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Corresponding Author:	Jarić Ivan Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology Ceske Budejovice, CZECH REPUBLIC
First Author:	Jarić Ivan
Order of Authors:	Jarić Ivan
	Uri Roll
	Marino Bonaiuto
	Barry W. Brook
	Franck Courchamp
	Josh A. Firth
	Kevin J. Gaston
	Tina Heger
	Jonathan M. Jeschke
	Richard J. Ladle
	Yves Meinard
	David L. Roberts
	Kate Sherren
	Masashi Soga
	Andrea Soriano-Redondo
	Diogo Veríssimo
	Ricardo A. Correia
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Societal extinction of species

Ivan Jarić[1,2*], Uri Roll[3], Marino Bonaiuto[4], Barry W. Brook[5,6], Franck Courchamp[7], Josh A. Firth[8], Kevin J. Gaston[9], Tina Heger[10,11,12,13], Jonathan M. Jeschke[12,13,11], Richard J. Ladle[14,15], Yves Meinard[16], David L. Roberts[17], Kate Sherren[18], Masashi Soga[19], Andrea Soriano-Redondo[20,21], Diogo Veríssimo[8], Ricardo A. Correia[20,21,22,15]

[1] Biology Centre of the Czech Academy of Sciences, Institute of Hydrobiology, České Budějovice, Czech Republic

[2] University of South Bohemia, Faculty of Science, Department of Ecosystem Biology, České Budějovice, Czech Republic

[3] Mitrani Department of Desert Ecology, The Jacob Blaustein Institutes for Desert Research Ben-Gurion University of the Negev, Midreshet Ben-Gurion, Israel

[4] Sapienza Università di Roma, Rome, Italy

[5] School of Natural Sciences, University of Tasmania, Hobart, Tasmania, Australia

[6] ARC Centre of Excellence for Australian Biodiversity and Heritage, University of Tasmania, Hobart, Tasmania, Australia

[7] Université Paris-Saclay, CNRS, AgroParisTech, Ecologie Systématique Evolution, Orsay, France

[8] Department of Zoology, University of Oxford, Oxford, UK

[9] Environment and Sustainability Institute, University of Exeter, Penryn, Cornwall, UK

[10] Technical University of Munich, Restoration Ecology, Freising, Germany

[11] Berlin-Brandenburg Institute of Advanced Biodiversity Research (BBIB), Berlin, Germany

[12] Leibniz Institute of Freshwater Ecology and Inland Fisheries (IGB), Berlin, Germany

[13] Institute of Biology, Freie Universität Berlin, Berlin, Germany

[14] CIBIO/InBio, Centro de Investigação em Biodiversidade e Recursos Genéticos, Laboratório

Associado, Universidade do Porto, Vairão, Portugal

[15] Institute of Biological and Health Sciences, Federal University of Alagoas, Maceió, AL, Brazil

[16] Université Paris Dauphine, PSL Research University, CNRS, Paris, France

[17] Durrell Institute of Conservation and Ecology, School of Anthropology & Conservation, University of Kent, Canterbury, Kent, UK

[18] School for Resource and Environmental Studies, Dalhousie University, Halifax, Canada

[19] Graduate School of Agricultural and Life Sciences, The University of Tokyo, Tokyo, Japan

[20] Helsinki Lab of Interdisciplinary Conservation Science (HELICS), Department of Geosciences and Geography, University of Helsinki, Helsinki, Finland

[21] Helsinki Institute of Sustainability Science (HELSUS), University of Helsinki, Helsinki, Finland

[22] CESAM - Centre for Environmental and Marine Studies, University of Aveiro, Aveiro, Portugal

[*] email ivan.jaric@hbu.cas.cz

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Abstract

The ongoing global biodiversity crisis not only involves biological extinctions, but also the loss of experience and the gradual fading of cultural knowledge and collective memory of species. We refer to this phenomenon as 'societal extinction of species' and apply it to both extinct and extant taxa. We describe the underlying concepts as well as the mechanisms and factors that affect this process, discuss its main implications, and identify mitigation measures. Societal extinction is

cognitively intractable, but it is tied to biological extinction and thus has important consequences for conservation policy and management. It affects societal perceptions of the severity of anthropogenic impacts and of true extinction rates, erodes societal support for conservation efforts, and causes the loss of cultural heritage.

