Rewilding – the missing link in nature restoration?

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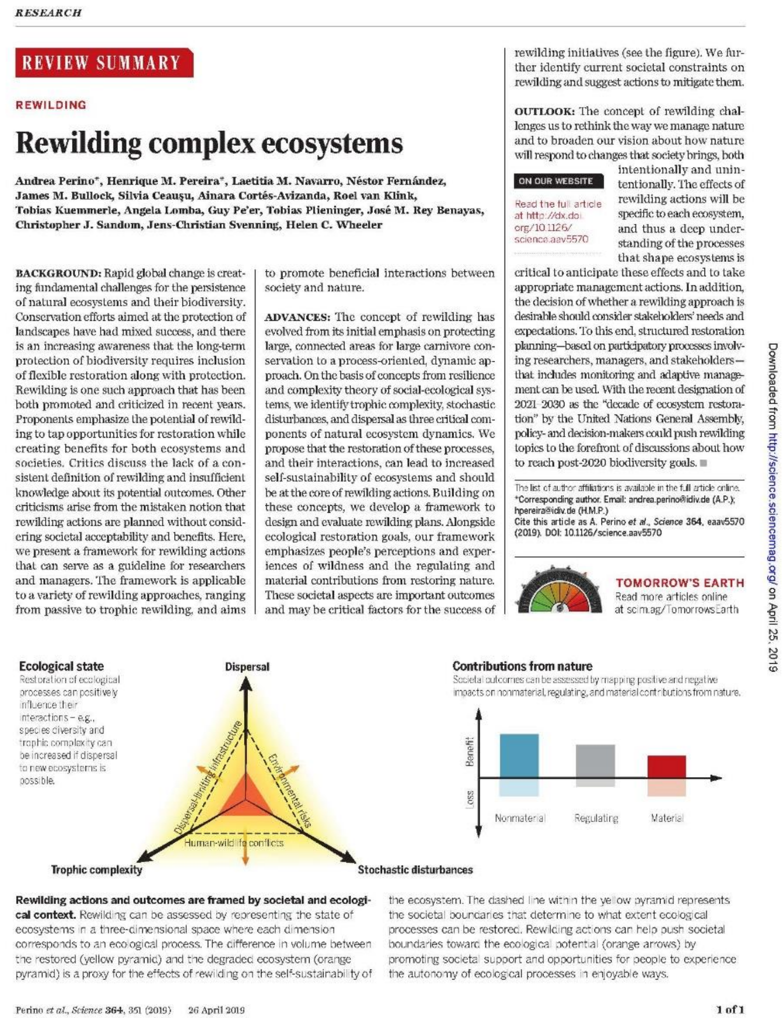
BIOCHANGE
CENTER FOR BIODIVERSITY DYNAMICS
IN A CHANGING WORLD

General framework for rewilding as a restoration approach

- Rewilding
  - **Ecological restoration to promote <u>self-regulating</u> biodiverse/complex ecosystems**
  - Key aspects
    - Reducing human control
    - Restoring ecological integrity (natural processes)
  - **Design and implementation**



RESEARCH

REVIEW SUMMARY

REWILDING

Rewilding complex ecosystems

Andrea Perino*, Henrique M. Pereira*, Laetitia M. Navarro, Néstor Fernández, James M. Bullock, Silvia Ceauşu, Ainara Cortés-Avizanda, Roel van Klink, Tobias Kuemmerle, Angela Lomba, Guy Pe'er, Tobias Plieninger, José M. Rey Benayas, Christopher J. Sandom, Jens-Christian Svenning, Helen C. Wheeler

BACKGROUND: Rapid global change is creating fundamental challenges for the persistence of natural ecosystems and their biodiversity. Conservation efforts aimed at the protection of landscapes have had mixed success, and there is an increasing awareness that the long-term protection of biodiversity requires inclusion of flexible restoration along with protection. Rewilding is one such approach that has been both promoted and criticized in recent years. Proponents emphasize the potential of rewilding to tap opportunities for restoration while creating benefits for both ecosystems and societies. Critics discuss the lack of a consistent definition of rewilding and insufficient knowledge about its potential outcomes. Other criticisms arise from the mistaken notion that rewilding actions are planned without considering societal acceptability and benefits. Here, we present a framework for rewilding actions that can serve as a guideline for researchers and managers. The framework is applicable to a variety of rewilding approaches, ranging from passive to trophic rewilding, and aims to promote beneficial interactions between society and nature.

ADVANCES: The concept of rewilding has evolved from its initial emphasis on protecting large, connected areas for large carnivore conservation to a process-oriented, dynamic approach. On the basis of concepts from resilience and complexity theory of social-ecological systems, we identify trophic complexity, stochastic disturbances, and dispersal as three critical components of natural ecosystem dynamics. We propose that the restoration of these processes, and their interactions, can lead to increased self-sustainability of ecosystems and should be at the core of rewilding actions. Building on these concepts, we develop a framework to design and evaluate rewilding plans. Alongside ecological restoration goals, our framework emphasizes people's perceptions and experiences of wildness and the regulating and material contributions from restoring nature. These societal aspects are important outcomes and may be critical factors for the success of rewilding initiatives (see the figure). We further identify current societal constraints on rewilding and suggest actions to mitigate them.

OUTLOOK: The concept of rewilding challenges us to rethink the way we manage nature and to broaden our vision about how nature will respond to changes that society brings, both intentionally and unintentionally. The effects of rewilding actions will be specific to each ecosystem, and thus a deep understanding of the processes that shape ecosystems is critical to anticipate these effects and to take appropriate management actions. In addition, the decision of whether a rewilding approach is desirable should consider stakeholders' needs and expectations. To this end, structured restoration planning—based on participatory processes involving researchers, managers, and stakeholders—that includes monitoring and adaptive management can be used. With the recent designation of 2021–2030 as the "decade of ecosystem restoration" by the United Nations General Assembly, policy- and decision-makers could push rewilding topics to the forefront of discussions about how to reach post-2020 biodiversity goals. ■

