Developing methodology for setting Favourable Reference Values for large carnivores in Europe

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This document has been prepared by the Norwegian Institute for Nature Research for the Istituto di Ecologia Applicata and with the contributions of the IUCN/SSC Large Carnivore Initiative for Europe (chair: Luigi Boitani) and other experts as partial fulfilment of contract N°09.0201/2023/907799/SER/ENV.D.3 from the European Commission.

Developing methodology for setting Favourable Reference Values for large carnivores in Europe

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Foreword

This report has been developed by the Norwegian Institute for Nature Research with the support of Istituto di Ecologia Applicata and with the contributions of the IUCN/SSC Large Carnivore Initiative for Europe (chair: Luigi Boitani) as well as other experts.

The European Commission issued a a call for tenders (ENV/2023/OP/0019) “Support for Coexistence with Large Carnivores” in 2023. The resulting contract N° 09.0201/2023/907799/SER/ENV.D.3 was awarded to a consortia of Istituto di Ecologia Applicata, Adelphi Consult and Callisto. The Norwegian Institute for Nature Research (NINA) were allocated a subcontract for a specific task (B3 – Assessment of large carnivores' conservation status). The tasks objective were specified as “*Development of a specific, operational methodology to define and quantify the Favourable Reference Values for the species wolf, brown bear, European lynx and golden jackal*”.

The report covers three inter-related aspects of the topic, including “Exploring the conceptual basis of setting Favourable Reference Values”, developing a “Methodological toolkit for setting Favourable Refence Values” and illustrating the consequences of these approaches via “Scenarios of conservation targets: setting Favourable Reference Values under different decisions”. The report was coordinated by NINA, but involves the input of the Istituto di Ecologia Applicata , the IUCN/SSC Large Carnivore Initiative for Europe (chair: Luigi Boitani) as well as other experts within specific fields. Discussions were held in a series of online workshops and by email exchange. Specifically, significant contributions were made by Luigi Boitani, Yorgos Iliopoulos, Juan Carlos Blanco, Ilka Rheinhardt, Joachim Mergeay, Robin Rigg, Djuro Huber, Igor Trbojevic, Alexander Trajce, Jonas Kindberg, Diana Zlatanova, Tomaz Skrbinsek, Astrid Strønen, Nuria Selva, Manfred Wölfl, Arie Trouwborst and Petra Kaczensky. In addition, we would like to thank Katharina Steyer, Robert Ekblom, Nikolas Dussex, Sami Niemi, Scott Mills, Madeleine Nyman, Gunnar Glörsen, Peep Männil, Ilpo Kojola, Janis Ozolins, Pierre-Yves Quenette, Vaidas Balys, Manuela von Arx, Urs Breitenmoser, Peter Sunde, Claudio Groff, Aleksandra Majic, Hugh Jasman, and Miroslav Kutal for providing information and useful discussions on early drafts. The third draft was commented on in detail by various national experts on Habitats Directive reporting as well as stakeholder representatives. We ae grateful for their critical, but constructive, comments and sharp eyes.

Summary

This report aims to develop new guidelines for the setting of Favourable Reference Values (FRVs), which are needed to assess Favourable Conservation Status (FCS), for the specific context of large carnivores (brown bear, Eurasian lynx, wolf, wolverine, golden jackal) in Europe. The work builds on the *Guidelines for Population Level Management of Large Carnivores in Europe* report that was published in 2008, but takes into account new developments in conservation science, new case law, experience with their implementation, and the rapid development of the conservation status of large carnivores.

The need for these guidelines is underlined by the fact that until now relatively few member states have set quantitative values for their FRVs, and there is a massive degree in variation in the scientific basis for those that have. The need for specific guidance on large carnivores stems from both their specific ecology, with wide ranging movements and transboundary populations, and from their complex and often conflictful relationship with humans.

In the report we explore the conceptual basis for setting FRVs. This involves trying to align best-practice and current scientific concepts with the legal / administrative language of the Habitat Directives and associated guidance documents. In recent years conservation science has made important developments in multiple relevant areas, including a shift away from the science of avoiding extinction to a science of planning for species recovery and long term persistence. This involves a focus on building representation of ecological conditions and building resiliency to changing environments, at least in part by ensuring redundancy. It also involves a greater focus on the long term genetics of populations in addition to shorter term demographic aspects. It is also important to recognise that conservation science has made important steps in mapping and understanding the diverse conflicts that are often associated with large carnivore populations in human-modified landscapes.

As a result of this alignment between science and law / policy we developed a number of conceptual recommendations that are important for developing functional FRVs. These include;

- Recognising FRVs as realistic and achievable targets for population recovery that represent the degree of member state contribution which is required for the collective conservation effort.

- Defining FRVs in terms of genetically effective population sizes aligned with the 50:500 heuristic. The 50 and 500 values refer to the effective population sizes required to minimise short term inbreeding and to enable long-term adaptive capability respectively. Effective population size is a genetical concept, where the effective population size is typically between one third and one tenth of the total population size depending on species ecology.

- Recognising that FRVs, and FCS, are not necessarily absolute values. To be achievable they must be scaled to member state preconditions (size, area of habitat, landuse).

- Accordingly we propose a separation between population level FRVs that are pegged on absolute values associated with genetically effective population sizes (often involving transboundary populations), and member state level FRVs that are scaled to their preconditions as long as the contributions of all member states sharing a population sum to a level that satisfies the population level FRV. In other words, FRVs and FCS are both absolute and relative concepts depending on the scale being considered.

- The need for large population sizes (FRP) requires a renewed focus on range (FRR) at national and international levels and ensuring that there are widely dispersed populations with high degrees of connectivity. Mapping and safeguarding this connectivity are important components of FRR.

- We also propose an additional focus on ensuring that range spans all Natura 2000 sites designated for the species, all relevant biogeographic regions, and all relevant ecosystem types. This helps address aspects

related to the ecological functionality of large carnivores which have remained a neglected component of the definition of FCS.

- This approach requires a high degree of coordination in monitoring across borders, and with a strong focus on monitoring both demographic and genetical properties.

- These efforts would be enhanced by transboundary cooperation and the setting of joint management plans, although we also propose post hoc mechanisms for larger scale assessment based on reports submitted by member states.

We integrate these concepts into simple checklists that can guide the setting of the FRVs that are necessary to reach FCS at both population and member state levels. In addition, we provide illustrative scenarios of how current distributions relate to Natura 2000 sites and biogeographic regions, as well as illustrating how different degrees of connectivity and different parameter choices would influence the size of populations required to reach the recommended effective population sizes for the different species.

If these concepts are followed it should secure the long term conservation of large carnivores in Europe. The requirements can be jointly met through transboundary cooperation which shares the effort across member states, and for most populations can be realistically achieved.

Abbreviations used throughout the text

Institutional	
Bern Convention	Convention on the Conservation of European Wildlife and Natural Habitats (19 September 1979)
Birds Directive	Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds
CJEU	Court of Justice of the European Union
CoE	Council of Europe
EC	European Commission
EEA	European Environment Agency
EU	European Union
GBF	Kunming-Montreal Global Biodiversity Framework adopted in 2022 by the Conference of the Parties (COP15) to the Convention on Biological Diversity
Habitats Directive	Council Directive 92/43/EEC of 21 May 1992 On the Conservation of Natural Habitats and of Wild Fauna and Flora
IUCN	International Union for the Conservation of Nature
LCIE	Large Carnivore Initiative for Europe, an IUCN's SSC SG
MS	Member State of the European Union
Natura 2000	Natura 2000 protected area network
Nature Restoration Law	Regulation (EU) 2024/x of the European Parliament and of the Council on nature restoration and amending Regulation (EU) 2022/869
SSC SG	Species Survival Commission Specialist Group (IUCN)
TFEU	Treaty on Functioning of the European Union
Conceptual	
CV	Current Value (the size of the current population or range)
FCS	Favourable Conservation Status
FRP	Favourable Reference Population
FRR	Favourable Reference Range
FRV	Favourable Reference Value
GSS	Green Status of Species, and IUCN assessment procedure
HWC	Human Wildlife Conflict
MVP	Minimum Viable Population
N_{tot}	Total population size, all age classes, both sexes
N_b	Number of breeding events, breeding units
N_c	Census Population Size (number of mature individuals)
N_e	Effective Population Size
N_i	Number of independent individuals (not following their mother)
PVA	Population Viability Analysis

Introduction

International conservation agreements have been instrumental in halting the declines and fostering the recovery of many species around the world (Trouwborst et al. 2017a). Among the diverse international instruments that exist for biodiversity conservation, the European Union's Habitats Directive (and its sister Birds Directive) stand out because of their strong foundation in super-national law where an international court has the power to impose sanctions for non-compliance on member states. This requires clear definitions of concepts such that compliance can be measurable in objective and repeatable manners. Even when disputes do not enter the legal system, it is highly desirable that legal instruments intended to achieve specific objectives are set-up in a manner that allows assessment of progress towards these goals. Although this is of importance for all species, it is especially important for controversial species whose conservation has large socio-economic impacts on stakeholders and livelihoods because of the need to reconcile biodiversity conservation with other policy agendas and social justice (Milner-Gulland 2024, Zimmermann et al. 2023).

Large carnivores (a collective term for brown bear *Ursus arctos*, wolf *Canis lupus*, Eurasian lynx *Lynx lynx*, wolverine *Gulo gulo* and more recently golden jackal *Canis aureus*) are one such species group. On one hand they are a species group that have responded to improved legislative protection through dramatic recoveries and expansion across the continent. On the other hand their conservation is associated with a diversity of challenges and conflicts where their conservation can have impacts on livelihoods and even human safety. Legal controversies around their conservation have until now mainly focused on cases of derogation from strict protection, but there is an increasing degree of discussion around how far member states have to go in the recovery of the species on their territory. Until now, the accumulated guidance and case law around the means of conservation (i.e. derogation vs protection) has been much clearer than that surrounding the issue of the goals of conservation (centered on the Habitats Directive's concept of Favourable Conservation Status (FCS) and its associated concepts of Favourable Reference Values (FRVs)). Derogation and FCS assessments are interlinked to the extent that one condition of derogations is that they not impede the achievement / maintenance of FCS. Although the Habitats Directive provides a conceptual definition of FCS in Article 1(i) it has proven hard to translate this into measurable parameters and directly equate it with established ecological concepts.

In this report we explore this issue of setting conservation objectives for large carnivores in Europe in three steps. Firstly, we will explore the conceptual basis of Favourable Reference Values and try to connect them to other and more measurable benchmarks that are well established in conservation biology. Secondly, we will propose a set of practical approaches to operationalise these concepts. Thirdly, we will illustrate the consequences of different choices for some real world examples.

Methodology

This report has used a desk-top and virtual workshop approach. Firstly, the literature (both the limited peer-reviewed literature and the wider grey, or technical report, literature) on the specific concepts associated with FCS and FRVs has been reviewed. Gathering this involved taking contact with scientists and administrators in multiple EU countries to gather hard-to-find reports and overviews of current practices. It should be noted that many documents have been automatically translated using online systems (Google Translate and the built in function in Microsoft Word). Secondly, we have reviewed the emerging scientific literature surrounding the topic of setting goals for species population recovery and associated ecological concepts such as population viability and genetical effective population size. Thirdly, we have tried to integrate these ideas into operational proposals that are applicable in a European setting. Fourthly, we have then discussed these in a series of online workshops with members of the Large Carnivore Initiative for Europe (LCIE) and other external experts within specific areas of competence (law and genetics). Fifthly, a third draft of the report was circulated among members of the Habitat Directives' Working Group on Reporting and key stakeholders for comments. A summary of these comments and our responses to them are available in Appendix 2. .

The report has been informed by a previous process that in 2008 produced a set of guidelines for large carnivore population level management (Linnell et al. 2008) which was developed after extensive consultation with stakeholders and competent authorities across Europe. However, we have critically reassessed these in light of the last 16 years of scientific and policy developments. The report has been developed parallel to the updated mapping of large carnivore populations conducted as Task B.4 of the same contract (Kaczensky et al. 2024).

This document is intended to be a presentation of the **best available, policy-relevant, interdisciplinary science**. It is written with the intention of being applied within the existing legal framework of the Habitats Directive. We have endeavoured to develop interpretations of key concepts that are feasible. As such, we have endeavoured to navigate the legal space defined by our reading of the Directive and the accumulating body of case law from the CJEU (Table 1) as well as legal and policy relevant scholarship (e.g. Christiernsson 2019, Darpo 2011, 2020, Epstein 2016, 2017, Epstein & Kantinkoski 2020, Epstein et al. 2016, 2019, Eriksen et al. 2020, Fleurke 2024, Hiedanpää 213, Hiedanpää & Bromley 2013, Köck 2019, Schoukens 2022, Trouwborst 2010, 2014, 2018, Trouwborst et al. 2015, 2017a,b,c) as well as other guidance documents produced by the EC and external contractors on their behalf (e.g. Bijlsma et al. 2019a,b, Van Eldik et al. 2024). The guidelines introduce, discuss and operationalise many concepts, and build on scientific insights, that were not available to the authors of the Habitats Directive when it was drafted and hence were not referred to in the text of the directive. However, we feel that it is appropriate to introduce them as they are the necessary underpinnings of the conservation strategies that are necessary to achieve the intentions which the directive advocates.

It is important to point out that this document is not legislative in character and is not of a binding nature. As such this document reflects only the views of its authors. In accordance with the EU Treaties, it rests with the Member States to choose the form and methods of achieving the objectives of the Habitats Directive. Ultimately **only the CJEU can decide** whether specific policies fall inside, or outside the law. Therefore, the guidance provided will need to evolve in line with any emerging jurisprudence on this subject.

Table 1. Accumulated CJEU case law on large carnivores (based on searches of https://curia.europa.eu/).

Date	Case Number	Location	Species	Topic
Pending	C-27/24	Italy	Bear	Request for preliminary ruling on questions related to derogation from strict protection
AG opinion available, judgement pending	C-629/23	Estonia	Wolf / Bear /Lynx	Request for preliminary ruling on questions related to favourable conservation status and scale of assessment
2024	C-436/22	Spain	Wolf	Request for preliminary ruling on questions related to monitoring, derogation and assessment
2024	C-601/22	Austria	Wolf	Preliminary ruling on questions associated with derogations from strict protection for wolves
2020	C-88/19	Romania	Wolf	Preliminary ruling on questions associated with derogations from strict protection for wolves
2019	C-674/17	Finland (Tapiola case)	Wolf	Preliminary ruling on questions associated with derogations from strict protection for wolves
2011	C-240/09	Slovakia	Bear	Preliminary ruling concerning the rights of environmental NGOs (under the Aarhus convention) to be involved in derogation decisions
2011	C-404/09	Spain	Bear	Ruling on questions related to degradation of a Natura 2000 site designated for bears
2007	C-342/05	Finland	Wolf	Ruling on questions associated with derogations from strict protection for wolves

A: Conceptual background for setting Favourable Reference Values

1 Legal and administrative background for Favourable Reference Values

Biodiversity conservation in Europe has to be seen within the wider context of multiple legal frameworks or laws and conventions that include, but are not limited by the Bern Convention, the Bonn Convention, the European Landscape Convention, CITES, the global Convention on Biological Diversity, the global Biodiversity Framework, the EU Biodiversity Strategy, the Habitats Directive and the recently enacted Nature Restoration Law. Combined, these set a very high level of ambition for European nature conservation that goes far beyond preventing extinction towards mandating large scale ecosystem restoration. Among these, it is the Habitats Directive that has the most direct bearing on setting policy frames for large carnivore conservation within the EU. The ambitious objective of the Habitats Directive is to ensure the long-term conservation of the wild species and habitats of community concern. Specifically Article 2(1) states that "*The aim of this Directive shall be to contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the Member States to which the Treaty applies*". The Directive formulates this goal through two overarching requirements on the Member States:

- "*Measures taken shall be designed to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest*".

- "*Measures taken pursuant to the Directive shall take account of economic, social and cultural requirements and regional and local characteristics*".

The term of **Favourable Conservation Status** (FCS) is defined for species in Article 1(i) of the directive in terms of an overall explanation and three criteria;

- "*Conservation status of a species means the sum of the influences acting on the species concerned that may affect the long-term distribution and abundance of its populations within the territory referred to in Article 2;*

- ***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 habitats, 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 populations on a long-term basis*."

Member States have the obligation to maintain species at FCS if they are already there, or restore them to this status if they are not yet at that status (Article 2(2)).

The overall **qualitative** objective of the legislation and criteria used to describe it are intuitively easy to understand. However, Favourable Conservation Status is not further defined at any point, in either the directive's text or subsequent case law from the Court of Justice of the European Union (CJEU), in concrete or **quantitative** terms that can be measured or unambiguously benchmarked against established scientific concepts. This has led to degree of discussion among conservationists, administrators and governments concerning whether or not this status has been reached or how far member states (MS) have to push species recovery to satisfy their obligations to the European community. For species on Annex V (Protected – "*species of Community interest whose exploitation may be subject to management measures")* of the directive this concept is crucial as it represents the lower acceptable limit of their conservation ambition and for species on Annex IV (Strictly Protected – "*animal and plant species of community interest in need of strict protection*") it is an important concept when assessing the validity of derogations from strict protection (Darpö 2019, 2020, Epstein et al. 2019). Guidance documents and legal scholarship point out that the Directive's goals are not meant to be minimum values, but rather are meant to be **ambitious and precautionary** with respect to the risk of environmental harm (Mehtala & Vuorisalo 2007).

Member States also have a "**surveillance**" (monitoring) obligation (Article 11) and a reporting obligation (Article 17) where they have to report their progress towards reaching FCS for the species and habitats included on the annexes of the Directive.

In order to introduce a greater degree of structure and consistency in reporting, the European Commission administratively introduced the concept of **Favourable Reference Values** (FRVs) for the 2007-2012 and 2013-2018 reporting cycles (endorsed by Habitats Committee in 2004). The idea is that the FRVs are measurable ways to assess progress towards reaching FCS. Two FRVs were introduced for species, namely **Favourable Reference Population** (FRP) and **Favourable Reference Range** (FRR), to measure population and range characteristics, respectively. The concepts are defined as;

Favourable reference range is the *"range within which all significant ecological variations of the species are included for a given biogeographical region and which is sufficiently large to allow the long-term survival of the species*." (Art 17 explanatory notes).

Favourable reference population is the *"population in a given biogeographical region considered the minimum necessary to ensure the long-term viability of the species*." (Art 17 explanatory notes).

Furthermore, for both values it is stated that the FRVs *"… must be at least the size of the population when the Directive came into force ….*" or "*…must be at least the range (in size and configuration) when the Directive came into force …*". Guidelines also underline that there is an interlinkage between range and population values and that they should be set in an iterative process.

Box 1 quotes full definitions and a set of principles for setting FRVs that were included in the current guidelines for Article 17 reporting (June 2023) from the European Commission to member states.

In current practices, member states are required to define FRVs for each of the species (and habitats) present in their national area and compare these to the current values (CVs) for each species as a way of establishing the extent to which they have reached FCS. Because of this central role in reporting and assessment it is obvious that the way in which FRVs is set can have large consequences.

Box 1 Definitions and General Principles for setting Favourable Reference Values (extracted from the EC document on "Guidelines on concepts and definitions: Article 17 of Directive 92/43/EEC. Reporting period 2019–2024")

Definitions (pages 20-21)
Favourable Reference Range = "*Range within which all significant ecological variations of the habitat/species are included for a given biogeographical region and which is sufficiently large to allow the long-term survival of the habitat/species; favourable reference value must be at least the range (in size and configuration) when the Directive came into force14; if the range was insufficient to support a favourable status the reference for favourable range should take account of that and should be larger (in such a case information on historic distribution may be found useful when defining the favourable reference range); 'best expert judgement' may be used to define it in absence of other data".*
Favourable Reference Population = *"Population in a given biogeographical region considered the minimum necessary to ensure the long-term viability of the species; favourable reference value must be at least the size of the population when the Directive came into force; information on historic distribution/population may be found useful when defining the favourable reference population; 'best expert judgement' may be used to define it in absence of other data."*

Principles (pages 21-22)
"The following general principles should be taken into account in the process of setting FRVs:
• FRVs should be set on the basis of ecological and biological considerations;
• FRVs should be set using the best available knowledge and scientific expertise;
• FRVs should be set taking into account the precautionary principle and include a safety margin for uncertainty;
• FRVs should not, in principle, be lower than the values when the Habitats Directive came into force, as most species have been listed in the Annexes because of their unfavourable status; the distribution (range) and size (population) at the date of entry into force of the Directive does not necessarily equal the FRVs; Or in exceptional cases (for example of species with overpopulations as result of non-conservation artificially feeding or of species which population is increasing since the Directive came into force and which are harmfull to other protected species) the favourable reference population (FRP) should be lower than the current population.
• FRV for population is always bigger than the minimum viable population (MVP) for demographic and genetic viability;
• FRVs are not necessarily equal to 'national targets': 'Establishing favourable reference values must be distinguished from establishing concrete targets: setting targets would mean the translation of such reference values into operational, practical and feasible short-, mid- and long-term targets/milestones. This obviously would not only involve technical questions but be related to resources and other factors';
• FRVs do not automatically correspond to a given 'historical maximum', or a specific historical date; historical information (e.g. a past stable situation before changes occurred due to reversible pressures) should, however, inform judgements on FRVs;
• FRVs do not automatically correspond to the 'potential value' (carrying capacity) which, however, should be used to understand restoration possibilities and constraints"

Factors to be considered (page 21)
• "*Current situation and assessment of deficiencies, i.e. any pressures/problems;*
• Trends (short-term, long-term, historical, i.e. well before the Directive came into force);
• Natural ecological and geographical variation (including genetic variation, inter- and intra-species interactions, variation in conditions in which species occur);
• Ecological potential (potential extent of range, taking into account physical and ecological conditions);
• Natural range, historical distribution and abundances and causes of change, including trends;
• Connectivity and fragmentation.
• Requirements for populations to accommodate natural fluctuations, allow a healthy population structure, and ensure long-term genetic viability;
• Migration routes, dispersal pathways, gene flow, population structure (e.g. continuous, patchy, metapopulation)".

2 Current practices in setting Favourable Reference Values

Each reporting cycle is accompanied by an extensive set of guidelines (see Box 1 for the current cycle). However, despite having existed for two decades, and having been through two complete reporting cycles (with the third currently underway), there is still considerable uncertainty surrounding the setting of FRVs. There has been relatively little formalised and structured research take into these concepts (Bonelli et al. 2021, Brambilla et al. 2011, Green et al. 2020). Green et al. (2020) went as far as to state that "*In our view, there is not yet any adequate, quantitative method to calculate a threshold for favourable population size to contribute to wider assessments of species' conservation status*".

Three large technical reports have analysed existing pattens (McConville & Tucker 2015, Van Eldik et al. 2024) and suggested more rigorous approaches (Bijlsma et al. 2019a,b). Currently there are many different approaches in use. Up to the publication of these guidelines in many cases no quantitative values are set, with countries simply choosing to say that the FRVs are "unknown". In other cases countries used "**operators**", or symbols such as ">" or """>>", "≠" or "=", to refer to the relative position of FRVs with respect to Current Values (CVs). Only a minority of cases use **numeric values**. When numeric values are set, they come from a huge diversity of different procedures including, (1) expert assessment, (2) various baselines / references, or (3) model based approaches.

