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Status of Large Carnivore Conservation in the Baltic States

Large Carnivore Control and Management Plan for Estonia, 2002-2011

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Introduction

Estonian is inhabited by three species of large carnivores – wolf, lynx and brown bear. Wolverine can be met only occasionally. All these species stand systematically apart and do not replace each other also ecologically. Lynx and brown bear are sole representatives of whole families in Estonia while wolves can be characterized by social way of life and the role of domestic dog ancestor. Although, in modern world large carnivores have several common features. They all need wide home ranges (in Estonia predominantly large forests) and they depend on prey abundance and human disturbance in their distribution areas. They all have deserved humans' attention due to their food preference and depending on what has been considered to be human property, they have been more or less mans competitors and enemies. People have never been indifferent regarding the large carnivores.

History of nature is history of changing human evaluations. Both presence and absence of large carnivores can have consequences that are not considered favourable by people at first sight. Still, it is doubtful whether large carnivores are to be controlled and managed namely because of these consequences or just the need is a product of mans ethic attitudes towards the surrounding world (Linnell et al. 2000). Shift of attitudes in favour of large carnivores is noticeable in recent years, but it takes place in the world where human population leaves less and less space for these animals. Analysis of goals and means is vital in these conditions to avoid turning of large carnivore protection into just hypocritical slogan. As the large carnivores are strictly protected in the European Union, so independently of Estonian membership in the union, it is necessary to think seriously about why wolves can be hunted in Estonian all the time by all means, why environmental strategy foresees reduction of lynx population to 500 specimen and whether rehabilitation centre of wild animals can provide the bear population with sufficient rising generation.

The aim of this action plan is to mitigate the conflict between humans and large carnivores with simultaneous maintenance of viable large carnivore populations in Estonian in the period 2002-2011. Accordingly, the plan is named Control and Management Plan. The work consists of five parts, three of which are a scientific review of the control and management needs and possibilities and the latter two construct a plan that is based on these needs and possibilities.

No action plan is perfect and final. Composers of this plan faced often the poor knowledge on the status and biology of the Estonian large carnivores. Missing data is the reason for including so extensively information from other parts of the world. We hope that with planned improvement of gathering of information and research in Estonia, the further conclusions contribute to new control and conservation regulations.

The working group of this plan involved scientists, naturalists and hunters. Such "community" is rather new to Estonia and obviously also a valuable addition to achieved results. Several other people contributed to the plan. We would like to stress Harri Valdmanns contribution, whose earlier working material (2000b) served as a cornerstone of this plan. The plan was critically reviewed by Matis Mägi and Einar Tammur.

Summary

The aim of this work is to establish a scientifically motivated plan for wolf (Canis lupus), lynx (Lynx lynx) and brown bear (Ursus arctos) control and protection in Estonian in period 2002 –2011. The plan consists of five parts, three of which are a scientific review of the control and protection possibilities and needs, the latter two present and analyse adjacent activities and strategies. The plan is to be renewed in 2010 or in appearance of extraordinary development also earlier.

Estonia is inhabited by 100-150 wolves and 300-500 brown bears (about 1% of European population of these species) and 600-900 lynxes (>1% of the European population). Two thirds of the bear population can be found in three eastern counties, lynx density is highest in the forests of North and Central Estonia while majority of wolves live in Pärnu and Jõgeva counties. Wolf and lynx populations are genetically related to large populations in Russia and Latvia, but the bear population is potentially relatively isolated.

With present population size, extinction probability of bear in coming 200 years is less than 5% without hunting, but with annual quota of only 20 speciemen, the probability is as high as 22-40%.

The main cost of maintaining a viable large carnivore population is preying on domestic animals, but with current practice of livestock breeding in Estonia the risk is rather small. Among game ungulates, wolfs negative influence to wild boar population is evident, but it is not effective when wolf population does not exceed 200 specimen. Positive effect of large carnivore is limiting of mesopredator and beaver populations and increasing of food basis for scavenger species.

The biggest dangers to Estonian large carnivores are over-hunting, potentially negative public opinion and in the case of bear also disturbance. As of habitat quality, influence of decreasing roe-deer population on lynx and potential bear distribution barriers deserve more attention.

Long term aim of the plan is maintenance of favourable conditions for large carnivores to facilitate in period 2002-2011 sufficient population size and its natural functions , keeping agricultural damages on optimal low level and maintain possibility to hunt large carnivores. To enable these functions, it is recommended to maintain a wolf population of 100-200 specimen and bear and lynx populations at least 500 strong in Estonia.

The action plan defines 38 activities that can be divided into eight categories: 1) improvement of legislation; 2) development of infra-structure; 3) monitoring and information systems; 4) applied research; 5) habitat protection; 6) control and rehabilitation; 7) large carnivore damage management; 8) increase of public awareness and moulding of public opinion. The highest (A) priority activity list includes 17 activities, medium priority (B) list 9 activities and low priority (C) list 12 activities. Minimal cost of the plan (only priority A) is EEK 242 000 – 577 000 annually, majority of which is formed by establishment and running of the coordinators post. Other high priority tasks are formation of an advisory group, training of regional experts, estimation of official census error , development of monitoring methodology, analysis of large carnivore conservation area expedience, rehabilitation of abandoned bear cubs and publishing of informational folders.

1. Distribution, population size and biology of large carnivores

1.1. Distribution and population size

1.1.1. Distribution and population size in the World and Europe

Large carnivore species, that can be found in Estonia have wide distribution areas and complex intra-specific structure. Wolf is distributed widely in northern hemisphere – in Eurasia from North-western and North-eastern Europe to Pacific Ocean (reaching Northern Arabia and India), in North America as a fragmented population from northern parts of United States to Alaska and as an isolated population in Mexico. World wolf population is estimated to hold about 300 specimen, that does obviously not exceed 1% of historical wolf population[1] . In Europe probably existed only two subspecies of wolf of which *Canis lupus albus* survived as a separate 30 strong population in 1960-ies, but nowadays has assimilated to with *C. l. lupus* (Mitchell-Jones et al. 1999) ,the subspecies that is also inhabits Estonia.

Lynx, inhabiting both Eurasia and North America was up to recent times treated as subspecies on one species, but currently four separate species are distinguished of which lynx (*Lynx lynx*) and globally endangered Iberian lynx (*L.pardinus*) live in Eurasia and the rest two species in North America. European lynx again is divided into three subspecies, of which nominotypical taxon *L. l. lynx* is distributed from South Scandinavia to Carpathian mountains and Balkan. Lynx population size in the worldhas not been estimates, but similarly to other large carnivores, it has dropped significantly during historic times.

[1] estimate is based on genetic structure, according to which effective population size (N_e, see chapter 2.1.1) of females in Upper – Pleistocene was about 5 million individuals (Vila et al. 1999). With sex ratio 1:1 and relative N_e 20% it corresponds to historical population in magnitude of 50 million specimen, 0.6 of which has survived till today.

Extinction is obvious in large part of Europe similarly to destiny of bobcats in North America. Today 75 % of lynx distribution area lies in Russia (Zheltuchin 1992, ref. Mace 1999).

Brown bear (further: bear) is similarly to wolf a Holarctic species, who is distributed in Eurasia from West-Europe (isolated populations) to Far East and Japan, in North America inhabits North Mexico, Rocky mountains, North and North-west Canada and Alaska. Bear population size reaches probably 200 000 specimen, 50 000 - 60 000 of them in North America and 32 000 –35 000 in Europe (Anon. 1996). There is no exact data on Asian population, but population size in Soviet Union territory was estimated to be at least 130 000 specimen in 1990 (Chestin et al. 1992). Out of the many subspecies, Europe is inhabited only by European brown bear (*Ursus a. arctos*).

Data on wolf, lynx and bear current population size in Europe and member states of EU is given in Table 1. Major proportion European population of all three species is formed by single subspecies (nominotypical taxon) and most of the specimens live in Russia. Estonia holds about 1% of wolf and bear population, the proportion of lynx population is probably higher. After the first circle of expanding of European Union to Eastern Europe, Estonia would host 20% of the Union bear and lynx population and 3-5% of wolf population.

Table 1. Abundance of large carnivores in Europe and European Union countries

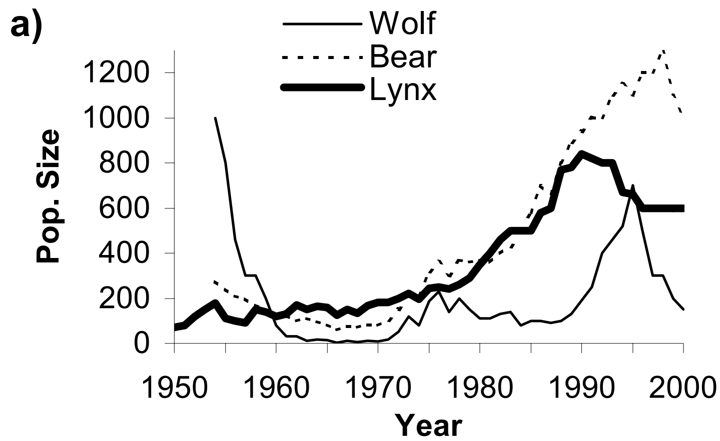
Species	Abundance (number of specimen)[a]		
	Europe	European Union countries	European Union candidate countries
Wolf	15 000–20 000	Finland 140, Sweden 25, Germany 5, Italy 300, Greece 300-500, France 10, Spain 1500-2000, Portugal 150	Estonia 100–150, Latvia >700, Lithuania 385, Poland 800-900, Hungary <50, Slovenia 10-20
Lynx	>10 000	Finland >750, Sweden 900, Germany ?, Austria <10, France some, Italy ?	Estonia 600–900, Latvia 500-600, Lithuania 77, Poland 200, Check Rep. 100-150, Hungary 10, Slovenia 75
Brown bear	32 000–35 000	Finland >700, Sweden 650–700, Austria 20-30, Italy 60–70, Greece 90–170, France 9-13, Spain 50-70	Estonia 300–500, Latvia 5, Poland 70-85, Hungary 1-2, Slovenia 300-400

[a] source: Swenson et al. 1995, Anon. 1996, Cerveny et al. 1996, Craighead & Vyse 1996, Ellegren et al. 1996, Taberlet et al. 1997, Breitenmoser 1998, Stahl & Vandel 1999, Ozolinš 2000, Data of Lithuanian Hunters Society (K. Roht), this work.

1.1.2. Distribution and abundance in Estonia

Histories of wolf, lynx and bear is in general similar in Estonia (reviews: Aul et al. 1957, Paaver 1965, Kaal 1980, 1983). Although subfossile findings date post-glacial occupation of Estonia by large carnivores to the end of preboreal period or to the boreal period (8000-9500 B.C), these animals came to Estonian territory already earlier and belonged to first post-glacial animal communities (Lepiksaar, 1986). Possibly these species remained rather abundant up to the beginning of annihilation campaigns in the second half of the 19th century and declined till the WW II (increase of wolf and lynx numbers was noticed also after WW I). Bear and lynx abundance increased after the WW II slowly and reached its maximum in 1990ies, wolf had a population peak also after the second world war (Figure 1.)

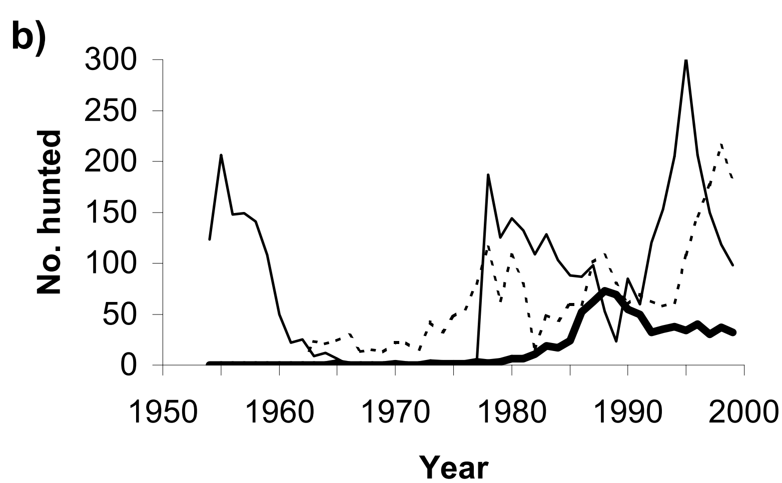
The main features of present distribution and abundance of Estonian large carnivores are well known, but all present estimates contain a systematic error (see 4.3.3). The most frequently, **official census** is used to sum up all abundance estimates gathered within a hunting region. Official census results obviously in ana overestimate and regional “differences” in abundance can also occur due to inconsistent application of estimation criteria. Historically, deliberate alteration of data (Kaal 1980, p. 29). Obviously more reliable distribution data is based on **regional hunting statistics**, but these data can be influenced by differences in hunting intensity. In years 1996-1998, abundance of large carnivores was established in **sample plots** using track count and interviews with hunters (Valdmann 2000b). Exactness of this method is not known, but possibly the result is under-estimated and subjective errors can be caused by different observation effort of hunters. Underestimate is possibly also the result of the **wolf and lynx observation day** , when wolf and lynx tracks are counted in county level during a single winter day. The source for this underestimate lies in the probability that tracks of some individuals is not detected during the day.



Data, gathered with above presented methods shows following evidence. Current distribution of large predators is concentrated on mainland, only lynx can be found in Hiiumaa and singular wolves in Saaremaa. Wolf abundance is highest in Pärnu and Jõgeva counties , where more than a quarter of all specimens is counted and hunted. In 1999, wolf census day resulted an estimated 150 specimen (counted 91, Valdmann 2000b), official census yielded a 200 strong population. Thus the different estimates (first an under- and second over-estimate) match quite well and allow to estimate the total Estonian wolf population size to be 100-150 individuals according to the result of official census in 2000 – 150 specimen.

Figure 1. Population dynamics of wolf, lynx and bear (a) and number of hunted individuals (b) in Estonia during the second half of the XX century according to the official hunting statistics.

Lynx has also spread all over Estonia, whereas according to the official census results a third of the total population lives Pärnu, Jõgeva and Harju counties . As far as lynx distribution is according to several sources related to forest (chapter 1.2.2.), relative abundance of lynx per forest area unit is a measure of habitat quality. According to hunting statistics this value is the highest in a relative uniform area of Northern and Mid- Estonia (Harju, Järva and Rapla counties), followed by western regions of



Estonian mainland (Pärnu and Lääne counties). Estimates of lynx abundance differ even more than wolf estimates; e.g. census day results in 1999 led to an estimate of 450 specimen (counted 330; Valdmann 2000b), while official census resulted in an estimated population size of 1200 specimen. The first estimate is obviously an underestimate as far as 181 lynxes were hunted the same year and 40% catch rate is not realistic. At the same time regionally there is evidence of notable population decline (P.Männil pers. comm) that is also to some extent reflected in official census results (estimated 1300specimen in 1998 and 1000 specimen in 2000). The decline indicates, that hunting pressure in recent years (ca. 200 ind. annually) strongly exceeds sustainable quota (10-15%; Anon. 1996). Conclusively - it is probable that current population size of lynx in Estonia falls between 600-900 specimen.

Of the three large carnivore species, bear census is the most complicated, but both official census and hunting statistics reveal that about two thirds of the species is mainly distributed in the three north-eastern counties (Ida-Viru, Lääne-Viru and Jõgeva; Table 2). In neighbouring Järva and Tartu counties, another 16% of individuals can be found and the rest of Estonia holds merely one fifth of bear population. There is contradicting data on the present population size, monitoring results from 1997-1998 are 230-240 bears (Valdmann 2000b) while official census from the period 1997 – 2000 resulted in 600 specimen. The probable true population size is between these values and it can be estimated to be 300-500 individuals.

Table 2. Distribution of large carnivores in counties according to official census and hunting statistics. Three highest estimates for a cell are given in bold.

