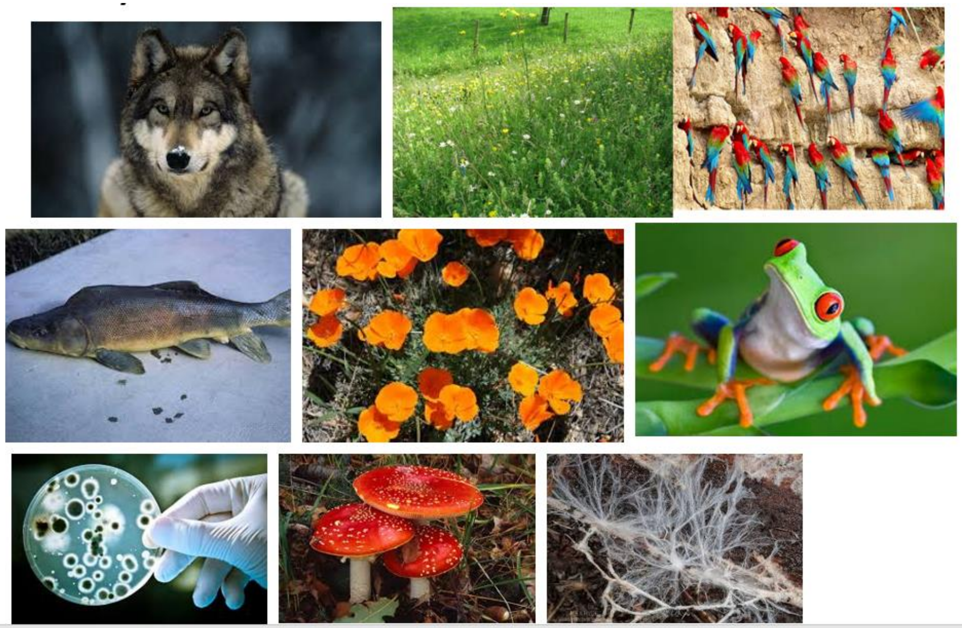
Natürlicher Klimaschutz aus Sicht der Klimawissenschaft

5. Juni 2023

Nachhaltigkeitsforum 2023 zum Thema „Natürlicher Klimaschutz“

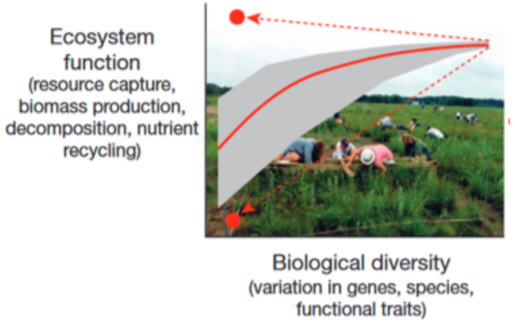
Prof. Markus Quante und Prof. Vicky Temperton

Biodiversität – Effekte des Klimawandels und aktiver nicht-zu-vernachlässigender Akteur für die Anpassung



Die Vielfalt an Arten und Eigenschaften (traits)

Die Vielfalt an Lebensräumen (Mosaik in der Landschaft)



Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., ... & Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature*.

→ **diverse Systeme sind resilienter/widerstandsfähiger**: fällt eine Art aus, kann eine Ökosystemleistung von einer anderen der zahlreichen Arten übernommen werden

LETTER

Isbell et al. Nature 2011

doi:10.1038/nature10282

High plant diversity is needed to maintain ecosystem services

Forest Isbell[1], Vincent Calcagno[1], Andy Hector[2], John Connolly[3], W. Stanley Harpole[4], Peter B. Reich[5,6], Michael Scherer-Lorenzen[7], Bernhard Schmid[2], David Tilman[8], Jasper van Ruijven[9], Alexandra Weigelt[10], Brian J. Wilsey[4], Erika S. Zavaleta[11] & Michel Loreau[1]

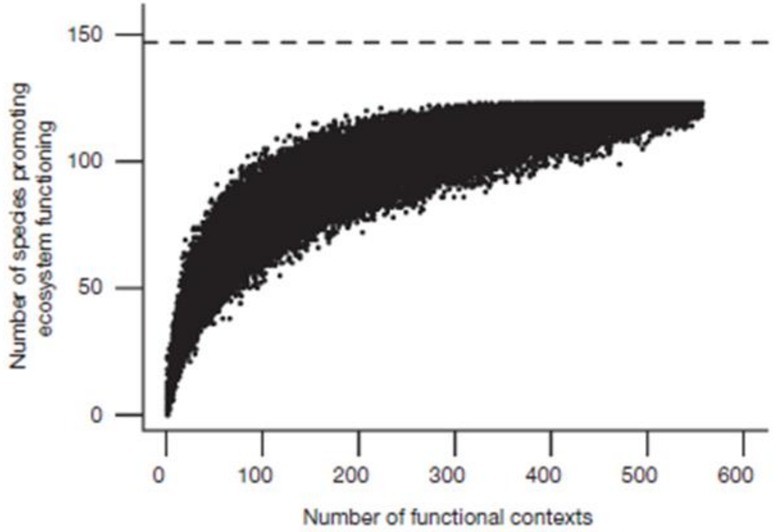


Figure 4 | The number of study species that promoted ecosystem functioning increased with the number of contexts considered across all studies. The points are the number of species that promoted ecosystem functioning when 1–557 contexts were sampled from all 557 contexts. The dashed line indicates the total number of studied species (147), which restricts the upper limit for these values. The *x* axis includes variation across years, places, functions, environmental change scenarios and species pools.

