The WISO Platform thanks the RowAlps Project for the work done, as well as to all the colleagues and the institutions taking part of its developments. The Platform adopts the RowAlps reports “Lynx and Wolf in the Alps: Recommendations for an internationally coordinated management” as part of the WISO Platform report to be accompanied by an introduction as follows and welcomes them as useful contribution to the fulfilment of the WISO Platform mandate.

Both reports should be considered as living documents that should be further developed as new data, approaches or methodologies come to light. The WISO Platform notes that the reports are based on the population level based management suggested by the Large Carnivore Initiative for Europe (LCIE).

The definition of Favorable Conservation Statuses for the entire Alpine lynx and wolf populations and the quantitative values for each Alpine country were elaborated on the basis of one of the suitable approaches available and should be further developed taking into account also the outcomes of the *ad hoc* Working group of the European Commission as well as relevant studies and publications, where appropriate.

The WISO Platform will present the WISO Report to the relevant bodies of the Alpine Convention in 2016, and will look for the opportunity to present it to the *ad hoc* Working group of the European Commission.

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Lynx in the Alps: Recommendations for an internationally coordinated management

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Arbeitsgruppe
Groupe de travail
Working group

AT – Georg Rauer, Martin Janovsky
DE – Harald Martens, Manfred Wölfl
IT – Piero Genovesi, Paolo Molinari
SL – Marko Jonozovic, Rok Černe
CH – Reinhard Schnidrig, Caroline Nienhuis

Bearbeitung
Adaptation
Editorial

Reinhard Schnidrig, Caroline Nienhuis, Regula Imhof, Roland Bürki, Urs Breitenmoser

Bezugsquelle
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Als PDF: http://www.kora.ch

KORA
Thunstr. 31
CH-3074 Muri
+41 (0)31 951 70 40
info@kora.ch

Titelbild
Page de titre
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Lynx B306 pictured above Ebligen, near Lake Thun, BE, Switzerland on 2 March 2013 © LANAT, Amt für Landwirtschaft und Natur Bern, and KORA

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Lynx in the Alps: Recommendations for an internationally coordinated management

Report of the RowAlps Project (Recovery of Wildlife in the Alps) in the framework of the WISO (Wildlife and Society) Platform of the Alpine Convention

Edited by Reinhard Schnidrig,
Caroline Nienhuis, Regula Imhof, Roland Bürki
& Urs Breitenmoser

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Abstract

The RowAlps (Recovery of Wildlife in the Alps) Project was founded in order to support the Platform "Large Carnivores, Wild Ungulates and Society" (WISO – Wildlife and Society) in fulfilling its Alpine Convention Mandates for the periods of 2013-2014 and 2015-2016: Develop practical goals and management options for the recovery and conservation of wolf, lynx and bear populations in the Alps and present these to the relevant bodies of the Alpine Convention.

Therefore, the overall goal of the RowAlps Project is to develop practical goals and management options for the recovery and conservation of wolf and lynx populations in the Alps. To reach this goal three objectives were defined. In brief these objectives are: 1) To review and assess the present situation of wolf, lynx and prey populations in the Alps, the expected development of the populations and discuss challenges in wildlife management as a consequence of the return of the carnivores; 2) To describe mechanisms to achieve tolerance for lynx and wolf for different interest groups and to identify factors defining the tolerance and the potential measures to influence these factors and 3) To assess the output from objectives 1 and 2 and develop management scenarios for the recovery and conservation of favourable wolf and lynx reference populations in the Alps and discuss them with interest groups.
For objectives 1 and 2, each a working group was established with experts and interest groups. For objective 3 a working group with delegated representatives of the country delegations of the WISO Platform was established.

The current report is the product of the working group assigned with fulfilling the 3rd objective. In seven chapters the following contents are presented: 1) Introduction; 2) Framework for large carnivore management; 3) Current situation of the lynx population in the Alps; 4) Discussion, interpretation and assessment of a future Alpine lynx population and main threats; 5) Practical goal; 6) Management options and implications and 7) Suggestions for priorities in time and space.

The RowAlps Project identified its *overall practical* goal as achieving a favourable conservation status (FCS, according to Linell et al. (2008)) of lynx in the Alps. To reach FCS for the Alpine lynx population, *at least 1000 mature individuals (lynx > 2 years of age)/1300 independent individuals (lynx > 1 year of age) need to be widely and evenly distributed across the Alps*. In other words, a minimal density of 1,3 lynx > 1 year of age per 100 km^2 favourable habitat is needed across the entire Alps. The *main threats* to the present and future Alpine lynx population were identified as illegal killing, inbreeding, habitat fragmentation, low acceptance and poor management structures. To address these threats, a set of *seven general management options* for the entire Alpine lynx population were identified: 1) Merge eastern and western subpopulations, 2) Active genetic management, 3) Secure and construct new connection corridors, 4) Prevent and persecute illegal action through law enforcement, 5) Foster dialogue among authorities, with wildlife managers, hunters and foresters by establishing information and consultation mechanisms regarding the lynx, 6) Integrate local people in lynx monitoring and 7) Secure sustainable damage prevention and compensation systems for livestock damages. Although there may be some regional and national variation in the priority of implementing these management options, *the level and timing of priority* for each of the seven management options were identified.

The current conclusions were elaborated on the basis of the suitable approaches and data available at the time of writing this report.

1. Introduction

1.1 Assignment and context of the present recommendations for an internationally coordinated management

The Platform "Large carnivores, wild ungulates and society"(WISO – wildlife and society) was set up by the X Alpine Conference in 2009 (Evian). Liechtenstein was assigned with the first presidency. Switzerland was allocated the second presidency by the XI Alpine Conference and Italy the third presidency by the XII Alpine Conference.

For the period of 2013-2014 the Platform dealt with the following mandate:

- Development of practical goals and management options for the recovery and conservation of wolf, lynx and (according to availability of funds) bear populations in the Alps and presentation to the relevant bodies of the Alpine Convention;
- Working towards an Alpine-wide genetic monitoring programme for large carnivores;
- Development of a map with the distribution and abundance of the Alpine ibex population in cooperation with the Alpine Ibex Group.

The "spirit of WISO" is based on the Alpine Convention and is expressed by the first president of the Platform, Felix Näscher with the following words:

"To ensure the continued existence of viable populations of large carnivores, regional planning must start taking their needs into account, e.g., by guaranteeing migration corridors, by defining tranquillity wildlife areas, by conserving functioning ecosystems, by applying adequate management strategies and measures as demanded by the protocols on "Spatial planning and sustainable development" and "Conservation of nature and the countryside".

A functioning ecosystem comprises both large predators and their prey species. Therefore, any concept for the conservation and management of wildlife species – be it large carnivores or wild ungulates – has to be based on a holistic and integral approach. Thus, speaking about large carnivores, you have to take into account the status of possible prey populations and of their habitats over the entire area occupied by these species; and, speaking about wild ungulates, you have to reflect the influence of predation by large predators over the entire area occupied by these species: Finally and above all, you have to go beyond a strictly ecological approach.

Any successful determination of development targets, strategies and measures with respect to these wildlife species will have to take it for granted, that economic and social aspects are duly taken into account on an equal level: Sustainable conservation and exploitation of wildlife can only be ensured when respecting and assessing all of these ecological, social and economical parameters, which are determining the system at stake.

Sustainable wildlife management can't never be a question of purely scientific knowledge – far away from it: Sustainable wildlife management has to be an expression of a will, how to deal with our wildlife species - by taking into account, by balancing and by harmonising ecological, economical and socio-cultural interests: A decision of all stakeholders involved is required - or let`s just say, a decision by society" (Näscher 2009).

To fulfil the overall goal the WISO Platform members understood, that additional expertise is necessary to analyse adequately the data and information of the different countries and to develop

appropriate solutions for the entire Alpine arc. This additional work, which goes beyond the Platform's capacity, is covered by the especially designed RowAlps project[1] for lynx and wolf. The project is financed by the MAVA foundation, Switzerland (Federal Office for the Environment) and Germany (Bundesministerium für Umwelt, Naturschutz, und Reaktorsicherheit). Switzerland coordinates and leads this project. The RowAlps project started in 2012 and will end in 2016.

The Alpine Convention Mandate of WISO for the period of 2015-2016 was adopted at the XIII Alpine Conference in Torino, on November 21st 2014. It focuses on the following tasks:

- *"To finalise drafting of practical goals and management options for the recovery and conservation of wolf and lynx populations in the Alps; to continue the development of practical goals and comprehensive advice for the application of management options in relation to recovery and conservation of bears in the Alpine region; to present all management options to the relevant bodies of the Alpine Convention in 2016.*
- *To develop procedures among the contracting parties concerned, which ensure a transparent flow of information and support decision-making processes as well as the coordination of responding actions for wolves and bears; common interpretations of behaviour of problem bears; and more effective and coordinated conservation actions for the lynxes involving the key stakeholders.*
- *To continue the development of coordinated programmes of genetic monitoring of wolves and bears on an Alpine scale, and to ensure a profound understanding of the genetic risks for the conservation of the lynxes to guide conservation policies in the Alps.*
- *These goals are to be pursued taking into account the results of the RowAlps project and other relevant projects, including EU-funded projects, and exploring synergies with the EU Platform on coexistence between people and large carnivores and other relevant initiatives"* (Alpine Convention 2014).

1.2 Main goals and general orientation of the guidelines „Large carnivores, wild ungulates and society" of the Alpine Convention

The work of the WISO Platform (and RowAlps) is based on and guided by the WISO guidelines that were adopted by the XI Alpine Conference in 2011 (Slovenia).

The main goal and general orientation of the guidelines is to achieve and conserve the favourable conservation status of wolf, lynx and bear in the entire Alps. Subgoals and options define the orientation of the WISO Platform to achieve the main goal.

[1] Recovery and conservation of wolf and lynx in the Alps: Options for transboundary conservation and management.

"MAIN GOAL – GENERAL ORIENTATION

Large carnivores and wild ungulates are preserved in balance with their habitat, other wildlife and human interest. Conflicts with human interests are addressed and negative impacts are counterbalanced. […]

Subgoals

1 - Dialogue: We inform, sensitize, and promote dialogue concerning the relations between wildlife, habitat, and society;

2 - Wildlife populations: We respect the intrinsic value of our wildlife as central components of our environment and steer the development of native wildlife populations in harmonization with their habitat and human interests, with the goal of securing viable wildlife populations;

3 - Wildlife habitat: We support close to nature land-use forms when using mountain pastures, agricultural areas and forests and aim for the conservation and improvement of wildlife habitats in terms of surface and quality;

4 - Integrative sustainable use: We use our wildlife sustainably, in recognition of and in harmonization with the various human interests in protection and use, and we further develop the various land use forms in a balanced manner;

5 - Cooperation: We cooperate transboundary in a cross-sectoral way and harmonize measures, as far as it is needed to reach common objectives, such as the amelioration of living conditions for wildlife species or the prevention of conflicts as regards different user interests as well as compensation of damages" (WISO 2011).

The WISO (wildlife and society) Platform, takes the role of a "Think Tank". WISO supports the member states and decision makers on a national and international level to achieve and conserve the favourable conservation status of the lynx, wolf and bear in the entire Alps. A special focus is given to cross border issues, international cooperation and necessary harmonization of processes relevant for a population level management.

1.3 Goals of the RowAlps project and current specification of the tasks

The overall goal of the RowAlps project is to develop practical goals and management options for the recovery and conservation of wolf and lynx populations in the Alps. These suggestions will support WISO to fulfill its current mandate.

To reach this goal, three objectives were defined and for each of them a working group was established.

Objective 1: To review and assess, based on available scientific publications and reports, statistical materials and up-to-date experience, the present situation of wolf, lynx and prey populations in the Alps, the expected development of the populations and discuss challenges in wildlife management as a consequence of the return of the carnivores.

Objective 2: To describe mechanisms to achieve tolerance for lynx and wolf for different interest groups and to identify factors defining the tolerance and the potential measures to influence these factors.

Objective 3: To assess the output from objectives 1 and 2 and develop, considering these biological-ecological and socio-economic findings, management scenarios for the recovery and conservation of favourable wolf and lynx reference populations in the Alps, discuss them with interest groups (in the frame of the WISO Platform), and report to the relevant bodies of the Alpine Convention.

These recommendations are based on the reports of the RowAlps objectives 1 and 2, further on the fact finding of the WISO Platform, on inputs of the members of working group 3 of the RowAlps project and finally on different documents, that have been drafted by WISO since its establishment in 2009.

The overall goal and objectives were fine-tuned during the discussions of three RowAlps workshops as well as the WISO Platform meetings during 2014. The working groups of objective 1 and 2 produced two separate reports[2].

1.4 Management definition

The members of the RowAlps project define management as follows: *"Management is any goal-oriented and deliberate intervention within the existing legal framework, carried out by an authorised or mandated actor. The WISO Platform defines management as a value-neutral term that can embrace a wide variety of involvements with large carnivores, their wild or domestic prey species, and habitats or with people. Regarding the carnivores, it could include activities such as translocation and reintroduction, culling and capturing, or also intentional (temporary) non-intervention, but implies always, as it is goal-oriented, a kind of monitoring. Regarding society, it could include activities such as communication, participation, compensation and damage prevention and social monitoring."*[3]

Management in the present recommendations is understood as: All legal activities in the biological and socio-political sphere with the goal of achieving a favourable conservation status of the lynx and wolf:

- on a biological level "management" includes different actions such as conservation, maintaining habitats, lethal removal of single specimens which e. g. are posing a threat to the human population (under the strict conditions laid down in § 16 of the Habitats Directive and the Bern convention) and other actions,
- on a socio-political level "management" means also dialogue, communication and cooperation.

1.5 Scope of the recommendations

The geographical focus for the present recommendations is the Alpine arc. The overall management of lynx and wolf across the Alpine arc focuses on international cooperation, whereas the concrete management options and strategies are understood as a transboundary framework.

[2] RowAlps report objective 1: The recovery of wolf Canis lupus and lynx Lynx lynx in the Alps: Biological and ecological parameters and wildlife management challenges. April 2015
Row Alps report objective 2. December 2014
[3] Workshop of the working group 3 of the RowAlps project, Vienna, 6th – 7th December 2012

1.6 Addressees

These recommendations address in the first place the official authorities of all member states of the Alpine Convention responsible for strategic planning and in charge of concrete actions concerning the conservation of large carnivores and wild ungulates. The recommendations provide a basis for decision-making regarding:

- strategic planning activities;
- concrete actions to balance large carnivores and wild ungulates with their habitat, other wildlife and human interest; as well as to address conflicts with human interests and counterbalance negative impacts.

Furthermore, they may serve as orientation for all non-governmental actors involved in wildlife management and finally as common vision for the realization of the overall goal to achieve a favourable conservation status of the lynx throughout the Alps.

More detailed reports, good practices, links on initiatives, references are available on the Alpine Convention web site[4] and MALME website[5].

2 Framework for large carnivore management

2.1 Legal framework of international and national treaties on large carnivores and population level management

Large carnivores have populations distributed across several countries and can have large individual home ranges, often >100 km^2. Therefore, legal instruments to protect these species need to be coordinated at an international level, and several international treaties have been established to address transboundary conservation.

The EU Habitats Directive

The EU Habitats Directive ("Council Directive 92/43/EEC on the Conservation of natural habitats and of wild fauna and flora") is a European Union directive adopted in 1992[6]. All the large carnivore species as well as their habitat are strictly protected by the Habitats Directive (annex II, which requires Natura 2000 sites, and annex IV). Wolf and brown bear, but not lynx, are additionally designated as priority species.

"Formally, the Habitats Directive does not explicitly specify that Favourable Conservation Status (FCS) should be achieved at the population level. Its reporting routines require that FCS be evaluated within each country (or within each biogeographical region present within each country), indicating that its intention is to operate on a national or sub-national scale. This scale of consideration may be suitable for a wide range of smaller species, but large carnivores present a wide range of very special challenges. As large bodied top-predators they naturally move over very large areas and occur at relatively low densities. This implies that many (maybe most) countries will never be able to host enough individuals to have a population that can reach FCS. In order for the intention of the Directive

[4] http://www.alpconv.org/en/organization/groups/WGCarnivores/default.html
[5] http://www.kora.ch/malme/20_malme/home/index_en.html
[6] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm

to be achieved for a species group like large carnivores, it must consider spatial scales that span borders. This is actually specified in the Directive's preamble as one of the prime objectives of the Directive. These population level management plans can simply be viewed as an instrument to achieve this goal. The Commission also says in its technical specifications for the tender of this project that "coordinating the management across national boundaries might be the solution to maintain viable populations over the long-term, an approach that is also important to put large carnivore conservation into the broader context of biodiversity conservation". A certain legal clarification is, however, required from the European Commission concerning the proposed practice of attaching favourable conservation status assessment to the population level, which in some cases may free member states from the obligation to achieve it on their own" (Linnell et al. 2008).

Formal requirements towards EU member states are more than "just avoiding extinctions". The requirement is to reach the Favourable Conservation Status (FCS), based on two reference values: Favourable Reference Range (FRR) and Favourable Reference Population (FRP). The "*Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species.*" (Article 11, EU Habitats Directive).

On behalf of the European Commission, the Large Carnivore Initiative for Europe elaborated the "Guidelines for Population Level Management Plans for Large carnivores" in 2008. The goals of these guidelines are:

1. To shift the focus from the species and the management unit to the (meta-) population.
2. To interpret FCS-term „Favourable Conservation Status" for correct and concrete use.
3. To recommend „best management practices" for large carnivores.

The Natura 2000 network was established under the Habitats Directive and comprises of a series of protected areas within the European Union (Emerald-Network for Switzerland and Liechtenstein).

The Bern Convention

All Alpine States and the European Union have signed the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). It lists wolf and brown bear as strictly protected (Appendix 2), while lynx is listed as protected (Appendix 3) together with the ungulate species. For species in Appendix 3 hunting is allowed as long as the population is not threatened.[7.]

"*The Bern Convention places considerable emphasis on the need to foster transboundary approaches in the preamble and in articles 1, 10 and 11. Recommendation 115 (2005) also calls for countries to work towards transboundary action plans for large carnivores, and the topic was given considerable attention in a workshop held in Slovenia in 2005 (Bath 2005)*" (Linnell et al. 2008).

The Bonn Convention

Furthermore, the Alpine countries are signatories to the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention)[8], which is specifically tailored to migratory species that cross international borders. The Bonn Convention even allows for states sharing migratory populations to sign legally binding treaties to govern the management of these species. Although the movements of large carnivores across borders do not follow the strict

[7] WISO Platform. Results of fact finding in the frame of the Platform, "Large Carnivores and Wild Ungulates". 2010

[8] http://www.cms.int/

definition of seasonal migration, it may be worthwhile exploring the potential for use of this convention, which has already been applied to several similar issues.

Whereas given that threatened habitats and species form part of the Community's natural heritage and the threats to them are often of a transboundary nature, it is necessary to take measures at Community level in order to conserve them:

"*The combined weight of the Habitats Directive and these two conservation conventions should be enough to motivate EU countries to develop population level management plans, especially if in so doing they will be permitted to adopt more flexible management practices than those allowed by a strictly national perspective. Furthermore, the Bern and Bonn Conventions should be useful frameworks to induce non-EU countries to take part in these plans. Although many Bern Convention signatories have taken reservations for wolves and bears concerning their placement on appendix II – these species are still covered under the Conventions general goals as expressed in articles 1 and 2*" (Linnell et al. 2008).

The Alpine Convention

The Alpine Convention is an international treaty (convention) for the protection of the Alps. It was signed beginning from 1991 by the eight countries of the Alpine Arc: Austria, France, Germany, Italy, Liechtenstein, Monaco, Slovenia and Switzerland and the European Community. Every two years is conducted an Alpine Conference in the country holding the presidency.

The Convention works with integrated policies and approaches for the sustainable development of the Alpine Space. Twelve key themes and out of them eight protocols, support the parties to navigate the implementation of highly complex sustainable developments in the Alps.

The Permanent Committee and the competent administrations are the main institutions primarily responsible for the Convention implementation. Working groups, platforms, committees etc. support and supervise the implementation of the Convention. One Platform of the Convention is the WISO (Wildlife and Society) which deals with large carnivores and wild ungulates.

Main themes and the protocols with relevance for large carnivores and wild ungulates in the Alpine Convention are

1. Spatial planning
2. Nature protection and landscape conservation
3. Mountain agriculture
4. Mountain forestry

Protocol „Spatial planning and sustainable development"
Article 3 of the protocol aims at considering of the criteria for environmental protection in the policies for spatial planning and sustainable development:

The spatial planning and sustainable development policies aim to achieve swift harmonisation of the economic interests with the needs for protecting the environment, with particular attention inter alia to:

a) safeguarding and restoring the ecological balance and the biodiversity of the Alpine region, […]

d) the protection of ecosystems, the species and rare landscape elements

And Article 9 of the protocol asks the countries that spatial and sustainable development plans and/or programmes include, at the most appropriate territorial level and taking account of the specific territorial conditions,: […]

4. Protection of nature and the landscape

a) delimiting of the areas for protecting nature and the landscape, and also for safeguarding the water courses and other vital natural resources,

b) delimiting of tranquil areas and areas in which construction of buildings and infrastructures is restrained or prohibited, as are other damaging activities.

Protocol „Conservation of nature and the countryside“

The objective of this Protocol is to lay down International laws, implementing the Alpine Convention and also taking the interests of the local population into account, in order to protect, care for and, to the extent necessary, restore nature and the countryside, in such a way as to ensure the lasting and widespread functional efficiency of the ecosystems, the conservation of countryside elements and wild animal and plant species together with their habitat, the regenerative ability and lasting productivity of natural resources, and also the diversity, specificity and beauty of the natural and rural landscape; and also, in order to encourage cooperation between the contracting Parties for these purposes.

The Contracting Parties undertake to cooperate particularly for: map surveying, drawing the boundaries and then managing and controlling protected areas and other natural and rural elements of the landscape worthy of protection, interconnecting a network of biotopes, defining landscape models, programmes and/or plans, preventing and rebalancing damage to nature and the landscape, systematically monitoring nature and the countryside, scientific research, and any other measure for protecting wild animal and plant species, their diversity and their habitat, and for defining the relevant comparable criteria to the extent that this is necessary and functional (Art. 3.1).

The Contracting Parties undertake to pursue the measures appropriate for preserving the indigenous animal and plant species with their specific diversity and in sufficient populations, particularly ensuring that they have sufficiently large habitats (Art. 14.1).

Finally the Contracting Parties shall undertake to promote the reintroduction and distribution of wild, indigenous animal and plant species and also subspecies, breeds and ecotypes, on condition that there are the necessary prerequisites and, by doing this, there is a contribution to the preservation and strengthening of those species and that no effects unsustainable to nature and the landscape, or to human activities, are caused (Art. 16.1). Scientific knowledge is to be applied for reintroducing and distributing these species. The Contracting Parties shall agree on common directives in this respect. Following the reintroduction, it will be necessary to control and, if required, regulate the development of these animal and plant species (Art. 16.2).