County	Official census 2000						Average annual kill 1998-1999			Hunted sp. / 1000 km^2 of forest		
	Wolf		Lynx		Bear							
	No	%	No	%	No	%	Wolf	Lynx	Bear	Wolf	Lynx	Bear
Harju	18	10	**112**	11	14	2	8	**30**	2.5	4.7	**17.5**	1.5
Hiiu	0	0	26	3	0	0	0	0.5	0	0.0	0.9	0.0
Ida-Viru	**19**	10	92	9	**160**	27	10.5	5.5	**6**	6.2	3.2	3.5
Järva	5	3	67	7	60	10	10	18	4.5	8.4	**15.1**	**3.8**
Jõgeva	**23**	12	**101**	10	**108**	18	**17**	11.5	**6.5**	**14.2**	9.6	**5.4**
Lääne	7	4	40	4	6	1	8	12	0	**8.8**	13.2	0.0
L-Viru	15	8	90	9	**114**	19	**13**	18	**9.5**	**8.9**	12.4	**6.5**
Pärnu	**26**	14	**114**	11	31	5	**13**	**30**	0.5	6.3	14.7	0.2
Põlva	6	3	24	2	24	4	5	5	1	5.3	5.3	1.1
Rapla	18	10	86	9	20	3	8	**24.5**	1.5	5.1	**15.5**	1.0
Saare	2	1	4	0	0	0	0.5	0	0	0.4	0.0	0.0
Tartu	14	7	49	5	35	6	3	10.5	1	2.7	9.4	0.9
Valga	10	5	86	9	11	2	6.5	11.5	0.5	6.4	11.2	0.5
Viljandi	16	9	67	7	11	2	2.5	8.5	1	1.5	5.2	0.6
Võru	9	5	39	4	5	1	3	13	0	2.8	12.0	0.0
Total	188	100	997	100	599	100	108	198.5	34.5			
Estimate	150		1000		600							

1.2. Biology

1.2.1. Wolf biology

Although the wolf inhabits a wide variety of habitats in the world, but in Estonia, specially in years of population depression, preference of natural landscapes bu wolves is clearly noticeable (Kaal 1983). While in general wolves avoid human settlements and big roads (Thurber et al. 1994, Mladenoff et al. 1995), with population increase habitats of lower quality are gradually taken into use (Mladenoff et al. 1999). Most of the wolf tracks have been observed in February in mixed forests that are probably also preferred habitat by wolf pray species and according to one hypothesis, wolf distribution is related to abundance of roe deer (Valdmann 2000b).

Wolf is social animal and a wolf-pack is led by so called alfa-couple. Singular wolves (who still can form temporary groups; Thurber & Peterson 1993) are mostly elderly specimen left out of the pack or migratory juveniles. Pack size depends on population density, hunting pressure and other factors. In Polaish protected population average pack size is 4-5 specimen and in Byelorussian hunted population the relevant value is 2.7 –3.2 (Okarma et al. 1998). In Estonia, in winter 1999 the wolf-pack average size was only 1.7 (1-11) specimen (Valdmann 2000b).

Home range of a pack varies widely depending on distribution and abundance of prey species (Anon 1996). In Europe wolf home range is from 80-240 km^2 in South and Central Europe to 415-500 km^{2}in northern Scandinavia (Okarma et al. 1998). In Estonia home range of wolves has not been determined but considering similar areas elsewhere, it is obviously at least 200-300 km^2. Territories of separate packs overlap very little (Okarma et al. 1998) and border conflicts often end with death of some individuals (Mech 1994). Aggression seems to decline with high abundance of food or related wolf-packs (Cook etal.1999).

Wolf is an opportunistic predator with wide spectre of pray . In Europe deer (*Cervus* spp.) is preferred to roe deer, elk and wild boar (Okarma 1995). Although, the dominant species in Estonia is roe deer both in summer and winter prey, preference of wild-boar by wolves is obvious while elks are avoided (Valdmann et al. 1998). This feature may be caused by prevalence of single specimen and pairs in Estonia as according to some data these prefer smaller prey items while packs take predominantly elks. (Kotchetkov 1988,Ref. Okarma 1995). In North America where elk is often the only prey species, they are also killed by single wolves (Thurber & Peterson 1993).

In Estonia, rutting season of wolves falls into February and cubs are born in May-June in dens dug or widened by the adults. Litter contains 1-10 cubs. Number of embryos from seven females analysed in Estonia in 1996 ranged from 3 to 7 with mean value of 4.7±0.47, respective mean value For Latvian lynx is 5 (Valdmann 2000b) and both these values concord with the general average (5-6). Natural mortality of cubs is as a rule high, e.g. in Bialowieza 50% during the first three months, totalling 65% during the first year of life with additional anthropogenic mortality (Jedrzejewska et al. 1996). In good food conditions mortality is reduced significantly (Fuller 1989). Yearly mortality of adult wolves has been estimated to be 23-45% by several studies (Ballard et al. 1997, Boyd & Pletcher 1999). Wolves become sexually mature in age of 2-3 years and their lifespan reaches 12-16 years (Anon. 1996).

1.2.2. Lynx biology

Distribution of lynx in Europe is primarily related to forests and roe deer distribution (Mitchell-Jones et al. 1999) In Estonia negative correlation between lynx distribution and proportion of open landscape is expressed by $y=e^{(0.11-0.025x)}$, where e is base of natural logarithm and x is proportion of open landscape in an area (Aunapuu 1994). Still, lynxes inhabit forests adjacent to cultural landscapes, probably due to abundant roe deer (Sunde et al. 2000). According to preliminary Estonian studies, carried out in February, most of lynx tracks have been observed in coniferous and mixed forests (Valdmann 2000b), several studies suggest that lynx prefers dense forests (Poole et al. 1996), e.g. in Latvia, forest stands with dense spruce undergrowth (Ozolins 2000). M.Aunapuu has detected a positive correlation between lynx population density and proportion of young mixed spruce forests.

Home range of lynx depends mainly on habitat quality, while as proposed by Schmidt et al. 1997, female distribution is determined by prey availability and male distribution by location of females. Male territories are larger than these of females, e.g. in Bialowieza (Poland) in winter 165 km^2 and in summer 143 km^2 while respective values for females are 94 km^2 and 55 km^2. Lifetime home range was estimated to be 248 km^2 for male and 133 km^2 for female lynxes (Schmidt et al. 1997). In Estonia, estimated winter home range of male lynx has preliminarily been estimated to be 100 km^2 (Valdmann 2000b). Adult home ranges can extensively overlap in case of different sexes while they do not overlap much for animals of the same sex (Breitenmoser et al. 1993, Poole 1995, Schmidt et al. 1997). Territories are maintained passively (Poole 1995).

Lynxes feed mostly on animals prayed by themselves. In Estonia as well as elsewhere in Palearctics roe deer is as a rule a preferred pray (followed in Estonia by hares and fox), in forest tundra raindeer and in Central Europe deer calves can be found in lynx prey (Okarma et al. 1997, Pedersen et al. 1999, Koppa 2000). Some specimen can specialise on killing domestic cats.

Rutting season of lynx falls into February – March. Litter consists of 1-4 cubs who are born in April – May in dens between tree roots, under fallen trees or just in dense forest. Early mortality in protected Bialowieza population is 48% and adult mortality of the same population 37% (Jedrzejewski et al. 1996). In Yukon population (Canada) where food basis is fluctuating, mortality ranges from 40 to 89% (Slough & Mowat 1996). Mortality depends on food basis. Lynxes become sexually mature in the end of the second year of life. North American lynx *L.canadensis* has lived up to 14 years of age (Chubbs & Phillips 1993).

1.2.3. Bear biology

Bear inhabits in our latitude most often large mixed spruce forests, less often coniferous forests adjacent to agricultural landscapes, peat bogs and thin pine forests (Pazetnov 1990). Intensity of logging is found to have negative effect (Pazetnov 1990) while logging should not influence the food basis significantly (Linnell et al. 2000a). Possibly the bears are rather sensitive to disturbance, as also shown by studies that are carried out in North America (Green et al. 1997, Mace et al. 1999).

Male bears are solitary for most of their lives, females stay alone or with their offspring. Individual home ranges vary geographically, but locally range depends mainly on sex – 700 –3000 km^2 for male and 200 –1000 km^2 for female bears (Anon 1996). Usually home ranges of different individuals overlap extensively.

Bear is an omnivore whose different populations consume meat (or fish) to different extents, whereas North American carnivorous bear populations are larger in size, have higher reproduction rate and population density (Hildebrand et al. 1999). Estonian bears are predominantly herbivorous (Kaal 1980) and probably consume game ungulate carcasses (In North America, 70% of game ungulates in bear diet are consumed carcasses, Mattson 1997), to less extent (mainly in spring) they kill elk calves and wild boar piglets. In summer, ants form an essential proportion of Eurasian bear diet.

Bears hibernate in winter and their body temperature fall 5-6 degrees, normally to 33 degrees. To achieve that they have to store sufficient fat reserves during the preceding season. “Winter lair” is often a simple bed in dense spruce forest or windfall, sometimes a true den. In Estonia bear winter hibernation lasts from mid-November to March-April (Aul et al. 1957).

Bears rut in mid-summer and cubs are born in mid-winter. The average litter size in recent years is estimated to be 1.6 – 1.7 cubs (Valdmann 2000b), earlier according to summer observations 2.0 cubs (Kaal 1980). Females breed over 2-3 years, for the first time in age of 5-8. Mortality in protected populations is relatively very low – cubs 13-16%, subadults 7-26% and adults 4-19% (Wielgus et al. 1994, Hovey & McLellan 1996, McLellan et al. 1999). Bears can live up to 30-40 years.

2. Ecological basis of control and protection

2.1. Maintenance of viable large carnivore populations.

2.1.1. Size of viable population

Every population can become extinct, but the probability of that event depends on several factors, including population size, growth rate and its variability (Belovsky 1987, Foley 1994). Extinction probability, acceptable for management purposes is an object of social agreement, but in general is should not exceed 5% during next 100 years. (Anon. 1996, Noss et al. 1996). Five percent risk level in system with three large carnivore species means, that probability of one of these species still to become extinct in given time interval is up to 13%

Role population size in extinction probability is strongly connected to genetic and demographic risks[2]. **Genetic risk** comes from loss of genetic diversity of the population gene pool through either genetig drift, when all alleles are not passed in the reproduction process or occasional loss of alleles in sudden drop of population size (genetic 'bottleneck'), or loss of individual viability of in-bred individuals. Relation of genetic risk to population size is expressed through effective population size (N_e), that reflects ideal population in genetic sense. For population management it is important that 1) As a rule N_e should always exceed 50 individuals and for long term effect of conservation population size should be in the range of 500 to 5000 individuals (Paetkau et al. 1998 a with further reference). The first number is based on frequecy of inbreeding ($F=½ N_e$), that should not exceed 2-3%. (Soulé, 1980); 2) In mammals, N_e is always several times lower than real population size (Korn 1994, Boman 1995).For brown bear the value is, based on genetic data 3,7 – 19% and according to demographic data 11%. It means that an isolated population of brown bear should yield 400-500 individuals to secure genetic diversity for short time, in evolutionary time scale (10^5-10^6 years), the population size should be not less than 4000 individuals. Also for lynx and wolf N_e does not exceed 20% of population size, so the population should hold at minimum 250 individuals for short time survival and, respectively, up to 2500 specimens for evolutionary effect [3].

In long term, N_e is equal to harmonic mean of the population sizes of the period, thus drops in population (e.g. as a result of unfavourable weather conditions, depression of prey populations or over-hunting) would reduce N_e disproportionally (Korn 1994). In naturally fluctuating population, mean population size securing avoidance of critical reductions, can be estimated. For example, geometric mean size of an "average" (with natural variation in size equal to 1.2 orders of magnitude in 50 years; Pimm & Redfearn1988) mammal population should be about 500 specimen to avoid reduction of population size to 100 individuals once in a century (Thomas 1990). It should be taken into account that the calculation does not consider effect of population control and is rather valid for planning the role of protected areas.

Demographic risk evolves from random dynamics of population age structure, reproduction rate and mortality. The smaller the population, the relatively stronger is the effect of every single deviation. For example, model based on wolf population at Isle Royal (USA) yielded a 30% survival probability for the population over next 100 years (Vucetich et al 1997).

2.1.2. Isolation and genetic changes in large carnivore populations

A population is considered to be genetically isolated, when less than one reproductive immigrant is added to the population per generation (Lande & Barrowclough 1987). In addition to islands, such large carnivore populations are found also on continent, while the genetic isolation of these populations is a result of human influence. Genetically isolated populations are prone to allele loss (specially rare alleles) and increase in homozygosity . Overview of changes in some isolated populations is given in Table 3.

Table 3. Changes of genetic diversity in wolf and bear populations, depending on population size and duration of the isolation. mtDNA – mitochondrial DNA, nDNA – nuclear DNA.

Species	Population	Pop.size	Duration (y)	Influence	Source [a]
Wolf	Scandinavia	< 25	15	Monomorfic mtDNA; reduced nDNA variability	1
	Italy	100–400	100–150	Monomorfic mtDNA, but normal variability of allozymes	2
	Isle Royal (USA)	2–50	50	13% heterozygosity reduction per generation and 80% per 50 years	3
Bear	Scandinavia	130–1000	?	mtDNA; normal nDNA diversity	4
	West-Carpathian Mts.	min 40	?	Normal nDNA diversity	5
	West -Europe	< 100	?	mtDNA with little variation	6
	Kodiak islands	2800	10000	nDNA heterozygosity very low (0.26)	7
	Yellowstone (USA)	250	100	nDNA heterozygosity reduced 15-20%	7
	Hokkaido	3000	10000	All 21 nDNA loci monomorfic	8

[a] sources: 1 – Ellegren et al. 1996; 2 – Randi 1993, Randi et al. 1993, Lorenzini & Fico 1995, Randi et al. 1995, 2000; 3 – Peterson et al. 1998; 4 – Taberlet et al. 1995, Waits et al. 2000; 5 – Hartl & Hell 1994; 6 – Randi 1993, Randi et al. 1994; 7 – Paetkau et al. 1998a; 8 – Tsuruga et al. 1996.

It is evident that long time isolation reduces genetic diversity even in bear populations 2800-3000 individuals strong, although the negative effect of these changes are unclear (Kodiak bears are also characterised by high reproduction rate and population density ; Paetkau et al 1988a). These populations have possibly eliminated negative recessive alleles, but at the same time response potential to new pathogens and environmental changes may be reduced. Small and shortly isolated bear populations are above all characterised by reduced mtDNA diversity, that can be caused by relatively sedentary females (mtDNA is passed along maternal line; Waits et al 2000). For Scandinavian population, temporary division to several small populations may have preserved the genetic diversity through reduced effect of the genetic drift (Waits et al 2000)

Reduced viability, caused by inbreeding has bee recorded both in captive wolves (expression of recessive alleles causing blindness; Laikre et al 1993)and bears (reduced litter size and expression of albinism, Laikre et al 1993, Laikre 1999). In natural conditions, lowered reproduction rate of Isle Royal wolves (Peterson et al. 1998) and Yellowstone bears (C.Serveheen, ref. Korn 1994) has been related to reduced genetic diversity. Survival probability of latter population is estimated to be 36% in the next 100 years and 0% in the next 200 tears (Shaffer & Samson 1985).

Interpopulational **migrations** intensity is dependant on distance and availability of migration routes. Both wolves and lynxes use "corridors" linking separate habitat patches (Heuer 1995, ref Beier & Noss 1998), mainly forests (Schmidt 1998). No differences in sedentary and diffusing specimen mortality has been detected (Poole 1997, Boyd & Pletscher 1999) while presence of good migration routes has compensated high mortality by immigration to many East European populations (Jedrzejewska et al 1996, Jedrzejewski et al1996, Cerveny et al 1996)

Dispersion range of wolves is in an average 78-113 km (Weaver et al 1996, Boyd & Pletscher 1999); of lynx, regardless of gender is 17-1100 km (Slough & Mowat 1996, Poole 1997) and of bear up to 90 km (Swenson et al 1998). Hence, considering also the difficulties to cross unfrozen water bodies, bear populations are the most vulnerable to become isolated. Although the bear is good swimmer, migration frequency is strongly reduced by water barriers 2-4 km wide and water bodies wider than 7 km stop all migration activities (Paetkau et al1998b). Eight male bears, studied in Norway at River Glomma (length 661, quantity of current 440 m^3/s) did not cross the river once (Webakken & Maartman 1994). In Sweden two bear populations are for long time separated along maternal line by only 134 km of land while these populations can be genetically linked by male migration (Taberlet et la1995, Waits 2000) because latter disperse more often, although not further than female bears (Swenson et al 1998, Kojola & Laitala 2000). In western Nort America, none of the 460 radio-tracked bears have moved from one sub-population to another while the distances between these populations range from 60 to 134 km (C.Servheen,ref. Weaver 1996). In Yellowstone, return rate of removed individuals is reduced from distances exceeding 75 kilometres (Blanchart & Knight 1995). Dispersion of bears is facilitated by old-stand, natural forests and areas with sparse road network (Boone & Hunter 1996), but bears seldom disperse from stable or falling populations (Kojola & Laitala 2000).

2.1.3. Demography and social structure of large carnivores.

For determination of population viability values of primary population parameters such as natality and mortality and their relation to population dynamics and human influence are very important. Empirical data indicates that potential population growth rate,including immigration, is up to 50% for wolf and not more than 0% for bear populations (Table 4.). For all species, population increase is density-dependantly regulated by food basis (e.g. Poole 1994, Slough & Mowat 1996, Okarma et al 1997, Badyayev 1998, Pease & Mattson 1999, Hayes & Harestad 2000, Kojola & Laitala 2000). There is no plain relation between population dynamics and official hunting pressure as in many cases the latter is substituted by illegal harassment (Table 5).

