biogeografie
uni bayreuth

# Climate change vulnerability of the Earth's terrestrial protected areas

## *Linking open Geo Data with free codes towards open-access products*

Carl Beierkuhnlein & Samuel Hoffmann

Biogeography
University of Bayreuth

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 641762

Bayceer
Bayreuth Center of Ecology and Environmental Research

# *Structure*

*Climate Change* Impact on **Global** PAs

*Climate Change* Impact on **European** PAs

*Climate Change* Impact on a **Mountain** PA

*Uniqueness* of **European** PAs

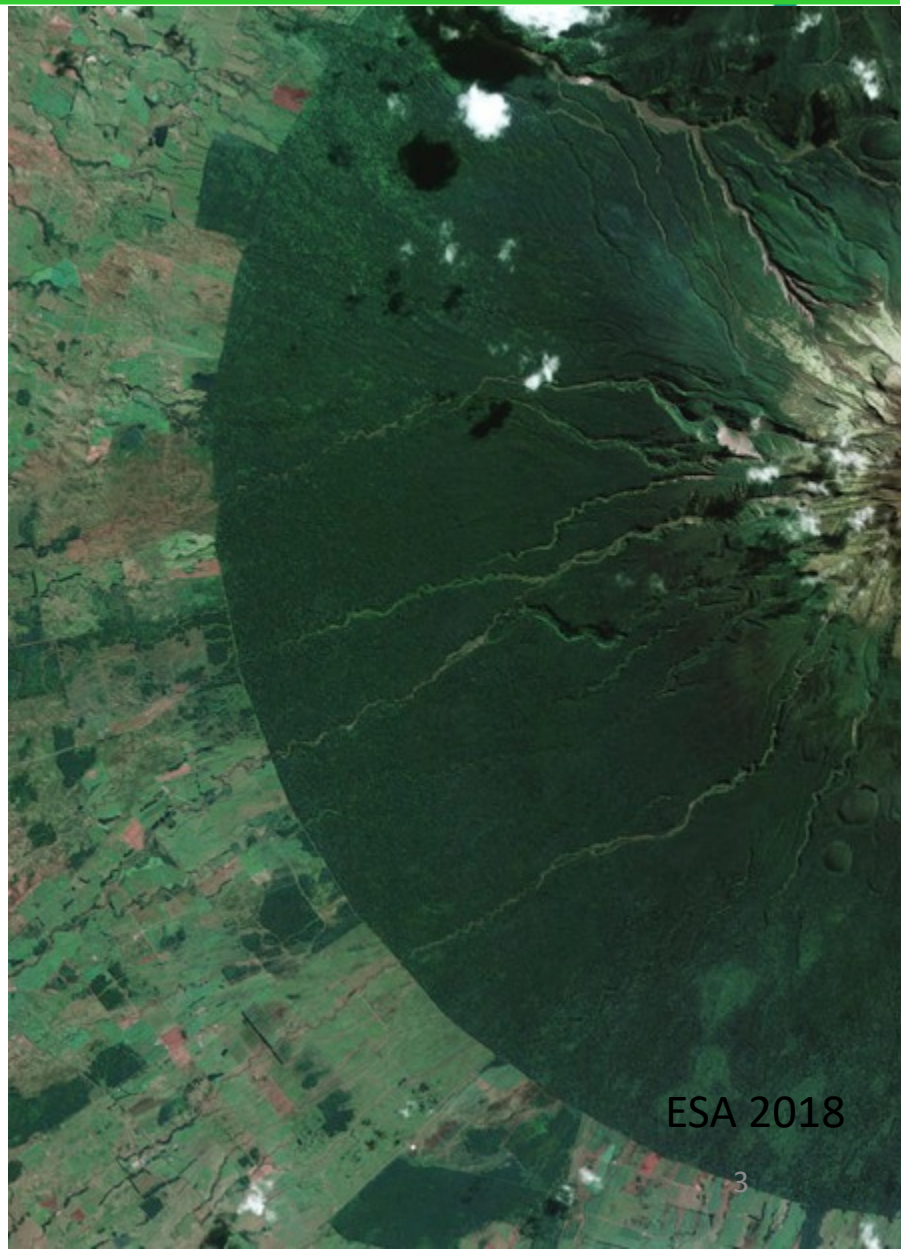
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 641762

# *PAs & Climate Change*

- Protected Areas are **spatially static refugia** for biodiversity with defined boundaries.

- Climate change is **altering habitats**, also **inside PAs**.

PAs **may** consequently **lose** biodiversity and conservation **value** under climate change.



ESA 2018

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 641762

# Current Paper

nature COMMUNICATIONS

ARTICLE

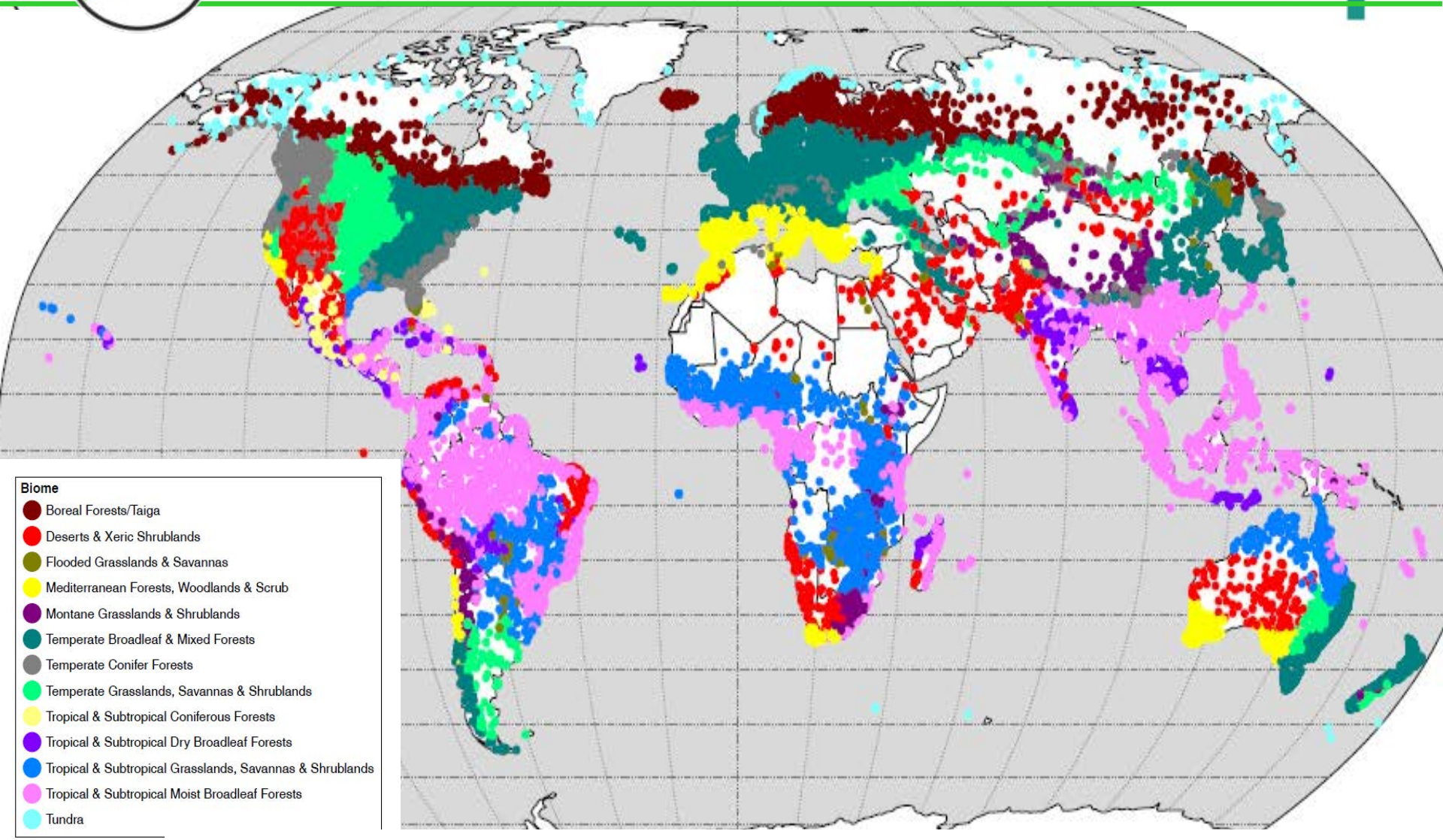
https://doi.org/10.1038/s41467-019-12603-w OPEN