Die Anzahl Pflanzenarten, die zum Funktionieren vom Ökosystem nötig ist, steigt mit der Anzahl von Jahren, Kontexten, Orten, Umweltveränderungen

Der Erhaltungszustand von Lebensräumen in Deutschland

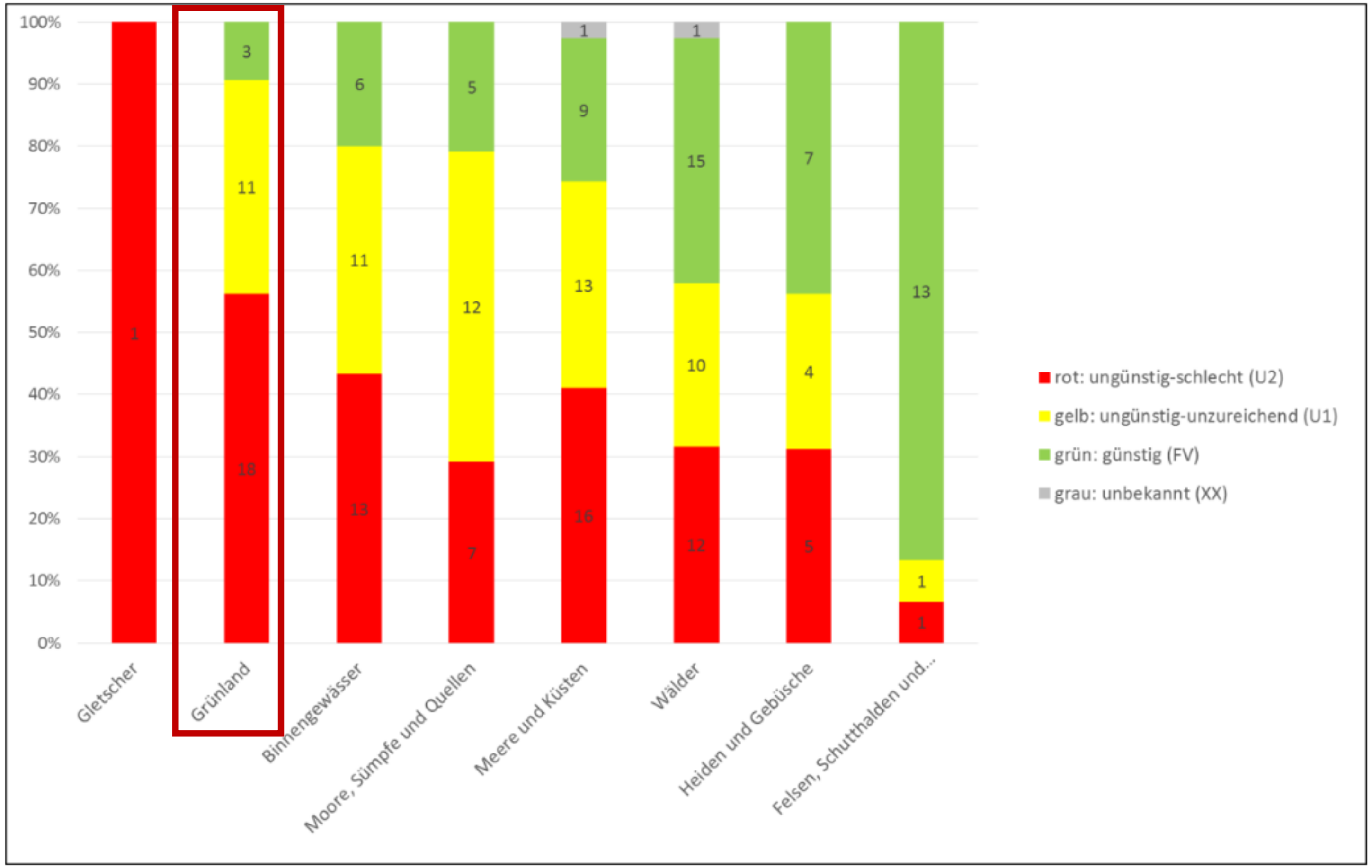


Abb. 4: Erhaltungszustand der Lebensräume nach Formationen in Deutschland. Vorkommen von Lebensräumen in mehreren biogeografischen Regionen werden einzeln bewertet.

