SPATIO-TEMPORAL ECOLOGY, HABITAT USE AND POPULATION SIZE OF BROWN BEARS (*Ursus arctos*) IN YUSUFELI, TURKEY

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ABSTRACT

SPATIO-TEMPORAL ECOLOGY, HABITAT USE AND POPULATION SIZE OF BROWN BEARS (*Ursus arctos*) IN YUSUFELI, TURKEY

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Brown bear is the largest mammal in Turkey and its main distribution lies in the Black Sea and Eastern Anatolia Regions. Its basic ecology is almost unknown in Turkey, except for a limited number of studies. This study aims to determine the spatio-temporal ecology and habitat use of brown bears in the Kaçkar Mountains, and to estimate their population size in the Özgüven Valley and Yusufeli, both firsts for Turkey. The study area is primarily covered with conifer and oak stands, but sparse mixed shrubland occurs in the Mediterranean climate influenced lower parts. GPS-GSM telemetry on seven captured bears (5 males and 2 females) was the main field technique used in this study. Other methods include monitoring via camera trapping, visual direct observations, and counting cubs of the year. Bears were fitted with GPS-GSM collars and tracked for 3 to 603 days. Mean home range size (HRS) was calculated by 95% kernel and MCP estimators for three different samples sizes.

95% MCP for all positions produced a home range size of 19.91 ± 8.89 sq. km. for females, and 130.68 ± 102.95 sq.km. for males. On average, males and females move at rates of 199 m/h and 129 m/h, respectively. Males hibernate around 140 days whereas females around 150 days and at lower elevations than males. According to camera trapping results, bears are generally active at twilight whereas activity data loggers produced disparate results for tracked bears. Resting patterns showed that bears may also rest at midnight. Estimated population density per 100 km^2. is 24.50 ± 1.74 individual using the Fcub method and 23.85 ± 2.51 using the mark–resight method. Captured bears indicated nonrandom distribution on habitat use and selected productive croplands and shrublands than other types of vegetation.

Brown bear HRS in the Kaçkars is smaller than reported from most countries. The large female-male HRS difference is probably due to polygamous mating system, sexual dimorphism, hard mast availability, high population density, and female's habitat exclusivity as a result of high tolerance by the local people in contrast with most northern countries. Although primary productivity is used to explain high population density and small HRS in other countries, the low productivity in the study area cannot explain the observed density and HRS difference. These findings will construct a scientific basis for brown bear management and conservation in Turkey.

Keywords: brown bear, home range, habitat use, population density.

ÖZ

YUSUFELİNDE BOZAYILARIN (*Ursus arctos*) UZAMSAL-ZAMANSAL EKOLOJİSİ, HABİTAT KULLANIMI VE POPULASYON BÜYÜKLÜĞÜ

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Türkiye'de en büyük memeli türü olan bozayı Karadeniz ve Doğu Anadolu bölgelerinde geniş bir yayılışa sahiptir. Türün Türkiye'deki ekolojisi neredeyse bilinmemektedir ve hakkında oldukça az çalışma bulunmaktadır. Bu çalışma Türkiye'de ilk defa Kaçkar dağlarındaki bozayıların (*Ursus arctos*) uzamsal-zamansal ekolojisi, habitat kullanımı ve Özgüven ve Yusufeli'nde populasyon büyüklüğünü tespit etmeyi amaçlamıştır. Çalışma alanı esasen ibreli ormanlar ve meşe toplulukları ile, Akdeniz iklimi etkisi altındaki düşük rakımlar ise karışık çalılarla kaplıdır. Bu çalışmada 7 bozayının (5 erkek ve 2 dişi) GPS-GSM telemetri ile izlenmesi temel arazi yöntemidir. Ayrıca yavrulu dişilerin sayılması, fotokapan çalışmaları, doğrudan gözlemler diğer yöntemleri oluşturur. Bu çalışmada yedi bozayı GPS-GSM tasması ile 3-603 gün arasında izlenmiştir. Ortalama gezinme bölgesi %95 en küçük dışbükey çokgen (MCP) ve Kernel alan tahmin yöntemleri kullanılarak üç farklı örnekleme sayısı için hesaplanmıştır.

Bütün noktalar kullandığında % 95 MCP alan büyüklüğü dişiler için 19,91 ± 8,89 km^2 ve erkekler için 130,68 ± 102,95 km^2'dir. Ortalama olarak erkekler saatte 199 m hareket ederken dişiler 129 m hareket etmektedir. Dişilerin kış uykusu 150 gün kadarken erkekler 140 gün civarında daha yüksek rakımlarda yatmaktadırlar. Fotokapan sonuçlarına göre bozayılar alacakaranlıkta hareketli olup tasma aktivite kayıtları, takip edilen ayılar için fotokapandan farklı sonuçlar vermiştir. Bozayıların gece yarısında da dinlendiği Türkiye'de ilk defa türün dinlenme deseni ortaya konularak gösterilmiştir. Yusufeli için hesaplanan populasyon yoğunluğu 100 km^2'de Fcub yöntemi kullanarak 24,50 ± 1,74 birey ve işaretle-yenidengör yöntemi kullanarak 23,85 ± 2,51 birey bulunmuştur. Bozayılar habitat kullanımında rastgele olmayan bir dağılım sergileyerek, üretken tarım alanlarını ve çalılıkları diğer habitat tiplerinde daha çok seçmektedir.

Bozayıların Kaçkarlar'daki gezinme bölgesi büyüklüğü birçok ülkeye göre oldukça düşüktür. Erkek ve dişi gezinme bölgeleri arasındaki fark muhtemelen dişilerin kuzey ülkelerine kıyasla köylülerin ayıları müsamahasıyla kendilerine özel alanları seçebilmelerine, ayıların çokeşli çiftleşme sistemlerine, yüksek populasyon yoğunluğuna, eşeysel farklılığa ve sert kabuklu tohumları besin olarak kullanmalarına bağlıdır. Diğer ülkelerde birincil üretim populasyon yoğunluğunu ve gezinme alanı büyüklüğünü açıklamak için kullanılsa da çalışma alanındaki düşük üretim bunları açıklayamamaktadır. Bu çalışmada elde edilen sonuçlar, Türkiye'deki bozayıların yönetimi ve korunması için gerekli bilimsel temeli oluşturacaktır.

Anahtar kelimeler: Bozayı, gezinme bölgesi, habitat kullanımı, populasyon yoğunluğu.

To Didos

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INTRODUCTION

Brown bear (*Ursus arctos* Linneaus, 1758) is the largest carnivore in Turkey. Its main distribution lies in Black Sea and Eastern Anatolia Regions, and partly in northwestern and southern Turkey. They are commonly herbivorous in diet and at the center of conflict with humans due to certain dietary behavior and habitat overlap with human settlements (Ambarlı 2006). This causes a growing resentment for bears among locals, pushing authorities for the annulment of the Animal Protection Law and the renewal of legal hunting (Ambarlı and Bilgin 2008), including the right for defensive kills in case of protection of property and life. Bears have a long lifespan following usually two years of female parental care and large home ranges (Pasitschniak-Arts 1993, Craighead 1985) and can disperse long distances from their natal area (Dahle et al. 2006). They are charismatic, large and solitary animals so they are often sought after by trophy hunters, and hence need a species management and conservation plan. All those features make brown bear as a target for studies of animal ecology in the world (Servheen 1999, Swenson et al. 2011).

In contrast, basic ecological research on bears in Turkey are largely lacking compared to the other European countries or the US. There is a preliminary study about bear distribution based on the map of the Turan (1984) by Can and Togan (2004). The first brown bear study have been conducted during 2003-2006 in Yusufeli, Artvin, and focused on the human-bear conflict; it also carried out the tracking of a radio-collared bear for the first time in Turkey (Ambarlı 2006). A population viability analysis carried out by Ağzıtemiz (2008) tried to figure out the future of bear population in Yusufeli if trophy hunting is allowed with also ongoing illegal kills. Another study regarding human-bear interactions was students' perception of bear in Yusufeli (Ambarlı 2010). There are also recent studies by camera traps to reveal the bear activity patterns and habitat selection in western Black Sea (Soyumert 2010). Scientific data particularly at the hot-spot of human-bear conflict site is required for solving problems and filling gaps such basic bear ecology for conservation and management purposes (Swenson et al. 2000).

1.1. Study Species Taxonomy and Status in Turkey

The species belongs to Order Carnivora, Family Ursidae, Subfamily Ursinae and the genus *Ursus*, which includes four species: *U. arctos*, *U. americanus*, *U. maritimus*, and *U. thibetanus* (Servheen 1999). Most authorities now recognize *U. arctos* as a single Holarctic species (Servheen 1999). Nine subspecies from the New World and seven from the Old World were described (Pasitschniak-Arts 1993). Turkish brown bears have been defined to belong the subspecies *syriacus* by several studies (Calvignac et al. 2008, Chestin and Mikeshina 1998) but this was not validated by current mtDNA based research (Çilingir et al., *unpub.data*).

Historically, brown bears ranged over most of the country, being absent only from the coastal plains and the open steppes (Turan 1984, Can 2001, Ambarlı 2006). They now occur from coastal areas in Mediterranean region (Muğla) to the highest mountains in Eastern Turkey (e.g. Mount Ağrı and the Kaçkar range) (Ambarlı and Bilgin 2012). Currently, even though some claims about declining of population still exists in bears and other mammals (Can 2008, Şekercioğlu et al. 2012), population trend is probably increasing upward except some local areas (Ambarlı and Bilgin 2012).

Until the last decade, the brown bear was not legally protected under the now outdated Hunting Law of 1937 (Official Gazette of Turkish Republic 1937). However, in 2003 a new law (No: 4915) was introduced that banned the killing of bears, except for regulated trophy hunting. The fine for illegally killing a bear is now 19,000 TL (equivalent to about 9,000 Euros) (Turkish Ministry of Forestry and Water Affairs 2012). However, there are efforts to ease the ban, at least in particular regions where increased complaints of bear damage are used as an excuse (Ambarlı and Bilgin 2008). As a result in 2007, a total of 15 brown bears in Artvin, Karabük, Kastamonu and Zonguldak were allowed for trophy hunting by the Nature Conservation and National Parks, Game and Wildlife Department due to nominal human-bear conflict (Ambarlı and Bilgin 2008).

1.2. Basic Ecology of Brown Bears

Bears have a unique metabolism and are the largest hibernators, characteristics that predominantly shape bear ecology and life history (Pasitschniak-Arts 1993). Brown bears have to mate soon after den arousal, need to gain a lot of weight during late summer, should care for cubs and avoid humans, and require a safe place for denning (Pasitschniak-Arts 1993, Servheen et al. 1999). Brown bears are solitary mammals that roam around to find a mate and utilize resources, yet home ranges may overlap (Craighead 1982, Dahle and Swenson 2006). Females show parental care to 2-3 cubs and protect them from males (Swenson et al. 2001).

1.2.1. Activity patterns

Most carnivores usually show either diurnal or nocturnal activity pattern which reach highest level at crepuscular times (Kaczensky et al. 2006). The activity pattern of brown bears depend on the season, food sources or prey, human disturbance and internal factors (Kaczensky et al. 2006) but it is hard to study at low population densities that show a nocturnal pattern (Swenson et al. 2000, Rauer and Gutleb 1997). Bears in human dominated landscapes such as Europe and Turkey show high avoidance behavior, either intrinsically or by learning (Ordiz et al. 2012, Moe et al.2007, Zedrosser et al. 2011). Therefore, most European brown bears are more nocturnal (Kaczensky et al. 2006) compared to North American brown bears that are mostly diurnal (Welch et al. 1997). In Turkey, bears are mostly nocturnal but in areas with low human disturbance, they can be seen in daylight hours (Ambarlı 2006). GPS collars provide activity data loggers and record at fix time intervals so that bear activity patterns can be revealed by analyzing these data (Yamakazi et al. 2008, Hwang and Garshelis 2007, Schwartz et al. 2010).

1.2.2. Diet

Brown bear dietary range is very wide and includes domestic livestock, to wild ungulates, grasses to hard mast and fruits, small mammals to fishes, ants to honey and bees (Bojarska and Selva 2012). Bears in Artvin are almost totally herbivorous in spring and autumn. A simple diet analysis conducted by dissecting scats in previous study (Ambarlı 2006, Ambarlı *unpub. data*) showed the consumption of mostly wild and cultivated fruits such as pears (*Pyrus* spp.), apples (*Malus* spp.), plums and cherries (*Prunus* spp.), grapes (*Vitis* spp.), figs (*Ficus* spp.), cornelian cherries (*Cornus* spp.), raspberries (*Rubus* spp), rosehips (*Rosa* spp.), hawthorn (*Crategeus* spp.), acorns of oaks (*Quercus* spp.) and beech (*Fagus orentalis*) mast, bearberry (*Vaccinium* spp.), hazelnuts (*Corylus* spp), walnuts (*Juglans* spp.), maize (*Zea* mays), *Frangula* sp., various vegetable crops including beans and carrots, clovers (*Trifolium* spp.) and ants (*Formica* spp.).

The main food items during hyperphagia at high altitude pastures were observed to be oak and beech acorns (hard mast), bearberry and rose hips (Ambarlı 2006). Meat in diets of bears in Artvin is much less in percentage compared to northern brown bears (Bojarska and Selva 2012) because in Turkey almost all livestock are protected either by a shepherd and/or a shepherd dog (Ambarlı and Bilgin 2008). Besides, prey numbers, such as ungulates in the region are too few in numbers to constitute a significant part of the diet (Ambarlı et al. 2010).Thus, although actually omnivorous, in Artvin bears are largely herbivorous (Ambarlı 2006).

A diet high in plant component may result in so much intake (due to the low protein and fat content) that it leads to higher conflict with people and lower survival of younger individuals that visit cultivated areas (Macdonald and Barrett

1993), leading to increased human caused bear mortality and bear caused human mortality (Ambarlı and Bilgin 2008).

1.2.3. Home Ranges

Main concerns in telemetry studies depends on the aims and can be about determining animals' home range size, habitat use, demographic parameters, or studying the ecology of different species and interaction with each other (White and Garrott 1990). Home range is described as an animal's use of a "normal area" over some specified time to conduct activities of securing food, mating, and caring for young (Burt 1943, Mohr 1947, White and Garrott 1990). The size of a bear home range is generally inversely related with abundance of food (McLoughlin et al. 2000). Mostly females show aggression to defend certain sites and exclude conspecifics; those parts of home ranges are called territory (McLoughlin et al. 2000). Brown bears mark areas of their home range through tree scratching and scent rubbing (McLoughlin et al. 2000, Karamanlidis 2008, Ambarlı 2010).

Home range size is not directly related to food availability and it is positively related to seasonality (Dahle and Swenson 2003, Ferguson and Mcloughlin 2000). As seasonality increases, more home range overlap is seen but territorial behavior also can be seen at moderate levels of habitat quality since it is not realistic to protect limited food resources (Mcloughlin et al. 2000). On the other hand, at a large geographical scale, a negative relationship between range size and food availability is evident because Scandinavian and North American brown bears have the largest annual home range comparing other countries (Dahle and Swenson 2003, Ferguson and Mcloughlin 2000). Hence, average home range sizes of bears are different according to density, seasonality, location, and some other unknowns.

In Europe, brown bears have low densities and large home ranges. For example, Sweden has 20-25 bears/1000km2 whereas Norway 0.5 bears/1000 km^2 (Swenson et al. 2000). Home ranges vary between 81-999 $km^2$for single females and 245 to 8264 km^2 for males (Dahle and Swenson 2003) in Scandinavia and between 107 to

349 km^2 in Greece (Mertzanis et al. 2004). The mean home range sizes for males and females respectively are 128 and 58 km^2in Croatia (Huber and Roth 1994), and 226 and 53 km^2in the Slovenia (Kaczensky et al. 2003). They get larger in Russia and reach 490 and 90 km^2, respectively, in far eastern parts (Seryodkin 2006). Home ranges become smaller in Japan (average female home range size 43.04 km^2) (Sato et al.2008). In USA, mean home range size is around 400 km^2but even female home ranges can reach 800 km^2size whereas male home ranges can be up to 3337 km^2large (Blanchard and knight 1991, LeFrancet al.1987). Such home ranges correspond to a density of 15-20 bears /1000 km^2 (Craighead and Mitchell 1982). Large scale comparisons among home ranges and seasonality were made by McLoughlin et al. (2000) and female home range sizes were found to be usually lower than males due to territorial behavior, food availability, promiscuous mating system and protecting from male predation on cubs (Dahle et al. 2006).

Home range size difference between male and female mammals were attempted to be explained variously: body weight hypothesis (Harestad and Bunnell 1979, Lindstedt et al. 1986), female territoriality and energy efficiency (Sandell 1989), male avoidance hypothesis (Wielgus and Bunnell 1994.) promiscuous mating system (Dahle et al. 2006), intraspecific competition and kin related spatial structure (Stoen et al. 2005, McLoughlin et al. 2000), population density and food conditions (Zedrosser et al. 2006), human disturbance (Martin et al. 2008). Besides there are comprehensive studies reviewing all hypothesis related to above (Fisher and Owens 2010, Dahle and Swenson 2003). Hence there is more than one explanation for range size difference in bears and a combined hypothesis can explain better (Dahle and Swenson 2003, Dahle et al. 2006, Fisher and Owens 2010).

1.3. Habitat Use

Bears within the home range use certain areas for feeding, resting and moving but not all (Horner and Powell 1990) such that habitat use can show the interior structure of home ranges and center of activities (Millspaugh and Marzluff 2001, Preatoni et al.2005). This structure inside the home range provides information about bear use and on which environmental factors are important and it in turn help conservation of bears in complex socio-environmental landscapes (Millspaugh and Marzluff 2001, Nielsen et al. 2002, Milakoviç et al. 2012, Fernández et al. 2010). For example, in Turkey agricultural areas are among main feeding sites of bears following the cutting down of wild fruit trees in the forests during 1970-80s and those agricultural attractants can behave like ecological traps for brown bears, as was shown in Alberta by Northrup et al. (2012).

1.3.1. Definition of Habitat

Habitat term is used commonly by researchers (review by Garshelis 2000, Johnson 2007) but habitat definitions are different according to different authors (Baker 1978, Chamberlin 1900, White and Garrot 1990, Hall et al. 1997, Krebs 2001) and such definitions integrate wild animal life and behavior into nature without any consensus (Johnson 2007, Özüt 2009). The most recent definition of habitat is simply the place where the animal lives and the collection of resources and conditions for its occupancy for which spatial extent is determined for a stated time period (Morrison et al. 2006). Habitat is a predictive concept for describing the physical area used by an animal whereas its power is limited except at the time and location of the particular study (Morrison 2001). Habitat use is considered variously by researchers e.g. 89 % of 50 reviewed articles used vegetation association as habitat or partially defined the habitat term (Hall et al. 1997). Besides, 82 % of the studies improperly used or did not define some terms such as habitat use, selection or preference (Hall et al. 1997).

Garshelis (2000) offered using vegetation as a main habitat type and this is also compatible with the common usage of habitat use. Garshelis (2000) stated that “habitat use is a critical facet that provides animal’s food and cover for population to survive and habitats that are available in the area may not be available for animals”. Habitat utilization can be figured out by using radio or GPS tracking equipment as a result of polygon approach around the animal positions associated with habitat type (Garshelis 2000). Habitats generally stay stable however animal usage of habitat can change so it reflects its niche (Morrison et al. 2006). Habitats cannot provide animals' population parameters such as fecundity and fitness since they depend on the critical resources and limiting factors of niche (Morrison 2001, Garshelis 2000).

1.3.2. Resource and Habitat Quality

Defining habitat is essential in term of brown bear conservation studies because they mainly depend upon protecting the core habitats, based on scientific data on bear habitat use (Nielsen 2005, Mertzanis et al. 2008). Morrison (2001) defined a resource as *any biotic or abiotic factor that is directly used by an organism.* Resources that are limiting to an organism could then be referred to as limiting resources *(*Morrison and Hall 2001*).*

While defining habitat as a resource, another term such as habitat quality should also be defined (Morrison et al. 2006). It is the capacity of environment to supply useful conditions for consistency of individuals and populations (McDonald et al. 2005). While measuring habitat quality, researchers generally measure the vegetation and resources surrounding animal whereas habitat is more than those and mostly related with critical resources like plant biomass, bedding sites, prey or safety (McLoughlin et al. 2000, McDonald et al. 2005, Johnson 2007). Besides, ecological restraints such as risk of predation, intensity of competition, and physical accessibility of resources may also be limiting factors (Morrison et al. 2006). Thus, habitat should be defined not only as the resources necessary for survival and reproduction but also the conditions that constrain its use (Johnson 2007; Morrison et al. 1998).

Most habitat studies related with animal distribution considered particular vegetation parameters as habitat quality but few of those studies measured vegetation metrics as a proxy for habitat quality (Scott et al. 2002, McDonald et al. 2005, Nielsen 2005). Habitat quality studies predict that animals should occupy more high quality habitats in terms of time spent on such habitats (Garshelis 2000). Therefore, habitat quality can be measured by means of timing, duration, and frequency of habitat occupancy (Johnson 2007). Unequal or proportional use of habitats with respect to their availabilities may reflect high-quality habitats and methodologies to measure it are well described in Manly et al. (2002), McDonald et al. (2005) and Morrison et al. (2006).

Another way of determining habitat quality as a representative of primary productivity (PP) is to calculate Normalized Difference Vegetation Index, NDVI (Turner et al. 2005). NDVI value of a study area can be calculated using spectral reflectance of red and infrared bands of LANDSAT or MODIS satellite images in resolutions ranging from 1km to 30 meters. Where NDVI values are high, PP is also supposed to be high, meaning more food resources are available. Several studies found that if no other additional food source such as migrating salmon is available, bear population density is positively correlated with primary productivity and NDVI values (Zedrosser et al. 2011, Ferguson and Mcloughlin 2001).

1.3.3. Habitat Selection and Use

Bear distribution on land is also related with site selection which does not only depend on resources but also on non-habitat factors (Morrison et al. 2006). While habitat factors affect, for example, forage ability to use resources, non-habitat factors can take a critical role in determining habitat effectiveness or “usability” after accounting for human influences (Hood and Parker 2001, Ciarniello et al. 2007). The main limitation in habitat selection studies is using only the plant cover as a factor for site selection, which is inadequate.

In USA, grizzly bears were reported often at landscapes of relatively high elevation, steep slope, rugged terrain, and low human access and linear distance to settlements (Nielson 2005, Schwartz et al. 2006). These landscapes generally include more avalanche chutes (forest openings), subalpine tundra, barren surfaces, and less young and logged forests (Nielson 2005). Results further support the contention that grizzly bear persistence is determined by three general factors: habitat quality, the number of humans within that habitat, and the behavior of those humans (Ciarniello et al. 2007, Mattson et al. 1996, McLellan 1998, Schwartz et al. 2006, Apps et al. 2004).

