École d'Été Interdisciplinaire – 3-6 juin 2019

European Research Council

CLIMATE CHANGE AND BIODIVERSITY
CURRENT TRENDS AND SCENARIOS

Wilfried THUILLER

Evolution, Modeling and Analysis of BIOdiversity [EMABIO]

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Communauté UNIVERSITÉ Grenoble Alpes

cnrs LECA Laboratoire d'Ecologie Alpine


Has the Earth's sixth mass extinction already arrived?
Anthony D. Barnosky[1,2,3], Nicholas Matzke[1], Susumu Tomiya[1,2,3], Guinevere O. U. Wogan[1,3], Brian Swartz[1,2], Tiago B. Quental[1,2†], Charles Marshall[1,2], Jenny L. McGuire[1,2,3†], Emily L. Lindsey[1,2], Kaitlin C. Maguire[1,2], Ben Mersey[1,4] & Elizabeth A. Ferrer[1,2]
CLIMATE CHANGE MY BUTT! LOOK AT THIS SNOW!
CUT!
AGAIN FROM THE TOP..BUT WITH MORE... ...HUBRIS...
Global Land-Ocean Temperature Index
Base period 1951-1980
Time series plot of annual anomalies smoothed with a 5-year running mean from 1/1880 to 1/2014
Global Surface temperature anomaly (°C)
Source: NASA GISS

C'EST QUOI LA BIODIVERSITÉ ???

Les différents niveaux de la biodiversité

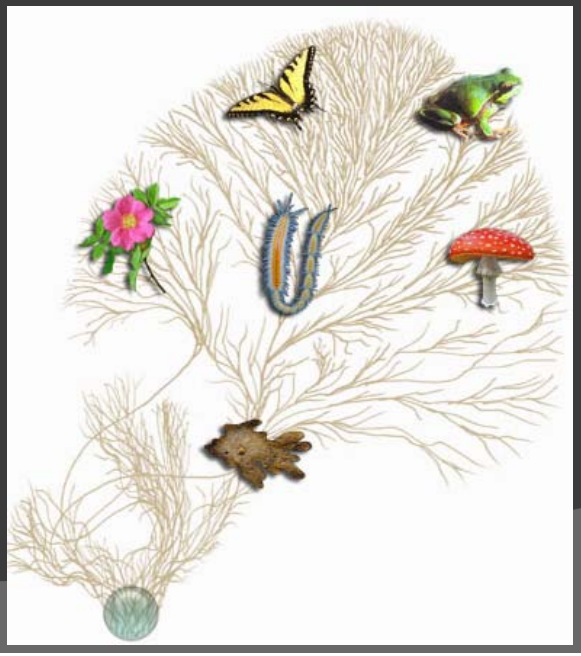
- **Le niveau des écosystèmes:** forêts, pelouses, rochers, zones humides, rochers, éboulis, etc.

• **Le niveau des espèces:** environ 3500 espèces végétale dans l'arc alpin, 2500 dans les Hautes-Alpes, 1500 autour du Lautaret, 680 à plus de 2500 m

- **Le niveau génétique:** entre populations, entre individus d'une même espèce

Les différents niveaux de la biodiversité

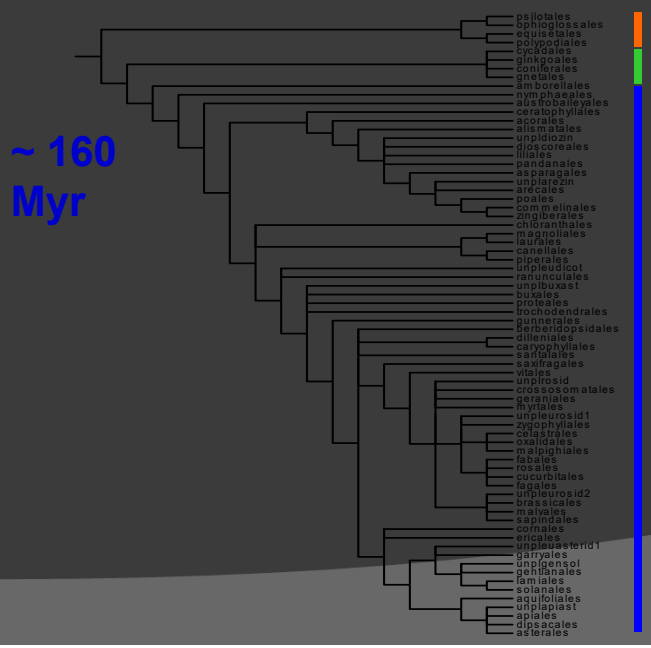
- **Le niveau phylogénétique:** les différentes familles et genres, leur position évolutive



