different types of radio tracking approach in general: triangulation, homing and aerial tracking (Samuel and Fuller, 1996). In triangulation, multiple bearings from at least three different locations are taken within a limited time period (i.e. max. 15 min). These bearings are then drawn on a map of the area and their intersection constitutes an estimation of the location of the transmitter – therefore the collared animal. However, there are algorithms used to estimate the solution point of this intersection along with a 95% confidence area (i.e. confidence ellipse of Lenth, 1981) of this location. Radiotelemetry was utilized to track the adult individuals throughout the study, while the juveniles were tagged with individually distinguishable color-coded ear-tags.

2.2.1 Equipments Used in The Study

Radiotelemetry equipments included radio-transmitter collars, radio receivers, yagi antennas and antenna cables. Additional equipments for field study comprised compass, GPS, handheld computer (Garmin IQue 3600), data notebooks, binoculars, spotting scopes and two-way communication devices. Additionally the map of the study area was formed as a handbook to facilitate data recording (Figure 2.2).

The transmitters (Wildlife Materials Inc., USA) were attached to collars and the frequencies were between 150.000 MHz to 151.000 MHz. with at least 25 Hertz separation. They had two signal types 60 beeps/minute normal mode and 120 beeps/minute mortality mode which became functional if the animal stayed continually inactive for at least 4 hours. The maximum range of the signal was around 20 km. However, hills and other obstructions could lead to significant decreases in the range. Receiving devices were capable of getting signals from 150.000 MHz to 151.000 MHz. range, equipped with a gain and tune knob. Additionally there was an attenuator switch to reduce the power of the incoming signal by half for short range reception.

Garmin E-Trex GPS devices were used for coordinate determination. Silva Ranger compasses were used for determining signal direction. Additionally Garmin IQue 3600 handheld computer was used to calculate triangulations for data quality. Once the animals are found they are observed with binoculars and spotting scopes.

Figure 2.2 Radiotelemetry equipments used in this study

2.2.2 Radiotelemetry Test Study

Using radiotelemetry to estimate the locations of the collared animals (transmitters) brings along its associated errors from various sources. Accounting for all or most of these errors is essential in order to quantify the magnitude of the error to improve the data acquisition methodology or to define an alternative way of data acquisition (Kenward, 1987). Besides the associated errors, the transmitter-receiver system should also be tested for any biases (White and Garrot, 1990). The main sources of error in radiotelemetry stem from:

a) Inherent limitations to accuracy due to the telemetry equipment (i.e. the receiving antennas, compass): the more the number of elements in a yagi antenna the higher the gain and narrower the directionality; the precision of the compass depends on the intervals between consecutive azimuths recorded on it (i.e. azimuths which are shown at every degree has 0.5° precision),

b) Variation in signal reception due to the location of the receiver: higher locations have better signal reception; the higher the antenna from the ground, the better its reception,

c) Signal bounce due to topography: the more rugged the topography the higher the signal bounce (reflected signals), when the transmitter is not within the visible range (non-line-of-sight bearings; i.e. signal obstructed by terrain such as a hill) (Garrot et al., 1986).

d) Electromagnetic wave sources: proximity to power lines (Parker et al., 1996) and even spiral bounds of notebooks affect the amount of bearing error.

A telemetry error study was performed in the release area, prior to the reintroduction, by distributing 40 collars, functioning as beacon transmitters in a stratified-random fashion to known locations which were chosen systematically to represent the whole area. Collars were tied on wooden poles of 70cm high (average shoulder height of mouflon). Poles with collars were put 0.5 – 1 km apart from each other in North-South and East-West direction (Fig. 2.3). Then using 19 other locations in the field, bearings from these collars were taken (Kufeld et al., 1987; Samuel and Fuller, 1996).

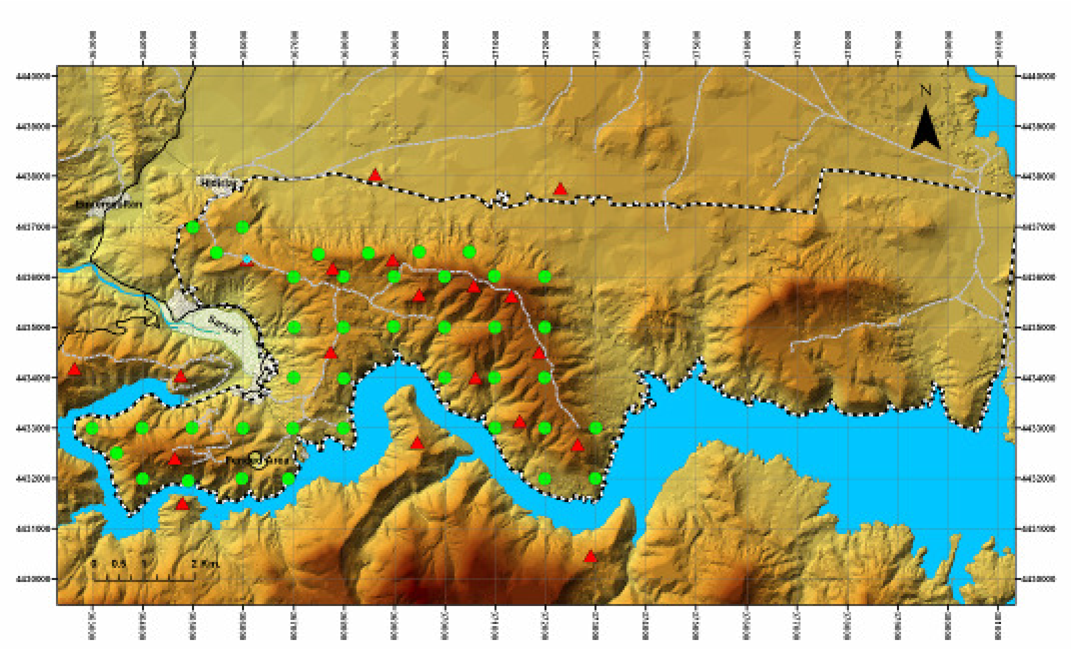


Figure 2.3 Map showing the details of the radiotelemetry test study. The green dots (n=40) are the locations of collars; the red triangles are the locations of the receivers (n=19). The black-white strip shows the study-area boundary; black lines and grey-dotted lines represent the primary and secondary quality roads.

The transmitter locations were chosen to represent the whole area equally. The numbers of the transmitter locations were limited by the man-power available to complete study. Only the protected portion of the study-area was included in testing due to:

a) limited man-power and transmitters to be used in testing study,

b) that the released population was expected to use the protection area during the initial years after release,

c) the assumption that the protected part of the area is representative of the whole study area with respect to topography.

The receiving locations were selected according to their accessibility by roads and their altitude for better signal reception. Nineteen receiving locations were used in order to increase the chance of finding good receiving locations for different parts of the area. From every receiving location every transmitter's signal was tried to be received and if the signal was received, its bearing was found using the bisector of the null signal directions. The bearing was taken twice from each transmitter from each receiving location (Whitey *et al.* 2001). Using this methodology, the bias of the telemetry system and the standard error of the bearings was estimated.

Bias and Error Estimation

Bearing bias and error determine the precision of radiotelemetry data. These parameters were estimated for the telemetry system and the study area using the data from the field test study. The error of a bearing is the difference between the azimuth of the bearing obtained with radiotelemetry and the true azimuth of the direction between the receiver and the transmitter location. The resulting errors of bearings comprise negative and positive values. To test for the bias in the radiotelemetry system, the mean value of the bearing error is used (White and Garrot, 1990). In a system without any bias, the mean bearing error is not significantly different than zero (Samuel and Fuller, 1996). The bias of the system is then estimated by estimating the mean of bearing error and testing its equality to zero using a t-test (Sokal and Rohlf, 2005).

The error associated with the precision of the location estimation through triangulation by radiotelemetry is quantified by the standard deviation of the bearings (White and Garrot, 1990). This standard error is then used in estimation of the 95% confidence ellipses obtained through triangulation (Lenth, 1981). However, due to topography or interferences from electromagnetic wave sources (such as power-lines) signal reflections and diffractions can occur. When these factors are in effect, significant increases in bearing error occur. By performing a test study, a threshold error value can be determined, and the errors higher than this value can be regarded as effective signal bounces and diffractions. Therefore, in calculation of the standard deviation of the bearings, the bearings having an error greater than this threshold value are excluded from the calculations (Zimmerman and Powell, 1995; Whitaker et al., 2002, unpublished report).

2.2.3 Homing

At the beginning of the study, in order to quantify the error associated with triangulation, 50 collars of known location were distributed at every corner of 1km^2 quadrats and their signals were received from 25 points around and inside the study area. This study revealed 3° error standard deviation, which is to be used in location calculations from triangulations. However, once the study has started, due to the topography of the area and insufficient road network, triangulation proved to be very inefficient if only a certain amount of error area (1 ha. at most) is to be accepted. Eventually triangulation method is abandoned and homing to each and every individual was performed.

In a weekly fashion, the study area is visited and every animal is found at least twice (each occasion 1 hour apart at least) every week through homing to its signal using a 4x4 vehicle and/or a boat. Once the individual is found its location is estimated using GPS, compass and map. The composition of the group is recorded. The behavior of the animals and the vegetation type of their location is recorded. The time of the day and date are also recorded. The exact methodology of locating and collecting data on radio-collared individuals by homing is as follows:

1. While the reintroduction area is being traversed by boat or a 4x4 vehicle, the radio signals of collared individuals are scanned by frequent stops and/or while moving. Whenever a strong signal is received from one or more collars, that direction is scanned with binoculars and spotting scopes. If necessary – due topographic obstructions and amount of distance – the boat or the car is driven towards that direction and animal is approached.
2. In conjunction with the boat and the car, animals are procured on foot with maximal attention for not disturbing them in order to be able to record the location of the animal without any observer effect.
3. Once the individual with signal emitting radio-collar is visually detected its location, behavior and the composition and identity (if possible) of the associated animals are recorded along with the time, day and observer.
4. To assign a map location, observer recorded:
    a. His/her location with a GPS device,
    b. The direction of the homed animal with a compass (with ± 1° error),
    c. The approximate distance from the animal (either by guessing or using the reticles of the binocular),
    d. The description of the topography of the animal's location and the surrounding terrain.

Then using these data on the topographical map of the area (i.e. fig 2.1), the location of the animal is put within a 50x50 m^2 square on the topographic map.

A test study was also made to determine the amount of error associated with assigning a map location using this methodology. For that test, a field assistant recorded his/her location using the GPS device (n=23) and communicating with the observers with a two-way radio, while the observers assigned his/her location using the above-mentioned methodology. Thus, the field assistant simulated a tracked animal. This test revealed an error of 29 ± 9 m (average ± standard error) for distances – between the observer and the field assistant – ranging between 100 m – 500 m. This would create an average of 2642 m^2, which is approximately equal to 2500 m^2 of the 50x50 m square, to which the map location of the animal is assigned as a result of homing.

2.3. Home Range

For home range calculations, the Animal Movements extension (Hooge et al., 1999) of ArcView GIS® 3.1 (ESRI) and the Adehabitat Package (Calenge, 2006) in R (R Development Core Team, 2009) are utilized. The results from both programs were compared and checked for concordance. As explained in the introduction section, fixed kernel method is preferred for estimation of the home ranges.

When home ranges are estimated using fixed kernel, two critical parameters of the method determine the size and shape of the home range: the bandwidth (smoothing parameter) and the percent utilization contour (Silverman, 1986; Worton, 1995). In kernel analysis, the width of the individual kernels is determined by the bandwidth: the higher the bandwidth, the greater the smoothing applied (Kernohan et al., 2001) Therefore, for the same data, low bandwidth values will result in multiple areas of activity centers, while large bandwidth values will result in much less or even a single center of activity. In fixed kernel estimation, the same bandwidth value is used for each kernel, while in adaptive kernel estimation, a local bandwidth is used for each observation and the value of the bandwidth gets larger in areas with less relocation data (Silverman, 1986). There are two widely used methods for selection of the bandwidth: the reference bandwidth (h_{ref}) and the least squares cross validation (LSCV) bandwidth (h_{lscv}) (Worton, 1995). The reference bandwidth approach assumes a bivariate normal distribution of relocations for the estimation of the bandwidth; while least squares cross validation do not assume any underlying distribution (Silverman, 1986). LSCV is being widely used ecological studies (Seaman *et al.* 1999). LSCV estimates a bandwidth which minimizes the discrepancy between estimated and true density. Kernel home ranges uses utilization distributions which produce density isopleths referred as home range contours. For representation of the kernel home range 95% contours are suggested in the literature (Powell, 2000). However selection of this value has been actually arbitrary. The 95% contour is based on the common use of 0.05 as the arbitrary choice for the limiting *p*-value in statistical significance (Horner and Powell, 1990). Börger et al (2006) recommends avoiding 95% isopleths in favor of 50-90% isopleths. Similarly Seaman et al. (1999) found a change in bias between inner and outer utilization distribution density isopleths and recommended using the inner part of the home ranges, especially isopleths equal to and lower than 80%. In general, bandwidth choice together with the choice of the home range contour, at its extreme, leads to one of the two results: over-smoothed single large home ranges, or multiples of small separate patches of home range.

2.4. Habitat Selection

The adaptation of reintroduced population to the new area depends, among other things, on the suitability of the habitat for the survival and reproduction of the Anatolian mouflon. The selection of the reintroduction area was made through short assessments of several candidate sites by several experts (unpublished reports to DNP). However these assessments were far from satisfying the requirements of the IUCN Guidelines for Reintroductions (1998). The only apparent positive aspects of the chosen area were:

a) Anatolian mouflon was known to have lived in the area until 1960s: therefore the action was a reintroduction,

b) The proposed area was neighboring a small number of villages : the area was relatively less affected by human land-use,

c) A reservoir lake was lying through the southern part of the area: abundant source of water was present

However many other aspects of the habitat was not evaluated properly and expert opinion was taken for granted. Additionally, only several other potential reintroduction areas were included in the selection process. Most of the extent of the previous distribution of Anatolian mouflon was not given any consideration.

Therefore an evaluation of the reintroduction area by monitoring the habitat use of the reintroduced population could give some hints about the suitability of the area, along with the monitoring of the demography, and the results could be utilized in the future reintroductions of the species. For that purpose a habitat selection study is planned through monitoring of the radio-collared individuals during 18 months of post-release period. Various habitat variables were quantified for the study area and the individuals were tied to be monitored on a regular basis.

2.4.1 Preparation of Habitat Variable Layers

The variables used to quantify the habitat selection of Anatolian mouflon were taken from various sources. Then, this information is digitized into a GIS platform (ArcGIS 9.2, ESRI) and the layers of habitat variables are created.

The topography of the area is taken from 1/25,000 scale military topographic maps (hereafter referred to as maps). The main variable digitized from the maps is the altitudinal isopleths, which had 10m altitudinal resolution. Through the digitization of the isopleths, slope and aspect maps of the area are created using ArcGIS tools. Additionally, roads, human settlements and water bodies were digitized from the maps. The vegetation is digitized from military aerial photographs of around 1/30,000 original map scale. The aerial photographs were first georeferenced to match with the topographic maps, and then the relevant layers were digitized in vector format. The details of preparation of each habitat variable layers are given below.

The raw images to prepare each layer were: i) 1/25,000 scale maps produced in 1999, and ii) black and white military aerial photos taken from a plane during 1998 and 1999, having images of base quality corresponding to around 1/30,000 map scale. Both these images were obtained from Turkish General Command of Mapping in paper format and then scanned in high quality for further digitization of the information they contain. The topographic maps covering the study area (H-26c3, H-27d4 and H-27d3 military topographic maps) were scanned and opened in ArcGIS 9.2 (ESRI). Using the georeferencing tool, the images were converted into georeferenced images according to the specific projection and datum that were used in the maps (Universal Transverse Mercator projection with European 1950 datum), whose details were given in the map legend. For georeferencing, five grid intersection points were used as control points and a mean residual error of less than 10 m were obtained in each map. Once georeferenced, the altitudinal isopleths were all digitized as a line layer (altitude) by hand under around 1/10,000 scale in order to include the details in rugged terrain. The altitude layer (vector-line) was first converted to a triangulated irregular layer (TIN) using the 3D analyst of ArcGIS, and then this TIN layer was converted to a raster layer (tingrid), which formed the basis for creating the digital elevation model (DEM), elevation, aspect and slope habitat layers. The aerial photos were also scanned and brought into the GIS environment as images. A total of five photos covered the study area (4525-3408, 4525-3410, 4526-3500, 4526-3502, and 4526-3512). These photos were georeferenced the same way as the maps. However, due to the distortion caused by shooting of the photo from an aircraft (the distances in the center of the photo – from where the picture was taken – tend to be represented as shorter, towards the edges of the photo, due to the increasing angle of sight) and the topography of the terrain, much more control points were utilized especially in the hilly parts of the area. For each photo, at least 20 control points with known GPS coordinates were used and a mean residual error of less than 20m was obtained in each photo. These photos were used in forming the vegetation habitat layer. The study area was delineated as the terrain used by the collared individuals released in 2007 until the end of the study (July 2009) and the surroundings excluding the (Sarıyar Dam Lake) with geographical connectivity.

a) **Aspect Layer:** The aspect layer was formed using the Spatial Analyst tool of ArcGIS. The tingrid raster layer was used to form a 50x50m^2 cell-sized new raster layer of aspect. The aspects were classified (in degrees from North, or azimuth) as:

   -1 – 0: Flat areas with no aspect

   0 – 45 and 315 – 360: North

   45 – 135: East

   135 – 225: South

   225 – 315: West

   Therefore the aspect layer became a "factor" layer formed of classes. The amount of sunshine reception changes according to the aspect of the terrain. The depth and duration of the snow cover in winter and the evapotranspiration from the plants in summer are related to the aspect of the terrain which in turn can affect the habitat use of the mouflon (Rachlow & Bowyer 1998).

b) **Elevation layer:** The elevation layer was also formed using the Spatial Analyst tool of ArcGIS. The tingrid raster layer was used to form a 50x50m^2 cell-sized new raster layer of elevation. The elevations ranged from 390 – 870m, and the elevation layer constituted a "numeric" layer of continuous data (meters as the unit). Elevation is one of the major determinants of animal distribution due to its effect on the change of the mean temperature. However, in Sarıyar, the range of present elevation plays a minor role in this respect. The importance of elevation change in Sarıyar is that the accessibility decreases as the elevation increases, and this could affect the habitat use of mouflon (Bangs *et al.* 2005).

c) **Slope layer:** The slope layer was also formed using the Spatial Analyst tool of ArcGIS. The tingrid raster layer was used to form a $50x50m^2$ cell-sized new raster layer of slope. The slopes were quantified as degrees ranging from 0 to 45 degrees (corresponding to 0% to 100% slope). The slope layer therefore became a "numeric" layer of continuous data (degrees as the unit). Mouflon and other *Ovis* species are known to use the higher slopes as escape terrain and during parturition (Bangs et al, 2005; Rachlow & Bowyer 1998). Therefore slope is likely to affect the habitat use of mouflon.

d) **Distance to water layer:** The distance to water (water) layer was also formed using the Spatial Analyst tool of ArcGIS. The tingrid raster layer was used to form a $50x50m^2$ cell-sized new raster layer of distance to water. Euclidean (straight line) distance option was used to calculate the distance of each cell to the main water source, which was the Sarıyar dam lake. This layer also became a "numeric" layer of continuous data (meters as the unit). Water is a crucial source for all the living things. Especially in summer, when rainfall is very limited, Sarıyar Dam Lake was the only regular source of water for mouflon and therefore is expected to affect the mouflon's habitat use.

e) **Distance to roads layer:** The distance to roads (road) layer was also formed using the Spatial Analyst tool of ArcGIS. The tingrid raster layer was used to form a $50x50m^2$ cell-sized new raster layer of distance to roads. Euclidean distance option was used to calculate the distance of each cell to the roads. This layer also became a "numeric" layer of continuous data (meters as the unit). Four types of road were determined using the military maps' legend: intercity roads, two-lane narrow roads, unpaved roads and summer-only roads. The effects of roads on wildlife are various, ranging from a cause of direct mortality (through collisions) to edge-effect considerations (i.e. Dickson & Beier, 2002; Merrill et al., 1999) In this study, the type of roads were not taken into such a consideration as having differential effects on mouflon's habitat use depending on their type, but rather assumed to have similar effects. Therefore the right distance between each habitat cell to the closest road represented the intensity of effect of roads on a particular cell: the closer the road, the higher its potential effect.

f) **Distance to settlements (villages) layer:** The distance to villages (village) layer was also formed using the Spatial Analyst tool of ArcGIS. The tingrid raster layer was used to form a 50x50m^2 cell-sized new raster layer of distance to villages. Euclidean distance option was used to calculate the distance of each cell to the villages. This layer also became a "numeric" layer of continuous data (meters as the unit). In calculating the distance to villages, the right distance between each habitat cell to the closest village represented the intensity of effect of human settlements on a particular cell.

g) **Vegetation layer:** The vegetation of the study area was derived from aerial photographs. The resolution of vegetation in aerial photos was limited. The main cover types and cover densities were discernible. This layer is formed as a "factor" layer of categorical variable of vegetation/cover type. The vegetation layer included seven classes: dense tree cover with 40% – 70% canopy coverage (HiTree), medium density tree cover with 10% – 40% canopy coverage (MidTree), low density tree covered grassland with >10% canopy coverage (LowTree), grassland with shrubs (Grass), sparsely vegetated grassland (Sparse), barren ground (bare rocks and soil with very little herbaceous plants; Barren) and crops (Crop) (see Fig .2.4). Vegetation provides food for the mouflon, and the density of the trees in tree-covered grassland affects the visibility of surrounding terrain. Mouflon is a good runner and has a vision sensitive to movements even in relatively far distances; therefore the mode of defense from potential predators is through scanning, detecting from a distance and running away (Risenhoover and Bailey, 1985). For that purpose, the open terrain and relatively low tree-covered grassland is expected to be selected over a dense tree cover, where the visibility of the surrounding terrain is low.

