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Wildlife, Environment and Society

Research strategy for the period 2021-2026 for the Swedish Environmental Protection Agency's research funding from the Wildlife Management Fund

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Foreword

The Swedish Environmental Protection Agency (Swedish EPA) has a government commission to fund research on wildlife issues with grants from the Wildlife Management Fund, a responsibility the agency has held for over 50 years. The Swedish EPA views its remit as a funder of research in a broad perspective where knowledge obtained from research on wildlife must serve the needs of the agency and the needs at the regional and local management level. The County Administrative Boards and their Wildlife Management Delegations play a key role in deciding on objectives at the regional level, and the Swedish Association for Hunting and Wildlife Management, as commissioned by the Swedish Parliament, is responsible for elements of the practical management of hunting and wildlife. In addition, other authorities and organisations have different responsibilities and interests in wildlife management in Sweden. Besides, there is a great public interest in wildlife. Wildlife is an important societal resource that deliver regulating, provisioning and cultural ecosystem services. Hunting as sustainable resource use is highly accepted among the public in Sweden.

Wildlife management should be evidence based and the Swedish EPA's overall *Strategy for Swedish Wildlife Management* therefore seeks to "build wildlife management on quality-assured knowledge*"*. Funded research should be of high scientific quality and highly relevant to wildlife management and hunting. Knowledge must reach the target authorities and organisations concerned and be transferred into practice. Through excellent, relevant and well communicated research and improved understanding, wildlife management in Sweden will improve its ability to manage wildlife in an ecologically, socially, culturally and economically sustainable way.

The research, funded by the Wildlife Management Fund, has produced ground-breaking scientific results. This is stated in the international evaluation by Sæther et al. (2019) that also judge the research to provide an excellent foundation for an evidence-based management system of many wildlife species that have significant ecological impacts and/or are of great public concern in Sweden. Further, all areas of wildlife research produced high quality scientific results of high relevance for the society, and the evaluation concluded that *"*it is of uttermost importance that funding is maintained for the Swedish EPA's Scientific Committee for Wildlife Research as an arena for open competition among projects based on scientific quality and relevance".

In this document, *Wildlife, Environment and Society – Research strategy for the period 2021–2026 for the Swedish Environmental Protection Agency's research funding from the Wildlife Management Fund*, we present the framework and focus for research funding over the period 2021-2026. The strategy has been written by the Swedish EPA's Scientific Committee for Wildlife Research. It provides an account of prioritised research areas, knowledge needs underpinning the research strategy, as well as fundamental principles and conditions for its implementation. The research strategy will form the basis for the Swedish EPA's calls for research funding from the Wildlife Management Fund over the next six years.

The Swedish EPA hopes that this research strategy will promote new knowledge useful to all parties involved in wildlife management jointly working towards a long-term sustainable management of wildlife.

Björn Risinger, Director-General
Swedish Environmental Protection Agency

Stockholm, June 11, 2020

Contents

1 Introduction

This research strategy has been written by the Scientific Committee for Wildlife Research (the Wildlife Committee) on behalf of the Swedish Environmental Protection Agency (Swedish EPA). It replaces the previous strategy *Wildlife and wildlife management - Research strategy for the period 2015-2020 for the Swedish Environmental Protection Agency's research funding from the Wildlife Management Fund*.

The strategy describes priorities for research funding for the period 2021-2026 (Chapter 6). The outline includes the purpose of the strategy (Chapter 2) and the purpose of research funding from the Wildlife Management Fund (Chapter 3). The Swedish EPA as a funder of research and the Wildlife Committee are described in Chapter 4 and Chapter 5 briefly explain the process through which research priorities were identified.

The appendices offers more detailed background information, including on the Wildlife Management Fund (Appendix 1), a recent international evaluation of Swedish EPA's previously funded wildlife research (Appendix 2), knowledge needs in wildlife management now and in the future identified through surveys and work-shops, as well as through a horizon scanning exercise (Appendix 3), fundamental principles and conditions, for example, forms of support, assessment of projects and research communication (Appendix 4) and finally, outcomes of the previous research strategy (Appendix 5).

Note that if information in this strategy differs from information in the yearly research call and instructions for applicants, the latter two documents takes precedence.

2 The purpose of the research strategy

The purpose of the research strategy is to outline the focus of research that will be funded by Swedish EPA over the six-year period 2021-2026 through its resources from the Wildlife Management Fund. The strategy identifies prioritised research that are of high relevance in addressing challenges and opportunities at all levels in wildlife management, current, anticipated, as well as potential for long-term knowledge building.

The strategy is aimed at researchers that will apply for research funding. It also provides information on prioritised research areas for authorities and organisations in society that have a responsibility for wildlife management and for which the funded research is needed to inform policies and operational knowledge. The strategy is also aimed at other funders of wildlife research, for which both delimitations in responsibility and potential areas for co-funding may be of interest.

3 Purpose of research funding to support wildlife management

The basic principle of wildlife management in Sweden is that all animal species naturally present in the country are to be conserved as viable populations and managed in a sustainable way. This has been stated in governmental bills, for example *Sustainable Predator Policy* (Prop. 2012/13:191) and *Moose Management*

(Prop. 2009/10:239). These bills also highlight that wildlife management should be ecosystem-based and adaptive, and that the concept of sustainability encompasses ecological, social, cultural and economic aspects.

In *Strategy for Swedish wildlife management – with objectives and measures by the Swedish Environmental Protection Agency* (Naturvårdsverket, 2015c) a vision for wildlife management in Sweden has been formulated: "A wildlife management in balance allows everyone to experience the values of wildlife". The Swedish EPA further writes that "The vision can be viewed as a long-term objective for Swedish wildlife management and draws on the values of wildlife in a broad sense - for nature experiences and tourism, for hunting, for the provision of game meat and for the conservation of biodiversity. Everyone should have access to these values, regardless of background, gender, disabilities or other conditions. To ensure that everyone is able to appreciate wildlife, we need to further develop the sustainable use of wildlife and find new ways to manage, and if possible, prevent damages and other problems caused by wildlife".

In line with earlier research strategies (Naturvårdsverket, 2002, 2008, 2014), and based on the origin of the Wildlife Management Fund, the use of the fund regulated by the Hunting Act, and current wildlife management policy, the Wildlife Committee has formulated the following purpose of the research funding:

The purpose of the research funding through resources from the Wildlife Management Fund is to develop scientifically based knowledge to support long-term sustainable management of wildlife. Research should be focused on game or potential game species, defined as species that are or potentially may be harvested, as well as species that today or in near future will require management action to, for example, regulate numbers, distribution or to reduce damage. In addition, research on people´s relationship to wildlife and management is of crucial significance as it is people who ultimately control the goals and means of wildlife management.

In the allocation of funding, the Wildlife Committee particularly considers the knowledge needs at the Swedish EPA as the nationally responsible wildlife management authority, the County Administrative Boards (Länsstyrelserna) as regionally responsible authorities for wildlife and hunting, and the Swedish Association for Hunting and Wildlife Management (Svenska Jägareförbundet), as responsible for parts of the hunting and wildlife management in Sweden as specified in a government commission. The responsibilities for hunting and for wildlife management in general are stated in legislation, the Government's commission and authority instructions, and in the annual directions of authorization from the ministries.

In addition, several other authorities have responsibilities and tasks in wildlife management, among them the Swedish Veterinary Institute (Statens Veterinärmedicinska Anstalt), the Swedish Forest Agency (Skogsstyrelsen), the Swedish Board of Agriculture (Jordbruksverket), the Swedish Agency for Marine and Water Management (Havs- och vattenmyndigheten) and the Sami Parliament (Sametinget). Land-owners and hunters can also be regarded as stakeholders, both in the form of interest organisations and as individuals. The knowledge needs of these authorities and organisations might be considered by the Wildlife Committee when evaluating projects for relevance. However, the Wildlife Committee, and consequently also researchers applying for funding, should always consider if other sources of funding are more relevant, as the origin of the Wildlife Management Fund is the governmental fee that hunters pay, and the use of the Fund is regulated by the Hunting Act. Research particularly relevant to other land-use interests like rural industries and enterprises, as agriculture, forestry, fisheries and reindeer herding, should therefore normally be funded through other sources such as the research councils or the industry's own research funds. This may also apply to research primarily aimed at conservation.

Nevertheless, there are always questions about delimitations in responsibilities. Some research may be partially relevant from several perspectives and the Wildlife Committee encourages applicants to consider potential solutions for co-funding of research. The Wildlife Committee also welcomes initiatives from other research funding bodies to find financial collaborations on current wildlife research issues. Dialogue and cooperation are important to reduce the risk of important research falling between different remits.

4 The Swedish EPA as a funder of research

The Swedish EPA has two principal sources of funding for scientific research and other specific actions related to the task of funding research. Besides the appropriation from the Wildlife Management Fund to fund research on wildlife and management of wildlife, as described in this strategy, the Swedish EPA also administrates the Environmental Research Grant (SEK 94 million in 2020) where research is supported which focus on for example the Swedish environmental objectives. However, research relevant for wildlife management can also be funded by this grant. For more information about the Environmental Research Grant and its current research calls, see the Swedish EPA's website (www.naturvardsverket.se).

Common to all research initiatives of the Swedish EPA are that they should combine high scientific quality with high practical relevance. The Swedish EPA has a needs-driven focus for its funded research and carries out broad and systematic analysis of knowledge needs prior to funding calls. The calls are subject to competition, and decisions on allocation of funding are made following a customary and proven process of review of the scientific quality and relevance of the research applications, and competence of applicants. The Director General or the head of department at Swedish EPA decides on the funding. These decisions cannot be appealed.

The Scientific Committee for Wildlife Research (the Wildlife Committee) is the Swedish EPA's advisory expert committee for allocation of research funding from the Wildlife Management Fund and other matters concerning research on wildlife. The Wildlife Committee's principal task is to assess and prioritise research applications scientifically and in terms of relevance according to the purpose of the Wildlife Management Fund and the current research strategy. Submitted research applications relevant to the call are also externally peer reviewed before the Wildlife Committee makes a combined assessment and prioritises the applications. The Wildlife Committee makes recommendations for decisions to the Swedish EPA.

At present (in 2020) the Wildlife Committee has nine members. Five are scientists representing different research disciplines. Four are representatives of the Swedish EPA, the County Administrative Boards and the Swedish Association for Hunting and Wildlife Management. The scientific members of the Wildlife Committee are recruited nationally and internationally. More information about the Wildlife Committee is presented at the Swedish EPA's website (www.naturvardsverket.se).

