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Guidelines for the Monitoring of Lynx

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for the Workshop on the

Conservation and Monitoring of the Balkan lynx

KORA

Koordinierte Forschungsprojekte zur Erhaltung und zum Management der Raubtiere in der Schweiz.
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SPECIES SURVIVAL COMMISSION
CAT SPECIALIST GROUP

Index

1. Introduction

Monitoring rare, elusive and forest living species is a challenging endeavour. Theoretical demands have to be considered, conceptual and organisational challenges tackled, and a never-ending list of practical problems must be solved. And if all these difficulties are overcome, the economic means are often lacking to continue the monitoring programme.

There is no cheap way out. The quality and reliability of a monitoring programme depend on the investment. A good lynx monitoring system requires a clever concept, reliable data collected by skilled people, sensible analyses, and a clear reporting system. But what is a "good monitoring system"? A good monitoring system is a survey design allowing the answering of the questions asked with a sufficient accuracy. Hence we first need to know what we need to know. Typically, the results from a monitoring programme are needed to make management decisions and/or to evaluate the effect of measures taken. Therefore, certain features or population parameters need to be measured over time. Now, we can think about how to measure the relevant parameters. This depends, above all, on the species' biology and life history. The questions to be answered and the species' biology will define the method, the spatial scale or resolution and the rhythm of the data collection. When we have compiled the field data, there are three more steps to go to complete the monitoring: We need to analyse the data, to interpret and to report the results. These guidelines are not meant to provide the theoretical background of monitoring, to explain the field procedures in detail or to describe methods of data analysis. For all this, we refer to the relevant literature. The purpose of these guidelines is to explain the principles of monitoring and the options and problems of monitoring lynx. The premises are that (1) we want to monitor a lynx population, (2) that this population expands over a large, but not exactly known area and (3) that it is often impossible due to economic and logistical constraints to initiate and uphold an intensive monitoring activity over the whole of the population's range.

And now to the situation of the Balkan lynx. The purpose of monitoring this critically endangered population (probably even subspecies) of the Eurasian lynx is obvious: The Balkan lynx is now below what we can consider to be a viable population. Conservation measures are urgently needed to stop further decline and to allow the Balkan lynx recovering. In order to define adequate measures, we first need a vigorous survey of the present status of the population – distribution, density – and its ecology – habitat, prey species. A subsequent conservation programme will be an adaptive process. Consequently, we will need a continuous control of the effect of conservation measures taken, allowing adaptative responses in conservation measures wherever needed. These guidelines should facilitate the design of an initial survey, which then can be extended into a monitoring programme. The recommendations made in this document are mainly based on the experience with the monitoring of the lynx populations in Switzerland and in the Alps through the SCALP[1] process (Molinari-Jobin *et al.* 2003), with some additional perspectives from Scandinavia.

2. Species information

Any wildlife survey, surveillance or monitoring must be designed in accordance with the species' biology and the environmental conditions of the habitat. The Eurasian lynx is a medium-sized cat living mainly in forested habitats at low densities, compared to its prey species or to other medium-sized carnivores. Direct counting of lynx is impossible. Not only the design of a monitoring programme, but also the interpretation of the field data need to respect the lynx's life history, land tenure system, and feeding ecology. As no ecological studies of the Balkan lynx are available, certain assumptions must be made, which may have to be adjusted in light of increasing ecological information on *Lynx lynx martinoi*. This chapter provides baseline information on the Eurasian lynx, with special emphasis on the Balkan lynx where information is available. It summarises the species' phylogeny, biology, morphology and ecology and its relation to humans, but neither exhaustively nor in a fully referenced form. The information is taken from introductory chapters of the European Action Plan (Breitenmoser *et al*. 2000), with some updates from the recent scientific literature.

2.1. Description and morphology

The Eurasian lynx (*Lynx lynx* Linnaeus, 1758; order Carnivora; family Felidae) is the third largest predator in Europe, after the brown bear and the wolf. It is the largest felid of the continent, twice the weight of the Iberian lynx *(Lynx pardinus*) and 3-4 times that of the wildcat (*Felis silvestris*). The appearance of the lynx is very characteristic (Fig. 2.1); it has long legs and large feet, a round head with a short neck, triangular ears with black tufts, and a short black-tipped tail. The flared facial ruff is often very prominent. The claws are sharp, strong, and hooked; especially the claws of the front feet are perfect tools to seize prey. The claws are retractile to keep them sharp, and hence they do normally not mark in the footprint (Fig. 2.2).

Fig. 2.1. Eurasian lynx, subspecies *L. l. carpathicus*, in the Swiss Alps. The picture was taken by means of a cmaera trap used for a monitoring programme.

Fig. 2.2. Lynx tracks.

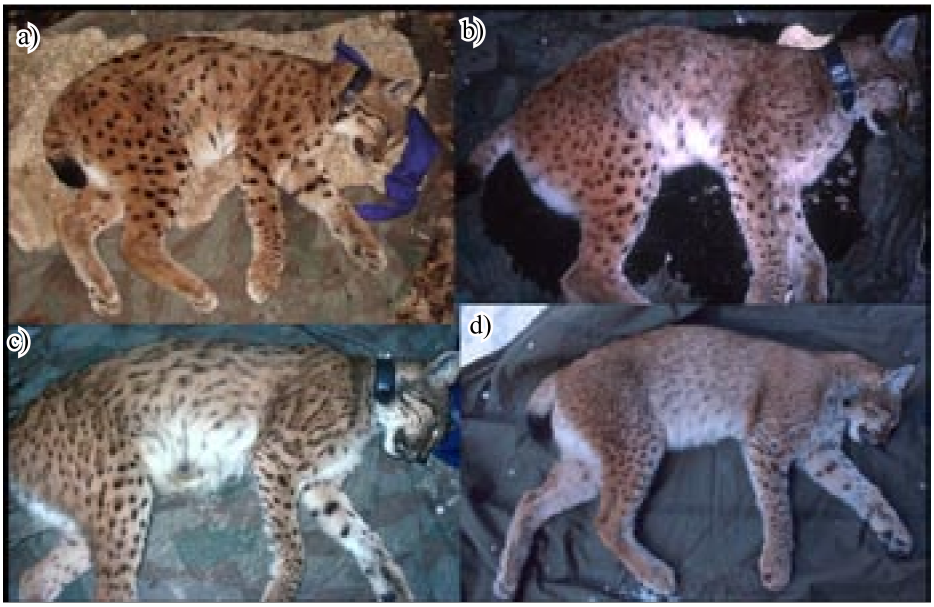


Fig. 2.3. Types of pelt pattern of Eurasian lynx as identified by Thüler (2002): a) large spots, b) small spots, c) rosettes, d) unspotted.

All lynx belong to the spotted cats. However, pelt colour is very variable within and between different parts of the distribution range. The coat is greyish with different tints (rusty, yellowish, or reddish) at the back and flanks, but whitish at the belly. There are four major coat patterns: Large spots, small spots, rosettes, and unspotted (Fig. 2.3; Thüler 2002). The pelt pattern is individually distinct; fairly good pictures allow the reidentification of an individual, a feature that can be used for population estimates. Also in the Balkan lynx, the coat pattern is very variable and can thus not serve as a characteristic for subspecies differentiation (Fig. 2.4). It is said to be smaller in body size (up to 25 kg at maximum), but according to Mirić (1978) the only reliable biometric variables clearly distinguishing the Balkan lynx from the other *Lynx lynx* subspecies are the smaller condylobasal length and zygomatic width (skull measurements).

Sexual dimorphism is pronounced in lynx, males being larger than females. Lynx from northern and eastern regions are larger than individuals from more southern latitudes or the west. This general pattern is however blurred by the differences between subspecies. Lynx from the Carpathians, for example, are relatively large, although they belong – within the species‘ total range – rather to the western and southern parts of the species’ area. Body mass of adults ranges between 12–35 kg; reports of body weights of lynx over 40 kg are doubtful. Total body length is 70–130 cm; shoulder height about 65 cm.

Fig. 2.4. Two individuals of the Balkan lynx. Collection of the Macedonian Museum of Natural History, Skopje.

Fig. 2.5. Skull of an adult male lynx from the Swiss Alps.

The snout of the lynx is short, giving the skull a round and high shape (Fig. 2.5), providing a high biting force of the canines. The intermediate part of the skull between the facial part and the brain-case is very small, and the skull crests are often poorly developed. The mandible is short and massive with a wide ramus and strong processes. Lynx have 24 deciduous and 28 permanent teeth.
The dental formula is:

$$I\ \frac{3}{3}\ C\ \frac{1}{1}\ P\ \frac{2}{2}\ M\ \frac{1}{1} = 28$$

2.2. Lynx biology and life history

Reproduction and mortality: Mating takes place from February to mid-April (Balkan lynx January to February according to Mirić 1981). Males follow the females to check their reproductive status. During these weeks, tracks of the two adult lynx can be found together. However, it is not always easy to interpret these tracks, as the cubs of the last year may still be with the female and track size of the subadults have almost reached adult size. During mating season, lynx are more vocal, though the characteristic lynx call – a far-reaching, melodic "miaou" – can be occasionally heard throughout the year. Lynx have induced ovulation. Oestrus lasts about three days, and a male accompanies the female all that time, copulating often. Birth takes place after 67–74 days, usually in late May. Litter size varies from 1–5, but most often, 2–3 kittens are born. A newborn lynx cub weighs about 300 g. Kittens follow their mother until the next mating season (Fig. 2.6). They leave the mother at an age of 10 months, when they have a weight of 9–14 kg. Females are sexually mature at the age of two years, whereas males usually mate for the first time when they are three years old. Lynx can be sexually active for a relatively long time; in nature, females reproduced at least until 14 years and males until 16–17 years.

The lynx has no natural enemies. Sporadic cases of lynx killed by wolves, wolverines, and tigers have been reported. A large prey animal – e.g. a chamois with its sharp hooked horns – can also fatally injure a lynx during the fight. Lynx can suffer from various parasites and diseases, such as rabies, sarcoptic mange or parvovirus. The natural mortality among juvenile lynx is high, about half of them do not reach adult age. Currently, the main mortality factors are man-caused, such as hunting, poaching or traffic accidents. Lynx were reported to live up to 17 years in the wild, whereas in captivity, they can reach an age of 25 years. The medium age of resident animals in a population is however much lower, about 4-5 years.

Fig. 2.6. Female lynx with young (just before separation) in the Swiss Jura Mts.

Demography and population dynamics: Under natural conditions, lynx density depends on prey availability and is limited through social interactions among lynx. There is no evidence for the widespread belief that the number of lynx is inversely correlated with the number of wolves in the area. In the cultivated landscape, man is the ultimate limiting factor of lynx density. In Poland, lynx density (adults) ranged 1.9–3.2 individuals per 100 km^2 (2.8–5.2 ind./100 km^2 including kittens). In Switzerland, density of independent individuals ranged 0.94–2.10 ind./100 km^2. From southern Norway, an area with a low roe deer abundance, a density of 0.25 ind./100 km^2 was reported. In a newly occupied area in south-central Sweden, lynx density was estimated to be around 1 ind./100 km^2. In Poland, sex ratio in the lynx population was 1:1. Adult males constituted 29% of all lynx, reproducing females 23%, kittens 35%, and subadults 12%. The abundances presented here were found in field studies using radio-telemetry and other sophisticated methods such as camera trapping. When densities are calculated from the number of lynx estimated and the area occupied, densities can be considerably higher. However, such high densities are often the consequence of an improper census method overestimating the number of lynx.

2.3. Habitat and land tenure system

The lynx inhabits forested areas in most of its range. Only the Central Asian subspecies *L. l. isabellinus* lives in a treeless environment. In Europe, the lynx used to live in all types of forest from the Mediterranean deciduous forests to the northern boreal forest. Today, the lynx is restricted to the remaining large forest complexes of the continent. In many areas, the recovery of the species was supported by the expansion of forests during the 20th century.
Lynx are solitarily living animals, except for females and the young of the year. Both males and females occupy individual home ranges ("territories"), which they mark with gland secretions, urine and maybe faeces[2]. The females choose their territories according to resources, e.g. prey and habitat, they need to raise kittens, the males set up territories to grant access to females. The home ranges of the males are larger than those of females; they monopolise one or two, rarely more females. Consequently, home ranges of males overlap to a certain extent, whereas ranges of females overlap only slightly, and sometimes do hardly touch (Fig. 2.7). In Scandinavia, some few mothers have been observed to have totally overlapping home ranges with their adult daughters.

Home range sizes vary considerably depending on habitat type, composition of prey community, and the availability of prey. Furthermore, reported home range size depends to a large extent on the method and duration of investigations. According to the literature, individual home range size ranges from 25–2000 km^2. Studies based on telemetry have brought precise estimates of mean home range size of lynx in Europe: 180–2780 km^2 for males and 98–759 km^2 for females. The highest values were found in the northern or mountainous regions of Scandinavia. Mirić's (1981) data of 18–38 km^2 (mean 30 km^2) for a Balkan lynx' home range are rather small and need verification by means of reliable monitoring methods like radio telemetry.

There is little seasonal variation in the home range size of males, but females occupy very small home ranges while nursing kittens (late spring to summer). In Scandinavia, female lynx roamed over 33–100 km^2 during the first eight weeks following birth, and then extended their home ranges gradually until winter. Distances travelled by lynx per night ranged from 1–45 km. The highest movement rates are observed

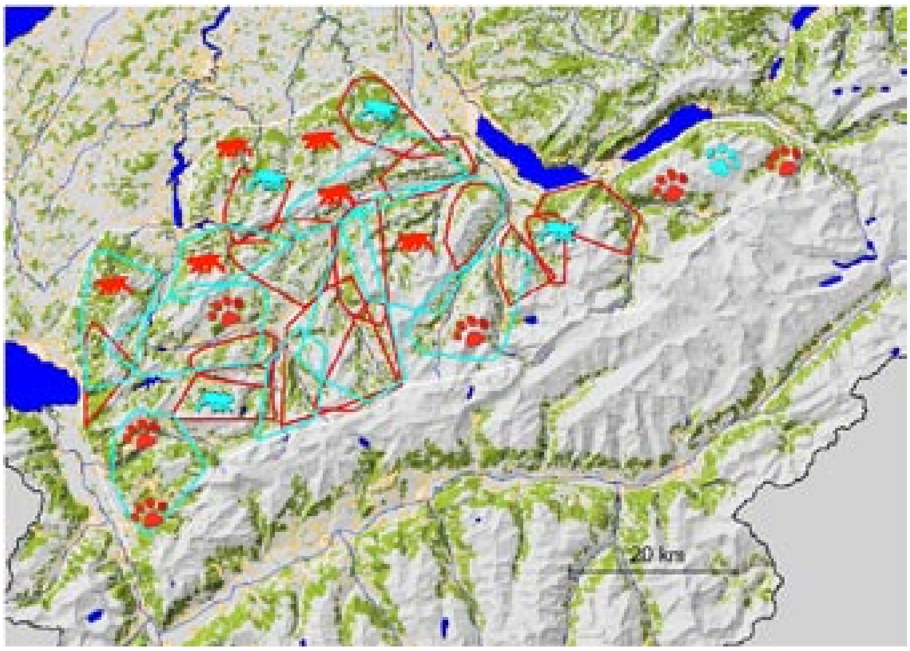


Fig. 2.7. Land tenure system of a lynx population and individual home ranges as revealed by means of radio-telemetry. The example shows the pattern of lynx home ranges in the north-western Swiss Alps in the years 1997–1999. Home ranges of radio-tagged lynx are indicated as outline polygons (males, females), lynx identified by means of camera trapping are shown as lynx symbols, other resident, but not individually identified lynx as footprint symbols (from Breitenmoser-Würsten *et al*. 2001).

in males during the mating season. Females with kittens, on the other hand, usually travel over relatively short distances. When a lynx has a fresh kill, it stays in its proximity for several days. The activity pattern is determined by sunrise and sunset. Lynx are mainly active at dusk and at night, and rest during daytime (Fig. 2.8), except for the rutting period when lynx are active also during daytime.

