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Mortality factors and population trends of the Eagle Owl *Bubo bubo* in Finland

Jari Valkama and Pertti Saurola

Mortalitätsfaktoren und Populationstrends des Uhus *Bubo bubo* in Finnland

Die finnische Brutpopulation des Uhus wurde in den 1960er Jahren auf 500 bis 1000 Brutpaare geschätzt. Seitdem hat der Bestand bis in die 1980er Jahre auf etwa 2500 Brutpaare zugenommen. Diese Bestandszunahme ist auf erhöhten Schutz und eine verbesserte Nahrungsverfügbarkeit durch eine wachsende Anzahl und zunehmende Größe von Mülldeponien mit großen Populationen von Wanderratten *Rattus norvegicus* in Verbindung zu bringen. Waldbauliche Maßnahmen haben ausserdem die Verfügbarkeit an potenziellen Brutplätzen und Nahrungsgebieten deutlich erhöht. Während des gleichen Zeitraum hat sich der Uhu, früher eine scheue Art abgelegener Waldgebiete, zu einem Kulturfolger entwickelt, der zunehmend in der Nähe von Mülldeponien, Dörfern und Städten brütet.

Gleichwohl zeigen die Ergebnisse spezieller Monitoringprojekte für Greifvögel ("Raptor Grid" seit 1982, "Raptor Questionnaire" seit 1986), dass die Bestände und deren Reproduktion in den letzten 20 Jahren signifikant zurückgehen. Der wahrscheinlichste Grund hierfür ist die Tatsache, dass rund 90 % der Mülldeponien in diesem Zeitraum geschlossen oder so modernisiert wurden, dass die Rattenpopulationen auf ihnen weitgehend ausgerottet wurden.

Daten aus Ringwiederfunden zeigen, dass die Hauptmortalitätsfaktoren für Uhus derzeit Stromschlag an Freileitungen und Verluste durch den Straßenverkehr darstellen. Der Anteil dieser Todesursachen hat zugenommen, während der Anteil der als getötet gemeldeten Uhus in den späten 1970er und frühen 1980er Jahren zurückging. Trotz einiger methodischer Vorbehalte, die sich aus den jährlichen Beringungszahlen ergeben, zeigt sich doch die Bedeutung von Stromschlag und Straßenverkehr als wichtigste Mortalitätsfaktoren finnischer Uhus in den letzten 10 Jahren. Trotz des aktuellen Rückgangs der Populationsgröße und der Reproduktionsraten ist es derzeit noch zu früh, Schlussfolgerungen hinsichtlich der langfristigen Populationsentwicklung finnischer Uhus zu ziehen.

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Introduction

Long-term monitoring data on bird populations have proved to be an extremely useful instrument especially when data are needed for conservation purposes (e.g. Furness et al. 1993, Newton 1995). In particular, monitoring of birds of prey as organisms on the top of food webs has revealed some major threats and changes in our environment, e.g. accumulation of DDT and its derivatives or heavy metals in several species (Solonen & Lodenius 1990, Helander et al. 2002). Without these data on population sizes, clutch size and ultimate breeding success, our knowledge and understanding of detected environmental changes would be considerably less.

In Finland, there is extensive experience of a plethora of long-term monitoring projects on birds of prey (e.g. Saurola 1976, 1985, 1997, Honkala et al. 2005). For example, there has been a national project on Ospreys *Pandion haliaetus* since 1971 (Saurola 2005), and a similar still ongoing project was established for White-Tailed Eagles *Haliaeetus albicilla* in 1973 (e.g. Koivusaari et al. 1973, Stjernberg et al. 2005). A specific monitoring program for all Finnish birds of prey ("Raptor Grid", see Saurola 1982) was initiated in 1982, and every year after that approximately 130 grids have been thoroughly surveyed. The Raptor grid project was supplemented in 1986 with "Raptor Questionnaire" in which all Finnish bird ringers report their nest and territory findings of birds of prey after each breeding season. Every year these voluntary ringers check approximately 45,000 potential nest sites for birds of prey.

