Hvorfor holder vi store dyr i naturen for naturens skyld?

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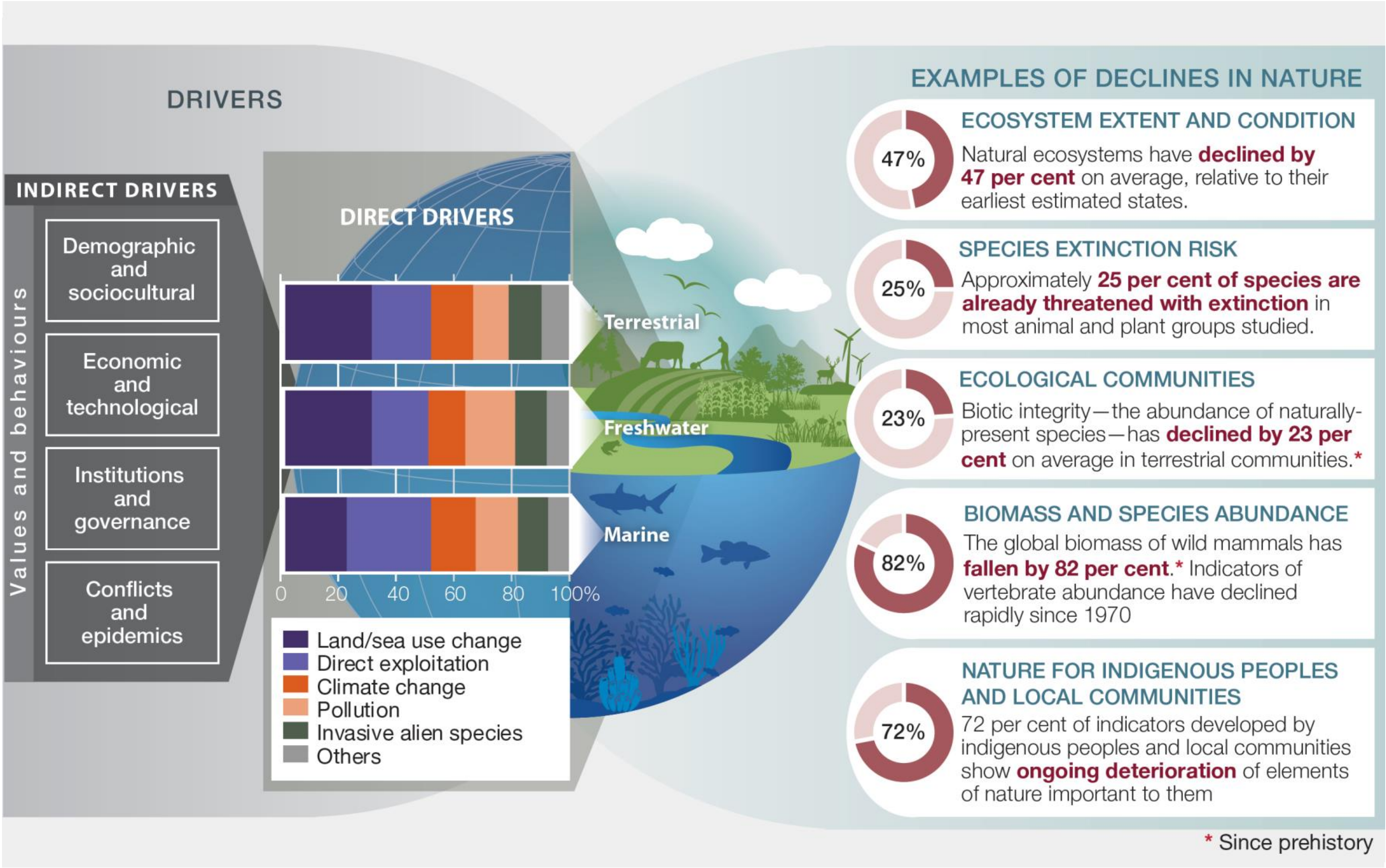
CENTER FOR BIODIVERSITY DYNAMICS
IN A CHANGING WORLD

AARHUS
UNIVERSITY

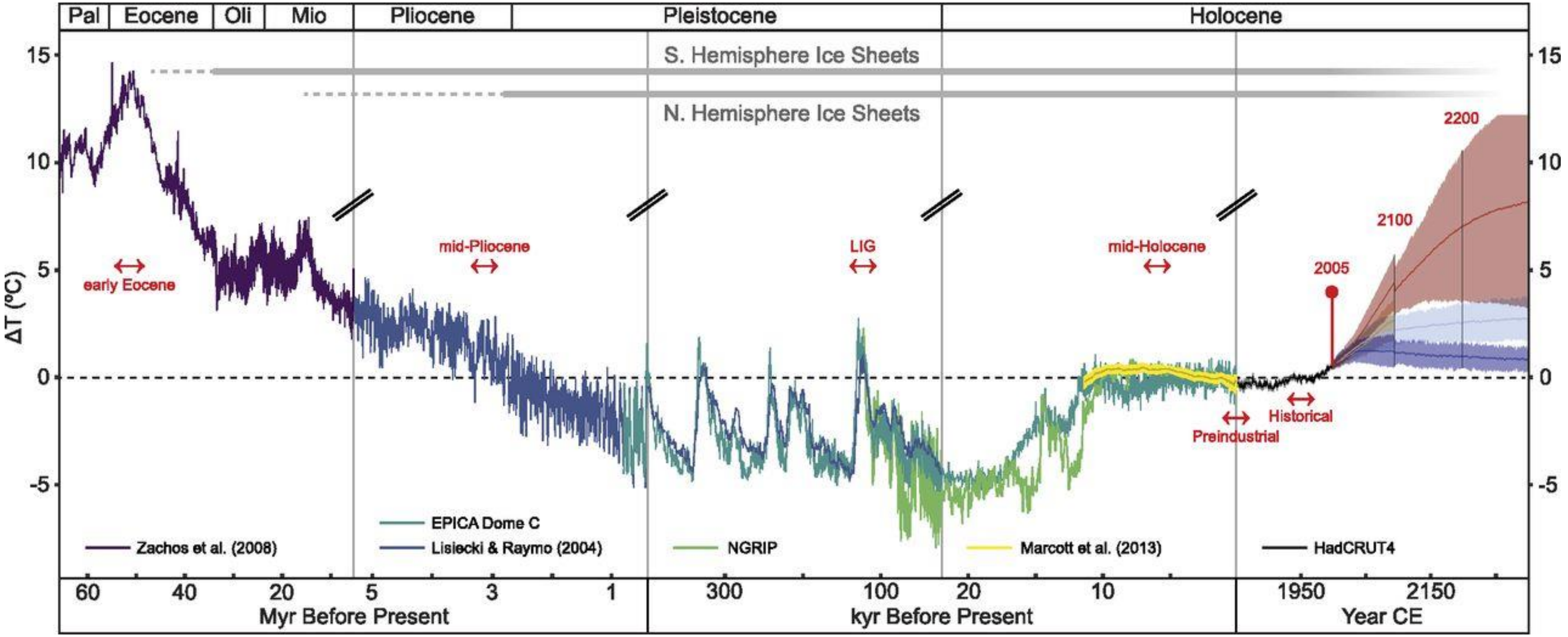
Biodiversitets- og klimakrise



IPBES 2019. *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany.

Biodiversitets- og klimakrise

- Likely massive biome shifts in the near future
- Leading to transient climates similar to climates millions of years in the past



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

Stort areal til funktionel natur

- Nøgleelement i sikring af biodiversitet og biosfærens funktion inkl. klima er prioritering af stort areal med funktionel natur
  →
  UN Decade on Ecosystem Restoration

- Rewilding er central løsningsmodel for at opnå stort areal med komplekse, resiliente økosystemer af høj værdi for Jordens biodiversitet*

*Svenning, J.-C. 2020. Rewilding should be central to global restoration efforts. *One Earth* 3:657-660; photo: JCS.

Hvad er “rewilding” ?

- Term introduceret i Nordamerika i 1990erne
- Siden 00erne i stigende grad brugt globalt
- Løbende ideudvikling og diskussion, ligesom fx naturgenopretning (“ecological restoration”)

- MEN det meste rummes fint i denne definition:

*Rewilding = restoration to promote **self-regulating complex ecosystems** through **restoring non-human ecological factors and processes** while **reducing human control and pressures***

(Svenning 2020 *One Earth* 3:657-660)

Stort international udviklings- og konsensusarbejde - videnskabeligt

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Conservation Biology

CONTRIBUTED PAPER

Guiding principles for rewilding

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RESEARCH

REVIEW

REWILDING

Rewilding complex ecosystems

Andrea Perino[1,2*], Henrique M. Pereira[1,2,3*], Laetitia M. Navarro[1,2], Néstor Fernández[1,2], James M. Bullock[4], Silvia Ceaușu[5,6], Ainara Cortés-Avizanda[3,7,8], Roel van Klink[1], Tobias Kuemmerle[9], Angela Lomba[3], Guy Pe'er[1,10], Tobias Plieninger[11,12], José M. Rey Benayas[13], Christopher J. Sandom[14], Jens-Christian Svenning[5,6], Helen C. Wheeler[15,16,17,18]

The practice of rewilding has been both promoted and criticized in recent years. Benefits include flexibility to react to environmental change and the promotion of opportunities for society to reconnect with nature. Criticisms include the lack of a clear conceptualization of rewilding, insufficient knowledge about possible outcomes, and the perception that rewilding excludes people from landscapes. Here, we present a framework for rewilding that addresses these concerns. We suggest that rewilding efforts should target trophic complexity, natural disturbances, and dispersal as interacting processes that can improve ecosystem resilience and maintain biodiversity. We propose a structured approach to rewilding projects that includes assessment of the contributions of nature to people and the social-ecological constraints on restoration.

knowledge about the possible outcomes of rewilding endeavors (31). In addition, concerns have been raised about rewilding activities being planned in a manner that excludes people from landscapes rather than being designed with local support (32).

