Wild animal welfare research priorities
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Introduction

In this document, Wild Animal Initiative provides a list of research areas important for advancing our understanding of animal welfare in the wild and for developing wild animal welfare science as a field. This list can guide researchers interested in developing a career in wild animal welfare science, or it can help those seeking to leverage an existing research portfolio to support wild animal welfare science. The list is divided into three main sections: 1) research that seeks to understand what wild animal lives are like, 2) methods to monitor wild animals and measure components of their welfare, and 3) research into the actual or potential impacts of interventions aimed at improving wild animal welfare or for other purposes, such as population management or climate mitigation.

Wild animal welfare is a relatively new scientific discipline that synthesizes and builds off of existing work in a large number of other fields. This document represents critical research questions that the field as a whole needs to address to determine the biology and ecology of welfare in the wild. As we learn more about critical knowledge gaps, this document will grow and change to reflect our understanding of the field’s needs. Although many research areas outlined here are aligned with our own mission, Wild Animal Initiative considers several other factors, including scope, tractability, neglectedness, and relevance, when determining our internal research and funding priorities. Therefore, this document does not represent Wild Animal Initiative’s specific internal research priorities or grant-making plans.

We hope this document will provide some clarity to many researchers who are interested in wild animal welfare but are not sure how to get involved, how their research fits in, or how to connect their existing work to wild animal welfare. By outlining wild animal welfare research priorities, we also hope to demonstrate the diversity of disciplines relevant to the field of wild animal welfare science. This is a “living document.” We will continue to update it to reflect our growing knowledge, the changing environment, and the expansion of the field.

A note on sentience

In order to identify ways to improve wild animal welfare, we need to understand what the subjective experiences of wild animals are like and how those experiences differ across individuals, populations, species, and environments. It is important to recognize the fundamental uncertainties involved in knowing what the subjective experiences of different animals are like and determining sentience. Since non-sentient organisms, by definition, do not experience the world and therefore do not have welfare, we are specifically interested in what the lives of sentient wild animals are like. However,
determining which organisms are sentient is often extremely difficult — especially for the animal groups that also have the largest population sizes, i.e., most invertebrate species.

We recognize that there is not widespread scientific consensus on which animals are sentient, to what degree, or on how sentience can be determined. Consequently, we operate and prioritize our work based on a few common assumptions related to the scientific community’s confidence regarding the sentience of different species. For example, although there is still debate regarding the sentience of fish (De Mori et al. 2019), there is good evidence available to generally recognize the group as sentient. We also acknowledge that there may be large differences among species within groups of animals. The diversity of invertebrates — and, moreover, of insects — makes it more difficult to generalize. Nevertheless, based on current evidence, we accept the possibility of sentience among invertebrate groups.

Tractability is a more important consideration with regard to wild animal welfare research priorities. In that regard, the tractability of research on most invertebrates and the potential for feasible interventions that improve wild invertebrate welfare in a known and quantifiable manner is much lower than that of other groups. For the long-term success of wild animal welfare science as a field, it is critical to improve our understanding of wild animal sentience. Thus, we rely on sentience research to inform wild animal welfare research and prioritize actions. We consider the field of animal sentience research, which is deeply embedded in psychology and neuroscience, as a parallel discipline on which we rely — much the same as we rely on philosophy and moral principles to frame our efforts.

Below, we outline broad research areas that will help answer the question, “what are wild animals’ lives like?” Core elements of sentience research are integrated into these areas and framed to be most relevant to wild animal welfare science. They are prioritized relative to our ability to convert knowledge into reasonable interventions.

This section frames an individual’s welfare in relation to biological and physiological processes, behaviors, individual experiences, population dynamics, community interactions, and within the context of different environments.

Section 1: What are wild animals’ lives like?

This section frames an individual’s welfare in relation to biological and physiological processes, behaviors, individual experiences, population dynamics, community interactions, and within the context of different environments.
Network dynamics resulting from the many connections between individuals, communities, and ecosystems present a fascinating and challenging aspect of wild animal welfare science. Individuals affect the welfare of other individuals through both direct and indirect interactions by participating in a shared ecosystem. In turn, changes in the environment impact the interactions within these networks. There may be features of these networks and how they relate to the environment that tend to be welfare-promoting, or the opposite. In this section, we outline key research areas that will help elucidate welfare consequences of individual experiences and how they relate to large-scale welfare patterns across ecological systems.