5 Identification of knowledge needs in wildlife management

The prioritised areas of research in this strategy (Chapter 6) have been formulated by the Wildlife Committee following a balanced evaluation, based on particular, the knowledge needs regarding sustainable management of wildlife identified by the Swedish EPA, the County Administrative Boards and the Swedish Association for Hunting and Wildlife Management. This assessment is also based on what has emerged through interactions with different stakeholders (Appendix 3) and through evaluations of previous research (Appendix 2). The Swedish EPA and the Wildlife Committee have promoted the participation of a range of wildlife stakeholders in identifying knowledge needs through surveys of managers and researchers, and through workshops and research seminars during a yearly symposium, the Wildlife Research Days (Appendix 3). The responses to the surveys and the results from the Wildlife Research Days, show a broad consensus on key challenges and research needs today and for the next 5-10 years. The combined assessment has provided an important basis for the prioritized areas of research. This strategy is also built on the previous strategy (Naturvårdsverket 2014) as it was clear that managers and researchers agreed that the 2015-2020 strategy was still highly relevant, both in terms of relevance and prioritised research needs to support wildlife management, and that many former parts could therefore remain in the new strategy with only minor changes.

Needs for knowledge and research in relation to the challenges in wildlife management are expressed and formulated in many other contexts, for example in parliamentary bills- and government inquiries, in national management plans and in reports from government mandates. In addition, horizon scans and future research needs are identified in scientific publications and reports from researchers, universities, authorities, and organizations. In an international context, knowledge gaps and needs are documented in, for example, reports from international organizations like the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

In the research strategy the Wildlife Committee has considered many of these sources and strategic documents within research and management, which are elaborated on in the *Horizon scan* (Appendix 3), but also integrated them into other parts of the strategy. Some of these are referred to in the text (and listed in Chapter 8), but the number of relevant documents is overwhelming, and the reference list does not claim to be complete.

The recent international scientific evaluation of the wildlife research funded in 2003–2014 (Sæther et al., 2019) (Appendix 2) made the following recommendations to further improve the scientific quality and societal impact of wildlife research in Sweden: 1) establish a new integrated research programme, 2) establish a monitoring programme of selected wildlife species in Sweden, 3) facilitate recruitment of early-career scientists into wildlife research, 4) enhance EU-funding of Swedish wildlife research and 5) extend the use of modelling in Swedish wildlife research.

The Wildlife Committee has evaluated the above recommendations. The first recommendation will be examined by the Wildlife Committee in more detail during the initial years of this strategy. Before a targeted research programme can be considered, investigations regarding both the state of knowledge and research needs, and the financial conditions and the possibility of co-funding such an initiative, are needed. Recommendation two is under consideration, especially regarding responsibilities and long-term funding, as this is not currently within the scope of research funding from the Wildlife Management Fund. Recommendations three and four are discussed in Appendix 4. Recommendation five is included in the

prioritised areas of research and developed in Chapter 6. In the annual research call and instructions to applicants any initiative following from the international evaluation will be explained.

The Wildlife Committee may set different priorities than those outlined in this strategy if this is required due to developments within current wildlife management policy, or other drivers that lead to the emergence of presently unforeseen research needs.

6 Prioritised areas of research

This research strategy identifies a broad range of research topics to support evidence-based and sustainable management of wildlife in Sweden. In addition to traditional research in wildlife biology there is also a demand for research within the social sciences or the humanities. The challenges in each prioritised area of research specified below are multifaceted and complex and require intra- and interdisciplinary research. Research that crosses the boundary between academia and the wider society will also be necessary. Involvement of stakeholders and local and regional managers in the projects, from the planning stage throughout the project life-cycle, is encouraged.

After a combined assessment of all chapters and appendices in this strategy document, the following priority areas of research have been identified by the Wildlife Committee for 2021-2026:

- Complexity in wildlife biology and management
- Instruments and practices for wildlife management

Further priorities are given within each area. It is important to point out that all the areas below are inter-related in various ways and partially overlap.

6.1 Complexity in wildlife biology and management

Wildlife systems are complex and exist within larger and even more complex socio-economic systems. Wildlife management is shaped by manifold interactions between ecology, societal needs, national and international legislation and treatises. Sustainable wildlife management aims to balance a multitude of factors from different realms and is therefore inherently difficult to achieve. Research under this heading seeks to better understand how wildlife populations are likely to respond to internal and external influences and drivers, and how these populations can be sustainably managed in the face of these drivers and inevitable uncertainty.

Future wildlife management will be dependent on better understanding of three important areas:

- Multispecies management
- Conflict and collaboration
- Large-scale and system-wide changes

6.1.1 Multispecies management

Species interactions, such as predation and competition, together with landscape characteristics influence population dynamics and resource use. From a societal perspective, these interactions affect management needs, including costs and benefits of sustainable wildlife management, and the use of wildlife as a resource. However, management often focuses on one or a few target species disregarding possible cascading effects throughout the ecosystem and their sometimes unexpected outcomes. This applies to species groups that are important from a management perspective, such as small game, ungulates, large carnivores and geese. Studies of multispecies ecology and management practices, including socio-ecological aspects and development of new management methods are encouraged.

6.1.2 Conflict and collaboration

Wildlife management involves the balancing of potentially conflicting interests and ambitions. It also involves collaboration between different actors, such as land managers and hunters. Nature conservation, agriculture, forestry and hunting do not always share the same goals, and each of these activities alone involve trade-offs and tensions. For example, hunting for population control can be in conflict with hunting for recreation and wildlife as a resource for game meat. There is also a potential conflict between organisational rules, regulations, and attitudes at local, national and EU-levels, or between urban and rural interests.

The management of conflicting interests and perspectives is a research area of high relevance and importance. How can legislative frameworks, management systems and practices encourage collaboration and support conflict management? How do resilient and sustainable collaborative management systems look, and how can such systems be successfully implemented?

6.1.3 Large-scale and system-wide changes

Wildlife populations and their management are influenced by large-scale drivers, including land use and climate change as well as societal changes relating to internationalisation, urbanisation and demographic change. Adding to these are the impacts of international policies, for example, related to EU agricultural development programmes, the EU Birds and Habitats Directive and climate change mitigation and adaptation. These large-scale drivers will affect entire ecosystems including wildlife. Future wildlife management must therefore be able to adapt to these changes and incorporate an understanding of how large-scale and long-term policy, societal and environmental changes interact with wildlife, its management and use as an economic resource.

6.2 Instruments and practices for wildlife management

Successful management requires reliable and cost-effective tools for measuring the state of the wildlife management system to provide reliable data and inform models for analyses and inference. There is also a need for reliable and economically feasible long-term population surveys/monitoring, and means of analysing and evaluating monitoring data. This requires development of practical tools, theory and models. Theory is needed for successful monitoring, but is also critical in all aspects of wildlife management, including the human dimension.

While it is obvious that knowledge and understanding of wildlife population numbers and trends underpins all wildlife management, it is not the role of the Wildlife Management Fund to fund wildlife monitoring programmes per se. However, one important aspect of wildlife research is the critical evaluation of management practices and methods. Studies to assess the efficacy of existing and emerging methods in terms of accuracy and precision in relation to cost and management objectives are strongly encouraged.

The following areas of knowledge are of high priority:

- Developing, testing and quality-assuring methods for monitoring
- Theory and modelling
- Damage assessment and mitigation
- Effects of management.

6.2.1 Developing, testing and quality-assuring methods for monitoring

Current monitoring needs to be developed to encompass more game species where population data are insufficient. There is also a need to include assessment of for example invasive species, wildlife health status, genetic variation and ecosystem services provisioning. Development is also required to make use of new and emerging technologies. Climate change increases the need for development of new methodologies, for example in areas where current practices rely on snow cover. Monitoring of human attitudes and behaviours in relation to wildlife management is also important as society changes in response to demography, technology, digitalization, urbanisation and climate adaptation. There is a range of existing and emerging methods, for example: camera traps, drones, artificial intelligence (machine learning) and molecular techniques that could be developed, evaluated and refined to inform robust evidence-based management. Given that needs are large while resources limited, there is a need to prioritise cost-effective methods for population assessment and monitoring, including methods that may be used for multiple species and fulfil multiple purposes.

6.2.2 Theory and modelling

Wildlife research often involves challenges linked to complex interactions extended over space and time. Data collection is difficult. Even existing good quality data are often beset with challenges associated with limited sample size, incomplete/restricted taxonomic and low geographic coverage, and data may be absent. Consequently, theoretical and statistical modelling and the use of advanced quantitative methods are essential for reliable and robust inference, and there is a need for stronger quantitative and theoretical approaches within wildlife ecology. Development of theories and models for wildlife management should be driven by practical needs. There is a demand for user-friendly models that help wildlife managers, particularly in County Administrative Boards and Wildlife Management Delegations, to plan for and forecast population development and to assess the effects of protective and license hunting under different scenarios, as well as models that support decision-making despite imperfect knowledge and uncertainty.

6.2.3 Damage assessment and mitigation

The economic damage caused by expanding and increasing wildlife populations, for example wild boar, fallow deer, red deer and some goose species, creates a need for research-based knowledge on the level of damage, economic cost, as well as damage prevention and mitigation measures. There is also a demand for

assessment of fodder resources as for example, the relationship between ungulate population densities, fodder availability, and damage levels in forestry, is still not fully understood. Societal costs related to damage, damage prevention and compensation to those who are negatively affected by wildlife are high. What are the most cost-effective and/or best legal, economic, and informal governance approaches to minimize those negative impacts? Research to develop and test methods to avoid, reduce and assess damage to for example agriculture and forestry, while also taking in to account wildlife as a resource and hunting interests (Chapter 3), is encouraged.

6.2.4 Effects of management

There is a need to scientifically evaluate the effects of wildlife management actions (ecologically, economically, socially and culturally) and their practical feasibility, as well as compiling existing data and experience from successful examples (best practices). Evaluating the effects of management decisions and practices is integral to adaptive management. Adaptive management implies the continual evaluation and correction of decisions, and the principles and tools for such procedures in wildlife management should be the focus of future research.

The principles of adaptive management are dynamic and context-dependent and further research toward sustainable and robust adaptive management is desirable. In addition, public attitudes to uncertainty about the outcomes of societal actions are highly relevant in wildlife management and must be incorporated into successful management practices.

7 Implementation of the strategy

The government appropriation from the Wildlife Management Fund to the Swedish EPA for funding of research and research administration was SEK 18 million for 2020, and the budget has remained the same since 2012. The Wildlife Committee has assessed the present-day budget situation and found that a budget which increases in line with inflation and increased costs at universities, is necessary to fully implement the 2021-2026 research strategy, i.e. to fund research within all prioritised areas of research (Chapter 6). With the current budget (2020) it is not possible to implement all the suggested recommendations required to strengthen wildlife research as laid out in the recent international evaluation (Sæther et al., 2019). However, the potential for both new and larger initiatives in line with the strategy and the international evaluation would improve if funding resources are increased.