Here, we articulate a conceptual framework for rewilding projects that addresses the aforementioned criticisms. We start by briefly reviewing the history of the rewilding concept, from its initial emphasis on protecting large connected areas for carnivore conservation (33) to the diversity of rewilding concepts today (25). We propose a framework to design and evaluate rewilding plans that integrates the current variety of rewilding approaches. Our framework draws on ecological theory to identify three interacting ecological processes that promote the self-organization of ecosystems and, therefore, should be the focus of rewilding actions. For each of these processes, we review ecological knowledge and identify rewilding actions that can assist the restoration of self-sustaining, resilient ecosystems (Fig. 1). Notably, these actions will vary depending on the societal context. Rewilding can occur spontaneously if humans withdraw from landscapes—for exam-

PNAS PNAS PNAS PNAS

SPECIAL FEATURE: PERSPECTIVE

CrossMark

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]

Edited by Yadvinder Malhi, Oxford University, Oxford, United Kingdom, and accepted by the Editorial Board August 5, 2015 (received for review March 16, 2015)

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

International Union for Conservation of Nature (IUCN)

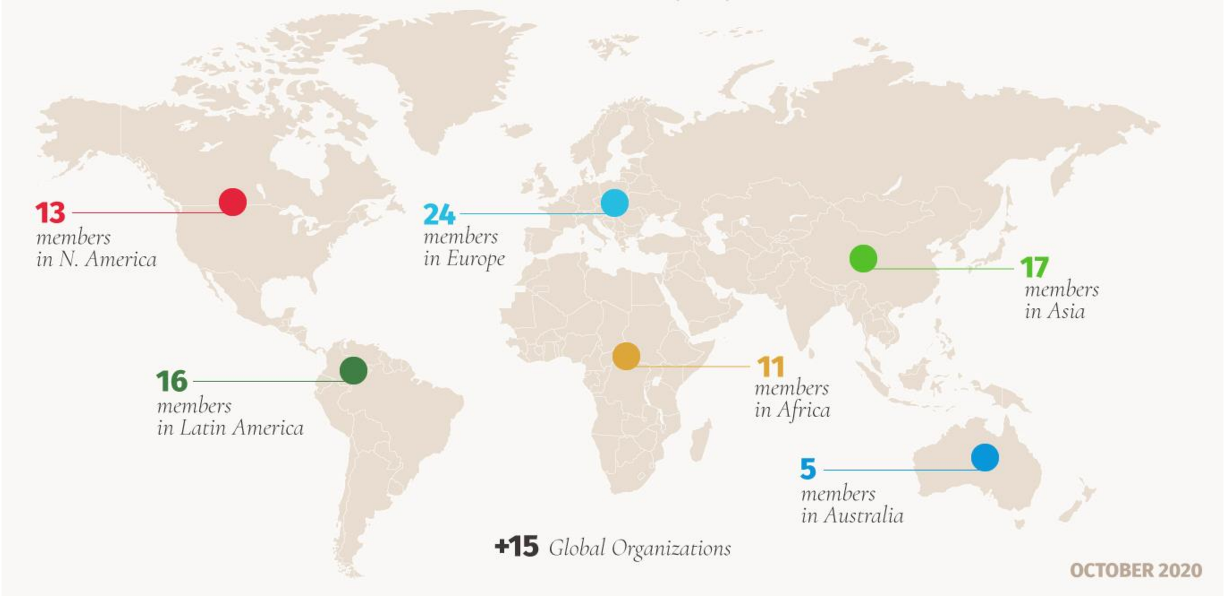
- IUCN Commission on Ecosystem Management
- Rewilding Thematic Group
- 10 principper*, bl.a.
  - Rewilding utilizes **wildlife to restore trophic interactions**
  - Rewilding employs **landscape-scale planning** that considers core areas, connectivity and co-existence
  - Rewilding focuses on the **recovery of ecological processes, interactions and conditions** based on reference ecosystems
  - Rewilding recognizes that **ecosystems are dynamic and constantly changing**
  - Rewilding is **adaptive and dependent on monitoring and feedback**
  - Rewilding requires **local engagement and support**

*Carver, S., *et al.*, Svenning, J.-C., Noss, R. *et al.* & Soulé, M. 2021. Guiding principles for rewilding. *Conservation Biology*, DOI: 10.1111/cobi.13730.

Bred og stigende international interesse i rewilding i praksis

Rewilding
THE GLOBAL ALLIANCE

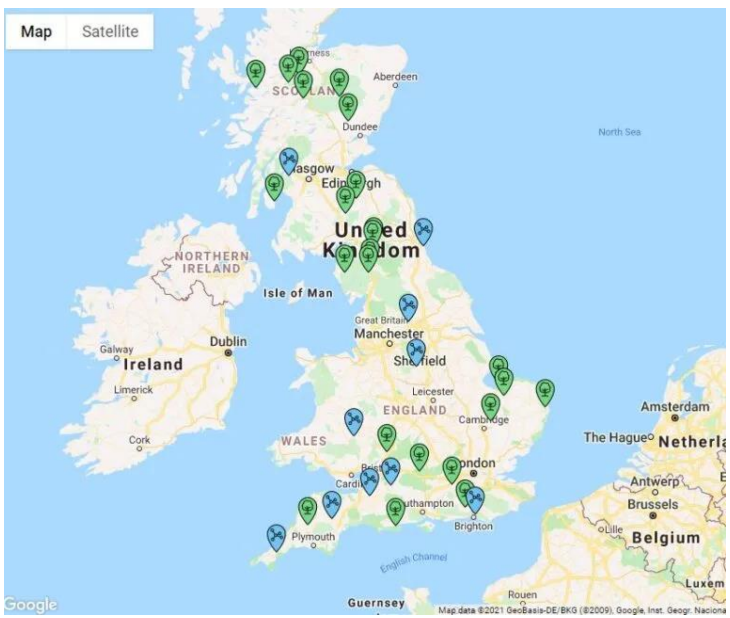
125+	100+	70+	3500+
Members (and growing)	Area in million hectare	Countries involved	Additional partners



Bred og stigende international interesse i rewilding i praksis

Rewilding Europe

REWILDING BRITAIN



Aktiv udvikling af pragmatiske principper

Rewilding THE GLOBAL ALLIANCE

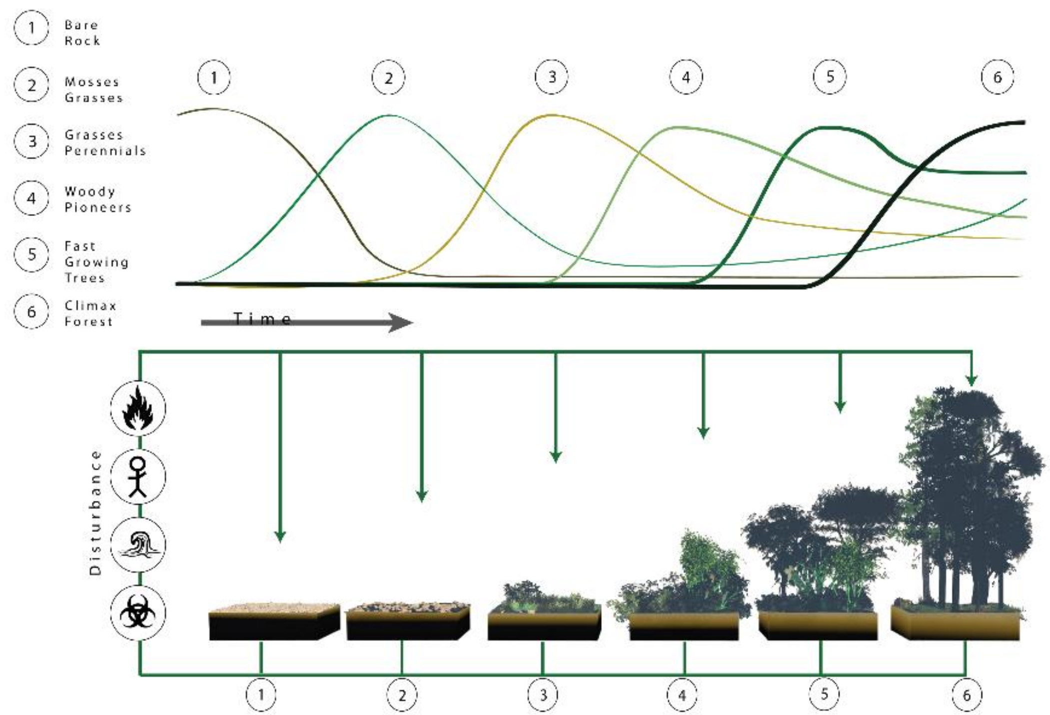
- Rewilding means helping nature heal. Rewilding means giving space back to wildlife and **returning wildlife back to the land**, as well as to the seas. Rewilding means the **mass recovery of ecosystems** and the life-supporting functions they provide. Rewilding is about allowing **natural processes** to shape whole ecosystems so that they work in all their colorful complexity to give life to the land and the seas

- *Global Charter for Rewilding the Earth*, 12 principper, bl.a.
  - Taking the long view
  - Evidence-based adaptive management
  - Letting nature lead
  - Working at nature’s scale
  - Building local economies
  - Working together for the good of ourselves and Nature

Videnskabelige baggrund

- **Masser af forskning og praksis i nøgleelementer**
  - Areal
  - Miljøvariation
  - Græsning
  - Succession
  - Spredning
  - Hydrologi
  - Skovdynamik
  - Store naturparker

Succession – uden store græssere



https://en.wikipedia.org/wiki/Ecological_succession

Økologiske elementer

- Fødekæde-effekter via store græssere mm.
- Naturlige forstyrrelser og abiotiske dynamikker, fx naturlig hydrologi
- Sammenhæng og areal
  - Store bestande = robuste bestande
  - Spredningsprocesser
  - Naturlige dynamikker

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. ■

ON OUR WEBSITE
Read the full article at http://dx.doi.org/10.1126/science.aav5570

