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Habitat model for the restoration of Lesser Kestrel (*Falco naumanni)* in Bulgaria

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Abstract of the thesis submitted by:

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Lesser Kestrel (*Falco naumanni,* Fleischer, 1818) is globally threatened small falcon species. Despite the secured legal protection and conservation efforts in Bulgaria there are presently no confirmed breeding of Lesser Kestrels. It is, however, considered that the main threats for the species have been eliminated and it might be feasible to restore Lesser Kestrels through human-induced reintroduction.

To support the planning and implementation of the reintroduction programme the current study has aimed to compile a general methodology for determining the habitat suitability for Lesser Kestrel in Bulgaria, identify potential restoration areas and develop a set of recommendations for the successful re-establishment of the species.

In order to achieve this aim a general overview of the habitat preferences of Lesser Kestrel was completed through literature review, field visit to existing Lesser Kestrel colonies and expert consultations. Based on these a general habitat suitability model was developed to identify potential Lesser Kestrel habitats. The model was then implemented in Geographic Information Systems for a target area in Southeastern Bulgaria and potentially suitable areas were found, compared and analyzed.

It was concluded that there are suitable areas for Lesser Kestrel restoration in Southeastern Bulgaria. Furthermore, considering the data collected on field on the nearest confirmed breeding colonies of the species human-induced reintroduction was suggested as a feasible strategy for re-establishing the species as opposed to the uncertain possible natural recolonization.

The findings of the study are included in the Feasibility Study for the Potential Reintroduction of Lesser Kestrel in Bulgaria conducted by the Green Balkans NGO.

Keywords: Lesser Kestrel, Habitat Suitability model, reintroduction, Bulgaria

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I Introduction

The Lesser Kestrel (*Falco naumanni,* Fleischer, 1818) is a small falcon species that is a useful ally of man in combating pests in agricultural landscapes. Once considered among the most abundant birds of prey in Europe (Bijleveld 1974), today, due to agriculture intensification, farmland abandonment, loss of nesting sites and intensive pesticide application (Hagemeijer and Iankov 1997) it has an uncertain future.

I.1 Background

I.1.1 Lesser Kestrel. Global distribution, threats and conservation status

The Lesser Kestrel has Palearctic distribution (Biber 1996), found from Southern Europe (mainly the Mediterranean region and to the North of the Black Sea), Turkey and Asia to China (Hagemeijer and Iankov 1997). It is mainly a migratory species (Cramp and Simmons 1987) and during winter only few European birds remain in Southern Spain, Southern Turkey and Malta, while the most migrate to their wintering quarters on south of Sahara – Senegal, Botswana, Namibia, South Africa (BirdLife International 2008; Cramp and Simmons 1987)

A massive population decline, equivalent to approximately 46 % of the population disappearing each 10 years in the period 1950 – 1990 took place in Europe (BirdLife International 2001, 2008). It was then followed by some stabilization in the period 1990-2000 (BirdLife International 2004), but despite that, the Lesser Kestrel populations continue to disappear, most notably in the Southeastern European countries (BirdLife International 2004). At present the entire European population is estimated at some 17 000 – 21 000 breeding pairs (BirdLife International 2008), undergoing a small decline (BirdLife International 2004). The strongest remaining Lesser Kestrel populations are found in Spain (12 000 – 20 000 pairs) and Turkey (5000 – 7000 pairs), while the species is considered to have already gone permanently extinct from Croatia, Slovenia (BirdLife International 2004) and Poland (EUNIS 2010). The species has good population in Asia, with Kazakhstan holding some 5000 – 8000 pairs (BirdLife International 2001). The disappearing population on the Balkans is thus an important link between the core Lesser Kestrel populations of Middle Asia and Turkey and the strongholds of the species in the Western Mediterranean countries (Portugal and Spain).

There are numerous suggested causes for the global Lesser Kestrel population decline such as: increased insecticide use, which have caused secondary pesticide poisoning by the used insecticides and heavy metals (Cramp and Simmons 1987), decrease of grasslands and field margins, afforestation and increase of sunflower plantations resulting in food shortage (Donazar *et al.* 1993). Additional reasons that have been identified to negatively impact Lesser Kestrel populations are lack of suitable nesting sites (Catry *et al.* 2009; Forero *et al.* 1996; Franco *et al.* 2005), as well as, on a much lesser scale - nest predation (Catry *et al.* 2009).

In an attempt to protect the species, it was included in numerous international and national nature conservation documents - The Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) - Annex II; The Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention) - Annex I, II; the Council Directive 79/409/EC on the conservation of the wild birds (Birds Directive) - Annex I; The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) - Annex II (EUNIS 2010). It is classified SPEC 1 – "species of global conservation concern" in the list of Species of European Conservation Concern, due to the proven large historical decline (BirdLife International 2004). In a further attempt to secure its survival, an International Lesser Kestrel Action Plan has been developed (Biber 1996). It provides for recolonization activities, additional studies on the habitat use and public awareness campaigns (Biber 1996).

Despite the secured legal protection, scientific attention and expert efforts, its global threat status remains *Vulnerable* (according to IUCN classification) and the most recent population trend estimate is "decreasing" (BirdLife International 2004).

I.1.2 **Status in Bulgaria**

In the past the Lesser Kestrel was widely spread in Bulgaria, nesting "everywhere" in the mid-XIX (Radakoff 1879). The species was still fairly common in the 1950s, when the Lesser Kestrel was mentioned to be breeding in Southern Bulgaria (Patev 1950). At 1965 the species had disappeared from its main nesting sites in settlements in most parts of the country, holding a patchy distribution mostly in Southern Bulgaria (Barov 2002). Breeding was later confirmed by Cramp and Simmons (1987), though the species' distribution was noted as "obscure", while numbers were claimed to have been affected by major decline and reduced to "few" (Cramp and Simmons 1987).

For the period 1980 – 1990 Snow (1998) suggested a minimum of 57 confirmed pairs (Snow 1998), while Michev (1990) estimated a breeding population of up to 10-100 pairs (Simeonov *et al.* 1990). Two of the colonies known at that time were located in Southeastern Bulgaria, close to the Turkish border (Barov 2002). For the entire period 1951 – 1991 the species was reported in a total of 86 nesting localities (Iankov *et al.* 1994).

More recent data on the numbers of Lesser Kestrels breeding in Bulgaria assume 57 – 100 pairs (Biber 1996), followed by estimates dropping to 0 – 5 breeding pairs for the period 1995 – 2000 (Barov 2002; BirdLife International 2004). At present only single wandering birds and small flocks are being observed and no nesting Lesser Kestrels can be confirmed (Barov 2002; BirdLife International 2004; GB 2010) (Annex IX.1).

I.1.3 Ongoing conservation efforts in Bulgaria

The Lesser Kestrel is included in the Bulgarian Red Data Book as "*threatened with extinction*" as well as in the national Biodiversity Conservation Act, Annex II and III.

At present there are several on-going projects aiming at restoring and conserving the Lesser Kestrel breeding population in Bulgaria. One of the main actors is the Green Balkans Federation of nature conservation NGOs, which is exploring the possibilities for restoring the species in Southeastern Bulgaria through captive breeding and further release in line with the recolonization provisions of the International Action Plan (Biber 1996) and the National Action Plan for the conservation of Lesser Kestrels (Barov 2002).

In 2009 Green Balkans started a three-year project "Conservation activities for EEC Birds Directive target species – Lesser Kestrel, Black Vulture and Imperial Eagle in their main habitats in Bulgaria", funded by the European Union through the Operational Programme "Environment" 2007-2013 (GB 2009a). Among its objectives are support and maintenance of the populations of the target species, creating conditions for increasing their numbers and restoring their populations in their former habitats, "ex-situ" activities for restoring the population of the Lesser Kestrel and identification of areas from the habitats of the target species sensitive to investment intentions (GB 2009a). The project comprises the areas of the Derventski Heights, Sakar, the Eastern Rhodopi Mountains, part of Strandja, and their adjacent areas, which harbour the main habitats of the three target species (GB 2009a) and are among the last confirmed breeding sites of Lesser Kestrels in Bulgaria (GB 2010; Simeonov *et al.* 1990). The project also provides for development of a Feasibility Study for the potential reintroduction of Lesser Kestrel in Bulgaria.

In addition to that, Green Balkans has just completed a project "Lesser Kestrel – no past, but future" Project, aiming at importing 2 breeding pairs of Lesser Kestrels from Walsrode Fogelpark, Germany and accommodating them in the Wildlife Rehabilitation and Breeding Centre at Green Balkans in order to create a captive-breeding stock of birds for potential release (GB 2009b).

I.1.4 Problem statement

Despite the secured legal protection and direct conservation measures aiming at Lesser Kestrel and its former nesting sites in Bulgaria, the species has an unclear nesting status in the country at present and no breeding colonies have been confirmed for the past 10 years (Barov 2002; BirdLife International 2004; GB 2010). It is however believed that the main threats which have caused the decline of Lesser Kestrel have been eliminated and that the species can be successfully restored in Bulgaria. This can be achieved through either natural recolonization or through human-induced reintroduction in potentially suitable areas.

Not only is reintroduction of Lesser Kestrels being discussed as a feasible alternative of the uncertain potential natural recolonization by expanding neighbouring populations, but there are also expert capacities, facilities and funds available for the conservation of the species in Bulgaria.

It is therefore important to assess if the contemporary environmental conditions in Bulgaria are indeed suitable to sustain the re-establishment of Lesser Kestrels. In addition to that, the preliminary identification of potential Lesser Kestrel areas would significantly improve the planning and implementation of any conservation and restoration activities.

However, considering the huge costs of a potential wide-scale reintroduction programme and the vast territory of Bulgaria it is suggested to develop a general approach and then test it on an area that was identified as most suitable in advance.

The preliminary scoping analysis pointed out the area of Southeastern Bulgaria as a most potential Lesser Kestrel target location. The selection was based on several characteristics of the region. On one hand, the last confirmed breeding colony of Lesser Kestrels was documented in Southeastern Bulgaria at the end of the 1980s (GB 2010)(Annex IX.1). In addition to that, a group of Bulgarian experts identified that area as most relevant for studying the possibility of restoring the Lesser Kestrel population in the country (GB 2009a).

On the other hand, the region borders Turkey, which is known to be a stronghold of the species, maintaining the third largest population of Lesser Kestrels in the world (BirdLife International 2004; Parr *et al.* 1997). Such close proximity to the stable large Lesser Kestrel populations in Turkey would allow for avoiding isolation of the restocked Bulgarian population and could potentially assist a future connection of the Asian population to the Western Balkan populations and thus to the growing Mediterranean population (Italy, Spain and Portugal) within the global range of the species.

I.2 Aim and objectives

Therefore the aim of the current study is to develop a methodology for determining the habitat suitability for Lesser Kestrels (*Falco naumanni,* Fleischer, 1818), identify potential habitats in Southeastern Bulgaria and formulate recommendations for successful recovery of the species in the country.

This aim can only be achieved after careful exploration of the environmental requirements of Lesser Kestrels. There are various sources of information: behavioural studies in different countries, field observations, journal articles, action plans and reports, but no attempts to aggregate this data into a distinctive set of general criteria within habitat suitability model, adapted to the Bulgarian conditions has been made. It is therefore crucial to collect, summarize and interpret the existing information from various sources in the context of Lesser Kestrel restoration planning and support in Bulgaria.

Nest site availability is among the key factors for securing a successful reintroduction program (Catry *et al.* 2009; Forero *et al.* 1996; Franco *et al.* 2005; Pomarol 1993) and the presence of suitable nest sites has been proven to be a limiting factor for Lesser Kestrel populations (Catry *et al.* 2007; Pomarol 1993). The Lesser Kestrel does not build its own nests but uses already existing holes, banks, ruins, freely taking holes on buildings, occasionally nesting on cliffs or in hollow trees or artificial nest boxes (Bux *et al.* 2008; Catry *et al.* 2007). It is thus of great importance to locate suitable nesting sites and such for installing artificial nesting structures considering various parameters, from local environment, land use patterns, food availability, adjacent habitat types to persecution and other potential threats. There is therefore a need to develop a set of criteria that describe the environmental characteristics of a successful breeding site. In order to formulate these criteria, the distribution of the existing populations close to the Bulgarian borders can be surveyed. This information can then be utilized to compile a habitat model to identify corresponding nesting areas in Southeastern Bulgaria.

The Lesser Kestrel is an opportunist feeder, exploiting mostly insects (locusts, beetles, butterflies, moths, etc), but also small mammals (shrews, mice, small birds) or reptiles (skinks, lizards) (Cramp and Simmons 1987). It is much dependent on the density of prey, foraging on lightly vegetated, partially bared terrains, dry grassland and low-intensity cultivated plains, avoiding wetlands, forests and scrubs (Cramp and Simmons 1987; Hagemeijer and Iankov 1997). Small differences in abundance of prey among different crop types has been proven to results in major differences in breeding success of colonies (Rodriguez *et al.* 2006). Furthermore, the high nestling mortality rates caused by starvation has been correlated with the decline of the Lesser

Kestrel populations in Spain (Hiraldo *et al.* 1996; Negro *et al.* 1993). All these studies show the great importance of securing suitable high-quality foraging sites for maintaining and restoring the eventual restocked Lesser Kestrel population in Southeastern Bulgaria.

Considering the careful planning and preparation, high expenses as well as expert capacity and time needed to complete an entire reintroduction programme, such activities are carried out only once there are no possibilities for natural re-establishment of the considered populations (IUCN 1998). It is therefore important to carefully plan the strategy required to restore the species in Bulgaria, also exploring the options for natural return.

Regardless the way the species is re-established in Bulgaria, through either reintroduction or natural recolonization, it is important to conserve and maintain the habitats it inhabits or are potentially suitable to maintain colonies. As agricultural intensification, farmland abandonment and pesticide use have been blamed for the major population decline throughout Europe (Donazar *et al.* 1993; Hagemeijer and Iankov 1997), the proper management of the preferred habitats is of crucial importance for the survival of the species. Therefore a set of recommendations for the adequate maintenance and management of the areas where a Kestrel population is to be reintroduced needs to be developed and enforced as a prerequisite for the success of the entire reintroduction programme. In addition to that, it is of crucial importance to identify and address the main stakeholders – both authorities and land users, who are directly responsible for the management of these areas in order to secure the proper conservation of the species and plan adequate ways to convey and implement the provided management recommendations.

The current study has therefore adopted the following objectives:

- Collecting and aggregating data on the environmental requirements of Lesser Kestrels from different sources and using different methods;
- Compiling a Habitat Suitability Model as a general set of criteria for identifying suitable breeding and foraging sites for Lesser Kestrels in contemporary Bulgarian environment;
- Identifying potentially suitable Lesser Kestrel sites in Southeastern Bulgaria applying the Lesser Kestrel Habitat Suitability Model;
- Assessing the perspectives for natural Lesser Kestrel recolonization against human-induced reintroduction programme;
- Suggesting a strategy for the Lesser Kestrel recovery and management in Bulgaria.

The results of the study will be used as a substantial part of the Feasibility Study for the Potential Reintroduction of Lesser Kestrel in Bulgaria.

II Literature Review

The following chapter introduces the terms used and attempts to review some successful examples of completed reintroduction programmes and the methods they have utilized to effectively predict the ecology and habitat requirements of the species reintroduced.

The first section provides explanation of the main terms and notions used.

The second part justifies reintroduction as a promising conservation approach, focusing on the strategies selected at the preparatory phase to secure the latter survival of the released animals. These strategies include the proper use of historic breeding records to assess reintroduction viability; the choice of the right parameters to evaluate the contemporary habitat suitability; the timely identification and addressing of the local stakeholders and authorities, etc. All these strategies are analyzed in order to identify common trends that have lead to success and are later taken into consideration for the development of the Habitat Suitability model for Lesser Kestrel. Furthermore, the Lesser Kestrel reintroduction programme attempted in Portugal (Pomarol 1993) and discussed below is of particular interest for identifying factors of key significance for the species and including them in the Habitat Model developed within the present study.

The third part discusses habitat modeling strategies in particular, comparing statistical and expert knowledge-based solutions, as well as their combinations. The overview and examples discussed are used to prove that successful habitat models can be built based on the three approaches described and to justify the approach chosen for the present study.

The fourth part is devoted to the use of Geographic Information Systems (GIS) to perform complicated habitat assessment analysis, combining spatial and attribute information (Malczewski 2004) from various sources, weighting and overlaying it to come up with new data to support decision and aid visualization of the obtained results. The section provides various examples for using GIS techniques within environmental studies on existing populations – deriving correlations, factor dependencies and statistical information in order to expand the knowledge on the biology and ecology of the reviewed species and support their conservation. The factors found out significant for the various species discussed are later considered also within the development of the current Lesser Kestrel Habitat Model. The section also provides comments on the use of the GIS approach, discussing potential sources of errors and problems related to this method.

II.1 Definition of terms

The term "*reintroduction*" refers to the attempt of establishing a species in areas, which are part of its historical range, but where it is no longer found (being extirpated or become extinct) (IUCN 1998). Reintroduction requires a broad multidisciplinary approach and aims at establishing a viable free-ranging population of the given species, securing its long-term survival, enhancing biodiversity and promoting conservation awareness (IUCN 1998). As it requires broad expert capacity, profound knowledge on the ecology and biology of the species and major financial investment (IUCN 1998) it is considered only when there are no prospects for natural recolonization.

"*Natural recolonization*" is the process of reclaiming of the formerly abandoned territories by expanding nearby populations of the species considered (IUCN 1998).

Considering the unclear status of the nesting population of Lesser Kestrel in Bulgaria, the term "*restocking*" is also used within the current study. "Restocking" should be perceived as supporting an already existing breeding population, releasing conspecifics (individuals of the same species).

Both reintroduction and natural recolonization should lead to "*re-establishment*" of the population, used below to refer to the restoration of a successfully breeding population in the formerly inhabited areas.

"*Habitat suitability*" should be interpreted as the capability of given environment to provide particular conditions for breeding and survival of the considered animal population (Block and Brennan 1993).

Thus, the "*habitat suitability model*" is a set of independent environmental factors and their range of values that determine the suitability of a given area for a particular species and can thus be used to predict or model the potential distribution of that species.

II.2 Successful reintroduction projects

Considering the contemporary rates of biodiversity loss, reintroduction programmes are becoming more frequent all over the world (IUCN 1998). Reintroduction programs can be successful only if the ecological requirements of the species are well-understood. On the other hand, reintroduction programs provide for better understanding of the species ecological needs (Hirzel *et al.* 2004). It is therefore important to review the already carried out attempts in order to justify the feasibility of a potential Lesser Kestrel reintroduction programme, as well as utilize and adapt the global practices that have proven most effective.

II.2.1 Case studies

The following section presents some successful examples for bird reintroduction projects, focusing on falcons and birds of prey in particular and stressing on the preparation and release habitat selection phases.

II.2.1.1 Lesser Kestrel restocking in Spain

The Lesser Kestrel disappeared as a breeding species from Catalonia, north-eastern Spain at the end of 1970s and the early 1980s, following an overall decreasing trend in Spain taking place from the 1960s (Pomarol 1993). Even though the reasons for the extinction of the species were not entirely clear, field research for the possible reintroduction of the Lesser Kestrel in Catalonia started in 1988, inspired by the existing population of 150 pairs breeding in neighboring Monegros (Aragon) (Pomarol 1993). Two reintroduction sites 200 km apart were selected – Alberes (Girona) and Algerri (Lleida). The choice was not based on historic distribution but rather on contemporary habitat quality: Mediterranean arid climate, scarcely vegetated or covered by cropland and presence of suitable nesting sites (Pomarol 1993). Releases started in 1989 and until 1991 more than 70 birds were successfully hacked back into the wild (excluding some that were too old or imprinted to people but were also released) (Pomarol 1993). It is estimated that the success of these 70 birds was some 85-90 %. A single year after the first release, in 1990, two breeding pairs were formed just 7 km away from one of the release sites (Alberes). One of the breeding birds was an adult non-ringed male, which had been seen in the area before and had probably acted as a conspecific attraction for the younger birds (Pomarol 1993). Until 1991 no returning or nesting birds were observed in the second release site – Algerri. Pomarol (1993) attributed that to the fact that though some of the Lesser Kestrels breed as one-year-olds, not all of them do, and considering the short period of only three subsequent years of releases, there was still a chance of some of the birds returning to site (Pomarol 1993). This restoration example was considered successful and encouraging (Pomarol 1993).

II.2.1.2 Peregrine Falcon global reintroduction programmes

There were four famous National reintroduction programs for Peregrine falcons (*Falco peregrinus*, Tunstall, 1771) in United States, Canada, Germany and Sweden. The releases were carried out in well-known historical sites as well as in habitat types that were not typically associated with peregrines (urban areas, city towers, etc.) (Burnham 1984). In some of the cases, such as the Eastern USA programme, the birds released in historic sites were even less successful due to predation on young (Burnham 1984). The first documented successful breeding of the reintroduced captive-bred Peregrines occurred in Canada in 1977 (Cade *et al.* 1988); followed by pairs that bred in United States, Germany and Sweden in the subsequent years (Cade *et al.* 1988).

II.2.1.3 Aplomado reintroduction in USA

The last confirmed breeding pair of Aplomado falcons (*Falco femoralis septentrionalis*, Temminck, 1822) in the USA was reported in 1946 (PF 2010). Their disappearance from their former northernmost range was associated with land-use transformations, change of agricultural practices and excessive grazing that had taken place in USA (PF 2010). Despite that, an existing breeding population remained in Chihuahua, Mexico, in direct proximity to the states of New Mexico and Southern Texas, where the Peregrine Fund started their reintroduction programme in the 1990s (Hunt *et al.* 2006; PF 2010). The releases started despite the fact that the native habitat of the species – savannah, had turned into farmland and patches of brush (Hunt *et al.* 2006). The reintroduction was considered justified as some of the last breeding attempts of the species had occurred in that area, the species held highest historical density there, there were unoccupied habitat patches and there were still observations of the species in the area (Soorae 2008). At 2008 there was already an established wild population of more than 40 territorial pairs formed by the reintroduced birds (PF 2010). As a crucial part of the reintroduction, at that same time, a total of 2,1 million acres of Aplomado suitable habitat in Texas were already recruited within a Safe Harbor Program, intended to develop agreements to reduce the owners' concerns related to endangered species and secure the survival of critical habitats for the falcon (PF 2010). This example is considered as a highly successful reintroduction (Soorae 2008).

II.2.1.4 Bearded vulture reintroduction in the Alps

The European Endangered Species Programme (EEP) for Bearded vultures (*Gypaetus barbatus*, Linnaeus, 1758) started in 1986 with a programme for captive breeding in breeding centres and zoos and further release of the young in selected areas in the Alps. Extensive studies on the habitats available in the Alps, historical breeding sites, potential food base, acceptance of people, etc. was completed prior to the start of the releases (Soorae 2008). Four release sites, 200 – 300 km away from one another were selected, almost all within protected areas – Hohe Tauern, Engadin/Stelvio, Haute Savoye, Mercantour/Alpi Marittime (WS 2010). The programme yielded first results in 1997, when the first breeding pair in the wild was discovered (Zinc 2005). At present breeding of second generation birds has been confirmed and therefore the programme is considered highly successful (Soorae 2008).

II.2.1.5 Californian condor global rescue

When only 22 Californian condors (*Gymnogyps californianus*, Shaw, 1898) remained in the wild (1980s), all of them were caught and set for captive breeding in California, Aidaho (PF 2010). Critical habitats were assessed and mortality factors were studied before initiating the releases (NPS 2009). By 1996 the Peregrine Fund had enough birds to start releasing, and the first young hatched by these birds in the wild appeared in 2003 (PF 2010). At 2008 there were already 66 wild condors in Arizona and some 12 more waiting to be released at Vermilion Cliff site (PF 2010). Still, poisoning from the lead pellets used by the local hunters is considered a main obstacle for restoring a viable and self-sustaining wild population of Californian condors, thus further work with the local communities is needed (Hunt *et al.* 2009).

II.2.1.6 Red kite restoration in UK

The restoration efforts for Red Kites (*Milvus migrans*, Boddaert, 1783) in the UK began in 1989 with a programme initiated by RSPB and the Nature Conservancy Council. In the period 1989 – 1994 a total of 93 birds of Swedish and Spanish origin were released in Scotland and England (RSPB/SNH 1999). In the period 1996 – 1998 other 57 young German kites were released in Scotland. The first recorded success came in 1992 with the first hatching of a young into the wild (RSPB/SNH 1999). Despite the success elsewhere, Kites remained scarce in northwest Hampshire so reintroduction efforts were initiated there too (Soorae 2008). The preparation included work with local stakeholders and landowners and selection of suitable habitats – a mixture of wooded patches to secure breeding sites and open areas for foraging (Seoane *et al.* 2003). In 2008 there were already 3 confirmed nests within 5 km of the selected release sites in northwest Hampshire as well, thus that programme was considered successful too (Soorae 2008). By 2007 more self–sustaining breeding populations established in all but the most recent release sites (Carter *et al.* 2008).

II.2.1.7 White-tailed Eagle return in UK

The White-tailed eagle (*Haliaeetus albicilla*, Linneus 1758) became extinct in UK in 1918, presumably mostly due to persecution, egg and skin collection, climatic changes and disappearance of important food items (Love and Ball 1979). The Nature Conservancy Council started a reintroduction programme on the Island of Rhum, Scotland, translocating 82 young birds from Norway in the period 1975-1985 (Evans *et al.* 2009). The island of Rhum was selected as being in the core of the former breeding range of the species, being less isolated than Fair Isle, where previous efforts had failed and at the same time rich in deer, feral goats, fish and seabirds around its coasts (Love and Ball 1979). In addition to that, the island of Rhum is a National Nature Reserve with strictly controlled access and where human disturbance could be kept to a minimum (Love and Ball 1979). The first success was reported in 1983, when the first chick hatched into the wild (RSPB 2005). The success of the programme is maintained through the joint efforts of nature conservationalists, police and local communities, encouraged by the tourist interest. Custodial sentences for egg-robbers have been introduced, while close collaboration has been developed with the local landowners and crofters (RSPB 2005). At present the Royal Society for Protection of Birds is carrying out a feasibility study for the possibilities of reintroducing the White-tailed eagle also along the Suffolk coast (RSPB 2009).

II.2.1.8 Osprey restocking in UK

Osprey (*Pandion haliaetus*, Linneus 1758) nesting pairs in UK dropped to some 40-50 in the 1850s, then disappeared for decades until a single nest was discovered in 1956 and RSPB started efforts of nest and area wardening (AW and LRWT 2009). Despite that, due to the slow natural recovery rate and the numerous factors threatening the population, a restocking programme was initiated in 1995 (AW and LRWT 2009). The site chosen was the Rutland Reservoir – a man-made pump storage reservoir, the largest in the UK (JNCC 2008), a designated Ramsar site, Site of Special Scientific Interest (SSSI) and NATURA 2000 Special Protected Area (SPA) (AW and LRWT 2009). In 1994, the Highland Foundation for Wildlife started installing artificial nesting platforms, thus securing nesting sites (AW and LRWT 2009). Before a license for translocation was obtained, the initiators consulted various national and international organizations, landowners, fish farmers, fishing societies and conservationalists (AW and LRWT 2009). The translocations began in 1996, using young birds from Scotland. In the period 1996 – 2005 a total of 74 young Ospreys were transported and released in the area (AW and LRWT 2009). At 2005 a return rate of 22 % was reported. In 2001 the first pair of Ospreys bred in the project area, successfully raising a healthy chick (AW and LRWT 2009).

II.2.1.9 Factors determining the success of reintroduction programmes

Reintroduction programmes are being implemented throughout the world – in North, South America, Europe, Asia and Africa in attempt to preserve various taxa: invertebrates, fish, amphibians, reptiles, birds and mammals (Soorae 2008). A joint case-study, considering a total of 61 reintroduction programmes showed that 21 % of the attempts have been highly successful, 33 % - successful, 43 % partially successful and barely 3 % of the projects have completely failed (Soorae 2008). Bird reintroduction attempts have mostly partial success, though the only failed projects among the 61 studied were reported for this taxon (Soorae 2008). The poor quality of the release habitat is considered among the reasons for failure or partial success (Soorae 2008).