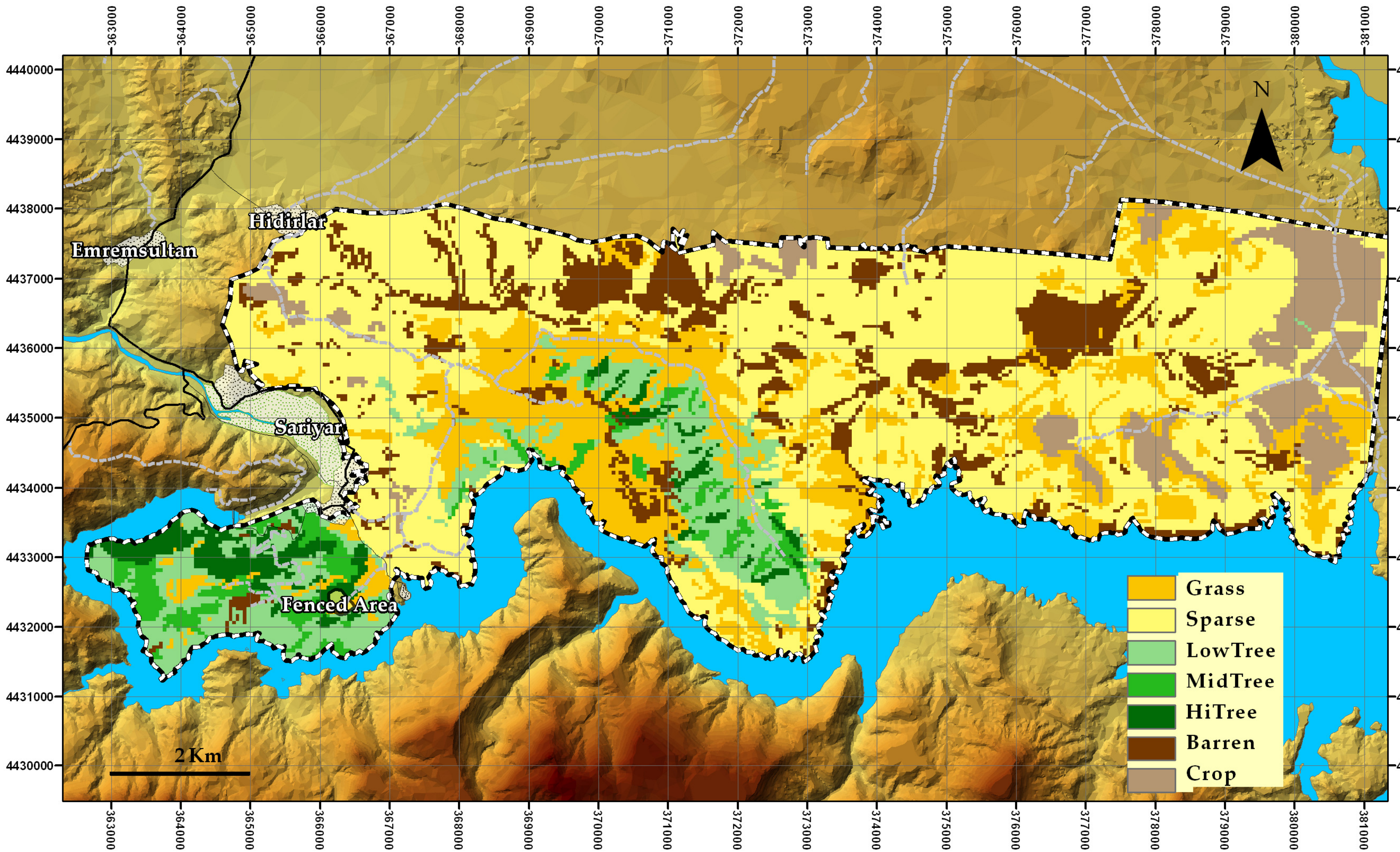


Figure 2.4 Vegetation map of the study area with seven classes (explained in text).

2.4.2 K-Select Method

K-select method is used to explore the effect of different variables on habitat selection of reintroduced Anatolian mouflon. The relocation data obtained from 22 animals were used for the analysis. In order to explore the selection in two scales, K-select analysis is performed for habitat selection within home range (design III: relocations represent use, home range represent availability) and habitat selection within the study area (design II: relocations represent use, study area – the delineated area in Fig 2.1 – represents availability).

For selection within home range, the 80% kernel home ranges of each animal were utilized as the available area. The relocations used for calculation of the home range of each animal were utilized as the use locations. The 50x50 m^2 pixels were the units of the availability (as explained in previous section). Data from each variable layer (slope, aspect etc.) had the same origin, which enabled the juxtaposition of all the variable layers. This has resulted in a single multi-variable map, in which each pixel has one value of each variable. The relocations of individuals got the multivariate value of the pixel, in which they fall. Using the multivariate habitat map with the relocations of animals, the 'kselect' function of the adehabitat (Calenge, 2006) package in R program (R Development Core Team, 2009) the K-Select analysis is conducted (Calenge et al., 2005). The computational steps of this analysis are explained in the help files of adehabitat package.

2.4.3 Compositional Analysis

Compositional analysis was performed using the 'compana' function in the adehabitat package of the R program. For the analysis, use and availability tables were prepared. The rows of the tables contained the individuals and the columns contain categories of the variables. Each individual' percent use of each category constituted the contents of the cells of the use tables. While in the availability tables the percent availabilities of each category for each animal are present.

Compositional analysis was performed in three different scales. In the first one, use of the animals is characterized by the relocations and the availability was characterized by the home range of the animal (design III). In the second case, the use was the same but availability for each animal was the whole study area (design II). In the third one use of the animals was characterized by the animal's home range and availability by the whole study area.

2.5. Demography

Demography is the statistical study of populations. The size, structure, distribution, spatial and temporal changes in these properties through birth, date, emigration and immigration are the subjects of demographic study (Gotelli, 2001). In wildlife studies, population specific parameters such as survival, mortality, fecundity, growth rate etc. are used to describe the demographic processes.

Demography of the reintroduced population was characterized by the survival and fecundity of female individuals.

2.5.1 Survival and Fecundity Estimations

There are many approaches to estimate survival rates of wildlife populations. Each method requires specific type of data. The data obtained from radiotelemetry is generally classified as known-fate data. The fate of each radio-collared individual is almost always known. Therefore estimation of survival is rather straightforward. Another widely used method, mark-recapture, on the other hand lack the knowledge of the fate of the marked individual. The reencounter rate should be estimated additionally in mark-recapture studies, in order to estimate the survival rates.

The two most widely used survival estimation methods for radiotelemetry data are Mayfield method (Trent and Rongstad, 1974) and Kaplan-Meier analysis. In Mayfield method, the survival of a population within a given period is estimated by summing up the total number of days spent alive by each individual of the population and number of individuals dead within the interval, using the formula:

$$S_d=1-(\text{\# of deaths/total exposure days})$$

Unbiased Mayfield estimates require no censoring (exclusion of a tracked individual from analyses due to its loss of signal during the study period) but can tolerate very low levels of censoring (Vangilder and Sheriff, 1990). Staggered entry into the study of newly released animals can be handled with the Mayfield method. The critical assumption of the Mayfield method is that the survival is constant throughout the period for which the survival is estimated. If the period is short, like day or a week, this assumption can be met. However for longer intervals this assumption can easily be violated. To overcome this problem, the intended period can be divided into smaller units and survival values are calculated for these smaller intervals. Afterwards these survival estimates for the smaller periods can be multiplied to obtain the survival estimate for the interval (Bart and Robson, 1982).

In Kaplan-Meier method (Kaplan and Meier, 1958), a survival function is used which is the probability of an arbitrary animal in the population surviving t units of time from the beginning of the study (Pollock et al, 1989):

$$St=\Pi\ [1-(\#\text{ of deaths at time } j)/(\#\text{ at risk at time } j)]$$

Unlike Mayfield method, Kaplan-Meier has no underlying assumption of constant survival and can produce unbiased estimates even with the presence of censored data. Staggered entry is also possible in Kaplan-Meier method.

In this study the Mayfield method was utilized using the Micromort software (Heisey and Fuller, 1985).

Assumptions of a survival analysis with radiotelemetry data are:

- Random sample of individuals: in order for the results to represent the whole population, every individual should be equally likely to be caught and radio-collared.

- Experimental units are independent: individuals' survival should not be dependant on or affected by other individuals.
- Radio-collared individuals are always located: because of the known-fate character of the radiotelemetry data, the individuals in the study area should be always detectable.
- Radio-collars do not affect the survival of the individual: if the radio-collars are negatively affecting the individuals then their survival can not represent the survival of the population.

2.5.2 Population Viability Analysis

Population viability analysis (PVA) is the method of estimating the probability that a population of a given size will persist for a specified length of time. In PVA, the probability of extinction is estimated. Many different types of approaches are available in PVA, depending on the available data or life history of the organism (White, 2000; Boyce, 1992). PVA models can use deterministic and stochastic approaches. The stochastic approaches incorporate variability and uncertainty while the deterministic approaches do not. The types of variation that can be included in PVA models include: stochastic variation (random variation), demographic variation (variation due to characteristics of a population such as population size or mating system), temporal variation (variation in the parameters of the model through time), spatial variation (variation across the landscape), individual variation (genetic and phenotypic variation) (White, 2000). The components of a PVA model for short term studies, are: i) a population model, ii) demographic, iii) temporal, iv) spatial, and v) individual variation.

PVA models are utilized in order to project the viability of the reintroduced population for the near future and explore the effects of individual parameters (age-specific survival, fecundity) on the viability of the population. Furthermore, using the PVA model, certain relevant conservation scenarios were evaluated.

To create the model and perform the calculations, RAMAS-Ecolab program (Akçakaya et al, 1999) is used. In preparation of the model, a stage or age structure for the study population is determined, according to the available data. Then a Leslie matrix containing age or stage-specific survival and fecundity values is formed. A standard deviation matrix of the stage matrix is formed, in which parameter-specific standard deviation values represent the environmental stochasticity. Model also requires a density dependence type to be chosen among the given alternatives; for short term evaluations an exponential growth model can also be utilized. One of the most important parts of the model is the initial abundances from which the projections are going to be started. PVA model's outcome is greatly affected by the initial abundance of the population, since this is one of the major constituents of demographic stochasticity.

To evaluate different conservation management scenarios the specific parameters of the model can be changed and its effects on the outcome of the projection and estimated extinction probabilities can be evaluated (sensitivity analysis). Additionally, effects of several actions such as harvesting or introducing new individuals to the population can be tested.

CHAPTER III

RESULTS

3.1. Radiotelemetry Study

The test study was completed in the end of 2006. Before that, during the end of 2005 and beginning of 2006, a small number of radio-collared individuals were radio-tracked (whose data is used in demographic calculations). The results of the test study (below) and the experience of triangulation field-work led us change the data collection method. To obtain location data from the radio-collared animals reintroduced in September 2007, homing was used instead of triangulation. Data collection by homing reduced the sample size, in the sense of location data per animal per given amount of time. Data collection by triangulation enable researchers to collect more location data per individual per given time, than data collection by homing, in general. Mainly due to signal bounce occurring in the entire study area, possession of a single off-road vehicle and limited road network in and around the study area rendered the use of triangulation ineffective. Switching to homing method was the only feasible option, with a big plus of obtaining highly accurate location estimates and recording other types of data from the radio-tracked individuals (such as, group size and composition, behavior etc.).

Radio-tracking study was performed on a weekly to biweekly basis and each field study lasted 1-4 days. In each field study, every individual included in the analysis was observed at least once. The radio-tracking was continuous for the initial 15 months (Nov. 2007 – Jan. 2009) and then halted for 3 months and last data were obtained in May 2009; all study period covering a total of 19 months. The summary of data is given in Table 3.1. On average 62 ± 3 (average ± standard error) relocations per individual was obtained during 19 months of radio-tracking. For 15 months of continuous tracking ~60 locations/animal were obtained (4 locations/month).

The radio-tracking data of individuals included relocations of the same animals within 15 min to two weeks. In order to reduce the temporal autocorrelation, the relocations that are less than one hour apart are excluded from the analysis, but no formal test of temporal autocorrelation was performed (Swihart & Slade 1985). Due to the limited amount of relocations per animal, a longer time interval was not preferred. Additionally, in order to avoid the effect of stress after the release, on habitat selection of mouflon, the relocation data was used starting from one month after the release.

Table 3.1 Identity, sex and relocation data on radio-tracked individuals

	Individuals										
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**
Frequency of collar (150.*XXX* MHz)	*056*	*096*	*126*	*326*	*345*	*365*	*466*	*505*	*546*	*566*	*606*
Sex	M	M	M	M	F	M	F	F	M	F	F
Number of relocations	49	54	45	78	61	77	65	63	68	63	54
Duration (months)	10	19	9	19	19	19	19	14	19	19	13
Home Range Size (ha, 80% Kernel)	1462	933	3435	1018	1744	2544	2004	1793	1648	2252	1918

	Individuals										
	L	**M**	**N**	**O**	**P**	**Q**	**R**	**S**	**T**	**V**	**W**
Frequency of collar (150.*XXX* MHz)	*624*	*694*	*715*	*735*	*765*	*786*	*805*	*836*	*855*	*935*	*986*
Sex	F	F	F	M	M	F	M	F	F	M	M
Number of relocations	70	86	67	72	55	45	68	74	28	60	59
Duration (months)	19	19	19	19	19	8	19	19	7	19	19
Home Range Size (ha, 80% Kernel, LSCV)	2102	805	2209	2152	3169	1214	2033	2318	2354	1388	2052

XXX denotes the different *frequency value* of each individual's collar, given in the first row.
M: male, F: Female

3.1.1 Test Study

Test study has shown that there is a good possibility of signal bounce from almost everywhere of the study area, depending on the location of the transmitter and the receiver: signal bounce was observed (through assuming that bearing errors greater than 15° are the result of signal reflection or diffraction) from every receiving location. Test study has also shown that the amount of bearing error associated with the radiotelemetry (details given below) leads to very large range of 95% confidence ellipse areas (Lenth, 1981; 95% CI areas ranging from 0.5 ha to 200 ha) estimated by Locate III software (Nams, 2006), making it inappropriate for home range and habitat selection.

The histogram showing the distribution of bearing errors is given in Fig. 3.1. The frequency distribution of bearing errors is also given in absolute values for visualization of 15° error barrier independent from the sign of the error (Fig. 3.2). Also apparent in this graph, more than 85% of the errors are smaller than 15°. The errors larger than 15° were most likely due to a signal bounce and represent minority of the situations. Therefore removal of these extreme values resembles the removal of the outliers from estimation (Lee et al., 1985). According to this, the error values larger than 15° were excluded from the calculation of bias and standard deviation estimations.

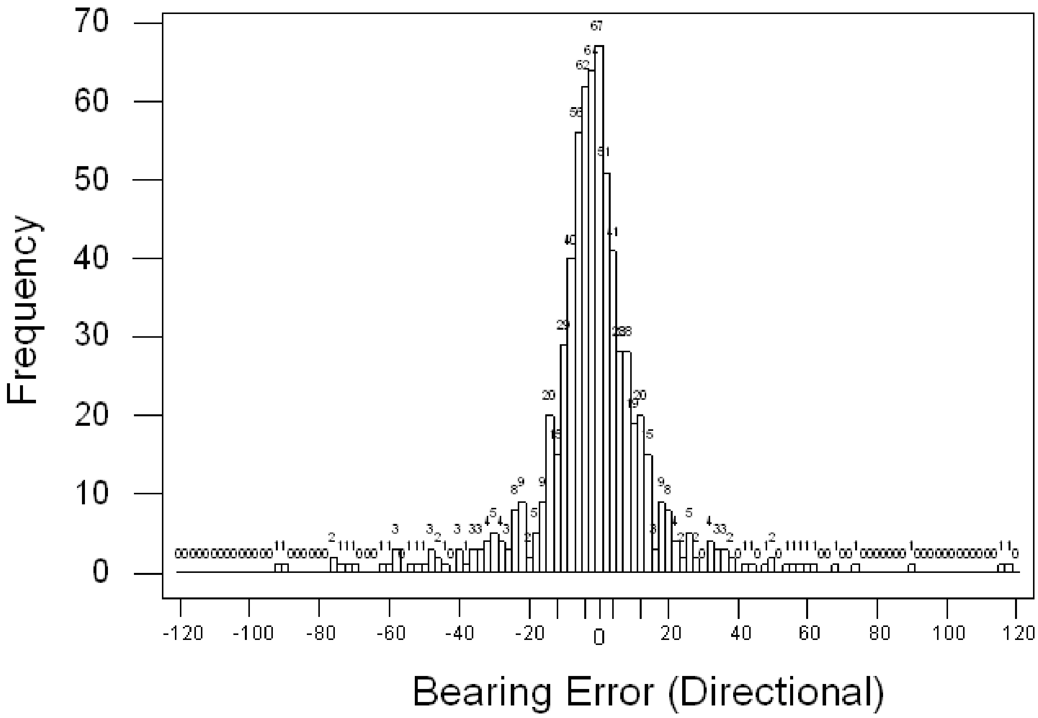


Figure 3.1 The frequency distribution of the bearing errors obtained from the test study. Resulting errors can be negative or positive (error = true azimuth – azimuth obtained telemetry) but their sum should be close to 0 if the system is unbiased.

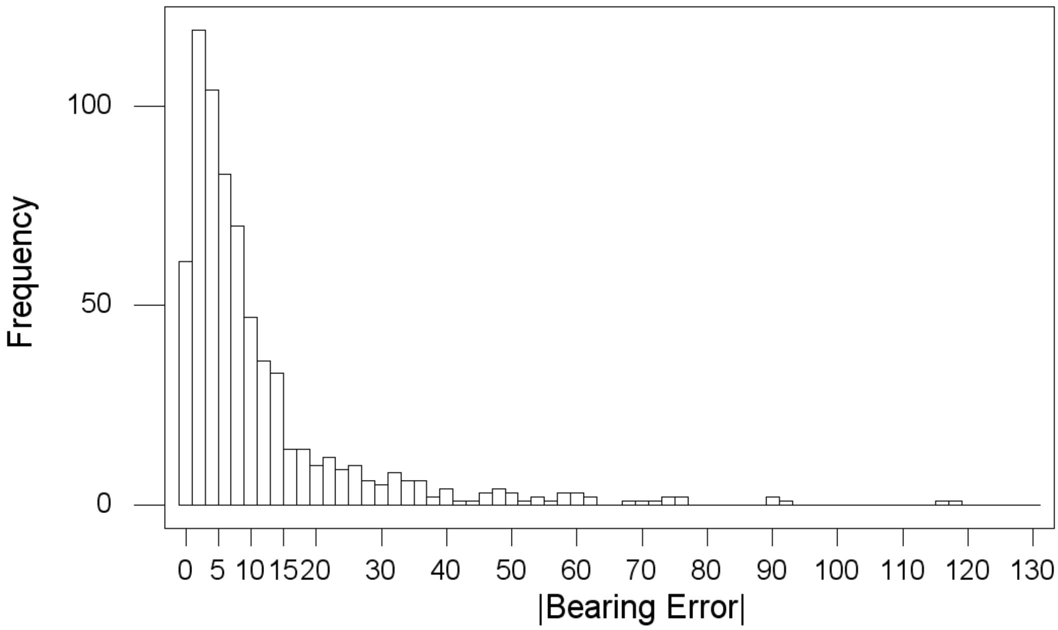


Figure 3.2 The frequency distribution of absolute values of bearing errors in the test study. There is a sharp decrease in frequency (of errors) after the 15° absolute bearing error.

The data obtained from the test study is analyzed by Minitab 13.2 (Minitab Inc., 2000). The mean bearing error estimates the bias of the radiotelemetry system (Lee *et al.* 1985) and it was estimated to be -0.19° ± 0.23° (average ± standard error). In order to test the significance of this bias, its difference from zero was tested using a t-test and no significant difference was found ($p = 0.411$). The use of +3.5° of declination value, calculated from the information on 1/25,000 scale topographical maps of the area has been crucial in avoiding a bias caused by the difference between magnetic North and true North (declination). The standard deviation (SD) of bearing error was estimated to be 6.04°. This was a rather high value and eventually led to abandonment of triangulation and use of homing to locate the radio-collared individuals.

3.2. Home Range Estimation

Out of 30 adult mouflon reintroduced in September 2007, 22 of them survived long enough to calculate a home range for the post-release study period. Single home range for each animal is calculated for the entire study period instead of seasonal or biologically meaningful periods (i.e. rut, parturition, gestation). The reasons for this choice are, i) relocation data per animal was not large enough to divide into seasons, ii) a reintroduced population do not have a prior knowledge of the release area and therefore during the initial post-release period, there could be factors other than the seasonal changes, affecting the home range and home range shift of an animal (Nelleman et al, 2007; Ostermann, Deforge & Edge, 2001). However, the area utilization according the seasons is visually presented by differential coloring of the relocations according to seasons.

The relocation data obtained during the first month of the post-release period was not utilized, as this period was considered to be part of the acclimatization period: one month within the pre-release enclosure and the first one month in the post- release period. In order to decrease the effect of temporal autocorrelation on home range estimation, some relocations closer than 1 h were discarded. This decision was not resulted from a formal statistical procedure, such as 'time to independence' (Schoener, 1981; Swihart and Slade, 1985) but was an arbitrary choice. Since the method of data collection was homing, once the radio-tracked animal is observed visually, several consecutive locations of the animal (and the associated individuals) within a short time frame (20-60 min) were recorded. The relocation records of such observations made within less than 1 h were the ones that were discarded. It is assumed that using relocations 1 h apart from each other would decrease the effect of autocorrelation.

For the estimation of the home range sizes, 80% (density isopleths) fixed kernel home ranges with a fixed bandwidth (h = 900) was used. The 80% contours was preferred in accordance with recent literature (Seaman et al, 1999; Börger et al, 2006) and the fit of the 80% home ranges to the documented (via relocations) and observed area use is evaluated (arbitrarily) to be optimum. Outer isopleths included areas where no documented or observed use is present, including mostly the human dominated landscapes such as intensive domestic use, human settlements, roadsides and Sarıyar Dam lake. For bandwidth selection, LSCV (h_{LSCV}) failed to give a bandwidth value in R program. Home ranges were produced using LSCV and reference (h_{ref}) bandwidth and visually evaluated for reflecting the temporal change in area use and treatment of the outliers. Additionally some intermediate h values to LSCV and reference bandwidth were evaluated. Eventually a fixed bandwidth value of h=900 was chosen to be used in home range calculation due to the better fit of resulting home ranges with above mentioned factors.

For kernel home ranges, the Sarıyar Dam lake was included partly in the home range for most of the animals. Exclusion of the lake from the home range estimation could not be achieved with available methods. As a result, the part of the home range that overlaps with the lake and the shores across were cropped from the home range. Other home range estimators such as the nearest neighbor convex hull (NNCH) (Getz and Wilmers, 2004) and cluster analysis (Kenward et al., 2001) were able to exclude the dam lake out of the home range area, but in expense of producing a highly patched/unconnected home range areas. These home ranges were also produced using R program but are not presented here.

Home ranges of individuals ranged between 805 – 3435 ha. Overall mean home range size is 1934 ± 140 ha. Average home range of females is 1883 ± 146 ha (mean ± std. error), males is 1985 ± 246 ha (Figure 3.3 There was no significant difference between home range sizes of sexes ($p=0.833$, one-way ANOVA).

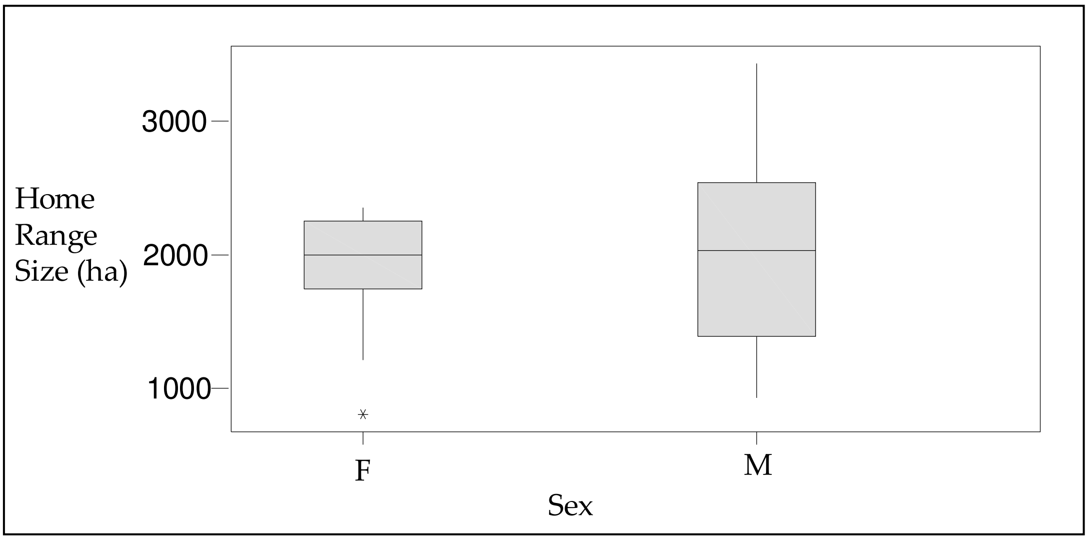


Figure 3.3 Boxplot of 80% fixed kernel home range sizes of females (F) and males (M)

The home ranges and the relocation points, drawn on the map of the study area are given for each radio-tracked individual in Figure 3.4.