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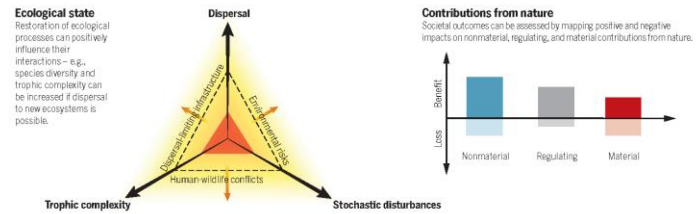
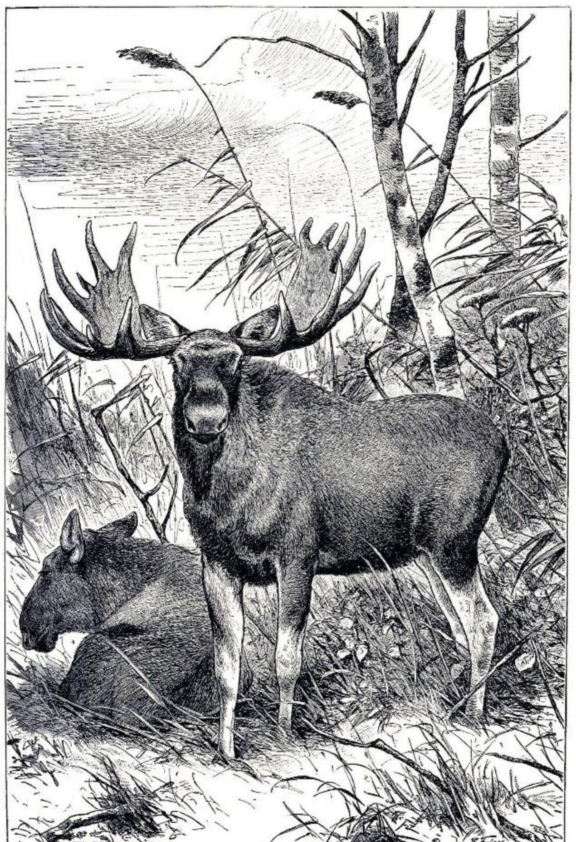
Cite this article as A. Perino *et al.*, *Science* **364**, eaav5570 (2019). DOI: 10.1126/science.aav5570

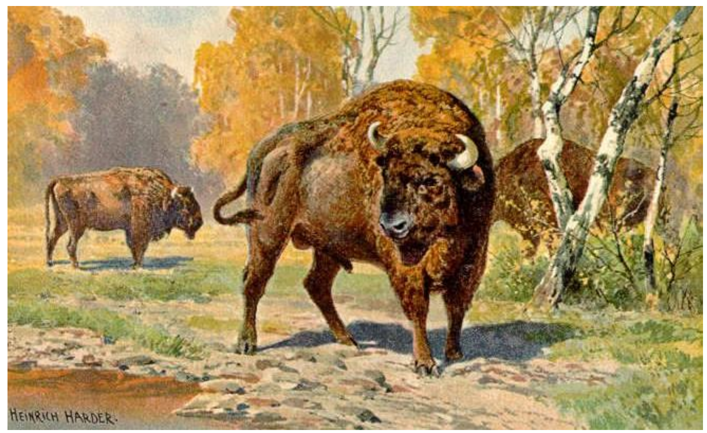


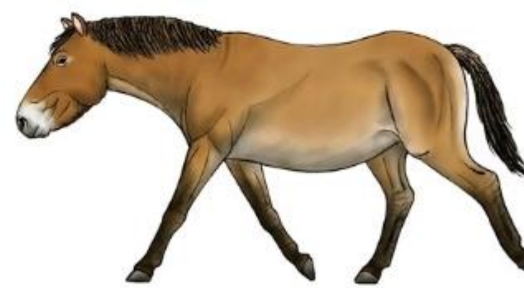
Rewilding actions and outcomes are framed by societal and ecological context. Rewilding can be assessed by representing the state of ecosystems in a three-dimensional space where each dimension corresponds to an ecological process. The difference in volume between the restored (yellow pyramid) and the degraded ecosystem (orange pyramid) is a proxy for the effects of rewilding on the self-sustainability of the ecosystem. The dashed line within the yellow pyramid represents the societal boundaries that determine to what extent ecological processes can be restored. Rewilding actions can help push societal boundaries toward the ecological potential (orange arrows) by promoting societal support and opportunities for people to experience the autonomy of ecological processes in enjoyable ways.

Svenning *et al*. 2016 *PNAS* 113:898–906; Perino *et al*. (incl. Svenning) 2019 *Science* 364:eaav5570; Carver *et al*. (incl. Svenning) 2021 *Conservation Biology* doi.org/10.1111/cobi.13730.

Store planteædere har en bred og dyb historie i naturen i Europa og verden over – men er massivt trængt tilbage





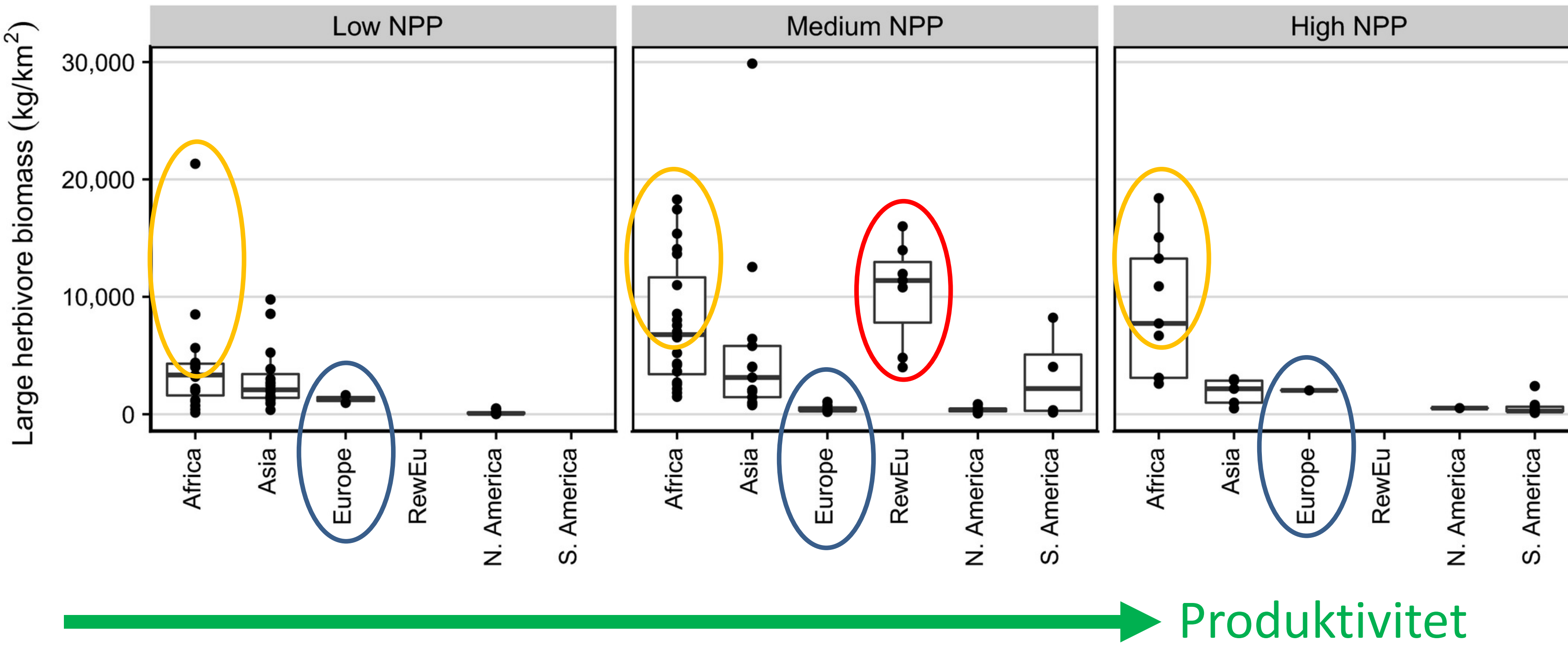


Crees et al. 2019 *Ecology* 100:e02783; Smith et al. 2018 *Science* 360:310-313; DFoidl

Store planteædere har en bred og dyb historie i naturen i Europa og verden over – men er massivt trængt tilbage

Zdeněk Burian: top - ~80,000 years ago (left), ~1.5 million ya (right), bottom - ~4 million ya (left), ~13 million ya (right)

Unaturligt lave tætheder af store dyr de fleste steder (inkl. Europa)



Fløjgaard, C. *et al*. (incl. Svenning, J.-C. 2021. Exploring a natural baseline for large-herbivore biomass in ecological restoration. *Journal of Applied Ecology*, doi:https://doi.org/10.1111/1365-2664.14047.

Stærkt stigende interesse for de store dyrs betydning for økosystemer

SPECIAL FEATURE: PERSPECTIVE

PNAS PNAS PNAS

SPECIAL FEATURE: PERSPECTIVE

Megafauna and ecosystem function from the Pleistocene to the Anthropocene

Yadvinder Malhi[a,1], Christopher E. Doughty[a], Mauro Galetti[b], Felisa A. Smith[c], Jens-Christian Svenning[d], and John W. Terborgh[e]

Edited by Robert M. May, University of Oxford, Oxford, United Kingdom, and approved December 10, 2015 (received for review October 6, 2015)

Large herbivores and carnivores (the megafauna) have been in a state of decline and extinction since the Late Pleistocene, both on land and more recently in the oceans. Much has been written on the timing and causes of these declines, but only recently has scientific attention focused on the consequences of these declines for ecosystem function. Here, we review progress in our understanding of how megafauna affect ecosystem physical and trophic structure, species composition, biogeochemistry, and climate, drawing on special features of PNAS and *Ecography* that have been published as a result of an international workshop on this topic held in Oxford in 2014. Insights emerging from this work have consequences for our understanding of changes in biosphere function since the Late Pleistocene and of the functioning of contemporary ecosystems, as well as offering a rationale and framework for scientifically informed restoration of megafaunal function where possible and appropriate.

extinctions | trophic cascades | vegetation structure | biogeochemistry | rewilding

For hundreds of millions of years, an abundance of large animals, the megafauna, was a prominent feature of the land and oceans. However, in the last few tens of thousands of years—a blink of an eye on many evolutionary and biogeochemical timescales—something dramatic happened to Earth's ecology; megafauna largely disappeared from vast areas, rendered either actually or functionally extinct (1, 2). Only in small parts of the world do megafauna exist at diversities anything close to their previous state, and, in many of these remaining regions, they are in a state of functional decline through population depletion and range contraction. In the oceans, a similar process has occurred over the last few hundred years: although there has been little absolute extinction, there has been a dramatic decline in the abundance of whales and large fish through overharvesting (3). Both on land and in oceans, declines continue today (4–7).