The examples of good reintroduction projects reviewed in Chapter II.2.1 exhibit several common features that have been prerequisites for their success. One of them is the careful planning and selection of release and foraging habitats to secure the establishment and survival of the reintroduced population. The successful attempts have considered various aspects from habitat quality and food availability to nesting site presence and predation. All these factors should therefore be given special attention when planning and designing the habitat suitability criteria. In cases where the habitats chosen have turned out not to be as suitable as assessed, even though the reintroduced birds have indeed survived, they have simply not returned to the release sites and have bred elsewhere.

Another key factor the successful projects cited share is the multidisciplinary approach uniting the efforts of various experts and securing the entire process from preliminary habitat assessment and threat analysis, to bird raising logistics and political coverage.

Last but not least, the projects reviewed all show close collaboration with the various stakeholders – landowners, farmers, hunters, authorities and conservation societies. The successful re-establishment of a given species is to a great extend dependant on the public awareness, tolerance and acceptance. The presented cases have successfully tested various approaches: from public consultations and active involvement in monitoring schemes (Bearded vulture, Osprey, White-tailed eagle, Red Kite case-studies, etc.) to specially designed habitat management schemes in support of the local land-owners (Aplomado example) and incrimination of bird-harming activities (White-tailed eagle case-study). The identification of suitable areas for the reintroduction of Lesser Kestrels in Bulgaria would allow for focusing on the relevant target group of stakeholders to prepare the successful return of the species.

II.3 Habitat modeling within reintroduction programmes

In order to assist the proper planning and implementation of reintroduction programmes, IUCN has formulated a set of necessary steps to undertake within a feasibility study and background research before carrying out such attempts. The set includes: choice of release site within the historic distribution area of the species and careful evaluation of the selected site in terms of habitat quality (change in historic terms) and threats (contemporary or future) (IUCN 1998). The present study is itself an attempt to complete this stage within the Feasibility study for the potential reintroduction of Lesser Kestrel in Southeastern Bulgaria.

Habitat suitability models are usually constructed on the basis of empirical statistical relationships between the presence of the species and certain characteristics of the site (such as land use patterns, elevation, climate, etc.) (Store and Kangas 2001). These models typically adjust quantitative relationship between a given taxon and its environment (Engler *et al.* 2004). They identify independent environmental variables (for example, elevation), arrange them by importance (weight them) and relate them to dependent habitat suitability values (elevation within a given range) (Ortigosa *et al.* 2000) to characterize the habitat – wildlife relationship and dependencies. The exact correlations and dependence indices are derived studying existing viable populations of the given species. The dependent variables are often assigned particular suitability indices, in according to the exact preferences of the given species (for example: elevation – 100-200 m.a.s. – most suitable, attributed index 3; 200-300 m.a.s. less suitable, but still possible, attributed index 2) (Store and Jokimäki 2003; Store and Kangas 2001). The compilation of raw scores, standardizing, weighting and combining the criteria can be done using multicriteria evaluation methods (Store and Kangas 2001). In addition to that, when such habitat models are being compiled especially for bird species, the landscape matrix, structure of habitats and adjacent environment and the need of a multiscale approach are all of great significance (Jokimaki and Huhta 1996).

II.3.1 **Expert-knowledge methods**

The collection of data for designing a habitat suitability model often turns out expensive, time-consuming or too difficult, especially for very rare species and can therefore be successfully substituted with expert knowledge (Store and Kangas 2001). An example for the compilation of a habitat suitability study on the basis of expert knowledge and literature data is the Feasibility Study for the Saker falcon (*Falco cherrug*) Reintroduction in Bulgaria (Ragyov *et al.* 2009). In this case widely-used statistical methods such as the standard stepwise multiple regression analysis cannot be applied to identify potential distribution as there is no existing population that can be studied on field (Store and Jokimäki 2003). The authors therefore considered the historic distribution of the species in Bulgaria, its contemporary distribution in Western Palearctic, as well as some of its ecological characteristics (main prey, nesting density, etc.). A total of 15 sites were then evaluated on the basis of several criteria: overall area size, available food supply (presence of sousliks, voles and small birds), nest site availability (density of nests of other birds of prey) and protection status (levels of legal and direct protection, disturbance and on-going conservation activities) (Ragyov *et al.* 2009). These independent parameters were given scores within preliminary set range and were then aggregated for each site to allow for individual ranking and comparisons (Ragyov *et al.* 2009). As a result, the study came out with recommendations for initiating a reintroduction programme in one of the 15 studied areas (Central Balkan National Park), concluding it provides suitable foraging habitat, nest site availability and reasonable protection status (Ragyov *et al.* 2009). The so-compiled habitat suitability model is to be tested and validated with the field start of the Saker falcon reintroduction programme in 2014.

II.3.2 Statistical methods

When however empirical data can be found and combined with expert knowledge, an integrated habitat suitability index can be used to design the habitat suitability models (Store and Jokimäki 2003). In these cases the correlation between the presence of the studied taxa and the independent environmental variables can be derived through various statistical methods, such as: generalized linear models (Bustamante 1997), (Donazar *et al.* 1993), (Tella *et al.* 2004), Forward Stepwise Branching Modeling Procedure (Donazar *et al.* 1993), step-wise multiple logistic regression (Parr *et al.* 1995), (Franco and Sutherland 2004), Chi-square goodness-of-fit tests (Alldredge and Ratti 1986), etc.

Some of these statistical methods are refined within specialized software for designing habitat suitability models. An example for that is the VVF software, which assigns partial suitability index (SI) to every variable, combines them to then give an overall habitat suitability index (HSI) and derives habitat suitability classes (Ortigosa *et al.* 2000). The software uses five main classes of environmental variables: morphological (altitude, slope, aspect), vegetation (land cover, land use), trophic (prey, predator competition, etc.), meteo-climatic (annual temperature, rainfall, etc.), anthropogenic (urban areas, potential disturbance, etc.) (Ortigosa *et al.* 2000). It has been successfully used to derive spatial criteria for Ibex (elevation, aspect, slope, vegetation map) and telemetry data was used to validate the output (Ortigosa *et al.* 2000).

II.4 Use of GIS as a decision-support tool

The evolution of models from intuitive to empirically justified, has allowed for the emergence of more environmentally correct models of the relationships between wildlife and their habitats (Roberts and Smithers 2000).

A relatively new approach in habitat modeling is using the individual requirements of the species as separate "layers" of spatial data in Geographic Information Systems (GIS) environment. The method allows for overlapping and displaying data (Store and Kangas 2001), analyzing and modeling the interrelations between the data layers (Bonham-Carter 1994) to come up with new data and support strategic decision-making.

II.4.1 GIS functionality

From a software perspective, GIS is an integrated system for collecting, preserving, querying, analyzing and visualizing geographic information, which can act as both transaction and analytical processing system (Maguire 2005). One of the greatest advantages of GIS lies in the fact that it allows for integrated analysis of attribute and spatial information of multiple sources (Malczewski 2004). In addition to that, a combination of GIS with spatial analysis and modeling systems allows for data management and modeling of huge output and input datasets, data integration, loading, reformatting and transformation (Maguire 2005). With the improvement of the spatial analysis capabilities of GIS, GIS software has proven extremely strong in the fields of vector and image processing, raster map analysis and interpretation, surface visualization, spatial interactions, location allocations and modeling (Maguire 2005). The ultimate aim of GIS is to provide support for decision-making, based on spatial data interpretation, to improve understanding data and the processes and patterns it represents (Bonham-Carter 1994; Maguire 2005).

The capabilities of GIS to merge spatial datasets from various sources, to visualize and manipulate the obtained combinations can be used to understand and interpret spatial phenomena that are not easily seen if studied in isolation (Bonham-Carter 1994). GIS spatial analyst software allows for overlying (multiplying, summing, etc.) map layers with weight coefficients, combining standardized and weighted scored maps, depending on their priority with cartographic modeling (Store and Jokimäki 2003). These methods also provide for using suitability indices for large areas, consume little time and are also applicable for species for which there is no empirical data (Store and Kangas 2001). GIS also allows for– using buffer and linear distances and simple overlays to describe possible threats so the method can therefore be used as grounds for applying policy-based conservation activities (Carter *et al.* 2009). In addition to already digitalized datasets, various elements of natural and human-built environment and existing community-based surveys can also be utilized to derive geographic context or come up with habitat predictor variables in GIS environment (Carter *et al.* 2009). All these operations allow for locating areas simultaneously fulfilling preliminary set conditions (Bonham-Carter 1994), which lies in the base of habitat suitability models.

This is why much of the earliest application of GIS has been in the environmental domain and it is still among the main drivers for further improvement of the GIS tools and techniques (Maguire 2005).

One of the possible environmental applications of the GIS methods is compiling habitat suitability models. Such models have been successfully developed in GIS environment for various species of animals – numerous species of birds (some examples discussed below), mammals – otter (Cianfrani *et al.* 2010), wolf (Belongie 2008), etc.

Among the software packages most-commonly used are ESRI ArcView, ArcGIS, etc.

II.4.2 GIS as a tool for habitat suitability modeling

The current overview will focus on a rather standard two-stage GIS approach towards habitat suitability modeling. In the first stage, GIS techniques are used for determining habitat preference information, deriving correlations between independent environmental factors and the species studied on the basis of presence-absence geographic data. Based on the revealed correlations, in the second stage GIS methods are utilized to combine the existing expert knowledge and empirical data, using geographic vector and raster files and to determine potentially suitable habitats and predict the possible distribution of the species studied.

The aim of the overview is to demonstrate the application of the GIS techniques within several completed habitat suitability models for birds in particular. In addition to that, the section is intended to emphasize on the parameters that have proven to be correlated to the presence of the bird species studied, so that the same parameters are later utilized for the compilation of the Lesser Kestrel Habitat Suitability model.

II.4.2.1 Establishing the overall ecological niche of a species

Another multivariate approach to study the geographical distribution of a given species, without considering absence data is called "ecological niche factor analysis" (ENFA). It is based on the application of GIS techniques in combination with Biomapper software (Hirzel *et al.* 2002). ENFA relies on two datasets – a global set, containing information for all cells in the study area and a species set, storing values for only those cells where species is present (Hirzel *et al.* 2002; Hirzel *et al.* 2004). The two datasets can be compared and the difference can be interpreted. The method also allows for evaluating the global marginality (how far the species optimum is from the average conditions in the area studied), as well as the global tolerance (the breath of the niche of the species) (Hirzel *et al.* 2004). This combined method was used to determine the ecological niche of Bearded vultures (Hirzel *et al.* 2004).

II.4.2.2 Determining Bald eagle habitat use in USA

ArcInfo GIS software was used to confirm scale-dependant relationships in the use of wildlife habitat of Bald eagle (*H. leucocephalus*) and evaluate its breeding habitat in Hudson River, USA (Thompson and McGarigal 2002). Three key habitat characteristics were used: proximity to feeding place, nest site availability (proximity to forest stands) and human disturbance (Thompson and McGarigal 2002). The study was conducted on grain (data grid) and local scale and habitat use was calculated for each of the identified habitat elements (Thompson and McGarigal 2002).

II.4.2.3 Identifying potential breeding sites for White-tailed eagle in Croatia

GIS methods were used to identify potential breeding sites for White-tailed eagles (*Heliaeetus albicilla*) in Croatia. The habitat model that was compiled using the following criteria: distance to water bodies, elevation, presence of forest, distance to urban areas and roads. The particular values for each of those independent variables were derived analyzing the habitat preferences of the existing population of 139 confirmed breeding pairs of White-tailed eagles in Croatia. GIS helped to formulate the criteria and create a particular set of habitat requirements for White-tailed eagle (Radović and Mikuska 2009). The study showed that some 3 % of the territory of Croatia was suitable for the species and the particular output was very close to the breeding distribution described for the White-tailed eagle in the past (Radović and Mikuska 2009).

II.4.2.4 Revealing suitable habitats for Golden eagle in Spain

A combination of stepwise logistic regression and GIS methods was used to design a predictive model of habitat suitability for Golden eagle (*Aquila chrysaetus*) in Northwestern Spain (Tapia *et al.* 2007). The presence or lack of Golden eagle nests was compared against the following set of criteria: topographic characteristics (slope, altitude), land use (habitat types, CORINE), habitat heterogeneity and anthropogenic pressure (Tapia *et al.* 2007). The model incorporated data from the present as well as the historic distribution of the species in Spain (Tapia *et al.* 2007). Bird tracking data was used to justify the criteria. Among the additional factors discussed for further model development were nest site availability, land use changes and human disturbance (Tapia *et al.* 2007). The model fed the results from the logistic regressions into ArcView software to generate maps of the possible distribution of Golden eagles, with different probability of occurrence and succeeded in predicting 84 % of the present distribution of the species in Northwestern Spain (Tapia *et al.* 2007).

II.4.2.5 Analyzing the habitat preferences of Bearded vulture in the Alps

In many cases, despite the gathered knowledge on the habitat preferences of a given species, reintroduction programs can help to better understand its particular ecological needs. Following the reintroduction programme for Bearded vulture described in the Chapter II.2.1.4, GIS methods were successfully used to identify the initial habitat requirements of the species and to plan further long-term conservation measures (Hirzel *et al.* 2004). The GIS-based habitat analysis completed was carried out using the vulture sightings collected in Valais (Switzerland) in the period 1987 – 2001 after the bird releases. The study identified some key environmental factors determining the distribution of the vultures, which were then extrapolated onto the entire area of the Alps to reveal potential trends (Hirzel *et al.* 2004). The criteria used as input were: topographic (altitude, slope, exposition), geological (underlying stone, water bodies), anthropogenic (presence, urban areas) and biological (habitat type and food availability – ibex and chamois) (Hirzel *et al.* 2004). The study revealed interesting behavioral patterns of the reintroduced vultures, which tended to occupy particular areas in the first years after their release and then shift to other Alpean areas that were found out to be more suitable for nesting (Hirzel *et al.* 2004).

II.4.2.6 Locating suitable reintroduction sites for White stork in Sweden

GIS methods were used to predict suitable reintroduction sites of White storks (*Ciconia ciconia*) in Sweden, based on presence-only datasets and extrapolating information from existing sample populations (Olsson and Rogers 2009). The method was based on a small but reliable stork presence dataset, using the following criteria: habitat type, nest site availability, relative wetness, and wetlands, processed with ArcGIS 9.1. , MatLab 7.1. (Olsson and Rogers 2009). The method successfully predicted the location of the already occupied stork nests in Sweden and came up with additional 300 km^2, considered as suitable stork habitat (Olsson and Rogers 2009).

II.4.2.7 Finding suitable nesting sites for Black vulture in Bulgaria

GIS methods were used for compiling a model of suitable nesting sites for Black vultures (*Aegipius monachus*) in Bulgaria also within the "Conservation activities for EEC Birds Directive target species – Lesser Kestrel, Black Vulture and Imperial Eagle in their main habitats in Bulgaria" project. The model used the following set of main independent environmental factors: disturbance (distance from settlements, distance from roads, distance from arable areas, other anthropogenic activity), slope, land cover, presence of old trees. Additional factors were also considered: presence of protected area, altitude, aspect, data for historical presence, presence of suitable perching and roosting sites, known concentration sites (obtained from visual observations or telemetry data), distance to the present colony of Griffon vultures in Dadia, Greece (*Aegipius monachus*) (Marin *et al.* 2009). The model is to be tested installing artificial nests and monitoring their success.

II.4.3 Discussion of the GIS methodology

The case studies presented in Chapter II.4.2 illustrate one among the numerous applications of GIS techniques – the compilation of habitats suitability models.

II.4.3.1 Common environmental factors used in GIS habitat models

Despite the different approached used, the case studies reviewed exhibit some common trends in terms of independent environmental factors correlated with the presence and distribution of the species considered. On overall these factors can be summarized as related to: topography (elevation, slope, etc.), ecology (foraging habitat, nest site availability, etc.) and anthropogenic pressure (distance to roads/urban areas, presence of protected areas, persecution, etc.). The suitability indices for each of these independent environmental factors vary in accordance with the characteristics of the particular species studied, but on overall the factors remain the same.

In all these cases, GIS methods were proven as an effective tool for conservation planners and decision-makers, capable of successfully modeling the habitat requirements and predicting the potential distribution of the species studied.

Bearing that in mind, it is also worth mentioning some disadvantages of the GIS techniques, which make the habitat models prone to errors, resulting in wrong data interpretation and incorrect further planning and decisions.

II.4.3.2 Sources of errors in GIS habitat models

The sources of errors in habitat modeling in GIS environment can be grouped in two main categories: data deficiency and internal model specifications (Barry and Elith 2006).

Data deficiency errors are related to missing information on significant environmental factors (such as predation, nest site competition, etc.) influencing the distribution of the species studied, or when the species in question has a very limited distribution or is very rare and little-known (Barry and Elith 2006). In addition to that there is a major issue with data quality as GIS models automatically assume that the available datasets represent the real situation on field (Malczewski 2004). Data quality problems can result in inaccuracy, imprecision and ambiguity (Malczewski 2004). When model criteria are constructed on the basis of presence and absence of species, it is very important to distinguish true absence from pseudo-absence resulting from lack of scientific knowledge, poor research or very limited species' distribution or extreme rarity (Olsson and Rogers 2009).

The other type of errors is related to the model setting itself. The standardization and weighting of the used habitat requirements during the multicriteria operations is crucial and often different values assigned to the suitability indices results in completely different distribution predictions (Malczewski 2004; Store and Kangas 2001). These errors can be easily proven by sensitivity analysis (Malczewski 2004). An additional crucial factor is the scale used for habitat suitability modeling, which has to be agreed with the particular ecological characteristics of the given species (Thompson and McGarigal 2002).

It should therefore be kept in mind that habitat suitability models are only approximations to reality (Barry and Elith 2006). Their reliability can be validated either testing them on output data or through reintroduction programmes to further study the correlations between the reintroduced animals and their direct environment.

III Research methodology

Based on the successful examples of habitat suitability models, realized in GIS environment, a Lesser Kestrel Habitat Suitability model was developed and GIS techniques were considered capable of applying it in order to identify appropriate habitats for reintroducing the Lesser Kestrel in Southeastern Bulgaria.

The task was fulfilled in four stages:

- Data collection;
- General Lesser Kestrel Habitat suitability model compilation;
- Application of the model in a target area in Southeastern Bulgaria;
- Compilation of practical recommendations for the further steps required to restore Lesser Kestrel population in Bulgaria.

These four tasks were carried out with a different set of tools as follows:

III.1 Data collection

The Lesser Kestrel Habitat Suitability model was based on successful examples of models, compiled for other species, as well as on a review of the biology and environmental requirements of the species itself. So that the model could be applied in GIS environment, precise and compatible GIS data to complete the computations was also required. Therefore the data collection was separated in four main phases as follows:

III.1.1 Literature review

The Lesser Kestrel Habitat suitability model, as a set of criteria for identifying suitable Lesser Kestrels foraging and nesting sites, was compiled on the base of data for the environmental requirements of the species obtained from the available literature on the following issues:

- Existing habitat models compiled for similar species to reveal the suitability criteria used, the environmental factors which affect the species the most and the weighting associated with the various habitat characteristics;
- General ecological characteristics of Lesser Kestrels and records for currently existing and stable populations to identify main environmental preferences and requirements;

- Available habitat preference studies completed in other regions, correlating environmental factors and Lesser Kestrel occurrence and providing empirical data for quantifying the studied relationships;
- Available historical records for the distribution and habitat preferences of the last known breeding colonies in Bulgaria in particular.

As a result of that, a set of primary environmental factors was formulated to identify the general location of the suitable areas, while some additional factors were set up as supplementary criteria to refine the position of the exact sites. The entire set of criteria was adjusted to correspond to the contemporary environment of Bulgaria.

III.1.2 **Field visit**

Additional information on the habitat preferences of the species was gathered during one-week field study of existing Lesser Kestrel active colonies in Northern Turkey, Turkish Thrace. The region was selected as closest suggested existing breeding site to the target area. The territory studied in Turkey is comparable in terms of land use, climate and topography to the target area, so the field visit was used to validate the criteria obtained from the literature review and adapt them to the contemporary habitat situation in Bulgaria.

Turkey was chosen as 1993 estimations suggest a clumped distribution of some 1500 – 3500 breeding Lesser Kestrel pairs (Parr *et al.* 1995). This means that Turkey holds the third largest population of Lesser Kestrels in the world and the second largest in Europe (BirdLife International 2004; Parr *et al.* 1997) and at the same time is in close proximity to the target area, thus allowing for future connection of the re-established Bulgarian population with a strong, core population of the species.

Therefore, a 7-day field study was completed in the period April 17-23d, 2010 in order to locate the active colonies of Lesser Kestrels nearest to the target area, as well as to further study the nest and foraging site selection of the birds. During the planning of the expedition, local experts and birdwatchers, as well as Bulgarian researchers working in the area of Turkey were contacted to obtain information on the possible location and characteristics of the colonies. Initial data was kindly shared by two local divisions of BirdLife International.

The period mid-April – mid-March was selected as it is the pre-laying period of Lesser Kestrels in Turkey, when birds are most conspicuous at the breeding colonies (Parr *et al.* 1995). The study was based on transect surveys as they have been proven to provide similar results to radio-tracking techniques (Franco *et al.* 2004) and allow for locating both foraging and breeding birds.

The literature review completed showed that Lesser Kestrels preferred nesting in settlements (Franco et al. 2005) (Barov 2002; Simeonov *et al.* 1990), and foraging on adjacent areas close to roads within a particular distance from the colonies (Garcia *et al.* 2006; Liven-Schulman *et al.* 2004; Negro *et al.* 1993). Therefore a total of 2000 km were covered and 115 settlements in Turkish Thrace were visited in search of foraging or nesting birds. Same survey method was utilized by Parr (1995), whose team visited 369 settlements and spent an average time of 21 min per settlement (Parr *et al.* 1995).

In the settlements where colonies of Lesser Kestrels were found, additional information on the number of inhabitants, type of land use, number of cattle raised, etc., was collected through written interviews filled in by the local people to obtain a better perspective of the birds' breeding and foraging habitats.

III.1.3 **Expert consultations**

The habitat suitability criteria, the independent environmental factors chosen, their weighting and standardization were discussed with local scientists and active conservationalists from Bulgaria and Turkey in order to obtain a realistic and down-to-the-ground list, fully adapted and corresponding to the contemporary Bulgarian environment. Experts from BirdLife International (Bulgaria, Hungary and Turkey), International Wildlife Consultants Ltd (Wales, UK), Green Balkans Federation, the Fund for Wildlife Flora and Fauna, the Central Laboratory for General Ecology at the Bulgarian Academy of Science, as well as other, non-affiliated experts and birdwatchers were contacted.

III.1.4 **GIS data collection**

In order to later apply the compiled Lesser Kestrel Habitat Suitability model for a target area in Southeastern Bulgaria, based on the completed literature review and revealed dependencies between the primary environmental factors and the presence of the species, relevant GIS digital maps and base information were collected: topography, CORINE land cover (2006), digital elevation maps, roads and protected areas of Bulgaria. All these datasets were obtained from the relevant national authorities: Agency on Geodesy, Cartography and Cadastre; Executive Environmental Agency; Road Infrastructure Agency, Bulgarian Academy of Science. Cadastre and forest maps were obtained from the Agency on Geodesy, Cartography and Cadastre and Regional Forest Units. The maps of nesting Long-legged buzzards and the data from the telemetry of Imperial eagles were obtained and digitalized from the ornithological database of the Green Balkans NGO. The outlines of the target site in Southeastern Bulgaria were provided by the Green Balkans NGO and were defined by the "Conservation activities for EEC Birds Directive target species – Lesser Kestrel, Black Vulture and Imperial Eagle in their main habitats in Bulgaria" project. In some cases the information was manually digitalized or imported from Google Earth polygons and points (last known breeding colonies and sightings of Lesser Kestrels in Bulgaria) or Map Source points (location of the nearest Lesser Kestrel colonies in Turkey).

III.2 Habitat model development

The Lesser Kestrel Habitat Suitability Model was based on a set of criteria, which describe the combination of independent environmental factors and their referent values, determining the presence of Lesser Kestrel as a breeding species in a given territory. The independent environmental factors selected were as follows: topography (altitude, slope, aspect), land management (land use, existence of protected areas and favourable land management practices), biological factors (proximity to existing Lesser Kestrel colonies, connectivity among sites, potential predator competition), demographic factors (road network, population density, presence of deserted buildings).

The choice of that particular set of environmental factors, their weighting, ranking in order of significance and their particular tolerance ranges were based on the data collected within the first stage of the development of the current study (literature review, field visit and expert consultations).

Using information on the environmental requirements of Lesser Kestrels from various sources, as well as historic records for the preferences of the species in Bulgaria in particular, the model was developed as a general Habitat Suitability Model, intended to predict Lesser Kestrel suitable sites throughout the country.

III.3 Habitat model application for a target area in Southeastern Bulgaria

The Lesser Kestrel Habitat Suitability Model developed was then applied in GIS environment for a target area in Southeastern Bulgaria. The boundaries of the target area were drawn by experts working within the "Conservation activities for EEC Birds Directive target species – Lesser Kestrel, Black Vulture and Imperial Eagle in their main habitats in Bulgaria" project. It comprises a former confirmed breeding site of Lesser Kestrels (Barov 2002; GB 2010). In order to practically check if this was indeed the most suitable reintroduction site, the area drawn by the experts was further extended with a buffer of 20 km, where same habitat suitability criteria were applied.

The established relations between the chosen independent environmental factors and the occurrence of the Lesser Kestrel were processed using ESRI ArcMap 9.3. software.

Following the algorithm prescribed by the Lesser Kestrel Habitat Suitability model developed, GIS operations were used to identify and visualize the best suitable Lesser Kestrel sites, as well as derive tabular statistical information to further assist the site selection process.

All collected data layers were converted into grid files, each grid cell was attributed a suitability index (SI) (Ortigosa *et al.* 2000; Store and Jokimäki 2003; Store and Kangas 2001) in accordance with the completed study on the ecological requirements of the Lesser Kestrel and the files were then overlapped using spatial analyst operations – weighted overlay of differently scored grid files, buffer and linear distance. The weighting and prioritization of the factors was based on the completed literature review, expert consultations and field observations. Technical operations for finding distance between points and clipping raster datasets with polygon objects were used to obtain additional statistical information and further assist the best site selection process.

The software provided maps depicting the location of the areas found out as most suitable.

The best locations found by the Lesser Kestrel Habitat Suitability Model in GIS environment will be tested by the field experts working on the "Conservation activities for EEC Birds Directive target species – Lesser Kestrel, Black Vulture and Imperial Eagle in their main habitats in Bulgaria" project, releasing birds and monitoring their adaptation and survival in the selected locations.

III.4 Management recommendations

Using the environmental requirements of the Lesser Kestrels reviewed and the findings of the Lesser Kestrel Habitat suitability model applied to a target area in Southeastern Bulgaria, recommendations for the future steps required to re-establish the species in Bulgaria were compiled.

In addition to that, based on the experience of other countries that have successfully preserved their Lesser Kestrel populations, a set of recommendations for the most appropriate site management and land use practices was compiled and adapted to the contemporary Bulgarian socio- and natural environment. GIS environment allowed for identifying the type of ownership and current authorities responsible for the sites, determined as suitable for proceeding with Lesser Kestrel restoration programme. This information was used to identify the target group which should be addressed before the start of the reintroduction efforts (particular communities, stakeholders and authorities).

As a final stage, recommendations on the further optimization and improvement of the Habitat Suitability model were made to consider additional factors of potential significance, identified within the completed overview of existing habitat suitability models and Lesser Kestrel environmental requirements.

IV Lesser Kestrel Habitat model development

The following chapter consists of two main sections. The first section provides general information on the environmental characteristics and habitat requirements of Lesser Kestrel. It summarizes various empirical, ecological and behavioural studies on existing breeding populations in Europe and Turkey, in attempt to correlate different independent environmental factors with the presence of Lesser Kestrels in a given environment. The last part of this section reviews the available information on the habitat preferences of the last confirmed nesting Lesser Kestrels in Bulgaria. Based on the outcomes of the first section, the second section develops a set of environmental parameters that are suggested to determine the suitability of a particular environment to maintain and support a Lesser Kestrel population. These parameters are assigned individual Suitability indices and, using the data gathered (literature review, field visit, expert consultations), combined altogether to form a Lesser Kestrel Habitat Suitability model, adapted to the contemporary Bulgarian environment.