RESTORATION ECOLOGY
The Journal of the Society for Ecological Restoration
2023
SER

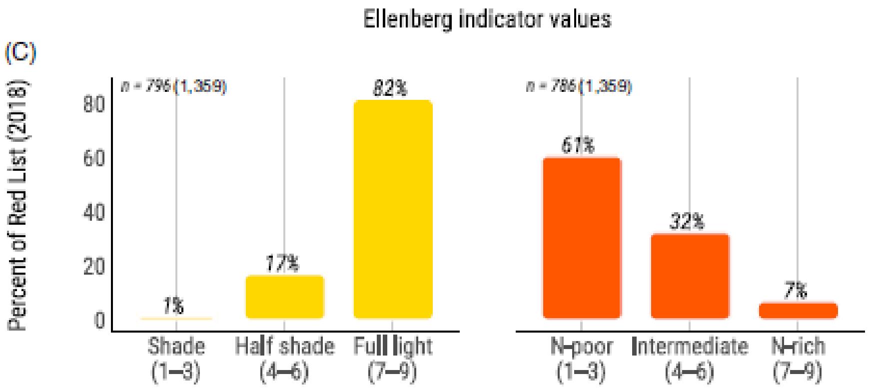
POLICY ARTICLE

Prioritize grassland restoration to bend the curve of biodiversity loss

Ingmar R. Staude[1,2,3], Josiane Segar[1,4], Vicky M. Temperton[5], Bianca O. Andrade[6], Michele de Sá Dechoum[7], Emanuela W. A. Weidlich[5], Gerhard E. Overbeck[6]

In times of unprecedented climate change, ecological restoration efforts have a strong focus on forests for the purpose of carbon sequestration. Grasslands, in contrast, remain relatively neglected in global restoration policies. Concurrently, we are in the midst of a biodiversity crisis—it is estimated that 1 million species are globally threatened with extinction. Here, we present analyses from central Europe and southern Brazil that show that the majority of our endangered plant species are in fact found in open ecosystems. Using Germany as an example, we show that we could reduce plant extinction risk by up to 82% if we restore open, grassy ecosystems. This also holds true for southern Brazil, where grassland species constitute the single largest share of endangered species, but where grassy ecosystems continue to be systematically neglected by restoration policies. We further expand on our biodiversity argument to include the role that grassland restoration can play in mitigating climate change. We posit that ramping up grassland restoration efforts may not only be our best bet to bend the curve of biodiversity loss, but it will also make a critical contribution to the resilience of ecosystems in the dynamic decades to come. It is time for grassland restoration to receive higher priority in global restoration efforts and policy.

Key words: biodiversity crisis, ecosystem resilience, extinction risk, forest bias, natural climate solutions, restoration policy



82% der Pflanzenarten auf der roten Liste in Deutschland brauchen viel Licht;

61% brauchen stickstoffarme Bedingungen

Zustand: in Deutschland und in Süd Brasilien.

BONN CHALLENGE

Trillion Trees

NATURAL CLIMATE SOLUTIONS

Win-Win

Klimaschutz und Wiederherstellung von Biodiversität

Natürliche Klimalösugen: Schutz und Anpassung

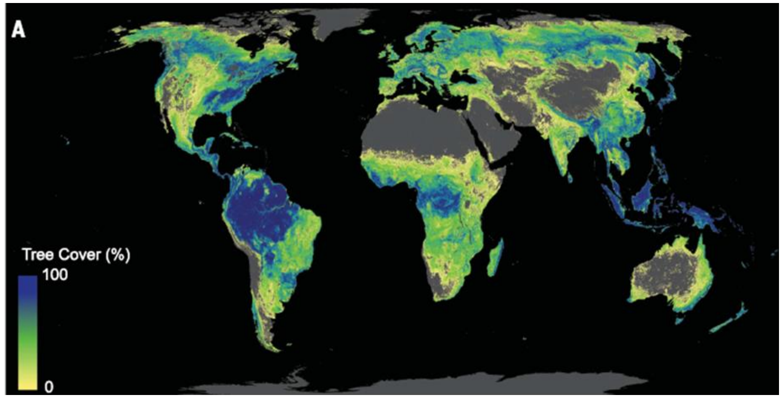
RESTORATION ECOLOGY

Bastin et al. Science 2019

The global tree restoration potential

Jean-Francois Bastin[1*], Yelena Finegold[2], Claude Garcia[3,4], Danilo Mollicone[2], Marcelo Rezende[2], Devin Routh[1], Constantin M. Zohner[1], Thomas W. Crowther[1]

The restoration of trees remains among the most effective strategies for climate change mitigation. We mapped the global potential tree coverage to show that 4.4 billion hectares of canopy cover could exist under the current climate. Excluding existing trees and agricultural and urban areas, we found that there is room for an extra 0.9 billion hectares of canopy cover, which could store 205 gigatonnes of carbon in areas that would naturally support woodlands and forests. This highlights global tree restoration as our most effective climate change solution to date. However, climate change will alter this potential tree coverage. We estimate that if we cannot deviate from the current trajectory, the global potential canopy cover may shrink by ~223 million hectares by 2050, with the vast majority of losses occurring in the tropics. Our results highlight the opportunity of climate change mitigation through global tree restoration but also the urgent need for action.