Hunting pressure on bear is undoubtedly strongest, influencing in addition to population size also age structure (by increasing adult mortality and reducing juvenile mortality). In North America, survival of adult males in protected and hunted populations is 0.81 and 0.70 respectively, while the relevant vales for adult females are 0.96 and 0.93, subadult males 0.78 and 0.89 and subadult females 0.78 and 0.89. Reduced proportion of adult males in the population brought about immigration of potentially cannibalistic subadult male bears. Reversely to relations with adult males, females avoided subadult males and their rich foraging areas that caused drop in reproduction rate (0.46 juv/ad*year) compared to protected population (0.74 juv/ad*year; Wielgus & Bunnell 1995, 2000). Illegal hunting can hamper increase of bear population (Wielgus et al. 1994), while replacement of adults by subadults can be caused even by substantial disturbance (Olson et al.1997).

There are different opinions about critical demographic mechanisms influencing wolf population viability. Some studies have found litter size and juvenile mortality to be significant factors (Vucetich et al. 1997) while other studies, in an opposite, show adult mortality to have critical influence (Fritts & carbyn 1995). Role of social structure appears in aspect that, as a rule, a wolf pod consists of a pair of adults and their offspring who are dependant on prey caught by adults (Schmidt & Mech 1997, Mech 1999), hence population increase is determined by number of reproducing pods rather than total number of individuals (Vucetich et al. 1997). When population numbers are low, even single wolves have reared their offspring successfully (Boyd & Jiminez 1994). Pod structure does not lead to inbreeding as far as wolves avoid close relatives (Smith et al. 1997).

Table 4. Selected data on growth rate of protected populations of large carnivores.

Species	Population	Growth rate (% year $^{-1}$)	Duration	Trend explanation	Migration effect	Source [a]
Hunt	Yukon (Canada)	45[b]	6	Control cancelled	Yes	1
	Montana	20	14	Reintroduction after extinction	?	2
Bear	Sweden	1,5	50	Weak hunting pressure (5,5±2,1% per year)	No	3
	Selkirk Ridge (USA/Canada)	ca 0	6	Illegal killing	?	4
	Flathead River (USA/Canada)	8,5±2,6	16	?	?	5
	Yellowstone	4,5		Population recovery	No	6

[a] allikad: 1 – Hayes & Harestad 2000; 2 – Pletcher et al. 1997; 3 – Swenson et al. 1994a; 4 – Wielgus et al. 1994; 5 – Hovey & McLellan 1996; 6 – Eberhardt et al. 1994

[b] after six years of increase, population size stabilised

2.1.4. Diseases and parasites of large carnivores

Several diseases and parasites are known from large carnivores, but as a rule they do not limit the population size. An exception seems to be wolf at Isle Royal (USA) where population suffered severely from introduced parvovirus (Peterson et al. 1998). It is worth of mentioning that population resistance capacity could have been reduced by loss of genetic diversity as described above. Elsewhere, lethal effect of parvovirus has been recorded only once (Mech et al. 1997), although probably its influence can be limiting in cases of epizootic (Mech & Goyal 1995) and thus it can be considerable risk factor for Ethiopian wolf (Daszak et al. 2000). Parvovirus has been in Europe recorded only in Italian wolf population (Martinello et al. 1997) while antibodies of the virus have been found In Horvatian bears (Madic et al. 1993).

The main natural reservoir of rabies is fox, who is responsibel for 61% of recorded cases in Europe(Nagy & Kerekes 1995), in Estonia 50-56% (Westerling 1991, Männiksoo 2001), while proportion of role of large carnivores in this relation is less than 1% (Westerling 1991, Nagy & Kerekes 1995). Rabies is very rare in most of the wolf populations, in Estonia it was detected last time 20 years ago (Kaal 1983); sometimes its outbreaks influence population size (Ballard & Krausmann 1997), sometimes not (Theberghe et al. 1994, Weiler et al. 1995). From all recorded rabies cases in Finland in period 1910-1959, only once a wolf was affected by the disease, during epidemic in 1988 no wolves were infected (out of 66 cases) while the species was considered responsible for distribution of the virus to Finland (Westerling 1991). In Estonia, rabies has been detected in lynx (chapter 3.9) who probably get infection from fox (Linnell et al. 1998, see also Stahl & Vandel 1999).

Table 5. Cause of death in large carnivore populations

Sp.	Population	Status	Trend	Division of causes (%)				Source [a]
				Anthropogenic causes			Natural or unknown cause	
				Legal hunting	Other killing	Traffic etc.		
Wolf	Bialowieza	Hunted	0..+[b]	78	20	1	1	1
	Bieszczady RP (Poland)	Hunted	0..+	86	5	0	9	2
	Montana (USA)	Partly protected	+	Altogether 80		0	20	3
	Northwest-Alaska	Hunted		69				4
Lynx	Bialowieza	Protected	ca 0		71			5
	France	Protected	0...+	0	19	54	17	6
	Norway	Hunted		100	0	0	0	7
	Canada	Partly protected	Fluc tuati ng	Altogether 35		0	65	8
Bear	Rocky Mts. (USA/Can.)	Partly protected		39-44	38-41	Altogether 15-23		9

[a] Sources: 1 –Jedrzejewska et al. 1996; 2 – Smietana & Wajda 1997; 3 – Boyd & Pletcher 1999; 4 – Ballard et al. 1997; 5 – Jedrzejewski et al. 1996; 6 – Stahl & Vandel 1999; 7 – Sunde et al. 1998; 8 – Poole 1994; 9 – McLellan et al. 1999

[b] trend probably maintained by immigration.

All large carnivores can host trichina (*Trichinella*). For lynx the recorded infestation rate is 21-40% (Zarnke et al. 1995, Oksanen et al. 1998), out of eight lynxes studied in Estonia, six were infested (Valdmann 2000a), and respective value for wolf is 36% (Zarnke et al. 1999). Theoretically, human infestation is possible by consumption of infested bear meat (see Kaal 1980).

2.1.5. Conclusions on viability of Estonian populations.

As presented in earlier chapters, loss of genetic diversity potentially severely affects large carnivore populations (Laikre et al. 1996, Paetkau et al. 1998a). Minimum population size should exceed 250-500 specimen in short time-scale and 2500-4000 specimen in long perspective. Based on isolation rate, Estonian large carnivores can be divided into two groups as follows:

1. Wolf and lynx populations are obviously related to large Russian and Latvian populations, although direct population increase through immigration is not supported by recent observations at national borders (Valdmann 2000b). Estonian populations of these species in complex with neighbouring Latvian populations can be considered viable in perspective of next 100 years. Wolf and lynx distribution and numbers in Estonia should be optimased according to:

- conservational striving to achieve maximum possible population size and meeting the principle of caution. The least, in this context, equals to minimum population size that with considerable probability is sufficient to temporarily guarantees survival of the species in Estonia only. Estimated size of such population is <u>at minimum 100-150 specimen</u>. This estimate is based on evidence, that large carnivore populations, in an average 100 strong, have survived in North American nature conservation areas for 75 years (Newmark 1986, ref. Soulé 1987); and on an estimation of a viable wolf population of 100-150 specimen, inhabiting a compact range with area of up to 20000 km^2 (Hummel 1990, ref. Anon 1996; Fritts & Carbyn 1995);
- possibilities to reduce (primarily) attacks on domestic animals and (in less extent) influence on ungulate populations (see chapter 2.2.)
- responsibilty in European Union scale (lynx approximately 20%, wolf 3-5% of expected EU populations) In a case where all other circumstances are equal, this means that lynx would deserve higher conservation attention than wolf.

2. Estonian brown bear population is relatively isolated, specially considering possible fencing of the border between Estonia and Russia. Narva river is in flow quantity comparable to River Glomma in Norway, that was not crossed by bears (Wabakken & Maartmann 1994). Status of small Latvian population is probably dependant on Estonian bears. The brown bear is considered to be one of the least tolerate species of large carnivores, regarding anthropogenic influence, in northern temperate zone (Weaver et al. 1996). Hence our 300-500 strong population is undoubtedly endangered and further drop in numbers must be avoided. This means mainly revision of hunting effect . Modelling (Appendix I) indicated, that without hunting mortality probability of extinction in next 200 years is less than 5%, while taking of 20 bears per year would rise the probability to 22-40%. In perspective of next ten years, hunting does not affect bear population, but in longer time scale flexible quotas should consider the real population size and dynamics.

2.2. Relation of large carnivores to other mammal species

2.2.1. Influence on ungulate game species

Ungulates (in Estonia elk, roe deer, wild boar and red deer) are the main food source for large carnivores in landscapes with little or moderate human influence (Jedrzejevski et al. 1993, Okarma 1995). Studies of large carnivore – ungulate interactions have contradicting conclusions, but main findings are following:

1. All large carnivores have prey preference (chapter 1.2) that is reflected in the strength of influence. Considering these preferences, and predominantly herbal diet of Estonian bears, wolf and lynx are of interest in this relation. Studies, carried out in Palearctics (Table 6) show that the most conflictory species in game management context is wolf, regarding roe deer, also lynx.

2. Predation pressure is mostly focused on youngest and, to less extent, oldest age classes of large species of pray (elk, red deer and wild boar), differing thus notably from the age structure of hunted animals (Boyd et al. 1994, Mattioli et al. 1995, Okarma 1995, Maccracken et al. 1997, Olsson et al. 1997, Solberg et al. 2000). In the case of roe deer as prey, there can be no age preference by predator (e.g. lynx, Okarma et al. 1997). As a whole, predation is responsible for in an average 67% of the first year natural mortality of game ungulates, while nature mortality is twice as high as in predator-free areas (Linnell et al. 1995).As in European part of the former Soviet Union predation effect on game ungulates varied 5-25 times (Filonov 1980, 1983) while natural mortality of these species varied only 1.5 – 2 times, predation has partly compensatory effect in natural mortality (Skogland 1991).

3. Many predator species are able to limit prey population size, but it remains unclear whether they can suppress it to stable low level (Skogland 1991). Although it is believed that predation impact on game ungulates is dependant on number of alternative prey species and presence of several predator species (Anon. 1996) there is not enough convincing evidence to support these views (Skogland 1991). Rather is

seems that landscape diversity offering refuge to pray species eases the limiting influence of predators on prey populations.

During preparation of this plan, a multiple factor regression models, takong into account also hunting pressure, were used to study relations between population dynamics of predators and prey species (Appendix II). Interpretation of such models presumes good knowledge of the studied system as concordance of population dynamics does not enable to detect strict difference between correlative and causal relations. For example, population maximums of wolf are in Estonia (Valdmann 2000a) and elsewhere (Okarma 1995) fallen into socially complicated periods with increased poaching and neglected game management. The only finding of the tests was limiting influence of wolf to <u>wild boar</u> population dynamics. This finding supports the detected prey preference by Estonian wolves regarding this species and enables to estimate wolf population size (200 –500 specimen) exceeding of which presumably causes reduction in wild boar population. Regardless of whether the relation is causal (what is considered rather probable by composer, the wolf influence on wild boar population can be complexly related to snow conditions etc.) or merely correlative, it appears that **it is possible to maintain a viable,100 – 200 strong wolf population in Estonia without putting wild boar or other ungulate population at risk**.

According to the modelling, main determining factor for elk population dynamics has been hunting. The often presumed influence of wolves was not detected, what is also supported by analysis of data published elsewhere (Table 7.) Pray preference of Estonian wolves (see above) allow to be of the opinion, that In Estonia, wolf influence on moose population is slightly smaller than considered usual Elsewhere in Europe. Respectively the current population density (100-200 specimen = less than 0.5 specimen/ 100 km^2) of wolves should not influence elk population more than 5% of its size. Estimate for Scandinavia has shown, that to compensate 5% "wolf tax" in a moose population, managed to the extent of natural population increase, a 10-20% hunting reduction should be implemented to maintain elk population level (Olsson et al. 1997). Hunting has also a considerable role in <u>roe deer</u> population dynamics (Appendix II), although in Estonia the population dynamics is predominantly dictated by winter conditions, morbidity etc. Althoug it has been estimated that a lynx takes annually in an average 50 roe deers (Koppa 2001), the **used model did not reveal influence of lynx abundance on roe deer population.** At the same time, increase of lynx population was dependant on roe deer abundance (See chapter 3.4.)

2.2.2. Large carnivores as keystone species

Influence of animals to economically managed systems is traditionally measured through costs, i.e. negative effect without discussing the positive aspects (Reimoser et al. 1999). This is also valid in the case of large carnivores, whose range of influence is nor restricted only to game ungulates. Obviously, in some cases large carnivores act as keystone species (with a significant effect on community structure even when numbers are low; Noss et al. 1996). In Estonia, et least four interactions deserve attention (presented below in order of probability).

<u>1. Population control of small predators</u>. Predation on other carnivores is common in nature and for some species can contribute as much as 68% to causes of mortality (Palomares & Caro 1999). If large carnivores can restrict population size of smaller predator species, (local) extinction of first would cause increase in the latter populations with respective strengthening of impact on their prey species (typically birds and small mammals; Crooks & Soulé 1999). The relation is so far poorly studied, but it has been proven in coyotes (Crooks & Soulé 1999) and lynx (sub)species *Lynx l. pardinus* (Palomares et al. 1995,1996). Extinction of wolf in eastern parts of North America was followed by strong increase of coyote population in these areas (Ballard et al. 1999, Vila et al. 1999). In Estonia, big changes in large carnivore populations would possibly have effect in one hand on fox, racoon dog and mink, probably also pine marten and maybe stray domestic cats, in other hand it would influence grouse, waterfowl and other bird species nesting on ground and bushes. Existence of this effect in Estonia is supported by findings on importance of fox in the diet of lynx (Koppa 2000, see also Linnell et al. 1998), decrease in population size and reproduction rate of North European grouse population, caused by mesopredators (Kurki et al.1997), and population dynamics of mink. It is worth mentioning that smaller carnivores, potentially

limited by large carnivores are main vectors of rabies in Estonia (see above). Viable wolf population would presumably restrict existence of stray wild dogs.

2. Influence in ungulate "damage" to forest. In conditions where large carnivores restrict ungulate populations , influence of latter to plant communities and structure of tree stands, is also decreased (Thompson & Angelstam1999). Empirical evidence, supporting this statement can be found in the first place from studies of North American elk (McLaren & Peterson 1994) as well as red deer. For example, formation of diverse aspen woods was facilitated by control of deer populations by large carnivores (Romme et al. 1995, White et al. 1998, Ripple & Larsen 2000). In Estonia the inter-specific economic aspect is rather theoretic because of weak or absent control of ungulate populations by predators. In principle, elk "damage" to forest, forming over half of the area of damaged stands in Estonia (Pilt & Õunap 1999), could be influenced by given interspecific relations. At the same time, Estonian elk population is already in the limits, desirable for forestry and environmental carrying capacity (i.e. 6000 – 10 000 specimen; Tõnisson 1999).

Table 6. Influence of predation to natural mortality of Estonian game ungulates (Palaearctic Lynx data from Jedrzejewski et al. 1993 and European wolf data from Okarma 1995). Differences in samples is explained by discrepancy in praying proportions of roe deer.

Prey species	Proportion of predation in natural mortality %	Proportion of predation (%)	
		Wolf	Lynx
Elk	59	75	~ 0
Roe deer	85	61	46
Red deer	80	71	14
Wild boar	25	51	~ 0

Table 7. Influence of wolf and lynx to populations of game ungulates

Predator	Region	Predator abundance (ind/100 km²)	Prey species	Proportion in diet (% biomass)	Impact on prey species population[a]	Source[b]
Hunt	Scandinavia	low	Elk	55	5	1
	Bialowieza	2,3	Elk	<1	0–29[cd]	2
	Alaska	0,2–0,4	Elk	predominant	6–7	3
	Bialowieza	2,3	Red deer	32–38	9–13[c]	2
	Bialowieza	2,3	Wild boar	3	3–4[c]	2
	Bialowieza	2,3	Wild boar	8–21	4–8[c]	2
	East -Poland	0,6–0,7	All game ungulates		6–9[e]	4
Ilves	Bialowieza	2,4–3,2	Red deer	}90	6–13[c]	5
	Bialowieza	2,4–3,2	Roe deer		21–36[c]	5

[a] Proportion of taken individuals (%) from local population size of prey species
[b] Source : 1 – Olsson et al. 1997, 2 – Jedrzejewski et al. 2000, 3 – Ballard et al. 1997, 4 – Glowacinski & Profus 1997, 5 – Okarma et al. 1997
[c] relative to spring-early summer abundance.
[d] Abundance of elk is very low in Bialowieza. This explains relatively high maximum values – 29% is formed by praying of two elks!
[e] total biomass of game ungulates

3. Limiting of beaver population. Occasionally beaver is preyed by majority of large and medium predators. Only wolf is known to feed on beavers regularly (Rosell et al. 1996), while beaver can be important alternative source of food in lack of main prey species (Forbes & Theberge 1996). In one case, limiting influence of American black bear (*Ursus americanus*) to Canadian beaver (*Castor canadensis*) population in North America (Smith et al. 1994). Feeding activity of beavers is reduced already by smell of predators (particularly otter) and these scents are recommended to be used to repel beavers (Engelhart & Mueller-Schwarze 1995, Rosell & Czech 2000). Also in Estonia, large carnivores and otter can influence the beaver abundance (N.Laanetu, pers. comm.).