Les différents niveaux de la biodiversité

- **Le niveau phylogénétique:** les différentes familles et genres, leur position évolutive





Ptéridophytes

Gymnosperme s


Angiospermes

Les différents niveaux de la biodiversité

- **Le niveau phylogénétique:** les différentes familles et genres, leur position évolutive

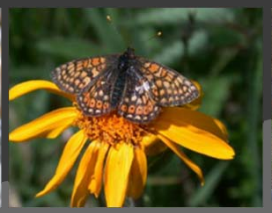





- **Le niveau fonctionnel:** les différents types biologiques (arbres, arbustes, herbes, plantes en coussins, à bulbes, annuelles, etc.), plantes fixatrices d'azote atmosphérique, carnivores, herbivores, détritivores…








Les fonctions/services de la biodiversité

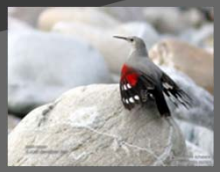
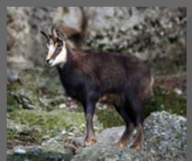
- Importance écologique/économique:
  - fertilité des sols, pollinisation, contrôle des ravageurs



- Rôle d'approvisionnement:
  - qualité de l'air, de l'eau, molécules utiles (médicaments)

- Rôle de régulation:
  - climat, puits de carbone, cycles de la matière, inondations


- Rôle culturel, esthétique, récréatif

Home > IPBES-7

7th Session of the Plenary of the Intergovernmental Platform for Biodiversity and Ecosystem Services

28 April and 29 April - 4 May 2019 | Headquarters of the UN Educational, Scientific and Cultural Organization (UNESCO), Paris, France

About | 28 Apr | 29 Apr | 30 Apr | 1 May | 2 May | 3 May | 4 May | 6 May | Summary

Daily Report | EN (HTML | PDF)

Highlights for Monday, 29 April 2019

IPBES-7 opens at UNESCO Headquarters in Paris with a dance performance by a youth group of the "Les Arts en Scèn
Montpellier titled "Steps for a Change"

IISD / SDG KNOWLEDGE HUB
A project by IISD

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STEFAN JUNGCURT PH.D.
Content Editor for Agriculture, Climate Change Mitigation and Sustainable Energy (Germany)

7 May 2019

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IPBES Global Assessment Finds We Must Act Now to Save Our Life Support System

LIGHTS

- Nature is in decline because of human activity.
- This decline is severely damaging the natural support systems of human life.
- Current trajectories of biodiversity loss will lead to severe consequences for human life and undermine efforts to achieve the SDGs.
- Immediate action to transform the relationship between humans and nature can avert the most severe consequences and put humanity back on track towards conserving nature while achieving other societal goals.

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6 MAY 2019

IPBES Global Assessment Report warns of 'unprecedented' decline in nature and species, calls for 'transformative changes'

Hawksbill Turtles floats underwater, Indian Ocean coral reef, Maldives. Photo credit: Andrey Armyagov/Shutterstock.com

IPBES - Global Assessment

- What is the status of and trends in nature and in indirect and direct drivers of change?
- How does nature contribute to the achievement of Global Goals?
- What are the plausible futures for nature and for a good quality of life between now and 2050?
- What pathways and policy intervention scenarios can lead to sustainable futures?
- What are the opportunities and challenges, as well as options available to decision makers relating to nature and its contributions to good quality of life?