0.9 milliarden Hektar Baumbestand (canopy cover) mit
205 Gigatonnen Kohlenstoff (C) Speicherung

- „Mitigation“ (Klimaschutz)
- Die Natur als Wald – „tree bias“

Strassburg et al. Nature 2020

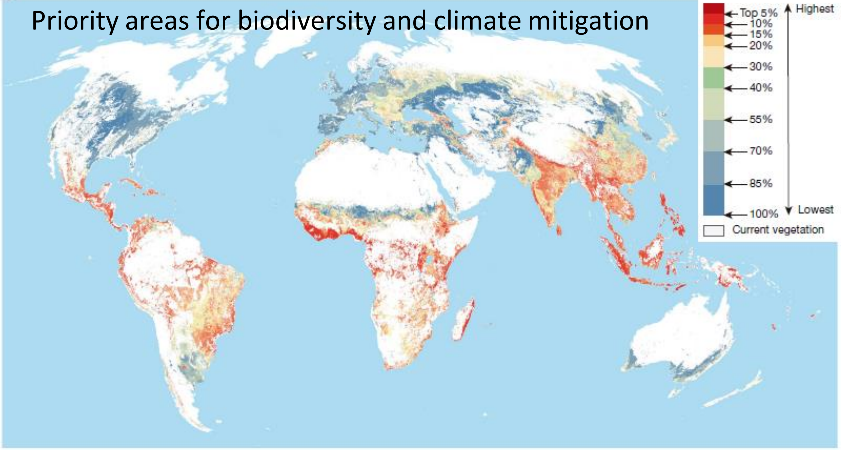
Article

Global priority areas for ecosystem restoration

https://doi.org/10.1038/s41586-020-2784-9
Received: 14 August 2019
Accepted: 8 September 2020
Published online: 14 October 2020
Check for updates

Bernardo B. N. Strassburg[1,2,3,4], Alvaro Iribarrem[1,2], Hawthorne L. Beyer[5], Carlos Leandro Cordeiro[1,2], Renato Crouzeilles[1,2,3], Catarina C. Jakovac[1,2,6], André Braga Junqueira[1,2,7], Eduardo Lacerda[1,2,8], Agnieszka E. Latawiec[1,2,9,10], Andrew Balmford[11], Thomas M. Brooks[12,13,14], Stuart H. M. Butchart[11,15], Robin L. Chazdon[2,16,17,18], Karl-Heinz Erb[19], Pedro Brancalion[20], Graeme Buchanan[21], David Cooper[22], Sandra Díaz[23], Paul F. Donald[11,15,21], Valerie Kapos[24], David Leclère[25], Lera Miles[24], Michael Obersteiner[25,26], Christoph Plutzar[19,27], Carlos Alberto de M. Scaramuzza[2], Fabio R. Scarano[3] & Piero Visconti[25]

e



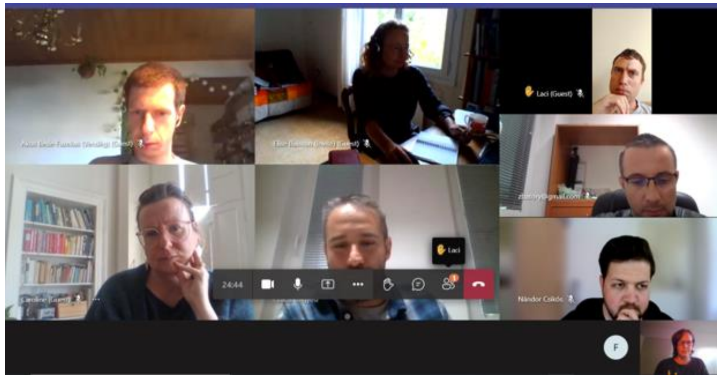
“Global priority areas that account for spatial variation in benefits and costs have yet to be identified”

Möglich: 480 Gt C (bis 2100)

15% Wiederherstellung: 72 Gigatonnen C

- „Mitigation” (Klimaschutz)
- Unterschiedliche Lebensräume

Global potential for sequestering carbon and restoring biodiversity with ecological restoration.
Tolgyesi et al.