IV.1 **Lesser Kestrel ecology**

The characteristics and environmental requirements of the Lesser Kestrel presented in this chapter were collected and summarized as a result of the completed literature review, field visit and expert consultations. Based on the algorithms utilized by the GIS habitat models reviewed, these findings were used to compile the Lesser Kestrel habitat suitability model.

IV.1.1 **General characteristics**

Lesser Kestrel is among the most gregarious Palearctic falcon species (Cramp and Simmons 1987). It is very rarely solitary, breeding almost always in stable conspicuous colonies from 2-3 up to more than 500 pairs (Cramp and Simmons 1987). It is also closely associated with other species dependant on similar food sources and can breed in mixed colonies with Jackdaws (*Corvus monedula*) or Feral Pigeons (*Columba palumbus*) especially if nest sites are available (Cramp and Simmons 1987; Forero *et al.* 1996). At the same time the species will often attack other raptors approaching the nesting site – Peregrine and Lanner falcons, Ravens, Egyptian vultures and even Griffon vultures, yet completely ignoring Buzzards, Kites and Harriers (Cramp and Simmons 1987).

IV.1.1.1 **Nesting habitat**

The Lesser Kestrel is on overall a lowland species, found up to about 500 m a.s.l. in Europe (Cramp and Simmons 1987; Simeonov *et al.* 1990), though there are records of birds hunting in areas up to 2000 m a.s.l. in Mongolia (BirdLife International 2001) and over 2300 m a.s.l. in Armenia (Ananian 2009). It prefers mountain foothills, nesting along river banks, crags, human artifacts, such as walls and buildings (Cramp and Simmons 1987), cliffs, quarries (Liven-Schulman *et al.* 2004); rarely on burrows or single trees (Cramp and Simmons 1987). Presence of single trees or wire (for roosting, resting, etc.) near the colonies seem favourable, especially during the post-fledge and pre-migratory period (De Frutos *et al.* 2009; Franco *et al.* 2005). Overall preferences towards sites of good quality soils, abundant livestock, close to paved roads, shallow slopes, no shrubs and plantations have been found out in Portugal (Franco *et al.* 2005; Franco and Sutherland 2004) (Figure 1).

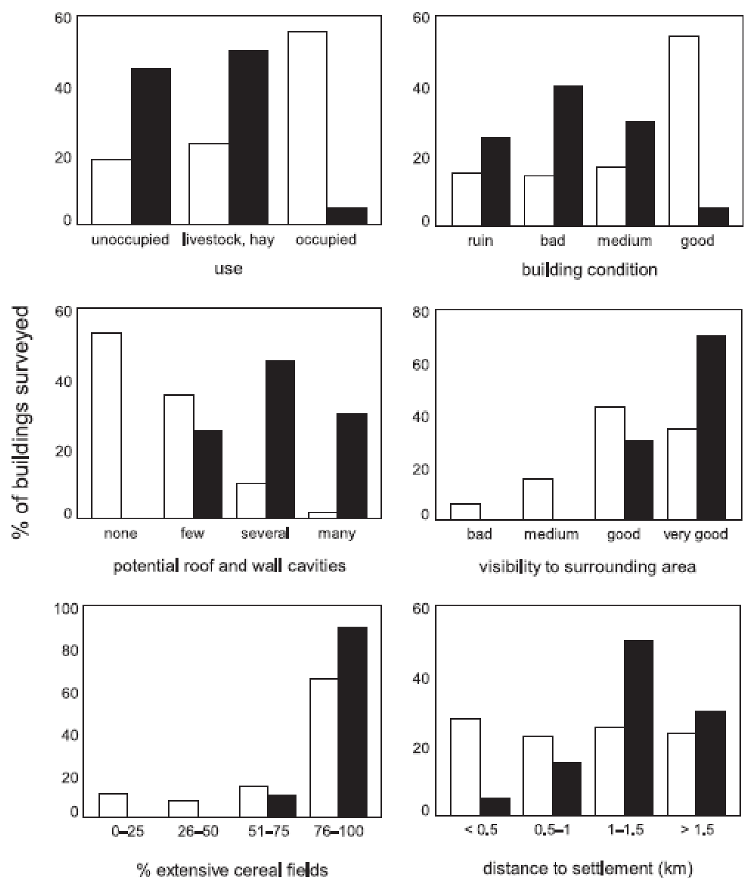


Figure 1. Factors, determining the nest location of Lesser Kestrels in Portugal. Black bars represent buildings with nests, white bars - without (Franco et al. 2005)

The breeding pairs show almost no intolerance of human presence, except for when actively persecuted (Cramp and Simmons 1987). Thus, Lesser Kestrels are often nesting in urban areas, as they provide nesting sites and reduced nest predation (Tella *et al.* 1996) and are usually surrounded by agricultural fields or open uncultivated grasslands, securing food sources (Bustamante 1997; Hiraldo *et al.* 1996). When nesting in urban areas, Lesser Kestrels prefer localities with many monuments (castles, churches) and old buildings and dense population (Franco *et al.* 2005) (Figure 5). In Israel the colonies are found adjacent to human settlements – both urban and rural, as well as on cliffs (Liven-Schulman *et al.* 2004). However breeding success on cliffs (3,16 fledglings/nest) was reported to be much higher than that in urban areas (1,91 and 2,44 fledglings/nest), probably related to long distance flight between colony and foraging areas, as well as the use of pesticides in urban spaces (Liven-Schulman *et al.* 2004). Colonies are most often located on urban and rural buildings also in Central Turkey (Parr *et al.* 1995) and Portugal (Franco *et al.* 2005). Our observations of 5 Lesser Kestrel colonies in Turkish Thrace also confirmed nesting in buildings in lively settlements with population exceeding 500 people and even in a highly urbanized area with a population of some 53 000 people.

Despite that, the species can be negatively affected by human disturbance such as intensive building use, construction works, destruction of nests, poaching (Catry *et al.* 2009). Another possible problem related to nesting in direct proximity to human settlements can be collision with wires, windows and vehicles (Kauffman *et al.* 2003).

The Lesser Kestrel nests under clay roof tiles (Central Turkey) (Parr *et al.* 1995) or in unoccupied buildings with many roof and wall cavities, in areas with good visibility (Franco *et al.* 2005). The nests found in Turkish Thrace were located in attics of one-storey deserted half-ruined adobe houses, in cracks between the roof and the walls of inhabited one-storey houses, in old adobe sheds, on mosques, in the attics of high residential buildings and on a coastal cliff in direct proximity to an active construction site and a harbour (Annex IX.7). The average measurements of Lesser Kestrel nesting cavities taken in Portugal are as follows: length: 29-30 cm; width: 16,5-18 cm; 300-340 cm high (Franco *et al.* 2005). Possible competitors for nesting habitats are – Common kestrel (*Falco tinnunculus*), Barn Owl (*Tyto alba),* Little Owl (*Athene noctua*)*,* Roller (*Coracias garrulus*) (Catry *et al.* 2009). Though observed in mixed colonies, the Jackdaw (*Corvus monedula*) and the Feral Pigeon (*Columba livia*) are proven not to outcompete Lesser Kestrels (Catry *et al.* 2009). Abundance of Common Kestrels (*Falco tinnunculus*) can actually be used as an indicator of abundance of prey, and both species freely breed together (Pomarol 1993). All observed colonies of Lesser Kestrels in Turkish Thrace, except for the coastal one, were indeed mixed with high numbers of Jackdaws*,* Feral Pigeons, Common Kestrels and Doves.

If nest sites are not available or are insufficient, Lesser Kestrels readily take artificial nesting boxes (Bux *et al.* 2008; Catry *et al.* 2007; Pomarol 1993). This measure has been successfully used in Portugal, where the Lesser Kestrel population increased from 155-158 pairs (1996) to 527-552 pairs (2007), and in 2007 52 % of the population reported was using the provided artificial nests (Catry *et al.* 2009).

IV.1.1.2 Home range

Lesser Kestrels tend to concentrate on particular suitable patches within their overall home range during the breeding season and be absent or infrequent elsewhere (Cramp and Simmons 1987). The species has been recorded to forage within 4,5 km from the colony (Garcia *et al.* 2006; Liven-Schulman *et al.* 2004), up to 16 km, if forced to (Garcia *et al.* 2006; Negro *et al.* 1993).

Analysis of the data gathered from 23 radio-tagged Lesser Kestrels in Northern Spain show home range of 63,56 km^2 in intensively maintained habitats as compared to only 12,36 km^2 in traditional agro-grazing systems (Tella *et al.* 1998) and foraging area of an average-sized colony of approximately 36 km^2 in the Guadalquivir River valley, Spain (Negro *et al.* 1993). Studies show that an average of 56 % of the home range habitat used (Tella *et al.* 1998). The study comparing intensively and extensively maintained habitats shows clear difference in both productivity and population trends of the two studied populations, as the birds hunting closer to the colony were more successful breeders (Tella *et al.* 1998). Our observations of Turkish Thrace show distances in the range of 1,84 km - 10,6 km between the colonies and the groups of hunting birds observed. The group of Lesser Kestrels foraging 10,6 km away from its colony inhabited the central parts of a highly urbanized area with a population of some 53 000 people, with a typical suburbs of service areas, petrol-stations and heavy traffic roads.

IV.1.1.3 Food

The Lesser Kestrel is an essentially insectivorous, opportunist feeder, capable of exploiting a wide range of terrestrial and aerial prey (Cramp and Simmons 1987). Its main food items are large insects from the orders Orthoptera – crickets, grasshoppers; and Coleoptera – chafers, dung-beetles and ground beetles; Hymenoptera – flying ants; Odonata – dragon flies; altogether invertebrates forming up to 85 – 94 % of the diet (Barov 2002; Cramp and Simmons 1987). The other part of the diet of the Lesser Kestrels consists of vertebrates – reptiles (especially lizards and skinks), small mammals (mice, shrews, voles) and passerine birds (finches, sparrows) (Barov 2002; Cramp and Simmons 1987; Parr *et al.* 1997). Earthworms, moths and butterflies are most probably taken too, though as no-identifiable remains can be found in the pellets collected, it is difficult to quantify their use (Cramp and Simmons 1987). Lesser Kestrels are highly dependent on the food density and tend to form temporary flocks at sites with insect population explosions (Barov 2002; Donazar *et al.* 1993). Simulation modeling of nestling growth has revealed that a minimum prey size of 0,6 g secures the survival of colonies, while lesser prey size turns the colonies into population sinks (Rodriguez *et al.* 2006). Increasing prey biomass and the probability of finding it increases breeding success and size is more important than the probability of finding (Rodriguez *et al.* 2006).

IV.1.1.4 Foraging habitat

The differences in abundance of prey among different crop types significantly impact the breeding success of the Lesser Kestrel colonies (Rodriguez *et al.* 2006). In addition to that, starvation of fledglings has been proven to be related with the decline of the Lesser Kestrel populations in Spain (Hiraldo *et al.* 1996; Negro *et al.* 1993). Studies show that the habitat suitability can be assessed on the base of the hunting performance, measured by the time, required to obtain prey (Rodriguez *et al.* 2006). This time varies in different habitats, arranged for least to most time needed as follows: cereal < field margin < grassland < sunflower fields (Rodriguez et al. 2006)(Table 1).

Table 1. Hunting performance in different crop types (Rodriguez et al. 2006)

Crop type	Time needed to get prey (Tapia *et al.*)	Source
Cereal	4,4	(Donazar *et al.* 1993)
Cereal	3,1 ± 0,5	(Tella *et al.* 1998)
Cereal stubble	3,9	(Donazar *et al.* 1993)
Field margins	5,1	(Donazar *et al.* 1993)
Field margins	5,6 ± 2,5	(Tella *et al.* 1998)
Grasslands	6	(Donazar *et al.* 1993)
Sunflower	9	(Donazar *et al.* 1993)

At the same time, the prey size obtained from these types of habitats is arranged as follows: field margins > cereal > sunflower (Rodriguez *et al.* 2006). The same study shows that the birds can sometimes prefer habitats of lesser quality prey (smaller size), provided that it is abundant enough to secure high breeding success (Rodriguez *et al.* 2006). At the same time, colonies with similar provision rates can exhibit different breeding success, related to the prey size (Rodriguez *et al.* 2006). All this proves that the presence and abundance of food sources within the home range of the species highly influences the occurrence and breeding of Lesser Kestrels and explains the overall habitat preferences exhibited.

There are several studies on the types of habitats preferred by Lesser Kestrels for foraging in Spain, Portugal and Central Turkey. These three countries presented were selected for several reasons. Spain and Turkey hold the greatest populations of nesting Lesser Kestrels in Europe (Spain: 12 000 – 20 000 and Turkey: 5000 – 7000 breeding pairs) (BirdLife International 2004).

Portugal has a smaller, but yet increasing population of some 300 nesting pairs (BirdLife International 2004). Therefore the Lesser Kestrel foraging and nesting habitats found in these countries should without doubt be considered suitable for the species.

In addition to that, the three countries are to a great extend comparable to Bulgaria in terms of climate, latitude and natural habitats. Furthermore, Spain and Portugal are members of the European Union and share the Common Agricultural Policy requirements and regulations that have shaped their contemporary rural landscapes. On the other hand, Bulgaria is an official part of the Union since 2007 and also needs to comply with the same agricultural policies.

Last, but not least, studies, using statistical and mathematical methods to correlate and quantify the presence of breeding Lesser Kestrels in the three countries (Spain, Portugal, Turkey) were carried out. These studies found Lesser Kestrels dependant to a different extend on various environmental factors, such as: topography, climate, land cover and land use, human disturbance, etc. (Bustamante 1997; De Frutos *et al.* 2009; Donazar *et al.* 1993; Franco *et al.* 2004; Franco and Sutherland 2004; Garcia *et al.* 2006; Negro *et al.* 1993; Parr *et al.* 1995; Tella *et al.* 1998). None of these studies considered the entire set of factors mentioned, however they all shared some common observations and conclusions.

IV.1.1.4.1 Spain

A study on nine radio-tagged adult Lesser Kestrels that took place in the period 1989-1990 in Southern Spain showed general preference for foraging over grassland and less over sunflower (Donazar *et al.* 1993). Nine categories of habitats used by the birds were recorded: woodland; fruit trees; olive trees; uncultivated grassland; cereals; sunflower; legumes; melons and other vegetables; urban areas (Donazar *et al.* 1993). Despite the notable individual differences of habitat use among the birds, most of them preferred foraging over grassland and cereals (44 % of the studied birds), while melon fields were used by only three birds. At the same time woodlands and urban areas were not visited by the hunting birds at all (Donazar *et al.* 1993). The frequency of habitat use was as follows: grassland > cereals > legumes > melons > olive trees > sunflower > orange trees; and legumes and melons were used for only a period of few weeks (Donazar *et al.* 1993). Uncultivated grasslands were also proven a preferred foraging habitat (Donazar *et al.* 1993)

Similar results on the habitat use were obtained by another researcher in Central Spain, who ranked the Lesser Kestrel foraging habitat preferences as follows: unploughed fallow > ploughed fallow > pasture > legume > cereal > vineyards (Garcia *et al.* 2006). The latter study shows that fallow patches were positively selected, while cereal, olive and vineyards were avoided (Garcia *et* *al.* 2006). This is most probably due to the high vegetation stand and the use of biocides and fertilizers that might have affected prey abundance (Garcia *et al.* 2006).

Another study on the factors, determining the presence / absence of Lesser Kestrels in Southern Spain has revealed positive association with urban areas, non-irrigated cereal, sunflower crops and mean annual rainfall and negative association with scrubland and forests (Bustamante 1997). The number of breeding pairs was found negatively correlated to altitude, forest coverage and irrigated cultures and positively associated with total length of riparian systems. A total of 19 environmental variables referring to topography, human disturbance, climate, land cover and land-use, suggested to have impact on the species were used to construct a habitat model (annual /spring rainfall; annual / spring temperature; number of inhabitants; length of sealed and dirt roads; percentage of urban area, orchards, cereals, vegetables, pastures, open land, scrubland, forest, olive groves, vineyards, irrigated cultures and unproductive land; altitude; rivers) (Bustamante 1997). The model revealed presence of Lesser Kestrels in sites with higher than the average population density, greater percentage of urban areas, non-irrigated cereal crops, open herbaceous vegetation, higher foraging suitability index (SI = pastures + 0,58 * cereals + 0,96 * vegetables), higher average annual temperature, lower altitude and smaller length of riparian systems (Bustamante 1997). Cereals, forests and scrubland correlated to all three studied population characteristics (presence, survival, density) and had good predictive abilities. Altitude was negatively correlated to all three characteristics. Annual rainfall was not directly correlated to presence, colony density and survival, but was positively associated with survival/presence when paired with other variables (Bustamante 1997). The model correctly classified 84 % of the grid squares, showing sufficient predictive power and statistical robustness. Statistically significant extinction of low predictive ability occurred in areas with wide areas of scrubland and low annual precipitation or in large or very limited areas of sunflower and non-irrigated cereal crops. Despite the observed correlation, the latter model explained barely 3-30 % of the kestrel number variance (Bustamante 1997).

In Northern Spain the occurrence of Lesser Kestrels during the post-fledged period was related to fallow, cereal stubble and field margins, while irrigated crops had a negative impact (De Frutos *et al.* 2009) (Figure 2). The occurrence showed more dependency on the distribution and abundance of the habitats preferred as compared to the habitat heterogenity (De Frutos *et al.* 2009) (Figure 3).

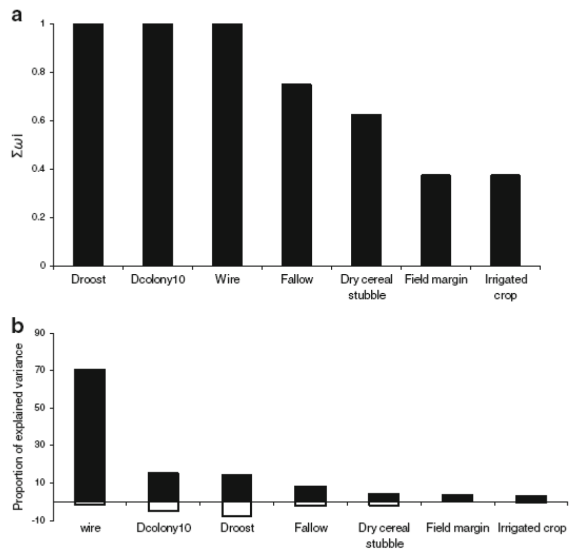


Figure 2. Relative contribution of different variables in the best models explaining the occurence of Lesser Kestrels (De Frutos et al. 2005)

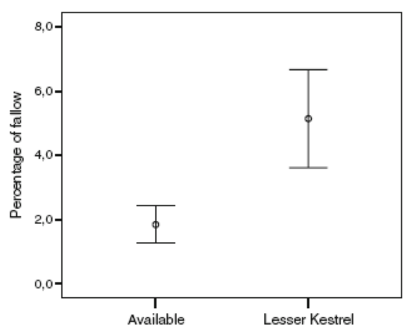


Figure 3. Percentage of fallow in the available and used by Lesser Kestrel plots, at 50 m radius spatial resolution (De Frutos et al. 2009)

Again in Northern Spain 23 Lesser Kestrels from 11 colonies were radio-tracked to study their habitat preferences in the pseudo-steppes (Tella *et al.* 1998). A total of seven habitat classes were studied: cereals, plowed fields, abandoned fields, Mediterranean scrubland, field margins, halophytic vegetation, salt lakes. (Tella *et al.* 1998). It was found out that the habitat use was ranked as follows: field margins > cereals (mostly) > abandoned fields > plowed fields > halophytic grassland > salt lakes > scrubland (Tella *et al.* 1998). Similar habitats were used in also intensively managed arable land, though the foraging patches and the prey size were recorded to be smaller (Tella *et al.* 1998).

During the winter in Spain, 15 % of the Lesser Kestrel population stayed in the study area, foraging on field margins and stubble, avoiding abandoned fields, scrubland, cereals, irrigated crops and ploughs (Tella and Forero 2000).

IV.1.1.4.2 Portugal

Lesser Kestrel habitat use studies in Portugal using 25 independent variables showed the importance of the presence of cereal steppe habitat and fields with livestock in proximity to colonies (Franco and Sutherland 2004). In addition to that, the species avoided tree plantations (Franco and Sutherland 2004). The regression model resulted in the following coefficients: thresholds: y = 0, 1.701; y = 1; -0,222; y = 2; 1,426 and coefficients: 0,76 * livestock - 0,587 * distance to the colony – 0,458 * tree plantations (Franco and Sutherland 2004) (Table 2).

Table 2. Independent environmental factors that showed correlation with Lesser Kestrels presence in Portugal (Franco and Sutherland 2004)

Variable	Relationship	P value
Distance to unoccupied buildings	Negative	<0,001
Soil suitability for agriculture	Negative	<0,001
Presence of livestock	Positive	<0,001
Distance to the colony	Negative	<0,001
Shrubs	Negative	0,001
Distance to villages	Positive	0,002
Unoccupied houses	Positive	0,005
Distance to inhabited houses	Positive	0,006
Distance to paved roads	Positive	0,008
Tree plantations	Negative	0,017
Slope	Negative	0,042

The model that described the best the distribution of the Lesser Kestrels in Portugal comprised three variables: livestock, tree plantations and distance to colony, while the second best model also included presence of roads and human settlements (Franco and Sutherland 2004) (Figure 4).

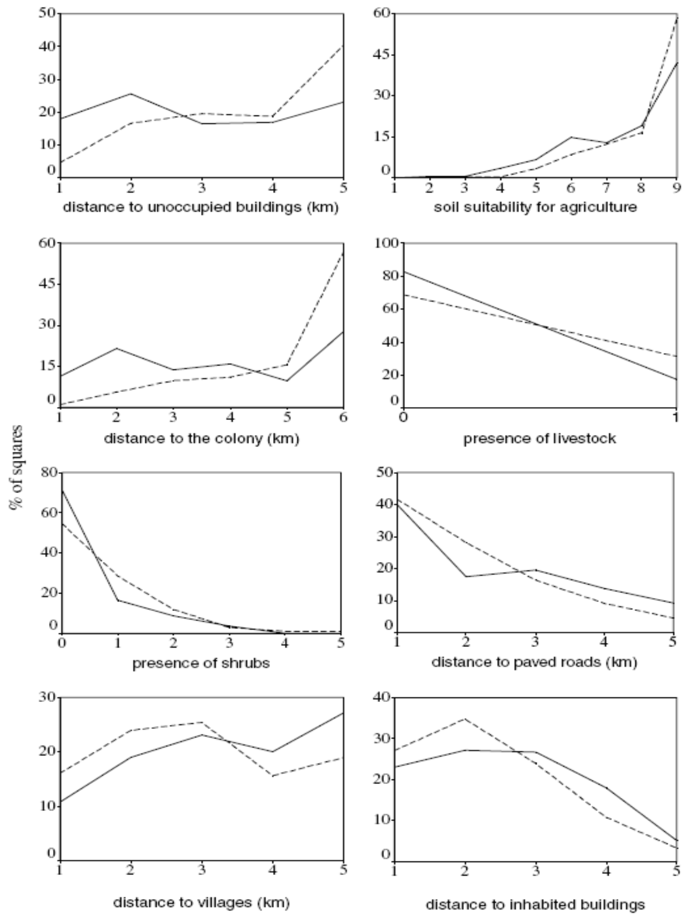


Figure 4. Variables proven significant for Lesser Kestrel presence. The continuous line represents the percentage of squares used by the birds; the dashed line is the percentage of squares with no Kestrel observations (Franco and Sutherland, 2004)

Another study on the habitat use of Lesser Kestrels, using data from radio-telemetry of 33 birds as well as sighting data from 35 km transects exhibited similar trends. Before hatching, the adult birds were found to forage on the following habitats (ranked in order of preference): grazed fallow (rank 6) > cereal > ploughed arable land > set aside > pine plantations > montado, while after hatching, their preferences changed as follows: stubble (rank 6) > ploughed > fallow > pine plant > set aside land (Franco *et al.* 2004). The authors correlated the positive selection of ploughed fields during the breeding season to suggested structural advantages for hunting (Franco *et al.* 2004).

In addition to that, Lesser Kestrels in Portugal showed no preferences for nesting in villages surrounded by high percentage coverage of woods, short-rotation cereal crops or olive plantations (Franco *et al.* 2005) (Figure 5). Unlike Spain (Bustamante 1997), the Lesser Kestrels in Portugal did not avoid irrigated areas (Franco *et al.* 2005).

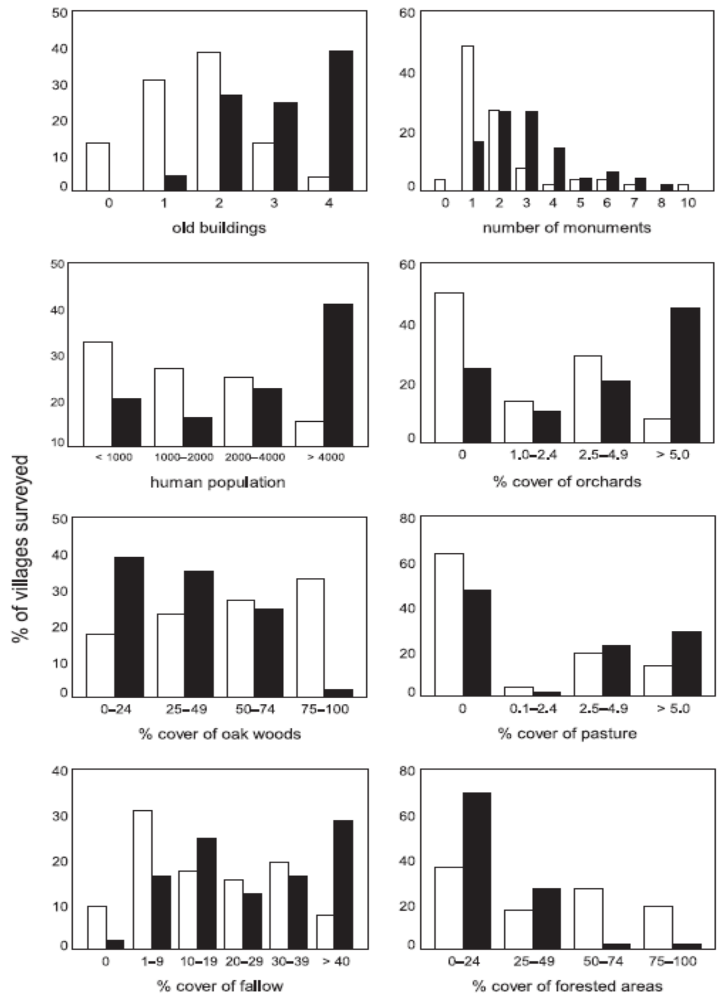


Figure 5. Variables, determining the presence of Lesser Kestrel nests in settlements studied in Portugal. Black bars represent settlements with Lesser Kestrels, white - without (Franco er al. 2005)

IV.1.1.4.3 Turkey

A study on 369 settlements in Central Turkey in 1993 revealed that Lesser Kestrels foraged over open areas with short vegetation, avoiding wooded upland, shrub-steppe and mixes patches of woodland and agriculture (Parr *et al.* 1995). The study explored the use of a total of 9 habitat classes: lowland dry grassland; arable agriculture; wet grassland; mixed agriculture; upland grassland and scrub; woodland (mainly coniferous plantations); marsh; open water and urban areas; as well as the occurrence of Lesser Kestrels in relation to altitude and topography (Parr *et al.* 1995). A positive correlation between the existence of breeding colonies and the presence of arable and mixed agriculture, marsh and reedbed habitats was found (Parr *et al.* 1995) (Table 3).

Table 3. SWMR Correlation between Lesser Kestrel presence and some environmental factors in 60 randomly selected 10-km squares in Central Turkey (Parr et al. 1995)

Variable	Estimate	SE	T-ratio	p
Constant	-1,685	1,573	-1,071	
Topography	-0,205	0,076	-2,698	<0,01
Arable agriculture	0,04	0,02	1,999	<0,05
Marsh and reedbed	0,638	0,44	1,541	>0,05
Open water	-0,332	0,212	1,569	>0,05
Mixed agriculture	0,038	0,212	1,09	>0,05
Settlement number	0,114	0,106	1,083	>0,05

The statistical analysis also showed highly significant positive relation to flat topography, though for Eastern Turkey there is evidence of colonies on hilly areas as well (Parr *et al.* 1995).