The Eagle Owl *Bubo bubo* is the largest owl in Europe. The size of the European population is less than 38,000 pairs, the highest estimates coming from Spain (2500-10,000 breeding pairs), Turkey (3000-6000), Russia (3000-5500), Norway (1000-2000) and Finland (2000-3000)(BirdLife International 2004). The populations have been reported declining in some areas, but the overall status of the species is considered as stable (BirdLife International 2004). Legal and illegal killing of Eagle Owls has been common in many European countries in the past, and Finland has not been an exception of this rule. The species was protected for the breeding season since 1966, and finally in 1983 it got a full-time protection. In this paper, we examine population trends and productivity of Finnish Eagle Owls during a period of 23 years (1982-2004) and discuss the potential implications for conservation of the species.

Material and Methods

The Eagle Owl is a generalist predator utilising a wide spectrum of prey animals (see Valkama et al. 2005 and references therein). In Finland, however, fluctuating populations of Water Voles *Arvicola terrestris* and *Microtus* voles (*M. agrestis* and *M. rossiaemeridionalis*) form the basis of the "natural" breeding season diet of the Eagle Owls especially during the population peaks of these voles (Korpimäki et al. 1990). The populations of *Microtus* voles typically fluctuate in three-four year cycles in northern Fennoscandia, while the population peaks of Water Voles occur more irregularly with probably longer time between population peaks (Korpimäki et al. 2003, 2004, E. Korpimäki unpublished data). It is typical that during the years of vole scarcity, many of the Eagle Owls do not breed at all, or produce only one or at most two fledglings (Helppi & Kalinainen 1984). Another important anthropogenic source of food for the Eagle Owl is the Norway Rat *Rattus norvegicus*, populations of which can amount to several thousands in large refuse dumps (see e.g. Mikkonen et al. 2005) and which are common also in cattle and fur farms in the countryside. Traditional and usually less efficiently managed refuse dumps with stable rat populations provide Eagle Owls with an access to easy and abundant food, enabling them to breed even during years of vole scarcity and raise larger broods than their conspecifics in natural territories (Helppi & Kalinainen 1984). It has been estimated that in 198 there were approx. 1000 municipal or industrial dumps in Finland, but due to application of strict EU directives their number diminished especiall in the 1990s such that in 2004 the number wa 101 (source: Finnish Environment Centre). In th province of Uusimaa, south Finland, the numbe decreased from 60 to 7 during the same period.

The Finnish Ringing Centre together wit the Ministry of Environment decided to initiat a project to monitor common raptors and owl (Saurola 1982). The aims of the project were (to collect data on the status of Finnish raptor and owls, (ii) to determine annual populatio fluctuations and trends and (iii) to establish database on nest sites of birds of prey for the us of conservation authorities. The Finnish Nationa Grid was chosen as the co-ordinate system of th project – not only because of the fact that by tha time Finnish ornithologists were already familia with the 10 × 10 km "atlas squares" used durin the first Finnish bird atlas in the 1970s (Hyyti et al. 1983). The thorough investigations of eac grid include, among other things, the followin duties: 1. watching of aerial displays of raptor to locate their territories and nests, 2. listenin for territorial calls of owls during early sprin 3. search for nests and 4. search for fledge broods. The ringers are strongly encouraged t work in groups as the finding of nests and terr tories in a study plot of 100 km² is very laboriou and time-consuming.