Homo sapiens evolved and dispersed in a world teeming with giant creatures. Our earliest art forms, such as the haunting and mesmerizing Late Pleistocene cave paintings of Lascaux and Altamira, show that megafauna had a profound impact on the psyche and spirituality of our ancestors. To humans past and modern, they indicate resources, danger, power, and charisma, but, beyond these impacts, such large animals have profound and distinct effects on the nature and functioning of the ecosystems they inhabit.

Martin (8) first posited a major human role in past megafaunal disappearances, and, since then, much has been written on their patterns and causes and the relative importance of human effects, climate change, and other factors (8–15). Only recently has work begun to address the environmental consequences of this dramatic transition from a megafaunal to a nonmegafaunal world on Earth's ecology, as manifested through vegetation cover (16), plant–animal interactions (17), ecosystem structure (16, 18), trophic interactions (7), fire regimes (19), biogeochemical cycling (20), and climate (21, 22).

In this paper, we review evidence for megafaunal impacts on ecosystem function, on timescales ranging from the Late Pleistocene to the present. Understanding the consequences of past extinctions is valuable for a number of reasons: in particular because the loss of megafauna may have an enduring but little-recognized legacy on the functioning of the contemporary biosphere. Much of our current understanding of

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Author contributions: Y.M., C.E.D., M.G., F.A.S., J.-C.S., and J.W.T. wrote the paper.

The authors declare no conflict of interest.

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REVIEW SUMMARY

CARBON CYCLE

Animals and the zoogeochemistry of the carbon cycle

Oswald J. Schmitz*, Christopher C. Wilmers, Shawn J. Leroux, Christopher E. Doughty, Trisha B. Atwood, Mauro Galetti, Andrew B. Davies, Scott J. Goetz

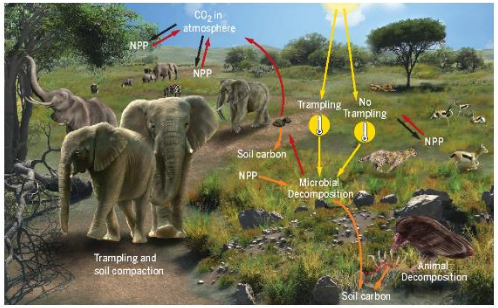
BACKGROUND: Modern advances in remote-sensing technology are providing unprecedented opportunities to accurately measure the global distribution of carbon held in biomass within ecosystems. Such highly spatially resolved measures of biomass carbon are intended to provide an accurate inventory of global carbon storage within ecosystems. They are also needed to test the accuracy of carbon cycle models that predict how global changes that alter biogeochemical functions—such as carbon assimilation via photosynthesis, carbon losses via plant and microbial respiration, and organic matter deposition in soils and sediments—will affect net ecosystem carbon uptake and storage. Emerging ecological theory predicts that wild animals stand to play an important role in mediating these biogeochemical processes. Furthermore, many animal species roam widely across landscapes, creating a spatial dynamism that could regulate spatial patterning of vegetation biomass and carbon uptake and soil carbon retention. But such zoogeochemical effects are not measured by current remote-sensing approaches nor are they factored into carbon cycle models. Studies are now providing new quantitative insights into how the abundance, diversity, and movement of animal species across landscapes influence the nature and magnitude of zoogeochemical affects. These insights inform how to account for animals in remote-sensing applications and in carbon cycle models to more accurately predict carbon exchange between ecosystems and the atmosphere in the face of global environmental change.

ADVANCES: Zoogeochemical effects have been measured using manipulative experiments that exclude or add focal wild animal species or along landscape gradients where animal abundances or diversity vary naturally. Our review of these studies, which cover a wide diversity of taxa (vertebrates and invertebrates and large- and small-bodied organisms) and ecosystems, reveals that animals can increase or decrease rates of biogeochemical processes, with a median change of 40% but ranging from 15 to 250% or more. Moreover, models that embody zoogeochemical effects reveal the potential for considerable under- or overestimates in ecosystem carbon budgets if animal effects are not considered. The key challenge, in light of these findings, is comprehensively accounting for spatially dynamic animal effects across landscapes. We review new developments in spatial ecosystem ecology that offer the kind of analytical guidance needed to link animal movement ecology to geospatial patterning in ecosystem carbon uptake and storage. Considerations of animal movement will require highly resolved spatially explicit understanding of landscape features, including topography, climate, and the spatial arrangement of habitat patches and habitat connectivity within and among ecosystems across landscapes. We elaborate on advances in remote-sensing capabilities that can deliver these critical data. We further review new geospatial statistical methods that, when combined with remote-sensing data and spatial ecosystem modeling, offer the means to comprehensively understand and predict how zoogeochemical-driven landscape processes regulate spatial patterns in carbon distribution.

ON OUR WEBSITE

Read the full article at http://dx.doi.org/10.1126/science.aar3213

OUTLOOK: There is growing interest to slow climate change by enlisting ecological processes to recapture atmospheric carbon and store it within ecosystems. Wild animal species are rarely considered as part of the solution. Instead, it is often held that managing habitat space to conserve wild animals will conflict with carbon storage. Our integrative review offers a pathway forward for deciding when and how conserving or managing a diversity of animal species could in fact enhance ecosystem carbon uptake and storage. Such understanding informs international climate and biodiversity initiatives such as those described by the United Nations Convention on Biological Diversity and national biodiversity strategies and climate action plans. All of these initiatives require better resolution of how biodiversity effects on ecosystem structure and biogeochemical functioning will become altered by global change. ■



CREDIT: NICOLE FULLER/SAYO-ART

The myriad animal zoogeochemical effects on carbon cycling. Animals can mediate net carbon sequestration by plants (net primary productivity, NPP) by altering CO_2 uptake into (black arrows) and from (red arrows) ecosystems. Herbivore grazing and tree browsing can alter the spatial distribution of plant biomass. Predators can modify herbivore impacts via predation and predator-avoidance behavior. Animal trampling compacts soils and alters soil temperatures by changing the amount of solar radiation reaching soil surfaces (yellow arrows). Animals also change the chemical quality of organic matter that enters the soil pool (orange arrows).

The list of author affiliations is available in the full article online.
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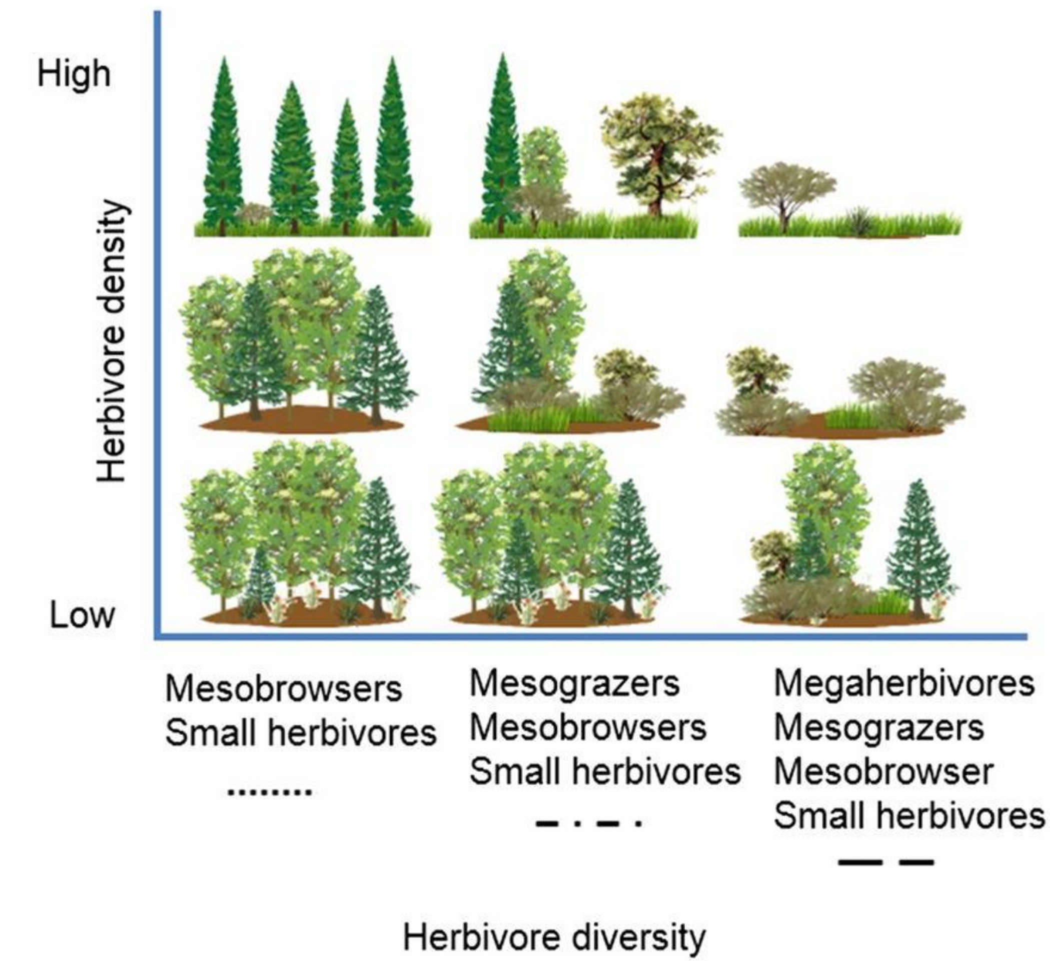
Cite this article as O. J. Schmitz *et al.*, *Science* 362, eaar3213 (2018). DOI: 10.1126/science.aar3213