## Predicted climate shifts within terrestrial protected areas worldwide

Samuel Hoffmann [1*], Severin D.H. Irl [1,2,3] & Carl Beierkuhnlein [1,2,4]

Hoffmann, Irl, Beierkuhnlein (2019) Predicted climate shifts within terrestrial protected areas worldwide. Nature Communications, **October 21st 2019**, doi.org/10.1038/s41467-019-12603-w

# PAs & Climate Change




Hoffmann, Irl, Beierkuhnlein (2019) Predicted climate shifts within terrestrial protected areas worldwide. Nature Communications, October 21st 2019, doi.org/10.1038/s41467-019-12603-w

# *PAs & Climate Change*

**137,432** terrestrial PAs

**20,658,583 km²**

**14%** of the global land area (incl. Antarctica)

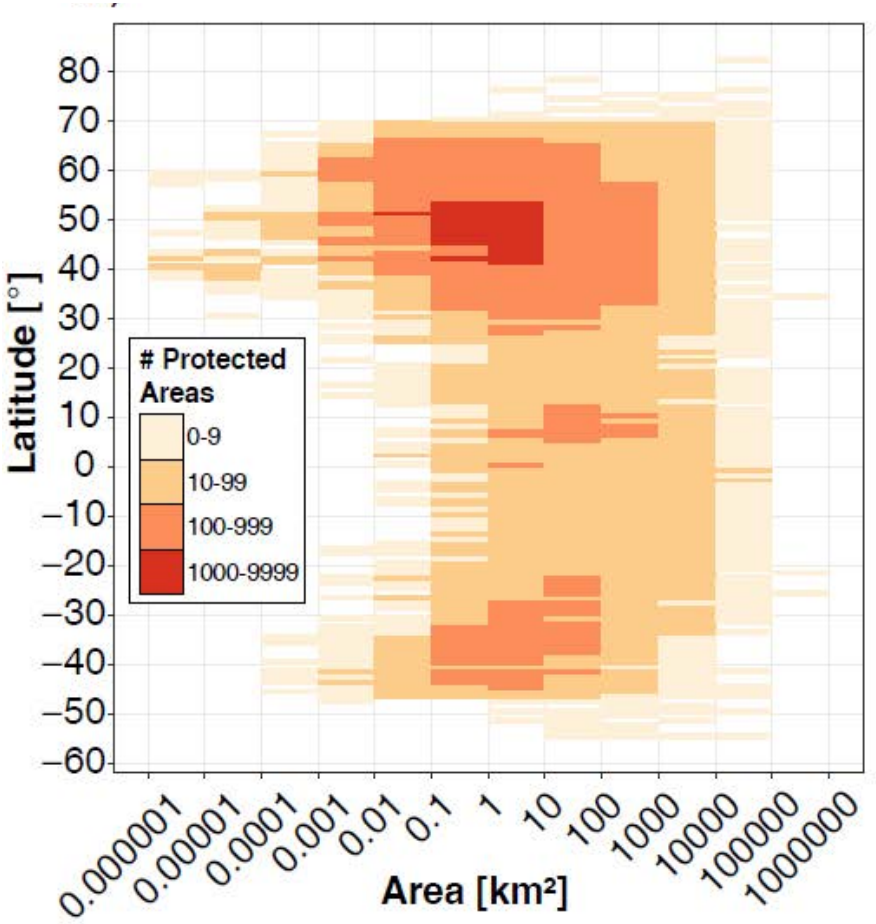
**99.9%** of global PA area

**26,038,594** terrestrial climate cells

Resolution **30 arc sec** (ca. 1 km)

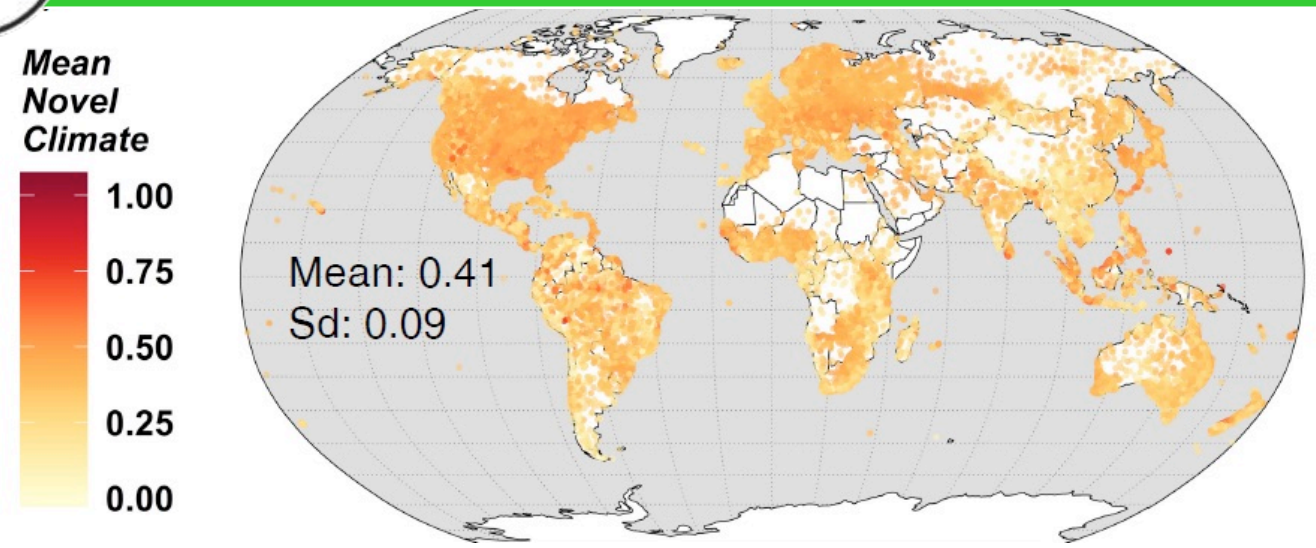
**10 GCMs**

**4 Scenarios (RCPs)**

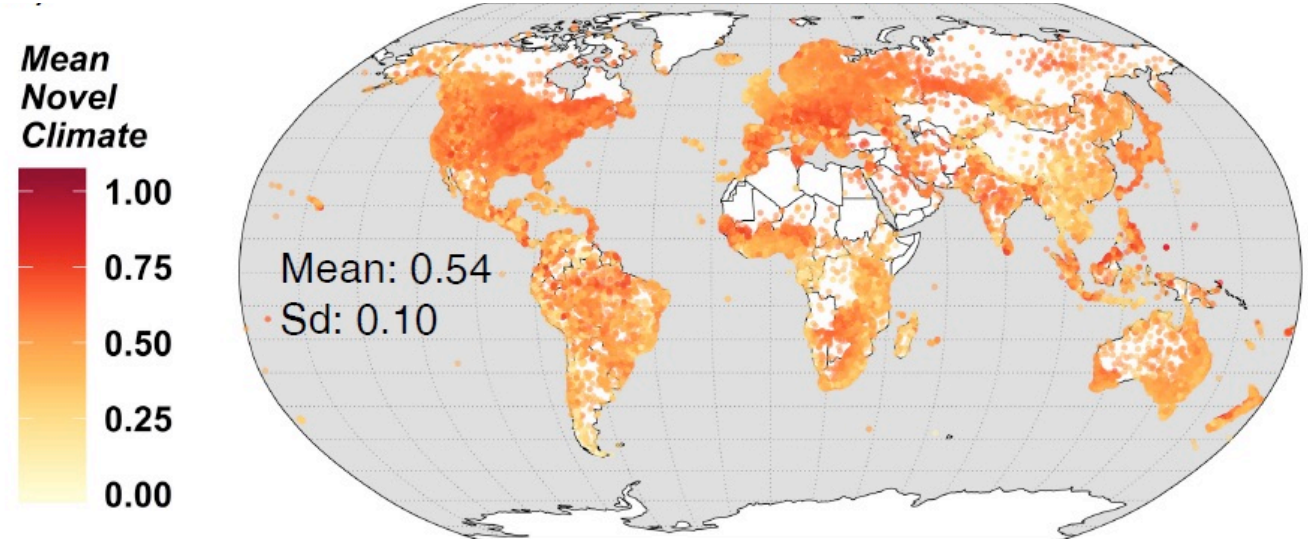



Hoffmann, Irl, Beierkuhnlein (2019) Predicted climate shifts within terrestrial protected areas worldwide. Nature Communications, October 21st 2019, doi.org/10.1038/s41467-019-12603-w