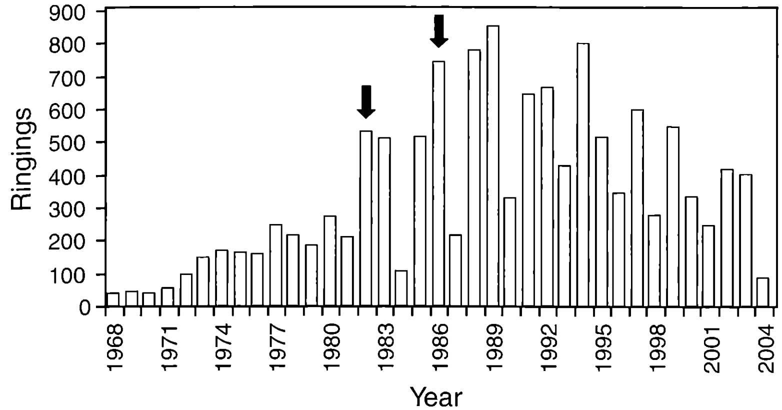

Fig. 1. Annual ringing numbers of the Eagle Owl *Bubo bubo* nestlings 1968-2004. The arrows indicate start of the Raptor Grid project (1982) and Raptor Questionnaire (1986). – *Jährliche Beringungszahlen von Uhu-Nestlingen in Finnland 1968-2004. Die Pfeile markieren den Beginn der größeren Greifvogelprojekte (Raptor Grid project 1982, Raptor Questionnaire 1986).*

In 1986, the Raptor Grid project was supplemented with specific Raptor Questionnaire, the aim of which was to fully utilise observations and expertise of Finnish raptor ringers. After each breeding season every bird ringer is requested to report to the Ringing Centre the numbers of all potential nest sites of birds of prey (including nest boxes and other artificial nests, and all natural twig nests, cavities etc.) checked during that year. In the same way the ringer should report by species the numbers of occupied nests and territories, and also clutch and brood sizes of each active nest.

All Finnish ringing and ring recovery data for Eagle Owls are stored at the Ringing Centre in the Finnish Museum of Natural History. By the end of 2004, a total of 13,579 Eagle Owls have been ringed since 1913 when bird ringing started in Finland (Tab. 1). The majority of these were nestlings (97 %). Annual ringing numbers were modest until the 1980s when the Raptor Grid project and Raptor Questionnaires were initiated (Fig. 1). Ringing numbers peaked in 1989, but since that the numbers have been declining.

Results

Population estimates. Unfortunately, the oldest population estimates are somewhat inaccurate. Merikallio's estimate from the 1950's was 200 pairs (Merikallio 1958), but it probably was an underestimate. In the late 1960's and early 1970's the population was estimated at 500-1000 pairs (Häyrinen & Sulkava 1965, Lagerström 1978), and in the 1970s at 1000-1500 pairs (Hyytiä et al. 1983). In the beginning of 1980s, the number of breeding pairs was approximately 2500 pairs (Saurola 1985), and e.g. in Satakunta, western Finland, the population increased by 50 % between 1968 and 1983 (Helppi & Kalinainen 1984).

Population development and productivity. The Raptor Grid data from 1982 to 2004 suggest that both the number of occupied Eagle Owl territories and active nests within them has been decreasing, although there has been considerable variation in the number of active nests (Fig. 2). Similarly, data from Raptor Questionnaire show that since 1986 the decline has occurred in the whole country (Fig. 3). Data on productivity (Fig. 4) show that in the beginning of the Raptor Questionnaire period (i.e., 1986) the Eagle Owls produced on average

Tab. 1. Ringing and ring recovery numbers of Finnish Eagle Owls *Bubo bubo* during 1913-2004 – *Anzahl der Beringungen und Ringwiederfunde finnischer Uhus von 1913 bis 2004.*

Ringings	13579
Total number of encounters	3101
Encountered individuals	2950
Encountered alive	111
Dead, details not known	1134
Dead, details known	1705