Habitat use, land tenure system and expected density are important factors to consider when designing a monitoring system; e.g. transect lines, spatial pattern of camera-traps, or the spacing of a grid of informants must be adjusted to these features.

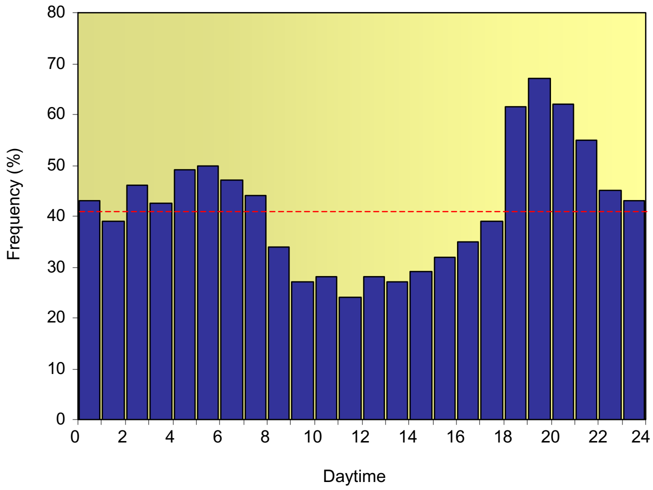


Fig. 2.8. Activity pattern of lynx in Switzerland (from Bernhart 1990).

2.4. Feeding ecology

The prey of lynx range in size from mice to moose, but the main prey of Eurasian lynx are small ungulates and hares. The genus Lynx is generally specialised for hunting lagomorphs, the Eurasian lynx, however, has evolved into a hunter of small ungulates in many parts of its range, most prominently in Europe. Only in north-eastern Europe mountain hares are the main prey. From among the ungulate guild, lynx select the smallest species: roe deer (Fig. 2.9), chamois, or musk deer. In northern Scandinavia, semi-domestic reindeer are in some areas the most frequent prey. The young of larger ungulates such as red deer, moose, or wild boar will sporadically fall prey to lynx. In areas with low ungulate availability, lagomorphs, birds and rodents can be an essential part of lynx diet. Lynx diet varies seasonally; small prey and young ungulates are killed mostly in late spring and summer. The composition of the Balkan lynx' diet is not really known, however some people suppose the hare to play a mayor role compared to other lynx subspecies (Fig. 2.10).

A lynx's consumption rate averages 1–2.5 kg of meat per day; after some days of fasting, the proportion eaten in one night can be much higher. Wherever lynx prey on large ungulates (red deer, wild boar), the youngest prey category is selected. In roe deer, however, which has the same body mass as the predator, all age and sex categories are preyed upon. The impact of lynx on prey populations has been widely, and controversially, discussed. Lynx do not eradicate their prey, but in marginal habitat or in specific situations, the predation impact can be considerable. Data about lynx-prey relationships from scientific studies are steadily accumulating, but it is still difficult to fit all the local and temporal studies into one general picture. At the edge of the roe deer's range in northern Europe, lynx were able to kill 30% of the roe deer population on a yearly basis. In Switzerland, re-introduced lynx were able to considerably reduce roe deer or chamois abundance in certain situations. The system can be very dynamic. In the north-western Swiss Alps, lynx killed only 6–9% of the roe deer population in the mid-1980s; about ten years later, the predation impact in the same area was estimated to be 36–39%. In Poland up to 36% of roe deer and 13% of red deer were taken by lynx. The influence of lynx predation on a local ungulate community depends on the structure, and especially the density, of the prey community, age and sex structure of the ungulate population, number and social structure of the lynx population, other causes of mortality and abiotic factors. Lynx can show a considerable numerical and functional response to changes in prey abundance and availability, and consequently, lynx predation is an important factor shaping the density, the distribution, and the behaviour of the main prey species. On the other hand, lynx also depend mostly on one or two staple prey, and a reduction in prey abundance or availability can quickly lead to a reduced lynx abundance and threaten a local population.

All reviews of depredation by lynx concluded that livestock losses (sheep, goats, poultry) to lynx are relatively low compared with those to other large predators, and that in most European countries, the lynx is not regarded as a major problem to livestock husbandry (see Kaczensky 1996, 1998, 1999). This seems also to be true for the Balkan lynx range countries. The exception is Norway, where the number of sheep killed by lynx has steadily increased over the past years and reached some 7'000–10'000 from 1996–2001. Depredation on sheep is a consequence of unattended grazing in carnivore habitat. This form of sheep husbandry is typical for regions where large predators have been absent or scarce for a long time. In the re-introduced lynx populations in the Swiss Alps or in the French Jura Mountains, depredation caused severe public conflicts, although the number of sheep killed by lynx was low compared to the losses from other causes. The problem was more psychological: farmers had lost the tradition of coexistence with large predators and did not accept the lynx as part of the natural system.

In all European countries where depredation by lynx occurs, compensation schemes have been implemented to mitigate the conflict with livestock breeders (von Arx *et al*. 2004). In most cases, the losses have to be reported by means of standardised forms, and in many countries, special approval systems have been established, e.g. the examination of the cases by a trained inspector like a game warden. These cases can form an important part of the monitoring database system.

Fig. 2.9. Roe deer (*Capreolus capreolus*) is the lynx' main prey in Europe. The lynx kills with a bite to the throat and starts to eat at a hindquarter.

Fig. 2.10. Hares can be an important part of the lynx' diet, especially where larger prey are scarce. Camera trap picture from the Swiss Alps.

3. Aims and principles of monitoring

3.1. Why monitor?

Conservation and management decisions should be based upon sound knowledge of the situation of a species or population. In order to know the status of a rare species of special concern, a field census must be carried out, and the population(s) must be monitored over time. Repeated censuses of a population on a regular basis allows the detection of changes in the population over time. Long-term census records can help to distinguish long-term population trends of increase or decrease from short-term fluctuations (Primack 1993) or random or methodological variation.

Monitoring is a process rather than a product of a scientific activity, and consequently cannot be defined independently from the overlying conservation plan. Hellawell (1991) proposes the following definitions:

(1) Survey: The compilation of qualitative or quantitative data by means of standardized procedures in order to define a status (e.g. a national survey, a single investigation into the status of a species).

(2) Surveillance: A series of surveys in order to ascertain a dynamic process, or the range or the variability of states (e.g. surveillance of epidemics, the progress of an invading species).

(3) Monitoring: A regular and structured surveillance in order to ascertain the compliance of a measure with an expected norm or a standard (goal) to be reached (e.g. recovery of a endangered population to a viable status).

According to this definition, monitoring is a series of surveys, of which the results are continuously compared with a desired goal (Fig. 3.1), whereas a surveillance observes a process without a clearly defined destination. The objective-oriented approach and the inherent feed-back distinguishes a monitoring program from a simple survey.

For the purpose of these guidelines, we furthermore distinguish two principle approaches:

(1) Passive monitoring: A monitoring system making use of data and information that were not gained specifically for the purpose of monitoring the species or population. Of course, the collection, compilation and analysis of such data is an active process, but the original data were collected for another purpose, randomly or not, and will most likely be biased.

(2) Active monitoring: The gaining of data and information specifically for the purpose of monitoring a species or a population. Scale, resolution, and rhythm of field activities as well as the methods used consider the objective of the monitoring system, the species' biology and the environmental conditions so that the data have the least possible bias and the result of the monitoring can directly answer the question asked with an absence of bias.

In the proper sense of the term, monitoring is what we call "active monitoring". However, in the real world of large carnivore conservation, where we always struggle for a sufficient amount of data and information, the "passive monitoring" approach – make use of whatever you get – will always be a realistic and essential part of the monitoring. The design of a monitoring programme includes the following steps:

(1) Definition of the objectives to be reached;

(2) Repeated measuring of parameters in order to describe the dynamics of the process being monitored;

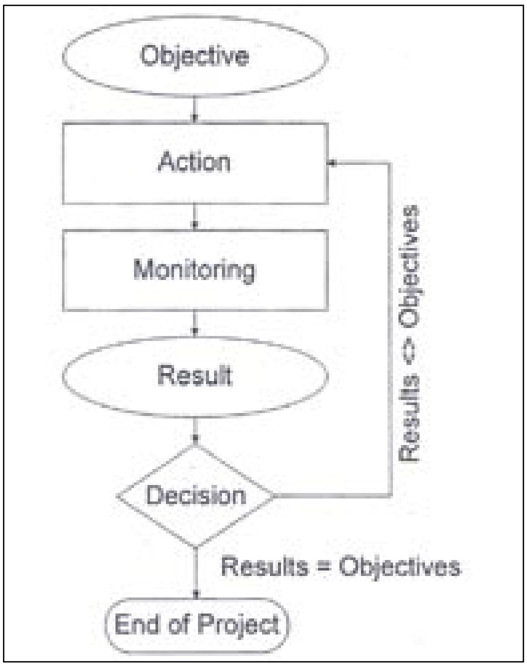


Fig. 3.1. Flow chart of a monitoring programme. The monitoring allows supervising the efficacy of conservation actions. As long as the Result does not match the Objective, further actions have to be taken and the monitoring programme is continued. The Objective defines the goal of the conservation programme, e.g. "recreate a viable population", or more concrete "the population comprises 1000 individuals". Then, Action is carried out to change the situation in the field allowing the population to increase. After an initial survey, the Monitoring allows comparing the status of the population (Result) with the Objective on a regular basis (e.g. yearly). As long as the Result does not match the Objective, the Action (adjusted or not) and the Monitoring is continued.

(3) Evaluation of the objectives against the outcome of the repeated measuring and decision on the adjustment of the Action (Fig. 3.1) and the continuation of the monitoring.

The parameters to be measured, the methods to be applied, and the repeat-time of the field work depend on the objective (Fig. 3.1) to be reached and on the timetable to reach them. To design a monitoring project, we should answer the following five basic questions (Roberts 1991, Usher 1991):

(1) Purpose. What is the aim of the monitoring project? What questions need to be answered?

(2) Method: How can this be achieved? Which parameter(s) do we need to measure? Which method(s) can be used to collect the data needed?

(3) Analysis: What analyses and statistical tests will be used? What sample size, quality or accuracy of data is needed, and what is the best repeat frequency?

(4) Interpretation: What might the data mean? Will the interpretation approve decisions and allow the adjustment of the actions (Fig. 3.1) if needed?

(5) Fulfilment: When will the objective of the actions (Fig. 3.1) be achieved?

Thoughtful answering of these questions before starting the collection of data will help to delineate an efficient monitoring program.

3.2. What can be monitored?

Any dynamic process aiming for a certain destination can be followed through a monitoring programme. For the purpose of species conservation, the features being surveyed include distribution, population size and trend, abundance, health and genetic status. Parameters can be measured directly or indirectly, in absolute or relative figures.

Distribution. The most basic information about a species is its presence in a certain spot, or, if a larger area is surveyed, its distribution. Surveys of species distribution are widely used for the production of mammal or bird atlases, and show in which areas a species is present, and where it is absent. The area can be described as an outline polygon – well known from bird field guides – with no differentiation within the distribution area, or in form of occupied and unoccupied raster-cells, allowing the identification of gaps in the continuous distribution. In the context of large carnivores, it is vital to separate between the distribution of reproducing individuals and the total distribution, because males of most species can have long dispersal distances and unstable home ranges before establishment (Zimmermann 2004). This can lead to the temporary and occasional presence of individuals in large areas where no reproduction occurs. Lynx usually have, when compared to other large carnivores, a rather compact distribution pattern, but there can nevertheless be a significant difference between the total area occupied (Fig. 3.2) and the areas of reproduction (Fig. 3.3).

Population trend. As well as knowing the distribution of a species, it is possible to record its relative abundance in different areas without estimating numbers. The frequency of direct or indirect signs (e.g. tracks, number of known mortalities, livestock killed, etc.) can be used to detect a population trend in a given area or over time in the same area if recorded consistently in a standardised way over time (Fig. 3.4). Indices are becoming more commonly used mainly because of the problems with obtaining precise counts or population estimates. One problem with indices is that we often do not know how they are related to changing population density. A common assumption is that they are a linear function of population density, which is however often not the case. Movements of lynx (measured as the average day-to-day displacement) e.g. is negatively correlated to home range size, indicating that transects recording tracks of lynx may be biased when calculating a population index. Another example is depredation. The number of attacks on livestock depends not only on the lynx density and availability of sheep, but also on the abundance of wild prey such as roe deer, the form of livestock husbandry, on landscape features (relation of pastures and forests) and most likely on the behaviour of individual lynx.

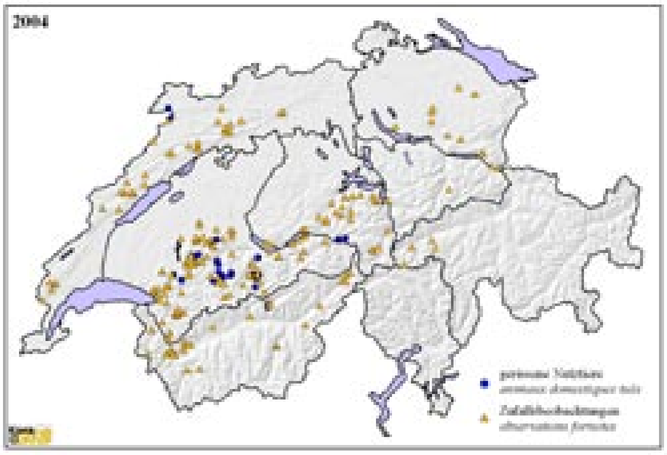


Fig. 3.2. Distribution of random lynx observations (yellow triangles) and livestock killed by lynx (blue dots) in Switzerland in 2004.