De store planteæderes rolle

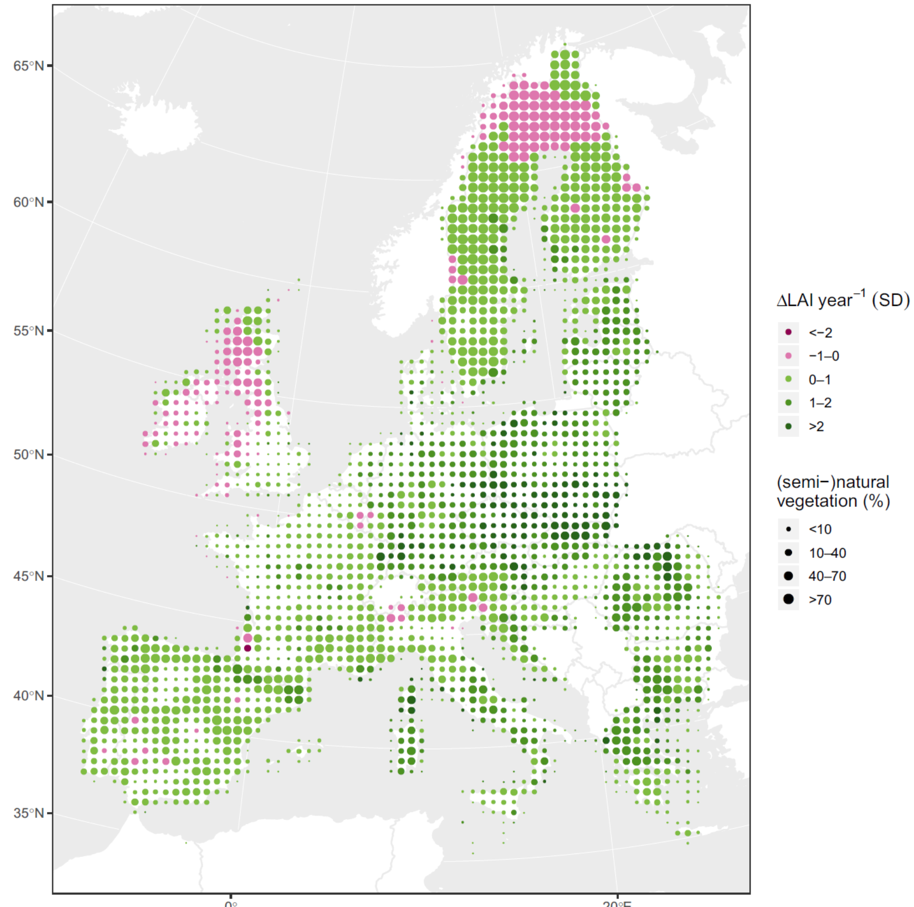
- Store planteædere har ofte stor effekt på vegetationen
- Fremmer ofte variation i vegetationen
- Heterogenitet i vegetation
  - har stor generel positiv effekt på biodiversitet*
  - fremmer resiliens ift. klimastress mm.



Bakker et al. & Svenning 2016 *PNAS* 113:848-855 http://bit.ly/herbivorePNAS; *Stein et al. 2014. Environmental heterogeneity as a universal driver of species richness across taxa, biomes and spatial scales. *Ecology Letters*, 17, 866-880.

Fortætning af vegetationen i naturområderne

- Meget væsentlig problematik i naturen i store del af Europa
- Central problemstilling i dansk naturforvatning
- Græsning meget væsentlig for at fremme varieret vegetation

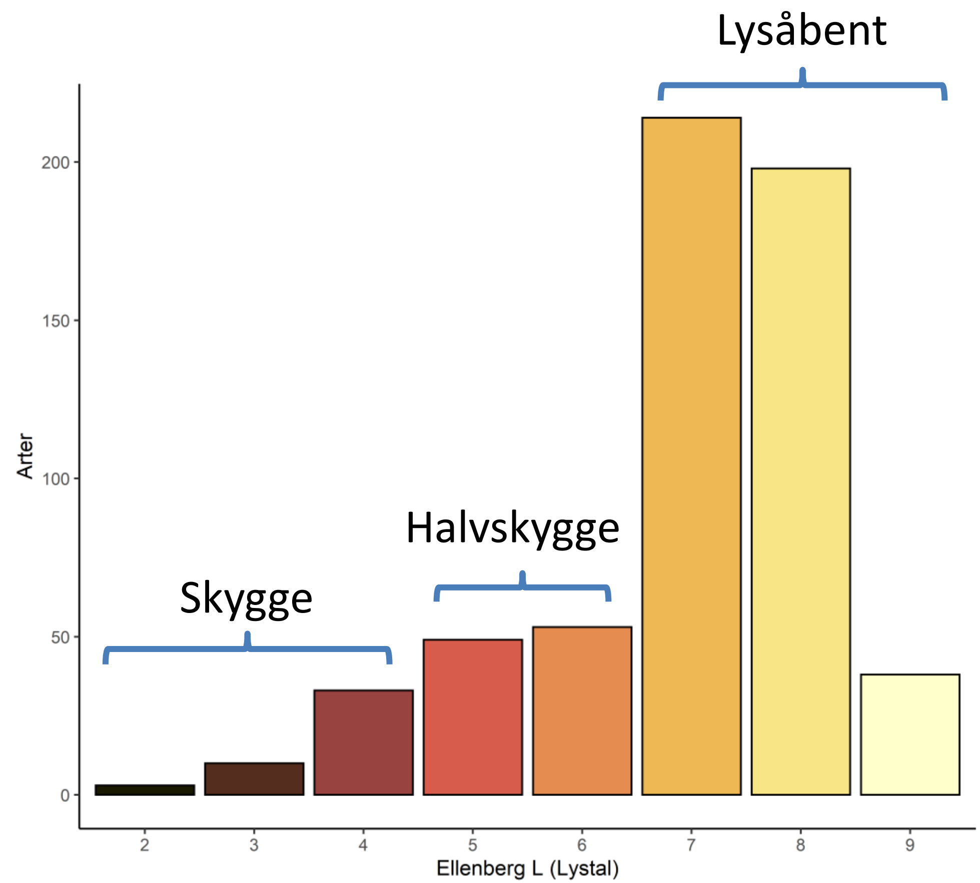


General increase in vegetation density 2001-2015 in natural areas

Buitenwerf, R. et al. & Svenning, J.-C. 2018 *Global Change Biology* 24:5789-5801
Timmermann et al. & Svenning 2015 *Journal of Applied Ecology* 52:21-30

Fortætning af vegetationen i naturområderne

- Danske plante-arter der er følsomme eller meget følsomme over for negative påvirkninger
  = Artsindeks ≥4
  56% af alle arter (~1100)
- Indikatorarter for truet natur, der også indeholder truede arter fra andre organismegrupper



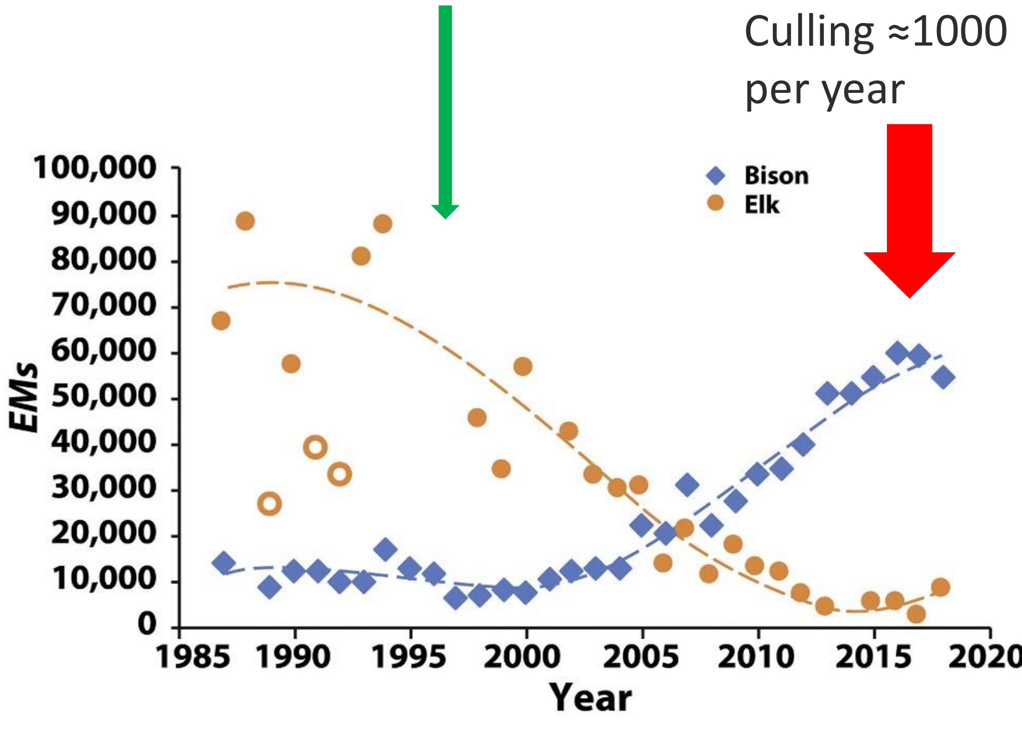
Buitenwerf, R. et al. & Svenning, J.-C. 2018 *Global Change Biology* 24:5789-5801
Timmermann et al. & Svenning 2015 *Journal of Applied Ecology* 52:21-30

Store dyrs bestande: Betydning af rovdyr?

Rovdyr kontrollerer ikke de helt store planteædere eller den samlede biomasse

1995–96 reintroduction of wolves

Culling ≈1000 bison per year



EM = 1 adult elk foraging for 1 month

Beschta et al. 2020 *Food Webs* 23:e00142.

Rovdyr nedregulerer ikke planteædere til niveau, hvor de ikke påvirker vegetationen

Herbivore exclosure in Yellowstone National Park

Photo: JC Svenning 2011

Store dyr genererer mikrohabitater for mange invertebrater, svampe mm.