World Land Cover Database: Verwandlung von degradierten Systemen in einen anderen Lebensraumtyp (Renaturierung): Grünland, Strauchgebiet, Feuchtgebiet, Wald:

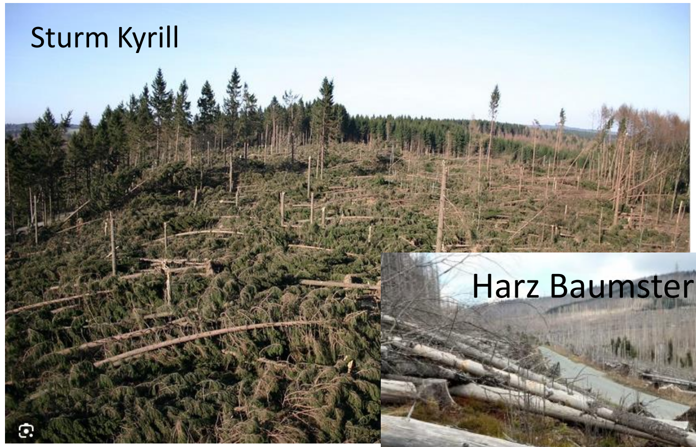
Möglich: 180 Gigatonnen C (bis 2100)

- viel weniger als Strassburg, weniger als Bastin et al. ;
- Realistisch? Schutz oder Renaturierung von ca. 15-30% der Landschaft (COP 15) wäre ca. **30-60 Gigatonnen C** (ähnlich wie Strassburg et al.).

Extremwetterereignisse (das Störungsregime) haben zugenommen und werden sich weiter gewaltig verändern

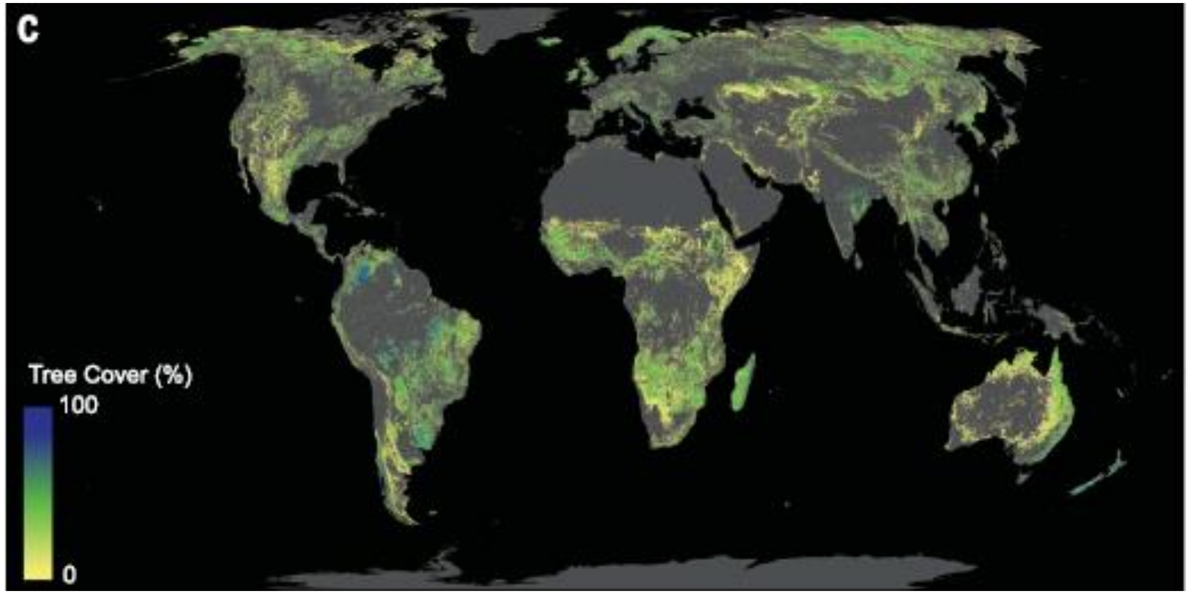
Bushfires destroy properties in the township of Hillville on the Mid North Coast of NSW, November 12, 2019. Credit: Nick Moir *Getty Images*

Global Warming Cartoon Style Illustration with Planet Earth in a Melting or Burning State and Image Sun to Prevent Damage to Nature and Climate Change
Pro Vector



https://public.wmo.int/en/resources/world-meteorological-day/previous-world-meteorological-days/climate-and-water/drought

Der Klimaschutz (Climate Mitigation) geht oft von stationären Bedingungen aus: Resilienz und Stabilität der Maßnahmen muss unbedingt mehr Aufmerksamkeit bekommen



Möglicher neuer Baumbestand (ohne urbane und landwirtschaftliche Flächen)