Although the use of baselines and models appears on the surface to offer a greater degree of standardisation, there may still be degrees of subjectivity and variation involved. **Baselines** taken at different periods in history can have huge impacts because of variation in the timing of human impacts on different species (Crees et al. 2016). **Models** also involve huge variation in model structure and different parameter settings, and in the suggestion that their outputs be "upscaled" by undefined factors.

A certain degree of **diversity in approaches** is understandable considering that the Habitats Directive concepts and reporting structures are designed to cover thousands of species as different as plants, beetles and bears for which the underlying ecology, human impacts and amount of data available varies dramatically. However, one needs to be mindful of the fact that the diversity of approaches also means that for any given species in any given country it may be possible to generate widely different FRV values depending on which approach is adopted, and which specific parameters are chosen. For example, different historical baselines (with associated estimated reference values) could produce very different FRVs as species have declined and recovered under changing human activities and policies for millennia. Although a lack of harmonisation / standardisation is not automatically a problem for some species and may well fall within member state discretion, it is important in cases where there is a need for extensive transboundary cooperation.

Bijlsma et al. (2019a,b) go a long way to set up a structured work flow for setting FRVs. Involving (1) developing a summary of the species specific ecology and conservation status and a clear narrative of **threat** and **recovery potential**, and (2) following a decision-making tree to arrive at decisions about best approaches to adopt. Their description of the background information needed is extensive and motivates careful consideration and classification of many aspects of species ecology and conservation status, especially the critical issue of adjusting the scale of assessment to the way in which different species use space.

When it comes to setting FRVs, Bijlsma et al. (2019a,b) divide approaches into two broad categories.

Firstly, they discuss the "**reference-based methods**" that are informed by **historical baselines**. Such information is clearly very useful to gain perspective on the present situation (Grace et al. 2019, Nores & Lopez-Bao 2022), but the result can be hugely influenced by the exact period chosen as the baseline and by the decision of how much of this baseline needs to be restored to represent FRVs for population and range?

Furthermore, the question remains as to how to apply this to species like the golden jackal currently expanding beyond their historical ranges (Sanderson 2019), and where it has been argued that there is a clear legal obligation to permit this expansion (Trouwborst et al. 2015). The CJEU has even ruled on this concept, underlining that range is a dynamic concept and even expansions into urban areas may in some cases be considered as natural (see Schoukens 2022 for an example on urban hamsters in Vienna and Case C-88/19 for a case with large carnivores in Romania). Bijlsma et al. (2019a) argue for 50 years before the Directive came into force as a suitable baseline, but for large carnivores this period in the 1940s and 1950s would correspond to their lowest levels ever in many areas (Chapron et al. 2014). Nores & Lopez-Bao (2022) discuss the challenges associated with using historical baselines for wolves in Spain. Finally, historical baselines ignore the reality of ongoing environmental change in the Anthropocene and the fact that nature conservation and natural recovery is leading to novel ecosystems with species appearing in areas for which there is no historical precedent (Corlett 2014).

The only exception where near-historical baselines may have some utility is among some of the newer EU members from **eastern Europe** (in the Balkans, Carpathians and Baltics). Many (but not all species in all countries) of these countries hosted sizeable populations of large carnivores when they entered the EU, and it could be argued following the logic of Bijlsma et al. (2019a) that these represented situations where populations had “**stabilised**” at some level in line with environmental circumstances (ecological and social). In which case these levels could make suitable references for FRVs.

It should also be noted that the status of a species when a country entered the EU (The Directive Value) is often used as a baseline to assess progress in conservation under the auspices of the Habitat Directive, although it is not particularly suited as a baseline in the context of setting FRVs.

Secondly, Bijlsma et al. (2019a) discuss “**model-based approaches**” that can either be based around demographic or **population viability models** or potential range models based around habitat modelling and estimates of carrying capacity. Despite both approaches being well-established scientific methods there is large scope for subjectivity when using them to make concrete goals. Bijlsma et al. (2019a) suggest that the results from population-based models should be **upscaled by a factor** without giving clear guidance on this factor. They suggest a factor of 10 as a rule of thumb, while Green et al. (2020) suggest a factor of 16 for UK birds.

Estimates of **potential habitat** and **carrying capacity** are also fraught with assumptions for species living in human-dominated landscapes, and as for the reference-based models there is always the need to make a subjective cut-off about how much of the potential should be occupied to satisfy FCS. Outstanding challenges relate to situations where carnivores depend heavily on livestock as prey (e.g. semi-domestic reindeer in northern Fennoscandia, or horses, goats and sheep in many parts of southern Europe) or the systems widespread across southeastern Europe where bear populations are subject to supplementary feeding. How should such issues be dealt with when calculating carrying capacity?

Despite their great efforts to bring a systematic approach to the process, the result still unfortunately offers a massive diversity of approaches that can potentially result in widely different assessments. Bijlsma et al. (2019b) present worked examples of their approach, including four large carnivore examples. For wolverines in Sweden they estimate that 600 individuals would be a suitable FRP, for bears in the Apennines they estimate FRP = 250, for wolves on the Iberian peninsula they suggest that FRP > 2500 while for lynx in the Alps they suggest that FRP should just be much greater than the present value (FRP >> 130). There is no clear reason why the different case studies result in such different outcomes. A final challenge is their proposal to adopt a "**sit-and-wait**" outcome when FRVs are based on operators. They formulate the objective as waiting to see when currently naturally expanding populations stabilize, and then adopting this as the FRV. Such approaches are problematic with species on Annex V for example that are subject to hunting because stabilization may happen on levels that humans set, and even for strictly protected species (Annex IV) it offers no guidance for planning recovery, and no measurable scale to assess progress. The only situations where it may be applicable is if there is simply too little knowledge to set more precise values.

Although all approaches may in some way reflect the relative progress of conservation from a less to a more favourable state the problem arises when these concepts become involved in legal proceedings between member states and the CJEU and / or when conservation requirements have large socio-economic impacts. In such cases, the absolute scaling of requirements for FRVs to reach FCS can have significant consequences for individual stakeholder groups and citizens directly affected by large carnivores (e.g. farmers, hunters, the forestry sector, agriculture, transport) and member states.

While different technical approaches will always produce slightly different outputs, the problem is exacerbated by the fact that there is no agreement on the unifying biological concept underlying the concepts of FCS and FRVs across species, or even within species but across different countries.

3 Why are large carnivores a special case?

The special features of large carnivores which make them a challenge for conservation have been dealt with elsewhere in great detail (e.g. Linnell et al. 2008). In this section we shall just list some of the key features relevant for setting FRVs.

- **Massive spatial requirements**. The scale of large carnivore movements make them unique among European terrestrial mammals. Typical home ranges for individual large carnivores, or wolf packs, range from 100 km^2 to several thousand km^2. Because they are often territorial (bears excluded) this results in very low densities. The implication is that their conservation requires very large areas indeed, and that very few European countries, if any, are large enough to host genetically viable populations by themselves. This implies that a transboundary approach to their conservation is essential. Their conservation cannot be achieved in protected areas alone and unavoidably requires that they are allowed to occupy a very large proportion of the landscape of the European continent. These large spatial requirements make their populations highly vulnerable to linear infrastructure (highways, railways, fences) that fragment their ranges.

- **Populations that span borders**. The vast majority of large carnivore populations in Europe span international boundaries requiring cooperation between different countries. In practice this challenge is magnified by the high degree of delegation of management authority from Federal states to their various sub-national entities. While the Habitats Directive provides a certain degree of policy coordination it is still the member states that have the authority to manage and report the segment of the population found within their borders. Many of these populations also embrace the territory of non-EU members, although most of these are now either EU-candidate countries or signatories of the closely related Bern Convention, which provides a high degree of policy coordination. One exception is the Finnish-Russian border, which has shared large carnivore populations under different levels of legal protection.

- **Long dispersal distance**. Young large carnivores are capable of natal-dispersal movements that can exceed 1000 km. Dispersal tendencies vary between species. Wolves have by far the greatest and best documented dispersal potential, with both sexes capable of making movements measured in the 100's of km, up to and exceeding 1000 km. Although less well documented the recent expansion of golden jackals across Europe implies that they too can disperse distances of many 100 km. Individual wolverines, lynx and bears have all been documented making dispersal movements of many 100 km as well, although the average distances are lower than for wolves, and in the case of bears especially there is a clear pattern of females showing far less dispersal than males. The implications for conservation are complex. On one hand the long movements allow spatially disjunct sub-populations to maintain connection even across patches of unsuitable habitat. On the other hand it implies that there is a low predictability in where they will appear, with the possibility of animals turning up in places from which they have been absent for decades. For bears, the low dispersal rates for females implies that populations spread very slowly and subpopulations will remain isolated to a greater degree than for the other species.

- **Broad habitat tolerances.** Large carnivore species in general have broad habitat tolerances. Wolverines occur and breed in 3 biogeographic regions, golden jackals breed in 5 and occur in 7, bears occur and breed in 5, lynx breed and occur in 5 and wolves breed and occur in 6 regions. Within these biogeographic regions they also occur in a wide diversity of habitats, and all show a high degree of tolerance to human habitat modification and human landuse / activity. Wolves again being the most adaptable. The advantage of this broad tolerance is that there is considerable scope for population recovery and restoring connectivity across large areas of the continent. The disadvantage is that it is hard to predict where they will colonise which means they may end up colonising high conflict areas.

- **Well studied**. Compared to many species listed on the directive the large carnivores are exceptionally well studied. Most countries have some form of monitoring in place which enables periodic continent wide assessments of distribution and status (Boitani et al. 2022, Chapron 2014, Kaczensky et al. 2024, Salvatori & Linnell 2005). The species have in general been subject to multiple research projects in different areas of their distribution such that their basic ecology and core parameters are well known. Within this broad picture is a large degree of variation. Golden jackals are less studied than the other four species, and in general populations in southern, and especially southeastern Europe are less studied / monitored than those in the centre and north. Overall, there is a very large pool of knowledge to use to inform conservation planning.

- **Depredation on livestock**. Throughout their distribution area all species are to some extent involved in depredation on livestock, especially sheep, goats and semi-domestic reindeer, but also horses, cattle and domestic dogs (Linnell & Cretois 2018). Bears also destroy beehives. Depredation rates can vary from the anecdotal (e.g. lynx depredation on sheep in the Baltic States) to levels where large numbers of carnivores nutritionally depend on livestock as their main prey (e.g. lynx and wolverine depredation on semi-domestic reindeer in northern Fennoscandia, or wolves in some parts of southern Europe). Depredation on livestock is a major driver of conflict in many areas, and represents a real socio-economic cost for their conservation.

- **Killing of companion and working animals**. Wolf attacks on dogs are well-documented across Europe. In Scandinavia from 1998 to 2017 there were 30.6 attacks on dogs annually, of which 6.8 occurred in Norway and 23.8 in Sweden. The majority (83%) took place during moose and hare hunting. Overall, 90.2% of the attacked dogs were hunting dogs. Most attacks occurred in proximity to wolf territories (72% in Sweden). In the Nordic countries, the use of free-ranging dogs is crucial for achieving wildlife management objectives and targets.

- **Impact on game species**. Wolves prey on wild ungulates, sometimes competing with hunters for the game. In some cases, wolves can have a significant impact on game populations in their range as well as certain hunting modalities. This can lead to challenges for wildlife management as well as significant socio-economic damage.

- **Social conflicts and charisma**. Large carnivores are species that generally have a large cultural role in Europe, they are well known to the public, and people tend to have clear opinions about them. These viewpoints can be very diverse, ranging from extremely positive to extremely negative. Those who are directly affected by large carnivores tend to be more negative than people who are not directly affected by their presence. Wolves and bears are classified as priority species under the Directive. This creates the basis for strong social conflicts concerning the way they should be managed and the extent to which they should be allowed to recover in terms of numbers and distributions. In recent years numerous social science studies have provided clear evidence highlighting that these perceptions and attitudes must be taken seriously and be fully taken account of when devising policy and management options concerning large carnivores, including when discussing higher ambitions and risk associated with the setting of FRVs.

- **A threat to human safety?** There is much debate about the potential danger that wolves pose for human safety. Two extensive reviews have documented their potential risk, but also demonstrated that the risks are very low in modern day European landscapes (Linnell et al. 2002, 2021). Brown bears indisputably represent a potential risk to humans (Bombieri et al. 2019, Penteriani et al. 2017, Støen et al. 2018) and recent years have seen an unfortunate number of high profile episodes in parts of southern and southeastern Europe (Cimpoca & Voiculescu 2022).

Overall this guild of species has shown their enormous potential for recovery across Europe, including in human-modified and human-dominated landscapes (Cimatti et al. 2021, Cretois et al. 2021), however, they are also associated with significant economic, social and cultural costs and high conflicts in some regions that should not be underestimated. Predicting the location of these impacts and conflicts is not easy, and may be fluid over time. Furthermore, all approaches to their conservation require a high degree of transboundary cooperation (between protected areas and surrounding landscapes, between sub-national administrative units, between countries within the EU, between the EU and countries outside the EU) and cross-sectorial policy coordination.

4 Existing practices for setting FRVs for large carnivores

During 2007-2008 the Large Carnivore Initiative for Europe developed a set of guidelines on large carnivores for the European Commission that included a section interpreting FCS and FRVs for this species group. The guidelines were developed by experts, but with extensive consultation from responsible authorities in member states, the Habitats Committee, the European Commission and stakeholders. These guidelines made several clear recommendations;

- Promoting the **population level** as the unit of assessment, which for most populations implied a need for transboundary coordination, on the condition of a binding transboundary agreement being developed.

- **Linking FRP to IUCN Red List criteria** such that the absolute minimum for a FRP would be at a level where the criteria would no longer consider the population to be at risk (i.e. it should be Near Threatened or Least Concern) based on either criteria D (1000 mature individuals) or E (using a PVA to calculate the MVP with <10% chance of extinction in 100 years). The recommendations included the option to accept a higher category of threat if there was adequate connectivity between populations when using criteria D, but not for E.

The **2008 guidelines** were endorsed as best practice by the European Commission as well as being recommended to signatories of the Bern Convention by the secretariat. Since their publication the guidelines have been widely quoted by responsible authorities from member states and there appears to have been a growing acceptance of many of the ideas and principles. However, although they are not a legal requirement it is interesting to note that there are as yet no examples of any countries entering into formal and binding transboundary population level management plans (Blanco 2012, Boitani et al. 2022, Eriksen et al. 2020, Kaczensky et al. 2024), despite the existence of widespread technical cooperation in monitoring and research. One good example of progress on the way is the strategy for the joint German-Czech-Austrian lynx population (Bohemian-Bavarian-Austria population) that was developed by the respective national and local level ministries (Czech Ministry of Environment 2020). A *Framework for Transboundary Cooperation on Management and Conservation of Wolves in Fennoscandia* was signed by the responsible technical agencies of Norway, Sweden and Finland in 2020. The technical agencies of the countries sharing the Alpine wolf population prepared a proposal for a coordinated plan in 2016 (Schnidrig et al. 2016) under the auspices of the Alpine Convention, but it was never adopted by the national governments. The Benelux countries, together with France, Germany and Denmark, are currently initiating a working group to coordinate wolf management in northwest continental Europe. However, despite this encouraging degree of technical engagement there as few politically binding agreements committing countries to a sharing of responsibility.

There has also been a degree of **critique** of the guidelines from scientists and conservationists (e.g. Epstein 2016, Epstein et al. 2016, Laikre et al. 2009). Issues mentioned have included;

- The idea that the IUCN criteria E (<10% extinction risk in 100 years) opens for too high a risk of extinction.

- Not enough attention has been paid to the issue of genetics when discussing viability.

- Not enough attention was paid to ecological functionality.

In other words, these critiques interpret the guidelines as being too focused on avoiding extinction and **not promoting a more ambitious recovery level** in line with directives aims.

These critiques, plus developments in science, policy and on the ground realities imply that it is logical to **revisit the recommendations** from these 2008 guidelines with respect to setting FRVs. Specifically;

- There have been many **advances in conservation science**, concerning the conceptual understanding of recovery (as opposed to avoiding extinction) and within conservation genetics that are relevant for setting FRP.

- The passing of the **EU Nature Restoration Law** in 2024 further enshrines the ambition level for ecosystem, habitat and species restoration.

- The guidelines did not treat ecological aspects of large carnivore recovery in great detail, which lead to a rather narrow focus on **FRR** as being only focused on supporting FRP, and not having additional associated criteria associated with **ecological functionality**.

- The **biogeographical regions** and Natura 2000 sites were not addressed in detail. Recent studies have shown that the sites are relevant for carnivore conservation, but that there is a much greater need to focus on this potential contribution of the sites for carnivores, and of the carnivores to the sites.

- Wolves have recolonised many of the very small and / or heavily **human-dominated countries** in western Europe (e.g. France, Germany, Denmark, the Benelux countries) to a degree that was probably not anticipated when the directive was drafted. This requires a reconsideration of the expected contributions from very small countries to collective conservation objectives and of the way conservation potential is conceptualised in landscapes with high human density and heavily human-modified landscapes.

- The failure of most countries to develop the suggested **transboundary management plans**.

- The increase of border security **fencing** (Linnell et al. 2016, Reljic et al. 2018) and veterinary fencing in response African Swine Fever outbreaks which is increasing fragmentation of habitats, and is dramatically decreasing connectivity between European populations and those further to the east.

Current practices in procedures for setting FRVs in different member states are discussed in Appendix 1.

5 Developments in conservation science

5.1 Towards a science of recovery

The science of ecology and its link to applied topics like sustainable wildlife management and biodiversity conservation has been in constant development during the last century. The tradition of **sustainable management** of wildlife populations is by far the oldest branch of applied ecology relevant for wildlife conservation (Leopold 1937, Redford et al. 2011), historically formed the basis of large carnivore management in most southern and eastern European countries prior to their entry into the EU, and still form the basis of large carnivore populations in areas where they are managed under Annex V and when derogations are issued under Annex IV, as well as their wild ungulate prey across Europe. However, the ideas and experience of wildlife management have become less visible as populations are managed under Strict Protection regimes of Annex IV. In contrast, the structures of the much younger science of Conservation Biology have had greater and more visible influence. The early days of Conservation Biology focused heavily on **avoiding extinction**. This is reflected for example in the IUCN Red List status overviews with their well known categories of Critically Endangered, Endangered, Vulnerable etc. These IUCN criteria were central in the 2008 large carnivore guidelines (Linnell et al. 2008) which aimed to align the legal ideas of FCS and FRVs with avoiding endangerment (i.e. setting FRVs at a level that would not justify classification on a threat level).

Science constantly moves forward, and the last two decades have seen a dramatic shift away from a single focus on extinction avoidance (avoiding an unwanted outcome) to that of **planning for recovery** (articulating a desired outcome). A wide set of scientific papers have discussed questions like “How much is enough? Setting measurable objectives” (Tear et al. 2005), “Moving beyond Population Viability Analysis” (Wolf et al. 2015) and “What does it mean to successfully conserve a species?” (Redford et al. 2011). Redford et al. (2011) identified six properties of a recovered population of a species;

- Self-sustaining demographically and ecologically [i.e. they have access to prey / naturally food] and maintaining critical ecological interactions,
- Genetically robust,
- Have healthy populations,

- Have representative populations distributed across the historical range in ecologically representative settings,
- Have replicated populations within each ecological setting,
- Be resilient across the range – e.g. large metapopulations.

These ideas have been condensed into the heuristic of the “**3 R’s**” (Tear et al. 2005, Wolf et al. 2015);

- **Representation** – present in the full range of ecological settings of a species’ range.

- **Redundancy** – multiple populations in each ecological setting.

- **Resiliency** – ability to persist in the long term in the face of changing threats and changing environmental conditions.

In a move to compliment the well-established Red List for threatened species the IUCN are currently working on a **Green Status of Species** (GSS) assessment procedure to measure the pathway to recovery for species as a result of conservation interventions (Akcakaya et al. 2018, 2019, Grace et al. 2021a,b, Stephenson et al. 2020). In a parallel to the 3 R's, the GSS assessment is based on 3 dimensions of recovery (Akcakaya et al. 2018);

- Viability of the population

- Functionality within the ecosystem

- Representation of different ecological settings

In many ways these new frames represent a return to some of the key concepts of biodiversity which recognise the existence of biodiversity at three levels – genes, species and ecosystems.

These developments within conservation thinking show a strong convergence towards the ideals of the Habitats Directive which has long been cited as representing a forward looking and outcome orientated view of conservation where goals, such as FRPs, have been stated as being much greater than Minimum Viable Populations (MVPs). We explore the links between emerging ecological concepts and the legal concepts of the Habitats Directive in section 1.

5.2 Viability – moving beyond demographics

Most of the conservation biology and applied literature has focused on a critical, but narrow, aspect of the concept of viability. This focus has been on **demographic viability**, which is typically based on a calculation of vital rates (birth rates and mortality rates) to estimate the probability of populations of different sizes becoming extinct over certain time frames. The idea of a minimum viable population is the size of the population that will only have a 5 or 10% chance of becoming extinct over a 100 year time horizon (see Linnell et al. 2008 for a longer discussion of PVAs). Such concepts are central when trying to avoid extinction in a crisis situation with small populations, but say little about planning for long term recovery.

Making the step towards longer term recovery requires focusing much more on the genetic components that underpin a species ability to avoid inbreeding and adapt to environmental change. Instead of focusing on the minimum viable population there is a related concept called **Effective Population Size**, typically represented by the expression N_e. Effective populations size is a formal concept in genetics that is more complex than just the number of individuals that breed as it also takes into account the variation in which different individuals contribute to the next generation and how this influences the genetic structure (heterozygosity levels and rate of genetic drift) of the next generation (Waples 2022, 2024). N_e is an area with rapid developments ongoing in terms of theory, simulation and collection of field data, and there is an ongoing flux in the understanding of the set of inter-related topics that fall under its umbrella (e.g. Allendorf et al. 2024, Kardos & Waples 2024, Laikre et al. 2016, Ryman et al. 2023). For example, there are slightly different forms of effective population size, referred to as inbreeding, variance, additive genetic variance, linkage disequilibrium, eigenvalue, coalescent, local, global, and metapopulation N_e (Ryman et al. 2019). Each represents a different, but related, concept, and each can be calculated in different ways from different data such that caution is needed when extracting operational values from the literature.

The most important point is that, as N_e increases, the first benefit is a reduction in the probability of short-term **inbreeding** which is critical to maintain demographic viability (because inbreeding is often associated with reduced fitness, Liberg et al. 2005). However, conserving the full genetic variation within the population and allowing space for new variation to arise is essential to maintain the adaptive and **evolutionary capacity** of the population over longer time scales. This typically requires much larger population sizes. For several decades a rule-of-thumb has existed stating that an N_e of 50 is necessary to avoid inbreeding and an N_e of 500 is necessary to maintain the evolutionary potential of the population. Although this **50:500 rule** was developed in the 1980's from a combination of domestic animals data, lab animal data and theory it has remained widely used in the absence of a better rule of thumb. While noting that there have been calls to upgrade it to a 100:1000 (Frankham et al. 2014, Rosenfeld 2014, Traill et al. 2010), it is the 50:500 rule that has been recently accepted as an indicator for monitoring the genetic health of populations as part of the Global Biodiversity Framework (GBF) (Hoban et al. 2020, Mastretta-Yanes et al. 2024). Other versions include the potential use of a 100:500 rule to exercise precaution on the timescales that influence current policy cycles.