Novel climatic conditions **WITHIN** any **PA**



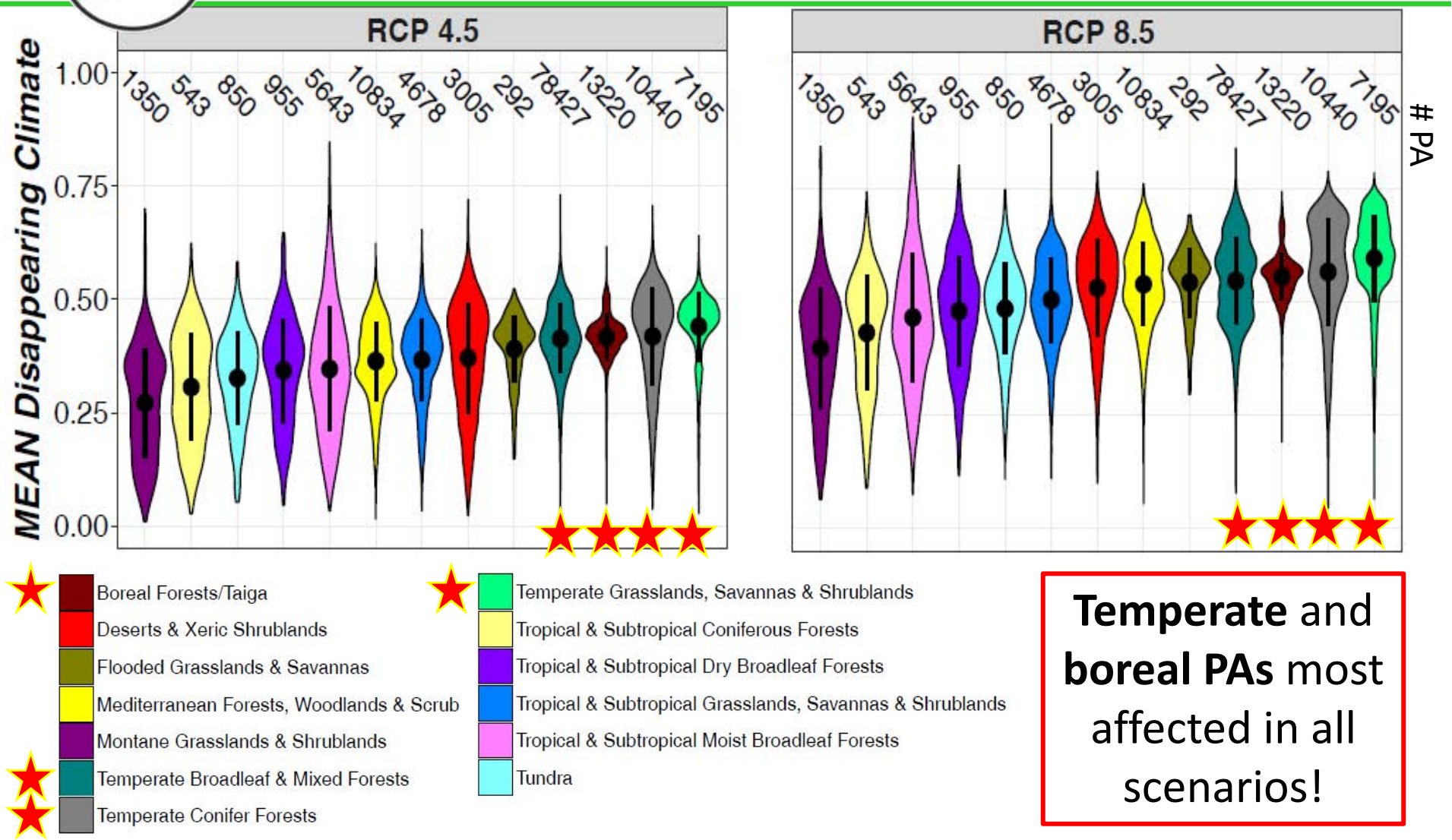

RCP 4.5




RCP 8.5

Hoffmann, Irl, Beierkuhnlein (2019) Predicted climate shifts within terrestrial protected areas worldwide. Nature Communications, October 21st 2019, doi.org/10.1038/s41467-019-12603-w

# PAs & Climate Change




**Temperate** and **boreal PAs** most affected in all scenarios!

Hoffmann, Irl, Beierkuhnlein (2019) Predicted climate shifts within terrestrial protected areas worldwide. Nature Communications, October 21st 2019, doi.org/10.1038/s41467-019-12603-w

# *Global Protected Areas*

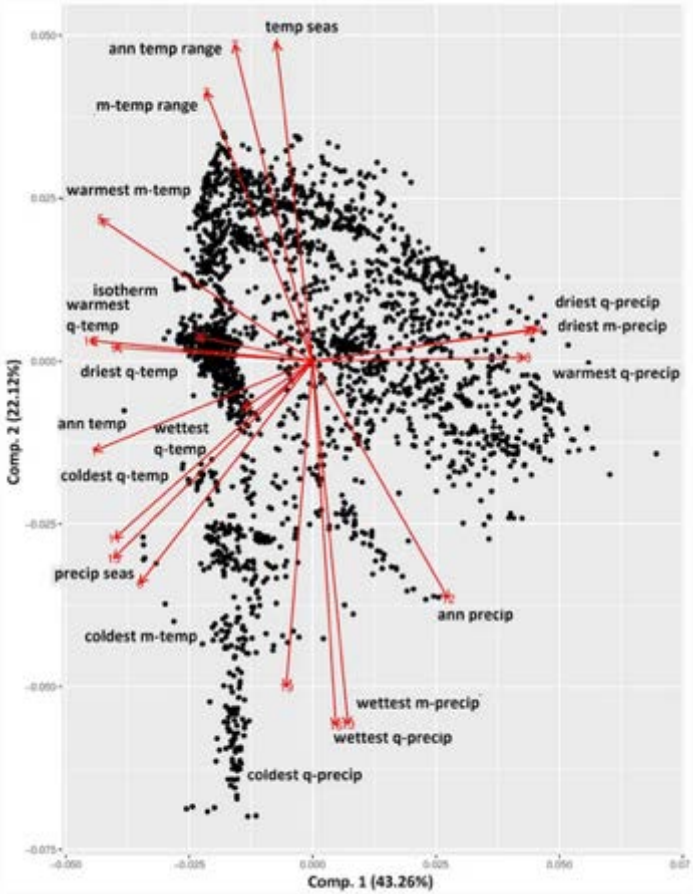
**In a nutshell:**

- PAs in the **boreal and temperate biome** will be most affected.
- In the **boreal** biome this is due to the stronger **warming**.
- In the **temperate** biome this results from small PA **sizes** and intense **fragmentation** in between them.

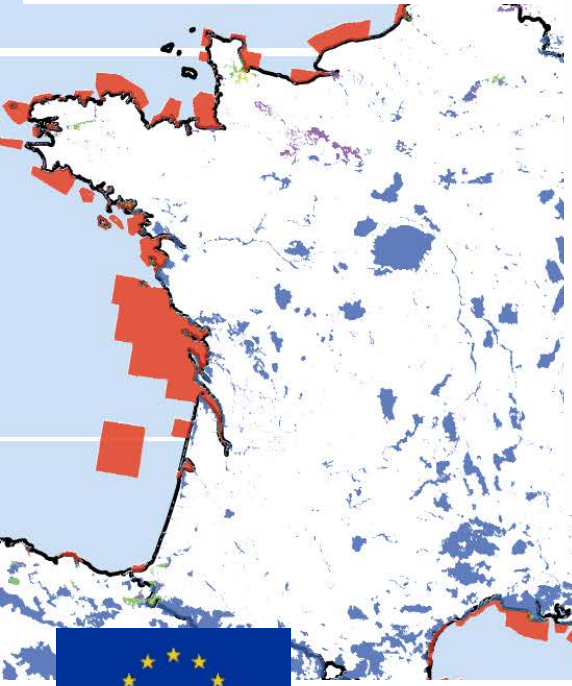
Hoffmann, Irl, Beierkuhnlein (2019) Predicted climate shifts within terrestrial protected areas worldwide. Nature Communications, October 21st 2019, doi.org/10.1038/s41467-019-12603-w

# European Protected Areas

Worldclim 30s resolution
RCP 6.0
2070
BCC-CSM1-1
PCA bin width: 2 units




Persisting Climate
Novel Climate
Disappearing Climate
Changing Climate Class Only
Marine




Nila, Beierkuhnlein, Jaeschke, Hoffmann, Hossain (2019) Predicting the effectiveness of protected areas of Natura 2000 under climate change, Ecological Processes, **8**(13) doi:10.1186/s13717-019-0168-6

# *European Protected Areas*

**In a nutshell:**

- **Oceanic European PAs** (West) will be **less exposed** to climate change compared to continental regions (East)!
- **Uncertainty** about future climate is **biggest for continental PAs**!