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TOMORROW'S EARTH
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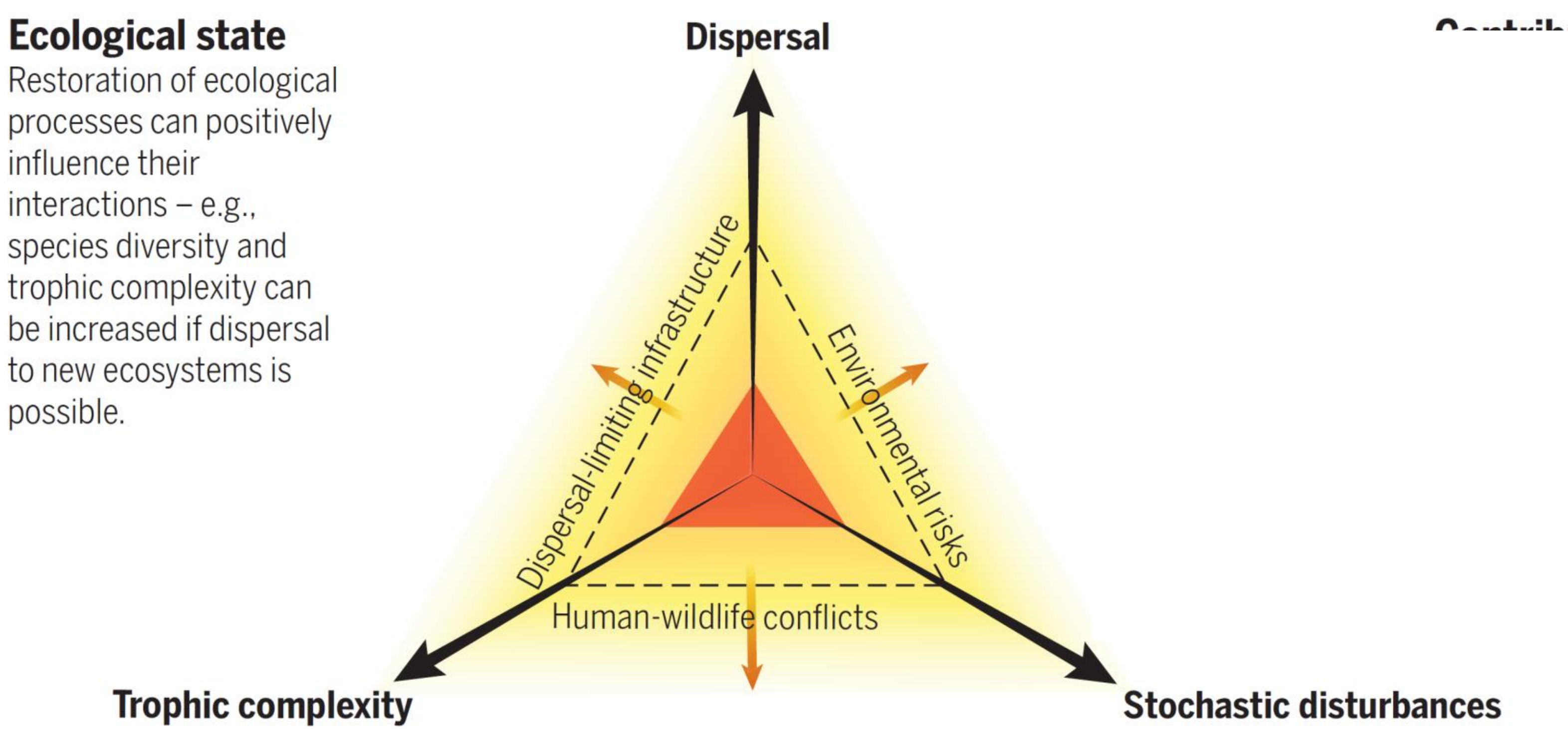
Perino *et al*. 2019 *Science* 364:eaav5570, http://bit.ly/rwScience.

Three key ecological components

- Trophic complexity
- Natural disturbances
- Connectivity/Dispersal



Perino *et al*. 2019 *Science* 364:eaav5570, http://bit.ly/rwScience.

Trophic rewilding

- Definition
  - **Species introductions to restore top-down trophic interactions and associated trophic cascades to promote self-regulating biodiverse ecosystems** (Svenning et al. 2016 PNAS)
- Mostly megafauna-based, due to
  - Ecological importance
  - Size-biased defaunation

SPECIAL FEATURE: PERSPECTIVE

PNAS

SPECIAL FEATURE: PERSPECTIVE

Science for a wilder Anthropocene: Synthesis and future directions for trophic rewilding research

Jens-Christian Svenning[a,1,2], Pil B. M. Pedersen[a,1], C. Josh Donlan[b,c], Rasmus Ejrnæs[d], Søren Faurby[a], Mauro Galetti[e], Dennis M. Hansen[f], Brody Sandel[a], Christopher J. Sandom[g], John W. Terborgh[h], and Frans W. M. Vera[i]

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Trophic rewilding is an ecological restoration strategy that uses species introductions to restore top-down trophic interactions and associated trophic cascades to promote self-regulating biodiverse ecosystems. Given the importance of large animals in trophic cascades and their widespread losses and resulting trophic downgrading, it often focuses on restoring functional megafaunas. Trophic rewilding is increasingly being implemented for conservation, but remains controversial. Here, we provide a synthesis of its current scientific basis, highlighting trophic cascades as the key conceptual framework, discussing the main lessons learned from ongoing rewilding projects, systematically reviewing the current literature, and highlighting unintentional rewilding and spontaneous wildlife comebacks as underused sources of information. Together, these lines of evidence show that trophic cascades may be restored via species reintroductions and ecological replacements. It is clear, however, that megafauna effects may be affected by poorly understood trophic complexity effects and interactions with landscape settings, human activities, and other factors. Unfortunately, empirical research on trophic rewilding is still rare, fragmented, and geographically biased, with the literature dominated by essays and opinion pieces. We highlight the need for applied programs to include hypothesis testing and science-based monitoring, and outline priorities for future research, notably assessing the role of trophic complexity, interplay with landscape settings, land use, and climate change, as well as developing the global scope for rewilding and tools to optimize benefits and reduce human–wildlife conflicts. Finally, we recommend developing a decision framework for species selection, building on functional and phylogenetic information and with attention to the potential contribution from synthetic biology.

conservation | megafauna | reintroduction | restoration | trophic cascades

Human impacts are so pervasive that a new geological epoch has been proposed: the Anthropocene (1). The effects on ecosystems and biodiversity are one of the biggest challenges facing modern society. Large-bodied animals are particularly affected, with massive prehistoric extinctions (2–4) and severe declines in many extant species (5). Over the last decades it has become increasingly clear that large animals are often important for ecosystem function and biodiversity via trophic cascades, the propagation of consumer impacts downward through food webs (6, 7). Their widespread losses have led to trophic downgrading on a global scale, with negative effects on ecosystems and biodiversity (6–8).

These observations have inspired a new ecological restoration approach that we here refer to as "trophic rewilding." The rewilding concept was introduced in the late 20th century as a large-scale conservation

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Author contributions: J.-C.S., P.B.M.P., and S.F. designed research; J.-C.S., P.B.M.P., S.F., and D.M.H. performed research; P.B.M.P. and S.F. analyzed data; and J.-C.S., P.B.M.P., C.J.D., R.E., S.F., M.G., D.M.H., B.S., C.J.S., J.W.T., and F.W.M.V. wrote the paper.

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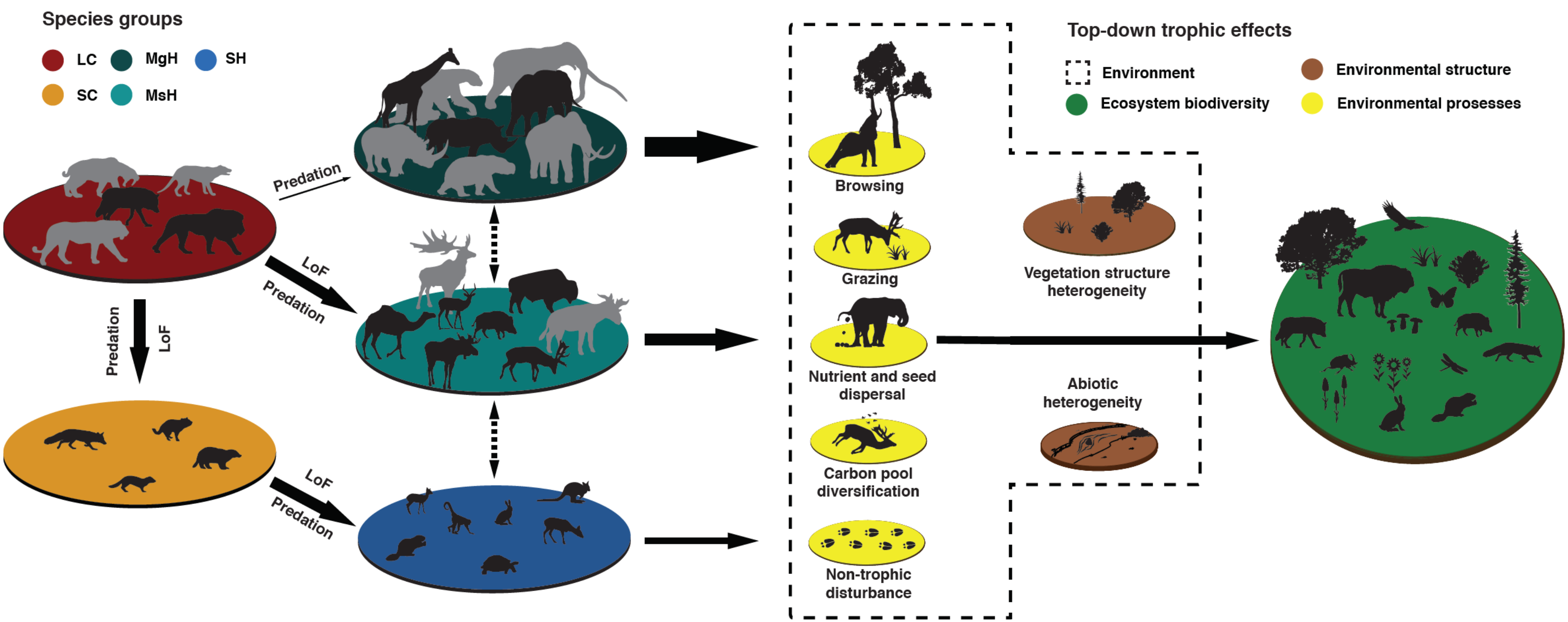
Svenning et al. 2016 *PNAS 113:898-906* http://bit.ly/rewildingPNAS.