(a) Individual A (56)

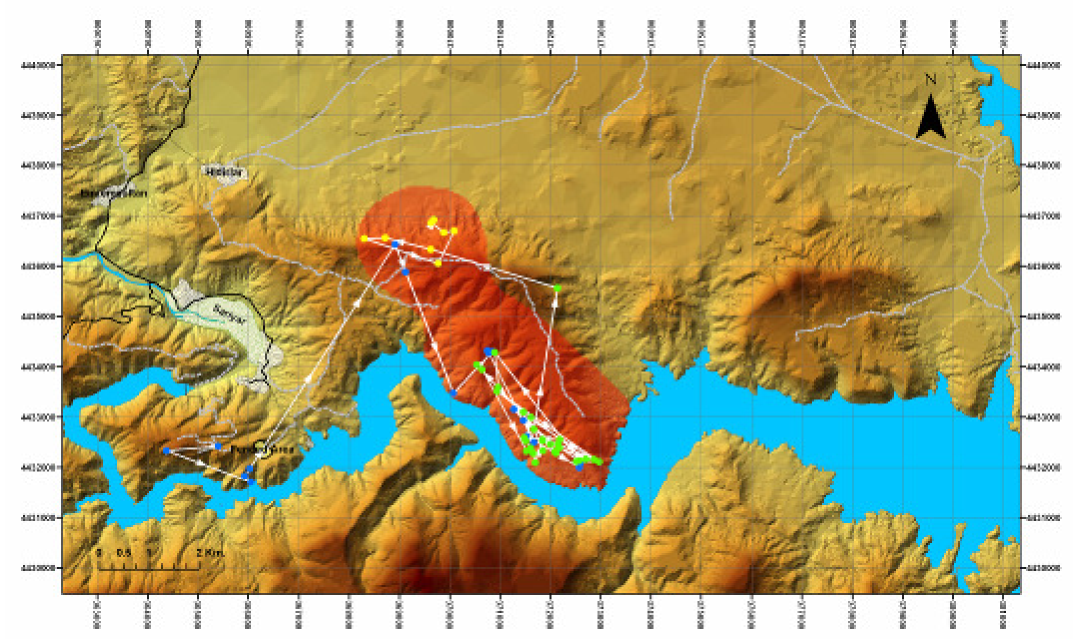
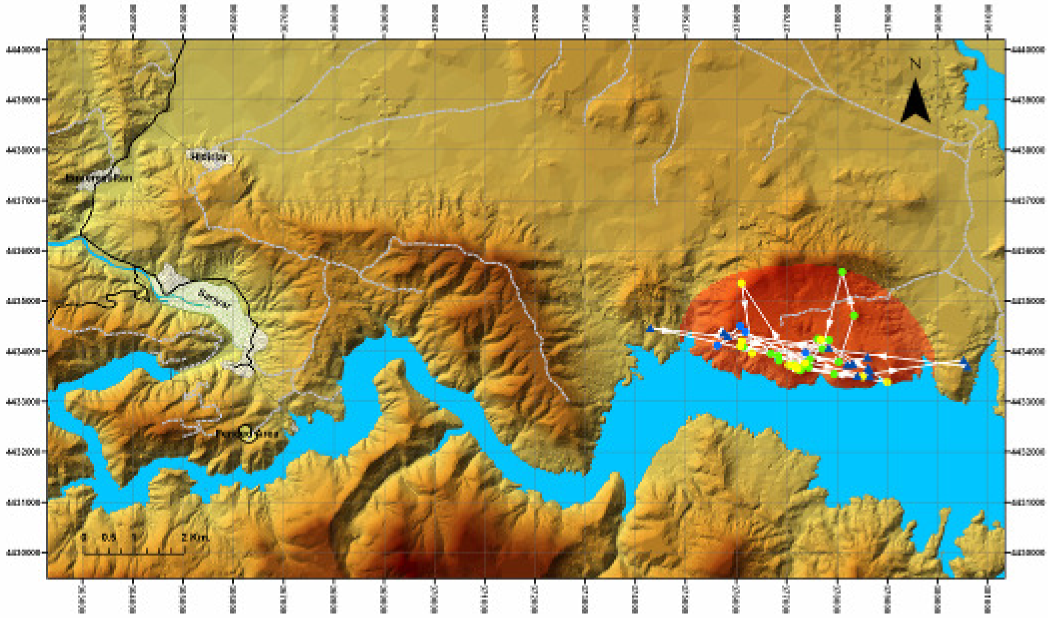


Figure 3.4 Home ranges, relocations and movements of 11 males and 11 females from (a) to (w). 80% isopleths are given in red shaded areas. The relocations used for home range estimate are given in two different shapes and five different colors: circles represent the first year, and triangles represent the second year; green color is spring (March-May), yellow color is summer (June-September), blue color is winter (October-February). White lines connect the consecutive relocations and show the direction of travel. Grey dotted lines are stabilized roads, black lines are asphalt roads. Villages are also shown and labeled. Projection of the Map is UTM (The figure continues in the following pages).

(b) Individual B (96)



(c) Individual C (126)

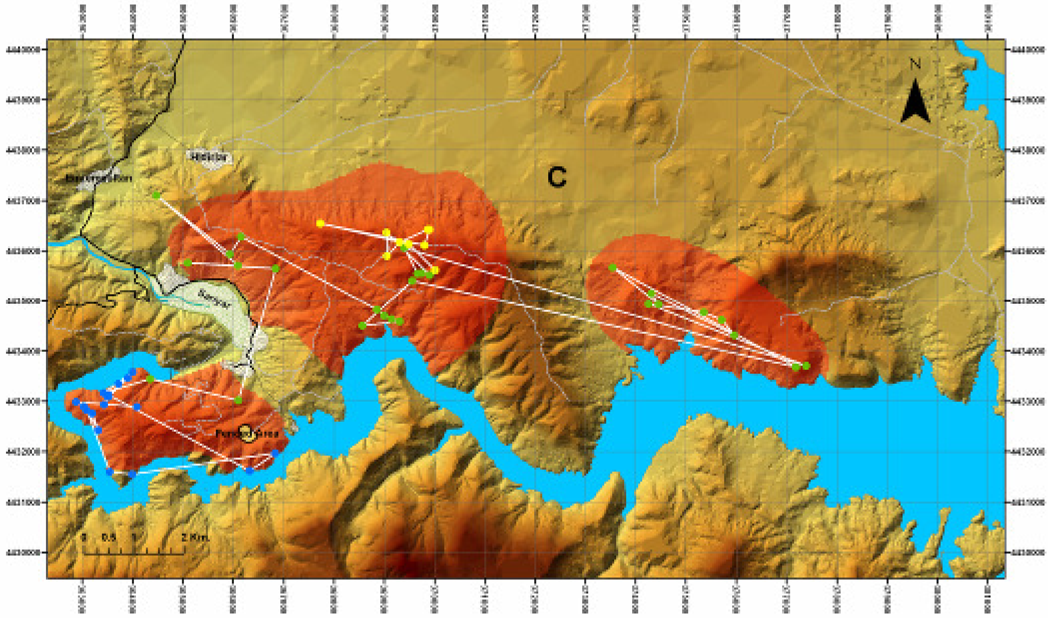
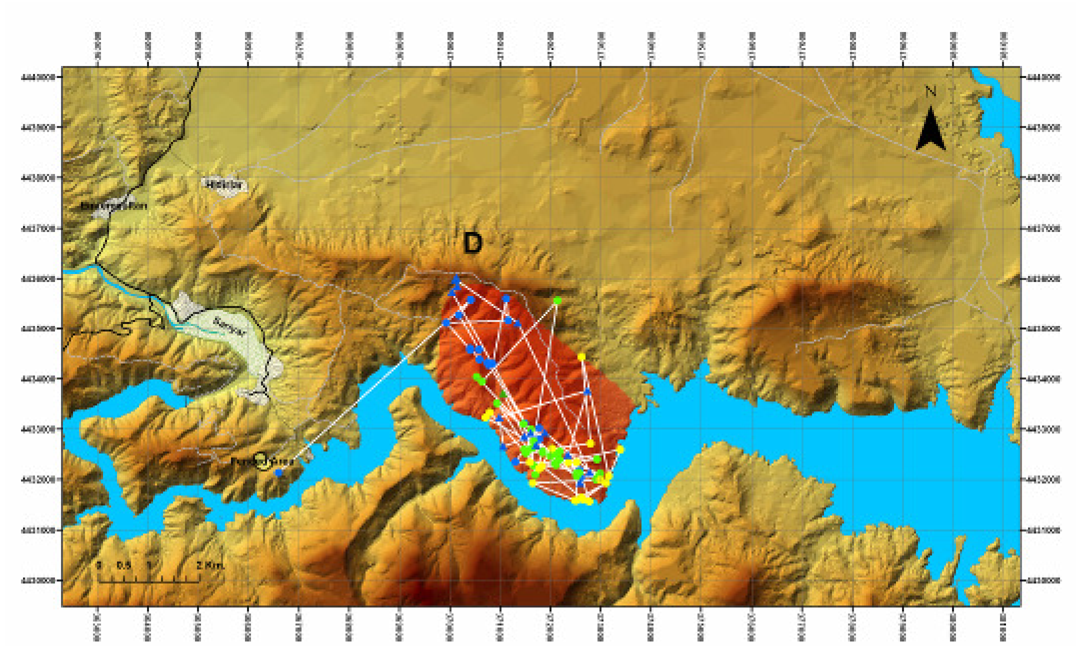


Figure 3.4 (contd.) Home ranges, relocations and movements of B and C

(d) Individual D (326)



(e) Individual E (345)

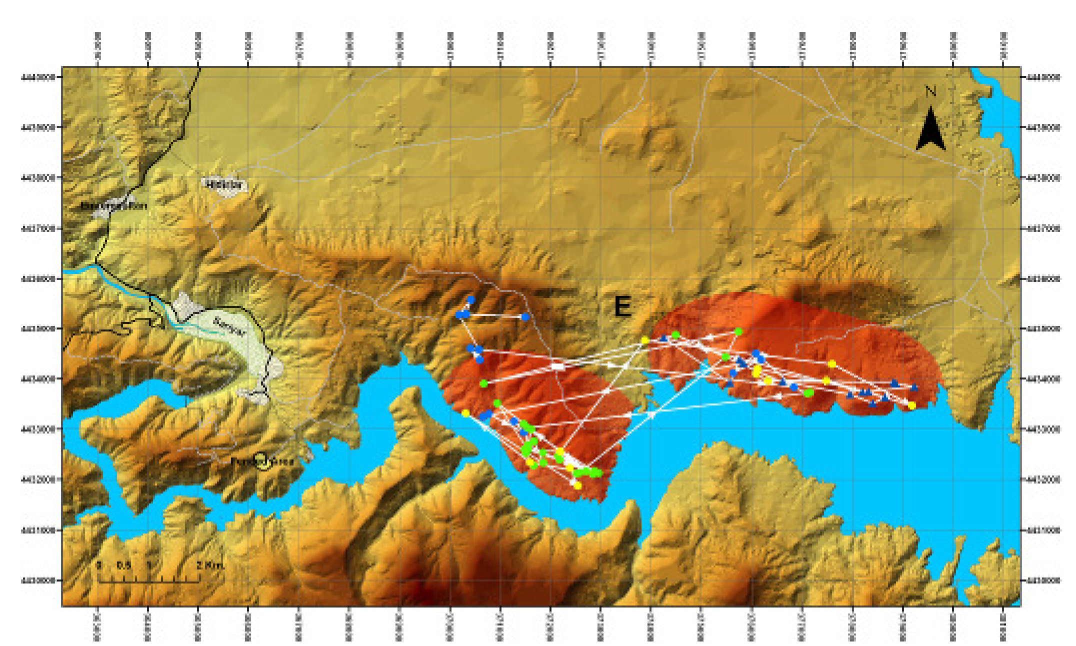
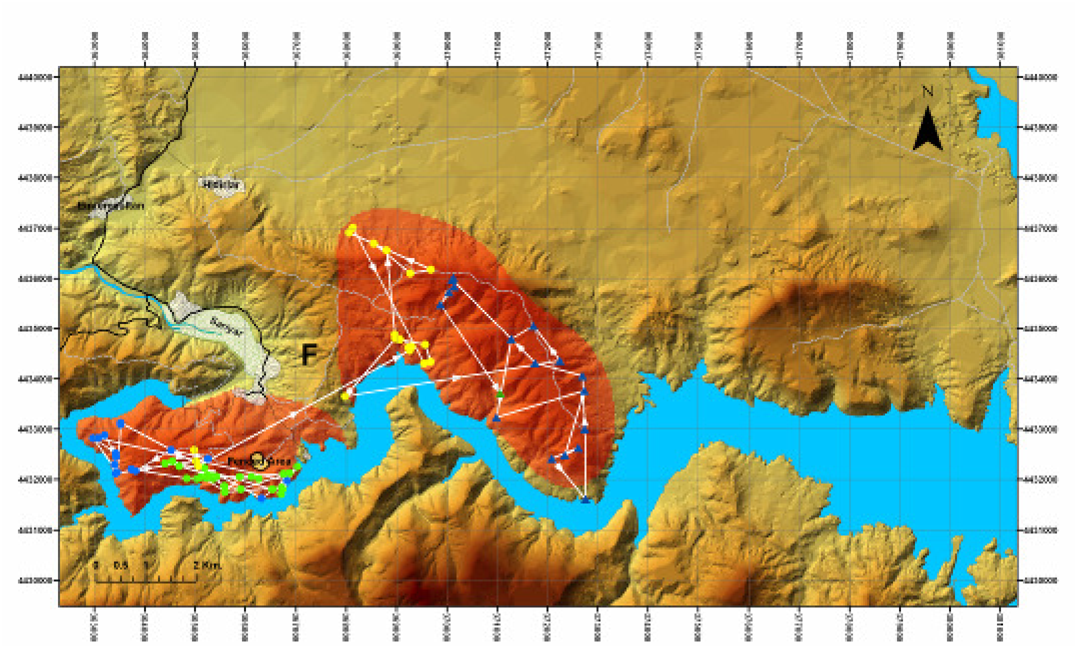


Figure 3.4 (contd.) Home ranges, relocations and movements of D and E

(f) Individual F (365)



(g) Individual G (466)

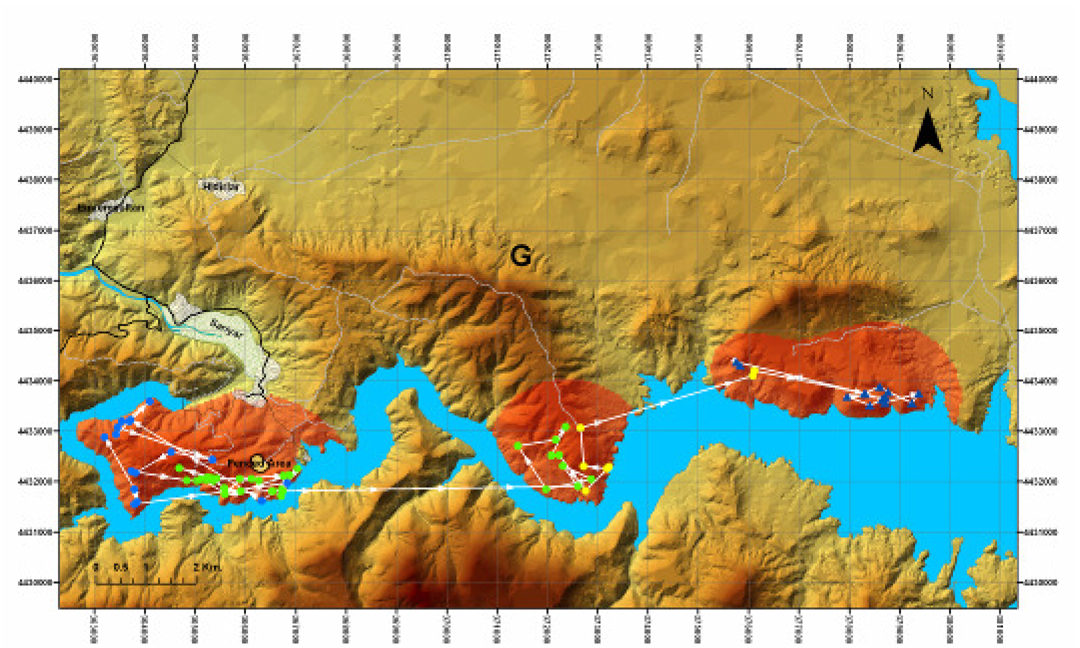
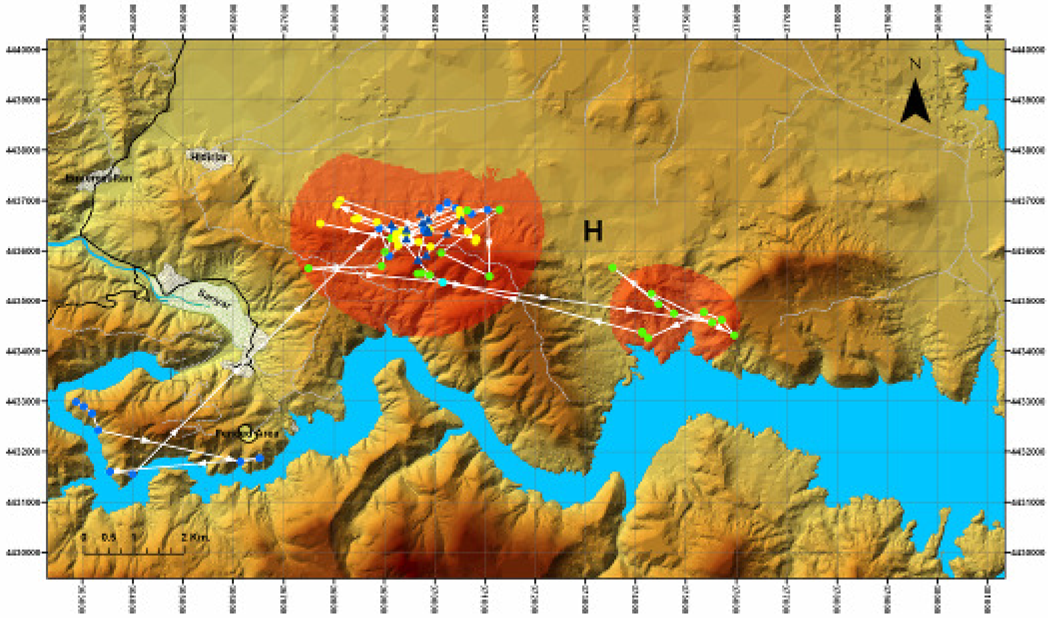


Figure 3.4 (contd.) Home ranges, relocations and movements of F and G

(h) Individual H (505)



(i) Individual I (546)

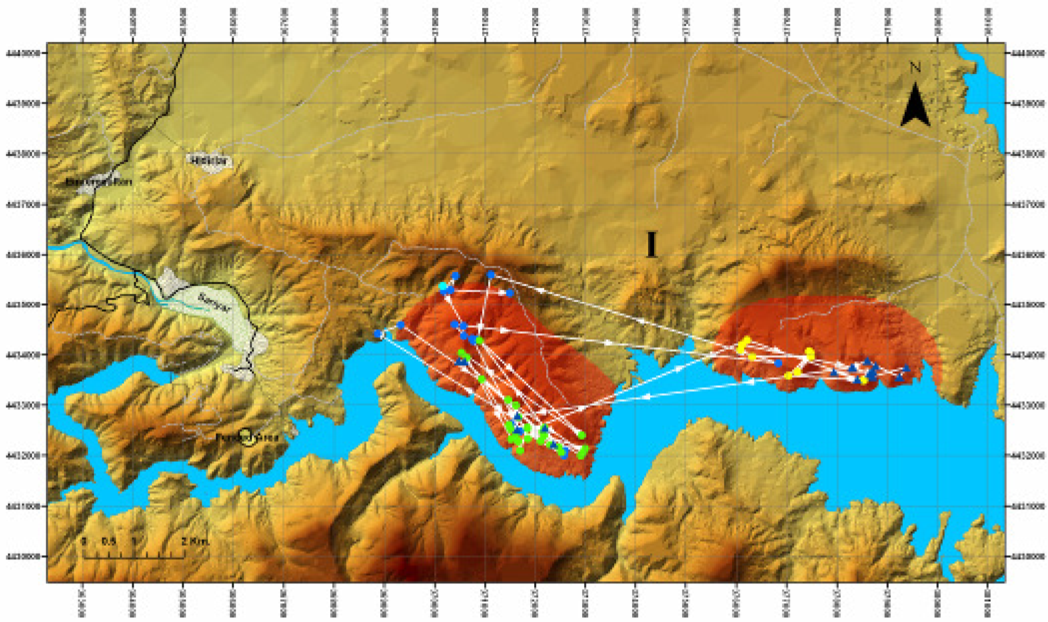
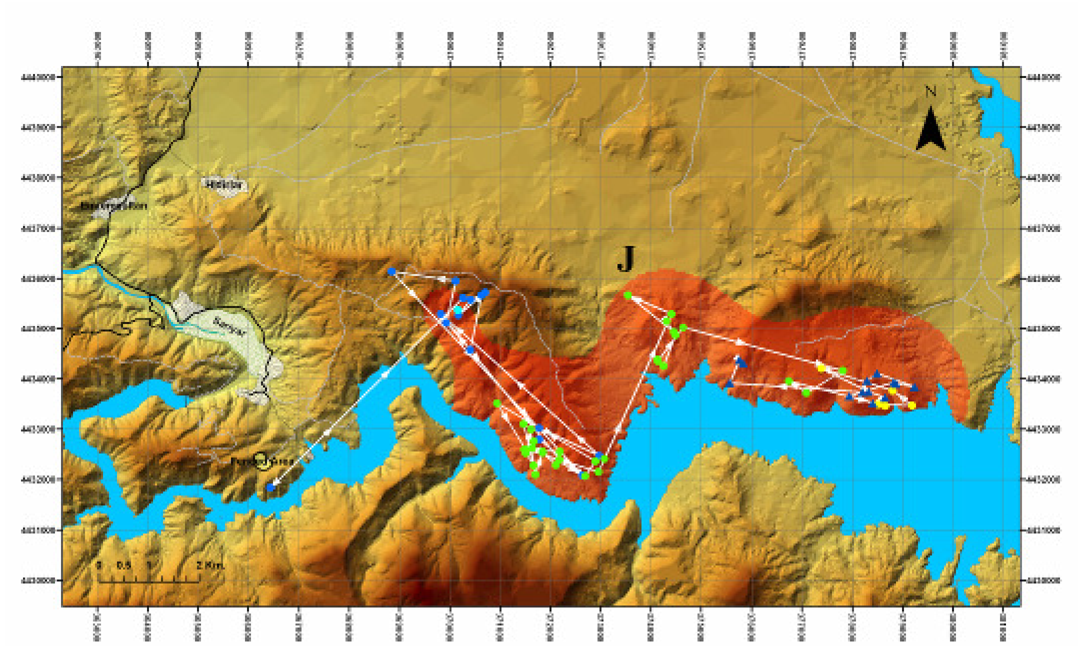