# *La Palma Science School*

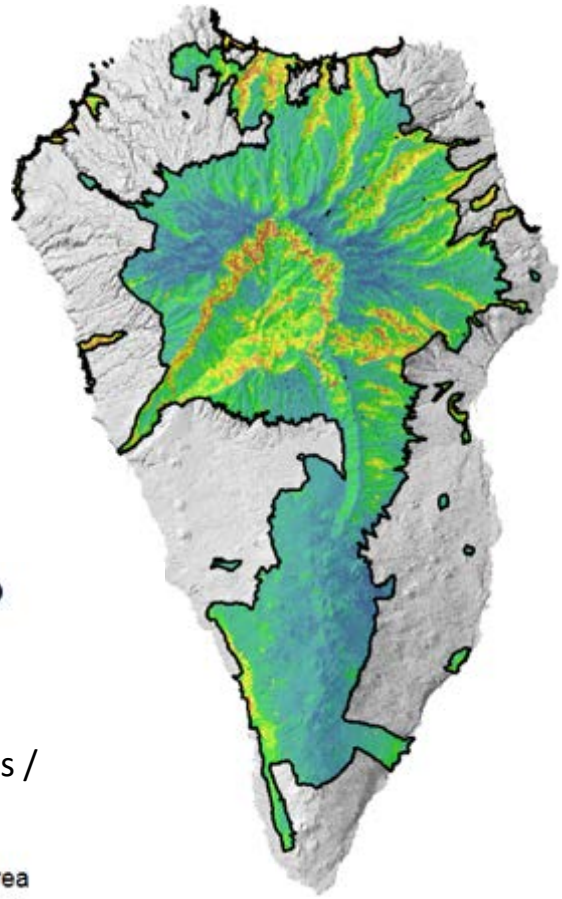
La Palma Science School

*Carlina spec. nov.*

# *La Palma*

## Endemism

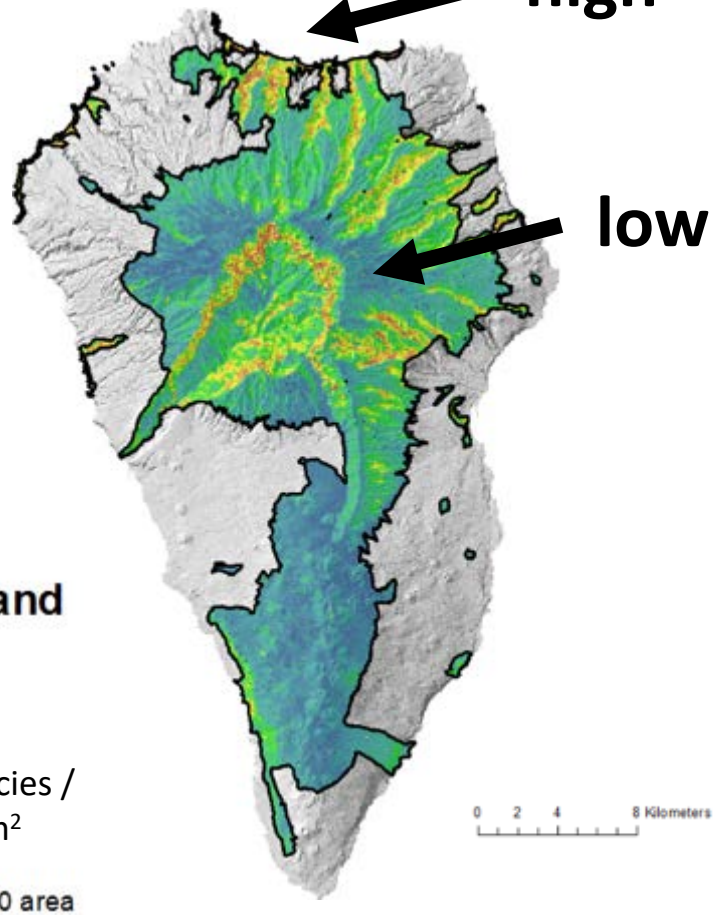
1500 in-situ data points



**Archipelago endemic richness**

24 # species / 0 400 m²

Natura 2000 area




**Single island endemic richness**

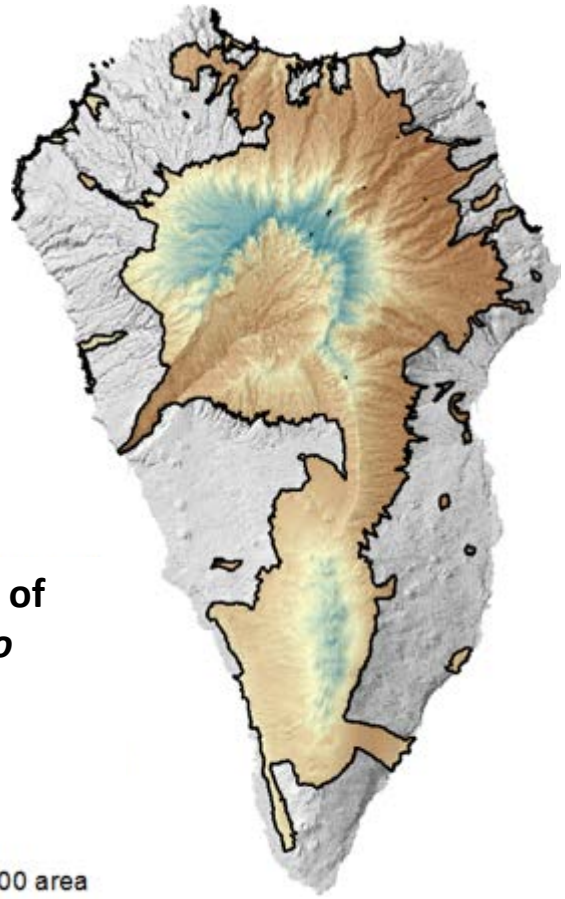
8 # species / 0 400 m²

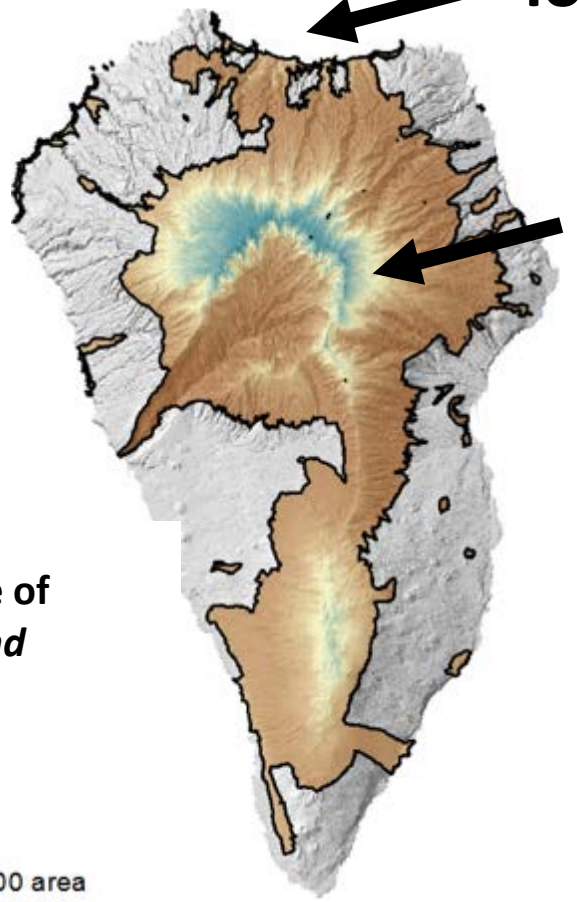
Natura 2000 area

Irl, Schweiger, Medina, Fernández-Palacios, Harter, Jentsch, Provenzale, Steinbauer, Beierkuhnlein (2017) An island view of endemic rarity – environmental drivers and consequences for nature conservation, Diversity and Distributions, **23**(10), 1132-1142.