4. Increasing food basis for scavengers . Depression of scandianvian wolverine (*Gulo gulo)* populations are partly blamed on disapperarance of wolf (Landa & Skogland 1995). In Estonia, carcass abundance in winted can influence e.g. population status of Golden eagle (*Aquila crysaetos*) as shown by studies elsewhere (Watson 1997), although at the same time offer additonal food to wild boar and other predators (e.g. Jedrzejewski et al. 1993) and thus being complexly related to small predator population limitation.

2.2.3. Feeding on domestic animals

All large carnivores can prey on domestic animals and this evidence is considered to be the main cost of large carnivore protection (Boman 1995). The problem is severest in areas that are densely inhabitated and where landscape difersity has been strongly reduced as e.g. Mediterranes countries, India, etc (Cozza et al. 1996, Meriggi & Lovari 1996, Mishra 1997). For management purposes, it is vital to know 1) factors determining livestock killing frequency; 2) distribution of damages individually and areally; 3) which possibilities livestock keepers have to avoid these damages.

Although killing of domestic animals is probabaly an aquirable activity in large carnivore populations, it is not know whether the domestic animals are preferred to wild species. Vice versa, for example in Slovakia roe deer is preferred to sheep by lynx and impact on least is rather weak in modern times (Hell & Slamecka 1996), wolves feed on domestic animals in significant rate only in areas, where game ungulates are rare (Okarma 1995, Meriggi et al. 1996, Meriggi & Lovari 1996). In Sweden it is believed, that decrease in taking of semi-domesticated reindeer by wolf is related to switcing of latter to wild game ungulates (Boman 1995). Conclusively, in areas with similar conditions, impact rate is dependant on predator abundance rather than amount of livestock (for bear: Wabakken & Maartmann 1994, Sagør et al. 1997) and without taking measures to prevent damage, concurrent rehabilitation of predator populations and reduction of livestock kill is rendered impossible.

From predator damages, compensated by state in Finland in 1995 (totaling FIM 326 999) 52% of the cases were formed by wolf (74% to sheep-breeding), 38 by bear (64% to bee-keeping, 18% to cattle) and 10% by lynx (87% sheep-breeding) (Anon. 1996).Compared to minimal abundance estimates (140, >700 and >750 specimen respectively), “wolf-keeping” is relatively the most expensive (FIM 1215/specimen), followed by bear (FIM 178) and lynx (FIM 44). In Sweden the main damage is considered to be caused to semi-domesticated raindeer, where wolverine is responsible for 95% of the cases (Boman 1995, Mysterud et al. 1996).

Although in general, killing of domestic animals by large carnivores is unevenly distributed (Anon. 1996, Sagør et al. 1997) and e.g. in Italy 4.1% of the applicants submitted one third of all claims (Cozza et al. 1996), specialised menacers are, as a rule, not known from large carnivore populations (Linnell et al. 1999). Both wolves and bears are attacking more frequently unattended livestock in woods or other sheltered areas, wolves do it predominantly at night (Sagør et al. 1997, Ciucci & Boitani 1998). In Italy three sheep were taken in an average during one wolf raid, but 2.3% of attacks ended with killing numerous (21-113) specimen (yielding 19% of killed sheep; Ciucci & Boitani 1998). Most of wolf and bear attacks take place in late summer or autumn (Kaal 1983, Wabakken & Maartmann 1994, Ciucci & Boitani 1998, Valdmann 2000b).

2.2.4. Relation of large carnivores to other species – applied conclusions

Presence or absence of large carnivores can influence natural systems in number of ways. Together with economic losses (taking of game ungulates), positive relations are found. There is evidence on wild boar population control by wolves, but it is not detectable with current and recommended viable population size (100-200 ind.). The population of the most important game ungulate – elk – is not influenced by large carnivores, and the population is now optimal regarding environmental carrying capacity. Depression of roe deer population is caused probably by other factors rather than large carnivore impact.

Thus, the main cost of large carnivore population maintenance is loss of domestic animals. It is necessary to gain an overview of total damage, prognose latter in different population levels of predators and avoid damage by improving practice of livestock keeping. One of the main risk factors (keeping unattended livestock, specially at night, in well-sheltered landscape) should not be very common in Estonian livestock keeping practice.

3. RISK FACTORS

Impact of the risk factors is estimated according to scale, applied to bird populations in following order:1) *of critical importance* – can bring a species to extinction in next 20 years; 2) *of great importance* – can reduce poualtion more than 20% in next 20 years; 3) *of minor importance* – can reduce population less than 20%in next 20 years (Heredia et al. 1996). Due to small area of Estonia, the category *medium importance* (i.e. reducing population less than 20% in notable part of distribution area in next 20 years). As far as status of large carnivores depends on several variable factors such (over-hunting, poaching, role of public opinion), the potential role of risk factor (in close future) is presented in case it differs from present effect.

The analyse is summarized in table 8. Major hazards to Estonian large carnivores is over-hunting and (potentially) unfavourable public opinion, in case of bear, also disturbance. Additionally, certain habitat quality factors such as decrease in abundance of prey species (roe-deer) for lynx and creation of distribution barriers for bears deserve more attention. These barriers increase danger of isolation while consequent risk factors, affecting isolated populations(chapter 2.1.) are not directly evaluated. Undoubtedly isolation would have negative effect, but effects and speed of the process can merely be speculated before the isolation occurs. Application of management measures should also be targeted to avoiding the isolation rather than dealing with the consequences of such condition.

Table 8. Importance of risk factors to Estonian large carnivores. “-“ not significant as a risk factor, “+” potentially with strongly increasing importance, “?” background data very insufficient.

Risk factor	Imortance to large carnivores		
	Wolf	Bear	Lynx
Over- hunting	big	big	big?
Illegal hunting	–	small?	small
Habitat destruction	small	small+	small
Decrease of prey abyndance	+	–	small+
Disturbance	small	big	small
Roadkill, artificial distribution barriers	small	small+	small
Negative public opinion	big+	small+	small+
Hybridization	–?	–	–
Epizootics	–?	–	–?

3.1. Over –hunting

Historically, hunting has been the main risk factor to large carnivores, pushing these species to extinction in many countries (e.g. Breitenmoser 1998). Potentially, over-hunting will remain a risk factor of critical or great importance, although real risk should be evaluated according to recent practice and current game management. Among other things risks of overhunting depent on methods of population estimate. The current hunting rate is based on an aim of Estonian Environment Strategy (Anon 1997) to etablish wolf population of 30-40 and lynx poulation of approximately 500 specimen strong, with a motivation to reduce influence on game ungulate populations, avoid direct danger to man and (in case of wolf) reduce taking of domestic animals (Valdmann 2000b). These aims and motivations are not sufficiently relevant to real sitation (Ch. 2 and Appendix II) and thus need ammendments. To some extent is this valid also in case of the bear, who is a subejct to sports hunting in Estonia without any linking it to economical damage. Analysis of recent history (Appendix II) shows the important role of hunting in population dynamics of wolf, although theoretically (cosidering population growth potential) is wolf the least and bear the most vulnerable species of large carnivores (Weaver et al. 1996). Cosidering the improvement of wolf status by means proposed in current manangement plan, risk of overhunting the species should become less severe, but because of unpredictable outcome it still classifies as factor of great risk.

Theoretically, over – hunting risk lies in the probability to exceed population growth potential by hunting. It is specifically valid for bear, who has been hunted in Estonia for so short time (since 1980ies) there is not enough observations avaialble to detect overhunting. In this work, pouplation growh rate estimate is based on official census- and hunting data that presumably reflect at least relative changes in population size (Table 9). Considering the official census to yield an overestimate (Valdmann 2000b) while the hunting statistics is quite reliable, the resulting conservative estimate (if the true population size is smaller, effect of hunting pressure is respectively higher) should be sufficient for the aims of population management. Seemingly low population growth potential in times of hunting ban[4] serves as an evidence of biased official population estimates.

Table 9. Population growt rate of large carnivores in Estonian according to census data and hunting statistics. Bear from 1950-1953 from Kaal 1980.

Species	Years	Pop.size[a]		Pop. increase[b] (% year^{-1})	Average hunting pressure (% year-1)	Growth potential[c]
		Beginning	End			
Wolf	1966–1977	8	186	33,1	0	33,1
	1954–1998	753	158	–3,5	46,3%	42,8
Lynx	1954–1997	241	1167	3,7	13,1	16,8
Bear	1950–1972	90	188	3,3	0	3,3
	1974–1992	230	820	7,3	4,0	11,3
	1990–1999	820	600	-3,1	5,5	2,4
	1950–1999	90	600	3,9	2,3	6,2

[a] population estimats for first and last three years have been averaged to reduce random counting error.
[b] calculatd from $N_2=N_1*(1+k/100)^t$, where k is population increase, N_1 and N_2 initial and final population sizes, respectively, and t duration of period in years
[c] growth potential was resulted by additive calculated (population increase + hunting pressure). Actually, influence can be partly compensatory.

In these times, population numbers were low and compensatory effect should not be considered. Furthermore, bear population growth potential is particularily high during the hunting period (compare periods 1954-72 and 1974-1992; Table 9) that is not obviously realistic. Hence, the population increase has been possibly overestimated during hunting periods and respectively, underestimated during hunting ban periods. As far as these trends can be partly compensatory over long periods of time, aquired values –

[4] negative trend of lynx population in 1954-1962 can be true, as some sources (Aul et al. 1957) show that 30-40 lynxes were hunted in these years while lynx was also severely endangered by poison baits used for wolf control.

33% for wolf, 17% for lynx and 6% for bear are further referred to as orders of magnitude. These estimates agree with data published elsewhere (see also Table 3). Accordingly, maximum sustainable hunting pressure of bears is estimated to be 5-8% (McCullough 1981 and ref), including 7.0 – 7.5% for Swedish bears (Swenson et al. 1994a, b). In 1990ies bears have been hunted in Estonia according to fixed proportinal quota – 4.4- 6.7% of officially counted population size. As far as it in general stays below natural population growt rate, the method can be considered acceptable and relatively safe for the population. There are still two sources of risk for bears: 1) unknown (and presumably big)error of official census that does not allow to establish flexible proportional quota; 2) effect of other negative factors that also would presume reduction of quota. Seemingly low population growth potential in 1990ies desrves special attention. If these data are reliable it means 4% drop in natural population growth that may be caused by either poaching or reduced reproduction rate due to disturbance. Considering both actual decrease in population and isolation risk, the hunting quota for bears should be significantly reduced in coming years

Lynx hunt has formed 12-17% of the official population estimate in years 1996-1999. This proportion is close to calculatedapproximal natural growth potential of Estonian lynx population (ca. 17%). Also in North America, 10-12% hunting pressure to lynx population is considered relatively moderate (Poole 1994), while in Finland, 8% of hunting pressure seems to maintain or in someplaces, even decrease population size (Anon. 1996). At the same time, lynx population has decreased locally decreased in Estonia in recent years (P.Männil, pers.comm.) and there is no ojective basis for population control in narrow size range. Based on presented evidence, it is recommended to reduce hunting in coming years to magnitude of 10% from officialpopulation estimate. The quota can be adjusted to measurable population increase in later years. (Over) hunting is also main risk factor to Lavian lynx (Ozolinš 2000).

- Overhunting is a major risk factor for all Estonian large carnivores, specially considering unfavourable attitude of currently valid Estonian Environmental Strategy.

3.2. Illegal hunting

Data on Illegal hunting is very sparce everywhere, including Estonia. Radio-tracking has shown , that in North America information about only a half of killed bears reach officials (McLellan et al. 1999). Possible reasons for illegal killing of large predators are specifically different. Wolf is hunted when consrevation regulations takes force, but local inhabitants proceed killing wolves in fear of wolf attacks on game or domestic animals (e.g. Forbes & Theberghe 1996). Considerable violation of restrictions set with this plan (game status, hunting season, penalty for illegal kill) is not likely in Estonia during next few years . Unauthorised taking of lynx in the course of other (specially wolf) hunting is known, but it is not very extensive. Bears are shot both intentionally and also erroneously due to wrong determination of species in wild boar hunt. Regarding extention of deliberate poaching expert have adverse opinions, but in worst case killing bears for trphy and meat trade is relatively frequent in Estonia.

- Illegal hunting has weak impact on lynx population, probably weak impact on bear population and is unimportant for wolf population.

3.3. Habitat destruction

Habitat destruction is gradual process that influences habitat characteristic in several ways. Two aspects of habitat quality – availability of pray and persistent sources of disturbance are treated for clarity in separate chapters, followed by discussion of location of habitat in landscape and loss of habitat quality through change in structure of plant cover.

Distribution and location of forested landscape is important in the habitat context. In the secomd half of XX century, forested areas have been expanding in Estonia (and will expand on account of fallows) and majority of forests are linked to each other. Because of this development, reduction and fragmentation of landscape is not a considerable risk factor to Estonian large carnivores.

Structural changes of wood stands with foreseen further developments in that direction are certainly more problematic. Disappearance of old stands of coniferous forests have negative influence on bear habitat and thinning of forests affect habitats of lynx. In some areas of the world, logging is considered to be a significant risk factor to wolves (Person et al. 1996), but relevant data is not available. from Estonia. At the same time, forest management is believed to favour prey species of large carnivores (Linnell et al. 2000b) while disturbance has more significant source of risk (chapter 3.5). Demolishment of traditional wintering forests to certain extent can be unfavourable to bears (see also Linnell et al. 2000a).

- Habitat destruction does not affect Estonian large carnivores significantly, but for bear this risk factor has potentially strong influence.

3.4. Decrease in abundance of prey species.

The most significant part in diet of Estonian wolves, lynxes and also bears is formed by game ungulates while the role of livestock, differently from cultivated and densely inhabited countries (e.g. South-Europe) in formation of habitat quality of large carnivores is almost non-existing. Status of main pray ungulates - elk (2000 specimen according to official census in 2000) and wild boar (11000 specimen) , together with the main alternative pray species – beaver- can be considered to be good in Estonia.

Also modelling has shown, that pray (roe deer) abundance has influenced only lynx population status during two last decades in Estonia (Appendix). Although roe deer population size today (30 000; official census 2000) exceeds slightly 27000 individuals - the amount estimated to be necessary for a stable lynx population (Appendix), and was last time below given size in 1960ies, certain risk persists. This risk is amplified by population depression of alternative pray species – mountain hare and grouse (least is related to intensive forestry in Linnell et al. 2000b).

- Decrease in prey abundance is a low (potentially increasing) risk factor for lynx . potential risk factor for wolf in coming years and does not obviously affect bear at all.

3.5. Disturbance

Main sources of disturbance to large carnivores are populated areas, transport and forest management (logging), potentially also hunting on other game species and nature tourism. Effect of disturbance depends on its strength and duration - populatied areas and roads are permanent while logging and hunting are a source of temporary disturbance. It is also reflected by preference of roadless areas and choise of breeding or resting areas by large carnivores (Clevenger et al. 1997, Mace et al. 1999, Mladenoff et al. 1999). In Estonia special studies have not been conducted, but from research elsewhere has shown that lynx avoid resting closer than 200 metres (Sunde et al. 1998) from a road and bears are wintering at least 1-2kilometrs from source of constant disturbance (Linnell et al. 2000a). Development of road network hence lowers large carnivore habitat quality. Processes, related to application of Scandinavian forestry system deserve further attention, as e.g. in Sweden forest road network is built so that wood stands are not farther than 500 metres from closest road (Esseen et al. 1997). At the same time intensifying of traffic on existing roads does not necessarily change behaviour of large carnivores (Burson et al. 2000) and in exceptional cases breeding sites can be rather close to source of disturbance (Kaal, 1980, Thiel et al. 1998).

Temporary disturbance may have influence mainly in breeding and in (bear) wintering sites. In Scandinavia, 9% of bears abandon their wintering site, mainly due to disturbance. In addition to abandoned offspring, litter of carrying females is lost relatively more often, compared to undisturbed females, if wintering lair has to be changed (Swenson et al. 1997). Bears react to disturbance sources form distances below 1 km, specially to sources closer than 200 metres – in our case logging or noisy (wildboar hunt with dogs) in winter. There is no record of lairs abandoned with cubs, but an estimate is 5-10 cases every winter (T.Randla, pers. comm). Although the roads and camping sites are as a rule avoided by large carnivores (e.g. Mace & Waller 1996, Green et al. 1997), influence of nature tourism of them in Estonia is not significant.

- Conclusively, increase in constant disturbance sources in Estonia can be considered to be not significant , but still deserving attention, while temporary disturbance is a risk factor of great importance for bears and of little importance for wolf and lynx.