**Behavioral ecology**

*Seeking to understand the relationship between behavior and individual welfare experiences and outcomes.*

- Consequences of early-life experiences on the long-term behavior and welfare of wild animals.
- How life-history traits interact with individual experiences to affect the welfare of individuals.
- How intraspecific interactions and conflicts of interest affect the welfare of individuals.
- Identifying what constitutes positive experiences relevant to an individual’s welfare and affective state.
- Determining whether wild animals of different species on average live net-positive or net-negative lives.
- How individuals spend their time and/or energy in different ecological contexts, such as in relation to population density, predation risk, or habitat quality (e.g. 1, 2, 3, 4, 5, 6).
- How the sentience of individuals varies with their development (ontogeny) and age.
- How an individual’s welfare condition influences their interactions with their environment, and vice versa.
- How life-history strategies and traits (e.g., parental care, age at maturity, sub-adult dispersal) of a species shape the experiences and lifetime welfare of individuals within that species.

**Disease ecology**

*Seeking to understand the relationship between disease and individual welfare experience.*

- How different diseases affect wild animals’ welfare.
- How the experience of disease differs among individuals.
- How disease interacts with other welfare threats and impairments (e.g., malnourishment, predation, injury).
- How different behaviors and demographic processes/parameters (e.g., dispersal, population density) affect disease risk in wild animals.
Population ecology

*Interactions between individuals, demographic processes, and their environment that affect the likelihood of particular welfare outcomes.*

- How individual welfare is influenced by population density (1).
- How interactions with individuals’ environment affect welfare through their behavioral responses.
- How causes of death vary within and between populations.
- How mortality rate varies in relation to demographic variables such as age and sex.
- Molecular ecology and population genetics/genomics: use of molecular markers to non-invasively understand how welfare is affected by the ways that individuals, populations, and species interact with each other and their environment.

Community ecology

*Conflicts and synergies among species as individuals seek to meet their needs.*

- How interspecific competition affects the welfare of individuals of each species.
- How cooperation/mutualism between species on an ecological/fitness level translates into welfare benefits for individuals.
- Welfare impacts of parasitism.
- The consequences of trophic interactions (especially predator-prey dynamics) on population sizes and welfare of predator and prey populations.
- The welfare consequences of trophic cascades.
- Welfare effects of complex food web dynamics.
- Impacts of keystone species on community dynamics.

Environmental interactions and landscape ecology

*Seeking to understand the ecosystem relationship to individual welfare.*

- Identify how environmental conditions influence an individual’s welfare condition.
- Make comparisons among experiences in relation to individuals’ context across different landscapes and environments and their impacts on welfare.
- Build an understanding of variation in welfare with respect to gradients in various variables or parameters, including: habitat type, latitude, island versus mainland environments, proximity...
to large water bodies, mountains versus lowlands, urban versus rural environments, frequency of extreme weather, fire risk, or number of predators present.

**Phylogenetics**

*Framing welfare within a taxonomic context.*

- Comparative assessments across species of the relationship between welfare and life-history strategy (e.g., migration, fecundity, age at sexual maturity, and parental care).
- How frequency of different causes of death varies between species.
- Phylogeography: comparative assessment of the interaction between phylogeny, geography, and welfare.

**Climate change**

*Predicting threats and opportunities to wild animal welfare that may emerge as a result of climate change.*

- Understanding how climate change will affect individuals’ welfare directly (e.g. extreme weather) and indirectly (e.g., changes in habitat quality or coming into competition with other species).
- Impacts of climate change such as forest fires and flooding.
- Understanding how individuals and species can adapt — through learning and/or evolution — to changes in their environment, and how these adaptations will affect their welfare and that of their offspring.

**Genomics**

*Seeking to understand individual welfare in the context of their genome.*

- How an individual’s genome frames their development and interaction with environmental factors and results in their unique subjective experiences.
- How certain genotypes affect welfare through juvenile development and interaction with environmental factors.
- Understanding whether gene expression or certain genotypes can change the subjective experience of individuals and welfare impacts.

**Evolution**

*Seeking to understand how evolutionary processes (e.g., fitness) relate to an individuals’ welfare.*
Comparing fitness and welfare expectancy outcomes in the context of evolutionary parent-offspring conflicts (e.g., adaptive behaviors for the parent limit fitness and/or welfare of offspring).

- Human-animal interactions
- Seeking to understand welfare in relation to human-dominated landscapes.
- The welfare effects of human alterations to the environment that inadvertently affect wild animals. This includes effects of logging, habitat fragmentation, forest fires, hydrological disruption, and conflict over urban spaces.
- Impacts of wild capture on wild fish populations.
- Humane capture methods.
- Urban environments.

Section 2: How can we measure wild animal welfare?