# *La Palma*

## Endemism

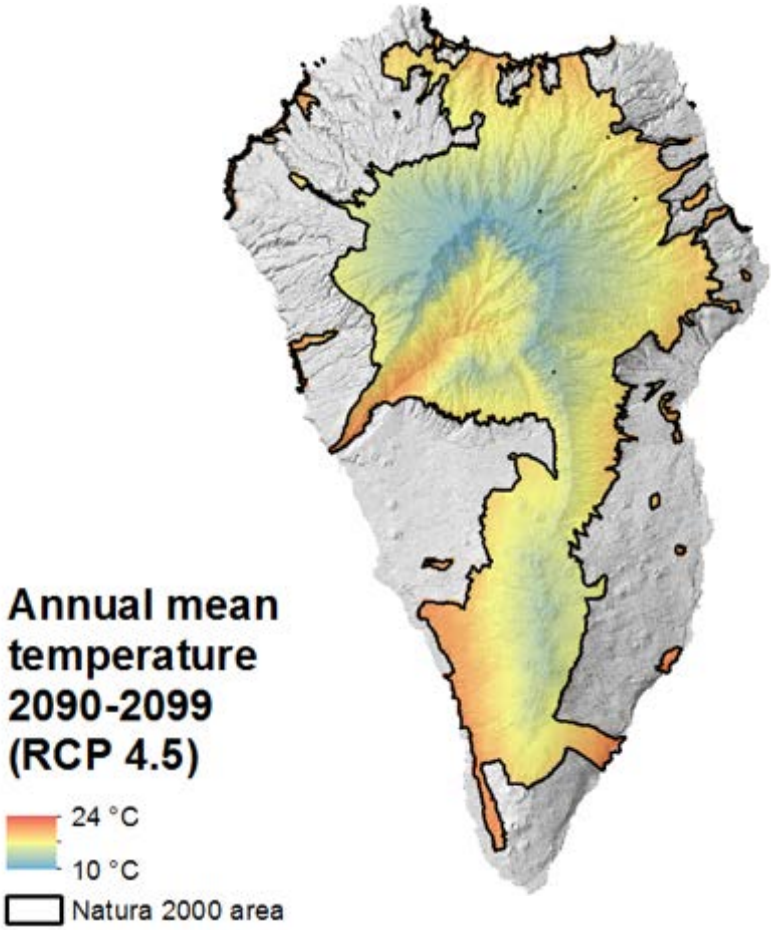


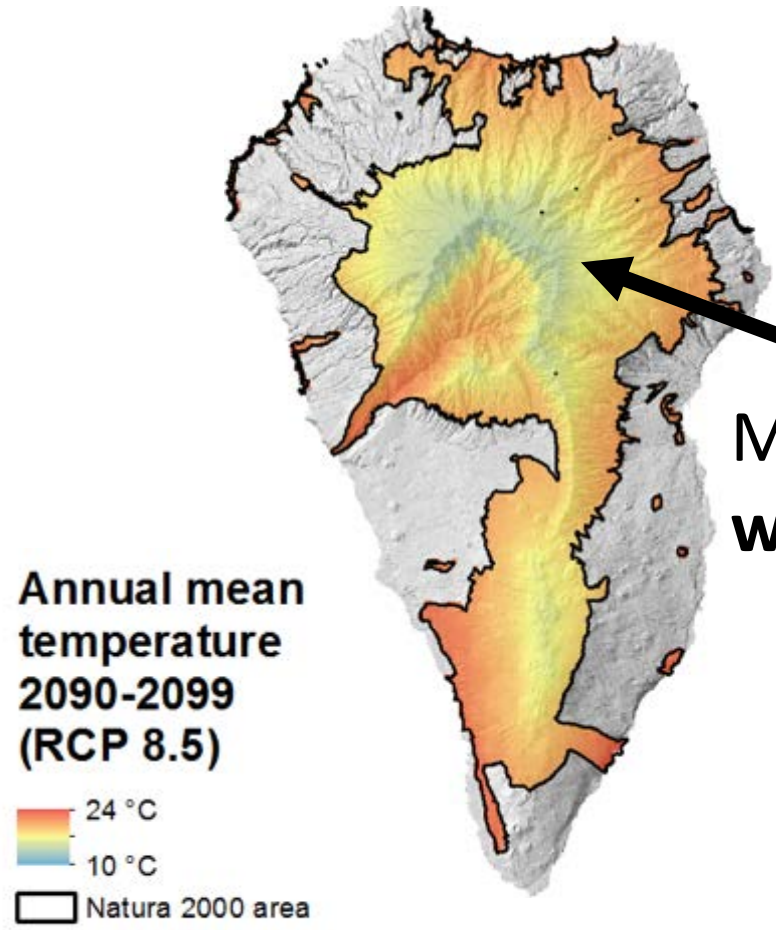




Irl, Schweiger, Medina, Fernández-Palacios, Harter, Jentsch, Provenzale, Steinbauer, Beierkuhnlein (2017) An island view of endemic rarity – environmental drivers and consequences for nature conservation, Diversity and Distributions, **23**(10), 1132-1142.

# *La Palma*

## Regional Climate Model

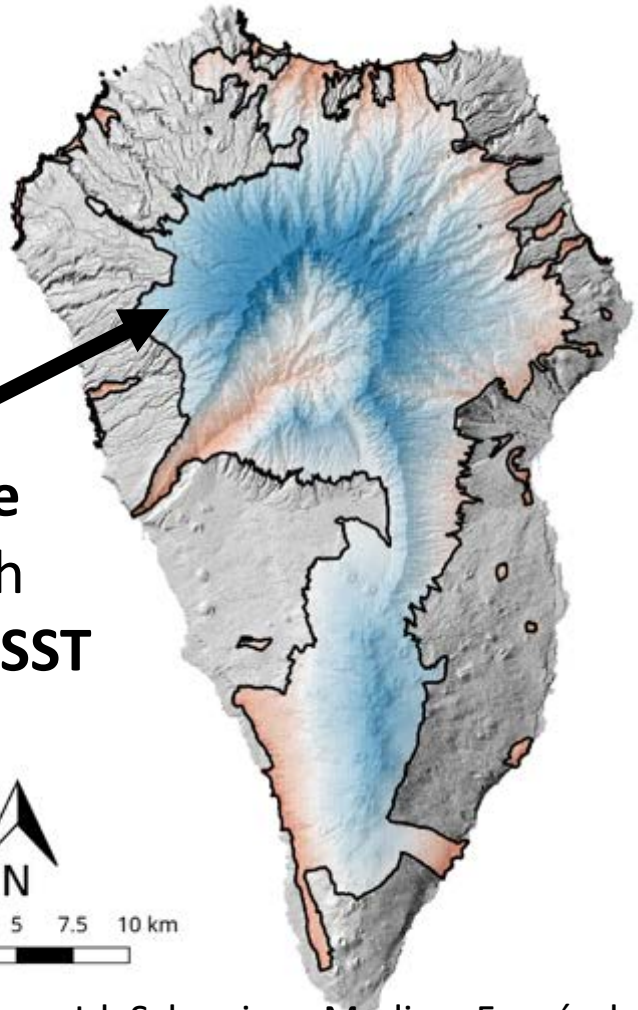



Much **warmer**

Irl, Schweiger, Medina, Fernández-Palacios, Harter, Jentsch, Provenzale, Steinbauer, Beierkuhnlein (2017) An island view of endemic rarity – environmental drivers and consequences for nature conservation, Diversity and Distributions, **23**(10), 1132-1142.