Idea: Megafauna promotes biodiversity via top-down trophic processes+



<u>Increase diversity capacity of natural and semi-natural areas</u>

Svenning et al., in Pettorelli et al. 2019 "Rewilding", *Cambridge University Press*, http://bit.ly/rwBESbook

Abiotic & passive rewilding

- Abiotic rewilding
  - Restoration of natural physical processes
- Passive rewilding (=Passive management)
  - Spontaneous ecological dynamics without any, even initial management
  - Always an important aspect

Marselis woods south of Aarhus (Denmark)

Vorsø, Horsens Fjord (Denmark)

Photo: JCS

Why is rewilding needed?

1) Evolutionary perspective on biodiversity
2) Wildness as a value

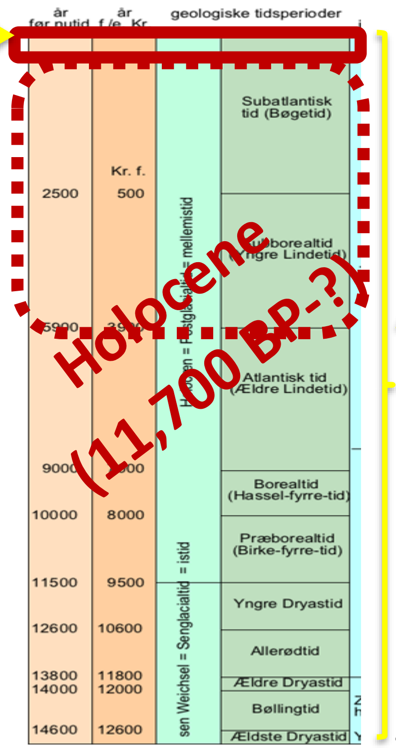
3) Overcome shifting baselines
4) Upscaling
5) Dynamic

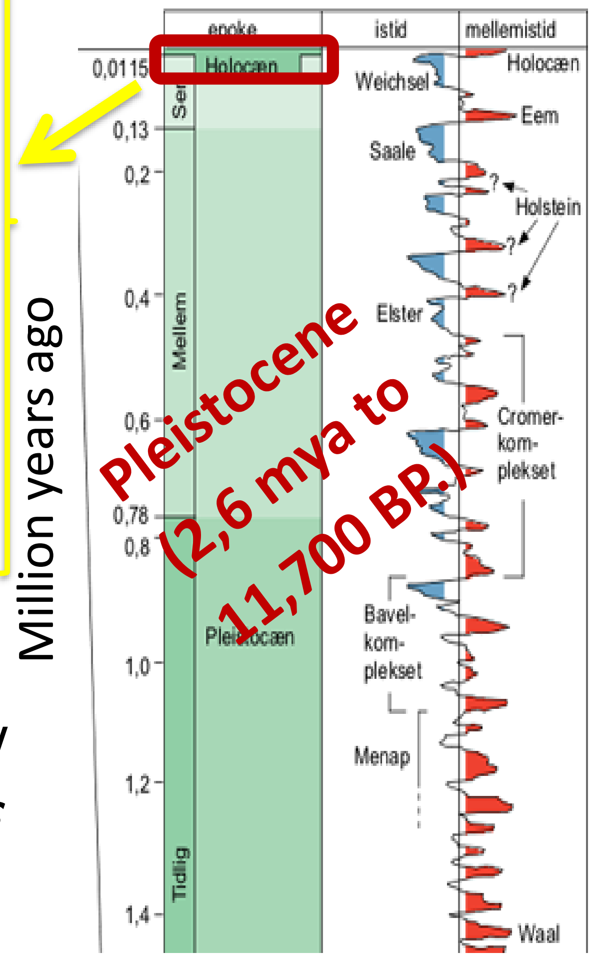
1: EVOLUTIONARY PERSPECTIVE

= restoring conditions functionally similar to those current species have evolved and persisted under through deep time should be most effective in long-term maintenance of biodiversity also in the future

Current species are ancient = evolved & persistent in wild ecosystems

Cultural landscape





Extant species

Mammals **Beetles** **Trees** **Vascular plants**

Evolutionary background of ecological adaptations even deeper

Den store danske, Kurtén 1968, Coope 2004 Phil. Trans. R. Soc. Lond. B, Mai 1995, Lang 1994

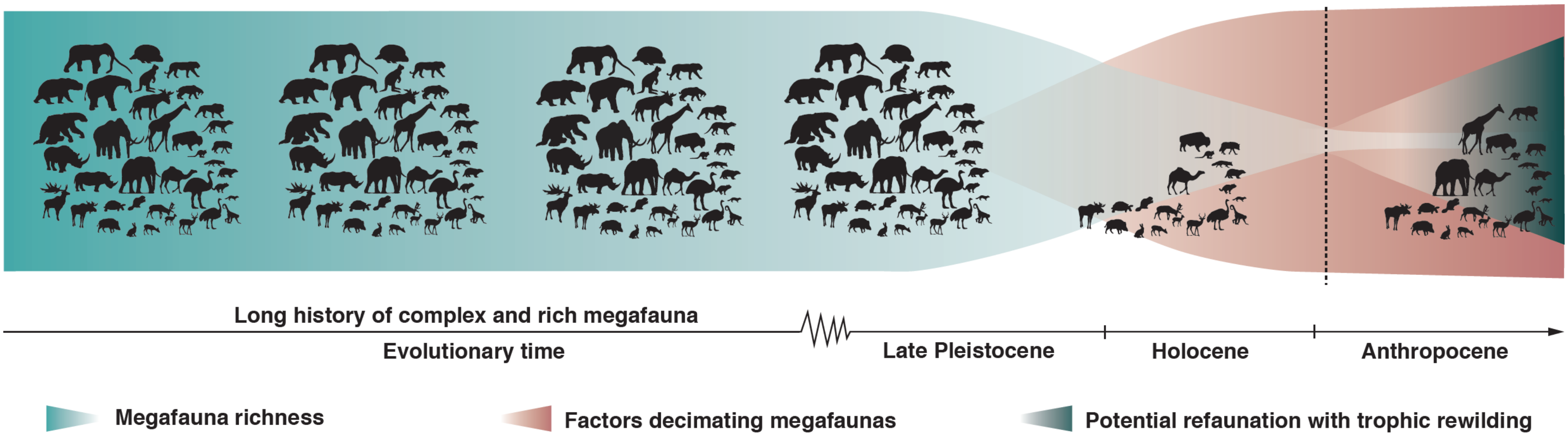
Skylark (*Alauda arvensis*)

Wikipedia

Beech (*Fagus sylvatica*)

Photo: JCS

Current species diversity evolved in megafauna-rich ecosystems



Rich megafaunas the evolutionary norm (an evolutionary base-line)