Resource selection studies can be conducted at various scales targeting a season, gender or age class, activity pattern of animals studied, etc. If an animal selects from the available units such that the probability of selecting a unit with $X = x$ is proportional to the resource selection function, this will produce the distribution of X that is shown for the used units (Figure 1.1. from McDonald et al. 2005). The general trend is to relate the locations and the frequency of use to resources that may be specifically significant for the studied animal (Manly et al 2002). These points represent ‘‘use’’ locations as would be derived from GPS telemetry and are assumed to have no associated location error. Additional points are randomly distributed across the landscape, with no bias, and these points represent the ‘‘availability’’ points required to calculate a resource selection function (RSF) (Neu 1974, Manly et al. 2002, Visscher 2006).

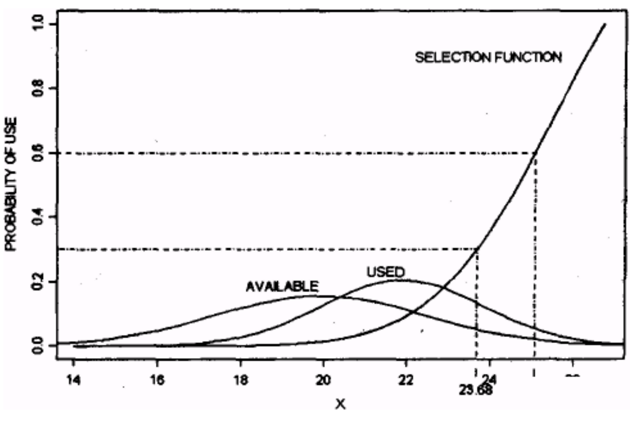

Figure 1.1: A resource selection function for the relative probability of use of resource units with a single variable X (Adapted from Manly et al. 2002 and Johnson 2007).

1.4. Monitoring of Brown Bears and Population Estimations

Monitoring wild animals with field based methods for estimation of population status and size by direct observations, tracking animals with collars or other noninvasive methods provide valuable information for conservation (Boitani and Fuller 2000, Sanderson and Trolle 2005, Mills 2007, Nielsen 2005). Determining activity patterns and movements of bears also provide possible risk assessments for human-bear conflict management (Chamberlain et al. 2012, Kaczensky et al. 2011).

Noninvasive research methods are varied, with most popular ones being camera trapping, track, hair and scat (genetic) sampling, and distance sampling (Swann et al. 2011, Buckland et al. 2001, Garshelis 2006, Boitani and Fuller 2000). There are different ideas on the invasiveness of the “noninvasive studies” such as radio telemetry and camera or hair trapping and the term “remote monitoring” was suggested instead (Garshelis 2006). There are many examples of noninvasive techniques for brown bears but the most recent one for bears is rubbing tree surveys which have been used to monitor bear populations by microsatellite analysis (Kendall et al. 2008, Karamanlidis et al. 2010) and determining brown bear diets from feces by using next generation DNA sequencing (Kendall et al. 2008, Karamanlidis et al. 2010). Noninvasive sampling by use of hair or feces provided a powerful new tool for monitoring bear populations all around the world (Waits et al. 2005, Swenson et al. 2011).

Animal sightings are another noninvasive source of information but bears are often difficult to see; nonetheless, visual observations and counts have been used to document changes in distribution, assess habitat use, monitor population trends, and estimate population size (Keating et al. 2002, Schwartz et al. 2008, Evans et al. 2003, Naves et al. 2003, Solberg et al. 2006).

Camera traps have been used approximately for one century, even if its importance was realized just two decades ago for searching cryptic and nocturnal wildlife species (Swann et al. 2011). It is fast becoming a main wildlife research tool and its contribution to science ranges from finding new species to determining population densities and obtaining detailed information for various aspects of wildlife ecology and conservation (Rowcliffe and Carbone 2008, Kitamura et al. 2008, Karanth et al. 2006).

A major limitation in wildlife conservation and management is uncertain population size (Seber 1982, Krausman 2002, Miller et al.1997) but this limitation is more significant for nocturnal and especially forest dwelling species such as black and brown bears (Miller et al.1997). In order to overcome this problem, mark-resight methods with camera traps have been used at least for two decades for black and brown bear population estimations with various estimators (Mace et al. 1994, 1987 and 2008, Matthews et al. 2008).

Finally, population estimation based on counting females with cubs of the year (FCOY or Fcubs) and yearlings of brown bears in consecutive years can provide good estimation of minimum number of females, population size or trends (Keating et al. 2002, Schwartz et al. 2008, Palomero et al. 2007).

1.5. Previous Research in the Study Area

Brown bear studies have been conducted for almost fifty years around the world, with the pioneering studies carried out by US scientists (Craighead 1982, Servheen, 1999). In Europe, too, the species has been studied for more than 30 years (Swenson et al. 2011, Servheen et al. 1999). The first carnivore telemetry study in Turkey was initiated in 2005 by radio collaring of one brown bear in Yusufeli, Artvin (Ambarlı 2006). This radio-collared bear had been monitored in the field by VHF equipment until 2010 when the battery died off. In addition, bear activity was obtained from camera trapping and visual observations for 4 years (2008-2011).

The home range of the collared bear was found to be smaller than was found in many studies in Europe or America (unpublished data). However, tracking one bear with limited funds via VHF cannot provide reliable results, perhaps only implying that bear density and home range size in Artvin is different than in other countries; increasing the sample size and changing the methodology was possible during this study.

Previous experience with radio-telemetry in Artvin suggest that utilizing GPS-GSM collars with UHF download might be the best choice because monitoring with antenna is difficult in extremely rugged terrain. Compared to VHF collars, GPS-GSM collars have adjustable battery life, lower field costs, and incomparable data acquisition rates under every condition and weather as far as the collars can see the sky (Boitani et al. 2004, Boitani and Fuller 2000).

1.6. Scope of this study

This study aims to find out the spatio-temporal ecology of brown bears, their habitat use and a reliable population estimate. My research have two main objectives and tries to reveal out unknowns related with brown bears by applying different field methods to useful information for better conservation of brown bears in Turkey: First, to determine the spatio-temporal ecology and habitat use of brown bears in the Kaçkar mountains, and second, to estimate brown bear population size in Özgüven Valley and Yusufeli.

Methods used include monitoring via camera trapping, visual direct observations, and counting cubs of the year. GPS-GSM telemetry on several captured bears was the main field technique in this study. Bears activity pattern was studied by both camera traps and GPS telemetry. The study is confined to brown bear populations in Yusufeli, Artvin, Turkey.

CHAPTER II

MATERIALS AND METHODS

First part of this chapter explains the study area and other associated information about bear habitats. The second part defines the methods of data collection and analyses for home range estimation, movement analysis, activity pattern, and habitat selection and population estimation.

2.1. Study area

This study covers the southern part of Kaçkar Mountains in Yusufeli district of Artvin province, in the northeast of Black Sea region of Turkey (Figure 2.1). The study area is located in the northwestern part of Yusufeli (situated roughly between 40° 33’ to 41° 06’ N, 41° 08’ and 41° 54’ E). It covers approximately 447.85 km^2. Within this area, a core study area surrounding Özgüven and Bıçakçılar valleys was defined as the focal point for detailed field work (61 km^2) (Fig. 2.2). Capturing and monitoring of bears, camera trapping and field surveys, and about half of direct observations, were conducted at this scale.

The study area encompasses the southern slopes of the Kaçkar Mountains located at the easternmost part of the North Anatolian Mountains. It forms the south-western part of the Lesser Caucasus. Many branches of the mountain run in an east-west direction and encircle the Barhal watershed within a relatively small area, making a quite rugged topography with steep slopes from 550 m to 3900 m at various aspects. Three stream branches run through Yaylalar, Altıparmak, Özgüven and Yüksekoba villages, feeding Barhal river and flowing into Çoruh river. The highest summit is the Kaçkar peak, 3937 m above sea level.

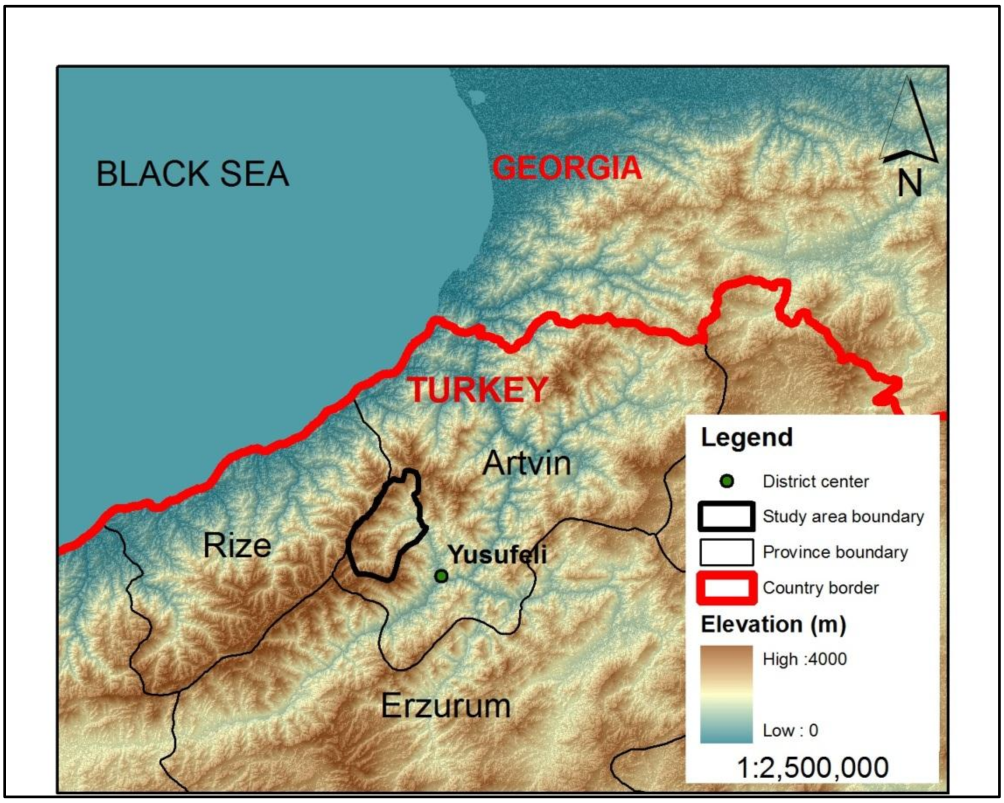

Figure 2.1 Location of study area in Turkey

The study area encompasses the southern slopes of the Kaçkar Mountains located at the easternmost part of the North Anatolian Mountains. It forms the south-western part of the Lesser Caucasus. Many branches of the mountain run in an east-west direction and encircle the Barhal watershed within a relatively small area, making a quite rugged topography with steep slopes from 550 m to 3900 m at various aspects. Three stream branches run through Yaylalar, Altıparmak, Özgüven and Yüksekoba villages, feeding Barhal river and flowing into Çoruh river. The highest summit is the Kaçkar peak, 3937 m above sea level.

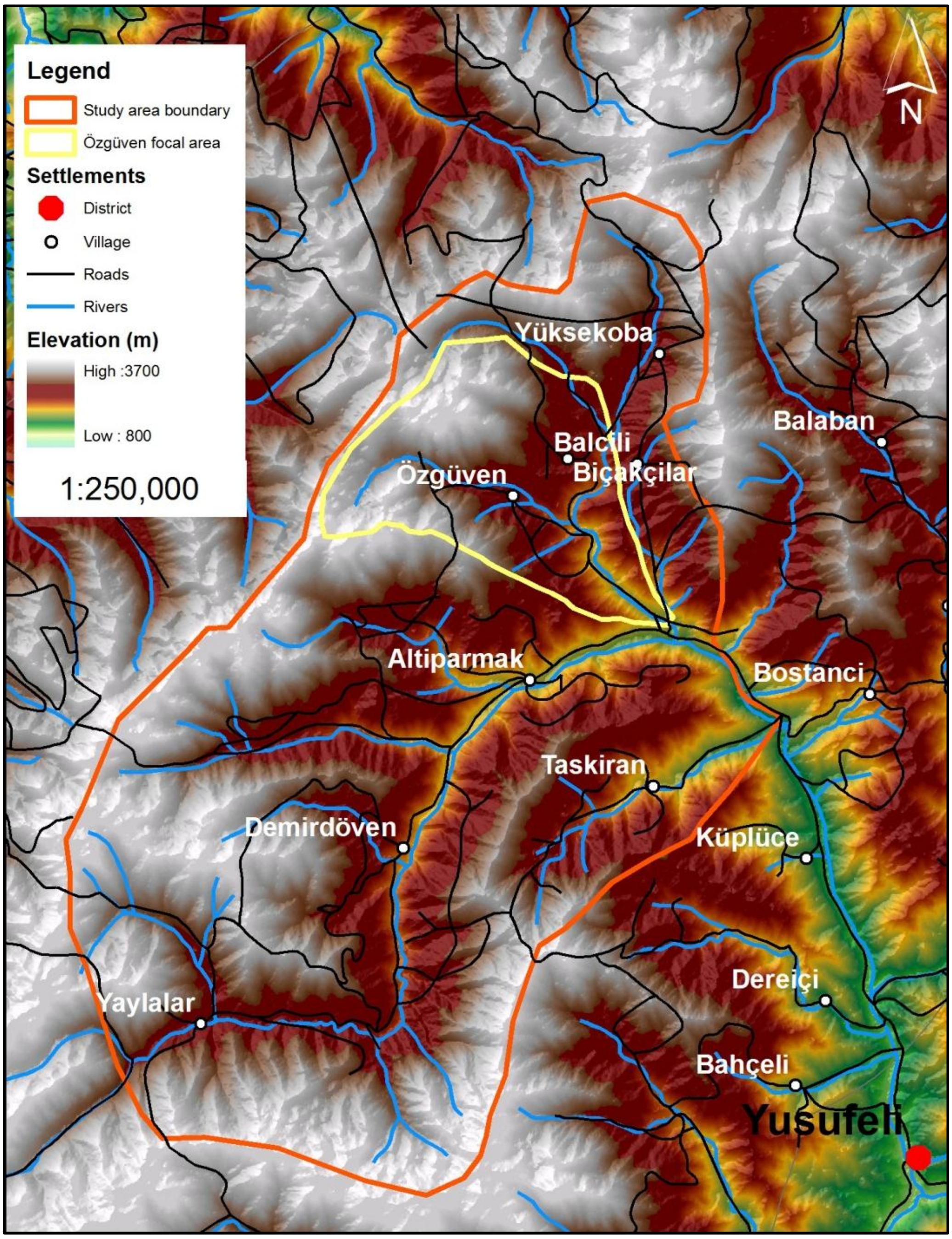

Figure 2.2 Study area in detail and focal study area in Özgüven Valley

The Kaçkar Mountain Range stands as a geographical and ecological barrier between Black Sea and Eastern Anatolia regions on northern and western parts of the study area because its mean elevation on the ridge is higher than 3000 meters, with even most passages being above 3200 meters above sea level. On the east main, the geographical barrier is the River Çoruh which starts at Mount Soğanlı in Erzurum, passes through Yusufeli and reaches Black Sea at Batumi in Georgia.

2.1.1. Climate

The study area is under the effect of a transition climate between subhumid Black Sea climate and Eastern Anatolia continental climate, depending on the elevation, aspect and proximity to Mount Kaçkar or River Çoruh. The Kaçkar Range functions as a rain shadow by preventing humid air from Black Sea at the north reaching the southern aspects, including the study area. On the east, the main barrier is River Çoruh. Those barriers enable a sub-Mediterranean microclimate to be experienced at the bottom of the Çoruh valley system.

To describe the climate of the study area data from nearest climate stations parameters of İspir, Tortum, Artvin and Yusufeli (see Fig. 2.3), were used by FAO NevLoc_Clim (2005) estimator. The annual mean temperature is between 9.18 and 10.4°C for Özgüven valley of Yusufeli (FAO NevLoc_Clim 2005). Relative humidity of the area ranges between 50-75 % depending on the season and increases towards northeast along the River Çoruh valley. The annual mean precipitation is about 300 mm at the Yusufeli district center (Özdemir and Çoşkun 2010) and 440 mm at the İspir district center, quite low for the region. On the other hand at upper elevations in Özgüven and Altıparmak Valleys have a higher mean precipitation between 477-657 mm annually (FAO NevLoc_Clim 2005).

Maximum precipitation falls during late spring and autumn. Minimum precipitation is observed in July and August (FAO NevLoc_Clim 2005, Özdemir and Çoşkun

2010). Winters are severely cold and snow depth reaches 2 meters at villages near high mountains, such as Özgüven, Yüksekoba, Yaylalar and Altıparmak. The high amount of snow when combined with sunshine in Spring produces avalanches in the valleys with high slopes and fast flowing rivers. Above 1200 meters, snow cover usually starts in early November and continues to late March.

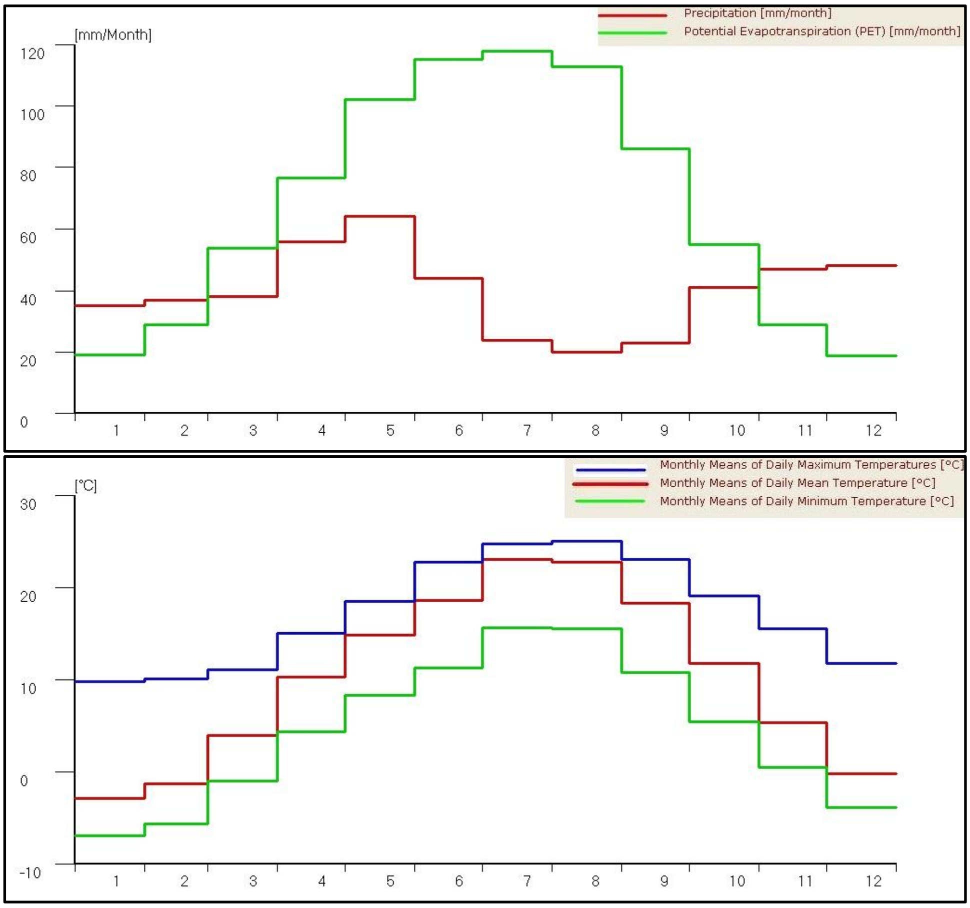

Figure 2.3: Average monthly precipitation and mean temperatures (FAO New Loc_Clim 2005)

2.1.2. Vegetation

Study area has a diverse vegetation due to deep valley system creating a wide range of altitudes (750-3937 m) as well as varied topographic and climatic conditions (Figure 2.4). Most of the study area falls into the Euro-Siberian phytogeographical region whereas Çoruh river valley represents Mediterranean enclave vegetation; some elements of Irano-Turanian origin occur in some parts of Yusufeli.

At the lowest slopes of the River Çoruh valley system, the sub-Mediterranean microclimate enables a Mediterranean enclave vegetation to exist (Eminağaoğlu et al. 2006). Mediterranean-type vegetation is represented by mixed shrublands on quite steep and rocky slopes of 700-1200 m elevation on the main river valley. The commonest shrubs are laurel (*Laurus nobilis*), turpentine tree (*Pistacia terebinthus*), Sicilian sumac (*Rhus coriaria*), Jerusalem thorn (*Paliurus spina-christi*), black locust (*Robinia pseudoacacia*) (planted), accompanied by hop hornbeam (*Ostrya carpinifolia*), European hornbeam (*Carpinus betulus*), European barberry (*Berberis vulgaris*) and *Cistus creticus* (Eminağaoğlu et al. 2006). Between 1200-1800 m, shrublands dominated by deciduous oaks (*Quercus petraea* subsp. *iberica*), junipers (*Juniperus oxycedrus* and *J. excelsa*,) and oriental hornbeam (*Carpinus orientalis*) are seen on the slopes (Hamzaoğlu and Aksoy 2008). Other common shrubs are hop hornbeam and aspen (*Populus tremula*) together with scattered Scots pine (*Pinus sylvestris*), fir and spruce trees.

Needle leaved, broad-leaved or mixed forests dominated by oriental spruce (*Picea orientalis*), Scots pine and Caucasian fir (*Abies nordmanniana* subsp. *nordmanniana*) are seen at a wide range of elevations i.e. 1100-2300 m (Forestry Management Plan 2011). Scots pine is seen on south and east aspects, fir on humid north and west slopes whereas spruce on a wide range of elevations and aspects. Those are accompanied by oriental beech (*Fagus orientalis*), various oaks, *aspen*, birch (*Betula* sp.), walnut (*Juglans regia*), Wych elm (*Ulmus glabra*), and wild service tree (*Sorbus torminalis*) (Eminağaoğlu and Anşin 2003).