Research on measuring, monitoring, and modeling wild animal welfare is also critical, both for understanding welfare degrees and changes over time and for ensuring that we are using or supporting the least harmful approaches. For example, identifying alternatives to invasive procedures such as monitoring hormonal changes from feces instead of by capturing animals can move us towards methods that are better for wild animals. Non-invasive or less invasive methods will need to be calibrated against known results for them to be established as a new norm. The field of animal welfare science, as a whole, has made great strides in developing methods for assessing the welfare of animals; however, monitoring and evaluating the welfare of wild animals can come with unique complications. Understanding the transferability of approaches used for captive or farmed animals is an essential step in understanding the lives of wild animals and, in particular, striving to do so as non-invasively as possible. Until recently, assessing the welfare of wild animals has generally received less attention (Harvey et al. 2020). Thus, there is limited research on how to assess the welfare of animals that are not in captivity or under human care.

The assessment of welfare in wild conditions is complicated by a variety of factors, such as the sheer numbers of animals involved, the wide number of species under consideration, complex and unforeseeable interactions among individuals, and the lack of human control over the environment (Wang et al. 2019). Wild animal welfare science will need to support the development of metrics for welfare that can be feasibly assessed in the field. It will also be important to establish baselines, ranges, and benchmarks for these metrics, as well as determine values for different species.

Conceptually, understanding which animals are sentient and to what degree is part of understanding how to measure welfare (e.g., who to count and how much to weigh them). Thus, an inherent part of
understanding how to measure and monitor wild animals is understanding which animals are sentient.

To understand welfare in the wild, we need to know not only the welfare consequences of particular events, but also how much of the life of a given animal those events make up. A relatively small welfare harm that occurs constantly may cumulatively be as equally concerning as a large welfare harm that might only occur infrequently. Thus, a core component of wild animal welfare is understanding the daily activities of wild animals and how they vary by ecosystem, species, and lifestage.

Unfortunately, the very nature of wild animals means there are challenges for monitoring and evaluating their lives. Although we aim to fill many gaps in the available knowledge, the process will take time. To address some of these knowledge gaps in the short term and identify some of the more critical targets for knowledge acquisition, we can develop approaches that help to estimate missing information from known information. Models are not perfect, but both statistical and systems models are useful for determining the most important data needs and for simulating multiple possible scenarios that create projections for testing empirically.

Research into the measurement of wild animal welfare will help to extend and validate existing welfare methods and metrics to free-ranging wild animals; identify measuring needs; define novel methods for determining wild animal welfare; define measurements and relevant new metrics by which to measure them; identify technologies that can be used to improve measurements of wild animal welfare; identify metrics (baselines, benchmarks, indicators, etc.) that can be systematically applied or adapted for many species, and determine how they can be calibrated to ensure accuracy. In identifying what indicators can be used to evaluate welfare, we will also establish whether there are species differences in how they need to be interpreted or applied and how past experiences might shape behavioral responses.

**Defining indicators and metrics**

*Defining, improving, and expanding the use of proxies for measuring welfare in wild animals, including identifying novel measures of welfare and affective state for wild animals and validating them against existing welfare assessment techniques.*

**Physiological indicators**

*Identifying, developing, and validating physiological welfare indicators in wild animals, including identifying physiological welfare indicators specific for rapidly assessing wild animals.*
Discrete measures of welfare

- Heart rate, respiratory rate, and body temperature.
- Stress hormone levels, such as adrenaline and corticosterone (e.g., in blood and saliva).
- Glucose levels.
- Presence of lactate or acute phase proteins.

Cumulative measures of welfare

- Stress hormones such as cortisol in urine, feces, or hair.
- Adrenal gland size.
- Immune function, such as the presence or absence of suppressed IgA (immunoglobulin A) secretion.
- Dehydroepiandrosterone (DHEA) levels and hypothalamic–pituitary–adrenal (HPA) axis activation.
- Inferred psychological states, such as PTSD.
- Telomere attrition.

Condition-based assessment

Identifying, improving, and validating the usefulness of condition-based assessments (e.g., percent body fat or length-weight ratio) and defining and developing them for new wild animal species to enable rapid and large scale welfare assessment.

Behavioral indicators

Defining, developing, and validating behavioral indicators of wild animal welfare, with a specific focus on making quantitative assessments, defining species-specific metrics and indicators, and identifying ranges in responses to define behavioral indicators.

Positive welfare metrics

Identifying and validating positive welfare metrics (i.e., the presence or absence of positive experiences, such as feeding on something nutritious) and their potential to complement negative indicators (i.e., the presence or absence of negative experiences, such as having a wound).