A later study in Central Turkey suggested association of the Lesser Kestrel colonies with the presence of dry and wet grassland habitats and correlation with lizard numbers as potential prey (Parr et al. 1997). Where colonies were found, land-use was dominated by semi-natural grasslands and short-rotation arable agriculture patches; there were rarely irrigated crops or other habitats (Parr et al. 1997). These results were explained with the abundance of lizards observed only on dry grassland (Parr et al. 1997). Lesser Kestrel presence was also positively correlated with semi-natural habitats such as pastures found within 1 km of settlements (Parr *et al.* 1997) (Table 4).

In addition to that, colonies were found to be adjacent to wet grassland and marshes (Parr *et al.* 1997).

Table 4. Percentage of land-use recorded along 2 km and 1 km transects around 30 settlements with Lesser Kestrels (n=21) and without colonies (n=9) in Central Turkey (Parr et al. 1997)

Land use	0-1 km	1-2 km	0-1 km	
			With LK	Without LK
Semi-natural grassland	61,9	40,9	50,1	67
Pasture	42,8	17,5	27,9	49,1
Dry grassland	14,6	16,4	18,8	12,8
Wet grassland	3,8	6,6	1,8	0,4
Salt pasture*	0,8	0,5	1,7	4,7
Fallow	27,9	43,5	32,9	25,8
Stubble	17,5	19,9	23,7	14,9
Bare fallow (ploughed < 1 month)	4,4	12,8	4,6	4,2
Fallow (ploughed > 1 month < 1 year)	4,2	7,7	1,4	5,4
Weedy fallow (ploughed > 1 year)	1,8	3,1	3,1	1,3
Cereal	4,1	10	8,9	2
Wheat	2,4	8	5,5	1,1

Land use	0-1 km	1-2 km	0-1 km	
			With LK	Without LK
Barley	1,3	1,6	3,4	0,4
Oats	0,1	0,4	0	0,2
Rye	0,2	0	0	0,3
Irrigated ground crop**	3,8	3,6	5,7	3,1
Other***	2,3	2	2,4	2,2
Total	100	100	100	100
***Dominated by halophyte species**				
****Sugar beet, nane, courgette, vetch, onions, cabbage, melon, alfalfa, vine, sunflower, chickpea, maize**				
*****Wood, bare ground, settlement, river**				

In Turkish Thrace Lesser Kestrels were observed feeding over pastures and grasslands in flat regions with highly developed agriculture and vast areas cultivated with cereals – wheat, rye, as well as sunflower and corn (pictures) (Kmetova *et al.* in press). One of the colonies was found on a shore cliff, while the birds were seen foraging over a grass patch between a construction site and a harbour (Kmetova *et al.* in press).

On overall, Lesser Kestrels do not use hunting area uniformly but actively select certain habitat types and avoid others (Rodriguez *et al.* 2006). A common trend is foraging on open areas with short vegetation, such as arable land and grasslands and actively discriminating dense woods or scrubland. In most of the cases, Lesser Kestrels also avoid irrigated cropland and wetlands (Bustamante 1997; De Frutos *et al.* 2009; Donazar *et al.* 1993), though in Turkey the nest locations were positively correlated to the presence of marshes (Parr *et al.* 1997) and in Portugal no negative correlation was found (Franco *et al.* 2005). Preferences towards certain topography was also commonly found (Franco *et al.* 2004; Kmetova *et al.* in press; Parr *et al.* 1995).

IV.1.2 Historic distribution and habitat use in Bulgaria

In Bulgaria the Lesser Kestrel is considered a lowland species, found mostly up to 500 m a.s.l (Simeonov *et al.* 1990). Despite the fact that most of the formerly known colonies have been reported within 100-200 m a.s.l., 11 nests were found above 600 m a.s.l.; other 3 nests – above 800 m a.s.l. and there was a colony known at about 1400 m a.s.l. (Iankov *et al.* 1994). For the entire period 1950 – 2000, the species was mostly reported in Southern Bulgaria, with a single observation in the Srebarna Reserve, Northern Bulgaria (Simeonov *et al.* 1990) and an occasional breeding in the Rusenski Lom Nature Park and close to the Belgradchik rock formations (Barov 2002). It was also recorded as a rare migrant along the Black Sea coast (Donchev 1980).

Lesser Kestrels were reported to nest in buildings under roof tiles (Patev 1950), in higher double-storey houses, monumental buildings and churches (Bozhkov 1972) and in old adobe village houses (Barov 2002). Other nesting sites used were rocks and rock formations and niches, including such in highly urban areas (Barov 2002; Reiser 1984 ; Shkorpil 1987), as well as hollows in old riparian trees (Boev *et al.* 1964). Data on 106 formerly known nests of Lesser Kestrels all over the country shows that 52,9 % of the nests were built on rocks (niches, hollows, nests of other species), 23,6 % on human artifacts (under roofs and in wall cavities), 20,7 % along riparian banks and 2,8 % in quarry sites (Barov 2002). The very last breeding pairs confirmed in Bulgaria were found in rural areas along river valleys with single trees and small forests, in Southern low-mountainous areas, covered by sparse woods and steppes (GB 2010; Simeonov *et al.* 1990).

The species is recorded as present in a total of 10 CORINE sites in Bulgaria – Konyavska planina (F00001900), Momina klissura (F00002800), Dobrostan – Prespa (F00004500), Valley of Arda River (F00005200), Byala reka (F00005300), Sakar (F00005600), Kotlenska planina (F00006300), Dervent (F00007100), Bourgasko Lake (F00007600), Lomovete (F00010600) (EUNIS 2010). Six of these ten sites are located in Southern Bulgaria and one is along the Via Pontica major migratory route (Bourgasko lake). In addition to that, the species is among the ones that have justified the designation of 13 Special Protection Areas (SPAs), part of the pan-European NATURA 2000 network of protected areas: Krumovitsa (BG00002012), Atanasovsko ezero (BG0000270), Sakar (BG0000212), Arda Bridge (BG0002071), Ropotamo complex (BG0002041), Rozov kladenets Reservoir (BG0002022), Belene Island Complex (BG0000217), Tsentralen Balkan (BG0000494), Madzharovo (BG0002014), Kotlenska Mountain (BG0002029), Burgasko ezero (BG0000273), Studen kladents (BG0002013), Byala reka (BG0002019) (EUNIS 2010).

Despite that, at present there are no Lesser Kestrel breeding pairs confirmed in Bulgaria (BSPB 2010; GB 2010).

IV.2 Suitability criteria and indexing

The following set of criteria is based on the independent environmental factors already proven to be correlated with the occurrence of various bird species and Lesser Kestrels in particular and described within the habitats suitability models reviewed in Chapter II. The suitability indices and tolerance ranges for these factors are derived on the base of the characteristic environmental requirements of the Lesser Kestrels, discussed in Chapter IV.1 .

On the base of the completed literature review, field visit and expert consultations, the following classes of independent environmental factors are suggested for determining the suitability of a given area for Lesser Kestrels: topography (altitude, slope, aspect), land management (land use, existence of protected areas and favourable land management practices), biological factors (proximity to existing Lesser Kestrel colonies, connectivity among sites, potential predator competition), demographic factors (road network, population density, presence of deserted buildings).

Resulting from the completed review on the behavioral characteristics of the species the following algorithm for compiling the habitat suitability model was adopted (Figure 6):

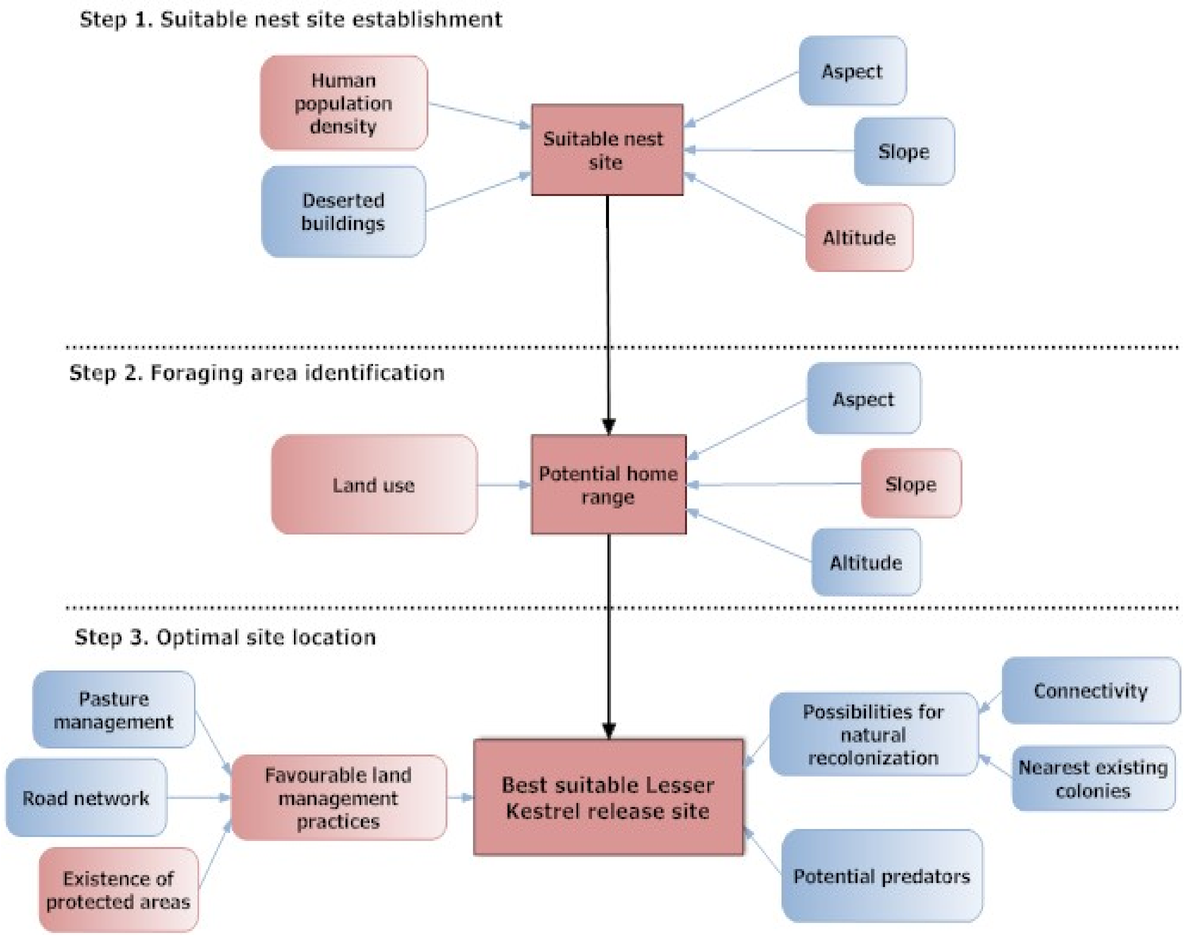


Figure 6. Habitat suitability model development. Rounded rectangles represent environmental factors. Squares are important milestones from the model development. Red indicates higher priority than the shapes in blue.

The habitat suitability model of Lesser Kestrel is based on the assumption that the survival of the species is determined by the presence of suitable nesting sites and foraging areas around them.

The first step suggested therefore is to identify the potentially suitable nesting sites on the base of the criteria described below (Chapter IV.2.1). After that step is executed, a buffer area around the suitable nesting sites is considered as potential home range these areas would offer to the species. As the foraging habitat would be a part of the potential home range, the second suggested step is to analyze the obtained home ranges in order to identify the presence of Lesser Kestrel preferred foraging habitat and topography. In order to find the optimal Lesser Kestrel site, the application of secondary criteria such as: presence of Lesser Kestrel favourable land management practices; possibilities for further natural recolonization; potential predatory pressure; is suggested as a third step.

In order to complete the described algorithm, the following suitability indices for the environmental factors chosen are proposed and justified:

IV.2.1 **Nest site criteria**

The completed literature review, field visit and expert consultations clearly show the preferences of Lesser Kestrels towards nesting in unoccupied buildings in urban or populated areas (Barov 2002; Cramp and Simmons 1987; Kmetova *et al.* in press; Parr *et al.* 1997; Patev 1950; Simeonov *et al.* 1990; Tella *et al.* 1996). Sites, distant to settlements (0-1 km) are also considered very suitable (Franco et al. 2005), as well as cliffs (Liven-Schulman *et al.* 2004) and river valleys (Barov 2002; Simeonov *et al.* 1990) (Table 9). In order to further identify the potentially most suitable urban areas, the use of some topographic and demographic factors is suggested.

IV.2.1.1 **Demographic factors**

The selection of urban areas potentially suitable for Lesser Kestrel nesting is based on the correlations of human population and Lesser Kestrel presence found by (Franco *et al.* 2005) (Figure 5). In addition to that too scarcely populated areas are considered possible indicators of deteriorated nesting and foraging habitats (Barov 2002), while at the same time too big urban areas would mean extra distance to feeding sites (Barov 2002; Tella *et al.* 1998). The indexation assigned to describe the suitability of settlements of different human population is also based on the observations in Turkish Thrace (Kmetova *et al.* in press) and is presented on Table 5

An additional demographic factor "population trend" is suggested to also evaluate the nesting suitability of the urban areas considered. As Lesser Kestrels prefer nesting in abandoned houses (Franco *et al.* 2005; Franco and Sutherland 2004; Kmetova *et al.* in press; Parr *et al.* 1995), human population trend is introduced to serve as a proxy for the presence of abandoned buildings and is indexed as shown on Table 5.

Table 5. Suitability indexing of two demographic environmental factors

Population density	Suitability index	Suitability
0 - 100	2	Suitable
100-1000	3	Most suitable
1000-2000	1	Less suitable
2000 - 4000	2	Suitable
>4000	3	Most suitable
Population trend	**Suitability index**	**Suitability**
> 50 % decrease	3	Most suitable
< 50 % decrease	2	Suitable
Stable or increase	1	Less suitable

IV.2.1.2 Topography

Topography is often correlated to Lesser Kestrel presence (Ananian 2009; Bustamante 1997; Cramp and Simmons 1987; Kmetova *et al.* in press; Parr *et al.* 1995; Simeonov *et al.* 1990). As a result of the completed literature review and field observations, three factors related to topography are suggested as most influential to Lesser Kestrel nesting in a given area: altitude, slope and aspect.

IV.2.1.2.1 Altitude

Altitude is mentioned by many authors describing the presence of Lesser Kestrels in a given area (Ananian 2009; Bustamante 1997; Cramp and Simmons 1987; Simeonov *et al.* 1990). It is therefore considered among the deterministic environmental factors and assigned suitability indices adapted to the data on the last confirmed Lesser Kestrel colonies in Bulgaria as follows (Table 6):

Table 6. Suitability indexing for "altitude" environmental factor

Altitude	Suitability index	Suitability	References
0-500 m	2	Most suitable	(Cramp and Simmons 1987; Kmetova *et al.* in press; Simeonov *et al.* 1990)
500–800 m	1	Less suitable	(Bustamante 1997)
>800 m	0	Not-suitable	Considering the past distribution of Lesser Kestrels in Bulgaria

IV.2.1.2.2 Slope

Slope is also mentioned by several authors describing the presence of Lesser Kestrel (Cramp and Simmons 1987; Franco *et al.* 2005; Franco and Sutherland 2004; Kmetova *et al.* in press; Parr *et al.* 1995; Simeonov *et al.* 1990). Positive relation to flat topography has been reported (Parr *et al.* 1995), as well as preferences towards lowlands (Simeonov *et al.* 1990), shallow slopes)(Franco *et al.* 2005; Franco and Sutherland 2004) and mountain foothills (Cramp and Simmons 1987; Simeonov *et al.* 1990). The observations in Turkish Trace also confirm the preferences of the species towards flat areas, especially for foraging. Based on the completed literature review and expert consultations, slope is assigned the following suitability indices (Table 7):

Table 7. Suitability indexing for "slope" environmental factor

Slope (degrees)	Suitability index	Suitablity
0-5	3	Most suitable
5-15	2	Very suitable
>15	1	Suitable

IV.2.1.2.3 Aspect

Aspect is not typically mentioned as deterministic for the nesting of Lesser Kestrels. However (Simeonov *et al.* 1990) reports preference towards southern terrains. Aspect is therefore considered a non-deterministic factor with positive impact on the quality of the sites compared. Based on expert consultations, aspect is assigned the following suitability indexation (Table 8):

Table 8. Suitability indexing of "aspect" environmental factor

Aspect	Degrees	Suitability index	Suitability
Flat	-1	4	Most suitable
North	0-22,5	1	Least suitable
Northeast	22,5 – 67,5	1	Least suitable
East	67,5 – 112,5	2	Less suitable
Southeast	112,5 – 157,5	3	Suitable
South	157,5 – 202,5	4	Most suitable
Southwest	202,5 – 247,5	3	Suitable
West	247,5 – 292,5	2	Less suitable
Northwest	292,5 – 337,5	1	Least suitable
North	337,5 - 360	1	Least suitable

IV.2.2 Foraging area criteria

Lesser Kestrels feed relatively close to their nesting sites and the presence of suitable foraging habitats within the potential home range is of utmost importance for their survival and successful establishment. For the aims of the current model, the suitability of the potential home range is considered to be defined by the presence of suitable Lesser Kestrel foraging habitats at a suitable topography.

IV.2.2.1 Home range

Various figures are reported for home range of Lesser Kestrels: 63,56 km^2 in intensively maintained habitats; 12,36 km^2 in traditional agro-grazing systems; approximately 36 km^2 for an average-sized colony (Tella *et al.* 1998); up to an average of 4,5 km away from colonies (Garcia *et al.* 2006; Liven-Schulman *et al.* 2004), up to 16 km away from colonies (Garcia *et al.* 2006; Negro *et al.* 1993), from 1,8 km to 8,01 km away from colonies in Turkish Thrace (Kmetova *et al.* in press).

For the aims of the current study and based on the contemporary conditions in Bulgaria, the completed literature review and field observations, 4,5 km buffer area around the potentially suitable nesting sites is considered to comprise the most probable and favourable home range of the Lesser Kestrels (Garcia *et al.* 2006; Liven-Schulman *et al.* 2004; Negro *et al.* 1993).

IV.2.2.2 Suitable foraging habitats

The identification and ranking of the suitable Lesser Kestrel foraging areas is completed adjusting the data derived from the literature review and field observation onto the CORINE 2000 land cover classification, developed by the Bulgarian Academy of Science (Table 9).

Table 9. Suitability indexing for "land use" environmental factor

CORINE Habitat type	Suitability index (foraging)	Suitability index (nesting)	Literature review equivalent
Airports	0	0	Urban areas with high disturbance
Bare rocks	0	3	Cliffs (Barov 2002; Liven-Schulman *et al.* 2004)
Beaches, dunes, sands	0	2	River banks (Barov 2002; Kmetova *et al.* in press; Simeonov *et al.* 1990)
Broad leaved forest	0	0	Woods, oak forests (De Frutos *et al.* 2009; Donazar *et al.* 1993; Franco and Sutherland 2004)
Burnt areas	1	0	Stubble of deteriorated quality (De Frutos *et al.* 2009; Franco *et al.* 2004; Tella and Forero

CORINE Habitat type	Suitability index (foraging)	Suitability index (nesting)	Literature review equivalent
			2000)
Coastal lagoons	0	2	Coastal areas (Kmetova *et al.* in press)
Complex cultivation patterns	2	0	Short-rotation arable land (Barov 2002; Kmetova *et al.* in press; Parr *et al.* 1997)
Coniferous forest	0	0	Woods, coniferious forests (De Frutos *et al.* 2009; Donazar *et al.* 1993; Franco and Sutherland 2004)
Construction sites	0	0	Urban areas with high disturbance
Continuous urban fabric	0	3	Unoccupied buildings, urban areas (Barov 2002; Cramp and Simmons 1987; Kmetova *et al.* in press; Parr *et al.* 1997; Patev 1950; Simeonov *et al.* 1990; Tella *et al.* 1996)
Discontinuous urban fabric	0	3	Unoccupied buildings, urban areas (Barov 2002; Cramp and Simmons 1987; Kmetova *et al.* in press; Parr *et al.* 1997; Patev 1950; Simeonov *et al.* 1990; Tella *et al.* 1996)
Dump sites	0	0	Never reported
Fruit trees and berry plantations	0	0	Orchards (Garcia *et al.* 2006)
Green urban areas	1	0	Green urban areas (Kmetova *et al.* in press)
Industrial or commercial units	0	3	Urban areas (Barov 2002; Cramp and Simmons 1987; Kmetova *et al.* in press; Parr *et al.* 1997; Patev 1950; Simeonov *et al.* 1990; Tella *et al.* 1996)
Inland marshes	1	0	Marshes (Parr *et al.* 1995)
Land principally occupied by agriculture, with significant areas of natural vegetation	2	0	Semi-natural grassland, field margins (Barov 2002; De Frutos *et al.* 2009; Kmetova *et al.* in press; Parr *et al.* 1997; Tella *et al.* 1998)
Mineral extraction sites	0	1	Quarries (Barov 2002; Liven-Schulman *et al.* 2004)
Mixed forest	0	0	Mixed forest (De Frutos *et al.* 2009; Donazar *et al.* 1993; Franco and Sutherland 2004)
Moors and heathland	1	0	Grass habitats on wet terrains (Barov 2002), marshes (Parr *et al.* 1995)
Natural grassland	3	0	Grassland (Donazar *et al.* 1993; Kmetova *et al.* in press)
Non-irrigated arable lands	3	0	Non-irrigated arable, cereals, fallow, stubble (Donazar *et al.* 1993) (Barov 2002; Bustamante 1997; Kmetova *et al.* in press; Tella *et al.* 1998)
Pastures	4	0	Pastures (Barov 2002; Donazar *et al.* 1993; Franco *et al.* 2004; Garcia *et al.* 2006; Kmetova *et al.* in press; Parr *et al.* 1997)
Peat bogs	0	0	Never reported
Port areas	0	0	Urban areas with high disturbance

CORINE Habitat type	Suitability index (foraging)	Suitability index (nesting)	Literature review equivalent
Rice fields	0	0	Wet grasslands of non-suitable vegetation height
Road and railway networks	1	0	See Chapter IV.2.3.1.2
Salines	0	0	Open water bodies (Parr *et al.* 1995)
Salt marshes	0	0	Salt lakes (Tella *et al.* 1998)
Sparsely vegetated areas	3	0	Grassland (Donazar *et al.* 1993; Kmetova *et al.* in press), pastures (Barov 2002; Donazar *et al.* 1993; Franco *et al.* 2004; Garcia *et al.* 2006; Kmetova *et al.* in press; Parr *et al.* 1997)
Sport and leisure facilities	0	0	Urban areas with high disturbance
Transitional woodland/ shrub	0	0	Scrubland, shrubs (De Frutos *et al.* 2009; Franco *et al.* 2004)
Vineyards	0	0	Vineyards (Garcia *et al.* 2006)
Water bodies	0	0	Open water bodies (Parr *et al.* 1995)
Water courses	0	0	Running water (Bustamante 1997)

The CORINE land use classes (Table 9) are allocated habitat suitability indexes as shown and justified on (Table 10).

Table 10. Habitat suitability indexing

Suitability index	Suitability
1	Least suitable
2	Suitable
3	Very suitable
4	Most suitable

IV.2.2.3 Topography

The topography criteria suggested for foraging area are based on the same factors and indexation explained in Chapter IV.2.1.2, Table 6, Table 7, Table 8. The only difference is that, based on expert opinion and field observations, slope is given higher weight when considering all three factors (Chapter V.1.1.2).

IV.2.3 Secondary criteria

The identification of optimal Lesser Kestrel nesting and foraging habitats is a complex task, defined by numerous other additional factors and criteria. Having completed the first two steps for identifying potentially suitable nesting and foraging areas, further analyses on some of the other qualities of the sites are suggested to assist their comparison and the selection of the optimal ones among them. Among the criteria suggested are Lesser Kestrel favourable land management practices, distance from nearest confirmed Lesser Kestrel colonies and potential predators. Some of the criteria discussed in this section are not given suitability indexing, but are set up to enable the comparison of the preliminary selected sites and the identification of the best one among them.

IV.2.3.1 Favourable land management practices

The favourable land management practices are intended to give additional value to the sites selected in terms of already introduced practices that have proven to have a positive impact on the Lesser Kestrel populations, as opposed to sites which are also suitable, but would need the establishment of such regimes to improve the chances of population recovery.

IV.2.3.1.1 Pasture management

Lesser Kestrels are considered dependant on low-grass pastures as most preferred foraging areas (Barov 2002; Donazar *et al.* 1993; Franco *et al.* 2004; Garcia *et al.* 2006; Kmetova *et al.* in press; Parr *et al.* 1997). The presence of livestock can maintain vegetation at suitable height for better Lesser Kestrel hunting success and is also associated with a variety of related invertebrates that can be potential food source (Franco and Sutherland 2004). It is therefore no surprise that livestock numbers have been found to positively correlate to the presence of Lesser Kestrels (Franco and Sutherland 2004). The number of cattle in the potentially suitable home range is therefore suggested as an indirect criterion for indicating the quality of the Lesser Kestrel foraging habitats. No indexing is assigned to this criterion as it is intended to be used for comparison of the preliminary selected sites only.

IV.2.3.1.2 Road network

Positive influence of paved road and Lesser Kestrel observations has been reported (Franco and Sutherland, 2004) (Figure 4). A possible explanation for that is the fact that electricity networks often run in parallel to the roads, and the presence of electric poles has been proven to secure roosting sites during hunting or for the young birds in the post-fledge and pre-migratory period (De Frutos *et al.* 2009; Franco *et al.* 2005). Distance from existing road infrastructure is therefore suggested as an additional criterion defining the quality of a given habitat and is assigned the following habitat suitability indexing (Table 11):

Table 11. Suitability indexing of "distance to roads" factor

Distance to roads	Suitability index	Suitability
0-2 km	3	Most suitable
2 – 3 km	2	Suitable
>3 km	1	Less suitable

IV.2.3.1.3 Existing protected areas

Protected areas and are under legal protection, require environmentally friendly management regimes, defined by specially designed Management Plans and have responsible authorities set to secure their adequate conservation and maintenance. It is therefore better for the potential Lesser Kestrel nesting and foraging areas to be located within existing protected areas, which are better managed and controlled. Thus habitat suitability indexing in accordance with the presence of already existing NATURA 2000 Special Protected Areas (SPA), potential Sites of Community Interest (pSCI) and CORINE sites is suggested as follows (Table 12).

Table 12. Suitability indexing of "protected areas" environmental factor

Presence of protected areas	Suitability index	Suitability
Presence of a protected area	2	Most suitable
Lack of a protected area	1	Less suitable

IV.2.3.2 Possibility for further natural recolonization

IV.2.3.2.1 Distance to nearest existing colonies

The proximity of the target sites to the nearest existing Lesser Kestrel colonies is of great importance for securing good connectivity and exchange of genes of the re-established population within the global range of the species. Lesser Kestrels are incredibly phylopatric (Negro *et al.* 1997; Serrano *et al.* 2008; Serrano and Tella 2003). Adults are rather reluctant to disperse from familiar areas, returning to the colonies on the basis of conspecific attraction, and the number of birds in the existing colony is used by the prospecting birds as an indicator of the patch quality (Serrano and Tella 2003). Thus, in Southern Spain 90 % of resights of 321 ringed Lesser kestrels from seven cohorts (1988 – 1994) have been observed within 30 km of birthplace, 57 % of the one-year birds settled in their natal colonies, while the rest dispersed at medial distance of 19 km for males, 18,5 km for females (Negro *et al.* 1997). Another study in Northeastern Spain indicates high natal dispersal rate from colony (83 %), at a median distance of 7 km (0,1 km – 136 km) (Serrano *et al.* 2008; Serrano *et al.* 2003). In addition to that, most of the

Lesser Kestrels surveyed in Northeastern Spain (88 %) settled on buildings that had previously been occupied by existing colonies and very few (26 %) of the birds moved out of the subpopulation where they had hatched (Serrano *et al.* 2003).

Furthermore, the distance to nearest unoccupied suitable building did not seemingly influence the tendency to disperse (Serrano *et al.* 2003). In addition to that, the recolonization chances decrease as isolation increases (Hansky 1994), which is especially important considering the global negative trend of the species.