Species go extinct twice – one time when the last individual stops breathing, and a second time when the collective memory about the species disappears.

[adapted from a quote attributed to both Banksy and Irvin Yalom]

The concept of societal extinction

The ongoing biodiversity crisis is characterized by extinctions, and impoverishment and homogenization of biological communities [1-3]. Extinctions cause the loss of ecological functions, ecological and cultural ecosystem services [3-5], and consequently the **extinction of experience** (see Glossary) [6]. This depletion of human-nature interactions [7] can reduce the societal salience of species, to a point where they are collectively forgotten. We refer to this phenomenon as '**societal extinction of species**': the loss of **collective memory**, attention, knowledge, representations and **cultural products** associated with species from cultures and/or societies (Figure 1). We suggest that societal extinction is typically associated with biologically extinct species, but can also occur for extant species that have lost societal salience. Societal extinction represents a link between societies and nature (in their broad, inclusive sense), and thus is affected by changes in **society**, nature, and/or in their intersection. Like biological extinction, societal extinction operates at multiple spatial scales: a species can be globally or regionally extinct from either a biological or societal perspective.

Societal extinctions are relevant for conservation policy and management because collective memory guides individual and collective decision-making [8,9]. We argue that societal

extinctions can affect people's perceptions of the environment, its natural state, severity of anthropogenic impacts, and true extinction rates. They can ultimately lead to collective generational amnesia, or a **shifting baseline syndrome** [8,10], and erode people's expectations of the state of the environment (i.e., what is normal or healthy) and their understanding of, and support for, conservation and restoration efforts [8].

Given the significance of these impacts, understanding the phenomenon of societal extinction could be important for mitigating the ongoing anthropogenic biodiversity crisis. Here, we suggest underlying mechanisms and factors that could affect this process, and discuss potential implications and mitigation measures.

Societal salience dynamics, transformation and extinction

Communicative and cultural memory

Collective memory and its two distinct but interrelated components—communicative and cultural memory—drive societal salience of species [11]. **Communicative memory** (also referred to as lived memory [9]) is generated through societal communication and interaction and transmitted through personal interactions or contemporary dissemination channels, like news, movies, social and other media [11-13]; its dynamics tend to be associated with relatively short timeframes. **Cultural memory** (sometimes referred to as distant memory [9]) is maintained by physical or digital recordings and cultural products, such as oral traditions, literature, paintings, and other artworks; it typically unfolds over longer timeframes [11,12].

Both phenomena affect, and usually reinforce, one another. Communicative memory of species is mainly based on personal memories of **direct experiences** and associated acts of communication (Box 1). However, it is also shaped by cultural memory and **vicarious experiences** based on cultural products [14]. In turn, species are more likely to feature in cultural products if they are present in communicative memory, through recurrent encounters and interactions [15], or

focusing events [14]. Such communicative acts increase the potential for generating cultural products, or restoring attention towards existing products, thereby contributing to cultural memory [11,13].

Species extinctions and societal salience dynamics

Many species go biologically extinct without ever entering the cultural memory, or even being discovered [16]. If known species decline, lose functional roles, and go extinct, the processes that generate and maintain their societal salience typically fade away. Direct experiences with such species gradually disappear and vicarious experiences dominate. Driven by the cessation of experience [6,17], communicative memory is lost over time through individual and generational amnesia, also termed shifting baseline syndrome [8,18,19]. For example, local knowledge of bird species in southwestern China diminished following their extirpation, to the point that people were unable to name any such species [20]. A similar story occurred among indigenous Tsimané in Bolivia [19]. Transgenerational, collective memory of extinct species, their vocalizations and appearance are lost [20,21]. Lack of records also contributes to this process; for instance, the Honshu wolf (*Canis lupus hodophilax*) has only a few specimens in museum collections, challenging its memory within Japanese society [21].

Reports of the dire state or extinction of salient species are often followed by a surge in media and societal attention [22]. However, such increases are typically transient [23,24]. Species losses are generally mirrored by reduced prominence in new cultural products and fading cultural memory [15]. Nevertheless, we argue that societal extinction is context-dependent, non-binary, and challenging to measure. For example, a species could become extinct from wider society but maintain salience as media symbols or within smaller groups, such as rural or Indigenous communities.

Drivers of societal extinction

The main factors affecting the magnitude and rate of societal extinctions include species charisma, taxonomy, extinction time, spatial factors, sociocultural factors, ecology and demography, technology, and the status and uncertainty of extinctions (Figure 2).