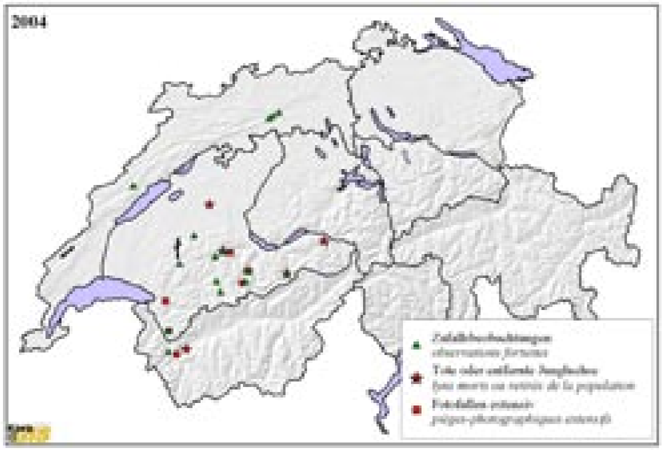


Fig. 3.3. Confirmed signs of lynx reproduction (green triangles: random observations; red stars: young lynx found dead; red squares: evidence from photo-trapping) in Switzerland in 2004 (from Zimmermann *et al.* 2005).

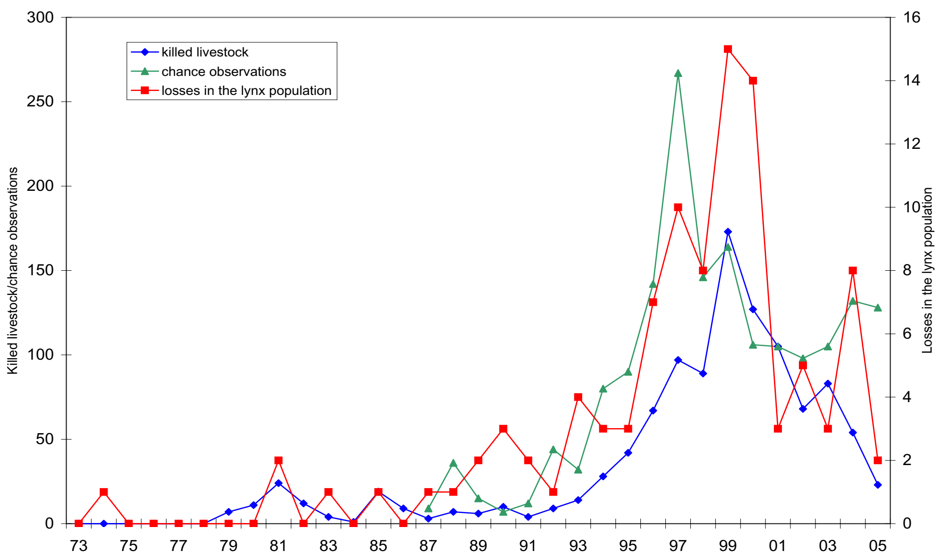


Fig. 3.4. Parameters that reflect the trend of a lynx population in Switzerland. An important increase in the mid-1990s was reflected in the known mortalities, the number of killed livestock and the occasional observations (KORA).

Abundance. Rather than trying to count all individuals present within a study area, population estimators attempt to sub-sample the population and calculate the proportion of individuals that are not counted. Methods such as mark-recapture belong to this category. These methods generally produce an estimate of statistical error that can be expressed as a confidence interval. Large carnivores – which occur at low densities – and especially small populations are problematic to estimate with capture-recapture approaches, as the error tends to be quite large. This can be partly compensated for through an increased sampling effort (e.g. use more camera-traps, make more transects, etc.), but there are most often limits due to restricted (financial) resources and limited favourable time for fieldwork.

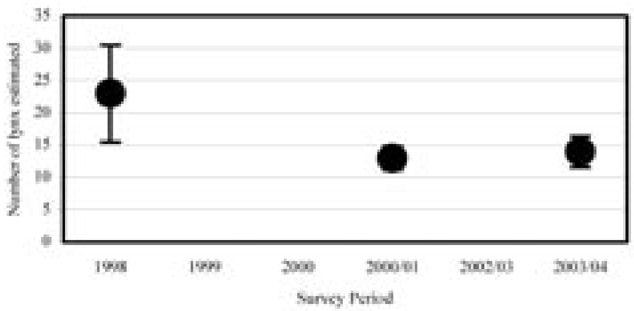


Fig. 3.5. Population estimation of lynx in the Swiss Alps. The estimation is based on the mark-recapture method with pictures from photo traps. The dots represent the estimated population size and the bars the error.

Health and Genetics. Viral and bacterial diseases and parasites may have a considerable effect on large carnivore populations. Especially small, threatened populations – which are always restricted in range – may suffer crucial losses. Consequently, the health and condition of individuals within a population should also be part of a monitoring programme (Nowell & Jackson 1996; Ryser-Degiorgis 2001). Such data can be obtained from individuals found dead (Stahl & Vandel 1999; Schmidt-Posthaus *et al*. 2002) or from animals handled during captures. For very small populations that have experienced a severe bottleneck it is also important to look for inbreeding depression correlates (e.g. heart problems, skeleton malformations, cryptochridism; Ryser-Degiorgis *et al*. 2004). Genetic assessment of a population allows detecting genetic drift and loss of genetic variability. The Balkan lynx population is extremely small and has been isolated for a very long time. Gaining information on the health status and the genetic structure is very important, even more because the subspecies status needs further clarification.

3.3. Biases and pitfalls

The data and information collected during the monitoring programme must be adequate (they must match the questions) and precise (they must fulfil the statistical requirements). If the monitoring is both adequate and precise, it allows us to answer the questions asked, to supervise the effect of the (conservation) actions and to initiate corrections where needed. According to Pelton & van Manen (1996), the most common pitfalls in a monitoring project are the following:

(1) Data bias: The data collected are not adequate or not representative for the question to be answered.
(2) Sampling sites: The test or sampling areas are not representative for the entire population. The test area might be in the wrong habitat type or too small.
(3) Time scale: The duration of the data sampling does not allow the determination of the dynamic process involved (Fig. 3.6; Magnuson 1990). Short-term population fluctuations or random variation hide longer-term trends.
(4) Interpretation: The interpretation of the results is not generally accepted.

Monitoring programmes for reintroduction or recovery projects usually do not have a problem with the sampling sites, as the study area is clearly defined. They however often face the problem of the time scale – the recovery of a population normally takes longer than originally planned –, and with the difficulty that not all interest groups involved agree with the interpretation of the findings and the conclusions drawn from the monitoring. It is therefore important that the interpretation of the results and the decision making in relation to the outcome of the monitoring programme is discussed among the interest groups in advance (→ chapter 6.2).

A common problem in many monitoring programmes is the existence of biases in the data sets. While biases in "active monitoring" (→ chapter 5) can be minimised through careful design of the programme; it is almost impossible to avoid biases in data sets gathered in a "passive monitoring" (→ chapter 4; possible biases of the different datasets are discussed there). As we most often for practical reasons cannot do without these "cheap" data, the only solution is to (1) be aware of the bias, (2) to correct for the bias as well as possible, and (3) to consider the bias in the interpretation of the results.

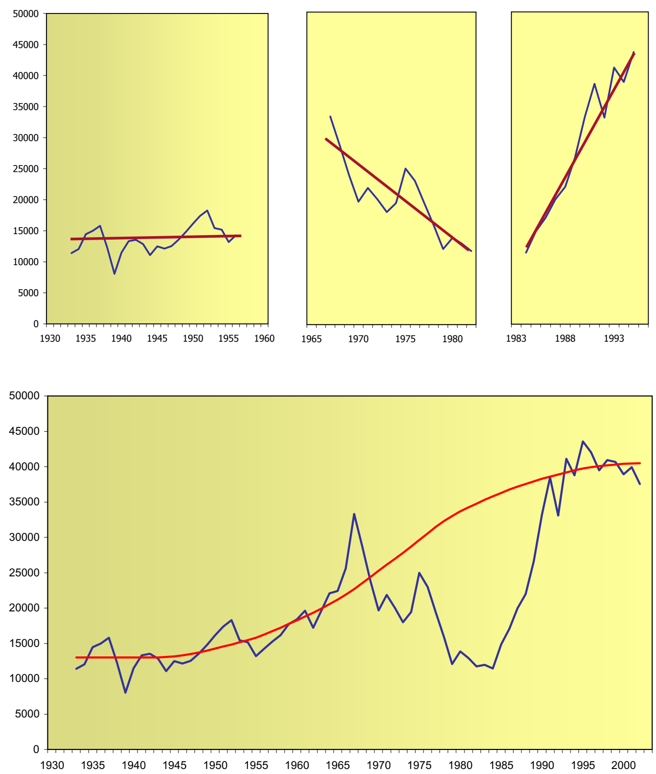


Fig. 3.6. Three different time segments (a-c) of the same set of data (d), the number of foxes hunted in Switzerland. The data in (a) suggest a fluctuation, in (b) a decrease and in (c) a strong increase of the populations. The long term surveillance reveals a gradual increase of the population (d) that has reached a asympotic value at the turning of the century. The dip in the population in the1980s was due to a rabies epidemics.

3.4. Stratified monitoring

Large-scale and long-term projects such as re-introduction or recovery projects of large carnivores have some very specific problems relevant to their monitoring:

(1) Large carnivore populations are often distributed over several countries with different administrative systems (and often with different languages). Several administrative units and levels, private organisations and scientists may be involved, and communication becomes a real challenge.

(2) The large size of the survey area does not allow all areas to be covered with the same intensity.

(3) The status of a population can vary from one region to the next and therefore management or conservation measures may differ between regions.

(4) The time scale is unpredictable. The recovery and expansion of a population of large carnivores depends on so many factors – which will change over time – that it is extremely difficult to estimate the duration of the project.

These difficulties complicate the design of a monitoring programme. Because financial resources are most often restricted and only granted for a limited number of years, a stratification of the project and the monitoring in space and time is required. We outline here a stratified monitoring concept with four levels of observation (Table 3.1), representing different geographical, biological and administrative units, different precision of question asked and intensity and accuracy of procedures applied. In a single range country, especially if it

Table 3.1. Model of temporal-spatial stratified monitoring.

Level	Unit	Definition	Example
IV	Biology	Range, part of the range	For the lynx e.g.
	Geography	Distribution range of the species, continent	Europe
	Questions	Distribution, occupied area, changes in the range, taxonomy	
	Methods	Presence/absence, reports of local observers, expert model, questionnaire, literature, genetics	
	Frequency	Multi-year rhythm	e.g. every five years
	Responsability	EU, Council of Europe (Berne Convention), international NGOs	
	Performance	LCIE, national correspondents	
III	Biology	Metapopulation, population	Alps, Dinaric Mts, Carpathians
	Geography	Region: e.g. mountain range	
	Questions	Distribution, expansion, population trend, relative abundance, fragmentation, viability	
	Methods	GIS models, PHVA, questionnaire (game wardens), expert model, genetics, sign survey, snow tracking, transects	
	Frequency	Multi-year rhythm	e.g. every 3-5 years
	Responsability	Countries, regional convention or organisation	
	Performance	International expert group, multi-national NGO	e.g. SCALP expert group in the Alps
II	Biology	Subpopulation, local population	
	Geography	Country, part of a country (region, province), topographical unit (compartment)	North-western Alps
	Questions	Population dynamics, abundance, status (sink - source), conflicts, management	
	Methods	Occasional observations, known mortalities, network of contacts, kills (wild and domestic), extensive camera trapping	
	Frequency	For most methods continued	
	Responsability	National authority	Ministry of environment, national wildlife service
	Performance	National service or contracted expert group	
I	Biology	Individuals, local part of population	
	Geography	Study area, part of a compartment	Simmental, national park
	Questions	Social and spatial structure, space use, density, demography, diet, habitat use, health, conflicts	
	Methods	Direct observation, capture-recapture, telemetry, intensive and extensive camera trapping, genetic and pathologic research	
	Frequency	1-2 years or continued	
	Responsability	National, regional authorities	Wildlife Service
	Performance	Experts	University, KORA

covers only part of a larger population, two or at most three levels of this stratified monitoring will be realised.

Top-down, from level IV to I, we ask more specific questions, whereas bottom-up, from level I to IV, we give answers that will allow the calibration, or at least the assessment, of the data gained with less intensive and cheaper methods over a larger area. It is not possible to "count" lynx for a whole country or population, at least not without the massive investment of economic and organisational resources. Chance observations and even census data such as number of tracks or scent marks found along transect lines can provide relative density indices and relative population trends at best, but in order to get an idea of the absolute figures, more precise data are needed for calibration. Such data can be gained in much smaller study areas, where more sophisticated methods such as radio-telemetry or systematic camera trapping allow the estimation of home range sizes, spatial structure, or density estimates by means of capture-recapture techniques. Such findings can then be used to calibrate and interpret the information gained with less expensive methods over a larger area. Calibration might not be straightforward, but more detailed knowledge from smaller test areas will at least allow the estimation of the magnitude or possible range of the relative data on an absolute scale.

For the calibration process and the presentation of monitoring data over a large scale, we need a standardized interpretation of the data and information collected on local scale. This includes a common terminology and an agreement on how to classify the data. For the monitoring of the lynx throughout the Alps in the frame of the SCALP surveys, the following terminology and standards were developed to coordinate or at least compare the different monitoring systems in the seven countries involved (Molinari-Jobin *et al*. 2003):

The collected data are classified in three categories:
Category 1: "Hard facts", verified and unchallenged observations such as (1) dead lynx, (2) orphaned young lynx or lynx captured, (3) clear photos of lynx, and (4) samples (e.g. excrements) attributed to lynx by means of (genetic) laboratory analyses.
Category 2: Observations controlled and confirmed by a specialist (game warden, wildlife ranger, biologist, trained member of the network, etc.) such as (1) killed livestock or (2) wild prey, (3) lynx tracks or other field signs, (4) scats, and (5) documented (recorded) and confirmed lynx calls. Category 2 data encompass a certain uncertainty; e.g. a kill can be erroneously be attributed to a lynx, even though experienced observers most often have no problem to identify a lynx kill. They are however collected and reported in a consistent way (most often by means of prepared forms) by trained staff and build the core of the set of chance observations used for the monitoring.
Category 3: Unconfirmed category 2 observations (kills, tracks, excrements, calls) and all unverifiable observations such as direct observations.

The classification of the observations in different categories is a first step in the analyses and already includes a degree of interpretation. Especially the attribution of direct observation to category 3 has triggered many disputes. Sightings cannot be confirmed and are therefore difficult to handle. Most of the direct observations reported are probably correct, but the fact that a lot of sightings come from areas, where no category 1 or 2 data are available, suggests that they should be handled with care. Repeated sightings – or other category 3 data – may indicate a newly settled or not seriously surveyed area, where more survey effort may be needed. The distribution of the data of the three categories can indeed vary considerably:

- The dispersion of C1 (Fig. 3.7) data reflects the distribution of the vital part of a population, with reproduction and mortalities. But both, dead lynx found or young lynx observed are – compared to other kinds of observations – relatively rare events, and missing just a few records can blur the picture.
- C2 data reflect the distribution of the entire population including core areas and expansion areas (Fig. 3.8). For the collection of C2 data, an expert network is needed and members need to be specially trained.
- C3 data (Fig. 3.9) are "cheap" information, because they do not depend on a trained network of observers. They are chance observations contributed by the interested public, which can be informed through media announcements. Nevertheless, advertisement can also provoke reporting; a news headline or a TV feature about lynx can trigger a lot of direct observations in the following days. The distribution in time and space of category 3 data is consequently strongly biased. It however helps to identify regions where the monitoring effort needs to be intensified.