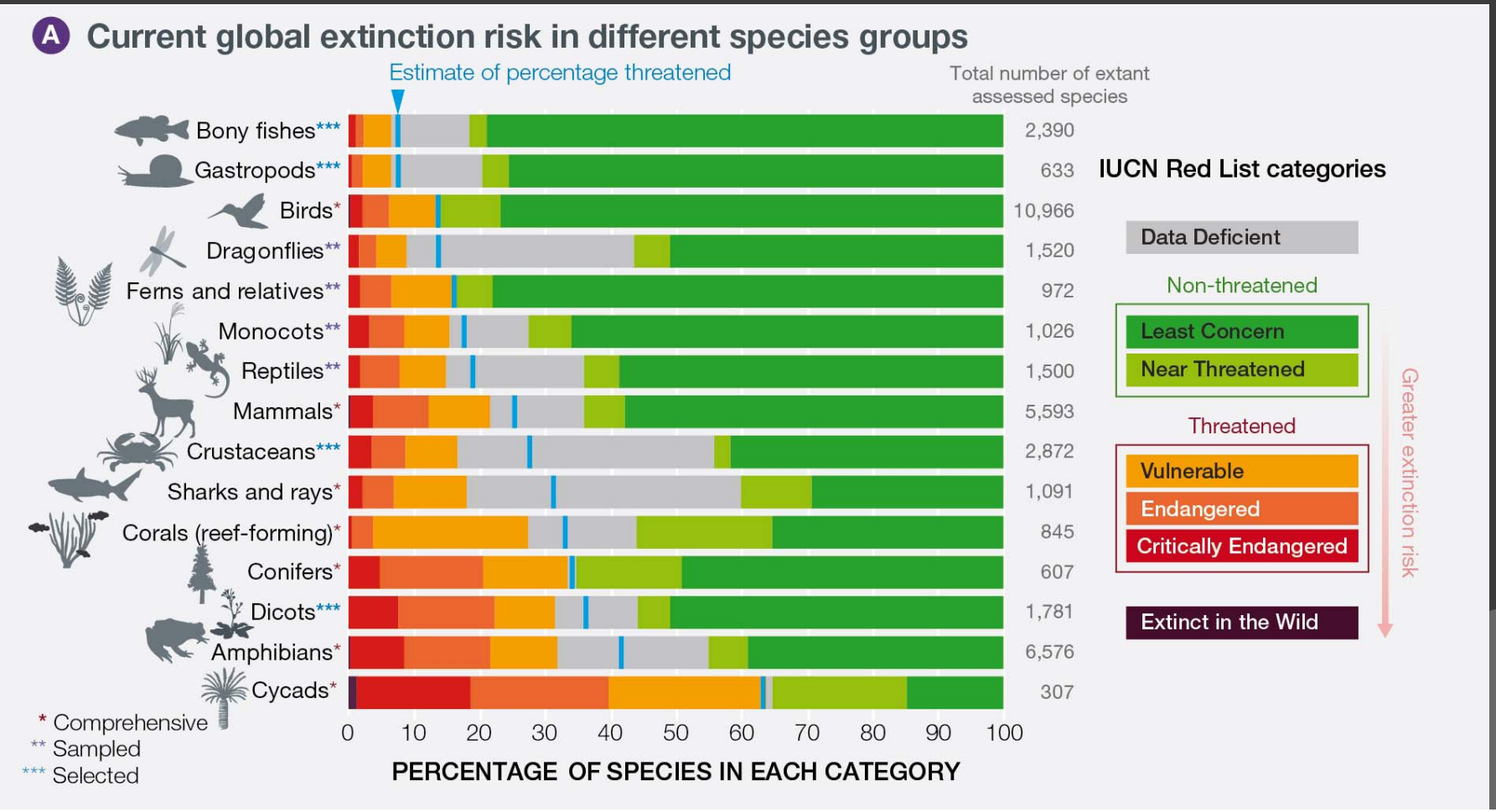
Life on Earth is deteriorating fast worldwide.

Virtually all indicators of the global state of nature are decreasing:

biomes, ecosystems, species, varieties and breeds

Bob Watson @ IPBES

More species of plants and animals are threatened with extinction now than at any other time in human history