Figure 3.4 (contd.) Home ranges, relocations and movements of H and I

(j) Individual J (566)



(k) Individual K (606)

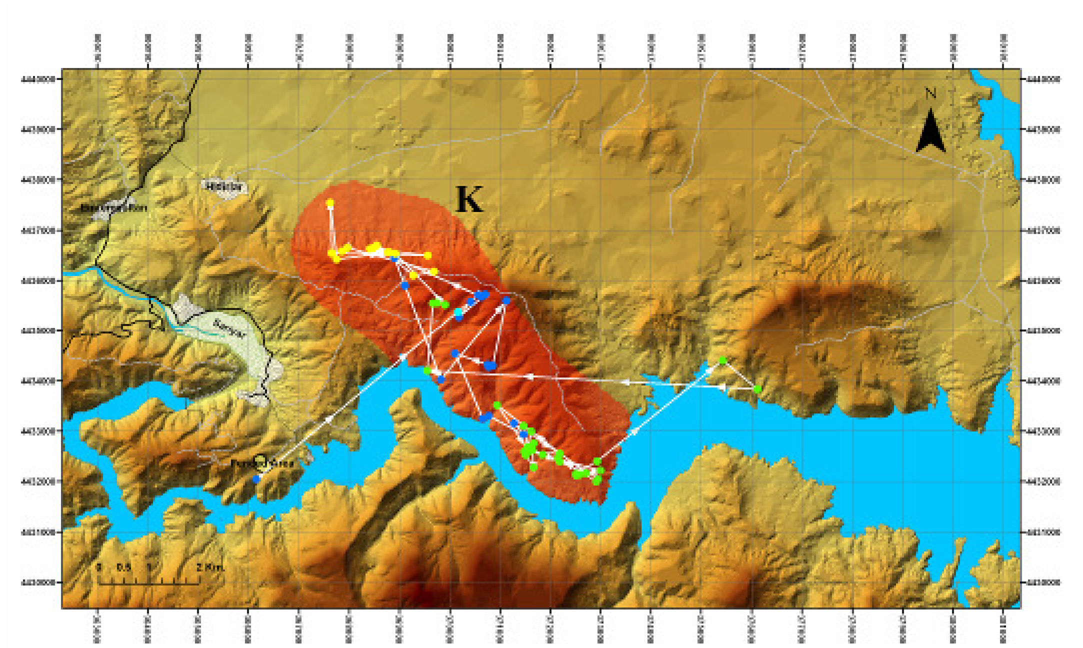
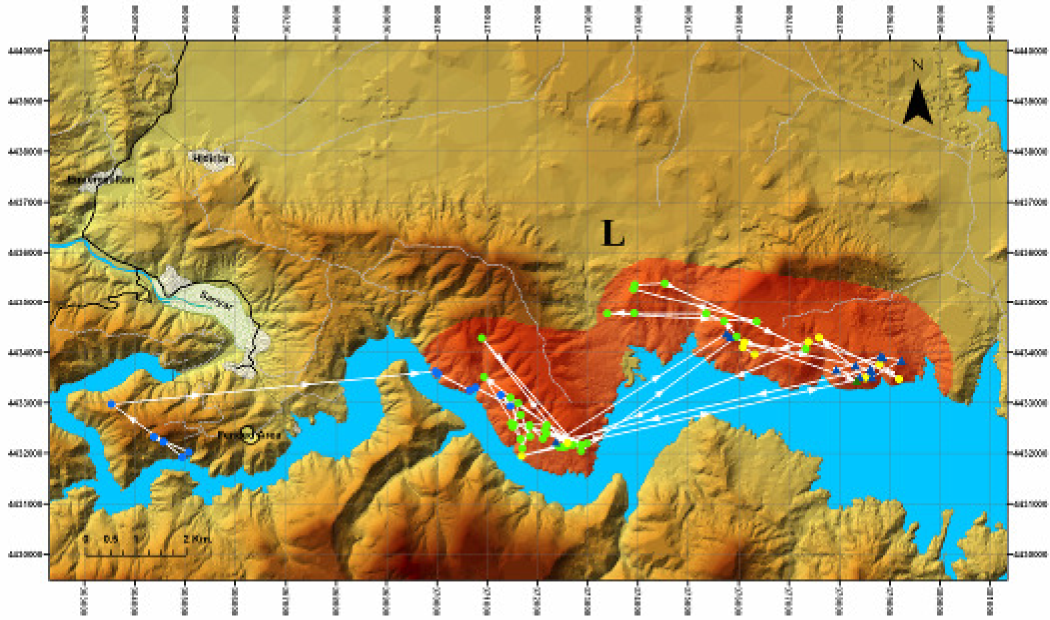


Figure 3.4 (contd.) Home ranges, relocations and movements of J and K

(l) Individual L (624)



(m) Individual M (694)

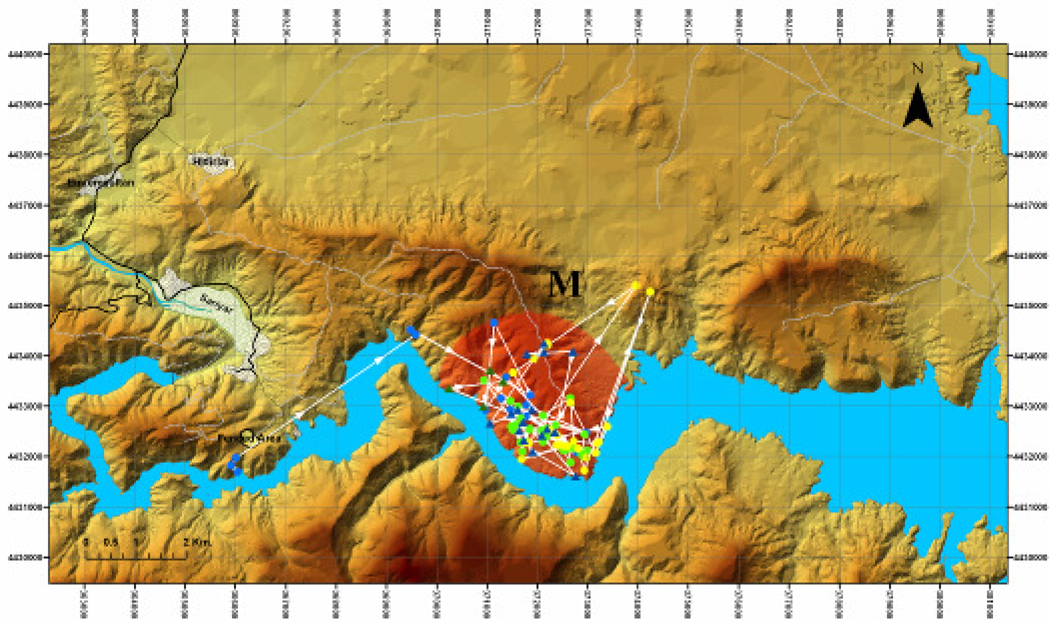
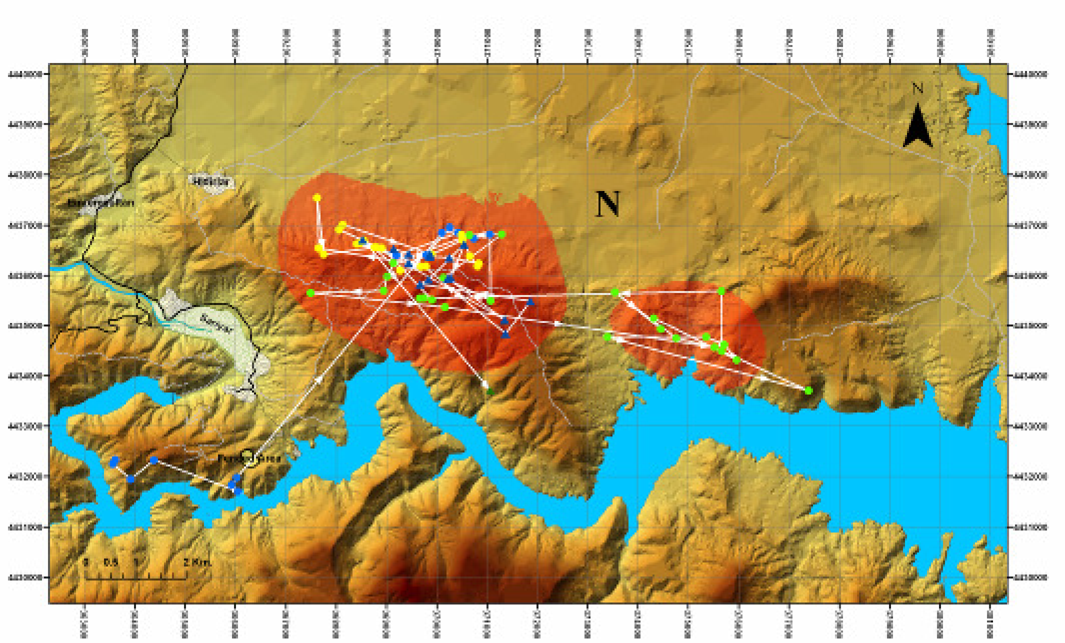


Figure 3.4 (contd.) Home ranges, relocations and movements of L and M

(n) Individual N (715)



(o) Individual O (735)

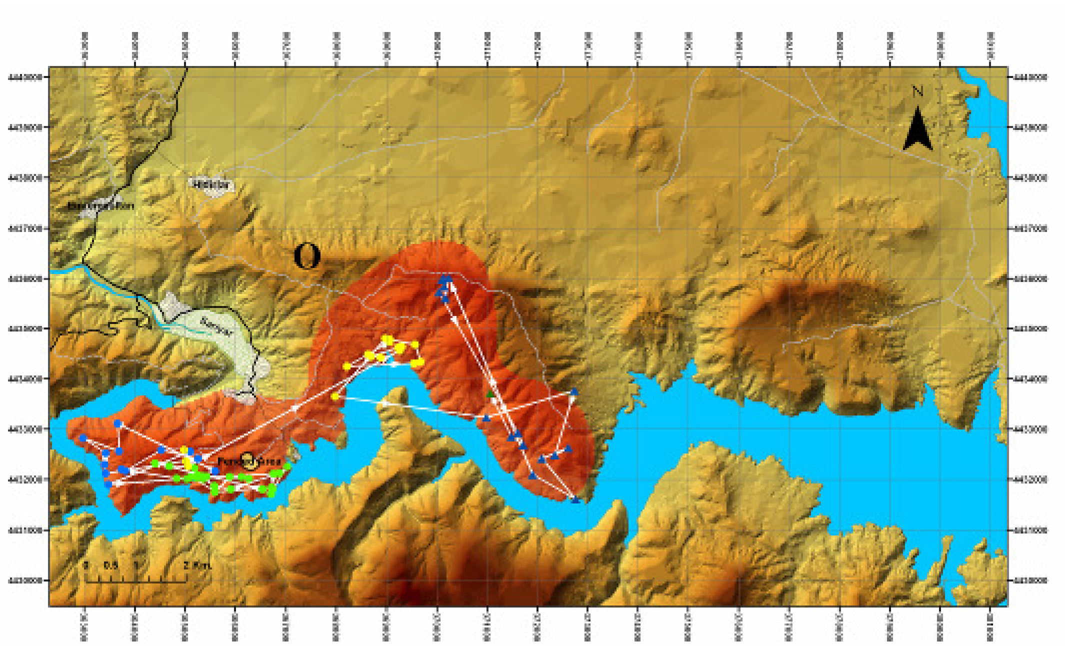
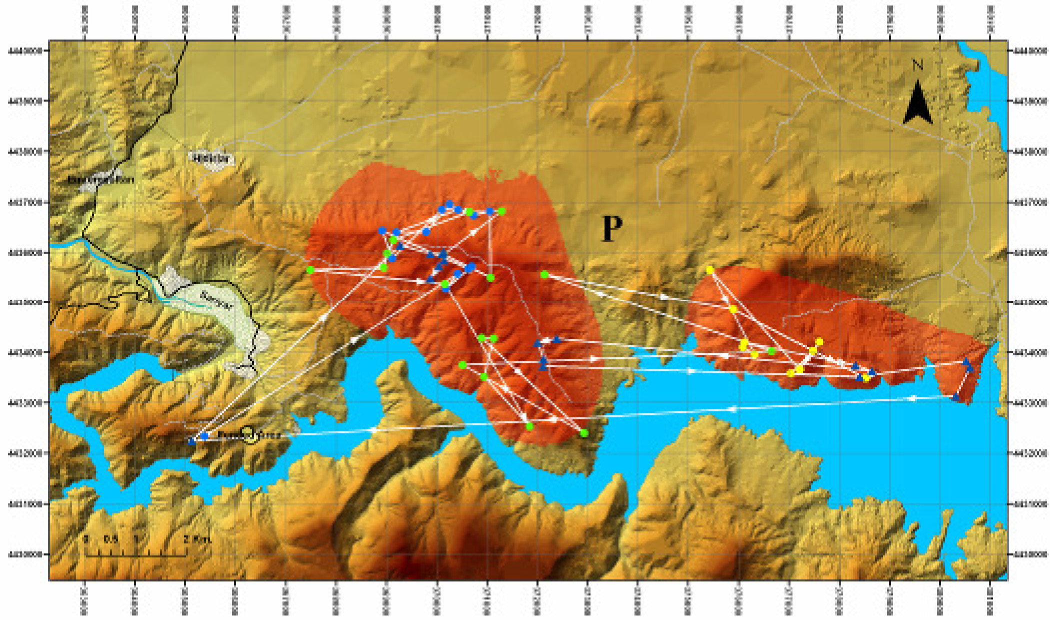


Figure 3.4 (contd.) Home ranges, relocations and movements of N and O

(p) Individual P (765)



(q) Individual Q (786)

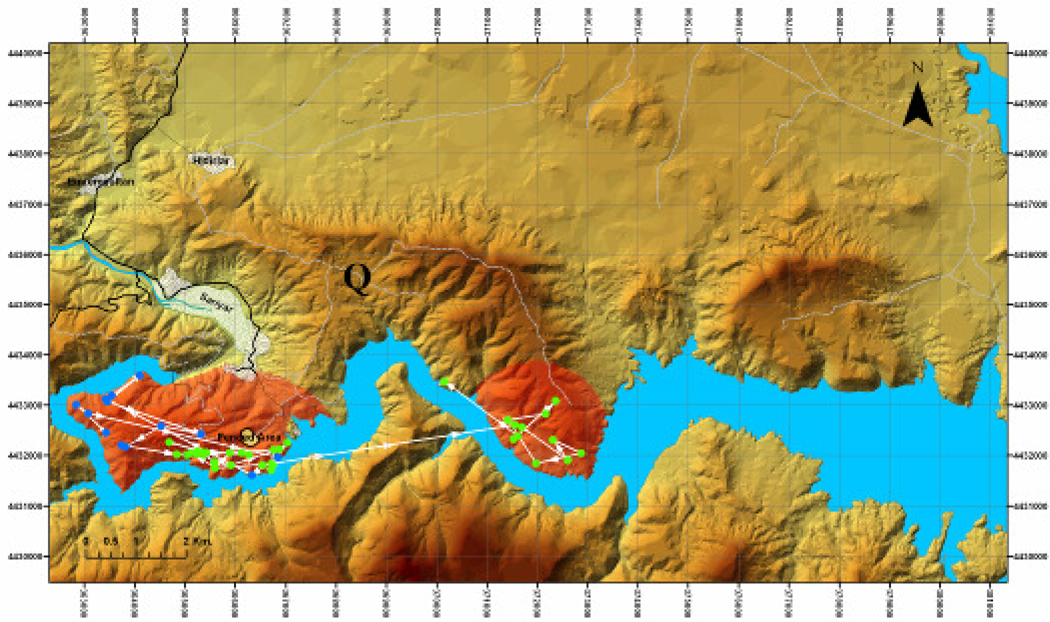
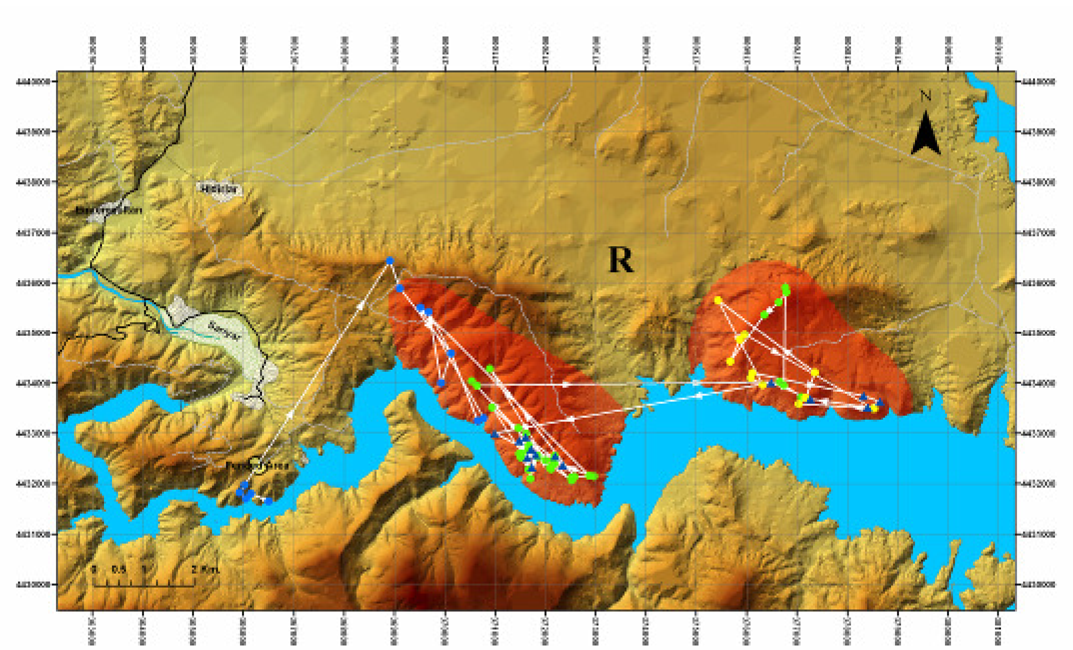


Figure 3.4 (contd.) Home ranges, relocations and movements of P and Q

(r) Individual R (805)



(s) Individual S (836)

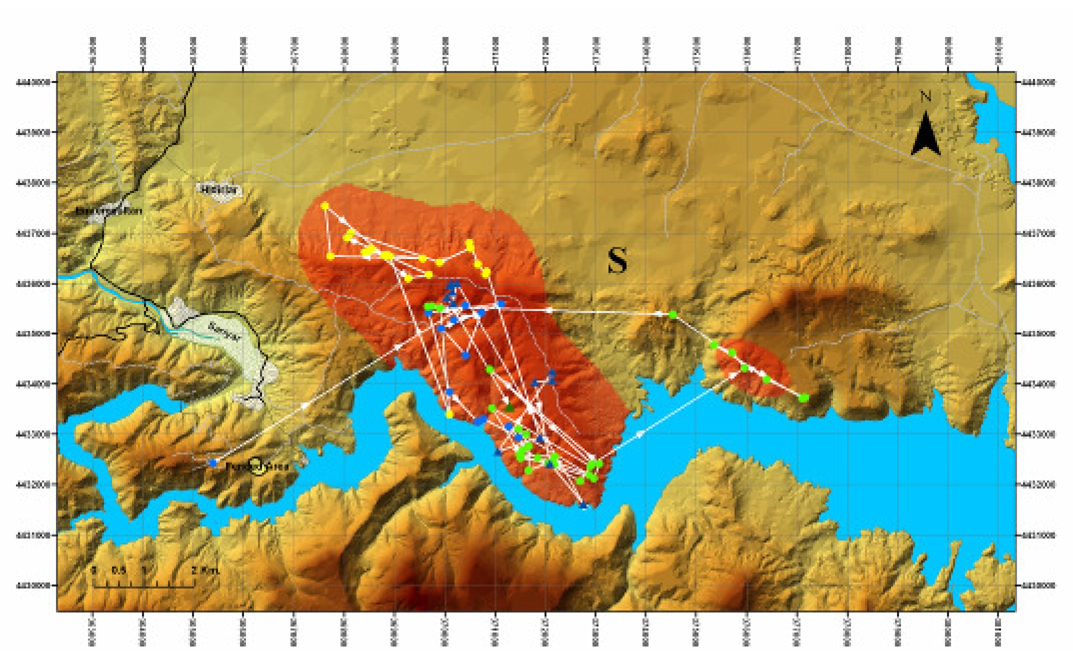
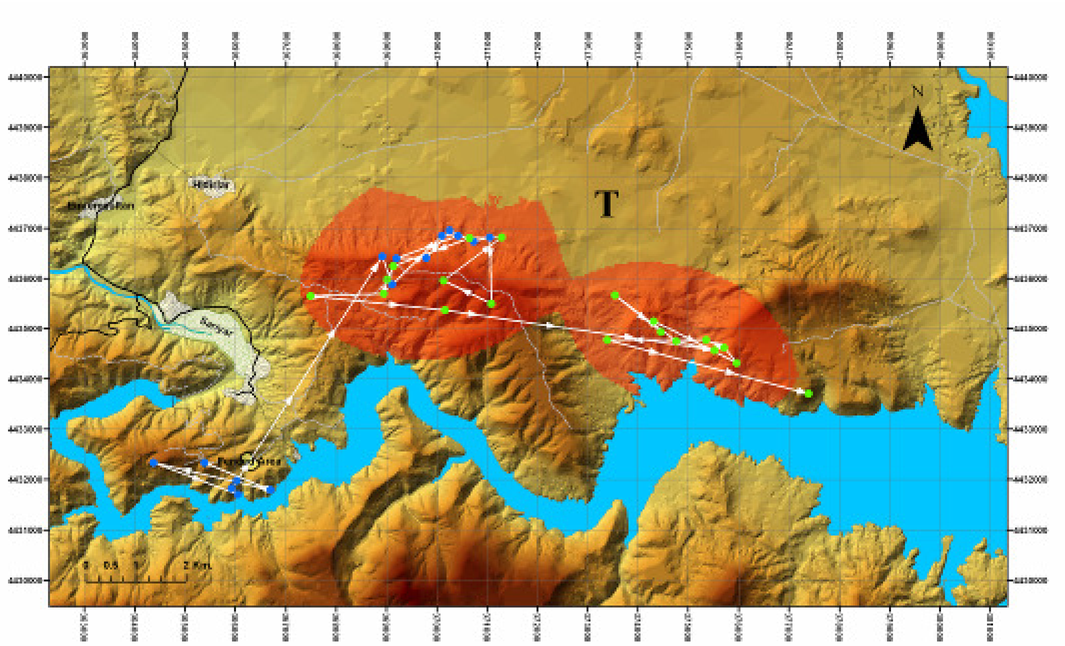


Figure 3.4 (contd.) Home ranges, relocations and movements of R and S

(t) Individual T (855)



(v) Individual V (935)