3.5. Network of observers

Monitoring a rare and elusive species such as the lynx over a large area requires a network of well-trained observers and reporters. These people can be professional staff such as game wardens or forestry guards, who are regularly trained for this task – we call this here the official network. It is often also beneficial to involve volunteers such as hunters or naturalists into the monitoring, especially if the official network is loosely woven or if the professional staffs do not have the time, resources, capacity or motivation to fulfil the monitoring tasks. Volunteers can collect chance observation on a local scale, or can help with transects or camera trapping. Both networks must however be maintained, and this needs a considerable investment:

(1) Professionals and volunteers forming a lynx-monitoring network must be trained in identifying field signs, using the equipment (e.g. camera traps) and reporting the data.

(2) All members of the network must get a feedback; they must be regularly informed about the use of their information (→ chapter 7).

(3) The members of a network should feel as such! The co-ordinators of any network are responsible for the group identity and need to communicate on a regular basis or to organise reunions.

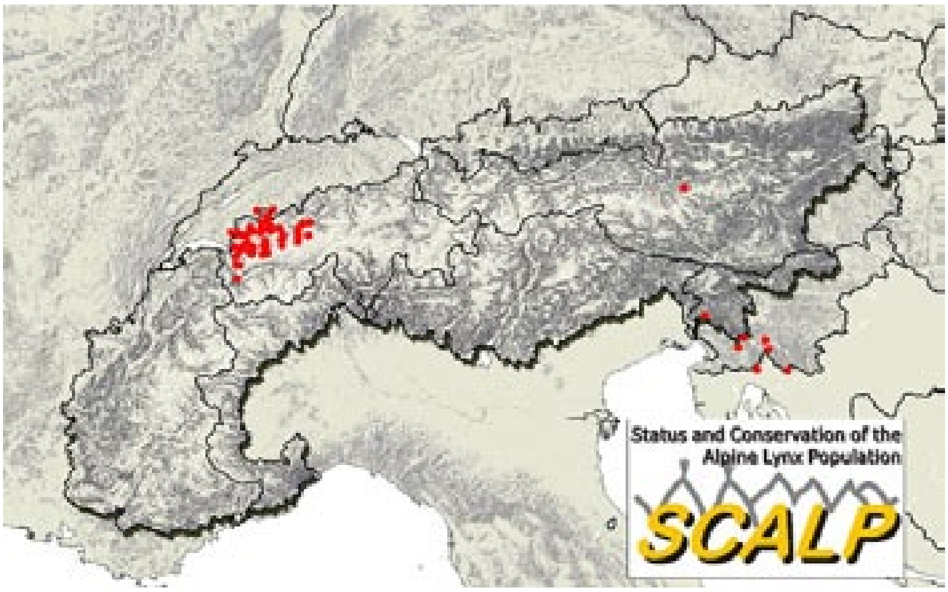


Fig. 3.7. C1 data for the lynx in the Alps 1995-1999. A core area in Switzerland and Slovenia and one record in Austria can be identified (from Molinari-Jobin *et al.* 2003).

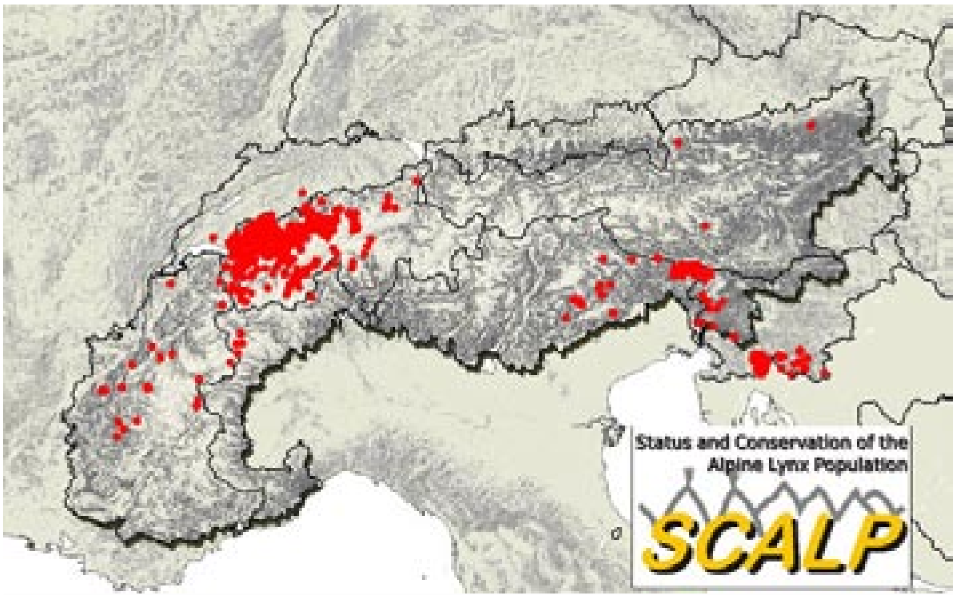


Fig. 3.8. C2 data for the lynx in the Alps 1995-1999. Besides Switzerland and Slovenia, lynx also occur in France and Italy (from Molinari-Jobin *et al.* 2003).

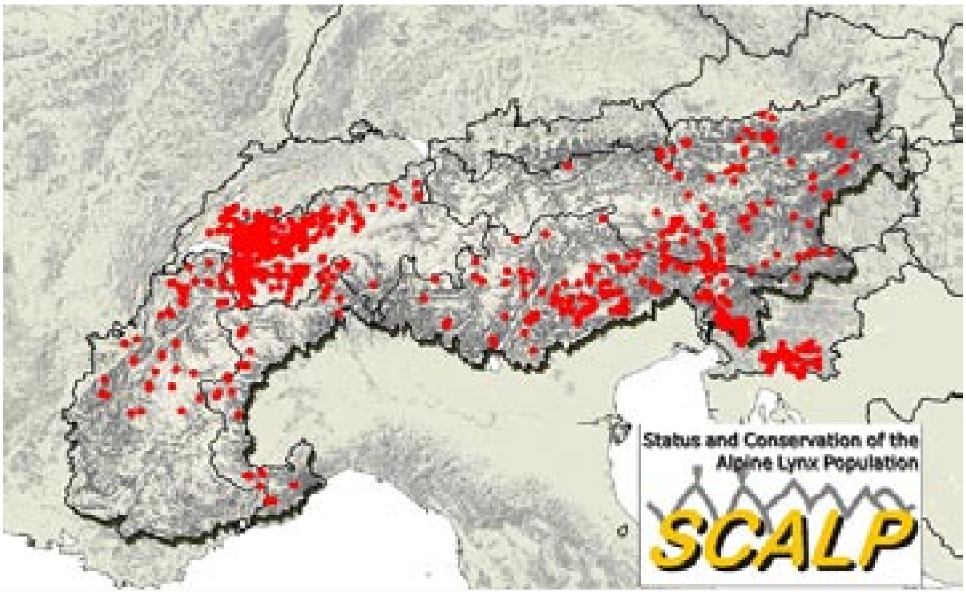


Fig. 3.9. C3 data for the lynx in the Alps 1995-1999. According to this data set, the lynx occurs all over the Alps. The monitoring needs to be intensified in Austria and Italy (from Molinari-Jobin *et al.* 2003).

4. Passive monitoring: Collecting second-hand information

The first step towards a systematic surveillance of a lynx population is to assure that chance observation or data that crop up “anyway” are reported and compiled into a database, most efficiently attached to a geographic information system (GIS). We here describe three types of information, which can be integrated into a passive monitoring system:

(1) lynx found dead,
(2) livestock or wildlife killed by lynx
(3) chance observations.

4.1. Dead lynx

Category 1 data such as dead specimens are of outstanding importance for the surveillance of any population. The value of information gained from dead lynx goes far beyond simple monitoring distribution. They provide important data on the structure and health of the population, mortality factors, and – especially important for the Balkan lynx – on genetic and taxonomic status.

Method of data collection and data quantity. Lynx found dead, either the whole carcass or parts of the body, must be collected from the entire distribution area. From a population, which is not legally hunted, they occur by chance and accidentally, therefore no sampling strategy is required. It is however important to inform all institutions possibly involved (wildlife and forest services, veterinarians, police, hunters and monitoring networks) on:

(1) How to collect a carcass or remaining parts. For pathological inquiries, all fresh carcasses should immediately be cooled (deep-freezing is not needed if the body does not need to be stored for more than several days or weeks), and the body should be brought to the pathological institute as soon as possible. For genetic analyses, blood samples[3] should be taken from live animals or very fresh carcasses, or tissue samples stored in alcohol.

(2) What data to record. A proposal for a data collection form is given in the Field Handbook. It is important to document the case by means of pictures or a sketch, and to note it on the form.

(3) Where to send parts and forms. These instructions should be given on the mortality form.

Analysis and data specific representation. Mortality data will always provide a relatively small sample. Number of losses during a certain time period can, however, confirm population trends when compared with other information (Fig. 4.1, 4.2). The data can also be presented regarding the age structure and sex ratio or according to the seasonal occurrence of the losses in the different age classes. Dead lynx furthermore provide source material for morphological studies (skeleton, skull, pelt), genetic analyses and a veterinary examination, what may be important to identify pathological threats (causes of death).

Interpretation. Mortality data are tricky to interpret, as high losses can indicate both an increasing or decreasing population. The evolution of the losses represents the population trend only over a longer period and with a delay of a few years. For an interpretation of mortality data over much shorter periods, they need to be compared with other datasets (Fig. 3.4). Then, mortality data can be an additional indicator for short-term trends. The rate of finding of dead lynx is however not the same in all regions, and may depend not only on the population density, but also on habitat, abundance of observers and reporting structure. Therefore, mortality data have to be assessed for each region separately (Fig. 4.1, 4.2).

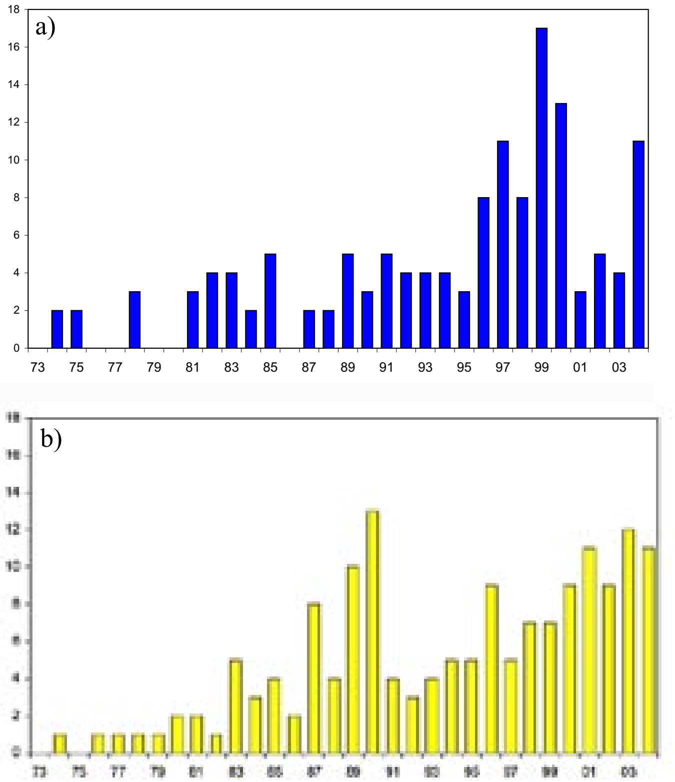


Fig. 4.1. Known losses to the two lynx populations Alps (a) and Jura (b) in Switzerland 1990–2004. Although the numbers are small, the fluctuations especially in the Alps are consistent with the development of the population as derived from other indicators (from Zimmermann *et al*. 2005).

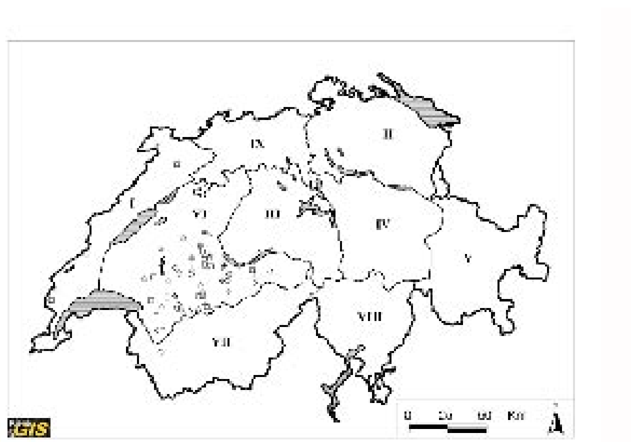


Fig. 4.2. Origin of the known death of lynx in Switzerland from 1996-2000. circle = 1996, square = 1997, triangle = 1998, cross = 1999, and star = 2000. The distribution of the dead lynx underlines the predominance of the lynx distribution in the north-western Alps during this period. The roman numbers stand for each management unit in Switzerland (from Breitenmoser-Würsten *et al*. 2001). (The management compartments have changed since.)

Reporting. All lynx mortalities should be presented in the yearly reports and periodic status reports. Special questions (e.g. pathological information) can be complied and reported in specific publications.

Effort for the data collection and analysis. The effort relies on the number of losses, and varies between years. Specialised institutions (pathological institutes, zoological museums) must be involved in the analyses, compilation of data and for the storage of any biological samples in scientific collections. The effort required for a detailed analysis and data collection (e.g. age determination by means of tooth cuts, genetic analysis, etc.) can be considerable.

Infrastructure requirements. Forms, computer database and GIS system. Specific institutes for pathological analyses and data storage (museum collection).

4.2. Livestock and wildlife killed by lynx

Killed wild or domestic ungulates belong to the most frequent and easiest to confirm signs of lynx presence. Small ungulates, above all roe deer form the staple food of lynx in Europe, and they are handled in a very typical way in most cases easily identified by a trained person. Kills of livestock such as sheep more often deviate from the "classical picture" (see Field Handbook), but are generally not difficult to distinguish from kills of other medium-sized and large carnivores, as lynx are the only felid predator of ungulates in Europe. Identification of the predator responsible for killing small prey items, such as hares, may be very difficult in the absence of snow as a tracking medium.