Bob Watson @ IPBES

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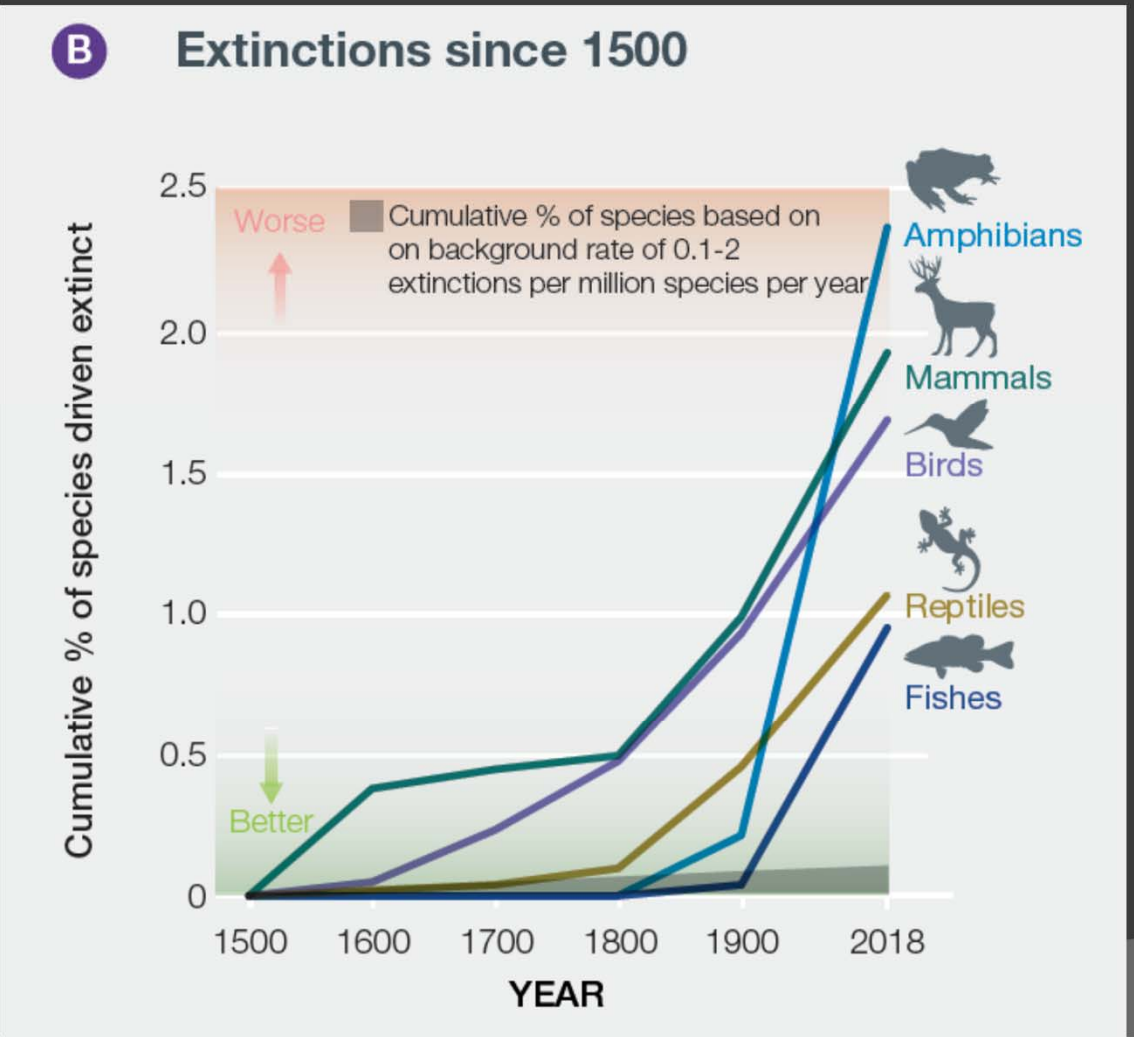
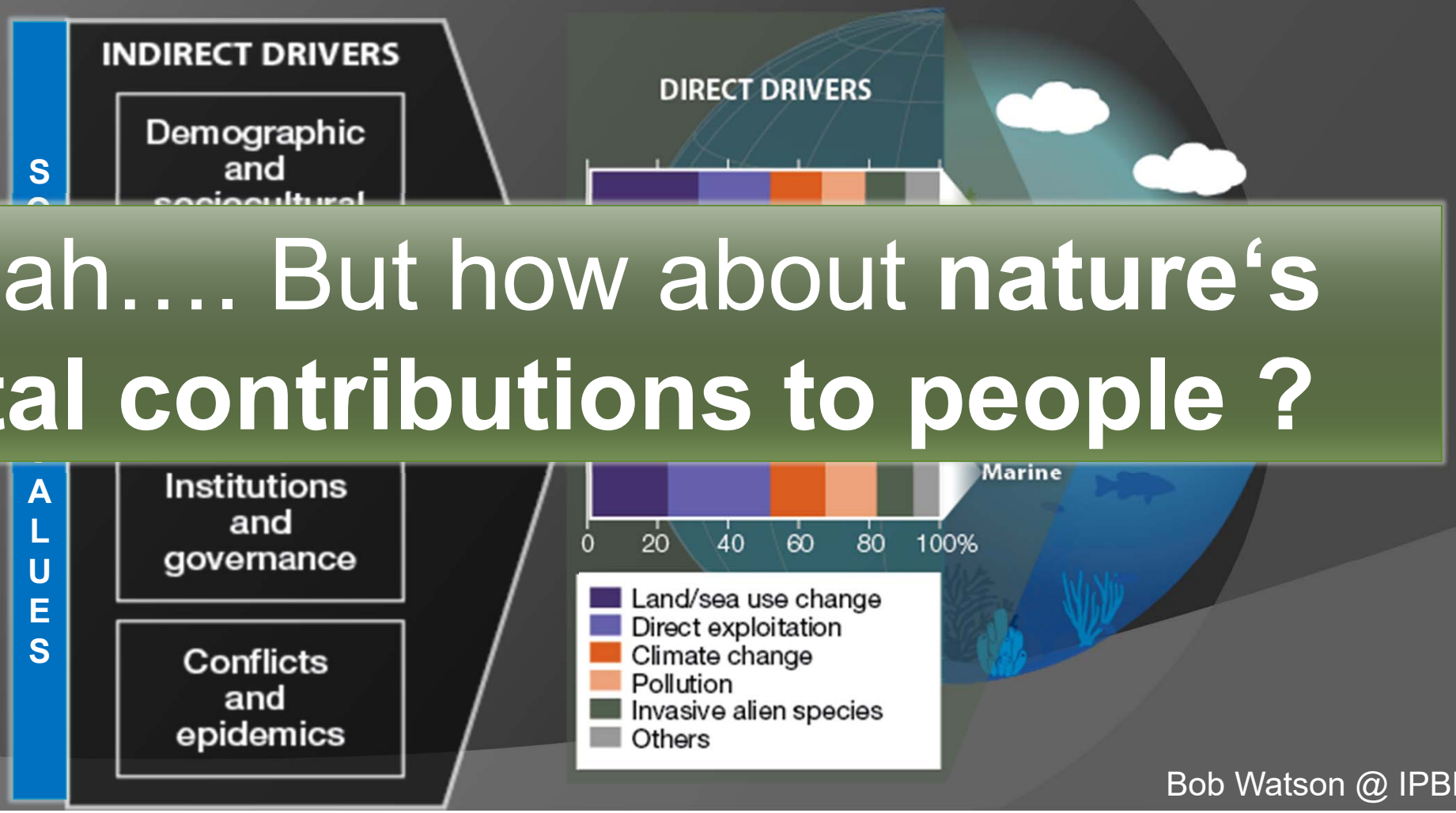