8 References

Aas, Ø., Indset, M., Prip, C., Platjouw, F. M. & Singsaas, F.T. 2020. Ecosystem-based management: Miracle or Mirage? Mapping and rapid evidence assessment of international and Nordic research literature on ecosystem-based management. NINA Report 1802. Norwegian Institute for Nature Research.

Andrén, H., Kjellander, P., Liberg, O., Persson, J., Sand, H., & Wikenros, C. 2018. De stora rovdjurens effekter på annat vilt och tamren. Naturvårdsverket rapport 6792. ISBN 978-91-620-6792-2

Backlund, L. 2019. Från Rovdjursforum till Rovbase – när Sverige bytte databas för rovdjursinventeringar. Naturvårdsverket rapport 6878. ISBN 978-91-620-6878-3.

Boyce, M. S., Hudson, P. J. & Ranta E. 2002. International review of Swedish Wildlife Research 1997–2001 funded by the Swedish Environmental Protection Agency and the Swedish Association for Hunting and Wildlife Management. Swedish Environmental Protection Agency, Report 5179.

Eide, W. et al. (red.). 2020. Tillstånd och trender för arter och deras livsmiljöer – rödlistade arter i Sverige 2020. SLU Artdatabanken rapporterar 24. SLU Artdatabanken, Uppsala.

Eklund, A., López-Bao, J., Tourani, M. *et al.* 2017. Limited evidence on the effectiveness of interventions to reduce livestock predation by large carnivores. *Sci Rep* **7,** 2097. https://doi.org/10.1038/s41598-017-02323-w.

Erikson, M. 2016. Changing attitudes to Swedish wolf policy: wolf return, rural areas, and political alienation. Diss. Umeå. Statsvetenskapliga institutionen, Umeå universitet. ISBN 978-91-7601-632-9.
EU Regulation 1143/2014. 2015. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1417443504720&uri=CELEX:32014R1143.

Forsberg, A., Sjögren-Gulve, P. & Lundvall, A. 2018. Webbaserad enkät om viltforskningen finansierad av Naturvårdsverket 2004–2014. Naturvårdsverket rapport 6831. ISBN 978-91-620-6831-8.

Gren, I-M., Andersson, H & Elofsson, K. 2019. Kostnader och värden av vildsvin i Sverige. DOI: 10.13140/RG.2.2.24675.71202.

Havs- och vattenmyndigheten [Swedish Agency for Marine and Water Management]. 2012. Nationell förvaltningsplan för knubbsäl (Phoca vitulina) i Kattegatt och Skagerrak.

Havs- och vattenmyndigheten [Swedish Agency for Marine and Water Management]. 2018a. Faktablad för att bedöma god miljöstatus enligt havsmiljöförordningen. 1.2D Abundans och trender av knubbsäl. https://www.havochvatten.se/download/18.73800df2167072a23ab85993/1549541359566/faktablad-1-2-d-abundans-och-trender-av-knubbsal.pdf.

Havs- och vattenmyndigheten [Swedish Agency for Marine and Water Management]. 2018b. Faktablad för att bedöma god miljöstatus enligt havsmiljödirektivet. 1.2E Abundans och trender för vikaresäl. https://www.havochvatten.se/download/18.73800df2167072a23ab859ab/1542893185668/faktablad-1-2-e-abundans-och-trender-for-vikaresal.pdf.

Havs- och vattenmyndigheten [Swedish Agency for Marine and Water Management]. 2019. Nationell förvaltningsplan för gråsäl (Halichoerus grypus) i Östersjön. Havs- och vattenmyndigheten rapport 2019:24.

IPBES (2018): Summary for policymakers of the regional assessment report on biodiversity and ecosystem services for Europe and Central Asia of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. M. Fischer, M. Rounsevell, A. Torre-Marin Rando, A. Mader, A. Church, M. Elbakidze, V. Elias, T. Hahn, P.A. Harrison, J. Hauck, B. Martín-López, I. Ring, C. Sandström, I. Sousa Pinto, P. Visconti, N.E. Zimmermann & M. Christie (eds.). IPBES secretariat, Bonn, Germany. 48 pages https://doi.org/10.5281/zenodo.3237428.

Jarnemo, A., Mysterud, A., Kjellander, P., Nöremark, M., Sand, H., Wikenros, C., & Andrén, H. 2019. Avmagringssjuka (CWD) hos hjortdjur. Naturvårdsverket rapport 6896. ISBN 978-91-620-6896-7.

Jordbruksverket [The Swedish Board of Agriculture]. 2019. Rapport − Uppdrag att bedöma behovet av förebyggande åtgärder för att hindra introduktion och spridning av afrikansk svinpest i Sverige.

Liberg O., Suutarinen, J., Andren, H.,Åkesson, M., Wabakken, P., Wikenros, C. & Sand, H. 2020. Poaching-related disappearance rate of wolves in Sweden was positively related to population size and negatively to legal culling. Biological Conservation.
https://www.sciencedirect.com/science/article/pii/S0006320719311498.

Manfredo et al. 2020. The changing sociocultural context of wildlife conservation. Conservation Biology. https://conbio.onlinelibrary.wiley.com/doi/abs/10.1111/cobi.13493.

Miljödepartementet. 2011. Överenskommelse mellan Sverige och Norge om förvaltning av genetiskt värdefulla vargar i den skandinaviska vargpopulationen. Ärendenr. M2011/2777/Nm.

Naturvårdsverket [Swedish EPA]. 2002. Forskning för hållbar förvaltning av vilt - Ramprogram för perioden 2003–2007 för Naturvårdsverkets medel ur Viltvårdsfonden.

Naturvårdsverket [Swedish EPA]. 2008. Forskning för hållbar förvaltning av vilt - Ramprogram för perioden 2009–2014 för Naturvårdsverkets medel ur Viltvårdsfonden.

Naturvårdsverket [Swedish EPA]. 2014a. Viltet och viltförvaltningen - Forskningsstrategi för perioden 2015–2020 för Naturvårdsverkets forskningsmedel ur Viltvårdsfonden.

Naturvårdsverket [Swedish EPA]. 2014b. Nationell förvaltningsplan för skarv.

Naturvårdsverket [Swedish EPA]. 2015a. En ny ekosystembaserad älgförvaltning i sikte. Naturvårdsverket rapport 6659. ISBN 978-91-620-6659-8.

Naturvårdsverket [Swedish EPA]. 2015b. En utvärdering av svensk kronhjortsförvaltning. Naturvårdsverket rapport 6673. ISBN 978-91-620-6673-4.

Naturvårdsverket [Swedish EPA]. 2015c. Strategi för svensk viltförvaltning. ISBN 978-91-620-8797-5.

Naturvårdsverket [Swedish EPA]. 2016a. Nationell förvaltningsplan. Vilt. Björn. ISBN 978-91-620-8761-6.

Naturvårdsverket [Swedish EPA]. 2016b. Nationell förvaltningsplan. Vilt. Varg. ISBN 978-91-620-8758-6.

Naturvårdsverket [Swedish EPA]. 2016c. Nationell förvaltningsplan. Vilt. Järv. ISBN 978-91-620-8759-3.

Naturvårdsverket [Swedish EPA]. 2016d. Nationell förvaltningsplan. Vilt. Lodjur. ISBN 978-91-620-8760-9.

Naturvårdsverket [Swedish EPA]. 2018a. Slutredovisning av uppdrag att koordinera genomförandet av grön infrastruktur i Sverige (M2015/684/Nm). Ärendenr. NV-01521-15.

Naturvårdsverket [Swedish EPA]. 2018b. Klövvilt och grön infrastruktur. Vägledning om klövvilt och regionala handlingsplaner för grön infrastruktur.

Naturvårdsverket [Swedish EPA]. 2018c. Beskrivning av det skandinaviska inventeringssystemet för stora rovdjur. Naturvårdsverket rapport 6830. ISBN 978-91-620-6830-1.

Naturvårdsverket [Swedish EPA]. 2018d. Hur fungerar inventeringssystemet för rovdjur i Sverige? En utvärdering med fokus på organisation, ansvar och samverkan. Naturvårdsverket rapport 6892. ISBN 978-91-620-6892-9.

Naturvårdsverket [Swedish EPA]. 2018e. Uppföljning av mål inom älgförvaltningen-redovisning av regeringsuppdrag. Ärendenr: NV-08872-17.

Naturvårdsverket [Swedish EPA]. 2019a. Viltvårdsavgiften - En studie av svenskarnas vilja att betala det statliga jaktkortet. Naturvårdsverket rapport 6853. ISBN 978-91-620-6853-0.

Naturvårdsverket [Swedish EPA]. 2019b. Underlag till regeringens klimatpolitiska handlingsplan. Redovisning av Naturvårdsverkets regeringsuppdrag. Naturvårdsverket rapport 6879. ISBN 978-91-620-6879-0

Naturvårdsverket [Swedish EPA]. 2019c. Fördjupad utvärdering av miljömålen 2019 – med förslag till regeringen från myndigheter i samverkan. Naturvårdsverkets rapport 6865. ISBN 978-91-620-6865-3.

Naturvårdsverket [Swedish EPA]. 2019d. Delredovisning av regeringsuppdraget Konventionen om biologisk mångfald. Ärendenr. Nv-05496-19.

Naturvårdsverket [Swedish EPA]. 2020. Nationell förvaltningsplan för vildsvin. ISBN 978-91-620-6921-6.

Proposition 1999/2000:73. Jaktens villkor.

Proposition 2008/09:210. En ny rovdjursförvaltning.

Proposition 2009/10:239. Älgförvaltningen.

Proposition 2012/13:191 En hållbar rovdjurspolitik.

Proposition. 2016/17:104. En livsmedelsstrategi för Sverige − fler jobb och hållbar tillväxt i hela landet.

Sæther, B-E., Boyce, M. S., Hovelsrud, G. K., Lundhede, T., Merilä, J. & Nudds, T. D. International evaluation of Swedish Wildlife Research 2003–2014 - funded by the Swedish Environmental Protection Agency through the Wildlife Management Fund. Naturvårdsverket rapport 6852. ISBN 978-91-620-6852-3.

Sandström, U. 2014. Bibliometric evaluation of SEPA-funded large research programs 2003–2013. Naturvårdsverket rapport 6636. ISBN 978-91-620-6636-2.

Sandström, U. 2018. Bibliometrisk rapport – Naturvårdsverkets viltforskning 2003–2014. Naturvårdsverket rapport 6832.

SFS 1987:259. Jaktlagen.

SFS 1987:905. Jaktförordning.

SOU 2012:20. Kvalitetssäkring av forskning och utveckling vid statliga myndigheter. Betänkande av Utredningen om Kvalitetssäkring av forskning och utveckling vid statliga myndigheter.

SOU 2013:43. Långsiktigt hållbar markanvändning. Delbetänkande av Miljömålsberedningen.