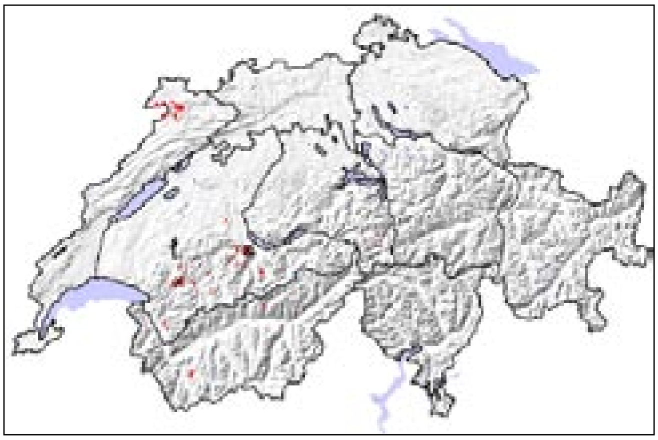


Fig. 4.3. Distribution of the compensated livestock (sheep, goat, and fallow deer) killed by lynx in Switzerland in 2001. The size of the points is proportional to the number of animals killed per flock. X = shooting permit for a damage-causing lynx which wasn't executed, circled X = lynx shot at a sheep. (from Angst *et al.* 2000)

Method and data quantity. Killed livestock and wild prey animals confirmed by an experienced observer provide a very reliable indication of lynx presence. In many European countries, verified livestock kills are compensated by the state, and a trained network of game wardens, foresters, etc. has been established to confirm reported kills. Because reporting and examination is mandatory to receive the compensation, the degree of registration is high for livestock. Wild kills are an even better indicator, but the probability of finding and reporting is much lower than for livestock. All lynx kills discovered should be correctly examined and reported. This requires a well trained and motivated network of observers, but also a high degree of awareness among hunters, farmers, foresters, and the general public to report potential lynx kills in the survey areas. Data recording and reporting is done by means of specific forms (see Field Handbook), which are generally mandatory for livestock compensation, but can, in a simpler form, also be used to record wild kills. Fresh kills found are very good spots to install camera traps in the frame of an extensive camera trapping programme (→ chapter 5.3).

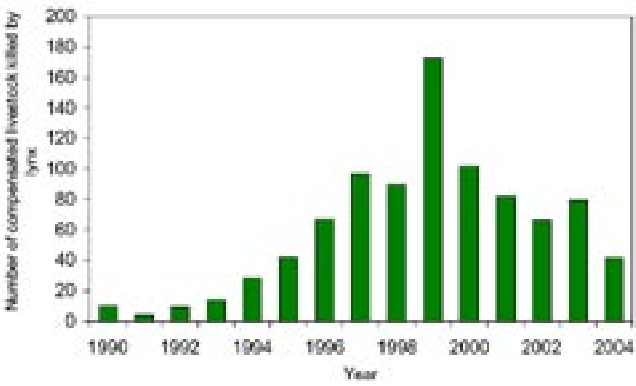


Fig. 4.4. Number of compensated sheep, goats and fallow deer killed by lynx in Switzerland from 1990-2004.

Analysis and data specific presentation. The information on the forms is integrated into a database with an underlying GIS system and can be continuously analysed and reported as required. Possible methods for representation are periodical maps (Fig. 4.3), histograms (Fig. 4.4) or tables.

Interpretation. If the examination and reporting is done by a network of trained personnel (e.g. game wardens), the kills found is the best category 2 dataset. Lynx have a relatively constant kill frequency – as a rule of thumb, a lynx kills and consumes about one ungulate per week, and hunt over more or less the entire individual home range. Of course the quality of the dataset depends on the probability of finding kills, but if the network of observers is well established, kill frequencies allow a relative comparison between different monitoring areas. The locality of the lynx kill sites gives indication of lynx distribution and habitat use. Livestock depredation is biased towards areas where (unguarded) small ruminants such as sheep and goats are available. However, to date, no case in Europe has been reported where lynx were living mainly from livestock, with the exception of lynx in northern Scandinavia that depend on semi-domestic reindeer.

The evolution of the number of lynx kills and their locality seem to be a good indicator of the status of a lynx population and allow – with some reservations – a prediction of the trend (increase or decrease). In the north-western Swiss Alps, lynx were found to show a clear numerical reaction to changing roe deer densities (Ryser *et al.* in prep.). If there is a strong sudden increase in reported lynx kills in a certain area, one can assume that the population is increasing. Changes in the number of livestock killed by lynx are more difficult to interpret. In the Swiss Alps, peak years of depredation were correlated with high lynx abundance and decreasing roe deer densities (Angst *et al.* 2000), but Stahl *et al.* (2001) observed in the French Jura Mountains that depredation on sheep by lynx was positively correlated to local roe deer densities. Livestock damage is often clumped in "hot spots" – which means that only one or a few pastures are regularly attacked. Typically problem pastures favouring lynx attacks were very bushy or surrounded by forests. Whether individual lynx "specialise" in killing sheep is a matter of dispute; however evidence for "specialist problem individuals" is weak so far.

Reporting. The data are analysed for periodical (yearly) reports and used for more specific analyses and publications. A special form of reporting and presentation is the online livestock damage statistic for lynx kills in Switzerland (www.kora.unibe.ch).

Effort for data collection and analysis. Reporting of kills by game wardens or rangers (livestock, prey) or the public (prey) by means of a special form (see Field Handbook). The effort depends on the number of kills found and reported. Specially trained personnel – the network members – are needed for the examination of the kills. Initial and continued training requires adequate education capacity (trainers, materials and documents, infrastructure).

Infrastructure requirements. Programs like Access, Excel, Photoshop and a GIS system.

Problems. The reliability of the assessment depends on the experience of the network members. Courses to instruct the assessors initially are important, but personal experience must deepen the knowledge. The difficulty is that assessors should be able to examine enough kills with known cause of death, and this is of course easier in the main distribution areas. As all network members have the natural tendency to produce positive proofs of lynx presence, there will be a bias towards lynx presence at the periphery of the distribution area. An excellent opportunity to train network members is a field project with radio-tagged lynx, allowing the finding of most of the lynx kills. Another highly recommended method is to set camera traps at kills, allowing the identification of the killer (or at least the scavenger). The "extensive camera trapping" is explained in chapter 5.3. Livestock kills are more difficult to assess, and the assessor may be additionally under pressure from the livestock owner, especially in areas where compensation is paid for lynx kills. It is recommendable to establish a referee or a jury (e.g. at a veterinary institute), which can reconsider a judgement if it is not accepted. Another source of error is incomplete or imprecise documentation of cases. Certain data analyses require the exact coordinates of the kill sites. Inexact coordinates (≥100 m) are for instance not sufficient for habitat analyses. Finally, there is always the possibility of disturbing a lynx that has not yet finished consuming its kill. It is easier to confirm the predator's identity when a kill is fresh, and only partially consumed. However, examining it at this stage may in some cases scare the lynx into abandoning the kill.

4.3. Chance observations

The collecting of chance observations about lynx presence (direct sightings, calls, tracks, and kills; → chapter 4.2) is an important and difficult element of the surveillance of lynx populations. These observations are called "chance" because they are not generated through a systematic field project using transects, telemetry or camera trapping. The making and the reporting of chance observations depend on the presence and the awareness of an observer, who is generally not a member of the trained monitoring network. Chance observations are therefore biased regarding their distribution and their reliability. Chance observations are classified according to their assessment (verifiability of the observation according to the SCALP criteria; Molinari-Jobin *et al.* 2003; → chapter 3.4) and give a first and most likely preliminary picture of the lynx distribution and abundance. If chance observations are collected continuously over a longer period and analysed over many years, they can provide an important control data set for the expansion or shrinking of the distribution range and for population trends.

Method and data quantity. Chance observations are collected by means of a form (name of observer, date, place, coordinates, altitude, kind of observation, additional evidence, etc., see Field Handbook) and compiled in a database. Chance observations should be collected in a systematic way. There will be a lot of variation within this data set, but the variation should not be the consequence of inconsistent data collection/ data storage. Chance observations are collected over a large area, e.g. the entire country. As chance observations are often the first indicator for the need of a more sophisticated survey, they should be gathered over an area larger than the assumed distribution area. Potential observers such as hunters, farmers, forest workers, ornithologists, hikers, etc. must be instructed about the importance of reporting occasional lynx observations. In the course of a year, dozens if not hundreds of indications can be collected. The amount of data will depend on the level of media focus on the program, or on the extent to which the program provides information to the public. A big campaign in the media is able to produce a lot of information, but most of them will likely remain unconfirmed.

Analysis and data specific representation. The observations are assessed and classified according to the SCALP criteria (C1 = "hard facts", C2 = confirmed observations, and C3 = unconfirmed observations; → chapter 3.4). The data are depicted as maps, diagrams or tables by categories and kinds of observations. The comparison of the distribution and trend of the different categories allows a first assessment of the power and reliability of the data set. If, for instance, a significant shift in the proportion of the different categories from one year to the next is observed, it is likely that the data collection is biased. In the cartographic illustration the observations are represented separately or summed up in a raster (Fig. 4.5–

4.8). Some information such as altitude, aspect, or even habitat can be obtained from the GIS system, provided that the coordinates are precise and the geographic baseline data such as digital elevation model, land use data, etc. are available. Nevertheless, it is wise to ask for these features and then to compare them with the same information retrieved from the GIS system, hence allowing assessment of the accuracy of the geographic locations.

Interpretation. Chance observations must be interpreted with care, as they likely include several biases. A considerable share of the reports are likely to be collected and forwarded by the network, e.g. rangers. The local presence of a known network member will increase the registration of chance observations; a bias in the distribution of the network members – so in the probability to record a chance observation – must be considered in the interpretation of the data. At the periphery of the known distribution area, presence or absence of chance observations indicates expansion or loss of area. Within the known area of occupation, they can – if collected consistently over years – be an indicator for population trends. Information on trends and reproduction can also be obtained.

Reporting. Chance observations are presented in the periodical reports.

Effort for the data collection and analysis. Effort for the collection depends on the number of chance observations reported, which in turn is correlated with the time invested in the information about the monitoring programme. The number of observations reported will increase after each information campaign, and the investment needed to maintain a constant data flow is considerable. As the information value of unconfirmed chance observations is limited, the investment in gathering them must be limited, too. It is recommended to specifically address a group of potential observers easily reachable through specific media, for instance once a year report about the lynx monitoring in hunting magazines and ask the hunters to report any observation.

Infrastructure requirements. A database program (e.g. Access), a GIS program (e.g. ArcView), topographic maps (e.g. 1:25‘000) for exact location, and digitised, geo-referenced maps for the analyses by means of the GIS are required.

Problems. In peripheral areas with only sporadic indications and no organised network, the assessment of chance observations in the field is often not possible, and hence many chance observations reported will fall into Category 3. These data are nevertheless a valuable indication for changes in the population or for lacks in the monitoring system. The importance of the systematic collection of chance observations for the lynx monitoring is often neglected. On the other hand, the compiled chance observations are often not carefully and critically examined for biases, and hence their information value tends to be overestimated.

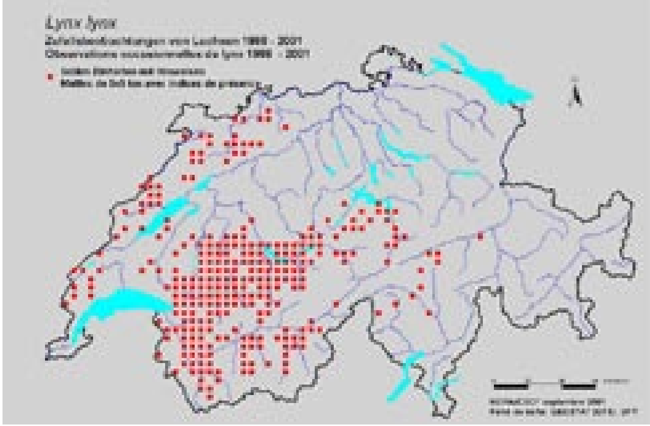


Fig. 4.5. Random observations of lynx in Switzerland from 1998-2001 in a raster of 5x5 km (KORA, unpubl.)

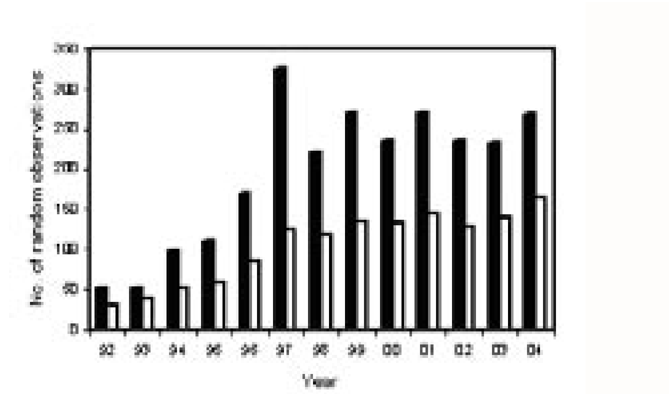


Fig. 4.6. Number of random observations in the Alpine lynx population, Switzerland from 1992-2004 (black=number of total observations, white=number of 5x5 raster squares with observations; from Zimmermann *et al*. 2005).

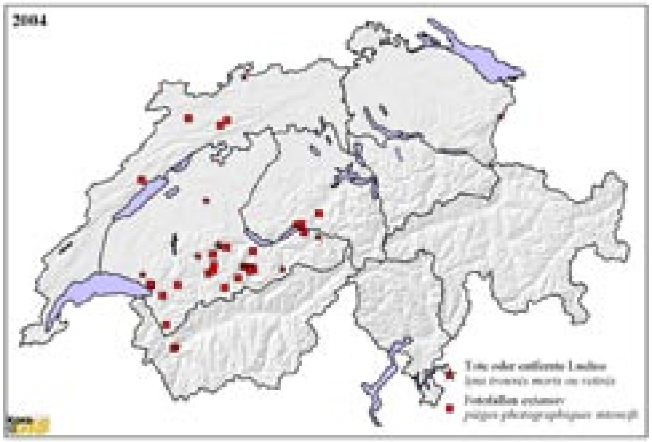


Fig. 4.7. Distribution of C1 observations in Switzerland. Stars = dead or removed lynx, squares = photos (from Zimmermann *et al.* 2005).

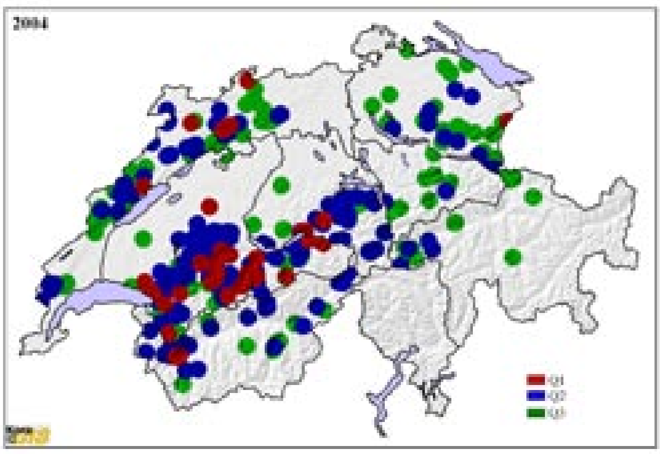


Fig. 4.8. Synthesis of the random observations in the criteria 1-3 in Switzerland in 2004. For each observation a buffer of 5 km is made to indicate the area. Isolated areas with only C3 data (green) have to be interpreted as temporary lynx occurrence (if there is not an observation error). If there’s a real colonization of an area – also by single individuals – C3 data have to be confirmed by C2 (blue) and C1 (red) data. The C2 indications build the backbone of a monitoring. (from Zimmermann *et al.* 2005).