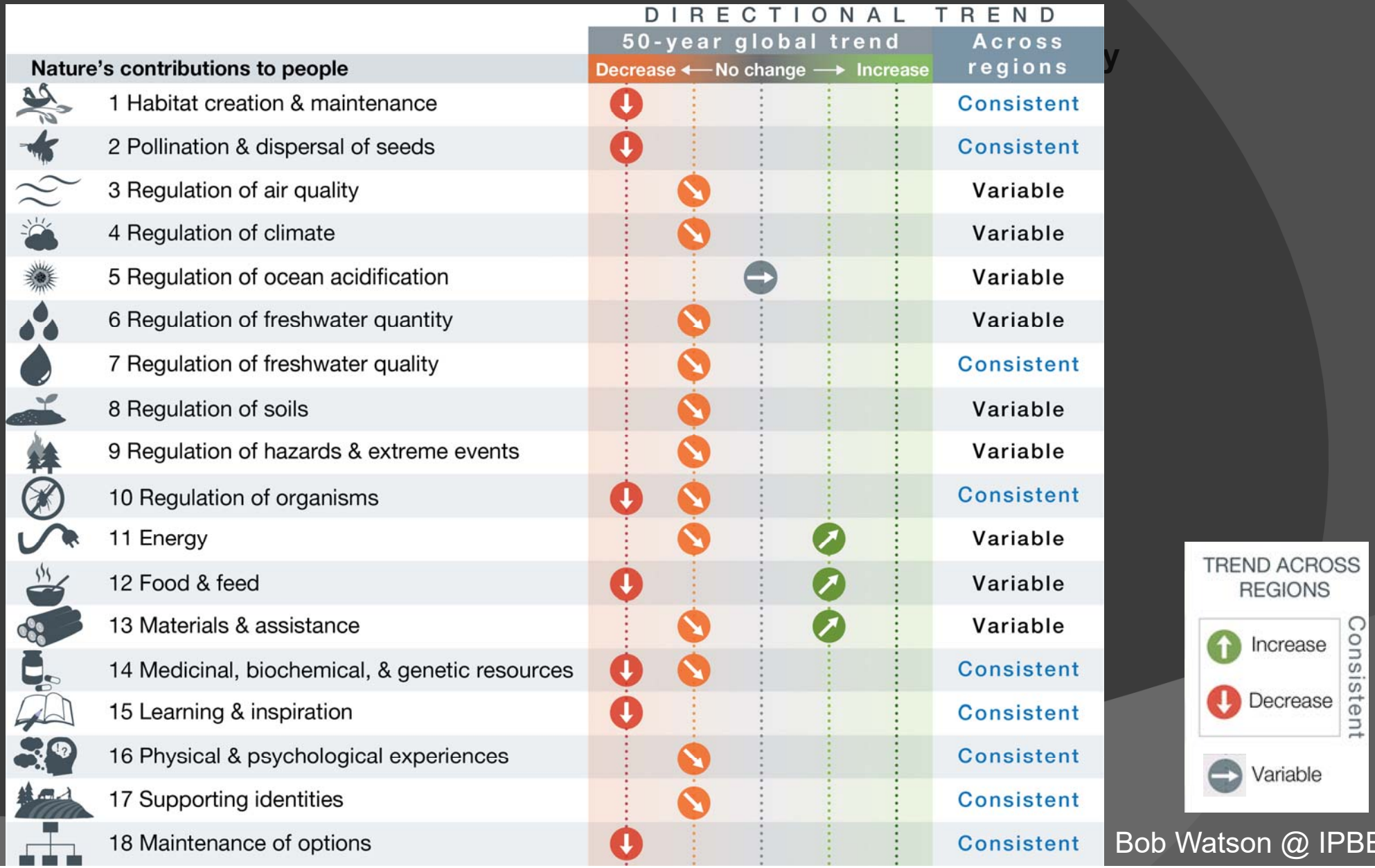
Bob Watson @ IPBES

Underpinning the proximate causes of deterioration in nature are the root causes, or indirect drivers of change.