SOU 2013:71. Viltmyndigheten – jakt och viltförvaltning i en ny tid.

SOU 2016:26. På väg mot en ny politik för Sveriges landsbygder– landsbygdernas utveckling, möjligheter och utmaningar. Delbetänkande av Parlamentariska Landsbygdskommittén.

SOU 2017:1. För Sveriges landsbygder – en sammanhållen politik för arbete, hållbar tillväxt och välfärd. Slutbetänkande av Parlamentariska landsbygdskommittén.

SOU 2019:22. Sveriges miljöövervakning – dess uppgift och organisation för en god miljöförvaltning. Del 1 & 2. Betänkande av Utredningen om översyn av miljöövervakningen.

von Essen, E., Hansen, H.P., Nordström Källström, H., Peterson, M.N., & Peterson, T.R. 2014. "The radicalisation of rural resistance: How hunting counter publics in the Nordic countries contribute to illegal hunting." Journal of Rural Studies. no. 39, p. 199-209.

Widemo, F., Elmhagen, B, & Liljebäck, N. 2019. Viltets ekosystemtjänster. En kunskapssammanställning. Naturvårdsverket rapport 6889. ISBN 978-91-620-6889-9.

Wiklund, E & Malmfors, G. 2014. Viltkött som resurs. Naturvårdsverket rapport 6635. ISBN 978-91-620-6635-2.

Öhrman, P., Ericsson, G & Sandström, C. 2019. En studie om tillit till inventeringssystemet för stora rovdjur. Naturvårdsverket rapport 6893. ISBN 978-91-620-6893-6.

Appendix 1: The Wildlife Management Fund – purpose and use

The Wildlife management fee (Viltvårdsavgiften) was introduced in 1938 and is set by the Government. Everyone who hunts in a given year must pay the fee and then receives a state hunting permit (in Swedish statligt jaktkort) valid for that year. At present (in 2020) the fee is SEK 300 for a hunting year, running from July 1 to June 30. The registration system for fees, the Swedish Hunting Registry (Jägarregistret), is administered by the Swedish EPA, but the resultant fund is administered by the Insurance Department (Kammarkollegiet) as the Wildlife Management Fund. The size of the Fund and the resources from the Fund which thus can be distributed by the Government (Ministry of Enterprise and Innovation) (Näringsdepartementet) depend on the number of paying hunters and the asset management of the Fund. The number of hunters paying the Wildlife management fee was approximately 287 000 in the hunting year 2018/2019 (www.naturvardsverket.se).

The Ministry of Enterprise and Innovation annually grants resources from the Wildlife Management Fund to authorities and organisations for activities in accordance with the purpose of the Fund, both for wildlife management and for research funding. Under the Hunting Act, the Wildlife Management Fund is to be used to “promote wildlife management or other similar aims which are compatible with the purpose of this law” (SFS 1987:259, Section 41). Wildlife (in Swedish vilt) is defined as all species of wild mammals and birds (SFS 1987:259, Section 2) and wildlife must be “managed with the aim of conserving the wildlife species that belong to the country’s wildlife populations and the bird species that occasionally occur naturally in the country, and promote an appropriate development of the wildlife populations in consideration of general and individual interests” (SFS 1987:259, Section 4). Forty-two wildlife species are hunted regularly (general hunting season) and another approximately 20 species can be hunted under license or protective hunting (SFS 1987:905).

The Government has assigned the Swedish EPA the task of funding needs-driven research to support wildlife management with resources from the Wildlife Management Fund since 1968. Research projects and other initiatives have been funded under specific research strategies since 1973. The assignment is based on an annual application from the Swedish EPA to the Ministry for Enterprise and Innovation for resources from the Wildlife Management Fund to fund research according to the current research strategy. The continuity of the assignment shows that the Government has high confidence in the Swedish EPA's management of research funding. The Government Bill *Conditions for Hunting* (Prop. 1999/2000:73) clarified the responsibility of the Swedish EPA for distributing research funding from the Wildlife Management Fund. This responsibility is in addition clarified by the Ministry through their annual budget decision.

The Swedish EPA is granted money from the Wildlife Management Fund for research funding and research administration (2019: SEK 18 million), and to administer the Hunter Registry and the Registry of hunter examinations (2019: SEK 6.1 million). In addition, the Swedish EPA received SEK 1 million from the Fund in 2019 to support the Swedish Museum of Natural History (Naturhistoriska Riksmuseet) for its monitoring of the health status of seal populations. The greater part of the Government's annual allocation of resources from the Fund goes to hunting organisations for wildlife management purposes. The Swedish Association for Hunting and Wildlife Management (Svenska Jägareförbundet) received funding for its work regarding hunting and game management in practice, called the Hunting and Wildlife Management Commission (Jakt och viltvårdsuppdraget). This includes providing competence and information on hunting and wildlife management, wildlife monitoring, ungulate management, wildlife and traffic as well as education of hunters (2019: SEK 52.2 million). The National Association of Huntsmen (Jägarnas Riksförbund) received a basic grant and a membership-related grant (2019: SEK 7.7 million). The National Veterinary Institute (Statens Veterinärmedicinska anstalt) received funding for its wildlife related work (2019: SEK 5 million). The County Administrative Boards received funding for administration of wildlife management areas (2019: SEK 0.6 million), the Swedish Police for tracking down wildlife wounded in traffic accidents (2019: SEK 1.0 million) and the Swedish Society for Nature Conservation (Svenska Naturskyddsföreningen) for projects on White-backed woodpecker and Peregrine falcon (2019: SEK 0.4 million). In addition, other authorities, for example the Swedish Forest Agency (Skogsstyrelsen) and the Swedish University of Agricultural Sciences (Sveriges Lantbruksuniversitet), have periodically received grants from the Fund for specific assignments or projects related to wildlife. Further information about the distribution of resources from the Wildlife Management Fund can be found on the Swedish EPA´s website (www.naturvardsverket.se).

Appendix 2: International evaluation of Swedish Wildlife research 2003-2014

The Wildlife Committee encouraged the Swedish EPA to conduct an international scientific evaluation of the wildlife research funded during 2003 to 2014 (two different research strategies). The evaluation consisted of three parts: 1) a bibliometric evaluation of the research (Sandström, 2018), 2) an evaluation of the relevance of the funded research for Swedish wildlife management (Forsberg et al., 2018), and 3) an assessment performed by an international scientific evaluation panel that incorporated aspects of the first two parts provided by the Swedish EPA (Sæther et al., 2019). The bibliometric evaluation and the relevance evaluation are presented in Appendix 3 and 4.

The international scientific evaluation by Sæther et al. (2019) concluded that "Swedish wildlife research projects funded by Swedish EPA from the Wildlife Management Fund over the period 2003–2014 produced high quality scientific results highly relevant to society generally and which provided an excellent foundation for an evidence-based management system for many wildlife species with significant ecological impacts and/or of great public concern in Sweden. The projects included in this evaluation probably represented for SEPA one of the most important sources for an evidence-based decision-making about management of wildlife in Sweden. Some of the insights gained through these projects also had an influence on the development of ecology as a research discipline". The evaluation panel noted that Swedish wildlife researchers are developing novel research approaches that merge scientists from social and economic research disciplines with wildlife biologists into interdisciplinary research projects. The interdisciplinary focus in Swedish wildlife research has been implemented by an increase in the number of projects in social and economic sciences as well as in projects involving researchers from different research disciplines, and this is considered as special characteristic of wildlife research in Sweden. Thus, Sæther et al. (2019) concluded that it is of "uttermost importance that funding is maintained for the Swedish EPA's Scientific Committee for Wildlife Research as an arena for open competition among projects based on scientific quality and relevance". The small game research was graded excellent (waterfowl research) and very good (grouse-related research). The ungulate research was graded excellent and the carnivore research outstanding. The social and economic research was graded very good. The integrated research programme *Adaptive Management of Wildlife and Fish* was graded outstanding.

The evaluation panel made the following five overall recommendations to further improve the scientific quality and societal impact of wildlife research in Sweden: 1) establish a new integrated research programme, 2) establish a monitoring programme of selected wildlife species in Sweden, 3) facilitate recruitment of early-career scientists into wildlife research, 4) enhance EU-funding of Swedish wildlife research and 5) extend the use of modelling in Swedish wildlife research.

Appendix 3: Surveys, work-shops and horizon scan

Surveys and work-shops

As a part of the evaluation of the wildlife research funded 2003–2014 by the Swedish EPA, a web-based survey was carried out in 2017 among wildlife managers, researchers and other stakeholders (Forsberg et al., 2018). The objective was to examine to what extent the funded research had delivered relevant and usable results and knowledge, if the results had been effectively disseminated and communicated, and if any important aspects were missing. The majority of the respondents who expressed an opinion found that the wildlife research had contributed useful knowledge for sustainable wildlife management at national, regional and local scales. Many respondents also specified needs for more research, foremost socioeconomic and other social science investigations regarding wildlife issues, but also research on multispecies management, large carnivores and prevention of wildlife damages. Most respondents stated that multidisciplinary research had not been funded to the extent necessary. Most respondents also stated that reviews of existing scientific knowledge on wildlife biology and management were not produced to the extent needed.

In 2019, the Swedish EPA conducted a web-survey among the employees. The survey is conducted every four years with the aim of identifying areas for future research priorities based on knowledge needs within

the agency. The highlighted wildlife-related challenges were, for example, the effects of climate change, the development of dialog-processes to handle and mitigate complex issues and conflicts within wildlife management, and the effects of cormorants on fish, ecosystems and fisheries.

During the Wildlife Research Days in Stockholm 12-13 November 2019 a workshop was held with the purpose to contribute to the basis for this new research strategy. It was co-organized with the Swedish EPA's annual conference on wildlife management and in cooperation with the Swedish Association for Hunting and Wildlife Management. The participants, 120 wildlife professionals (managers and researchers), should identify current and future (5-10 years perspective) knowledge needs to support sustainable wildlife management. They generally stressed that the research strategy for 2015-2020 remained relevant, and that only minor revisions were needed, but that the new strategy could be more precise and have more clear priorities. The discussion groups identified a number of research areas including adaptive management of two multispecies systems (ungulates and large carnivores as well as the seal-cormorants-fish-seabird-system), wildlife damages and preventive methods, effects of climate change, effects of altered land use in agriculture and forestry, urban wildlife, changes in distribution and abundance of existing and non-native (including invasive) species. Generally, the discussion groups stressed the need for a better understanding of the socio-ecological systems, including concerns about the future management of wildlife against the background of changing numbers of hunters and hunting communities and urbanization, which may affect management practices and attitudes towards hunting. Buzzwords in all discussions were cooperation, dialogue, confidence and how to build trust, participation and acceptance. In addition to knowledge and research needs, the participants emphasized a need for improved wildlife monitoring to achieve adaptive management (as well as evaluation of present monitoring schemes). Such monitoring should include more wildlife species than today, as well as fodder, wildlife diseases, and damages and other impacts from wildlife. The participants even asked for more knowledge compilations, syntheses, policy briefs and management guidelines. The need for greater involvement of management/stakeholders in the research projects, throughout the project life-cycle, and better communication between management and research were also identified, along with a need to speed up communication of results to promote and quicken the use of new knowledge.