3.6. Roadkill and artificial distribution barriers.

Death of large carnivores on roads and artificial distribution barriers (highways, defence constructions etc.) are above all a problem of advanced industrial countries (Fritts & Carbyn 1995), forming a majority (50%) of death causes of introduced lynxes in France (Stahl & Vandel 1999). In Estonia, roadkill of large carnivores is notably less frequent. Road Department holds no records of accidents with large carnivores involving human injury from past five years (H. Lõhmus, pers. comm), but absence of such cases can be fictitious because these collisions (particularly with lynx or wolf) do not necessarily bring along big damage. For example, on Tallinn- Tartu road in Alam Pedja area, two wolves and a young bear have been run over by car whereas insecure behaviour of larce carnivores on roads refers to high accident probability (E.Tammur, pers. comm). In addition two cases are known from bear kills on railroads. Obviusly such accidents happen annually whereas risk is still rather low for all species (but increasing with growth in car population and improvement of roads).

Role of distribution barriers is long-lasting compared to traffic because the isolations consequences develop slowly. There is no such barriers in Estonia today, but two aspects deserve attention in close perspective: 1) appearance of fenced road strips, mainly on Tallinn –Tartu road. Animals are already unsuccessfully trying to cross a fenced part of the road near Kärevere bridge. Obviously a more reasonable solution would have been open road with sufficient speed limit (E.Tammur, pers. com); 2) Potential fencing of national border between Estonia and Russia that would bring about an effective isolation of at least Estonian bear.

- Traffic and distribution barriers are of minor risk to Estonian large carnivores, while for bear, rolle of these factors are potentially increasing

3.7. Negative public opinion

Of all Estonian wild species, survival of large carnivores is directly related to prevalent social values and attitudes. Centuries ago, annihilation of large carnivores was a categorical striving of all European rural communities (Breitenmoser 1998), in many places it was caaried out successfully. Wolf was feared and hated the most (Breitenmoser 1998); compared to other species, human attitude to this species has always been pronounced (Kellert et al. 1996). Subsequently it has become obvious that a substantial part of wolf "crimes" have been exagerated, fabricated or related to misidentification of species (Gipson & Ballard 1998, Gipson et al. 1998). Compared to wolf, attitudes regarding bear have been more contradictory and lynx is known and feared less (vähem (Kellert et al. 1996, Breitenmoser 1998). Considering thess evidence, main effort in moulding public opinion should be put on wolf.

Inquiries carried out in Estonia (T.Randveer unpubl.), Finland (Lumiaro 1998) and North America (Lohr et al. 1996, Pate et al. 1996) show following. Approximately one third of Estonian and Finnish adult population, predominantly women, are afraid of meeting a wolf. Typically the fear is related to hostility, whereas in addition to personal security, people are worried about damaged caused to game ungulates and domestic animals. The most positive attitude was among educated young urban people. At the same time, hunters and naturalists' knowledge about wolf can be poor, e.g. in Canada where special educational programs are found to be necessary before facilitation of wolf reintroduction. Both in Finland and Estonia, two thirds of inquired people think that there should be (Finland: at least) as many wolves as now, and number of wolves proposed by Estonian Environmental Strategy (30-50) is considered to be too low by 71% of the Estonian participants. Unexpectedly, 75 of Estonians responded that wolves should be able to choose freely the ranges, while only 23% of Finns represented this view. Although people who have suffered from wolves, often also hunters have more negative attitude, it is not reflected in their opinion about optimal wolf population size.

Conclusively , attitude of Estonian habitants can be considered rather positive, perhaps due to increasing urbanisation, relatively high level of education and undeveloped ownership relations in rural areas. Current trends in least two aspects refer to a possibility of negative shift in these issues. Misinterpretation of damage caused by large carnivores is also dangerous, but it can be avoided by systematic registration and control of the damage.

- Current public opinion can be considered as a risk factor of great importance (potentially critical) to wolf and of minor importance (potentially great) to lynx and bear.

3.8. Cross – breeding

From Estonian large carnivores only wolf cross-breeds with close species, in our case with domestic dog. Although in wolf populations can be found in Eastern Europe where genetic influence of domestic dog is detectable (Randi et al. 2000), it is not considered hazardous to their viability as far as cross-breeding is rare reproduction possibilities of cross-breeds are very limited (Vila & Wayne 2000). Different matter is whether these hybrides can be dangerous to humans (e.g. Rajpurohit 1999). In north America, period were detected when higher frequency of cross–breeding influenced wolf morphometrics, but these changes are reversible after the end of cross-reeding period (Clutton-Brock et al. 1994). A proven case of dog-wolf hybride is known from North Latvia in 1999 (Valdmann 2000b).

- Despite of several doubts, there is no verified evidence of wild cross – breeds of wolf and dog from Estonia in past 20 years, thus the hybridisation risk does proably not exist. Still action plan is necessary for the case of appearance of cross – breeds.

3.9. Spread of diseases in population.

Limiting effect of disease and parasites is rare for large carnivore populations (Chapter 2.1.4.) and, in current situation where abundance of all three species is lower than in mid-1990ies, rather improbable. For example, out of 129 rabies cases registered in 1999, only one case was registered for large carnivores (lynx; Männiksoo 2001). Lynx has been found to be infected most frequently – four cases in past three years (1998 – 2; 1999 – 1; 2000 – 1). Last rabic wolf was recorded in Estonia 20 years ago. Continuos record of rabies cases enables immediate reaction to disease outbreaks and avoid risks to large carnivore as well as human population.

- Despite of few cases of infection, outbreak of epizootic is unlikely in populations with present density.

4. Population control and management

4.1. Aims

The main objective is preservation of wolf, lynx and bear as free –ranging species in natural habitat.

Aims in Estonia. Long term objective of the control and management plan of large carnivores in Estonia is maintenance of favourable state of wolf, lynx and bear populations. To achieve that, following goals are set by the plan for years 2002 – 2011:

- Number and natural functions (pray, habitat, behaviour) of Estonia Large carnivore populations are preserved as much as possible to maintain viability and evolutionary potential of these populations;

- Damages caused by large carnivores to agriculture are kept in lowest possible level, considering the population viability;

- Possibility to hunt large carnivores is preserved.

To achieve these goals, in years 2002 –2001 following steps are to be taken in Estonia:

1) maintenance of 100-200 strong wolf population. In this range of abundance the wolf is feeding mainly on wild animals and inhabits natural habitats without endangering wild boar or other game ungulates. Presumed damage to livestock is close to recent experience, that has not caused negative public opinion. The abundance range can be achieved by regulated hunting.

2) Maintenance of lynx and bear[5] populations at least 500 strong. As far as determined peak values of these populations (1300 and 800, official census) have not caused significant agricultural damages, lower population levels are not required, but hunting has to be continued to preserve shyness. Possibilities of other kind of hunting activities are dependant on a) results of EU negotiations b) improvement of current seemingly low increase of bear population. Hunting potential of lynx population is satisfactory.

4.2. Legal basis of large carnivore management.

Wolf and lynx have been game animals in Estonia for long time, although their abundance was very low in the beginning of 20th century. High abundance period after the WW II was met by introduction of bounty hunting, proscription of the species, formation of state-paid hunting platoons and use of toxic baits. There measures forced the population almost to extinction In Estonia by late 1950ies. After ban of poisoning and dismissing of hunting platoons the populations of wolf and lynx started to increase.

Bear was rare in Estonia in the middle of 20th century and was included to list of protected species with Resolution No 2015 of the Council of Ministers of Estonian SSR in Dec. 24, 1958, where it stayed up to 1980. After application of strict protection and rehabilitation measures (establishment of forage fields) number increased and the species become common widespread species on Estonian mainland. Fist damage to crops and bee-keeping appeared and in 1980 bear was erased from the list of protected species and included to list of game species with adjacent determination of hunting season. In the first Red Data book of Estonian SSR (1979) the bear was included as rare and vulnerable species, in later redaction (1990, 1998) the species is not considered endangered.

Current legal status of large carnivores in Estonia is regulated by Law on Hunting Management (1994; Estonian Government Resolution No. 251,15. Oct.1996,

Confirmation of the List of Game), internationally they are subject to several conventions and EU Habitat Directive (Table 10).

Table 10. Legal status of large carnivores in Estonia and Europe. In bold - currently valid legal acts in Estonia and in italics potenially obligatory acts.

Akt	Wolf	Lynx	Bear
Estonian List of Game	Oher game	Large game	Large game
EL Habitat Directive (92/43/EEC) [a]	Annex II ,IV, excl. Finland (partially), Spain and Greece (V)	Annex II , IV, Excl Finland (V)	Annex II , IV, Excl. Finland and Sweden (V)
Bern Convention [b]	Annex II	Annex II	Annex II
Washington Convention (CITES)[c]	Annex II	Annex II	Annex II
EL CITES regulation (EC 338/97) [d]	Annex A Spain and Greece B	Annex A	Annex A
IUCN Red List	Mediterranean populations	–	–

[5] These population sizes can not be directly interpreted as critical reserve of natural resource, as given in Act of Sustainable Development § 5 (2) with relevant interpretation of excess as managed resource (§ 5 (4)). Reason for this is based on evidence that population viability 1) is positively correlated to population size and critical limits are definable as orders of magnitude; 2) depends, in addition to population size also on population structure and risk factors. Hunting quotas of large carnivores are defined, considering these factors, annually by expert panel.

[a] Annex II – species requiring designation of special areas of conservation; Annex IV - species in need of strict protection; Annex V - species whose taking in the wild and exploitation may be subject to management measures

[b] Annex II – Strictly protected species

[c] Annex II – Species not in danger of extinction now , but they can be exposed to the risk through uncontrolled trade

Hunting of lynx and bear is seasonally limited and license has to be applied for every case. Out of hunting season, the licence can be issued only by the Minister of Environment. In case of illegal hunt of bear and lynx, an 15,000 EEK penalty fee has been set by Estonian Government (Order No. 275, 25 July 1995), for taking of a pregnant female, the penalty is tripled. The wolf does not belong to list of big game and there is no penalty for illegal kill of the species.

Hunting seasons and methods are regulated by Hunting Rules (Order of Min. of Environment No. 28, 15 Jun. 1995) that permits hunting:

- of wolf with all legal means and methods, except foot-traps, year-round;
- of lynx by decoy, stalking, chase, and dogs from 1. November to 28. February;
- of brown bear by stalking from 1. August to 30. September, by stalking and dogs (except beagle) from 1 October to 31. October. Additional conditions are preliminary shooting test, use of bullet (except full –mantle) with calibre not less than 6.5 mm and weight not less than 9 grams.

4.3. Activities, necessary for control and protection.

Activities, deriving from the protection aims, are in following described through their priority, biological reasoning, legal basis, international practice and presumable complications in Estonia. Activities are ranked into three categories where A is indispensable, B medium and C low priority category. Brief overview of activities is given in Table 11, where the four activities are distinguished, actuality and essence of which are dependant on the results of EU negotiations. Two alternative action plans are discussed according to :

1) According to Estonian application to EU commission to exclude all Estonian large carnivore populations from Habitat Directive Annexes II and IV and include them to Annex V

2) According to current position in the Estonian EU negotiations:

   - Estonian wolf population will be excluded from Habitat Directive Annex II (need for establishment of protection areas) and Annex IV (strict protection) and included to Annex V (allowed regulated hunting);
   - Estonian lynx populations are kept in Annexes II and IV;
   - Estonian bear population is excluded from Habitat Directive Annex II bit is kept in the Annex IV.

Table 11. Activites planned in the Control and Management Plan of Estonian Large Carnivores, for years 2002-2011,with relevant priority (PR.). Essence (for V-4 also necessity) of activities marked by asterisk depend on Estonian negotiation results with EU.

No.	Tegevus	PR.	Related activities
Changing and improvement of legal acts			
I-1	Changing and improvement of hunting regulations	A	VI-1
I-2*	Changing and improvement of nature conservation legislation	A	V-3,4
I-3	Changing penalty fees of illegal kill	B	II-5
I-4	Modernisation of management plan	A	II-1,2
Development of infrastructure			
II-1	Establisment of a post for large carnivore control and protection coordinator	A	—
II-2	Establisment of working group for large carnivore control and protection	A	—
II-3	Training of large carnivore experts	A	II-1,2
II-4	Training of hunters in description and sampling of killed large carnivores	B	II-1,3
II-5	Improvement of control over actions with large carnivores	C	I-3
Monitoring and information systems			
III-1	Improvement of hunting statistics	A	IV-1,VI-1
III-2	Development of monitoring methods and concept	A	II-1,2
III-3	Monitoring	B	II-1,2;III-2
III-4	Registration of rabies cases	B	VI-3
III-5	Establishment of system for bear wintering site regisration	B	II-1,II-3
Applied studies			
IV-1	Official census error estimation	A	III-1
IV-2	Study of demography and population growth potential	B	II-4,III-1
IV-3	Genetic study of dog-wolf crossbreeds	C	II-4,VI-2
IV-4	Study of locationa and quality of large carnivore habitats	C	V-1,2;VI-5
IV-5	Evaluation of disturbance effect for wintering bear population	B	III-5,V-1,2;VI-4
IV-6	Evaluation of traffic impact on large carnivore populations	C	—
IV-7	Estimation of lynx influence on roe deer population	C	—
IV-8	Sociological study about bear	C	—
Habitat protection			
V-1	Seasonal protection of bear wintering sites	A	III-3,IV-4
V-2	Conservation of traditional bear wintering sites	C	III-3,5;IV-4
V-3*	Analysis of expediency of large carnivore conservation areas	A	I-2, V-4
V-4*	Establishment of a large carnivore conservation area	C	V-3
Control and rehabilitation			
VI-1*	Regulated hunting	A	I-1,II-1,2,III-1,VI-2
VI-2	Removal of dog-wolf cross-breeds	C	IV-3
VI-3	Removal of rabic large carnivores	B	III-4
VI-4	Rehabilitation of abandoned bear cubs	A	V-1,V-2
VI-5	Additional feeding of bears	C	IV-4
Dealing with damage caused by large carnivores			
VII-1	Establishment of order for informing about damage	A	—
VII-2	Registration and verification of damage	A	II-3,VII-1
VII-3	Development of compensation mechanisms	C	II-2,VII-2
Increasing of awareness and moulding of public attitudes			
VIII-1	Publishing of folders on large carnivores	A	—
VIII-2	TV series about large carnivores	B	—
VIII-3	Publishing shortened version of action plan	A	—
VIII-4	Compilation and administration of web-page	C	—

4.3.1. Changing and improving of legal acts

Proposals for changing legal acts are based in this action plan mainly on the need of better management of large carnivore hunt. Current position of the EU negotiations **does not mean** including lynx and bear to list of protected species according to Estonian Law of Protected Natural Objects, because in that case, killing of these animals would be possible only in scientific and educational purposes and respectively derogative taking of menacers and general pest control would be impossible.

Because of these needs, both mentioned species should maintain the status of big game and hunting season[6]. In neighbouring countries, wolf is protected in all Fennoscandian countries (in finland outside of reindeer - breeding areas), Lynx in Sweden since 1991 and bear in Norway since 1973.

I -1 <u>Changing and improving of hunting legislation.</u>

Priority A.

Motivation: to secure favourable status of large carnivores, more strict regulation (incl. introduction of quotas for all species, also wolf) of hunting is required. Introduction of quotas is necessary to avoid overexploitation and it is also related to ethic motives, like possibility to stop hunting during breeding period of wolf. Changing of bear hunting season is connected to recommended reduction of hunting (see ch. 3.1.) and possibility to increase quality of selected shooting through abandonment of hunting with dogs. Hunting period of lynx is timed to period of snow cover. Hunting management should be flexible, considering sudden changes in population status (see Appendix I) and this presumes obligatory monitoring. The latter is also required by EU Habitat Directive and Washington Convention , while as a country of origin of the large carnivores, Estonia has the obligation to report the population size, conservation status and hunting extent every second year.

Content: current management plan proposes following changes in hunting legislation:

- Wolf will be transferred from category ‘other game’ to ‘big game’ with adjacent hunting management (introduction of quotas);
- Hunting seasons are determined as follows: wolf – 1. August – 1. March, lynx 1. December – 29. February and bear, stalking from 15. August – 15. October;
- Chase of bear is prohibited
- Prohibiting shooting of bear and lynx females with cubs, in case of bear also prohibiting to shoot cubs of the year
- Decision of control of large carnivores on state level, compilation and renewing of control and management plan with obligatory monitoring system (the latter to be defined either in environmental monitoring law or its application act.)

International practice: In Finland, bear hunt season lasts from 20.08 – 15.10, shooting of cubs of the year is prohibited, wolf is hunted from 01.11 to 31.03 (outside the reindeer-breeding areas hunting is prohibited, lynx season lasts from 01.11 to 29.02 (Anon. 1996). In Latvia, lynx is hunted 01.09-15.03, but according to new management plan it is recommended to be changed to 01.12-31-03 (Ozolins 2000).