# *La Palma*




Much **more** precip. with **increasing SST**

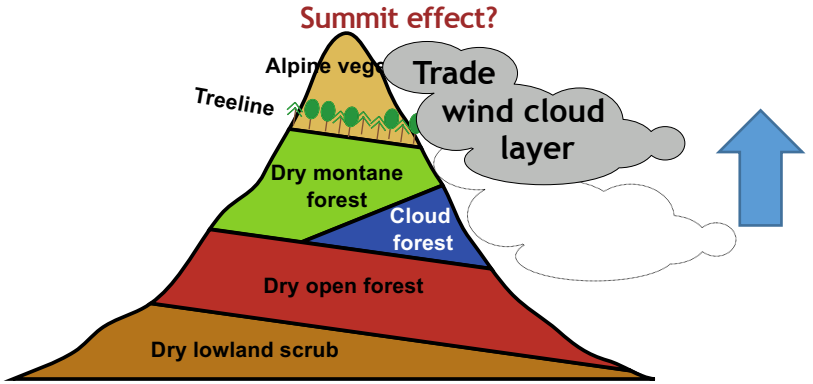
Annual precipitation difference between current climate and 2090-2099 (Ascending trade wind cloud layer)

-200
-100
0.0
100
200
mm

Extent of Natura 2000 areas

***Precipitation Change***

***Higher clouds***




Irl, Schweiger, Medina, Fernández-Palacios, Harter, Jentsch, Provenzale, Steinbauer, Beierkuhnlein (2017) An island view of endemic rarity – environmental drivers and consequences for nature conservation, Diversity and Distributions, **23**(10), 1132-1142.

# *La Palma*

**In a nutshell:**

- **High Mountain Island Ecosystems** are built up by **endemic species!**
- **High Mountain Ecosystems** will be most impacted by **warming and precipitation change!**
- **Unique ecosystems and their services can be lost!**

Irl, Schweiger, Medina, Fernández-Palacios, Harter, Jentsch, Provenzale, Steinbauer, Beierkuhnlein (2017) An island view of endemic rarity – environmental drivers and consequences for nature conservation, Diversity and Distributions, **23**(10), 1132-1142.