Horizon scan

The challenges and opportunities of wildlife management, as well as the needs for new knowledge, are described in many documents. This horizon scan refers to literature examined by the Wildlife Committee in its assessment of research needs to support wildlife management today and in the future. Several of these are also referred to in other parts of this strategy where appropriate. Many, but not all, knowledge needs identified in the horizon scan below have been highlighted by the Wildlife Committee within the priority research areas of the strategy (Chapter 6).

In the previous research strategy (Naturvårdsverket, 2014a) many changes were identified, for example ecological and environmental changes, and changes within wildlife management and in wider society, that affect or might affect the management, and consequently also the need for support in terms of new knowledge and new management tools. Some of these factors are still relevant and of concern, and new have emerged.

Many of the challenges in wildlife management are not exclusively issues concerning animal populations and their habitats (to be addressed by the natural sciences), but also relate to people and society. Issues

central to the social science and the humanities such as power, democracy, legitimacy, administrative systems, policy instruments, ethics and, not least, human values are topical in this as well as in the previous research strategy. A societal and governance perspective on wildlife management is of vital importance to understand and predict acceptance of prospective management measures by different groups in society, and the potential for conflict. This can help determining the feasibility of different management approaches and their potential for implementation.

Previous research (Manfredo et al., 2020) show that changes in society (e.g. urbanisation, internationalisation, and views on nature changing from utilitarian to preservationist) can have an impact on views on hunting and other forms of wildlife management both among hunters and non-hunters. Social media is increasingly used in debates over wildlife management, but also as a forum to connect interest groups, and for hunters it can provide means to learn new hunting and management approaches. Our understanding of what impact these changes and mechanisms might have for wildlife management is still relatively poor. The future role of hunting and hunters in wildlife management must be analysed concerning the status of hunting in society, not least, processes of change that may affect the size and capacity of the hunting community (economic, social, cultural and demographic factors). The numbers of hunters are decreasing, and the average age is increasing (Naturvårdsverket, 2019a). At the same time, numbers of hunting women are increasing. A small proportion of the hunters live close to where they hunt. Hunting practices are also changing with for example new forms of hunting, new technology and changing uses of dogs.

The government inquiry *Wildlife Authority - hunting and wildlife management in a new age* (SOU 2013:71) concluded that contemporary game populations are unusually abundant in a historical perspective. This has led to increased damage to agriculture by wild boar and geese, to forestry by ungulates, to reindeer husbandry by carnivores, to commercial fishing by seals and cormorants, and to an increased number of traffic accidents involving wildlife. However, the inquiry also highlighted wildlife as a growing resource in society. Moreover, not all wildlife populations are increasing. A recent analysis of population sizes and trends for wildlife species during the last thirty years estimates that for example, moose and roe deer populations have decreased, while fallow deer, red deer and wild boar have shown strong increases in range and/or abundance (Widemo et al., 2019). Capercaillie has a stable population, but mountain hare and European hare are decreasing. Large carnivores have increased during the last thirty years, however, the population trend for lynx is difficult to interpret. All seal species have increased during the last decade, but the rate of population growth differed between species and populations (Havs- och vattenmyndighten, 2018a-b and 2019). Many seabirds show decreasing populations. The recent biodiversity assessment (Red List) from SLU Swedish Species Information Centre (Artdatabanken) classifies several game species as vulnerable, near threatened or endangered (Eide et al., 2020).

The Swedish EPA has a governmental mandate to review the timing of the hunting seasons. The present review is ongoing (2020) but has produced two referral versions. They show that we lack updated monitoring data of sufficient quality for several small game species (population status and trend). There is also a concern that reproduction patterns of for example red fox, mountain hare and beaver may have changed in response to climate change. Research on the underlying drivers of these population changes and potential implications for sustainable hunting is needed.

Invasive species are one of the greatest threats to biodiversity both in terrestrial and in aquatic environments (IPBES, 2018). There is a risk that species are introduced, for example through the effects of increasing global and regional transport of goods and people. Climate change may also facilitate the expansion of already established invasive species. To protect the environment and society from the dispersal and damage

caused by invasive alien species the EU has decided on regulation management (EU Regulation 1143/2014, 2015). At present, 16 birds and mammals are listed as invasive in the EU, and some of these species are already established in Sweden. The Swedish EPA is presently (2020) funding measures which, in line with EU regulations, aims to eradicate for example raccoon dog and muskrat. A greater understanding of the threats and mitigation of existing and potential invading species is needed.

Changing wildlife populations call for research to support the evaluation and development of both existing and new management practices aimed at managing population sizes and distributions. Managers need population modelling, including multi-species and harvest models, that could be used to set hunting quotas and predict short and long-term consequences of different management decisions. Previous evaluations of research funded by the Swedish EPA (Boyce et al., 2002, Sæther et al., 2019) recommend the Swedish EPA to fund more research which aims to develop theoretical models and advanced quantitative methods that fulfil this need.

There is also a need to scientifically evaluate the effects of management actions (ecologically, economically, socially and culturally) and their practical feasibility, as well as compiling existing data and experience from successful examples (best practices). Wildlife management authorities and organisations are responsible for evaluating effects of their management practices, which needs to be supported by the scientific studies. Research contributing to knowledge on the effects of existing management actions as well as development of new practices, is of high priority. Research on the effects of hunting and wildlife management actions has been emphasised as a priority in previous research strategies, but few research projects have earlier addressed these questions. Experimental approaches for testing the effects of various actions are particularly crucial, but expensive. Comprehensive reviews of knowledge from previous research and experience from management, with international outlooks, should when appropriate be performed before full-scale scientific experiments. It is usually possible to apply for funding of such initiatives in the annual research calls for the Wildlife Management Fund.

The single-species perspective in Swedish wildlife management has been, and is, successful in many contexts and is still needed for certain species. However, many present-day challenges in wildlife management require a broader perspective, where interactions between several species, their habitats, food resources and underpinning drivers of population change (e.g., climate change, land use change) are addressed. Awareness that actions aimed at one species have indirect effects on other parts of the system has led to wildlife management with increased focus on multi-species systems. Even if research focusing on multi-species management (both ecological and social science) was funded under the previous research strategy, it continues to be highly relevant to wildlife management also in this strategy.

The need to understand multi-species systems and the outcome of predation and competition can be exemplified by several population trends. In many areas, wild boar, fallow deer and red deer are expanding in number and geographical distribution where roe deer and moose previously dominated the ungulate community. Large carnivores are also present in the systems to a varying degree, and there are areas where all four large carnivores (brown bear, lynx, wolverine and wolf) co-occur. Brown bear, lynx and wolverine are expanding south, and wild boar, fallow deer and red deer are expanding north. What, for example, will be the overall effect of these predators on the density and structure of the ungulate populations, and thus the possibility for hunting? How is the vegetation affected? Are there cascading effects across trophic levels? These research questions also apply to small game species such as birds and smaller carnivores. To achieve ecosystem management, knowledge is additionally required on the direct and indirect effects of these interactions on other parts of the ecosystem.

If the ecosystem perspective is expanded to socio-ecological systems, knowledge is required on how wildlife affects and is affected by people and their interests and activities. Experiences from ecosystem-based management of natural resources show high demands on collaboration and communication between actors at different management levels in society. A main conclusion from a recent systematic review of ecosystem-based management and governance is a need for more critical studies and monitoring studies addressing the (lack of) improvement and change of decision-making processes in sectoral policy integration (Aas et al., 2020). Studies of multi-species and socio-ecological systems may require large resources, particularly if they include extensive experimental designs with multiple study areas. Since this area has high priority in both research and management, from both the scientific and management points of view, a more targeted effort may be warranted.

Measures to create green infrastructure in the landscape has gained attention in Sweden (Naturvårdsverket, 2018a) and can be expected to receive more attention in the future at all levels of management. Green infrastructure can be defined as ecologically functional networks of habitats and structures, natural areas and landscaped elements that are designed, used and managed in a way that preserves biodiversity and promotes important ecosystem services throughout the landscape. In practice, green infrastructure involves protection, conservation, restoration and recreation of habitats, ecosystem functions and natural processes to be considered in both physical planning and ongoing land and water use, as well as in the use and management of natural resources. Preservation and efforts for green infrastructure should be considered as obvious assets for local and regional development, and in this context, wildlife and its ecosystem services and disservices. Research on how the needs of wildlife can be addressed and considered in the County Administrative Boards' regional action plans for green infrastructure and in physical planning of for example infrastructure is needed. The Swedish EPA’s guidance document about ungulates and regional management plans for green infrastructure shows the importance of research-based knowledge (or lack of) in order to be able to find trade-offs between various interests in society (Naturvårdsverket, 2018b).

The expansion of human settlement into rural areas and the expansion of wildlife into urban areas possess several challenges to wildlife and people ranging from damage to property and business, wildlife collisions and disease risk. Wildlife management seek to better understand the positive and negative effects of wildlife in urban areas, and how negative impacts can be mitigated and prevented.

Changing land use within rural industries and enterprise affect wildlife directly and indirectly, and national and international legislation and support systems are important drivers. One example is EU's Common Agricultural Policy (CAP). It is well known that CAP affects several wildlife species associated with the agricultural landscape. In addition, land use in agriculture is affected by ongoing climate change. Some species benefit from the changes, other species are disadvantaged. A better understanding of how game species will be affected by CAP and other international agreements and directives is needed. Similarly, changes in forestry practices, under the influence of both climate change and international conventions have effects. Expected effects of climate change, for example shortage of water, droughts and changing temperature zones (Naturvårdsverket, 2019b), combined with changing practices within forestry and agriculture may have a strong impact on wildlife and wildlife management. An important knowledge need is the development of methods for habitat management in agriculture and forestry that favour wildlife and maintaining production at the same time.

A circular bio-based economy is highlighted by many as an important development in society (Naturvårdsverket, 2019d). The transition to a bio-based economy involves a change from a fossil fuel-based economy to a more resource-efficient economy based on renewable raw materials produced through the sustainable use of ecosystem services. Increased productivity and the production of new types of biomass

can impact other types of land use, forests and water, and thus have socio-economic consequences for hunting and other uses of wildlife as a resource. This transition might therefore, for example, increase land use conflicts, as demand and competition for natural resources is expected to increase.