Obstacles: So far none

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[6] This conclusion is based on circumstances, that game species is not defined neither by the Law of Hunting Management nor by related legal acts. Game species, incl. large game are enlisted on species level in the list of game with relevant possibilities and conditions of game usage, incl. “legal killing” resp. hunting, allowed by §4(1) of Animal Protection Act. Accordingly, it seems fairly lawful that hunting of a species included in game list is restricted to minimum and a protection area is established for the species (this aspect should be reflected in the nature conservation legislation). Another question is, which demands are set to legal status of species by Bern Convention.

I-2. 1 Changing and improving of nature conservation legislation

Priority A (not based on management plan of large carnivores)

Motivation: Estonian nature conservation legislation should be complied with EU relevant acts, incl. Habitat directive (92/43/EEC). Among other things, nature protection legislation should define status of species that are subject to derogative hunting and conservation status of nature reserves.

Obstacles: Activity depends on the EU negotiation results.

I-3. Revision of compensatory fees for illegal hunting

Priority B.

Motivation: with presumed transfer of wolves into game list (I-1) and potentially considerable extent of illegal bear hunting, the penalty fees for poaching these species should be revised.

Content (proposal): Penalty for illegally killed wolf is set to EEK 3000 (like roe deer or wild boar, for bear the fee is set to at least EEK 25 000.

Legal basis: Estonian Government Order No. 275, 25.07.1995

Obstacles: Lack of conceptual approach to estimation of damage, caused to fauna in Estonia.

I-4 Renewing of management plan

Priority A

Motivation: current control and management plan defines activities for period 2002-2011. The plan should renewed in year 2011 to enable planning of activities from 2012 onwards. The plan is renewed earlier, if survival of large carnivores seems to be endangered by sudden changes in environment or development of other unexpected conflict situation of extraordinary extent.

Obstacles: ordinary renewing has none, need for extraordinary renewing is decided upon by the large carnivore working group proposed by activity II-2

4.3.2. Development of infrastructure

Control and conservation of large carnivores presume continuous extensive work whereas the status of these species is under constant international attention. Favourable situation, concentration of vital information and flexible conflict resolution can not be guaranteed by singular projects an existing structures. The draft infrastructure proposed by this plan has three main components: 1) co-ordinator, responsible for management of control and conservation; 2) advisory working group, responsible also for strategic planning; 3) regional co-ordinators.

II-1. Establisment of a post for large carnivore control and protection coordinator

Priority A.

Motivation: implementation of control and management plan, obligation of monitoring and account, regular determination of quotas and reporting on national and European level presume appointment of responsible person. Duties of the co-ordinator include establishment and maintaining of information exchange system, co-ordination of monitoring and other state projects, preparation of reports and documentation for quota determination etc.

Current practice: In Estonia such post has been established for elk management at Centre of Forest Protection and Restoration and is operative (exchange of information, regular and related research and monitoring, trusted by hunters, game scientists and officials).

Obstacles: there are no direct obstacles. Although, working with conflict species requires high professional qualification as well as good communication ability, thus finding a suitable person can be difficult.

II-2 <u>Establisment of working group for large carnivore control and protection</u>

Priority A

Content: a working group is formed by the order of the Minister of Environment to monitor implementation of the management plan and to make strategic decisions (approval of hunting quotas and reports, extraordinary renewing of the plan etc.) and advising of the co-ordinator of large carnivore control and protection. The group should include primarily species experts, but should also involve representatives of conflict parties (hunting, nature conservation, agriculture).

Motivation: establishment of state working group helps to bring the hunting management from regional level to state level, what is necessary considering the vast home ranges of large carnivores. Also it facilitates more effective and methodologically integrative use of basic information.

Legal basis: §5(5) of Act on Sustainable Development states that extent of the usable reserve and the allowable annual rate of use shall be determined by the

Government of the Republic of Estonia. This can contradict with the competence of the working group to approve the hunting quotas.

International practice: formation of working group is common method for involvement of different interest groups.

Obstacles: presumably do not exist; similar effects are experienced during compilation of current plan.

II-3 <u>Training of large carnivore experts</u>

Priority A

Motivation: several activities concerning control and conservation of large carnivores (gathering of information, expertise of damages caused by large carnivores etc.) are carried out on regional level. Today there are no experts in these regions, while in every county there should be 2-3 ‘supporting persons’, some of them professionally related to hunting or nature protection.

International practice: Similar expert network is (further) developed in Finland (Anon. 1996).

Obstacles: (possible) lack of interested persons in some regions. As a temporary solution, game experts of local environmental services can be obliged to do the work.

II-4 <u>Training of hunters in description and sampling of killed large carnivores</u>

Priority B

Motivation: data on population structure, reproductivity and other demographic aspects is needed for large carnivore comtrol and conservation. Presumably the information is gathered and analysed by the coordinator (see II-2) or research projects, but a source of information can be primarly hunted specimens. This presumes from hunters ability to determine basic features and gathering samples for further analysis. Attestation of hunters does not require these specific abilities and thus extra training is necessary.

Content: training of hunters in establishing the gender, determination of age, measurement and sampling (stomach content, female reproductive organs, parasites) of animals, storage of samples.

Legal basis: obligatory muscle sample for trichina analysis from all trunks of bear and lynx, ment for human consumption, stands in Rules of Trichina Control (Ministry of Agriculture, order No.24 from 26.06.1995), while results of the analysis are to be written to returned hunting license.

Obstacles: presumes operation of co-ordiator and support persons (actions II-2, II-3)

II-5 Improvement of control over transactions with large carnivores

Priority C

Motivation: possibility to trade large carnivore trophies and other products is obviously one of the main reasons for illegal hunting. More strict control of transactions with large carnivores enables to reduce poaching and is also related to fulfilment of conditions set by Washington Convention (CITES) and Law on the Protection and use of Wild Fauna. After joining of EU, the EU CITES regulation will step into force in Estonia, that also demands strict control over domestic and international transactions.

Content: training of environment and customs inspectors to secure control of CITES licenses and possible domestic transactions.

Legal basis: Washington Convention, Law on the Protection and use of Wild Fauna (§12, partly §§6-9), in perspective EU CITES regulation (EC 338/97) and their application acts

Obstacles: none

4.3.3. Monitoring and information systems

According to activity I-1 an obligatory monitoring system must be introduced in Estonia (in addition to need for better hunting management, monitoring is also prescribed by EC Habitat Directive and Washington Convention) to enable 1) determination of annual hunting quota; 2) review of population size of all three species, conservation status and hunting effects at least in every second year. These aspects indicate importance of monitoring and account of large carnivore resource utilisation in the control and conservation of large carnivores.

III-1 <u>Improvement of hunting statistics</u>

Priority A

Motivation: hunting statistics is collected from hunters of hunting region level from where it is forwarded to county governments and Ministry of Environment. The statistics involve data on hunted specimens and official census results that in practice means estimate of hunting organisations. Preservation of both information components is vital, but (specially in the case if hunting statistics pertain to large carnivore monitoring but also in EU reporting) information on shot specimen should be more detailed.

Content: the collection of data for hunting statistics is carried on according to the traditions of earlier decades, but the data is more detailed and related to geo-informational system. Official census (results are submitted in March) is appended by Bear observation form (Appendix 3), that enables mapping of individuals, identified from print measurements, gather data on litter size and size distribution of individuals (observation time July – December, gathering of forms in the end of the year together with other materials.).

Obstacles: key question is if and to which extent the cheap hunting statistics can be used for population monitoring. According to H.Valdmann (2000b), official census is just a gross estimate that is not based on methods, reflecting objectively (with a time-lag) trends in large carnivore populations, but in absolute sense the results are over-estimates. The least is caused partly by small size of the census units hunting regions). Solution lies in estimation of official census error (IV-1) that allows to decide whether alternative monitoring methods should be introduced (see III-2, III-3).

III-2 <u>Development of monitoring methods and concept</u>

Priority A

Motivation: official large carnivore census (III-1) is the only long term data set on number of large carnivores in Estonia, but its precision could be insufficient for monitoring purposes. Due to this aspect, as soon as possible 1) error of census should be estimated (IV-1); establish alternative monitoring method and conception. Comparative analysis of both aspects reveals whether official census is valid for monitoring and to which extent alternative methods should be used.

Content: co-ordinator of large carnivore management develops a monitoring method and conception and submits it to expert group for approval. In addition to population size, it is recommended to involve other aspects like distribution, reproductivity movements across national borders and status of prey populations.

International practice: development of alternative monitoring methods (transect census, mark-recapture experiments) is recommended also in Finland (Anon. 1996).

Obstacles: dependance on co-ordinator (II-2).

III-3 Monitoring

Priority B

Motivation: if official census even in some substantial aspects does not fit for large carnivore monitoring, alternative monitoring methods should be employed partially or in full.

Content: depends on developed monitoring method and concept. According to H.Valdmann (2000b) a universal game monitoring system should be introduced to survey the status of all game species including large carnivores and their prey abundance and distribution. According to compiler of this plan, simultaneous monitoring of all game species with same methods and in the same areas is not realistic, also in Finland, use of different methods has been found to be inevitable (Anon. 1996).

Existing experience: in years 1996-1998 alternative large carnivore monitoring was carried out by H.Valdmann by use of volunteer trustees and relative estimates in monitoring areas. According to his estimation (Valdmann 2000b) obtained absolute values are smaller than real population values, but abundance trends are objective. An additional value of the survey was an opportunity to gather data on reproductive units.

International practice: There is no common monitoring system for the Baltic countries. Three methods are in use in Finland: 1) gathering data by ca. 900 specially trained volunteers ; monitoring of large carnivores crossing national borders; 3) the game triangles (triangle of census transects) used for (lynx) census (Anon. 1996)

III-4. <u>Registration of rabies cases</u>

Priority B.

Motivation: to avoid spread of this deadly disease in animal and human populations it is necessary to survey existence of the disease, among other animals, also in large carnivores.

Legal basis: Veterinary Activity act (§4(3)) states that protection of human health from diseases, common to both people and animals and prevention against spread of such diseases is a state obligation. According to Infectious Animal Disease Act §47 (1,2) infectious animal disease prevention and control is carried out by Food and Veterinary Board together with Environmental Inspection and physical and legal bodies holding the license to hunt and fish. By §35 of the same act, additional measures are set in the Rules for Rabies Prevention, although according to Law on the Protection and Use of Wild Fauna, animals with clear symptoms of rabies can be killed without a permit. The killed animal must be immediately presented to the veterinary inspection officer or veterinarian serving the relevant region who puts the diagnosis according to Infectious Animal Disease Act §37 (1). Also, rabies can be interpreted as a disease, belonging to obligatory notification with consequent obligation to notify about rabies suspicion and diagnosis[7]

[7] although rabies was defined as extremely dangerous disease with Estonian Government regulation No.393, 21.Dec. 1999, this clause was annulled by Estonian Government regulation No.259 from 1.August 2000. For the outbreak of extremely dangerous disease, special measures are prescribed by Infectious Animal Disease Act § 46.

III-5. Establishment of system for bear wintering site registration

Priority B.

Motivation: disturbance in winter and destruction of wintering sites are major risk factors to bear in addition to over-hunting. Protection of wintering sites (V-1 and V-2) presume exact, extensive and upgraded review of bear wintering site location. This review can be achieved only by continuos register.

Content: Registration system of bear wintering sites is established together with information collection form and database. The needed information is: location, description of habitat, relatedness to nature conservation areas and key habitats, status (e.g. logging damage) and data on use by bears.

Obstacles: poor experience in locating bear wintering sites

4.3.4. Applied research

Several aspects on large carnivore biology is poorly (distribution and habitat preference patterns, home range, population structure and wintering sites) or averagely (reproductivity, general distribution and population size) studied . Several poorly studies aspects have great practical value and because of that these studies have been added to activities of this plan.

IV-1. Error estimation of the official census

Priority A

Motivation: official census is the only long-term data set on number of large carnivores in Estonia, while principally it is an estimate that is based on impressions rather that on measurements. Although the official census probably reflects trends in the large carnivore populations, it does not serve as a basis for objective abundance estimates (specially for bear). In the other hand, namely the trends (together with information on risk factors incl. hunting intensity) are the most significant measurement for population management, and if it is reflected in the census well enough there is no reason to reject this cheap and traditional monitoring method. Estimation of precision and reliability of official census results would allow to consider the relevance of official census for at least monitoring the changes in population size and in best case, provide possibilities for correction of official census results (by correction factors etc.). If the error appears to be substantial and unpredictable, an alternative monitoring method (activities III-2 and III-3) should be employed immediately.

Content: other, more precise methods for population estimates like: 1) standardised winter track counts of bear and lynx; 2) telemetric studies or genetic mark-recapture studies of bear are used together with conventional census. Cost-effectiveness of the latter mentioned method is better and a pilot study is being carried out by Institute of Zoology and Hydrobiology, Tartu University in co-operation with Estonian BioCentre.

Obstacles: presumes higher qualification of personnel than official census, while both surveys should be carried out simultaneously. To achieve independent results, use of same investigators is not favourable or the estimate (official census) should be presented before control surveys (possible only in a single year). Track count is not sufficiently independent also, as the official census is based largely also on tracks. Also, track census does not lead directly to real population size but needs correction by factors calculated elsewhere (e.g. Russia or Finland).

IV-2. Study of demography and population growth potential

Priority B

Motivation: demography (natality, mortality, movements, population structure) of Estonian large carnivores is known very poorly, but in case of population decline it is necessary to know the demographic mechanisms, controlling the process. To detect these mechanisms, comparative data is needed from a stable or growing populations.

Content: database for registering demographic data is established to collect data on hunted specimen (sex, age, measurements, health condition, e.g. presence of parasites and injuries) and casual observations (litter size, incl. disturbed female bears in winter, information about specimen found dead or killed in course of activities other than hunting), when possible also retrospectively. Information can be complemented by special studies carried out in better observable regions (e.g. study of bear population structure from print measurements like done in Väätsa hunting region).

Obstacles: presumes creation of observation network by training of support personnel and hunters (II-3 and II-4).

IV-3. <u>Genetic study of dog-wolf crossbreeds</u>

Priority C.

Motivation: Considering potential danger to genetic integrity of wolf population and possible risk to humans the dog-wolf crossbreeds should be removed from nature (activity VI-2). Despite of several suspicions, nowadays there is no proof of presence of crossbreeds in Estonian nature. Detection of these hybrids and determination of their proportion in the population can lead to rearrangement of wolf management.

Content: in suspicion of wolf-dog crossbreeds, DNA test of the killed animal is committed.

Obstacles: lack of study material (solution in activity II-4). So far, genetic studies of Estonian animals have been carried out abroad. As technical basis exists also in Estonia, it may be worthwhile purchasing necessary primers. So far, analysis are cheaper to run in other labs in frames of international co-operation.

IV-4. <u>Study of location and quality of large carnivore habitats</u>

Priority C

Motivation: habitat destruction, mainly due to forestry, is potentially at least for bear a risk factor of major influence. The influence of this factor is still unknown because of insufficient knowledge of Estonian large carnivore habitat requirement, availability and location of high quality habitats. For management purposes foraging, breeding and (bear) wintering sites are of primary interest.

Content: 1) determination of main traits of large carnivore habitat requirements, 2) using this knowledge, compilation of models predicting habitat choice by large carnivores, 3) application of these models to determine amount and location of areas, meeting these requirements. Consequently, overlap of modelled and real ranges can be controlled and estimate of habitat carrying capacity can be given.

International practice: wide, but mainly related to areas (South Europe, North America) that are not directly applicable to Estonian conditions.

Obstacles: most complicated steps are 1. (by which randomised method data on habitat requirements are obtained?) and 3. (which factors, important to large carnivores are available in existing GIS or other geographical databases?).

IV-5<u>. Evaluation of disturbance effect on wintering bear population</u>

Priority B

Motivation: influence of disturbance on wintering bears is great, specially in form of abandoned litter, while its scope is not known. Very rough calculation shows that if 5-10 broods are disturbed, it may form >10 % of all broods (from presumably 300 female bears only a half is older than three years, and only a part of them is breeding).

Content: in simple cases potential or real disturbance rate is determined for found wintering sites (the first for cases, where disturbance is avoided by protection measures, activities V-1 and V-2), in more complicated cases the disturbance probability is related to reproductivity or survival of bears. Other methodological approaches are also possible, like comparison of relative abundance of female bears with offspring in areas of active forestry and in large nature conservation areas.

International practice: considerable results are published only in recent years (Swenson et al. 1998, Linnell et al. 2000a).

Obstacles: related mainly to effective registration of bear wintering sites.

IV-6. <u>Evaluation of traffic impact on large carnivore populations .</u>

Priority C.

Motivation: road kill of large carnivores is presumably a risk factor of minor influence, ut this presumption is based on very scanty material. The study helps to evaluate the importance of the factor as well as to detect regions, where accidents involving large carnivores are more frequent.

Content: a single study that takes together data on large carnivore collisions with cars and trains as well as information on meeting of large carnivores at road sides and their relevant behaviour.

International practice: stationary component of management research in developed industrial countries, mainly as a part of a wider study (usually a radio-telemetry).

Obstacles: none foreseen, but presumes good co-operation with Road Department.