5. Active monitoring: Periodic surveys and field procedures

Active monitoring is monitoring in the strict sense of the word. Data are collected in a targeted and systematic way to assure that the sample is as homogenous as possible. There will still be considerable variation and biases inherent to the data, but at least the inquiry should not be biased. There is a smooth gradient from active monitoring to biological and ecological (field) research. On one hand, data gained in a systematic monitoring process can often be used to answer basic scientific questions, and on the other hand, baseline data about life history, land tenure system, predator-prey-relation, etc. can be used to calibrate monitoring data. We here mention methods that have been used in Europe to monitor lynx. For more information on the field procedures and the (statistical) analyses, we refer to the specific literature.

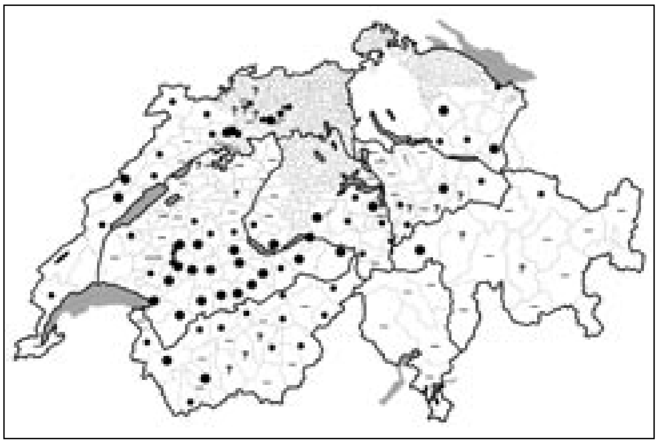


Fig. 5.1. Relative abundance of lynx presence indications from the yearly inquiry among game wardens in Switzerland. The areas indicate the wardens' districts (or hunting grounds, respectively, for NE Switzerland). Solid black lines show the large carnivore management compartments. Big dots represent more than 5 indications, small dots 1-5 indications, question marks uncertain indications, "-" indicate lacking feedback (from Zimmermann *et al.* 2005).

5.1. Periodical inquiries

The simplest systematic surveys are regular inquires with network members. Any network with an adequate membership density can potentially be used for this type of monitoring: game wardens, hunter's associations, district foresters, etc. The result will be an investigation based on subjective opinion and observations rather than on objective data measurement, but provided that the network members all have the same professional skills (or the same bias), the results will allow a relative assessment of changes in space and time. In Switzerland, an annual inquiry of game wardens by means of a questionnaire has been established since 1993 (Capt *et al.* 1998), providing important information on the distribution of lynx and the development of the populations. In contrast to the chance observations, these inquiries are carried out at strict periodical intervals and for a constant grid, with the rangers' districts as grid cells[4].

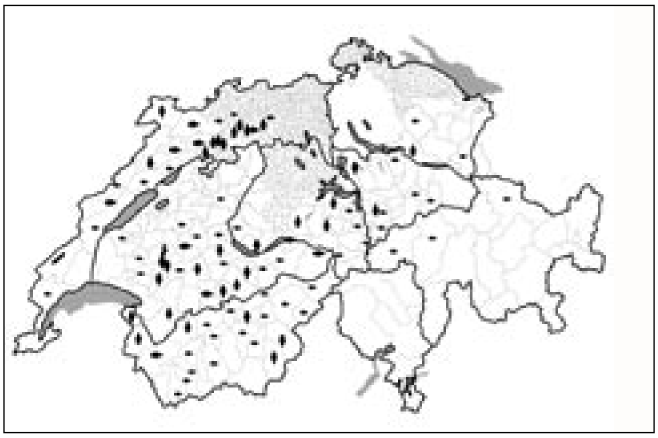


Fig. 5.2. Personal assessment of lynx population trends from the yearly inquiry among game wardens in Switzerland. The areas indicate the wardens' districts (or hunting grounds, respectively, for NE Switzerland). Solid black lines show the large carnivore management compartments. Upward, downward or horizontal arrows indicate increasing, decreasing, or stable lynx presence, respectively (Zimmermann *et al.* 2005).

Method and data quantity. Rather simple and straight-forward questionnaires (see Field Handbook) are distributed to all game wardens in the lynx area once a year. The respondent indicates whether lynx have been (1) observed, (2) not observed, or (3) whether there have been only unconfirmed observations in his district. The main difference to passively collecting chance observations is that the inquiry allows distinguishing "no lynx" from "no information". Additional questions concern obvious biological features (reproduction and mortality) and help to assess the information gained from the passive monitoring. The number of lynx presence signs in the district is classified into classes of abundance (1-5 indications, >5 indications, unknown number of indications). The type of observation is reported qualitatively: direct observations, tracks, kills, and dead lynx. Furthermore, the respondents give their personal judgement regarding the development and status of the lynx population in their districts. In order to guarantee a high return rate over many years, the questionnaire needs to be kept simple and straight-forward, so that it can be filled in with a relative low time investment.

Analyses and data specific representation. The data are incorporated into the monitoring database and the GIS systems and analysed periodically. Presentation is in form of text, tables, statistics, diagrams, and, above all, as maps (Fig. 5.1 and 5.2). The observations are cartographically represented per survey unit (in Switzerland the wardens' districts and the hunting grounds[4], respectively).

Interpretation. The inquiry among game wardens or another comparable group of respondents allows a quick and easy overview of the total distribution area, trends and gaps in the survey and provides information about reproduction. The yearly inquiry is the most important baseline monitoring and important for the control of the interpretation of the passive monitoring and to adjust the monitoring if discrepancies or gaps have been discovered.

Reporting. The data are presented and commented in a yearly report to the wildlife management units, nature conservation agencies and the general public. In addition, the members of the network (game wardens) receive a specific feedback report once a year, when the new questionnaires are distributed. This feedback is important to maintain the motivation of all network members.

Effort for the data collection and analysis. The distribution of about 300 questionnaires, and the collection, processing and analysis of the data needs about four weeks of work for one person each year, provided that the questionnaire, the address list, the databases and the GIS system are already established.

Infrastructure requirements. The units (e.g. game wardens' districts) of the investigation have to be available in digitalised form. Furthermore, a database and GIS system is needed.

Problems. In spite of the relative homogenous network of the state game wardens, the size of districts and the experience and motivation of the individual wardens varies across the country. The return flow of the questionnaires never goes without considerable reminders. The yearly inquiry nevertheless provides the most reliable and un-biased baseline monitoring data for the whole distribution area.

5.2. Track transects

Line transects have been used in different forms in many cat census work, e.g. for tigers (Miquelle *et al.* 2001; Karanth & Nichols 2002) or for snow leopards (known as the SLIMS approach; e.g. Jackson & Hunter 1995). Eurasian lynx, living mainly in forested habitat at low densities, leave very few signs – with the exception of tracks in the snow. Transect census of lynx are exclusively done in winter and in areas with stable snow conditions. Winter track transects to estimate lynx abundance are used in countries such as Russia, Poland and mainly in Scandinavia (Jedrzejewski *et al*. 1996; Linnell *et al*. 1998). In mountain ranges with a difficult topography and a very dynamic snow cover such as the Alps or the Dinarc Mountains, systematic track transects are not easy to use for monitoring lynx. Nevertheless tracks in the snow give important information on the presence of lynx, and, if combined with other methods, can at least provide semi-quantitative information (Ryser *et al.* 2005). Searching for lynx tracks is a good tool to confirm the presence of the species in an area. If larger areas are searched by means of systematic track transects, (relative) lynx abundance can be estimated, and the consecutive application of the same methods over years can provide information on the population trend. Using distance based rules to avoid counting the same individuals several times, a minimum number of lynx within the surveyed area can be estimated. Furthermore, tracking lynx provides additional information, e.g. about reproduction, habitat use or predation. Back-tracking along lynx tracks can also help find scats (for diet, genetics and parasite studies) or kills (for diet studies). Furthermore it is usually possible to confirm the presence of reproduction when the tracks of females with dependent young are located.

Method and data quantity. Lynx tracks are searched for in the snow along forest roads, paths or pre-defined transect lines. The survey is best made 2–3 days after new snowfall, when the animals had time to move, but tracks are still neat and easy to identify. The number of lynx tracks crossing the transect lines and their direction is recorded. All tracks are mapped, measured (length and width of foot prints and pace length) and a picture taken. Double counting is avoided by either backtracking all tracks encountered (to join sections), by ensuring that at least one transect without tracks lies between two transects with tracks, or by using distance rules based on known movement rates or home range sizes (this requires local telemetry data).

Within a given survey area, transect routes can either be positioned randomly or according to a strict pattern, e.g. a grid. In reality, especially in rough terrain, neither approach is practical. Because the goal is to detect as many lynx as possible, transects should be designed in order to assure a high probability to encounter lynx tracks. So they should be placed in good lynx habitat and consider the movement pattern of lynx. Maximum efficiency of encountering tracks can be achieved by following trails, ridges, forest roads, or natural travel corridors. As lynx often use paths or trails, following roads is not only easier, but also more efficient. A transect should be long enough to encounter tracks with a high probability. In high mountains with an alpine zone (so areas above the timberline, which are usually not frequented by lynx), transects will run from the open (agricultural) areas in the valleys up to the timberline and so cross the entire band of lynx habitat. All lynx tracks encountered on the transects – and of course also those found off the transects – are recorded and indicated in a map. Furthermore, tracks of lynx prey species (ungulates, hares, tetraonids) or other carnivores should be recorded as well.

Lynx movement patterns and day-to-day movements changes within the year. Peak activity is during the mating season from February to April, when especially male lynx travel fast and far. Towards the end of the mating period, females will also move more, and most of the last year's kittens will already be independent. While this is the best season to find tracks, the attribution of a track to an individual lynx might however be rather difficult.

Analysis and data specific representation. All information gathered while doing the transects are entered in a database and in a GIS system, where also the transect routes are recorded. Records comprise not only track data, but also information such as weather and snow conditions, date and time, tracker name, etc. Data analyses include geographic distribution (mapping), statistics and diagrams showing the distribution of tracks in regard to altitude, aspect, habitat, etc., and calculation of indices for tracks or signs per distance units. Comparison between transects or years must not only consider statistical variation, but also changing conditions in the field. Information gained are presence/absence[5], minimum number of individuals, minimum number of families (females with kittens), furthermore habitat and range use, and relative changes in lynx presence in time and space. If the transects are surveyed in an organised network it is possible to use year to year changes in track encounter frequency as a rough index of changes in population density.

Interpretation. Presence/absence of lynx tracks on survey routes. Minimum estimations, and comparisons between different regions and years strongly depend on the variability of the results and the snow and weather conditions and must be done with care.

Reporting. The data are analysed and reported after each survey season.

Effort for the data collection and analysis. Track transects are time consuming. The effort depends on the number and length of the transects, on how often they are done per season and on weather and snow conditions. Systematic surveys of large areas by means of track transects – as they are done in Scandinavia – can involve dozens or even hundreds of trackers and require an enormous organisational investment.

Infrastructure requirements. Cars to get to the survey areas, field equipment including skis or snowshoes, accurate maps, eventually GPS, and security equipment[6]. For data treatment database and GIS software.

Problems. The finding and identification of tracks relies strongly on the snow conditions and on the experience of the field personnel. Trackers must not only have good (winter) field skills, they must also be well trained in recognising tracks and field signs.

5.3. Camera trapping

Camera trapping, the use of automatically released photo cameras to picture animals, has become a standard method to census elusive species. Especially for spotted cats, which can be identified individually from good pictures, this non-invasive method has a high potential and is today used for a variety of species. In-depth descriptions of camera trapping technique have been published e.g. for tigers (Karanth *et al.* 2004) and for snow leopards (Jackson *et al.* 2005). The principle of the method is to make as many pictures of the species as possible within the study area during a pre-defined period of time and then to estimate the number of specimens by means of capture-recapture statistics. Validity and power of the results depend above all on the sample size, so on the number of pictures taken from different individuals. For a species with such a low average population density as Eurasian lynx, the sample size is always a problem. To get enough pictures requires a lot of camera traps (which is expensive) and/or their use over a prolonged field session which can violate the condition that the population should be closed. We here distinguish between two different deployments of camera traps: (1) intensive use, the "classical" application for capture-recapture estimations, and (2) extensive use, the opportunistic use of camera traps throughout the year in order to identify as many lynx as possible. The two methods can be combined, as the pictures of the extensive use helps the identification of lynx during the intensive camera trapping.


Fig. 5.3. Camera-trap installed at a hiking trail (from Laass 2001).

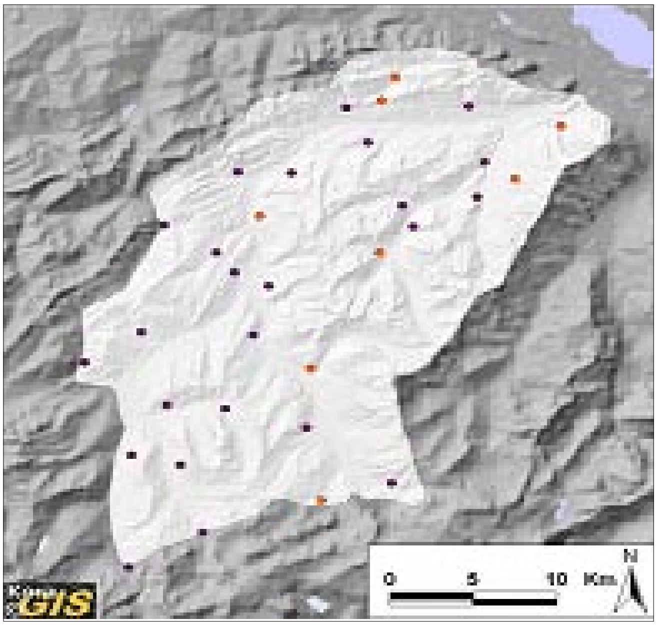


Fig. 5.4. Distribution of camera traps in the study area in the north-western Swiss Alps during an intensive session. Traps were set at "best" sites within a grid, which was defined using information from radio-tagged lynx (from Laass 2001).

5.3.1. Intensive camera trapping

The intensive use of camera traps allows the estimation of the population size within a confidence interval depending on the sample size and survey design.