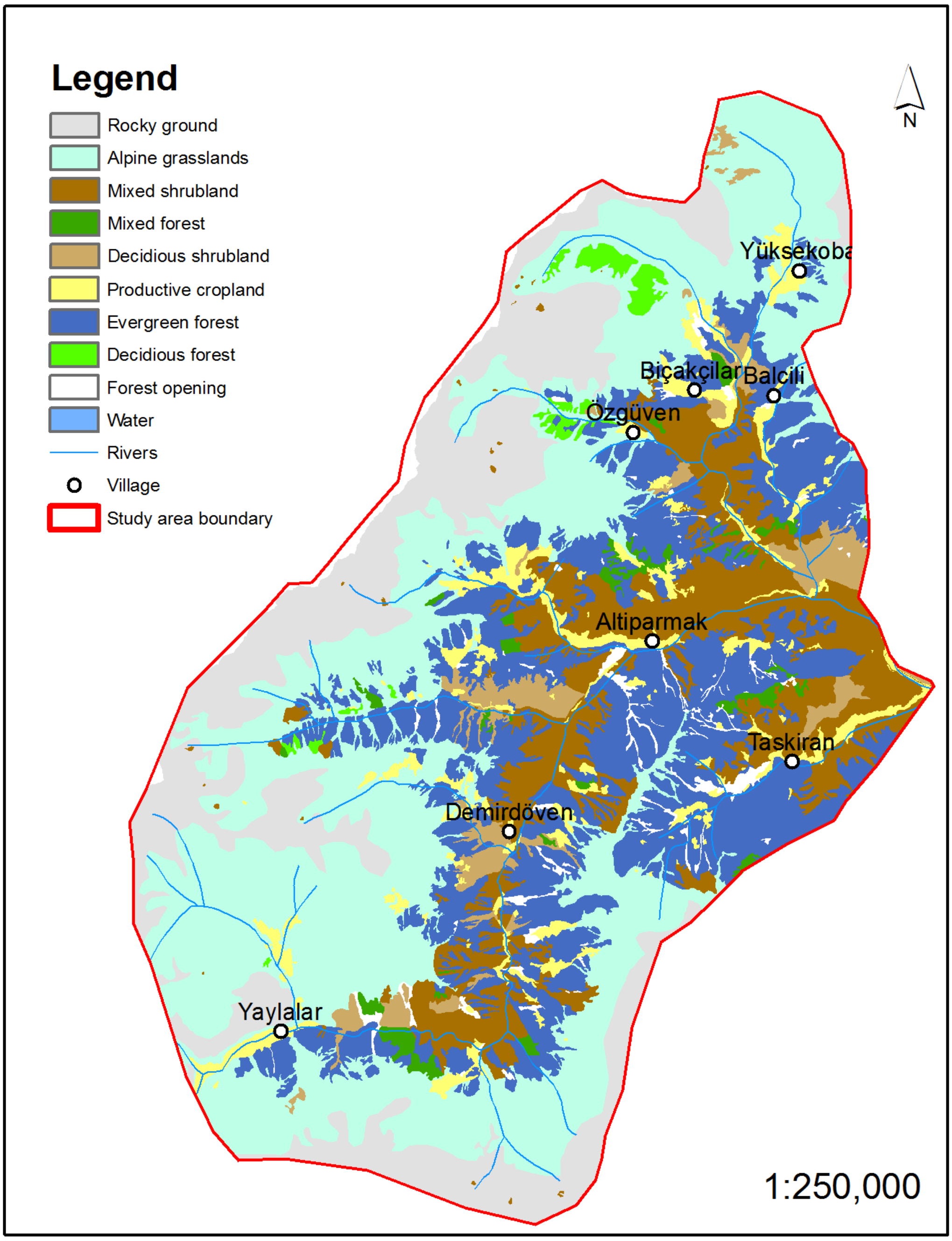

Figure 2.4 Vegetation map of the study area

In forest openings or at transitions to alpine grasslands, shrubs and herbs like *Rosa canina*, *Rhododendron luteum*, *R. ponticum*, *Rubus* sp., *Senecio pandurifolius*, *Sambucus ebulus*, *Petasites hybridus*, *Dryopteris filix-mas*, *Geranium ibericum*, *Campanula rapunculoides* and *Silene vulgaris* are common (Hamzaoğlu and Aksoy 2008).

Starting from forest upper limit (2100-2400 m depending on the aspect) to the rocky summits of the mountains, alpine grasslands adapted to a humid climate cover the mildly sloped land. The dominant species are *Festuca woronowii*, *Poa alpina*, *Trifolium repens*, *T. rytidosemium*, *Alchemilla erythropoda*, *Vaccinium uliginosum, Astragalus frickii, Potantilla humifusa*, *Psoralea acaulis*, *Gentiana nivalis*, *Veronica gentianoides, Thymus praecox, Polygala major, Ajuga orientalis, Helleborus orientalis, Aquilegia olympica, Anemone narcissiflora, Campanula tridentata, Campanula stevenii, Aster alpinus, Festuca pratensis,* and *Rubus idaeus* (Hamzaoğlu and Aksoy 2008). Accompanying shrubs are *Rhododendron* sp., *Vaccinium* sp., *Juniperus communis* var. *nana*, aspen, *Salix sp.* and *Daphne glomerata* (Eminağaoğlu and Anşin 2003).

Hygrophilous vegetation is seen along the rivers and gallery forests composed of alders (*Alnus* sp.), willows (*Salix* sp.), planted poplars and orchards. Next to the riverine vegetation, orchards, small fields and cut meadows are seen, if topography is mild. The commonest fruit trees are apple, pear, walnut, mulberry, and cherry. Beans, potato and cabbage are grown commonly in small fields. The cut meadows are dominated by *Dactylis glomerata*, *Trifolium pratense*, *Vicia* sp., *Silene vulgaris*, *Ranunculus* sp., *Plantago lanceolata*, and *Achillea millefolium* (Ambarlı and Ambarlı, unpublished data).

2.1.3. Social and Agricultural Structure

Number of people living in villages of Yusufeli is 15407 according to the 2008 census (TUİK 2011). On average, human density is about 3-4 people/ km² which is quite low and the settlements are distributed sparsely over the land. The population density is lowest during winter and temporarily increases during summer (up to 9-10 people/ km^2, TUİK 2011). However, in the last two decades people started to permanently leave for bigger towns in the west to find better jobs and earn more money (Ambarlı and Bilgin 2008).

Main income activities are agricultural farming, animal husbandry, bee keeping, and ecotourism at higher elevations; transportation, fish farming and greenhouse farming occur at lower elevations. Adult and young men generally work outside of their hometown as construction workers while women largely carry out agricultural practices on their own, except for cutting down grasses which is practiced jointly (Özdemir and Çoşkun 2010). Mostly people produce their own agricultural products at small plots for their own use, not for marketing (Kurt and Kantar 2010). Therefore it becomes more important for local people not to lose their winter provisions due to bears or wild boars. People produce mainly beans, potatoes, maize, cabbage, as well as apples, pears, walnuts, mulberries, cherries and grapes. Barley and clover can also be cultivated for their livestock in some villages. Animal husbandry is practiced at the family level and 1-5 cows are kept per family. Sheep and goats are in the minority and usually kept at lower elevations. Animals are usually accompanied either by a shepherd alone or with dogs. Families spend the winters at lower elevations, moving to alpine pastures in May for cutting hay and grazing animals in pastures.

Locals inhabit from 550 to 2500 meters, temporarily at the higher alpine pastures (Ambarlı 2006). The distribution of agricultural plots is scattered due to very limited suitable arable land in the rugged mountains (Kurt and Kantar 2010). About three quarters of potential brown bear habitat overlaps with human settlements at between 900 and 2500 meters (Ambarlı 2006). In addition, abandoned fields have become once again suitable habitats of wildlife, especially for the brown bear (Ambarlı 2006). As a result bears mostly feed on agricultural land and orchards in human dominated environments of Yusufeli.

2.2. Data Collection and Analyses

2.2.1. Summary of Field Studies

Studying bears or any wild carnivore requires both close and remote monitoring of species, behavior and its daily activity. The most modern methods for tracking animals are by GPS-GSM or Argos telemetry collars (Hebblewhite and Haydon 2010), remote cameras (Swann et al. 2011) and non-invasive genetic studies (Waits et al. 2005, Kendall et al. 2008); however, their efficiency and cost vary according to aims of the study.

In this study, data were collected by the use of GPS-GSM and VHF telemetry collars, camera traps, direct observations, interviews, and by counting females with cubs of the years. Field studies have been conducted from 2008 to 2011 at different time periods covering 8 villages in Yusufeli. In the early season female brown bears are generally accompanied by the cubs of the year (Fcub) or yearlings so that observing and differentiating them are easier than in autumn surveys. A summary of the fieldwork and study design are given in Table 2.1 and Figure 2.5 details of the each method are provided in the following pages.

Table 2.1: Timing, total length and aims of fieldwork

Dates	Activities
8 May- 15 Nov 2008 (45 days)	Preparation of the field equipment, bears observations and counting females and cubs of the year (Fcubs)
10 May - 26 Nov 2009 (65 days)	Observation of brown bears and signs, counting Fcubs, setting of camera traps, brown bear catching session: Setting up of snare and culvert traps, preparation of GPS-GSM collars
1 May- 22 Dec 2010 (90 days)	Observation of brown bears and signs, counting Fcubs, setting of camera traps; brown bear catching sessions: setting up of snare and culvert traps and capturing bears,
19 May-11Oct 2011 (60 days)	Observation of brown bears and sings, counting Fcubs, setting of camera traps; brown bear catching sessions: setting up of snare and culvert traps and capturing bears

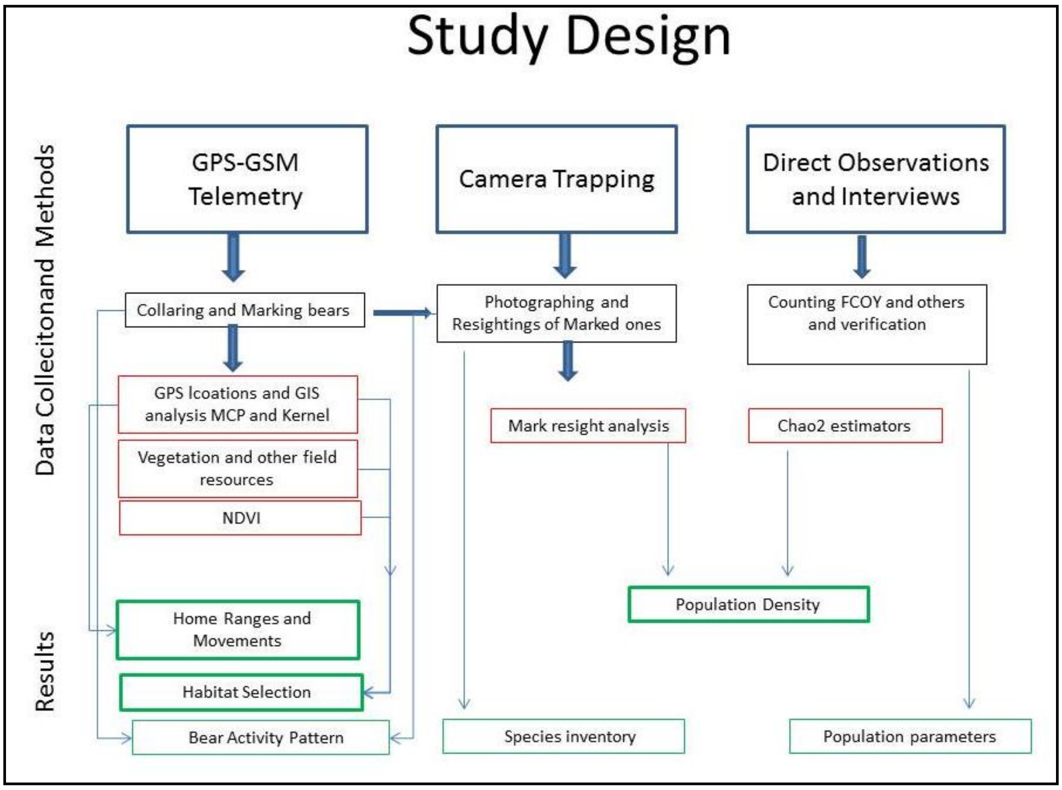

Figure 2.5 Study design

2.2.2. Telemetry Studies

Telemetry is based on capturing the animal, putting a collar with a transmitter, releasing it safely and then collecting position data from the animal. It has three main types: VHF, GPS-GSM, and GPS-Argos. The last one is not preferred in Turkey due to low coverage. VHF is based on radio signals and it needs the researcher to be in the field with the receiver to collect data whereas once GPS-GSM collar is put on, it sends signals through GSM network.

Telemetry has been used to determine presence/absence of animals at particular places, to study movement patterns, habitat use, survival, behavior of animals, and in mark-recapture or resight studies for population estimation (Boitani and Fuller

2000, Samuel and Fuller 1994, White and Garrott 1990). Wildlife telemetry was first used in Turkey by Oğurlu (1994). The technique was first used on brown bears by Ambarlı (2006) followed by studies on mouflon (Özüt 2009), goitered gazelles (Durmuş 2010), and a few other species.

Well-designed GPS-GSM or satellite telemetry studies can be considered inexpensive compared to VHF telemetry, which requires to be in the field more often and results in extra field costs (White and Garrot 1990, Millspaugh and Marzluff 2001). In this study both VHF telemetry and GPS-GSM telemetry were used as will be explained below. Four GPS-GSM collars were used for 7 captured bears. Another bear, Karabey which was captured during a previous study (Ambarlı 2006) was also monitored via VHF telemetry.

2.2.2.1. VHF Telemetry

VHF telemetry is used only for one bear, Karabey and data collected via triangulation and Locate III was used for estimating animal locations (relocation). In VHF, receiving antennas are connected to a receiver via cable and signal pulses can be listened directly or with earphones. Receivers generally include a gain control button to fix sensitivity of receivers to radio waves. A Yagi antenna is the most commonly used wildlife receiving antenna, supplying direction and preferable gain during locating the animal via triangulation (Samuel and Fuller 1994, White and Garrott 1990).

2.2.2.2. GPS-GSM Telemetry and Position Data

GPS collars have a high capacity for acquisition of a fix (i.e. position with coordinates) every minute or down to one position every day or month (Boitani and Fuller 2000) but normally the ideal fix interval time is around 1 to 4 hours; more frequent fixes may cause easy battery exhaustion (Yamakazi et al. 2008). The supposed main disadvantage of GPS telemetry is auto correlation.

GPS collars compared to VHF collars are more susceptible to auto correlation (AC) due to their systematic data collection mechanism from every one hour to every minute (White and Garrott 1990, Millspaugh and Marzluff 2001). AC is an undesired situation in statistical analyses and has to be dealt with during analysis. However, old statistical methods for AC calculations in home range tools (Rodger et al. 2007) downgrade the GPS data to an almost equal level with VHF data so it becomes meaningless to study with GPS collars. Therefore, Arthur and Schwartz (1999) offered that animal relocations can be treated as a census if fixes were taken at short intervals and movements were considered as insignificant. AC data might be more useful to understand animal behavior because correlation generally occurs in any data set in terms of time and space (Cagnacci et al. 2010).

Another important aspect of GPS data is the reliability of taken fixes. Similar to VHF telemetry, GPS fixes have also location error but it is very small compared to VHF. This can be due to many unknowns e.g. vegetation coverage, weather or animal position but it is represented as horizontal or positional dilution of precision (HDOP or PDOP) in the data sets (D'eon and Delparte 2005, Dussault et al. 2010). This precision increases with the number of connected satellites and it is preferable to be connected to four or more satellites but usually at least 3 to 5 meters of error from the real position of the collared animal exists (D'eon and Delparte 2005, Dussault et al. 2010). In this study it is assumed that a HDOP value larger than or equal to 10 is not precise and so was excluded from analysis (D'eon and Delparte 2005, Dussault et al. 2010). Normally HDOP preferably less than 5 is very precise (Dussault et al. 2010) and the mean HDOP values for tracked bears in this study are all close to 3 so they are within the reliable range.

In this study bears were fitted with GPS-GSM collars with drop-off mechanism (Televilt GPS Simplex collars; Televilt International, Lindesburg, Sweden). The lifespan of the collar was calculated by using Televilt battery calculator (2010) and drop-off mechanism was set to the worse conditions. However a new battery calculator in 2012 was released by Televilt regarding the effects of GSM coverage and vegetation, which considerably reduced former predictions of battery life.

2.2.2.3. Capturing and Immobilizing Brown Bears

In telemetry studies, monitoring and retrieving position data is almost noninvasive except when fitting radio collars, which requires capturing and anesthetizing the animal (Garshelis 2006, Caulkett et al. 2008). In wildlife research, the most important issue is not the cost of the equipment but being able to capture animals safely and release them back to nature in healthy condition in a remote area with limited personnel (Jonkel 1993, West et al. 2006).

Figure 2.6: Photos of GPS-GSM collar, box trap, foot snares

Two common capture methods for brown bears are Aldrich foot snares and modified culvert (or box) traps (see Figure 2.6) (Jonkel 1993). Ten Aldrich foot snares and one box trap were used for capturing bears. A four-wheeler truck was used to move the box trap and place it close to a forest patch. Foot snares also should ideally be set close to roads due to ease of access and safety considerations but in the field this is usually difficult to achieve, particularly on the steep slopes of Yusufeli. Snares were set on bear trails between forest patches, orchard trees and entrances to established feeding sites like villages, based on camera trap results. Baits were rarely used, and then only for masking the traps' odor.

Bears in Artvin are extremely cautious at around traps and on any changes on their normal paths so extra attention was spent during capture sessions not to leave human smell around trap sites. Hand gloves were used and the equipment was boiled prior to use. Twigs, dried leaves and sandy soil were used for camouflaging the trap site. The sites were checked every morning and night. Precautions were taken while approaching the captured bear (Jonkel 1993, Caulkett and Shurry 2007). One person was responsible for safety with firearm backup; one person (either a veterinarian or the investigator) held the bear deterrent spray and one person carried anesthetizing syringes to sedate the bear. Bears became very aggressive and began to roar when a person approached with an anesthetic dart. Carrying a rifle-shaped blowgun projector makes it worse because most bears in the study area had probably experienced a similar situation after being trapped or coming across with locals carrying a gun.

Captured bears were immobilized with a mixture of Zoletil 50 and Domitor (1 mg/ml) (or Sedazoo: 10 mg/ml) using a combination of Dis-inject blowgun projectors, blow dart, pole syringe and normal handmade jab stick. Plastic two-chambered compressed gas darts were used in the projectors (West et al. 2007). Zoletil is a safely used mixture of Tiletamine HCl and Zolazepam HCl, requiring a dose of 3-4 mg/kg for bears when combined with 0.025-0.04 mg/kg Domitor

(Medetomidine) (Caulkett 2007, West 2007). All vital rates were monitored and recorded during anesthesia. Bears were weighed with a large scale and all body measurements were taken. Antisedan was used as an antagonist in an equal volume with the Medetomidine (Caulkett 2007, West 2007).

Figure 2.7: Released collared bears, Bayram and Kesikkulak in 2010

Brown bears are smaller than grizzlies and have slightly different metabolism, therefore dosage changes were necessary in various studies in Europe (Kaczensky 2002, Caulkett et al. 2003, Cattet et al. 2008). Normally 250 mg Zoletil 50 were mixed with 1.5 ml Domitor and it was taken into a syringe and added to the dart. 2ml Domitor was also added and mixed (West et al. 2007). According to the size of the animal, extra 3-6 ml Domitor may be needed but for a small animal i.e. one less than 100 kg, an additional 3 ml is enough for at least one hour sleep (Armin Rigler, pers. comm.). After fitting the collars, all caught bears were securely released back to the nature (see Figure 2.7).

During 2009-2011, seven bears (5 males, 2 females) were captured and monitored with Televilt GPS-GSM collars for 3 days to 20 months. Bears were named as Kesik Kulak (M), Bayram (M), Dido (F), Hazal (F), Tosun (M), Bozo (M), Toraman (M).

2.2.2.4. Bear Phenology and GPS Data Acquisition

Bear relocations were obtained via GSM or after some collars were removed by bears (see Table 2.2). Besides, where GSM coverage is not good, an UHF receiver was used in the field to transfer position data from collars. Systematic sampling was used according to the schedule in "bear seasons" (12, 30 and 1 fixes per day) (Otis et al. 1999, Kenward 2001, White and Garrott 1990, Boyce et al. 2010).

Bear annual phenology is used as an indicator of its metabolic activity and seasons. The phenology was determined based on the denning, arousing, mating time, eagerness to feed more, and lowering metabolism:

- Hypophagia: Emerging from dens till May 14
- Prehyperphagia: May 15-August 15
- Hyperphagia: 16 August- 30 October
- Late hyperphagia: 1 November till denning

When a seasonal shift occurs in a year, these dates may also shift but they are considered valid for 2011. Bear relocations during these seasons were systematically collected. 12-30 positions fixes/day were obtained according to the schedule of the collars. During winter sleep between December and March, only one position per day was taken. It is supposed that summer is the season when bears are most active because it includes mating therefore fixes were increased to 30 during that time to better understand bear movements. GPS fix interval was set up as follows:

- Between1 March-15 May and 1 July-1 December: Every 2 hours (12 fixes/day)

- During the mating season: Every 1 hour + six half hours (30 fixes/day)
- During hibernation season (1 December-1 March): Once every day

Table 2.2 Sample data received via GSM network

Date	Time	TTF	Lat	Long	SAT´s	2D/3D	H-DOP	Temp	X	Y
27.04.12	18:00	43	40.9310283	41.3785917	5	3D	5.3	13	6	4
27.04.12	20:00	80	40.9293883	41.3798933	3	2D	8.0	14	28	22
27.04.12	22:00	49	40.9293633	41.3791067	4	3D	1.6	13	11	9
28.04.12	00:00	43	40.9267833	41.3684033	6	3D	2.9	15	4	10
28.04.12	02:00	30	40.9309400	41.3748050	5	3D	5.9	13	5	5
28.04.12	04:00		GPS Time Out		0	x	X	13	19	22

2.2.3. Estimating Bear Home Range Size

Home range (HR) is described as the area traversed by an individual during its "normal activities" (Burt 1943). Home range size (HRS) of an animal is usually estimated by applying a minimum convex polygon or through kernel density estimation methods on point data by the use of various HR estimators in a GIS environment or with statistical software (Burt 1943, White and Garrott 1990, Worton 1989, Laver and Kelly 2008, Kernohan et al. 2001).

Minimum convex polygon (MCP) connects outermost relocations of animals with lines and delineates the home range. It is a common method and good for comparison (White and Garrott 1990). Kernel utilization distribution (KUD) is instead a density estimator (Worton 1989, Kernohan et al. 2001, Kie et al 2010) that explains the most intensively used sites in the home range and give a probability surface with isophlets that is the area where the collared animal can be found with a high probability. MCP does not reflect animal utilization distributions (UD) (Kernohan et al. 2001). UD and home range are often used similarly but only UD reflects space use intensity in a third dimension (Smouse et al. 2010).

KUD uses least-squares cross-validation (LSCV) and Href for smoothing by adding a buffer around animal relocation according to utilization, and is responsive to sample size [e.g. animal locations numbering in the thousands often give rise to under-smoothing by LSCV and a UD consisting of small perimeters around individual data points (Kie et al. 2010, White and Garrott 1990)]. This method has two options, namely fixed kernel and adaptive kernel. Fixed kernel with LSCV technique is preferred at sample sizes between 50 and 150 (Kie et al. 2010, Seaman et al. 1999, Gitzen et al. 2006) but it can be used for larger sample size with Href. A small bandwidth reflects a reduced amount of smoothing and the output involves many unconnected hills and valleys whereas a large bandwidth increases the smoothing of data and details disappear and the output UD becomes a single over-smoothed surface (Kernohan et al., 2001). Therefore it is reported that kernel models can overestimate home range size due to small sample size and by adding isophlets to boundary relocations (Seaman and Powell 1996).