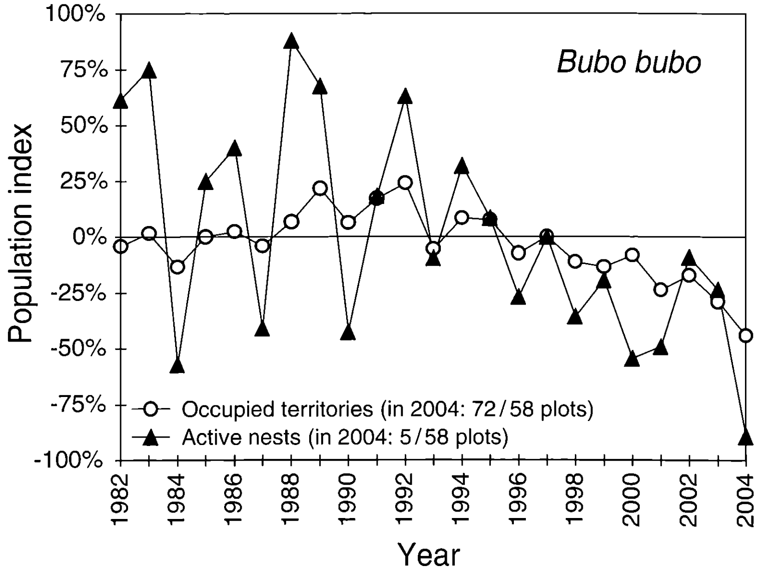

Fig. 2. Population changes of Eagle Owls *Bubo bubo* in 100 km² study plots from 1982 to 2004. For each spe and year, only the plots in which the species was censused also in 1997, were included. The numbers of territo (O) and nests found (▲) were related to the corresponding numbers in 1997. The size of data used is given the year 2004: the number of territories or nests and the number of study plots in which the data was collec – *Populationsschwankungen des Uhus auf 100-km²-Untersuchungsflächen von 1982 bis 2004. Der Populationsi (O: Reviere; ▲: Nestfunde) ist auf das Jahr 1997 normiert. Verwendet wurden nur Probflächen, aus denen für 1997 D vorlagen. Für das Jahr 2004 ist die Anzahl der Reviere bzw. Nestfunde und die Anzahl der Probeflächen, auf denen D erhoben wurden, angegeben.*

0.2 chicks more per breeding attempt than at the end of the period. The productivity decreased in the same way for successful and all active nests which indicates that the decrease is not a result of increased nest failures.

Ring recoveries and causes of death. The Finnish ring recovery data on the Eagle Owl consist of 3101 encounters (Tab. 1). However, a small proportion of these include recaptures of the same individuals within a short period of time or findings of dead fledglings close to their site of ringing. When only the last encounter of each individual is taken into account and when recoveries of dead chicks are excluded, we are left with data on 2950 individuals. Of these, 111 individuals were encountered alive and 1134 found dead without any details as to why the bird had died. For 1705 individuals the cause of death was identified. The most important single mortality factor was electrocution (39 %, Fig. 5), followed by collision with road vehicles (20 %), other causes of death (e.g. "found sick", 19 %), starvation (9 %) and persecution (7 %). Figure 6 shows that the relative importance of different causes of de has changed considerably through time. In 1970s and in early 1980s killing of Eagle O was common, but after the full-time protect only very few individuals have been shot were reported shot). During the last 25 years proportion of electrocution and especially t of collision with cars have been increasing, a nowadays they account for more than 60 % of causes of death. Figure 7 shows the geograp cal distribution of sites where an Eagle Owl been killed by a car. These sites are distinctiv concentrated in the surroundings of the bigg cities of Helsinki, Tampere, Turku and Pori a in the road network connecting these cities.

Discussion

At present, the size of the Finnish Eagle Owl po lation is approximately 2000-3000 pairs (Birdl International 2004). It is likely that the populat peaked some 10-15 years ago, during the ti when the number of improperly managed a