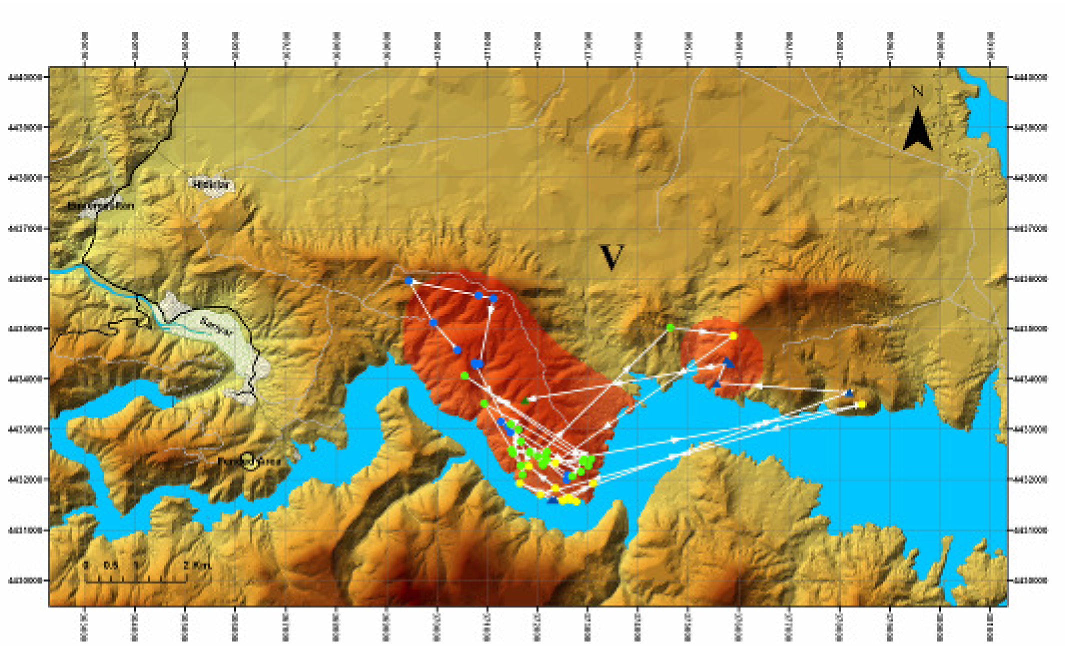


Figure 3.4 (contd.) Home ranges, relocations and movements of T and V

(w) Individual W (986)

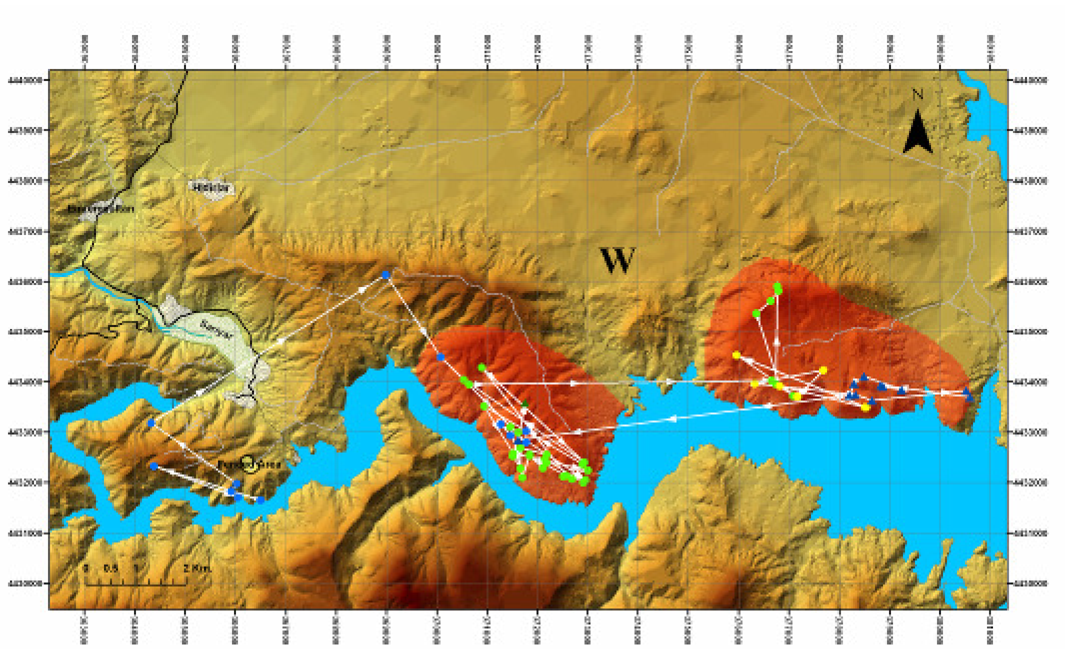


Figure 3.4 (contd.) Home ranges, relocations and movements of W

After the release from the fenced area, half of the animals (11/22) left the release area within a month and traveled for an average of 6140 ± 544 m (average ± std. error) away from the release area, within one week. In total, the mean time to leave the vicinity of the release area for more than 5 km. (shift of the center of activity) was 84 ± 19 days (average ± std. error). For the study period, most of the animals' home range (15/22) composed of geographically separate areas and almost all had differing centers of activities coinciding with either different seasons and/or different biological periods such as parturition. All pregnant females except one (8/9) have shifted their center activity before or during parturition (end of April to mid-May, mean date is 2^{nd} of May) with an average distance of 4811 ± 362 m (average ± std. error). This, along with our observations indicates a seasonal range shift and more importantly a jumpy type of dispersal throughout the study area as the individuals get to know the area.

3.3. Habitat Selection Analyses

3.3.1. K-select Analysis

For habitat selection analyses, the individuals with more than 50 relocations were used. Therefore only the data on the 22 of the radio-collared individuals released in 2007 were used for habitat selection analyses. Although the habitat selection of an individual is expected to change throughout the year due to environmental (seasonal change in climatic conditions) and/or behavioral (reproduction, migration etc.) changes in different periods of a year (Krausman et al., 1999; Bangs et al., 2005), all the localizations of an individual throughout a 19 months period (actually 15 months, see section 3.1) were taken all together into the analysis. Main reason for this was the low sample size that made it impossible to allocate the limited number of localizations of an individual to different parts of a year. Another reason was that, a reintroduced population, unlike an established population, lacks the acquaintance of the surrounding regions and an experience of available resources to accommodate their seasonal/behavioral needs. Therefore treating the year together could represent the habitat selection of the adaptation period as a whole.

The first two factorial axes have Eigen values of 0.811 and 0.155 respectively. These two axes explain 97% of the marginality (0.811 + 0.155 = 0.966), and the amount of explained marginality decreases substantially after the second axis (Table 3.2).

Table 3.2 Eigen values for the factorial axes

Axis	1	2	3	4	5	6	7	8	9	10
Eigen value	0.810	0.155	0.097	0.036	0.028	0.020	0.018	0.014	0.013	0.006
Axis	**11**	**12**	**13**	**14**	**15**					
Eigen value	0.005	0.004	0.003	0.002	0.001					

The relative effects or loadings of each variable on the first and second axis can be interpreted from the length and direction of each variable's vector on Fig. 3.5.

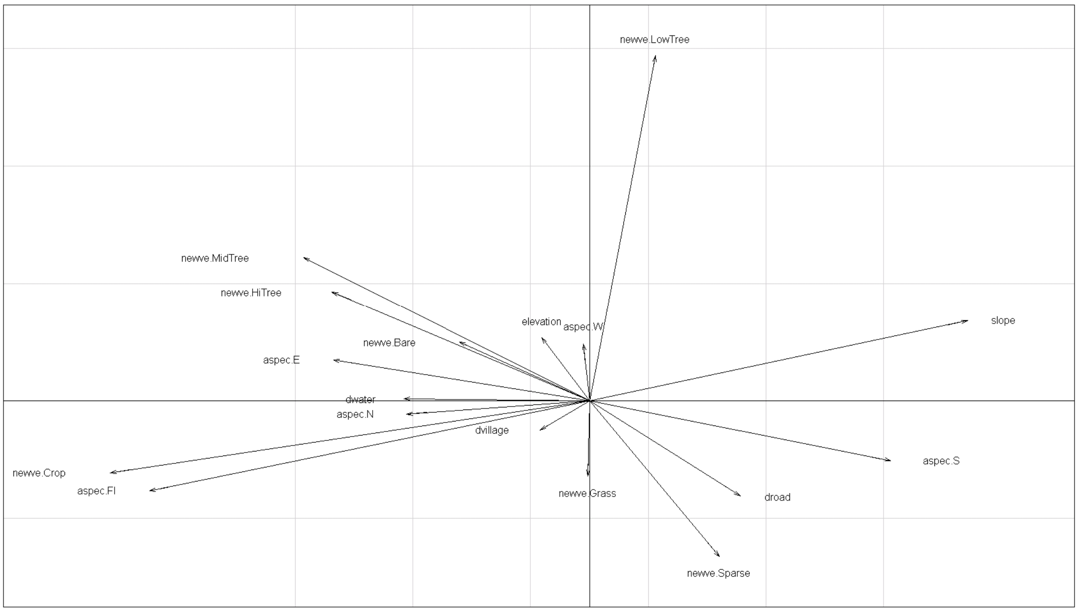


Figure 3.5 The variable loadings on the first two factorial axes

The continuous variables (slope, elevation, distance to water, distance to village and distance to roads) are represented with a single vector, while the categorical variables (aspect and vegetation) are represented with one vector per category (vegetation has 7, aspect has 5 categories). The variables with strong influence on the first axis are the flat areas and cropland (decreasing); and slope and southern aspects (increasing). Other variables that have minor but still considerable loadings on the first axis are high density tree vegetation, northern and eastern aspects and distance from water (decreasing); and distance to road (increasing). The variables with strong influence on the second axis are sparse grassland (decreasing) and low density tree cover (increasing).

Table 3.3 Summary table for selection of habitat variables by each animal (A-W). Positive sign indicates preference and negative sign indicates avoidance.

Individuals →	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	V	W	Total (Avg.)*
Slope	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	22 (0.63)
Aspect-South	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+	+	+	+	+	+	18 (0.44)
Dist. to Road	+	+	-	+	+	-	+	-	+	+	+	+	+	-	+	-	+	+	+	-	+	+	10 (0.17)
Sparse Grass.	+	+	-	+	+	-	-	-	+	+	+	+	+	-	-	-	-	+	+	-	+	+	4 (0.14)
Aspect-West	-	+	-	-	+	+	+	+	-	-	-	-	+	-	+	+	+	+	+	+	-	-	2 (0.00)
Elevation	-	+	+	-	-	-	-	+	-	+	-	-	-	+	-	+	-	-	+	+	-	+	-4 (-0.03)
Grassland	+	-	+	+	-	-	-	-	+	+	-	+	-	-	-	+	-	+	+	-	-	-	-4 (0.00)
Low Dens. Tree	-	+	+	-	-	+	+	-	-	-	-	+	+	-	+	-	+	-	+	-	-	-	-4 (0.10)
Barren ground	+	-	-	+	-	-	+	+	-	-	+	-	-	+	-	+	+	-	-	+	-	-	-4 (-0.06)
Dist. to Village	+	-	-	+	-	-	-	-	-	+	+	-	-	-	-	+	-	-	+	-	-	-	-10 (-0.08)
High Dens. Tree	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	+	-	-	-12 (-0.27)
Med. Dens. Tree	-	+	+	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-14 (-0.47)
Aspect-North	-	-	+	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-16 (-0.26)
Flat (no aspect)	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-16 (-0.51)
Dist. to Water	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-16 -0.28)
Aspect-East	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-18 (-0.38)
Croplands	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-18 (-0.78)

*average marginality values for each variable calculated from Table 3.4

The marginality values for each animal on each variable are given in Table 3.4 and a summary of that table is given in Table 3.3. None of the marginality values were found to be significant mainly because of the drawback of Bonferroni test which becomes more conservative as the number of tests carried out increases (significance at an overall α=0.05 level, the Bonferroni p-value becomes: 0.05/(17*22) = 0.0001). Since the K-select method was used – with a high number of variables – mainly for exploratory reasons, a general picture of selection can be drawn by inspecting Table 3.4. Although not found to be statistically significant, there is a general tendency for higher slopes, southern aspects and distant areas from the road network. On the other hand, there is also a general avoidance of crops, medium to high density tree cover, flat and north facing areas and places distant from the water resources. Although these results may give a general picture of the population-level selection, there are differences among the individuals.

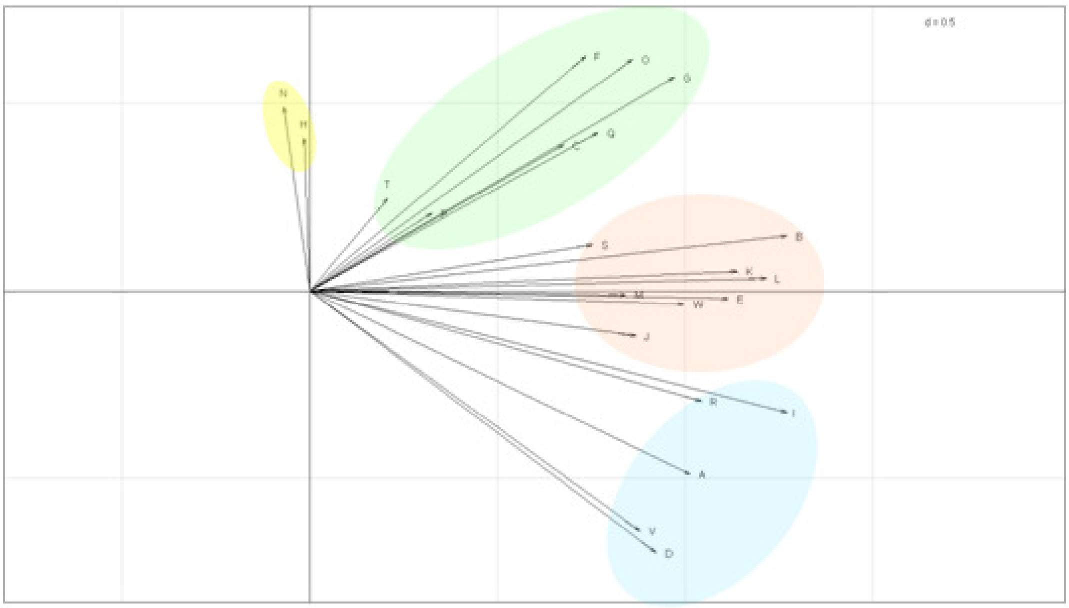


Figure 3.6 Projection of the marginality vectors for all animals (A-W) on the first factorial plane (with first and second axis). All marginality vectors are recentered such that habitat availability is the same for all animals (common origin to all vectors). Vectors are identified by individual's symbols. Color shadings are made to highlight seemingly different groupings.

Table 3.4 Selection of habitat variables by each animal (A-W). The values represent the coordinates of the marginality vectors (mean used coordinate – mean available coordinate) on each habitat variable for each animal.

		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	V	W
Slope		0.53	1.04	0.76	0.39	0.82	0.57	0.82	0.39	0.88	0.61	1.00	0.95	0.58	0.39	0.66	0.39	0.49	0.65	0.60	0.36	0.37	0.66
Elevation		-0.32	0.09	0.09	-0.45	-0.02	-0.15	-0.10	0.28	-0.21	0.12	-0.04	-0.02	-0.06	0.34	-0.10	0.25	-0.15	-0.10	0.09	0.15	-0.43	0.09
Distance to water		-0.46	-0.44	-0.42	-0.39	-0.30	-0.44	-0.28	0.08	-0.33	-0.32	-0.42	-0.33	-0.19	0.18	-0.37	-0.03	-0.25	-0.32	-0.37	0.07	-0.42	-0.34
Distance to road		0.53	0.27	-0.02	0.48	0.25	-0.01	0.22	-0.40	0.60	0.41	0.33	0.33	0.16	-0.39	0.04	-0.17	0.12	0.28	0.13	-0.14	0.48	0.25
Distance to village		0.04	-0.03	-0.10	0.02	-0.19	-0.17	-0.33	-0.02	-0.10	0.02	0.08	-0.14	-0.01	-0.08	-0.11	0.02	-0.11	-0.20	0.01	-0.08	-0.04	-0.23
Aspect	**North aspects**	-0.35	-0.19	0.11	-0.35	-0.16	-0.71	-0.28	0.38	-0.31	-0.32	-0.08	-0.30	-0.26	0.73	-0.83	-0.49	-0.50	-0.38	-0.37	-0.40	-0.38	-0.28
	East aspects	-0.57	-0.48	-0.13	-0.65	-0.82	-0.31	-0.22	0.12	-0.32	-0.26	-0.34	-0.70	-0.71	0.04	-0.28	-0.49	-0.46	-0.64	-0.19	-0.01	-0.61	-0.54
	South aspects	0.77	0.42	0.17	0.69	0.70	0.34	0.26	-0.32	0.61	0.49	0.55	0.78	0.66	-0.34	0.49	0.33	0.49	0.68	0.32	0.16	0.62	0.70
	West aspects	-0.21	0.07	-0.19	-0.04	0.02	0.44	0.10	0.05	-0.25	-0.15	-0.32	-0.12	0.05	-0.13	0.28	0.22	0.21	0.04	0.08	0.14	0.00	-0.18
	Flat (no aspect)	-1.06	-1.03	-0.40	0.39	-1.25	-0.83	-0.99	-0.42	-1.52	-1.11	-1.07	-1.05	-1.93	-0.69	-0.63	6.39	-0.71	-1.22	-0.97	-0.93	1.28	-1.46
Land Cover	**Grassland with shrubs**	0.26	-0.13	0.22	0.03	-0.15	-0.38	-0.31	-0.07	0.26	0.15	-0.01	0.22	-0.28	-0.03	-0.44	0.40	-0.09	0.41	0.05	-0.08	0.00	-0.04
	Sparsely vegetated grassland	0.27	0.52	-0.30	0.71	0.43	-0.35	-0.15	-0.10	0.52	0.29	0.14	0.11	0.40	-0.22	-0.22	-0.22	-0.28	0.50	0.15	-0.17	0.65	0.45
	Low density tree cover	-0.57	0.00	0.04	-0.82	-0.10	1.38	1.39	-0.24	-0.35	-0.13	-0.03	0.00	0.20	-0.07	1.62	-0.22	1.62	-0.55	0.18	-0.34	-0.78	-0.02
	Medium density tree cover	-1.15	0.00	0.27	-1.14	-0.65	0.84	-0.91	-0.08	-0.94	-0.24	-0.20	-0.54	-0.39	-0.06	0.18	-0.20	-2.12	-0.80	-0.52	-0.27	-1.18	-0.31
	Dense tree cover	-1.03	0.00	3.28	-1.39	-0.43	-0.58	-0.05	-0.01	-0.76	-0.48	-0.79	-0.37	-0.72	0.32	-1.41	0.41	-1.02	-0.73	-0.32	0.55	-0.22	-0.13
	Barren land (rock, soil)	0.30	-0.26	-0.88	0.03	-0.10	-0.16	0.04	0.86	-0.39	-0.54	0.06	-0.30	-0.33	0.83	-0.12	0.30	0.06	-0.61	-0.44	1.27	-0.18	-0.77
	Crop	0.00	-3.90	-0.80	0.00	-0.86	-0.02	-1.79	-0.27	-2.24	-0.68	0.00	-0.82	0.00	-0.46	-0.04	-1.52	-0.03	-1.77	-0.07	-0.84	-0.11	-0.98

The marginality vectors of each animal are drawn on the first factorial plane as shown in Figure 3.6. In this graph, the availability for individuals are centered in the origin. Individual marginality vectors start from this origin and end in somewhere else in the factorial space. The end of each vector represents the use of the individual. The longer the vector the more pronounced the distance between the availability and use, and therefore the more pronounced the selection of the individual. This graph should be evaluated together with Figure 3.5 (variable loadings graph) since the factorial space in both graphs are the same. The comparison of the direction (and length) of the marginality vectors (Fig. 3.6) with the variable's vectors (Fig. 3.5) forms the basis in evaluating which variables are selected or 'avoided' (Calenge et al., 2005). In this sense, there is an overall trend for almost all individuals towards high sloped, southern aspect terrain, distant from the road network with low density tree cover and sparse grassland vegetation. All individuals seem to avoid flat areas, medium to high density tree cover and eastern aspects. A group of males (A, D, I, R, V, blue-shaded area) marginality aligns with southern aspects, sparsely vegetated grassland and areas distant to roads, meanwhile away from any tree cover. Another group of female dominated group's (E, J, K, L, M, S and two males B and W, red-shaded area) marginality aligns with southern looking, high sloped areas away from flat areas, crops and villages (all of which are human dominated areas). Two females (N and H, yellow-shaded area) with most distinct use, have marginalities aligning with higher elevation, western aspects and low density tree covered grassland. The rest of the animals (C, G, O, P, Q, T, mixed sex, green-shaded area) formed the last group with a distinct grouping, whose marginalities align with low density tree covered grassland, high slopes, away from flat areas, crops and villages. However, no individual's average marginality was significant (Table 3.5).

Table 3.5 Tests of marginality* for each animal over all variables

	A	B	C	D	E	F	G	H	I	J	K
Marginality	1.408	2.005	1.418	1.454	1.325	1.216	1.447	0.561	1.850	0.876	1.487
P-value*	0.011	0.005	0.013	0.008	0.018	0.022	0.014	0.308	0.004	0.068	0.008

	L	M	N	O	P	Q	R	S	T	V	W
Marginality	1.547	0.834	0.715	1.425	0.851	1.262	1.298	0.659	0.481	1.300	1.120
P-value*	0.009	0.099	0.158	0.011	0.109	0.015	0.013	0.208	0.406	0.019	0.030

*to be compared with Bonferroni α level: 0.002

3.3.2. Compositional Analysis

According to the results of the K-select analysis, the habitat variables with the highest preference and avoidance values are further analyzed with compositional analyses to evaluate the rankings of preference of their categories. Those habitat variables were vegetation, aspect, slope, distance to road and distance to water. Compositional analysis utilizes categorical variables. Categorizing distance variables (distance to water and road) and ranking them would not give additional information as it would in vegetation or aspect. K-select analysis's results already indicate sufficiently a preference of areas close to water and distant from roads. Therefore compositional analysis was performed only on the other three habitat variables. Since vegetation and aspect layers were already categorical (as they were used in K-select analysis) only slope layer was categorized. Categorization of slope was made by using four categories (the available slopes in the study area ranged between 0-45 degrees the possible range is 0-90 degrees):

1. 0-5 degrees slope: flat areas
2. 5-15degrees slope: moderately sloped areas
3. 15-30 degrees slope: sloped areas
4. 30-45 degrees: highly sloped areas

For the aspect layer, areas with no aspect were occupying very small areas. This has caused its absence from most of the animals' usage (usage as relocations and usage as home range) and availability data (availability as home range). Therefore the no-aspect (flat) category in aspect layer was removed in compositional analyses. Since the flatness is already evaluated as a category in slope layer and no-aspect category was used for completeness of the classification of the aspect layer, its removal is not accepted to have a significant effect on results of selection analyzes.

The vegetation layer has a similar situation with the crop category. Most of the home ranges did not include any crop category. Crop category was absent from most of the animal's usage (usage as relocations and usage as home range) and availability data (availability as home range) as the no-aspect category in aspect layer. In order to be in conformity with the requirements of the compositional analysis (Aebischer et al., 1993) the crop category is also removed from the vegetation layer for the compositional analysis.