Svenning et al., in Pettorelli et al. 2019 "Rewilding", *Cambridge University Press*, http://bit.ly/rwBESbook

Rich megafaunas have been the standard for millions of years

England (Trafalgar Square) 125,000 years ago (Roman Uchytel)

Rich megafaunas have been the standard for millions of years

Germany (Dorn-Dürkheim), 8 million

Large animals are important

Exclosure in Yellowstone National Park

Foto: JCS

Large animals are important

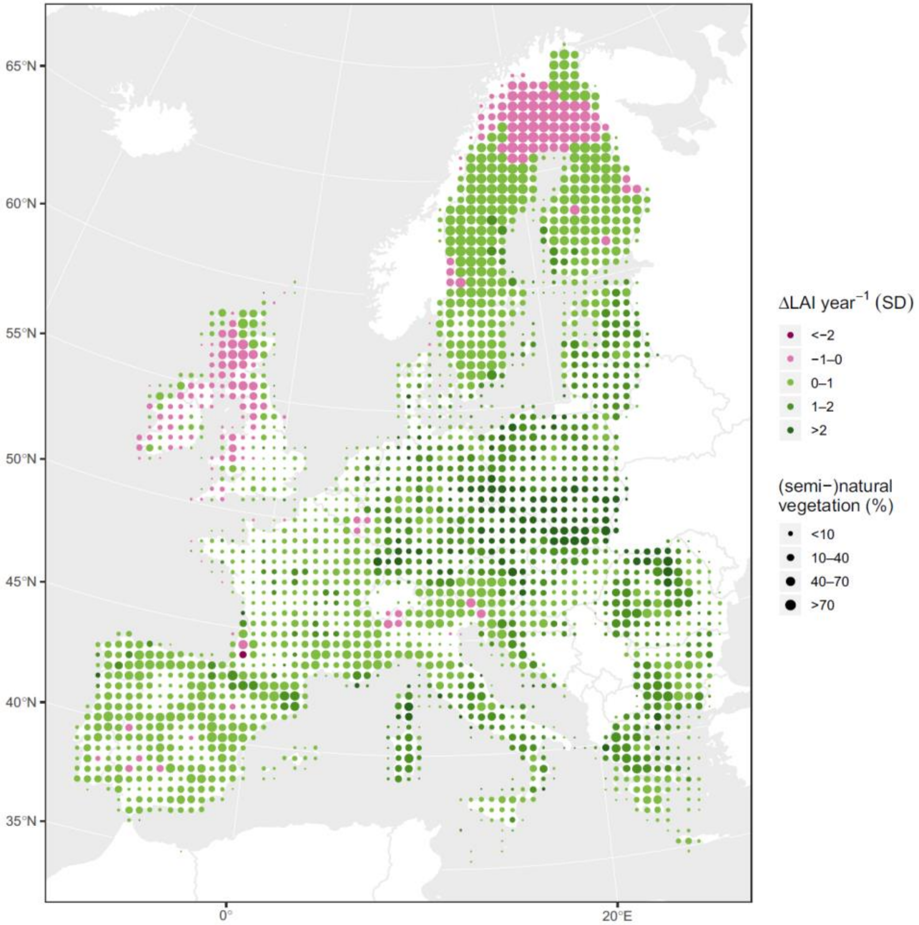
Tabel 4.2. Oversigtstabel over faglige skøn og vurderinger af biodiversitetseffekter ved forskellige plejemetoder. Jo flere +'er, jo større positiv effekt.

Type af effekt	Maskinel biomassehøst	Intensiv sommer-græsning	Sommer-græsning	Rotations-græsning	Vinter-græsning	Helårs-græsning	Vild-græsning
Hæmme tilgroning	+++	++	+	+	++	++	++
Hæmme konkurrenceplanter	+++	+++	++	++	+	++	+
Skabe blottet jord	++	+	-/+	+	+++	+++	+++
Abiotisk variation	-/++	++	++	++	+++	+++	++++
Sprede frø	-	+	+	+	+	++	++++
Kulstof variation	-/++	+	+	++	++	+++	++++
Blomstring	++	-	-/+	++	++	+++	+++
Hvirvelløse dyr	-	-	-/+	+	++	+++	+++
Lysstillede veterantræer	+	++	+++	+++	+++	+++	+++
Gødning til faunaen	-	++	++	+	-	+++	++++
Ådsler	-	-	-	-	-	-	++++

Fløjgaard, Bladt & Ejrnæs 2017 Naturpleje og arealstørrelser med særligt fokus på Natura 2000 områderne DCE

Process problem

- **Negative eller manglende processer**



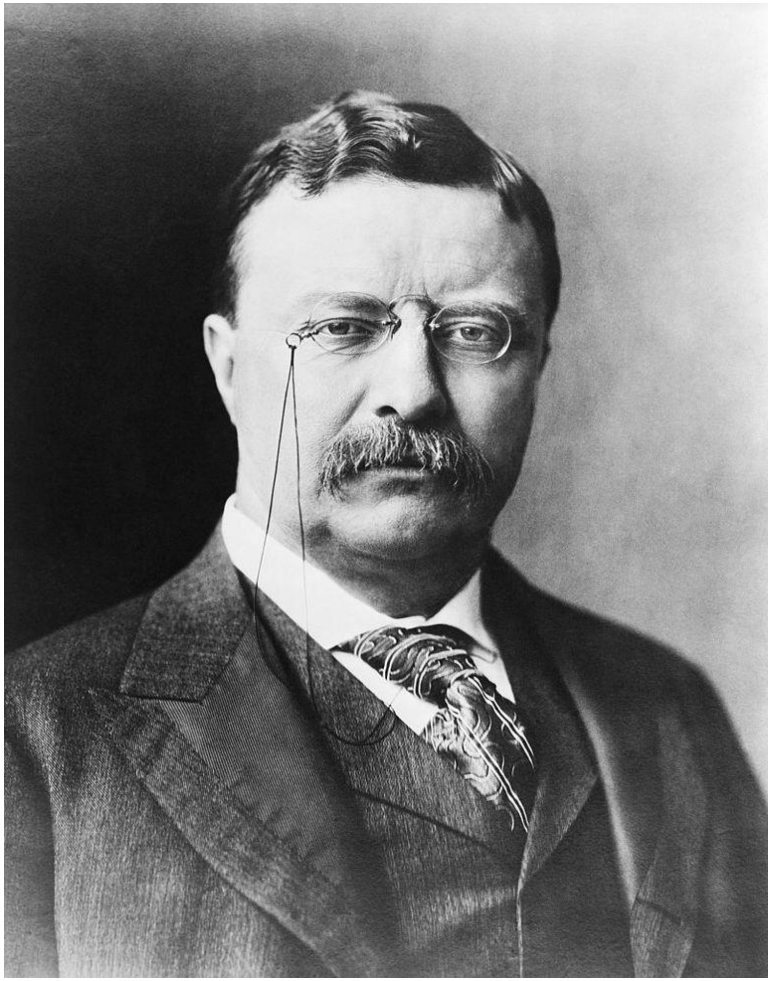
Buitenwerf, R., Sandel, B., Normand, S. Mimet, A. & Svenning, J.-C. 2018. Land-surface greening suggests vigorous woody regrowth throughout European semi-natural vegetation. *Global Change Biology* 24:5789–5801.