Method and data quantity. In the study area – which should be big enough to encompass a representative part of the population – the camera traps are distributed at random or according to a pre-defined structure. For lynx, which live solitarily in stable home ranges, distribution according to a grid is obvious. Within each grid cell, a place with a high probability to "capture" a lynx is chosen, so a game path, a hiking trail (Fig. 5.3) or a forest road. Excellent spots are known scent-marking places along trails. The number of camera traps should be at least 2 per resident lynx. In the Swiss Alps, we place 3–6 photo traps per resident female, depending on the density, or one photo trap per 15 km² (Fig. 5.4; Zimmermann *et al.*, in preparation). The best time to do intensive photo trapping is the second half of the winter, when lynx move a lot and when we can expect little disturbance of the trapping sites by humans. In this season, however, camera traps need to be controlled more often (every 3–5 days). Snowfall and melting / freezing can cause troubles and the low temperatures can reduce battery capacity considerably. To get a minimum sample of pictures for a quantitative population estimation using capture-recapture statistics, the camera traps in the Swiss Alps had to be in place for a minimum of two months.

Analysis and data specific representation. As lynx can be distinguished individually on the basis of their coat pattern, there is no need to physically mark the animals. The registration of the individual coat pattern is sufficient (Fig. 5.5). The power of the statistical analyses can however be improved – or the minimum sample size for a acceptable confidence interval reduced, respectively – when individuals are already "marked" (i.e. pictures from both sides are available) at the beginning of the intensive trapping period. We therefore took pictures from both sides from all animals that were captured for radio-collaring, and during summer time, any opportunity to picture lynx at kills were taken (→ chapter 5.3.2). Still the problem of the two sides remains. The left and right side show distinct pelt patterns, and the loss of information (or power of the statistics) is considerable if both sides of an individual were not identified. This problem can be solved by setting two camera traps face to face at one spot (Zimmermann *et al*., in preparation), however this requires the use of double the amount of cameras or half the number of sites.

Fig. 5.5. Identification of the lynx by comparing coat patterns. Red = characteristic features of the coat pattern of this individual used to distinguish it from other lynx.

The procedure to calculate capture-recapture statistics must be defined before the fieldwork, as it will influence the distribution pattern and duration of the camera trapping session. Each first picture is considered a "capture", a second or third picture of the same individual a "recapture". However, the identification of individuals by comparing pictures is not easy, and errors will strongly influence the results! Lynx are long-living animals, which can disperse over large distances, so pictures must be considered over a large area and over several years. It is essential to create a good database of all pictures and to maintain it with discipline. Analogue photos should be scanned and stored as digital pictures. Baseline information for each picture should be stored in a database, including information on the pelt pattern type (Fig. 2.3) allowing a quick search. To illustrate the results of the intensive camera trapping, diagrams (Fig. 5.6) and GIS maps (Fig. 5.7) are best. For the estimation of the number of individuals present consult the available freeware, e.g. MARK.

Interpretation. The interpretation of a capture-recapture statistic is straightforward. It provides a population estimation and a confidence interval, that is an upper and lower range. If the range is too large – so that the power of the statistics are weak – the sample size was too small. In this case, a rough analysis still allows for an estimation of the minimum number of different lynx in the study area. A capture-recapture estimation at regular intervals (yearly, every second year, etc.) gives an excellent indication of the population's development. The camera trap pictures will furthermore give a lot of valuable detail information, such as reproduction, the use of the same spot by different individuals, and last but not least, the presence of other species than lynx. In addition, the intensive use of camera traps allows for the calibration of results from other monitoring methods.

Reporting. Pictures of lynx indicate clear evidence for the presence of the species and are, above all, a perfect tool for communication and public relation. The data and pictures gathered are compiled in a monitoring report after each field run, and can be used for scientific publications.

Effort for the data collection and analysis. Systematic camera trapping is a labour intensive tool, and the technical equipment is expensive. Experience in the Swiss Alps show that one person can maintain 31 photo traps covering an area of 600 km². There is however a considerable effort needed to organise the field work and to analyse the data. The field work and subsequent analysis of the results of an intensive use of camera traps keeps one person busy for around 30 weeks a year. Additionally, the picture database and the technical equipment have to be continuously maintained throughout the year.

Infrastructure requirements. Especially relevant is the acquisition and maintenance of the camera traps, material (films, bat-

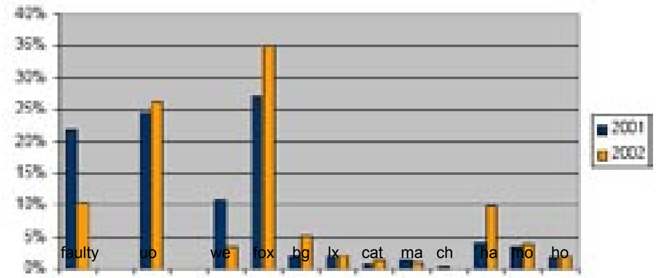


Fig. 5.6. Frequency of causes triggering camera traps: session Nov./Dec. 2001 (n = 986) compared with session Jan./Feb. 2002 (n = 977). Faulty = system errors, uo = unknown, we = weather, bg = badger, lx = lynx, ma = marten, ch = chamois, ha = hare, mo = mouse, ho = human being (from Laass 2001).

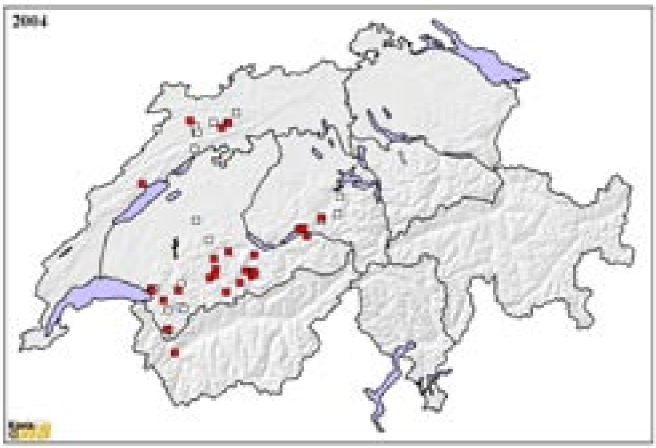


Fig. 5.7. Positive (red = photograph of lynx taken) and negative (white = no lynx) camera trap positions during the extensive use in the Swiss Alps and the Jura in summer 2004 (from Zimmermann *et al.* 2005).

teries). For fieldwork, a car and winter equipment is needed. To analyse the data, a computer working-place with database, GIS software, and a slide scanner are essential to digitise analogue pictures.

Problems. The problem of the method lies particularly in the requirements of the capture-recapture methodology. It is difficult to get enough pictures without violating the condition of a closed population during the study period. Even with several statistical models that are available to meet the conditions found in the field, the struggle for a sufficient sample size is a constant factor when using camera traps to estimate large carnivore populations. Other problems encountered came from difficult topography of the study area, bad weather conditions (e.g. very cold temperatures), and lack of experience among field staff. In addition, there is always a certain risk of theft or sabotage of the camera-traps installed next to forest roads and hiking trails.

5.3.2. Extensive camera trapping

The extensive camera trapping is an opportunistic use of camera traps in the study area throughout the year without respecting methodical or statistic requirements.

Method and data quantity. The extensive use of camera traps serves to gain data on the lynx in a given area with a relatively small effort. For this, camera traps are installed along paths known to be used by lynx or mainly at fresh kills, where we can assume that the lynx will return to (Fig 5.8). To be able to react quickly to opportunities, camera traps should be spread across the study area, maybe placed with members of the network. The additional advantage of involving monitoring network members is that they gain experience on lynx kills through the systematic surveillance of kills by means of camera traps. In Switzerland, camera traps are given to game wardens, but also to naturalists participating in the monitoring during the summer time, when no intensive monitoring is going on, allowing the coverage of a large area and to gain pictures and information at relatively low costs (Fig. 5.8). The motivation of the members to use the cameras and their discipline to maintain them is of course a crucial point. Furthermore, the transfer of data and information must be organised.

Analysis and data specific representation. The resulting lynx pictures are stored in a picture database. For the identification of the individual, all new photographs are compared with the already existing ones. The results can be presented in the form of tables or GIS maps (Fig. 5.7). In addition, the resulting pictures can be used in many ways (e.g. for public relations).

Fig.5.8. Lynx photo-trapped at a killed sheep. Cases of depredation offer a good opportunity to identify lynx.

Interpretation. The main aim of the extensive use of camera traps is to get as many pictures as possible from a maximum number of individuals. The opportunistic approach does not allow for capture-recapture analyses, and the statistic value of the data is limited. Nevertheless, the minimum number of lynx present in the area can be evaluated. Furthermore, information on the whereabouts of known individuals is gained, unknown lynx can be identified, and occasionally, reproduction success or dispersal distances and spatial use can be documented. It also helps to confirm the presence of the species in new areas. The identification of unknown individuals with pictures of both body sides is of special importance if an intensive use of camera traps is planned for the same area. Pre-identifying animals can considerably increase the validity of an intensive camera trapping session. If the extensive use is applied over several years, the documentation of the individual history of lynx allows certain statements on survival and population trend.

Reporting. The information gained from the extensive camera trapping first of all needs to be reported back to the people involved, that is the network. Beyond this, results from extensive trapping are incorporated into the regular monitoring reports, especially if identification of individuals is used in the intensive camera trapping. Special reporting may be required for special questions. In Switzerland, "problem animals" (livestock raiders) are identified by means of photo traps, and, as the regional authorities have to take decision about their removal, the wildlife management units in charge are immediately informed. A compilation of the data and results is published yearly.

Effort for data collection and analysis. In Switzerland, photo traps for the extensive monitoring are mounted by game wardens and other monitoring network members, which provide their time for free. For the supply of material, the training of and communication with the network members, managing and analysing of the lynx picture and reporting, we count about 10–12 weeks for one person per year.

Infrastructure requirements. Required are camera traps, battery chargers, films, a car as well as a computer infrastructure as mentioned for the intensive camera trapping (→ chapter 5.3.1).

Problems. The success of the extensive use of camera traps depends mainly on the number of opportunities to take pictures during the year. This is again correlated with the quality and motivation of the network and the information network members get from the public, e.g. indication of lynx kills. The importance of the extensive use of camera traps goes however beyond the lynx pictures taken. It is an important training and communication tool and a good way to actually integrate the network into the local population. If a farmer reports a killed sheep and a network member "catches" the predator by means of a camera trap, the resulting picture, whether it is a lynx or not, will not only be an additional gain of information for the monitoring, but also the farmer will be interested to see the picture and hence to report further cases. It is therefore important to instruct the network members to always give a feedback to their own informants.

5.4. Captures and radio-telemetry studies

Captures done for a radio-telemetry study can provide important information for the monitoring, as the results of the study can be used for the calibration of data gained from the monitoring programme. Of course, radio-telemetry is the most efficient way to study the biology and the ecology of lynx in the field, and its application goes far beyond monitoring. The literature on capture and radio-telemetry techniques is huge and not considered here. We only briefly want to outline, which aspects of a telemetry study are of direct importance for monitoring.
Of lynx caught to be equipped with a transmitter, good quality pictures from both sides and from different angles must be made, so that they can be easily identified if later "captured" in a camera trap. The radio-collar – which can be individually marked with coloured codes – is an additional help to identify the animal on a photo.
Surveying lynx by means of radio-telemetry provides a wealth of information that can be used to design a monitoring programme and to calibrate the results. If the radio-telemetry study and the monitoring takes place at the same time in the same study area, the mutual benefit is obvious and direct. The monitoring can provide information about uncollared individuals, and the telemetry study allows optimising the design of the monitoring programme. Information about home range size, habitat use and the land tenure system (Fig. 5.9) must be considered when plotting track transects or defining the distribution of camera traps. Furthermore, the absolute values and figures gained from a radio-telemetry study – e.g. home range size or population density – can be used to estimate the total population size or regional abundance from the relative values gained with the monitoring programme (for an example from the Swiss Alps, see Molinari-Jobin *et al.* 2001).
In the context of the stratified monitoring concept outlined in chapter 3.4, radio-telemetry studies clearly belong to the Level I, where the most accurate data are gained over a relatively small area. Probably nobody will initiate a radio-telemetry study just for the sake of monitoring a population. However, the interpretation of any monitoring results will be difficult if no baseline data on the biology and ecology of the species is available. Up to now, several intensive field studies using radio-telemetry have been carried out on lynx in Europe. Specific ecological data on the Balkan lynx, however, are not available. Even a small-scale radio-telemetry study would help to assess the uniqueness of the Balkan lynx, and help calibrate the monitoring programme.

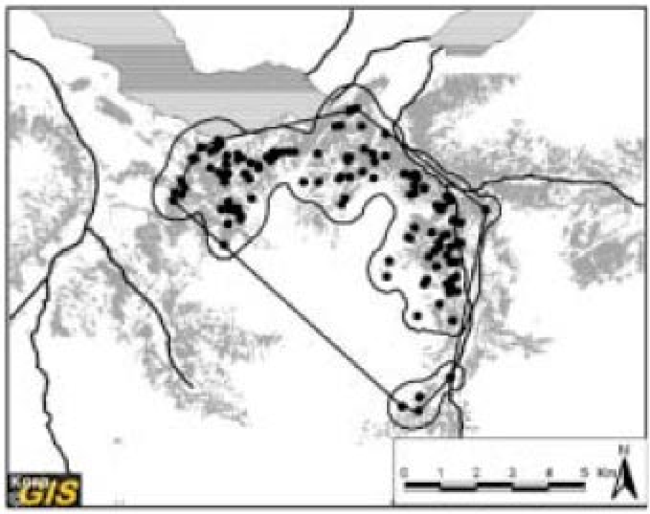


Fig. 5.9. Home range of a resident female lynx in the Swiss Alps. Dots represent telemetry locations, lines the MCP convex polygon and the 95%-Kernel area, respectively. Forests are grey. The lynx uses mainly the forests distributed along the mountain slopes. The MCP often includes large areas that are never used by any lynx (from Breitenmoser-Würsten *et al*. 2001).

6. Compilation, analyses and storage of monitoring data

Data and information used for monitoring can be compiled, analysed and stored in many different ways. We have given some guidelines for each dataset of the passive and active monitoring (→ chapters 4 and 5). In this chapter, we summarise important and general aspects. Most often, the gathering and management of monitoring data is an adaptive process, starting with little information in a short time. As in this early stage, it is no problem to keep track, the consequent management and storage of the information is often neglected. It is important to develop a clear data management system at an early stage and to review it repeatedly. Especially when working with camera trapping, the amount of information (pictures) can pile up quickly and will become confusing if not consistently managed. Another important, but often neglected topic are documentation and archives. Even though monitoring should be specific and targeted, in the practice of large carnivore population surveillance, a lot of data will be gathered that will become more valuable when they accumulate over the years. In the future, the data gained during a monitoring programme may allow the answering of questions, which we have not even begun to ask yet. Hence, it is important to store all date in save archives and to document thoroughly the methodology behind their collection.