In usage tables, several animals appeared to have 0% utilization of one or more categories of some habitat variables. Actually, a utilization of 0% represents a use value too low to be recorded, within the frame of a given study (i.e. daytime). Aebischer et al. (1993) recommends replacing of the 0% utilization values of an available habitat type with a value that is an order of magnitude smaller than the smallest nonzero value found in either available or utilized compositions. Therefore, for aspect layer, the 0% values are replaced with 0.001. Although Bingham and Brennan's (2004) simulations have showed that replacing 0% usage with small nonzero values (such as 0.001) inflates the type I error rate, removal of individuals with 0% usage for one or more categories can also bias the results (Aebischer et al., 1993).

Rearranging the slope, aspect and vegetation accordingly, compositional analysis was performed as design II and III, under three different scales:

1) Design III: Relocations are considered as used, and home range is considered as available (Relocations vs. home range).

2) Design II: Relocations are considered as used, and whole study area is considered as available (Relocations vs. study area).

3) Design II: Home ranges are considered as used, whole study area is considered as available (Home range vs. study area).

In their article, Aebischer et al. (1993) used the scales (1) and (3) from above, in their examples of compositional analyzes. The scale (2) is also utilized in this study in order to check for any differences when the availability for design II is defined as a smaller (in option 3) or larger area (in option 2).

For the compositional analysis of use-availability in three habitat variables, the 'compana' function of the adehabitat package (Calenge, 2006) in R program (R Development Core Team, 2009) was used. The rank tables taken from the result files of the R are presented below (Table 13.11 – 13.13). In these tables the λ and the associated p-value is given for each scale (1-3) separately. The last column shows the ranking of selection, with the largest rank being the most selected for, and the lowest rank the least selected category. Triple signs (– – – or +++) indicate significant difference between the elements of the rank table matrix: a triple plus sign indicates selection of the category in the first column over its corresponding category in the matrix; and the triple negative signs vice versa. At the bottom of the ranking matrix of each scale, the categories are ordered from higher to lower selection from left to right. A triple 'greater than' sign (>>>) indicates a significant selection of one category over the next. As seen from the p-values in the three tables (Table 3.6 – 3.8), use differed significantly from the available habitat distribution.

Table 3.6 Ranking matrix for Slope, for three types of compositional analysis performed. (See text for further details).

Slope (0-90 degrees scale; no values present in study area gretaer than 45 degrees)

1) Relocations vs. Home Range (λ=0.097, p=0.001)

	0-5	5-15	15-30	30-45	**Rank**
0-5	0	– – –	– – –	– – –	**0**
5-15	+++	0	– – –	– – –	**1**
15-30	+++	+++	0	– – –	**2**
30-45	+++	+++	+++	0	**3**

Hi>>>Mid>>>Low>>>No Slope

2) Relocations vs. Study Area (λ=0.048, p=0.002)

	0-5	5-15	15-30	30-45	**Rank**
0-5	0	– – –	– – –	– – –	**0**
5-15	+++	0	– – –	– – –	**1**
15-30	+++	+++	0	– – –	**2**
30-45	+++	+++	+++	0	**3**

Hi>>>Mid>>>Low>>>No Slope

3) Home Range vs. Study Area (λ=0.083, p=0.002)

	0-5	5-15	15-30	30-45	**Rank**
0-5	0	– – –	– – –	– – –	**0**
5-15	+++	0	– – –	– – –	**1**
15-30	+++	+++	0	+	**3**
30-45	+++	+++	–	0	**2**

Mid>Hi>>>Low>>>No Slope

For the slope in Table 3.6, use of four slope categories differed significantly from the habitat distribution within the available areas ($p \leq 0.02$ in all three options). Reintroduced Anatolian mouflon shows a significant selection for the highest available slopes at all the scales, except in (3), where there is no significant selection between high and middle slopes but still a significant selection of higher slopes over the lower sloped areas.

Table 3.7 Ranking matrix for Aspect, for three types of compositional analysis performed. (See text for further details).

Aspect (315-45: North, 45-135: East, 135-225: South, 225-315: West)

1) Relocations vs. Home Range (λ=0.304, p=0.001)

	North	East	South	West	**Rank**
North	0	−−−	−−−	−−−	**0**
East	+++	0	−−−	−−−	**1**
South	+++	+++	0	+++	**3**
West	+++	+++	−−−	0	**2**

South>>>West>>>East>>>North

2) Relocations vs. Study Area (λ=0.201, p=0.001)

	North	East	South	West	**Rank**
North	0	−−−	−−−	−−−	**0**
East	+++	0	−−−	−−−	**1**
South	+++	+++	0	+++	**3**
West	+++	+++	−−−	0	**2**

South>>>West>>>East>>>North

3) Home Range vs. Study Area (λ=0.169, p=0.001)

	North	East	South	West	**Rank**
North	0	−−−	−−−	−−−	**0**
East	+++	0	−−−	−−−	**1**
South	+++	+++	0	+++	**3**
West	+++	+++	−−−	0	**2**

South>>>West>>>East>>>North

A similar selection pattern is obvious for the aspect of the area utilized: the use of four aspect categories differed significantly from the habitat distribution within the available areas (p = 0.01 in all three options).

For all the scales Southern aspects are selected significantly over all other aspects and Northern aspects are the least preferred within the available aspects.

Table 3.8 Ranking matrix for Vegetation, for three types of compositional analysis performed. (See text for further details).

Vegetation						
1) Relocations vs. Home Range (λ=0.716, p=0.037)						
	HiTree	MidTree	LowTree	Grassland	Sparse	**Rank**
HiTree	0	–	–	–	–	**0**
MidTree	+	0	–	– – –	– – –	**1**
LowTree	+	+	0	–	–	**2**
Grassland	+	+++	+	0	– – –	**3**
Sparse	+	+++	+	+++	0	**4**
Sparse>Grassland>LowTree>MidTree>HiTree						
2) Relocations vs. Study Area (λ=0.234, p=0.001)						
	HiTree	MidTree	LowTree	Grassland	Sparse	**Rank**
HiTree	0	+	– – –	–	–	**1**
MidTree	–	0	– – –	– – –	– – –	**0**
LowTree	+++	+++	0	–	–	**2**
Grassland	+++	+++	+	0	+++	**4**
Sparse	+	+++	+	– – –	0	**3**
Grassland>Sparse>LowTree>HiTree>MidTree						
3) Home Range vs. Study Area (λ=0.169, p=0.001)						
	HiTree	MidTree	LowTree	Grassland	Sparse	**Rank**
HiTree	0	+	– – –	– – –	–	**1**
MidTree	–	0	– – –	– – –	–	**0**
LowTree	+++	+++	0	+	+++	**4**
Grassland	+++	+++	–	0	+++	**3**
Sparse	+	+	– – –	– – –	0	**2**
LowTree>Grassland>>>Sparse>HiTree>MidTree						

There is a significantly different use of vegetation by animals than a random use pattern, in vegetation layer too (p<0.05 in all scales). However the results of the selection of vegetation categories are more complicated than the previous two variables. For the third-order selection of Johnson (1980), which is selection of the habitat components within a home range (1) none of the categories in the rank are significantly different from each other. However, sparsely vegetated grassland and grassland were used by animals significantly more than moderate to high density woodland. For the second-order selection of Johnson et al. (1980), which is the selection of a home range area from study area (2), the results were different: grassland and low density woodland is selected significantly over sparse grassland and mid-to-high density woodland. This may be due to an association between grassland and low density woodland: these two habitats have similar herbaceous cover, as low density woodlands have open canopy cover enabling well grown herbaceous layer underneath.

3.4. Demographic Results and Population Viability Models

The demography of the reintroduced population is characterized through survival and fecundity of the radio-collared females and ear-tagged juveniles. The data used for the demographic analyzes are obtained from the individuals reintroduced at different times, starting from 2005 until 2007. This period is summarized in Table 3.9.

Table 3.9. Timetable for the reintroductions showing the number and sex of individuals released, mark type, and observation periods.

			2005 Reintro.	2006 Reintroduction		2007 Reintroduction	
Year	**Month**	**Study Months**	**Radio-Collared Adults 3♀ - 4♂**	**Radio-Collared Adults 3♀**	**Ear-Tagged Lambs 4♀ - 6♂**	**Radio-Collared Adults 13♀ - 13♂**	**Ear-Tagged Lambs 7♀ - 5♂**
2005	Oct-05	**1**	Release				
	Nov-05	**2**	+				
	Dec-05	**3**	+				
2006	Jan-06	**4**	+				
	Feb-06	**5**	+				
	Mar-06	**6**	+				
	Apr-06	**7**	+				
	May-06	**8**	Birth (1)				
	Jun-06	**9**	+				
	Jul-06	**10**	+				
	Aug-06	**11**	+				
	Sep-06	**12**	+				
	Oct-06	**13**	+				
	Nov-06	**14**	+				
	Dec-06	**15**	+	Release	Release		
2007	Jan-07	**16**	+	+	+		
	Feb-07	**17**	+	+	+		
	Mar-07	**18**	+	All Dead	+		
	Apr-07	**19**	+		+		
	May-07	**20**	+		+		

Table 3.9 (continued)

			2005 Reintro.	2006 Reintroduction		2007 Reintroduction	
		Study Months	Radio-Collared Adults	Radio-Collared Adults	Ear-Tagged Lambs	Radio-Collared Adults	Ear-Tagged Lambs
Year	Month		3♀ - 4♂	3♀	4♀ - 6♂	13♀ - 13♂	7♀ - 5♂
2007	Jun-07	21	+		+		
	Jul-07	22	+		+		
	Aug-07	23	+		+		
	Sep-07	24	+		+	Release	Release
	Oct-07	25	+		+	+	+
	Nov-07	26	+		+	+	+
	Dec-07	27	+		+	+	+
	Jan-08	28	+		+	+	+
	Feb-08	29	+		+	+	+
	Mar-08	30	All Dead		+	+	+
	Apr-08	31			+	+	+
	May-08	32			+	Birth (9)	+
2008	Jun-08	33			+	+	+
	Jul-08	34			+	+	+
	Aug-08	35			+	+	+
	Sep-08	36			+	+	+
	Oct-08	37			+	+	+
	Nov-08	38			+	+	+
	Dec-08	39			+	+	+
	Jan-09	40			+	+	+
2009	Feb-09	41			+	+	+
	Mar-09	42			+	+	+
	Apr-09	43			+	+	+
	May-09	44			+	Birth (6)	+

- The shaded grey areas represent yearly periods (June-May) which coincides with the parturition. End of May is taken as the turn of age and years divided accordingly, except for the first interval which starts in October 2005 with the first reintroduction.
- Release dates are indicated; animals released together are regarded as cohorts; number of lambs born to radio-collared females is given in parenthesis; plus (+) sign means there is at least one animal surviving from the same cohort in that month.

3.4.1. Survival

For survival calculations only the females were evaluated. The reason for this was utilizing the survival and fecundity estimates in a population viability analysis of females, whose fecundity can be estimated by the birth and lamb survival records of the radio-collared females. Females are divided into five age-classes: lambs (0 year-old), 1 year-old, 2 years-old, 3 years-old, and a composite age class of 3+ years-old. The photographs of the incisor teeth of the females were taken when they were caught for translocation. This enabled us to determine the age classes until 3 years-old, since the incisor teeth development takes place until three years of age and the age of the individual can be estimated (Kaya, 1989). An animal is considered to be in the previous age class until completes its whole year (i.e. an animal born on May 2006 is 0 years old until May 15, 2007, the same animal is considered as 1 year-old from May 15, 2007 until May 15, 2008).

The survival of the reproductively adult females (age classes: 2, 3, 3+) are estimated using the Micromort software (Heisey & Fuller 1985). Micromort uses Mayfield method to calculate the survival rates. The day of death of the radio-collared individuals is assigned by the mid-date between the last day observed and the collar/carcass was found (White & Garrott, 1990). Therefore radio-collared females and their observed number of days alive are calculated for four consecutive intervals (Table 3.10). These intervals are determined according to the reintroduction dates and the assumed date of turn of age (May 15). By this way, the individuals that grew older are included in the next age class within the next interval. Within these intervals, the survival is assumed to be constant. Survival estimates for four consecutive yearly intervals (2005-2006, 2006-2007, 2007-

2008, 2008-2009) are estimated by Micromort and results are given in Table 3.10.

Table 3.10 Radio-collared females' data for four time intervals (shades of grey)

Year	Individual	Age Class	Begin	End	Total Days	Survival
2005	486	3+	27/10/05	15/05/06	200	1
	624	3	27/10/05	15/05/06	200	1
	445	2	27/10/05	01/02/06	97	0
2006	486	3+	15/05/06	01/11/06	170	0
	624	3+	15/05/06	30/10/06	168	0
	505	3+	15/12/06	01/02/07	48	0
	645	3	15/12/06	05/02/07	52	0
	836	2	15/12/06	01/02/07	48	0
2007	786	3+	15/09/07	15/05/08	243	1
	715	3+	15/09/07	15/05/08	243	1
	466	3+	15/09/07	15/05/08	243	1
	566	3+	15/09/07	15/05/08	243	1
	345	3+	15/09/07	15/05/08	243	1
	694	3	15/09/07	15/05/08	243	1
	855	3	15/09/07	15/05/08	243	1
	585	2	15/09/07	15/05/08	243	1
	836	2	15/09/07	15/05/08	243	1
	505	2	15/09/07	15/05/08	243	1
	606	2	15/09/07	15/05/08	243	1
2008	566	3+	15/05/08	15/05/09	365	1
	345	3+	15/05/08	15/05/09	365	0
	466	3+	15/05/08	15/05/09	365	1
	786	3+	15/05/08	03/06/08	19	0
	505	3+	15/05/08	20/11/08	189	0
	694	3+	15/05/08	15/05/09	365	1
	855	3+	15/05/08	15/05/09	365	1
	715	3+	15/05/08	15/05/09	365	1
	585	3	15/05/08	15/05/09	365	1
	836	3	15/05/08	15/05/09	365	1
	606	3	15/05/08	22/09/08	130	0
	624	2	15/05/08	15/05/09	365	1

Begin: date of release, End: ending date of interval or date of death of the individual, Total Days: days spent alive within the interval; Survival: 0 is dead, 1 is alive. Intervals are highlighted by different shades of grey: 2005-2006, 2006-2007, 2007-2008, 2008-2009 (from upper in dark grey, to lower side in light grey of the table).

For the survival of the female lambs and 1 year-olds, the observation data from the ear-tagged juveniles is used. For lamb survival, the data from 4 female lambs reintroduced in December 2006, 7 female lambs reintroduced in September 2007, and 9 lambs born in May 2008 were used. The lambs released in 2006 and 2007 were ear-tagged while the ones born were not. For the ear-tagged lambs, a mark-recapture methodology could not be employed due to very low rate of encounter. Instead, the observational records of these ear-tagged individuals were used for survival estimation.

The four ear-tagged female lambs released in December 2006 were all seen alive after May 15, 2007; hence the lamb survival for 2006-2007 interval (Start: 15/5/2006, End: 15/5/2007) is estimated as 4/4 = 1. For the seven ear-tagged female lambs released in September 2007, four were observed to be alive after May 15, 2008; hence the lamb survival for 2007-2008 interval (Start: 15/9/2007, End: 15/5/2008) is estimated as 4/7 = 0.5714. For the latter case, the other female lambs' fate is unknown but they are assumed to be dead. Therefore this estimate can be considered as a conservative one. Out of the nine lambs born to radio-collared females in May 2008, eight were dead within a month (they were never observed alongside their mother, assumed dead), only one of them was observed to be alive until winter, but never again observed alongside the mother afterwards. However, the size of the lambs get very close to adult size by the first winter, and since this lamb was also not ear-tagged, there is the possibility that it may no longer have been recognized as a lamb near its radio-collared mother. Assuming that this individual survived the winter and lived until May 15, 2009, the survival of female lambs in 2008-2009 interval (Start: 15/5/2008, End: 15/5/2009) would be estimated to be

(1/9)/2=0.0556. The difference of the latter lamb survival from the previous two is that, the latter ones were born in the reintroduction area and all except one died as newborns (within a month after birth). Therefore the newborn survival in the reintroduction area is very low. The survival values of the sampled intervals are given in Table 3.11.

For one-year old survival, a similar approach is used. Out of the four female lambs who survived to be one-year olds by May 15, 2007, two were observed to be alive after May 15, 2008. The fate of the other two is unknown but assumed dead. Apart from these ear-tagged individuals, one radio-collared female who was 1 year-old when reintroduced in September 2007 (individual 624) was also alive by May 15, 2008. The 1 year-old survival for 2007-2008 interval (Start: 15/5/2007, End: 15/5/2008) is therefore conservatively estimated to be 3/5=0.6. This result is also given in Table 3.11.

Table 3.11 Survival estimates of age-classes of females according to years

Age-Classes → / **Years**	**0**	**1**	**2**	**3**	**3+**
2005	-	-	0.1259	1.0000	1.0000
2006	1.0000	-	0.0005	0.0008	0.0580
2007	0.5714	0.6000	1.0000	1.0000	1.0000
2008	0.0556	-	1.0000	0.6540	0.6332
Average	***0.5423***	***0.6000***	***0.5316***	***0.6637***	***0.6728***
St. Dev.	0.4729	-	0.5433	0.4711	0.4449

Instead of multiplying the survival values of the consecutive years of a given age-class to estimate span survival (2005-2009), the averages were estimated. These averages are used in population viability analyzes.

It has been impossible to assign the specific cause of death for each and every animal. Therefore three mortality causes were defined along with their assumptions. The defined causes of mortalities were:

1. Poaching: The cause of mortality was assigned as ‘poaching’ whenever the following conditions are met; i) collar of an individual is found in the field with no other trace of animal such as carcass or blood, ii) the individual was seen alive and well a week before its collar was found, iii) no sign of bites or residue of blood on the collar, iv) no tree or branch nearby where the collar was found, which may indicate that the collar was tangled on it got off animal’s neck. It was assumed that the collar can not fall off the animal’s neck by itself (it is highly unlikely).
2. Disease: The cause of mortality was assigned as ‘disease’ whenever the following conditions are met; i) the animal is known to be paratuberculosis positive by the ELISA test, ii) the animal was obderved to show symptoms of paratuberculosis such as diarrhea, and loss of weight recently
3. Other: The cause of mortality was assigned as ‘other’ whenever disease or poaching can not be assigned. Predation and accident (fall) are among other causes of mortality.

Cause specific mortality was also estimated using Micromort software (Heisey and Fuller, 1985; Table 3.12)

Table 3.12 Cause specific mortality estimates according to years and age classes for adult females (numbers in paranthesis are the number of individuals)

		INTERVALS					
			2005			2006	
	Mortality causes →	Other	Disease	Poach.	Other	Disease	Poach.
AGE CLASS	**2**	0.874 (1)	0	0	0	0	0.999 (1)
	3	0	0	0	0.999 (1)	0	0
	3+	0	0	0	0.628 (2)	0.314 (1)	0
			2007			**2008**	
	Mortality causes →	Other	Disease	Poach.	Other	Disease	Poaching
AGE CLASS	**2**	0	0	0	0	0	0
	3	0	0	0	0	0	0.346 (1)
	3+	0	0	0	0.122 (1)	0	0.245 (2)

Cause specific mortalities were calculated for female individuals whose data were used in PVA. On the other hand the general relation between paratuberculosis and mortality was tested using Fisher's exact test (Sokal and Rohlf, 1995). Out of 29 reintroduced known-fate animals (radio tracked) in 2007 release, 18 were negative and 11 were positive in the paratuberculosis test results (ELISA test). By the end of 2008, nine of the positives died and 3 of the negatives died. Fisher's exact test revealed a significant relation between being paratuberculosis positive and being dead at the end of the first year ($p=0.001$).

3.4.2. Fecundity

Fecundity can be defined as the average number of offspring per individual of age x censused at the next time step (Akçakaya et al, 1999). Since the demographic calculations are based on females only, average age-class specific fecundities can be calculated using: 1) number of lambs born per female, 2) ratio of female lambs to male lambs (since the sex of the lambs born could not be observed), and 3) lamb survival.

Records of lambs born per radio-collared female is obtained through observations in parturition periods in 2008 and 2009. The number of lambs born per specific female age class in a given year are calculated as in Table 3.13.

Table 3.13 The number of lambs born per female in adult age classes in 2008 and 2009 (0 and 1 year-olds did not have any lambs)

Year	age-class	# of females alive	# of lambs born	# of lambs per female
2008	2	3	2	***0.6667***
	3	2	2	***1.0000***
	3+	6	5	***0.8333***
2009	2	1	1	***1.0000***
	3	2	1	***0.5000***
	3+	3	2	***0.6667***

The average number of lambs born per female is calculated by taking the averages of same age-classes in different years. As a result age-class specific values are obtained (**age class**: average number of lambs per female: standard deviation): **2:** 0.8333±0.2357, **3:** 0.7500±0.3536, **3+:**0.7500±0.1179.

The catch records from 2005 and 2007 show that 11 female and 11 male lambs were caught in total, which were reintroduced. Therefore the male : female lamb ratio was assumed to be 1:1. Lamb survival was taken as the average value obtained by survival estimations.

Table 3.14 Average age-class specific fecundity calculation

Age-Class → / Parameters	0	1	2	3	3+
# of Lambs per Female	0.0000	0.0000	0.8333	0.7500	0.7500
% Female lambs	0.5000	0.5000	0.5000	0.5000	0.5000
Lamb Survival	0.5423	0.5423	0.5423	0.5423	0.5423
Fecundity	***0.0000***	***0.0000***	***0.2260***	***0.2034***	***0.2034***

3.4.3. Population Viability Analysis

In order to project the population into near future (i.e. next 20 years), population viability analysis (PVA) approach is used. For that purpose the RAMAS-EcoLab program was used (Akçakaya et al., 1999). To construct the PVA model in RAMAS-EcoLab, the required inputs are:

1. Stage matrix: containing the stage-specific survival and fecundity values.
2. Standard deviation matrix: standard deviation values for survival and fecundity estimates.
3. Density dependence: type of density dependence type.
4. Initial abundances: the abundance of each stage at the time when the model is going to run.
5. Replications: number of times the model will be run.

6. Duration: the number of years into the future for which period of time the projection will be made.
7. Management and migration options: population management actions such as harvest and introduction can be specified as number of individuals from one or more stages.

The stage matrix used in the PVA model is formed using the survival and fecundity tables (Table 3.15). The first row in table has the fecundity values of each age-class. The values in the other columns have the survival value of the column's age-class.

Table 3.15 Stage matrix used in PVA model of RAMAS-EcoLab

	0	**1**	**2**	**3**	**3+**
0	0	0	0.2260	0.2034	0.2034
1	0.5423	0	0	0	0
2	0	0.6000	0	0	0
3	0	0	0.5316	0	0
3+	0	0	0	0.6637	0.6728

Since the survival and fecundity estimates were the averages of several years, the standard deviation due to different years could also be estimated, which represent the effect of environmental fluctuations. These standard deviation estimates of survival and fecundity values are used in the standard deviation matrix of PVA model (Table 3.16). The 1 year-old survival could be estimated for a single year, and no standard deviation could be calculated. In order to make this value different from zero, the average of the other age-classes' standard deviations are estimated and used in the standard deviation matrix (in *italics* in Table 3.16).