Species charisma

The charisma of a species affects its societal salience both before and after extinction and may prolong or weaken the process of societal extinction. Charismatic species are often large, colorful, with forward-facing eyes, and phylogenetically close to humans; they are usually positively perceived, can be evolutionary outliers or otherwise behaviorally novel, but sometimes also dangerous animals [25-29]. For example, the enduring popularity of the dodo (*Raphus cucullatus*) and thylacine (*Thylacinus cynocephalus*) has led to their use as conservation flagships [30] or as targets for **de-extinction** [31]. Decades to centuries after their biological extinction, they feature prominently in cultural and commercial products, as mascots, emblems, and logos [32]. Some species may even become societally *more* salient post-extinction *because* they are extinct [30], potentially undergoing **cultural transformation** (Box 2), and sometimes even leading to 'cultural mythicism' [33].

Most species, however, cannot become societally extinct because they never had a societal presence. Such societal absence is common in uncharismatic, small, cryptic, or inaccessible taxa. This includes most of biodiversity, predominantly invertebrates, plants, fungi and microorganisms. Societally absent species can be divided into two sub-groups: (a) species that are known by scientific and/or Indigenous experts but unknown by laypeople, and (b) species unknown to humankind. The second group is part of the **Linnean shortfall** in biodiversity knowledge, affecting understanding of societal salience and extinction.

Taxonomy

Societal taxonomies do not always align with biological taxonomy. Many biological species are only societally salient as representatives of higher taxa, such as bats, sharks, or spiders. Moreover, societal salience can also be shaped by morphological and **evolutionary distinctiveness** [34]. For example, loss of a fish species from a large family such as Cyprinidae (e.g., Beyşehir bleak, *Alburnus akili* [35]) would likely be perceived as less troubling than the extinction of the Chinese paddlefish (*Psephurus gladius*), which was one of the last two members of the relict family Polyodontidae [36]. Furthermore, public concern about extinction is more focused on the loss of species than of subspecies or other evolutionarily significant units [37]. Moreover, some biological species may have multiple societal identities, often regionally differentiated. For example, *Rangifer tarandus* is known as reindeer in Northern Eurasia where it is herded and domesticated, but as caribou in North America where it is not. In addition, societal identity can jump from one species to another, mainly through taxonomic misidentification, as was the case with the red hen (*Aphanapteryx bonasia*), which inherited the dodo's name and identity in Mauritius following the extinction of the latter [38].

Extinction time

Extinctions can be distinguished by timeframe: contemporary, historic, or prehistoric. In contemporary extinctions, collective memory of species includes lived memory and direct experiences. Consequently, their extinction may be associated with strong emotions such as environmental grief, loss, and shame [39,40], which can strengthen societal attention and memory. In historic extinctions, species may remain within collective memory especially if they are iconic. However, most are fully culturally transformed (Box 2), and often maintained only in folklore. Rarely, awareness of societally extinct species can be restored from cultural products, as was the case with extinct goose species identified from ancient Egyptian paintings [41]. Prehistorically

extinct species have never been part of human lived memory. These species can only enter cultural memory through vicarious experiences from museums and popular media. For example, dinosaurs only became known to science in the 18th century [42]. Their abstract, stylized, and symbolic representation in culture is more akin to mythical creatures (e.g., unicorns, griffins, or dragons) than real species.

Spatial factors

Societal salience and extinction dynamics vary spatially [32]. Collective memory is most resilient within a species' geographic range, where it emerged through direct interactions [7]. Outside of ranges, collective memory arises predominantly through vicarious experiences (but sometimes also in botanical gardens, zoos, and museums). However, following biological extinction and cultural transformation, collective memories inside and outside the former range will converge. Furthermore, local biological extinction could lead to societal extinction, while elsewhere the species at issue may remain societally salient. The thylacine and the Tasmanian devil (*Sarcophilus harrisii*) were both extirpated on mainland Australia in the mid-Holocene [43] and lost from Indigenous people's memory. Concurrently, both species persisted in Tasmania, where they remained important and salient among the Indigenous people.