Therefore, when comparing the suitable sites, priority is suggested for the sites within 30 km or as close as possible to confirmed breeding Lesser Kestrel populations.

IV.2.3.2.2 Connectivity among the suitable sites

Connectivity among the potentially suitable Lesser Kestrel sites is of significant importance for securing the potential natural recolonization and further dispersal of the species once a viable population is re-established in the selected target areas. Lesser Kestrels have been reported up to 30 km away from birthplace in Northeastern Spain (Serrano *et al.* 2008; Serrano *et al.* 2003) and at an average distance of 18,5-19 km from their colonies in Southern Spain (Negro *et al.* 1997) (See Chapter IV.2.3.2.1). Therefore, it is suggested to give priority to clusters of suitable sites located within the Lesser Kestrel mean dispersal distances of 19 km.

IV.2.3.3 **Potential predators**

Empirical studies in Kazakhstan have showed that the number of breeding Lesser Kestrels is negatively correlated to the presence of large raptors (Tella *et al.* 2004). In addition to that, large species of eagles, falcons, eagle owls have been proven to prey on adults and fledglings (Tella *et al.* 1996) and can therefore potentially jeopardize or hinder the Lesser Kestrel population recovery.

IV.2.3.3.1 Imperial eagle

Imperial eagle (*Aquila heliaca*) is a large bird of prey that could potentially disturb the Lesser Kestrel colonies. Furthermore, the food spectrum of Imperial eagles can also consist of birds (Petrov and Stoychev 2002) and it can therefore be considered as a potential predator on recently fledged inexperienced Lesser Kestrels. It is therefore suggested to consider the distance from confirmed Imperial eagle nests when locating the optimal Lesser Kestrel site.

IV.2.3.3.2 Long-legged Buzzard

Long-legged Buzzard (*Buteo rufinus*) is a fairly large bird of prey. There is no data on the interaction between Lesser Kestrels and Long-legged Buzzards in particular, even though it is thought that similar species – such as the Common Buzzard (*Buteo buteo*) are generally being ignored (Cramp and Simmons 1987). Despite that, same authors report observations of an intruding Common Buzzards being severely mobbed by a group of 100 Lesser Kestrels (Cramp and Simmons 1987). Extreme proximity to Long-legged Buzzard nests could therefore potentially cause anxiety and disturbance in the Lesser Kestrel colonies. The distance from confirmed Long-legged Buzzard nests is therefore suggested as an additional criterion when locating the optimal Lesser Kestrel site.

V Model application within a Lesser Kestrel restoration programme in Southeastern Bulgaria

The following chapter will discuss the use of the Habitat Suitability model developed in Chapter IV.2 and the various applications the model can have when executed in GIS environment – from identifying potential nesting and foraging sites to comparing the qualities of individual sites and deriving complex statistical information on their particular environmental or demographic characteristics.

The model was applied on a target area in Southeastern Bulgaria, derived on the base of former Lesser Kestrel breeding sites, proximity to the second highest European population found in Turkey and expert consultations. The target area comprises a total of 3076 km^2, 97 settlements in 13 municipalities from 4 districts (Haskovo, Stara Zagora, Kurdzhali and Jambol) and 17 CORINE land-use classes (Table 16). In addition to that, the site almost entirely falls within the Sakar SPA (BG0002012) and Sakar pSCI (BG0000212) and comprises a great part of the Sakar (F00005600) CORINE area. It was selected being the last confirmed Lesser Kestrel nesting site in the Southern part of the country (GB 2010). (Annexes IX.1, IX.2).

Following the suggested Lesser Kestrel Habitat Suitability model algorithm (Figure 6), the application of each of the suggested criteria is explained in terms of necessary GIS processing operations and the resulting outcomes are then presented and discussed.

Each of the criteria was presented by a digital layer that was processed with ESRI Arc Map 9.3 software in the way shown on Figure 7.

Before any of these operations was completed all layers were clipped or intersected with the target area outlines to limit the range and size of the datasets used to only the region of interest.

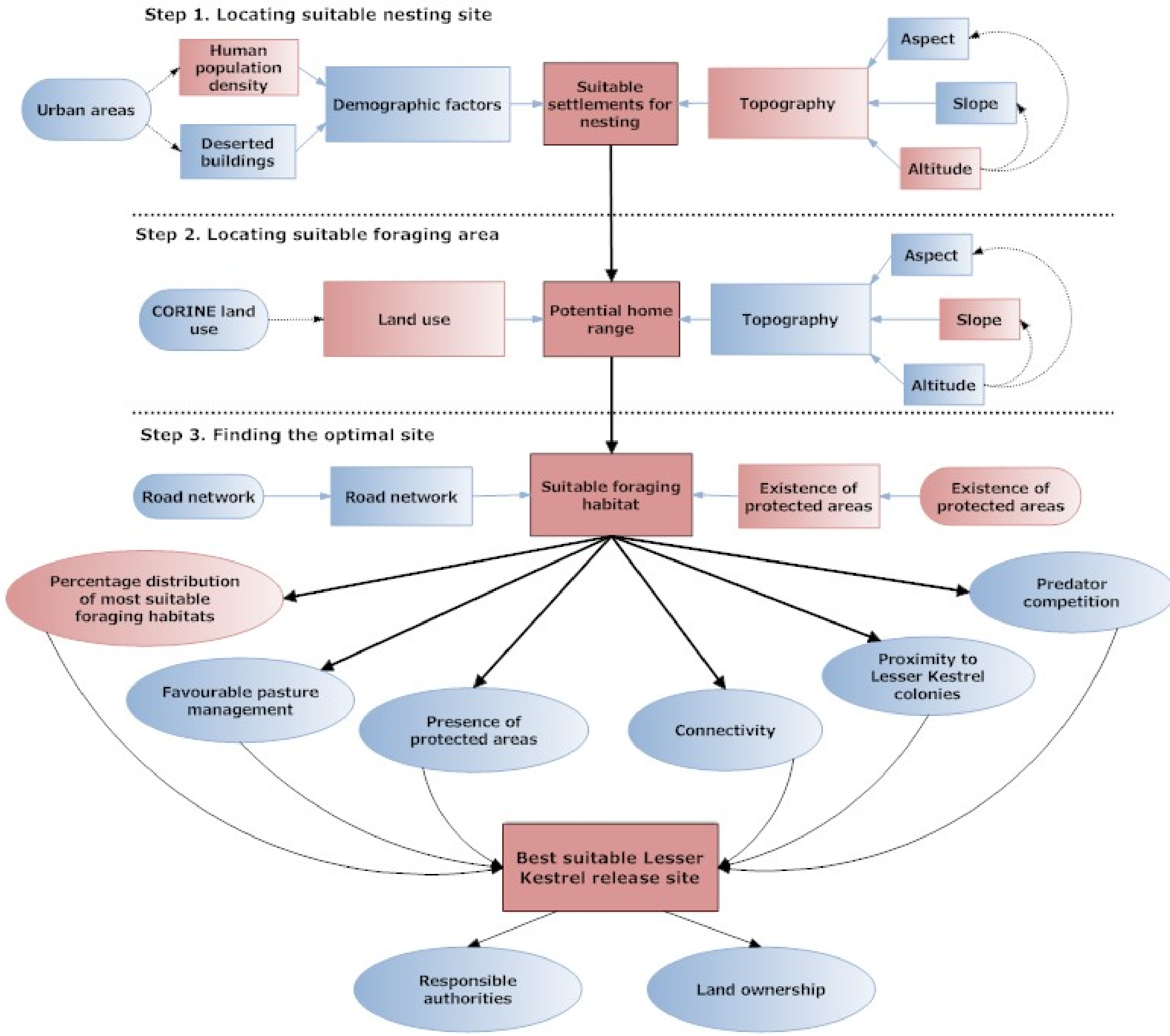


Figure 7. Implementation of the Lesser Kestrel Habitat suitability model in GIS environment. Rounded rectangles represent polygon layers, rectangles represent grid layers, ovals represent derivative tables and statistics. Red indicates higher priority than the shapes in blue.

V.1 Locating suitable nest site

V.1.1 GIS operations

Considering the limitations of the available GIS datasets, the need of further field verification of the data on cliffs, valleys and quarries, as well as the observations in Turkish Thrace, only the urban areas were selected as most probable Lesser Kestrel nesting site. The selection was then narrowed to the ones that fit best to the topographic and demographic criteria described in Chapter IV.2.1. The analysis started with a total of 97 settlements located within the target area and followed the procedure described (Annex IX.1).

V.1.1.1 Demographic factors

A shapefile of polygon urban areas was intersected with the target area to extract only the objects within the project area. The polygon file was then joined with a point layer of the urban areas to extract the names and population data (1994) of the ones in the target site. Population numbers from 2009 were manually added using the freely available tables provided by the Bulgarian "Citizen Registration and Administrative Services" Head Directorate and population trends were then calculated in GIS environment.

The shape file was then converted into two grid files, one with values equal to the population in 2009, while the other with values corresponding to the calculated population trend. The files were then reclassified to address the suitability indexation (Table 5) and overlaid using weighted overlay operation, assigning 70 % importance to the population in 2009 and 30 % to the population trend. The output layer represents the nesting suitability of the urban areas considering the described demographic factors and narrows down the potentially most suitable nesting sites to 61 settlements (Figure 8).

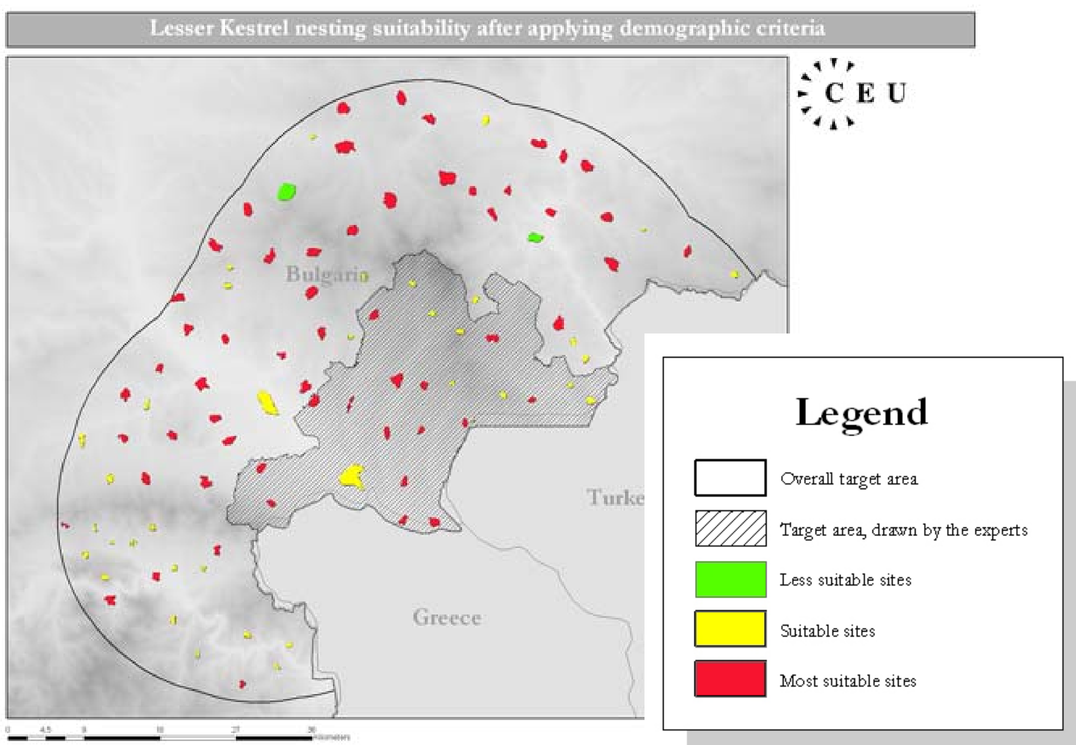


Figure 8. Screen shot of Lesser Kestrel nesting suitability after applying demographic criteria.

V.1.1.2 Topography

Aspect and slope were derived from the digital elevation map available, using the standard tools of the Spatial Analyst extension of Arc Map 9.3. Once the three topography raster files were reclassified to address the suitability indices (Table 6, Table 7, Table 8), they were overlaid through Spatial analyst weighted sum operation, assigning the following weights based on expert consultations and field observations – altitude – 1; slope – 0,3; aspect – 0,1.

The output topography layer was then multiplied by the demographically processed urban layer to find out which of the already ranked settlements are located within the suitable topography. The output raster file was classified according to the rounded integer result from the calculation (9 classes from 2 to 10) and statistics for the class coverage of each settlement was extracted using the Thematic raster summary (by polygon) tool of the Hawth's tool. The output table was processed with Microsoft Office Excel and then classified according to the amount of the territory of the settlements falling within the suitable topography criteria (Table 13).

Table 13. Suitability indexing of settlements according to the percentage of their territory falling within the most suitable topography

Criteria	Suitability index	Suitability
Coverage of class 10 > 50 %	3	Most suitable
Summed coverage of class 10 and class 9 = 100 %	2	Suitable
Summed coverage of class 10 and class 9 > 50 %	1	Less suitable
Others	0	Non-suitable

V.1.2 Results and discussion

A total of 15 out of the 96 settlements scored 3 at the final stage (combined demographic and topographic factors) and were therefore considered most suitable and processed for further analysis.

GIS tools allowed for easy and quick identification of the administrative affiliation of the potentially suitable nesting sites identified straight away. The completed GIS operations show that all of the 15 most suitable nesting locations fall within the territories of the Haskovo District, the Kurdzhali Regional Directorate of Forestry and the following other administrative structures of Bulgaria (Table 14).

Table 14. Settlements ranked most suitable for nesting of Lesser Kestrels

Name of settlement	Municipality	RIEW	State forestry unit
Dositeevo	Harmanli	Haskovo	Harmanli
Generalovo	Svilengrad	Haskovo	Svilengrad
Kapitan Andreevo	Svilengrad	Haskovo	Svilengrad
Lozen	Liubimets	Haskovo	Svilengrad
Mladinovo	Svilengrad	Haskovo	Svilengrad
Mramor	Topolovgrad	Stara Zagora	Topolovgrad
Mustrak	Svilengrad	Haskovo	Svilengrad
Nadezhden	Harmanli	Haskovo	Harmanli
Oryahovo	Liubimets	Haskovo	Svilengrad
Rogozinovo	Harmanli	Haskovo	Harmanli
Shtit	Svilengrad	Haskovo	Svilengrad
Srem	Topolovgrad	Stara Zagora	Topolovgrad
Studena	Svilengrad	Haskovo	Svilengrad
Svetlina	Topolovgrad	Stara Zagora	Topolovgrad
Valche pole	Liubimets	Haskovo	Svilengrad

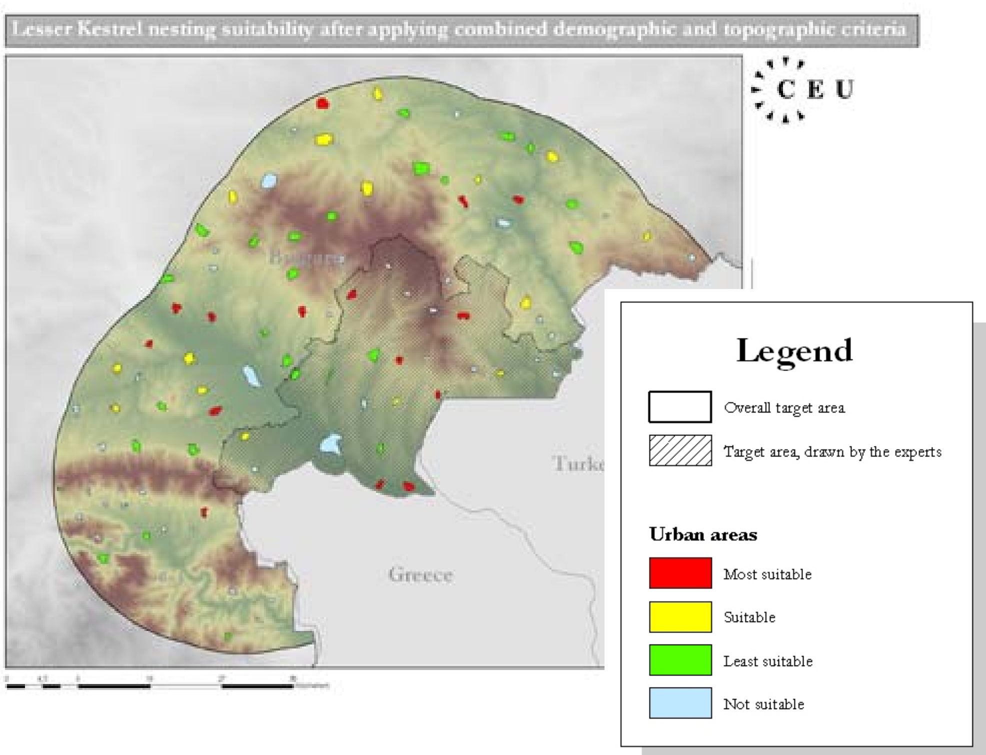


Figure 9. Screen shot of Lesser Kestrel nesting suitability after applying combined demographic and topographic criteria.

The best-ranked fifteen settlements are located on the territories of altogether four municipalities (Harmanli, Liubimets, Svilengrad and Topolovgrad). The municipality that holds the highest number of potentially suitable nesting sites is Svilengrad (6 settlements). Two Regional Inspectorates of Environment and Waters (RIEW Haskovo and RIEW Stara Zagora) and three state forestry units share the responsibility for the entire group of settlements (Figure 9).

V.2 Determining suitable foraging area

V.2.1 GIS operations

Based on the most suitable nesting sites identified (Chapter 0), a buffer area of 4,5 km was drawn using the Buffer tool of Arc Map 9.3 to represent the potential home range of the birds that would nest in these sites. In order to distinguish the individual home ranges, from this point onwards, they are referred to with the names of the settlements they were drawn around.

The CORINE land cover shapefile was then converted into grid file and reclassified according to the suitability indexes assigned (Table 9). The home range buffers were also rasterized and overlapped with the indexed land use raster. Statistics on the percentage distribution of each of the land classes within each of the potential home ranges was derived using the "Clip raster by polygons" tool of the Hawth's toolbox (Table 15 Table 16).

The suitable topography was obtained, using the Weighted sum operation of the Spatial analyst extension, summing the indexed topographic layers (Table 6, Table 7, Table 8) and assigning them the following weights, based on expert consultations and field observations – altitude – 0,6; slope – 0,4; aspect – 0,1.

The output layer was then summed with the layer, representing suitable foraging topography, using weighted sum and assigning priority to suitable land use (0,6) as compared to topography (0,4) based on expert consultations and field observations.

V.2.2 Results and discussion

The GIS analysis completed show that the 15 potential Lesser Kestrel home ranges comprise a total of 17 CORINE land use classes in the proportions shown on Table 15 and Table 16, Figure 10:

Table 15. Indexed land-use coverage of 4,5 km buffers around the most suitable nesting settlements of Lesser Kestrels:

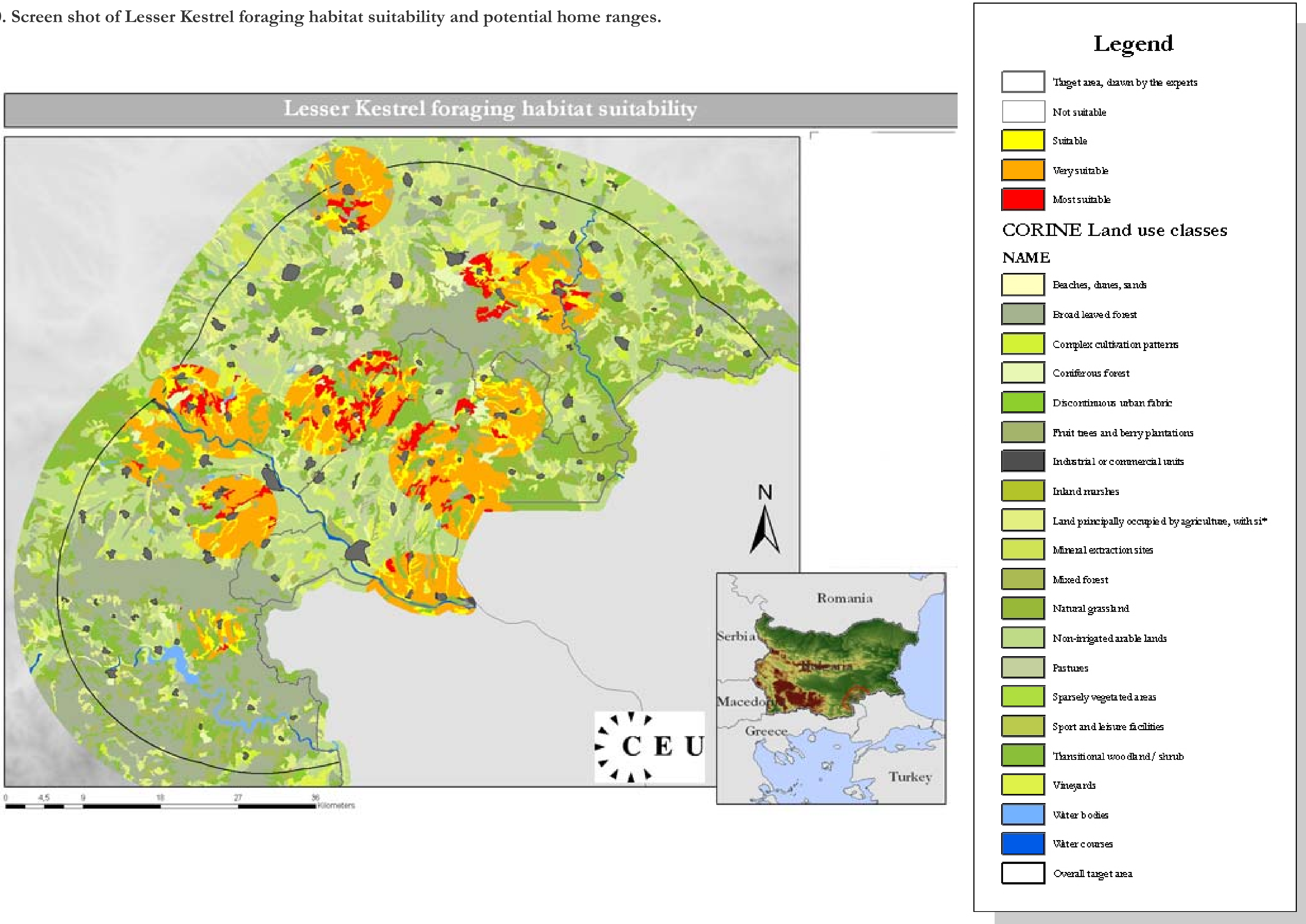
Settlement buffer	Suitability index % coverage					Total %	Classes 4+3	% of polygon in project area
	0	1	2	3	4			
Shtit	18	0	9	70	4	100	**73**	85
Lozen	24	0	9	62	5	100	**67**	100
Generalovo	25	0	11	60	3	100	**63**	69
Mustrak	28	0	10	50	12	100	**62**	100
Kapitan Andreevo	25	0	14	61	0	100	**61**	60
Dositeevo	27	0	12	53	8	100	**61**	100
Svetlina	31	0	11	50	7	100	**57**	100
Oryahovo	**26**	**0**	**17**	**40**	**16**	**100**	**57**	**100**
Rogozinovo	36	0	12	39	12	100	**51**	100
Srem	33	0	17	45	5	100	**50**	100
Studena	33	0	17	45	5	100	**50**	100
Mladinovo	**39**	**0**	**11**	**27**	**22**	**100**	**50**	**100**
Nadezhden	55	0	8	36	1	100	**37**	100
Mramor	**50**	**0**	**15**	**19**	**16**	**100**	**35**	**100**
Valche pole	77	0	10	12	1	100	**13**	100

Table 16. Land use types in the 15 most-suitable Lesser Kestrel nesting settlements

Settlement	Land use type																	TOTAL %	% of polygon in
Buffer	ARB	AGR	PST	BRF	TRNS	DURB	MXFR	VIN	SPRT	GRSS	WCRS	CNIF	WAT	MIN	FTRE	CULT	IND		target area
Dositeevo	39	**10**	8	0	13	1	1	6	0	14	2	1	1	0	2	2	0	100	100
Generalovo	**60**	8	3	2	13	3	0	3	0	0	4	0	0	0	0	**3**	1	100	69
Kapitan Andreevo	**61**	11	0	4	11	2	0	2	0	0	4	0	0	0	0	**3**	3	100	60
Lozen	62	9	5	7	8	3	2	3	0	0	0	0	0	0	1	0	1	100	100
Mladinovo	27	11	**22**	1	28	2	4	3	0	0	0	0	0	0	1	0	0	100	100
Mramor	17	13	**16**	24	6	2	4	10	0	2	0	3	0	1	0	2	0	100	100
Mustrak	**43**	10	12	4	15	2	1	3	0	7	0	2	0	0	1	1	0	100	100
Nadezhden	28	8	1	10	26	3	4	5	0	8	2	3	0	0	1	0	1	100	100
Oryahovo	40	**16**	**16**	1	14	2	1	6	0	0	0	1	0	0	1	1	0	100	100
Rogozinovo	38	12	12	1	13	4	3	3	0	1	2	6	1	0	1	1	2	100	100
Shtit	**45**	9	4	3	13	1	0	0	0	**25**	0	1	0	0	0	0	0	100	85
Srem	32	16	5	12	5	1	6	3	0	13	3	2	0	0	0	1	0	100	100
Studena	22	**17**	5	3	10	2	6	3	0	**22**	0	7	0	0	1	0	1	100	100
Svetlina	50	10	7	9	6	2	3	3	0	0	0	0	0	0	8	1	0	100	100
Valche pole	12	9	1	45	27	0	4	1	0	1	0	0	0	0	0	0	0	100	100

ARB Non-irrigated arable lands
AGR Land principally occupied by agriculture, with significant areas of natural vegetation
PST Pastures
BRF Broad leaved forest
TRNS Transitional woodland shrub
DURB Discontinuous urban fabric
MXFR Mixed forest
VINE Vineyards
SPRT Sport and leisure facilities
GRSS Natural grassland
WCRS Water courses
CNIF Coniferous forest
WAT Water bodies
MIN Mineral extraction sites
FTRE Fruit trees and berry plantations
CULT Complex cultivation patterns
IND Industrial or commercial units

Figure 10. Screen shot of Lesser Kestrel foraging habitat suitability and potential home ranges.



The calculation results show that a total of twelve of the settlement buffers fall entirely within the target area, while three others (Shtit, Generalovo and Kapitan Andreevo) are at the border with Turkey so when buffer area of 4,5 km was drawn, the output polygons were partially outside the territory of the country. It should be notes that only the information available for Bulgaria was analyzed.

The settlements that have highest percentage coverage of habitats of the best quality for Lesser Kestrels (index 4) are Mladinovo (22 %), Oryahovo (16 %) and Mramor (16 %). Studies show that Lesser Kestrels use about 56 % of their home range on average (Tella *et al.* 1998), and eight of all fifteen settlements exceed 56 % coverage of the two most suitable habitat classes (index 3 and index 4). The three settlements that hold least coverage of suitable foraging habitats are Nadezhden, Mramor and Valche pole, even though 100 % of their territories were analyzed.

The calculations show that four out of the six sites that scored best in terms of presence of suitable foraging habitats are located at the border area with Turkey and within the target area preliminary drawn by the experts. The other suitable home ranges are generally found along the Maritsa River valley. This is a well-known agricultural area, though the results also show that the percentage coverage of pastures and grasslands there is mostly lower than that of the settlements at the border sites.