Protocol „Mountain farming“

In Article 13 of the protocol the Contracting Parties agree that the complementary nature and partial interdependence of farming and forestry in mountain areas necessitate an integrated approach. Consequently, they shall encourage:

(a) forestry compatible with nature both as an additional source of revenue for farms and as a sideline activity for farm workers;

(b) consideration of the protective, productive and recreational as well as the environmental and biogenetic functions of forests, in relation to farmland, taking account of the specific local conditions and in harmony with the countryside;

(c) regulation of grassland farming and of the game population, to avoid any intolerable damage to forests and crops.

Protocol „Mountain forests“
The Contracting Parties undertake to also consider the objectives of this Protocol in their other policies. This primarily applies to the following areas: […]

b) Populations of game. The game population is to be contained within limits permitting the natural reforestation of the mountains by indigenous trees, without having to take recourse to special protective measures. In the border areas, the Contracting Parties undertake to harmonise their measures for regulating the game animals. To restore a system of natural selection on the hoofed species, and also in the interest of protecting nature, the Contracting Parties shall encourage the reintroduction of predators, to an extent appropriate for the general needs of the region (Art. 2).

CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora, is an international agreement between governments to ensure that international trade in specimens of wild animals and plants does not threaten their survival. It came into force in 1975. Lynx is listed in Appendix 2 (www.cites.org). In the EU countries CITES is implemented by EC regulation 38/97.

The national laws on hunting and on large carnivores

In the Alpine countries wildlife is managed through legal and practical means such as protective laws and selective hunting.

Lynx is granted protection in all Alpine countries, in Germany it is strictly protected. However, there are exceptions mainly concerning livestock raiding individuals which are removed in France and Switzerland. In most of the countries, national authorities are in charge of lynx conservation and management. However, in Germany, Austria and partly also in Switzerland, power is delegated to the regional authorities. Complete legal protection of lynx was adopted in Slovenia in 2004 (Kos & Potočnik 2013). To prevent local extinction, according to Kos et al. (2012) an active approach addressing demographic factors as well as improving the depleted gene pool is needed for a revitalisation of the population.

In France, wildlife and environmental monitoring are carried out by the Office National de la Chasse et de la Faune Sauvage ONCFS. The role of hunting in Italy is primarily to control wild boar, red deer and roe deer populations (Apollonio et al. 2010). Switzerland has licence hunting across the Alpine range, with 41 federal wildlife reserves where hunting is banned (Imesch-Bebié et al. 2010). Ungulate management and hunting practices in Germany are carried out with the objective of reducing and preventing damage to crops and forests. There is a federal hunting law, but the 16 “Bundesländer” all have additional regulations (Wotschikowsky 2010). Austria uses the "Reviersystem" similar to the system in Germany; the Austrian "Bundesländer" are responsible for legislation and management of game (Reimoser & Reimoser 2010). The current Slovenian Law on Wildlife and Hunting controls the wildlife management system in Slovenia (Adamic & Jerina 2010).

Table 1: Legal status of lynx, restrictions to the status and authority in charge for lynx conservation and management in the Alpine countries.

Country	Legal status	Management interventions	Authority in charge
France	Strictly protected.	Selective removal of stock raiding individuals.	Ministère de l'écologie, du développement durable et de l'énergie
Italy	Strictly protected.		Ministry of Environment; enforcement of general policies by the local administrations
Switzerland	Strictly protected.	Selective removal of stock raiding individuals. Criteria for population regulation under discussion.	Federal Office for the Environment FOEN; the cantons for the implementation of the lynx concept (Chapter 6.1.2).
Liechtenstein	Strictly protected.		Amt für Umwelt (former Amt für Natur, Wald und Landschaft).
Germany	Strictly protected, but also subject to the hunting law with year-round closed season.		Nature conservation authorities of the federal states, but the respective hunting authorities also have a responsibility.
Austria	Mainly subject to the district's hunting laws, but year-round closed season.	Special permits to shoot a lynx to be issued by the district authorities on request, so far never used.	Hunting and nature conservation authorities of the provinces.
Slovenia	Strictly protected since 2004 (before quota hunting from October to February)		Ministry of Environment and Spatial Planning

2.2 Administrative framework concerning current management of large carnivores at national and local level of Alpine countries

All Alpine countries have a decree that defines, which species are protected and which ones are hunted. While e.g. the authority in charge is the state in France, in Austria the federal provinces (Länder) are responsible for large carnivores and wild ungulates.

In Austria, the three large carnivores are managed under the hunting law with year-round closed hunting season.

In France, wolf and bear management are organized at the national level through national action plans. The actions planned at national level are put in practice by departmental authorities and coordinated at the regional level. Lynx conservation is managed at regional and departmental levels, except for derogation to its protection status which implies a decision at national level.

In Germany all large carnivore species are strictly protected by the Federal Nature Conservation Act and the lynx in addition in the national hunting law with year-round closed hunting season. The administrative structure of huntable species in Bavaria is divided in three levels: local, the district and state level (Ministry of Food, Agriculture and Forestry).

In Italy large carnivores are protected on ministerial level and the ungulates are contained in the regional hunting law.

In Slovenia, protected species (bear, wolf, lynx) are regulated by nature protection legislation, game (chamois, ibex, roe deer, red deer, wild boar, mouflon) are regulated by hunting legislation.[9]

In Switzerland and Italy the general conditions are defined in the national laws, but some species are managed on cantonal or regional level, respectively. In Switzerland all three large carnivores are protected by federal law. The federal law also gives the general guidelines about wild ungulate management, but delegates the management itself to the cantons.

France, Switzerland, Germany and Austria have established large carnivore management boards with representatives of GOs, NGOs and scientists as discussion forums on regional and/or national level. The aim is an objective discussion about emerging problems and possible solutions to serve conflict management.[10]

Liechtenstein will in future be integrated in the management plans of Switzerland.

Table 2: Countries with operative management plans for large carnivores for the whole Alpine part of the population ✓ or regionally [✓].

Species	France	Italy	Switzerland	Liechtenstein	Germany	Austria	Slovenia
Wolf	✓	✓	✓		✓		✓
Lynx			✓		✓		
Brown bear	✓	[✓]	✓		✓	[✓]	✓

In Germany there is no nation-wide policy concerning lynx management. So far, only Bavaria has a regional lynx management plan (StMUGV 2008). In that respect, projects implementing transboundary cooperation and monitoring are done regularly with Czech Republic and Austria working on the Bohemian-Bavarian-Austrian population (e.g. Wölfl S. 2015).

Switzerland is the only Alpine country that has elaborated and implemented a lynx management plan. The first “Swiss Lynx Concept” was endorsed in August 2000 and was revised in 2004 (BUWAL 2004a). It defines the general conservation and management goals, the co-operation between the Federal Office for the Environment FOEN and the cantons, and criteria for interventions.

A national lynx management plan for Slovenia is in development. The document is expected to formulate and formalise the management goals and facilitate the implementation of a planned population augmentation project (Kos & Potočnik 2013). It is currently in the final stage and expected to be adopted by the Slovenian Government in 2015 (M. Jonozovič, pers. comm.).

In 2003, a Pan-Alpine Conservation Strategy PACS for the lynx was published (Molinari-Jobin et al. 2003) under the hospice of the Bern Convention. The strategy was elaborated by the SCALP expert group (Chapter 4.1) and proposed standards aimed at boosting transboundary activities and co-operation from local to international levels. The goal of the strategy was “to establish and maintain, in co-existence with people, a vital lynx population covering the whole of the Alpine arc” (Molinari-Jobin et al. 2003). This goal was then specified in four objectives:

[9] WISO Platform. Results of fact finding in the frame of the Platform, “Large Carnivores and Wild Ungulates”. 2010

[10] WISO Platform. Results of fact finding in the frame of the Platform, “Large Carnivores and Wild Ungulates”. 2010

1. The lynx populations in Slovenia and Switzerland maintain their vitality and must be helped to expand;
2. The populations in Slovenia and Switzerland are joined through colonisation of the area in between (Alps of Austria, Germany, Italy and Liechtenstein);
3. This unified population in the central Alps is allowed to expand to the north-east (Austria) and the south-west (France, Italy);
4. Gene flow is assured between the Alpine sub-populations and the population of Slovenia and Croatia, the population of the Jura Mountains and the population of the Bohemian/Bavarian forest.

To operationalise these objectives, actions on the pan-Alpine level as well as for each country were proposed (Molinari-Jobin et al. 2003). However, this Pan-Alpine Conservation Strategy was never implemented at the national level.

Wolf and lynx are strictly protected by international and national laws, but with regard to practical management, almost all countries having substantial populations of these carnivores are applying some regulations allowing for exceptional removals of problem animals. For the wolf, France is applying the principles of “tir de défense” and “tir de prélévemènt”, and Switzerland has set limits for how many livestock a wolf is allowed to kill before it can be lethally removed.

2.3 Human developments in the Alps

Since 1871, the resident human population in the Alps has almost doubled, from 7.8 million to 15.2 million people (Bätzing 2015). However, the population development has varied hugely within the Alps and the population distribution became much more uneven: the majority of people live below 500 m. Areas along major transport routes have become urbanised and cities at the edges of the Alps have become “commuter towns” for the metropolises surrounding the Alps. Tourist destinations have grown, too. The population has increased especially in the western parts of the eastern Alps. The population in higher elevation areas has decreased, mostly because agriculture has become unprofitable due to limited mechanisation. The population decrease was most prominent in the Italian Alps (except South Tyrol), eastern Austrian Alps, and some regions in the French Alps. Young people and families moved away, and the population in these communities is considerably over-aged. A further population decrease is expected in areas with unfavourable economic conditions.

Tourism in the Alps has been stagnating on a high level since the early 1980s. About 60 million people visit the Alps every year for daytrips and an additional 60 million people stay for 370 million nights in the Alps every year (Siegrist 1998). However, tourism is spread unevenly across the seasons and across the Alps (37% of municipalities in the Alps offer no tourist beds at all; Price et al. 2011).

The influence of tourism on large carnivores and wildlife in general is twofold: Firstly, tourism requires infrastructures (e.g. transport infrastructure, ski slopes, or golf courses), which influences the landscape and the habitat of wildlife. Secondly, touristic activities (e.g. hiking, skiing, paragliding, but also added traffic from visitors) create disturbances for the local wildlife. Nonetheless, the populations of ungulates have increased throughout time. Large carnivores have a high capacity to adapt to human activities. Wildlife and especially large carnivores also represent a chance for tourism as visitors see them as the embodiment of pure nature and untamed wilderness. Wildlife tourism is however weakly developed in the Alps.

2.4 Ecological framework

Habitat loss and fragmentation are the leading human-caused deterministic factors affecting wildlife populations with effects being caused by e.g. altered connectivity or increased edge effects (Mills 2007).

The fragmentation of the landscape in Europe is increasing, which has various negative effects on wildlife (e.g. barrier effect, loss of habitat, increased numbers of traffic collisions). Nevertheless the Alps still feature some of the largest unfragmented low-traffic areas in Central Europe but valley floors can be just as heavily settled and fragmented as the lowlands surrounding the Alps and present considerable barriers for animal movements.

The Alps are one of the best-known mountain ranges as well as being one of the richest in biodiversity, it is, however, also one of the most densely populated. The traditional tool used to conserve biodiversity and the natural environment has always been the creation of protected areas, however it has become increasingly obvious that a majorly important aspect in the conservation process is to connect protected areas to one another to allow the migration of species across the entire Alpine range.

Besides the extent and quality of forests (which have improved over the past 100 years in the Alps), the connectivity between forest patches is decisive for far-roaming terrestrial species.

Forests in the Alps have been strongly overexploited in the 18th/19th century, but have recovered and forested areas have expanded again in in the 20th century. About 52% of the Alpine area is forested, and “forest creation and management” contributes the majority to recent changes in land cover (EEA 2010).

The realisation of an ecological continuum and the reduction of fragmentation lead to concrete spatial links (corridors) and measures in favour of the establishment of a pan-alpine ecological network (ECONNECT 2011).

Genetic flow across the whole Alpine range is important. Across the whole Alpine range a coordinated and transnational approach is needed in accordance with the legal framework provided by the Alpine Convention. Together with the “Ecological Continuum initiative” and the “Platform Ecological Network” of the Alpine Convention, Econnect created the Alpine ecological network to join efforts focussing on the Alpine massif as a whole in order to create a functioning ecological network in the Alps to contribute to conserve the extraordinary rich alpine diversity.[11]

According to the analysis of the ECONNECT Project[12], for lynx the attention should be drawn to motorways as they are the major barriers for the migration of lynx populations. Conservation should aim at the connection of core areas that are separated by motorways. Settlements as they are at the moment, seem to have little negative impact on lynx in the Alps.

[11] http://www.alpine-ecological-network.org/the-alpine-ecological-network
[12] ECONNECT, Alpine Space Project, 2008-2011, http://www.econnectproject.eu/cms/?q=homepage/en

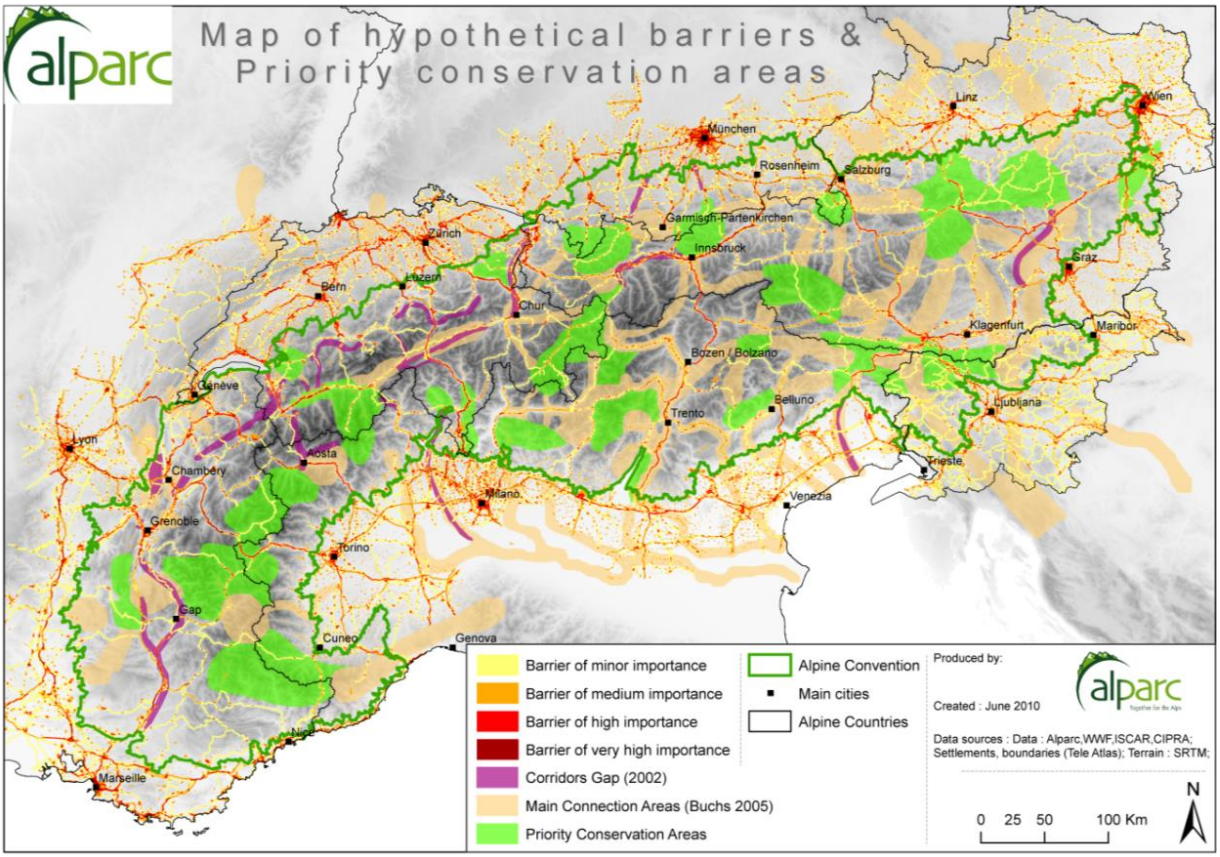

Fig. 1: Map of barriers and priority conservation areas. The map was based on expert opinion expressed during a workshop for the Ecological Continuum Initiative in 2010.

While enough suitable habitat and prey in the form of wild ungulates are available to lynx, one of the major threats lies in the fragmentation of said habitat. Some of the fragmentation stems from the natural Alpine landscape (e.g. high mountain ridges), but much of it originates from anthropogenic structures, especially in the lower regions. As a result, there is a lack of connectivity within the Alps as well as to other populations adjacent to the Alps. Although individual lynx have the ability to cross most types of barriers, its dispersal ecology is such that the population as a whole cannot overcome them. Consequently, there is a lack of population expansion, which contributed to a high amount of inbreeding in the population.

A natural population expansion over the whole of the Alpine Arc is highly improbable, even in the long term (Chapter 4.2). Therefore, the anthropogenic support is required and needs to be organised. A way to aid the expansion of the lynx population are translocations and further small-scale reintroduction projects as the ones carried out in north-eastern Switzerland or in the Kalkalpen National Park in Austria. These were indeed the latest significant population developments in the Alps. Rüdisser (2002) proposed such an approach also for the western Austrian Alps. Reintroduction projects in southern Vorarlberg, eastern Tyrol and western Salzburg would allow establishing further subpopulations and eventually connect the now isolated lynx occurrences in the Alps (Rüdisser 2002).

3. Current situation of the lynx population in the Alps

3.1 Return of the lynx to the Alps and population development

The historic decline and eventual eradication of the large carnivores in the Alps between 1800 and the early 1900 proceeded in parallel and was related to the expanding human population and the over-exploitation of natural habitats and resources, including forests and game. Increasing numbers of sheep, goats, cattle and horses affected the forests negatively due to browsing and out-competed the wild ungulates. The large predators were forced to kill livestock and were therefore persecuted, encouraged by governmental bounties. However, hunting alone did not lead to the eradication of the large carnivores. Only the massive intervention at the level of the landscape (forests) and the substantial reduction of wild ungulates led to the final eradication of lynx and wolf (Zimen 1978, Breitenmoser 1998a).

A radical change in forest management and the growing sensitivity of people for the protection of nature in the first half of the 20th century were the basis for the recovery of the forests (Breitenmoser 1998a). Wild ungulates started to recover and expand from remnant source populations after they were granted a certain legal protection (change of hunting legislation). Their renaissance was supported by numerous translocations and reintroductions. A swift increase in all wild ungulate populations – which is still continuing for roe deer, red deer and wild boar in many regions – was the result. The ecological recovery was facilitated by industrialisation, which drew people away from rural areas. As a consequence, the number of goats and sheep in the Alps declined drastically in the first half of the 20th century.

All these factors prepared the ground for the return of lynx to the Alps.

Today, the Alpine Lynx population consists of several occurrences, all originating from reintroductions in the 1970s: Switzerland 1970–76 (Breitenmoser et al. 1998), in the Dinaric part of Slovenia 1973 (Cop & Frkovic 1998) and Austria 1977–79 (Huber & Kaczensky 1998). There were also several attempts to initiate the reintroduction of lynx into the German Alps but none of the projects could be carried out because of very controversial attitudes towards the species and because of competition between institutions (Kaczensky 1998).

The strongest population is currently in the north-western Alps of Switzerland. Although lynx immigrated into neighbouring countries (France, Italy; see below) the forty years since the first releases have not allowed establishing a continuous population throughout the Alps.

3.2 Present status and distribution of the Alpine lynx population

The total population of lynx in the Alps is still small and endangered according to the IUCN Red List assessment (IUCN Standards and Petitions Subcommittee 2014). Kaczensky et al. (2013a) have assessed the large carnivore populations across Europe, based on the most recent data available. They have listed the Alpine lynx population as EN(D), meaning that the population is Endangered under the criterion D (total population size smaller than 250 mature individuals). The population was considered stable or slightly increasing in Switzerland, and stagnant in Italy, France, Austria, and decreasing in Slovenia, and the conclusion was that “the observed rate of development will most likely not allow for a natural fusion of the western and eastern Alpine populations within the next decades”.

The Alpine lynx consists today of five relatively isolated subpopulations (Molinari-Jobin 2010). They are slowly recolonising the Alpine region and their status has been studied in varying detail in the respective countries. Over the past 10 years, they have increased their area of presence by around 6,000 km^2 or 50%, mainly after a translocation in Switzerland (see below). However, the population size remained more or less the same. In 2011, the number of lynx estimated for the entire Alpine region was between 130 and 180 individuals.

Table 3: Lynx abundance in the Alps in 2001 and in 2011 (mature inidviduals). Sources: von Arx et al. (2004), SCALP (2012), Kaczensky et al. (2013a).

Country	2001	2009–2011	2011*	Trend 2006 –2011
France	single individuals	15–20	13**	West: slight increase
Italy	10-13	10 –15	10-15	
Switzerland	70	100–120	96-107	
Liechtenstein	0	0 –2	0	East: decrease
Germany	0	0 –1	0	
Austria	20	6 –12	3-5	
Slovenia	10	5 –10	few	
Alps	**~120**	**136 –180**	**~130**	

* estimates in Kaczensky et al. (2013a). **extrapolated from densities of the Jura population.

For the Alpine lynx population, the most important area is in the north-western Alps (western Switzerland), followed by north-eastern Switzerland and the south-eastern Alps (Italy and Slovenia. Both populations are the result of reintroductions in the early 1970s with very few founder animals, and both populations show today a high inbreeding coefficient. Two other smaller nuclei lie in the Chartreuse (France) and the Kalkalpen region (Upper Austria). However, only in four areas reproduction has been reported: north-western Swiss Alps, Friuli, north-eastern Switzerland and the Chartreuse region (Molinari Jobin et al. 2010a, b). More recently, reproduction also occurred in the Kalkalpen (Fuxjäger 2014). There is no permanent lynx presence with reproduction between or outside these areas, and even single confirmed observations are rare (Molinari-Jobin et al. 2010a, b).

In Austria nine wild lynx from the Carpathian Mountains were reintroduced in Styria between 1977 and 1979 (Huber & Kaczensky 1998), but the reintroduction failed. Recent observations concern lynx that immigrated from the Dinaric population or the Bavarian-Bohemian population (in the east) or from eastern Switzerland (in the west). The population in the Kalkalpen National Park consisted of a male which settled in the area in 1998 (Kaczensky et al. 2013c). A female from the Swiss Alps and a female and a male from the Jura Mountains were translocated to the Kalkalpen National Park in 2011 and 2013; both females have already reproduced (Fuxjäger 2014; Nationalpark Kalkalpen 2011a, b). Outside the Kalkalpen, two camera-trap photos were taken in 2009 by hunters of two individual lynx in two different regions of Salzburg, from where no other signs (not even unconfirmed) were known (Fuxjäger et al. 2012).