Rhinoceros tick (*Dermacentor rhinocerinus*)

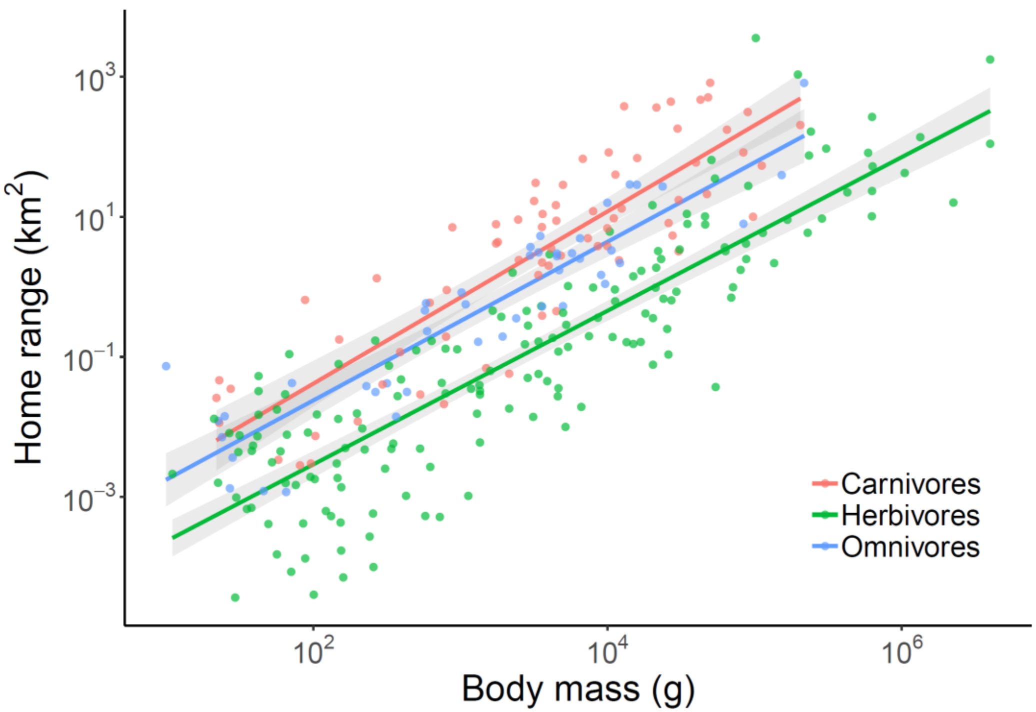
Horned dung beetle (*Copris lunaris*)

Bone skipper (*Thyreophora cynophila*)

Photo: JCS; Knapp, S., Krecek, R., Horak, I. & Penzhorn, B. (1997). Helminths and arthropods of black and white rhinoceroses in southern Africa. *Journal of Wildlife Diseases*, 33, 492-502; Natural England Commissioned Report NECR224; Siga (Wikimedia); Carles-Tolrá et al. 2010 Boletín de la Sociedad Entomológica Aragonesa 46:17

Store dyr er særligt mobile og fremmer spredningsprocesser

- Home range scales to general dispersal effect
- Dispersal of:
  - Plants
  - Fungi
  - Invertebrates
- Megafauna particularly important for dispersal

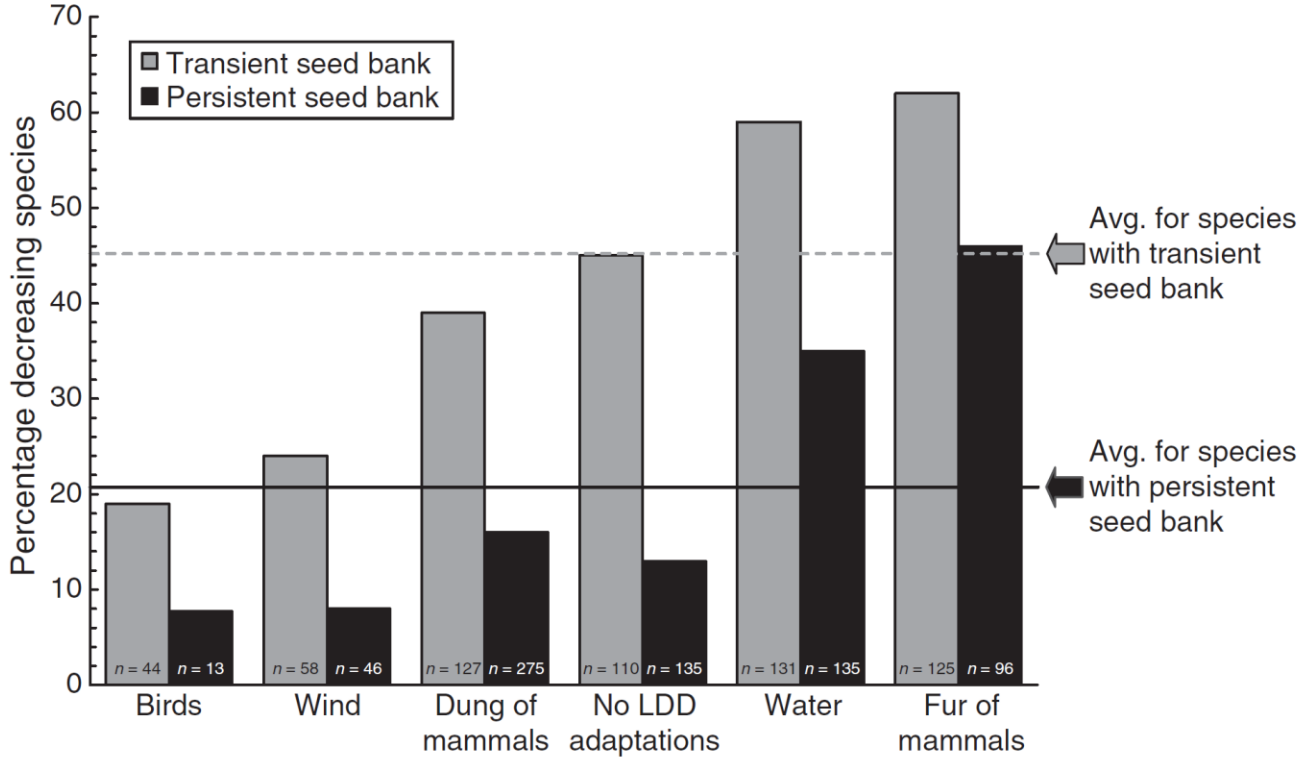


Berti, E. & Svenning, J.-C. (2020). Megafauna extinctions have reduced biotic connectivity worldwide. *Global Ecology and Biogeography* 29, 2131– 2142.

. Dispersal failure contributes to plant losses in NW Europe

- Stort historisk og forhistorisk tab af dyrespredning
- Arter der spredes med dyrs pels og med vand er overrepræsentere de blandt arter i tilbage
- "Our findings call for measures that aim to restore the dispersal infrastructure across entire regions and that go beyond current conservation practices"

Plantearter med >25% tilbagegang over 20. årh. (NL)



Ozinga *et al.* 2009 *Ecol. Lett.* 12:66-74.

Meget forskning direkte vdr. store planteæderes effekter under naturnære forhold

Photo: Mols Laboratory, March 2021 (JCS)

Cattle foraging habits shape vegetation patterns of alluvial year-round grazing systems

- Genoprettet 87 ha engområde i NV Tyskland med helårsgræsning me konik og heck:
  - We found a mosaic of five structure types in the study area
  - Three of them, the ''tall forb-grass mixture'', the ''grazing lawns and the ruderal grazing lawns'', were completely absent prior to the grazing management
  - Year-round grazing resulted in the successful creation of eutrophic grassland communities on former agricultural land after 15 years

Table 2 Results of indicator species analysis (Dufrene and Legendre 1997)

Vegetation structure		Tall forbs		Tall forb-grass-mixture		Tall grasses		Ruderal grazing lawn		Grazing lawn	
	N =	8		9		8		5		14	
Species	IV	f	a	f	a	f	a	f	a	f	a
Solidago gigantea	51.9	60	69	36	5	13	2	60	18	36	6
Mentha aquatica	42.8	75	57	22	12	13	10	20	6	57	14
Eupatorium cannabinum	40.8	88	47	22	5	0	0	60	42	29	7
Galium palustre	33.0	38	88	0	0	0	0	0	0	7	12
Urtica dioica	46.6	75	47	67	33	50	11	20	9	7	1
Glechoma hederacea	42.0	100	32	78	32	50	16	80	11	36	8
Elymus repens	39.0	38	14	89	44	25	6	60	20	50	15
Dactylus glomerata	54.4	38	11	78	40	88	32	60	11	36	6
Holcus lanatus	42.2	25	5	44	32	75	47	20	2	36	14
Arrhenatherum elatius	62.1	13	2	44	25	88	71	0	0	7	2
Plantago intermedia	56.8	13	11	11	4	0	0	100	57	57	28
Potentilla reptans	52.8	25	6	11	3	0	0	80	66	36	26
Odontites vulgaris	50.1	25	3	78	14	38	5	100	50	79	27
Festuca pratensis	42.8	13	5	33	17	38	9	80	54	36	16
Melilotus officinalis	33.9	0	0	0	0	0	0	40	85	7	15
Trifolium pratense	33.6	13	5	22	15	13	5	60	56	36	19
Festuca arundinacea	31.8	0	0	0	0	0	0	40	79	14	21
Trifolium repens	62.4	13	1	22	5	13	2	60	46	79	45
Ranunculus repens	59.0	13	1	67	12	13	3	100	45	79	38
Medicago lupulina	53.2	0	0	44	14	0	0	60	26	71	60
Agrostis stolonifera	46.8	38	8	56	13	63	13	100	33	93	33
Lolium perenne	43.9	0	0	11	4	0	0	40	35	50	61
Taraxacum officinale	43.4	0	0	56	18	38	8	80	34	71	39
Plantago lanceolata	40.1	13	2	56	14	50	18	100	31	71	35

The first column shows the maximum indicator value (IV) for the shaded structure type(s). For each structure type percentage frequency (f) and relative abundance comparing all types (a) are given. Species list is sorted by IV for the considered group. Only significant species are shown

Gilhaus et al. 2014 *Plant Ecology* 215:169-179.