Sociocultural factors

The importance of nature to societies and cultures has been studied at great length from ethnographic and anthropological perspectives. Within this body of work, the importance of species loss from shared experiences and memories has also been noted [44,45]. Sociocultural changes may lead to societal extinction when species remain extant, as happens when the loss of Indigenous societies, cultures, rights to land, or languages causes the loss of their collective memory of species [46]. Cultural losses experienced by Indigenous communities from biological extinctions might be

more acute because of their strong cultural ties to species. Furthermore, socio-economic changes driven by urbanization, industrialization, globalization, and modernization may radically change relationships with nature, leading to collective memory loss. For example, the replacement of traditional herbal medicine by modern medicine in Europe has degraded knowledge of many medicinal species [47]. Societal extinction may accelerate as intergenerational environmental knowledge-sharing is reduced [19]. More generally, sociocultural factors can decouple a species' societal status from its biological status.

Ecology and demography

Demographic or ecological changes in extant species can also lead to societal extinction, as happens if species go functionally extinct, or remain only in remote, inaccessible locations. Species found in inaccessible habitats with low detectability, such as aquatic environments, are less salient to begin with, so can easily become societally extinct [48,49]. Furthermore, collective memory may fade more quickly for species whose habitats were lost. Societal extinction may also be affected by changes in species population structure, such as shifts to less salient age classes, behavior, or morphology.

Technology

New technologies can change the way we share and maintain collective memory. Internet usage changes memory and attention at individual and population levels [50], while print and digital media may replace oral traditions and older people's roles as keepers of collective memory [9]. Shifting to technology-mediated experiences of nature further affects public perceptions and intensifies cultural transformation of species [51]. This process can accelerate via positive feedback, whereby digital content drives the generation of similar content (e.g., memes), potentially exacerbating representational inequality among species. Such digital amplification could accelerate

societal extinction, as local species representations are replaced by globally iconic species [52].

Status and uncertainty of extinctions

Finally, species extinction status and the potential of rediscovery or reintroduction can also affect collective memory loss [39]. For example, a species may be perceived differently if it is biologically extinct, compared to extinct in the wild. Moreover, uncertainty about whether a species is extinct may help maintain its societal salience. Uncorroborated sightings of the ivory-billed woodpecker (*Campephilus principalis*), long considered extinct, revived public interest, search efforts, investments in recovery plans, and boosted birdwatching tourism [53]. Similarly, declaring the extirpation of the ghost orchid (*Epigogium aphyllum*) in the UK raised its profile and boosted search efforts by amateur botanists, eventually contributing to its rediscovery [54]. Species rediscoveries and efforts towards extinction reversal, such as reintroductions, rewilding, or de-extinction, often reinvigorate species societal presence [31,39,55].

Implications and mitigation solutions

Consequences

Understanding societal extinction of species is important for conservation theory, policy, and practice. Collective loss of memory can weaken pro-environmental attitudes and behaviors (Figure 2) [6,17]. Moreover, the shifting baseline syndrome changes public perceptions regarding the natural state of the environment, and reduces likelihood of pursuing ambitious conservation goals [8]. For example, megafaunal rewilding efforts might have greater support if wild Pleistocene megaherbivore herds were preserved in collective memory. Reintroduction efforts of more recently extirpated species, such as Eurasian beaver (*Castor fiber*) in the UK, may also suffer from their absence in collective memory as natural parts of ecosystems [56]. Societal extinction of traditional ecological knowledge can lead to cultural heritage loss [47].

In biologically extant but societally extinct species, societal absence may hinder conservation measures and accelerate biological extinction if, for example, core habitat is destroyed by development. Paradoxically, societal extinction could also be exacerbated by conservation policies, for example those that restrict access to natural areas. Conversely, societal extinction can help conservation by removing pressure on a species from exploitation or over-tourism [57].

Mitigation solutions

We suggest that conservation education and marketing campaigns could be important to counteract societal extinction [26,58]. Reviving the memory of societally extinct species is especially important when no living eyewitnesses remain [9]. Such initiatives should embrace a biocultural perspective on extinction that transcends ecological aspects of species to include their societal profile [39]. Indigenous people can be key allies in this process. Cultural memory of species should be incorporated in outreach activities to drive conservation support [59]. Targeted, long-term marketing campaigns could aim to increase connections with extinct species [30]. For example, the National Threatened Species Day in Australia is held annually on September 7, the anniversary of the death of the last captive thylacine in the Hobart zoo [60]. Finally, tackling the process of societal extinction necessitates reducing the extinction of experience by, for example, combining direct nature interactions with conservation marketing [6].