Alternatively, a new method developed to utilize GPS data better and to figure out movement corridors is called Brownian bridges (Horne et al. 2007). Even though Kie et al. (2010) imply that Kernel utilization distribution, (KUD) can reflect corridors, it is mostly calculated by Brownian bridges (Horne et al. 2007). Rather than knowing animal fixed position, Brownian bridges provide an estimate of a specific location between fixes and is a continuous stochastic process (Kie et al. 2010). However, it was not used in this study because there is limited number of studies using Brownian bridges and results are not a comparable with previous bear home range studies.

Home range sizes were calculated by using two different estimators i.e. 95% Minimum Convex Polygon (Mohr 1947, Harris et al. 1990) and Fixed Kernel (Worton 1989). Home ranges (HR) were separately calculated for all valid GPS positions (min 552 to max 3676), for 250 random GPS positions, and for positions at 30 hour intervals. Positions with HDOP values less than 10 and 5 were used for 3D and 2D fixes, respectively. Movement analyses were conducted in ARCGIS 9.3 and BIOTAS (2005).

The last one has the lowest sampling size from 29 to 40. The Schoener index was used to calculate autocorrelation and exclude correlated samples (Schoener, 1981; Swihart and Slade, 1985). It is difficult recovering from AC in GPS data. Even temporal correlation is disregarded, spatial correlation still exists (Otis and White 1999). Therefore some researchers stated that AC structure shows the peculiarity of the data and should be evaluated in that respect (Cagnacci et al. 2010, Martin et al. 2008).

Home range estimates were conducted by using HAWTH tool analysis (Beyer 2004) and Animal Movement Analysis (Hooge and Eichenlaub 1997) for ArcView 9.3 GIS (ESRI, California, USA). There is no widely accepted method to determine the minimum number of locations necessary for an accurate estimate, but Odum and Kuenzler (1955) suggested that sample size should be sufficient so that estimated area increases by <1% for each additional relocation. An analysis was carried out in BIOTAS to assess the required sample size for HRS unbiased estimates (Harris et al. 1990). Home ranges were calculated annually for 2011 and according to bear phenology when GPS points are available.

2.2.4. Daily Activity Pattern

GPS-GSM Collars provide GPS positions with information on fix quality, date and time, temperature, and activity of bears on x and y axes (Table 2.2). X and Y can change between zero and 90 because maximum collar fix time is 90 seconds and activity logger records the position in two dimensions at every second while trying to connect to satellites. Low X means bear is not moving; even if Y is high that reflects stationary feeding of the animal. If X is high with respect to Y it means that the bear is moving and shaking its head from side to side. GPS-GSM collars can also give a VHF signal with one beep either in 40 or 80 seconds indicating the bear as active or inactive, respectively (Televilt-Followit 2012).

Activity data were categorized and sorted from smallest to largest for differentiating activity levels. Both x and y activity data equal to or smaller than 2 were assumed to reflect inactivity and data larger than 2 were assumed to reflect activity. Besides, bears were assumed inactive when one value of X or Y is below 10 while the other value is less than 2. These data were explored and pooled into 4 hour intervals to reveal individual bear activity patterns.

Bear activity patterns were also determined using camera trap photos (see Table 2.3). Bear photos were firstly identified as individuals and then recorded according to time, date and individual ID. Time on the photos was categorized according to 4-hour intervals to figure out bear activity patterns (Can 2008, Mengüllüoğlu 2010, Soyumert 2010).

Table 2.3 Bear camera trap data samples

Date	**Time**	**Animals**	**#**	**Male**	**Female**	**Cub of the year**	**Yearling**
6/9/2010	7:45	Brown bear	1		1	2	
6/14/2010	5:59	Wolf	1				
6/18/2010	15:13	Brown bear	1	1			
6/23/2010	18:30	Lynx	1				
6/30/2010	21:43	Brown bear	1		1		1

2.2.5. Spatio-temporal Ecology

2.2.5.1. Bear movement

Movement analysis includes computing the main direction during activity, velocities, turning angles, maximum and total displacements, minimum or maximum elevations, and proximity to settlements. For this analysis, BIOTAS and ArcGIS 9.3 Hawth tools were used. Bears behave differently in different seasons; for example, during mating season most of them roam to find a possible mate, except for females with cubs which alter their activity according to male bear activity and stay at rugged (i.e. safer) areas (Dahle and Swenson 2006, Boyce et al. 2010). During hyperphagia, they frequently visit agricultural fields and stay close to such feeding sites.

In order to understand the pattern of movements and relate them with available food at the sites visited, NDVI values of the study area were calculated as a measure of productivity and plant biomass (Zedrosser et al. 2011, Tucker and Sellers 1986, Ruimy et al. 1994). LANDSAT images (data available from the U.S. Geological Survey) without scanning errors of high-productivity seasons (May to September) were used for every year between 2006 and 2011. NDVI values were calculated from band 3 (Red) and 4 (Infrared) by using ArcGIS9.3 and NDVI Calculator (Huete et al. 1999). Mean NDVI values were calculated for the Özgüven valley . Alpine or rocky ground parts above 2500 meters were excluded to get average maximum productivity in Özgüven valley whereas for the whole study area every pixel NDVI value were considered and a mean was obtained. NDVI values below zero were excluded. Mean NDVI for summer season is calculated for productivity from 2006 to 2011.

2.2.5.2. Habitat Use and Selection

There are a number of key studies defining brown bear habitat, habitat preferences, selection and use but most of the literature on these issues faces several problems

(Garshelis 2000). The first problem is using vegetation type in line with habitat based on some unverified assumptions; secondly, using only observational data to find out about the animal's habitat selection or preference; thirdly, relating those possibly biased studies with fitness and population growth rate in a vague way (McLoughlin et al. 2000, Krausman 2001, Morrison 2001, Manly et al. 2002, Garshelis 2000, Johnson 2007). In addition, study designs with recently emerging methodologies contribute to the problem (Garshelis 2000).

A habitat selection study can be designed in three ways by use and availability designs: (1) describing population level selection, (2) including individual selection but availability at population level, and (3) describing the use and availability at individual level (Manly et al. 2002, McDonald et al. 2005, Garshelis 2000). Besides, habitat selection study includes three sampling schemes according to used, unused and availability of resources (Manly et al. 2002) but animals in nature are not randomly distributed but instead mostly show a clumped distribution (Krebs 2001) due to distribution of available resources. All resource usage forms the habitat of a species.

There are different ways of doing habitat selection analysis (Manly et al. 2002, Boyce 2007) but use-availability design has been the oldest and the most widely used (Klar et al. 2008). It is also known as the Neu method (1974) which uses X^2 (Chi-Square) analysis of proportional occurrence in a contingency table.

Depending on the probability of detection (used or unused), expected value of response can be given by linear, logistic or discrete choice models with respect to combination of variables. The linear equation such as below (Figure 2.8) can be produced to define resource use (Manly et al 2002):

$$E(Y) = f(\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_p X_p)$$

Figure 2.8: Linear resource selection equation

All resource selection studies require some statistical assumptions (Manly et al., 2002). For example, it is assumed that radio-marked bears are arbitrarily selected from the population; relocations of bears are not temporally interrelated; resource use is independent of other collared individuals; availability does not change during the study period. However, recent studies (Martin et al. 2008, Boyce et al. 2010) claimed that AC is not an unwanted situation in animal ecology.

I determined habitat use and availability for each individual bear by using 250 random used and 250 random available points by the use of GIS software ArcGIS 9.3.1. I computed selection indices by dividing observed numbers of locations by expected numbers of locations for each resource. The expected proportion for each resource type was calculated by the 250 random points inside the home range of a specific bear. A resource-selection index >1 indicates preference and an index <1 indicates avoidance of that resource (Neu 1974, Kamler 2000, Preatoni et al. 2005).

Resource selection parameters can be obtained by intersecting many explanatory variables such as topographical features and animal relocations as used areas. Then standard statistical programs can be used to develop resource selection functions (Manly et al. 2002). They differentiate common groups related to topography, vegetation and land use, as well as the composition of the spatial neighborhood around each cell. The final habitat selection is estimated with the use of Bonferroni statistics (Neu et al. 1974). In that method proportions of the population of available resource units in category “i” that are used (the resource selection probability function) is designated as “W”.

In resource selection studies many explanatory variables can be considered. Mostly vegetation and other habitat information such as topographical information, slope, elevation and aspect are parsed (Milakovic et al.2012, Manly et al. 2002) (Figure 2.9). Those variables can be obtained from a Digital Elevation Model (DEM) or recorded in the field. Other habitat-affecting factors such as settlements, road network and human population density can be used by forming raster surfaces in standard GIS programs (Manly et al. 2002, Nielsen 2005). Then those used points can be compared to random points which are available or unused to obtain proportion of use (Manly et al. 2002). To understand vegetation usage forestry maps were processed to produce a 9-class vegetation map according to dominant species in the forests. In addition, land cover types other than forest were mapped in a few classes. Fixes within the home range of bear were used to describe use availability design (White and Garrott 1990, Manly et al. 2002). A digital elevation model developed from ASTER imagery (NASA and METI 2011) was processed to produce surface layers such as aspect, slope, ruggedness and distance to road while settlements (including nearby productive cropland) were produced from settlement and road maps obtained from topographical maps as continuous raster layers (Yılmaz 2010, see Table 2.4).

Table 2.4 Explanatory variables used in habitat use analyses

Explanatory variable	Data type	Data source
Altitude	Numerical (m)	Obtained from digital elevation model (DEM) from ASTER imagery
Aspect	Categorical (4 cardinal directions)	Obtained by processing DEM by GIS tools
Slope	Numerical (degrees)	Obtained by processing DEM by GIS tools
Ruggedness	Numerical	Obtained by processing slope in percent by GIS tools
Distance to productive cropland	Numerical (m)	Obtained by processing the vegetation and land cover map by GIS tools
Distance to mast vegetation	Numerical (m)	Obtained by processing the vegetation and land cover map by GIS tools
Distance to roads	Numerical (m)	Obtained by processing rod layer by GIS tools
Vegetation and cover types	Categorical (9 categories)	Obtained by processing vegetation map of Kaçkar region

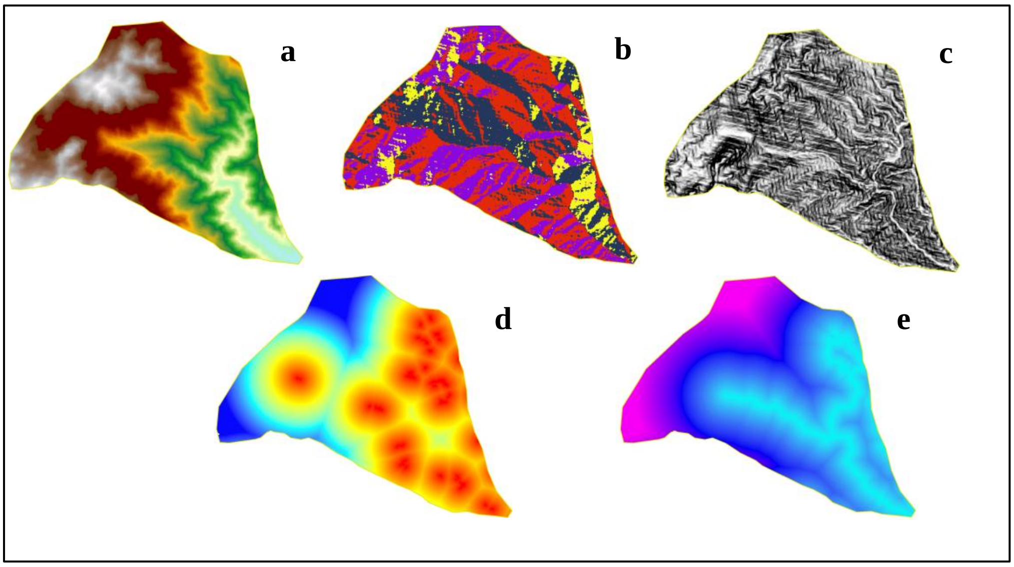

Figure 2.9 Sample layers for resource analysis: a) digital elevation model, b) aspect, c) ruggedness, d) distance to settlements, d) distance to roads

2.2.6. Population Estimation

There is no detailed inventory on the numbers of brown bears in Yusufeli except intermittent inventories by NCNP personnel between 2002 and 2004 (Ambarlı 2006). Numbers obtained by those censuses cannot be used since the quality and quantity of the effort spent are not comparable, and redundant counts might have occurred. Therefore a main problem in the study area is the vague population size of brown bears despite surveys (Ambarlı 2006).

A simple method for population estimation is direct observation from a high point with wide scenery and search carefully for the target species by binoculars. This may supply information about the presence of the species, cub ratio, breeding status, and diet (İsfendiyaroğlu and Welch 2005, Palomero et al. 2007, Bagher and Farhadinia 2011) where forest openings or alpine pastures are present. The latest techniques in population estimation especially for brown bears are genetic mark-recapture estimation methods based on noninvasively collected hairs (Waits et al 2005, Kendall et al. 2008), mark-resight estimation by using camera traps (Matthews et al. 2008, Mace et al. 1994), classical capture-mark-recapture or resight estimations (Seber 1982), and counting females with cubs of the year (FCOY) by comparing the previous years' data and applying some estimator function to obtain the probable population size of brown bears (Schwartz et al. 2008; Keating et al. 2002, Solberg et al. 2006). In this study two modern methods, mark-resight and Fcubs are implemented with field observations and camera traps.

2.2.6.1. Camera Trap Surveys

10 camera traps of Stealthcam brand were used between 2008 and 2011. An additional 6 camera traps of Scoutguard brand were used in 2011. Totally 22 camera trap stations were established but intermittently, with 10 of those positioned to monitor the focal study area. They were set on trails, ridges, in forest openings, in agricultural fields, in the forest, and near settlements. Total camera trap days varied every year (totally 2936 camera trap days).

For mark-resight analysis, 10 stations within 48 square kilometers were used in 2011 and individual identification was made by applying standard protocols (e.g. leaving 24 hours between consecutive bear events). Approximate area of 48 km^2 with 2x2 square kilometers was surveyed from June 2011 to the end of October 2011 (see Figure 2.10).

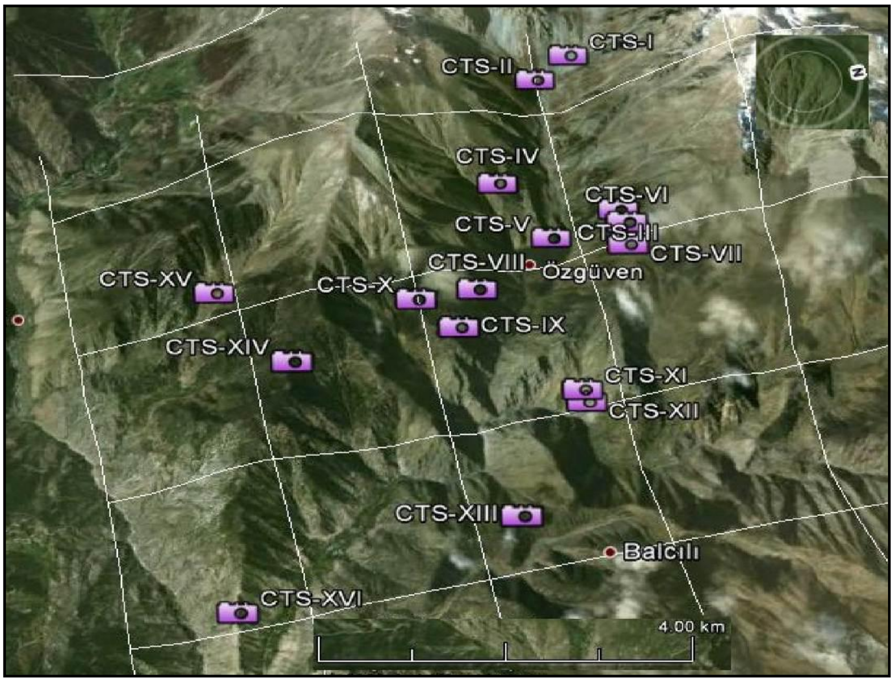

Figure 2.10 Camera trap stations for mark re-sighting surveys

2.2.6.2. Mark-Resight Analysis for Population Estimation

A study by Mace et al. (1994) stated that bears can be monitored and population can be estimated by using cam-recorders and individual markings on black bears. Recently a new advance in population estimation was published by Kelly (2008) and Rowcliffe et al. (2008). They modeled the detection process under natural conditions using camera trapping rates of individuals and calculated population size. Mark-resight population estimation uses mainly Peterson, Bowden and Joint hypergeometric estimators (JHE). Some of them require closed population in demography and multiple observations such as Bowden estimator (Bowden 1993, White 1996). It has a special property that confidence intervals on the estimate are based on the variance of resighting frequencies of marked bears (Matthews et al. 2008). The main trouble in this kind of mark- resight studies is meeting the prerequisites or assumptions of statistical tests.

$$\hat{N}^* = \frac{\left(\frac{u.^* + m.^*}{\bar{f}^*} + \frac{s_f^{2*}}{\bar{f}^{2*}}\right)}{\left(1 + \frac{s_f^{2*}}{T.^*\bar{f}^{2*}}\right)} \quad (1)$$

where

$u.^*$ was the number of observations of unmarked animals ($u.$) multiplied by the mean animal equivalent for the study area to correct for proportional use of the study area,

$m.^*$ was the number of resightings of a marked animal multiplied by its individual animal equivalent, summed across all marked animals,

$\bar{f}^* = \frac{m.^*}{T.^*}$ was the mean number of times marked animals were resighted,

$T.^*$ was the sum of animal equivalents in the population at the time of the resighting period, and

s_f^{2*} was the variance of the resighting frequencies, calculated by:

$$s_f^{2*} = \frac{\sum_{i=1}^{T.} (f^*_i - \bar{f}^*)^2}{T.^*} \quad (2)$$

where

f_i^* was the number of times the ith marked animal was observed during the resighting period multiplied by its animal equivalent.

Confidence intervals (90% calculated here) are computed from a log-transformation as

$$\hat{N}^*/\exp\left(t_{1-\frac{\alpha}{2}, T.^*-1}\,\hat{CV}^*\left(\hat{N}^*\right)\right) = 0.471$$

and

$$\hat{N}^* \times \exp\left(t_{1-\frac{\alpha}{2}, T.^*-1}\,\hat{CV}^*\left(\hat{N}^*\right)\right) = 1.621$$

Figure 2.11 Modified Bowden estimator taken from Matheews et al. 2008

Mark-resight has fewer assumptions than other methods but it assumes the following (White and Garrott 1990):

"-The subset of the population selected for marking is representative of the entire population in terms of sighting probabilities

-All sightings of marked and unmarked individuals in the population are recorded. If individually identifiable marks are used, then the individual identities of marked individuals are also recorded.

-The sighting surveys have two simple essences: sampling with or without replacement".

However, in many circumstances sampling must be with replacement. Sampling with replacement differs from other mark-recapture sampling because here sighting occasions need not to be distinct, and consideration is given only to some closed period of sampling (Matthews et al. 2008, White 1996).

For mark-resight analysis, two bear seasons, during pre-hyperphagia and hyperphagia, respectively, were sampled in the focal study area. Resighting periods were 1 June to 15 August 2011 and 16 August to 30 October 2011. A one week period is accepted as one observation and for two periods 10 observations were made. The study area was divided into 2x2 km grids and 10 camera trap stations were placed within those grids. Only radio collared bear data were used for resighted bears. A 24 hour interval was put between occasions of bear photographs for sighting independency to reduce chances of repetitive sighting of the same individual. Only individuals with distinct features, such as a female with certain number of cubs or a male (urinating or alone) were counted as different sightings of unmarked bears.

Each marked bear was weighted by the proportion of time it spent on the study site during the entire resighting period (Matthews et al. 2008). Bears that took out their collars with earmarks or distinct features were supposed as present in the area during observations according to their previous tracking period in the area. Besides, if marked bears were seen during the field study, it was counted as marked bear resighting. Bear population was supposed to be geographically open whereas demographically closed during the 10 weeks of resighting period. Population density was then calculated by using the formulas in Figure 2.11.

2.2.6.3. Counting Females with Cubs of the Year

First studies offered by Knight and Eberhardt (1985), conducted by Mattson (1997), but reanalyzed and criticized in various studies, it is concluded that counting females with cubs of the year provides reliable minimum population size and growth rate estimates (Keating et al. 2002, Brodie and Gibeau 2007, Cherry et al. 2007, Harris et al. 2007, Palomero et al. 2007). Identification of family groups may work in harmony by the application of rules as a whole and provides differentiation of repetitive sightings of the same bear from sightings of unique bears (Schwartz et al. 2008). It is concluded that the current rule set yields conservative estimates, but with minor improvements, counts of unduplicated females-with-cubs can serve as a reasonable index of population size useful for establishing annual mortality limits (Schwartz et al. 2008).

Direct observations for females with cubs were conducted usually by two persons. Binoculars, a field-scope and digital camera were used during observations. Direct observations were made in the early morning from 5.00 to 8.00 am and from 15.00-16.00 to 19.00 p.m. in the field during May and June which is most suitable season for observing female with cubs of the year (F_{COY} or Fcubs) and yearlings. The observations lasted variously from one hour up to four hours, depending on the weather conditions. Between May and June in 2008-2011, for every survey site approximately 15 days were spent in the Özgüven focal area, and 5 more days at other parts of the study area.

In this method, females with cubs of the years are differentiated from each other based on three criteria: “distance between sightings, family group descriptions, and dates of sightings” (Knight et al. 1995, Keating et al. 2002). The distance changes according to bear annual home ranges from 30 km to 2 km (Solberg et al. 2006). In this study it was taken to be between 0.5 and 2 km because home range size is very small in the study area compared to northern bear populations. Four years’ worth of observation data were used in the analysis.

The original Chao estimator (Chao 1984) is known to give higher population sizes compared to the bias-corrected estimators i.e. Chao 2 (see Figure 2.12), especially with small sampling efforts although both results tend to converge with increasing observation intensity (Keating et al. 2002). In this study female with cubs of the year (Fcubs) observations were conducted and Chao2 estimator was used to estimate minimum Fcubs (see Figure 2.12 for formulae). Study area is calculated to be 61 km^2 and the fecundity was found to be 0,249. For Fcubs-based monitoring to be useful, long (5-10 years) time-series data are preferred and, it is better to remove sampling variance and other forms of observation error before estimating confidence intervals (Brodie and Gibeau 2007).

Since in mark-resight surveys only independent bears are taken into account, thus cubs, yearlings and two years old individuals were excluded from the final population estimation in Fcubs estimate. Both mark-resight and Fcubs estimates were converted to number of independent bears per 100 km^2 including only independent age groups.

$$\hat{N}_{Chao2} = \hat{N}_{Obs} + \frac{f_1^2 - f_1}{2(f_2 + 1)}$$

$$N = F + M + CUBS + YEAR + TWO$$

$$F = \frac{FC}{PFC}$$

$$M = F$$

$$CUBS = REPR \times F$$

$$YEAR = CUBS \times Scubs$$

$$TWO = YEAR \times Syear$$

N – Estimated total population size

F – Total number of females $\geqslant 3$ years

FC – Estimated number of females with cubs

PFC – (1 – Proportion females in oestrus)

Figure 2.12 Chao2 formula and population estimation method (taken from *Solberg et al. 2006*)

2.3. Statistical Analyses

Spatial and temporal autocorrelations, directionality, turning angle and movement direction in the relocations of bears were parsed for the movement analysis by using Rao's spacing, chi-square and Rayleigh's correlation tests for the significance $p<0.05$.