Selecting metrics

- Assessing and comparing cost-effectiveness of welfare indicators by, for instance, looking at the cost per measured animal for methods with comparable reliability.
● Assessing accuracy, precision, and cost-effectiveness of combinations of welfare indicators.
● Assessing whether fitness can be used as a metric or indicator of welfare under different circumstances.
● What information/metrics are needed for informing decision-making by wildlife managers, other relevant stakeholders involved in wild animal-related management, interventions, or policy-making.
● Identification of keystone species/indicator species that can be used to represent the welfare of groups of species, ecotypes, or other relevant groups.

Methods for monitoring wild animals and their welfare

*Identifying the most appropriate methods for continuous assessment of welfare, how it varies with time and environmental conditions, and the least invasive ways to obtain such information.*

Monitoring systems

● Evaluating animal monitoring systems in terms of reliability, cost, and potential welfare impacts (e.g., satellite surveillance, camera-trapping, radio-tracking, biologgers, trapping).
● Identifying, validating, calibrating, and expanding the use of less invasive methods for identifying and tracking individuals, such as alternatives to bio-loggers, motion-activated cameras, eDNA, non-invasive molecular methods, and other innovative solutions.
● Use of genetics and other molecular markers to non-invasively monitor welfare in populations and interactions between species.
● Exploring remote-sensing and citizen-science opportunities for remote monitoring of welfare.
● Use of biologging tools, such as accelerometers, and acoustic surveillance to remotely distinguish specific behaviors in order to better understand how wild animals spend their time.

Physiological assessment

*Identifying, validating, calibrating, and expanding the use of non-lethal or less invasive alternatives for physiological assessment (e.g., use of hair, feathers, eDNA, etc.) to evaluate stress hormones.*

Temporal assessment

● Monitoring the varying welfare of individual animals throughout their lives and cumulative welfare over time.
● Monitoring the welfare of individual animals throughout their lives.
● Exploring opportunities for establishing long-term time-series monitoring of the welfare of individuals.
Modeling welfare

*Developing theories of wild animal welfare, testing hypotheses using theoretical projection models, modeling potential scenarios and outcomes with predictive power, and empirically testing theoretical models with available data.*

- Modeling the welfare consequences of interventions and natural pressures.
- Modeling the lives of wild animals of different species to determine the scale of negative to positive experiences and average wild animal life experience.
- Modeling the welfare outcomes of concepts such as optimal population density, welfare expectancy, and life fates.
- Modeling the welfare cost of death in relation to affective state.
- Modeling differences in behavior and physiology in relation to welfare.
- Modeling relationship between components of welfare, subjective experience, and affective state.
- Modeling disease and welfare.
- Modeling interactions between climate and welfare.
- Modeling interactions between predicted climate change and welfare outcomes.
- Modeling ecosystem trophic dynamics and welfare outcomes.
- Modeling consumer-producer interactions and welfare outcomes.
- Modeling predator-prey interactions and welfare outcomes.
- Modeling welfare outcomes in relation to variation in behavioral strategies (e.g., animal personalities).
- Modeling impacts of early-life behavior, choices, and provisioning on later life welfare.
- Modeling individual welfare with respect to demographic and environmental predictors (e.g., age, sex, habitat type, etc.)
- Modeling energy and time budgeting by individuals (e.g., 1,2,3,4,5).

**Section 3: What can we do to improve the lives of wild animals?**

Overall, management of wild animal populations will be needed to improve the welfare of wild animals. Therefore, it is important to identify the most promising currently available methods as well as develop novel methods to steward nature in a way that improves wild animal welfare, whilst being cautious of the unknowns and making every effort to limit any unintended negative consequences. To do this will require investigating the impacts of existing management approaches, as well as...
evaluating the potential of novel approaches and welfare approaches that are yet to be trialed in the wild.

Converting the knowledge gained from the study of wild animal welfare science into tangible interventions requires building a community of practitioners who can apply the knowledge and understanding to practice. Interventions for wild animal welfare would be best targeted selectively by dedicated practitioners, but in the near-term, management of wild animals will occur irrespective of an understanding of their welfare. Identifying how existing management can be more mindful of welfare considerations also represents an important and more immediate opportunity for improving wild animal lives. It is necessary, therefore, to identify ways to incorporate actions that can both mitigate negative welfare impacts and improve wild animal lives into existing management approaches. Determining the least harmful and most beneficial methods for wild animal management is an important near-term goal of wild animal welfare research.

Studies that help define best practices for wild animal welfare interventions and research that defines good norms for implementation are also essential to establish good standards in the field of wild animal welfare science.