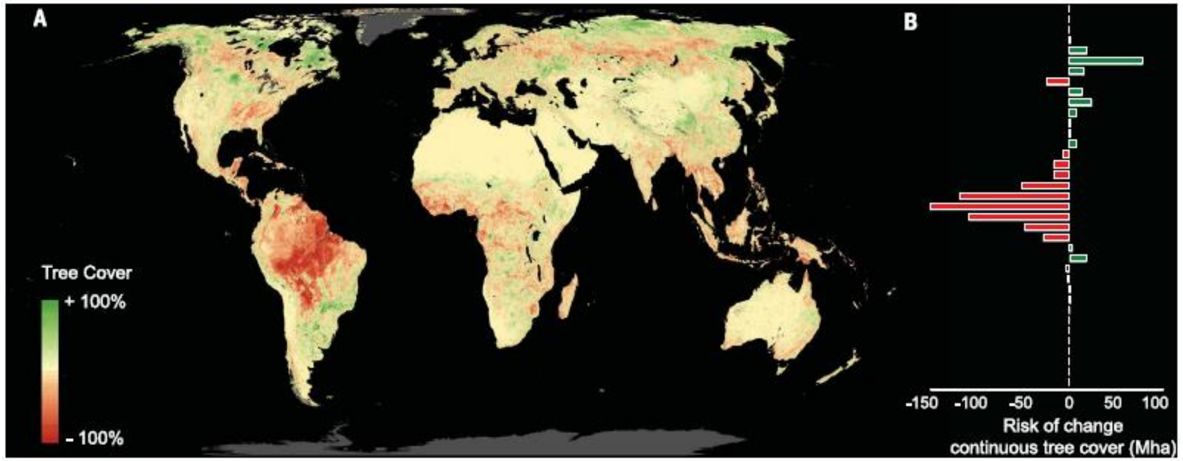


Fig. 3. Risk assessment of future changes in potential tree cover. (**A**) Illustration of expected losses in potential tree cover by 2050, under the "business as usual" climate change scenario (RCP 8.5), from the average of three Earth system models commonly used in ecology (cesm1cam5, cesm1bgc, and mohchadgem2es). (**B**) Quantitative numbers of potential gain and loss are illustrated by bins of 5° along a latitudinal gradient.

Risikogebiete für Änderungen im Baumbestand durch den Klimawandel

Bastin et al. Science 2019

DRYLAND FORESTATION

Limited climate change mitigation potential through forestation of the vast dryland regions

Shani Rohatyn[1]*, Dan Yakir[2]*, Eyal Rotenberg[2], Yohay Carmel[1]

Forestation of the vast global drylands has been considered a promising climate change mitigation strategy. However, its actual climatic benefits are uncertain because the forests' reduced albedo can produce large warming effects. Using high-resolution spatial analysis of global drylands, we found 448 million hectares suitable for afforestation. This area's carbon sequestration potential until 2100 is 32.3 billion tons of carbon (Gt C), but 22.6 Gt C of that is required to balance albedo effects. The net carbon equivalent would offset ~1% of projected medium-emissions and business-as-usual scenarios over the same period. Focusing forestation only on areas with net cooling effects would use half the area and double the emissions offset. Although such smart forestation is clearly important, its limited climatic benefits reinforce the need to reduce emissions rapidly.

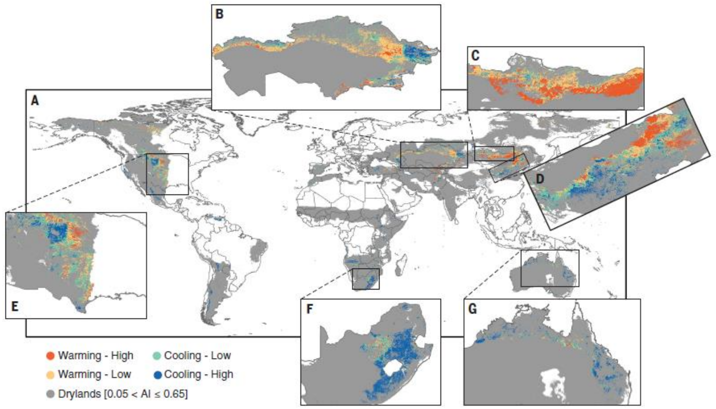
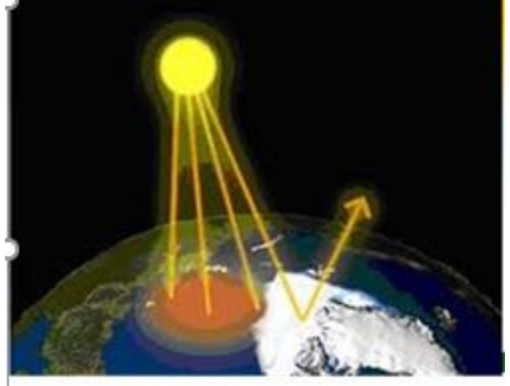


Fig. 1. Net equivalent carbon stock change obtainable from the afforestation of suitable nonforested drylands. (**A** to **G**) NESC outcomes calculated as the net difference between the carbon sequestration potential (ΔSP) and the emissions equivalent of shortwave forcing (EESF) arising from forestation-induced changes in albedo. Colors represent the NESC effect range, where NESC was calculated in units of tons of carbon per hectare over a forest lifetime of 80 years (2020–2100): high warming, NESC ≤ −50; low warming −50 < NESC ≤ 0 (represents a near-neutral climatic effect); low cooling, 0 < NESC ≤ 50; and high cooling, NESC > 50 (represents the largest potential climate cooling effect). The dark gray background indicates the full extent of global drylands [defined as semiarid and dry-subhumid lands within the aridity index (AI) range of 0.05 < AI ≤ 0.65]. (A) Global map. Zoom-ins of drylands in (B) Kazakhstan, (C) Mongolia, (D) northeastern China (Inner Mongolia), (E) USA, (F) South Africa, and (G) Australia. An interactive map of the results can be found here: https://tinyurl.com/mrt4ycha.