Foto: JCS

2: Wildness as a value

"There are no words that can tell the hidden spirit of the **wilderness**, that can reveal its mystery, its melancholy, and its charm‟

- Theodore Roosevelt, US president 1901-1909



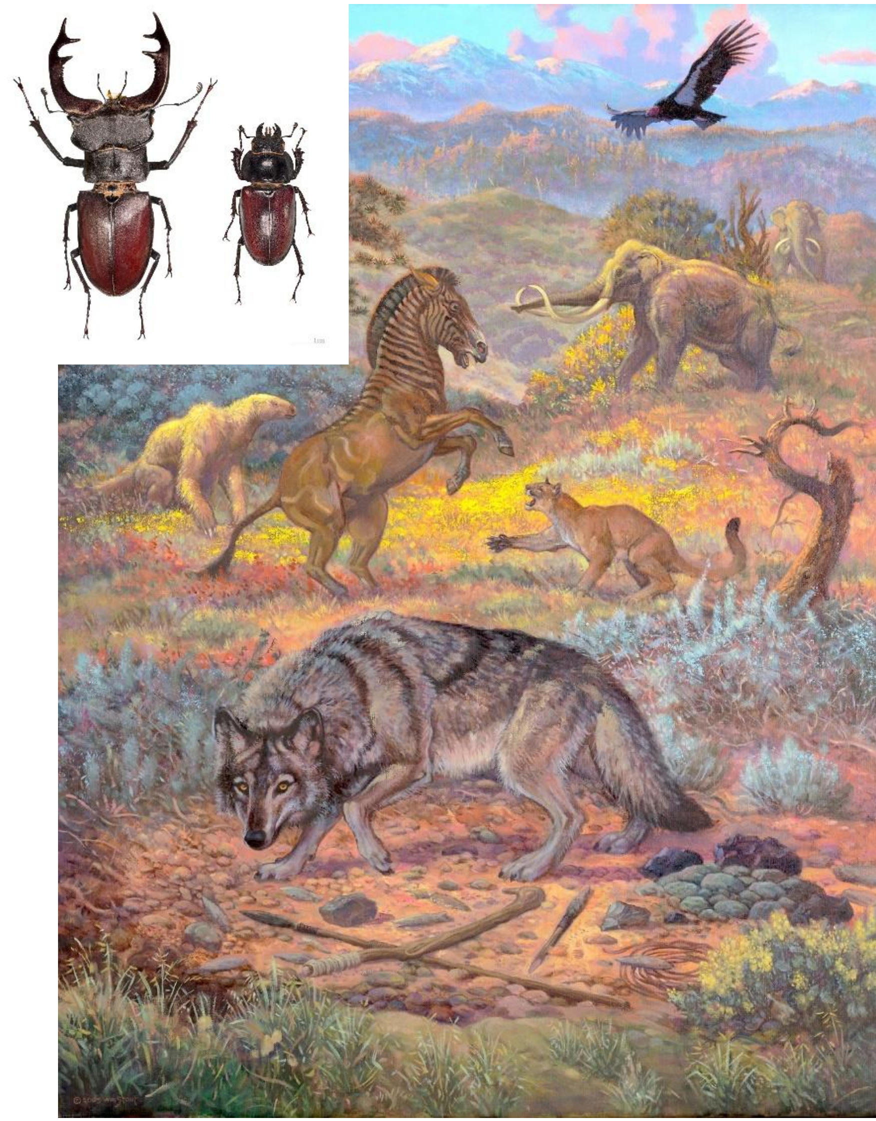

Yellowstone National Park
Foto: JCS

Autonomy of non-human life

George Cruikshank, British Museum

3: Shifting baseline

- Critically assess ecological integrity
  - Especially relative to evolutionary conditions
- Active restoration may be needed to not get locked into biodiversity-poor degraded persistent states
  - Especially as societally relevant time scales are decades, not millenia



William Stout, 2005; Wikipedia

4: Upscaling

- Functional area for nature/biodiversity is the biggest need to encounter the biodiversity crisis
- **Upscaling** crucial
  - Only practical & effective if strongly based on **autonomous** natural processes
    - Low cost/labor
    - Maximum value for biodiversity
- Key in relation to land abandonment

Selfsown oak (*Quercus robur*)