Collective memory also needs to be rekindled in reintroduction programs, especially for species extinct in the wild. In the same way that cultural identity has been strengthened by resurrecting dead languages (e.g., Cornish [61]), highlighting society's historic links with extinct species could lay the groundwork for rewilding and reintroductions and increase conservation support. A good example is Alagoas Curassow (*Pauxi mitu*), an endemic bird from northeast Brazil that went extinct in the wild 40 years ago [62] and was reintroduced in 2019 [63]. Prior to reintroduction it was the subject of a high-profile public campaign that used the slogan "Let's bring

this Alagoan home", explicitly linking its reintroduction to regional cultural identity.

Concluding remarks

Ultimately, the escalation of societal extinction can cause many problems for conservation practitioners (see Outstanding Questions). The ongoing extinction crisis and increasing disconnection of humans from nature are creating a growing **societal extinction debt**, with many occurrences of societal extinction likely lying ahead. Sustaining awareness of species and their threats also holds cognitive and emotional consequences for individuals [64]. Resolving these issues will require multidisciplinary approaches that go beyond ecology and conservation biology.

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Box 1. Direct and vicarious experiences.

Collective memory of a species stems from both (1) direct or embodied experiences, and (2) indirect, vicarious, or disembodied experiences [51]. Direct experiences are mainly built through direct human-nature interactions based on sensory (mainly visual and acoustic) contact [7]. As such, they are associated with specific, first-hand species knowledge and awareness, its morphology, behaviour, environment, and its cultural ecosystem services. Except for contact with species in captivity, especially in zoos and botanical gardens [65], direct experiences are spatially constrained to the species' range. Direct experiences are also highly dependent on a species' abundance, population trends, behaviour, visibility, and accessibility.

Conversely, vicarious experiences are based on virtual exposure to species (i.e., without direct sensory contact with the species), through various physical or digital records from natural history, literature, art, oral traditions, and media [66]. While vicarious experiences may involve realistic species representations, they can also be highly stylized, symbolic, or even fantastical representations (e.g., anime), and may not directly link to species in their natural settings [51,65]. They tend to be less dependent on species presence, distribution, or status, and are more influenced by other factors, such as a species' charisma, historical fame, socio-economic or symbolic value. The type of experience on which a memory is based can affect its characteristics. Individual vicarious memories tend to be faint and ephemeral, while direct experiences, especially those associated with strong emotions, generate more long-lasting individual memories [9,51], and even environmental epiphanies [67]. Also, the psychological intensity of an individual's nature experience is often positively correlated with their resulting drive to achieve pro-environmental actions [68].

Box 2. Cultural transformation.

Following their biological extinction, some species undergo societal extinction, while others remain societally salient, or even increase in presence (Figure 1). However, collective memory of such extinct but salient species often undergoes substantial changes: it is disassociated from its biological identity and culturally transformed. Direct experiences and lived memory are lost, while vicarious experiences and inaccurate, stylized, or simplified representations become dominant [51]. For example, following the extinction in the wild of the Spix's macaw (*Cyanopsitta spixii*), children living within the Curaçá municipality, part of its previous range, incorrectly believed that this species resides in Rio de Janeiro following its appearance in the animated movie 'Rio' [69]. Moreover, prior to extinction, virtual species can compete with the real populations for societal attention and provide a false appearance of abundance [70]. Processes of cultural transformation mostly occur in species that were societally salient. These species have more virtual representation in commercial, artistic, and cultural outlets, which enables the disassociation of their societal from biological fates [70].

Glossary:

Collective memory: shared pool of memories, sustained by a community.

Communicative (lived) memory: memory generated through societal communication and interaction.

Cultural (distant) memory: memory maintained by physical or digital recordings and cultural products.

Cultural product: tangible and intangible creations of a particular culture.

Cultural transformation: substantial changes in collective memory of a species, characterized by its disassociation from its biological identity.

De-extinction: recreation of once-extinct species, such as by genetic resurrection [31].

Direct (embodied) experiences: experiences built through direct human-nature interactions based on sensory contact [66].

Extinction of experience: progressive loss of daily interactions between people and nature [6].

Evolutionary distinctiveness: the amount of non-redundant evolutionary change embodied within a given taxon [34].

Focusing events: sudden, relatively uncommon attention-grabbing events, which often concentrate attention on previously dormant issues.