To understand the habitat preferences of the bears, 8 explanatory variables are analyzed. The analyses were conducted over the statistics of used (observed) versus available (expected) amount or portion of each variable. To obtain observed and expected frequencies, 2 sets of 250 points were selected for each bear: one set was selected randomly from the home range and the other set was selected among the points used by the bears. The attributes of variables for each point is extracted from the maps by the use of GIS. So matrix of explanatory variables versus observed or available points were obtained. For the numerical (continuous) data, student's t-test is applied to the two sets assuming normal distribution and large sample size (Sokal and Rohlf 2001). Categorical aspect data were analyzed by the use of Chi-square test. Finally vegetation data is analyzed by the use of G-test and Bonferroni test explained below.

To find out whether bears use the vegetation proportionately to the occurrence of the vegetation in the study area, goodness-of-fit test (G-test) for more than two classes was applied based on Sokal and Rohlf (2001). It analyses frequencies of more than two categories of a variable sampled in large numbers and uses Chi-square distribution (see Figure 2.13).

$$G=2\sum_{i}^{k} O_i \ln \frac{Oi}{Ei}$$

Figure 2.13 G-test formula

Where O_i is the observed frequency, E_i is the expected frequency and all the $_i$ is each category or classes of the variable considered. For each bear, G-test is with 0.05 significance level was applied to the proportions of random and used points in each vegetation type. The statistics computed is compared with Chi-square value for α singificance level and (k-1) degrees of freedom.

If the G-test is found to be significant, it means that the bears do not use vegetation types in proportionate to the occurrence in the field. To find which vegetation types are used more or less than expected, in other means preference of and avoidance of certain vegetation types, Bonferroni z-statistic was applied. It is first applied for wildlife data by Neu et al (1974) and revised by Byners et al. (1984). Confidence interval for the used proportion of each vegetation type is calculated based on used and occurrence frequencies of vegetation types (see Figure 2.14).

$$p \pm Z_{\alpha/2k}\sqrt{p(1-p)/n}$$

Figure 2.14 Bonferroni z-statistic confidence interval calculation formula

“Where p is the proportional use of each vegetation type (O_i in the previous test), n is the number of observations (points) and k is the number of categories (vegetation types) and α is the significance level (0.05).” After the confidence interval for each vegetation type used by the bear is calculated, it is compared with the proportion of occurrence of that vegetation type in the study area. If the actual proportion is inside of the confidence interval, then it is concluded that the certain vegetation type is used in proportion to its occurrence and there is no preferences. If the actual proportion is smaller than the interval, then that vegetation type is used more than its occurrence showing a preference. If the actual proportion is larger than the interval, it indicates that certain habitat types are avoided.

CHAPTER III

RESULTS

3.1. Spatio-temporal Ecology

3.1.1. Basic Denning and Ecology

Denning time of bears in Yusufeli varies according to seasonal changes and food availability (see Table 3.1). In 2010 there was almost no snow until early December and the tracked bears went to denning sites between 26 November and 10 December 2010 whereas the female Dido went to its denning site on the last days of 2010 and began to hibernate on 1 January 2011. Hazal and Bayram aroused after mid-April whereas Dido aroused earlier, probably because of the milder conditions at the denning site (1600 m. above sea level vs 2790 m. and 2760 m.).

In 2011, 3 bears began hibernation in mid-November whereas one bear roaming at lower elevations went to its denning site on 5 December. The earlier denning time in 2011 is probably due to increased snow cover at the time. All bears except a female with cubs aroused in the first week of April 2011. Dido continued denning until 21 April.

Our early estimates for denning time (1 December-1 March) were based on information obtained from locals who claimed that bears aroused in early March. However, tracked bears (except for one out of seven) did not arise in March and most arousing occurred during early April.

Table 3.1 Collared bears denning times and elevation

	Bayram		Bozo	Toroman	Dido		Hazal
Years	**2010**	**2011**	**2011**	**2011**	**2011**	**2011**	**2010**
Denning	10 Dec.	16 Nov	15 Nov.	5 Dec.	1 Jan.	12 Nov.	26 Nov.
Arousing	24 Apr.	9 Apr.	3 Apr.	5 Apr.	28 Mar.	21 Apr.	18 Apr.
Days of Hibernation	136	146	140	132-150	86	161	144
Elevation	2790	2655	2875	1250-1950	1600	1425	2760

The denning sites of 2 females were visited after they were deserted. They were both in a very rugged area with high slope and could not be spotted easily without knowing the exact location. The entrance in both is smaller than the inside dimensions, which are usually of 200 cm in length and less than 1 meters in height. Hazal in 2011 and Dido in 2012 gave birth to two cubs each in early January (Figure 3.1).

Figure 3.1 Den site of Hazal with cubs in 2011

3.1.2. Mating

In late May and early June, most female bears in Özgüven Valley come into oestrus e.g. Dido and Kesik Kulak mated in late May and many day time observations were made in early June during 2004-2012 (Figure 3.2). Nevertheless, there are some unusual cases as well such as mating of bears in August 2011 (documented in a video taken by a camera trapping in the focal study area). Female bears usually mate after leaving their cubs when they reach 26-28 months old. There are observed cases of mixed litters for 2 times.

Bears were observed to be promiscuous and a female was usually followed by 3-4 four male bears and courtship behavior continued a whole day or for two days, with usually a larger male appropriating the female and defending from others. Courtship behavior continues until female becomes available. During this time they roam, graze, rest together and repeatedly smell each other. Male bears usually took the female bear away from other bears and then left the area after mating. The largest observed male group following one female is composed of 6 bears at outside of the focal study area in Yusufeli.

Figure 3.2 Dido and Kesikkulak mated in the focal study area

3.1.3. Home Range Sizes

Male home range sizes are bigger than females and male's (Bayram) home range (HR) is largest among all. Male and female utilization distribution (UD) areas overlap during mating (e.g. those of Kesikkulak and Dido). Dido roamed throughout almost all its home range during the 2011 mating season whereas Hazal, a female with cubs, stayed around two villages, Özgüven and Bıçakçılar. Seasonal HR size (HRS) is largest for males and alone female, Dido during mating season. Females inhabit lower elevations than males during all seasons (Table 3.1). Relocations having high HDOP were excluded from calculations and mean HDOP is about 3.08 (Table 3.2).

Table 3.2 Tracked bears and positions taken

Bear Name	Kesik Kulak	Bayram	Tosun	Bozo	Toraman	Dido♀	Hazal♀
Recieved positions	969	6054	71	2910	794	4552	5179
Excluded pos. (High HDOP)	22	201	1	291	51	225	191
Usable positions	866	3896	67	2141	579	3411	4510
GPS Time Out	81	577	3	478	164	916	478
Mortality signals	x	56/171	2	80	x	75/12	16
Mean HDOP	2.86	2.94	3.38	3.29	3.11	2.95	3.05
Days monitored	**36**	**603**	**3**	**304**	**60**	**590**	**312**

Home ranges calculated using different sample sizes or estimators are provided in Table 3.3. Using either 30-hour interval or 250 random positions, the computed area does not differ in 95% MCP whereas 95% Kernel estimates vary. Using all valid bear positions in estimations produced the largest home range size and UDs. 95% MCP estimators using 250 random fixes resulted in 10.46 km^2 average HR size for female with cubs and 21.53 km^2 for single female Dido. On the other hand 95% MCP based HRS for males range between 88.92 to 150.91 km^2 and has a mean of 86.64 km^2. The 95% Kernel estimator produced 15.63 km^2 mean UD for females and 109.38 km^2 for males.

Table 3.3 Bear home range size (sq.km.) by two estimators for three different sample sizes

	All Valid Points		30 h. interval		Random 250	
	MCP 95 %	**Kernel 95%**	**MCP 95%**	**Kernel 95%**	**MCP 95%**	**Kernel 95%**
Hazal♀	13.62	17.26	8.36	13.80	10.46	9.53
Dido♀	26.20	16.29	19.79	10.98	21.53	21.73
Mean	**19.91**	**16.775**	**14.075**	**12.388**	**15.995**	**15.63**
STDE	8.90	0.69	8.08	1.99	7.83	8.63
Bozo♂	102.03	117.91	80.00	163.00	88.92	92.26
Toraman♂	86.00	138.00	73.00	216.00	92.38	138.00
Bayram♂	282.00	184.75	160.00	272.00	150.91	175.00
Kesik kulak♂	52.69	18.68	20.00	43.56	15.13	32.26
Mean	**130.68**	**114.84**	**83.25**	**173.64**	**86.84**	**109.38**
STDE	**102.95**	**69.95**	**57.75**	**97.47**	**55.62**	**61.55**
Karabey*♂	6.39		6.00			
HRS M/F Ratio	**6.56**	**6.85**	**5.91**	**14.02**	**5.43**	**7.00**

Mean estimated 95% MCP HRS for males is 14.07 whereas it is 83.25 km^2 for females using a 30-hour interval between relocations. 95% Kernel UD with a 30-hour interval between relocations produced the lowest HRS of 10.98 km^2 for females and the largest HRS for males (272 km^2).

When all valid positions were used, estimators gave the largest home ranges such that mean male HRS were 130.68 and 114.84 km^2, respectively for 95% MCP and 95% Kernel (Figure 3.3). Mean female HRS were similarly 19.91 and 16.78 km^2. Although these are the largest values for different sample sizes, home range sizes thus obtained are among the smallest among brown bears around the world (Mcloughlin et al. 2000).

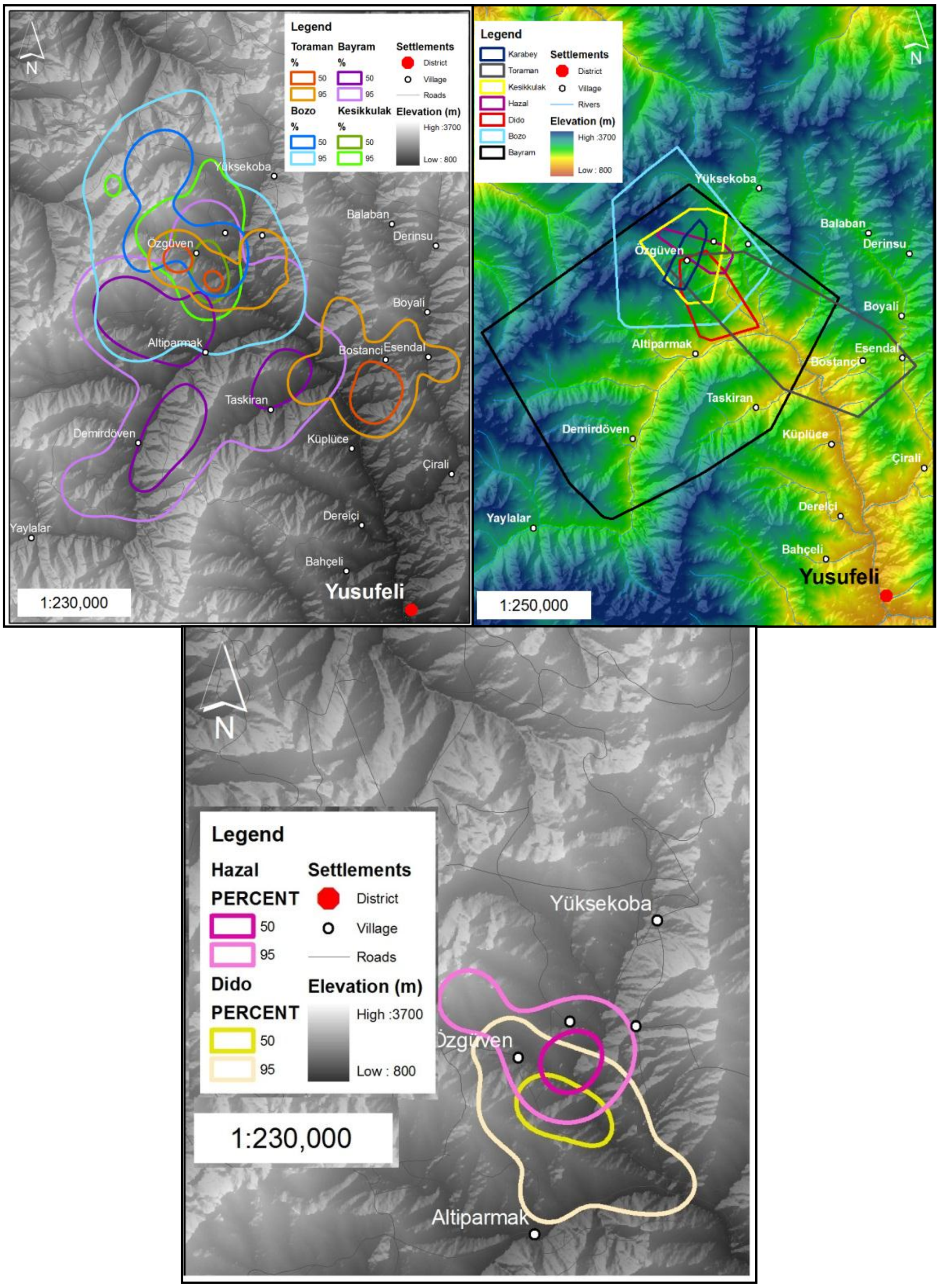

Figure 3.3 All home ranges for males and females by Kernel and MCP

3.1.4. Movement ecology

On average, males and females move at rates of 199.46 m/h and 129.00 m/h, respectively. Maximum velocities were 1749.50 m/h (females) and 4107.25 m/h (males). Females stay close to villages where they were captured showing a maximum displacement of 5.82 km. while males moved up to 37.33 km (Details in Table 3.4). Tracked bears indicate nonrandom selection of space and show site fidelity by Raos's spacing statistics. However, bears are not active always therefore their daily displacement is usually less than 5 km.

All male bears with GPS-GSM collars have both temporal and spatial autocorrelation in their locations. On the other hand, the VHF collared Karabey showed no temporal autocorrelation due to irregular VHF tracking schedule yet showed spatial auto correlation. Both female bears exhibited spatial and temporal autocorrelations in their movements.

Table 3.4 Bear movements and velocities

Male	Mean displacement	Max. Velocity m/h	Max. Displacement
Bayram	186.5	4736	19314
Bozo	181.83	6015	10037
Kesik Kulak	212	2178	7843
Toraman	217.5	3500	37333
Means	**199.46**	**4107.25**	**18631.75**
Female			
Dido	129	1558	5818
Hazal	115.8	1941	3379
Means	**122.4**	**1749.5**	**4598.5**

Bayram and Toraman displayed random direction change according to Rao's spacing test and no significant differences existed between observed and expected use ($p=0.62$ and 0.69 respectively for α 0.05). Bozo's and Kesik Kulak's directional change are not random and angles are not evenly spaced ($p<0.01$ and 0.048 for α 0.05). Hazal, the female with cubs, displayed nonrandom changes in direction whereas Dido presented random directional changes.

3.1.5. Collar Efficiencies

GPS collar efficiency can vary due to dense vegetation, rugged terrain, and position of the collar or the animal. Efficiency declines as the percentage of GPS timeout increases. GPS timeout (GTO) means that the collar cannot see the satellites in the sky within 90 seconds. If there is no bias related with collars or positional difference, GTO can be linked with external factors such as closed vegetation and ruggedness. Kesikkulak has the lowest GTO with high 3D data but the same collar when later fitted to Dido produced the highest GTO (see Table 3.5). Collar 2671 with Toraman demonstrated the highest GTO but again when the same collar was used on Hazal it showed the second lowest GTO percentage. Bozo with collar 2673 has the highest 2D data percentage. Individual differences probably seems important rather than vegetation and topography.

Table 3.5 Collar data acquisitions according to bears

% of Data Acquisition							
Bears	**K.Kulak**	**Bayram**	**Tosun**	**Bozo**	**Toraman**	**Dido**	**Hazal**
Collar ID	2674	2672	2673	2673	2671	2674	2671
GTO	7.99	12.34	x	16.4	22.07	20.12	9.23
2D	6.54	13.33	x	17.2	12.92	14.85	10.72
3D	**85.48**	**74.33**	**x**	**66.4**	**65.01**	**65.03**	**80.05**

3.1.6. Habitat Productivity and Bear Use

Bear home range sizes and density can be related to primary productivity. Therefore a mean NDVI value of 0.3549 ± 0.027 was calculated for the last five years after excluding high mountains and rocky areas to obtain the maximum value (Table 3.6). Although mean NDVI is around 0.20-0.25 in the whole study area, it increases to 0.50-0.75 or even higher along the rivers and productive croplands near settlements. For example, Bozo's average NDVI within its 100% MCP home range is 0.30 whereas average NDVI of Bozo relocations is 0.47 and for the main localities it spent time it is above 0.60. It means that bears use or track habitats with high NDVI values, probably reflecting a higher productivity (Figure 3.4).

Table 3.6 Average NDVI values for the most productive months in Ozguven valley between 2007-2011.

Years	2007	2008	2009	2010	2011
June NDVI	0.399	0.321	0.421	0.259	0.421
July NDVI	0.339	0.366	0.289	0.401	0.456
August NDVI	0.426	0.270		0.389	0.249
Sept. NDVI				0.314	
Mean NDVI for years	0.388	0.319	0.355	0.341	0.375

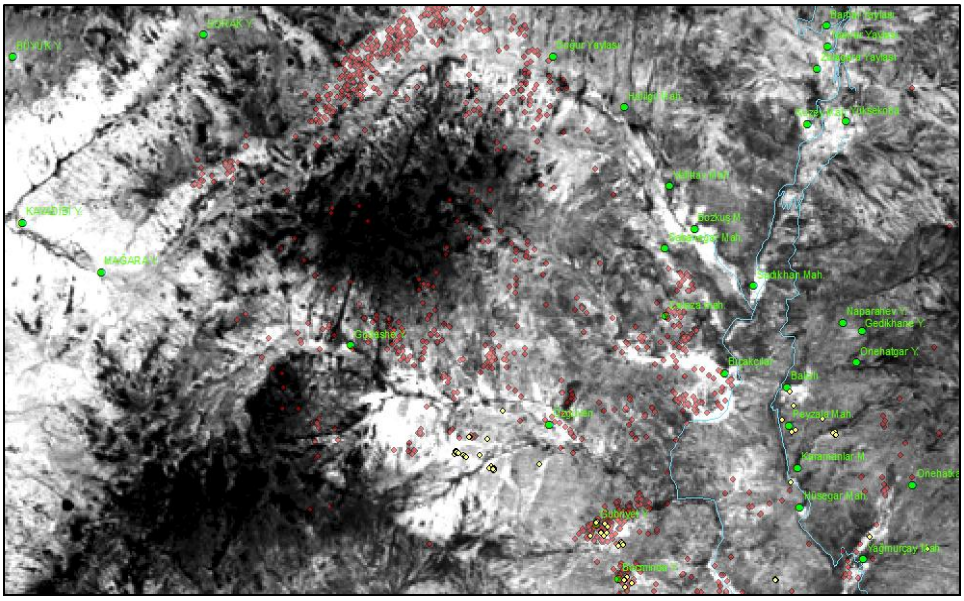

Figure 3.4 Locations of Bozo on NDVI map (white patches have high NDVI values whereas black patches have low or zero NDVI)

3.2. Habitat Selection

Habitat selection analysis with 250 random and points used by the bears within the 100% MCP revealed that bears in Yusufeli mostly use productive croplands such as orchard sites, current and abandoned agricultural fields, including those around settlements, as a major habitat. Secondary habitats selected by bears are evergreen forests, followed by the equally probable deciduous and mixed shrublands, mixed forests and forest openings. Bears do not select for alpine grasslands whereas at least one individual displayed selection for rocky ground. Female bears usually show strong selection for mixed or deciduous shrublands and productive croplands, but not for rocky grounds or alpine grasslands. The details for vegetation or land cover selection based on animals can be seen below (Table 3.7).

Table 3.7 Habitat selection percentages and W index values for each individual (w > 1 indicates selection and shown as bold)

	Bayram			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	14.9	9.6	2.0	0.21
Alpine grasslands	24.5	22.4	6.0	0.27
Mixed shrubland*	17.0	22.0	19.6	0.89
Mixed forest	1.3	2.0	0.4	0.20
Decidious shrubland	5.8	6.4	2.0	0.31
Productive cropland	5.6	4.0	29.2	**7.30**
Evergreen forest	27.3	30.0	37.2	**1.24**
Decidious forest	1.0	0.8	0.4	0.50
Forest opening	2.6	2.8	3.2	**1.14**
	Bozo			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	23.6	15.2	38.4	**2.53**
Alpine grasslands	34.0	34.0	16.0	0.47
Mixed shrubland	12.6	20.4	8.0	0.39
Mixed forest	1.3	0.8	0.8	1.00
Decidious shrubland	2.6	3.2	8.0	**2.50**
Productive cropland	5.6	8.0	12.0	**1.50**
Evergreen forest	17.7	16.8	13.6	0.81
Decidious forest*	1.9	0.8	2.8	**3.50**
Forest opening	0.5	0.8	0.4	0.50
	Toraman			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	0.1	0.0	0.0	NA
Alpine grasslands	9.0	10.0	7.2	0.72
Mixed shrubland	25.2	29.2	9.6	0.33
Mixed forest	11.4	13.6	21.2	**1.56**
Decidious shrubland	15.5	13.6	9.6	0.71
Productive cropland	6.9	6.4	18.0	**2.81**
Evergreen forest	27.9	25.2	32.4	**1.29**
Decidious forest	0.1	0.0	1.2	NA
Forest opening	3.9	2.0	0.8	0.40

Table 3.7. Habitat selection percentages and W index values for each individual (w > 1 indicates selection and shown as bold) (cont'd.)