Any such rule-of-thumb obviously glosses over myriad details caused by differences in species' life-history, ecology and management, and as such should only be considered a rough guide (Hoban et al. 2024). This discussion over the values (50:500 vs 100:1000) merely reflects the fact that maintaining long-term evolutionary potential requires very large populations and that populations **cannot be too large, or too connected**! It should be noted that increased viability is enhanced by the degree of connection between populations as well as the size of a population.

Calculating the N_e of a population is not a trivial task as it is not simply the number of (potentially) reproducing or adult individuals. It is possible to **calculate it directly** using a variety of genetical methods (Sindicic et al. 2013, Skrbinsek et al. 2012, Snjegota et al. 2021), although there are many potential challenges and pitfalls that need to be carefully avoided (Kardos & Waples 2024, Ryman et al. 2023). Interestingly, such methods also work on historical, or even zooarchaeological, material permitting the reconstruction of long-term changes in N_e over time (e.g. Rodriquez et al. 2011).

In most cases N_e needs to be **estimated indirectly**. The total size of the population is normally proportional to the effective population size. One important consideration is that formally speaking in calculations of N_e it is normal to only consider the number of mature or potentially breeding adults (of both sexes), a parameter that is known as **census population size**, or N_c. Because most field monitoring methods quantify other parameters (see Box 2), it is often necessary to use **conversion factors** to calculate N_c from the metrics obtained in practice (Mergeay et al. 2024).

Depending on species life histories the ratio between census population size and effective population size (known as the **N_e/N_c ratio**) varies dramatically. For example, many species of marine fish that produce eggs in massive numbers will typically have very low, and often highly variable, ratios. Species such as large carnivores tend to have less variable and larger ratios, typically in the range from 0.1 to 0.4 (Clarke et al. 2024, Harris & Allendorf 1989, Hoban et al. 2020, Mergeay et al. 2024). For example, in cases where the N_e/N_c ratio is 0.1, it would mean that the effective population size is 10% of the census population size (mature individuals). Many large mammal models use an assumed default value of 0.2 or 0.25 (e.g. Dussex 2024, Waples 2022, 2024).

Effective population size can also be influenced by the way a species is managed. For example, different harvest / culling / control strategies or mortality patterns may influence the parameter depending on how they influence the variation between individual reproductive success or select for specific properties.

There is one important additional consideration about genetics. Effective population size only reflects the degree of heterozygosity in a population and does not measure the **allelic diversity**. Allelic diversity is the real foundation for long term evolutionary adaptation, and is unfortunately far more sensitive to bottlenecks. It is therefore important to be aware that N_e does not tell the whole story of the genetical health of a population (Allendorf et al. 2024). Conserving allelic diversity is best done by conserving the widest range of surviving populations and sub-populations, especially those for example that result from different subspecies, or come from different colonisation routes, or survived in different glacial refuges, or occupy different ecosystems (Carroll et al. 2020, Swenson et al. 2011).

With respect to setting goals for population recovery the key point is that in the short term populations have **to urgently reach an N_e of 50 and that long-term conservation requires an N_e of at least 500**. Assuming an N_e/N_c ratio of 0.2, for example, this would translate into census population sizes (mature individuals) of 250 and 2500, respectively. It is also urgent that all surviving source / **relict populations** are conserved so that their genetic diversity can be included into the pool from which future populations can draw from as they adapt to the increasing rapid rates of environmental change.

In practice reaching these goals is going to require the contribution of populations that stretch across many borders, including international borders, such that **connectivity within and between populations** is the essential goal. Connectivity is an important issue when considering the fragmented nature of the European landscape and much knowledge is available with respect to barrier effects, and mitigation measures, for the effects of roads, railroads etc. However, a new consideration concerns the unprecedented increase in border security **fencing** of the last decade triggered first by the migrant crisis and then by the development of war in Ukraine (Linnell et al. 2016). The current situation has effectively led to a near continuous border fence running along the eastern border of the continental EU with Belarus and Russia, in addition to an internal fence along the Hungarian-Serbian border, and external fences on the Turkish border. The fences on the Belarussian and Russian border will have dramatic effects on the overall level of connectivity between European carnivore populations and those in the larger populations to the east. The implication is that Europe can no longer count on geneflow from these populations and must therefore plan for viability in effective isolation. The planned border fences on the Finnish-Russian border are unlikely to have such large effects on Fennoscandian geneflow because they are only planned to cover shorter sections of the border. Veterinary cordon fences designed to impede the spread of African Swine Fever in wild boar are an additional obstacle, with thousands of kilometres of fencing appearing in some European countries with little environmental impact assessment.

Box 2 Linking population monitoring data obtained in the field with key assessment concepts.

Approximate estimates of effective population size (Ne) are typically calculated based on the number of mature individuals / adults / potential breeders in the population. This is known, somewhat confusingly, as the census population size (Nc) by geneticists. However, very few, if any of the field census methods in use for large carnivores actually directly measure this parameter. Different large carnivore species are typically monitored in different ways in different areas depending on their behaviour and ecology, local climate conditions, available resources, and the extent to which different stakeholders and institutions are involved.

The non-invasive DNA methods widely used for bears and wolverines (and sometimes wolves) typically estimate the total size of the population, i.e. animals of all age classes including young-of-the-year (N_{tot}).

Snow-tracking methods (wolves and lynx), natal den surveys (for wolverines), counts of female bears with cubs-of-the-year, and methods like howling surveys (wolves and jackals) typically record the number of reproductive events or reproductive groups like wolf packs or pairs (N_b). Such methods rarely produce statistical estimates of uncertainty.

Camera trapping can produce different values. For wolves, and lynx in many areas of northern Europe, camera trap data is mainly used to produce more observations of reproductive units / events (for lynx, wolves, bears) – and thus contributes to Nb. In central Europe, camera trapping of lynx is typically analysed with capture-recapture methods that can either produce statistical estimates of total population size (N_{tot}) or of the number of independent animals (Ni) if the visually recognisable dependent kittens (<1 year old) are excluded from the calculations.

Based on demographic data (birth and mortality rates for different age classes) it is possible to create conversion factors that allow a calculation between different values. There are examples of specific conversions, typically between N_b and N_{tot}, in regular use for wolves (Chapron et al. 2016), lynx (Andrén et al. 2002), and wolverines (Landa et al. 1998). It is important that these are locally adapted because different populations may have different demographic rates or different patterns of social structure. It is also critical to consider important practical details such as at what time of the year data is collected because mortality can be quite high among juvenile age classes. Hunting can also strongly influence numbers and age structure so it makes a difference in a census is performed before, or after, the hunting season.

Such calculations will require data on the tendency of individuals of different ages to reproduce. While this data is widely available for females of species like bear, lynx and wolverine it is much less available for females of golden jackal and wolves and for males of all species. There may be large differences between the number of males physiologically capable of reproducing and those that actually reproduce in polygynous species.

If effective population size is going to become a key benchmark for population assessment there will be a need to utilise the best available research and monitoring data to produce realistic, and comparable, conversion factors between what is actually censused in the field and the idealised value of N_c (mature individuals) that can be used to approximate Ne (effective population size).

An additional benefit of these harmonised conversion factors would be to make the presentation of population estimates more comparable between regions or countries (see Kaczensky et al. 2024 for a discussion of the problem).

5.3 Ecosystem Functionality & Representation

Ecological functionality is a key concept within the emerging recovery assessment frameworks. The Habitats Directive aim is to *" … contribute towards ensuring bio-diversity through the conservation of natural habitats and wild flora and fauna ….*" (Article 2(1)) and the definition of Favourable Conservation Status mentions that species should be " *…. A viable component of its natural habitats, …*" (Article 1(i)). Furthermore, the current definition of favourable reference range "*range within which* ***all significant ecological variations*** *of the species are included for a given biogeographical region*" further places a focus on species being concerned as interactive elements of their environment. The FRR definition from the Article 17 reporting guidelines is even more explicit than the Directive text as it focuses on all interactions in each biogeographical region. Bijlsma et al. (2019a) articulate this as involving the conservation of "*ecological / genetic variations within the (historical) range i.e. geographical, climatological, geological and altitudinal gradients as well as significant differences in historical landuse*".

Large carnivores are potentially strongly interactive species (sensu Soulé et al. 2005). These interactions can include;

- Behavioural, demographic and selective impacts on their prey populations.

- Numerical impacts on smaller carnivores (meso-predators).

- Interactions with each other.

- Providing carrion for scavengers.

- Seed dispersal and habitat modification (mainly bears).

However, the nature and strength of these interactions will vary dramatically between large carnivore species, with the structure of ecological community within which they live, with the degree of human impact on the landscape and with the overall environmental productivity of the ecosystem. Strong top-down effects on other trophic levels (also known as **trophic cascades)** may operate in some locations, but both theory and empirical data indicate that their occurrence and strength is likely to be highly **context dependent** (Hayward et al. 2019, Ray et al. 2005, Terborgh & Estes 2010). This context dependence makes it very hard to predict the strength of carnivore impacts, especially in human-modified landscapes where humans influence all trophic levels (landuse, hunting of shared prey, providing livestock and supplementary food mortality impact on the carnivores) (Kuijper et al. 2019, 2024). Although we have little data, it can also be expected that human induced mortality of carnivores may also influence their ecological functioning in addition to their demographics.

A large degree of focus is currently being spent on comparing ecosystem function to ancient, or so called “natural” ecosystem states with minimal human intervention. While this may be of scientific interest, it does not provide very useful guidance for future orientated recovery visions in continental scale landscapes that will always be heavily modified by human agency (Linnell et al. 2015) to the extent that they must be viewed as socio-ecological ecosystems (Levin et al. 2015), albeit with a wide variation of degrees of human impact.

It is also very hard to develop metrics to measure the degree of functionality. The most practical and basic measure of functionality is to document that the **structure of an ecosystem** has been restored (i.e. all of the strongly interacting and important species are at least present), even if the exact nature of the **dynamics** between them is not known. This would be to simply recognise the permanent **presence of reproductive populations of large carnivore**s in different areas as a metric for the potential for these functions to occur within that local area. The fact that the expression “*all significant ecological variations*” is defined within the context of range (FRR), rather than population (FRP) is a powerful argument that the intention is to view this as a qualitative goal rather than quantitative. The presence of large carnivores in different ecological settings will create the potential for the full diversity of ecological interactions to occur and also satisfy the need for representation of different settings. In a measurable sense this would involve ensuring the permanent presence and / or presence of reproductive units of large carnivores in;

- Parts of all of the **biogeographical regions** that can be considered natural range.

- All **Natura 2000 sites** designated for the species.

- Within all major **ecoregions** / broad **habitat** types / **topographic** formations.

- Within all of the different potential **prey communities** (or forage types for bears).

The extent to which the carnivores, their prey, and the prey habitat are directly influenced by humans should provide a proxy for the degree of ecological functionality based on the assumption that low human intervention increases the degree of large carnivore function. Clearly this is not a model that can be generally advocated for the whole landscape, but may be relevant for protected areas, including Natura 2000 sites, etc.

To ensure coherence with the ideas of redundancy, representation and resilience it would not be enough for one population of each species to be present in one biogeographic region somewhere in Europe. It would rather require that as many as possible regions are occupied, in other words, each member state should have an independent responsibility to contribute to this is the various ecological conditions present within their borders.

Our proposed focus on effective population size (see previous section) implies that there is a need for an even greater focus on ensuring that large carnivore populations achieve a high degree of connectivity on a continental scale. This focus, together with our proposal for incorporating a new focus on ecological functionality and representation (this section), will require the presence of large carnivores across very large parts of the European landscape. In these massive areas they will occur within a huge diversity of different settings with very different degrees of human landuse and activity, ranging from semi-natural protected areas to multi-use forests, agricultural and peri-urban areas. This has two implications. Firstly, is a need to develop realistic views of the extent to which carnivores can assert significant ecological impacts. In more human-dominated landscapes their impacts are likely to be masked by human effects on all trophic levels and will be far from “natural”. In more natural areas the scope for larger ecological effects is greater. In other words, there is a need to create realistic expectations of very different ecological functions in different settings. However, because of the need to ensure connectivity, carnivore populations inhabiting areas where their ecological role may be diminished will still be essential for ensuring the much needed connectivity. Secondly, the need to allow large carnivores to occupy many areas that will have heavy human presence implies that their management in these areas must be conducted in a pragmatic manner that promotes tolerance and coexistence based on the insight that many of the “ecological functions” may also be a source of conflict for some stakeholders (see section 5.4).

5.4 Recognising the costs of living with success

In addition to an increase in the understanding of ecology and genetics of large carnivores, the last decades have seen a dramatic increase in the level of inter-disciplinary research and policy experience focusing on both the **impacts and conflicts** associated with successful large carnivore conservation. These are diverse and range from the **economic** (e.g. depredation on livestock, potential impact on harvestable game populations, attacks on companion animals) to the **social** (e.g. conflicts between different people over the appropriate way of managing large carnivores) (see Linnell 2013 and Redpath et al. 2013 for reviews). The last years have also seen the extent to which these conflicts have become **political** in nature in Europe (Niedzialkowski 2022, Zscheischler & Friedrich 2022, von Hohenberg & Hager 2022) and multiple member states have expressed a desire to change the annex designations of both wolves and bears on the directive. At the time of writing, the European Commission has taken active steps to downlist the wolf on the Bern Convention (December 2024) as a first step in a process to change its status on the Habitats Directive.

Such conflicts are not limited to large carnivores in Europe, and there is a strong global movement to both recognise them and adapt the ways of doing conservation to move to a more **socially just** form of conservation policy implementation (Levin et al. 2015, Milner-Gulland 2024, Redpath et al. 2017). The IUCN has consolidated these ideas in specific guidelines on Human-Wildlife Conflict and Coexistence (HWC)(Zimmermann et al. 2023), and the Global Biodiversity Framework now includes both a reference to HWC and an indicator to monitor actions dealing with them.

The implementation for European large carnivore conservation and the setting of FRVs must recognise that conflicts with large carnivore presence will be diverse and widespread, although highly variable in space and time, and the distribution of costs and benefits will be highly scale dependent (i.e. local costs and distant benefits). This means that from a conservation science best-practice perspective there will often be a need to consider socio-economic factors as well as ecological factors when planning for recovery, both in terms of range and densities. Article 2(3) of the directive requires the need to take into account "*economic, social and cultural requirements and regional and local characteristics*". Many national action plans for large carnivores are explicitly based on balancing conservation ambition with conflict (see Appendix 1 for carnivore examples and Van Eldik et al. 2024 for wider examples from other species). Many of these action plans have also been developed with extensive stakeholder involvement through elaborate participatory practices which are viewed as being best-practice in terms of ways to identify pathways to coexistence. However, this broad set of conditions has not always been reflected in guidelines on setting FRVs which have tended to focus on issues of technical feasibility without considering the socio-economic factors. The current state of research-based knowledge on this issue indicates that it is both practically and politically problematic to ignore socio-economic factors when considering FRVs for species groups like large carnivores that are associated with real economic costs, potential risks to human safety, and widespread social conflicts. This is a very special situation for large carnivores because of their very specific ecologies and complex relationships with people. Levin et al. (2015) express the need as "*It is a truism that if we do not know where we want to go, we will surely have a hard time getting there. Perhaps equally as axiomatic is the fact that if a broad constituency does not contribute to defining the destination, the road will be very bumpy*."

There are clearly a range of opinions concerning the manner in which these economic, social and cultural issues can and should be included in (1) setting FRVs, (2) setting targets that go beyond FRVs, and (3) impacting the way of achieving these objectives. It is also unclear where the border between technical aspects and economic, social and cultural aspects lies as well as the relevant importance of aspects in the directive text and various guidelines. Although the final CJEU judgement is not yet available, the opinion of the advocate general in case C-629/23 would seem to indicate their admissibility as long as the criteria of FCS are achieved. Finally, Article 191(3) of the TFEU would also seem to provide some openings for "*the economic and social development of the Union as a whole and the balanced development of its regions*" being taken into account.

There is also a need to make a distinction between the extent to which these factors can influence setting FRVs at different levels. These guidelines propose FRVs at the population level based on biological criteria (effective population size and connectivity) that cannot be compromised without endangering the objectives of the Habitats Directive. There is also a need to ensure that the contributions of all member states sharing a population add up to a population level FRV to reach this biological threshold. However, there is much more scope at the sub-national level to incorporate these social, economic and cultural factors to determine how much above these thresholds FRV values, or targets, are set.

Overall, there is clearly a need for clarity around these issues concerning both the interpretation of the Habitats Directive text and the relationship between different EU policy areas that may be impacted by large carnivore conservation.

5.5 Recognising the diversity of European countries capabilities

In the last 16 years since the 2008 guidelines were developed there have been considerable **positive developments** in virtually all European large carnivore populations. Most notable has been the expansion of the wolf population in Central Europe. From 2008 to 2022 the number of wolves in Germany increased from

5 packs to 185 packs and the first wolves arrived in Denmark, the Netherlands and Belgium in 2012, 2015 and 2018, and then bred in 2018, 2019 and 2019, respectively. Non-resident wolves have even been recorded in Luxembourg since 2017. Reconnection has been established between many previously isolated populations such as the Alpine, Dinaric-Balkan and Carpathian populations (Boitani et al. 2022). Bear populations have also increased, for example in the Cantabrian mountains of Spain, the Pyrenees, and the Italian Alps (Kaczensky et al. 2024), and multiple lynx reintroduction / reinforcement projects have been conducted, or are underway, in continental Europe.

These positive developments, especially the return of wolves to some of the smallest and most heavily human developed countries (Box 3), require for the first time a consideration of what concepts like FCS and the associated FRVs mean for **very small countries**, or very densely populated countries, which may not have the best preconditions for large carnivore conservation.

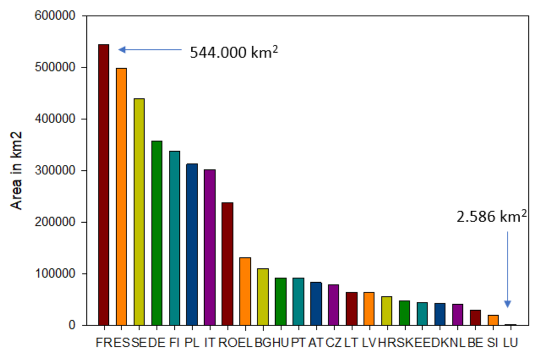
Size *per se* has not been an obstacle to making large contributions to large carnivore conservation as small countries like Slovenia and Estonia have long hosted substantial populations of bears, wolves and lynx. However, these countries are heavily forested and have low human densities (and bears are provided with supplementary feeding in many cases). The situation for the Benelux countries, for example, is very different due to the combination of small size, low area of forest cover, and high human densities. There is no legal doubt (especially after CJEU ruling on Case C-601/22 in 2024 concerning Austria) that **all countries have an obligation** to contribute to the objectives of the Habitats Directive. But the question remains if it is reasonable (proportional) for such small countries to have the same absolute requirements for making a contribution to EU objectives as large countries. In other words, would Luxembourg have the same absolute requirement for FRVs as France which is 220 times larger? If so, then many (most) countries would never be able to achieve FCS for large carnivores using any reasonable definition of the concept. An alternative interpretation would consider that a countries expected contribution would be scaled to their size or environmental preconditions, and that their assessment of FCS would then be relative to what they could maximally contribute. This concept was originally proposed by Epstein et al. (2016), but has not been explicitly developed or addressed since. However, the fact that potential habitat / distribution maps are suggested as a possible means of setting FRVs would indicate an implicit understanding of this interpretation because such maps are by definition adjusting to the local realities within member states.

A still contested aspect concerns the extent to which social, cultural and economic aspects should be given weight in this evaluation of a countries potential contribution. One example concerns Sami reindeer herding in northern Fennoscandia where the difficulties of preventing large carnivore depredation, and the paucity of wild alternative prey, have led management authorities to adopt relatively low levels of recovery ambition for large carnivores, especially wolves, in an area that constitutes almost 40% of the countries' area (Rasmus et al. 2020). Similar claims have been raised by European sheep farmers in some areas (see CJEU Case C-601/22). The ruling in the latter case implies that member states have some discretion in evaluating this issue, but the extent of this discretion is likely to be contested. The previous section (5.4) raises the need for legal clarity around this matter.

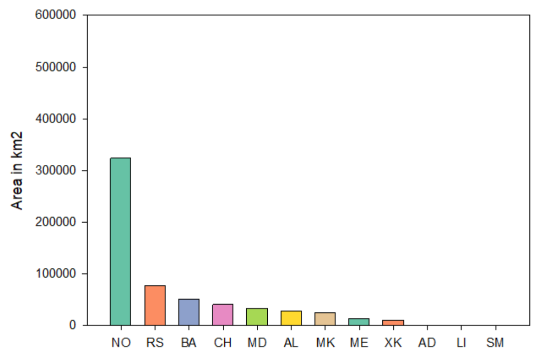
Box 3 Diversity of European countries preconditions for large carnivores

In a European context large carnivores are present, or potentially present, in 24 EU countries, in addition to 12 other countries that are either EU-candidates, potential candidates, or associated countries (European Economic Area) and bound by the Bern Convention. As such, all are bound by similar pan-European legislation, but have very different preconditions to contribute to these common obligations.

Size of the countries – varies by factor of 220.

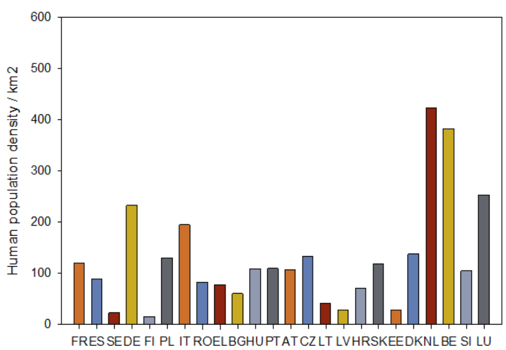


EU countries

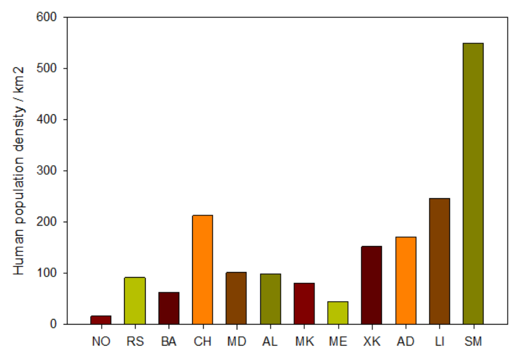


EU candidate countries and / or Bern Convention

Human population density – varies by factor of 23.