IV-7. <u>Estimation of lynx influence on roe deer population</u>

Priority C.

Motivation: roe deer belongs to main game species in Estonia and is at the same time the main prey item of the lynx. An understanding has spread among hunters that lynx has caused collapse of the roe deer population or hindered recovery of the population. As this understanding is at the same time the main motive of lynx population control, its validity has to be tested. Lowest priority has been assigned to this activity because the preliminary analysis did not support significance of proposed relation (Chapter 2.2. and Appendix). Lack of correlation can also be caused by poor quality of primary data.

Content: covariation analysis of temporal (corrected data) and spatial changes in lynx and roe deer population , i.e. attempt to test in nature the validity of theoretical calculations (based on analysis of lynx diet and abundance of predator and prey) of lynx impact on roe-deer population.

Obstacles: depend on demands on data quality. Surely the study results depend on strength of other disturbance factors (incl. hunting) in lynx and roe deer populations.

IV –8. Sociological study about bear

Priority C.

Motivation: unfavourable public attitude can seriously hamper implementation of the management plan. The attitude of Estonian population towards wolf has been studied (Chapter 3.7), but similar studies about other species have not been carried out. Public opinion about bear is more important from the point of population management (lynx is not well known), the more that bear is the most vulnerable out of the three Estonian large predator species.

Content: public enquiry with an aim to find weak points of the population management.

International practice: some enquiries in Europe (Breitenmoser 1998) and North America (Kellert et al. 1996).

Obsatacles: none

4.3.5. Habitat protection

V-1. <u>Seasonal protection of bear wintering sites</u>

Priority A

Motivation: disturbance of hibernation is a risk factor of major influence (Chapter 3.5). Both main disturbance factors (logging and hunt on other game) are planned activities, thus their timing can be altered. From other activities, big nature tourism and sport events, specially use of skidoos in wilderness , deserve extra attetion in this relation.

Content: restriction of logging and hunting with dogs in known bear wintering sites. It can be achieved by: 1) warning of hunters, avoid hunting and movement of hunters in the wintering regions; 2) warning of forest owners and prohibit logging from December up to the time when bears wake up. Principally logging can be allowed before December , when disturbed bear can find a new suitable place and female still has an opportunity for successful breeding.

Legal basis: §16 of the Law on the Protection and use of Wild Fauna states that environment protection inspectors have the right to prescribe suspension of forestry during reproduction period of animals. As difference between wintering single bear and female with brood cannot be told *a priori* , then establishment of temporary forestry restriction is motivated in every wintering site in disturbance range.

Obstacles: presumes up-to –date information on location of the wintering lair (activity III-5) as well as on potential disturbing activities in the area. The latter can be gathered by regional co-ordinators (activity II-3).

V-2. <u>Conservation of traditional bear wintering sites</u>

Priority C.

Motivation: disturbance of hibernation is a risk factor of major influence to bear (Chapter 3.5.). According to some data (Kaal 1980, p. 53) bear can use in undisturbed circumstances the same wintering lair for years. This evidence serves as a basis for conservation of these forest stands as key habitats for bear.

Content: compile and approve a list of bear traditional wintering sites as key habitats of bear.

Legal basis: §13 of the Law on the Protection and use of Wild Fauna

Obstacles: 1) insufficient knowledge on location of traditional wintering sites. Solution – register of wintering sites (activity III-5); 2)Missing of long term data in Estonia on use and occupation rate of wintering sites as well as lack of estimates or experience about which changes in wintering sites are unfavourable to bear and which are not. Solution: monitoring and applied research of these aspects (activities III-3 and IV-5)

V-3. <u>Analysis of expediency of large carnivore conservation areas</u>

Priority A.

Motivation: considering the fact that control of large carnivore population size is largely related to presumed damages it is logical to zone landscape according to damage probability into areas with different hunting pressure(e.g. Mech 1995). Hunting of large carnivores in wild nature protection areas has no reasonable basis and these areas could serve as refugia for large carnivores in favourable natural conditions (sufficient food basis, suitable structure and distribution of forest). The current nature protection areas in Estonia are too small to provide effective protection to large carnivores, while occurrence or staying of these animals in protection areas is related to hunting activities on much wider areas. For example, in North American nature protection areas the main cause of mortality in wolf and bear populations (83% and 88%, respectively) was killing by man, predominantly outside the area boundaries (Woodroffe & Ginsberg 1998). Because of this it is reasonable to define larger areas where large carnivores are not hunted, the more that in larger scale wolf and lynx ranges overlap and current position of EU negotiations foresee establishment of conservation areas for lynx in Estonia. Although area demands of lynx are the smallest among the large carnivores, it is still not evident whether the requirements of named lynx conservation areas can be met by existing nature protection areas. "Critical area" (population survival probability 50%) of a reserve is 766 km^2or wolf and 3981 km^2 for bear (Woodroffe & Ginsberg 1998).

Content: 1) determine amount of large carnivores in nature conservation areas and in proximity and estimate influence of hunting on survival of large carnivores in protection areas; 2) based on nature protection and wild areas, define on map a possibly largest large carnivore conservation area, evaluate its quality for large carnivores and prognose ecological, economical and social outcome of the area establishment. Composers of current plan see three alternative ways to define such area(s): 1) current hunting restriction areas; 2) large nature protection areas and their proximity; 3) 1-3 large conservation areas (incl. large nature protection areas) in Mid-Estonia. Brief description of possible areas with maps are given in Appendix 4. Further analysis is a task for special state working group.

Obstacles: presumes formation of working group (Activity II-2).

V-4. Establishment of a large carnivore conservation area.

Priority C.

Motvation: current nature protection areas are too small to protect large carnivores effectively and survival or occurrence of large carnivores in these areas is related to hunting in larger territories (see activity V-3 for details).

Content: introduce basic ban on hunting of large carnivores (excl. removing of menacers) in the area defined according to activity V-3. That does not mean general protection regime, i.e. is not equal to establisment of a nature protection area and is more likely to be applied to rent contracts of hunting regions.

Current practice in Estonia: current system of protected areas and some attempts to establish special "bear strict protection areas" (see Kaal 1980, p.78) are obviously promoted the status of large carnivore populations, but due to their small extent they have probably not provided effective protection.

International practice: recommended by many authors (Boscagli et al. 1993, Forbes & Theberghe 1996, Slough & Mowat 1996, Smietana & Wajda 1997, Woodroffe & Ginsberg 1998), but practical implication unclear.

Obstacles: depends on results of the analysis of necessity and possibility of a protection area (activity V-3). Absence of status of protection area makes the legal status of large carnivore conservation area.

4.3.6. Control and rehabilitation

VI-1 Regulated hunting

Priority A.

Motivation: huntng of large carnivores is aimed to fulfill at least three roles in coming decades: control of wolf abundance, removal of menacers or sick individuals of all three species and maintenance of misanthropy. When Estonia applied for exclusion of all Estonian populations of large carnivores from EU Habitat Directive Annexes II and IV and inclusion to Annex V, this application has been fully met only in the case of wolf. Opinion of composers of this plan is that limited hunting of lynx and (in less extent) bear could be carried on in Estonia, while in current situation it would be possible only in damage areas (in the form of derogation, that brings about more strict order of reporting both in Estonia and along EU lines).

Content: organise hunting of large carnivores and determination of quotas. Determination of quotas according to the best available information is a task of the working group. According to the opinion of the composers of this plan the quota for coming decades should not exceed 100 individuals for lynx, 20 individuals for bear (incl. menacers, see also appendix 1). These quotas can be corrected after clarification or reduction of risk factors. Remocal of menacers is guided by state co-ordinator. According to H.Valdmann (2000 b), wolf hunt should be organised so, that issued licenses exceed quota, and the hunt will be stopped when quota is fulfilled and remaining licenses are voided.

International practice: In Finland sustainable hunting pressure is estimated to be 10-15% of lynx and 7% of bear population Anon 1996), see also chapter 3.1.

Obstacle: dependance on EU negotiations.

VI-2 <u>Removal of dog-wolf cross-breeds</u>

Priority C.

Motivation: considering potential danger to genetic pureness of wolf population and possible hazard to people the dog-wolf hybrids should be removed from nature.

Legal basis: indirectly applicable §20 (5;7) of Law on the Protection and use of Wild Fauna. By the act, wolf-dog cross-breed does not belong to aboriginal (wolf) population and accordingly represents an alien population (and its releasing to nature is allowed by a permit, based on expertise, of environment minister), or alien species (control of which is regulated by minister).

International practice: need for removal of the wolf-dog cross-breeds is also formulated by Finnish expert group(Anon.1996).

Obstacles: determination of cross-breeds by exterior may be impossible, so this activity can be carried out only by 1) removing specimen that are very probably hybrids; 2) controlling their genetic background with analysis (activity IV-4). After confirmation of first hybrids it is possible to adjust control strategy (belongs to competence of the state working group).

VI-3. <u>Removal of rabic large carnivores</u>

Priority B

Motivation: in singular cases of large carnivores can be infected by rabies (chapter 3.9.) and be of risk to domestic animals or humans (one registered case of attack in past 20 years).

Content: removal of obviously rabic specimen. Diagnosis is proven by veterinarians and all cases are registered (activity III-4).

Legal basis: Veterinary Activity Act §4(3) states that protection of human health from disease common to both human beings and animals and disease prevention are obligations of state veterinarian control. According to Infectious Animal Disease Act §47 (1,2) infectious animal disease prevention and control is carried out by Food and Veterinary Board together with Environmental Inspection and physical and legal bodies holding the right to hunt and fish. By Law on the Protection and use of Wild Fauna §21 and §22 obviously rabic specimens can be killed without license and in case of common danger, based on veterinary diagnosis, governor approves control of the population.

Obstacles: presumably none.

VI- 4. <u>Rehabilitation of abandoned bear cubs</u>

Priority A.

Motivation: disturbed female bear does not return to abandoned winter lair and disturbance of hibernation is a risk factor of major influence to bear (Chapter 3.5) As the abandoned litters can form a substantial part of the population increase, rehabilitation is the temporary means to reduce disturbance impact on reproductivity.

Content: methodology involves 1) artificial feeding during the lactation period; 2) protection from potential enemies until the protective behaviour develops; 3) gradual shift to natural diet through self-learning; 5) optimal timing of release (July of the year).

Legal basis: Law on the Protection and use of Wild Fauna §5, §19 (4,6)and specially §20 (2) that allows to treat abandoned bear cubs as animals in helpless situation, whose rehabilitation and release is organised by the Ministry of Environment if the property owner or user can not carry out these actions.

Current practice: In 1999a rehabilitation centre has been established in Nigula nature protection area and two persons have been trained by rehabilitation expert V. Pazetnov. in period 1999-2000, 11 bear cubs have been rehabilitated in Nigula. Four of these (incl a litter 3 from 1998) of have caused trouble to man, two of them have been shot but the rest have not caused any trouble on their third year of life. One cub has perished during release and one has been killed by adult male bear. So, presumably 7-9 individuals have been returned to nature (P.Männil pers. com).

Obstacles: none with sufficient funding

VI-5 Additional feeding of bears

Priority C.

Motivation: although additional feeding principally contradicts with the aim of preservation of the population natural functions, it can be expedient in exceptional cases (as sudden decrease in number). In essence , additional feeding means that natural habitats do not provide enough food for bears and additional feeding is an artificial short-term means for maintaining of population level.

Content: oats fields are sown in the forest, but these fields are not harvested. Principally, also carcasses of livestock and meat and fish industry leftovers can be taken to woods if it does not conflict with legal acts (see below).

Current practice: regionally used method of game management or maintaining the viability of a hunted population, that has been related to increase in Estonian bear population in the second half of the 20th century. (Kaal 1980, page 79).

Legal basis: according to Infectious Animal Disease Act §19 (1), animal waste must be treated in a way that prevents spread of infectious agents and other dangerous material. Section 5 of the same paragraph, animal waste treatment is regulated by the minister of agriculture.

Obstacles: establishment of forage fields is possible, but obviously not very attractive to hunters if the fields are not related to maintaining or increasing the number of hunted animals. Taking of carcasses, meat or fish products to forest are probably restricted in close perspective by strict veterinary regulations of European Union, also obtaining of these products or carcass is not easy or cheap in current depression of livestock breeding.

4.3.7. Dealing with damage caused by large carnivores

VII-1. Establishment of order for informing about damage

Priority A.

Motivation: damages, caused by large carnivores to agriculture (livestock-breeding, bee-keeping, oats fields) needs constant surveying, because need for controlling of wolf, and to a smaller extent other large carnivore populations is defined mainly through damage caused by these animals.

Content: order of registration of the large carnivore damage (Appendix 5) is established 1) with hunting region rent contract for places outside of nature protection areas, 2) by environment minister regulation on nature protection areas. The basics of registration order is an immediate expertise in the damage site (activity VII-2) and forwarding of the record to state coordinator (II-1).

Current practice: no experience in Estonia from recent decade; such registry was kept for livestock insured in Estonian SSR State Insurance in 1950ies and 1970ies (see Kaal 1983).

Obstacles: presumably none.

VII-2 Registration and verification of damage

Priority A.

Content: damage, claimed to be caused by large carnivores is registered and verified according to established order (Appendix 5). During damage verification, responsible species has to be established, thus a trained large carnivore expert must attend the process (activity II-3).

Current practice: none in last decade, earlier expert from insurance company visited the scene.

Obstacles: presumes execution of activities II-3 and VII-1.

VII-3 Development of compensation mechanism

Priority C.

Motivation: compensation of damages caused to livestock is currently possible by insurance companies in presence of insurance policy. Situation can change if any of the large carnivore species is taken under protection (this is not probable, see chapter 4.3.1.), or analysis of data, gathered in the process of damage registration and verification, indicates a need to change the compensation system (activity VII-2 , decision is taken by the state working group, see II-2).

Legal basis: according to §23 of the Law on the Protection and use of Wild Fauna owner is obliged to take preventive measures to protect the property against presumable attack of an animal, e.g. define relevant conditions in the appendix of hunting rental contract. Owner can not kill large carnivores (lynx and bear are holding status of large game, and in perspective wolf will also be included to the list) while hunting tenant can do that (In the event of recurring damage by big game, a permit for killing an animal outside the hunting season shall be issued to the hunting tenant by county governor.) .State does not compensate damages caused by large carnivores, except in cases when the species is defined as protected animal (§25).

International practice: very variable. Compensation is not paid in Hungary and Croatia. State or county government compensates damages caused by large carnivores e.g. in Finland, Sweden, Italy and Spain, hunting organisations in Poland, insurance in Bulgaria and Romania.

Obstacles: related to activities I-2.

4.3.8. Increasing of awareness and moulding of public attitudes

VIII-1. Publishing of folders on large carnivores

Priority A.

Motivation: public knowledge about large carnivores, their tracks, abundance and biology is not sufficient for objective solution or prevention of conflict situations (praying on livestock and wild fauna, meeting of large carnivores and people). Thematic folders enable to spread basic information, also mould public opinion and obtain feedback information on large carnivores. The folders can be used in schools to acquaint hunting and nature conservation.

Content: three folders are published, of which one deals with large carnivore abundance and biology, one gives first-hand instructions for conflict situations and the third is designed to gather feedback data on distribution and behaviour, presenting also the basics of gathering such data (tracks etc.) .Main target group of the least are more competent people who potentially get into contact with large carnivores (hunters, foresters, nature protection workers) .

International practice: widely spread, simple means of management

Obstacles: lack of good quality picture material.

VIII-2. <u>TV series about large carnivores</u>

Priority B.

Motivation: : public knowledge about large carnivores, their tracks, abundance and biology is not sufficient for objective solution or prevention of conflict situations (praying on livestock and wild fauna, meeting of large carnivores and people). TV is holding leading position in media and audience of nature programs is very wide.

Content: at least two programs are produced, one of which deals with large carnivore biology, habitats and status and the other is focused on conflict solution.

International practice: wide. Large carnivores deserve frequently attention of nature films.

Obstacles: presumes existence of hi-quality film material

VIII-3. <u>Publishing shortened version of action plan</u>

Priority A

Motivation: analysis presented in this plan together with planned activities must be available to different (incl. international) interest groups to enable acceptance of planned changes and feedback on implementation experience and potential mistakes of the plan.

Content: a shortened version of control and management plan is published in Estonian with parallel translation to English.

Obstacles: none.

VIII-4. <u>Compilation and administration of web-page</u>

Priority C.

Motivation: : public knowledge about large carnivores, their tracks, abundance and biology is not sufficient for objective solution or prevention of conflict situations (praying on livestock and wild fauna, meeting of large carnivores and people). Web page has different audience compared to printed material, it offers an opportunity to present more diverse and complex information that is regularly updated and receive comments and feedback on actual themes. Locating of home page can be eased by links on other relevant popular sites. A web page can also be used in schools to to acquaint hunting and nature conservation.

Content: compilation of a web-page about Estonian large carnivore status and biology. The page can be related to spread and gathering of information.