	Kesikkulak			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	28.8	24.8	3.2	0.13
Alpine grasslands	37.2	34.0	19.6	0.58
Mixed shrubland	6.5	7.6	9.2	**1.21**
Mixed forest	0.4	0.4	1.2	**3.00**
Decidious shrubland	1.4	2.0	4.8	**2.40**
Productive cropland	3.9	2.8	30.0	**10.71**
Evergreen forest	14.1	18.8	26.8	**1.43**
Decidious forest	6.5	6.8	2.4	0.35
Forest opening*	1.1	2.8	2.8	1.00
	Dido			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	2.0	0.8	0.4	0.50
Alpine grasslands	12.2	10.4	1.2	0.12
Mixed shrubland	34.2	35.2	27.2	0.77
Mixed forest	2.8	3.2	0.8	0.25
Decidious shrubland	7.3	8.8	12.0	**1.36**
Productive cropland	8.3	10.0	28.0	**2.80**
Evergreen forest	31.7	30.0	28.8	0.96
Decidious forest	0.8	0.8	0.0	0.00
Forest opening	0.7	0.8	1.6	2.00
	Hazal			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	15.9	16.4	6.4	0.39
Alpine grasslands	22.5	19.6	0.0	0.00
Mixed shrubland	29.2	36.4	82.4	**2.26**
Mixed forest	0.8	2.0	0.8	0.40
Decidious shrubland*	3.5	3.6	3.6	1**.00**
Productive cropland	8.9	6.4	5.6	0.88
Evergreen forest	18.0	14.4	1.2	0.08
Decidious forest	0.0	0.0	0.0	NA
Forest opening	1.1	1.2	0.0	0.00
	Karabey (80 points)			
Cover type	**% in MCP**	**% Random**	**% Used**	**W**
Rocky ground	0.0	0.0	0.0	NA
Alpine grasslands	43.5	48.8	46.3	0.95
Mixed shrubland	13.0	13.8	15.0	**1.09**
Mixed forest	1.3	1.3	0.0	0.00
Decidious shrubland	0.0	0.0	0.0	NA
Productive cropland	8.1	2.5	7.5	**3.00**
Evergreen forest	32.3	31.3	31.3	1.00
Decidious forest	0.3	0.0	0.0	NA

Resource selection by bears (in terms of slope, aspect, elevation, distance to roads, settlements, rocky areas, hard mast) was measured by comparing randomly available and actually used positions within bear home ranges statistically by Bonferroni, G and t-tests. For the difference with the degrees of freedom (DF) 498 except Karabey were taken for the significant difference ($p<0.05$) from the random available points. Bayram (♂) displayed significantly more use of southern aspects ($p=0.002$), lower elevations, lower slopes ($p=0.033$), and sites near roads, settlements, rocky areas, or hard mast ($p<0.01$).

Bozo (♂) displayed significantly more use of southeastern aspect rather than available southern aspects ($p=0.002$). On the other hand it did not show any significant preferences for elevation while using higher slopes ($p<0.01$). His relocations are significantly closer to roads, but further away from settlements, rocky areas and hard mast ($P<0.01$).

Toraman (♂) displayed no significant preferences for a particular aspect ($p=0.124$) or elevation ($p=0.643$). Nevertheless, it occurred significantly further away from roads ($p=0.016$), settlements ($p<0.01$), rocky areas ($p<0.01$) but was closer to hard mast ($p=0.002$) and more often at lower slopes ($p<0.01$).

Kesikkulak (♂) displayed significantly higher use of southeastern aspects rather than available eastern aspects ($p=0.002$); it also selected lower elevations ($p<0.01$) and slopes ($p=0.002$), and sites closer to roads, settlements, rocky areas and hard mast ($p<0.01$).

Karabey (♂) with its limited sample size showed no significant preferences for the elevation, aspect, distance to roads, rocky grounds, hard mast and settlements ($p>0.05$) but showed significant preference for lower slopes ($P=0.049$).

Dido (♀) did not display any significant preferences for the aspect ($p=0.057$), slope ($P=0.069$), elevation ($p=0.234$) or distance to roads ($p=0.086$) and rocky areas

(P=0.949). On the other hand it showed significantly higher use of areas closer to settlements and hard mast woodland (p<0.01).

Hazal (♀) preferably used eastern aspects instead of southeastern (p=0.013); it also preferred lower elevations (p<0.01), sites closer to roads (p<0.01), rocky areas (p<0.01) and hard mast woodland (p<0.01). However, unexpectedly it didn't show any avoidance or preference for sites near settlements (P=0.053).

Except Bozo and Karabey, all bears stayed close to hard mast. Male bears live at higher elevations than females. Mean elevation of male occurrences is 1934.63 ± 344.59 whereas for females 1634.24 ± 308.40 (as derived from 250 random fixes).

3.3. Daily Activity and Resting Patterns

All available data were used to document general activity patterns (see Table 3.8). Bears were largely nocturnal but there were exceptions (Figures 3.5-3.10). For example, Toraman showed much diurnal activity during late hyperphagia (Fig 3.8). Minimum and maximum values in figures correspond to percentages of the either physical activity or resting. All bears except for Toraman had a higher percentage of active time than resting time. The difference between active and resting percentages is lower in Hazal (the female with cubs) but higher in Dido. The most active bear is Bayram, followed by Bozo and Kesik Kulak.

Table 3.8 Bear activity and resting percentages (in total 100%)

% of Total Activity and Resting							
Bear Name	**Kesik Kulak**	**Bayram**	**Tosun**	**Bozo**	**Toraman**	**Dido**	**Hazal**
Active %	59.7	66.48	X	61.4	48.72	57.92	51.65
Resting %	40.3	33.52	X	38.6	51.28	42.08	48.35

3.3.1. Activity pattern based on collar activity loggers

3.3.1.1. Kesik Kulak

The active period of Kesik Kulak is more than resting period: 59.7 and 40.3% respectively. It mainly rests in the morning and continues resting until night (Figure 3.5). It is mostly active early in the night and morning but activity also rises after 16:00. It displayed minimum activity at noon (6.13%) but resting seems uninterrupted (77.53%) except when activity peaks occurred in early morning and night.

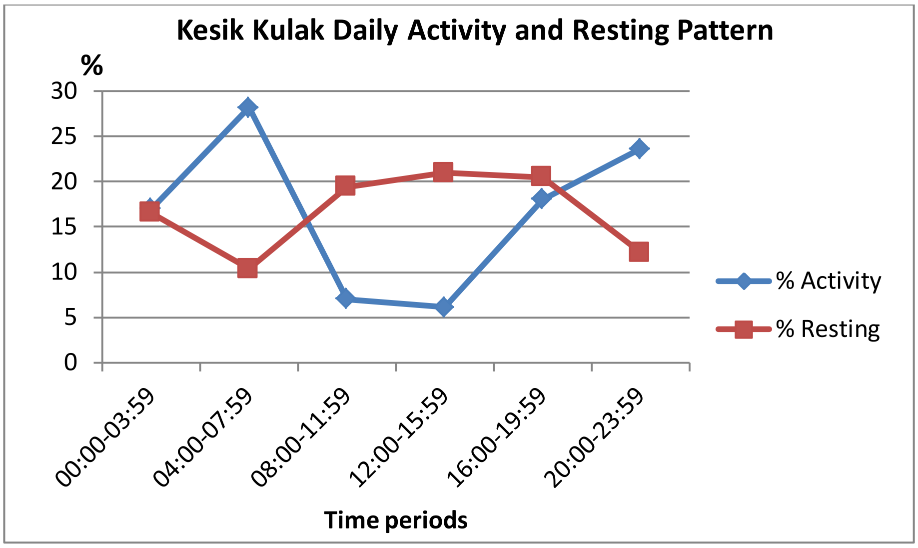

Figure 3.5 Daily activity and resting pattern of Kesik Kulak

3.3.1.2. Bayram

Bayram was a subadult bear in 2010 but in 2011 a new photo showed that it was almost an adult bear. It was mainly active (66.48%) rather than resting (33.52%). It showed continuous activity during all hours except when it fell to a minimum (4.68%) between 8 am to noon (Figure 3.6). Resting occurred mainly between 8 am to 4 pm (62.80% of resting) and took minimum levels on the most active times of bear (figure 3.6). Therefore it was mainly nocturnal.

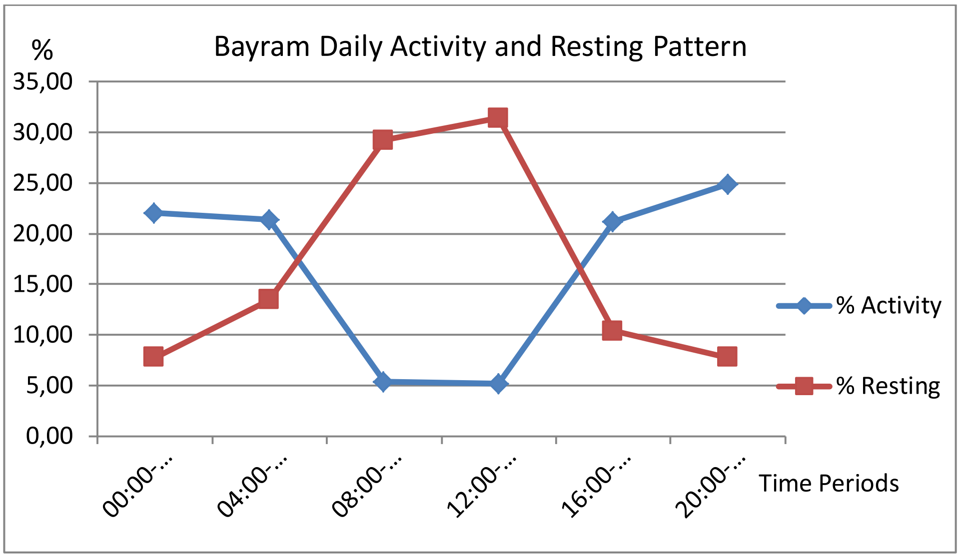

Figure 3.6 Daily activity and resting pattern of Bayram

3.3.1.3. Bozo

Bozo is a 4 years old male bear and probably mated during June 2011. Like Bayram, it was active (61.36%) rather than resting (38.64%) and showed minimum activity (4.41 %) between 8 am to 12 am but resting is smooth between midnight to 4 pm (76.22% of resting). On the other hand, maximum activity took place in the afternoon and night hours whereas resting was unusually also during midnight close to the peak value of early afternoon (Figure 3.7).

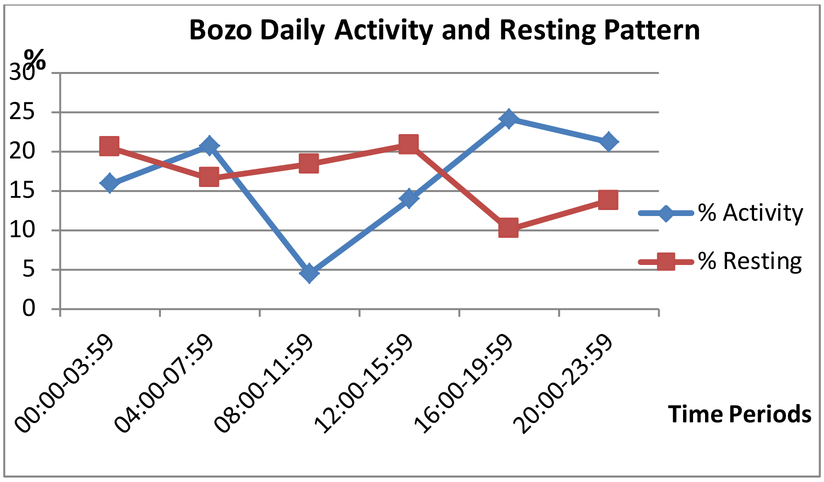

Figure 3.7 Daily activity and resting pattern of Bozo

3.3.1.4. Toraman

This male was the biggest bear captured during hyperphagia and behaved almost fully diurnal. Highest activity and lowest resting took place in the early night but differences between intervals were low (Figure 3.8).

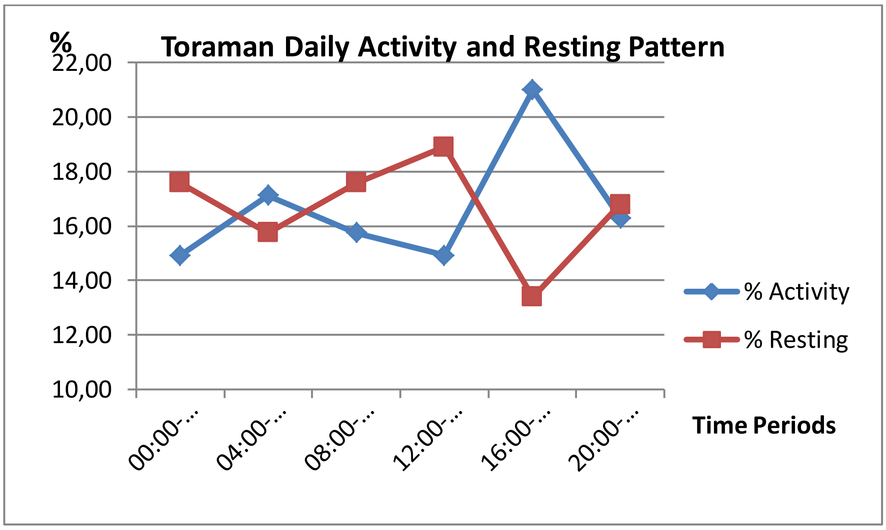

Figure 3.8 Daily activity and resting pattern of Toraman

3.3.1.5. Dido

It was mainly active (57.92%) rather than resting (42.08%). It showed minimum activity levels during daylight hours (8.54% of activity) between 8.00 to 16.00; 46.92% of resting also took place between these hours. On the other hand, maximum activity was during the night, with resting taking minimum values in the evening and morning hours (Figure 3.9).

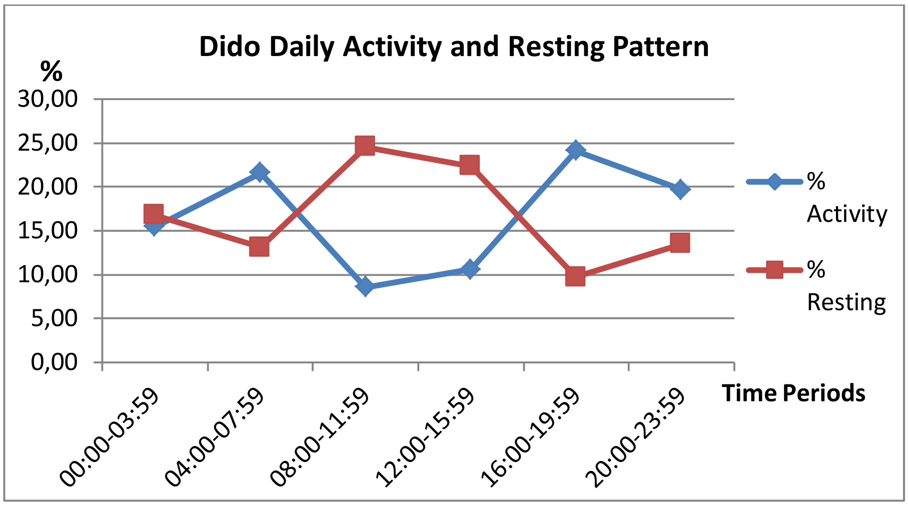

Figure 3.9 Daily activity and resting pattern of Dido

3.3.1.6. Hazal

This female bear demonstrated almost diurnal activity and resting were mainly at night compared to others probably because it had two cubs. Its maximum activity was during the afternoon and early night hours coinciding with the minimum resting during early night (Figure 3.10).

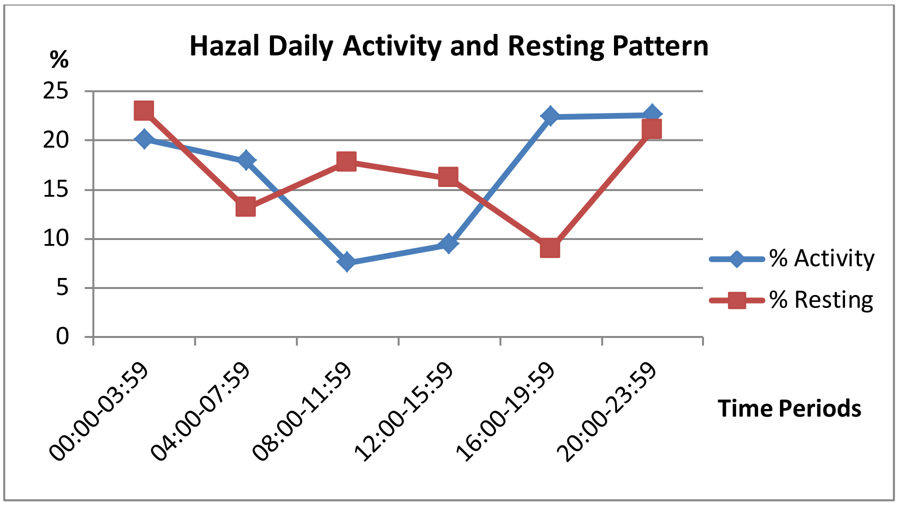

Figure 3.10 Daily activity and resting pattern of Hazal

3.3.2. Daily Activity pattern based on camera traps

Camera trap results imply that bears are mainly nocturnal but show crepuscular behavior. They are active on trails and forested parts in the early morning 04.00 to 07.59 a.m. and in the evening 16:00 to 19.59 (N=352). Bears have the least active periods during daylight hours from 8:00 to 16:00. Nonetheless, inactivity may only be revealed by GPS-GSM collars which record both activity and inactivity. Thus, camera trap activity corresponds to times of bear images shot by camera traps. It includes all ages and no sex bias and is an indicator of daily activity but does not show periods when the animal is resting (Figure 3.11).

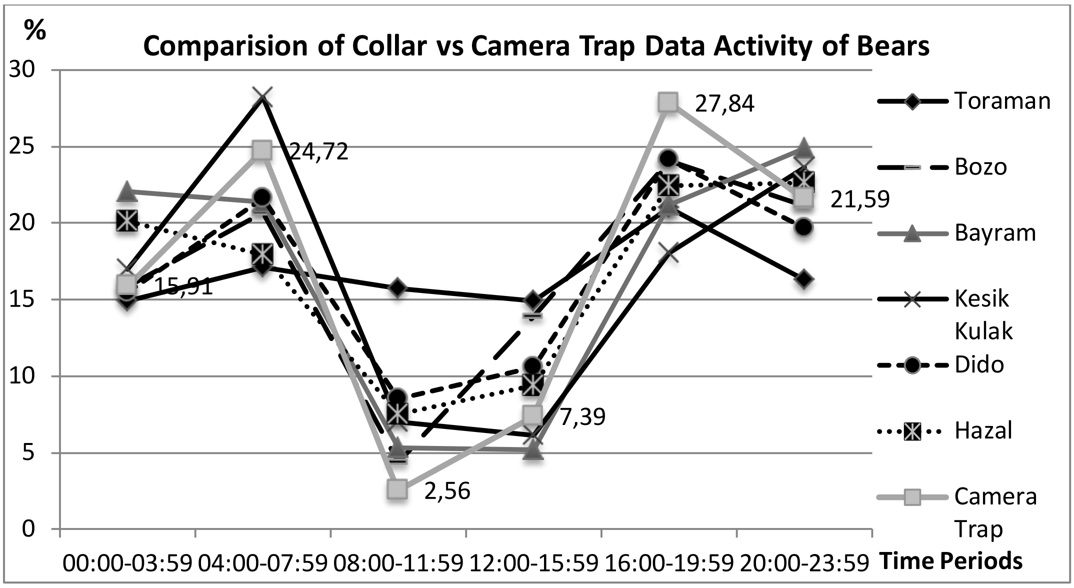

Figure 3.11 All bears' activity patterns by collars compared with the activity pattern recorded by camera traps indicated by squares

3.4. Camera Trap Surveys

Camera traps produced 697 images that belong to 13 mammal species in 2936 trap-days between 2009 and 2012 (Table 3.9 and 3.10). In addition, 14 images of birds, domestic cats and dogs, as well as more than 100 untargeted images of people were taken (Table 3.10). Of those 697 images, 352 were of brown bears (see example in Figure 3.12) and were used for documenting bear activity pattern. 43 bear images were excluded from the analysis of encounter rates since they triggered the same camera trap more than once within an hour. Camera trap encounter rates obtained are compared with a similar field study by Mengüllüoğlu (2010) in Ankara. Red deer (*Cervus elaphus*) encounter rate in Ankara is assumed to correspond to wild goats, the main ungulate and prey species in Artvin.

Table 3.9 Camera trap days during 2009-2012 in Yusufeli (* outside of focal study area)

Camera trap days	Years
639	2009-2011*
602	2009
528	2010
870	2011
297	2012
Total: 2936	2009-2012

The bear encounter rate was higher than the total of encounter rates for all other medium and large herbivore/omnivore species such as wild boar, wild goat and brown hare. The carnivore encounter rate (14.89) was also twice as high as the total encounter rates for ungulates and other prey species (7.08) in contrast to the study in Ankara. In the focal study area, almost no fox and badger were recorded although there are suitable habitats and agricultural plots.

Bears were attempted to be differentiated one from another by using head and nose shape, specific coat patterns, body size, height of the shoulders from ground, and presence of cubs. Specifically in the focal study area, 602 camera trap-days of effort were spent from May to December 2009. 104 animal photos were taken, of which 50 were bears. As a result, 16-18 bears were identified through process of identification of photos. In 2010, 69 bear photos were taken during 528 trap-days. In 2011, 157 brown bear images were obtained in Özgüven between May and December 2011. These photos were sorted according to date to be used in a mark-resight analysis. Other brown bear photos were obtained at different parts of Yusufeli.

Camera trapping also verified the presence of marked individuals (e.g. Karabey) within their home ranges. Four different photos belonging to Karabey were taken as it stayed more than a month on the same slope while moving back and forth within Özgüven.

Table 3.10 Documented species and encounter rates in Yusufeli

Species	# events / 100 CT days in Yusufeli	# events per 100 CT days in Ankara (Mengüllüoğlu 2010)
Brown bear (*Ursus arctos*)	10.52	*0.03*
Wild boar (*Sus scrofa*)	3.47	*1.65*
Brown hare (*Lepus europaeus*)	1.98	*8.59*
Golden jackal (*Canis aureus*)	1.74	*1.38*
Wolf (*Canis lupus*)	1.43	*1.49*
Wild goat (*Capra aegagrus*)	1.33	*5.16* Red deer*
Eurasian lynx *(Lynx lynx*)	0.89	*0.22*
River otter (*Lutra lutra*)	0.31	**-**
Marten (Martes sp.)	0.24	*0.86*
Dormmouse (?)	0.20	**-**
Hedgehog (*Erinaceus concolor*)	0.10	*0.08*
Badger (*Meles meles*)	0.03	*1.97*
Red fox (*V. vulpes*)	0.03	*4.76*

Figure 3.12 A sample photograph of Dido from camera trapping in Özgüven

3.5. Bear Trapping Efficiency

Success in brown bear trapping changes according to seasons. There are also reasons for capturing bears in September rather than in late spring or early summer (Table 3.11). This is because collars may fall off from bears that lose weight during the mating season, and because bears visit orchards and agricultural fields near villages during autumn more frequently as they roam around accessible areas and hence are easier to capture. Trapping efforts in 2009 were not included in results because cubby style traps, which are used mostly in USA, were prepared but did not work in Yusufeli. Although a box trap was used throughout the study during trapping sessions, and one or two bears got accustomed to trap, no bear was captured by the box trap. The most productive season was September 2010 when 4 bears were captured.

Table 3.11 Trap effort and captured bears during 2010 and 2011

	2010	**2011**
Total trap days	533	118
Captured bears	5	2
Trap days effort per bear	106.6	59

3.6. Population Estimates

3.6.1. Fcub estimate

Observations of females with cubs and females in oestrus were mostly carried out in the focal study area. Mean Fcubs seen in Özgüven were 1.50, less than the overall Fcubs value (1.628) in Yusufeli. Fecundity in Özgüven was calculated as 0.259. Monitoring of females with cubs of the years (Fcubs) during 2008-2011 produced the observations shown at Table 3.12.