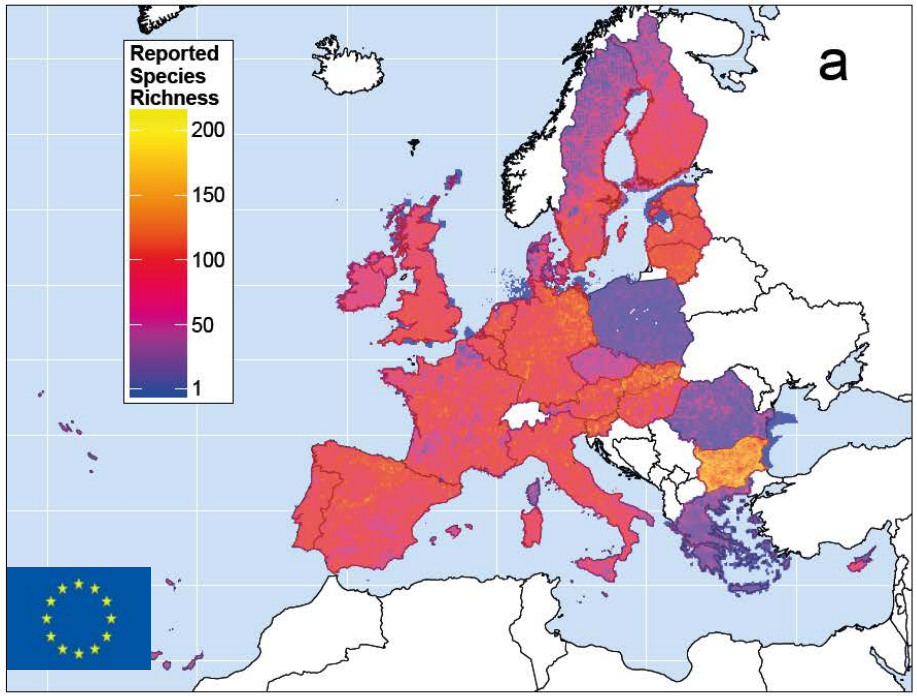
# Uniqueness

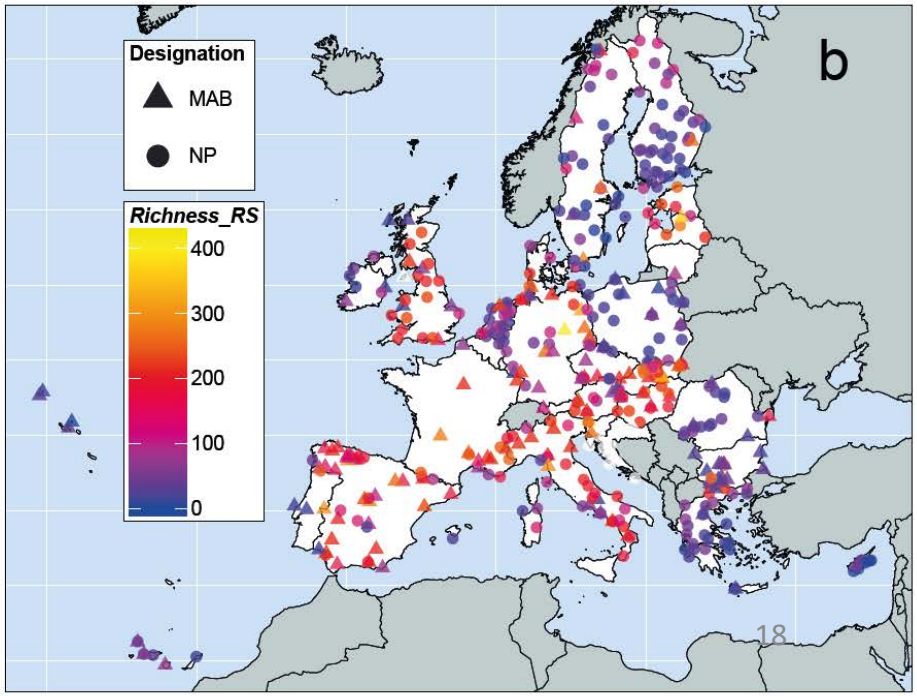
www.nature.com/scientificreports

SCIENTIFIC REPORTS

OPEN

## Uniqueness of Protected Areas

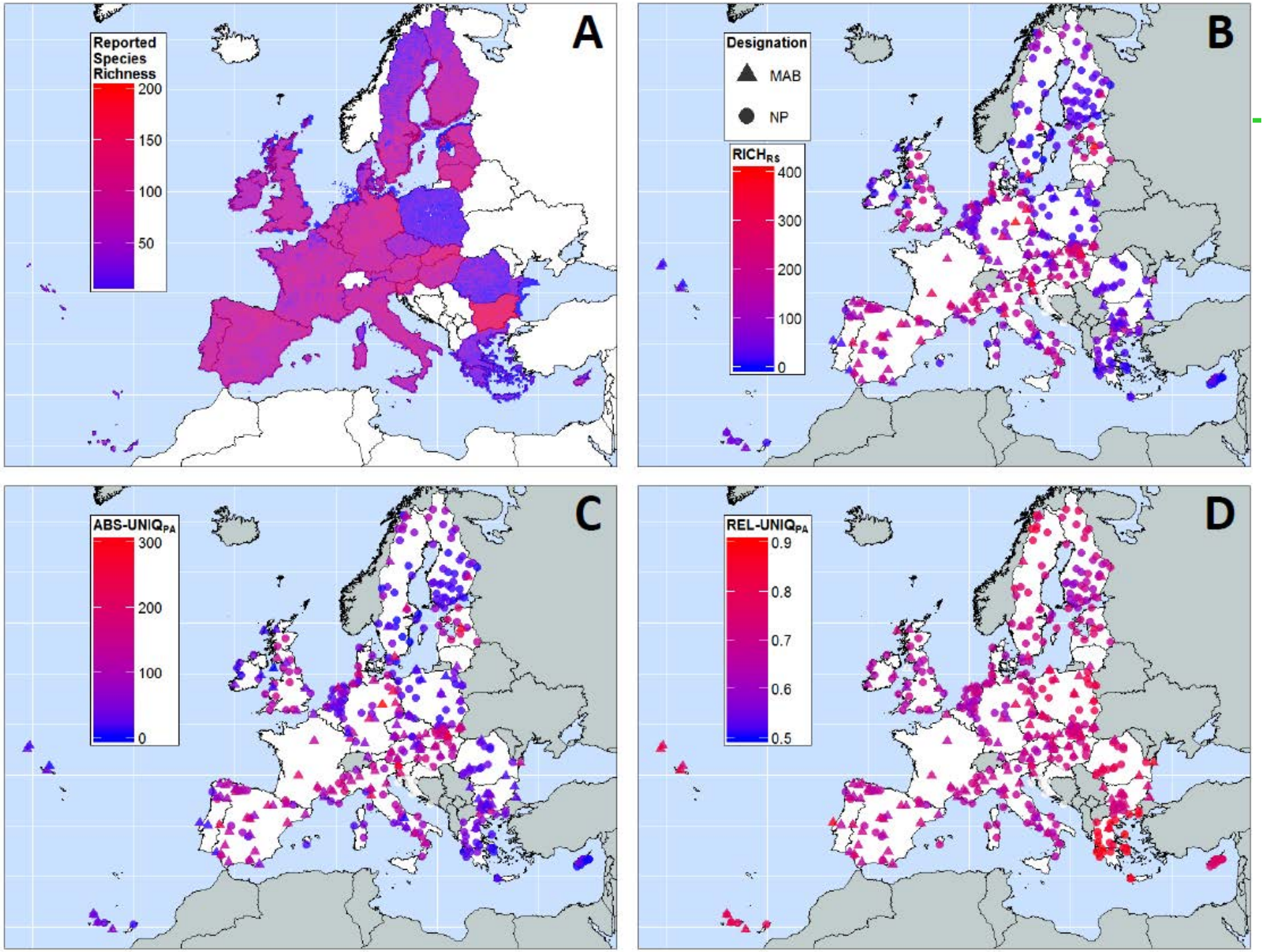


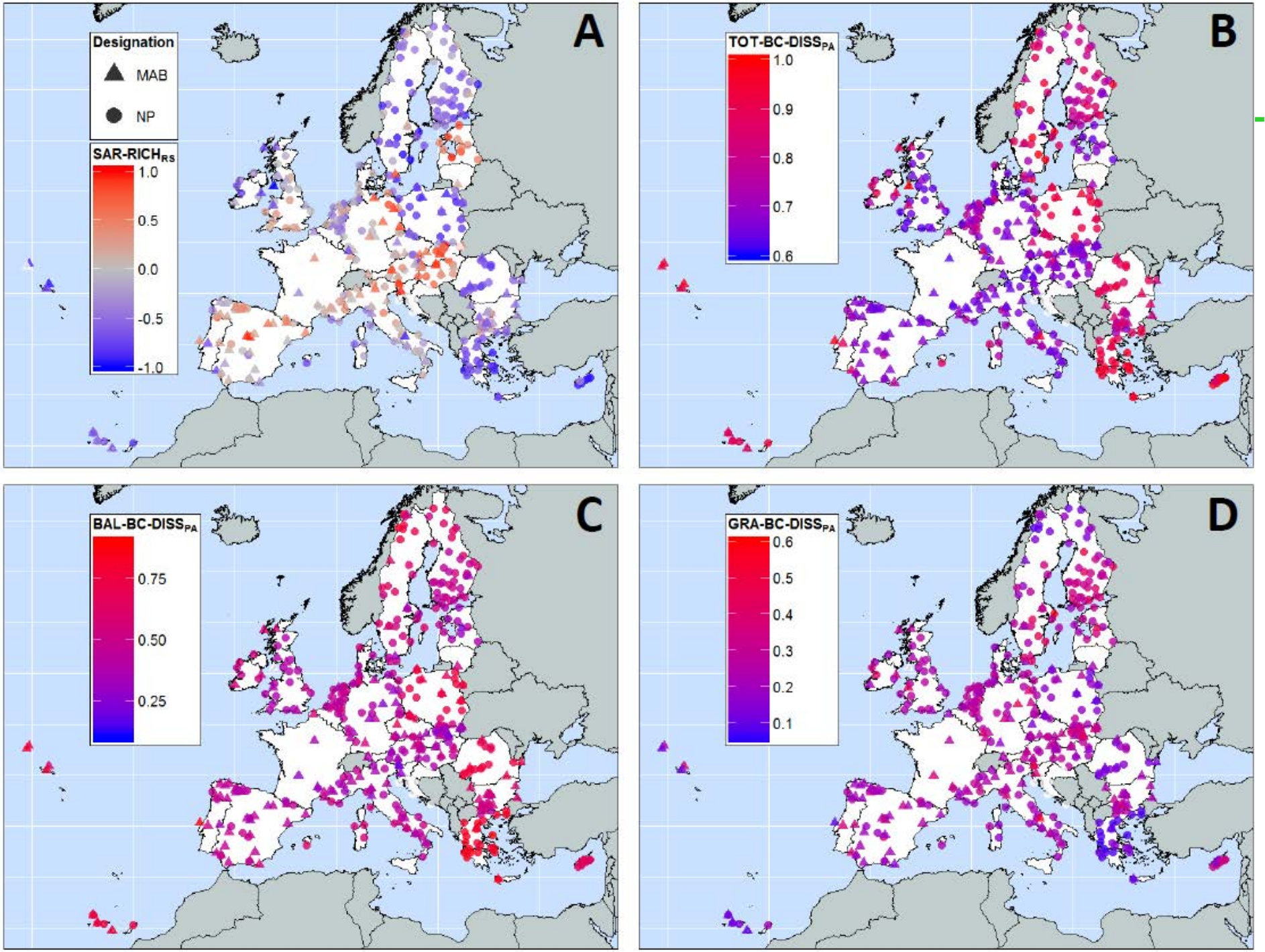



# *Uniqueness*

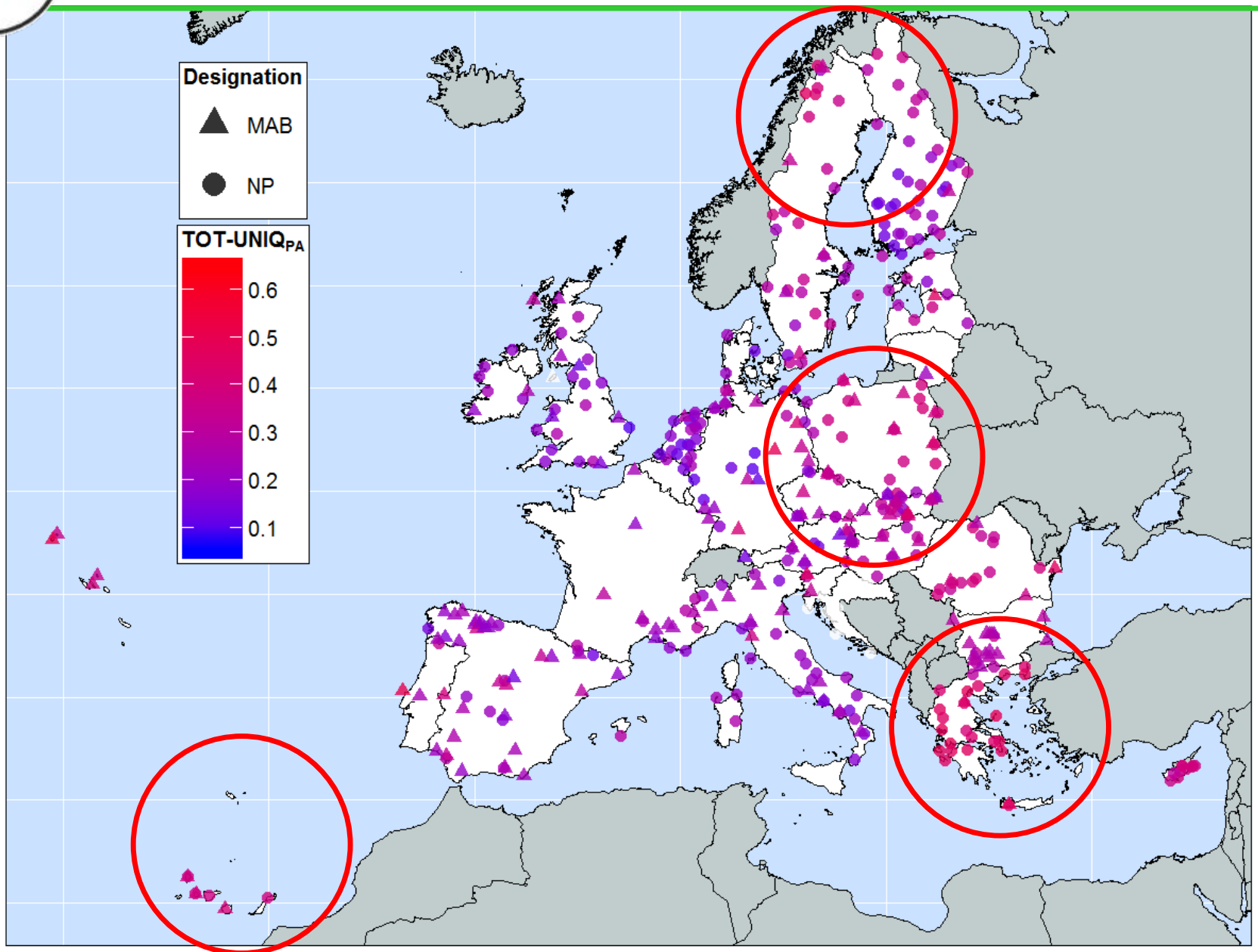
- **Reported Species Richness** per 10 km by 10 km grid cell
- **$RICH_{RS}$** - Reported Species Richness per PA
- **$ABS\text{-}UNIQ_{PA}$** - Absolute Uniqueness (richness and rarity)
- **$REL\text{-}UNIQ_{PA}$** - Relative Uniqueness (rarity)
- **$SAR\text{-}REL\text{-}RICH_{PA}$** - Species richness relative to PA area, i.e. considering Species-PA Area-Relationship
- **$TOT\text{-}BC\text{-}DISS_{PA}$** - Mean pairwiseTotal Bray Curtis dissimilarity of one PA to all other Pas (Baselga 2013)
- **$BAL\text{-}BC\text{-}RICH_{PA}$** - Mean pairwise Balanced Bray Curtis dissimilarity of one PA to all other PAs (i.e. turnover, Baselga 2013)
- **$GRA\text{-}BC\text{-}DISS_{PA}$** - Mean pairwise Gradient Bray Curtis dissimilarity of one PA to all other PAs (i.e. nestedness, Baselga 2013)
- **$TOT\text{-}UNIQ_{PA}$** - Total Uniqueness is sum of scaled $ABS\text{-}UNIQ_{PA}$, $REL\text{-}UNIQ_{PA}$, $SAR\text{-}REL\text{-}RICH_{PA}$, and $TOT\text{-}BC\text{-}DISS_{PA}$)