Table 3.16 Standard deviation matrix of survival and fecundity, used in PVA model

	0	1	2	3	3+
0	0	0	0.0639	0.0959	0.0319
1	0.4729	0	0	0	0
2	0	*0.4831*	0	0	0
3	0	0	0.5433	0	0
3+	0	0	0	0.4711	0.4449

The density dependence options in RAMAS-EcoLab include exponential, scramble, contest competition and ceiling. For modeling the reintroduction study, exponential type density dependence was assumed, since the reintroduced population is a colonizing population and within the near future, such as 20 years, no significant effect of density dependence is expected to occur. In addition to that, Ginzburg, Ferson & Akçakaya (1990) recommends omitting density dependence from PVA models to obtain conservative estimates of extinction.

The total number of reintroduced females from 2005 to 2007 is 58 (0: 15, 1: 3, 2: 13, 3: 9, 3+:18). This number (and numbers of females in each age-class) is taken as the initial abundance to be used in the PVA model.

Replications are taken the maximum available in the program as 1000, in order to include the stochasticity in the model.

Duration of the projection is set to 20 years. This period is neither a very long nor a very short time frame.

The results of this PVA model are summarized in population trajectory graph (Figure 3.7).

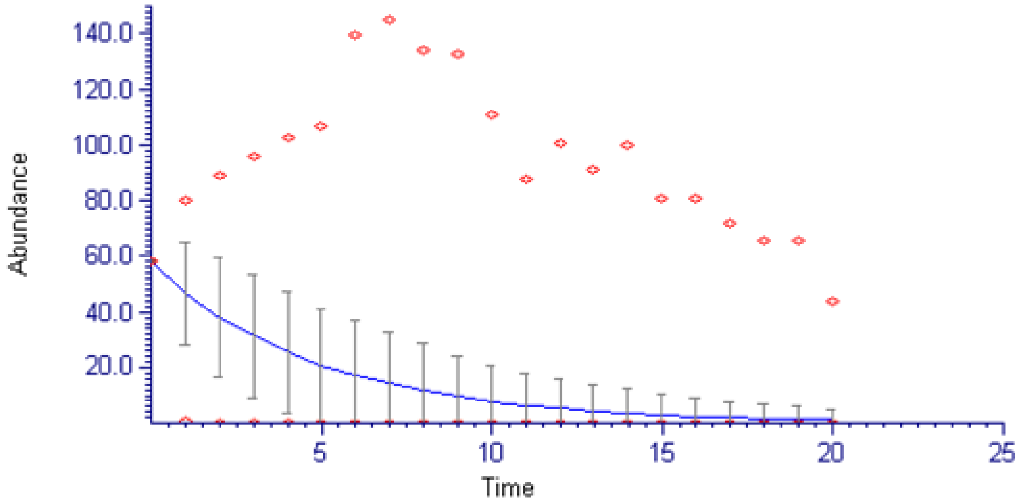


Figure 3.7 The trajectory summary for the original PVA model, created by RAMAS. The ± 1 standard deviations are displayed symmetrically around the mean (blue line). The minimum and maximum values are represented with red circles. Time is in years.

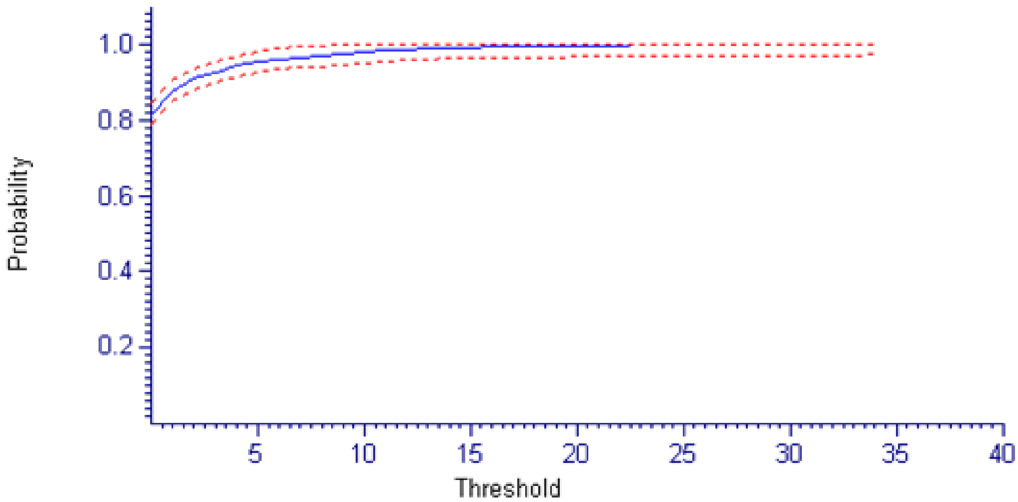


Figure 3.8 The extinction/decline curve for the original PVA model, created by RAMAS. The red dotted line represents the 95% confidence intervals based on Kolmogorov-Smirnov test statistic (Sokal and Rohlf, 1995). Threshold value is the number of individuals. Probability is the risk that the population will fall below the corresponding threshold value at least once during the next 20 years.

Table 3.17. Probability of decline under the threshold population size within next 20 years.

Threshold	Probability	95% confidence int.	
0	0.816	0.788	0.844
1	0.876	0.848	0.904
2	0.907	0.879	0.935
3	0.925	0.897	0.953
4	0.942	0.914	0.970
5	0.953	0.925	0.981
6	0.961	0.933	0.989
7	0.966	0.938	0.994
8	0.969	0.941	0.997
9	0.973	0.945	1.000
10	0.979	0.951	1.000
11	0.983	0.955	1.000

The trajectory summary shows the results of possible and mean trajectory for the population in the next 20 years. It is obvious from the graph that population is decreasing and at best, the population will have less number of individuals than the initial case, after 20 years. The extinction/decline curve and its table (Table 3.17) shows that the population will fall below 10 animals with a 99% probability, during the next twenty years.

However, the survival of adult females in 2006 was extremely low, which does not seem to be a general trend (as seen from much higher survival values of the other three years). In order to estimate a general variation of annual survival, the low survival values of 2006 were left out of average survival calculations. The first diagnosis of paratuberculosis disease in Anatolian mouflon were actually made using samples from females released in 2006. Therefore the very low survival of these females, which constitute the majority of the individuals from which the survival was calculated, can be due to high mortality caused by paratuberculosis. Additionally, the lamb survival of the same year was obtained from lambs which spent the first 8 months of their life in Konya-Bozdağ and therefore have a much higher survival than what was observed for the lambs in the following years – which were born in the release area. For these reasons the data from 2006 left out and a new stage and standard deviation matrices obtained (Table 3.18 and 3.19, respectively) to be used in a new PVA model.

Table 3.18 Modified stage matrix used in new PVA model

	0	**1**	**2**	**3**	**3+**
0	0	0	0.2260	0.2034	0.2034
1	0.3135	0	0	0	0
2	0	0.6000	0	0	0
3	0	0	0.7086	0	0
3+	0	0	0	0.8847	0.8777

Table 3.19 Modified standard deviation matrix of survival and fecundity, used in new PVA model

	0	**1**	**2**	**3**	**3+**
0	0	0	0.0639	0.0959	0.0319
1	0.3647	0	0	0	0
2	0	*0.4831*	0	0	0
3	0	0	0.5047	0	0
3+	0	0	0	0.1998	0.2118

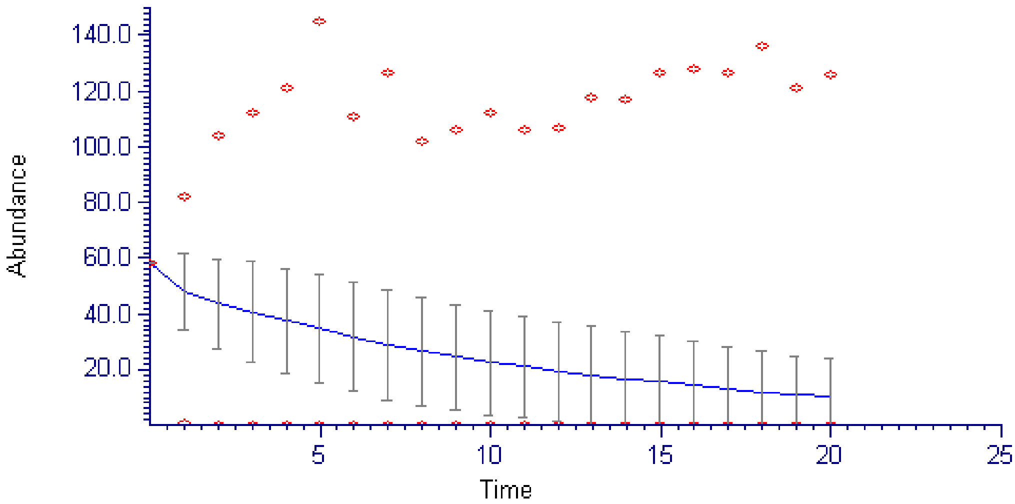


Figure 3.9 The trajectory summary for the new PVA model, created by RAMAS.

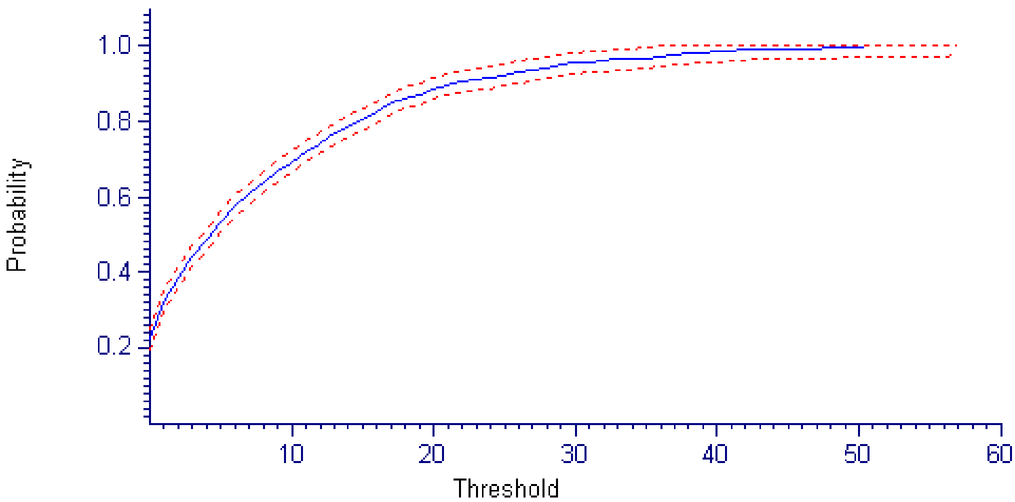


Figure 3.10 The extinction/decline curve for the new PVA model, created by RAMAS.

Table 3.20 Probability of decline under the threshold population size within next 20 years.

Threshold	Probability	95% confidence int.	
0	0.224	0.196	0.252
1	0.322	0.294	0.350
2	0.389	0.361	0.417
3	0.444	0.416	0.472
4	0.486	0.458	0.514
5	0.533	0.505	0.561
6	0.578	0.55	0.606
7	0.606	0.578	0.634
8	0.639	0.611	0.667
9	0.668	0.64	0.696
10	0.690	0.662	0.718
11	0.720	0.692	0.748
12	0.739	0.711	0.767
13	0.767	0.739	0.795
14	0.784	0.756	0.812
15	0.804	0.776	0.832

The results of the new PVA model (where 2006 is excluded) differ from the original model (where 2006 is included) in that the overall rise in survival values and decrease in standard deviation values decreased the probability of decline under threshold values (Table 3.20).

3.4.4. Conservation Management Scenarios

The PVA model enables to evaluate the effects of changes in the fitness parameters, such as survival and fecundity. For instance, with sensitivity analysis, the specific parameters that are most affective on the PVA model can be revealed. Such a sensitivity analysis was made using the new PVA model (in which data from 2006 was excluded). The results of this sensitivity analysis showed that the new PVA model is most sensitive to 3+ years-old female survival, assessed by the average probability of decline below 10 individuals within 20 years (Table 3.21).

Table 3.21 Probability of decreasing below 10 individuals within 20 years, to be compared with the model value of 0.690 (from Table 3.19).

Parameter Tested	+ 10% Difference	- 10% Difference	Sensitivity to Paramater
Lamb survival	0.666	0.696	0.030
1 year-old survival	0.682	0.709	0.027
2 year-old survival	0.665	0.731	0.066
3 year-old survival	0.663	0.748	0.085
3+ year-old survival	0.117	0.961	0.844

Therefore, focusing the conservation efforts to increase the survival of adult females could have a higher impact on the viability of the population than focusing on other parameters. Survival of adult females can increase as a result of natural adaptation to the reintroduction area. Another way to decrease the probability of decline is restocking the population with adult females. Effects of such a management action can also be evaluated through 'management and migration options' function provided in RAMAS-EcoLab. Hence two conservation scenarios were evaluated for their effect on population viability in the near future.

1) Increase in 3+years old survival: 3+ years old age group survival increases 10%,

2) Restocking: six adult females (three 3 years-old, and three 3+ years-old) will be released to the area every year

Scenario 1: Increase in 3+ years-old survival

As the sensitivity analysis showed, the 3+ years-old survival is the most sensitive parameter of the model. Therefore an increase (or a decrease) in older aged female survival would affect the population much more than similar changes in other parameters. Concentrating the conservation efforts towards amelioration of adult female survival could be a feasible first choice in urgent conservation actions. With increased protective measures and adaptation to the new area, the 3+ years-old female survival can be increased to 'normal' levels of what is given in the literature for the established mouflon populations (Cransac et al, 1997). In this case the average size of the female population stabilizes close to 50 individuals (Figure 3.11).

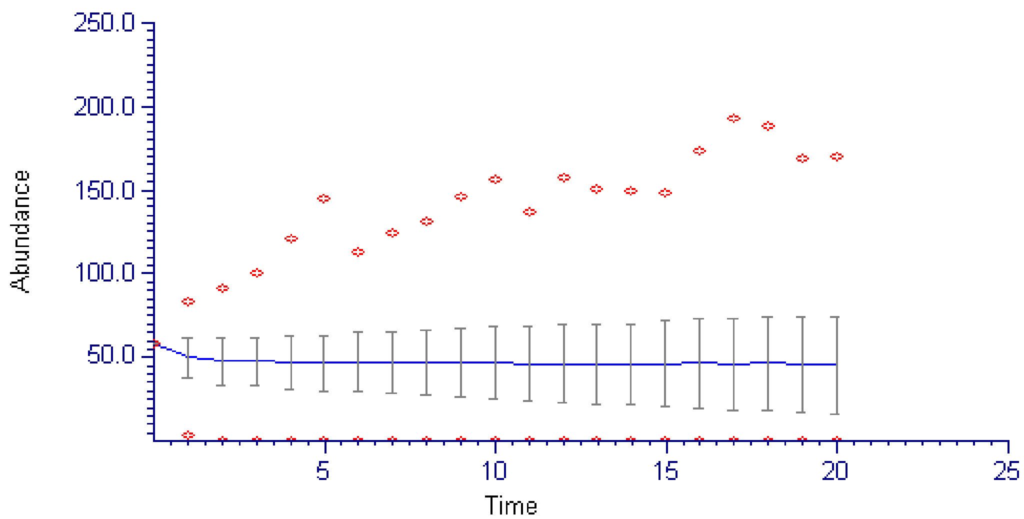


Figure 3.11 The trajectory summary for the PVA model in which survival increases in 3+ years old females.

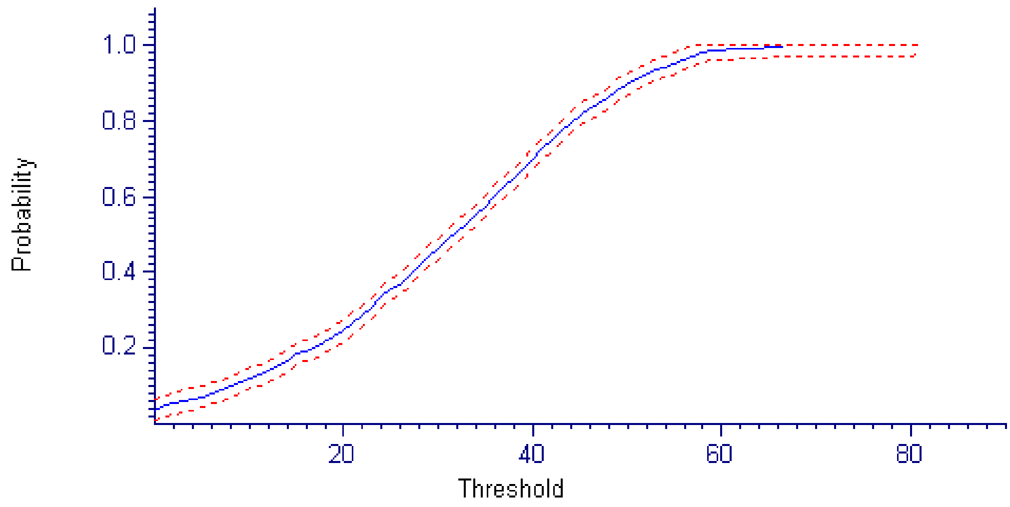


Figure 3.12 The extinction/decline curve for the increased survival scenario. Probability of extinction is reduced.

The probability of extinction is reduced compared to the original model: the population size falling below i.e. 10 individuals is only 12% compared to 69% in the new model (Figure 3.12 and Table 3.22).

Table 3.22 Probability of decline under the threshold population sizes within next 20 years in increased survival scenario

Threshold	Probability	95% confidence int.	
0	0.037	0.009	0.065
1	0.048	0.020	0.076
2	0.053	0.025	0.081
3	0.060	0.032	0.088
4	0.065	0.037	0.093
5	0.072	0.044	0.100
6	0.082	0.054	0.110
7	0.089	0.061	0.117
8	0.100	0.072	0.128
9	0.110	0.082	0.138
10	0.122	0.094	0.150
11	0.130	0.102	0.158
12	0.139	0.111	0.167
13	0.154	0.126	0.182
14	0.166	0.138	0.194

Scenario 2: Restocking

Unlike the first scenario, restocking the population with three 3 years-old, and three 3+ years-old female can be an option if the protective measures can hardly be taken or realized in the short-term. With this scenario, the population size steadily increases to over 80 individuals within 20 years (Fig 3.13)

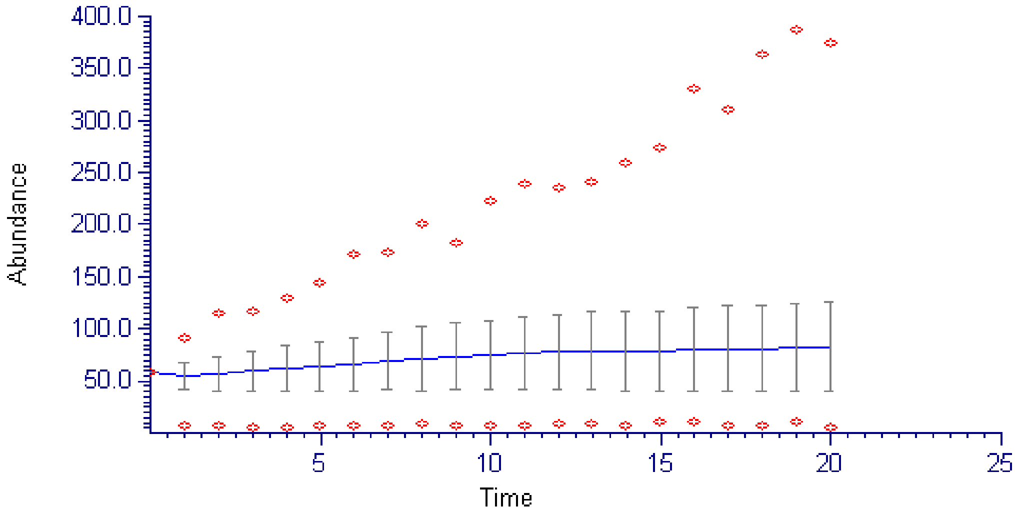


Figure 3.13 The trajectory summary for the restocking scenario. The average population size steadily increases to over 80 individuals within 20 years.

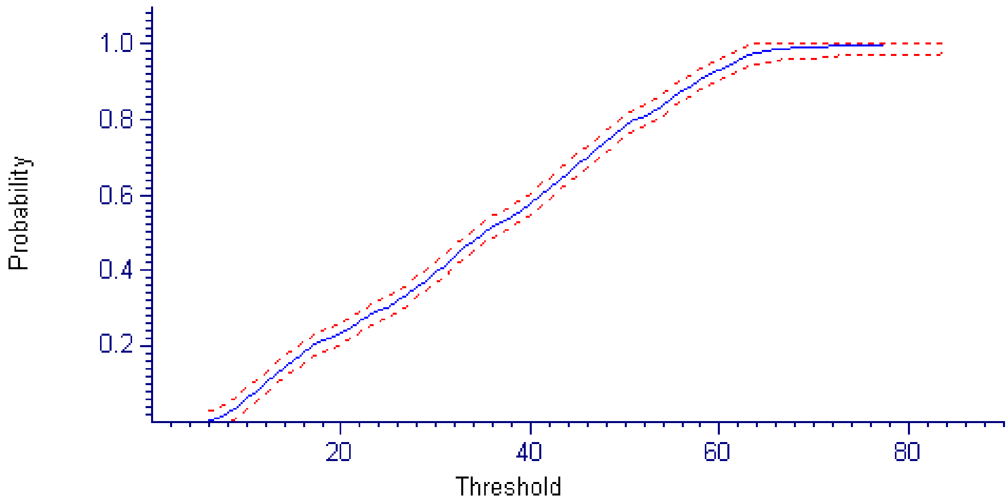


Figure 3.14 The extinction/decline curve for the restocking scenario. The probability falling below 10 individuals is still very high.

Table 3.18. Probability of decline under the threshold population size within next 20 years in restocking scenario.

Threshold	Probability	95% confidence int.	
6	0.003	0	0.031
7	0.009	0	0.037
8	0.025	0	0.053
9	0.039	0.011	0.067
10	0.065	0.037	0.093
11	0.081	0.053	0.109
12	0.103	0.075	0.131
13	0.127	0.099	0.155
14	0.147	0.119	0.175
15	0.163	0.135	0.191
16	0.181	0.153	0.209
17	0.199	0.171	0.227
18	0.214	0.186	0.242
19	0.221	0.193	0.249
20	0.234	0.206	0.262

Restocking scenario gave similar results compared with the previous scenario. Both scenarios decreased the possibility of extinction within 20 years from 80% to 20%.

CHAPTER IV

DISCUSSION

Questions are the seeds of scientific studies. Proper scientific design in search for the answers of these questions would enable the formation of a fruiting body. In the present study, the major deficiency had been the lack of proper design. But in majority of similar conservation studies, more definitely in post-release monitoring of a reintroduction, descriptive studies – observation of natural processes – dominates over correlational studies – testing of previously formed hypothesis (White and Garrot, 1990). However, conservation biology is a 'crisis discipline' (Soulé, 1985) and more often than not, the scientist is caught without a warning. These critical times struck much more frequently in developing countries than they do in first-world countries. For the present study, the initial drawbacks were:

1. The lack of adherence to basic reintroduction guidelines (IUCN, 1998) in responsible government agency (General Directorate of Nature Conservation and National Parks – DNPNP) caused to an ill-planned reintroduction study, in which the post-release monitoring was not included at all in the reintroduction plans. Additionally, the GDNP did

not acknowledge other individuals, such as restricted number of experts who has experience on the species ecology, or institutions such as universities, neither in the planning phase nor during the practice. This has given a very limited amount of time for planning and application for funding, to perform a well-designed post-release monitoring study.