Table 3.12 Observation and frequencies of resightings of Fcubs and number of oestrus females observed according to years(“F-x Cubs-y” indicates Females with x number of cubs of the year and sighted y times. 1O indicates Oestrus female)

Bears	2008	Bears	2009	Bears	2010	Bears	2011
1 O	07.06.08	1O	23.05.09	1O	27.05.10	1 O	24.05.11
1 O	08.06.08	1O	06.07.09	1O	29.05.10	1 O	01.06.11
1 O	22.05.08			1O	05.06.2010	1 O	03.06.11
F-1 Cubs-1	31.07.08	F-1 Cubs-2	04.07.09	F-2 Cubs-2	04.05.10	F-2 Cubs-2	26.05.11
F-2 Cubs-1	31.07.08	F-1 Cubs-1	24.05.09	F-1 Cubs-1	15.05.10	F-2 Cubs-2	29.05.11
F-1 Cubs-2	07.06.08	F-2 Cubs-1	17.06.09	F-1 Cubs-1	17.07.10	1F-3 Cubs-1	16.06.11
		F-1 Cubs-1	25.07.09	F-1 Cubs-1	09.06.10	1F-1 Cubs-1	16.06.11

Identifying unique Fcubs and recording sighting frequencies establish the basic needs of a population estimate using bias-corrected Chao estimator. Bias corrected Chao formulae estimate the minimum Fcubs as and then a population size estimate is obtained by formulae given below modified by Solberg et al. (2006) for 61km^2. This value was converted to density in 100 km^2 for comparison with densities in other countries (Table 3.13).

The estimated N value includes all independent age groups. To estimate only independent individuals (usually older than two years old) the “N Est.= F+M+Three years old” formula was used and resulted in a mean density of 24.50 ± 1.74 / 100 km^2.

Table 3.13 Population estimation according to Solberg et al. 2006 with modified formula in 61 km^2

Pop. Estimation	**2008**	**2009**	**2010**	**2011**
FC	3.50	4.5	4.5	4.33
PFC	0.50	0.67	0.57	0.57
F	7.00	6.75	7.88	7.58
M	7.00	6.75	7.88	7.58
Cubs	1.81	1.75	2.04	1.96
One Year old	1.31	1.26	1.47	1.42
Two years old	1.11	1.07	1.25	1.21
Three years old	1.04	1.00	1.16	1.12
N Estimated all ages	19.27	18.59	21.68	20.86
N Est. Independents	15.04	14.50	16.92	16.28
N Est. Ind. per 100 Km^2	23.49	22.65	26.44	25.43

3.6.2. Mark-Resight Estimate

72 bear images in the first resighting season between June- August 2011 included 35 sightings of unmarked bears and 10 resighting of marked bears (Figure 3.13). 23 bear photos were excluded from the analysis due to incomplete or unidentifiable marked or unmarked bear photographs or a presence of less than 24 hours in consecutive photographs. N was calculated for per 100 square kilometers in summer: 23.90 ± 2.66.

Table 3.14 Bear resigthings in 1 June-15 August 2011 AE= Observation in the area/ Total observations, Fi=AE*number of resightings

Animal ID	Observation in the area	Total Observations	Animal Equivalent (AE)	Resightings	Sighting frequency (Fi)
K. Kulak	7	10	0.7	4	2.8
Dido	9	10	0.9	1	0.9
Hazal	9	10	0.9	1	0.9
Bayram	0	10	0	0	0
Tosun	5	10	0.5	1	0.5
Bozo	7	10	0.7	3	2.1
Karabey	0	10	0	0	0

For the second mark-resight season which corresponded to hyperphagia between 16 August and 31 October 2011: 99 bear images were obtained. They included 12 marked bears and 50 unmarked bears (resightings and frequencies can be seen at Table 3.14 and Table 3.15). Other photographs were excluded due to reasons stated above. Unmarked bears were more numerous than in the first season. The calulations produced a population density in autumn of 26.42 ± 2.56 / 100 km^2.

Table 3.15 Bear resightings during 16 August -31 October 2011

Animal ID	Observation in the area	Total Observations	Animal Equivalent (AE)	Resightings	Sighting frequency (Fi)
K. Kulak	7	10	0.7	4	2.8
Dido	8	10	0.8	1	0.8
Hazal	8	10	0.8	3	2.4
Bayram	2	10	0.2	1	0.2
Tosun	5	10	0.5	0	0
Bozo	7	10	0.7	3	2.1
Karabey	0	10	0	0	0

Figure 3.13 Resighted bears, Bozo and probably his sibling in 2011

CHAPTER 4

DISCUSSION

4.1. Bear Trapping and Collar Efficiency

Investigators typically report trapping efficiency as the number of days required to capture one bear. For example, in Slovenia the efficiency is 139 trap nights around hunting towers for brown bears (Kaczensky et al. 2002), between 36.3-39.3 trap days for black bears in North America (Grogan and Lidnzey 1998), and about 50 trap days for grizzly bears (Ciarniello et al. 2003). However, trapping days can change according to season and bear behavior in different countries and with the experience of the researcher with bears. For example, the cubby set technique, a frequently used trapping system for grizzlies in the USA that sets foot snares next to an object (Jonkel 1993), did not work well in Yusufeli.

Bears there show extra caution to “decorated” trap sites and to any changes along their usual path. The technique’s very low efficiency might also be a result of not using large baits (e.g. killed elk or deer). In this study, culvert trap was not effective as the foot snares although it has been shown that it had high efficiency capturing black bear and nuisance grizzly bears that likely lost fear of people (Clark et al. 2002, Jonkel 1993). The first radio-collared bear in Turkey was captured by a culvert trap but a new culvert trap used for this study did not capture any bears, perhaps due to its unnatural shape and size or its metallic smell.

Capturing is just one part of the study, even though it is the most crucial step in telemetry tracking. The collar should fit well to the animal's neck and should not be too loose, otherwise they fall or be removed by the bear. Trapping of males should preferably take place in the autumn, which would enable one to monitor them at least for 6 months, before they lose weight and possible lose the collar. In addition, GPS efficiency is important for reliable analyses. In this study, GPS collar efficiencies with low HDOP (less than 5) were good but for most collars battery life was shorter than expected. Overall, the collars functioned well. Contrary to the experience in this study, for former collar models of the same brand various studies reported very low efficiencies of 37% to 56% (Ciarniello et al. 2003, Heard et al. 2008) and corrupted collars after deployment (Gau et al. 2004).

4.2. Denning Sites

Den sites of tracked bears provided new information but needs further research due to limited sample size in this study. First of all, bears went into hibernation at higher elevations than reported in most European studies, and similar to Slovenian bears they chose rock dens at steep slopes with rugged terrain (Petram et al. 2004, Linnell et al. 2000). However bears in Norway and Sweden prefer to stay in forested habitats during hibernation and in nest dens (Linnell et al. 2000, Elfström and Swenson 2009). In contrast, bears in Yusufeli spent the winter at usually inaccessible areas with snow cover, and particularly males denned far away from settlements.

Denning period of bears changes according to climatic conditions but it is usually three to six months (Pashiniack-Arts 1993, Collins et al. 2005). Bears denning in Yusufeli stayed in their dens for at least four months under normal conditions. Bears are not considered true hibernators (Heldmaier 2011) but it is shown that they decrease their metabolic rates sharply down to 75% of normal rates, similar to hibernating small mammals (98% decline of rate) and reduce oxygen consumption

(Tøien et al. 2011). Unlike small mammals, they keep their body temperature between 30-36 °C instead of 4-5 °C (Tøien et al. 2011). Our results showed that body temperature of pregnant female bears stay almost constant about 35-36 °C till parturition and then decrease to 33-31 °C as similar to other bears. Metabolic rate was not measured but female bears gave almost no mortality signal (after waiting motionless for 5 hours) prior to parturition but other tracked bears gave in various numbers.

The hibernation den of Bayram was probably better in 2011 than in 2010 since he tried to find place and roamed more than usual in December 2010 and due to unusual weather conditions. It was not snowing and he passed over the other side of the Güngörmez Mountains and hibernated there at a higher elevation than 2011. He stayed more motionless in 2011 than 2010 and gave more mortality signal. On the other hand November 2011 was the coldest month in Artvin during the last 40 years, with highest snow depth (Sensoy et al. 2012). Therefore almost all bears went to hibernation in 13-15 November 2011, but they waited for hibernation till December in 2010. Bozo and his probable sibling tried to find a safe place but while snowing, they stayed at a temporary place then found another horizontal crack on the Karataş boulder and stayed there for four months. On the other hand, Toraman came down to lower elevations and he probably hibernated on 5 December 2011.

4.3. Bear Activity and Movements

Daily movements of Yusufeli bears (about 2 km) seem to fall into the range of variation reported elsewhere. For example, average bear daily movements in British Columbia is 2 km and ranged between 0.4 to 6.2 km (Stevens and Gibeau 2005), whereas there are cases of individuals moving 10 km within 12 hours (Mano 1994) as it was also demonstrated by Kesikkulak, Bayram and Toraman several times. In contrast, females with cubs move shortest distances and spend more of the daytime foraging (Klinka and Reimchen 2002, Lewis et al. 2011), as exemplified by Hazal.

Camera trapping data implied that bears are mainly crepuscular, similar to findings of other studies in Turkey (Can 2008, Soyumert 2010). On the other hand, a new viewpoint of activity pattern based on resting patterns was possible with the use of activity data loggers in collars for the first time in Turkey. Contrary to presumed bear behavior, data implied that bears can rest during any time within the 24-hour day, even at the midnight when bears are supposed to be mostly active; both physical activity and resting may alternate within the same time window.

For example, Bozo showed highest percentage of resting around midnight instead of the noon as expected. Hazal decreased its activity at night, probably to better protect her cubs from foraging males. Toraman, the largest tracked male, decreased activity prior to hibernation and increased resting times, with its activity peaking in the afternoon instead of the usual night hours. When activity patterns revealed by collars and by camera traps were compared, the latter technique underestimated the activity of some bears at certain periods (midnight activity for Bayram and Hazal, and noon time activity of all bears). On the other hand, camera trapping overestimated bear activity in the evenings. Camera trap results also produced different encounter rates for species in Yusufeli compared to studies in other parts of Turkey (Akbaba and Ayaş 2012, Can 2008, Mengüllüoğlu 2010, Soyumert 2010) because of high population density.

Bear activity in Europe is mostly nocturnal (Kaczensky et al. 2006) whereas in North America bears typically display diurnal activity pattern (Klinka and Reimchen 2002). The activity patterns obtained from camera trap and collar data demonstrated that Turkish brown bears are in between two counterparts and show predominantly crepuscular daily activity pattern. Besides where human disturbance is low they can be seen during day times. Some researchers believe that nocturnal behavior is a result of negative experiences with humans (Kaczensky et al. 2006) but it is not certain yet because there are individual variations and bears easily can learn and shift their movements and activity patterns.

Home Range size of subadult male bear Bayram was the biggest in 2010 because he fled to other villages and habitats form his probably natal area. The dispersal behavior was only shown by Bayram. Then in 2011 his home range became more consistent and probably based on sites of feeding, mating and hibernating from previous experiences. Toraman was the biggest male who probably followed pre-determined paths with high NDVI values. While doing this movement, he shifted to the outside of the study area by moving 10 to 20 km per day and then turned back within 15 days. After releasing, he probably went back to his natal area either for safety or better feeding habitats.

Although Bozo was at least four years old, camera trap videos and photographs revealed that he travelled with probably his sibling in 2011. Besides, there were photographs of two male bears again in the focal study area in September 2012 but it couldn't be verified whether they were Bozo and his sibling because he removed his collar after hibernation. KesikKulak's home range was completely in the focal study area during 40- days monitoring period. He was the most popular bear in camera traps and photographed also at his favorite feeding site in 2008. He has been monitored via GPS-GSM collar in 2010 and via camera traps in 2011, he was the most resighted bear during whole year within the focal study area.

Female home ranges were all within the focal study area and they were depended on their exclusive habitats. Exclusive habitats were somehow territorial areas and there were apparent attempts of intrusion to each other's home range during the mating time in 2011. As expected Hazal with cubs of the years had the lowest home range size and but it had the widest during mating time when female roamed alone.

4.4. Home Range Size and Population density

Average female and male home range sizes of brown bears by 95% MCP were found to be 20 km^2 and 130 km^2, respectively in Yusufeli. Both male and female HRS is one of the smallest in the world except for island brown bears in N. America (Le Franc et al.1987). For comparison, average HRS for males and females, respectively, are as follows: Average 1600 km^2 and 225 km^2 (Norway, Dahle and Swenson 2003); 128 km^2 and 58 km^2 (Croatia, Huber and Roth 1994); 322 km^2 and 59 km^2 (Greece, Mertzanis 2004, Kanellopoulos et al.2006); 218 km^2 and 136 km^2 (Poland, Zieba and Zwijacz-Kozica2005); 490 km^2 and 90 km^2 (far eastern Russia, Seryodkin 2006). In Japan the female HRS is 43.04 ± 9.52 km^2 (Sato et al. 2008) while in North America they range widely. For example, in the British Columbia (Canada) females mean home range size is 356 km^2 whereas males' HRS is 800 km^2 (Collins et al. 2005, Le Franc et al.1987); in Admirality and Kodiak Islands female home range sizes are 24 and 28 km^2, respectively (Le Franc et al.1987), and in Montana average male and female HRS are 768 and 128 km^2 respectively (Mace and Waller 1997) (Figure 4.1).

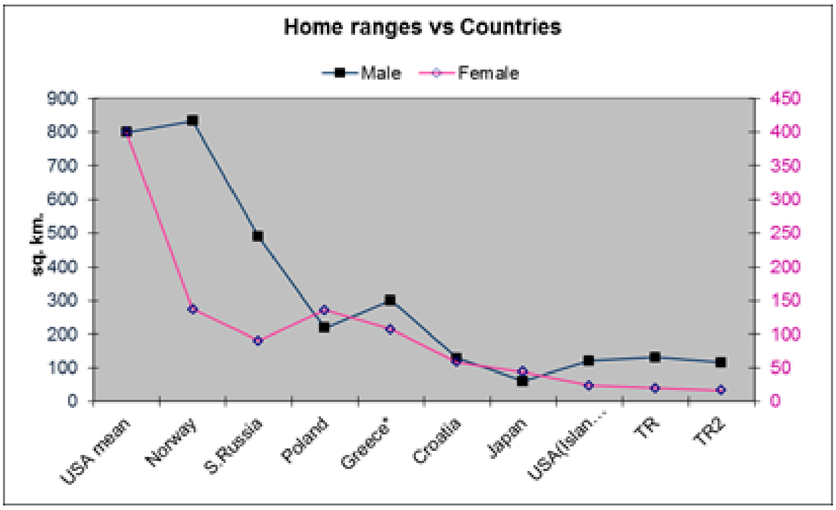

Figure 4.1 Comparison of bear home ranges in different countries by sex. TR and TR2 represent MCP and Kernel estimates.

Dahle and Swenson (2003) attempted to explain low HRS in southern countries by latitudinal difference and enhanced food sources because in temperate forests, there are more foods available compared to boreal forests in northern countries, and body size decreases towards the south. Although these are true, it is difficult to explain the low HRS by only one factor because if that was the case HRS in Croatia or Greece would have been lower HRS similar to that in Yusufeli (which is at comparable latitude). Therefore it is crucial to construct a combined hypothesis that also takes into account bear density, bear and people's behavior, food availability, etc.

Low HRS might also be related to concentrated food sources around settlements in Yusufeli since most of the temporary settlements have been abandoned for years and those areas usually inhabited by bears again. In addition to this, locals do not pick up fruits every year and leave them usually on orchard trees at around their villages. These areas probably were selected by individual female bears as an exclusive habitats (Mcloughlin et al. 2000) because local population is mainly formed by elderly individuals and they don't carry fire guns much and they are afraid of killing a bear due to possibility of prosecute. On the other hand in northern countries productive croplands around settlements are not available to bears and in case of an intrusion to these lands, bears become a target of the locals and these "problem bears" in northern countries probably killed due   to defense of a property or life (Swenson et al. 2000, Servheen et al. 1999, Huber et al. 2008).

Moreover, public hunting is a lifestyle in Balcan and Baltic countries (Linnell et al 2000., Huber et al. 2008, Bischof and Swenson 2009) thus there is always human disturbance which may push bears to roam at a large scale compared to Yusufeli. It was shown that it is the main disturbance factor in bear populations (Linnell et al.2005, Miller et al. 2003, Zedrosser et al. 2011). Another parameter is described by Mcloughlin et al. (2000) for the distribution patterns of home ranges in space for female bears that can affect HRS and density. Thus female bears' home ranges can be thought as distributed without gaps along food sources with possible partial mutual areas in Yusufeli.

In addition to low HRS, bears in Yusufeli also display high HRS dimorphism with a ratio of about 6.56 (by 95% MCP) and 7.00 (by 95% kernel). Although most studies around the world provide a lower dimorphism then this study (Yusufeli), there are cases in Montana (USA) and Sweden where the male and female home range ratio is similar (Mace and Waller 1997, Dahle and Swenson 2003). Sex differences in HRS were revealed by numerous studies in mammals (Ferguson et al. 2009, Lindstedt et al. 1986, Fisher and Owens 2010, Lefranc et al. 1987, Wielgus and Bunnell 1994, McLoughlin et al. 2000, Mace and Waller 1997, Dahle and Swenson 2003). However, a general approach is not sufficient to explain the high ratio of HRS observed in Yusufeli. Therefore, it is also required to discuss population density.

Bears in Yusufeli display a high population density of 230-260 individuals/1000 km^2 and such high densities can also be observed in island populations because of extra food sources, usually in the form of salmon runs (Le Franc et al. 1987). Bear population densities in other parts of the world change mainly according to geographical location and levels of human persecution. Among reported densities are 11.1±8.9 bears/1000 km^2 in Norway and 29.3±18.9 bears/1000 km^2 in Sweden (Støen et al. 2006); 292-342 bears/1000 km^2 in Alaska (Barnes and Smith 1998); 122 bears/1000 km^2 in North America (Miller et al. 1997); 238 individuals / 1000 km^2 (only females) in Admirality Island (Le Franc et al.1987). In Europe the highest densities were reported from Romania (110-200 bears / 1000 km^2, Swenson et al. 2000) and Slovenia (100 bears /1000km^2, Petram et al. 2004).

Therefore, brown bear density in Yusufeli is close to the island populations in N. America which have migrating salmon fishes as an additional dietary item. An extra animal protein source in the diet of Yusufeli bears could have been ungulates; however, only chamois and wild goat occur in bear habitats, but marginally and in too low densities to support such a dense population of bears. Even though natural bear habitats in Yusufeli are not so productive, they can be classified at intermediate quality according to selection in home ranges and HRS overlaps in space for individuals (McLoughlin et al. 2000).

High population density and low home range size in mammals are usually attributed to high density of food resources and primary productivity, which is associated with NDVI (Ferguson et al. 2009, McLoughlin et al. 2000, Harestad and Bunnell 1979, Gompper and Gittleman 1991, Fisher and Owens 2010, Zedroser et al. 2011, Milakovic et al. 2012). Although the average NDVI at the regional scale is too low to support a high density of 239 bears/1000 km^2 in Yusufeli, average NDVI within bear home ranges at the local scale is usually high enough to may support such density.

Female bears are supposed to act as food maximizers, with minimum energy spending and minimum risk of intraspecific conflict (Dahle and Swenson 2003, Dahle et al. 2006). Therefore, females usually stay close to high NDVI areas within small home ranges. Those areas can be called as exclusive habitats used by mostly female bears while male bears need to roam more than females because female show territorial behavior and demonstrate aggression to male bears inside of those habitats. Besides, it has been shown that mammals feeding on sparsely distributed food sources (fruits, hard mast and meat) should have larger home range size than those feeding on uniformly distributed food items, such as grass or leaves (Gompper and Gittleman 1991, Clutton-Brock and Harvey 1978).

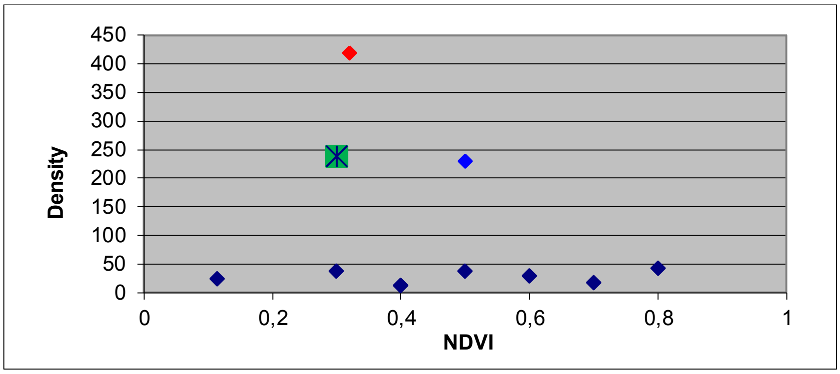

Figure 4.2 Density and NDVI relationship (data were taken from *Zedrosser et al. 2011*). The green square indicates Özgüven whereas red and pale blue dots reflect Alaskan populations

Figure 4.2 shows that density is not much associated with NDVI since despite an eight-fold increase in NDVI densities stayed well below 100 individuals for almost all populations, except Yusufeli and the island populations that have an extra animal protein source. This pattern of constant density by increasing NDVI can be seen in highly territorial species or in managed populations where people determine the density of animals (i.e. Baltic and Balcan countries: Klenzendorf and Vaughan 1999, Huber et al. 2008). Hunting and poaching are important activities which determine the animal abundance viability in the future.

Alternatively, the relation of body size and mean litter size to NDVI might be a good starting point to review the hypothesis that relates primary productivity and density, since there is a positive correlation with primary productivity and biomass (Ruimy et al. 1994, Milakovic et al. 2012, Zedrosser et al. 2011, Ferguson et al. 2009). Primary productivity was measured by average NDVI for representing the available plant productivity for consumers (Ruimy et al. 1994, Zedrosser et al. 2011, Ferguson et al. 2009). Even if, mean female mass in Yusufeli is in line with values in other countries according to NDVI, litter size is lower than expected, so that it is not straightforward to explain the high population density by considering merely the NDVI value (Figure 4.2).