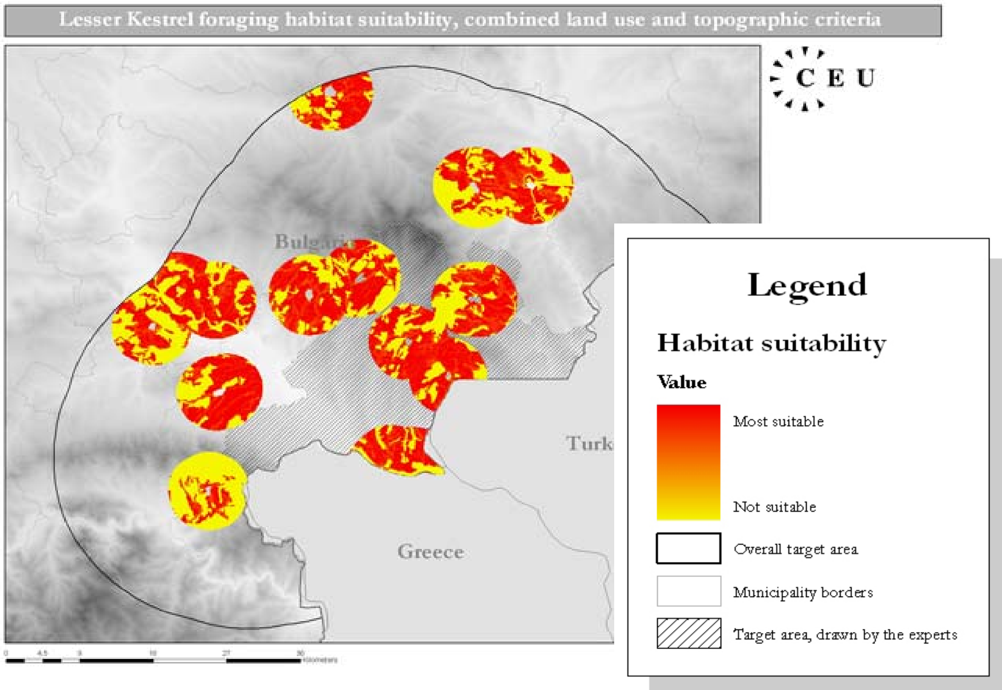


Figure 11. Screen shot of Lesser Kestrel foraging habitat suitability, combined land use and topographic criteria.

Despite these results, the selection of the most suitable potential foraging area cannot be simply based on the suitability of the land use types. The observations in Turkish Thrace showed numerous sites with seemingly appropriate foraging habitat of the same type as the ones where Lesser Kestrels were present. This is why topography was included in the habitat suitability model developed (Chapter 0) and the output suitability map looks as follows (Figure 11).

V.3 Finding an optimal restoration site

V.3.1 Finding favourable land use management practices

V.3.1.1 GIS operations

The output layer from Chapter V.2 was summed with the reclassified indexed layers of road network and protected areas (Table 11, Table 12). Resulting from expert consultations and field observations, the following weighting was assigned: suitable foraging areas – 1; distance to roads – 0,3; presence of CORINE sites – 0,2; presence of NATURA 2000 SPA – 0,5; presence of NATURA 2000 pSCI – 0,5. The output layer was then multiplied by the reclassified layer of non-suitable habitat types and altitude.

In order to carry out the pasture quality comparison using livestock numbers, the National Agriculture Advice Service was approached for obtaining information on the livestock in the settlements found to be suitable for Lesser Kestrels. Unfortunately, only municipal statistics was provided for the period 2002-2005 and no detailed settlement-by-settlement data could be obtained. Using the information on the administrative affiliation of the best-ranked settlements, the livestock density in number of animals per square kilometer was calculated for each of the municipalities where the best-ranked settlements were found (Table 18).

V.3.1.2 Results and discussion

The execution of the described overlaying operations in GIS environment allowed for visualizing the most suitable Lesser Kestrel resulting from the application of all mentioned criteria (suitable nesting site at suitable topography, suitable foraging area at suitable topography, distance from roads and presence of protected areas) (Figure 12).

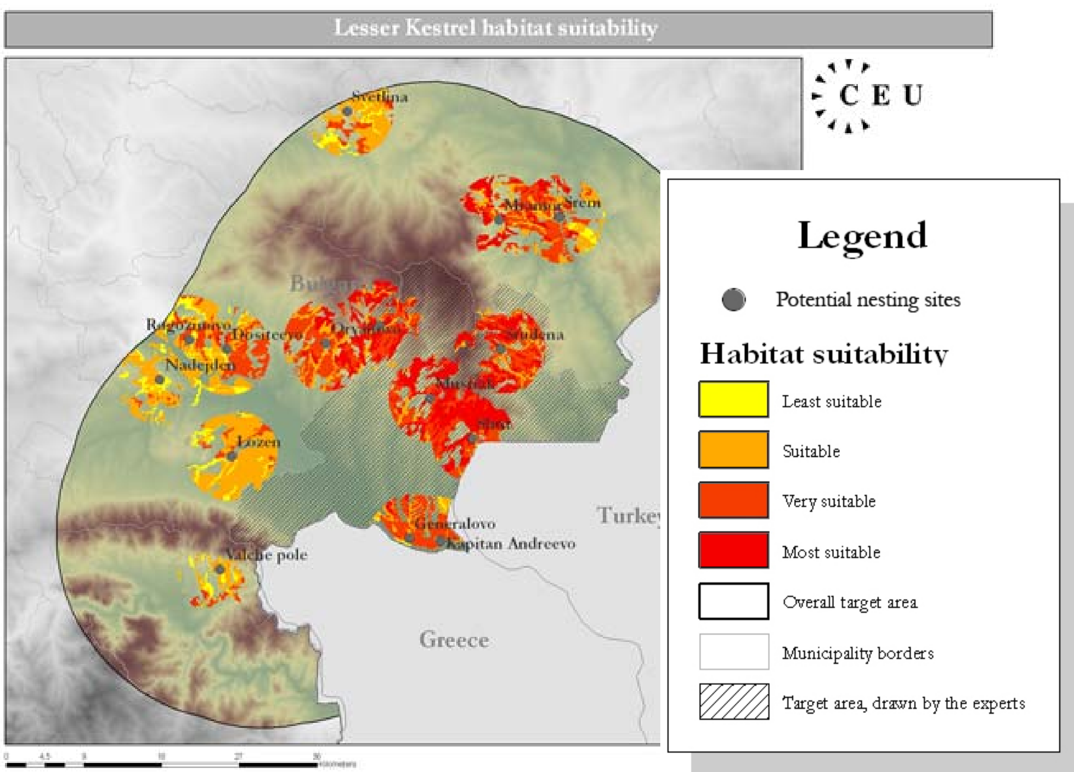


Figure 12. Screen shot of Lesser Kestrel habitat suitability, combined criteria.

The overlapping of the best-ranked potential Lesser Kestrel sites with the existing NATURA 2000 and CORINE sites shows that only three of them (Mustrak, Shtit and Studena) fall entirely within all the three types of protected areas (Table 17). Three other sites (Mladinovo, Mramor and Srem) are covered by only the two NATURA 2000 types of protected areas, while a total of four sites (Lozen, Nadezhden, Rogozinovo and Svetlina) are entirely outside the existing network of protected areas (Table 17, Annex IX.3).

Table 17. Existing protected areas and the 15 best-ranked potential Lesser Kestrel nesting sites

Settlement or buffer area	SPA Sakar BG0002021	pSCI Sakar BG0000212	CORINE Sakar F00005600
Dositeevo		yes	
Generalovo		yes	
Kapitan Andreevo		yes	
Lozen			
Mladinovo	yes	yes	
Mramor	yes	yes	
Mustrak	yes	yes	yes
Nadezhdan			
Oryahovo		yes	
Rogozinovo			
Shtit	yes	yes	yes
Srem	yes	yes	
Studena	yes	yes	yes
Svetlina			
Valche pole		yes	

In terms of livestock availability, the only municipality that shows an increasing livestock trend and holds the greatest absolute and density numbers of animals is Topolovgrad, found on the Northeast of the target area. The municipality of Harmanli, on the Northwest of the target area, maintains second highest numbers and stable livestock trends. Both of these municipalities are outside the target area preliminary drawn by the experts and contain 3 best-ranked nesting settlements each (Table 18).

Table 18. Cattle and sheep, municipal statistics (2005), trend calculated using numbers 2002 - 2005

Name	Municipality	Cattle			Sheep		
		number		trend	number		trend
		total	per sq km		total	per sq km	
Dositeevo	Harmanli	2348	3	decrease	12741	18	stable
Generalovo	Svilengrad	1550	2	decrease	7404	11	decrease
Kapitan Andreevo	Svilengrad	1550	2	decrease	7404	11	decrease
Lozen	Liubimets	530	2	decrease	2500	7	decrease
Mladinovo	Svilengrad	1550	2	decrease	7404	11	decrease
Mramor	Topolovgrad	2348	3	increase	21000	30	increase
Mustrak	Svilengrad	1550	2	decrease	7404	11	decrease
Nadezhden	Harmanli	2348	3	decrease	12741	18	stable
Oryahovo	Liubimets	530	2	decrease	2500	7	decrease
Rogozinovo	Harmanli	2348	3	decrease	12741	18	stable
Shtit	Svilengrad	1550	2	decrease	7404	11	decrease
Srem	Topolovgrad	2348	3	increase	21000	30	increase
Studena	Svilengrad	1550	2	decrease	7404	11	decrease
Svetlina	Topolovgrad	2348	3	increase	21000	30	increase
Valche pole	Liubimets	530	2	decrease	2500	7	decrease

V.3.2 Exploring the possibilities for further natural recolonization

V.3.2.1 Identifying the proximity to confirmed Lesser Kestrel colonies

V.3.2.1.1 GIS operations

In order to explore the proximity of the nearest Lesser Kestrel colonies to the probable Bulgarian restoration sites, a 7 day-field trip was carried out to locate and confirm nearby colonies in Thracian Turkey. A total of 5 active colonies were found, 3 of them discovered for a first time (Kmetova *et al.* in press). Their location was recorded with GPS and then exported and processed as an ESRI shape file. The Analysis section of the Hawth's tool allowed for compiling a table with the distance between the confirmed colonies in Thracian Turkey and the most suitable Bulgarian locations identified (Table 19).

V.3.2.1.2 Results and discussion

The results show that the nearest confirmed Lesser Kestrel breeding site is on average 98 km away from the Bulgarian sites, while the most distant colony found in Turkish Thrace was found at an average distance of 178 km (Annexes 2, 6). Logically, the nearest settlements are those located at the Bulgarian - Turkish border – Kapitan Andreevo, Generalovo, Shtit, Mustrak, Studena, Vulche pole (Table 19).

Table 19. Distance between confirmed breeding colonies of Lesser Kestrels in Turkey and suitable nesting settlements in Bulgaria (km)

Settlement	Distance in km					
	Lesser Kestrel colonies, Turkey					average
	1	2	3	4	5	
Kapitan Andreevo	**96,1**	**159,2**	**98,7**	**99,8**	**75,2**	**105,8**
Generalovo	99,4	162,4	101,2	101,1	76,6	108,1
Shtit	99,5	162,6	106,3	110,3	85,6	112,9
Mustrak	106,2	169,3	112,8	115,8	91,2	119,1
Studena	103,6	166,3	113,5	119,7	95,0	119,6
Valche pole	117,7	180,1	113,8	106,4	83,3	120,2
Lozen	121,9	184,9	121,7	117,2	93,5	127,9
Mladinovo	115,9	178,9	122,9	125,3	100,7	128,7
Srem	109,8	171,2	124,3	133,8	109,2	129,7
Oryahovo	119,6	182,7	124,7	125,1	100,7	130,6
Mramor	114,2	176,1	126,8	134,3	109,6	132,2
Dositeevo	128,7	191,8	131,2	128,5	104,6	137,0
Nadejden	133,5	196,6	133,8	128,7	105,3	139,6
Rogozinovo	133,0	196,1	134,9	131,3	107,6	140,6
Svetlina	135,2	197,3	145,7	149,7	125,1	150,6
Average	**115,6**	**178,4**	**120,8**	**121,8**	**97,5**	**126,8**

V.3.2.2 Determining the connectivity among the sites

V.3.2.2.1 GIS operations

In order to determine connectivity, the individual distance between each of the 15 most suitable nesting sites was obtained using the operation "Distance between points (from the same layer)" tool in the Analysis section of the Hawth's tool.

V.3.2.2.2 Results and discussion

The connectivity analysis shows the formation of several clusters of settlements: Kapitan Andreevo and Generalovo; Shtit, Mustrak and Studena; Mladinovo and Oryahovo; Dositeevo, Lozen, Rogozinovo and Valche pole; Mramor and Srem. In addition to that, these clusters are found in close proximity to each other so a network pattern can be seen (Table 20) (Annex IX.5)

Table 20. Distance among the 15 best-ranked settlements

	Settlement	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Valche pole	0														
2	Kapitan Andreevo	25,8	0													
3	Generalovo	22,3	3,6	0												
4	Lozen	12,9	26,1	22,6	0											
5	Shtit	32,9	12,2	13,5	28,0	0										
6	Mustrak	31,2	16,2	16,1	23,9	6,7	0									
7	Nadejden	22,6	37,4	34,1	12,1	36,9	31,4	0								
8	Dositeevo	25,0	33,0	30,2	12,2	30,3	24,2	8,5	0							
9	Studena	41,0	22,8	23,9	33,5	10,7	9,9	39,7	31,7	0						
10	Oryahovo	28,4	26,1	24,2	16,9	20,1	13,6	19,7	11,5	20,3	0					
11	Rogozinovo	26,3	37,1	34,2	14,2	34,8	28,8	5,7	4,5	36,2	15,9	0				
12	Mladinovo	33,3	25,5	24,4	22,7	16,8	10,1	26,2	17,9	14,3	6,5	22,1	0			
13	Mramor	51,2	37,1	37,6	41,0	25,0	21,8	43,3	34,8	14,7	24,5	38,4	18,3	0		
14	Srem	56,2	39,3	40,4	46,8	27,1	25,5	49,9	41,4	16,5	30,7	45,2	24,3	7,1	0	
15	Svetlina	54,0	49,9	49,0	41,4	39,9	34,0	37,4	30,4	32,3	26,4	31,7	24,6	21,5	27,4	0

V.3.3 Determining the potential predatory pressure

V.3.3.1 Distance to confirmed Imperial eagle nests

V.3.3.1.1 GIS operations

Using data on 20 confirmed Imperial eagle nests in the area (GB 2010), summarized statistics on the distance between the nests and the best-ranked Lesser Kestrel potential nesting sites was derived through the Analysis section of the Hawth's tool. Data granted by the Bulgarian Society for Protection of Birds (BSPB 2010), the Green Balkans Federation (GB 2010) and own observations in Turkish Thrace (Kmetova *et al.* in press) allowed for compiling a similar distance table for 32 confirmed nests of Imperial eagles and the 5 discovered colonies of Lesser Kestrels in Turkish Thrace.

V.3.3.1.2 Results and discussion

The completed GIS operations show that the fifteen best-ranked settlements are on average 50,9 km away from the 20 confirmed Imperial eagle nests (Annex IX.4). The distance to the closest nest ranges from 2,3 (Shtit) to 20,4 km (Valche pole). Srem, Shtit, Studena and Sladun have a confirmed Imperial eagle nest within 5 km range (Table 21).

Table 21. Distance between 20 confirmed Imperial eagle (*A.heliaca*) nests and suitable Lesser Kestrel nesting sites

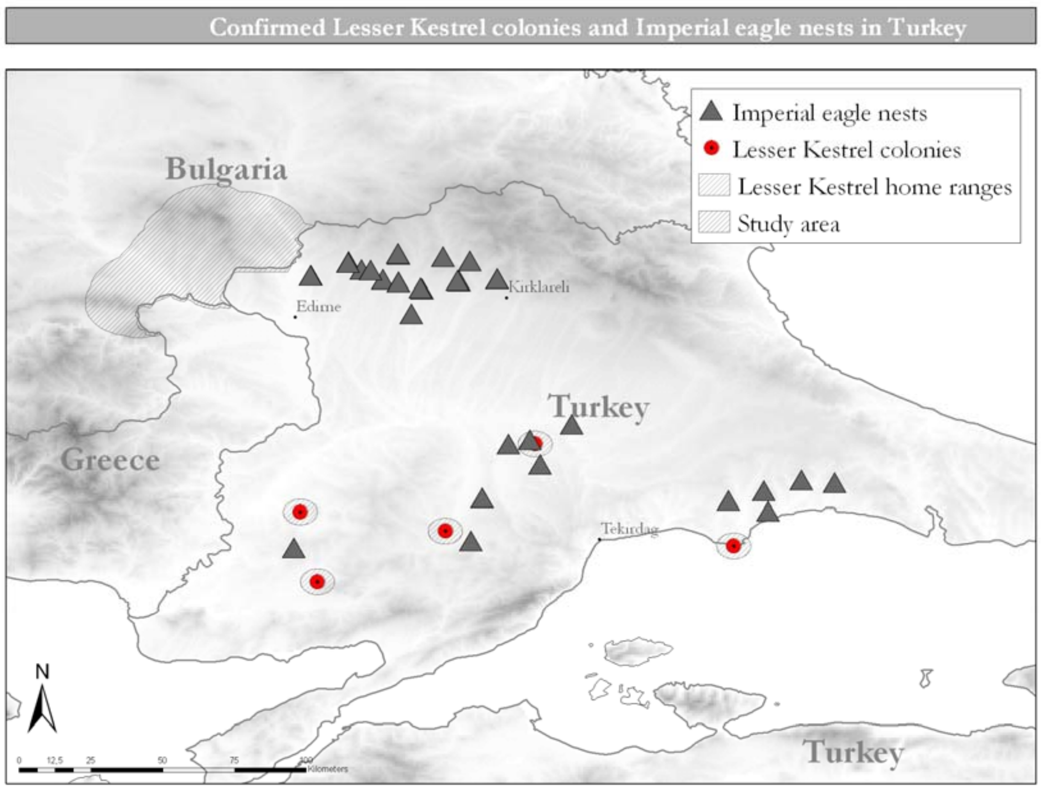
Settlement	Distance from Imperial eagle nests, km (n=20)			
	min	max	mean	STDEV
Dositeevo	7,0	149,1	56,0	31,6
Generalovo	14,8	179,0	56,2	38,9
Kapitan Andreevo	14,0	182,0	55,5	39,4
Lozen	8,0	157,1	60,4	34,4
Mladinovo	9,4	162,1	44,3	34,6
Mramor	6,6	168,3	37,7	33,8
Mustrak	3,2	171,5	44,5	38,2
Nadejden	12,4	145,1	63,0	30,3
Oryahovo	9,2	158,0	48,1	34,1
Rogozinovo	11,0	144,9	59,1	30,1
Shtit	2,3	178,2	45,7	39,6
Srem	2,7	174,5	36,9	35,0
Studena	4,8	175,5	40,2	37,8
Svetlina	16,9	147,1	46,2	26,6
Valche pole	20,4	164,7	69,2	34,8
Average	9,5	163,8	50,9	34,6

On the other hand, the confirmed Lesser Kestrel colonies in Turkish Thrace are on average 84,6 km away from the Imperial eagle nests in that area. The minimum distance ranges from 2 to 15,2 km (Kmetova *et al.* in press) (Table 22).

Table 22. Distance between 32 confirmed Imperial eagle (*A. heliaca*) nests and confirmed Lesser Kestrel colonies in Thracian Turkey (Kmetova *et al.* in press)

Colony	Distance from Imperial eagle nests, km (n=32)			
	min	max	mean	STDEV
Kestrel colony 1	2,0	83,1	58,7	23,4
Kestrel colony 2	15,2	145,6	99,6	42,4
Kestrel colony 3	7,6	104,1	77,7	26,3
Kestrel colony 4	13,5	140,9	101,5	26,6
Kestrel colony 5	12,4	141,3	86,6	25,1
Average	10,1	123,0	84,6	28,8

The results obtained for Turkish Thrace show that the closest Lesser Kestrel colonies are found in the range 2 – 15,2 km away from the confirmed Imperial eagle nests (Figure 13). On the other hand, the minimal distance between the potentially suitable Lesser Kestrel nesting sites in Bulgaria and the known active Imperial eagle nests ranges from 3,2 to 20,4 km. Therefore the minimal distance recorded between an active Lesser Kestrel colony and an inhabited Imperial eagle nest in Turkey (2 km) is actually smaller than any of the minimal distances calculated for all the fifteen potential Lesser Kestrel sites in Bulgaria



Sources: BSPB 2010; GB 2010; Kmetova, in press

Figure 13. Confirmed Lesser Kestrel colonies and Imperial eagle nests in Turkey

V.3.3.2 Distance to confirmed Long-legged Buzzard nests

V.3.3.2.1 GIS operations

Using the data on 89 confirmed Imperial eagle nests in the area (GB 2010), summarized statistics on the distance between the nests and the best-ranked Lesser Kestrel potential nesting sites was derived through the Analysis section of the Hawth's tool.

V.3.3.2.2 Results and discussion

The fifteen analyzed settlements are on average 26,6 km away from the 89 confirmed Long-legged buzzard nests in the area (Annex IX.4). The villages of Valche pole, Svetlina and Nadezhden are located the furthest from the buzzards' nests on average (over 30 km), while Mustrak, Mladinovo and Oryahovo are closest (19-20 km on average) (Table 23).

Table 23. Distance between 89 confirmed Long-legged Buzzard (*B. rufinus*) nests and suitable Lesser Kestrel nesting sites

Settlement	Distance from Long-legged buzzard nests, km (n=89)			
	min	max	mean	STD
Dositeevo	1,0	83,7	25,7	19,5
Generalovo	4,5	100,3	28,1	16,0
Kapitan Andreevo	2,0	100,3	28,3	16,0
Lozen	8,7	95,0	29,5	18,3
Mladinovo	1,0	76,6	18,7	13,5
Mramor	1,7	63,8	25,7	9,1
Mustrak	3,1	84,2	18,8	14,2
Nadezhden	8,1	89,8	33,1	19,7
Oryahovo	5,0	79,8	19,9	15,6
Rogozinovo	3,4	84,3	29,6	19,6
Shtit	0,5	88,6	21,0	15,2
Srem	6,1	64,2	28,5	10,3
Studena	1,9	78,5	20,0	13,3
Svetlina	17,2	53,6	34,1	7,7
Valche pole	21,4	107,7	38,4	17,7
Average	5,7	83,4	26,6	15,0

V.4 Lesser Kestrel habitat suitability in Southeastern Bulgaria

Based on the findings obtained applying the Lesser Kestrel habitat suitability model in GIS environment, and combining the outputs of the executed suitability criteria, it is considered that the target area in Southeastern Bulgaria is suitable for restoring Lesser Kestrel in the country. The following chapter will discuss the outputs of the habitat suitability model in terms of the optimal Lesser Kestrel restoration sites within the target area studied.

V.4.1 **Most suitable areas**

Based on the outputs obtained in GIS environment applying the Lesser Kestrel Habitat Suitability model developed, the areas around the villages of Shtit, Mustrak, Studena, Mladinovo and Oryahovo are ranked as potentially most suitable to sustain and form a core area for the re-establishment of Lesser Kestrel in Southeastern Bulgaria (Annex IX.5).

In terms of foraging area availability, Mladinovo shows highest percentage of pasture coverage (22 %) among all other sites. Pastures are considered the most preferred Lesser Kestrel foraging habitat (Table 9) and this explains the high ranking of that site. On the other hand, Shtit is ranked best if the two most-preferred foraging habitat classes are considered (overall coverage of 73 %). Despite the fact that two of the sites (Mladinovo and Studena) show only 50 % coverage of the two most-preferred foraging habitat classes, they both are within existing protected areas (Table 17), fall within the preferred topography and exhibit excellent connectivity with the villages of Shtit, Mustrak and Oryahovo (Table 20), including habitat-wise. The five sites have overall coverage of forests (broad-leaved, coniferous and mixed) under 20 % and these results are comparative with the Lesser Kestrel preferences determined by (Franco er al. 2005) (Figure 5). Unfortunately the habitat percentage coverage cannot be compared to the data published on Turkey (Table 4), as the habitat classes used in the two studies are not fully compatible.

The villages of Shtit, Mustrak and Studena are among the five settlements closest to the nearest confirmed Lesser Kestrel breeding colonies in Turkish Thrace (between 112,9 – 119,6 km on average from all confirmed 5 breeding colonies) (Table 19). They are therefore gaining an extra advantage, providing good opportunities for potential linking of the re-established population with the already existing one in Turkey.

In terms of potential predation, three of the settlements (Shtit, Mustrak, Studena) are relatively close to existing Imperial eagle nests (the average distance between them and the 20 confirmed nests is lower than the mean distance recorded for all the 15 best-ranked potential nesting settlements) (Table 21) (Annex IX.4). This was partially expected as Imperial eagles in Bulgaria show preferences towards somewhat similar habitats – steppe and dry grass habitats and arable land (Petrov and Stoychev 2002). Despite of that these sites should still be considered most suitable due to several reasons. First, the results from the analysis of the proximity of confirmed Lesser Kestrel colonies and Imperial eagle nests in Turkish Thrace show presence of breeding Lesser Kestrels even closer to eagle eyries (2 km; 7,6 km) (Table 22) (Figure 13). Second, the available data on the feeding preferences of the Imperial eagles in the target area show that young eagles mainly feed on voles and mice (more than 76 % from 32 analyzed pellets), while at the same time very little (2 %) bird remains, only from passerines, were found (Zhelev *et al.* 2009). I therefore consider that the re-establishment of breeding Lesser Kestrels in the area will not be impeded by the presence and proximity of Imperial eagle nests.

The average proximity of four of the five best-ranked settlements (Mladinovo, Mustrak, Shtit and Studena) to confirmed Long-legged Buzzard nests is also smaller than the obtained mean distance for the entire lot of 15 suitable nesting settlements (Table 23) (Annex IX.4). This is also not a surprising discovery, considering the fact that the species is related to grassland and arable land in the same way (BirdLife International 2009). There is no direct data about the interaction between Lesser Kestrels and Long-legged Buzzards. Similar species are usually ignored, though an attack of an intruding Common Buzzards has once been reported (Cramp and Simmons 1987).

The presence of Long-legged Buzzard and Imperial eagle nests in the area of the five selected Lesser Kestrel sites should therefore be rather considered as a good indicators of habitat quality, though the location of the nests should be taken into consideration when nesting boxes are to be installed and Lesser Kestrels are to be released, in order to limit the potential disturbance of the three species to a minimum.

In order to properly identify the stakeholders within the selected settlements, the land ownership of the potential home ranges was derived using official cadastre maps, obtained by the State Agency on Geodesy, Cartography and Cadastre. Unfortunately, information was partial and only covered the target area preliminary drawn by the experts. Therefore only the buffer area around Mustrak was 100 % covered, while the buffer around Oryahovo was covered at only some 7 %. However the land ownership on the 4,5 km buffer areas around the settlements that could be derived from the available dataset showed the following pattern (Table 24).

In terms of land ownership, fairly good data coverage was present for the villages of Mladinovo, Mustrak, Shtit and Studena (Table 24). The private ownership varies from 52 % (Mustrak) to 26 % (Mladinovo) (as for Oryahovo, the private ownership of 2,2 % is nearly a third of the available information on only 7 % of the entire buffer area). At the same time the state owned land (state public and state private) varies between 10 % (Shtit) and 19 % (Mladinovo, Mustrak), while the municipal managed land is between 14 % (Mladinovo) and 42 % (Studena). The high percentage of municipally owned and managed land determines the municipality of Svilengrad as one of the main stakeholders of significant importance when planning and implementing the Lesser Kestrel restoration activities.

Table 24. Land ownership in the potential 4,5 km home ranges around the suitable Lesser Kestrel nesting sites (in %)

Buffer around settlement	Percentage land ownership											
	Ownership type										No data	Total
	SPUB	SPR	PUB	MPB	MPR	REL	MUN	CO	PRIV	FOR		
Mladinovo	14,3	5,0	0,0	0,6	3,1	0,1	10,4	0,3	26,4	0,00	40	100
Mustrak	5,6	13,7	0,7	1,7	14,9	0,1	10,3	0,6	52,3	0,04	0	100
Oryahovo	1,6	0,7	0,0	0,1	1,7	0,0	0,4	0,0	2,2	0,00	93	100
Shtit	0,1	10,1	0,2	0,1	9,4	0,1	19,6	0,6	33,5	0,02	26	100
Studena	0,2	13,1	0,1	0,1	36,4	0,6	5,1	1,4	35,4	0,03	7	100
Average	4,4	8,5	0,2	0,5	13,1	0,2	9,2	0,6	30,0	0,02	33	100

SPUB	state public	**REL**	religious
SPR	state private	**MUN**	municipal managed
PUB	public organizations	**CO**	co-owned
MPB	municipal public	**PRIV**	private
MPR	municipal private	**FOR**	foreign

V.4.2 Second best suitable areas

The second best suitable set of areas for restoring Lesser Kestrels in Southeastern Bulgaria is split in two groups as follows: Kapitan Andreevo and Generalovo on the Southwest and Dositeevo, Lozen and Rogozinovo on the Northwest (Annex IX.5).