2. The lack of any previous national studies and any acknowledged and experienced researchers or practitioners to give expert opinion and support.
3. A limited amount of funding secured within a short amount of time, which was used for obtaining all the equipments for radiotelemetry, materials for genetic analyses, providing salary for researchers and the budget for field work (transportation, accommodation etc.).

For these and other reasons, every aspect of the present study had been limited. However, throughout the study period, the interface between policy/governance and science came close and both sides had the opportunity to learn from each other. In order for any conservation study be successful or serve for the conservation of the target system, it should penetrate into policymaking process. The most critical step of developing and implementing policies and plans for conservation is in the hands of others, unless scientists work together with the decision-makers (Groom et al, 2006).

Radiotelemetry

When an animal is released to an area that is totally unknown to him/her, his/her behavior is expected be totally different than the inhabitant of this area. Kaczensky (2000) found that the home ranges of reintroduced brown bears (*Ursus arctos*) in Slovenia were 5-20 folds bigger than the native bears in the same area. Therefore appropriate tools to monitor the reintroduced animals are essential. Radiotelemetry is one such tool. Although there are better ones such as GPS telemetry, the budget limitations in most studies preclude their use. However, dominant in the literature that, advantages of specific techniques get much greater attention and audience than the disadvantages (with some exceptions, i.e. Kenward 1987). And much of the effort spent to apply the technique properly is not mentioned at all in the relevant literature.

The decision of using radiotelemetry to monitor the reintroduced individuals was made under such influences. However, as the test studies of telemetry error have suggested (detailed in section 2.2.2) and during the initial phases of field studies of radio-tracking, location determination using triangulation proved to be difficult. There was limited access by roads in the reintroduction area especially the areas which were frequently used by the mouflon. This has limited any opportunities to collect radiotelemetry data through triangulation, using the single available 4x4 vehicle and take three consecutive bearings from three different locations within a short enough (i.e. 10-15 min) time frame. We have tried to use the lake as a 'road' with a boat simultaneously with the 4x4 vehicle, to place the field personnel with telemetry receivers in different parts of the area to obtain simultaneous bearings from same animals. However due to the topography of the area frequent and high amounts of signal bounce prevented well intersecting triangulations, which were controlled in the field using a handheld PDA-GPS device (Garmin IQue 3600) with Locate III software (Nams, 2006). To compensate the signal bounce, the receivers had to change their locations, but due to limited amount of mobility, this took a lot of time, during which the animals also changed their locations. This in turn caused, at least for one of the other receivers that had good signals originally, to get bouncing signals. This forced them to change their locations too. Even if for some of the animals a good triangulation could be obtained, for majority of the animals either signal bounce or lack of signal forced the field personnel to change locations. This continuous change of place led to a kind of movement which eventually caused all the receivers to come so close to the tracked animal that the animal was visually detected. Due to a great amount of signal bounce and the subsequent shifting of receiver locations the triangulation type of data collection was abandoned in favor of homing.

Efficiency of homing is much lower than can be obtained from a 'non-problematic' triangulation, but provides much more accurate location data and collection of auxiliary data such as behavior and group composition. One of the major advantages of triangulation in non-problematic areas is to obtain multiples of location estimations from the same animal in a given amount of time without having to spend time searching the animal. But we could not use this advantage because of the practical inapplicability of triangulation due to signal bounce and underdeveloped road network.

Apart from these difficulties the error of the triangulation system (the standard deviation (SD) of bearing error) was estimated by the test study, to be large (6.04°). The meaning of the magnitude of this error becomes clear when its potential effect on the linear error of location estimations is realized. With a 6° of SD, there is a 100 m long error arc per km. The average distance of the receiver locations from the transmitter locations in the test study was around 2500 m. The actual distances between the receivers and the radio-collared animals during the radiotelemetry study would be of similar lengths. A 2500 m distance corresponds to 260 m linear error when SD is 6°. Such a high linear error leads to very large 95% confidence ellipses and becomes useless for valid estimation of home ranges and valid inferences for habitat selection.

Home Range and Area Use

As explained in the previous section, unavoidable revert to homing caused a decrease in the number of relocations obtained from animals during the study period. Eventually an average of 60 locations per animal could be obtained during 15 months of field study (4 relocations per animal per month). Literature emphasizes the importance of sample size for accurate estimation of home range size and shape (White & Garrot, 1990). In their study Börger et al. (2006) has shown that the biggest proportional reduction in variance was achieved by increasing sampling from 4 days/month to 8-12 days/month. But they have also found no difference in mean and variance of home range size estimated by a 4 days/month sampling regime and 17 days/month sampling intensity, in the case of monthly 80% kernel home ranges. And they only found 5% reduction in mean (and 18% reduction in variance) for annual home range size when the sampling intensity increased to 17 days/month. Therefore the sampling intensity achieved in this thesis study should be enough to give close to accurate results for the home range estimation of a recently reintroduced Anatolian mouflon population.

Several researchers emphasized about the increase in bias of outer isopleths of kernel home ranges and recommended using the inner part of the home range (Seaman et al., 1999). Börger et al., 2006 also stressed that use of 95% isopleths be avoided and that isopleths between 50% – 90% be used, due to their increased accuracy, especially between 80% - 50% isopleths. Decision of utilizing of 80% contours in this study was partly affected by these recommendations. Other reasons to prefer 80% contours over larger or smaller isopleths were: i) larger isopleths included larger areas that are unsuitable or even inaccessible to mouflon such as large patches of active croplands, Sarıyar Dam Lake and the shores across the lake. ii) smaller isopleths left many relocations of exploratory movement and certain localized areas of use (i.e. during rut) out of the home range. For a native animal, the exploratory movements may not be considered a part of the home range (Burt, 1943) but for a recently reintroduced individual, most of these movements are a part of its expected behavior (Benson & Chamberlain, 2007).

Börger et al. (2006) also quantified the contribution of number of marked individuals, the number of sampling bouts and the number of relocations to the variance in home range estimates and concluded that variation between individuals contributed most to the total variance in home range size, whereas the effect of sampling less relocation data was relatively small or negligible. Therefore, even though the sampling regime of 4 days/month had not been the best choice, tracking of more than 20 animals and utilizing 80% isopleths should have provided reliable estimates of home range representing the adult population in the present study.

The yearly home ranges of the individuals differed from each other in size and number of different center of activities. Males tend to traverse greater distances during the rut. This higher movement may lend those individuals susceptible to an increased amount of threats, decreasing their chances of survival. As seen from the results of the study and observations, females shifted their range in the beginning of parturition in 2008, to a geographically separate, higher sloped, rough terrain. However that part of the area was outside of the officially protected zone and heavily used by domestic herds of size 500-2000, accompanied by 2-5 shepherd dogs. Result was a catastrophe. Almost all the newborns were died, most probably through disturbance by the movement of herds and harassment by shepherd dogs. More than half of the females turned back to their winter range after spending one or two weeks in that area, without their offspring – their offspring either died or left behind.

Although the average home range size of males and females did not differ significantly, the individual variation in male home range sizes was considerably higher than in females' (see Fig. 3.3). Martins et al. (2002) have found similar results in an introduced mouflon population in Caroux-Espinouse, France, using the differences in arithmetic centers of activity and degree of overlap of locations: all females and some males concentrate their yearly and year to year activities in specific parts of the area, while other males change their center of activities within and among years.

Habitat Selection

For habitat selection analyses K-select analysis was preferred owing to its exploratory qualities. A rather large number of variables can be analyzed together in a multivariate framework by K-select analysis. (Calenge et al., 2005). The interpretation of the results is not limited to several numerical values as in most other habitat selection analyses, but rather enables the visual representation of relative effects of variables on selection of individuals.

It is well known that the animals' selection of habitat show considerable seasonal differences (Geist, 1971; Festa-Bianchet, 1988; Millspaugh & Marzluff, 2001). This being a reintroduction study, the introduced animals did not initially know the area. They lack a pre-developed seasonal preference within the release area. Therefore the habitat selection analysis was performed using the entire year's data, without giving consideration to seasonal differences. Another reason for not segregating the data according to seasons was the insufficient relocation data.

In the yearly habitat selection study, some noticeable results were that Anatolian mouflon, as in other wild sheep species, selected steep slopes, areas near the water and far from the roads. They however do not select areas with medium to high tree cover, flat areas and agricultural land. It is important to note that the land use of the majority of flat areas is agricultural. Two different variables, flat land and agricultural land, that spatially overlap may have an exaggerated effect in the habitat selection of the individuals in the K-select analysis, while in reality this may not be the case. When compared with its closest relative, wild goat (*Capa aegagrus*), living in Anatolia, Anatolian mouflon is adapted to much less steep and more open terrain. The reintroduced population's preference of highest slopes and rugged terrains in the study area, however, do not contradict this fact. Such areas are the only available 'safe' terrains found in the area, which mouflon uses to avoid its predators and other threats. The topography of the area is totally different from the Konya-Bozdağ area where rolling hills extend throughout large connected areas in all directions. Therefore, while the 'preference' of mouflon can be the mildly sloped open terrain, the 'selection' of mouflon in the reintroduction area has been the higher sloped rugged terrain due to the availability of the latter and absence of the former terrain type.

Most wild ungulate species select habitat far from human settlements (i.e. Krausman, 2000, 2002). However in the K-select analysis, distance to village was not very prominent in the Anatolian mouflon's selection of habitat. An explanation may be that there is very little human settlement in the release area and most of the available area is far enough from human settlement.

The mouflon select the South looking aspects. The fact that the dam lake, the most important water resource in the area lies along the southern border of the area may be a reason for this selection. Additionally, most human activity, such as agricultural activities and roads take place in the bordering regions in the north.

The fact that more than half of the homing data was taken using the waterway of the dam lake, which lies in the south of the area may have created a bias on the results of the selection of the mouflon of southern aspects. However this is rather unlikely since similar amounts of western and eastern aspect slopes are looking towards the lake; and whenever the individuals were not located from the lake, they were sought by car or on foot, until seen.

There seem to be certain groupings in the habitat selection among individuals. However these are not very pronounced groupings, but rather they show more of a continuous pattern.

K-select analysis does not perform hypothesis testing on selection of particular habitat types. It predicts which variables are most influential on the habitat selection profiles. Using randomization tests one can perform hypothesis testing. However because there are many variables, it is difficult to obtain significance using Bonferroni confidence limits. That is why compositional analysis was preferred to test the significance of selection of particular values of some of the habitat variables.

Compositional analysis was performed with the variables that were shown to be influential in the habitat selection of the mouflon by the K-select analysis. Compositional analysis was performed on aspect, slope and vegetation. The compositional analysis performed for slope and aspect variables in three different scales of selection, resulted in the same selection pattern for all scales. There was, however, a difference between second and third order selections for the vegetation layer. The mouflon select sparsely vegetated grassland and grassland for their individual locations within their home ranges. However their home range is composed significantly more of low tree cover areas and grassland than sparsely vegetated grasslands. This could be due to that low tree areas still harbor more natural (closer to the original steppe flora of the area) vegetation than the old croplands (regarded as grasslands) – since the presence of trees prevented men to use these areas as croplands – and more vegetation the sparsely vegetated grasslands.

Cransac & Hewison (1997) studied seasonal habitat selection of different sexes of mouflon and found a difference in selection only in lambing (spring) and rutting periods (autumn). They have found that mouflon selected meadows (grassland) in general and males occasionally swiched to forested areas in spring and autumn. The difference in habitat selection of males and females accoding to seasons were not analysed in a hypothesis testing scheme such as compositional analysis. But the results of K-select analysis do give some hints. As shown in Figure 3.6 one male dominated grouping of individuals selected southern looking open terrain (away from any tree cover) while female dominated grouping of indviduals similarly southern looking areas but additionally with high sloped areas away from human influenced areas (crop, road, village). Different than Cransac & Hewison's (1997) study, these groupings are not the actual male or female groups observed in the field but rather a convergence of selection of individuals from similar sexes revealed by K-select analysis. Although the actual group compositions of the monitored individuald are known, their analyses were not included in the thesis.

Demography

The survival values were statistically stronger in the reintroduction done in 2007, because the number of radio-collared animal and therefore the sample size was higher. The sample sizes in 2005 and 2006 were much smaller and this could be one of the reasons of getting very low and very high survival estimates. These estimates belong to individuals which were the first ones to be reintroduced. The individuals reintroduced in 2007 have higher survival rate. One of the reasons can be the presence of individuals from the first reintroduction, who were already acquainted with the resources and threats of the new area. By joining these 'experienced survivors' or their groups, the individuals from the second reintroduction could have increased their survival. The meteorological data do not show a dramatic change between the years sampled.

The reintroduction of Anatolian mouflon can not be said to be a well planned and performed application according IUCN criteria. The post-release monitoring phase which was accomplished through this thesis study has also suffered from this deficient planning. Monitoring started much later than should have. However the results came out to be valid and useful.

The significant relation between being paratuberculosis positive and being dead at the end of the first year of release in 2007 do indicate the effect of disease on the lower survival of the population. The low survival of the reintroduced population and the neonatal survival were likely to be adversely affected by the disease as well as by the reintroduction related causes. However it could be hypothesized that not being in an enclosure as opposed to the source population in Konya-Bozdağ, the chances of disease outbreaks are much lower in Ankara-Sarıyar population. With the elimination of infected individuals and using non-infected females for re-stocking, the Ankara-Sarıyar population can recover from the devastating effects of the disease sooner. By this time the individuals would have gained experience about the threats and learned the whereabouts of the area. These two important factors would work together to turn the Ankara-Sarıyar population into a colonizing state with a high growth rate.

A pre-release plan would have decreased such tragic events. The domestic herds could have been restricted from the area during parturition and the following few months. The observations of this study on the parturition of 2008 was shared with the GNDP officials, and prior to the parturition period of 2009, shepherds and herd owners were warned about this situation. Additionally there had been rumors about several individuals of wild and domestic canids (feral dogs, grey wolf and jackal) being shot by GNDP officers in the reintroduction area one month prior to the parturition. Our observations of newborns in 2009 parturition increased substantially.

The number of lambs spotted daily in the Summer of 2009 was substantially higher than the number spotted in the Summer 2008. The lambs of all six radio-collared females survived the parturition of 2009. The reason for this increase in survival may be the fact that the animals are better aware of the threats and opportunities offered by the release area following the first year of reintroduction.

Population viability analyses estimated a rather high extinction risk in general for the reintroduced population within the near future. Two PVA models were utilized. In one of them all the survival estimates for all years were used (original model), while in the second one year 2006 left out (new model). While the two models gave a similar picture of high extinction risk within 20 years, the model without 2006 revealed lower extinction risk. The extraordinarily low survival values for 2006 affected both the average and the temporal variation of survival estimates, causing them to be very low. However the reason for such low values in 2006 was due to very low sample size of adult females for that year and that all these females were paratubeculosis positive, with obvious diarrhea and loss of weight. This fact is not apparent in cause-specific mortality results for 2006 since disease may not be the actual reason of mortality but renders the individual vulnerable to predation and other causes of mortality. Hence the 'new' PVA mode was preferred over the 'original' one and management scenarios were based on it.

Two scenarios of conservation management planning have been considered to lower this extinction risk. Since sensitivity analyses have revealed the most influential parameter on the viability of the population as the older female survival, one of the scenarios took into account this fact and tested its effect on viability. This finding is in accordance with other studies on large herbivores (Gaillard et al, 2000). It is expected that a reintroduced population's survival during the first years would be lower than an established population's survival as observed in many reintroduction studies (i.e. Robert et al., 2004). However as the released individuals adapt to the new environment their viability is expected to increase in general, given the habitat conditions, predation and human-induced disturbances do not exceed critical thresholds. So one option for conservation management would be spending every effort to decrease the effects of threats towards adult females, such as poaching and meanwhile keeping the habitat within the protection area and the surrounding buffer zones, undisturbed by domestic herds and other human activities. The survival of lambs during the study period was also found to be lower than the estimates of other mouflon population (Cransac, 1997). There have been studies suggesting that maternal experience can decrease vulnerability of offspring to predators (Ozaga & Verme, 1986; Gaillard et al, 2000). It can be asserted that as adult females increase their knowledge of the area and their experience in avoidance of predators and domestic herds, their and their offspring's survival would increase.

In case an increase in adult female survival seems unachievable, in the short-term, to address the threats in the area, such as poaching and domestic herds, the population should keep on being restocked in order to continue its existence at a stable size. Calculations show that restocking with six adult females each year would keep the population stable at around 40 individuals. The GDNP have enlarged the size of the fenced area to around 100 ha in 2009 and translocated 45 individuals from Konya-Bozdağ, in order to establish a captive-breeding station in Sarıyar. All translocated individuals were selected to be paratuberculosis negative and the lambs were all vaccinated against paratuberculosis. This station can serve as the source for restocking in the forthcoming years.

It has been documented in various studies that certain life history parameters such as lamb survival of large herbivores are density-dependent (Geist, 1971; Jorgenson et al., 1997; Festa-Bianchet et al., 1998). Therefore many authors suggest using density-dependence in PVA models (i.e. Ginzburg, Ferson & Akçakaya 1990; Sezen, 2000). Ginzburg, Ferson & Akçakaya (1990) suggests that whenever there is not sufficient data to make reliable estimates of the character of density dependence, it would be conservative not include density dependence into PVA model. Therefore, in our PVA model, density dependence was ignored and the population was regarded as a colonizing one, with an exponential growth regime, which would be expected from a reintroduced population. In order to see the effect of adding density dependence to PVA model, a trial PVA model was made where the same paramaters from Sezen (2000) were used: scramble competition with an R_{max} derived from abundance estimates of last 34 years (R_{max} = 1.09). The results did reveal a much better scenario than the ones without density dependence (Fig 4.1 and 4.2).

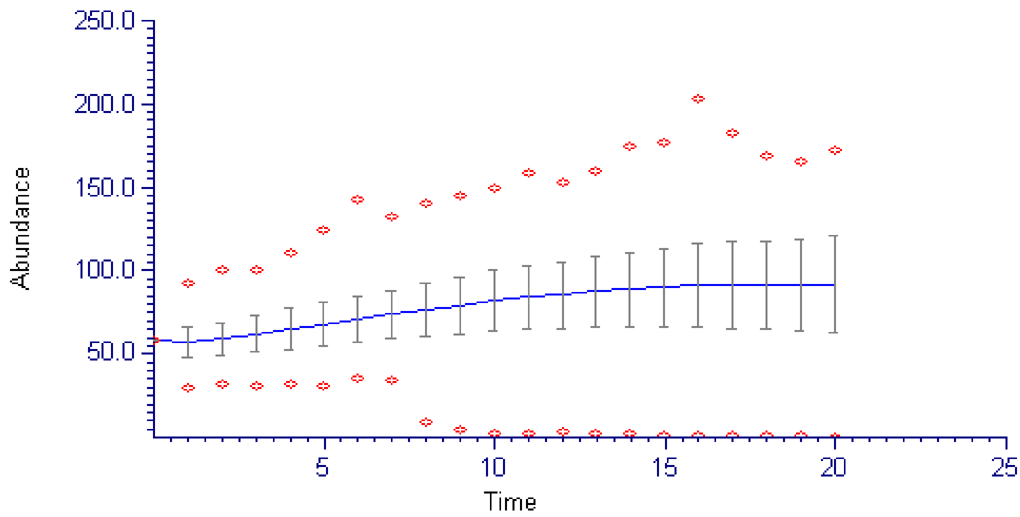


Figure 4.1 The trajectory summary for the PVA model in which density dependence was set to scramble with R_{max} = 1.09.

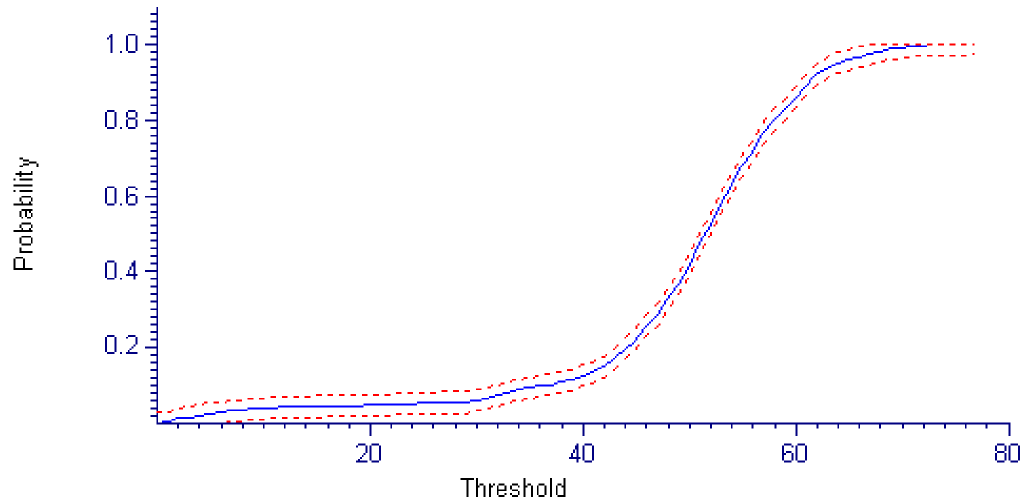


Figure 4.2 The extinction/decline curve for the PVA model with density dependence added.

When compared to the 'new' PVA model resulting graphs, the extinction probability of the reintroduced population, without any ameliorative management, is quite lower with density dependence included in the model. This result conforms to the Ginzburg, Ferson & Akçakaya (1990) suggestions to avoid using density dependence in the model – when low or mild levels of density dependence is expected – to be more conservative, in case of insufficient data.

In conclusion, the results of this study can be used for selection of new and better suited reintroduction sites in Central Anatolia for the Anatolian mouflon. The characteristics of the habitat, the size of the protected area needed to be established, number and ages of individuals to be used, potential sources of threat to viability of a reintroduced population, are all partly covered within this study. Although every new attempt will have its unique conditions due to various factors, this study can provide basic quantitative and qualitative information to form an initial framework and guideline for future reintroductions of mouflon and other large herbivores in Turkey or elsewhere.

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CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Özüt, Deniz
Nationality: Turkish (TC)
Date and Place of Birth: 23 November 1976, Ankara
Marital Status: Married
Phone: +90 312 2850745
Fax: +90 2866820
email: deniz@fulbrightweb.org

EDUCATION

Degree	**Institution**	**Year of Graduation**
MS	METU Biological Sciences	2002
BS	METU Biological Sciences	2000
High School	Antalya Anatolian High School	1994

WORK EXPERIENCE

Year	**Place**	**Enrollment**
2009 – Present	Nature Conservation Centre	Project Coordinator
2000 – 2007	METU Dept. of Biological Sci.	Research Assistant

FOREIGN LANGUAGES

Advanced English, moderate Portuguese

PUBLICATONS

1. Weinberg P. & Özüt D. (2007) Wild goat and mouflon surveys in Turkey, *Caprinae*, Newsletter of the IUCN/SSC Caprinae Specialist Group, May.

2. Maudet C., Beja-Pereira A., Zeyl E., Nagash H., Kence A., Özüt D., Biju-duval M.P., Boolormaa S., Coltman D . W., Taberlet P. & Luikart G. (2004) A standard set of polymorphic microsatellites for threatened mountain ungulates (Caprini, Artiodactyla) *Molecular Ecology Notes*, **4**, 49-55.

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