Overall, the French Alpine lynx sub-population was assessed to be stable with a regular population range of less than 1,350 km² and a population size of not more than 10–15 resident adults (Marboutin et al. 2012).

Besides a few unconfirmed direct sightings and rumours there was no confirmed evidence of lynx presence in the German Alps (Wölfl & Kaczensky 2001, Wölfl 2006, Wölfl & Wölfl 2012). The nearest lynx sub-populations to the Germans Alps are found in north-eastern Switzerland (distance 70 km) and in Slovenia (distance 180 km), besides the population in the Bavarian-Bohemian Forest, which is however separated from the Alps by open agricultural land.

The Italian Alps were naturally recolonised in the 1980s by individuals from the reintroduced populations. However, the initial positive trend was soon reversed and population estimates decreased from 21 individuals in 1995 with observed reproduction (Ragni et al. 1998) down to less than 15 in 2009 with no signs of reproduction (Molinari et al. 2012). In April 2014, a male and a female lynx were translocated from Switzerland to Tarvisio in the Julian Alps in order to reinforce the south-eastern Alpine/Dinaric lynx population (Molinari-Jobin 2014).

The first observations of lynx in Liechtenstein occurred in January 2004 and January 2005 (Fasel 2006). In March 2013, there was a visit from a female lynx radio-collared in the canton of Grisons (A. Ryser, pers. comm.), however, no lynx settled in the country so far.

The Slovenian lynx population is divided between the Dinaric and the Alpine populations (Kos & Potočnik 2013). The Jesenice – Ljubljana – Trieste highway marks the border between the two populations. The majority of the Slovenian lynx belong to the Dinaric population. During 2000–2004 a total of 30–50 lynx were estimated for Slovenia, of which 15 in the Alpine part (Koren et al. 2006). Estimates place the current population at 15-25 individuals, with about 5–10 individuals in the Alpine region and 10–15 in the Dinaric Mountains in southern Slovenia (Kos et al. 2012). In addition, no reproduction had ever been recorded in the Slovenian Alps up to then (Potočnik et al. 2009). The population of lynx in the Alpine region has further decreased to few (2-3) individuals (R. Černe pers. comm.).

In the Swiss Alps, the lynx population is part of the western subpopulation and occurs mainly in the north-western and central regions of the country. Between 2001 and 2008, 12 lynx from the north-western Alps and the Jura Mountains were translocated to the north-eastern Swiss Alps to create a new population nucleus and hence to contribute to the expansion of the species especially since spontaneous long distance migrations are rare. The population in Switzerland currently forms the largest subpopulation of lynx in the Alpine region (von Arx & Zimmermann 2013) with an estimated population of 96–107 independent individuals (von Arx & Zimmermann 2013). Signs of reproduction were found in the north-western region between 2000 and 2004 and between 2005 and 2009 with reports of juveniles each year in that region as well as in the north-eastern and central Alps (von Arx & Zimmermann 2013).

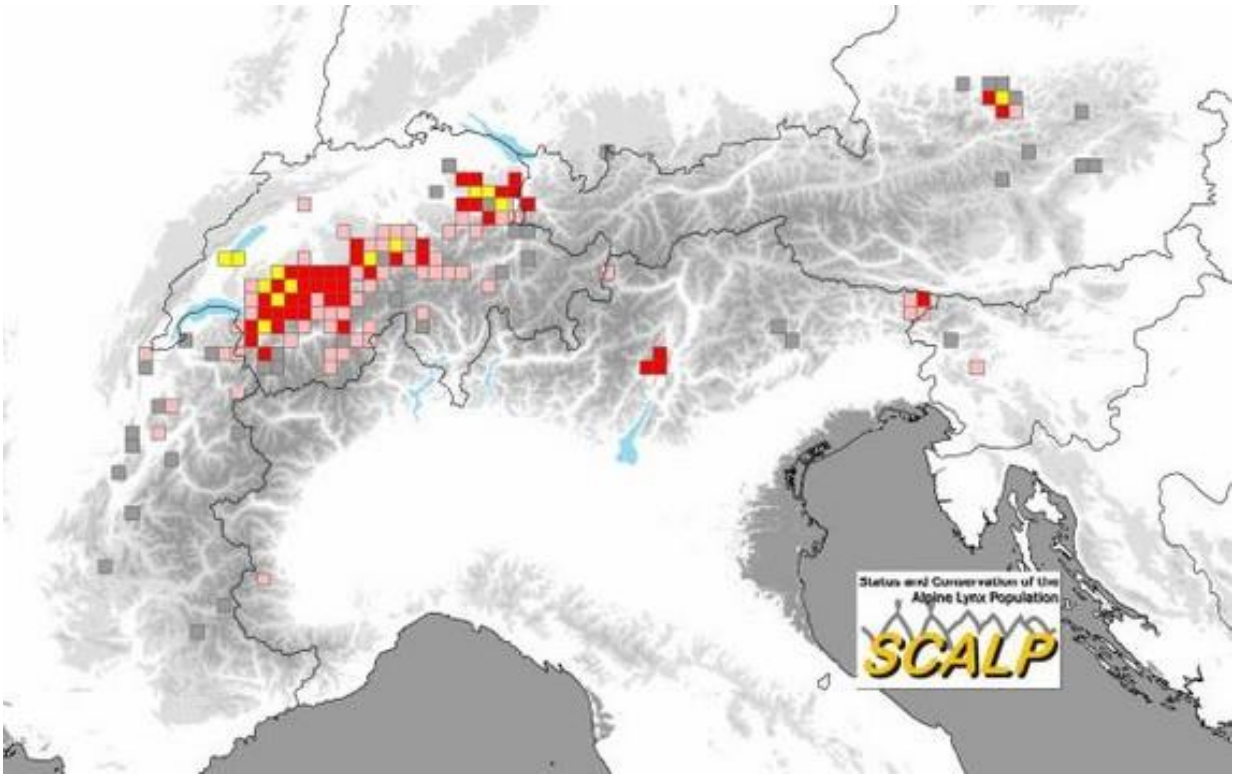

Fig. 2: Lynx distribution in the Alps 2012 based on a 10x10 km grid; yellow cells = cells where reproduction was reported from, red cells = C1, cells with hard fact records, pink cells = C2, cells with confirmed records, grey cells = C3, cells with unconfirmed record (SCALP 2012).

3.3 Diet and predation of lynx

The main prey of lynx in Europe are small to medium-sized ungulates (Nowicki 1997). Wherever roe deer are abundant, they form the staple food, followed in the Alps by chamois. This basic pattern was observed e.g. in Switzerland where these two prey species comprise up to 90% of the lynx diet (Breitenmoser et al. 2010) and in the French Vosges (Herrenschmidt & Vandel 1989). Where roe deer and chamois are either rare or even lack completely, red deer can function as secondary or even primary prey species, e.g. in Italy (Molinari 1998), Austria (Gossow & Honsig-Erlenburg 1985) and the Dinaric mountains in Slovenia (Krofel 2006). Other prey species may include foxes, hares, marmots, edible dormice, and (mainly in Scandinavia) tetraonids (Nowicki 1997, Breitenmoser & Breitenmoser-Würsten 2008, Krofel et al. 2011). Livestock depredation by lnyx is generally low (Kaczensky et al. 2013a). Between 2006 and 2011, only 7 to 47 sheep were predated on per year by lynx in the Swiss Alps (von Arx & Zimmermann 2013). A total of 317 depredation cases have been recorded in the Slovenian Alps since 1994, but none since 2011 (M. Jonozovič, pers. comm.).

Depending on the size of the prey, lynx can return from one to seven consecutive nights to feed on their kill (Breitenmoser & Breitenmoser-Würsten 2008). Generally, lynx consume their prey fully so that the skeleton, skin, head, legs, stomach and intestines are all that remains (Capt 1992). Domestic sheep or goat kills are often abandoned before they are completely consumed because the cadavers are removed or the lynx is disturbed by the presence of people. Average daily consumption of meat was estimated to be 2 kg with a maximum of 3.0-3.5 kg (Haglund 1966, Bufka & Cerveny 1996). The yearly consumption rate for lynx in Switzerland, based on radio-telemetry studies (Breitenmoser & Haller 1987, Haller 1992, Jobin et al. 2000, Molinari-Jobin et al. 2002), was estimated to be 56 ungulates (roe deer and chamois) for an adult male lynx, 57 for subadult lynx, 59 for solitary females, and 72 for females with cubs. So considering the proportion of the social categories in the lynx

population, this would come on average to about 61 ungulates per independent lynx and per year (Breitenmoser & Breitenmoser-Würsten 2008).

Predation impact of lynx on ungulates

The effect of predation on roe deer on a European scale was found to be weaker the more productive the environment was (Melis et al. 2009). However, under certain conditions, depending e.g. on the population status of predator and prey, on the recolonisation state (e.g. immigrating predators), and on other important mortality factors (e.g. winter mortality or human-caused mortality), lynx can have a significant impact on a local roe deer population.

The longest observation series to assess the quantitative impact of lynx predation for the Alps are available for Switzerland (Breitenmoser et al. 2010). The observed roe deer mortality caused by lynx predation (based on the assumed local abundance[13]) varied substantially (Breitenmoser et al. 2007). Indeed, the extreme values (9 and 63% of the known roe deer mortality, respectively) came from the same study area in the north-western Alps about 15 years apart. Haller (1992) observed a strong predation on roe deer in a high valley in the central-western Alps (Canton of Valais) shortly after the recolonisation by lynx. A sudden drop of the roe deer population was also observed in Central Switzerland (Canton of Obwalden) about 10 years after lynx had been reintroduced (Breitenmoser & Breitenmoser-Würsten 2008). Such observations were attributed to the lack of vigilance and behavioural adaptation of roe deer after the recolonisation by lynx (Breitenmoser & Haller 1993). However, another period of strong predation impact was observed in the years 1997–2000 in the north-western Alps, where lynx had been present for almost 30 years. This experience – although only a case study – illustrates the potential predation impact and the importance of cofactors (anthropogenic and climatic factors) influencing the predator-prey system and should be considered in a wildlife management system in the Alps with large carnivores present.

In the late 1980s and early 1990s, probably as a consequence of a series of mild winters and low winter mortality, the roe deer population in the north-western Alps increased, followed by a numeric response (a population increase with a certain time delay) in lynx (Fig. 3a). The growing roe deer population had also triggered an increasing human hunting pressure (Fig. 3b), demanded for by the foresters. After about 1995, the roe deer population started to decline, first slowly and then faster, causing a reduced hunting bag, as the hunters were no longer able to fulfil the quota. During this time, the lynx population still increased, and the predation impact reached its peak in the years 1997–2001. Lynx were in these years responsible for about 60% of the known local mortality in roe deer, besides hunting and “Fallwild”, and about 33% in chamois (Breitenmoser & Breitenmoser-Würsten 2008). Lynx maintained a rather high predation pressure on roe deer in spite of (or as a consequence of) part-switching to other prey, namely to chamois and more obviously to sheep (Fig. 3a).

[13] Wild ungulate abundances are notoriously hard to measure and usually suffer from large uncertainties. All numbers that then are estimated from such abundances therefore have large uncertainties as well.

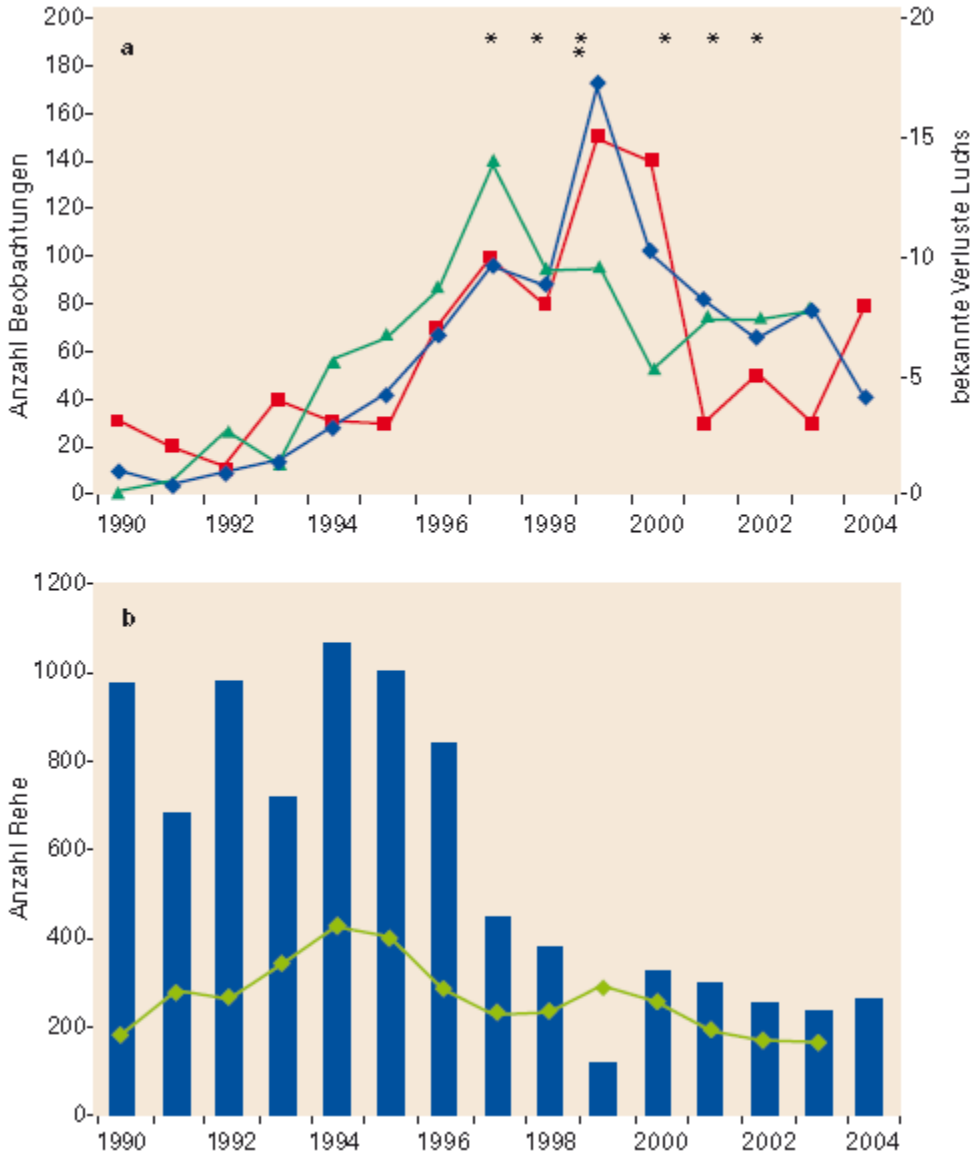

Fig. 3: Development of the lynx population (a) and the known roe deer mortality (b) in the north-western Swiss Alps 1990–2004. After 1992, the number of chance observations of lynx (a, green curve, left y-axes), the known lynx mortality (a, red curve, right y-axes) and the number of attacks on livestock (a, blue curve, left y-axes) steadily increased, indicating a growing lynx population. In the early 1990s, the hunting bag of roe deer also increased (b, histogram), parallel to a slight increase of the number of roe deer killed in traffic accidents in the same area (b, green curve). After about 1996, a drastic decline in the roe deer population was observed, illustrated by a drop of the hunting bag and a decreasing number of traffic victims. After a "lynx peak" in 2000, the lynx population dropped, too. In these years, 8 lynx (a, asterisks) were removed as stock raiders (source: Breitenmoser & Breitenmoser-Würsten 2008).

After the peak years and the crash of the local roe deer population, lynx showed a negative numeric response, but its importance cannot be estimated, as it was strongly supported by "management measures", including the lethal removal of stock raiders, the translocation of 9 lynx in the years 2001–2003 into the eastern Swiss Alps, and an increase in illegal killings of lynx (Breitenmoser & Breitenmoser-Würsten 2008). In winter 1998/99, the local abundance of lynx was estimated at 2.6 independent individuals/100 km², and it dropped to 1.0 lynx/100 km² in winter 2001/02 (capture-mark-recapture estimations based on camera trapping; Laass 1999, 2002). In 2000, roe deer hunting bags for the canton of Bern (not just the study area) have already recovered again and reached almost the level of the early 1990s where they have stabilised (BAFU 2014). Meanwhile, lynx

densities have nowadays stabilised at around 2 independent individuals/100 km² (Zimmermann et al. 2014).

Both, the increase and crash of the roe deer population seemed to have been a consequence of mild and harsh winters, respectively. Winter mortality is a driving force of roe deer population dynamics in the Alps. But the case study demonstrates that lynx can show a considerable numeric response and that the combined impact of predation and hunting can strongly impact roe deer abundances if the effect of predation and the population dynamics of predator and prey are not understood and considered in wildlife management decisions.

3.4 Wild ungulates

3.4.1 Wild ungulate availability

The existence of a sufficient prey base is a key factor determining the successful return of large carnivores (Breitenmoser 1997). Populations of all wild ungulate species have been increasing over the past decades and continue to do so in many Alpine regions except for the chamois. Some countries make regular records of wild ungulate population sizes available (but often do not state census methods clearly), but others like Austria do not (Reimoser & Reimoser 2010). Hunting bag data were the only data sets almost consistently available across the Alpine countries. Of course, data on hunting bags show clear weaknesses, e.g. not being linked with the real hunting effort invested. In Bavaria for example, hunting efforts to reduce ungulate numbers were raised considerably over the last 20 years in order to decrease browsing impact on forest regrowth. Nevertheless, the existing data on population numbers and hunting bags were used to indicate the development of large herbivores and differences between the Alpine countries. More detailed population numbers and hunting bags are listed in the RowAlps report objective 1.[14]

Red deer have naturally recolonised the Alps, helped by reintroductions. Numbers are still increasing across the Alps according to censuses and hunting bags, with an especially strong increase of hunting bags in Austria. Hunting bags in the Alpine districts of Bavaria appear to be rising again as well, after experiencing an initial sharp drop by approx. 25% in the late 1980s followed by a slight further decrease for the next 15 years.

Roe deer are abundant and widespread across the Alps. Hunting bags appear to be still increasing in Austria and the Alpine districts of Bavaria. In the other countries they appear to be rather stable.

Wild boar hunting bag numbers are fluctuating strongly in some of the countries, with wild boar generally expanding their range and hunting bags increasing. In fact, the data compiled in the RowAlps report objective 1 show for all countries the highest hunting bags for wild boar for the most recent years.

Chamois are widespread across the Alps, but trends differ. Hunting bags in France continue to rise, while they stagnate in Bavaria and Slovenia. Meanwhile, in Switzerland and Austria, hunting bags have decreased by about a third since the early 1990s.

[14] Breitenmoser et al. 2015. The recovery of wolf Canis lupus and lynx Lynx lynx in the Alps: Biological and ecological parameters and wildlife management systems. RowAlps Report Objective 1. KORA, Muri bei Bern, Switzerland. 276 pp.

3.4.2. Wild ungulate management

Red deer and roe deer are the most widely distributed ungulates across Europe and the Alpine range; along with wild boar they compose the most important game species (Linnell & Zachos 2011). These populations recovered from a net decline in the 19th and 20th centuries due to widespread unregulated hunting (Putman 2011). Management practices such as regulated and selective hunting practices, increasing migratory corridors and habitat connectivity, reduction in habitat fragmentation and protection of habitat, but also reintroductions, reinforcements and artificial feeding have led to an increase and recently stabilisation of these populations. In many regions of Europe, wild ungulates are so abundant today that management practices include measures to reduce damage to crops and forests and prevention or mitigation of diseases. Hunting is the most important management practice and is used in many countries to control populations and hence limit damage to agriculture and forests (Putman 2011). Culling of wild ungulates is widespread across Europe and is largely linked to the claims of agriculture, forestry and transport sectors (Morellet et al. 2011).

In spite of these challenges, few countries have established robust long-term census system to monitor ungulate populations. Direct and indirect censuses are the most commonly used methods to monitor ungulate populations. Direct census methods may include capture-mark-recapture method (Switzerland), open hill counts (Switzerland), animal vocalisations (Italy), spot lighting (Italy, Switzerland) and drive counts (Italy, Switzerland) (Morellet et al. 2011). Estimates from indirect methods use faecal samples, animal vital rates (France), snow tracking (Switzerland) and habitat quality (France, Slovenia) among several other sampling methods (Morellet et al. 2011).

Wildlife in the Alpine countries is managed through legal and practical means such as protective laws and selective hunting. Legislation operates at different levels (national, regional, provincial, etc.) across Europe. One generality however, exists across European countries: game does generally not belong to the land owner (Putman 2011). Game belongs to everyone or no one – *res communis* or *res nullius*. In the case of *res communis*, the state can either sell hunting licenses or allocate the sale of hunting licenses to individuals or hunting groups and do not involve landowners in this aspect (e.g. Italy, Slovenia[15], Switzerland). In the case of *res nullius*, hunting rights belong to the landowner who allocates licenses while the state has the right to determine management goals (e.g. Austria, Germany, France; Putman 2011).

Although hunting seasons in European countries should ideally be determined based on the ecology and natural history of the species that are hunted, it is currently not the case in several countries (Apollonio et al. 2011). Factors that should ideally be taken into account when determining a hunting season include the period of rut, pre-parturition and post-parturition. These are important factors as hunting during these key moments can disrupt reproduction and have a negative impact on the population. Hunting during periods of late pregnancy can also be negatively perceived by the non-hunters with regard to ethical concerns. Culling adult females with young can result in the death or loss of fitness of young animals still dependent on their mothers. Many European countries allow the hunting of animals during these three critical periods during the breeding season for species such as red deer, roe deer, chamois and wild boar (Apollonio et al. 2011).

[15] In Slovenia, the state is the legal owner of game according to the Environmental Protection Act of 2004.

Table 4: Comparison of management systems across the Alpine countries (adapted from Putman 2011), showing strong state controlled management practices on the left and individual landowner management types on the right.

	Impose/determined by state (National or regional authorities)	**Proposed by land owners associations/ Hunters' associations, approved by State**	**Proposed by landowners associations/ Hunters' associations or equivalent voluntary**
Game management district/group	Switzerland, Slovenia, France, Austria	Germany, Italy	
Management objectives	Switzerland, Slovenia, France, Austria	Germany, Italy, Austria	
Management Plan	Switzerland, Slovenia, France	Germany, Italy, Austria	
Quota/Cull Targets	Switzerland, Slovenia, France Cull carried out by game wardens	Germany, Italy, Austria Individual licenses allo-cated (per animal)	Global quota allocated to leaseholders
	Cull carried out by State hunters	**Individual licenses allocated (per animal)**	**Global Quota allocated to leaseholders**
Global Quota/ Individual licenses	Switzerland (Canton of Geneva), France	Switzerland, France	Slovenia,Germany, Italy, Austria

3.5 Livestock husbandry

Livestock husbandry is much less important for the lynx than for the wolf therefore more detailed information on livestock husbandry can be read in the wolf recommendations.