Generalovo, Kapitan Andreevo, Lozen and Dositeevo rank among the five best sites in terms of Lesser Kestrel preferred foraging habitat coverage (index 4 and 3) (Table 15). The only reason Kapitan Andreevo and Generalovo are not selected as top-suitable potential locations is the fact that there is data for barely 60 % of the land use of the potential Lesser Kestrel home ranges (Table 16) and the relatively fair coverage of protected areas to comprise the two settlements and provide legal protection and increased attention (Table 17). As for Lozen, despite the extremely high coverage of potentially suitable foraging habitats, these mostly consist of arable land (suitability index 3) and only few pastures (suitability index 4) (Table 16). The overall forest coverage of the 4,5 km buffer areas for all five sites is also less than 15 %, ranking the sites high as compared to the correlations found by (Franco er al. 2005) (Figure 5). In addition to that, the villages of Dositeevo and Rogozinovo belong to the municipality of Harmanli, which show the second best livestock trends and absolute numbers (Table 18). The livestock numbers and trends can be considered a good indicator for the quality of the pastures present and the positive cattle trend can be seen as potential for increasing the coverage of the pastures in the future.

In terms of connectivity and proximity to existing Lesser Kestrel colonies, the distance between the settlements in the core area and these two group of settlements would allow for potential spreading of the population from the established core area to the South (via Kapitan Andreevo and Generalovo) to connect with the nearest confirmed Lesser Kestrels in Turkey and to the Northwest (via Dositeevo, Lozen and Rogozinovo) – towards Central and Western Bulgaria, where the population used to be (Table 20) (Annex IX.6).

The mean distance between the two groups of settlements and the confirmed nesting sites of Long-legged Buzzards and Imperial eagles is around and above the average reported for all the 15 studied possible locations. This is considered to indicate a relatively lower chance for disturbance and potential predation.

V.4.3 Third best suitable areas

The villages of Mramor, Srem and Svetlina are ranked as the third best set of potential Lesser Kestrel restoration sites (Annex IX.5). They are classified less suitable than the sites already mentioned (Chapters V.4.1 and 0) as they have less percentage coverage of suitable foraging habitats as compared to the rest of the settlements considered (Table 16, Table 17). Despite that, the three settlements belong to the Municipality of Topolovgrad, which has highest density and absolute numbers of cattle (Table 18). This indicated good potential for developing extensively grazed pastures and thus expanding the coverage of suitable Lesser Kestrel foraging habitats. In addition to that, Srem and Mramor and relatively close to the potential core population and would secure expanding of the re-established population to the Northeast towards the inner parts of the country (Table 20) (Annex IX.6).

Despite that, these settlements are somewhat topographically separated from the potential core population and it would be easier for the population to spread to the Northwest and inhabit the areas given second priority prior to expanding towards Mramor and Srem.

V.4.4 Non-suitable areas

Among the 15 settlements identified as potentially suitable for Lesser Kestrel nesting, Vulche pole and Nadezhden show the least percentage coverage of suitable foraging areas (Table 15, Table 16). Vulche pole has nearly 50 % coverage of forests, while Nadezhden shows too high coverage of scrubland and transitional habitats (Table 15, Table 16). This makes the two sites non-suitable also as compared to the findings of (Franco er al. 2005) (Figure 5). The distance between the two settlements and the confirmed Imperial eagle and Long-legged Buzzard nests, which is higher than the average reported for the entire lot of 15 studied settlements (Table 21, Table 23). Even though this would potentially mean lesser disturbance and predation risk, it can also be used as an indicator of poor shared habitat quality and cannot compensate the lack of other site qualities. In addition to that, Vulche pole is fairly isolated from the rest of the potential sites (Table 20) and ranks poor also in terms of connectivity.

V.5 **Alternative hypothesis on habitat suitability**

The Lesser Kestrel Habitat Suitability model uses a demographic human population trend as a proxy for the presence of abandoned houses, as they are among the preferred Lesser Kestrel nesting sites (Chapter IV.2.1.1). However the species is known to willingly occupy nesting boxes when nesting substrate is not available (Bux *et al.* 2008; Catry *et al.* 2007; Pomarol 1993). It is therefore potentially possible to compensate for the lack of suitable nesting sites installing nest boxes.

As GIS environment allows for very quick image processing, data reformatting and transformations (Malczewski 2004), the model internal settings were altered in order to explore a different nesting scenario as follows.

Settlements of positive human population trend in the period 1994 – 2000, originally considered least suitable due to lack of potential nesting areas, were re-classified as most suitable (index 3). In addition to that, based on the data from the confirmed Lesser Kestrel breeding colonies in Turkish Thrace (Kmetova *et al.* in press), the settlements that had human population between 100-1000 and >4000 were also assigned highest suitability index 3. After the demographic indexing was changed, all technical operations described in Chapter V.1.1 and V.2.1 were repeated to see if any of the settlements with increasing population trend would fall within suitable topography and foraging area. The amended demographic criteria identified a total of 6 new potentially suitable settlements (Liubimets, Bolyarski izvor, Svilengrad, Vurbakovo, Selska polyana and Dolni glavanak). They were mostly found in the Western part of the target area, close to one of the last Lesser Kestrel observations after 1995 (Barov 2002) (Annex IX.1). When the topographic and land use criteria were however applied, only the area of Svilengrad ranked suitable, while the other 5 settlements, including the last Lesser Kestrel observation site, were eliminated. The exclusion of a former Lesser Kestrel sighting area can be explained with the intensive afforestation of the Western parts of the target site, which has changed the land use patterns to an extent that make the area unvafourable for Lesser Kestrel restoration in the contemporary conditions. The further analysis of the Lesser Kestrel suitable foraging habitat coverage of the site of Svilengrad (8 % pastures, over 50 % arable land), combined with all other additional factors (protected areas, road network, etc.), is comparable to the results obtained for the second best Lesser Kestrel cluster of sites (Chapter 0.). In addition to that, the potential Lesser Kestrel home range around Svilengrad overlaps the buffer area drawn around the village of Generalovo. Generalovo is indeed among the second best potential group of Lesser Kestrel sites (Chapter 0.). Svilengrad can therefore be considered as a part of the Generalovo – Kapitan Andreevo cluster, selected as the second best potential Lesser Kestrel area (Figure 14).

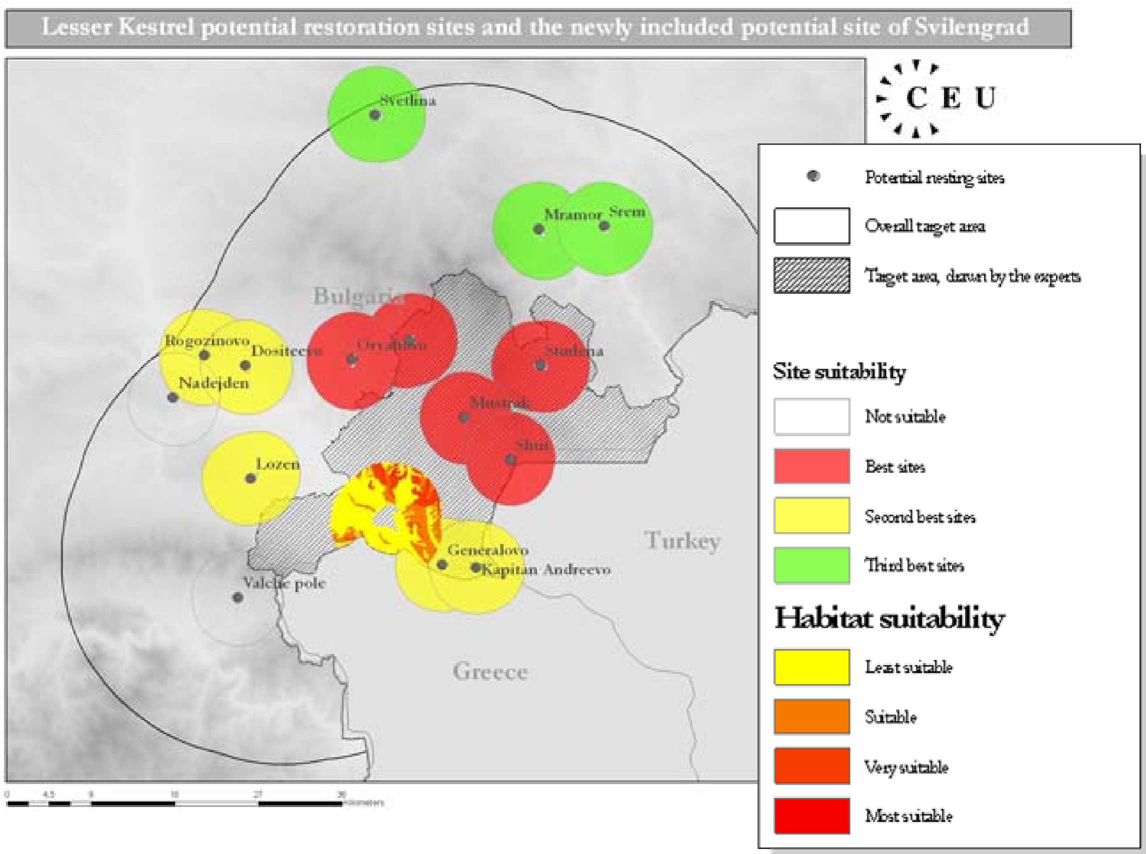


Figure 14. Screen shot of Lesser Kestrel potential restoration sites and the newly included potential site of Svilengrad

These results do not change the location of the best suitable Lesser Kestrel restoration sites identified by the original Habitat Suitability model and the further planning of the overall reintroduction process can therefore use the original outputs of the model.

V.6 Model validation

There are different ways to validate the credibility of Habitat Suitability models. Among the most used ones is checking the outputs of the model directly against independent presence data (field observations, VHF telemetry, etc.) (Franco and Sutherland 2004; Jokimaki and Huhta 1996; Ortigosa *et al.* 2000). Another option is comparing the results to the outputs of other models compiled for the same species (Nikolakaki 2004).

It is therefore very challenging to validate the Lesser Kestrel Habitat Suitability model developed, as there are no confirmed Lesser Kestrel breeding pairs in Bulgaria at present and no other studies have assessed the habitat suitability in such detail, especially for the target area.

An alternative way of validating the model was to check its outputs against the very last confirmed breeding colonies of Lesser Kestrels in Bulgaria. The last confirmed breeding of the species in the target area dates back from 1989 and its location was obtained from the Green Balkans ornithological database (GB 2010) and the National Lesser Kestrel Action Plan (Barov 2002). It was then digitalized on Google Earth and imported as an ESRI shapefile onto the output habitat suitability map. As seen from Figure 15, the last confirmed Lesser Kestrel breeding colony in the target area falls within the areas selected by the model as most suitable.

In addition to that, as the model and its outputs will be used to plan the future reintroduction of the species, it will be later validated on field initiating bird releases in the best-ranked sites (See Chapter VI.2) and monitoring their post-release behavior and dispersal.

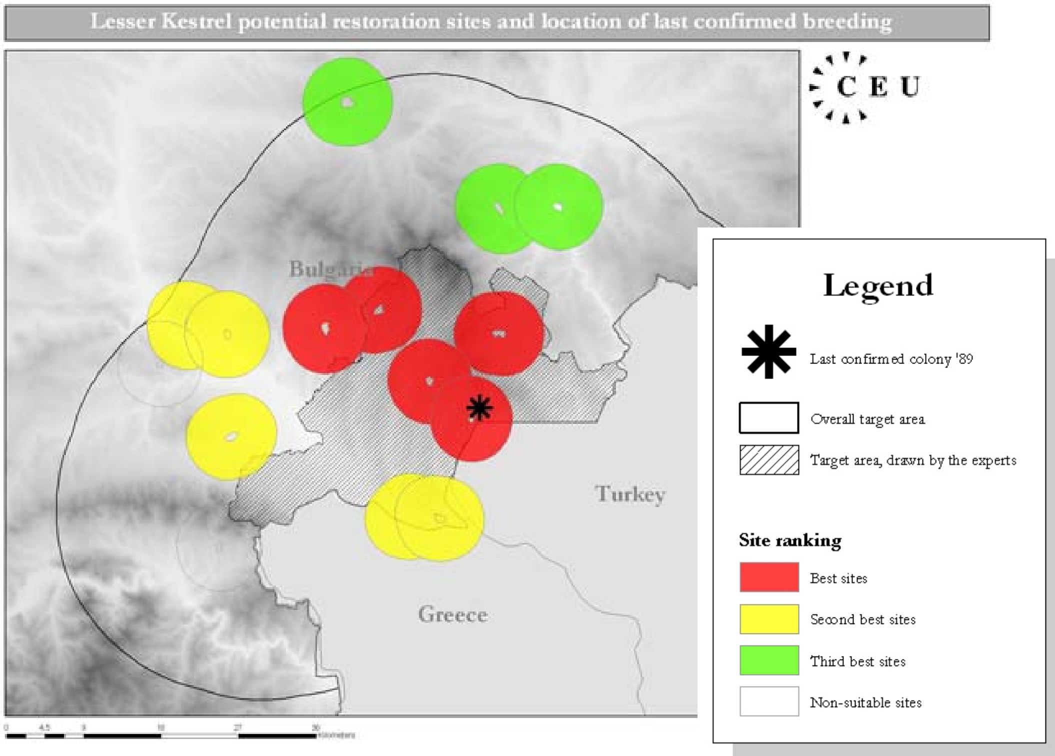


Figure 15. Screen shot of Lesser Kestrel potential restoration sites and location of last confirmed breeding in the target area

VI Recommendations for successful restoration of the Lesser Kestrel in Bulgaria

The following chapter presents some recommendations, derived on the base of the completed literature review on the Lesser Kestrel characteristics, the compiled habitat suitability model and its outputs.

The first part explores the strategy required to successfully re-establish Lesser Kestrel as a breeding species in Bulgaria, comparing human-induced Lesser Kestrel restoration programme with the possibilities for natural recolonization. The second part provides some legislative, land management and communication recommendations meant to keep the potentially suitable Lesser Kestrel sites at "most favourable Lesser Kestrel condition" in order to secure the successful re-establishment and survival of the population. The third part contains recommendations on the possible improvement and elaboration of the Lesser Kestrel Habitat Suitability Model developed.

VI.1 Restoration strategy

The breeding status of Lesser Kestrel in Bulgaria is quite obscure at present. Since the habitat suitability model has revealed that there are potentially suitable Lesser Kestrel nesting and foraging habitats in Southeastern Bulgaria, there are two possible strategies towards population re-establishment. The first strategy is to provide opportunities for natural recolonization of the suitable areas through expansion of the nearby populations. The alternative way is to launch a human-induced reintroduction programme.

The possibility of natural recolonization is determined by the fact that Lesser Kestrels still successfully breed fairly close to Bulgarian – in Turkey, Macedonia and Greece (BirdLife International 2008; Cramp and Simmons 1987; Parr *et al.* 1995; Parr *et al.* 1997). A positive indicator in support of that strategy is the observation of groups of 23 – 25 birds following the calamity of grasshoppers and foraging in the area of the Eastern Rhodopes, Southern Bulgaria in 2000 (Barov 2002). The birds were seen coming from South, probably from a nearby colony in Greece (Barov 2002).

Unfortunately the closest located Lesser Kestrel breeding colonies were found on average 127 km away from the most suitable potential Lesser Kestrel sites identified by the Habitat Suitability model in Southeastern Bulgaria (Table 19). The closest colony distance measured between a potential Lesser Kestrel site in Bulgaria (Kapitan Andreevo) and an existing active colony in Turkish Thrace was 75,2 km. As the median dispersal distances reported for Lesser Kestrels in

Spain range between 7 – 30 km (Negro *et al.* 1997; Serrano *et al.* 2008; Serrano *et al.* 2003), it is clear that the chances for natural recolonization are slim and the process is unlikely to happen in the near future.

The idea of launching a reintroduction programme to restore or improve the status of the Lesser Kestrel in Bulgaria through captive breeding and release is therefore supported. The reintroduction examples reviewed in Chapter II.2 also prove that, if carefully planned and carried out, such a programme can be successful.

VI.2 **Management recommendations**

In order to maintain and support a re-established Lesser Kestrel population in Bulgaria, it is crucial to adequately manage the newly inhabited nesting and foraging sites. The following set of recommendations is a compilation of measures that have proven to support a "Lesser Kestrel favourable" state of the sites, successfully inhabited by the species elsewhere. The measures have been adapted to meat Bulgarian contemporary reality and provide optimal prerequisites for the re-establishment and survival of the reintroduced population. The necessary steps are grouped into recommendations for legislative amendments intended to improve the legal protection of the species and ease the process of reintroduction; recommendations for land use measures to secure adequate managing of the potentially suitable foraging and nesting sites; and recommendations for further studies to improve the knowledge on the species and secure public awareness and support for the entire reintroduction process. Some of these recommendations (especially the ones considering land use) can be directly included as requirements within the Management Plans of the existing protected areas in the target area (SPA Sakar BG0002021 and pSCI Sakar BG0000212). Once introduced, these management regimes can be promoted among the identified stakeholders responsible for the best suitable Lesser Kestrel sites – forestry units, municipal and district authorities, local communities and land-owners (Table 14).

VI.2.1 **Legislation changes**

Securing adequate legal protection and support for the Lesser Kestrel reintroduction programme, involving the responsible authorities and local stakeholders are of primary importance for the success of the programme. These goals can be achieved through the following measures:

- Enforcement of nature conservation and land management laws to support the recovery and survival of the reintroduced Lesser Kestrel population (Barov 2002; Hiraldo *et al.* 1996). The legislation should aim at direct conservation of the species and its habitats, as well as supporting the "Lesser Kestrel" favourable land management practices, described in Chapters VI.2.2 and VI.2.3;.

- Some contradictions between the "Lesser Kestrel" favourable land management practices and the Common Agricultural Policy of the European Union have been spotted (Franco and Sutherland 2004; Garcia *et al.* 2006). These should be further investigated and eliminated to a greatest possible extend;
- Update of the National Action Plan for the Conservation of the Lesser Kestrel and focusing on captive breeding and restocking activities as a primary option for restoring the population of the species in Bulgaria;.
- Completion of the Feasibility Study for the potential reintroduction of Lesser Kestrel in Bulgaria, developing the rest of the chapters, required by the IUCN Reintroduction guidelines (IUCN 1998): contemporary threats and limiting factors, potential donor stock for setting up a captive breeding programme, hacking and release methods, etc;.
- Signing a Memorandum of Understanding with the Ministry of Environment and Waters of Bulgaria to prove the legal support for the Lesser Kestrel restoration activities and assist the collaboration with the other state bodies responsible for the successful implementation of the programme;.
- Securing legal protection designating new protected areas in case of discovery of Lesser Kestrel colonies or concentration sites outside the national network of protected areas.

VI.2.2 **Nest site management**

Securing the conservation of the Lesser Kestrel nesting sites is of crucial importance for the survival of the species in the suitable habitats. The following recommendations concern the adequate preservation of the Lesser Kestrel nesting sites:

- Lesser Kestrels prefer nesting in deserted old buildings, walls and monuments (Barov 2002; Cramp and Simmons 1987; Kmetova *et al.* in press; Parr *et al.* 1997; Patev 1950; Simeonov *et al.* 1990; Tella *et al.* 1996), which often collapse without any maintenance and care, destroying the nests or preventing the colony to return the next year. It is therefore of primary importance to restore the old adobe buildings, manage and repair the old roofs and other potential nesting sites, thus preventing collapse and destruction (Forero *et al.* 1996; Franco *et al.* 2005);
- Many studies show that artificial nesting boxes can successfully substitute for lack of substrate (Bux *et al.* 2008; Catry *et al.* 2007; Pomarol 1993). They are also often safer and

easier to maintain than the collapsing old adobe houses. Despite the fact that the habitat model used to identify the best suitable nesting sites using a proxy for the presence of deserted buildings, since no field verification was done, it is recommended to install and maintain nesting boxes. They should be installed in the villages identified as most suitable within the current study: Mustrak, Studena, Shtit, Oryahovo, Mladinovo; Kapitan Andreevo, Generalovo; Dositeevo, Lozen and Rogozinovo, as well as in close proximity to them in nearby abandoned buildings and potentially suitable riparian areas. The location of the nest boxes should be agreed with the location of the closest nests of Imperial eagles and Long-legged Buzzards.

VI.2.3 **Foraging habitat management**

Two models used to predict the extinction and presence of Lesser Kestrels in Spain have suggested the importance of land-use changes as a factor in the contemporary drastic population declines (Bustamante 1997). It is therefore of primary importance to secure proper management for the potentially suitable foraging areas as follows:

- The overall foraging quality of the areas should be improved, promoting grass field-margins, in-field strips (Hiraldo *et al.* 1996), low-intensive farming systems, with patches of crops and semi-natural areas and voluntary set-asides (De Frutos *et al.* 2009). The introduction of field margins for example increases the presence of prey, without imposing too much cost for the local farmers (Donazar *et al.* 1993; Rodriguez *et al.* 2006);
- Foraging area quality should be maintained through traditional agriculture practices, characterized by grazed fallow and cereal rotation (Franco *et al.* 2004; Franco and Sutherland 2004);.
- Harvesting cereal crops spread over June and July can be introduced to secure food during the fledgling period as done in Portugal (Franco *et al.* 2004);
- In order to maintain the low-grass state of pastures, cattle breeding in Lesser Kestrel areas should be promoted and supported (Franco *et al.* 2004; Franco and Sutherland 2004);
- Desertification of villages negatively impacts Lesser Kestrels, causing deterioration of their foraging and nesting sites – overgrowing of the pastures and arable land, collapsing of buildings and suitable nesting sites (Barov 2002). Measures against abandonment should be implemented in the Lesser Kestrel suitable regions;

- Lesser Kestrels are proven to avoid afforested and transitional areas (De Frutos *et al.* 2009; Donazar *et al.* 1993; Franco *et al.* 2004). Measures should therefore be taken to prevent afforestation of arable or deserted areas and expansion of the wood plantations (Barov 2002; Franco and Sutherland 2004). Reintroduction plans should therefore be coordinated with the responsible forestry units – Harmanli, Svilengrad, Topolovgrad;
- There is data on Lesser Kestrels avoiding cereal cultivations in Spain where biocides and fertilizers have been widely used and have severely reduced the prey abundance (Donazar *et al.* 1993). Strictly controlled and greatly reduced pesticide and biocide treatment should therefore be introduced in the Lesser Kestrel favourable areas (Barov 2002; Tella *et al.* 1998);
- Lesser Kestrels can also benefit from restoring and conserving the wet and dry grasslands and marshes (Parr *et al.* 1997).

VI.3 **Further measures**

VI.3.1 **Model optimization**

The provided case study of using GIS techniques to execute the Lesser Kestrel Habitat Suitability model developed demonstrated the wide range of applications of the method and the various ways it can potentially assist nature conservation decision making and planning. It has to be noted, that the predicted locations have some limitations, as not all factors of the general Habitat Suitability model were considered (potential nesting sites, other than settlements; other potential predators, etc.), and some additional factors can also be considered for data collection and inclusion in the model.

VI.3.1.1 **Nest site location**

Only urban areas were considered as potential nesting sites in the current case-study application of the Lesser Kestrel Habitat Suitability Model for Southeastern Bulgaria. However, the Lesser Kestrel has been proven to be closely related to cliff walls, old quarries and high vertical river banks in Bulgaria (Barov 2002). Since the CORINE land cover classes used were not able to distinguish such areas, it is recommended that direct data is gathered on field, mapping potentially suitable nesting sites and then performing the same type of land use and topography analysis.

VI.3.1.2 Food availability

Food analysis was not included in the current habitat suitability model as no datasets on insect distributions could be found. Food availability is considered directly correlated to land use type for the aims of this study. The model is based on the assumption that, similar to the habitats in Turkey, Orthoptera species are significantly more abundant in edge habitats, Coleoptera species are less and observed mainly in cereal crops, while lizards are found in high numbers mainly on dry grassland (Parr *et al.* 1997). However additional data on the distribution and abundance of potential target species (invertebrates and reptiles) can be collected and added to the model.

VI.3.1.3 Meteo-climatic factors

The meteo-climatic factors were not included in the current model, due to the small relative size of the target area that does not provide for significantly different climate patterns. The climatic conditions are assumed to be suitable due to the historic evidence for successful breeding in the area (Simeonov *et al.* 1990). In addition to that, Lesser Kestrels are found both on the South (Turkey) and the North (Romania, Moldova, Ukraine) (BirdLife International 2004; IUCN 1998) of the target area so even if contemporary climate change trends have affected the area, it would still fall within the Lesser Kestrel tolerance limits. However data on the particular climatic preferences of the species can be further included in the model.

VI.3.1.4 Wire networks and single trees

Wire networks and single trees have been proven to have a positive impact securing roosting sites during hunting or for the young birds in the post-fledge and pre-migratory period (De Frutos *et al.* 2009; Franco *et al.* 2005). Unfortunately no such digital data could be found. For the aims of improving the current study such data can be obtained digitalizing the images available on Google Earth.

VI.3.1.5 Indicator species

Various studies show that Lesser Kestrels are often related to other species, such as Jackdaws and Common Kestrels, which can be used as indicators of habitat quality and suitability (Cramp and Simmons 1987; Forero *et al.* 1996; Kmetova *et al.* in press). As these species are considered relatively abundant and non-threatened, no digital data on their distribution and numbers in the target area could be found. It is therefore strongly suggested to collect, digitalize and include information on the density and nesting sites of these species.

VI.3.1.6 Predator species

There is a known case of a Great Owl (*Bubo bubo*) predating on Lesser Kestrels in Bulgaria (Barov 2002). Digital information on the nest site locations of Great Owl can therefore be incorporated in the model, in order to secure less possible disturbance and predation risks.

VI.3.2 Additional measures

Additional measures can be promoted to better understand the environmental requirements of the Lesser Kestrel and gain wide public support and interest in its conservation. Such measures are:

- Further studies on the biology, ecology and distribution of the Lesser Kestrel in order to better understand the environmental requirements of the species and be able to tackle potential threats and support its survival and re-establishment;
- Identifying the closest Lesser Kestrel breeding colonies in Greece and Macedonia to explore the potential for the return of the species through natural recolonization or further reintroduction to other areas of Bulgaria as well;
- Initiating wide campaigns for public awareness and support of Lesser Kestrel conservation activities. Working on municipal as well as land-owner level for involving the local communities in the Lesser Kestrel conservation activities – construction, installation and monitoring of the nest boxes, as well as the monitoring and care for the re-established bird stock;
- Developing a LIFE+ project proposal to fund and support the further development of the Lesser Kestrel conservation activities in Bulgaria, including the direct measures and public awareness campaigning.

VII Conclusions

The aim of the current work was to develop a Lesser Kestrel habitat suitability model and apply it in GIS environment to identify potentially suitable Lesser Kestrel sites in a target area in southeastern Bulgaria.

In order to develop the model, an overview of environmental requirements of the species has been completed through a literature review and expert consultations. In addition to that, a seven-day expedition for locating active breeding colonies of Lesser Kestrel has been carried out in Turkish Thrace. The expedition has allowed for collecting valuable additional data on the Lesser Kestrel habitat preferences and discovered three new breeding colonies of the species. As a result, a set of criteria determining the suitability of an area for the survival of the Lesser Kestrel has been developed. The set of criteria is based on the assumption that the re-establishment of the species is determined by the presence of suitable nesting and foraging sites. The suitability of these sites is based on a number of independent environmental factors such as: topography (altitude, slope and aspect), land management (contemporary land use and existence of protected areas), biological factors (connectivity, proximity to existing Lesser Kestrel colonies and potential predatory pressure), demographic factors (road network, human population density and presence of deserted buildings). These factors have been either given suitability indices or used for direct site comparison on order to identify the potentially most-suitable Lesser Kestrel site, capable of maintaining a re-established Lesser Kestrel population.