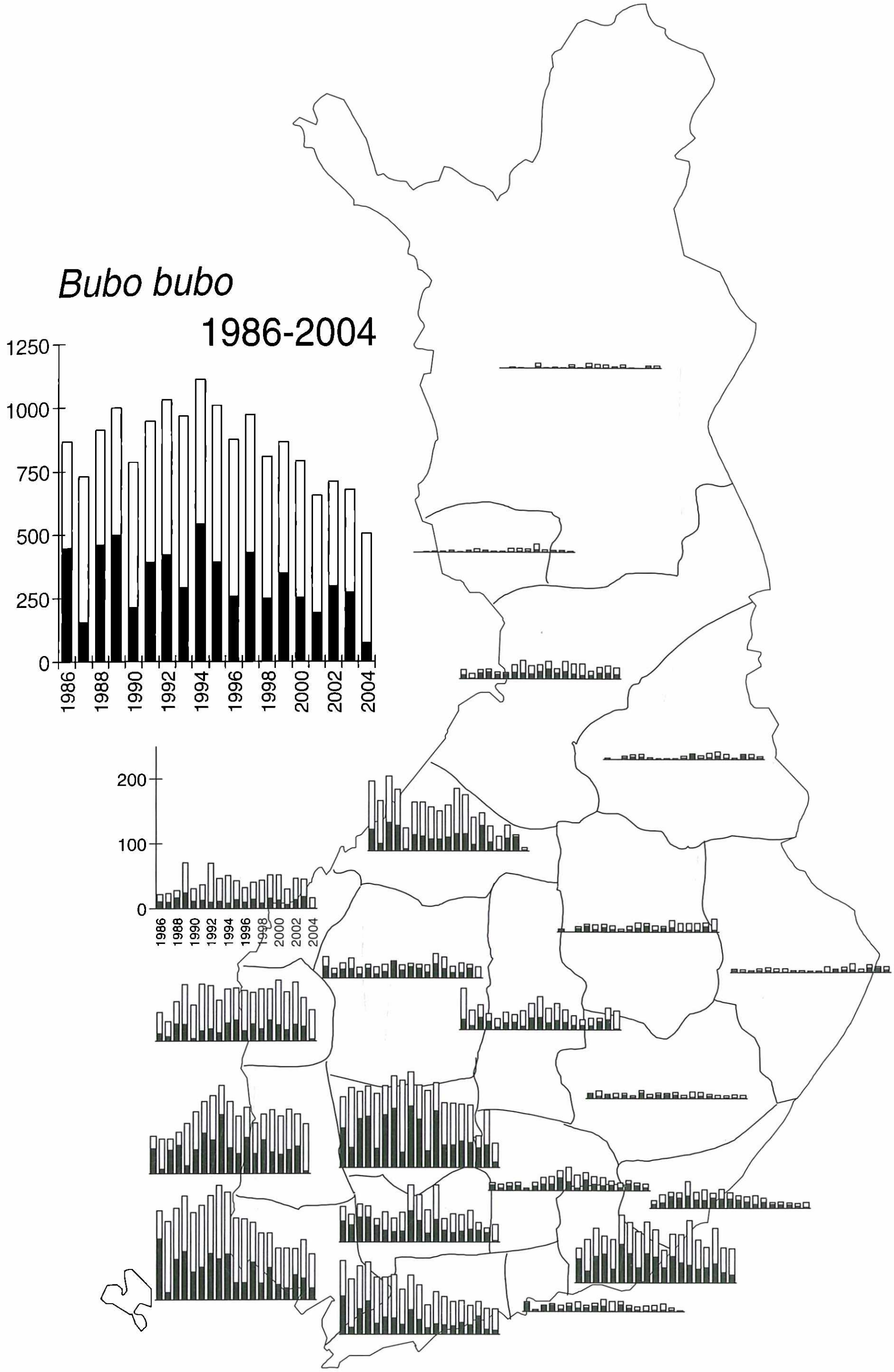

Fig. 3. The annual numbers of active nests found (■) and occupied territories (□) of Eagle Owls *Bubo bubo* by the local areas from 1986 to 2004 according to the Raptor Questionnaire. The scale for the whole country (upper left) is different from that of local areas. – *Jährliche Anzahl von Nestfunden (■) und besetzten Revieren (□) des Uhus in verschiedenen Gebieten Finnlands (Daten aus dem Monitoring-Programm "Raptor Questionnaire" Man beachte die abweichende Skala für die Bestandsentwicklung in ganz Finnland (links oben).*