Obstacles: none.

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Appendix 1

Analysis of Estonian bear population viability with program *VORTEX*

Asko Lõhmus

INTRODUCTION

Population viability analysis (PVA) is widely used in nature conservation to evaluate vulnerability of population and predict effects of different conservation measures (Boyce 1992). Recent comparative analysis showed good concordance of different PVA – programmes and fit of prognoses (Brook et al. 2000), although these effects may disappear in the course of extensive simplifications (Brook et al. 1997).

Brown bear is the most vulnerable Estonian large carnivore species, mainly due to slow reproduction, late sexual maturity and risk of isolation (see also Weaver et al. 1996). The population viability estimate is primarily necessary for planning of hunting pressure. Wholeness of the Estonian bear population with tendency to be isolated from neighbouring populations enable to commit the analysis by relatively simple means. Aim of this study is to estimate the viability (resp. extinction risk) of Estonian bear population, effect of its different components and errors evolving from inaccuracy of original data. To achieve the aim, following steps were taken: 1) simulation model was compiled using existing demographic data; 2) Prediction capacity of models was estimated by comparing predicted and actual changes in size of a non-hunted population; 3) controlled models were used to estimate viability of bear population in next 100-200 years and its dependence on hunting pressure; 4) sensitivity of simulation results to precision of original data was determined.

MATERIAL AND METHODS

Population viability was estimated using programme *VORTEX* 8.21 (Lacy 1993), which enables simulation of random demographic and genetic processes. Bear was treated as a polygynous animal and extinction was defined as absence of at least one sex in the population.

Following aspects were excluded from the models: 1) loss of viability through inbreeding that has been recorded in captive bears (Laikre et al. 1996), effect of which is very difficult to detect and significant only in very small populations; 2) catastrophes that can influence extinction probability significantly in long period of time (Mangel & Tier 1994), but sudden changes in population size that refer to catastrophes have never been registered in Estonian bear population (period covered with data 200-400 years, see Kaal 1980). All simulations were repeated for 500 times.

The study consists of four stages:

All available demographic data was gathered and used as a basis for simulation models describing a non-hunted population. Main parameters used in the model are given in table 1. Of these, only the litter size is based on data gathered in Estonian population, other reproductivity and mortality data are determined as mean values from North American non-hunted population data. Accounting of density dependant abundance regulation is predominantly a guess that may bring about large deviations from truth. Thus the population viability is analysed both by density dependant and independent models as also suggested by Mills et al (1996). Environmental carrying capacity was estimated from real population dynamics considering the fact that even in known periods of high abundance (according to official census 840 specimen in 1990) there is no evidence of reduced population viability that may be caused by competition or stress. Increase in environmental carrying capacity for Estonian bears in the second half of the 20th century is probable (specially up to 1980ies), and this is mainly due to additional feeding, increase of forested areas and hunting of game ungulates (see also Kaal 1980).

Due to uncertainties with reliability and exactness of original data, the simulation models were controlled by comparing the calculated population forecasts with population dynamics of Estonian bear population dynamics in period 1950-1979, when bears were hunted in non-significant amounts (since

1965 only problematic specimen, in an average only one per year) and the census data is critically revised (Kaal 1980, p. 30). Simulating later periods is impossible due to extensive hunting (up to 73 specimen per year in 1988) and data on age and sex structure of the game was not available for modelling. Still it was possible to compare modelled population increase with potential annual increase throughout the whole period of 1950-2000 that was covered with censuses. A formula $N_2=N_1*(1+k/100)^t$, was used where k is population increase and t duration of period in years. Mean value of first three years was used as initial population size (N_1=60) and value 600 was used as final population size (N_2). The model results in 3.9% annual population growth rate with average hunting pressure of 2.3%, hence the potential growth rate of Estonian bear population can be estimated to approximately 3.9 + 2.3 = 6.2%.

After testing the models they were applied to calculate bear population viability in next 10 (period of the management plan), 100 and 200 years. In addition to protected population, a hunted population was modelled, using, according to recommendations of the plan, annual quota of 20 individuals for the whole period . Structure of the game was assumed to be stable and consist of 13 males (7 subad. and 6 ad.) and 7 females (4 subad. and 3 ad.). This assumption is based on recommendation that proportion of females in game should not exceed 30 % (Mills et al. 1996). Stable hunting quota with given structure is an extreme simplification but in this case primary objective was to estimate influence of hunting on population viability rather than determine extinction probability.

Sensitivity of simulation results to exactness of original data was tested through the "worst case " study. Using the simulation yielding highest extinction probability, additional simulations were performed with , at a time, each parameter value changed 20% to unfavourable direction. Consequent increase in extinction probability was recorded to detect influence of possible errors to final result and also it allowed estimating the effect of management measures to population.

RESULTS AND DISCUSSION

Application of simulated model to 1950-1979 data is shown in Figure 1. Compared to official census results, both density dependant and independent models yielded in average the same trend but lower abundance. As in absence of critical review gathering of reports, which also serve as a basis for official estimate, leads to probable overestimate (e.g. Elgmork 1996), there is no basis to assume a big error of model estimates. This is supported by closeness of deterministic modelled population trend (5.1% annually) to calculated potential annual increase of 6.2% in period of 1950-2000.

As the models reflect the real situation rather well, data in Table 1 was used to forecast bear population viability in next 100 and 200 years (Table 2). Results showed low, less than 5% extinction probability in non-hunted population but a noticeably higher probability in population, hunted with fixed quota. In the first ten years extinction probability is low (about 1%) but it will significantly increase in later decades, independently of the density dependant effects (Figure2).

Highest extinction probability was produced the most realistic model that involves both hunting and density dependant effects. This so called worst case sensitivity analysis showed that although the model was not sensitive to data quality I the first ten years, in longer perspective data quality affects the estimation significantly. The largest biases are wrong estimates of young female mortality and proportion of reproductive females in the population, followed by estimates of initial population size, adult female mortality and precision of environment carrying capacity estimate (Table 3). Probably manipulation with these factors in nature has effect of similar scale to the viability of population.

CONCLUSIONS

Although annual hunting of 20 specimens does not put Estonian bear population to extinction risk in coming decade, such risk can develop in later decades in case of using a fixed quota. Conclusively, bears may be hunted in Estonia according to flexible quotas that are set according to real population dynamics, whereas quota should not exceed 5% of the population. This presumes constant monitoring of abundance and hunting pressure.

Out of the activities planned for the period 2002 – 2011 in the Control and Management Plan at leas two are targeted to manipulate the critical or important factors: a) reduction of disturbance of wintering bears, that should increase proportion of successfully breeding bears; b) ban on hunting of female bears with cubs to reduce adult female bear mortality. Aspects that are not considered so far are also reduction of juvenile female bear mortality and avoidance of habitat degradation (reduced environmental carrying capacity).

Table 1. Demographic data used for Estonian bear population modelling. I – density-independent model; II – density dependant model.

Parameter	Values I	Values II	Source [a]
Female age at first parturition, years	6	6	1–3
Male age at sexual maturity , years	6	6	
Maximum reproductive age	30	30	2, 4
Proportion of males in births, %	50	50	5
% or reproductive males in adult males	49	49	6
% of single offspring litters	18,9	18,9	4
% of litters with two cubs	61,6	61,6	4
% of litters with three cubs	17,5	17,5	4
% of litters with four cubs	1,3	1,3	4
% of litters with five cubs	0,7	0,7	4
Annual mortality			1, 7
cubs (=1. year), %	14±10	14±10	1, 7
subad. females (=2.-5. year), %	14±10	10±10	1, 7
ad. females, %	4,5±4	4,5±4	1, 7
Males (from 2. year), %	10±17	10±17	1, 7
Reproduction dependant on abundance (N)	No	Yes	
Env. Carrying capacity (K) year 1950	1000±100	1000±100	8
year 2000	1500±100	1500±100	8
Proportion of reproductive specimen in ad. ♀, if N=K		10	8
Proportion of reproductive specimen in ad. ♀ if N→0	33±7	33±7	7
Exponent of correlation between reproduction and abundance		2	5
Alley effect (population size, where proportion of ad. ♀ is 2x smaller than in absence of the effect)		10	8

[a] Source: 1 - Hovey & McLellan 1996, 2 - Mills et al. 1996, 3 - Wielgus & Bunnell 2000, 4 - Kaal 1980, 5 – common assumption, 6 - Craighead et al. 1995, 7 - Wielgus et al. 1994, 8 - assumption.

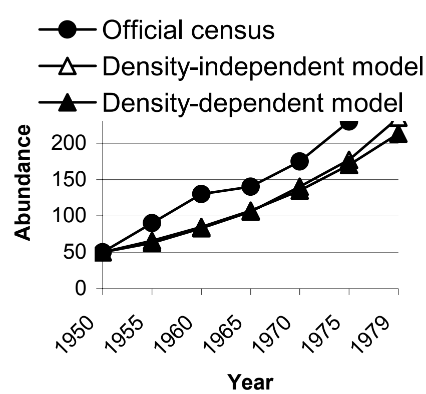

Table 2. Prognosis of Estonian bear population viability for 100 and 200 years, depending on density-dependant population regulation and hunting pressure .

Conditions	Extinction probability (%)		Mean size of survived population [a]	
	100 years	200 years	100 years	200 years
Non-hunted population				
Density-independent	0	2,0	1286±200	1279±212
Density dependent	4,6	4,6	1141±227	1128±243
Hunted population [b]				
Density-independent	19,2	22,2	1212±252	1221±259
Density dependent	31,6	40,2	988±306	1016±287

[a] mean ± SD

[b] constant quota of 20 specimen per year is used in the model.

Figure 2. Extinction probability of Estonian bear population, with density dependant regulation and hunting effects. Hunting was simulated as stable 20 specimen quota.

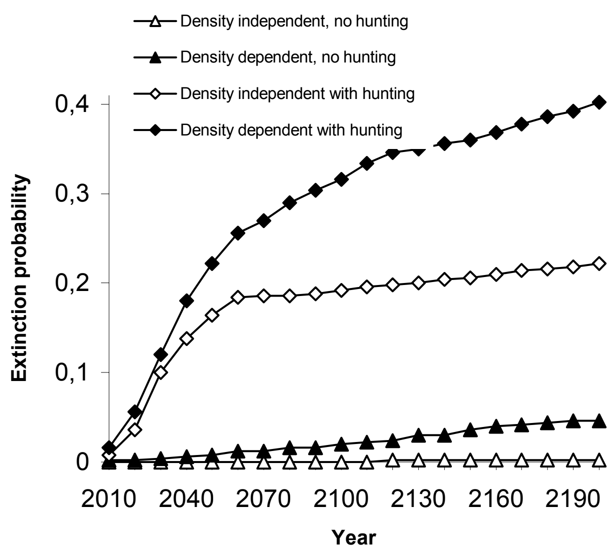

Table 3. The "worst case " analysis: extinction probability of a hunted density dependant population. Parameters were changed 20% to unfavourable direction. The parameters are listed in order of their contribution to the extinction probability.

Parameter	New value	Extinction probability (%)		
		10 years	100 y.	200 y.
Subad. ♀ (=2.-5. years old) mortality, %	17±10	0,6	68,0	81,2
Proportion of breeding females , if N→0	27	0,8	65,8	76,6
Initial population size	360	2,2	49,4	56,2
Ad. ♀ mortality, %	5,4±4	1,2	43,0	55,0
Env. Carrying capacity (K)	1200	1,2	42,2	53,8
Cub (=1. year mortality, %	17±10	1,6	36,6	45,0
Proportion of breeding females, if N=K	8	1,2	33,6	42,6
Initial model (parameters unchanged)		*1,6*	*31,6*	*40,2*
Male (2 years and older) mortality, %	12±17	0,6	29,0	31,6
% of reproductive males	40	1,4	29,0	36,2

Appendix 2.

Multi-factorial regression modelling of changes in Estonian large carnivore and their prey abundance and role of hunting pressure

Asko Lõhmus

Six species of mammals (wolf, bear, lynx, moose, roe deer and wild boar) were studied. The aim of the analysis was to establish a relationship between change in predator and prey abundance in consecutive, abundance of these animals in each year and proportion of hunted specimen. Official census data and hunting statistics from period 1954-2000 was used.

Linear multinomial regression models were compiled using software package STATISTICA 4.5. Two approaches were adopted: 1) model was compiled by using all initial parameters to determine their relative significance; 2) the best simplified model was developed through step-by-step analysis. Weakness of the latter approach lies in dependence of model component significance on which other components are involved in the model, but with careful interpretation, step-by –step analysis allows to relate relatively more significant components. Depending on parameter *a* (initial point of the regression line) significance in the model it was either considered or not.

Large carnivore abundance

Components of model

Dependant variable: relative change of large carnivore abundance during preceding year.

$y=(N_t–N_{t–1})/N_{t–1}$, where N is large carnivore abundance and t is year.

Independent variables:

PD – moose abundance in year *t*

MK – roe deer abundance in year *t*

MS – wild boar abundance in year *t*

x – proportion of hunted large carnivores in preceding season in counted abundance (hunting pressure).

Results

WOLF. Hunting pressure was the only significant factor influencing abundance when all components were included in modelling. The coefficient of determination is $R^2=0.26$ and probability p=0.003. Step-by-step regression added also roe deer abundance, but as the latter was least important in the all-component model this relation is to be treated sceptically:

$y=1.11*10^{–5}MK–0.56x$. Model $R^2=0.24$ and $p=0,001$.

BEAR. In all-component model none of the components proved to be significant and the coefficient of determination was very low ($R^2=0.06$, $p=0.16$). Step-by-step regression yielded a lowly significant correlation to moose abundance: $y=5.5*10^{-6}PD$, $R^2=0.07$, $p=0.038$.

LYNX. In all-component model, only significant factor to influence population dynamics was the roe deer abundance ($R^2=0.27$ and $p= 0.002$). Step-by-step regression selected also roe –deer abundance and hence its leading role among studied factors seems probable: $y=6,23*10^{-6}MK–0,17$. $R^2=0,27$, $p=0,0002$

Game ungulate abundance

Components of model

Dependent variable: relative change in game ungulate abundance in preceding year .

$y=(N_t–N_{t–1})/N_{t–1}$, where N game ungulate abundance and t is year.

Independent variables:

H – wolf abundance in year t

K – bear abundance in year t

L – lynx abundance in year t

x - proportion of hunted game ungulates in preceding season in counted abundance (hunting pressure).

Results

MOOSE. All-component model revealed hunting pressure to be the only significant factor of population dynamics ($R^2=0.32$, $p<0,001$). Step-by-step regression chose also hunting pressure, hence its leading role among studied factors seems probable: $y=0,20–0,45x$. $R^2=0.30$, $p<0,001$.

ROE DEER. In all-component model, only hunting pressure had marginally significant influence, ($p=0.05$; model $R^2=0.16$, $p=0.024$). Step-by-step correlation chose also hunting pressure, hence its leading role among studied factors seems probable: $y=0.16-0.89x$. $R^2=0.16$, $p<0,004$. Influence of lynx abundance is non-significant, although it is plaxed second aftet hunting pressure and including of the factor does not improve determination strength of the model ($y=0.16–0.63x–8,4*10^{–5}L$; $R^2=0.17$, $p=0.008$.).

WILD BOAR In all-component model only wolf abundance had significant influence on population dynamics ($R^2= 0.26$, $p=0.003$). Wolf abundance was also selected by the step-by-step regression ($y=0.253–0.0009H$, $R^2=0.27$, $p=0,0001$). Maximum wolf population that population that maintains stable wild-boar population ($y=0$) is from the given model in an average 280 specimen, with application of the factors confidence interval (±0.0004), 200-500 specimen. Although coming next to wolf abundance, hunting pressure has no significant effect on wild boar population dynamics and involving of this factor does not improve the description strength of the model ($y=0.30–8.7*10^{–4}H–0.155x$. $R^2=0.27$ ja $p=0.0005$).

Interpretation of the results

It must be considered that the analysis did not involve several important factors such as e.g. weather conditions. Thus the weak association is not surprising, even in the best case of moose the model described only one third of the variability. Still it is quite possible that the factors, controlling population dynamics of bear and, in great extent, also roe deer were not revealed in this analysis. The main problem with bear is low quality of original data due to difficulties in census, roe deer population in Estonia is obviously influenced by severity of winters, diseases etc.

With relatively high probability hunting pressure has been the main factor controlling wolf and moose populations, for lynx it has been abundance of the main pray species – roe deer and the wild boar is influenced by wolf abundance. The latter agrees with discovered prey preference of Estonian wolves (preferring wild boar and avoiding moose) and allows to speculate upon the size of wolf population (200 – 500 specimen) exceeding of which would cause drop in wild boar population. Using the same logic, minimum roe deer population size can be estimated (ca. 27 000), which would guarantee stable lynx population. Both mentioned criteria are fulfilled in Estonia today and thus it can be stated that although not in the best state, current roe deer population does not have negative effect on Estonian lynx as well as wolves do not endanger wild boars.