Sheep are the most important and most abundant domestic victims of predators in the Alps (Kaczensky 1996). Therefore the chapter focuses not exclusively but very much on summered sheep.

3.5.1 Development of livestock husbandry and pastoral systems in the Alps

Livestock husbandry has largely influenced Alpine societies and traditions. After a peak in the 19th century, the agricultural crisis as a consequence of industrialisation, which drew people away from remote areas, led to the abandonment of many Alpine pastures. The importance of sheep declined around 1830, when the domestic wool production lost its competitiveness to wool from abroad and cotton. Sheep husbandry is today promoted to prevent that remote pastures in the Alps are grown over by forest. Goats have today totally lost their former economic significance in the mountains. Only the financial support in the frame of subsidies (since the 1980s) attenuated the trend of a reduction in in numbers of summered livestock and the variability of summered livestock. Nevertheless the species of livestock can still change (e.g. sheep instead of cattle or horses, sheep instead of goats and so on; Ringler 2009).

In the past 100 years numbers of summered sheep and goats have significantly decreased in the northern parts of the Alps (A: decrease to 1/7 of the numbers between 1927 to 2008; D: decrease to ½ of the numbers between 1950 to 2003; FL: decrease to 1/8 of the numbers between 1977 to 2003) whereas in Switzerland and in Italy summered sheep and goat numbers decreased only slightly (around 15%) and increased heavily in Slovenia (up to 4 times the number between 1923 to 2003) and France (additional 43%; Ringler 2009).

3.5.2 Mountain pastures and pastoral systems today

In absolute figures the surface of alpine pastures is the highest in France (more than 2 million ha), the number of pastures however is the highest in Austria (more than 13'000). Today, between 5 and 50% of the Alpine area are pastures, depending on regions.

Pastoral systems and practices vary depending on the country, traditions and type of terrain. There are three main types of mobile sheep herding: nomadic, transhumance (i.e. seasonal change of grazing areas) and the alp system. On each alp other responsible bodies, managers and partners are engaged and make the mountain pasturing and pastoral system in the Alps a diversified and complex system.

3.5.3 Present figures and distribution of livestock

Presently ca. 1.5 million sheep are distributed on Alpine pastures across the Alps. The trend in livestock husbandry varies (see above). Cattle are still the most abundant livestock species summered in the Alps (ca. 2 million), but sheep are the most abundant in remote areas. Sheep are often an alternative to cattle for farmers with less time and personnel.

The differences between numbers of animals and the species in the Alpine regions are high. More than 50% of the alpine sheep are in the French Alps. Sheep pastures are generally dominant in the southwestern Alps and are generally stronger in the western Alps, than in the eastern Alps. Mixed regions with sheep and cattle are widespread in the Isere, Alpes Maritimes, Piemonte, Wallis, Slovenia, Werdenfelser Land and parts of Tyrol. The regions in Upper Austria and Bavaria are currently the regions with the fewest sheep in the Alps. Goats play still a role in Haute Savoie, Grisons, Ticino, in the Fribourgian Alps and finally around the Upper Italian lakes.

3.5.4 Livestock protection measures

With the disappearance of large carnivores from their historical range, the traditional livestock protection methods were also abandoned. It was a common practice in the past, when predators were rare, to leave large herds of livestock unattended in the mountain pastures, in countries like France, Switzerland and the Alpine region of Slovenia. However, the return of large carnivores, in particular wolves requires a return to traditional pastoral ways and guarding which can be an expensive option. In most Alpine countries, the greatest number of attacks occurred during the summer season when livestock graze on alpine pastures (Anonymous 2010). The most effective protective measures against predation include guarding dogs, electric fences and the presence of a shepherd.

In order to implement effective protection measures against large carnivores, the current livestock management system is of major importance. It is e.g. easier to implement protection measures if personnel is available on pastures, if the pastures are furnished with infrastructure for shepherds, if flocks or herds are rather large and held together on a specific surface area (facilitates the integration of livestock guardian dogs).

Current monetary and management measures

The rational for the compensation is that the legal protection and the recovery of the large carnivores are a societal desire, and that therefore society (hence the state) should pay for losses of those who economically suffer from the return of these animals.

In all Alpine countries losses of livestock to large carnivores are reimbursed by the government or associations (e.g. hunting). A compensation system has been adopted in France, Italy, Switzerland, Germany, Austria and Slovenia. The compensation techniques vary in the different countries depending on the socio-economic status of the country as well as culture and traditional practices (Boitani et al. 2010). In the Alpine countries, most of the compensations are monetary in nature. Except for the case of some provinces in Austria, this compensation is part of a pre-arranged government programme. These programmes include the examination of the dead domestic animal and determination of cause of death by an expert. The "typical" case of lynx depredation is rather easy to identify, whereas it is more difficult to distinguish between attacks of wolves or of stray dogs (Molinari et al. 2000, Fico et al. 2005). If confirmed that the animal was attacked and killed by a lynx or a wolf, the farmer or livestock owner is entitled to a predetermined sum of money which is generally based on the breed and age of the animal.

Current prevention and compensation of predation by lynx on livestock per country

In the Austrian "lynx areas", along the Austrian-Bohemian-Bavarian border (outside the Alps) and around the Kalkalpen NP, sheep farming is a relatively unimportant activity. In recent years, there have been no cases of livestock depredation in this region. In the case of damages, a "voluntary" (no legal base for compensation) reimbursement would be available in most provinces and is covered by the hunting insurance of hunting associations. The predation of wild ungulates is the main source of the conflict between lynx and hunters in Austria.

Depredation cases of lynx on livestock in the French Alps are low. The average number per year of depredation cases attributed to lynx in the whole of France between 2000 and 2011 was 72 and the compensation cost amounted to less than 20,000 € per year (Marboutin 2013b).

Currently, the state of Bavaria has provisions for compensation payments for cases of lynx depredation. All kills have to be assessed and documented by trained personnel.

The main conflict over lynx in Bavaria is with hunters with regard to the predation of wild ungulates.

All lynx depredation cases in Slovenia are compensated by the government (Kos & Potočnik 2013). Compensation costs between 1995 and 2014 varied from 0 –13,225 €, 0 € in 2013 and 2014 (M. Jonozovič, pers. comm.). In some areas, livestock are brought back to stables or fenced in at night to reduce the risk of attacks in the Slovenian Alps (AGRIDEA 2014b).

In 2013, there were 21 cases of depredation in the Swiss Alps. The compensation of losses of sheep and goat between 2006 and 2011 amounted to 6,500–25,000 CHF per year. Killed livestock have to be examined by an official and trained person and are compensated up to 100% if predated by lynx. If a lynx kills more than 15 sheep within a given area per year, the canton can ask for permission to remove the individual. The last such case was registered in 2003.

3.6 Perception of interest groups and individuals regarding large carnivores

The following chapter does not differ between the large carnivores. The chapter is based on the report for objective 2 of the RowAlps project, which was developed by working group 2.

Already when talking about the spirit of WISO at the very beginning of this report, the hypothesis was, that *sustainable wildlife management can't ever be a question of purely scientific knowledge – far away from it: Sustainable wildlife management has to be an expression of a will, how to deal with our wildlife species - by taking into account, by balancing and by harmonising ecological, economical and socio-cultural interests: A decision of all stakeholders involved is required - or let`s just say, a decision by society* (Näscher 2009).

Therefore an analysis of the social framework and entry points for a successful management of conflicts has been required for these management recommendations. The objectives of working group 2 of the RowAlps project were to describe tolerance mechanisms for lynx and wolf among various land-user groups, and to identify factors that influence tolerance as well as potential measures to alter these factors. To reach these objectives,

- a meta-analysis of existing social science research on large carnivores across Europe was conducted by the Eidgenössische Forschungsanstalt für Wald, Schnee und Landschaft (WSL) and
- interviews and workshops with experts in the fields of hunting, alpine farming and social science research on LC were conducted by the Technische Universität München (TUM), Chair of Forest and Environmental Policy.

Due to limited resources the approach had some limitations which mainly are:

- Due to the qualitative methods used, the interpretation of the interviews and workshop outcomes are the results: a separation of the results and an interpretation of those results are not possible as in many other scientific investigations.
- Land users were interviewed only in Bavaria and then only those from the agricultural sector, as there were no resources available to working group 2 to conduct further interviews with hunters or land-users in other Alpine countries.
- Only one of the two originally planned hunting workshops was held because of a lack of participants from the western Alps section.
- All authors live and work in Germany. Although they interviewed experts from nearly all Alpine countries, their analysis is, by their account, undoubtedly influenced by the German situation in which they were socialized.

Every actor concerned with the (re)occurrence of large carnivores has his or her own view of both the central problems and the main goals of large carnivores management.

These largely implicit framings of the problem or the issues to be addressed influence the entire management process (IRGC 2005). Three different types of problem framings were identified: The population dynamics of large carnivores , the direct interactions between large carnivores and those affected; and the social and political conflicts. All three problem framings are influenced by the individual perception of large carnivores. In reality, a conjunction of these problem frames will be the basis of all large carnivores management.

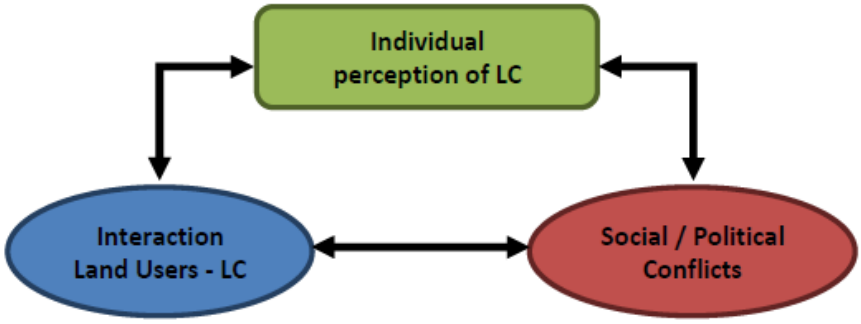

Fig. 4: Interdependencies among the various levels where factors influencing attitudes towards LC are settled.

3.6.1 Direct interaction of large carnivores and those affected

On the level of direct interaction, six main factors influencing the effect of the presence or imminent return of large carnivores on Alpine farming systems were found.

1. Financial burden / opportunity costs
Farmers evaluate the state subsidies for flock protection on two different levels. On the one hand, they want all direct expenses for flock protection covered by the state. On the other hand, the working capacity of the farmer is a restricting factor for flock protection. The farmers expect that also the opportunity costs are covered by the state.

2. Farming practices
Different types of farming practices (e.g. free ranging vs. directed grazing with the help of shepherds or fences; grazing only during summer or also in winter; herd size) require different types of flock protection. Especially in the case of the more extensive forms of grazing, protecting flocks in the presence of large carnivores is extremely difficult in the view of many farmers.

3. Type of animals
It is well known that sheep and goats are much more vulnerable to predation from large carnivores than cattle. A special focus should be put on ancient breeds which are highly subsidized within the Common Agricultural Policy of the European Union (CAP) and also often have a high non-monetary value for the farmer.

4. Legal framework / grazing rights
Legal regulations and old grazing rights sometimes complicate both the implementation of flock protection measures and the reorganization of grazing systems.

5. Natural conditions
Natural conditions, such as the extent and density of forest, local weather conditions and topography, influence the likelihood of damage to livestock due to large carnivores.

6. Tourism
Flock protection measures using livestock guardian dogs (LGDs) might lead to conflicts with hikers and bikers, especially in regions where tourism is important.

These six influencing factors can be summarized by the concept of vulnerability. The concept of vulnerability is not meant to be a concept of zoning, but rather it is a strategy to set priorities for efforts to mitigate conflicts.

Influencing factors for the vulnerability of Alpine farming regions are the historical development, on the basis of natural and cultural conditions, actual land use policies (subsidies for shepherds, subsidies for rare breeds (often sheep and goat), less subsidies for free ranging grazing (example Switzerland)) and large carnivores management (feasibility of flock protection).

Additionally, some currently practiced methods of hunting and ungulate management will be challenged by the return of large carnivores. The impact of large carnivores on both the size and the behaviour of ungulate populations must be considered in hunting and forest management planning. For example, various methods of feeding ungulates (such as efforts to influence their spatial distribution to reduce browsing effects on silvicultural crops) will be more problematic if large carnivores adapt their hunting habits to take advantage of accumulations of ungulates caused by feeding stations and winter enclosures. Adaption to the return of large carnivores may be more demanding in countries where such types of winter feeding are common than in other countries.

3.6.2 Factors in social and political conflicts with large carnivores as a trigger for conflicts

On the social and political levels, the conflicts detected could be described as mainly power struggles and value conflicts. Here, large carnivores are often only one issue within an already existing larger conflict. The distribution of power among the various actors in such conflicts has changed in the course of the reoccurrence of large carnivores. The following conflict constellations were found:

1. Urban – rural (Power struggle and value conflict)
This conflict constellation has no clear actor structure, and is displayed within public and political discourses. Land-use actors criticize the higher degree of influence that urban actors have on political decisions. On the discourse level, a clear difference in values is constructed, in which land-use actors are seen as having a use-orientated, anthropocentric image of nature, while the urban population are portrayed as viewing it more from an aesthetic oriented, ecocentric point of view. Also, the self-image of Alpine farmers differs from the image they have among the general public. Generally, both the general public and urban actors often criticize the negative impact of farming on the environment and the high level of subsidies. In return, farmers base the legitimacy of their practices and the subsidies they receive on their role as food suppliers.

2. Land-use actors – state (Power struggle)
The common conflicts here revolve around the subsidy system and legal regulations. Regulations that reduce the level of autonomy of land-use actors and increase the amount of control state agencies have are opposed by land-use actors.

3. Land-use actors – environmental NGOs (Power struggles and value conflicts)
The basis for the power struggle is the question of which group should have the power to make decisions about what occurs in the Alps, while the basis for the value conflict is the question of which value is more important: High levels of biodiversity and / or wilderness (environmental NGOs) or tradition and culture (land-use actors).

4. Horizontal / vertical conflicts between or within state agencies (Power struggles)
In most Alpine countries, the central conflict is a horizontal conflict between the ministries for agriculture and environment.

3.6.3 Interaction of both levels – social/political and direct interaction

The two levels of analysis are interconnected. Negative perceptions of large carnivores might result in a reduced willingness to adopt flock protection measures. An unsuccessful implementation of flock protection might increase political conflict. Political conflict influences individuals' perceptions of large carnivores and large carnivores' management. Nevertheless, we formulate the hypothesis that there is a correlation between the reason a particular actor is practicing animal husbandry and the level on which large carnivores management is or can be most successful. If the main reason for practicing animal husbandry is economical, work at the level of direct interaction between land users and large carnivores is most important. In regions where other reasons, such as tradition or cultural identity are more important, the resolution of social conflicts is crucial.

3.6.4 Management implications

The following chapter is focused on a land use perspective and mainly on agriculture. The results do not analyse nor focus on differences for single countries.

Preconditions for all paths of actions are that the social norms and values of farmers are obviously generally opposed to large carnivores:

- The extinction of large carnivores is perceived as a cultural achievement.
- Animals that are being bred are perceived as the "nature to be protected".
- Conservation of the cultural landscape is a central justification for their position. Farmers disagree with the target of establishing wilderness in the Alps, for which large carnivores are perceived as a symbol (Caluori & Hunziker 2001).

A slightly different situation concerning social norms and values of farmers can be observed in parts of Slovenia and Italy, where farmers are more familiar with large carnivores because of the relatively long tradition there of living alongside them.

Management implications in hunting

Hunters have a more ambiguous view:

- On the one hand, there is a tradition of purposeful extermination or hunting of predators. Thus, some hunters still perceive the extinction of large carnivores in the Alps that occurred in the 19th century as a good and necessary end. On the other hand, the idea of game keeping is common and could be applied to large carnivores. For example, in Slovenia hunters actively reintroduced the lynx.
- Norms that guide hunting practices are very important (Schraml 1998, Stengeli 2014). These norms can be influenced by in-group communication.
- Large carnivores have a relevance as potential trophy animals.
- Especially in Germany, the perception is common that large carnivores, particularly wolves, will not have suitable habitat in such a densely populated country (Kaczensky 2006, Stengeli 2014).

Given that the main threat to LC populations is illegal killing, in general two aspects of this problem have to be addressed:

1. Accidental killing and the
2. encounter rate between hunters and LC (and thus, the concomitant potential that an illegal killing of a LC will occur).

Furthermore, stronger control on hunters by official bodies would be necessary in order to be able to enforce protection of LC. Game wardens like the “guardacaccia” in Italy or the “Wildhüter” in Switzerland are examples of ways to implement better on-site control of hunters.

Legal regulations and financial aid (e.g in Switzerland hunters get a reduced hunting licence fee if they can prove that large carnivores are present in their hunting area) to the hunting sector will also need to be evaluated to determine if the outcome of these steering instruments hinders the goals of large carnivores protection. Hunting regulations should be analysed if the influence of the presence of large carnivores is considered. For example, hunting quotas are often not adapted to the special challenges of large carnivores presence.

Management implications in power distribution between political actors

Managing social conflicts requires an understanding of the relationships and the distribution of power between different actors in different countries. Comparing the position and power of interest groups and actors in the Alpine countries, it seems obvious that every country has its own tradition affected by its own unique institutional setting. The return of LC and the accompanying societal discussion might cause a change in the distribution of power among the institutions involved which will also either shift the existing lines of conflict or generate new ones. The following paragraphs summarize the political actors involved, likely changes in the distribution of power between them and the main drivers of the discussion about LC are described for each Alpine country.

Austria

In Austria, private land owners, state and public forest owners and hunting associations are considered to be the most powerful players. With the return of LC, especially wolf, land owners and hunting associations are expected to lose power, and the pressure other actors will be able to exert on them will increase. The eNGOs, the environmental authority and hunters whose main purpose in hunting is to stem the threat ungulates pose to forests will gain more influence in the field. The agricultural sector was judged as the main driver.

France

Due to the centralized political system in France, the agricultural, hunting and environmental authorities have the most power of the institutions participants identified as being involved in LC issues but also receive the most pressure from interest groups. Sheep farmers are land users, but often do not own the land they use, unlike most of their counterparts in other countries. This fact makes them a less powerful interest group in France than in other countries. With the return of the wolf to France, sheep farmers are gaining power and putting pressure on the authorities responsible for LC management. Environmental NGOs (eNGOs) have also become politically more important through their efforts to restrict traditional land-use practices (drive hunts) due to the danger they pose to the bears that are now present in the Pyrenees and hence exciting conflicts with the hunting association. The agricultural sector is perceived to be the main driver of the discussion regarding LC in France.

Germany - Bavaria

In Bavaria, private land owners and the organizations that represent them, such as the farmers' association, currently have the most power with regard to LC. Forest authorities (the forest ministry and the state forest administration) and the hunting association are struggling to influence land owners within an ongoing conflict about forest regeneration. With the return of LC, especially the wolf, both the farmers' association and the hunting association are expected to receive more pressure from eNGOs and environmental authorities. The agricultural sector was judged as the main driver of the discussion about LC.

Italy - South Tyrol

In contrast to France, land owners here are rather powerful. The "Landeshauptmann" (governor of the province) plays an equally important role as that played by the state government (Rome). Here, the hunting sector was listed as the main driver.

Slovenia

The Slovenian Forest Service (SFS) is in charge of hunting management, forest management and LC management. The fact that all of these tasks are undertaken by a single public body makes the influence of the SFS stronger than the forest agencies in the other countries investigated here. This could possibly help mitigate conflict. As a technical body that serves as a consulting entity to the Ministry for Environment and Farming, the University of Ljubljana is also perceived as a quite powerful actor that is for the most part not greatly influenced by other actors. Thus, the university has a greater influence on LC management than universities in other countries. With the return of LC, the pressure on the SFS is expected to rise, because the conflicts between land users (land owners, hunting association) and between land users and the SFS will intensify. The hunting sector was judged as the main driver of the discussion about LC, especially wolves.

Land-use practices like ungulate (game) and forest management are largely directed towards meeting economic goals. As ungulates are herbivores and browse on trees, forest regeneration is dependent on both ungulate density and forest structure (management). This implies that there are competing interests between the hunting sector (which is interested in high ungulate densities) and the forestry sector (which is interested in high levels of forest regeneration). In each of the different Alpine countries, one or the other interest prevails depending on the relative economic importance of the respective sectors.

Management implications in farming

In the view of the experts interviewed, prerequisites for livestock breeders tolerating large carnivores are:

- functioning flock protection measures and
- sufficient funds for financial aid and compensations.

Effective flock protection demands experience with different measures under different conditions to be able to recommend the most promising method to farmers given their particular situation. Numerous open questions about the effectiveness of flock protection methods still need to be addressed.

In terms of sufficient financial aid - for example, in cases where it is not clear if damage was caused by large carnivores or other predators - solutions that involve little bureaucracy and favour land users should be established. Central here is that compensation will continue to be paid, even if compensation costs rise tremendously. Furthermore, late or reduced payments must be avoided.

These are preconditions for establishing trust in and credibility for the state (agencies). In this context, processing of compensation payments through agricultural administrations is crucial. The distribution of compensation and financial aid via the established network is more promising than attempts to establish relationships between farmers and other government entities with which they have no existing relationships (e.g. environmental authorities). Farmers already have a relatively trusting relationship with agricultural authorities.

Agricultural funding must be adapted in the long term to eliminate contradictions, especially concerning the promotion of vulnerable livestock species (sheep) and inconsistencies between subsidies for extensive pasture management and flock protection measures (Meschnig 2014). In the Alps, rare breeds are often sheep or goat breeds. Thus, two biodiversity conservations goals – conservation of rare breeds vs. large carnivores protection – will have to be balanced.

Diverse synergies exist among farming methods on the one hand, which are adapted to be more suitable for a coexistence with large carnivores and pasture- and herd management methods on the other hand, that are adapted to promote biodiversity and animal welfare and are more ecologically sound.

To be able to effectively promote tolerance towards large carnivores and to find suitable solutions, the level on which conflict emerges (direct interaction or social / political) must be considered. And therefore it is crucial to be clear about the actual phase of large carnivores colonization that is taking place (as, for example, is used in Bavarian management plans; Phase 1: before return; Phase 2: occurrence of single animals; Phase 3: small population established; Phase 4: expanding population). Different phases demand different management measures, and every phase (appearance of an animal, establishment of pack etc.) must be immediately communicated to the land users.