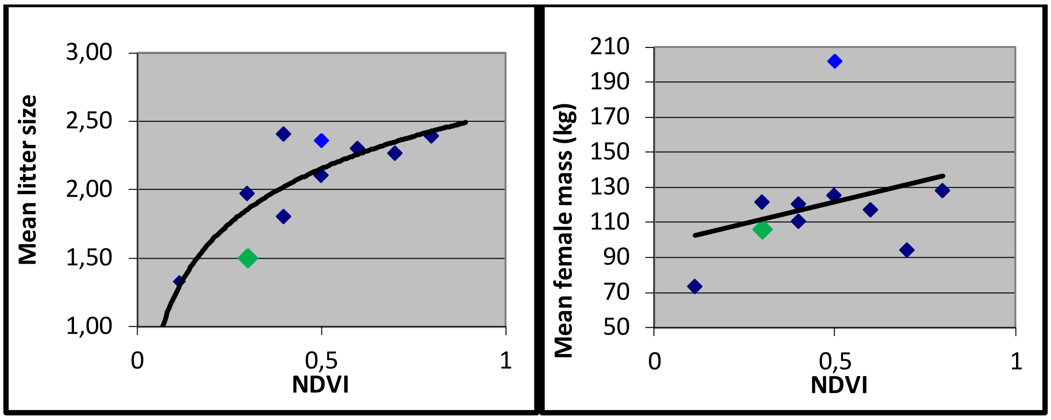

Figure 4.3 Mean females and litter size with respect to NDVI in different countries (Table 4.1 andgreen diamond indicates Yusufeli)

Although the body size measured in this study is close to the lowest end of the mean female mass range and that may explain lower home range sizes observed in southern bears (Harestad and Bunnell 1979) but considerable outstanding variation remains when Dahle and Swenson (2003) analyzed the effects of body size within southern populations. This variation has been attributed to differences in diet, climate, interspecific competition, predation risk, human disturbance, and bear behavior (Harestad and Bunnell 1979, Damuth 1981, Gompper and Gittleman 1991). Factors known to affect HRS in bears include food abundance, population density, and habitat quality (McLoughlin et al. 2000, Gompper and Gittleman 1991, Zedroser et al. 2011, Dahle and Swenson 2003). In Yusufeli, the observed high HRS dimorphism might be the result of numerous characteristics of both sexes and the environmental factors, such as female spatial behavior, body size, cub caring, male avoidance, or food patchiness.

The available natural habitats with a relatively low productivity should not be sufficient to support a high density of bears in Yusufeli. On the other hand NDVI as a representative of productivity could not be a good indicator because pure coniferous forest can reflect high NDVI value around 0.75 whereas an oak stand with mast can reflect 0.5 NDVI value. Thus, even though bears cannot feed on coniferous forest, they seem to provide more food instead of oak patch. Besides, agricultural plots may also reflect lower NDVI values than mixed or evergreen forest but they can provide more food sources to bears. So, primary productivity by using NDVI can create an illusion.

However, anthropogenic food sources in the form of more productive croplands (either actively tended or recently abandoned) and hard mast producing forests may support the high population density directly; also, there is little human-caused mortality since the species is fully protected. Although there is a chance of defensive kills in case of property damage, locals do not practice this option commonly due to possibility of prosecute. Therefore Locally high NDVI values, hard masts, and highly tolerant people towards to bears are the main reasons of high density in Yusufeli compared to other countries aforementioned above.

On the other hand litter size is also lower than many other countries. There might be two reasons of this. The first one may be the population is close to the carrying capacity so litter size is suppressed intrinsically. The second one is that except the Yusufeli population other bear populations are the target of continuous illegal, legal and trophy hunting with artificial feeding which is shown that this lead to increase of litter size in other countries (Huber et al. 2008). The first hypothesis was also partially supported by a study by Ağzıtemiz (2008) that population can continue to grow even by the removal of two female and three male bears from the population in Yusufeli.

Table 4.1 Examples of density, mean litter size and female mass according to primary productivity (Zedrosser et al. 2011) Boldface indicates this study

Population	NDVI	Density (ind./ 1000 km2)	Salmon Avaliability	Mean Female Mass	Mean Litter Size
Pakistan	0.12	24	No	73	1.33
Kluane MP (Canada)	0.3	37	No	121	1.97
Admirality island (Alaska)	0.32	419	Yes	169	1.8
Özgüven (Turkey)	0.36	**239**	**No**	**106**	**1.5**
MacKenzie Mts (Canada)	0.4	12	No	110	1.8
North Sweden	0.4	11	No	120	2.4
Kenai Peninsula (Alaska)	0.5	230	Yes	202	2.36
Denali MP (Alaska)	0.5	37	No	125	2.1
Southern Sweeden	0.6	29	No	117	2.3
West Cantabria (Spain)	0.7	17	No	94	2.26
Dinaric Mts (West Balcan)	0.8	41	No	128	2.39

After aforementioned explanations, several hypotheses were constructed to reveal the situation in Yusufeli and they have two sides. Female contribution to the large female-male HRS difference is probably due to high population density, sexual dimorphism, hard mast availability and female's habitat exclusivity due to high tolerance by the local people in contrast with most northern countries (Table 4.1). Although productivity is used to explain high population density and small HRS in other countries, the observed overall low productivity (mean NDVI=0.338 ±0,071) cannot explain the HRS difference.

It was routinely observed that females prefer to stay close to feeding habitats around villages, abandoned or temporary settlements by constructing exclusive habitats similar to explained by McLoughlin et al. (2000). Secondly, female ranges do not typically overlap so that females can be considered partially territorial or specialized in use exclusive habitats (home range exclusivity *sensu* McLoughlin et al. 2000). Thirdly, to reduce the cub predation risk (male avoidance hypothesis) females restrict their home ranges and stay at highly specialized areas that contain both rugged areas with high slopes and feeding habitats (both hard mast forests and orchards) close to their center of activity (Dahle and Swenson 2003).

Besides, it was shown that female bears can demonstrate aggression not only towards males but also towards females with cubs (McLellan 1994, Wolf and Peterson 1998). Thus it is also probably the case for Yusufeli since two females with cubs were never observed in close proximity but always at distant patches. Females with cubs also travel less than females without cubs, therefore typically restricting themselves within non-overlapping home ranges of about 15 km^2. Cub predation was not recorded despite the high population density but we can speculate that female show more aggression to female bears and mate with more males within their home ranges to decrease a chance of predation from different males. As a result of above and high density, female home range size is smaller than any other result of around the world.

Male contribution to the HRS difference is again associated with male bear characteristics and environmental properties. First of all, males have larger body size than females so they need more food to sustain a higher metabolic rate and activity. Male body size is almost 1.5 times that of female and this can result in at least a two to three times larger HRS difference, Secondly most of the feeding habitats within male home ranges are defended by females with overlapping ranges, especially those with cubs (observations in the field). Thirdly, male bears are highly vigilant to human disturbances due to continuous illegal hunting (roughly at the rate one bear/100 km^2 per year), and probably learned avoidance as a result of experiences with humans and former legal trophy hunting activities (Zedrosser et al. 2011). Therefore they do not protect feeding habitats longer than an hour if they are close to settlements (based on field observations). As the bear mating system is promiscuous, males search possible mates within their home ranges (and sometimes beyond) and always compete with other males for available females. Therefore, their home ranges usually include home ranges of three or four females (Dahle and Swenson 2003). In addition, Dahle and Swenson (2003) speculate that males roam more in order to learn about possible competitors during mating.

Therefore, a male bear needs to cover a range approximately six times bigger than that of a female because it needs to share its resources with other males whose ranges partly overlap with its own, and because, unlike females, males appear to avoid the high nutrient areas around villages due to female aggression. Hence, they must supply their energy requirements from fruits in forest patches or openings and from alpine grasslands instead of meat from wild or domestic animals as in Europe or N. America. Yusufeli bear population is also distinct in its low levels of human-caused mortality than the studied European populations where trophy hunting and defensive kills are frequent. The local people in Yusufeli unintentionally share almost everything they grow with bears and they are more accepting of the damages caused when compared to locals living e.g. in Norway or N. America (Swenson et al. 2000, Huber et al. 2008, Herrero et al. 2001).

4.5. Habitat Selection

All collared bears seem to avoid to alpine grasslands and forest openings probably because of low plant productivity. However, this observation does not agree with the studies in British Columbia where bears preferred forest openings and avalanche chutes (Nielsen 2005, Milakovic et al. 2012). Similar to this study, grizzly bears did not select coniferous forest due to its low productivity but instead selected burned areas within the forest (Milakovic et al 2012). Moreover, hard mast (oak, beech and hornbeam) forest patches appear to provide important bear food as four of the tracked bears showed a significant preference on either deciduous forest or mixed shrubland habitats. Two bears did not show any preference and one showed avoidance. These varied results might be due to low sample size or individual characteristics of the collared bears since the importance of hard mast was shown by recent studies (Kanellopoulos et al. 2006, Kozakai et al. 2011, Milakovic et al. 2012).

There are some unexpected findings related to use of certain features such as roads and settlements which are thought to be limiting by other studies (Nielsen et al. 2002, Apps et al.2004). Overall, roads and human settlements are disturbance factors in terms of bear behavior but in the study region most roads in bear habitats are unpaved and narrow and the settlements have low populations. Therefore, such limiting resources do not restrict a bear's movement (except for Toraman, the biggest male bear tracked) because volume of passing vehicles is low (1-10 vehicles/ per day). Thus bears mostly use roads and do not show avoidance to roads compared to other countries.

On the other hand, productive croplands were important for 6 bears but 3 of them preferred those areas more than expected according to Bonferroni test. Frequent use of agricultural fields as in Greece, Japan and Canada (Kanellopoulos et al. 2006, Sato et al. 2008, Northrup et al. 2011) might provide not only easy accessible food but also incur extra costs. Such agricultural fields were recently defined as an ecological trap for bears (Northrup et al. 2011) because even though they provide good food sources, they can also raise the human-bear conflict and may lead to removal of visiting bears from the population.

It was shown that bear selection by Neu method (1974) produce more accurate results than compositional analysis techniques (McClean et al., 1998). In terms of tracked bears, Bonferroni tests revealed that Bayram only preferred productive croplands and avoided deciduous shrublands, mixed forest, rocky ground and alpine grasslands. Bozo mainly feeds on mixed shrublands at very rugged terrain and avoids croplands. Habitat selected by Dido is productive croplands while it avoids some others. Although only one female without cubs was tracked, it is predictable from the data obtained that female bears usually stay around settlements and agricultural fields, and hence occur at lower elevations than males. In addition to this, Martin et al. (2010) revealed that females with cubs stayed around steep slopes and rugged terrain to avoid other bears and in order to obtain olfactory information by wind as it was practiced by Hazal. Besides Martin et al. (2012) couldn't find any avoidance to settlements as female bears did in Yusufeli. Olsen et al. (1997) and Tollefson et al. (2005) suggest that human infrastructure may even be an attractive feature in the landscape once females no longer fear them, because they may provide access to food or reduced intraspecific competition.

4.6. Population Estimate and Density

Population estimates within the focal study area were very close to each other. Fcubs estimation gave a similar result to the mark resight estimation. In addition, personal and more subjective identification of bears either from camera trap photos or from observed individuals resulted in a population size of 18-20 bears within the focal study area. So, three estimates provided consistent results although they have different confidence intervals and bias. Overall population size within the focal study area was higher than in many countries as before mentioned in population density and HRS sections.

Even though population estimates gave high densities within 100 km2, the level of high density could not be maintained easily in the future because human population will be decreasing and abandoned fields including orchards will be decreasing, too.

So bears may not feed well and conflict will probably increase. Therefore, survivals would decrease and local people will try to handle the conflict causing bears with illegal ways: either by capturing or directly killing. Moreover, litter size was comparatively lower than in other countries, similar to less reproductive habitats. Within thirty years by decrease in agricultural fields, female bears could not be feed well and probably litter size may decrease below the current size and population may decrease. Their signs actually were seen in the spring 2012 after our studies finished in the area, two of our collared bears were poached by locals from a village responsible from the most of the illegal kills in the study area: Altıparmak and Bıçakçılar.

Overall population size was around 103-124 bears in the Kaçkar Mountains part of Yusufeli. This means that population might be at the level of carrying capacity. Even if there are repetitive counts in former inventories in 2002 and 2004 and 2005 and Department of Game and Wildlife in Artvin revealed 70 to 130 bears in various scales. This study clarified that population size in southern part of Kaçkar mountains in Yusufeli is above 100 independent individuals.

CHAPTER 5

CONCLUSION

This study revealed brown bear home range sizes in Southwest Asia including more than 10 countries for the first time. HRS was one of the lowest in the World and close to island populations. HRS difference by sex was very similar to Montana and island bear populations in Alaska. Females demonstrated extraordinarily territorial behavior on their exclusive habitats around settlements with higher productivity. Brown bear feeding habitats were mainly around settlements including agricultural and orchard land and abandoned fields where human inference was very limited. Although brown bear population in Yusufeli has one of the high population densities in the world, they mainly depended on anthropogenic agricultural products and hard mast instead of extra animal-based food sources like salmon and wild ungulates.

Population size in the focal study area and density in the whole study area were at least 20 adults/100 km^2, verified by three different field methods. Besides, human caused mortality rate was low compared to European and American countries. Based on findings, experiences in the field, locals' demands, poaching and PVA studies, it is quite likely that bear populations are probably extending their distribution to former habitats and population size may have been increasing as overall in Turkey. Brown bear conservation strategy should be revised based on this fact.

Animal protection law is a prestigious legislation but it is insufficient for effective conservation. A comprehensive vision is needed in wildlife management to serve the needs of brown bears and local villagers. The vital action would be to establish damage compensation schemes since damage is about $ 20.000 in Yusufeli annually. The budget can be obtained from the funds of Local Governor or money obtained from scientific trophy hunting.

Decreasing illegal kills or poaching by compensation mechanisms will support viability of bear populations. Besides, the department can develop some preventive measures and establish a bear management team to deal with illegally captured bears by locals and accustomed bears to decrease damage to both sides. Usage of bear frightening devices should be supported by Nature Conservation and National Parks. Electric fence must be provided with locals and bee keepers by local Governance or Nature Conservation and National Parks. Besides, collaboration with the Department of General Directory of Forestry and Nature Conservation and National Parks to increase plantation of the wild orchards tree at the temporary settlements could keep bears at high elevations and decrease human-bear conflict.

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APPENDIX A

CAPTURING BEARS

Too many equipment are needed to conduct this kind of study but the main ones are binocular, telescope, digital cameras, GPS device, tripod, preferably netbooks and external hard drives, head lamp, a big torch, all camping material (stove, four season tent, insulator, sleeping bag and sticks, personal wilderness experience and travel medicine), too many rechargeable batteries, game cameras and a four wheel drive car for carrying and transporting stuff.

Main capturing equipment are foot snares, box traps and a carrier, all toolboxes of carpenter and big barrels for storing baits and boiling snares, hand gloves, masks, rain protections, big sticks, scales, rifle and two accompanying persons and field veterinarian (Jonkel 1993, West et al. 2006). Anesthetizing bear also require all veterinarian equipment and drug for example blow pipe, air powered rifle, many syringes, cold water, thermometer (Jonkel 1993, West et al. 2006). Tracking animal requires collars, VHF, UHF antennas and computer programs and dedicated persons.

During four capturing session in Yusufeli, seven brown bears (5 Male-2 Female) were captured by using Aldrich foot snares. One male (11 years old, 135 kg) was captured in May and other four (3 years old-75 kg subadult male, 9 years old female 123 kg, 7 years old female 85 kg, 5 years old male 160 kg). One adult male (82 kg, 4 years old) was captured in early June and biggest male (180 kg, 11-12 years old) was captured during early October. The most interesting captured brown bear was the female that had lost part of its right leg. She was probably captured by a local jaw trap several years ago but escaped and recovered. The biggest bear Toraman was also probably captured by a trap that was a tightening cable snare in the past because it had a circular scabby wound on the bottom part.

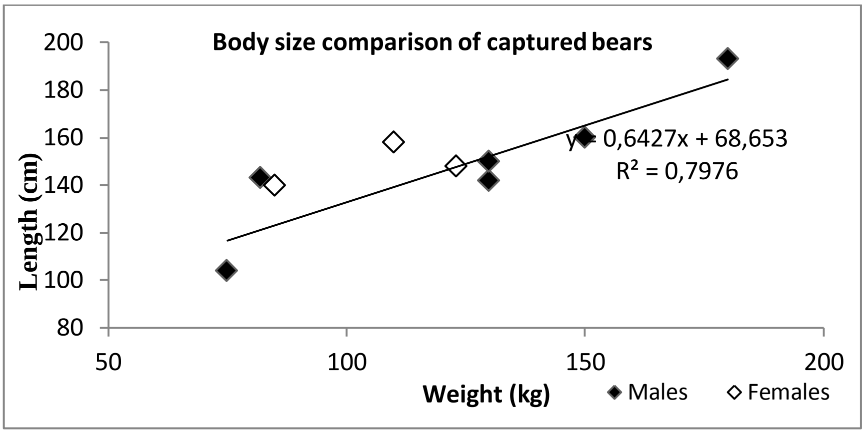

Figure A.1 Bear weight and body size comparison that include two more bear, not GPS-collared

Head measurements can give clues about bears' sex and age groups (table 3.2). From the captured animals females have shorter head length and narrower width whereas males have long and wider head. For example, the width/length ratio is around 0,58 in males whereas only 0,35 in females. Another important measurement during fitting a collar is the neck girth since improper adjustment of the collar can lead to malfunction of GPS collars, hurt the animal or drop prematurely. The mean male neck girth, 71,4 cm is larger than that of females, 58 cm. Such information is useful while ordering a collar because new GPS-GSM collars has only 10 % adjustability compared to VHF collars.

Table A.1 Bear head and neck measurements

Bears	E (cm)	F (cm)	Ratio F/E	Neck Girth
Hazal	36	12	0,33	64
Dido	36	13	0,36	52
Bayram	34,5	13	0,38	49
Bozo	34	18	0,53	55
Kesikkulak	52	29	0,56	80
Tosun	31	18	0,58	68
Toraman	48	28	0,58	80

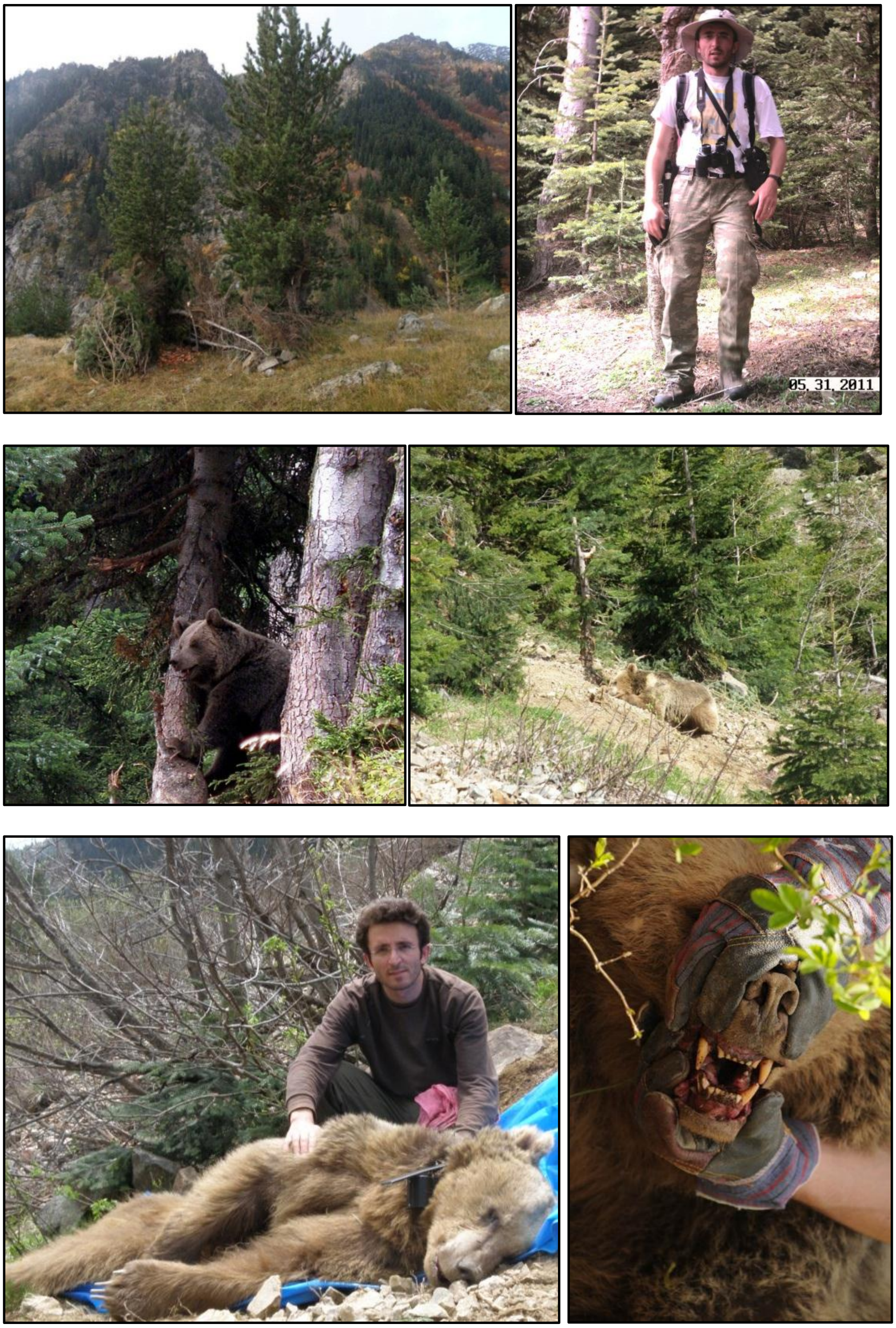

Figure A.2 Trap sites, captured bears, and field photographs

CURRICULUM VITAE

1. **Name** : Hüseyin Ambarlı
2. **Date of birth**: 30.08.1980
3. **Nationality** : Turkey
4. **Civil status** : Married
5. **Web page and e-mail**: bearstudy.blogspot.com- huseyinambarli@gmail.com
6. **Education** :

Institution **[Date from - Date to]**	**Degree(s) or Diploma(s) obtained:**
METU Biological Sciences Department 1998 – 2003	B.Sc. Biology
Graduate School of Natural and Applied Sciences of METU, 2003-2006	M.Sc. Biology
Graduate School of Natural and Applied Sciences of METU - 2006 -2012	Ph. D. Biology

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

Language	**Reading**	**Speaking**	**Writing**
English	1	1	1
Turkish (native)	1	1	1

8. **Membership of professional bodies:**
   - Society for Conservation Biology
   - International Bear Association
   - METU Mountaineering and Winter Sports Club
9. **Other skills:** (e.g. Computer literacy, etc.)

- Basic Computer Programs: All MS Office Suite and Star Office Suit
- GIS and RS programs: TNT-mips, Arc-GIS intermediate
- System / Network : Local Area Network (Good), Linux (Intermediate), MS Systems
- Statistical programs: MINITAB and SPSS(intermediate), RAMAS Eco Lab. and various PVA software (Good)

10. Artistic skills and Competences:

Mountaineering and climbing, , professional Nordic skier, Nature photography, line skating, volleyball and playing percussions

11. Publications

Ambarlı, H. ve Bilgin, C.C. 2008. Human–brown bear conflicts in Artvin, northeastern Turkey: Encounters, damage, and attitudes. Ursus 19 (2): 146-153

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