The Lesser Kestrel Habitat Suitability model developed was then applied in GIS environment to identify the most suitable potential Lesser Kestrel sites in a target area in Southeastern Bulgaria. GIS techniques prove extremely useful for a range of applications: from ranking and visualizing the potential Lesser Kestrel nesting and foraging areas, to deriving additional statistical information in order to assist decision-making process, planning and organization of a potential reintroduction programme. The supplementary information obtained using GIS tools comprised: the distance among the potentially suitable sites, the distance from confirmed breeding Lesser Kestrel colonies and potential predators (Imperial eagle and Long-legged Buzzard nests), the administrative affiliation of the potentially suitable settlements, the type of land ownership and the authorities, responsible for the management and control over the identified areas.

Considering all the factors that determine the presence of Lesser Kestrels in a given area and the outputs of the GIS data processing, it is concluded that there are sites in the target area in

Southeastern Bulgaria suitable for maintaining a re-established Lesser Kestrel population. The villages of Mustrak, Miladinovo, Shtit, Studena and Oryahovo have been found the most suitable in terms of combined environmental factors (in terms of availability of nesting sites and foraging habitats, suitable topography, connectivity, proximity to confirmed Lesser Kestrel colonies, presence of protected areas, etc.) to sustain a potential core area of a re-established Lesser Kestrel population. The model suggests the villages of Kapitan Andreevo and Generalovo; Dositeevo, Lozen and Rogozinovo as the second best sites for Lesser Kestrel reintroduction. They are also considered as potential colonization target sites in case of future natural expansion of the re-established population from the core area. In case of an even further natural population expansion, the villages of Mramor, Srem and Svetlina are suggested as the third best cluster of suitable Lesser Kestrel areas.

GIS software allowed for identifying the land-ownership and the authorities responsible for the management of the best-ranked sites. This information will be directly used when planning the Lesser Kestrel reintroduction programme in terms of local community involvement and awareness raising campaigns.

The outputs of the Lesser Kestrel Habitat Suitability model were validated using data on the last confirmed breeding colony of Lesser Kestrels in Southeastern Bulgaria. The best suitable Lesser Kestrel areas identified by model coincided with the location of the last confirmed Lesser Kestrel breeding site in the area.

Apart from applying it for a target area in southeastern Bulgaria, The Habitat Suitability model has been developed as a general model, suited for application in other territories of Bulgaria as well. It can however be further improved, including additional environmental factors to determine the presence of Lesser Kestrels in a given area and some recommendations for further optimization have been suggested.

Having confirmed the presence of suitable Lesser Kestrel sites in southeastern Bulgaria a strategy for assisting the restoration of the species has been suggested. Based on the outputs of the Lesser Kestrel Habitat Suitability model and the information on the closest confirmed breeding colonies obtained during a field trip in Turkish Thrace, it is concluded that the chances for natural recolonization and recovery of the population of Lesser Kestrels in Southeastern Bulgaria are low. Therefore the initiation of human-induced Lesser Kestrel captive breeding and restocking programme is recommended. Such decision is considered feasible also in the light of the successful examples of bird reintroduction programmes reviewed.

This strategy is supported by various non-governmental organizations which have stated their preparedness to work on Lesser Kestrel conservation issues in Bulgaria. One of them, the Green Balkans Federation is currently developing a Feasibility Study for the Potential Reintroduction of Lesser Kestrel in Bulgaria. Such a document is required by the IUCN Guidelines for Reintroduction (IUCN 1998) in order to justify the need of human intervention. At the same time, the identification of potentially suitable Lesser Kestrel areas is among the prerequisites for the completion of the Feasibility Study and will play a major role for the final decision on the viability of human-induced reintroduction as a Lesser Kestrel restoration strategy. The Lesser Kestrel Habitat Suitability model outputs will therefore be directly included in the Feasibility Study and will be later checked on field, once a reintroduction programme is launched.

In order to further support the planning and implementation of the Lesser Kestrel restoration in Bulgaria a set of recommendations for the legal and land management steps required to support the reintroduction programme has been developed. The legal steps recommended can be practically introduced after the completion of the Feasibility for the Potential Reintroduction of Lesser Kestrels in Bulgaria. On the other hand, the land management recommendations can be directly included in the Management Plans of the existing protected areas within the selected target area (SPA Sakar BG0002021 and pSCI Sakar BG0000212). They should also be promoted among the responsible municipal authorities and local communities as well as private land owners identified. The results of the current study justify the necessity of launching a human-induced Lesser Kestrel reintroduction and can be used to compile a European Commission LIFE+ funding proposal to support the Lesser Kestrel conservation activities with an emphasis on the initiation of human-induced restocking and reintroduction.

As an overall conclusion, GIS techniques have proven to be extremely successful tool for executing various operations in support of the planning and implementation of nature conservation activities. GIS provides for obtaining various types of results from visualization of the best-possible locations to tabular and statistical derivatives to be used to support decision making and further planning.

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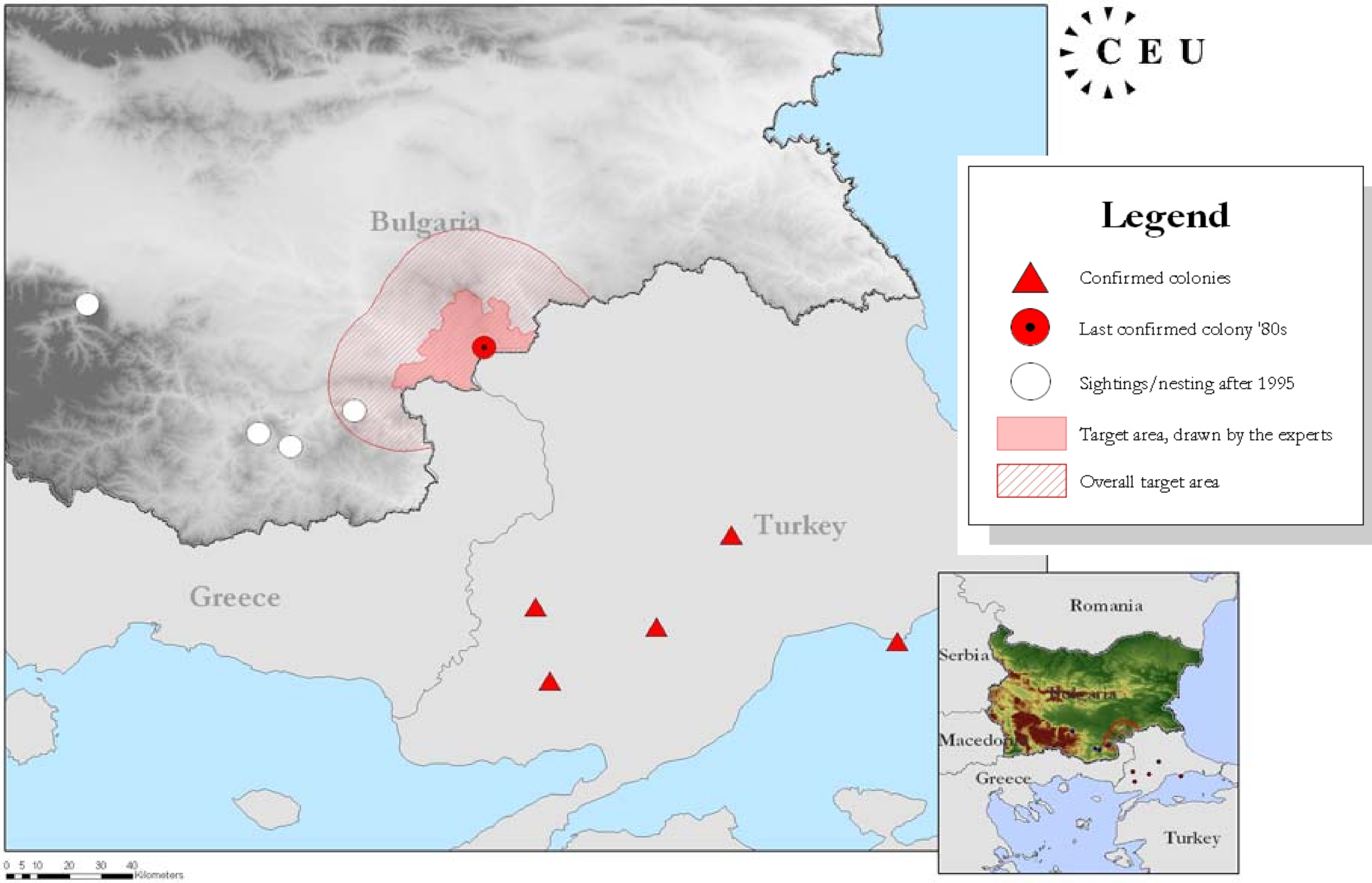
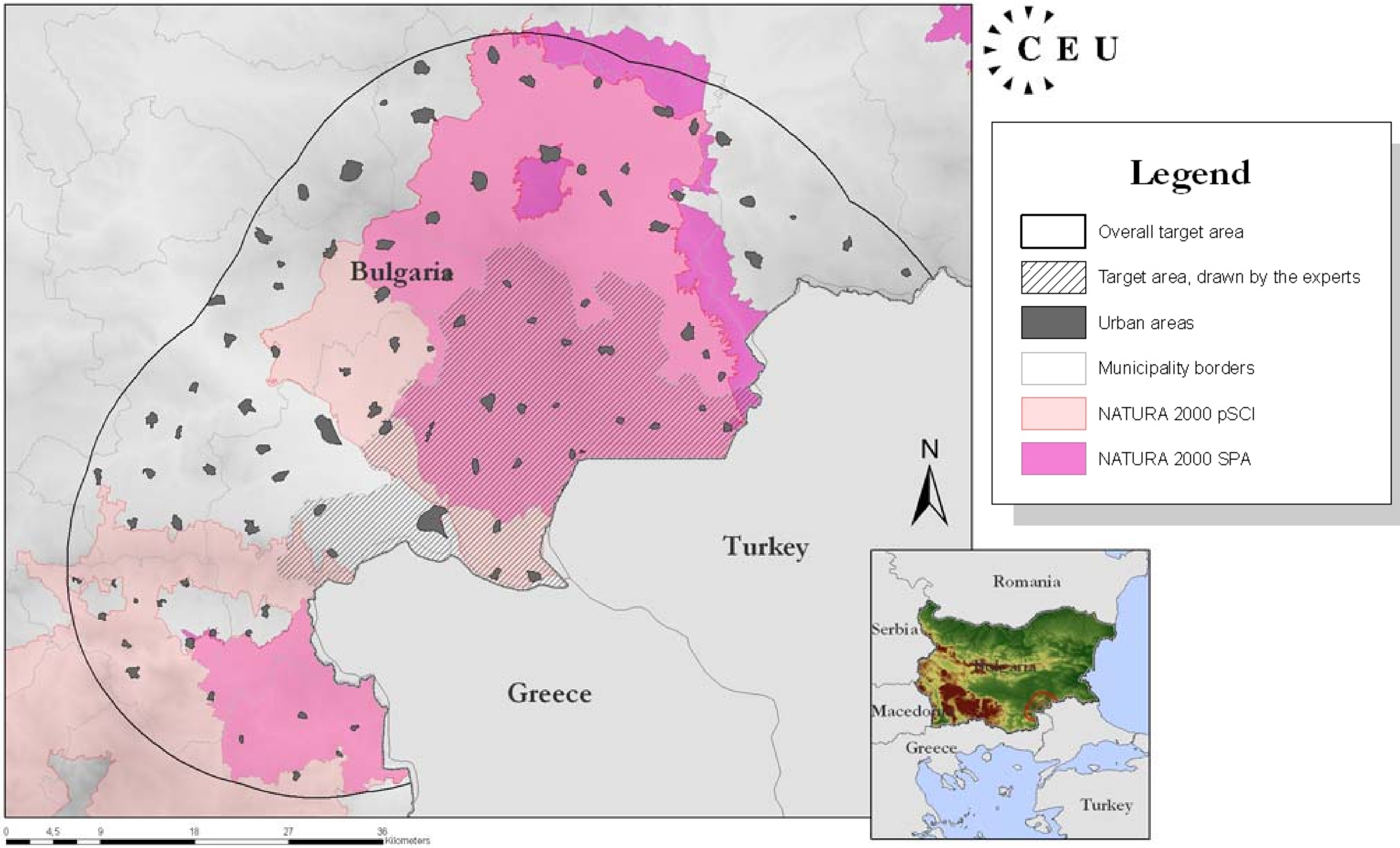
IX.1 **Map of Lesser Kestrel last confirmed sightings and breeding in Bulgaria**

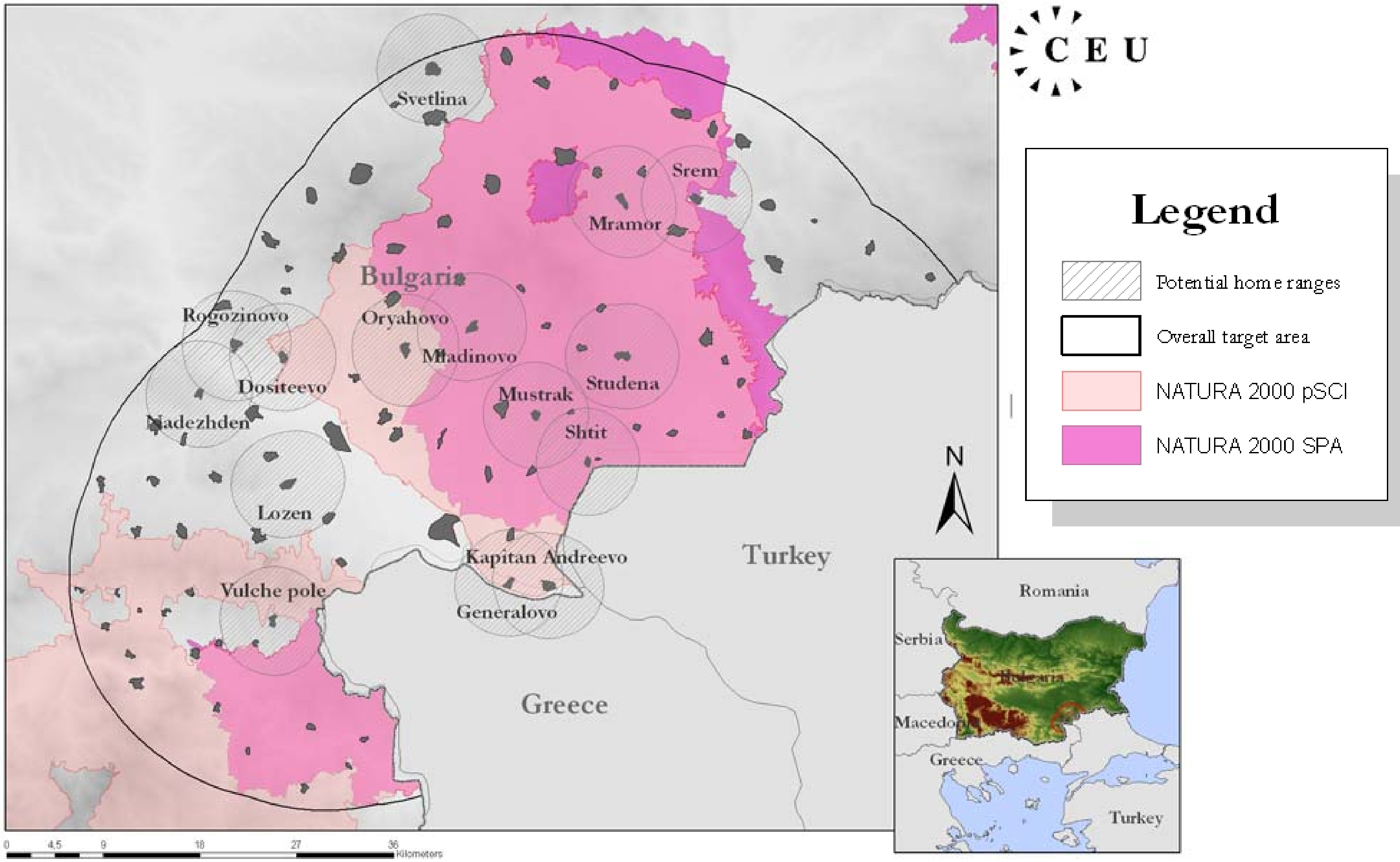


Source: (Barov 2002; GB 2010; Kmetova *et al.* in press)

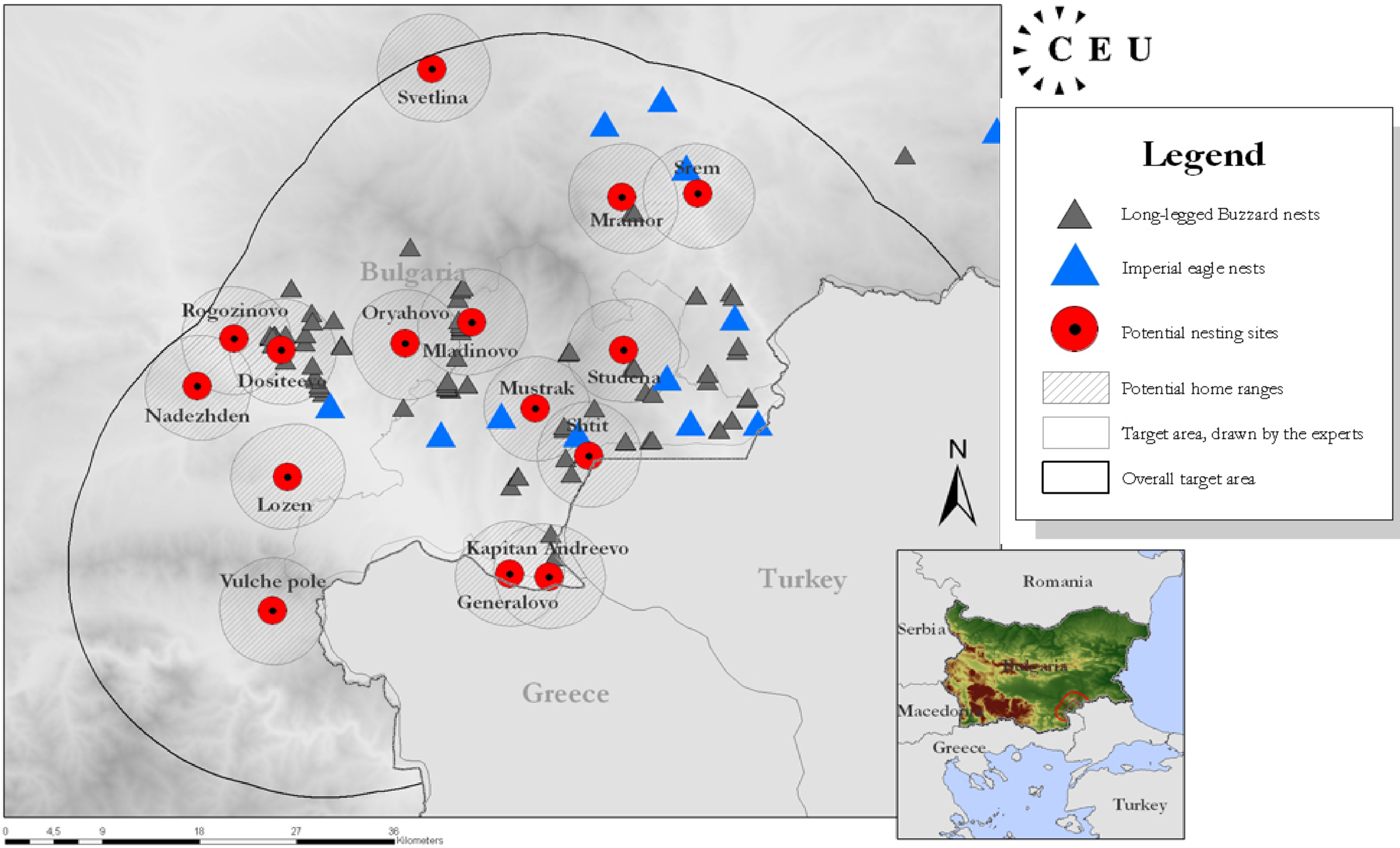
IX.2 **Map of the study area in Southeastern Bulgaria.**



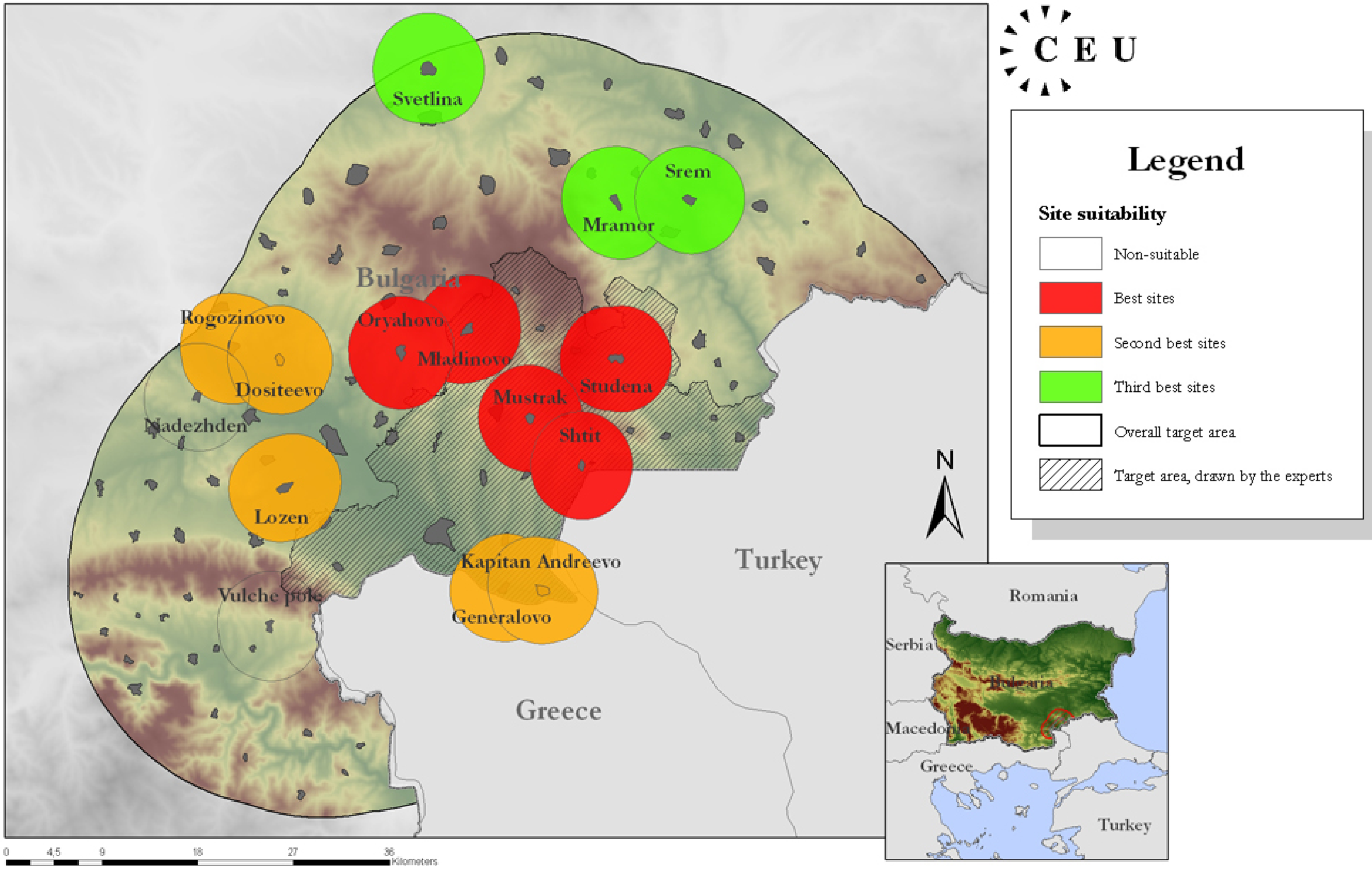
IX.3 Map of the Lesser Kestrel restoration sites and NATURA 2000 sites



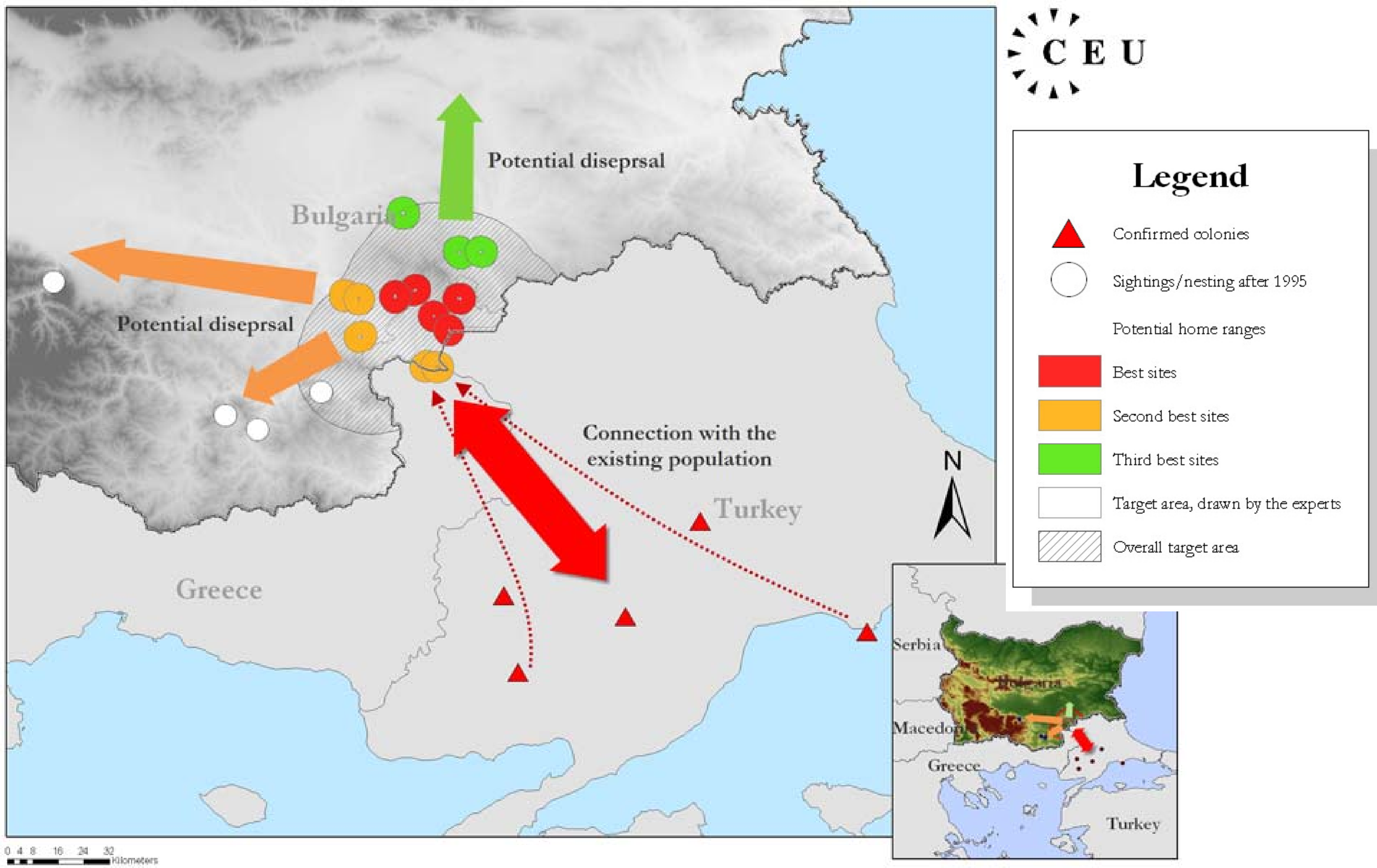
IX.4 Map of the Lesser Kestrel potential nesting sites and confirmed Imperial eagle and Long-legged Buzzard nests



IX.5 **Map of the Lesser Kestrel potential restoration sites in Southeastern Bulgaria**



IX.6 **Map of the Lesser Kestrel potential restoration site connectivity.**



IX.7 **Pictures from the Lesser Kestrel expedition, Turkish Thrace, April 2010**

Looking for Lesser Kestrels

Collecting data from the locals

Lesser Kestrel nesting sites

Lesser Kestrels in inhabited buildings

Lesser Kestrel nest in inhabited house

Lesser Kestrel in abandoned buildings

Lesser Kestrels

Lesser Kestrel foraging habitats