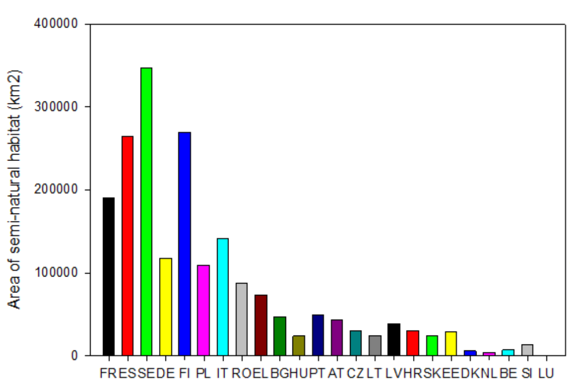


EU countries

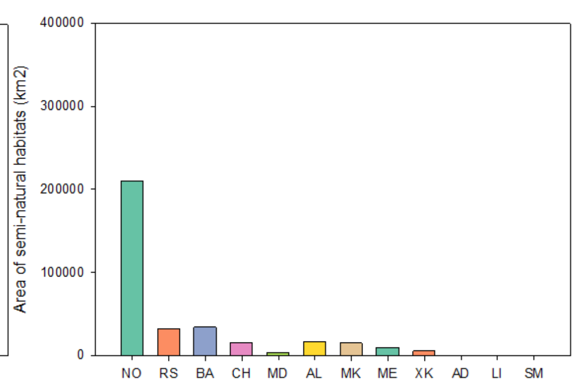


EU candidate countries and / or Bern Convention

Semi-natural habitats – varies by factor of 352 in EU.



EU countries



EU candidate countries and / or Bern Convention

Estimating the potential habitat for large carnivores is a complex task as it depends on many factors such as human density, amount and configuration of habitat, topography, amount of linear infrastructure, many details of human landuse etc (e.g. Cimatti et al. 2021, Cretois et al. 2021, Cristescu et al. 2019, Magg et al. 2016, Oeser et al. 2023, Scharf & Fernandez 2018). However, for the sake of a quick illustrative comparison we have presented graphs with the area of semi-natural habitats – extracted from the EU's EUNIS classes Level 1 data (Weiss & Banko 2018) – using classes D (mires, bogs and fens), F (heathlands, scrub and tundra) and G (woodland, forest and other wooded land). Grasslands were excluded because they only constituted a minor area in this dataset. The figure shows that the absolute amount of suitable habitat varies by a factor of 352. Based on the figure we can recognise at least three classes of country. The very small with less than 10.000 km^2 of semi-natural habitats (Luxembourg, Netherlands, Denmark, Belgium), medium sized with from 10.000 km^2 to 50.000 km^2 (Slovenia, Estonia, Latvia, Lithuania, Slovakia, Croatia, Czechia, Austria, Portugal, Hungary and Bulgaria), and the large with everything from 50.000 km^2 to 346.000 km^2 (Greece, Romania, Italy, Poland, Finland, Germany, Sweden, Spain, France). Again, it should be underlined that these figures are intended to be illustrative, and any application of our guidelines would require much more robust habitat suitability models and a more objective evaluation of cut-offs between size classes of country. The main take-home message is simply that different countries have radically different preconditions for conservation which requires scaling ambition to these preconditions.

6 FRVs vs targets

There is no dispute that the objective of the Habitats Directive and other nature conservation legislation is to both prevent extinctions and to promote recovery **beyond minimal levels** (Mehtala & Vuorisalo 2007). Extinction is a clearly defined state in ecological terms and there are clear scientific frameworks to set thresholds for avoiding short-term extinction (e.g. PVA approaches). In contrast, **recovery is not a clearly defined state** in ecological terms and there are no undisputed scientific tools to determine thresholds. As a result it is clear what we are trying to avoid, but less clear as to what we are trying to collectively achieve. The recovery of large carnivores will inevitably be associated with significant conflicts with diverse stakeholders and economic interests that will vary between countries and regions depending on environmental, economic, social, cultural and political factors. It is therefore likely that different jurisdictions will have different motivations and different capabilities on how far they wish to pursue the process of recovery.

As a result there may be a point at which member states (or sub-national units with delegated authority) will switch the question of recovery ambition from being one of "what level of recovery **do we need** to satisfy biological needs and legal obligations to the EU" to "what further level of recovery does our society **wish to live with**"? Along this gradient of recovery there will also be a switch in emphasis as different issues, processes and components of recovery get greater or lesser emphasis (Figure 1). This issue has been previously discussed, albeit indirectly, in numerous guidelines where it has been stated that FRVs are not the same thing as targets. However, for the purposes of going further we think **it would be helpful to view FRVsas as the point at which obligations to the EU's collective effort to cooperate on conservation end (i.e. achieving and maintaining FCS), and where there is a greater opening for national, or sub-national, democratic processes to decide on higher levels of ambition.** This implies that for the purposes of these guidelines we recommend that FRVs should be viewed as achievable targets that member states can realistically reach. Member states will of course have the freedom to set even more ambitious goals for themselves.

There has been much discussion as to whether FRVs are meant to be the same thing as targets. In some interpretations FRVs have been described as long-term, ambitious "stretch goals" that may be hard to achieve in practice, but which provide a long term aspiration that members can strive towards. This interpretation is, however, rather complicated as multiple legal rulings have indicated that a member state's management options (under both Annex IV and Annex V designations) are constrained until FCS (which requires achieving FRVs) is reached. Therefore it is practically significant to have FRV values that can be reached and maintained, otherwise management options will be permanently constrained.

For species on Annex IV this difference may t be less crucial because the limitations on killing resulting from Strict Protection will likely set limits on how much constraint on further population growth can be imposed. For species on Annex V it will be more crucial as reaching and maintaining FCS is the only constraint imposed on member states' freedom of management and is an essential yardstick against which adaptive management can be measured.

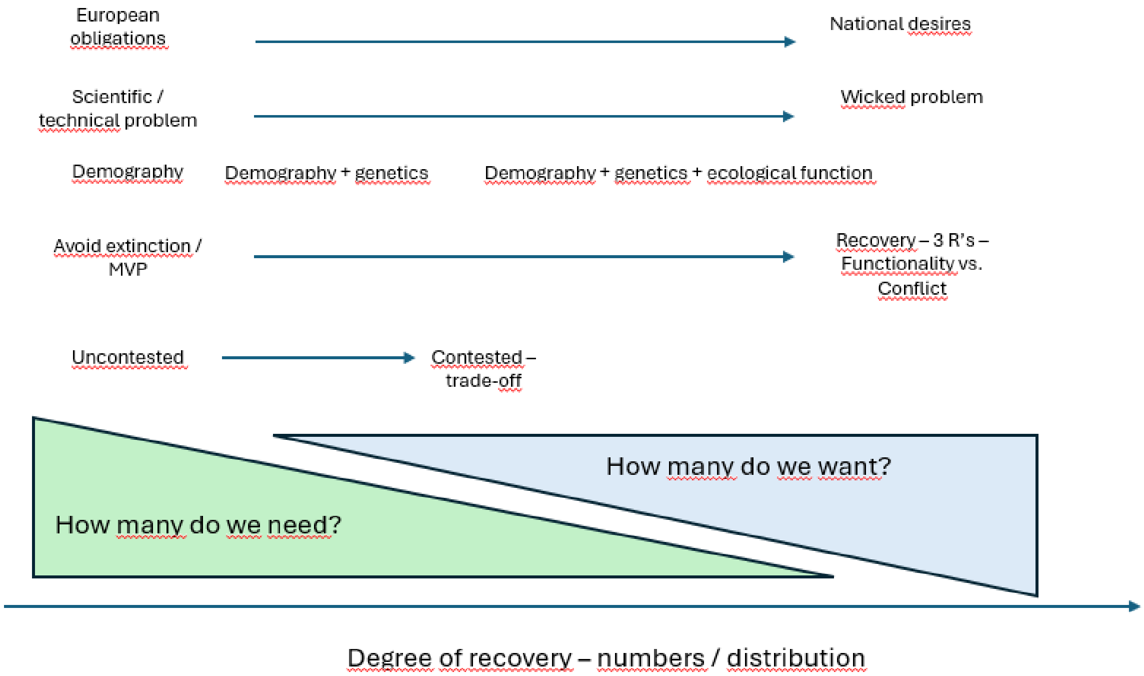


Figure 1. illustrates the way that questions and concepts vary along the recovery gradient. As recovery proceeds the questions will change from "how much recovery do we need?" to "how much recovery is wanted", the role of EU obligation will fade in favour of the role of national desires, and different concepts will gain in importance. Favourable Reference Values represent the point at which obligations to the EU switch to being national desires.

B: Practical approaches for setting Favourable Refence Values

7 Linking biological concepts and the terminology of the directive

In this section we link the legal / administrative terms understanding of FRVs with the scientific concepts that have been discussed in the previous sections and propose practical approaches to make these connections.

7.1 Scales of assessment

A central question concerning reporting of FCS and setting of FRVs has concerned choosing the appropriate scales of assessment. The default level within EC documents has been at the level of each **biogeographic region** within each member state. During the last decades there has been a growing realisation that different species have such different ecologies that they need different scales of assessment. For example, this concerns migratory species as well as species that make very large movements or occur at low densities such that international (transboundary) coordination is required to assess and conserve their populations. Bijlsma et al. (2019a) cover the issue of scale at great length, presenting a detailed breakdown of different spatial structures and movement patterns for species and aligning this with the most appropriate scale of assessment. Large carnivores clearly fall into the category of species that generally **require a supranational scale of assessment**. The Article 17 reporting guidelines currently open for joint assessment of shared populations, although there is still a need to disaggregate the information down to the biogeographic regions and member state level. These developments represent a realisation of the importance of considering species ecology and life-history, although there is still some way to go to fully operationalise this within reporting structures (i.e. this is currently included under “additional information”).

The 2008 guidelines (Linnell et al. 2008) strongly encouraged the adoption of a **population approach** for large carnivores, and this has been followed up in expert led reporting processes and evaluations ever since (see Boitani et al. 2015, 2022, Kaczensky et al. 2013, 2021, 2024). Many member states have embraced the idea in principle and there has been an increased degree of technical cooperation in research and monitoring. Regional conventions (Alpine Convention and Carpathian Convention) and initiatives (Dinaric-Balkan-Pindos Large Carnivore Initiative, Central European) have been promoting transboundary coordination and made many gains in terms of information exchange, dialogue and practical coordination. A working group within the Alpine Convention came as far as proposing a model for commitment between parties (Schnidrig et al. 2016). Unfortunately there has of yet been no signing of politically binding population level management plans being developed (see also section 4).

Based on a combination of actual distributions, genetics, history, topography and administrative / political borders the LCIE has proposed an operational set of populations for each of the large carnivore species, for a total of **35 populations**, plus a number of recently established “occurrences” (Table 2). The best available knowledge currently recognises 10 bear populations, 11 lynx populations (plus 2 small occurrences that have not yet stabilised enough to be called populations), 9 wolf populations, 2 wolverine populations and 3 golden jackal populations (with many small additional and recently established occurrences scattered across northern Europe). 29 of these 36 populations are transboundary (Kaczensky et al. 2024) involving from 2 to over 10 countries. Some countries find themselves at the interface between multiple populations. For example Poland contains portions of 3 wolf populations (Baltic, Carpathian, Central European) and 3 lynx populations (Baltic, Carpathian), and Austria has documented the presence of individual wolves from 4 different populations (Alpine, Dinaric-Balkan, Central European and the Carpathians).

A high degree of continuity in distribution and / or sufficient migration to have a demographic effect was a prerequisite for aggregation into a population, although some more or less continuous distributions were split to create more homogenous operational units, or management units. It should be noted though that the situation on the ground is dynamic (and some borders are contested, e.g. Gula et al. 2020, Szewczyk et al. 2019). As populations expand and reconnect there may be advantages of merging some of them into larger units if this facilitates coordination. However, it is also possible that future research will reveal a greater than anticipated degree of sub-structuring or unrecognised barriers such that what appears to be single populations today may actually need to be split. In practice there will be an optimal size for units, big enough to be biologically meaningful, yet small enough to be manageable. There are also limits to the practical size of management units. At too large scales there are simply too many actors, stakeholders and authorities involved to make management possible. Furthermore, even for wide ranging species there are limits to the size of a distribution that can be considered as a functional unit.

One unresolved issue concerns the **minimum threshold of movement** between areas that is necessary to recognise it as a functional genetic population. Based on our conceptual definition of a population there are both demographic and genetic aspects at play. For genetics it is usually recognised as being sufficient with 1-5 effective migrants per generation (i.e. animals that both move and reproduce), which in practice means a substantially greater number of animals making the move. Technically, the ratio of effective migrants to total number of migrants follows the N_e/N_{tot} ratio, so if this is 0.1 for example (Mergeay et al. 2024) then it would need 10 migrants to produce one effective migrant. Certainly anything less will be too little to justify aggregation, and the precautionary principle would indicate a need consider a higher rate of migration for this key parameter because of the massive impact of the fate of individual wolves on the outcome. A multi-year average will also be more robust than a single year's data.

A result of these considerations is that there are some cases where it might be necessary or justified to consider different units for assessment of effective population size than the populations that have been used since 2008. This is especially true for wolves, where Mergeay et al. 2024 have argued for example that the Italian and Alpine wolf populations should be considered as a single genetical unit, as could the Dinaric-Balkan and Carpathian wolves. Similar arguments have also been proposed for the Scandinavian and Karelian wolf and wolverine populations, the Alpine and Dinaric-Pindos bear populations and some of the central European lynx populations. This different scale of assessment for effective population size assessment vs the previous populations / management units from 2008 makes sense because of the different focus on genetics vs demographics, and was anticipated in the 2008 report. However, any such merging requires a serious documentation of actual exchange rates of animals or of real continuity of distribution.

Table 2. Currently recognised "populations" of large carnivores in Europe (Kaczensky et al. 2024). The two marked with an asterix are designated as "occurrences" implying that it is too early in their establishment to determine if they have become self-sustaining populations yet.

Population	Countries	Population	Countries
Brown bear		**Eurasian lynx**	
Alpine	IT, CH, AT	Alpine	IT, FR, CH, AT, SI
Baltic	EE, LV	Balkan	AL, MK, XT
Cantabrian	ES	Baltic	EE, LV, LT, PL
Carpathian	PL, CZ, SK, RO, RS, HU, UA	Bohemian-Bavarian-Austrian	DE, CZ, AT
Central Apennine	IT	Carpathian	PL, CZ, SK, RO, RS, BG, UA
Dinaric-Pindos	SI, HR, BA, RS, ME, AL, MK, XT, EL	Dinaric	SI, HR, BA
East Balkan	BG, EL	Harz	DE
Karelian	FIN, NO	Jura	FR, CH
Pyrenean	FR, ES	Karelian	FI
Scandinavian	SE, NO	Scandinavian	SE, NO
		Vosges-Palatinian	DE, FR
		Black Forest – Swabian Jura*	DE
		Pomeranian*	PL, DE
Wolf		**Wolverine**	
Alpine	IT, FR, CH, DE, AT	Scandinavian	SE, FI, NO
Baltic	EE, LV, LT, PL	Karelian	FI
Carpathian	PL, SK, RO, RS, CZ, HU, UA		
Dinaric-Balkan	SI, HR, RS, BA, ME, Al, MK, XK; EL, BG	**Golden jackal**	
Central European	PL, DE, CZ, DK, NL, BE, LU, AT	Continental	EL, MK, XK, AL, RS, BA, MD, ME, PL, DE, IT, RO, BG, HU, AT, CZ, LT, LV, HR, SK, EE, SI, UA (DK, NL, NO, FI, CH, ES, FR, DE)
Iberian	ES, PT	Samos	EL
Italian peninsula	IT	Peloponnese	EL
Karelian	FI		
Scandinavian	SE, NO		

7.2 Favourable Reference Population

Because of the scales at which large carnivores occupy space (large individual home ranges, low population densities) it is only on the scale of the **population** that any reasonable **long-term viability** can be achieved – and even then really long-term genetic viability will depend on interconnections at the metapopulation, or continental wide, level. As a consequence, the only biologically meaningful scale of assessment is at the population level. However, it is at the **political level** of the member state that legal obligations and management structures lie.

This implies that we need to view all assessment criteria (FRVs) on **two scales**, following Bijlsma et al. (2019a) suggestion of adopting “partial FRVs”. On one level FRVs are properties of the biological populations, while on another they are properties of the administrative / political scales of the member states. We propose to use the subscripts “POP” for the population level and “MS” for the member state level – such that FRP at the population level becomes FRP_{POP} and at the member state level it would be FRP_{MS}. Similarly, we would have FRR_{POP} and FRR_{MS}. A natural consequence of this is that the same concepts, FRP and FRR, would take on different meanings and have different values at different scales.

At the **population level** we propose that these concepts need to be **anchored on absolute values** because they must ensure the long-term viability of the species concerned, and species life-histories are not scaled or adjustable to political realities. Based on the ideas initiated in the 2008 guidelines, but further refined above, we recommend that the ideal default benchmark for FRP at the population scale be **an effective population size of at least 500** (i.e. $FRP_{POP} = N_e >500$). If we use the N_e/N_{tot} ratio proposed by Mergeay et al. (2024) then this would correspond to 5000 wolves or 500 packs (other ratios from the literature would of course give other conversions, for example 0.2 would result in half the number). In practice, this benchmark is broadly similar to that of IUCN criteria D which was one of the options included in the 2008 guidelines, although it represents an increase on the IUCN criteria E option. The change is justified on multiple arguments, including;

- Clarification on the meaning of “long-term” in the Directive text to embrace long-term genetical aspects of viability (i.e. closer to evolutionary time than decades).

- We now focus on a single metric (rather than Criteria D or E that may gave different answers) that can be directly calibrated to species ecology.

- Developments in the policy related, conceptual, and scientific understandings of recovery (i.e. spoltlight on Habitat Directive goals being more than just avoiding extinction).

- Developments in the understanding of the importance of genetic viability for long term survival of species.

- New empirical studies on the impacts of inbreeding and the observed effective population size of various European populations.

- The recent disconnect between continental European and Russian / Belarussian populations due to border fences.

- The benefits of harmonising concepts and reporting to the Directive with that of the Global Biodiversity Framework.

Because of the importance of **non-EU countries** to many of the populations (especially in the Alps, Scandinavia, Dinaric-Balkans and Carpathians) we recommend that population level assessments should be able to include the individuals in these non-EU countries because they are bound by the Bern Convention (and Bonn Convention) that harmonises with the broad objectives of the Directive (Eriksen et al. 2020) whenever possible. This follows on existing recommendations with the Article 17 reporting guidelines. The CJEU has clearly stated that the Fennoscandian countries (and presumably the Baltic countries by extension) cannot count on their connectivity with Russian populations in an *a priori* manner, because Russia is not bound by the same legislation. However, if research and monitoring can document that there is an actual and ongoing geneflow across the border it would seem disingenuous to deny the reality of the situation (i.e. if the parts of the population that extend into Finland, Sweden and Norway or the Baltic States are really extensions of a continuous population with large effective population size). We would therefore suggest that this connectivity be counted as long as it can be continuously documented.

By the same logic, it should be possible to at least partially **consider inter-population connectivity** (i.e. metapopulation level effective population size) within the area covered by the Habitats Directive and Bern Convention if it can be documented that it is of significant magnitude when assessing population level FRP. The implication is that we may need to consider some of the larger meta-population structures as units rather than the current populations where there is a high degree of connectivity. However, it would be completely against the forward looking spirit of the directive if the reestablishment of connectivity between populations was subsequently used to downsize the level of conservation ambition / obligation from that which was present before reconnection.

On the **member state level** there needs to be a certain degree of **scaling** of concepts to recognise the different sizes, suitable habitats, and other realities of the diversity of countries that share populations. This means that the concepts become more relative than absolute as long as they sum up to a value that brings the shared population to a level consistent with its FRP_{POP}. Ideally, member states would scale their contributions in a manner which is proportional to their size and presence of habitat (while considering social, cultural and economic aspects to the extent which is legally possible). Where member states host more than one population the cumulative impact of contributing to all of them should be considered so it is their **total contribution** to large carnivore conservation that counts.

Member states have **diverse situations** (Box 3). It is therefore natural that they should have a certain degree of **flexibility** when it comes to setting their national contributions (FRP_{MS}) to the overall population level viability (FRP_{POP}). There are multiple approaches currently in use (see Bijlsma et al. 2019a, and Appendix 1 in this report) that could be considered.

- Filling up all, or a substantial part of the **potential available habitat** would be a very ambitious objective, although the amount that can be filled will differ in many contexts because of conflicts with landuse and rural communities. Defining potential habitat a priori for golden jackals and wolves can be a challenge because of their high degree of ecological flexibility and tolerance for anthropogenic landuse (compared to lynx and bears for example), but for all species it is possible to identify gradients of preferred habitats or use semi-natural vegetation types (e.g. forests / heaths) as a very broad proxy. Carrying capacity is also hard to assess for large carnivores as it depends to a high degree on the way people manage the wild and domestic prey base (and forage) on which large carnivores feed. There is also a subjective element involved when opting for a “substantial part”. Epstein et al. (2016) suggested **50% as a minimum**, as does the “Nature-needs-half” movement (Müller et al. 2000). The 50% value is intuitive as it means that the status is then closer to full recovery than to extinction, even if it lacks an objective basis. Recent global initiatives to protect 30% of the planet's land area offer another potential benchmark. Either way, the choice will always be subjective (Svancara et al. 2005). Overall such approaches are probably most suited to the smallest countries with the least amount of potential habitat because of the challenge of realistically benchmarking other more absolute ecological goals to their small size.

- For medium sized countries a range of options for setting numerical values of FRP_{MS} may be appropriate related to **MVP concepts** (extinction risks less than 5 or 10% over 100 years) or preferably effective population sizes that at least **avoid inbreeding** on shorter time scales (i.e. N_e above 50, or 100 if applying precaution, but less than 500). Benchmarking to such concepts implies that member states are making real contributions to the overall population level viability and that even in isolation their portion of the overall population has a certain degree of viability on short to medium time scales.

- For larger countries it would be in keeping with a spirit of fairness and proportionality to **go beyond MVP or N_e >>>50** if their contributions are going to be proportional and if the overall population is going to reach an absolute benchmark linked to a FRP_{POP} with an N_e > 500. It is likely to be the need to reach this overall goal for FRP, as well as FRR (see below) that set the values for these countries. Dependent on habitat availability it would seem logical that many large countries should aspire to values closer to 500.

- There is a clear need for a degree of proportionality and **fairness** between countries such that they make contributions broadly in line with their potentials of size and habitat.

A special case concerns the **very small populations** of bears (Cantabria, Pyrenees, Apennines) and lynx (all populations apart from the Scandinavian, Karelian, Carpathian and Baltic). In many cases entire populations are present within a single country (such that $FRP_{POP} = FRP_{MS}$) or only shared by two. Most of these are very far from being able to reach a FRP_{POP} >500. Due to ongoing reintroduction projects many of the lynx populations have the potential to reconnect into large clusters which collectively may be able to reach this goal at a metapopulation level. Unfortunately these 3 bear populations are too geographically isolated to expect reconnection, and population growth occurs too slowly to reach such ambitious goals, on any time scales measured in decades. However, the importance of the Cantabrian and Apennine bears (and the Balkan lynx which is currently outside the EU) far exceeds their numbers because they represent unique genetic lineages / relics that are potentially of great importance to giving future bear populations the greatest possible genetic platform for adaptation. As a result it is important that conservation efforts are prioritised in these populations even if the current situation is far below any FRVs.