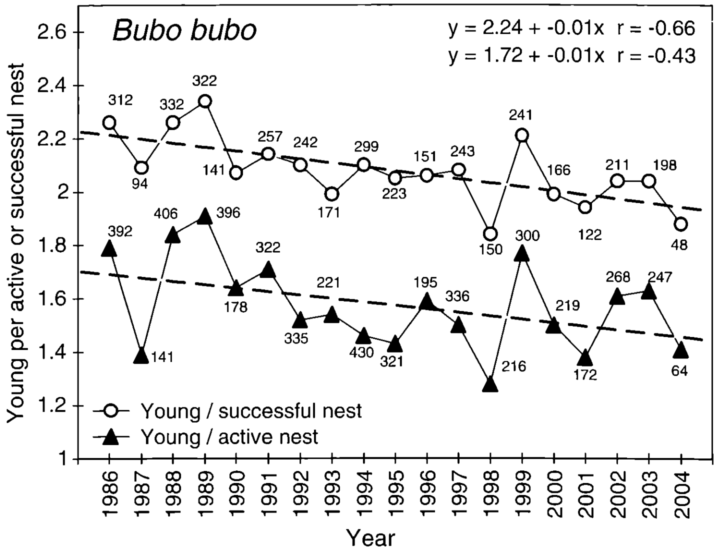

Fig. 4. Annual breeding success (O: young per successful nest; ▲: young per active nest) of Eagle Owls *Bubo bul* in Finland 1986-2004. – *Jährlicher Bruterfolg (O: Jungvögel pro erfolgreicher Brut; ▲: Jungvögel pro besetztes Nest) d Uhus in Finnland 1986-2004.*

rat-rich refuse dumps was highest. Each dump probably hosted at least one Eagle Owl pair in its vicinity, indicating that in the past even 1000 pairs could have been more or less dependent on the easy food provided by the dumps. It is much more difficult to demonstrate what had happened prior to this period as there are no long-term nation-wide studies on this species before the start of the monitoring project in 1982. Nevertheless, it is likely that the population had indeed increased from 1950s until 1990s. In addition to the increase in the number of dumps there are at least two other contributing factors for this: (i) part-time protection of the Eagle Owls in 1966 and full-time protection in 1983 has probably increased popula tion due to higher breeding success and surviva of the birds, and (ii) modern intensive forestry ha created an endless number of suitable nest site and hunting grounds (i.e., clear-cuts) for the spe cies. One very important aspect combining thes two factors is that after the full-time protectio the owls have become significantly less sensitiv to disturbances caused by people and therefor they have been able to utilise new breeding area (such as dumps) close to human settlements. was not more than thirty years ago when th Eagle Owl was considered a classic example o the bird of remote wilderness.

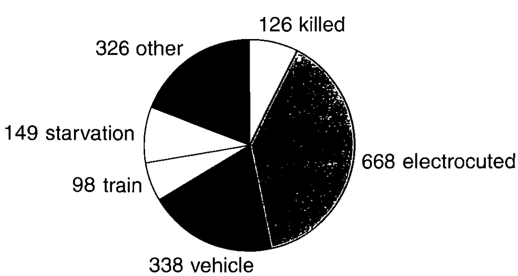

Fig. 5. The proportions of different causes of death for Finnish Eagle Owls *Bubo bubo* as indicated by the ring recovery data. – *Verlustursachen finnischer Uhus anhand von Ringwiederfunden.*

We found evidence that both population siz and productivity of the Eagle Owls have signif cantly decreased during the last two decades. Th extensive and almost simultaneous modernisatio or complete closure of dumps especially durin the last 15 years is most likely the main reaso for the observed declines in population trend an productivity (Figs 2-4). Although the data did no allow us to test it, the unpublished data from som Eagle Owl ringers clearly suggest that producti ity of owls was generally much better in dum territories than in natural ones: in dump territori the owls regularly produced three (or even fou fledglings while values like these were reache in natural territories only during extremely goo