Social conflicts are often the dominant ones, even where technical arguments are being used. A central entry point here is negotiating with the actors involved (Primm & Clark 1996; Majić et al. 2011). Preferably, this should be done before large carnivores enter a region, or at least before the first conflict occurs. Though it is tempting to adopt a “wait and see” attitude as long as there are no conflicts, or only relatively few, management of a conflict which has already escalated is much more difficult (Glasl 2002).

Especially in countries like Slovenia and Italy that have been forced to take cost-cutting measures due to the economic crisis, the risk exists that spending little or no money early on will mean either having to spend more money later or having to deal with a major conflict.

To what extent money should be spent on managing conflicts has to be decided, and the consequences of this decision have to be borne. In France, a discussion about the amount of money spent directly or indirectly on wolves popped up.

Such questions have to be worked out among the actors involved and communicated appropriately.

Nevertheless, even early intervention and commendable handling of conflicts (financial, communicative etc.) cannot guarantee peaceful coexistence everywhere. There could be situations where it will not be possible - particularly where extensive pasture management and large carnivores (esp. wolf) must exist side by side. In those cases, appropriate courses of action will have to be defined and communicated. (See Primm & Clark (1996) for the importance of understanding and working with the policy process.)

As it is unlikely that public communication will reach land users, it is suggested developing and establishing a communication concept with land user associations as the central communicator. Affected actors should be the first to obtain new information and have the opportunity to communicate this information to their own group. An effective manner of communication will have to be worked out with the actors themselves. Role models (collection of best practice examples, farms etc. with charismatic personalities where coexistence with large carnivores works) are needed that will be perceived as in-group and, therefore, accepted in the field. These role models will have to be well-financed and scientifically assisted. For a project to be seen as in-group supported action, comprehensive involvement of actors is necessary. Examples of projects that have involved agricultural actors are the Swiss "AlpFUTUR" project[16] and the Austrian shepherding and flock protection projects. In our opinion, the best mode of operation is one in which the group charged with developing measures includes the actors that must implement these measures later.

Management implications for participation and communication

It is proposes to have an increased focus on management of social and political conflicts by:

- Implementation of participatory approaches of high quality.
- Minimize goal conflicts with land use regulations (e.g. high importance of the EU Common Agricultural Policy, hunting regulations have to consider LC presence)

Finally participation is very important when dealing with management of Large Carnivores. The participatory approaches have to be of high quality (whereas the criteria of this quality have still to be identified, e.g. fitting discussions to the level of decision making, Inclusion of all relevant interest groups and state agencies). And finally a further management implication is an increased focus on in-group communication (e.g. projects in collaboration with land use actors).

The following entry points for the social acceptance of wolf and lynx can be summarized:

1. Consideration of conflict level;
2. Negotiation with actors - for example, in participatory processes or model projects - with the goal of optimizing both flock protection and conflict management;
3. Development of a communication process with actors.

4 Discussion, interpretation and assessment of a future Alpine lynx population and main threats

4.1. Minimum viable population (MVP), ecological carrying capacity (ECC), and favourable conservation status (FCS) for the Alpine lynx population.

Concepts of population viability

Per definition, a viable population size lies somewhere between the ecological carrying capacity (ECC) and the minimum viable population (MVP). The ECC is the point in an unmanaged population where the birth rate and the mortality are at equilibrium. It may be temporarily exceeded, but then the mortality will surpass the birth rate and the population will steer towards ECC again (Mills 2007). The

[16] http://www.alpfutur.ch/index.php

ECC is not static but may change over time due to changes in environmental conditions and/or resource management, which influence birth rate and mortality.

The lower end of the spectrum of a viable population size is given by the MVP. However, there is more than one concept of population viability:

- *Demographic viability* calculates the probability of extinction for a population of a given size within a specified number of years as a function of natality and mortality.
- *Genetic viability* concerns the long term persistence of genetic variation and evolutionary potential, and the avoidance of genetic impoverishment through inbreeding and genetic drift.
- *Ecological viability* refers to the interaction between a species and its environment. This encompasses both the needs, but also the effects of a species regarding its environment (Linnell et al. 2008). It is more a function of the ecosystem than of the species.

Despite many uncertainties about the exact ratio between the concepts, it is agreed that it usually takes a far larger population (e.g. by a factor 10) to maintain genetic viability and/or ecological viability than for demographic viability. In general, demographic and ecological viability are assessed at the population level, and genetic viability at the metapopulation or ecosystem level (Linnell et al. 2008). However, the concept of MVP is difficult to apply: scientifically, it is not possible to correctly determine a single minimum number of individuals that will secure long term survival of the population because of the inherent uncertainty and stochasticity in nature and management; and ethically, it is questionable to manage for a minimum number of individuals (Mills 2007). Consequently, the EU Habitats Directive does not demand MVP as a target for species, but to achieve Favourable Conservation Status (FCS). The definition in Article 1 of the Habitats Directive says:

"The conservation status will be taken as 'favourable' when:

- *population dynamics data on the species concerned indicate that it is maintaining itself on a long term basis as a viable component of its natural habitat, and*
- *the natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future, and*
- *there is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis"* (Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora)."

The guidance document "Assessment, monitoring and reporting under article 17 of the Habitats Directive" indirectly states that a population must be at least bigger than a MVP to be able to reach FCS. The upper limit is defined by what the potential habitat can support at an "optimum density" (i.e. ECC).

FCS is based on two major Favourable Reference Values (FRV) – the Favourable Reference Range (FRR) and the Favourable Reference Population (FRP) – according to the DocHab-04-003/03 rev 3 and the guidance documents. It is stated in the guidance documents that FCS is a positive goal, where the goal should be to make species status as favourable as possible, and not just to have passed a minimum benchmark.

Like any legal text, the directive text is not based on scientific definitions. This poses major challenges in its operationalisation per se, and especially for species as diverse as lichen and lynx. An interpretation for large carnivores was made by Linnell et al. (2008) in the "Guidelines for Population Level Management Plans for Large Carnivores in Europe".

Operational proposal to define Favourable Reference Population

"[W]e suggest that favourable reference population be defined as the sum of the following criteria:

(1) The population must be at least as large as when the Habitats Directive came into effect, and,
(2) The population must be at least as large (and preferably much larger) as a MVP, as defined by the IUCN criterion E (extinction risk based on a quantitative [Population Viability Analysis] with <10% extinction risk in 100 years), or criterion D (number of mature individuals).
(3) *The population's status is constantly monitored using robust methodology"* (Linnell et al. 2008).

A population can be considered as viable (i.e. at least MVP) according to the IUCN Red List if it reaches at least the category "Near Threatened NT", which is not formally a threatened category[17]. This category is reached under criterion D with a population of 1,000 or more mature individuals in the population. However, if the considered regional population is connected to a neighbouring population to such an extent that immigration can have a significant positive effect on the demographic viability of the population and the sum of the populations (hence the metapopulation) reaches the benchmark, then the threat category for the regional population (hence the subpopulation) can be downgraded by one level; i.e. if two connected neighbouring populations exceed the benchmark of 1,000 mature individuals, the regional subpopulation is still considered as not threatened if it exceeds the next lower benchmark of 250 mature individuals (which would classify as "Vulnerable VU" in an un-connected population; Linnell et al. 2008).

Operational proposal to define Favourable Reference Range

Put simply, the Favourable Reference Range (FRR) is the area needed to contain the Favourable Reference Population. However, the issues of habitat quality, density (e.g. societal carrying capacity) and connectivity warrant consideration.

"*As a result we generally recommend that Favourable Reference Range be considered larger than the area strictly necessary to support the Favourable Reference Population, and that it attempts to ensure (1) the continuity of distribution within a given population, and (2) the possibility for connectivity between populations*" (Linnell et al. 2008).

Operational definition for favourable conservation status for large carnivores

"We […] suggest that a population can be regarded as having reached FCS if it satisfies all of the following criteria;

(1) 'Population dynamics data on the species concerned indicate that it is maintaining itself on a long term basis as a viable component of its natural habitat' *(Article 1 (i)). We interpret this as implying that monitoring data indicate the population has a stable or increasing trend. We believe that a slight reduction in population size may be permitted if it is a result of response to changes in prey density or habitat quality that are not the cause of direct human action, unless conditions for derogations apply […]. All segments of a population should have stable or positive trends, and not just the population as a whole. And,*
(2) 'The natural range of the species is neither being reduced nor is likely to be reduced for the foreseeable future' *(Article 1 (i)). We interpret this as implying that the overall distribution of the population is stable or increasing. And,*

[17] The ICUN Red List threatened categories are Vulnerable VU, Endangered EN, and Critically Endangered CR.

(3) 'There is, and will probably continue to be, a sufficiently large habitat to maintain its population on a long-term basis' *(Article 1 (i)).We interpret this to imply that the quality and continuity of habitat should be sufficient, and have a stable or increasing trend. And*,
(4) *The population size and range are equal to or greater than when the Directive came into force. And,*
(5) *The Favourable Reference Population size has been reached. According to our proposal this will be set at levels greater than those regarded as being viable using the IUCN Red List criteria E or D. And,*
(6) *The Favourable Reference Range has been occupied. And,*
(7) *Connectivity within and between populations (at least one genetically effective migrant per generation) is being maintained or enhanced. And,*
(8) 'Member States shall undertake surveillance of the conservation status of the natural habitats and species referred to in Article 2 with particular regard to priority natural habitat types and priority species' *(Article 11) and* 'Member States shall establish a system to monitor the incidental capture and killing of the animals species listed in Annex IV (a)' *(Article 12.4). These statements combine to indicate that the population should be subject to a robust monitoring program.*

Criteria 1-3 and 8 are taken from the text of the Directive, criteria 4 and 6 are taken from the guidance documents, while criteria 5 and 7 are based on our own recommendations" (Linnell et al. 2008).

"[T]he absolute minimum requirements that Member States must meet are:

(1) Countries sharing one population, or segments of a population, contribute to ensuring between them that the population reaches and maintains FCS, and
(2) They allow for connectivity between neighbouring populations and segments within the same population, and
(3) Management activities do not create a sink that can influence the FCS of a population of any of its segments, and
(4) *Populations should in general not be allowed to go below the level they had when the Directive came into force on their territory"* (Linnell et al. 2008).

Assessment of the current Alpine lynx population

The current population in the Alps is isolated and estimated at 130–180 animals (Kaczensky et al. 2013a, SCALP 2012; cf. Chapter 3.2) and, as such, far away from reaching FCS.

4.2 Potential distribution of the lynx in the Alps and hypothetical expansion of the population

The recolonisation of previously occupied habitat and the expansion of a recovering species or population are determined by factors such as the habitat and landscape features, land-tenure system, dispersal characteristics, resource availability and distribution, as well as human attitudes and activities (Zimmermann 2004).

Potential distribution

Three lynx habitat suitability models for the entire Alpine range have been published, by Zimmermann (2004), Signer (2010) and Becker (2013). Although the three models differ in type and

the data origin, the results are very similar, predicting approximately 90,000-100,000 km² (~50% of the area of the Alpine Convention) of suitable habitat.

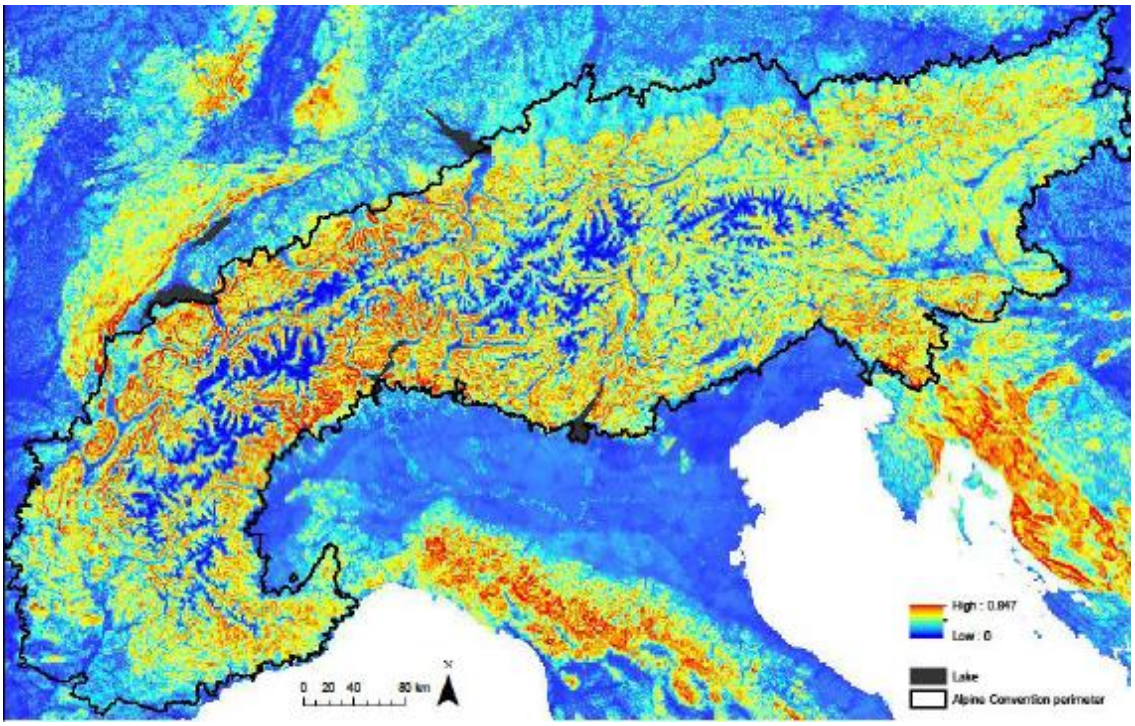

Fig. 5: Lynx habitat suitability map based on MaxEnt. Red = highly suitable habitat, blue = low suitable habitat (Becker 2013).

However, contrary to the models by Zimmermann (2004) and Becker (2013; Fig. 5), which revealed a slightly higher suitability of the western Alps, the model of Signer (2010) indicated a higher suitability for the eastern Alps. This is a consequence of differences between the input data sets. Zimmermann (2004) and Becker (2013) used among others radio-telemetry data from Switzerland, whereas Signer (2010) based the model on chance observations from Austria. As all habitat models perform better closer to the place of origin of the input data, Zimmermann's and Becker's model may be too conservative for the eastern Alps, while Signer's model may underestimate the suitable habitat in the western Alps.

Different (regional) models confirmed the lynx' preference for forested areas, followed by shrubs and herbaceous vegetation and an avoidance of intensive agricultural areas (Schadt 2002, Zimmermann 2004, Basille et al. 2008, Herdtfelder 2012). In the models, lynx avoided urban settlements and areas of high human activity (Zimmermann 2004). However, areas occupied by lynx are not necessarily free of human presence. "Distance to roads" was not negatively correlated to lynx presence in most of the models of Zimmermann (2004), indicating that, when lynx occur in good habitats, they can tolerate human presence. However, mainly highways seem to affect lynx occurrence (Zimmermann 2004, Basille et al. 2008, Rolland et al. 2011). Considering the bias towards the region of origin of data, the fact that Becker (2013) used the most comprehensive lynx data set (e.g. including GPS-telemetry fixes), and the fact that lynx can adopt to a certain degree to human presence, we conclude that at least 100,000 km² in the entire Alpine Arc consist of suitable habitat for lynx.

Fragmentation within the Alps (subpopulations)

Both, the habitat suitability map produced by Becker (2013) and Zimmermann (2004) predict a reasonably well connected area of suitable habitat throughout the Alpine range. However, when important barriers (major highways, rivers and high elevation areas), thought to be difficult but not impossible to cross by lynx, are included, the suitable habitat range is fragmented (Fig. 6). The model by Zimmermann (2004) predicts 37 patches ranging from 50 to 18,711 km² (patches smaller than 50 km² were removed from analysis because they are too small to host resident lynx) with 16 patches over 380 km². The model of Becker (2013) differed slightly; it detected 32 patches. Patch sizes ranged from 57–17,378 km² with 22 patches >400 km², supposed to be large enough to sustain a lynx subpopulation (Fig. 6; Becker 2013). Major barriers were defined subjectively based on experiences from radio-collared lynx in Switzerland, thus, patch division and size are only indicative and not definitive (Becker 2013).

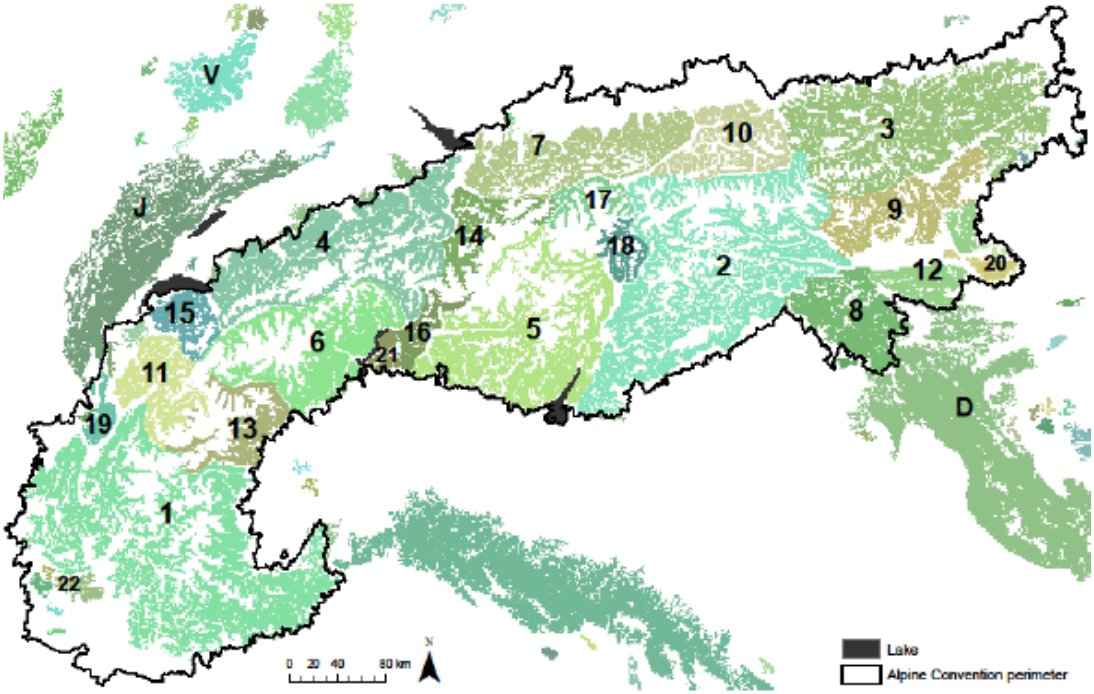

Fig. 6: Map of suitable lynx habitat patches divided by barriers as identified from experiences from radio-collared lynx in Switzerland. Each different coloured patch is assumed to represent lynx subpopulations. Patches greater than 400 km^2 are numbered in decreasing order of size. J = Jura, V = Vosges and D = Dinaric Mountains (Becker 2013).

Connectivity to neighbouring populations

The Alpine range is, in theory and according to the models, connected to the Dinaric Mountains, the Jura Mountains and to a lower extent the Bohemian-Bavarian lynx populations (Zimmermann 2004). The expansion of the Dinaric lynx population into the Slovenian Alps may have slowed down by urban areas, open habitats and the transport network (Potočnik et al. 2009). Two corridors connect the Alps and the Chartreuse, a 688 km^2 mountain which is relatively isolated from the rest of the French Alps (Zimmermann & Breitenmoser 2007), but close to the Jura Mountains. The French Alps are furthermore connected to the Jura Mountains through a corridor via the Salève Mountain (a

wooded mountain south of Geneva; Zimmermann 2004). Indeed, a subadult male lynx with a GPS collar used in 2013 exactly this corridor moving from the Swiss Jura Mountains to the French Alps.

Hypothetical expansion of the population

Of several reintroduction attempts in the 1970s, only the releases in in the central-western Swiss Alps were successful (Breitenmoser and Breitenmoser-Würsten 2008). The lynx population expanded rather fast across the north-western Alps until about 1985 and then came to a halt. About 40 years after the first reintroductions, less than 20% of the total suitable habitat in the Alpine region is occupied and the spread of the lynx population appears to have stagnated in spite of the high amount of suitable habitat still available (Molinari-Jobin et al. 2010a). Only following translocations and releases to north-eastern Switzerland and the Austrian Kalkalpen, the distribution of lynx expanded slightly (Zimmermann 2004, Becker 2013).

Dispersing lynx can – just like wandering wolves – overcome almost any human-made barrier and can also cross high alpine passes. However, the land tenure and social system of the two species and consequently the spread of a population differ considerably. While wolves were observed to build packs and form new population nuclei far away from the permanently occupied areas in the Alps (REF TO WOLF REPORT), lynx were never observed to do this (in the Alps). Lynx are conservative colonisers, as they need to settle in contact to neighbouring resident lynx in order to breed (Breitenmoser and Breitenmoser-Würsten 2008). Therefore, a lynx population does not easily spread across barriers that are no major obstacle to the movement of an individual dispersing lynx (see below).

The lynx populations in the Alpine range are relatively isolated from each other and only very few migration events between populations occur (Becker 2013). The social structure of the lynx, their need for contact with conspecifics to establish a home range, their dispersal behaviour and the supposed low migration rate between subpopulations, based on cost-distance analysis and experience, is thought to be too low to allow the foundation of a new population in a not yet occupied area (Zimmermann 2003, Zimmermann 2004, Becker 2013). Thus, the natural recolonisation of not yet occupied areas by lynx in a fragmented landscape such as the Alps is impeded (Zimmermann 2004, Zimmermann et al. 2007). For example, due to the low probability that even a single lynx (e.g. from the north-eastern Swiss Alps) would reach the Bavarian Alps, a natural recolonisation of this area and the establishment of a viable population was considered relatively unlikely (Molinari-Jobin et al. 2010b). Based on the empirically observed expansion rate between 1995 and 2007, Molinari-Jobin et al. (2010b) estimated that in 2017, only 28,000 km² of the Alps will be occupied by lynx; still less than 20% of the Alpine Arc.

4.3 Assessment of a future Alpine lynx population

We base the assessment of a future Alpine lynx population on the situation where the whole of the Alpine Arc is settled, i.e. the Favourable Reference Range is occupied according to Criterion 6 of the operational definition of FCS by Linnell et al. (2008; Chapter 4.1). Obviously, the crucial points in the operational definition for the future lynx population in the Alps are Criteria 5 (number of mature individuals) and 7 (connectivity within and between populations).

Potential abundance

The Alpine-wide habitat models calculated an area of suitable habitat of approximately 100,000 km². The camera trap monitoring in Switzerland calculated densities of 1.36–3.61 independent individuals per 100 km² of suitable habitat[18]. Based on these densities, the Alps could host about 1,350–3,600 lynx. However, these calculations were done for "independent individuals", not for mature individuals. "Independent individuals" include subadult lynx (in their second year of live, likely on dispersal). The number of subadult animals compared to the total number of lynx >2 years of age depends on the status of the population and can fluctuate. In one study (Breitenmoser-Würsten et al. 2001), the share of subadults compared to the resident mature individuals was estimated to be 25% in the north-western Swiss Alps. In other words, 1,000 mature individuals equal approximately 1,300 independent individuals. By coincidence, this is the lower range of potential abundance estimated from habitat models and empiric densities.