Photo: JCS

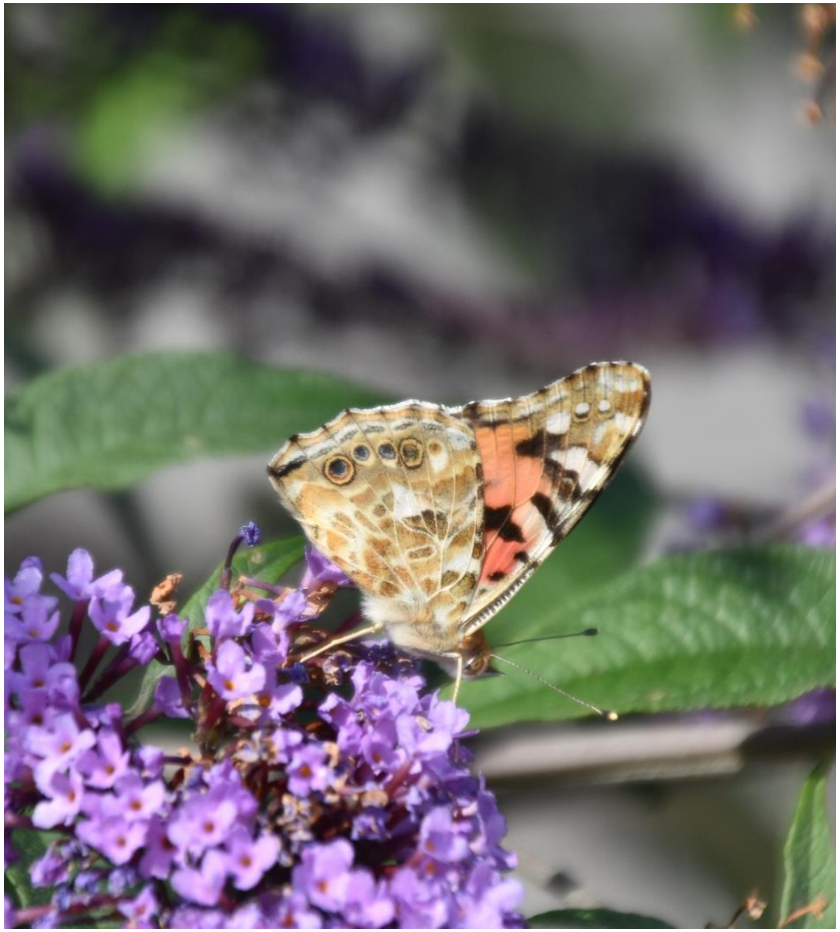
5: Dynamic

- Rewilding's focus on natural processes

↓

- Open-ended*
- Dynamic

- Good fit to global change



Hughes *et al*. 2011 Journal for Nature Conservation 19:245-253

Photo: JCS

Climate change

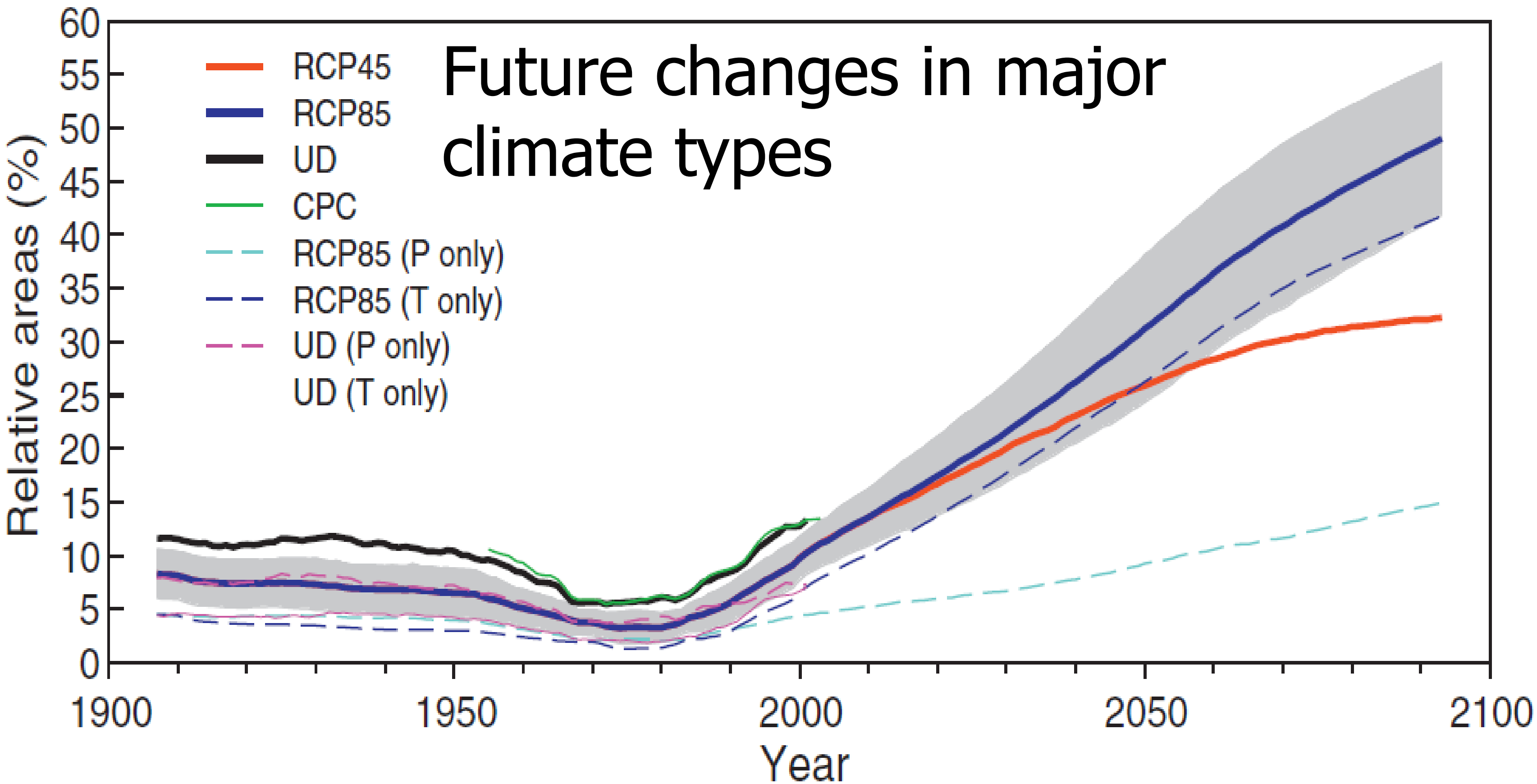
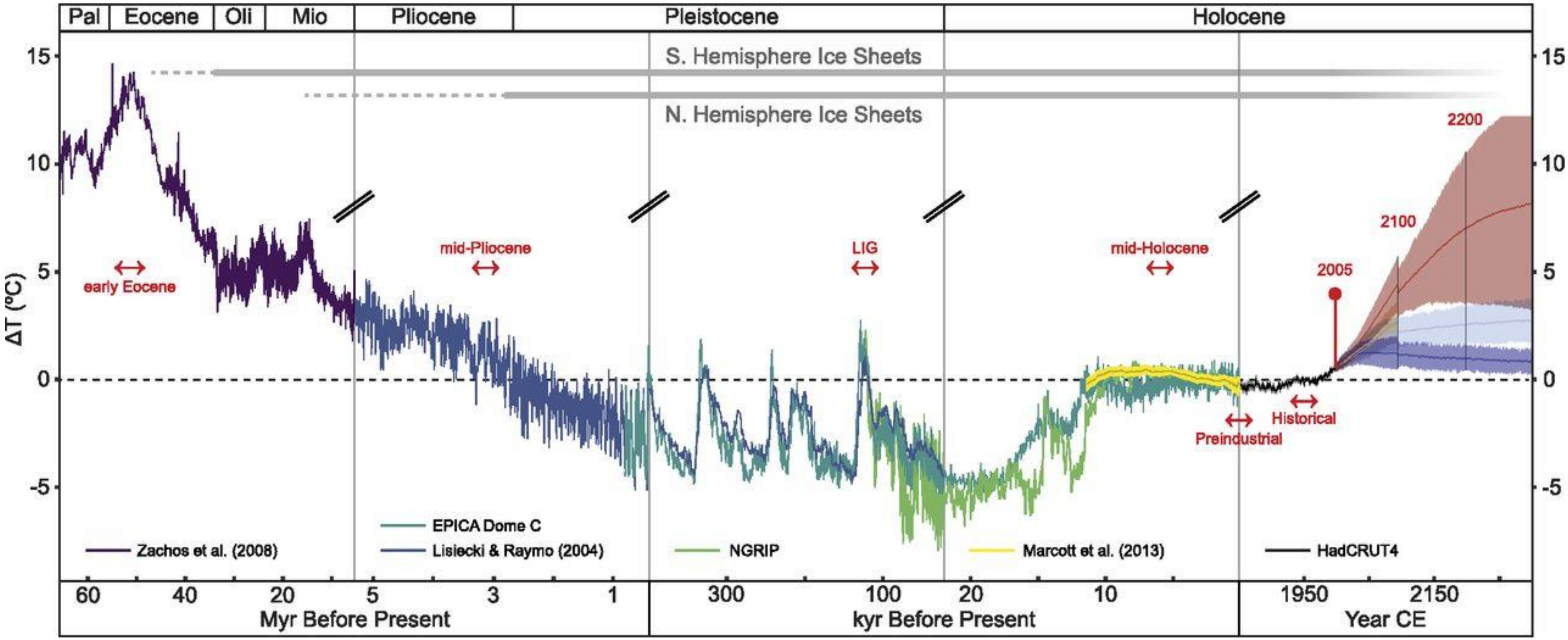


Fig. 7. Time series of the percentage of the global land area (60°S–90°N) assigned different climate types compared to the present day condition (1961–90). The black (green) lines are the temporal variations based on the dataset from the University of Delaware (UD) and CPC, respectively. Thick blue (red) lines are the ensemble average of the 20 models from historical/RCP8.5 (RCP4.5) simulations. The gray shading denotes one standard deviation of the 20 models from historical/RCP8.5 simulations. Blue (light blue) dashed line is the temporal variation based merely on the temperature (precipitation) changes from historical/RCP8.5 simulations. Pink (pink dashed) line is the temporal variations based merely on the temperature (precipitation) changes from the UD dataset. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Comparison to past climate



Temperature anomalies are relative to 1961–1990 global means and are composited from five proxy-based reconstructions, modern observations, and future temperature projections for four emissions pathways. Pal, Paleocene; Mio, Miocene; Oli, Oligocene.