6.1. Databases and archives

All data and information from forms, field notebooks, photos, etc. is entered into a database. These databases are the starting point for the analyses, but also the basic archives. For each data set (→ chapters 4 and 5), a centralised database with a responsible database manager is needed. The data(base) manager is responsible for regular updates, controls, and backups of the database. It is impossible to totally avoid errors in the database, which hopefully will be detected during the analysis and reporting. Hence, a procedure to correct errors must be established. Frequent errors are wrong coordinates. All geo-referenced information from the field needs to be entered into the database so that it can easily be used in a

GIS system. Make sure you have all data in the same format (UTM or long/lat in decimal degrees). Some principles of data collection and storage:

(1) Data recording in the field (e.g. forms) and digital databases must be fully compatible; forms should be designed in order to allow easy data entry.
(2) Organise a continuous data entry! Immediate data processing is not only less tiring and less faulty, it also allows easy correction of errors in the field forms as people will still remember.
(3) Define a person responsible for the database. The database manager is responsible to organise the data entry, the control and correction of the database and regular backups.
(4) Define a master database, which should only be manipulated by the database manager. If several persons are working with the database, make working copies.
(5) Organise the reporting and corrections of errors, e.g. design an error reporting form that people can fill in and hand over to the database manager. Only the database manager should make corrections in the master database!
(6) Make regular backups of all databases. In addition, organise an archive, which contains the original field forms and all electronic databases, analyses, reports, etc. Field forms should be stored at least for several years (they may later be scanned and stored as electronic pictures). All digital information must be put on long-term storage media (e.g. CDs).

The archive must be spatially separated from the master and working databases.

For the lynx in Switzerland, for instance, all information is stored in either a Microsoft Excel file (killed livestock) or a Microsoft Access database (lynx mortality, Table 6.1; chance observations; camera trap photos). For each database, a different person is identified who is responsible so the task remains manageable. The original forms from the field or reports from other institutions (e.g. autopsy reports) are stored in files. The following examples from the Swiss lynx monitoring programme may illustrate the practical approaches:

Losses in the lynx population. Dead lynx or lynx removed from the population are very important information, especially from small and threatened populations. Most often, lynx mortalities produce a number of reports from different institutions (e.g. from traffic police, veterinary pathology institute, wildlife management service, etc.) and the monitoring programme is responsible for compiling and storing all information. After entering the data into the database (Table 6.1) all additional information are put into archives. The database allows for various (retrospective) analyses. Although any dead lynx discovered is an important mosaic stone for the immediate monitoring of the population, many questions can be only addressed after data have been gathered over several years, e.g. demography (Fig. 6.1) or causes of mortality (Fig. 6.2).

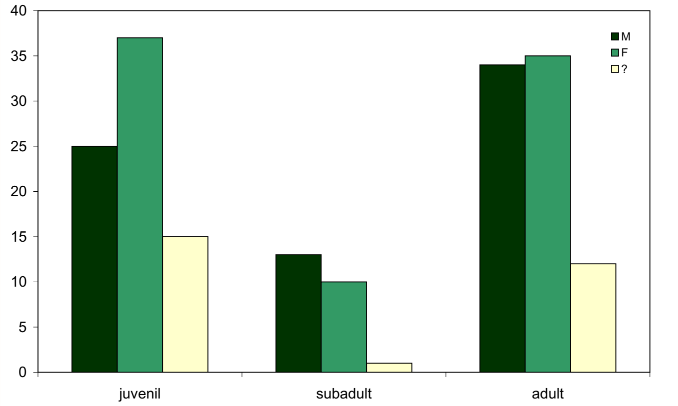
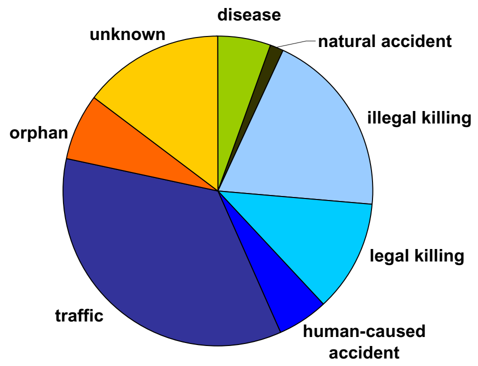


Fig. 6.1. Age and sex of known losses in the two lynx populations in Switzerland (KORA, unpubl.).

Table 6.1. Structure of the database for known losses of lynx.

Field	Explanation
Running ID	
Date	
Year	For analysis per year (see Fig. 4.1.)
Locality	Name of the nearest place
Coordinate X	UTM, latitude (decimal degree)
Coordinate Y	UTM, longitude (decimal degree)
Population	Jura or Alps (for analysis per population, see Fig. 4.1.)
Lynx	Name or number if radio-collared
Sex	
Age	juvenile, subadult, adult
Exact age	identified with the cementum annuli method, i.e. counting of year rings in the root of a tooth
Weight	
Cause of mortality	Traffic, accident, disease, legal killing, illegal killing, orphaned juvenile, unknown
Pathology examination	Yes/No
Medical history	Details on disease or traffic
Remainings	Where are the remainings (skull, skin, bones) stored (museum name, name of private person, zoo (orphans)
Documentation	photos, newspaper articles, etc.
Remarks	



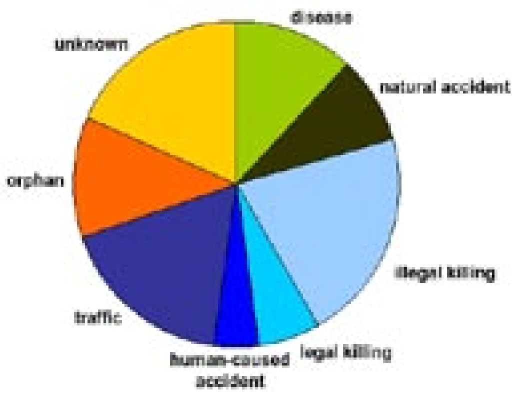


Fig. 6.2. Causes of losses in the lynx population in the Jura Mts (top) and in the Alps (below). In the Jura Mts, losses due to traffic accidents are very important, whereas in the Alps, more animals die in an accident (avalanches, land slides) or due to a disease (KORA, unpubl.).

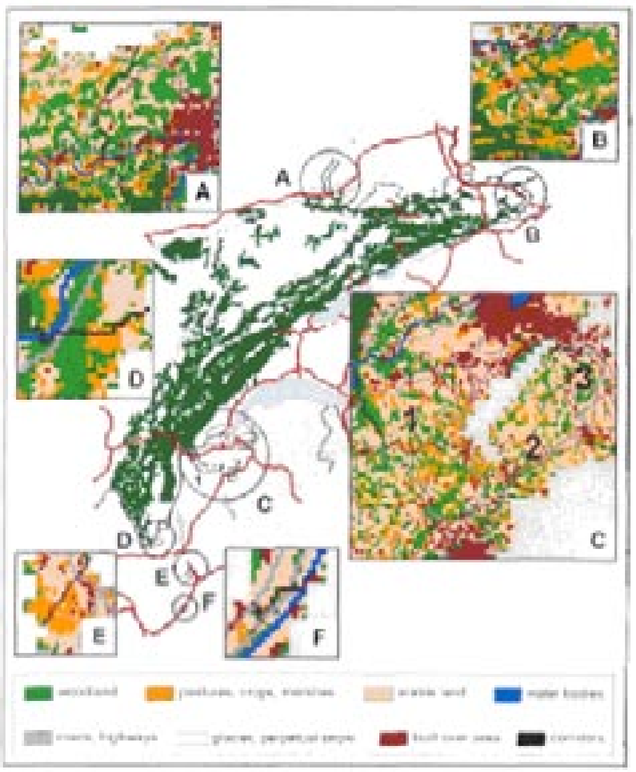


Fig. 6.4. Habitat suitability map for the lynx in the Jura Mountains and potential corridors to adjoining areas (details in Zimmermann 2004). All data gathered during a monitoring programme can potentially be used for research helping to develop conservation strategies.

Camera trapping. Photos taken by camera traps are all entered into a Microsoft Access database. Each developed film and photo receives a number ID. Each lynx photo is entered into the database (Fig. 6.3). The negatives[7] are stored in a classifier under the film number ID. Lynx pictures are scanned and the digital picture is stored in the computer. As digital pictures quickly use up a lot of disk space, make sure you have enough space on your working system and on the back-up system from the beginning. It is very important to have the picture management system in place when you start! Data accumulate fast and need to be stored right away or you will loose the overview. A categorisation of the coat patterns (Fig. 2.3) will help to search the database for known individuals.

Fig. 6.3.Entrance page of the Access database of photo trap pictures. The database is menu-driven and allows for searching by name (lynx identification number) or by pelt pattern type, additional queries and reports, entering records for new lynx, and entering new records for already identified lynx.

6.2. Analyses and interpretation

Data analysis, interpretation and reporting depend on the goal of the monitoring and the methods used and are discussed with the individual data sets (→ chapter 4 and 5) or later (→ chapter 7). Here, we briefly summarise some principles. The most important instruments for the analysis of data are – besides standard programs to do statistics and produce graphics – the database and a Geographic Information System (GIS) project. All monitoring data have a geographic reference, and such data are best analysed by means of a GIS system. The use of these instruments not only requires the adequate hard- and software, but above all the professional skills of the operators! When establishing a data management system for your monitoring programme, you need to involve database and GIS specialists. A GIS does not only allow the production of all kinds of (distribution) maps, but will be an important tool for the assessment of the population and the development of a conservation programme. You can for example produce habitat suitability maps and identify potential barriers and corridors (Fig. 6.4). When the monitoring data have been analysed, they need to be interpreted. Not all findings from the monitoring are straightforward, and not all clients of the monitoring results have the same ability to read statistics and graphics.

7. Reporting

Reporting is crucial, but is often neglected. There is an obvious need for reporting if the monitoring results are important for taking decisions. But beyond decision makers, a lot of people are interested in the outcome of the monitoring, above all those involved in producing and gathering data. Sharing information builds bonds, but a lack of feedback demotivates. To plan the reporting scheme, the following questions must be answered:

(1) Who must be informed? Who are the decision makers, the partners, the stakeholders, the mediators or just the interested public?

(2) What needs to be reported? Which information is important to follow the process observed or to assess the effect of the (conservation) measures taken?

(3) How and how often should we report?

These questions should be discussed at the beginning of a monitoring programme, because reporting is an integral part of the design of the whole programme. All three questions are closely interlinked; not all parties involved or interested may need the same kind of information, and not with the same urgency. So a stratified reporting may be needed. The most important customers for monitoring results are those who depend on information to make management decisions, e.g. who need to decide whether a conservation action should be continued or changed. The kind of information needed for the decision making process should be known from the beginning, because this is the main purpose of the whole monitoring programme. The second group of people to be informed are those providing data; they want to know whether any progress has been made, and they want to see their own data integrated into the big picture. Last but not least, reporting monitoring data is an important instrument of public relation and education! Conservation programmes – especially those for large carnivores – need public support, and monitoring reports are a welcome opportunity to address stakeholders, the media and the general public.

If we consider these three groups (there may be even more) – decision makers, contributors, and the public – it is obvious that these three groups do not need the same information and a differentiated reporting must be provided. One straight forward way to do this is to produce an "average" report targeted for the contributors and stakeholders, which want to have some details, but are most likely not interested in methodology and statistical details. This widely distributed report can then be upgraded on one hand with an additional, specific report for the project partners and decision makers, and can be generalised on the other hand by producing a short and comprehensive document – e.g. a press release – summarising the monitoring results for the journalists and the general public.
The interested groups may also not need the information in the same time intervals. The lynx monitoring in the field will be organised in a yearly cycle because of the snow cover in the winter. Hence, an annual report is the logical period under review. Some costly surveys may only be carried out every second year or at even longer intervals. The survey of the status of the European lynx populations was for instance done about every five years (von Arx *et al.* 2004; www.kora.ch > ELOIS). On the other hand, the decision makers may need certain information immediately. An example of this is the removal of livestock killing lynx in Switzerland. This is a controversial business, and the authorities need to take a decision immediately after the threshold conflict level has been reached, and the decision taken must be understandable to all stakeholder organisations. To allow for fast information and to assure that everybody has the same information at the same time, an online reporting system was installed allowing both, the data entry and the presentation of information in form of lists or maps (www.kora.ch). The World Wide Web offers an excellent platform to share information. Everyone has access to the same information, and monitoring reports should therefore be provided on a website. Nevertheless, decision makers, contributors and stakeholders should be informed specially and maybe specifically.

Of course, the distributed monitoring report must be the final version. It is a common nuisance that documents labelled as "drafts" are distributed and are never replaced by a final version. Another pitfall of reporting is overlapping report periods without a clear reference to earlier releases. The following recommendations may help to avoid confusion and to introduce a consistent, understandable reporting in the monitoring system:

· Produce monitoring reports for a clearly defined, if possible regular period (e.g. a year). Avoid overlapping report periods, or, if you cannot avoid this, clearly define the report periods.

· Explicitly mention the reporting period, the release data and the responsible authors.

· The final version of the report should be "officialised", e.g. produce a PDF[8] to distinguish it from earlier versions. Do not circulate several versions of the same report! The final report should refer to earlier reports within the series and all additional documents (e.g. press releases, translations) should refer to the report as the mother document.

· For international or multi-language use, produce an executive summary in English.

· Make a formal release with an announcement that the new monitoring report is now available. Use this opportunity to inform the media and the public about the progress of the conservation programme.

Interpretation and reporting goes hand in hand. You must assure that all decision makers, monitoring network members, stakeholders and the interested public are informed in time and in an understandable way. Monitoring data can (and should!) also be used for scientific publications. But generally, the "applied" reporting of monitoring results cannot be delayed until scientific papers have been published. Consequently, popular interpretation and reporting must often be done ahead of sound scientific analyses and must therefore be done with special care. In most cases, large carnivore conservation is a controversial issue. A monitoring programme is a good opportunity to involve stakeholders and inform the public. A thoughtful presentation of the monitoring results is therefore an important part of the conservation programme.

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Endnotes

1 Status and Conservation of the Alpine Lynx Population

2 The three smaller lynx species – Iberian lynx, Canada lynx and bobcat – use excrements for marking; this was occasionally reported also for the Eurasian lynx, but it seems not to be consistent.

3 Best is to take the sample in EDTA tubes and to centrifuge serum; see specific form in the Field Handbook.

4 Switzerland has two different hunting systems. Most of the country has a licence hunting with state game wardens supervising the hunters' activities. Some cantons in the north-eastern part of the country have however a system with hunting grounds leased to hunters' associations. These are the areas with small units in Fig. 5.1 and 5.2. For this region, the results of the annual inquiry are not fully compatible to the rest of the country.

5 Absence can of course not be demonstrated from one transect survey. The probability of lynx presence decreases however with an increasing number of negative transects in a given region.

6 In the Alps, risk of avalanches often forbid running transects in a given area or at a given time. Even under "normal" conditions, communication and security equipment is mandatory.

7 At present, most camera traps are equipped with analogue cameras. Field-proofed digital systems are still rare and expensive, but increasingly available, which will reduce the effort for the management of the pictures considerably.

8 Portable Document Format, the Adobe Acrobat document form which has become the standard for not editable documents.