Effects of year-round grazing on the vegetation of nutrient-poor grass- and heathlands—Evidence from a large-scale survey

- Grazing vs abandonment compared at 5 sites
  - Grazing increased plant species richness, especially of endangered species
  - In grazed sites reduction of green biomass, litter and woody species were typical
  - Species on grazed sites were mostly small-growing and followed a ruderal strategy
  - More tall-growing, mesophilic and competitive species were typical for abandoned sites

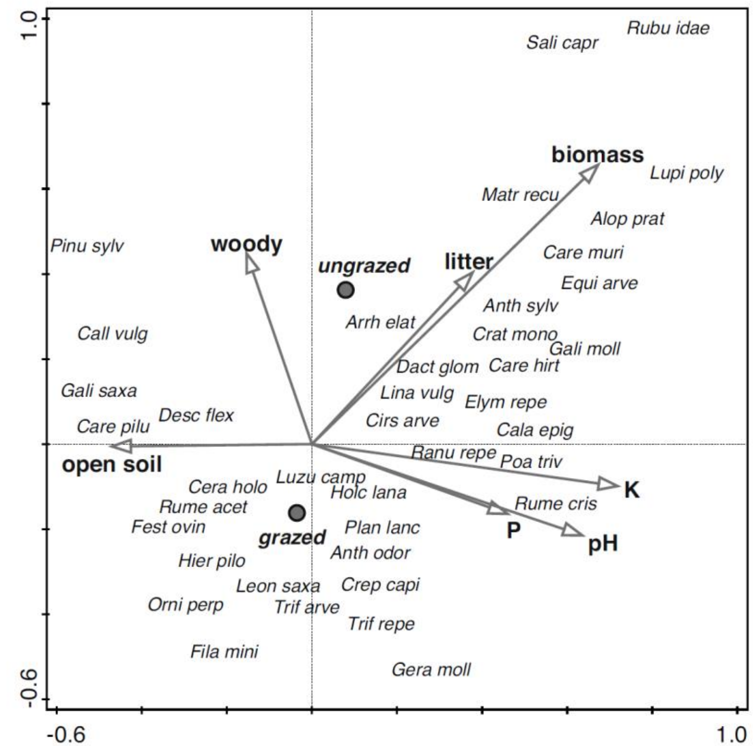


Fig. 2. CCA species and environmental variables biplot. Species data were square-root transformed prior to the analysis and rare species were downweighted. Only the best fitting 40 species are depicted. Response data (species) have a gradient 6.2 SD units long. Total variation is 10.824, explanatory variables account for 18%. woody = cover of woody species [%], open soil = open soil [%], P = P in soil [g/100 g], pH pH-value ($CaCl_2$), K = K in soil [g/100 g], biomass = green biomass [g/m^2], litter = litter cover [%].

Rupprecht et al. 2016. Effects of year-round grazing on the vegetation of nutrient-poor grass- and heathlands—Evidence from a large-scale survey. *Agriculture, Ecosystems & Environment* 234:16-22.

Year-round cattle and horse grazing supports the restoration of abandoned, dry sandy grassland and heathland communities by suppressing *Calamagrostis epigejos* and enhancing species richness

- 800 ha heathland in E Germany
  - Abandoned; strong expansion of *Calamagrostis* + woody plants
  - Year-round grazing w/ Heck cattle and Konik horses, 2008
- Grazing successfully reduced the coverage of *Calamagrostis epigejos*, whereby *Calamagrostis* stands developed towards species-rich sandy grasslands after seven years of grazing

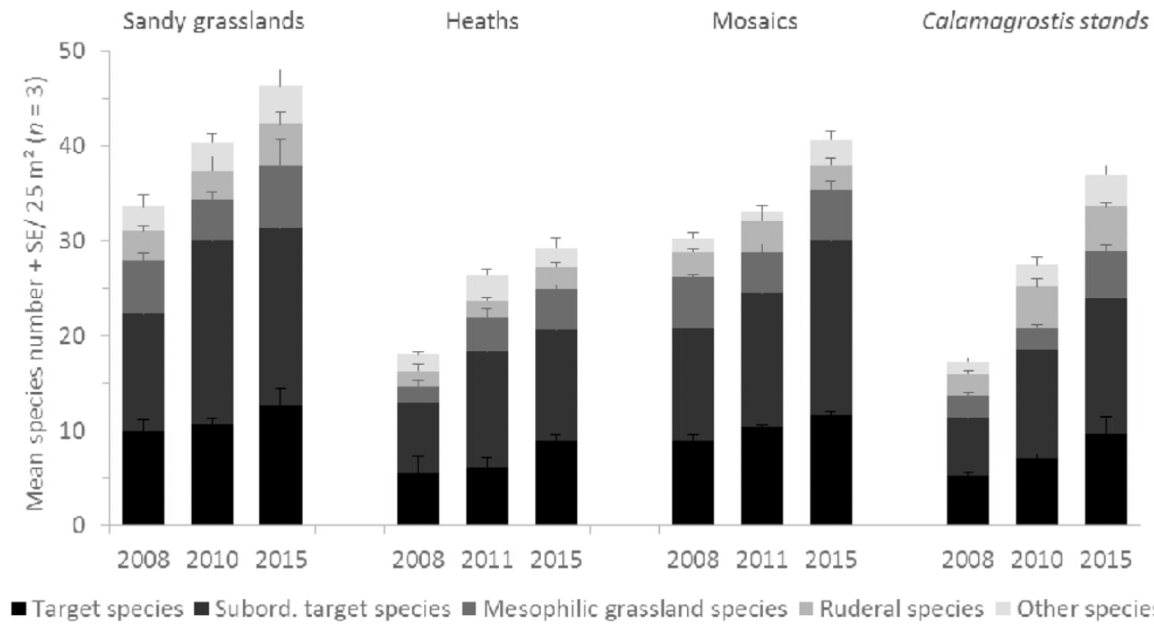
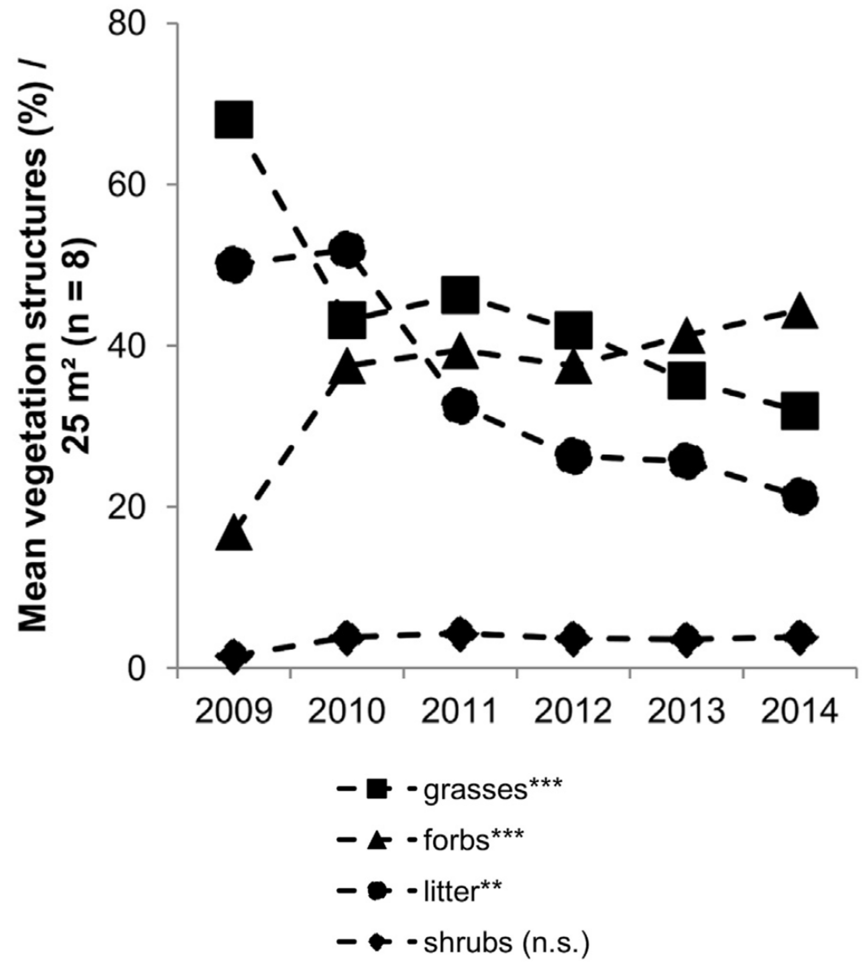


Fig. 6. Changes in ecological groups on permanent grazed plots (25 m^2) within sandy grasslands, heaths, mosaics and *Calamagrostis* stands between 2008 and 2015 (paired *t*-test). Means and +1SE are shown (n = 3). Total: total species number, Target: target species, SubTarget: subordinated target species, Meso: dry mesophilic grassland species, Ruderal: ruderal species and Other: other species.

Henning *et al*. 2017 *Journal for Nature Conservation* 40:120-130.

Year-round horse grazing supports typical vascular plant species, orchids and rare bird communities in a dry calcareous grassland

- 90 ha calcareous grassland in C Germany
- Year-round grazing with konik horses since 2009
- Previous: Dominance by tall, competitive grasses
- Results
  - Vegetation structure and species diversity were significantly improved
  - Year-round horse grazing was suitable to restrict shrub encroachment.
  - Horse grazing did not negatively affect sensitive orchid and bird target species

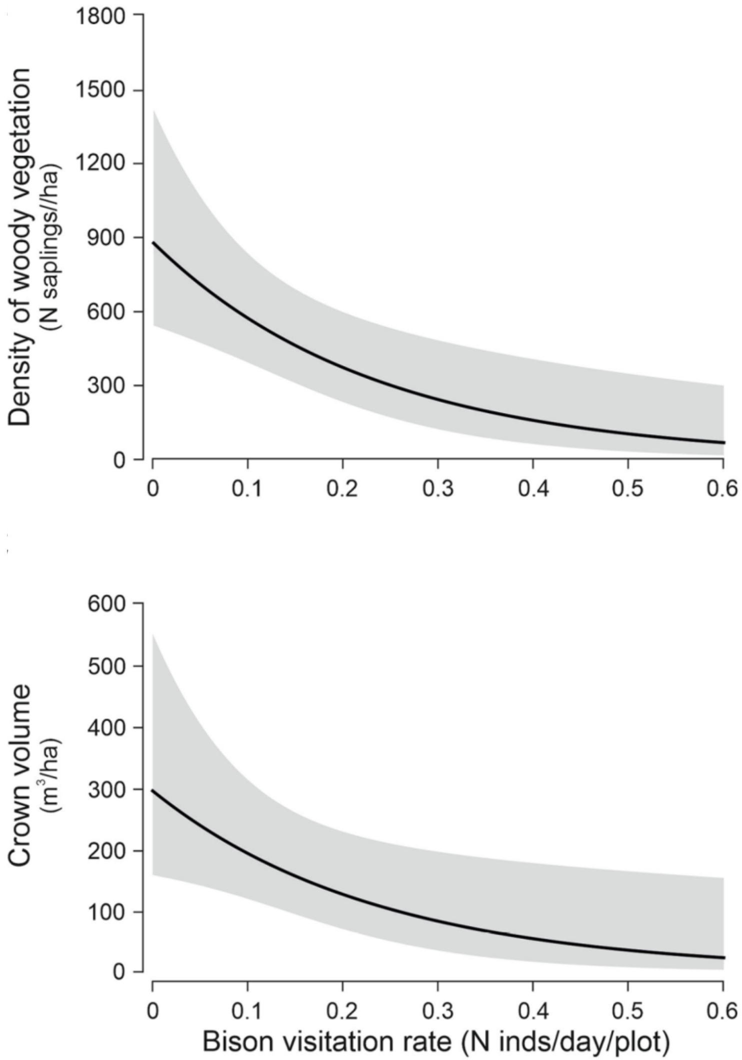


Köhler *et al*. 2016. *Agriculture, Ecosystems & Environment* 234:48-57.