- For some of these cases it may be appropriate to **set FRP_{POP} with an operator** (>>CV) rather than a number. This would require members states to continue monitoring (both population size and the genetics) and achieve population growth. It may be realistic to set shorter term targets that aim to reach an N_e greater than 50 as soon as possible as a "**stage goal**" to mark progress on the long-term route towards more substantial recovery. Translocation of animals from other populations (assisted connectivity) could also quickly allow an increase in effective population size.

7.3 Favourable Reference Range

In the 2008 guidelines, Favourable Reference Range was somewhat superficially treated as being large enough to embrace the Favourable Reference Population and attempting to ensure connectivity. Many of the arguments from the previous section on FRP indicate a need to adopt a more rigorous and specific definition of the FRR. As for FRP, we consider that FRR needs to be considered at multiple scales, mainly that of the population and that of the member state, designated with the FRR_{POP} and FRR_{MR} subscripts, although conceptually the two levels are much more aligned conceptually. In addition, it may be necessary to consider FRVs at sub-national levels within federal states.

Firstly, the recommendation to benchmark population level Favourable Reference Population on effective population size (and ideally greater than 500, $FRP_{POP} = N_e>500$) implies that rather large numbers of animals are required because an $N_e>500$ implies that there will several thousand animals in the total population depending on the conversion factor chosen. This will require a large amount of space in all member states to give enough place for the **total population**.

Secondly, when taking long-term genetic aspects seriously it becomes apparent that maintaining **connectivity** is essential. This connectivity refers to all scales, both within a member state and between member states, to ensure internal connectivity within populations, and where possible between populations to create a functional metapopulation. There may be some acceptable discontinuities in distribution within these ranges as long as they are within the species' dispersal capabilities and not associated with unmitigated or impermeable barriers (highways, fenced railways, veterinary fences, border fences etc). As outlined in the 2008 guidelines, broad distributions with high connectivity are far more important than localised high densities in building long-term viability and resilience.

Thirdly, the FRR should embrace all of the **remnant distribution areas** of large carnivores such that the maximum possible range of genetic variation lies at the foundation of further recovery.

Fourthly, ensuring a wide range is the primary way to ensure that the necessary aspects **of ecological functionality** ("all significant ecological variations") are achieved. This implies that to ensure functionality, in addition to both representativeness and redundancy, FRR must include a permanent presence (equivalent to "Present regularly" (PRE) in Article 17 reporting terminology) in;

- The **Natura 2000 sites** designated for the species.

- At least part of all the **biogeographic regions** within the country.

- In all suitable **major ecosystems** and **prey communities** within the country.

The result of this need to take range seriously is that large carnivores are going to need to occupy very large amounts of space, with at least some species occurring in a high proportion of the European landscape. Their successful conservation will in effect mean that they will become "normal" (widespread) parts of the countryside. However, none of these objectives is strictly numerical leaving member states with certain **discretion** concerning how much of each biogeographic region needs to be occupied for example.

7.3.1 Natura 2000 in context

Until recently there has been relatively little continental scale focus on leveraging the full value of Natura 2000 sites for large carnivore conservation. Overall concerns have been based on the mismatch between their size, and the spatial needs of large carnivores (Boitani & Linnell 2015, Santini et al. 2016). Recent research has shown that some protected areas (which are included in the Natura 2000 network) actually have major importance for the persistence of some populations, for example lynx in the Bavarian-Bohemian forest system (Magg et al. 2016, Müller et al. 2014) and small bear populations in Cantabria, the Apennines and the Alps. Other studies have also identified that the Natura 2000 network can protect some key habitats for large carnivores (Diserens et al. 2017, Marucco & Avanzielli 2022, Santini et al. 2016, Votsi et al. 2016), although it is important to differentiate between those sites that are only Natura 2000 sites and those that are an overlay between Natura 2000 and other, more strictly protected, area types (Cristescu et al. 2019). Natura 2000 designation holds the potential for strong habitat protection that can benefit large carnivores (see CJEU court ruling C-404/09 with respect to Cantabrian bears) although the extent to which member states follow their responsibilities is variable (Sazatornil et al. 2019).

It is, however, important to realise that no protected area network will ever be enough to conserve large carnivore populations. Their long term persistence depends on their presence across very large areas of multi-use and human-dominated landscapes that will never be protected. Modern developments in conservation planning have shown the benefits of coordinating site-based (i.e. Natura 2000 and other protected areas) and whole-landscape based approaches to conservation to develop plans for connected landscapes (e.g. Hebblewhite et al. 2021 for a North American example). Leveraging the value of protected areas requires adopting a realistic understanding of their potential role. Due to the above mentioned scale mismatch there are few, if any, European protected area networks that will fully embrace substantial numbers of large carnivores solely within their boundaries. However, the extra protection that they afford individuals for all, or part, of their annual life cycle may be critical in some regions to provide a safe “core” from which expansion can develop (e.g. Müller et al. 2014). The rapid expansion of large carnivores has led to their colonisation of areas where no Natura 2000 sites exist for them because their future presence was not anticipated.

On the one hand the large carnivores may make contributions to the ecology of the protected areas through their ecological role as top-predators, although as highlighted above this may be highly contextual. Protected areas, including Natura 2000 sites, may represent areas where large carnivores can be allowed to display a greater degree of ecological functionality than in unprotected sites (Kuijper et al. 2019, Ordiz et al. 2013). On the other hand it is important to still bear in mind the nature of European protected areas. While some are managed as minimal intervention sites, the vast majority represent mosaics of natural and anthropogenic habitats (e.g. heath lands, meadows), where many of the anthropogenic habitats are themselves subject to protection under the Directive. Most protected areas contain human settlements and active forms of landuse such as forestry, livestock production and hunting (Tsiafouli et al. 2013, van Beeck Calkoen et al. 2020). Protected areas can also be associated with high rates of recreational or touristic visitation, which may be a driver of conflict in some cases (Penteriani et al. 2017). It is therefore important to adopt a realistic level of expectation into what the Natura 2000 network means for large carnivore conservation and what they mean for the Natura 2000 sites. Maximising the benefits and minimising potential conflicts requires careful management planning and the coordination of different policy instruments.

7.3.2 Biogeographic regions in context

Although the biogeographic regions are not mentioned in the directive’s text, following current guidelines member states are assessed on species conservation status within the different biogeographic regions within their boundaries. As we have discussed, large carnivore populations function, and are best assessed, at supra-national scales. This implies that fragmenting the scale of assessment of a member state’s portion of a wider populations to the different biogeographic regions within that member state is unlikely to convey any biologically meaningful information about the overall viability of large carnivores. This procedure will almost always **underestimate** the favourability of a species conservation state within a member state.

The procedure of aggregating species status across non-continuous sections of a biogeographic region (such as Alpine areas in the Alps, Apennines, Pyrenees, Scandes and Carpathians is even less biologically informative as individuals from these disjunct regions of Europe will rarely, if ever, interact and therefore cannot contribute to each others population viability. This procedure will almost always **overestimate** the extent to which a species conservation status is favourable.

Likewise, a focus on a priori defined biogeographic regions can **obscure** other important connections, or discontinuities, in the actual distribution of large carnivores which are critical for on-the-ground conservation (see section 11 for examples of the consequences of these issues).

It should be noted that in the Directive, biogeographic regions are only mentioned with respect to habitats types and the criteria for creating Natura 2000 sites, not for species conservation. Their connection to species reporting was an administrative decision taken when reporting guidelines were first developed.

In contrast, the biogeographic regions can serve as a **proxy** to document that the large carnivores have been allowed to spread and occupy a diversity of habitats and ecosystem types, which is essential to both conserve their "**ecological variation**" and promote the widespread connectivity which is essential for viability.

We would therefore recommend that assessment of conservation status at the biogeographic region within member state scale be focused on documenting the permanent **presence** of the species within a non-trivial proportion of that regions area within the member state in order to assess progress to restoration of ecological processes.

Although we have not considered it explicitly in this document, it would be possible to conceptualise a specific interpretation of what FCS means at the biogeographic level, i.e. an FCS_{BIO}, because it is clear that the biogeographic regions require a different understanding of the concept than that for the population and member state levels.

7.4 The special case of the golden jackal

Golden jackals represent a very special case for both FRP and FRR. In the last decade there has been an incredible expansion of the species both within and outside its historical "core" in southeastern Europe. Individuals have turned up in almost all European countries (except Portugal, Sweden, Luxembourg and Belgium) during recent years, including the boreal and arctic areas of Norway, Finland and Russia. Currently, the northernmost reproductions are in Estonia, Germany and Poland (Kaczensky et al. 2024, Mannil & Ranc 2022). The reasons for the rapid expansion are unknown (Krofel et al. 2007, Cinze & Klimpel 2022). Because this expansion is taking the jackal beyond the traditional areas that it has occupied for centuries it is impossible to predict if these colonising individuals will establish or disappear. This makes it hard for these newly colonised countries to set FRVs for the species, so that we would suggest that the only appropriate option at present is to set both FRP and FRR with an operator of ">CV" or simply as "unknown".

For the countries in southeast Europe where they have had a stable presence over longer time scales the problem is the general lack of high quality / high resolution data on jackal densities and distributions. The species has never been subject to the same intensity of ecological study or monitoring as the four larger carnivores. This lack of data makes it hard to set numeric values for either FRP or FRR. For the smaller populations on the island of Samos and on the Peloponnese peninsula there is an urgent need for more intensive census work at the scale of the entirety of the populations to better understand the size of the populations and their distribution. It is unknown if Samos has any scope for population expansion so the only possible option is to say that FRP_{POP} and FRR_{POP} are equal to or greater than today (>=CV). The Peloponnese population clearly has scope for expansion but is hard to predict so setting FRR_{POP} and FRR_{POP} at greater than today (>CV) or unknown would seem justified.

Although the continental population is much larger it is subject to poorly regulated hunting in many countries. There is a need to establish both a system of reference areas that can be used to monitor changes in density over time, and establish a system of systematic record keeping that can help with detecting jackal expansion into new areas around the edges of the current distribution, and even detect contractions. Until these needed data are in place it is hard to suggest anything other than FRP and FRR at both member state and population scales should be set as equal to the current value (FRP = CV, FRR = CV).

7.5 Monitoring

Monitoring is an essential obligation under the Habitats Directive. Article 17 requires surveillance and reporting every 6 years. Article 18 mandates the necessary research (Louette et al. 2015). The fundamental definitions of Favourable Conservation Status in Article 1(i) implicitly require an assessment of trends in the amount of potential range and the quality of habitat within this range, as well as explicitly requiring data on the population dynamics of the species. It should also be noted that much of this data is needed for CBD indicator reporting under the GBF.

The suggestions for approaches to define FRP and FRR above will depend on monitoring data to determine the trajectory of the portions of the population within each member state and of the populations as a whole. The basics will include;

- Census of large carnivore population size that can be used to estimate the number of mature individuals (see Box 2).

- Indirect indicators of population trends in abundance.

- Distribution mapping in a manner that permits the separation of areas of reproduction / permanent presence and regions of occasional presence or vagrancy.

- Mapping of the permeability of the range – including areas of permanent distribution and connectivity corridors between them. At the very least this should focus on large infrastructure development, especially linear features that may obstruct connectivity.

Furthermore, because of the proposal to benchmark values on effective population size it would be highly useful, if not essential, to also monitor the genetical structure of the population including;

- Direct assessment of effective population size.

- Monitoring the allelic diversity.

- Documenting inter-population movements and geneflow.

- The minimisation / exclusion of including wolf-dog hybrids from estimates of wolf numbers.

Monitoring inter-population movements may be challenging in large populations because of the low probability of detecting immigrants. In such cases documenting a continuous distribution of reproductive units may be an acceptable, although inferior, surrogate. It should be noted that with less robust data there is a need to adopt a greater degree of precaution (see section 7.10).

The recent ruling by the CJEU in the case of wolves in northern Spain (C-436/22) also underline the need for surveillance at large scales, including transboundary scales, such that the impacts of management actions can be assessed. Coordinated and harmonised management across borders (both intra-national and inter-national) is viewed as an essential measure in large scale conservation planning and will be essential for the operationalisation of these guidelines in light of the fact that most large carnivore populations are transboundary in nature. Avoiding double counting, detecting migrants, and having comparable methods to fairly divide responsibility are just some of the reasons why a high degree of cross-border coordination is needed. Technical cooperation with respect to monitoring across borders is becoming increasingly common in Europe and there are many good examples of best practice. However, there are still examples of where this cooperation is sub-optimal and where there is a need to encourage better cooperation.

7.6 Threat assessments

The definition of FCS in the Directive invokes clear conditions on future prospects as well as present condition. To assess this the current reporting procedures involve large lists of pressures and threats (available online on EIONET's Central Data Repository https://cdr.eionet.europa.eu/help/habitats_art17) While these are exhaustive with respect to many issues related to habitat and environmental conditions and infrastructure related threats, they fail to recognise many of the threats that actually face large carnivores, or if they broadly cover the threat they do not identify the appropriate mechanism. For example, the threats posed by livestock husbandry (Threat category PA07, 08, 10) are not related to the livestock production per se, but to the extent to which appropriate husbandry methods are used to protect the livestock. The threats posed by forestry (Threat categories PB) don't deal with issues related to disturbance (e.g. of dens) or ensuring the supply of food (for example masting trees or berries for bears) or related to wildlife management of natural prey of large carnivores. Category PG08 does refer to hunting directly and on prey, but wildlife management is often determined in part by large herbivore damage to forestry, such that it is important that the interface between these two considerations, hunting and forestry, also considers the herbivores as a prey base for carnivores. The section on military action (Threat category PH) does not include border security fencing. Furthermore, there are no recognised threats related to poor institutional arrangements or lack of social acceptance related to conflicts between large carnivores and humans, or between different groups of humans over the way to manage large carnivores (Linnell 2013). One consequence of these threats may operate via illegal killing (which is recognised, threat PG11). 7.7 The process of population level assessment

Although not a legal requirement, in the 2008 guidelines it was hoped that member states would take the opportunity to form binding transboundary management plans that would coordinate management of the different parts of the populations that lie within different national borders. In the 16 years since their release no countries have yet made this step. While we would continue to encourage member states to make these plans it is apparent that other mechanisms need to be developed to allow population level assessments to be made based on the national level data submitted by member states. The European Environmental Agency already conduct post-submission aggregated analyses of FCS at the level of the biogeographic regions, so it would be possible to conduct a similar analysis for the large carnivore populations based on what is submitted.

7.8 The need for landscape scale planning

Because of this strong focus on connectivity it will become increasingly important to conduct population (or continental) scale landscape planning exercises to identify the critical areas for connectivity for all large carnivores (e.g. Hebblewhite et al. 2021, Oeser et al. 2023, Scharf & Fernandez 2018, Schnidrig et al. 2016, Vlkova et al. 2024). Plenty of data exists from telemetry and population monitoring studies to construct maps of suitable habitat. These layers should be examined for bottlenecks and barriers of impermeable infrastructure or other landuse developments that may need to be mitigated. Such mapping exercises will be important for (1) assessing realistic levels of connectivity under today's situation, (2) planning connectivity restoration exercises, (3) targeting conflict reduction measures, and (4) guiding future developments to prevent increased fragmentation.

This work could be reinforced if the Commission initiated regional population forums for knowledge exchange and assessment such as mandated by Article 18(1), and through landscape level planning (see section 7.7). It could be conducted in cooperation with regional initiatives – such as the Alpine and Carpathian Conventions – expanding on existing activities (e.g. Hacklander et al. 2021, Schnidrig et al. 2016). On a continental scale it could also be embedded in a pre-existing format of European Species Action Plans and involve ongoing activities like the EU Platform on Coexistence between People and Large Carnivores or expert groups such as the Large Carnivore Initiative for Europe. In order to ensure legitimacy and avoid conflicts over contested knowledge it would be best if such exercises were conducted using a broad consortia of technical experts and with a high degree of consultation with stakeholders and competent authorities in member states.

7.9 Consequences of the multi-scale approach

When splitting FRV into two different concepts at least two scales (we consider member state and population scales here, but the discussion on member state scale also needs to be downscaled to subnational units too – or be applied to biogeographic regions) the question arises if a member state can reach FCS even if the overall population has not, and vice versa, can a population be viewed as being at FCS even if all contributing member states have not yet reached their objectives? In other words there is a question about the relationships between FCS_{MS} and FCS_{POP}.

It is certainly possible for a member state to reach its FRV_{MS} even if its neighbours have not yet reached theirs and if the overall population is not at its FRV_{POP} values. This should be acknowledged, although if this should extend to using the term FCS at the member state level or not is unclear. On one hand, member states can only be held responsible for their own actions within their own borders. On the other hand, for some smaller countries at least, these FRV_{MS} may be so small that there is little overall viability of the species concerned. Because the Directive definitions of FCS focus on absolute outcomes (long-term conservation) it would be logical to withhold the status of FCS at a member state level until the population as a whole can be judged to have reached it, although it should be acknowledged then that the member state in question has delivered on its obligations even if the sum of the neighbours' actions have not.

However, the opposite situations are not necessarily true. A member state cannot claim to be at FCS just because the overall population is at FCS without making an own contribution and reaching its FRVs (rejected by CJEU Case C-601/22). Furthermore, if enough member states have contributed enough to bring the overall population to a level compatible with its FRV_{POP} it is logical that the population as whole can be declared at FCS (FCS_{POP}), as well as the member states (FCS_{MS}) that have fulfilled their obligations, even if one or more other member states have not yet reached their goals.

It is important to note that the recent ruling by the CJEU in case C-436/22 underlines that it is highly problematic if the administration in one unit begin killing carnivores if the wider population has not yet reached FCS. The implication is that even if a country has reached FCS_{MS} it needs to be extremely restrictive with management until the overall FCS_{POP} has been reached. IT is important to note that this also concerns cases of Annex V as well as Annex IV designation.

7.10 Precautionary considerations

The precautionary principle is enshrined in Article 191(2) of the Treaty on Functioning of the European Union "*Union policy on the environment shall aim at a high level of protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle ….*".

This has consequences for all aspects of these guidelines. Operationalising these guidelines requires conducting many analyses where the outcome is dependent on both empirical data and a set of assumptions about many ecological and genetical properties of species' populations. Furthermore, all calculations in science require making decisions about acceptable probabilities of certain outcomes happening. There is considerable variation in the degree of scientific knowledge about European large carnivore populations. A logical application of the precautionary principle is that where up-to-date and contextual knowledge lacks there will be a greater need to apply precaution. As a result, many of the rules-of-thumb and heuristics that we apply include a high degree of precaution. If more specific data or analyses are available to circumvent these heuristics there may accordingly need to be less precaution. Key parameters where precaution may be considered concern (1) the heuristic of one effective migrant per generation which is minimal, and (2) the 50:500 rule, where 100:500 or even 100:1000 have both been proposed as more cautious rules-of-thumb.

8 Summary of proposal for FRVs at population and member state levels

This section presents the results of the background and discussions in all previous sections in a brief operational overview / checklist fashion.

For all levels there is a requirement that no favourable reference values can be lower than at the point in time when the member state entered the EU (with the possible exception of situations where local population densities were artificially high, for example because of supplementary feeding). It also follows that improvements in status in another member state with which a population is shared or in connectivity between populations cannot automatically be used to then justify downgrading (degrading) the level of ambition in FRVs.

For all scales both FRP and FRR should be considered together so that the value with the larger requirements takes precedence (i.e. if fulfilling FRR requires occupying more areas than would be strictly necessary to satisfy FRP when viewed in isolation then it is the FRR that sets the overall level for FRP, and vica versa).

There should obviously be no expectation for any administrative unit at any level to host more large carnivores than the habitat can support in a sustainable manner.

In countries with federal structure or other structures that delegate some management authority to subnational levels the principles of the member state level can be downscaled to suit their size, location and ecological preconditions, however it is essential that higher level coordination is maintained.

8.1 Population Level

FRP_{POP}:

- The sum of all member state contributions (plus non-member state contributions) represents an effective population size (N_e) greater than 500.

- For a unit to be assessed there must be either a continuous distribution (i.e. the current large carnivore populations) or sufficient exchange of individuals across areas of non-continuous distribution to ensure effective geneflow.

- Where there is a connection to a population in a country that is not bound by the Habitats Directive or Bern Convention there is a higher threshold to demonstrate the absence of barriers (border fences) and documentation of effective geneflow.

FRR_{POP}:

- Composed of a continuous and aligned area of interconnected distribution, or potential distribution, with sufficient habitat and without serious internal barriers to movement or discontinuities beyond average dispersal distances.

- An area large enough to embrace the FRP_{POP} with realistic population densities.

- Including potential connection corridors to neighbouring populations through which individuals can regularly disperse even if they are not resident.

8.2 Member State Level

FRP_{MS}:

- It is recommended that the minimum requirement is that FRP_{MS} should be large enough so that the sum of FRP_{MS} values of all member states (and non-member states included) within the shared population reaches FRP_{POP} (N_e>500).

- With this overall goal the FRP_{MS} goal could be of a size that represents a fair and proportional sharing of the common obligation between member states towards reaching the overall FRP_{POP} while taking into account the combination of ecological, social, cultural and economic requirements and regional and local characteristics of the different member states (see Box 3 for a very rough approximation of some key issues).

  - For countries with "very small" (i.e. less than 10.000 km^2) areas of potential habitat the contribution should allow for the permanent presence of reproductive units of large carnivores in a significant proportion of the country, but without setting quantitative goals.

  - For countries with "small to medium" (i.e. from 10.000 km^2 to 50.000 km^2) amounts of potential habitat the contribution should be scaled to quantitative goals benchmarked against either MVP or an effective population size of 50 (or 100 if applying a large degree of precaution).

  - For countries with "large" (i.e. > 50.000 km^2) amounts of potential habitat the contribution should be scaled far above an N_e of 50, ideally as close to N_e of 500 as possible.

- To satisfy the ecological functionality conditions there will also need to be an actual permanent presence of reproducing units of the species in the Natura 2000 sites designated for the species in question, biogeographic regions and range of ecological conditions defined within the FRR_{MS}.

Note: A special case concerns countries that host portions of multiple populations. For very-small and small-to-medium sized countries it is reasonable that their FRPs refer to their total contribution. However, for large countries it will both reasonable and necessary that there is a need for a substantial contribution to each of the populations that they co-host, although the cumulative contribution they make to all populations within their territory should be considered when deciding on the fair level of sharing responsibility between countries.

FRR_{MS}:

- Composed of a continuous and aligned area of interconnected distribution, or potential distribution, with sufficient habitat quality and without serious internal barriers to movement or discontinuities beyond average dispersal distances.

- Habitat types of sufficient quantity and quality are included within the range.

- Aligned with FRR_{MS} of neighbouring states with which the population is shared to ensure connectivity between member states and satisfy the requirements for FRR_{POP}.