Connectivity within the Alps

Zimmermann et al. (2007) found that subadult lynx were rarely crossing major barriers such as highways. Molinari-Jobin et al. (2010b) predicted that natural dispersal will not suffice for the recolonisation of the Bavarian Alps. The models of Becker (2013) and Zimmermann (2004) showed a separation of the Alpine population into 32 and 37 different patches, respectively. All these findings do not answer the question about connectivity within the Alps in a definitive manner, but they give a hint that connectivity may be a problem for lynx in the Alps, at least during the phase of recolonisation. However, although the natural and anthropogenic barriers are hindering the expansion of the extant populations, they will most likely not be a problem for the maintenance of the genetic viability of the "subpopulations" if once the whole of the Alpine Arc is occupied. There are enough empiric observations of dispersing lynx from radio-telemetry or camera trapping to conclude that at least one animal will cross the barriers between subpopulations per generation.

Connectivity to neighbouring populations

The Alpine range is, in theory and according to the models, connected to the Dinaric Mountains, the Jura Mountains and to a lower extent the Bohemian-Bavarian lynx populations (Zimmermann 2004). Whether this connection would exceed the benchmark set in the Guidelines of one genetically effective migrant per generation has not been studied. So far, only one lynx was documented to have dispersed from the Alps to the Jura Mountains across the Swiss Plateau and reproduce successfully. Two were known to have dispersed in the other direction, but both did not integrate into the population. This anecdotic observation suggests that the dispersal of lynx leads only to a very low amount of exchange between populations. The Chartreuse, a region in the French Alps on the east side of the Rhone river, was obviously settled from the Jura Mountains (Zimmermann & Breitenmoser 2007). But the Chartreuse itself seems so far being separated from the Alpine population. However, all three populations, but especially the one in the north-western Alps and the Dinaric population suffer from inbreeding and might (e.g. in Slovenia and Croatia) have presently a reduced recruitment.

[18] In one case, a density of 0.92 independent lynx per 100 km² of suitable habitat has been revealed. However, this value comes from an obvious sink population and has therefore not been considered for the present calculation.

Conclusions

When once the whole of the Alpine Arc is (re-)colonised by the lynx, it would probably have a sufficient genetic exchange with neighbouring populations (considering those have an adequate conservation status, too). However, the migration rate would probably be so low that it would be demographically insignificant. Therefore, current knowledge dictates that the FCS for the Alpine lynx is set for an isolated population, i.e. at 1,000 mature individuals (NT). Habitat models predict that a healthy and evenly distributed Alpine lynx population has a good potential to reach FCS at this level, even at low to moderate lynx densities. Indeed, if the prerequisites allow lynx to occur at high densities across the Alps, the abundance at carrying capacity may be almost than three times as high as the minimum requirements for FCS.

4.4. Challenges for the recovery and conservation of the Alpine lynx population

4.4.1. Ecological/biological challenges

Connectivity and habitat fragmentation

While enough suitable habitat and prey in the form of wild ungulates are available to the lynx, one of the major threats lies in the fragmentation of said habitat. Some of the fragmentation stems from the natural Alpine landscape (e.g. high mountain ridges), but much of it originates from anthropogenic structures, especially in the lower regions. As a result, there is a lack of connectivity within the Alps as well as to other populations adjacent to the Alps. Although individual lynx have the ability to cross most types of barriers, its dispersal ecology is such that the population as a whole cannot overcome them. Consequently, there is a lack of population expansion, which contributed to a high amount of inbreeding in the population.

A natural population expansion over the whole of the Alpine Arc is highly improbable, even in the long term (Chapter 4.2). Therefore, the anthropogenic support is required and needs to be organised. A way to aid the expansion of the lynx population are translocations and further small-scale reintroduction projects as the ones carried out in north-eastern Switzerland or in the Kalkalpen National Park in Austria. These were indeed the latest significant population developments in the Alps. Rüdisser (2002) proposed such an approach also for the western Austrian Alps. Reintroduction projects in southern Vorarlberg, eastern Tyrol and western Salzburg would allow establishing further subpopulations and eventually connect the now isolated lynx occurrences in the Alps (Rüdisser 2002).

Inbreeding

The north-western Alps population is by far the largest subpopulation in the Alps. However, as a consequence of the very small number of founder individuals some 40 years ago and the slow growth of the population, it is now strongly inbred. Evidence of genetic drift and reduced heterozygosity are clearly visible in the lynx population in the north-western Alps (Breitenmoser-Würsten & Obexer-Ruff 2003). Criterion D in the IUCN Red List assessment, simply considering "number of mature individuals", does not recognise issues resulting from inbreeding, which is a major threat to the current lynx populations in and adjacent to the Alps. To present a more realistic picture, the number of individuals (both sexes) contributing genetic variation to the population size ($N_{e\ genetic}$) should be considered to estimate the size of the population instead of just mature individuals (MI). Inbreeding can considerably reduce $N_{e\ genetic}$ compared to MI. For instance, the

inbred lynx populations in the Dinaric range and the north-western Alps have a strongly reduced N_e if inbreeding is considered. During the International Workshop "Genetic status and conservation management of reintroduced and small autochthonous Eurasian lynx *Lynx lynx* populations in Europe" held in November 2011 in Saanen, Switzerland, the experts estimated $N_{e\ genetic}$ for the Dinaric population to be about 11 and for the NW Alps about 18 (in a population with a MI of about 54 lynx). In the latter case, N_e would be only 0.33 of the number of independent lynx as estimated from camera trapping (Ch. Breitenmoser-Würsten, pers. comm.). In both reintroduced populations, the inbreeding factor F_{it} is close to 0.25, indicating that all members of the population are as closely related to each other as siblings. Consequently, regardless of the total size of the present population, the genetic remedy of the reintroduced population is a prerequisite for the colonisation of the whole of the Alps, or in other words, the low $N_{e\ genetic}$ and the limited distribution is a more serious obstacle to reaching FCS in the future than the actual number of MI in the Alps. So far, the inbreeding in the North-western Alps has not led to measurable demographic problems (e.g. reduced litter size or juvenile survival; Ch. Breitenmoser-Würsten, pers. Comm.). However, in the Dinaric population, where the inbreeding coefficient has reached F = 0.3, a strong population drop combined with a decrease in natality was observed, suggesting an inbreeding depression (R. Černe, pers. comm.).

For a colonisation of the entire Alpine range by lynx and to allow genetic exchange, it is necessary to close the gaps between the nucleus in the eastern Alps (Slovenia and Austria) and the one in the north-western Alps (Kaczensky 1998, Molinari-Jobin et al. 2003). For the long-term survival of the lynx in the Alpine range and the conservation of the species, it is crucial to connect the small and genetically isolated lynx subpopulations in the Alps so that they form part of larger metapopulations allowing the exchange of individuals between neighbouring subpopulations and thus to guarantee genetic viability (Rüdisser 2002, Zimmermann 2004, Becker 2013). Kramer-Schadt et al. (2011) analysed the effect of “stepping stones” (local lynx population nuclei) and found that they could significantly enhance the colonisation. They however postulated that stepping stones would need to be big enough to produce new dispersers; otherwise they could even negatively impact the colonisation success by binding animals. This is especially noticeable in areas with low to medium dispersal habitats and in cases of high mortality among dispersers. Reintroductions and translocations to new parts of the Alps should additionally be done in a way to remedy the inbreeding of the remnant populations, that is, when exchanging animals, the genetic constellation of the respective populations must be considered, and new individuals from the original Carpathian source population must be added.

4.4.2. Management challenges

Multitude of administrative units

While the measures may change over time with the development of the population, they should still follow the same goals and respect the same management principles in different administrative units to allow a consistent management of the entire population. The “administrative fragmentation” is a two-level challenge in the Alps. On the one hand, the suitable lynx habitat in the Alpine Arc is distributed over seven countries; on the other hand, in some of these countries (Italy, Switzerland, Austria and Germany), hunting and wildlife management is a competence of the federal states (provinces). Although all large carnivores are legally protected by national, hence higher-ranking laws, the implementation of conservation or management measures generally leads to discussions

over competences, and the implementation of international agreements is hence a challenge at national level.

Guiding strategic document

Unfortunately, no guiding strategic document exists, which would define the aforementioned common goals and management principles for the lynx population in the Alps. There is the Pan-Alpine Conservations Strategy for the lynx (Molinari-Jobin et al. 2003), which was formally endorsed by the Standing Committee of the Bern Convention. However, it was never endorsed or considered at national level. Switzerland has a national Action Plan (BUWAL 2004a) and Slovenia is currently in the final stage of developing a national strategy for conservation and sustainable management (M. Jonozovič, pers. comm.). Germany has a framework document by the Federal Agency for Nature Conservation on how to deal with management issues concerning lynx, wolf and bear (BfN 2010) some parts of which have been published elsewhere (Kaczensky et al. 2009, Reinhardt et al. 2012). The results from the RowAlps process and possible follow-ups in the WISO Platform and the Alpine Convention may contribute towards the abatement of this shortcoming, insofar as they may establish a basis for an overarching guiding strategy or national documents. However, the RowAlps itself cannot replace a Regional Strategy/National Management Plan.

Wildlife management systems

The presence of lynx also poses a challenge to the established wildlife management and hunting systems. Lynx have an impact on the populations of their prey species. The nature and magnitude of such impacts in terms of changes in abundance and behaviour is hard to predict exactly because it depends on several important co-variables. However, it is undisputable that lynx and hunters are using the same resource, wild ungulates, and that their “harvest rates” often show the same trends (i.e. an increase in the game population results in a higher hunting quota, but also allows a higher predator density, which in turn results in a higher predation on the prey population). Therefore, the lynx needs to be included in management decisions (e.g. calculation of hunting quota). This requires an adaptive approach with changes over the years depending on the gained experience about the impact of lynx on the huntable species. Hence, the monitoring of the wild ungulate populations may require intensification so that the possible necessity for adaption of the management can be detected in time. Whatever the changes in the established wildlife management system will be, at least a good communication towards the stakeholders is crucial, preferably even an involvement in the decision-making process.

Conclusions

Tackling the socio-economic and management challenges will require both, top-down and bottom-up approaches, and will heavily rely on good communication. For example, necessary changes to long-lasting, possibly even traditional, wildlife management or livestock husbandry systems might be perceived negatively by those affected. The involvement of stakeholders in all processes should aid in preventing, or at least limiting, such a negative effect. Treves & Bruskotter (2014) emphasised the importance of always pointing out actual benefits of carnivore presence. If only the avoidance and reduction of problems and risks are addressed, social acceptance might decrease, possibly by increasing the perception of problems and risks (Treves & Bruskotter 2014).

However, even without any anthropogenic threats, the Alpine lynx population would still be in peril in the long-term due to genetic problems resulting from inbreeding. The cure for this situation calls for the insertion of new, genetically appropriate individuals. The natural expansion of the population

is hampered by obstacles emerging from habitat fragmentation. The creation of new population nuclei through translocation projects is probably necessary. Again, good communication is required in preparation of such projects. Affected stakeholders, e.g. hunters, are usually more tolerant towards the appearance of a species in an area, if the recolonization happens naturally (WISO 2010).

On the positive side, financial requirements for managing conflicts with livestock owners are relatively low compared to the wolf, and especially compared to other elements at national level. Nevertheless, even a comparatively low financial provision demands a commitment from society and political bodies.

4.4.3. Most important threats and/or shortcomings

The threat assessments published since the year 2000 (Breitenmoser et al. 2000, Molinari-Jobin et al. 2003, von Arx et al. 2004, Council of Europe 2012, Kaczensky et al. 2013a, Boitani et al. 2015; compiled in Breitenmoser et al. 2015) largely agree on the main threats to the lynx population in the Alps and in Europe in general. They consist mainly of persecution, accidental mortality (vehicle collisions), habitat deterioration due to infrastructure development, and low acceptance due to conflicts with hunters, combined with the intrinsic limited dispersal capability of the species. The more recent assessments also list inbreeding as a threat for the present and/or future lynx population. Additionally, the most recent assessment in Boitani et al. (2015), lists poor management structures as a threat to the present lynx population in Europe. The same was already the case in Kaczensky et al. (2013a), the analysis of which was performed by sending questionnaires to the members of the Large Carnivore Initiative for Europe (LCIE) and further experts, for the present lynx population in Europe. However, poor management structures were not among the top 4 threats for the future population. This is due to the increased importance of other threats, not due to a decrease in importance of this threat.

At the workshop from 12–13 March 2015 of the RowAlps working group3, the major threats to the lynx and/or shortcomings were identified based on a presentation of the reports mentioned above. Illegal killing was evaluated to be the main threat, followed by inbreeding/genetic problems, and habitat fragmentation. Poor management in general was rated as one of the main shortcomings, but two more specific parts of the management were listed as well. Issues related to wildlife management systems and/or hunting systems were rated among the major shortcomings (e.g. the regional overharvest of prey), as well as the lack of strategic documents, management or conservation plans with national or regional goals. Accidental mortality and the lack of regionally specific knowledge were also nominated.

Major threats to the Alpine lynx population and shortcomings:

1. Illegal killing
2. Inbreeding/Genetics
3. Habitat fragmentation
4. Management issues
    a. Wildlife management systems/hunting system
    b. Lack of strategic documents, management or conservation plans
    c. Poor management in general
5. Accidental mortality
6. Lack of regionally specific knowledge

5 Practical goal

The overall practical goal is to achieve a favourable conservation status (FCS) of lynx in the Alps of at least 1000 mature individuals/1300 independent individuals widely distributed across the Alps. This implies especially strengthening transboundary cooperation, dialogue with local people and interest groups and active conservation measures.

To reach FCS, a more or less even distribution of the 1000 mature lynx at low to moderate density is required across the Alpine countries according to suitable habitat.

Table 5. Minimum number of mature and independent individuals, respectively, needed per country to reach FCS. Allocation to the countries was made in proportion to available suitable habitat[19].

Country	Minimal number of mature/independent individuals to reach FCS of at least 1000 mature individuals
France	184 mature / 245 independent ind.
Italy	308 / 410
Switzerland	138 / 184
Liechtenstein	1 / 2
Austria	290 / 387
Slovenia	49 / 65
Germany	33 / 44

The main threats to the present and future lynx population in the Alps are illegal killing, inbreeding and habitat fragmentation. Moreover, low acceptance, poor management structures and accidental mortality have to be dealt with, in order to reach FCS for the lynx in the following decades.

For this purpose, the most important management issues are to merge the eastern and western subpopulations, to manage these populations genetically, to secure and construct new connection corridors, to prevent illegal action, to foster dialogue among authorities, with wildlife managers, hunters and foresters, to integrate local people in monitoring systems, and finally to secure damage prevention and compensation systems.

6 Management options and implications

Lynx conservation in the Alps needs to be actively managed, namely the genetic remedy and the merging of the subpopulations requires interventions. As most of the threats and challenges are related (e.g. the high anthropogenic mortality is responsible for the slow growth of the population, which in turn is speeding up the genetic drift), conservation measures must be considered jointly where appropriate.

[19] The minimum number of lynx per country were calculated from the proportion of suitable habitat per country according to Becker (unpublished data from the model of Becker 2013). As the calculated numbers of lynx per country were a minimum, all numbers were rounded up, resulting in a sum that is slightly higher than 1000. These numbers correspond to a density of 1.0 mature individuals (lynx > 2 years of age)/1.3 independent individuals (lynx > 1 year of age) per 100 km^2 favourable habitat.

6.1 Merge eastern and western subpopulations

Currently, the eastern and western lynx subpopulations in the Alps are separated and isolated and it is most improbable that the connection between the existing subpopulations will be established in a natural way. However, such a connection is vital for the survival of the Alpine lynx population, simply by combining the two subpopulations into a larger meta-population with an improved genetic pool and reduced extinction probability.

The intrinsic dispersal capability of the Eurasian lynx in the fragmented Alpine landscape is rather limited. Long-range dispersal is very rare and between the existing subpopulations highly unlikely. Individual lynx are capable of crossing most kinds of landscape barriers (possibly with the exception of large water bodies and high mountain ridges). However, for example, three out of four lynx were not able to cross a highway and turned back after spending a few days in its vicinity, leading to circular dispersal. The few individuals which manage to disperse across major barriers, are then isolated on the other side and subsequently not able to form a new population nucleus. Therefore, actively creating “stepping stones” in form of a small number of lynx, possibly taking advantage of known isolated individuals, would help to spread and eventually to merge the populations.

Option 6.1.1: Founding of a new subpopulation

A main contributor to the recent population expansion in the Alps was a reintroduction project in north-eastern Switzerland between 2001 and 2008. It was created by translocating a total of 7 females and 5 males. A decade after the translocations, the subpopulation now consists of 16 independent individuals (16-22, 95% CI) and at least 8 juveniles, and the density has significantly increased over the last six years.

The creation of another subpopulation in the central-eastern Alps would considerably increase the chance of connecting the two remnant subpopulations. A full reintroduction project (with the goal to create a self-sustaining population) is a big endeavour requiring the necessary capacity and funding. Furthermore, it requires careful preparation and planning, regarding the source of suitable animals and the area of release. The reintroduction should be carried out according to the “IUCN Guidelines for Reintroductions and Other Conservation Translocations” (IUCN/SSC 2013). The endorsement of official governmental bodies and the involvement of relevant stakeholders are key preconditions.

Option 6.1.2: Create new population nuclei between the eastern and western subpopulations by colonising “stepping stones”

In ecology, the term “stepping stones” is used for rather small habitat patches lying between larger habitat areas. While the larger habitat areas are not within reach of each other for a dispersing animal, the stepping stones lie within dispersal distance of the larger habitat areas and of each other. Of course, the design of the stepping stones must adhere to certain principles to be effective (see Kramer-Schadt et al. 2011). However, in the case of the Alpine lynx population, we refer to “stepping stones” as “small population nuclei” funded in suitable habitat anywhere between the two remnant subpopulations.

The creation of new “stepping stones” population nuclei would create a connection between the subpopulations. Individuals will still not be able to disperse all the way to the other subpopulation, but they may reproduce within the “stepping stone”, creating a genetic exchange and producing offspring, which may disperse again to further “stepping stones”. *Ergo*, “stepping stones” do not need to be large populations, but strong enough to create new dispersers.

As the main ridges in the Alps pose a very strong barrier to the expansion of a lynx population, two chains of “stepping stones” are suggested, one in the north, the other in the south. “Stepping stones” would be smaller than reintroduced subpopulations (Option 6.1.1). Hence, the effort per “stepping stone” is considerably smaller. Still, the same care in the execution is required and the principles of the “IUCN Guidelines for Reintroductions and Other Conservation Translocations” (IUCN/SSC 2013) should be considered. The endorsement of official governmental bodies and the involvement of relevant stakeholders are key preconditions.

Option 6.1.3: Add lynx to areas with isolated individuals

The basic reasoning and goal is the same as for Option 6.1.2. The main difference between this option and Option 6.1.2 lies in the selection of an area of release. While the area in Option 6.1.2 is selected by experts and wildlife managers, here it is specified by the lynx occurrence. Single, isolated individuals should be reinforced, as has happened e.g. in the Kalkalpen National Park, thus creating new population nuclei “stepping stones”. Apart from the selection of the area, the preparation and planning requires the same care as for Option 6.1.2. As the first individual recolonised the area naturally, the acceptance of the local population might be slightly more positive than for the creation of a completely new nucleus in a formerly uncolonised area.

The reinforcement of the isolated individuals should be carried out according to the “IUCN Guidelines for Reintroductions and Other Conservation Translocations” (IUCN/SSC 2013).

All three options for an active merging of the remnant Alpine lynx populations require suitable source animals (see Note under 6.2. Genetic management).

The north-western and south-eastern Alpine lynx subpopulations (incl. the adjacent Dinaric population) suffer from strong inbreeding, which should be addressed for the sake of the Alpine lynx population. The inbreeding is a consequence of a too small founder group and genetic drift, and considerably threatens their survival. Genetic remedy of the north-western Alpine and the Dinaric (south-eastern Alps) populations is urgent.

A requirement for any genetic management of a (sub-)population is an adequate genetic and demographic monitoring, also of the potential source populations. Such a monitoring has been established for the existing (sub-)populations in the Alps and Dinaric range.

6.2 Active genetic management

The north-western and south-eastern Alpine lynx subpopulations (incl. the adjacent Dinaric population) suffer from strong inbreeding, which should be addressed for the sake of the Alpine lynx population. The inbreeding is a consequence of a too small founder group and genetic drift, and considerably threatens their survival. Genetic remedy of the north-western Alpine and the Dinaric (south-eastern Alps) populations is urgent.

A requirement for any genetic management of a (sub-)population is an adequate genetic and demographic monitoring, also of the potential source populations. Such a monitoring has been established for the existing (sub-)populations in the Alps and Dinaric range.

Option 6.2.1: Enrich the genetic pool

There is only one option to address this issue: the impoverished genetic pools of the existing subpopulations must be enriched again, i.e. alleles which have become rare or even non-existent in a population, need to be reintroduced via suitable new individuals. There are several options

possible/available for the execution of this basic concept (see below), and suitable source animals need to be defined on a case by case basis. Generally, according to the recommendations of participants of a workshop on the genetic status of lynx, we consider as suitable an individual of the same subspecies L. l. carpathicus with a good genetic and health record and in reproducible age, preferably from the wild.

Option 6.2.1a: Reinforce the existing subpopulations

The genetic situation may be remedied by simply releasing new individuals within the remnant subpopulations. Release areas should be carefully chosen according to information from the *in situ* monitoring in order to minimise potential conflicts of the new animals with resident lynx. If such information is not available, individuals may be released at the edge of the known distribution area – if suitable habitat is available there. Adding lynx to a local population that may be considered "too large" by local people and land users could however enhance conflicts, and information and communication is therefore of outstanding importance.

Option 6.2.1b: Replace known anthropogenic mortality

In contrast to Option 6.2.1a, Option 6.2.1b does not change the population size as it would only replace any known anthropogenic mortality with genetically suitable individuals. The social acceptance for this option may hence be higher than for Option 6.2.1a. As the basic idea is to compensate for human-caused losses (e.g. traffic mortalities), the release area should be chosen relatively close to the site where the animal died.

Option 6.2.1c: Replace known illegal mortality

In contrast to Option 6.2.1b, Option 6.2.1c would only replace any known illegal mortality. The general social acceptance for this option may be higher still than for Option 6.2.1b. However, this may create a management link between the conservation measure of the genetic remedy, and the controversies surrounding the social acceptance and illegal killings, which may hamper the conservation measure. Furthermore, much of the illegal killings are most likely never discovered, and hence the rate of new genes brought into the population may be very low.