Linnean shortfall: the major gaps in taxonomic knowledge, with only a fraction of species worldwide described by science.

Shifting baseline syndrome: a gradual change in the accepted norms for the condition of the natural environment due to lack of past information or lack of experience of past conditions [8].

Societal extinction debt: time-delayed societal extinctions of species.

Societal extinction of species: loss of societal attention and collective memory of a species.

Society: a group of people who live together in a particular social system.

Vicarious (indirect, disembodied) experiences: experiences based on virtual exposure to species, through various physical or digital records from literature, art, oral traditions, and media [66].

Figure captions

Figure 1. Diagram outlining the main conceptual types of trajectories of societal extinction. Trajectories are based on biological and societal species status (extant or extinct). Continuous red line – standard scenario, societal salience declines following species extinction towards complete societal extinction. Blue dashed line – societal extinction occurs while the species is still extant, often due to different socio-cultural, demographic or ecological changes. Green dotted line – species experiences increasing societal salience following its biological extinction, most often due to its charisma and value. Orange striped line – societal salience of a species remains unaffected by its extinction, often because it was already culturally transformed. Black dash-dotted line – species was already societally absent prior to biological extinction, so its societal status remains unaffected by its disappearance. The figure presents only the major types of scenarios, while there are many more possible variants and more complex combinations of trajectories. It also does not present transient peaks in societal salience, such as those that often follow extinction reports, nor the trajectories characterized by extinction 'reversal', for example due to species rediscovery, reintroduction, or de-extinction.

Figure 2. Framework displaying the causes and consequences of societal extinction. Societal extinction is caused by collective memory loss, driven either by population decline and species extinction, or by different societal factors that can decouple the process of societal extinction from the biological status of a species, often through the process of cultural transformation. Societal extinction process could be affected by several main drivers: extinction time, status and uncertainty of extinctions (extinction status/certainty), ecology and demography (ecology/demography), taxonomy, species charisma (charisma), spatial factors, sociocultural factors, and technology. It

650 leads to a loss of interest in societally extinct species, decreased support for conservation or
651 reintroduction measures, and decreased conservation outcomes, which in turn drive and further
652 strengthen the causes of societal extinction. Links among the elements are to a great extent
653 hypothesized, and further studies are now needed to assess and quantify evidence for such links.
654
655

Highlights

- Just as population declines may lead to biological extinction, the decline of collective attention and memory may lead to the societal extinction of species.
- Direct and vicarious experiences with species affect their societal salience and likelihood of societal extinction.
- Societal extinctions affect perceptions of the environment, lead to a shifting baseline syndrome, hinder establishment of more ambitious conservation/restoration targets, and diminish support for conservation efforts.
- Several mitigation actions, relying predominantly on conservation education and marketing, are needed to reduce or reverse the societal extinction of species.

Outstanding questions

- Under what conditions, and over what spatial scales, is societal extinction of a species likely to occur and to progress more rapidly?
- Can we tease apart the biological from human drivers of societal extinction?
- How omnipresent and differently manifested is societal extinction across societies, and how specific is it?
- Under what conditions does preventing societal extinction of a species make it less likely to become biologically extinct?
- What are the best methods to record and maintain local and indigenous knowledge of species?
- What is the relationship between the ongoing process of loss and impoverishment of languages and societal extinction?
- What are the best approaches and strategies for societal de-extinction?
- What measures are needed to promote public awareness of societally non-existent species, and how do such interventions differ from (and influence) those aimed at maintaining interest in salient (societally extant) species?
- Should we strive to remind people about fully or nearly extinct species with an impending or already manifested societal extinction, or should we allocate efforts to other species that are more likely to societally persist?
- Could a stronger focus on societally extinct species detract much needed attention from imminent or future societal extinction risks to other species, and how can we balance this potential trade-off?
- When does mainstreaming knowledge about a species risk increase in the threats to its survival, for example through unsustainable exploitation?
- Will focusing on societal extinction take conservation attention from other conservation issues, or are these new messages mostly synergistic with previous ones?
- What are potential negative effects of promoting cultural and national identity through local nature?

- Should we always strive to combat collective memory loss, or should we accept that there are human psychological and cognitive constraints that will inevitably lead to a change in saliency for different species through time?
- Are the emotional costs of remembering species too high for individuals, given the growing prevalence of ecological grief?

Figure 1