- Overlapping all Natura 2000 sites designated for the species.

- Overlapping all biogeographic regions within the country that can be considered natural range.

- Overlapping all relevant ecological conditions, ecosystems and prey communities.

9 Implementing these new guidelines

9.1 Check lists for assessing Favourable Conservation Status based on new FRVs

Based on the argumentation presented in section 7, and summarised in section 8, together with the basic principles of key concepts outlined in section 1 this section summarises the key elements of FRVs and their linkage to FCS into a "checklist". It is important to bear in mind the multiple caveats and special cases identified in the previous sections, and additional elements of FCS classification that are used during the formal Article 17 reporting process. The precautionary principle should also be exercised with respect to data quality and uncertainty in parameter estimates.

Population level

	Parameter	**Yes/No**
FRP_{POP}		
1	Does the sum of all member state contributions represents an **effective population size** greater than **500**?	
2	Is the population **trend** positive or stable?	
FRR_{POP}		
3	Is the FRR composed of a continuous and aligned area of **interconnected distribution**, or potential distribution?	
5	Is the range stable or increasing?	
5	Is there **sufficient habitat** and without serious **internal barriers** to movement or **discontinuities** beyond average dispersal distances?	
6	Is the **area large enough** to embrace the FRP_{POP} with realistic population densities?	
7	Is the **prognosis for the habitat** quality and connectivity positive?	
8	Are there **potential** connection corridors to **neighbouring populations** through which individuals can regularly disperse even if they are not resident?	
9	Have all **genetically distinct units** or subspecies been included in the range?	
FCS_{POP}	If answer to **all** parameters (1-9) is yes – then FCS has potentially been achieved – if the answer to any parameter is no, then FCS_{POP} has not been achieved.	

Member state level (potentially down-scaleable to sub-national levels)

	Parameter	Yes/No
FRP_{MS}		
1	Is your FRP greater than or equal to when you **entered the European Union**?	
2	Is your FRP large enough so that when **summed** with FRPs from other member states (and other contributing states) sharing a population it will allow an effective population size of at least 500?	
3	Does your population have a stable or positive **trend**?	
4	"Very small countries" – do you have the permanent presence of reproductive units of large carnivores in a significant proportion of the country?	
5	"Small to medium size countries" – is your population size greater than a demographic MVP or an effective population size greater than 50?	
6	"Large countries" – is your FRP for each segment of a population that you co-host much greater (proportional to the available habitat) than an effective population size of 50?	
7	Are reproducing units of the species present in the full range of Natura 2000 sites, biogeographic regions and relevant ecological conditions?	
FRR_{MS}		
8	Is the FRR composed of a continuous and aligned area of **interconnected distribution**, or potential distribution?	
9	Is the range **stable or increasing**?	
10	Is there **sufficient habitat** and without serious **internal barriers** to movement or **discontinuities** beyond average dispersal distances?	
11	Is the **area large enough** to embrace the FRP_{POP} with realistic population densities?	
12	Is the **prognosis for the habitat** quality and connectivity positive?	
13	Is the FRR **aligned** with neighbouring states to ensure sufficient connectivity to allow FCS_{POP} to be attained?	
14	Does the FRR overlap all **Natura 2000** sites designated for the species?	
15	Does the FRR overlap all **biogeographic regions** within the country that be considered natural range?	
16	Does the FRR allow for the presence of the species in all **ecological conditions**, ecosystems and prey communities?	
17	Are all subspecies of distinct genetic populations included?	
FCS_{MS}	If the answer to **all** parameters 1-3 and 7-17 and **either** parameter 4, 5 or 6 (depending on your situation) is yes – then FCS has potentially been achieved – if the answer to any of these parameter is no, then FCS_{MS} has not been achieved.	

9.2 Preparatory actions need for implementing the new guidelines

Implementing these new guidelines is not a trivial task. There is a need for many scientific, administrative and possibly even political actions. It is therefore unlikely that member states will be able to fully operationalise them for the current reporting cycle. The following represents a list of some of the most basic actions that are needed. It should be noted that for many parts of Europe most of these elements already exists in one form or another.

Recommendations for scientific and technical actions

- Analysis of data to develop **conversion factors** between monitoring metrics and numbers of mature individuals.

- Analysis of data to develop best estimates of the **N_e / N_c ratio** for all the large carnivore species in their different contexts.

- Assessment of degree of **connectivity** between existing "populations" to produce **revised units of assessment** (possibly merging some populations) relevant for calculation of effective population size.

- Development of comparable metrics for **population level assessment** of transboundary populations using harmonised methodology.

- Assess **current effective population size** for this population and identify **population level FRVs**.

- Development of new, and integration of existing, **habitat suitability maps** as well as maps of potential **connectivity** and identification of **barriers**.

- Make broad assessments of approximate **ecological carrying capacities** of these distribution areas under different scenarios.

- Examine **overlap** with Natura 2000 sites, biogeographic regions and major ecosystem types within the member state's area.

- Identification of **social, economic and cultural** considerations that may need to be considered.

- Decide on **member state level FRVs** needed to ensure that population level FRVs can be reached or maintained while ensuring a fair and proportional distribution of the responsibility among member states.

Recommendations for administrative actions

- Adjustments to Habitats Directive **reporting forms** to better accommodate transboundary reporting and the metrics described in these guidelines.

- Establishment of a **working group** to make post hoc transboundary assessments of population status based on reported or published data in situations where member states do not deliver coordinated reporting of shared populations. This group could make a first assessment of the situation based on the current round of reporting to provide better practical guidance for its application in the next reporting cycle.

- Creation and facilitation of **transboundary forums** for discussions around policy coordination, and if possible, the creation of transboundary management plans.

- Develop a step-by-step **user guide** for implementation in the context of the next reporting cycle.

9.3 Subjectivity, scientific uncertainty and scope for member state discretion

Although our rational has been to align the best scientific practice with legal and policy framings it is clear that the approaches we outline can we addressed in different ways. It was never our intention to develop a prescriptive cookbook. For example, multiple approaches exist for calculating effective population size and minimum viable populations or for modelling habitat suitability. Similarly, many of these models require placing values on parameters for which there may be no empirical basis, or on transferring values from different study populations to deal with data gaps (see section 12). In some cases there will be a need to make predictions about future or potential conditions. Finally, most modelling and analytical approaches involve making choices about acceptable probabilities of risk of different outcomes and different ways of dealing with uncertainty.

The decisions made on these matters are likely to influence the outcome of the calculations. To a large degree this is inevitable as it reflects a diversity of scientific approaches and the constant development of methods and data availability in the field. There is not a single right way of doing this type of science, although there are many wrong ways. This also opens for a certain degree of member state discretion with respect to how they go about setting their FRV reflecting different thresholds of risk acceptance.

Because of the controversial nature of large carnivore management we strongly recommend that all processes are conducted transparently and that all data, calculations and models are made available for critical assessment by scientific peers and colleagues.

C: Scenarios: setting Favourable Reference Values under different parameters

These sections are intended to illustrate the real-world consequences of different criteria included in our proposal for FRVs.

10 Natura 2000 coverage

These maps illustrate the extent to which Natura 2000 sites designated for large carnivores are already included within the distribution range of the species for which they were designated, thereby also identifying sites designated for that species which are not yet included within the current distribution range of the species. Several member states took out an exception for some of the large carnivore species with respect to Annex II. For wolf, an exception was taken by Estonia, Latvia, Lithuania, Finland and Spain north of the river Duero. For bears, an exception was taken by Estonia, Finland and Sweden. For lynx, an exception was taken by Estonia, Latvia and Finland. Golden jackals are not listed on Annex II. Swedish files have been submitted to the EU but could not be downloaded and could therefore not be included. For wolves, bears and lynx we first show an overview of continental Europe and then zoom on a selection of additional areas for illustration. The current distributions of large carnivores are taken from Kaczensky et al. (2024), including all categories of distribution (permanent, occasional and unclassified).

In the case of wolves (Figure 2), the upper left map illustrates the fact that most of the Natura 2000 sites created for wolves are currently covered by present day wolf distributions. The upper right figure shows a major exception in the case of Iberia where many Natura 2000 sites in the south and southwest of the country are currently outside of wolf distribution. At the time that Spain entered the EU the Sierra Morena wolf population was still extant, but it is now viewed as being extirpated since the 2000's. Wolves disappeared in Extremadura earlier, in the late 1980's or 1990's. Spain also has many Natura 2000 site sin the Pyrenees that may soon be occupied if expansion from both the west and the north continues, potentially providing a major stepping stone linking the two populations. The bottom left figure shows that the Alpine and Dinaric-Balkan wolf populations have good coverage of the designated Natura 2000 sites, with the exception of one in northern Italy (in the region of Parco Regionale delle Orobie Bergamasche).

The current distribution of lynx in central Europe is clustered around sites designated for lynx (Figure 3). However, there are multiple sites for the species that are currently unoccupied, especially in the southern French Alps, the eastern Alps of Italy and central Austria. The latter two regions represent vital connections that need to be established to reconnect populations and will therefore have a vital role to play in the future.

The examples selected for bears (Figure 4) show contrasting situations. The left hand map shows how the Carpathian bears have a very good coverage of the designated sites, with the exception of an area in southwest Romania (centered around Parcul National Semenic-Cheile and Parcul National Cheile Nerei - Beusnita) which could be important for connections towards Serbia. The right hand maps focuses on the connection area between the Alpine and Dinaric-Balkan-Pindos populations. Most striking is the area in central Austria where many sites were created for the small bear population that was extant at the time but which has now disappeared. There are also unoccupied sites in Italy that could help establish connection between the Alps in Italy and Slovenia, and provide space for the population in the Italian Alps to expand westwards.

In addition to the sites designated for the species the maps show that there are many other Natura 2000 sites in these connection zones that were not designated for large carnivores at the time, but which could become important to foster connections between these expanding populations. The maps also show the very large disparity between different countries in the size and configuration of their Natura 2000 networks. However, in no case is the Natura 2000 network enough to ensure conservation or connectivity of large carnivores without their presence in the surrounding landscape.

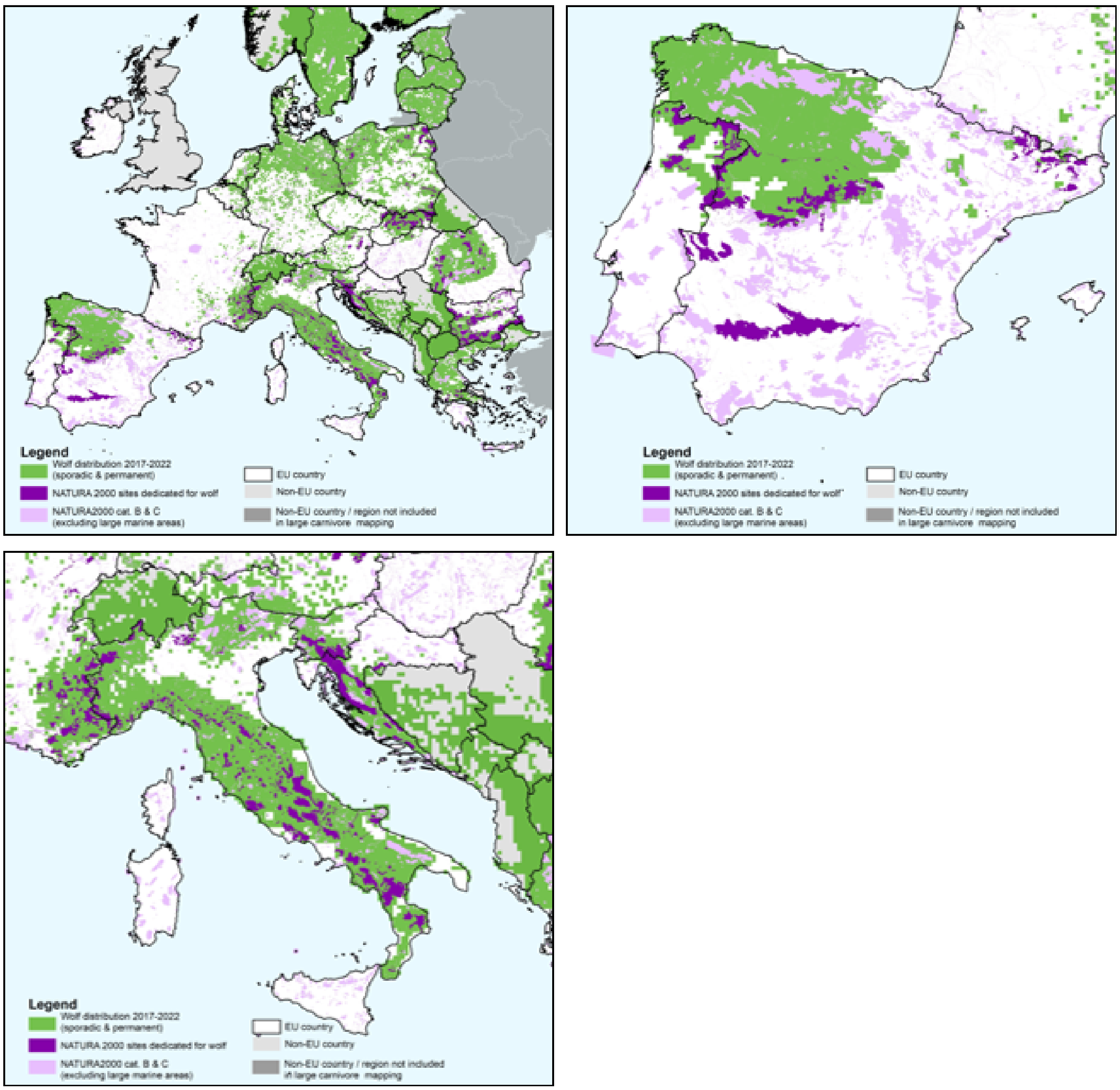


Figure 2. Overlays between current wolf distribution and Natura 2000 areas designated for wolves.

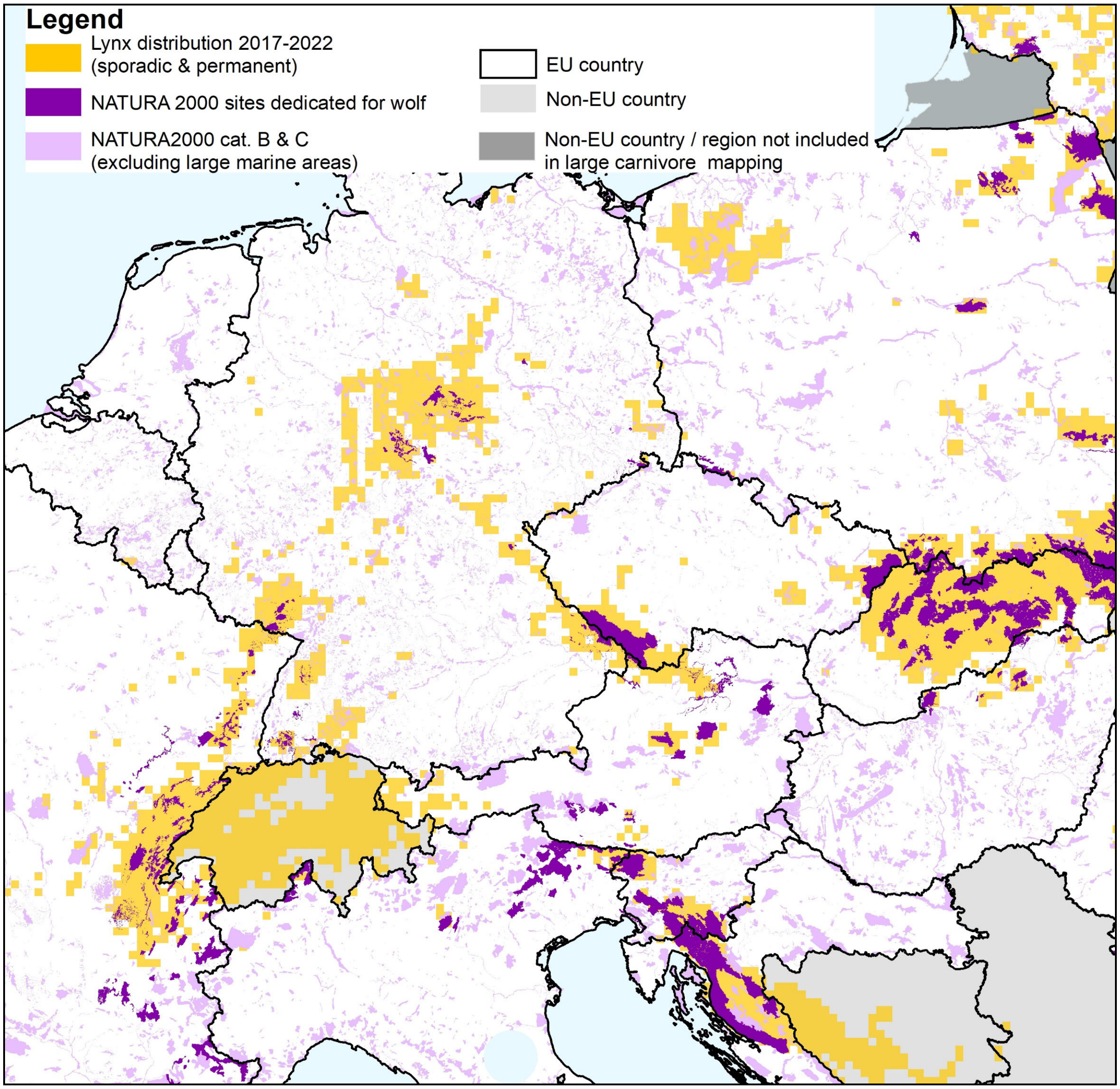


Figure 3. Overlays between current lynx distribution and Natura 2000 areas designated for lynx.

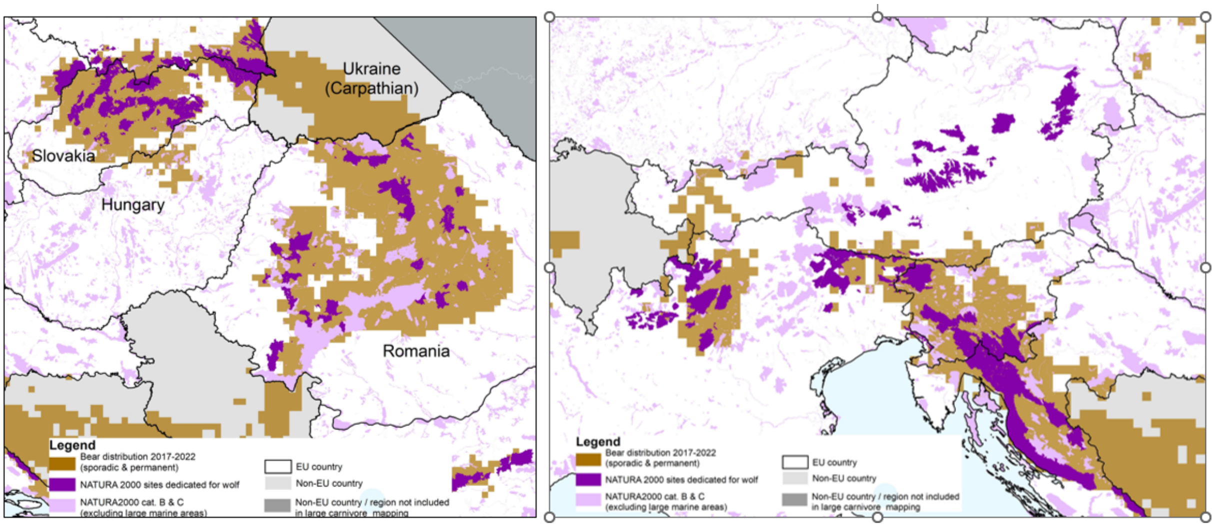


Figure 4. Overlays between current bear distribution and Natura 2000 areas designated for bears.

11 Biogeographic region coverage

These maps (Figure 5) overlay current large carnivore distribution with the biogeographic regions to illustrate the extent to which large carnivores are currently found in the regions. Overall one of more species is present in all of the biogeographic regions, but the extent to which they are covered varies. The Alpine, Boreal and Continental regions have by far the highest degree of coverage, while the Atlantic and Pannonian Basin have the least.

If having at least some presence in all regions is a requirement to satisfy FRR at both member state and population scales gains will be needed in the Atlantic biogeographic region. The recent expansion of wolves into the Benelux countries and northeast Germany provides good coverage, as does the long term presence of wolves in northeastern Iberia. However, France is the country with by far the largest area of Atlantic and as of yet has almost no wolf presence. Fostering modest expansion in the northeast (connecting Alpine and Central Europe wolf populations) and the south (connecting Alpine and Iberian wolf populations) would satisfy twin goals of building population connections and bringing wolves into this under represented biogeographic region. From the perspective of habitat this expansion would seem to be technically feasible.

For bears it is very unclear how much scope there is for further expansion in the Atlantic region outside of the northern part of Spain (Cantabria) and southwest France (Pyrenees). The degree of human landscape dominance in most of the region in other parts of France and the Benelux would seem to represent irreversible changes from the perspective of bears. Bears are also only present on the fringes of the Continental region at the ecotones with the Alpine. It is unclear how much scope there is for bear expansion into the Continental because of irreversible habitat changes from a bear's perspective. At best it'll be a question of expanding how far outside the Alpine regions bears are able to expand.

Lynx are also barely represented in the Atlantic region. Realistically speaking, the area where there is a chance of improvement on short-term time-scales is in northwestern Germany and the Benelux countries. This would have the advantage of allowing expansion and enhancing connections between many of the small lynx populations and occurrences that are scattered across the region. Lynx also only have a small presence in the Mediterranean region on the coast of Slovenia and Croatia. There is some scope for expansion in Croatia, although Greece holds the greatest potential. Unfortunately there is still no confirmed presence of the Balkan lynx there.

The Pannonian basin stands out as a biogeographic region with very little large carnivore presence (apart from golden jackals), although lynx, wolves and bears are present all around it. From a habitat perspective it is unlikely that it represents suitable habitat for bears. It is also marginal for lynx. In contrast, there should be potential for wolves to colonise at least parts of it. However, the area needs a detailed habitat analysis. There are abundant sources of colonising carnivores to the north and east (Carpathians), but connection to the south and southwest is severely hindered by Hungary's border security fence on the Serbian and Croatian borders.

Overall, focusing on the FRR requirement and fostering at least some large carnivore presence in all suitable biogeographic region could be achieved with relatively modest expansions of existing populations with the greatest need involving the Atlantic and Pannonian basins.