Option 6.2.1d: Remove and replace "genetically problematic" individuals

An adequate genetic monitoring may be able to identify individuals carrying maleficent alleles or areas with locally high degree of inbreeding. For example, in the north-western Alps subpopulation, the genetic lineage responsible for the observed heart problems (Wahli 2015) is known. In such cases, it is an option to actively remove the carriers of these alleles from the population and to replace them with suitable new individuals. Genetically, this option may be the most desirable as it removes the problematic genes from the population.

Note to options under Chapter 6.1 and 6.2:

The lynx population in the north-western Alps and the Dinaric population (including their Alpine part) cannot serve as sources for further translocations, as they are strongly inbred. Source populations can be the Carpathian population (Slovakia or Romania) and any genetically suited reintroduced population.
To support the preparation of the above options, i.e. to ensure that enough animals can be provided, the establishment of adequate infrastructure and capacity in the source populations/countries should be secured, e.g. in Slovakia or Romania. Assistance may be in the form of, e.g. training courses for "capture teams", but also knowledge transfer and information exchange regarding the screening and preparation of suitable animals (genetic monitoring, quarantine, etc.).

6.3 Secure and construct new connection corridors

One of the requirements for reaching FCS is a functioning connectivity within the population, while the connection to neighbouring populations can facilitate achieving FCS. Lynx seem to be less able to cross barriers than e.g. wolves, and models have shown that a future Alpine population would possibly be divided into separate subpopulations due to barriers. However, individual lynx are capable of crossing most kinds of landscape barriers (possibly with the exception of large water bodies and high mountain ridges) incl. (fenced) highways. The point is that the spread of the population is still not granted across a barrier even if individuals are able to cross the obstacle. Therefore, corridors allowing a constant flow of individuals should be managed to ensure the connectivity within the population and possibly enhance the connectivity to neighbouring ones.

Option 6.3.1: Improve connectivity between existing subpopulations within the Alps

The connectivity between existing subpopulations within the Alps should be enhanced. Even if the current level of connectivity in the existing subpopulations is probably sufficient, for when the Alpine meta-population has once established. However, it is not enough to allow the natural population expansion. Enabling the natural expansion requires the improvement of the connectivity by removing barriers where possible and installing habitat corridors.

Connectivity is generally understood as a net of large quiet and/or protected areas for both ungulates and large carnivores and connecting habitat corridors between them. Such a green infrastructure can be maintained and improved with the help of spatial planning especially by realising projects in regional, national and transboundary contexts that are based on participatory processes and supported by local politicians and communities. Such projects might restore fragmented landscapes where possible (e.g. by green bridges, habitat corridors etc.) or reduce disturbance by tourists (by e.g. raising awareness or guiding tourists with hiking and biking trails using signs etc.). Finally, respective goals on connectivity shall be integrated in national policies and strategies (e.g. national strategies for biodiversity conservation) and concrete measures shall be synchronised within the Alpine countries.

Option 6.3.2: Create or maintain connectivity between potential subpopulations

Reaching the long-term goal of one large Alpine population requires ensuring the connectivity within the future Alpine population. This could be done in advance, before lynx actually recolonise the areas concerned. Crucial points can be recognised from models (cf Fig. 6 in Chapter 4.2) and/or identified based on experience. The scale of the project wold differ on a case by case basis and may reach dimensions of ensuring connectivity across a landscape feature such as the Rhine valley in eastern Switzerland. A special focus should lie on the connection of the existing subpopulations and areas of possible reintroductions.

Option 6.3.3: Maintain or improve connectivity of (potential) Alpine subpopulations with populations adjacent to the Alps

Achieving FCS can be facilitated by enlarging the meta-population; in the case of the Alps by establishing a sufficient connection with neighbouring populations (e.g. Jura, Dinaric). The scale of the project would differ on a case by case basis. In the south-east, where the Alpine population is separated from the Dinaric population by a highway, the creation of green bridges may suffice. Elsewhere, measures on a landscape scale would be required, e.g. to achieve a connection with the Bohemian-Bavarian-Austrian population.

Option 6.3.4: The Alpine Convention Contracting Parties pursue the creation of an ecological network at national and cross border level

To achieve this goal (Protocol "Conservation of nature and the countryside"; art. 12) the platform ecological network supports the establishment of an alpine ecological network, a coherent network of interlinked natural spaces in order to guarantee the sustainable protection of the Alpine biodiversity (by promoting transboundary cooperation, practical workshops, nomination of pilot regions etc.)

6.4 Prevent and persecute illegal action through law enforcement

Illegal killing is one of the main threats to lynx in Europe and can have a severe effect on the local population. However, environmental crimes are usually not a priority in law enforcement and only special cases are even noted publicly (e.g. Stadt Bern 2000[20], Bayerischer Rundfunk 2015[21], ORF 2015[22]). The following options intend to increase the awareness of the problem and of its severeness, and to improve its persecution/abatement.

Option 6.4.1: Establish or strengthen corps of independent state employed rangers and game wardens

In some Alpine countries (e.g. France, Slovenia) or in parts of these countries (e.g. Switzerland, Italy), state wildlife rangers with official status are overseeing the implementation of hunting and wildlife protection laws. Such institutions are generally better positioned to investigate or persecute wildlife crime than privately employed game wardens. An official wildlife crime corps should be established.

Option 6.4.2: Awareness raising within police, state attorneys and judges regarding illegal mortality of protected species

The law enforcement corps may not be aware of the severeness of crimes against strictly protected species, e.g. large carnivores or are generally not familiar with nature conservation regulations. Awareness of the issue should to be raised for all levels of legal intervention, from the game warden to the judge by e.g. inviting enforcement authorities to round tables (see option 6.5.1) and offering training courses.

Option 6.4.3: Secure and guarantee professional investigation methods

Investigations on illegal wildlife killing require specific professional skills. In the past, CITES and Interpol have collaborated in the organisation of courses, specific to the issue of wildlife crime. Contact with these two organisations should be made regarding the education of investigators and prosecutors.

Option 6.4.4: Enable and encourage interest groups to address illegal actions

Law enforcement – especially with regard to wildlife crime – is generally only successful if it has a broad societal acceptance and is supported by specific interest groups, such as the hunters. Stakeholder groups should be informed about the severeness of the problem of illegal killing of lynx and should be invited to rigorously employ the existing legal framework and address the issue in the broad public.

[20] http://www.bern.ch/mediencenter/aktuell_pol_feu/2000-02-926
[21] http://www.br.de/nachrichten/oberpfalz/inhalt/tote-luchse-bayerischer-wald-100.html
[22] http://ooe.orf.at/news/stories/2715954/

6.5 Foster dialogue among authorities, with wildlife managers, hunters and foresters by establishing information and consultation mechanisms regarding the lynx

Law enforcement, but also the implementation of conservation and management options listed above, require the support by the public and especially by interest groups concerned (e.g. land owners and land users). More than forty years of experience since the start of the lynx reintroductions in the Alps have revealed that a strong legal framework alone does not guarantee the survival of the populations. Participatory processes are required. Participation, by definition, means more than just the provision of information. It is the aim to turn persons affected into persons involved, which means that compromises and common decisions must be possible. This means also that, for some issues, participatory processes are not possible. Political and legal preconditions are required which enable the possibility of reaching such compromises and common decisions. Otherwise, the process will cause frustration. However, even if a participatory process is not possible in the decision-making for a certain issue, it may e.g. still be possible for the when, where and how of the implementation. For a review of key elements of stakeholder engagement and public participation we refer to Linnell (2013). In general, the inclusion of all affected actors in decision making but specifically in the process of developing management plans is absolutely essential.

Option 6.5.1: Establish round tables and workshops to encourage dialogue among authorities and interest groups

There are conflicting goals between and within the fields of agriculture, forestry, hunting and nature protection. While the legitimacy of each of these conflicting goals cannot be discussed, the extent of the disagreement should be identified. A possible solution is a prioritisation of the goals. An earnest dialogue addressing all critical and controversial points between the different interest groups should be started with the aim to develop common ground and find compromises with regard to lynx management and conservation. This dialogue should be facilitated by an independent and broadly accepted institution or mandated key person.

Option 6.5.1a: Establish different forms of participation in pilot regions and evaluate outcome in terms of best practice projects

There are different forms of participation processes. These vary in terms of organisation of the group, e.g. who moderates the group, the requirements of work investment for the participants of the group, the influence that the results of the group can have (participation of GO representatives from different administrative levels and agencies). For example, the analysis of one participatory process can be found in Boutros & Baumgartner (2004). The effectiveness of such variations should be tested in order to establish best practice guidelines.

Option 6.5.1b: Based on consultations with interest groups, authorities develop and implement guidelines on how to integrate lynx presence into ungulate and forest management.

The experience with previous round tables and involvement of interest groups reveal that for the lynx the main conflict zone lies within the ungulate hunting management. Wildlife management as it has developed in the Alpine countries in the 20th century mainly tries to balance between hunting and forest harvest, hence to maintain relatively high ungulate densities while mitigating browsing damage. The impact of an efficient predator such as the lynx on the ungulate populations is a “new” and maybe considerable factor in this system and should now be taken into account in order to avoid conflicts of goals. In the field of hunting, potential ways to adapt ungulate (game) management to the presence of lynx should be discussed, for example with

regard to harvest quotas and feeding practices (feeding stations, baiting, fruit trees, waste management in villages) as well as hunting practices and regulations. Furthermore, adaptation of forest management practices to reflect the carrying capacity for ungulates, and compensation schemes to address the impacts of browsing damage by ungulates due to verifiable impacts of lynx should be considered. This would require a dialogue between wildlife managers, hunters, foresters, and conservationists with the aim to adapt given wildlife management practices, especially ungulate and forest management. In addition, measures to improve ongoing internal communication and exchange between hunters regarding lynx should be integrated into lynx management plans.

Option 6.5.1c: Create suitable units for lynx, ungulate and forest management within the national borders and cross-border

As lynx need a lot of space, its management entails a different spatial scale than traditional ungulate or hunting management. Inadequate management units (e.g. for monitoring or assessment of status) often result in wrong conclusions. The Alpine countries should therefore identify and establish adequate management units for the monitoring and conservation of lynx. Such units should consider habitat and subpopulation models, but can also be based on existing units (e.g. hunting units or national subunits).

Management units could also incorporate areas that are especially important for the return of lynx (cross-border regions, regions that adjoin core areas of lynx etc.) and areas, where the implementation of livestock protection might be more complex and/or land use practices require fundamental changes.

Option 6.5.2: Enable and foster fact-based in-group communication

Norms that guide, for example, hunting practices are very important and can be influenced by in-group communication. Therefore such in-group communication should be encouraged and also supported by providing relevant facts. The information used should come from a source which is generally accepted to be objective. A structure for the communication of such objective information should be established, too. It is even more effective, if in-group actors were involved in the gathering of the information.

Option 6.5.3: Undertake regular systematic public surveys to evaluate and refine work with interest groups and broad public ("social monitoring")

The management of any animal population should include a monitoring in order to assess the effectiveness of the management, enabling the managers to adapt the management in case of adverse results. Similarly, the effectiveness of measures to increase the social acceptance requires its own monitoring. This should be established by regular public surveys in the interest groups and the broad public.

Social-scientific aspects should be included in the monitoring process:

1. Systematic evaluation of reporting about large carnivores should be done in order to be able to reliably interpret changes in attitudes. For example, in Slovenia it was found that the behaviour of individual problem bears was responsible for a large part of negative reporting.
2. Focus groups should be created with participants from different sectors (hunting, agriculture, tourism, nature conservation) in regions with large carnivores presence in order to identify emerging problems immediately.

3. Regular systematic public surveys should be conducted, with special focus on the most relevant interest groups (hunting, agriculture, tourism, nature conservation) in order to detect changes in attitudes at early stages and to evaluate the quality of large carnivores management.

6.6 Integrate local people in the lynx monitoring

The involvement of local people increases amongst other things the feeling of involvement of more than just the person actually involved, but also of their peers. Furthermore, it may empower stakeholders through the co-generation of knowledge and make the research more robust by providing higher quality information input. It also contributes to the dialogue between the local stakeholders/interest groups and the managers/administration and can help to increase the information flow in both directions. For a review of key elements of stakeholder engagement and public participation we refer to Linnell (2013).

Option 6.6.1: Involve interested people at local level, e.g. hunters, foresters and nature enthusiasts in the monitoring of lynx

A scientific robust monitoring is the basis of all meaningful conservation and management actions. However, monitoring results should also be communicated, understood, and accepted by the local population concerned. The performance and the acceptance of monitoring, but also the general dialogue could be improved by integrating individuals from (different) interest groups into the field work by e.g. providing specific web portals designed for the collection and assessment of observation/records of lynx individuals.

Option 6.6.2: Authorities develop an incentive system for the documented presence of lynx at regional or communal level

The presence of lynx can hamper the fulfilment of the required hunting quota or reduce the harvest of ungulate game. State institutions or land users should therefore also consider mitigating conflicts between hunters and lynx through e.g. offering (financial) incentives to hunters' associations who have lynx in their hunting grounds, if in accordance with national legislation. Such a system also offers the opportunity to integrate hunters into the lynx monitoring, e.g. by giving them the burden of onus of lynx presence.

6.7 Secure sustainable damage prevention and compensation systems for livestock damages

The amount of livestock killed by lynx is rather small and generally involves only one victim per attack. However, even the loss of very few animals often results in a hostile attitude towards the carnivore. To mitigate the negative impact of livestock depredation by lynx, the development of a sustainable damage prevention and compensation system is recommended. "Sustainable" in this case means that it must be long-lasting and reliable even if compensations costs are rising; i.e. farmers must not fear every year whether the compensation payments are continued or not.

Option 6.7.1: Secure the general, sustainable governmental compensation of livestock damages caused by lynx

Authorities in charge should establish a system of compensation payments. The presence of a legal obligation would additionally strengthen the sustainability of the system. The amount paid per victim is usually equal to the market price. The payments may be split between different institutions, but there should be a single, clear point of contact for the concerned farmer.

Option 6.7.2: Establish adequate damage prevention measures where livestock damages have been repeatedly confirmed

Lynx attacks on livestock – mainly sheep herds – are on average so rare and unpredictable that no general specific measures to prevent damage is recommended. However, in case of repeated attacks on the same herd, protective measures should be taken. An overview of possible measures and preconditions for the application of a specific measure can be found in Angst et al. (2002).

Option 6.7.3: Secure mechanisms for the advice on and assistance in implementing damage prevention measures by institutions in charge

As already indicated under Option 6.7.2, not all methods of protection of herds against lynx attacks are reasonable in all cases. To assist the (sheep) farmers, the institutions in charge should provide advice on implementing damage prevention measures, e.g. based on Angst et al. (2002).

Option 6.7.4: Link compensation payments to application of damage prevention measures

It is possible to link the payment of compensation to the prior establishment of protective measures. With lynx, it would not be sensible to establish such a condition as a general rule, but only in case of repeated attacks. A benchmark would have to be set, after which further damages are only compensated if adequate prevention measures have been implemented. “Adequate” would need to be defined with regard to (1) the effectiveness of the protective measure, and (2) the effort required putting the protective measure in place.

7 Suggestions for priorities in time and space

Despite the diversity of situations that lynx management is faced with across the Alpine countries, the RowAlps project has identified a set of general management options for the entire Alpine lynx population. Although there may be some regional and national variation in the priority of implementing these management options, suggestions for pan-Alpine priorities in time and space are needed. Therefore, working Group 3 of the RowAlps project identified the level and timing of priority for each of the seven management options (Table 6). The report of the European Commission “Key actions for Large Carnivore populations in Europe[23]” provided a basis for defining the level of priority and the timing of implementation for most of the options (marked with an asterisk in Table 6). The remaining ones have been assigned to a level of urgency according to the rating of Working Group 3. The timing of implementation was defined separately for areas with and without established lynx populations.

[23] Boitani, L. et al. (2015): Key actions for Large Carnivore populations in Europe. Institute of Applied Ecology (Rome, Italy). Report to DG Environment, European Commission, Bruxelles.

Table 6: Suggested level of priority and timing of implementation for management options for the Alpine lynx population.

Management option	Level of priority	Timing of implementation
Active genetic management (Option 6.2)	High	> Establish measures: - where necessary and as soon as possible in areas with established lynx populations > Continuous implementation
Foster dialogue among authorities, with wildlife managers, hunters and foresters by establishing information and consultation mechanisms regarding the lynx (Option 6.5)	High	> Establish measures: - as soon as possible in areas with established lynx populations - upon first appearance of individual lynx in areas without established lynx populations > Continuous implementation
Merge eastern and western subpopulations (Option 6.1)	High/Medium	> Establish measures: - within next 10 years (2016-2026) > Continuous implementation
Secure and construct new connection corridors (Option 6.3)	High/Medium	> Establish measures: - where necessary and in accordance with merging eastern and western subpopulations > Continuous implementation
Integrate local people into lynx monitoring (Option 6.6)	High/Medium	> Establish measures: - as soon as possible in areas with established lynx monitoring - from the onset of developing new monitoring systems > Continuous implementation
Prevent and persecute illegal action through law enforcement (Option 6.4)	High/Medium	> Establish measures: - as soon as possible in areas with established lynx populations - upon first appearance of individual lynx in areas without established lynx populations > Continuous implementation
Secure sustainable damage prevention and compensation systems for livestock damages (Option 6.7)	Low	> Establish measures: - in areas with repeated attacks where lynx populations have established > Continuous implementation

Annex 1: Literature

Chapter 1

Alpine Convention. 2014. Mandate proposal of the "WISO PF" for the period 2015-2016. XIII Alpine Conference, Torino, Italy. 5 pp.

WISO. 2011. Guidelines "Large carnivores, wild ungulates and society". Prepared by the Platform WISO (Large carnivores, wild ungulates and society) of the Alpine Convention. Adopted by the XI Alpine Conference, Brdo, Slovenia. 10 pp.

Chapter 2

Bätzig W. 2015. Die Alpen – Geschichte und Zukunft einer europäischen Kulturlandschaft. 4th edition. C.H. Beck, Munich, Germany.

EEA (European Environment Agency). 2010. Europe's ecological backbone: recognising the true value of our mountains. European Environment Agency, Copenhagen, Denmark, 252 pp.

Linnell J., Salvatori V. & Boitani L. 2008. Guidelines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe report prepared for the European Commission (contract 070501/2005/424162/MAR/B2). 85 pp.

Mills L. S. 2007. Conservation of wildlife populations – demography, genetics, and management. Blackwell, Malden, Massachusetts, USA, 407 pp.

Molinari-Jobin A., Molinari P., Breitenmoser-Würsten Ch., Wölfl M., Stanisa C., Fasel M., Stahl P., Vandel J.-M., Rotelli L., Kaczensky P., Huber T., Adamic M., Koren I. & Breitenmoser U. 2003. The Pan-Alpine Conservation Strategy for the Lynx. Council of Europe Publishing, Strasbourg, France. Nature and environment No. 130.

Price M. F., Borowski D., Macleod C., Rudaz G. & Debarbeieux B. 2011. From Rio 1992 to 2012 and beyond: 20 years of Sustainable Mountain Development. What have we learnt and where should we go? - The Alps. Federal Office for Spatial Development ARE. 76 pp.

Rüdisser J. 2002. Beurteilung Westösterreichs als potentieller Lebensraum für den Luchs (Lynx lynx).In Angewandte Geographische Informationsverarbeitung XIV – Beiträge zum AGIT-Symposium Salzburg. Strobl J., Blaschke T. & Griesebner G. (Eds). Wichmann Verlag, Berlin, Germany, pp. 1-10.

Siegrist D. 1998. Daten zu Tourismus und Freizeit. In Alpenreport: Daten, Fakten, Probleme, Lösungsansätze. CIPRA (ed.). Haupt, Bern, Switzerland, pp. 418-441.

Chapter 3

AGRIDEA 2014b http://www.protectiondestroupeaux.ch/fr/international/slovenie/ (Last accessed on 03.12.2014)

Apollonio M., Putman R., Grignolio S. & Bartoš L. 2011. Hunting seasons in relation to biological breeding seasons and the implications for the control of regulation of ungulate populations. In Ungulate management in Europe: problems and practices. Putman R., Apollonio M. & Andersen R. (Eds). Cambridge University Press, Cambridge, United Kingdom. pp 80-105.BAFU (Bundesamt für Umwelt). 2014. http://www.wild.uzh.ch/jagdst/index.php (last accessed on 24.07.2015)

BAFU (Bundesamt für Umwelt). 2014. http://www.wild.uzh.ch/jagdst/index.php (last accessed on 24.07.2015)

Boitani L., Ciucci P. & Raganella-Pelliccioni E. 2010. Ex-post compensation payments for wolf predation on livestock in Italy: a tool for conservation? Wildlife Research 37, 722-730.

Breitenmoser U. 1997. Significance of food resources in re-introduction projects of large carnivores: the case of the lynx. Suppl. Ric. Biol. Selvaggina 17, 269-275.

Breitenmoser U. 1998a. Large predators in the Alps: the fall and rise of man's competitors. Biol. Conserv. 83(3), 279-289.

Breitenmoser U., Breitenmoser-Würsten Ch. & Capt S. 1998. Re-introduction and present status of the lynx in Switzerland. Hystrix 10(1), 17-30.

Breitenmoser U. & Breitenmoser-Würsten Ch. 2008. Der Luchs. Ein Grossraubtier in der Kulturlandschaft. Salm Verlag. Wohlen Bern. 537 pp.

Breitenmoser U. & Haller H. 1987. Zur Nahrungsökologie des Luchses in den schweizerischen Nordalpen. Zeitschrift für Säugetierkunde 52, 168-191.

Breitenmoser U. & Haller H. 1993. Patterns of predation by reintroduced European lynx in the Swiss Alps. The Journal of Wildlife Management 57, 135–144.

Breitenmoser U., Ryser A., Molinari-Jobin A., Zimmermann F., Haller H. & Breitenmoser-Würsten Ch. 2007. Changing predation impact of reintroduced lynx in Switzerland. Conference proceedings.

Breitenmoser U., Ryser A., Molinari-Jobin A., Zimmermann F., Haller H., Molinari P. & Breitenmoser-Würsten Ch. 2010. The changing impact of predation as a source of conflict between hunters and reintroduced lynx in Switzerland. In Biology and conservation of wild felids. MacDonald D. W. & Loveridge A. J. (Eds). Oxford University Press, Oxford, United Kingdom, pp 493-505.

Bufka L. & Cerveny J. 1996. The lynx in the Sumava region, southwest Bohemia. Journal of Wildlife Research 1, 167-170.

Capt S. 1992. The Reintroduction of Lynx in Switzerland. The situation, conservation needs and reintroduction of lynx in Europe. Strasbourg, Council of Europe. Conference Proceedings, pp. 53-55.