Yeah…. But how about **nature's vital contributions to people ?**

Bob Watson @ IPBES



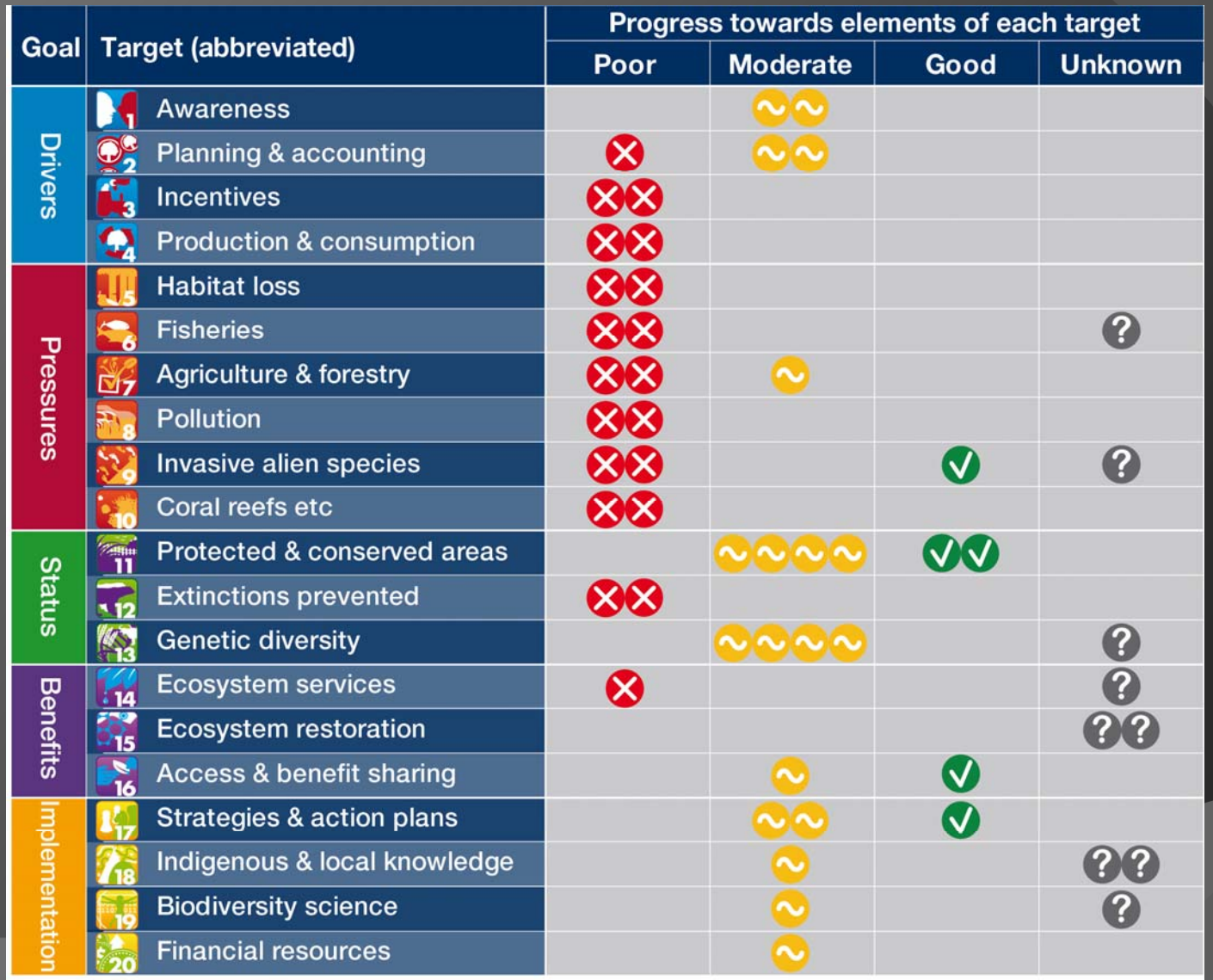
Bob Watson @ IPBES

Aichi Biodiversity Targets

Sustainable Development Goals

Bob Watson @ IPBES

Progress towards the Aichi Biodiversity Targets



Goal	Target (abbreviated)	Progress towards elements of each target			
		Poor	Moderate	Good	Unknown
Drivers	1 Awareness		~ ~		
	2 Planning & accounting	✗	~ ~		
	3 Incentives	✗ ✗			
	4 Production & consumption	✗ ✗			
Pressures	5 Habitat loss	✗ ✗			
	6 Fisheries	✗ ✗			?
	7 Agriculture & forestry	✗ ✗	~		
	8 Pollution	✗ ✗			
	9 Invasive alien species	✗ ✗		✓	?
	10 Coral reefs etc	✗ ✗			
Status	11 Protected & conserved areas		~ ~ ~ ~	✓ ✓	
	12 Extinctions prevented	✗ ✗			
	13 Genetic diversity		~ ~ ~ ~		?
Benefits	14 Ecosystem services	✗			?
	15 Ecosystem restoration				? ?
	16 Access & benefit sharing		~	✓	
Implementation	17 Strategies & action plans		~ ~	✓	
	18 Indigenous & local knowledge		~		? ?
	19 Biodiversity science		~		?
	20 Financial resources		~		

Bob Watson @ IPBES

Progress towards the UN Sustainable Development Goals

Selected Sustainable Development Goals	Recent status and trends in aspects of nature and nature's contributions to people that support progress towards target *			Uncertain relationship
	Poor/Declining support	Partial support	Unknown	
1 NO POVERTY — No poverty	↓ ↓			U U
2 ZERO HUNGER — Zero hunger	↓	→ → →		
3 GOOD HEALTH AND WELL-BEIN — Good health and well-being			? ?	U U
6 CLEAN WATER AND SANITATIO — Clean water and sanitation	↓ ↓ ↓	→		
11 SUSTAINABLE C AND COMMUNIT — Sustainable cities and communities	↓ ↓ ↓ ↓	→		
13 CLIMATE ACTION — Climate action	↓	→	? ? ?	
14 LIFE BELOW WATER — Life below water	↓ ↓ ↓ ↓	→ → →		
15 LIFE ON LAND — Life on land	↓ ↓ ↓ ↓ ↓ ↓	→ → → → →		

* There were no targets that were scored as good/positive status and trends

Bob Watson @ IPBES

How well protected is global biodiversity?