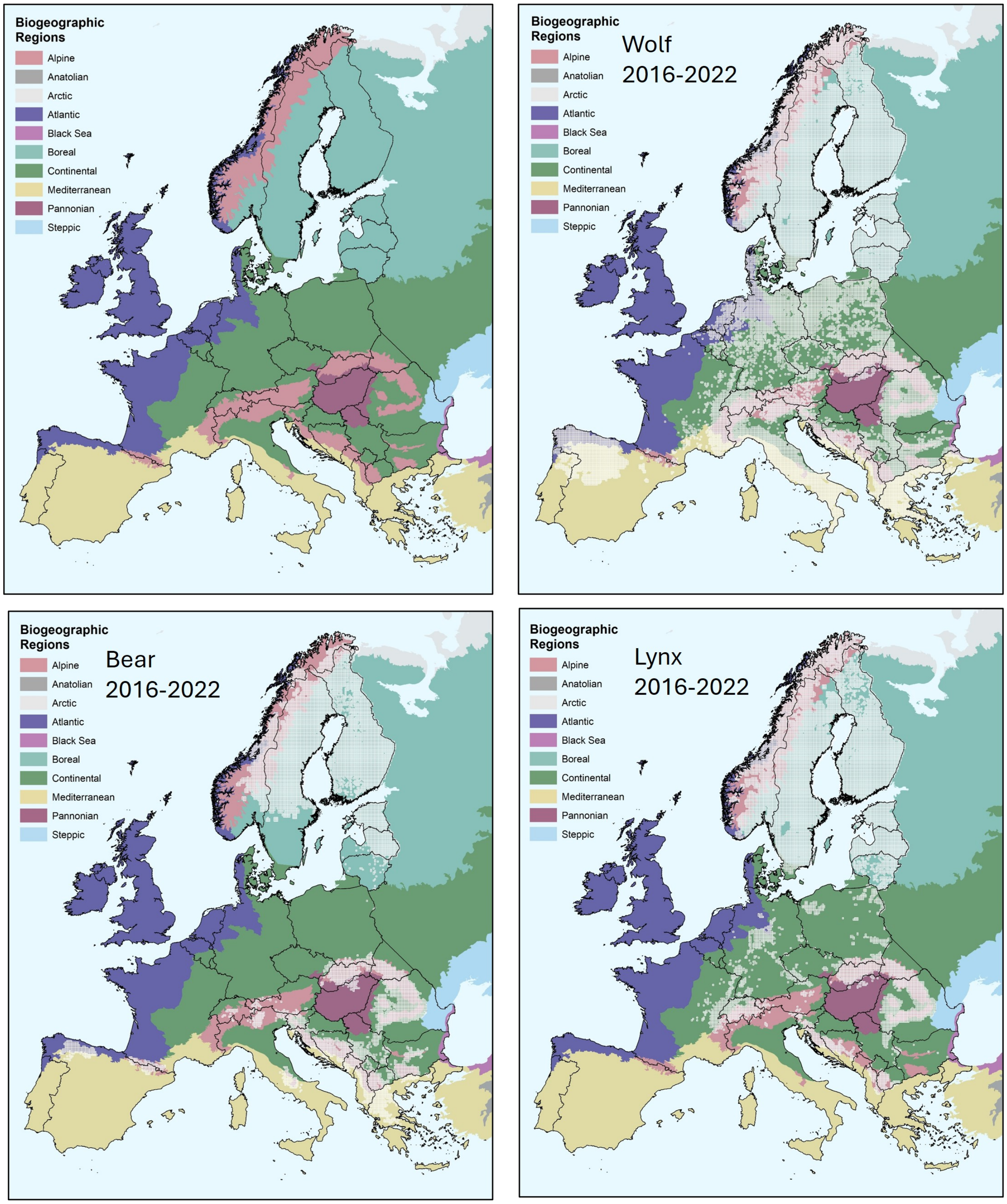


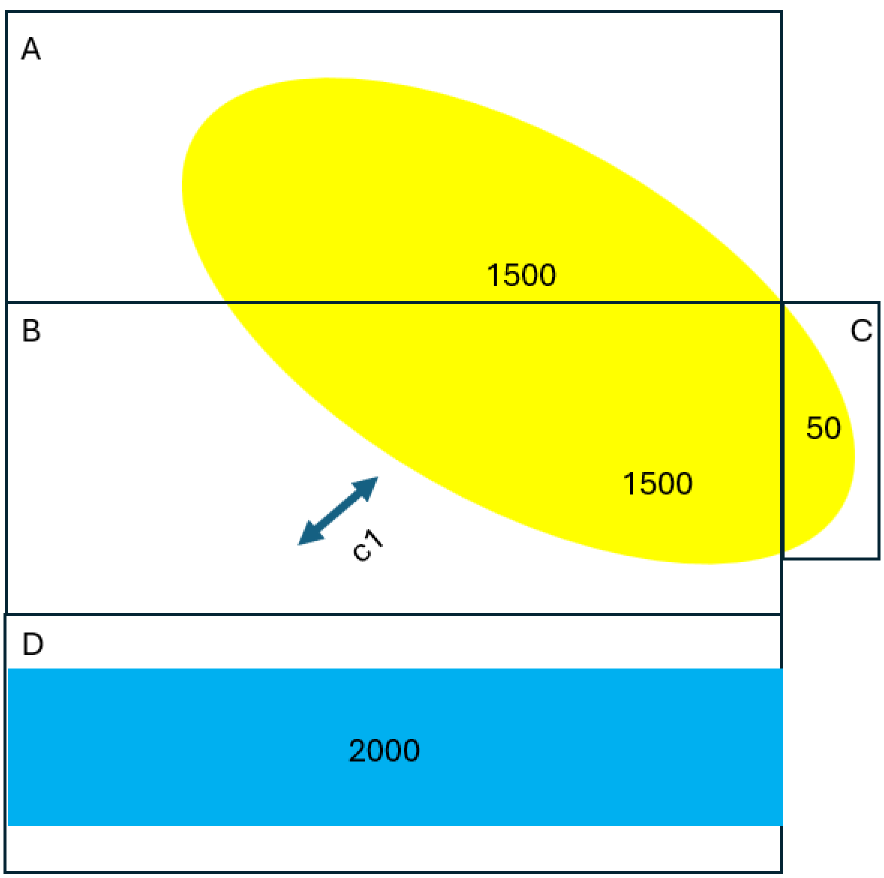
Figure 5. Overlays between wolf, bear and lynx distributions (data from 2016 to 2022, all distribution types combined, Kaczensky et al. 2024) and the biogeographic regions recognised by the Habitats Directive.

12 Population size and distribution with respect to proposals for FRVs: model scenarios

In this section we provide some **illustrative model scenarios** to illustrate how different population situations might translate into different FRV assessments. Rather than basing the scenarios on real life assessments of named populations we have chosen to show some model or idealised situations that loosely reflect real life situations. Although Kaczensky et al. (2024) presents updated distribution maps and status assessments of populations there are several parameters that are essential for accurate assessment that are not presented in that report. This includes the assessments of actual connectivity between regions and accurate estimates of parameters linking population size estimates with effective population size (i.e. the N_e / N_c ratio). The use of idealised models allows the importance of this uncertainty to be revealed and prevents a too hasty preliminary assessment of a real life population / national situation without all of the necessary information becoming available. It should therefore be viewed more as an illustration of what our proposal for FRPs **could** mean in real life, more than an assessment of how different member states are **actually** performing.

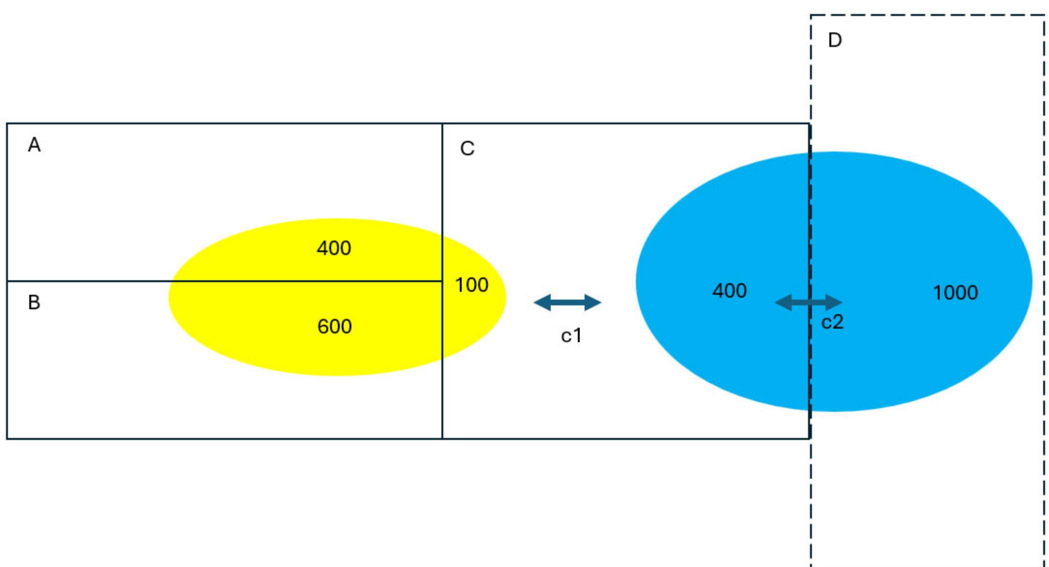
Example 1. A simple scenario where two large countries (A, B) and a small country C share a common population (Yellow) under three different N_e/N_c ratios and with different degrees of connectivity to another population (Blue). The outcomes in green show cases where FRPPOP and FRP_{MS} are above their expected thresholds (N_e >500 at population level, and N_e >50 in each of the large countries and country C has made a significant contribution with respect to its potential. Outcomes in yellow show cases where each of the countries have made significant contributions, but are not enough to bring the population as a whole to a level where the N_e>500. All population sizes refer to number of mature individuals.

N_e/N_c	Country A	Country B	Country C	Population
	1500	1500	50	3050
No connectivity between Blue and Yellow populations				
0.1	150	150	5	305
0.2	300	300	10	610
0.3	450	450	15	915
Enough connectivity between Yellow and Blue populations so that they can be considered a single genetic unit				
0.1	150	150	5	505
0.2	300	300	10	1010
0.3	450	450	15	1515



Example 2. This illustrates 3 large countries (A-C) that are all signatories of a binding treaty, bordering onto a fourth large country (D) which is a signatory – but where there is a real connection. We consider scenarios with different N_e/N_c ratios (0.1, 0.2, 0.3), different degrees of connectivity between the Yellow and Blue populations (c1 and c2), and situations where the contribution from country D can be considered or not. The outcomes in green reveal where the overall populations can be considered to have a large enough population to reach a FRV_{POP} that would be acceptable as FCS (N_e>500), and where the national FRPMS are at a level where N_e>50 and the overall population is at N_e>500. Outcomes in yellow illustrate situations where each country has made a meaningful contribution by reaching a level where N_e>50, but where the overall populations have not yet reached a combined level of N_e>500. For these cases to turn green would require increasing their population sizes. All population sizes refer to number of mature individuals.

N_e/N_c	Country A - Yellow	Country B - Yellow	Country C - Yellow	Country C - Blue	Population – Yellow	Population Blue
	400	600	100	400	1100	400 (1400)
No connectivity between Yellow and Blue population – and unable to consider portion of Blue population in country D						
0.1	40	60	10	40	110	40
0.2	80	120	20	80	220	80
0.3	120	180	30	120	330	120
No connectivity between Yellow and Blue population – but able to consider portion of Blue population in country D						
0.1	40	60	10	40	110	140
0.2	80	120	20	80	220	280
0.3	120	180	30	120	330	420
Enough connectivity between Yellow and Blue population to consider as one genetic unit – but unable to consider portion of Blue population in country D						
0.1	40	60	10	40	150	40
0.2	80	120	20	80	300	80
0.3	120	180	30	120	450	120
Enough connectivity between Yellow and Blue population to consider as one genetic unit – and able to consider portion of Blue population in country D						
0.1	40	60	10	40	250	250
0.2	80	120	20	80	500	500
0.3	120	180	30	120	750	750



Appendix 1 Current practices associated with setting FRVs in a selection of European countries

Member State reports from the 2013-2018 reporting cycle

The overview of member state reporting of Favourable Reference Values from the 2013-2018 reporting cycle indicates that very few have chosen to give numerical values. Instead most have chosen to give operators such as “more than”, “less than”, or “approximately equal to” (Table 3). With the exception of Sweden which has high quality monitoring systems in place, most of the countries that have given numerical values only have relatively poor monitoring systems in place that lack the precision to produce such exact numbers, or document where the current status is with respect to these values (Kaczensky et al. 2024). Paradoxically, many countries that have good monitoring and research systems in place have chosen to avoid giving numerical values. Based on these values it is impossible to determine the extent to which member states are achieving their goals or not. Many indicate that they are far below their FRVs, although a few indicate that they are currently above (Slovenia and Sweden for bears). It should be noted that all numbers in these tables refer to the total number of carnivores and not to the effective population sizes that form the basis of these new guidelines.

Table 3. Overview of Favourable Reference Values provided by member states in the 2013-2018 Article 17 reporting cycle on biogeographic level. For each country the numerical values have been summed for all biogeographic regions. Where different operators were used for different regions we have shown both symbols separated by a comma. "N/" and "x" indicate that no data was given. Source: extracted from https://nature-art17.eionet.europa.eu/article17/species/summary/

Country	Wolf		Bear		Lynx		Jackal		Wolverine	
	FRP	FRR	FRP	FRR	FRP	FRR	FRP	FRR	FRP	FRR
AT	N/	N/	>>	>>	>	> , >>	N/	N/		
BE	N/	N/								
BG	920	122000	525	28400	≈	21300	38126	123900		
CZ	>	>	N/	N/	>	>	x	x		
DE	>>	>>			>>	>>				
DK										
EE	≈	≈	≈	≈	>	≈				
ES	578 + x	≈ , >	492	≈						
FI	>	≈	≈	≈	≈	≈			≈ , >	≈
FR	≈ , < , N/	≈ , N/	>	>	> , > , x	> , ≈ , x				
GR	>	≈	>	≈	x	x	x	≈		
HR	>	≈ , x	≈	≈ , x	>> , x , x	> , ≈ , x	800	≈		
HU	>	>			>>	>	≈	≈		
IT	≈	≈	> , >>	≈ , >	>>	>>	≈	≈		
LV	300	64589	30	X	600	64589				
LT	≈	≈			>	≈				
LU	>>	>>								
NL	N/	N/			N/	N/				
PL	≈ , >	≈ , >	≈	≈	>	> , ≈				
PT	≈ , >	≈ , >								
RO	2700	≈	5960	≈	2300	≈	1900 , x	≈		
SI	≈	≈	<	≈	>>	>	≈	≈		
SK	≈ , >	≈ , >	≈	≈	> , ≈	>				
SE	300 , N/	238800 , N/	1400	315900 , N/	870 , N/	421400 , N/			600	293700

Detailed examination of some recent FRV processes

This represents a summary of a selection of national level processes that have led to the formulation of concrete FRVs for various large carnivores (mainly wolves, but also bears, lynx and wolverines). It is not a complete overview, but is based on those that were most accessible in terms of language, most complete, and most clearly linked to official policy processes. There are other good expert reports (e.g. Hulva et al. undated, Jansman et al. 2021) and national plans that were not included because of time constraints or uncertainty about their official status with respect to policy. Furthermore, several countries are currently working on models at the time of writing but are not yet finished.

Lynx in the Bohemian-Bavarian-Austrian lynx population

Under the auspices of an Interreg funded project (3Lynx Project) the responsible management agencies of Bavaria, Upper Austria and the Czech Republic, together with a range of scientific and NGO partners have developed a conservation strategy for lynx in the shared 3-country population. They developed a shared vision "to restore and maintain, in co-existence with people, a viable lynx population within the Bohemian-Bavarian-Austrian border region connected with other metapopulations in Central Europe" which embraces the idea of a multi-scaled population approach (i.e. the three country population as a part of a wider meta-population).

The strategy explicitly links an interpretation of Favourable Conservation Status to the IUCN Red List Criterion D (of 1000 mature animals). Because this large number cannot fit into the available habitat they have pragmatically adopted a two-pronged strategy of aiming for 250 mature lynx in the three country border population while securing genetic exchange with neighbouring populations to secure a meta-population with at least 1000 mature individuals in total. This adjustment of objective from 1000 to 250 is in line with IUCN Red List practices if there is sufficient connectivity. The objective of at least 250 mature animals is further specified as 165 reproducing females and 85 mature males. The strategy also identifies a large number of actions to monitor demographic and genetic aspects of the population, improve landscape permeability for connectivity, and evaluate the potential for assisted (translocation) connectivity if needed. There is, however, little discussion of the details of the wider meta-population connectivity. New continental scale maps of lynx habitat are now emerging (Iannella et al. 2024, Oeser et al. 2023) as are guidelines on connectivity analysis (Potocnik et al. 2024) which will support such larger scale planning.

Source: Czech Ministry of Environment (2020).

Brown bears, wolves and lynx in Estonia

Estonia has had a series of management plans for its large carnivores since at least 2002 which are updated every 10 years. The current plan is for the period 2022-2031 and focuses on the large carnivores present in Estonia while making reference to the wider shared Baltic population and its neighbor, Russia. The current plan states that the goal for Estonia is to ensure demographically viable populations (extinction risk <5% in 100 years) within Estonia. Threshold values for favourable conservation status are set for each species, formulated in terms of numbers of reproductions (the monitoring unit). These are 20-30 wolf packs, >80 lynx reproductions, and >70 brown bear reproductions. All values are expressed as being before any annual harvest (i.e. late summer / autumn values). Additional targets are formulated based on the total number of individuals after any annual harvest (i.e. spring); >140 wolves, >350 lynx, >650 bears. These targets are based on (1) must exceed the minimum of demographic viability within Estonia, (2) a need to reach Baltic wide populations of 1000 breeding individuals, and (3) the share of habitat and prey status within Estonia compared to other Baltic countries.

Source: Anonymous (2022).

Wolves in Finland

An extensive expert report (Mäntyniemi et al. 2022) provides an exhaustive conceptual and empirical analysis of FCS and the Finnish wolf situation. It is built on the premise that FCS, and associated FRVs, allows for decision makers to make certain choices about subjective parameters, although it must of course be within the frames of lower thresholds (set by a Minimum Viable Population and the size of the population when they entered the EU) and upper limits (set by the ecological carrying capacity). The report directly links FCS to various viability concepts; demographic viability, short-term genetic viability and long-term genetic viability. The issue as to whether Finland needs to opt for short-term or long-term genetic viability depends on the extent to which it can consider the connectivity with the larger Russian populations or not, however, it is stated that long-term genetic viability cannot be achieved within Finland's borders. By extension the report then focuses on maintaining demographic and short-term genetic viability as the goals for Finland with respect to FCS. Empirical data from field studies – reproduction and survival of collared wolves, population monitoring data and genetical data – was used to parameterize a set of viability models. The availability of >20 years of combined genetical and ecological monitoring data has permitted the calculation of population specific estimates of the Ne/Nc ratios (ranging from 0.3 to 0.5) and inbreeding rates.

The report is based on conservative choices, namely adopting a 100 / 1000 rule-of-thumb for genetic viability rather than the more normal 50 / 500 rule, and by considering two sub-populations within Finland as being separate units despite the fact that the establishment and separation of these two units has happened on much shorter time scales than those considered for viability assessments.

Estimates of the number of wolves necessary to reach demographic viability (<5% extinction risk over 100 years) ranged from 100 to 300 depending on the extent that immigration from Russia is considered. Estimates of the numbers of wolves needed for short-term genetic viability were 309-376 in western Finland and 187-233 in eastern Finland. The importance of connectivity with Russia and Scandinavia emerged as a central theme from all analysis. The report does not conclude about exact values of FRVs, but provides a basis for political decisions based on decisions about permissible degrees of uncertainty.

Source: Mäntyniemi et al. (2022).

Wolves in Sweden

Sweden (in cooperation with Norway with which it shares the Scandinavian wolf population) has invested heavily in a series of field studies to obtain data on demographics and genetics of the recovering wolf population. There have been multiple processes to analyze this data to inform decisions about FCS and associated FRV values (Bruford 2015, Chapron et al. 2012, Ebenhard 1999, 2000, Nilsson 2004). Based on these analyses and various stakeholder and political processes Swedish interpretations of FRPs have fluctuated over the years, with values of 200 wolves, 20 annual reproductions, 450 wolves, 380 wolves, 170 wolves, and 170-270 wolves – with independent scientists suggesting values ranging from 270 to 1600 (Liberg et al. 2015).

One major process ended in 2015 when different research groups presented and discussed results of their respective analysis of the data. There was a broad consensus that the Habitats Directive goals required the achievement of long-term genetic viability (N_e>500) which was estimated to require around 1700 wolves. However, there was no consensus whether this would need to be achieved within the borders of Sweden or could be achieved as part of a wider meta-population embracing Fennoscandia, western Russia and the Baltics. A majority of researchers agreed that achieving a goal of demographic and short-term genetic viability (N_e>50) would be a more realistic goal within Sweden's borders – and that this could be achieved with a wolf population of c. 300 wolves in Sweden plus c. 40 in Norway and under the assumption of 1 effective immigrant per generation - which formed the basis for a recommendation for the FRP. This figure was based on an estimation of 100 wolves being enough to satisfy demographic viability and an estimate of 170 wolves being enough to satisfy the N_e>50 requirement of short-term genetic viability (assuming N_e/N = 0,3). They then doubled this value to reflect the precautionary principle. These values assume one effective immigrant from outside Scandinavia per generation. A target for the maximum permissible inbreeding coefficient was also proposed at 0.2 (Liberg et al. 2015). There was, however, some internal disagreement among the experts with a minority advocating for larger goals, with more responsibility on Sweden to achieve long-term genetic viability within its borders and to pay more attention to ecological aspects of the recovery concept. Mills and Feltner (2015) supported the 300 wolves as a short-term goal, but suggested that a longer term goal should be to build the population to 600 wolves to achieve greater ecological functionality.

The value of 300 wolves as the FRP for Sweden was reported in their 2013-2018 Article 17 report. However, in their updated management plan from 2016 that was extended to 2021 (Anonymous 2016) the FRP was proposed to be downsized to 270. The FRR is defined as the whole of mainland Sweden, but excluding the alpine zone (because of conflicts with semi-domestic reindeer. In independent analyses using different modelling approaches Miller and Dussex (2024) confirmed that a wolf population in the range of 170 – 270 would be both demographically viable and genetically viable in the short-term, again under the assumption of 1-3 effective immigrants per decade. Different documents on the web currently give both values of 270 and 300 as the current FRP.

Source: Anonymous (2015, 2016), Liberg et al. (2015), Miller & Feltner (2015).

Wolverines, lynx and bears in Sweden

Like for wolves, Sweden in cooperation with Norway has invested heavily in research and monitoring of lynx, wolverines and bears since the late 1980's and early 1990's resulting in a solid platform of knowledge on which to base management decisions. They have also invested heavily in political and stakeholder processes to negotiate population goals.

A parliamentary decision (Reinfeldt & Ek 2013) from 2013 decided on Favourable Reference Population for wolverines, lynx and bears. These values were supported by a set of population viability analyses (Nilsson 2013) that modelled both demographic and genetic aspects of viability, under multiple scenarios involving different degrees of uncertainty and with, and without, catastrophic events. The analysis was based on the premise that the Habitats Directive required long term genetic viability (i.e. N_e>500) but also on the idea that this was not necessarily to be achieved by Sweden alone so "responsibility" was portioned across the Fennoscandian countries to illustrate the potential contribution of each. No politically binding transboundary agreements with concrete goals corresponding to these distributed objectives are currently in place. A follow-up PVA (Mills et al. 2018) has explored the viability of wolverines and lynx in greater detail, but with an emphasis of how different lethal control strategies might influence the viability of these populations.