Albedo

Aufforstung von globalen Trockengebieten als Chance oder Fehlinvestition durch den verlorenen Albedoeffekt?

C Speicherungspotential bis 2100 beträgt 32.3 Gt C

Aber 22.6 Gt C davon wird gebraucht um den verlorenen Albedoeffekt (durch Verdunkelung der Oberfläche) zu kompensieren.

C Speicherung ist nicht gleich Kühlung.

+ Verlust an Biodiversität durch Aufforstung enorm.

Kohlenstoffumsatz und Speicherzeit sollten unbedingt mitbedacht werden

Environmental Research Letters

LETTER

OPEN ACCESS

RECEIVED
10 January 2018

REVISED
17 May 2018

ACCEPTED FOR PUBLICATION
8 June 2018

PUBLISHED
10 July 2018

Original content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence.

Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Grasslands may be more reliable carbon sinks than forests in California

Pawlok Dass[1,5], Benjamin Z Houlton[1,2], Yingping Wang[3] and David Warlind[4]

1 Department of Land, Air and Water Resources, University of California, Davis, United States of America
2 John Muir Institute of the Environment, University of California, Davis, United States of America
3 CSIRO Oceans and Atmosphere, Private Bag 1, Aspendale, VIC 3195, Australia
4 Department of Physical Geography and Ecosystem Science, Lund University, Lund, Sweden
5 Author to whom any correspondence should be addressed.

E-mail: dass@ucdavis.edu

Keywords: carbon cycle, climate change, drought, wildfire, grassland, forest, cap and trade

Supplementary material for this article is available online

Abstract

Although natural terrestrial ecosystems have sequestered ~25% of anthropogenic CO_2 emissions, the long-term sustainability of this key ecosystem service is under question. Forests have traditionally been viewed as robust carbon (C) sinks; however, extreme heat-waves, drought and wildfire have increased tree mortality, particularly in widespread semi-arid regions, which account for ~41% of Earth's land surface. Using a set of modeling experiments, we show that California grasslands are a more resilient C sink than forests in response to 21st century changes in climate, with implications for designing climate-smart Cap and Trade offset policies. The resilience of grasslands to rising temperatures, drought and fire, coupled with the preferential banking of C to belowground sinks, helps to preserve sequestered terrestrial C and prevent it from re-entering the atmosphere. In contrast, California forests appear unable to cope with unmitigated global changes in the climate, switching from substantial C sinks to C sources by at least the mid-21st century. These results highlight the inherent risk of relying on forest C offsets in the absence of management interventions to avoid substantial fire-driven C emissions. On the other hand, since grassland environments, including tree-sparse rangelands, appear more capable of maintaining C sinks in 21st century, such ecosystems should be considered as an alternative C offset to climate-vulnerable forests. The further development of climate-smart approaches in California's carbon marketplace could serve as an example to offset programs around the world, particularly those expanding into widespread arid and semi-arid regions.

RCP 8.5 business as usual

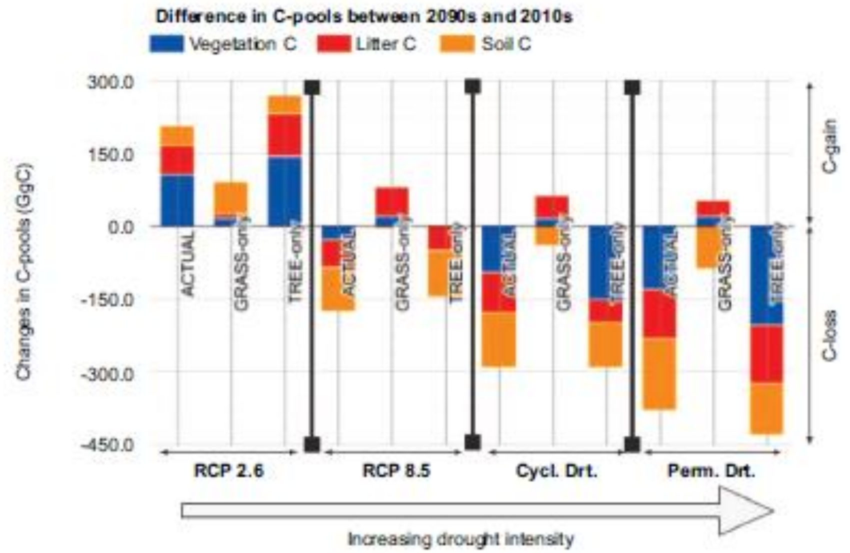
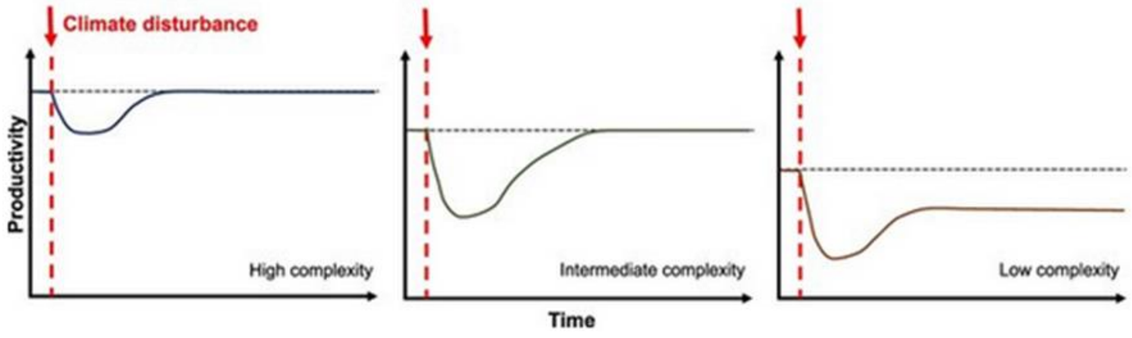