The prevention of damage and other problems caused by wildlife is one out of five directions to develop Swedish wildlife management that was highlighted by Swedish EPA in the *Strategy for Swedish Wildlife Management* (Naturvårdsverket, 2015c). There is a great need for research-based knowledge about damage prevention measures to assess and mitigate damages caused by wildlife. One example is damages caused by wild boar in agriculture. Boar damages were estimated for more than SEK 1 billion in 2015 (Gren et al., 2019). In the Swedish EPA's management plan for wild boar (Naturvårdsverket, 2020), one goal is that the costs of wild boar's damage to crops should be halved and less than SEK 500 million per year by 2025. All present national management plans for wildlife (Naturvårdsverket, 2014b, 2016a-d, 2020 and Havs- och vattenmyndigheten 2012, 2019) includes targets and measures for both reduced damages and mitigating conflicts. The management of red deer has been evaluated and knowledge needs identified includes effects of preventive measures to reduce damages (Naturvårdsverket, 2015b). The Swedish EPA is developing new national management plans for large grazing birds (geese, cranes and swans) and for moose and red deer (2020) which will include these issues. There is a need to scientifically assess and evaluate the effects of different management actions (ecologically, economically, socially and culturally) aimed at reducing damages by wildlife in agriculture and forestry. A variety of permanent and urgent measures to stop, prevent and minimise damages by large carnivores are, for example, commonly used around the world, but few have an evidence base to inform their use or effectiveness (Eklund et al., 2017). To a large extent, quantitative research is also lacking on how effective measures are to reduce damage of ungulates on crops and forests.

There is a need for better knowledge on how governance instruments and control means in wildlife management are used, both separately and in combination (economic, legal and informal instruments). Knowledge is required on the need for new or expanded instruments, on the managing, avoiding and reduction of conflicts through different forms of participation in decision making processes, data gathering and practical wildlife management, and lastly on the consequences of the authorities' ways of relating to the involved stakeholders. The prospects of wildlife management reaching goals depend on people´s acceptance and tolerance of the species to be managed, but also on trust in management actions applied. This depends in turn on trust in institutions and organisations involved in wildlife management (including wildlife research and monitoring), which sometimes is regarded as deficient or not legitimate. There is a further need to examine if dialogue and communication about wildlife management and research could help reduce conflicts.

A topical issue in wildlife management in Sweden today, where trust and legitimacy are key issues to understand, is illegal hunting (von Essen et al., 2014). One management goal in the Swedish EPA's national management plans for large carnivores is no illegal hunting. Prevalence of illegal hunting, the reasons underpinning it, acceptance of illegal hunting and suitable prevention methods are areas where more knowledge is needed. The risk of wolves dying from different causes during 2001–2017 has been analysed and the results indicate that most of these disappearances were caused by illegal hunting. The poaching-related disappearance rate of wolves in Sweden was positively related to population size and negatively related to legal culling (Liberg et al., 2020).

The use of wildlife for different purposes is also part of a bio-based economy. Hunting and tourism signify important forms of land use that represent significant economic assets and may contribute to good public health and increased well-being (SOU 2013:43). Hunting and wildlife are an essential part of quality of life for many people. The development of a diverse use of land for many purposes is a constantly on-going

societal process. The hunting value of wildlife has for example been estimated SEK 4.5 billion, of which the value of meat is approximately one third, and the value of recreation is the remaining part (Widemo et al., 2019). The focus on wildlife as an important component of land use alongside forestry and agriculture is expected to continue. In the Swedish Government Official Report, *A food strategy for Sweden - more jobs and sustainable growth throughout the country* (Prop. 2016/17:104), wildlife and game meat are viewed as important natural resources with limited climate impact, and with a large unused potential in society. The same perspective is found in Swedish EPA's *Strategy for Swedish Wildlife Management* (Naturvårdsverket, 2015a). The Board of Agriculture, The Swedish Food Agency, the County Administrative Boards and the National Veterinary Institute have at present (2020) a common governmental mission to promote trade of meat from wild boar.

Climate change has raised the issue about the climate impact of meat production from game species and highlight a lack of knowledge on this topic. An estimate shows that meat production from forest living game species causes significantly lower emissions of greenhouse gases than meat from domestic animals like cattle and lamb, but the calculation does not consider emissions linked to the hunt itself and the subsequent handling of the meat (Wiklund & Malmfors, 2014). What developments can be expected regarding wildlife as a resource, that is to say, the value of wildlife in a broader perspective, and what new knowledge is needed to support this?

The term ecosystem service is increasingly used in discussing the impacts and trade-offs associated with the management of our environment and its natural resources. The concept is applicable to wildlife management and reviewed by Widemo et al. (2019) with respect to ungulate, carnivores and large birds (geese, swans and cranes) in Sweden. The report highlights the benefits that humans receive from wildlife, but also how the ecosystem services of wildlife are co-produced in an interplay between ecosystems and human activities, the existence of trade-offs between ecosystem services that limit each other, as well as potential negative impacts of ecosystem disservices. From a wildlife management perspective, game species are part of the biological diversity and key components shaping ecosystem structure and function. Wildlife provide regulating services such as structuring impacts on the vegetation through grazing, provisioning services such as meat and other products, and cultural services connected to recreational hunting, wildlife watching, nature tourism and our cultural heritage. However, not all ecosystem services can be maximised simultaneously, so these benefits may limit each other and other ecosystem services. For example, there are trade-offs with agriculture and forestry as the amount of meat provisioning from wild animals can be connected to grazing pressure on crops and timber production. Likewise, large carnivores may provide cultural and regulating ecosystems services, but predation and depredation involve trade-offs with biodiversity conservation, hunting and livestock husbandry. In addition, wildlife can cause disservices such as spread of diseases (including zoonoses), fear and traffic accidents, but may also confer ecosystem resilience to, for example, the emergence and spread of invasive species and diseases. Research needs stressed by Widemo et al. (2019) are related to the ongoing change in the size and distribution of wildlife populations; the effects on the ecology of the species involved, including changing species interactions and the growing need for multispecies management. Widemo et al. (2019) further highlighted the need for knowledge on trade-offs between the ecosystem services of wildlife, forestry and agriculture, as well as tools to mitigate these conflicts, and take cultural services into account as these are often highly valued by the society. Other knowledge needs include methods to mitigate wildlife damage, as well as psychological and economical effects of different wildlife species (both positive and negative), lack of analyses on the effects of climate change on ecosystem services from wildlife, and how climate interacts with other drivers of change such as land use. There is also a lack of knowledge on the spread of diseases and zoonoses in wildlife communities.

The Swedish Parliament has adopted sixteen environmental quality objectives, one generational goal and twenty-four milestones targets. In the in-depth evaluation of the environmental quality objectives (Naturvårdsverket, 2019c) there are few conclusions explicitly about wildlife and the management of wildlife, but the general conclusion is that environmental objectives of particular relevance to wildlife management, *A Rich Diversity of Plant and Animal Life*, *Sustainable Forests* and *A Magnificent Mountain Landscape*, will not be reached. The evaluation states that much remain to be done before the significance of biodiversity and the value of ecosystem services are integrated into considerations and decisions in nature management where relevant and reasonable. Work aimed at attaining the environmental quality objectives forms the basis of national environmental policy, and research supporting work on wildlife in the environmental objectives, or other specific objectives in wildlife policy and wildlife management is important.

The roles and responsibilities for wildlife management have changed during the last decade, with increasing decentralisation and regionalisation of decision-making, and it continues to be one of the most important objectives in governmental wildlife policy. The Government has taken several steps toward decentralisation and regionalisation of management decisions by launching, for example, the Governmental Bills *A New Predator Management* (Prop. 2008/09:210) and *Moose Management* (Prop. 2009/10:239) and through the establishment of the collaborative Wildlife Management Delegations in all County Administrative Boards (in 2010). It is always a great challenge in wildlife management to balance different interests in society. The Wildlife Management Delegations are meant to be an arena for handling of the trade-offs between different, and sometimes competing, ecosystem services and societal interests of wildlife by for example deciding on principal guidelines for wildlife management and on management goals of large carnivores, moose, deer and wild boar populations in the counties. More politicians and interested stakeholders as hunters and landowners have become more directly involved in decisions on wildlife management through work in the delegations. However, recent research suggests that although the composition of the delegation reflect the attitudes present within the general public, there is a polarisation between urban and rural interest in the general public that is reflected in the two coalitions within the delegations (resource use vs. conservation interests). This potentially implies a risk that the delegations consolidate rather than resolve societal polarisation (Eriksson, 2016).

Decentralisation and regionalisation have to same extent been successful in achieving goals within wildlife management, but there are still many challenges and issues to improve at all management levels, and knowledge to support this was topical in the previous strategy and remains relevant in this strategy. Moose management can in many ways exemplify the present status of decentralisation and regionalization. In the Swedish Parliament´s decision from 2010, on a new moose management system, management should be locally endorsed and ecosystem-based and adaptive to generate a moose population of high quality in balance with food resources. In this context, management needs to take into account issues such as large carnivores, competition with other ungulate species, preventive measures concerning road traffic accidents involving moose, damage to forests and impact on other biodiversity. The moose management reform has since then been evaluated twice by the Swedish EPA. The first evaluation concluded that management essentially is moving in the right direction and has become more ecosystem based, adaptive and locally anchored. However, several areas still need to be reviewed or remedied for the management to fully achieve the objectives and intent of the governmental bill (Naturvårdsverket 2015a). The second evaluation concluded that forest damages and traffic accidents have increased, which implies that the general objective "a moose population in balance with the food resources" cannot be considered fulfilled. Several explanations are discussed. Planned culling of moose has not been fulfilled, a need for follow-up and planning at all levels in moose management system has been identified, and roles and responsibilities of stakeholders are

unclear. The evaluation concludes that many hunters and landowners think (2018) that there are not enough animals to hunt, and still forest damages are high. Furthermore, the evaluation concludes that conflicts between stakeholders have increased and knowledge to support conflict management is needed (Naturvårdsverket, 2018e).

Two reports of the Parliamentary Rural Committee (in Swedish Parlamentariska Landsbygdskommittén) express that people living and working in the countryside is most affected by wildlife management and the presence of large carnivores, and that it is reasonable and urgent that those affected have significant influence over the decisions taken. The Parliamentary Committee concludes that wildlife management needs to be further decentralized, from European level to national level and from national level to regional level (SOU 2016:26, SOU 2017:1). Today there are more hierarchical levels involved in decisions concerning wildlife management compared to just ten years ago, both through the County Administrative Boards and the Wildlife Management Delegations and through the roles played by courts and the EU.

During the last decade, both government administration and researchers have agreed on wildlife management to be ecosystem-based and adaptive (Prop. 2009/10:239, 2008/09:210 and 2012/13:191). This has also been expressed in *Strategy for Swedish wildlife management* (Naturvårdsverket, 2015c) and in the national management plans for large carnivores, wild boar and seals. Although the ambition for adaptive management in wildlife management is clear, much remains to be done to obtain truly adaptive, ecosystem-based management. The international scientific evaluation by Sæther et al. (2019) recommended the Swedish EPA to launch a specific research programme to focus on the use of adaptive management to aid in decision-making for sustainable management of wildlife in changing ecosystems.