Burke *et al*. 2018 PNAS 115:13288-13293

Comparison to past climate

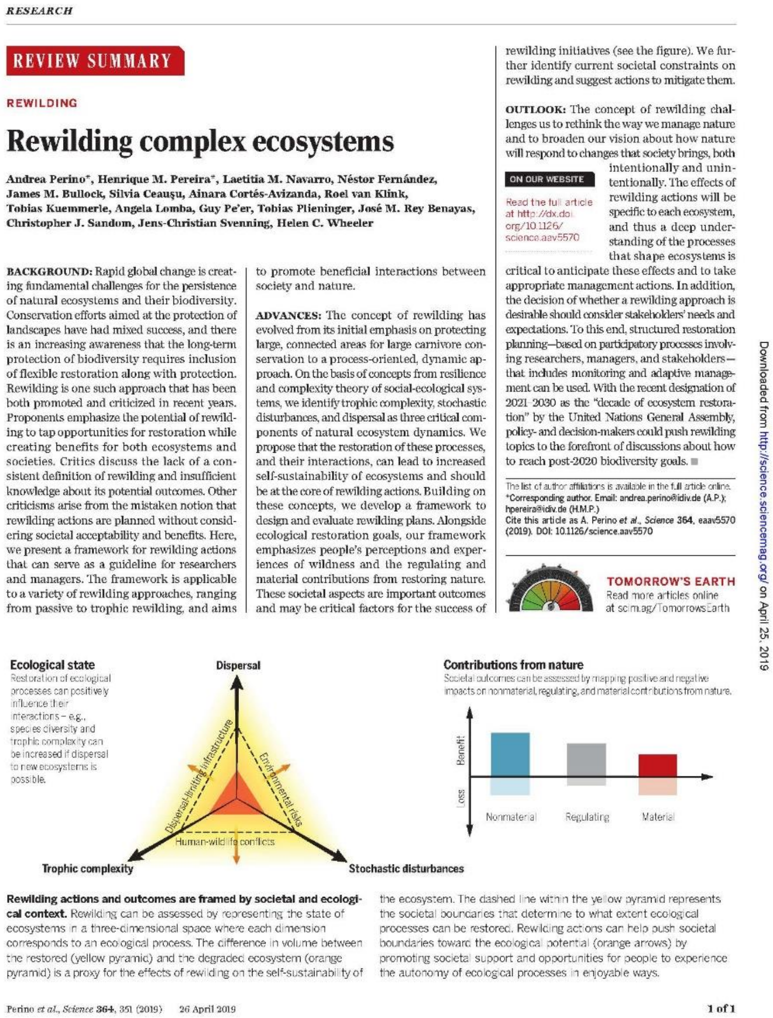
Ellesmere Island, 3.4 mio years ago

https://www.nationalgeographic.com/science/phenomena/2013/03/05/the-giant-camels-of-the-prehistoric-high-arctic/

IMPLEMENTATION

Framework for design & implementation

- Design:
  - Trophic complexity
  - Natural disturbances
  - Dispersal/Connectivity
- **Implementation**
  1) Ecosystem status assessment
  2) Social-ecological constraints
  3) Adaptive management



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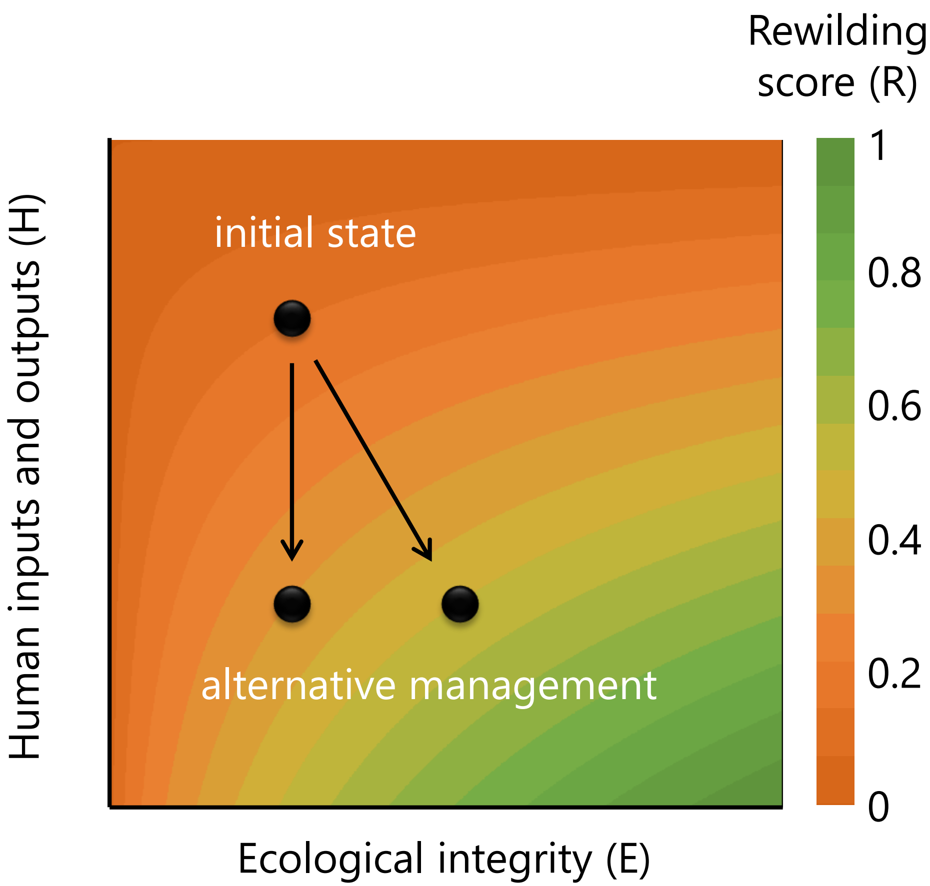
Perino *et al*. 2019 *Science* 364:eaav5570, http://bit.ly/rwScience.

Framework for measuring rewilding progress



H axis

$H = f(i, o)$

- ☐ Supplementary feeding to wildlife
- ☐ Population reinforcement (e.g., reintroductions)
- ☐ Agricultural inputs and outputs
- ☐ Forestry inputs and outputs
- ☐ Grassland inputs and outputs
- ☐ Mining inputs and outputs
- ☐ Harvesting of terrestrial wildlife
- ☐ Harvesting of aquatic wildlife
- ☐ Carrion removal
- ☐ Deadwood removal