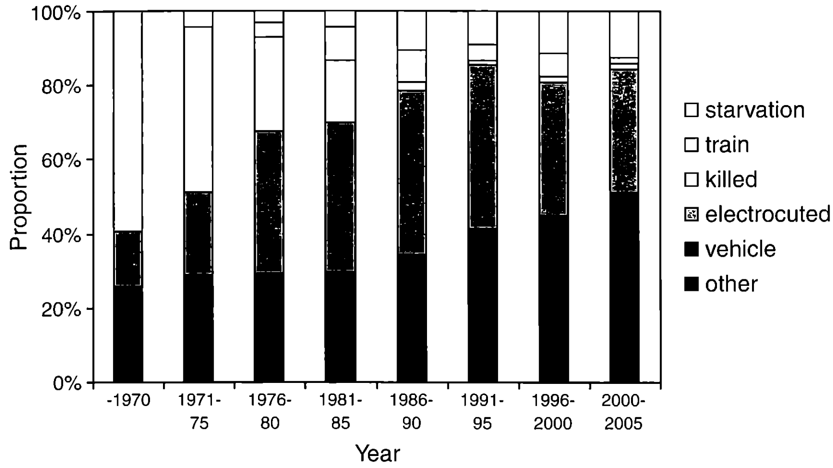

Fig. 6. Temporal changes in the causes of death for Finnish Eagle Owls *Bubo bubo* as indicated by the ring recovery data. – *Zeitliche Veränderung des relativen Anteils verschiedener Todesursachen finnischer Uhus anhand von Ringwiederfunddaten.*

vole years (see also Helppi & Kalinainen 1984). The same data from ringers also indicate that in dump territories the owls started breeding on average one week earlier than in natural territories which further improved survival prospects of the young.

The observed decline may, on the other hand, be connected with modernisation of agricultural practices especially in southern and western Finland, where the Eagle Owl density has traditionally been highest and which thus can be considered the core area of the Finnish Eagle Owl population (see Fig. 3). It is in these areas where open ditches have been replaced by sub-surface drainage and cattle farms with traditional hay fields have given way to monocultures of cereals. These dramatic changes in farmland habitats have probably been fatal for *Microtus* and Water Voles, which have lost important breeding and shelter habitats and consequently become more susceptible for specialist and generalist predators (e.g. Hansson & Henttonen 1985). In fact, during the last 20 years the traditional vole cycles with population peaks in every 3-4 years have almost completely disappeared from south-western Finland. Another factor contributing to the disappearance of vole cycles can be the fact that winters have been very mild in southern Finland during the last 20 years, which can be harmful to vole populations in two ways: (i) the lack of snow cover makes them easy prey for predators, (ii) rapid and steep variation in weather conditions (snowing, melting of snow, flooding and thereafter freezing again) can drastically impair living conditions of voles (e.g. Solonen 2004, 2005).

The time span is still too short to assess how well Eagle Owls have survived the abrupt change in their living conditions. It is possible that the decline we have recently detected is partly natural density variation and that the population is now returning back to natural conditions which prevailed prior to rapid influx of rat paradises.

Electrocuted and overdriven owls. Finnish recovery data on ringed Eagle Owls indicate that the most frequent causes of mortality are electrocution and collision with vehicles. There is also a clear temporal pattern in causes of death: before 1980s every second dead Eagle Owl was shot but after the full-time protection the killings rapidly decreased. After the owls became less shy and started to live closer to human habitation, they were faced with completely new threats, i.e., electric cables and traffic. Ring recovery data suggest that nowadays three out of five Eagle Owls, whose cause of death can reliably be identified, loose their lives either in powerlines or under a car. However, this is the point where one has to consider the potential shortcomings of ringing and recovery data. A bird that has a very visible way of dying (such as collision with car) has a higher probability of being found and reported than a bird that dies for a natural reason in the middle of nowhere. In other words, recovery data may