Wolverines: The PVAs (Nilsson 2013) suggested a need for an overall population of 1378 wolverines for long term viability, which when distributed across the 3 countries and rounded upwards produced a tentative FRP of 500 wolverines for Sweden. This also corresponds to the estimated population when Sweden entered the EU in 1995. The government therefore stated that the FRP should be from 500-600 individuals, which was then operationalized by the Environmental Protection agency as 600 for the FRP with a requirement of at least one reproducing individuals immigrating from Finland or Russia every generation (7 years), with an associated FRR of the alpine zone of Sweden with the surrounding forest areas (Anonymous 2016b). The value of 600 was included in the 2013-2018 Article 17 reporting.

Lynx: The PVAs (Nilsson 2013) suggested a need for an overall population of 1821 lynx for long term viability, which when distributed across the 3 Fennoscandian countries and rounded upwards produced a tentative FRP of 800 lynx for Sweden. The estimated population size when Sweden entered the EU in 1995 was around 700. The government stated that the FRP should be between 700 and 1000 lynx, which was then operationalized by the Environmental Protection Agency (Anonymous 2016c) as an FRP of 870 lynx under the condition of at least one immigrant from Finland or Russia every generation (7 years) if the combined Norwegian and Swedish lynx population was less than 1180 individuals. The FRR was set as all of mainland Sweden. The value of 870 was included in the 2013-2018 Article 17 reporting.

Bear: The PVAs (Nilsson 2013) suggested a need for an overall population of 6838 bears for long term viability, which when distributed across the 3 Fennoscandian countries and rounded upwards produced a tentative FRP of 2800 bears for Sweden. The estimated population size when Sweden entered the EU in 1995 was between 950 and 1200. In contrast to the reasoning for wolverines and lynx above, the government chose a value of 1100-1400, with the lower value based on PVA results for short term genetic viability (<5% heterozygosity loss in 100 years), rather than a long term N_e>500 reasoning, but this time placing all responsibility on Sweden alone. This was then operationalized by the Environmental Protection Agency (Anonymous 2016d) as an FRP of 1400 bears under the condition of at least one immigrant from Finland or Russia every generation (10 years) if the combined Norwegian and Swedish bear population was less than 2350 individuals. The FRR was set as all of the four northern counties and parts of 3 western counties. A value of 1090 was included in the 2013-2018 Article 17 reporting.

Source: Anonymous (2016a,b,c,d), Mills et al. 2018, Nilsson (2013), Reinfeldt & Ek (2013).

Wolves in Lithuania

The objectives of the national Wolf Conservation Plan (produced in 2014, updated in 2019) aim to maintain a wolf population between 31 and 62 packs (from 250-500 wolves). Adaptive management of hunting quotas is used to keep the population within these broad limits. It is apparently implicitly assumed that these national goals align with Favourable Reference Population values. The plan also calls for the maintenance of a wide distribution of these packs throughout the country, which again can be assumed to align with Favourable Refence Range values.

Source: Ministry of the Environment of the Republic of Lithuania (2019).

Eurasian lynx and wolves in Latvia

In the 2013-2018 Article 17 reporting cycle Latvia stated the Favourable Reference Population for wolves was 300 wolves, and the Favourable Reference Range was the whole country. No formal reasoning exists behind this FRP beyond the fact that it broadly corresponds to the population size when Latvia entered the

EU in 2004 and it was assessed as being at Favourable Conservation Status at this time. The Latvian wolf action plan for the period 2018-2028 (Ozolins et al. 2017a) contains no concrete target for the desired size of the wolf population beyond stating that goal is to maintain the conservation status as favourable.

Likewise the FRP for lynx was set at 600 in the 2013-2018 reporting, with the whole country set as FRR. These values correspond to the level when the country entered the EU. The 2018-2028 action plan (Ozolins et al. 2017b) doesn't confirm these exact numbers, but states that the goal is to maintain the favourable conservation status.

Source: Eionet and Ozolins et al. (2017a,b).

Brown bears in Slovenia

The Slovenian bear management plan for the period 2020-2030 defines the Favourable Reference Population value at 800 bears (assessed after reproduction in the spring – i.e. including cubs-of-the-year and before any eventual lethal removal). The objective is further specified in terms of maintain the age and sex structure "as natural as possible". This FRP is justified as being (1) greater than the estimated 540 bears present when Slovenian entered the EU in 2004 such that the precautionary principle is satisfied, (2) the statement that "the size of the brown bear population in Slovenia exceeds the thresholds of the minimum abundance necessary to avoid inbreeding", and (3) a desire to avoid exceeding the social carrying capacity (i.e. the tolerance of rural people). The plan also aims to ensure that habitat remains of suitable quality an that connectivity is maintained within Slovenia, and towards neighbouring countries with which it shares the wider Dinaric-Pindos and Alpine populations, but no quantitative values for range are given.

Source: Ministry of Natural Resources and Spatial Planning (undated)

Lynx and brown bears in France

Current action plans are available for both lynx (2022-2026) and brown bears (2018-2028) in France. The status of both species is recognized as being unfavourable. The action plans clearly state the ambition to improve the conservation status of the species. Large amounts of data are presented, including modelling of potential recovery and intensive monitoring of numbers, distributions and conflucts. Many actions are presented to improve population status and reduce conflicts with rural human communities. However, despite this abundance of technical information and insights no concrete targets are presented and no quantitative values of Favourable Reference Values are given.

Source: Ministry of Ecological Transition and Territorial Cohesion 2018, 2022

Wolves in Denmark

Wolves have only recently colonized Denmark (first wolf in 2012, first reproduction in 2017). Danish authorities have not yet set Favourable Reference Values for wolves. However, an official expert group have analysed the potential for wolves in Denmark which sheds some light on the way that experts in a small and recently colonized country envision the future. Their analysis indicates that Denmark would have the potential to host from 11 to 30 pairs or packs (corresponding to 77 – 210 wolves) if all suitable habitat was occupied. They assume that genetic viability issues can only be achieved via connection to the wider Central European population (Germany, western Poland, Benelux countries) and that Denmark should instead focus on achieving demographic viability, which they estimate can be reached with a population of around 100 wolves (13-17 packs)when transferring data from Scandinavian models and adding a safety margin for precaution.

Source: Sunde et al. (2023).

Discussion

Overall there is an increasingly widespread use of model based approaches to set FRVs. However, there is a wide range of rationales behind the choice of specific model structures. There appears to be a widespread understanding that long-term genetic viability is the overarching goal of the Habitats Directive (corresponding to an N_e >500, or >1000 in some cases), however, in all cases it is made clear that this cannot be reached by single countries and that this must be a collective international objective. National level ambition was variously set with respect to (1) demographic viability or (2) shorter-term genetic viability or (3) taking a share of a collective goal of longer-term genetic viability, depending on national preconditions (size, habitat). A new generation of even more complex PVA models are emerging in some countries / regions that will further refine these approaches. There are however a diversity of technical approaches in use and a diversity of assumptions made about key parameters which means that different methods may produce different estimates, that will have more or less equal validity. Model based approaches underline that resulting estimates depend on many of these assumptions and on subjective choices (such as the range of acceptable probabilities of extinction, acceptable levels of inbreeding or time horizons considered). Ultimately the final choice on many of these parameters may become political decisions with national discretion because there is no legal guidance on such details, and scientific best-practices are not unified.

In contrast, there are still some countries that have FRVs that have no obvious basis beyond approximating what they had when entering the EU and assuming that they were at FCS at this point. There are other countries that present FRVs and where there may be a strong scientific basis, but where it is challenging to find the explicit links within policy documents. And many countries lack quantitative FRVs entirely.

Most countries where we could follow action plans and policy documents discussing conservation targets and FRVs were explicit in that goals for large carnivore conservation must balance conservation concerns (viability) and socio-economic concerns (diverse conflicts), such that upper limits are in placed on carnivore population growth because of conflict potential associated with high densities and certain regions.

Appendix 2 Comments from stakeholders and authorities

The draft report was circulated in advance and discussed among the commission's group of experts on reporting under the Habitats Directive on 21st November 2024 in an online meeting. The draft was then circulated among national authorities and comments were received up until the end of December from a total of 16 entities, including national authorities, individual experts and NGOs. The following is an overview of comments and some short replies. Because many questions were repeated I have organised the issues raised so that each is only addressed once. It is therefore not possible to link a set of comments to the entity that provided them. Many concrete comments on typos, suggestions of minor textual changes for clarity etc have been made directly into the draft report and are not mentioned here.

List of commentators

Individual names have been removed from the list of comments for the sake of anonymity, but institutional characteristics and countries are retained for context.

#1. Individual researcher commenting on behalf of several NGOs. Austria.
#2. Representatives of two Austrian nature management authorities.
#3. Two individual researchers providing scientific support to Austrian authorities
#4. WWF
#5. Individual scientist providing scientific support to Benelux countries
#6. Portuguese nature conservation authorities
#7. Polish biodiversity monitoring authorities
#8. Spanish nature conservation authorities
#9. Individual researcher commenting on request of German authorities
#10. Italian nature conservation authorities
#11. German nature conservation authorities
#12. European hunters NGO
13. An Austrian hunters NGO
#14. Wilderness Society
#15 Slovenian nature conservation authorities
#16 Swedish nature conservation authorities

Comments and responses

1. General comments

The respondents made many highly detailed comments, both around the general approach and specific issues, with many of them providing several pages of comments and / or many suggestions directly on the text. Overall the comments from the different individuals and institutions were very divergent. Many welcomed the initiative to develop more harmonised, robust, and specific guidelines that were linked to issues of genetical viability, transboundary cooperation and forward looking recovery goals (rather than simply minimising the risk of extinction). In contrast, a few questioned the need for any new guidance and / or viewed the targets as being much too ambitious and impossible to achieve. While some felt that the new guidelines left issues open such that Member States would exploit the subjectivity to set minimum goals, others feared that the goals may be too ambitious to be politically or socially acceptable. These different positions led to contrasting comments on the guidelines. The major conceptual developments in these new guidelines – namely the pegging of FRVs to genetical concepts like effective population size and the splitting of the FCS concept to mean different things at different scales were not commented on, hopefully implying broad tacit support.

Because of the often contrasting comments it was not possible to accept all suggestions and requests for changes. However, we have made every effort to include as many comments as possible.

In the following sections we list the main issues identified and give our brief responses to how we have responded to them.

2. Timeline

Issue raised: There was a repeated expression of concern about the time required to adopt the new approach, stating that it would be impossible to incorporate it into the 2019-2024 reporting cycle. It was also proposed to create a specialised working group within the Reporting Working Group.

Response: We agree. Not only would implementing these new guidelines require a large amount of technical and scientific analysis, they may also require multi-national coordination, planning and / or negotiation between competent authorities. We have added a new section (section 9.2) that lists the necessary first steps for implementation of these guidelines for the next reporting cycle. However, it should be possible for an external group of experts or the European Environmental Agency or a working group within Reporting experts to use the data and results from the 2019-2024 reporting process to make a first transboundary assessment of the status of European large carnivores as a pilot study to inform the next round of reporting.

3. Species scope

Issue raised: Why is the Iberian lynx not included? What is the definition of a large carnivore?

Response: There is a certain degree of subjectivity in all such groupings. Iberian lynx were excluded for several reasons, (1) they have a very limited distribution in Europe, (2) the issues with their conservation are very specific and contextual, (3) their spatial ecology is very different, using much smaller home ranges and (4) there is already a huge amount of work being done on their conservation and management, including multiple models looking at their recovery goals, viability and FRVs as well as long established cooperations between responsible authorities. In contrast wolves, bears, Eurasian lynx and wolverines are united by (1) natural low densities and high mobility, (2) high degrees of conflict, (3) very similar management issues, (4) a need to promote better international cooperation. Golden jackals are somewhat different ecologically but are also involved into the same conflict and management challenges and have recently shown a massive expansion across Europe, triggering many discussions that need clarity. The general principles in these guidelines could be applied more widely, although there would be a need to adapt them to species' ecologies and scales of movement.

4. **Social carrying capacity**

Issues raised: Many comments focused on the issue of social, cultural and economic considerations and of the need to take these into account in setting FRVs. It was also the topic with the greatest degree of divergence. On one hand, multiple respondents commented that it was essential to explicitly consider these issues in the guidelines and open for setting FRVs that are lower than what could be achieved from a purely ecological position. In other words claiming that the social carrying capacity was lower than the ecological carrying capacity and that considering this was essential to build sustainable relationships with rural people. These statements quoted Article 2(3) of the Habitats Directive "*Measures taken pursuant to this Directive shall take account of economic, social and cultural requirements and regional and local characteristics*" . In their interpretations it is clear that they view the setting of FRVs as a measure to reach overall conservation goals. On the other hand, multiple respondents quoted the same article from the Habitats Directive along with Article 288 of the Lisbon Treaty "*A directive shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods*" in support of the opposite conclusion that social, economic and cultural issues cannot overrule the ecological criteria. In this interpretation it appears that the respondents are not viewing FRVs as "measures" and "methods". The latter interpretation is also in line with existing guidelines from the European Commission which underline that only "Technical issues" can overrule ecological criteria in setting FRVs.
Response: We explicitly discuss this issue in section 5.4 of the report and also mention it as being a common issue implemented in national management plans (Appendix 1). In section 5.4 we point out the controversy in interpretation of the legal basis of the argument and identify it as an area that requires more scholarship and / or clarification by the Commission or the CJEU. It is also apparent that Article 191(3) of the TFEU (Treaty on the Functioning of the European Union) may also be relevant. We have updated the section, also in light of the opinion of the advocate general with respect to CJEU case 629/23. However, based on the widespread existing practices and on the well documented conflicts associated with large carnivores these guidelines are built on a premise that long-term tolerance for large carnivores and their long-term conservation is not necessarily enhanced by maximising local densities as opposed to promoting wide distributions and interconnected populations – in other words we also consider that social, economic and cultural need to be considered when setting realistic goals.
Issue raised: The issue of how to estimate social carrying capacity was raised.
Response: It is in principle not something that can calculated directly. Rather it is a product of negotiation between stakeholders and within society, and will almost certainly vary across time and across space.
Issue raised: Calculation of FRVs according to these guidelines requires choosing multiple parameters and setting threshold probabilities, and can be done using multiple alternative analytical approaches. The choice of these involves a certain degree of subjectivity. The subjective values chosen locally / nationally can reflect the extent to which issues like rural development and public safety are given priority over ecological issues associated with population / genetic viability.
Response: This is correct. Issues surrounding effective population size are complex and there are multiple approaches as well as many parameters with uncertain values. This does open for a certain subjectivity in choice of approach. Furthermore, the different levels of scientific knowledge for different species and populations will require different approaches in different situations. There is also a legitimate need to allow some Member State discretion. However, while there are multiple valid ways of making these calculations, there are also many invalid ways that fall outside the current best scientific practice such that the degree of subjectivity has limits.

5. **Complexity**

Issue raised. Multiple respondents commented on the complexity of the new guidelines, mentioning the complex concepts and multiple items on the checklists. They felt that it might be hard for competent authorities and stakeholders to operationalise the,
Response. There is no doubt that these new guidelines are complex, but unfortunately there are no simple answers to complex wildlife management issues. However, previous guidelines have also been complex and

non-specific. These new guidelines are at least much more specific. In section 9 we present multiple checklists and rule-of-thumb heuristics to help operationalise these guidelines. The updated version includes new information to try and make this simply.

6. **Parameter estimates**

Issue raised: The lack of specific values for key parameters and conversion factors was mentioned as an obstacle to implementation.
Response: We understand this critique. Where numbers exist we have presented them. But the fact remains that values for many key parameters and conversion factors are not readily available. Most of these can be calculated from existing data, but doing so was beyond the scope of this report's resources.

7. **Updating populations**

Issue raised: The starting point for many discussions are the population units identified in the 2008 report on population level management. In light of the expansion of wolves across Europe there are questions concerning if these remain the unit for assessment of FCS or if we should now consider new larger units.
Response: This is mainly a wolf issue because they have undergone the most dramatic expansions. It is true that most populations have now re-established some degree of connectivity with their neighbours, although this may not be enough to constitute the required level of exchange for effective connections. There have also come new barriers in the form of border security fences that have dramatically reduced the connectivity between the Baltic States and Russia / Belarus / Poland and between Hungary and Serbia / Croatia. We have expanded the text in section 7.1 to state that there is a need to revisit wolf populations and include a preliminary suggestion to consider larger units for genetic viability assessment, reducing the 9 wolf populations to 6 units (1) Nordic, (2) Baltic-Central-European, (3) Italian-Alpine, (4) Carpathian, (5) Southeast Europe, (6) Iberian. This is however highly conditional on new scientific data about geneflow and connectivity. Although the goals of wolf conservation may like to see one continuous distribution this will probably not function as a single genetic unit because of isolation by distance and the high degree of habitat fragmentation that forces sub-structuring of the population. Furthermore, such a unit would be unwieldy as a management unit.
There has been less expansion with other species. One respondent mentioned that Alpine bears should b assessed with those in the Dinaric-Pindos population. This makes sense once connection is established. A similar situation could soon exist for the Scandinavian and Karelian wolverine population.

8. **Ecological function**

Issue raised. Respondents commented that we had both too much, and too little focus on ecological function, and that it would be hard to measure. It was also mentioned that conflicts between large carnivores and hunter harvest of wild herbivores should get more attention.
Response. The issue cannot be ignored because it is mentioned, albeit obliquely, in the Habitat Directive text. Our proposal is an attempt to explicitly address it in an operational way that can be easily measured through distribution of reproductive units. However, we freely admit that this is at best an indirect measure of the extent of ecological function, but there is no practical alternative for regular monitoring in addition to a lack of conceptual understanding of what the term actually means. We have added a mention of the fact that enhanced ecological function may lead to more conflict in section 5.3.

9. **The need for a precautionary approach**

Issues raised: Multiple respondents expressed concern that any ambiguity in how the guidelines are applied might be used to opt for minimum interpretations of FRVs. They cited the need to follow the precautionary principle in interpreting the guidelines. Examples of issues include; (1) That when a range of values is produced for a parameter estimate – such as with confidence intervals – it should be best practice to at least take the mean / median value or upper value, and not always the lowest. (2) The one effective migrant per generation requirement for connectivity is really a minimum because it assumes that all populations are connected to each other, and doesn't consider the stepping stone situation where populations are only

connected in sequence i.e. populations A to B, B to C, C to D – but where A has no connection to C or D and B has no direct connection to D and C has no direct connection to A. In such cases, which reflect many European populations of large carnivore, there would need to be more. It is also underlined that effective migration doesn't just mean individuals moving and surviving, it also requires them to breed. (3) There was a suggestion to use a 100:500 rule rather than 50:500 rule as a precautionary step to reduce risks of short term inbreeding. (4) It was mentioned that it was risky to depend on gene flow from Russia because of he fact that they fall outside any conservation agreements. (5) It was pointed out that using simulations of geneflow rather than empirical measures of geneflow may lead to false conclusions. However, another respondent also pointed out that detecting all geneflow can be almost impossible in large populations, indicating that a functional surrogate would be to document continuity of the reproductive part of the population. (6) It was also pointed out that the Iberian and Italian wolves represent distinct subspecies – *Canis lupus italicus* and *C. l. signatus* which deserve specific conservation attention.
Response: We agree that these are all valid concerns and we have integrated many of the suggestions into the text by adding a section 7.10 on precautionary concerns and in 7.5 on monitoring. However, many of these issues are also too detailed to include a report of this type.

10. Hybrids

Issue raised: Concern was raised that packs of wolf-dog hybrids should not be included in the Ne estimates for wolves.
Response: We agree and have mentioned this in section 7.5.

11. National and sub-national obligations

Issues raised: Multiple respondents expressed concern that the ambiguity resulting from providing a certain degree of discretion to national or sub-national authorities might lead to interpretations for minimal large carnivore populations or that there may even be reductions in some local populations as a result of reaching overall FCS status through connection to transboundary populations. It should also be pointed out that other respondents expressed concerns that reaching these FRVs would require so many large carnivores that it was unlikely to be socially or politically acceptable. Specifically, (1) Multiple respondents referred to the "50% of carrying capacity" heuristic proposed by Epstein et al. as a minimum objective for both member states and sub-national administrative units. (2) Countries that sit at the junction between multiple populations felt that it was important to be explicit that their FRV requirements should be viewed as a cumulative national contribution rather than as population specific. (3) It was requested to make it explicit that no MS should be able to lower its population, even if it was above the FRV at the MS level until the whole population had reached its FRV for the POP level. (4) It was requested to transfer the same scaling logic applied to member states to the sub-national levels too.
Response: We have attempted to be more specific in the guidelines in sections 8 and 9 of the report. However, the reality is that Europe is a diverse place, with diverse ecological situations, an the species concerned here are very different. It is impossible to offer universal concrete numbers / parameters / guidance. In contrast, there is both an ecological and a political need to allow discretion at member state (and possibly also at sub-national levels in federal structures) levels for locally adapted implementation and for national / local level democratic structures. The philosophy of these guidelines is to provide very concrete and ambitious objectives at the larger scales (mainly transboundary) which is where the main European level concerns lie. All administrative / political levels have to ensure that these common minimum goals are reached and maintained. But after that contribution to the collective goal is reached we believe that it is only reasonable to allow a certain discretion for national / sub-national entities to decide the level of ambition and the measures used. This is the same philosophy that was articulated in the 2008 Population Approach guidelines and is simply further articulated in these new guidelines.

12. Guidance on hunting

Issue raised: One respondent requested specific guidance on ensuring that hunting / lethal control was conducted in a way that did not jeopardise reaching transboundary objectives, including issues like scientific

quota calculations, annual impact assessments and cross-border alignment of quotas as well as real time information exchange.
Response: We agree with these points and have added them under section 7.8

13. Cross border monitoring

Issue raised: One respondent mentioned the need to focus more on harmonising cross border monitoring activities and information exchange – asking for real time data exchange and specific forums for planning cross-border management.
Response: We agree have underlined this in section 7.5.

14. Status of the guidelines

Issue raised: Questions were raised as to the status of the guidelines.
Response: At present the guidelines represent the intellectual work of the authors and the others who have contributed. They do not have official legal status. As such the ideas represent a recommendation for best practice. This is clearly stated in the disclaimer on the title page. We have also adjusted the language of the document.

15. FRVs as targets

Issue raised: Several respondents pointed out that there was some confusion surround the issue of if FRVs should be viewed as realistic targets that can be achieved or if they should represent ideal and ambitious reference points that may not be reached.
Response: We have explicitly chosen to view FRVs as concrete targets that represent the level of conservation ambition that is a community obligation. Beyond this is a matter of national or sub-national discretion. Our argumentation is made clearly in section 6, but the essence is that recent CJEU rulings differentiate between management options above or below FCS which implies that in practice it is necessary for member states to be able to reach their FRVs.

In addition to these thematic issues there were many specific comments made onto the draft text concerning typos, areas that needed clarity, areas where greater precision was needed, suggestions for new references etc.

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