Do large herbivores maintain open habitats in temperate forests?

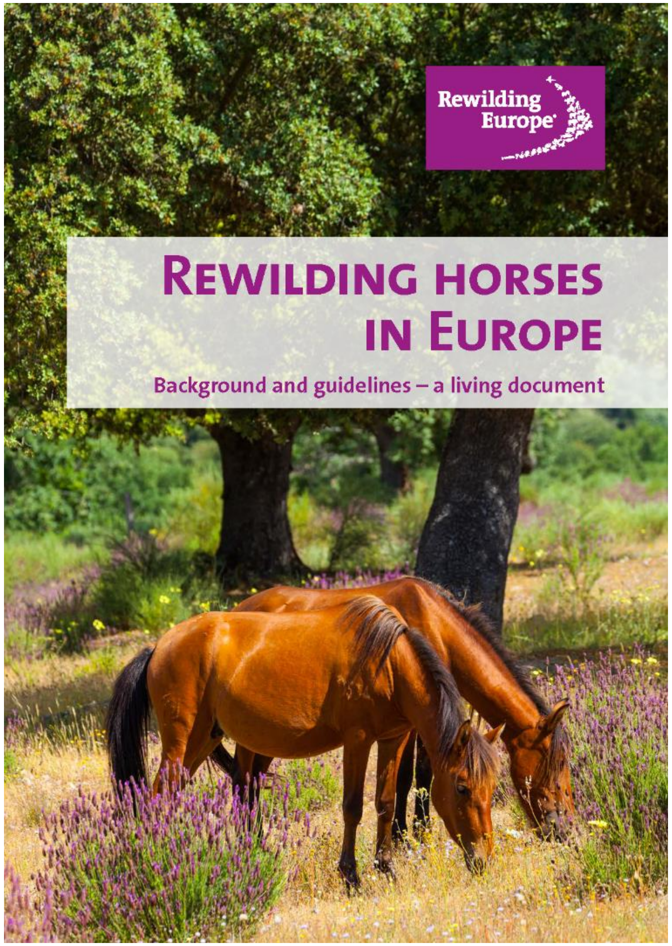
- Study of meadows in the Bialowieza forest:
  - Increased visitation by European bison resulted in a significant reduction in the density and volume of woody vegetation
  - The reducing effect on woody vegetation was over eight times higher in frequently visited plots when compared to unvisited plots
    - the density of woody vegetation decreased from 879 to 101 saplings/ha
    - the crown volume declined from 295 to 35 m^3/ha
  - Combined visitation by other ungulates did not affect either the volume or density of woody vegetation

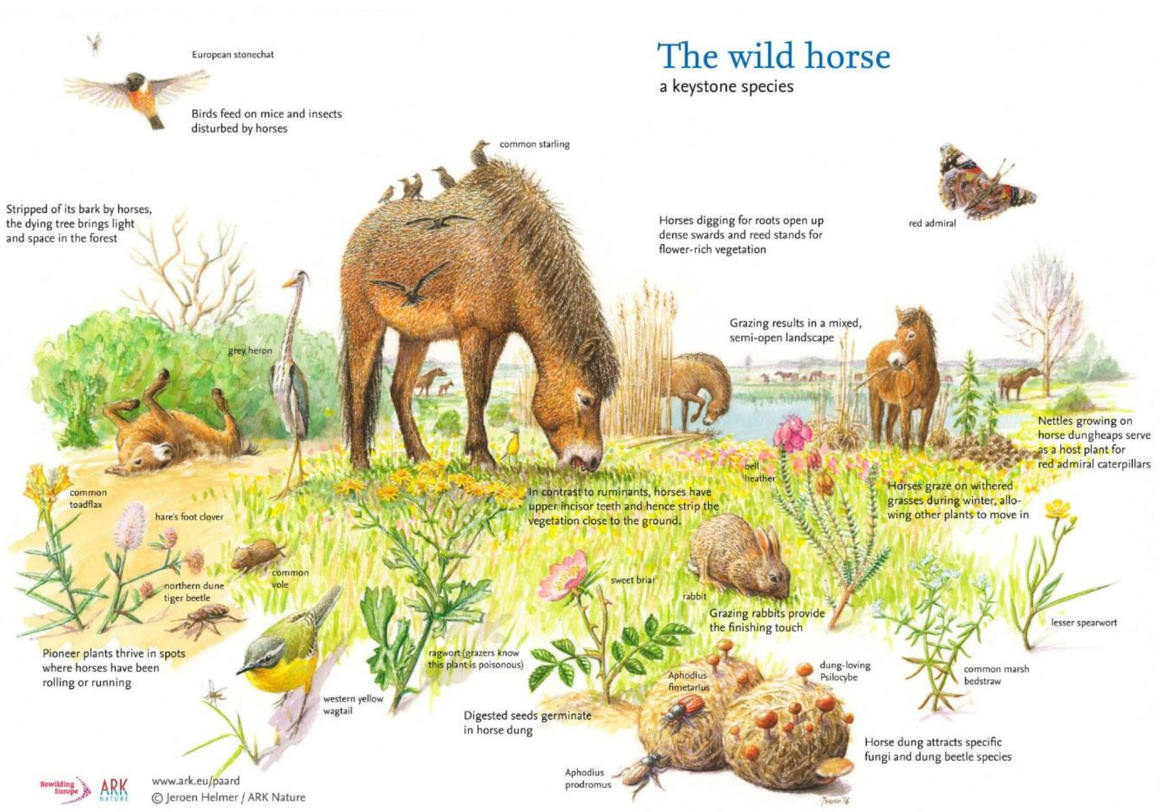
  - potential key agent for shaping vegetation structure in some specific conditions
  - worth emphasizing that cattle and European bison differ in their impact on woody vegetation
    - European bison strip bark more, whereas cattle browse on twigs, thus bison can have a stronger negative effect on woody plant survival and may curb or even reverse woody encroachment in areas of intensive use



Kowalczyk *et al*. 2021. Do large herbivores maintain open habitats in temperate forests? *Forest Ecology and Management* 494:119310.

Meget praktisk erfaring med store planteædere under naturnære forhold





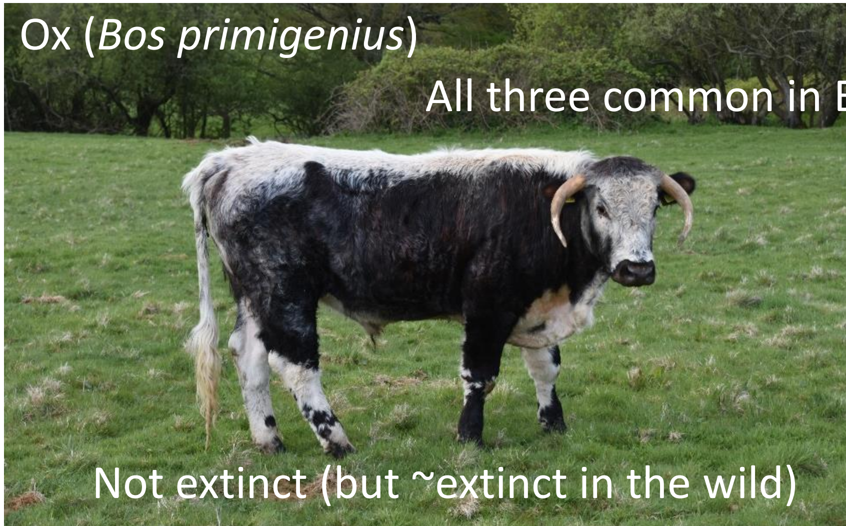
https://rewildingeurope.com/rewilding-in-action/wildlife-comeback/wild-horses/

Meget praktisk erfaring med rewilding

- Hegn
- Bestandsforvaltning
- Dyrevelfærd
- Publikum

Millingerwaard, Holland (JCS)

Store græssere = Værdifuld biodiversitet, ikke bare "funktionsdyr"



Blind vinkel: Der burde være genopretnings-program for okse og hest som vilde dyr – ligesom for andre arter, der er sjældne eller uddøde i naturen

Hofman-Kamińska *et al.* 2019 *Global Change Biology* 25:2915-2930; Bocherens et al. 2015 *PLoS ONE* 10:e0115090; Boulbes & van Asperen 2019 *Frontiers in Ecology and Evolution* 7:doi:10.3389/fevo.2019.00301; Pruvost, M. *et al.* 2011 *PNAS* 108:18626-18630; Librado, P. et al. 2021. *Nature* 598:634–640. photos: JCS.

Konklusioner

- Hvorfor holder vi store dyr i naturen for naturens skyld?
  - Et central element for imødegå biodiversitets- og klimakriserne er at give stor plads til funktionel natur
  - De store dyr er økologiske meget vigtige
    - Fremmer heterogenitet
    - Øger spredning af planter mm.
    - Danner biotiske specialhabitater
    - Vigtige for biogeokemiske cyklusser
  - Stor og stigende evidens
    - Grundvidenskab
    - Genopretningsprojekter
  - De store dyr hører til i naturen og er selv biodiversitet

DK & South Africa (JCS)

BIOCHANGE
CENTER FOR BIODIVERSITY DYNAMICS
IN A CHANGING WORLD

AARHUS UNIVERSITY

Tak

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- VILLUM FONDEN *(VILLUM Investigator grant) "Biodiversity Dynamics in a Changing World"*
- Independent Research Fund Denmark
- Carlsberg Foundation
- Marie Skłodowska-Curie Actions – European Commission

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MARIE CURIE ACTIONS

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