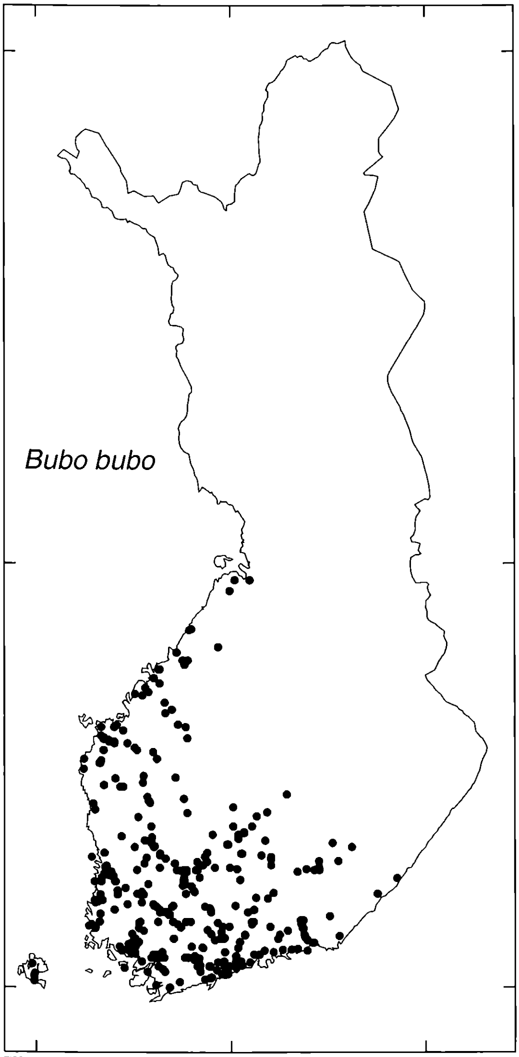

Fig. 7. Map of Finland showing the finding sites of ringed Eagle Owls *Bubo bubo* which died due to collision with a vehicle. – *Wiederfundorte durch Straßenverkehr umgekommener finnischer Uhus nach Ringfunden.*

underestimate deaths that occur as a result of disease, senescence, wounding in a territorial fight, poison, etc. Further, it is possible that all recoveries have not been reported to the Ringing Centre, or that individuals that in fact were shot, have just been reported as found dead. Nevertheless, we should bear in mind that of the 13,579 Eagle Owls ringed *at least* 1006 (7.5 %) have certainly died due to electrocution or traffic accident, which simply means that in reality almost every tenth Eagle Owl ends its life in this way, providing that the fate of the ringed birds does not deviate from that of unringed birds (as it should not).

In Finland, little has been done so far to modify powerlines and especially powerline poles such that they would no longer be dangerous for animals. It is not only the Eagle Owls that suffer from these poles, but also large numbers of other owl species (such as the Ural Owl *Strix uralensis* and White-tailed Eagles die each year through electrocution. In Germany there is encouraging experience to solve this problem, as there the poles have been modified such that a bird sitting on a pole will no longer be in contact with the cables (Haas et al. 2005). This method should be applied in Finland, too, as now there exist tool and knowledge to reduce risks of electrocution to wildlife, only political will and money are required to fully utilise them. The traffic accident are a far more difficult issue to deal with, as it i likely that the density of cars will still increase in the future. The most critical periods for the owl are late evening and early morning hours whe they are hunting most actively and therefor are likely to cross roads or perch close to them Limiting of the amount of traffic appears to b an unrealistic option to reduce owl collisions but perhaps it would be possible to change th drivers' attitudes such that they would reduc speed at high-risk areas (and during high-ris hours) which most likely could be identified wit the help of experienced ornithologists.

Summary

According to the available population estimates, th size of the Finnish Eagle Owl *Bubo bubo* populatic was 500-1000 pairs in 1960s. Since then the populatic increased gradually until the 1980s, when the numb of breeding pairs was approx. 2500. This increase wa probably associated with the improved protectic status of the species (breeding season protection 196 year-round 1983), with the improved food availabi ity through a growth in the number and size of tl improperly managed waste disposal sites ('dumps hosting colossal populations of Norway rats *Ratt norvegicus*, and with increased availability of potenti nest sites and hunting grounds through highly effecti forestry practices. During the same period of time tl previously timid species of the remote forests showe an excellent ability to adapt to human settlement ar started to live and nest close to dumps, villages ar cities. However, evidence from a specific monitori program on birds of prey (Raptor Grid, running sin

1982, and Raptor Questionnaire, since 1986) targeted at bird ringers inevitably shows that the population as well as its productivity have been decreasing significantly during the last 20 years. The most likely reason for these is the fact that even 90 % refuse dumps have been closed or modernised during the same period such that rat populations have been eradicated from them. The ring recovery data suggest that at the moment the main mortality factors for Eagle Owls are electrocution and collision with vehicles. The share of these causes of death has been increasing through time while the proportion of Eagle Owls reported killed declined in the late 1970s and early 1980s. When different causes of mortality are related to the annual ringing numbers, there is reason to believe that electrocution and traffic accidents have indeed been major mortality factors for Finnish Eagle Owls during the last decade. Despite the recent decline in population size and productivity, it is still too early to draw any firm conclusions regarding the long-term population development.

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