Wildlife monitoring is an integrated part of wildlife management and central to adaptive management. Sweden has a well-developed monitoring system of large carnivores and some game species, like moose, and has also a well-developed system for recording game bag statistics and their use to monitor the development of wildlife populations. Swedish wildlife monitoring is in many ways at the forefront in a European perspective, for example by developing cooperation across national borders. However, the monitoring system needs to be developed further to include more species (ideally within one monitoring framework – integrated monitoring) and address more research and management issues. The international evaluations of previously funded research by Boyce et al. (2002) and Sæther et al. (2019) both recommend the Swedish EPA to establish an integrated wildlife-monitoring programme as it will benefit both management and research.

In *Sweden's environmental monitoring - its task and organization for good environmental management* (SOU 2019:22) the Swedish EPA calls for broader monitoring of game species, invasive species and genetic variation as well as monitoring specifically for ecosystem services. The issue of establishing an integrated wildlife monitoring programme and expand it to include more species, is a matter for the responsible authorities to decide on. At the same time, there are research needs to support authorities and organisations working with monitoring. In the light of growing populations, for example wild boar, fallow deer, red deer and some geese species, and consequently increased damages in agriculture and forestry, there is a need to develop new population monitoring methods, and methods to monitor damages by these species. Improved methods to estimate fodder resources for the ungulate communities is also needed. For example, a discussion is taking place in the society on whether damages on pine by moose is a consequence of large population sizes, or if it is due to changed management practices in forestry industry creating less fodder (pine and deciduous trees) for ungulates.

One of the largest changes in monitoring of wildlife over the past decade is the establishment of common Swedish-Norwegian methodology for monitoring of large carnivores and a shared Scandinavian database for monitoring data (www.rovbase.se). During the years 2017-2019, the Swedish EPA evaluated the monitoring system for large carnivores which resulted in four reports (Naturvårdsverket, 2018c-d, Öhrman, 2019, Backlund, 2019). The monitoring system generally works well, however, new or complementary methods mainly for the monitoring of wolverine and lynx are asked for, as well as more cost-effective methods, maybe by using new technologies. Also, trust between those responsible for different parts of the carnivore monitoring system needs to be improved and confidence in the results of the inventories also needs to be strengthened. Some stakeholders involved experience the system as unequal. Thus, more knowledge on how to create legitimacy and trust in the monitoring system for large carnivores is requested.

Climate change increases the need for new methods when for instance monitoring methods developed for snow cover can no longer be used. This need has been obvious during recent years when for example monitoring of large carnivores in southern and middle Sweden rely more and more on genetic methods and camera traps rather than traditional snow tracking methods. Furthermore, the geographic expansion of native, non-native and invasive wildlife species calls for a further developed monitoring, and more knowledge on how to mitigate effects.

Monitoring of attitudes and behaviours in and towards wildlife management is important as we currently experience rapid changes in society caused by climate change, digitalization and urbanization continuously affecting wildlife management in different ways.

New technologies that are or could be used in wildlife management, e.g. remote cameras, drones, new genetic methods, and machine learning, are changing rapidly. There are many ongoing and possible future applications of these technologies, not the least for the purpose of wildlife monitoring. New techniques originally developed for other purposes than wildlife management, drones as a recent example, might be of interest for future wildlife management, and cooperation with other parts of society might therefore be needed.

Due to climate change, and possibly globalisation with extensive trade and traveling, wildlife diseases are expected to emerge to a greater extent, which calls for methods to detect, follow and mitigate the effects of diseases. Wildlife diseases have in general received a lot of attention over the last years and are expected to present major and growing challenge to both agriculture (domestic animals), reindeer herding and wildlife management. Chronic wasting disease (CWD), an incurable and fatal prion disease that infects cervids, and the virus disease African swine fever (ASF), are two current problematic diseases. During 2019 three female moose in the county of Norrbotten were diagnosed with CWD, and they were the first cases recorded in Sweden (Jarnemo et al., 2019). Swedish authorities are presently (2020) writing a common management plans for handling of CWD. The Swedish Board of Agriculture has assessed the need for measures to prevent the introduction and dispersal of ASF in Sweden (Jordbruksverket, 2019).

Appendix 4: Principles and conditions

General information on calls

The Swedish EPA has an annual competitive call for applications for funding from the Wildlife Management Fund. This research strategy 2021-2026 provides the basis for calls. The call is announced on

the Swedish EPA website, usually before midsummer with the call open until mid-September. Any application received outside the research-call period is rejected by the Swedish EPA without prior preparation by the Wildlife Committee.

The Swedish EPA funds scientific research at universities and university colleges, research institutes and authorities that undertake research as part of their remit. Research institutes are defined as establishments focused principally or entirely on research. Another prerequisite is that the administrating organisation that receives and administrates the grant must have a Swedish organisation number, and be approved by the Swedish EPA as an administrating organisation in the research application system PRISMA.

The main applicant of the research project must have a doctoral degree not later than the last application date for the call for the project to be eligible for research funding. A researcher can only be a principal investigator (PI) on one research project funded by the Wildlife Management Fund at a time, but may be a co-applicant/co-worker on other funded research projects. A researcher that is PI of a research project can also be PI for other types of funded initiatives, such as reviews of current knowledge and workshops.

A prerequisite for funding is that the applicant and co-applicants have provided a final report from previously funded projects approved by the Swedish EPA. The issue of making the research available and communicating the research and its results are developed under the heading *From knowledge to action* below, and is also developed in the yearly revised instruction to applicants that are published as the same time as the research call.

Further information about the current call for applications and yearly revised instructions for applicants can be found at the Swedish EPA website (www.naturvardsverket.se). Information to applicants is also integrated in the research portal PRISMA (https://prisma.research.se/).

Some fundamental principles and conditions relating to the research and the funding are presented below. Note that if information in this strategy differs from the annual call and instructions to applicants the latter two documents take precedence.

Forms of funding

The yearly research call describes priorities according to this research strategy and the forms of funding which apply in that specific year.

Funding is predominantly awarded to single research projects, typically for up to three years. However, longer and larger research projects may be considered and funded subject to review of progress and renewed evaluation of scientific quality and relevance of project applications (including possibly evaluations of mid-term application). For example, during the research strategy period 2015-2020, a specific call was made for six-year research projects on multispecies management.

In addition to single research projects, reviews of current knowledge, scientific synthesis, conferences and workshops are funded. In line with recommendations in the recent international evaluation (Sæther et al., 2019) (Appendix 2) it will at times (stated in the annual call) be possible to apply for ad hoc-funding of small projects to establish an international consortia to develop projects aiming for EU-funding and supplemental funding of successful proposals, e.g. to provide support for additional PhD-students.

The Wildlife Committee may occasionally complement the ordinary research call with specific or extended calls. Previous examples include collaborative research programmes containing several sub-projects over a

longer time-span and specific knowledge compilations to prepare future research calls. In addition, the Wildlife Committee can propose smaller calls for applications during the year if necessary. In case the Wildlife committee identifies specific research questions, contract research may also be commissioned.

The Wildlife Management Fund do not fund long-term provisioning of knowledge and expertise through funding of academic positions. Funding of, for example, doctoral student positions is a task that has been assigned to research councils, for example the Swedish Research Council for Sustainable Development (Formas) and the Swedish Research Council (Vetenskapsrådet), and to universities and university colleges. However, the Wildlife Management Fund may support research projects where research is mainly or partly undertaken by a PhD student, as long as the principal project leader (the main applicant) has a doctoral degree and is employed for the duration of the award at an eligible administrating organisation.

According to recommendations from the international evaluation (Sæther et al., 2019) the Wildlife Committee will annually consider how to facilitate recruitment of early-career scientists into wildlife research (project leaders who are between 3 and 8 years after award of PhD). The Committee encourages younger applicants and takes their career stage into account in the evaluation process. However, it is currently not possible for the Wildlife Committee to allocate a set proportion of the research budget to "early-carreer scientists" as the research budget is limited, and at present (2020) has been the same since 2012.

The Wildlife Management Fund have no responsibility to fund long-term wildlife or environmental monitoring. It may, however, fund research projects to develop and test survey and monitoring approaches and tools, and monitoring activities that are needed to gather data to test specific research hypotheses or assess specific management actions.

Assessment of projects

The Swedish EPA has an annual competitive open call for applications for research funding from the Wildlife Management Fund. Decisive factors in the Wildlife Committee’s assessment of the applications, within the frame of the strategy and the prioritized areas of research (Section 6), are the scientific quality of the research, the competence of the applicant (s) and the relevance to the research strategy and the current prioritized wildlife management needs.

Other criteria and considerations might be important in the evaluation and prioritization of applications, for example, maintaining and promoting research in a wide range of disciplines and topics, as well as promoting equality and capacity building, supporting early career stage researchers and developing expertise in new areas of research. It is important for the Wildlife Committee to promote research that includes and integrates both natural sciences and social sciences and the humanities.

According to the governmental appropriation to the Swedish EPA on the Environmental Research Grant “The funds should be distributed so that equality between women and men is taken into account”. A corresponding writing is at present (2020) not found in the Government's decision regarding research funding from the Wildlife Management Fund, but the Swedish EPA considers it to apply to both grants. The scientific quality and relevance outweigh the issue of gender equality, but if the evaluation of the applications is otherwise equal, the underrepresented gender should be funded.

The research expertise regarding sustainable management of wildlife is a valuable national resource. The universities have a special responsibility for this, but also research funders. It is important that research

funding regarding sustainable management of wildlife contributes to both maintaining and developing existing expertise, in areas essential to wildlife management, while also creating room for initiatives in new areas and for the recruitment of new expertise.

The priorities in this research strategy may change to reflect rapidly evolving ecological, management and policy needs. Hence, research applications that do not fall within the scope of the strategy´s prioritised research areas, but which are of relevance regarding the overall aim of research supported by the Wildlife Management Fund (Chapter 3, Appendix 1), may also be eligible during the programme period. This may, for example, apply to research of a particularly innovative nature, research on emerging urgent issues, or topics of high policy relevance.

The Swedish EPA supports applied and need-motivated research, meaning that knowledge relevant for sustainable wildlife management should be developed. To ascertain that the research outcomes are applied and disseminated, the researcher needs to consider the end-user in his/her initial planning of application. At this stage, a dialogue between researchers and managers is important, so that experiences and questions within the management and policy community are recognised. The Wildlife Committee welcomes co-creation of research involving stakeholders in developing ideas and concepts, so that shared problems are solved in close cooperation.