Hoffmann, Beierkuhnlein, Field, Provenzale, Chiarucci (2018) Uniqueness of protected areas for conservation strategies in the European Union. Scientific Reports **8**(6445), 1-14


A
Reported Species Richness
200
150
100
50
B
Designation
MAB
NP
RICH$_{RS}$
400
300
200
100
0
C
ABS-UNIQ$_{PA}$
300
200
100
0
D
REL-UNIQ$_{PA}$
0.9
0.8
0.7
0.6
0.5


A
Designation
MAB
NP
SAR-RICH$_{RS}$
1.0
0.5
0.0
-0.5
-1.0
B
TOT-BC-DISS$_{PA}$
1.0
0.9
0.8
0.7
0.6
C
BAL-BC-DISS$_{PA}$
0.75
0.50
0.25
D
GRA-BC-DISS$_{PA}$
0.6
0.5
0.4
0.3
0.2
0.1

# Uniqueness



# *Uniqueness*

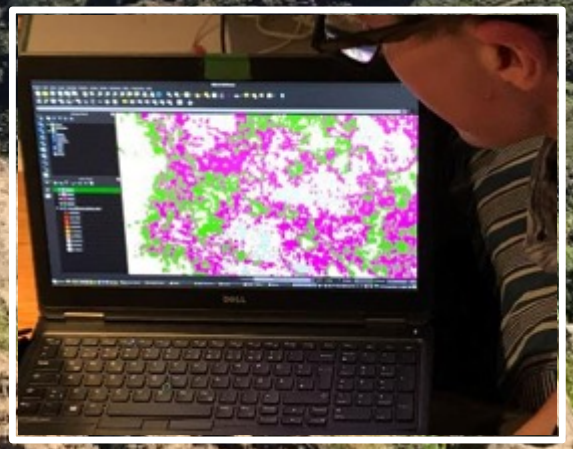
**In a nutshell:**

- **Uniqueness in European** National Parks and Biosphere Reserves that is based on **reported species (Habitats Directive, EEA)** is not correlated with species richness but with **particular ecosystems and landscapes**.

Hoffmann, Beierkuhnlein, Field, Provenzale, Chiarucci (2018) Uniqueness of protected areas for conservation strategies in the European Union. Scientific Reports **8**(6445), 1-14

# *La Palma*

Capacity Building and forming a community of practice



# La Palma

Biodivers Conserv (2014) 23:2273–2287
DOI 10.1007/s10531-014-0722-6

ORIGINAL PAPER

## The Hitchhiker's guide to island endemism: biodiversity and endemic perennial plant species in roadside and surrounding vegetation

Severin D. H. Irl · Manuel J. Steinbauer · Lilith Epperlein · David E. V. Harter · Anke Jentsch · Susanne Pätz · Christian Wohlfart · Carl Beierkuhnlein

Received: 16 August 2013 / Revised: 13 April 2014 / Accepted: 6 May 2014 /
Published online: 28 June 2014


*Diversity* **2012**, *4*, 59-73; doi:10.3390/d4010059

OPEN ACCESS

*diversity*
ISSN 1424-2818
www.mdpi.com/journal/diversity

*Article*

## Mosses Like It Rough—Growth Form Specific Responses of Mosses, Herbaceous and Woody Plants to Micro-Relief Heterogeneity

**Benjamin F. Leutner [1,2], Manuel J. Steinbauer [1,*], Carina M. Müller [1], Andrea J. Früh [1], Severin Irl [1,3], Anke Jentsch [3] and Carl Beierkuhnlein [1]**

[1] Biogeography, BayCEER, Univ... Bayreuth 95440, Germany;
E-Mail: b.leutner@... M.Mueller@web.de (C.M.M.);
frueh.and... (A.J.F.); severin.irl@uni-bayreuth.de (S.I.);
...@uni-bayreuth.de (C.B.)
...plical Modelling, BayCEER, University of Bayreuth, Bayreuth 95440, Germany
...Disturbance Ecology, BayCEER, University of Bayreuth, Bayreuth 95440, Germany;

**BASED ON STUDENT PROJECTS FROM LA PALMA SCIENCE SCHOOL**

*Arctic, Antarctic, and Alpine Research*, Vol. 46, No. 4, 2014, pp. 1–11

## Burned and devo... introduced herbivore... and the ende... flora of the high-elevation ecosystem on La Palma, Ca... Islands

*Severin D. H. Irl*@*
*Manuel J. Steinbauer†*
*Jana Messinger†‡*
*Gesche Blume-Werry†§*
*Ángel Palomares-Martínez#*
*Carl Beierkuhnlein† and*
*Anke Jentsch**

*Department of Disturbance Ecology, BayCEER, University of Bayreuth, Universitätsstraße 30, D-95447 Bayreuth, Germany
†Department of Biogeography, BayCEER, University of Bayreuth, Universitätsstraße 30, D-95447 Bayreuth, Germany
‡Ecological-Botanical Garden, University of Bayreuth, Universitätsstraße 30, D-95447

**Abstract**

...disturbance regimes (e.g., introduced herbivores and fire) are among the major drivers of degradation in island ecosystems. High elevation ecosystems (HEEs) on islands might be especially vulnerable to these disturbances due to high endemism. Here, data from an 11-year exclosure experiment in the HEE of La Palma (Canary Islands) are presented where mammalian herbivores have been introduced. We investigate the combined effect of herbivory and fire on total species richness, seedling richness, and seedling establishment on the whole system and a subset of highly endangered species (target species). Total species richness, seedling species richness, and seedling establishment decreased with herbivory. Five out of eight target species were exclusively found inside the exclosures indicating the negative impact of introduced herbivores on endemic high elevation flora. Target species were generally affected more negatively by introduced herbivores and were subject to significantly higher browsing pressure, probably owing to their lack of defense strategies. A natural wildfire that occurred six years before data sampling substantially increased total species richness and seedling richness in both herbivory exclosure and reference conditions. We conclude that species composition of the HEE has been severely altered by the introduction of non-native herbivores, even though fire seems to

Journal of Vegetation Science
...plant community ecology

Original Article

## An 11-yr exclosure experiment in a high-elevation island ecosystem: introduced herbivore impact on shrub species richness, seedling recruitment and population dynamics

Severin David Howard Irl[1,2,*], Manuel Jonas Steinbauer[2], Wolfgang Babel[3], Carl Beierkuhnlein[2], Gesche Blume-Werry[2], Jana Messinger[2], Ángel Palomares Martínez[4], Stefan Strohmeier[5] and Anke Jentsch[1]

Article first published online: 17 MAY 2012
DOI: 10.1111/j.1654-1103.2012.01425.x


Issue

Journal of Vegetation Science
Volume 23, Issue 6, pages 1114–1125, December 2012


Thanks