Cop J. & Frkovic A. 1998. The re-introduction of the lynx in Slovenia and its present status in Slovenia and Croatia. Hystrix 10(1), 65-76.

Fasel M. 2006. The lynx in Liechtenstein. Acta Biologica Slovenica 49(1), 53-54.

Fico R., Angelucci S. & Patumi I. 2005. Accertamento dei casi di predazione sul bestiame domestico: metodi, validazione dei risultati e implicazioni gestionali. Lupo o cane: chi è stato? In Grandi Carnivori e Zootecnia tra conflitto e coesistenza. Ciucci P., Teofili C. & Boitani, L. (Eds). Biologia e Conservazione della Fauna 115, 52-63.

Fuxjäger C. 2014. Luchsmonitoring 2013 – Jahresbericht. Natinalpark Kalkalpen, Molln, Austria, 10 pp.

Fuxjäger C., Laass J. & Molinari-Jobin A. 2012. Eurasian lynx (Lynx lynx) in the Austrian Alps in period 2005-2009. Acta Biologica Slovenica 55(2), 65-69.

Gossow H. & Honsig-Erlenburg P. 1985. Several predation aspects of red deer-specialized Lynx. 17th international Congress IUGB, Brüssel. pp. 285-291.

Haglund B. 1966. Winter habits of the lynx and wolverine as revealed by tracking in the snow. Viltrevy 4(3), 81-310.

Haller H. 1992. Zur Ökologie des Luchses Lynx lynx im Verlauf seiner Wiederansiedlung in den Walliser Alpen. Mammalia depicta 15, Beiheft zur Zeitschrift für Säugetierkunde. 60 pp.

Herrenschmidt V. & Vandel J.M. 1989. Dossier Lynx. Commissions d'Observation. Commissions d'Expertise Formation. Office National de la Chasse. 68 pp

Huber T. & Kaczensky P.1998. The situation of the lynx in Austria. Hystrix, 10(1):43-54.

Jobin A., Molinari P. & Breitenmoser U. 2000. Prey spectrum, prey preference and consumption rates of Eurasian lynx in the Swiss Jura Mountains. Acta Theriologica 45(2), 243-252.

Kaczensky P. 1996. Large carnivore-livestock conflicts in Europe. Munich Wildlife Society, Ettal, Germany. 106 pp.

Kaczensky P. 1998. Status and distribution of the lynx in the German Alps. Hystrix 10(1), 39-42.

Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H. & Linnell J. (Eds) 2013a. Status, management and distribution of large carnivores - bear, lynx, wolf & wolverine - in Europe. Part I. Europe summaries. A Large Carnivore Initiative for Europe Report prepared for the European Commission (contract N°070307/2012/ 629085/SER/B3). 72 pp.

Kaczensky P., Engleder T. & Fuxjäger, C. 2013c. Lynx – Austria. In Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H. & Linnell J. (Eds) 2013. Status, management and distribution of large carnivores - bear, lynx, wolf & wolverine - in Europe. Part II. Species Country Reports. A Large Carnivore Initiative for Europe Report prepared for the European Commission.

Koren I., Jonozovic M. & Kos, I. 2006. Status and distribution of the Eurasian lynx (Lynx lynx L.) in Slovenia in 2000-2004 and comparison with the years 1995-1999. Acta Biologica Slovenica 49(1), 27-41.

Kos I. & Potočnik H. 2013. Lynx- Slovenia. In Kaczensky P., Chapron G., von Arx M., Huber D., Andren H. & Linnell J. 2013. Status, management and distribution of large carnivores- bear, lynx, wolf & wolverine- in Europe. Part 2. European Commission.

Krofel M. 2006. Predation and feeding habits of Eurasian lynx in the Slovenian Dinaric mountains. Diploma thesis, University of Ljubljana, Ljubljana, Slovenia. 100 pp.

Krofel M., Huber D. & Kos I. 2011. Diet of Eurasian lynx in the northern Dinaric Mountains (Slovenia and Croatia). Acta Theriologica 56(4), 315-322.

Laass J. 1999. Evaluation von Photofallen für ein quantitatives Monitoring einer Luchspopulation in den Alpen. Diplomarbeit Universität Wien, Vienna, Austria. 75 pp.

Laass J. 2002. Fotofallen-Monitoring im westlichen Berner Oberland 2001. KORA Bericht Nr. 14. 27 pp.

Linnell J.D.C. & Zachos F.E. 2011. Status and distribution patterns of European ungulates: genetics, population history and conservation. In Ungulate management in Europe: Problems and practices. Putman R., Apollonio M. & Andersen R. (Eds). Cambridge University Press, Cambridge, United Kingdom. pp. 12-53.

Marboutin E. 2013b. Lynx – France. In Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H. & Linnell J. (Eds.) 2013. Status, management and distribution of large carnivores - bear, lynx, wolf & wolverine – in Europe. Part II. Species Country Reports. A Large Carnivore Initiative for Europe Report prepared for the European Commission.

Marboutin E., Duchamp C., Moris P., Briaudet P.-E., Leonard Y. & Catusse M. 2012. Survey of the Lynx lynx distribution in the French Alps: 2005-2009 update. Acta Biologica Slovenica 55(1), 29-34.

Melis C., Jędrzejewska B., Apollonio M., Bartoń K.A., Jędrzejewski, W., Linnell, J.D.C., Kojola I., Kusak J., Adamic M., Ciuti S., Delehan I., Dykyy I., Krapinec K., Mattioli L., Sagaydak A., Samchuk N., Schmidt K., Shkvyrya M., Sidorovich V.E., Zawadzka B. & Zhyla S. 2009. Predation has a greater impact in less productive environments: variation in roe deer, Caprolus capreolus, population density across Europe. Global Ecology and Biogeography 18, 724-734.

Molinari P. 1998. The lynx in the Italian South-Eastern Alps. Hystrix 10(1), 55-64.

Molinari-Jobin A. 2014. SCALP News April 2014, 2pp.

Molinari-Jobin A., Molinari P., Breitenmoser-Würsten Ch. & Breitenmoser U. 2002. Significance of lynx predation for roe deer and chamois mortality in the Swiss Jura Mountains. Wildlife Biology 8(2), 109-115.

Molinari-Jobin A., Marboutin E., Wölfl S., Wölfl M., Molinari P., Fasel M., Kos I., Blazic M., Breitenmoser-Würsten Ch., Fuxjäger Ch., Huber T., Izotok K. & Breitenmoser U. 2010a. Recovery of the Alpine lynx Lynx lynx metapopulation. Oryx 44 (2), 267–275.

Molinari-Jobin A., Kos I., Marboutin E., Molinari P., Wölfl S., Fasel N., Breitenmoser-Würsten C., Fuxjäger C., Huber T., Koren I., Schmidt K., Kusak J., Valdmann H., Zimmermann F., Wölfl M. & Breitenmoser U. 2010b. Expansion of lynx in the Alps. KORA and Bavarian Environment Agency. KORA Bericht Nr. 50. 17 pp.

Molinari P., Bionda R., Carmignola G., Filacorda S., Groff C., Mingozzi T., Marucco F. & Molinari-Jobin A. 2012. Status and distribution of the lynx (Lynx lynx) in the Italian Alps 2005-2009. Acta Biologica Slovenica 55(1), 35-41.

Morellet N., Klein F., Solberg E. & Andersen R. 2011. The census and management of populations of ungulates in Europe. In Ungulate management in Europe: Problems and practices. Putman R., Apollonio M. & Andersen R. (Eds). Cambridge University Press, Cambridge, United Kingdom. pp. 106-143.

Nationalpark Kalkalpen. 2011a. http://www.kalkalpen.at/system/web/sonderseite.aspx?menuonr=224008125&detailonr=224008125 (Last accessed on 03.12.2014)

Nationalpark Kalkalpen. 2011b. http://www.kalkalpen.at/system/web/news.aspx?bezirkonr=0&menuonr=221353046&detailonr=224690894 (Last accessed on 03.12.2014)

Nowicki P. 1997. Food habit and diet of the lynx in Europe. Journal of Wildlife Research 2(2), 161-166.

Potočnik H., Skrbinšek T. & Kos I. 2009. The reintroduced Dinaric lynx population dynamics in PVA simulation, The 30 years retrospection and the future viability. Acta Biologica Slovneica 52(19) 3-18.

Putman R. 2011. A review of the various legal and administrative systems governing management of large herbivores in Europe. In Ungulate management in Europe: Problems and practices. Putman R., Apollonio M. & Andersen R. (Eds). Cambridge University Press, Cambridge, United Kingdom. pp. 54-79.

Ragni B., Possenti M., Mayr S., Carrer M., Zangrando E., Catello M., Dorigatti E., Di Lorenzo M., Mosca A., Fattor M. & Lombardi G. 1998. The lynx in the Italian Alps. Hystrix 10(1), 31-38.

Reimoser F. & Reimoser S. 2010. Ungulates and their management in Austria. In European ungulates and their management in the 21st century. Apollonio M., Andersen R. & Putman R. (Eds). Cambridge University Press, Cambridge, United Kingdom, pp. 338-356.

Ringler A. 2009. Almen und Alpen – Höhenkulturlandschaft der Alpen – Ökologie, Nutzung, Perspektiven. Selbstverlag Verein zum Schutz der Bergwelt, München, 1448 pp.

SCALP 2012. Monitoring Report 2009-2011. 3pp.

von Arx M., Breitenmoser-Würsten Ch., Zimmermann F. & Breitenmoser U. (Eds.) 2004. Status and conservation of the Eurasian lynx (Lynx lynx) in Europe in 2001. KORA report No. 19, 1-330.

von Arx M. & Zimmermann F. 2013. Lynx – Switzerland. *In* Status, management and distribution of large carnivores - bear, lynx, wolf & wolverine - in Europe. Part II. Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H. & Linnell J. (Eds). A Large Carnivore Initiative for Europe Report prepared for the European Commission.

von Arx M. & Zimmermann F. 2013. Lynx – Switzerland. *In* Status, management and distribution of large carnivores - bear, lynx, wolf & wolverine - in Europe. Part II. Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H. & Linnell J. (Eds). A Large Carnivore Initiative for Europe Report prepared for the European Commission.

Wölfl M. 2006. Present status and distribution of the lynx in the German Alps 2000-2004. Acta Biologica Slovenica 49(1), 51-52.

Wölfl M. & Kaczensky P. 2001. Present status and distribution of the lynx in the German Alps. Hystrix 12(2), 39-41. W l S. & W l M. 2011. Status of the lynx in the German Alps from 2005 2009. Acta Biologica Slovenica 54(2), 81-83.

Zimen E. 1978. Der Wolf. Mythos und Verhalten. Meyster Verlag GmbH, Wien, München. 333pp.

Zimmermann F., Foresti D., Bach J., Dulex N., Breitenmoser-Würsten C. & Breitenmoser U. 2014. Abundanz und Dichte des Luchses in den Nordwestalpen: Fang-Wiederfang-Schätzung mittels Fotofallen im K-VI im Winter 2013/14. KORA Bericht Nr. 64. 16 pp.

Chapter 4

Basille M., Calenge C., Marboutin E., Andersen R. & Gaillard J.-M. 2008. Assessing habitat selection using multivariate statistics: some refinements of the ecological-niche factor analysis. Ecological Modelling 211, 233-240.

Bath A. & Frank B. (2011): Social, Educational and Cultural Aspects: Human Dimensions as a Tool for Bird Conservation. Report, European Conference on Illegal Killing of Birds, Larnaca, Cyprus (6-8 July), T-PVS/Inf (2011) 12, Council of Europe, Strasbourg, 20 pages.

Becker T. 2013. Modelling Eurasian lynx distribution and estimation of patch and population size in the Alps. Master thesis, University of London, London, United Kingdom. 69 pp.

BfN (Bundesamt für Naturschutz). 2010. Grundlagen für Managementkonzepte für die Rückkehr von Großraubtieren. Unpublished Final Report.

Boitani L., Alvarez F., Anders O., Andren H., Avanzinelli E., Balys V., Blanco J. C., Breitenmoser U., Chapron G., Ciucci P., Dutsov A., Groff C., Huber D., Ionescu O., Knauer F., Kojola I., Kubala J., Kutal M., Linnell J., Majic A., Mannil P., Manz R., Marucco F., Melovski D., Molinari A., Norberg H., Nowak S., Ozolins J., Palazon S., Potocnik H., Quenette P.-Y., Reinhardt I., Rigg R., Selva N., Sergiel A., Shkvyria M., Swenson J., Trajce A., von Arx M., Wölfl M., Wotschikowsky U. & Zlatanova D. 2015. Key actions for Large Carnivore populations in Europe. Institute of Applied Ecology (Rome, Italy). Report to DG Environment, European Commission, Bruxelles. Contract no. 07.0307/2013/654446/SER/B3. 119 pp.

Breitenmoser U. & Breitenmoser-Würsten Ch. 2008. Der Luchs – ein Grossraubtier in der Kulturlandschaft. Salm Verlag, Wohlen, Bern, 537 pp.

Breitenmoser U., Breitenmoser-Würsten Ch., Okarma H., Kaphegyi T. A. M., Kaphegyi-Wallmann, U & Müller U. M. 2000. Action Plan for the Conservation of the Eurasian Lynx in Europe (Lynx lynx). Council of Europe Publishing, Strasbourg, France. Nature and environment No. 112, 70pp.

Breitenmoser et al. 2015. The recovery of wolf *Canis lupus* and lynx *Lynx lynx* in the Alps: Biological and ecological parameters and wildlife management systems. RowAlps Report Objective 1. KORA, Muri bei Bern, Switzerland. 276 pp.

Breitenmoser-Würsten Ch. & Obexer-Ruff G. 2003. Population and conservation genetics of two re-introduced lynx (Lynx lynx) populations in Switzerland – a molecular evaluation 30 years after translocation. Council of Europe Publishing, Strasbourg, France. Environmental encounters 58, 51-55.

Breitenmoser-Würsten Ch., Zimmermann F., Ryser A., Capt S., Laass J., Siegenthaler A. & Breitenmoser U. 2001. Untersuchungen zur Luchspopulation in den Nordwestalpen der Schweiz 1997–2000. KORA Bericht Nr. 9. 90 pp.

BUWAL (Bundesamt für Umwelt, Wald und Landschaft). 2004a. Konzept Luchs Schweiz / Concept Lynx Suisse. 8 pp.

Council of Europe (ed.) 2012. Group of Experts on the conservation of Large Carnivores in Europe. Saanen, Gstaad (Switzerland), 24-26 May 2012. Convention on the Conservation of European Wildlife and Natural Habitats. T-PVS (2012) 7. Council of Europe, Strasbourg, France, 75 pp.

Dickman A. (2010): Complexities of conflict: the importance of considering social factors for effectively resolving human-wildlife conflict. Animal Conservation 13: 458-466.

Dressel S., Sandström C. & Ericsson G. (2015): A meta-analysis of studies on attitudes toward bears and wolves across Europe 1976-2012. Conservation Biology 29 (2): 565-574.

Glasl F. (2010): Konfliktmanagement. Ein Handbuch für Führungskräfte, Beraterinnen und Berater. 9., aktualisierte und ergänzte Auflage. Haupt Verlag, Bern. Pp. 1-530.

Herdtfelder M. 2012. Natur- und sozialwissenschaftliche Analysen anthropogen bedingter Mortalitätsfaktoren und deren Einfluss auf Überlebenswahrscheinlichkeit des Luchses. Dissertation. Albert-Ludwigs-Universität, Freiburg im Breisgau, Germany, 144 pp.

Kaczensky P. 1998. Status and distribution of the lynx in the German Alps. Hystrix 10(1), 39-42.

Kaczensky P., Kluth G., Knauer F., Rauer G., Reinhardt I. & Wotschikowsky U. 2009. Monitoring von Grossraubtieren in Deutschland. BfN-Skripten 251, 1-89.

Kaczensky P., Chapron G., von Arx M., Huber D., Andrén H. & Linnell J. (Eds) 2013a. Status, management and distribution of large carnivores – bear, lynx, wolf & wolverine – in Europe. Part I. Europe summaries. A Large Carnivore Initiative for Europe Report prepared for the European Commission.

Kramer-Schadt S., Kaiser T. S., Frank K. & Wiegand T. 2011. Analyzing the effect of stepping stones on target patch colonisation in structured landscapes for Eurasian lynx. Landscape Ecology 26, 501-513.

Linnell J., Salvatori V. & Boitani L. 2008. Guidelines for population level management plans for large carnivores in Europe. A Large Carnivore Initiative for Europe report prepared for the European Commission (contract 070501/2005/424162/MAR/B2). 85 pp.

Mikschl K., Pukall K. & Wölfl S. (2014): RowAlps Report Objective 2.2.-2.4. 60 pages.

Mills L. S. 2007. Conservation of wildlife populations – demography, genetics, and management. Blackwell, Malden, Massachusetts, U.S.A. 407 pp.

Molinari-Jobin A., Molinari P., Breitenmoser-Würsten Ch., Wölfl M., Stanisa C., Fasel M., Stahl P., Vandel J.-M., Rotelli L., Kaczensky P., Huber T., Adamic M., Koren I. & Breitenmoser U. 2003. The Pan-Alpine Conservation Strategy for the Lynx. Council of Europe Publishing, Strasbourg, France. Nature and environment No. 130, 25 pp.

Molinari-Jobin A., Marboutin E., Wölfl S., Wölfl M., Molinari P., Fasel M., Kos I., Blazic M., Breitenmoser-Würsten Ch., Fuxjäger Ch., Huber T., Izotok K. & Breitenmoser U. 2010a. Recovery of the Alpine lynx *Lynx lynx* metapopulation. Oryx 44(2), 267–275.

Molinari-Jobin A., Kos I., Marboutin E., Molinari P., Wölfl S., Fasel N., Breitenmoser-Würsten Ch., Fuxjäger C., Huber T., Koren I., Schmidt K., Kusak J., Valdmann H., Zimmermann F., Wölfl M. & Breitenmoser U. 2010b. Expansion of lynx in the Alps. KORA and Bavarian Environment Agency. KORA Bericht Nr. 50. 17 pp.

Mondini M. & Hunziker M. (2013): Factors influencing attitudes towards large carnivores. RowAlps Report Ojective 2.1. 36 pages.

Potočnik H., Skrbinšek T. & Kos I. 2009. The reintroduced Dinaric lynx population dynamics in PVA simulation: The 30 years retrospection and the future viability. Acta Biologica Slovenica 52(19), 3-18.

Reinhardt I., Rauer G., Kluth G., Kaczensky P., Knauer F. & Wotschikowsky U. 2012. Livestock protection methods applicable for Germany - a country newly recolonised by wolves. Hystrix 23(1), 62-72.

Rolland J., Basille M., Marboutin E. & Gaillard J.-M. 2011. Comparing profile methods and site-occupancy modelling for the study of occurrence of an elusive species. European Journal of Wildlife Research 57, 1115-1118.

Rüdisser J. 2002. Beurteilung Westösterreichs als potentieller Lebensraum für den Luchs (*Lynx lynx*).*In* Angewandte Geographische Informationsverarbeitung XIV – Beiträge zum AGIT-Symposium Salzburg. Strobl J., Blaschke T. & Griesebner G. (Eds). Wichmann Verlag, Berlin, Germany, pp. 1-10.

SCALP 2012. Monitoring Report 2009-2011. 3pp.

Schadt S. A. 2002. Szenarien für eine lebensfähige Luchspopulation in Deutschland. Thesis, Technische Universität München, Fakultät Wissenschaftszentrum Weihenstephan für Ernährung, Landnutzung und Umwelt, Munich, Germany. 116 pp.

Signer J. 2010. Distribution and connectivity of Eurasian lynx in the Alps. Workpackage 5: “Corridors and Barriers”. Environment Agency Austria, Vienna, Austria. 16 pp.

Sponarski C.C., Vaske J.J. & Bath A.J. (2015): The Role of Cognitions and Emotions in Human-Coyote Interactions. Human Dimensions of Wildlife 20 (3): 1-17.

Treves A. & Bruskotter J. 2014. Tolerance for predatory wildlife. Science 344, 476-477.

von Arx M., Breitenmoser-Würsten Ch., Zimmermann F. & Breitenmoser U. (Eds.) 2004. Status and conservation of the Eurasian lynx (Lynx lynx) in Europe in 2001. KORA Bericht Nr. 19. 330 pp.

WISO. 2010. Results of fact finding in the frame of the Platform “Large Carnivores and Wild Ungulates”. WISO, 34 pp. [Is there an official/suggested citation for this document?]

Zimmermann F. 2003. Lynx habitat fragmentation of the Alps – a preliminary model. Council of Europe Publishing. Environmental encounters 58, 47-50.

Zimmermann F. 2004. Conservation of the Eurasian Lynx in a fragmented landscape- habitat models, dispersal and potential distribution. PhD thesis, University of Lausanne, Lausanne, Switzerland, 194 pp.

Zimmermann F. & Breitenmoser U. 2007. Potential distribution and population size of the Eurasian lynx in the Jura Mountains and possible corridors to adjacent ranges. Wildlife Biology 13, 406-416.

Zimmermann F., Breitenmoser-Würsten Ch. & Breitenmoser U. 2007. Importance of dispersal for the expansion of a Eurasian lynx population in a fragmented landscape. Oryx 41(3), 358-368.

Chapter 6

Angst C., Hagen S. & Breitenmoser U. 2002. Übergriffe von Luchsen auf Kleinvieh und Gehegetiere in der Schweiz. Teil II: Massnahmen zum Schutz von Nutztieren. KORA Bericht Nr. 10d. 64 pp.

Becker T. 2013. Modelling Eurasian lynx distribution and estimation of patch and population size in the Alps. Master thesis, University of London, London, United Kingdom. 69 pp.

Boutros D. & Baumgartner H. (eds). 2004. Erfahrungen der Kontaktgruppe Luchs Simmental und Saanenland: Auswertung einer Umfrage unter den Mitgliedern. KORA Bericht Nr. 20. 21 pp.

IUCN/SSC (2013). Guidelines for Reintroductions and Other Conservation Translocations. Version 1.0. IUCN Species Survival Commission, Gland, Switzerland. 57 pp.

Kramer-Schadt S., Kaiser T. S., Frank K. & Wiegand T. 2011. Analyzing the effect of stepping stones on target patch colonisation in structured landscapes for Eurasian lynx. Landscape Ecology 26, 501-513.

Linnell J. 2013. From conflict to coexistence: insights from multi-disciplinary research into the relationships between people, large carnivores and institutions. A Large Carnivore Initiative for Europe Report prepared for the European Commission (contract N°070307/2012/629085/SER/B3).

Wahli T. (ed.). 2015. Jahresbericht 2014. Zentrum für Fisch- und Wildtiermedizin, Bern, Switzerland. 62 pp.

WISO. 2010. Results of fact finding in the frame of the Platform “Large Carnivores and Wild Ungulates”. WISO, 34 pp.