**Identifying and establishing best practices for wild animal welfare interventions**

It is important to approach the opportunity to convert knowledge to action with caution. Because animals interact with each other and their environment, most interventions will have knock-on impacts from the target individual(s) to others. Identifying best-practice approaches when faced with uncertainty and balancing urgency and caution are needed to ensure that knowledge converted to practice does not do more harm than good.

**Best practices in the study of wild animals**

- Determining the effectiveness of the 3Rs principles for wild animal welfare research.
- Defining best practices for animal use, balancing information and impact of laboratory analysis, and identifying alternatives to animal use.
- Defining best practices for monitoring wild animals — balancing information and impact of surveillance.
- Identifying and reducing welfare impacts of captivity stress on wild animals.
- Understanding and defining best practices for the use of captive animals to support wild animal welfare.
Best practices for policy and legal frameworks that support wild animal welfare

- Identify and define the most appropriate targets for policy.
- Identify appropriate avenues and engagement mechanisms for advocacy.

Best practices for wildlife interventions

- Defining best practices for operating under uncertainty.
- Defining best practices for monitoring impacts of interventions.
- Establishing adaptive processes for interventions.
- Assessment of persistence and reversibility of interventions.
- Defining best practices for decision-makers (e.g., politicians and managers) with regard to wild animal welfare considerations.

Human-animal interactions

The nearest-term interventions that might reasonably be accomplishable are those with the fewest system effects. Thus, changing the way humans interact with wild animals could represent the most impactful, tractable, and realizable way to improve the lives of wild animals in the short-term. In particular, identifying more humane ways to control populations and reducing or improving the ways that wild animals are killed have the potential to improve the lives of many wild animals in the short-term. Therefore, while human-animal interactions are not a strong focus for Wild Animal Initiative, it is a priority area for wild animal welfare research.

- Improving fish catch methods to be more humane.
- “Pest” control (e.g., rat control, pesticides, etc.)
- More humane methods for population control of wild species (e.g., deer, foxes, badgers, etc.)
- Understanding impacts of development on wild animal welfare.
- Understanding impacts of sustainable development on wild animal welfare.

Determining impacts of interventions

Areas where practitioners are actively engaged with wild animals include population control, disease control, rehabilitation, restoration, conservation, and climate change. Although there are other areas of relevance for interventions, these represent (at least in the short-term) the most viable opportunities for interventions that are likely to be impactful. Identifying ways to address the welfare needs of wild animals and improving practices for interventions in these areas are important areas of research.
Welfare effects of population control

- Validation of positive welfare effects of wildlife contraceptives.
- Comparison of welfare effects of different wildlife contraceptives.
- Understanding population and demographic impacts of supplemental feeding.
- Development of more humane pesticides and comparison of welfare impact among methods.
- Assessment of methods for invertebrate population control.
- Welfare consequences of past wild animal control.
- Impact of management of keystone species on welfare of other individuals in the community.

Welfare effects of disease control

- Understanding direct impacts of vaccines on wild animals.
- Investigate the potential knock-on effects that vaccine (and other disease control) programs have on target and non-target animals.
- Investigate impacts of parasite control (e.g., deworming).
- Sterile Insect Technique (SIT).

Welfare effects of ecosystem restoration

- How restoration ecology impacts the welfare of individuals living within restored environments.
- Evaluation of which ecosystem conditions (historical or novel) restoration ecology efforts should target to maximize the welfare of individuals living within restored environments.

Welfare effects of conservation and rehabilitation

- Understanding the direct and indirect welfare impacts of headstarting.
- Post-release welfare impacts of headstarting.
- Comparative assessment of wild-born versus captive-raised and released individuals.
- Directed studies of post-release welfare of rehabilitated individuals.
- Understanding welfare effects of supplemental feeding.
- Comparative welfare assessment of captive enriched versus wild lives of animals.
- Welfare impacts of habitat provisioning, such as nest boxes.
- How conservation efforts to support one species affect other species sharing the habitat.
- Welfare impacts of reintroductions on target and non-target species.
- Welfare impacts of environmental enhancement (e.g., water quality improvements).
- Determining welfare impacts of population enhancements/management (as opposed to control).
Welfare effects of climate change mitigation efforts

- Determining the wild animal welfare impacts of interventions to mitigate climate change.
- Impacts of short-term climate adaptation interventions.
- Impacts of mitigation efforts to reduce climate change impacts on humans, such as forest fires and flooding.
- Impacts of interventions that aim to mitigate longer term effects of climate change.