For more information on for example assessment criteria, see yearly up-dated instructions for applicants at the Swedish EPA website (www.naturvardsverket.se) and the annual research call.

Communication - from knowledge to action

Research in support of wildlife management generates valuable new knowledge but translating this knowledge into uptake and practical management can be challenging. Researchers must therefore work to convert new knowledge into practical management and tools, and to clearly convey the background and rational of research and research outputs to stakeholders. An effective and engaging dialogue, communication and knowledge transfer between researchers and stakeholders is essential for the success of wildlife research and management. To promote the use of research results, cooperation between research and management is strongly encouraged. Applications must include a detailed time- and communication plan in order to promote dialogue between researchers and management and other stakeholders. It is strongly recommended that such a dialogue should start at the planning stage and then continue throughout the project.

Funded scientists have an important task in communicating the results of the research, both during at the end of the project. Scientists are expected to work together/in cooperation with the Swedish EPA to develop the communication plan regarding communication activities. A regular contact with relevant representatives of the Swedish EPA, for example the research communication officer and the research officer, is expected.

Additional guidelines on how researchers are expected to make research available and communicate results and conclusions are presented in instructions for applicants which are annually up-dated at the time of the research call.

Researchers are not only expected to publish their results in scientific journals but also regularly provide information to everyone concerned, or interested in, for example through popular-science publications and social media. A mandatory requirement is that all projects submit a final report in Swedish to the Swedish EPA.

Several on-going research projects (2020) depend on voluntary involvement of hunters and other stakeholders. The involvement of the hunting community in research and monitoring linked to wildlife management has been, and will continue to be, of key significance in conducting the research supported by the Wildlife Management Fund. The hunters have an important role in ensuring that research results become known and are used in practice. It is vital that researchers provide feedback and research outcomes to voluntary participants in a research project, as well as to the hunting community. When relevant it is valuable to involve other stakeholder groups.

The responsibility of researchers to inform and communicate their research follows the obligation of researchers at universities and university colleges: in addition to research and teaching they should interact with society to enhance the impact of their research.

Nordic and European cooperation

For several transboundary wildlife species, international cooperation in research and management may be crucial to ensure long-term conservation and sustainable management. Wildlife management issues are principally dealt with at the national level, though many species occur throughout Europe and some have transboundary populations. Many challenges are, however, similar across Europe, for example, similar changes in wildlife populations such as increasing numbers of geese, seals, deer, wild boar and large carnivores. For large carnivore populations, for example, Swedish and Norwegian Authorities have a long-term cooperation involving co-funding of research, co-developed methodology for surveys, and joint databases for monitoring data and citizen-science data. This cooperation mutually benefits both management and research. The *Strategy for Swedish Wildlife Management* (Naturvårdsverket, 2015c) strongly encourage international cooperation with the aim to contribute to international exchange of knowledge about wildlife. Accordingly, the Wildlife Committee is keen to promote and increase cooperation on wildlife research, especially in the Nordic Region, but also elsewhere. The Wildlife Committee welcomes research initiatives were international cooperation add value to Swedish wildlife management. During the previous research strategy period 2015-2020 the Swedish EPA has for example funded research targeting transboundary management of geese (African-European flyway management plans, AEWA) and a Swedish-Norwegian project on camera-trap methodology for monitoring of wildlife.

To strengthen international cooperation the Wildlife Committee may initiate specific calls to establish international consortia aimed for EU-funding or other initiatives to promote international research cooperation. Swedish participation in international research programmes can contribute to enhanced knowledge that can promote sustainable and evidence-based wildlife management in Sweden. This is in line with recommendations given by the international evaluation of Swedish wildlife research (Sæther et al., 2019). In the annual research call and instructions to applicants such funding initiatives and application procedure will be clarified.

Funding, co-funding and delimitations of funding responsibility

Research funded by resources from the Wildlife Management Fund has a specific origin (the governmental hunting fee) and purpose (Chapter 3). The applications are ranked by relevance to Swedish wildlife management, also taking the origin and purpose of the Wildlife Management Fund into account. Research projects which primarily are relevant for other land-use like rural industries and enterprises, involving forestry, agriculture, fisheries and reindeer herding, should primarily be funded from other sources than the

Wildlife Management Fund. The Wildlife Committee encourages dialogue and cooperation to reduce the risk of important research falling between different remits.

Historically, co-funding of projects has been carried out for example within the Swedish EPA, with Norwegian authorities and with the Swedish Association for Hunting and Wildlife Management. Co-funding has also been of "in-kind" support, where for example research might be undertaken alongside management-related activities carried out by the County Administrative Boards. Within the Swedish EPA both the Environmental Research Grant and management related resources have funded, and co-funded, research projects and programmes related to wildlife management. The Swedish Association for Hunting and Wildlife Management funds research on wildlife management through what is known as *Forskningstjugan*, a fund built on yearly contributions from the membership fee. The Wildlife Committee welcomes co-funded applications but stresses that co-funding should add value and that all applications are evaluated equally.

When necessary, research funding is discussed at meetings between the key wildlife management authorities in the Nordic countries. For a long time, scientific and financial cooperation within and between the countries has been an important basis for effective management, for example to achieve long-term research on the four large carnivores. This is expressed, for example, in a secretary of state agreement (Statssekreterareöverenskommelse) between Sweden and Norway (Miljödepartementet, 2011) about management of genetically valuable wolves. It includes research and research funding as a collaboration arena. In recent years, cooperation with Finland and Russia has been strengthened, which among other things has favoured genetic research on the large carnivores through the exchange of tissue samples between the Nordic countries and Russia. Within the framework of The African-Eurasian Migratory Waterbird Agreement (AEWA) both Swedish researchers and managers work together to ensure that research results and Swedish interests have an impact on AEWA fly-way management plans. When other providers of research funding such as research councils and foundations have an interest and responsibility, discussions can be held.

There are several other funders of relevant research of wildlife and management although the Wildlife Management Fund has long been the single largest funder. In the international evaluation by Sæther et al. (2019), approximately 50 % of the total funding of the projects 2003-2014 came from additional sources including research councils, universities in kind and foundations. Between 20% and 100% of the budget of single projects were provided by the Wildlife Management Fund. The Government has given the Swedish Research Council for Sustainable development the responsibility for basic research and needs-motivated research, for example on biodiversity and research in support of the knowledge needs of rural industries and enterprises (e.g. forestry and agriculture, fisheries and reindeer herding). Research on wildlife issues can thus also be relevant to Formas. Formas funds research under general calls for applications, targeted initiatives and through funding of academic positions in research. The limitations of the funding responsibilities of Formas are clarified in appropriation directions, research strategies and targeted calls for applications (www.formas.se). Furthermore, the Research Council (www.vr.se) funds basic research in all scientific areas.

Evaluation of research and research administration

The Swedish EPA regularly performs external evaluations of its funded wildlife research portfolio and is itself also regularly reviewed. Boyce et al. (2002) evaluated research funded by the Wildlife Management Fund and concluded that the scientific quality was high to very high in an international perspective and of

very high relevance for conservation and utilisation of wildlife as a natural resource. In a bibliometric evaluation of seven SEPA-funded research programmes 2003-2013 it was concluded that the research programme *Adaptive management of wildlife and fish* had a citation score that corresponds to the grade very good, corresponding to three on a five-point scale (Sandström, 2014). In a government inquiry it was noted that the Swedish EPA has well-functioning routines to ensure the scientific quality and relevance of research initiatives (SOU 2012:20).

A bibliometric evaluation of wildlife research funded by Swedish EPA 2003–2014 (Sandström, 2018) showed that "SEPA has a good exchange of resources in terms of number of articles and expected citation response from the larger research community. Particularly the research on large carnivores has proved to be an investment with good productivity and substantial recognition from the international research community. During the programme period, citation strength increases significantly, from 40% to 60% of researchers have strong achievements, i.e. they are included in the top 20% of Swedish researchers". The bibliometric evaluation concluded that there are no significant gender differences and that the Swedish EPA, and the Wildlife Committee, have chosen good researchers for the implementation of the research strategies. The research portfolio was shown to be relatively broad and it covered all essential aspects of ongoing international wildlife research.

Forsberg et al. (2018) evaluated the relevance of the funded research for Swedish wildlife management during 2003-2014 and concluded that the majority of the respondents who expressed an opinion, found that the wildlife research during the period had contributed useful knowledge for sustainable wildlife management at national, regional and local scales. Many respondents specified needs for more research on different wildlife issues (Appendix 3). An international scientific evaluation of the wildlife research funded in 2003–2014 (Sæther et al., 2019) is presented in Appendix 2.

Appendix 5: Outcome of the research strategy 2015-2020

During the research strategy 2015–2020, the Swedish EPA received in total SEK 108 million from the Government from the Wildlife Management Fund for funding of research and related projects (SEK 96 million), administration of the funding (SEK 6.6 million), research communication (SEK 2.7 million) and the Nordic Council for Wildlife Research (SEK 2.7 million). The Swedish EPA distributed its research grants (SEK 96 million) between three different forms of funding: 1) grants to individual research projects (1-3 years duration) (SEK 52.6 million), 2) grants to research projects with six years duration (SEK 38.6 million), and 3) grants to knowledge compilations, work-shops and congresses (SEK 1.6 million). Moreover, an annual operating budget (base resource) for wildlife research technicians at Grimsö Research Station (the Swedish University of Agricultural Sciences, SLU) (SEK 3.2 million) was also funded 2015-2016, according to a previous agreement between the Swedish EPA and SLU.

In total, 31 different research projects were funded during the period. The majority of these, 28 projects, were grants to individual research projects (1-3 years duration) (ended or starting during the period 2015-2020) which also includes five research projects that was decided on during the research programme 2009-2014, but whose budget burdened the period 2015-2020. Three six-year long projects were funded during the period. Finally, six other projects (work-shop, conference, knowledge compilation) were funded, including one knowledge compilation that was decided on during the research programme 2009-2014.

The following areas of research were prioritised in the research strategy 2015-2020 and parentheses shows how much of the total allocation of research funds (SEK 91.2 million) that has been allocated among these research areas and the number of projects; 1) tools for wildlife management (SEK 14.75 million, 11 projects), 2) from single-species to multi-species management (SEK 57.2 million, 13 projects) and 3) wildlife management in the future (SEK 18.55 million, 7 projects). The research area *Tools for wildlife management* was further divided into three sub-areas: 1a) wildlife monitoring (SEK 5.85 million, 3 projects), 1b) measures to regulate populations and mitigate damage (SEK 8.1 million, 7 projects) and 1c) harvesting models (SEK 0.8 million, 1 project).

Approximately 80% of the funded projects were natural science and 20% were social science. However, some of the research projects included more than one of the prioritised areas above, as well as both natural and social science, so the distribution of money between areas and disciplines is somewhat simplified. Out of the 31 research projects 37% of principal investigators were women.