Figure 3. Net C drawdown or loss in the 21st century, i.e. difference between the 2090s and 2010s (10 year means) of vegetation C (blue), litter C (red), and soil C (yellow) in response to 21st century climate change. Positive values reveal a net increase of a given C stock, negative values reveal a net decline of C. Units are in GgC (10^9 gC). As drought, fire and heat intensify from RCP 8.5 (business as usual) to permanent drought scenarios, grasses emerge as the most reliable C sink. In the most extreme permanent drought conditions, grasses are a net C source but still maintain some C sink potential in litter and vegetation pools.

- Mit steigender Trockenheit werden Ökosystemen zu C Quellen (nicht mehr Senken).
- Grünland ist am resilientesten

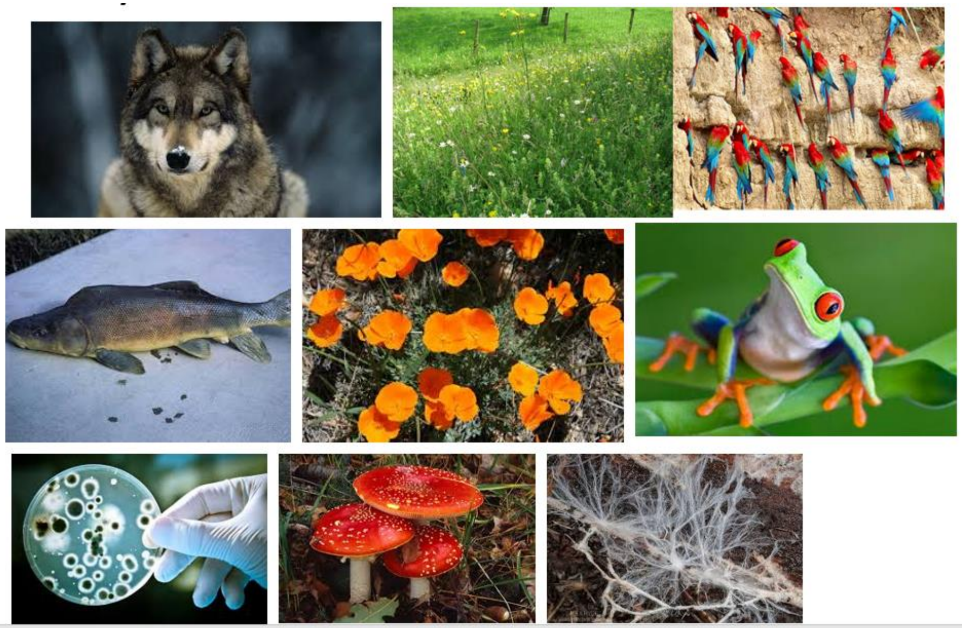
Was bedeutet das?

- Möglichst eine Vielfalt an Lebensraumtypen einplanen und artenreiches Grünland als Hauptkomponente in der Biodiversitätskrise und Langzeitkohlenstoffspeicherung unterirdisch fördern.
- Genauso viel auf Klimaanpassung setzten.
- Die „Insurance Hypothesis“ anwenden – soviele Arten und so viele Lebensräume schützen/wiederherstellen wie möglich.



Predictions of the landscape-moderated insurance hypothesis on how the productivity of landscapes with different complexities respond to climate disturbance (adapted from Tscharntke et al., 2012)

Biodiversität und Ökosystemfunktionen werden oft *innerhalb* eines Lebensraumes (Habitat) gemessen, selten explizit *zwischen:* Forschungslücke für Vergleiche



Die Vielfalt an Arten und Eigenschaften (traits)

Die Vielfalt an Lebensärumen (Mosaik in der Landschaft)