N axis

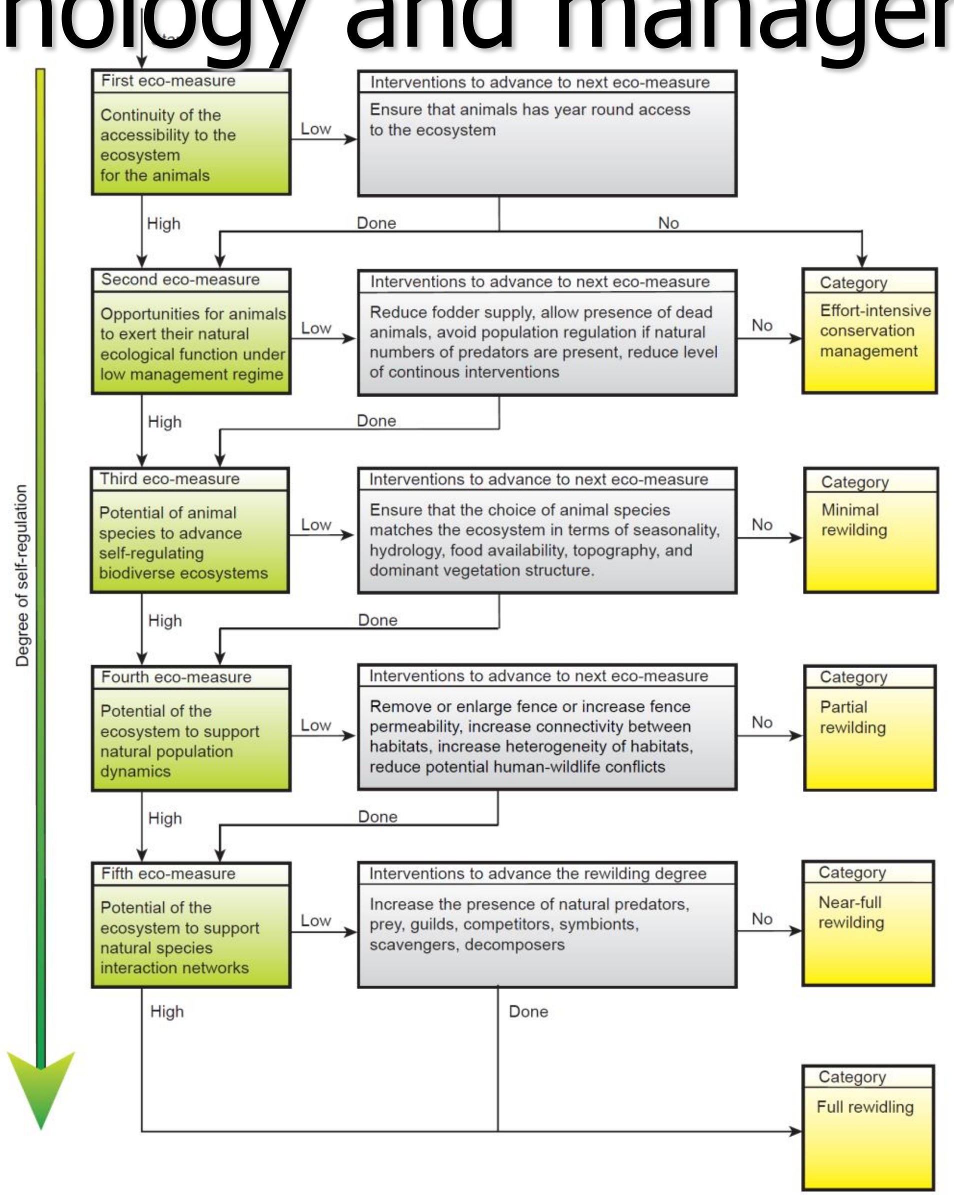
$N = f(d, c, t)$

- ☐ Natural snow and rock avalanche regimes
- ☐ Natural fire regimes
- ☐ Natural hydrological regimes
- ☐ Natural pest regimes and mortality events
- ☐ Terrestrial landscapes fragmentation
- ☐ Aquatic landscapes fragmentation
- ☐ Spontaneous vegetation dynamics (ecological succession)
- ☐ Absence of harmful invasive species
- ☐ Terrestrial species composition (occupancy, viability, time spent in the area)

Restored megafauna species

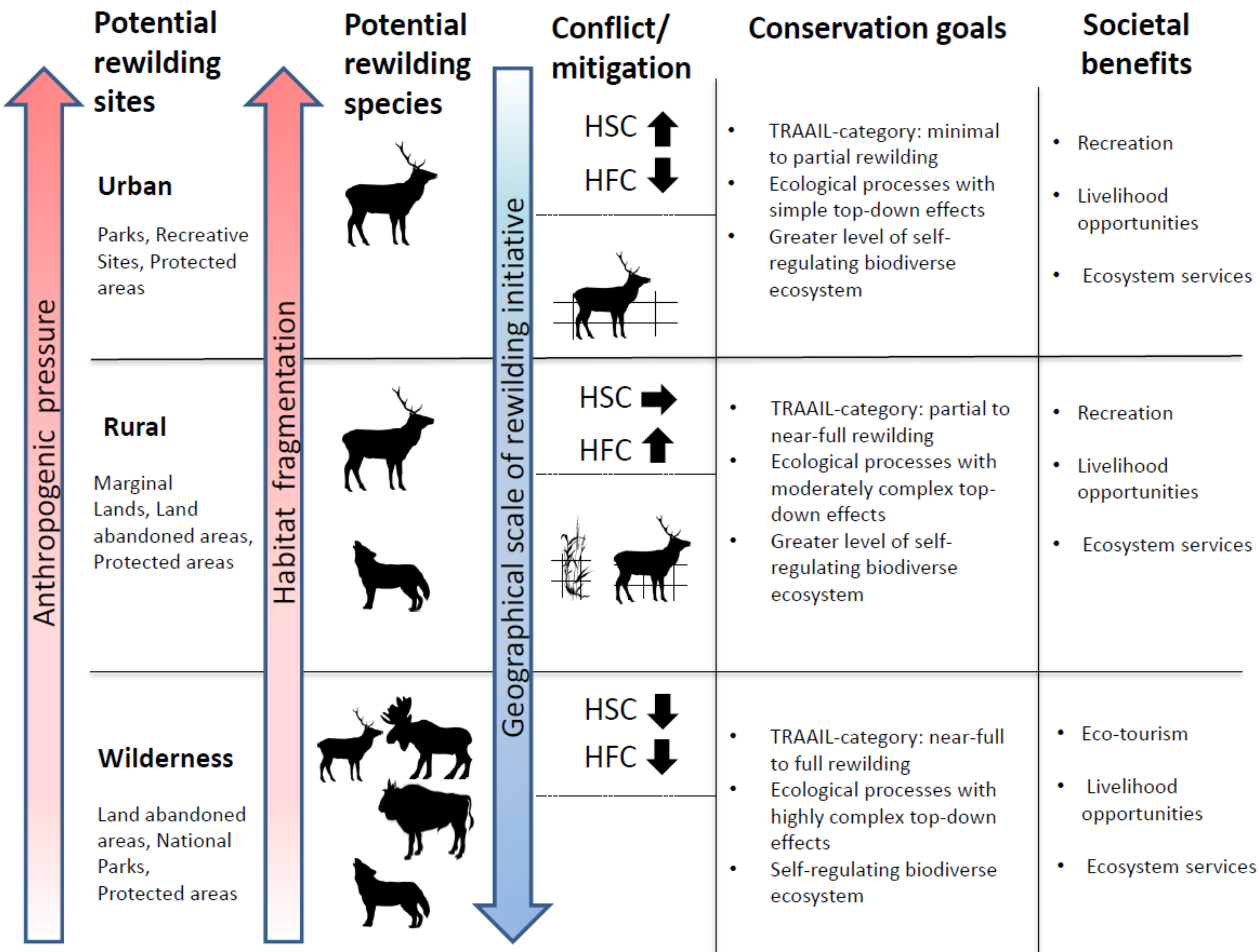
Torres *et al*. 2019 *Philosophical Transactions of the Royal Society B* B 373: 20170433, http://bit.ly/RWprog.

A trophic rewilding scale to guide terminology and management



Pedersen *et al*. & Svenning 2019 *AMBIO*, https://doi.org/10.1007/s13280-019-01192-z

Socio-ecological context



HSC: Human-Safety Conflicts

HFC: Human-Food Conflicts

Pedersen *et al*. & Svenning 2019 *AMBIO*, https://doi.org/10.1007/s13280-019-01192-z

Why is rewilding needed?

1) Evolutionary perspective on biodiversity
2) Wildness as a value
3) Overcome shifting baselines
4) Scaling
5) Dynamic

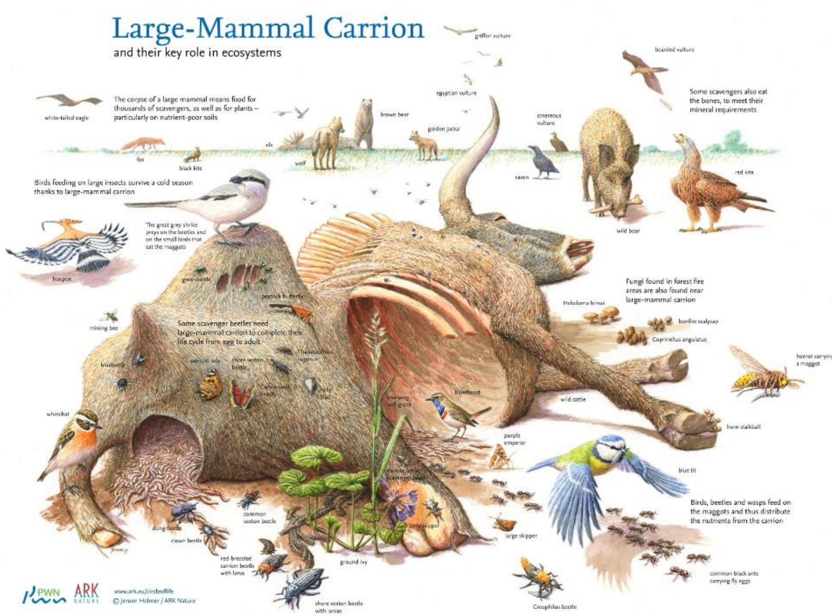


Photo: Lascaux (www)

Thanks

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@JCSvenning

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  - Innovation Fund Denmark

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MegaPast2Future

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