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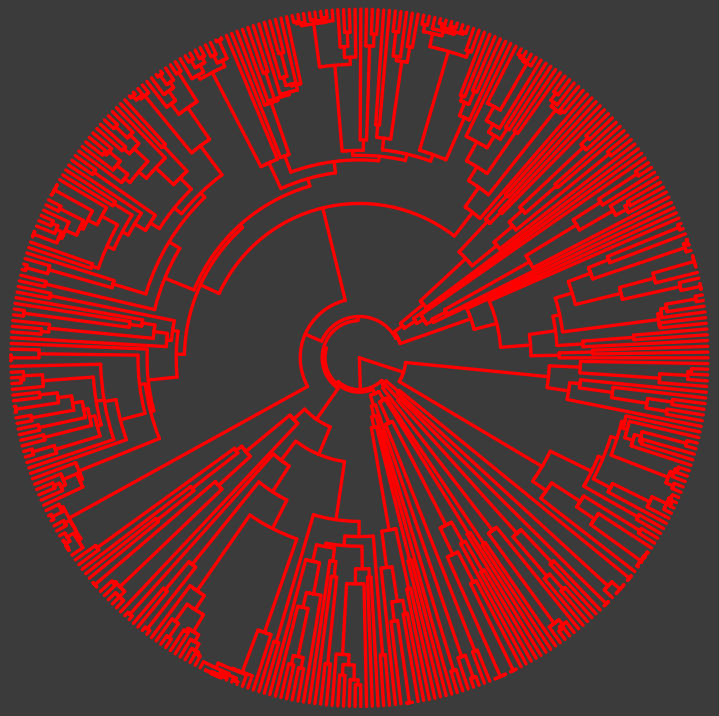
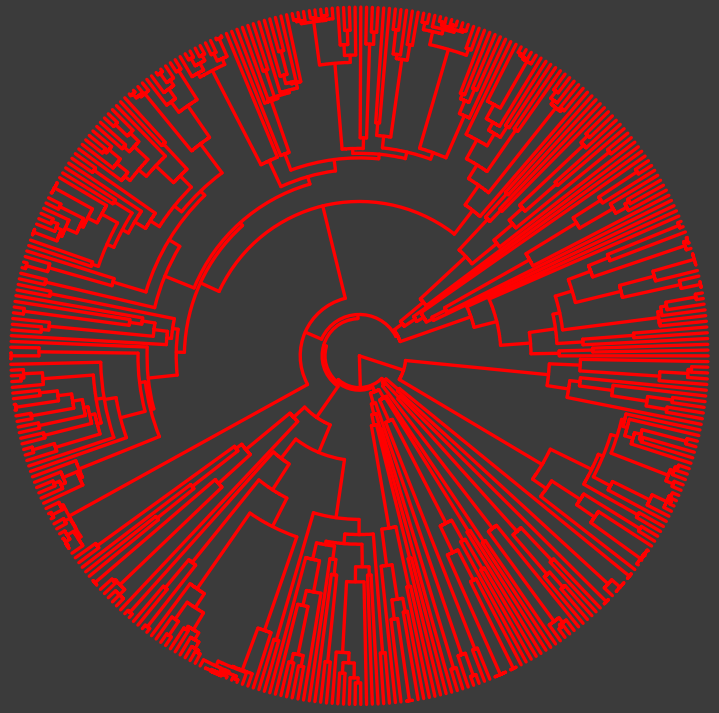
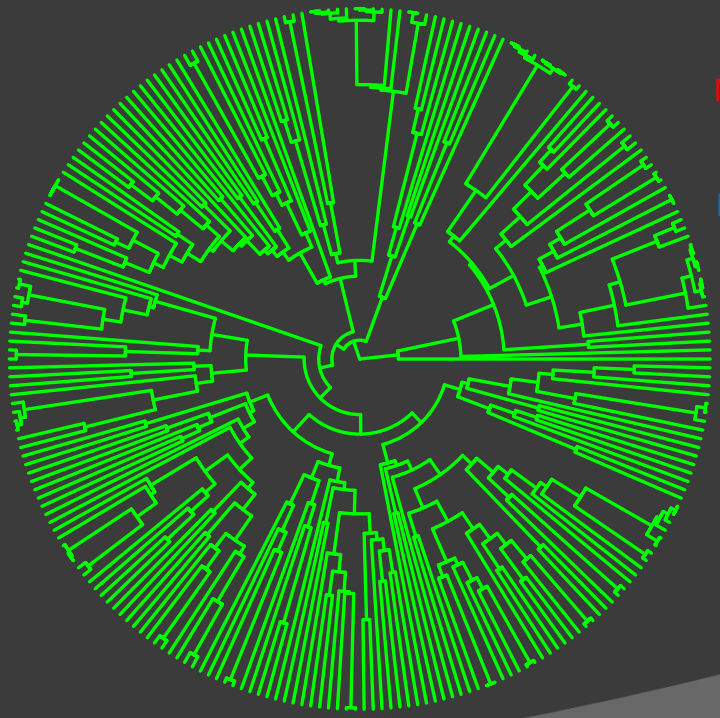


Tree of life

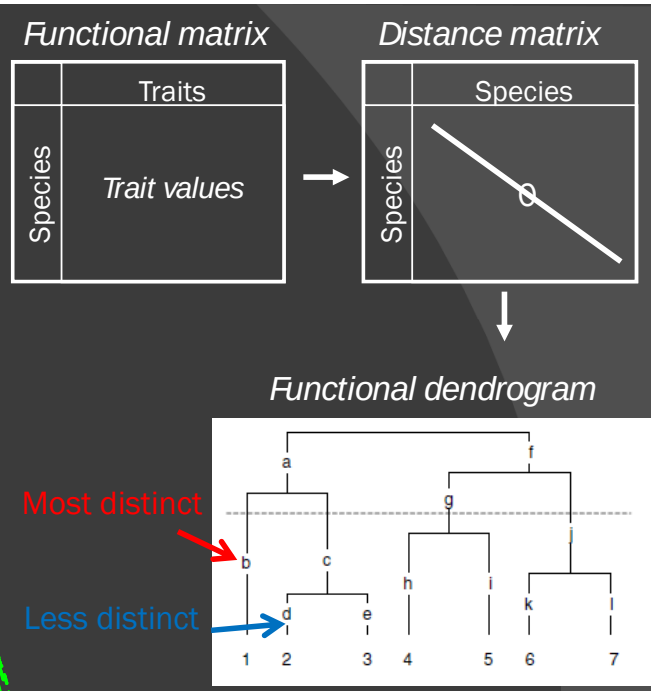
How well protected is global biodiversity?



Tree of life

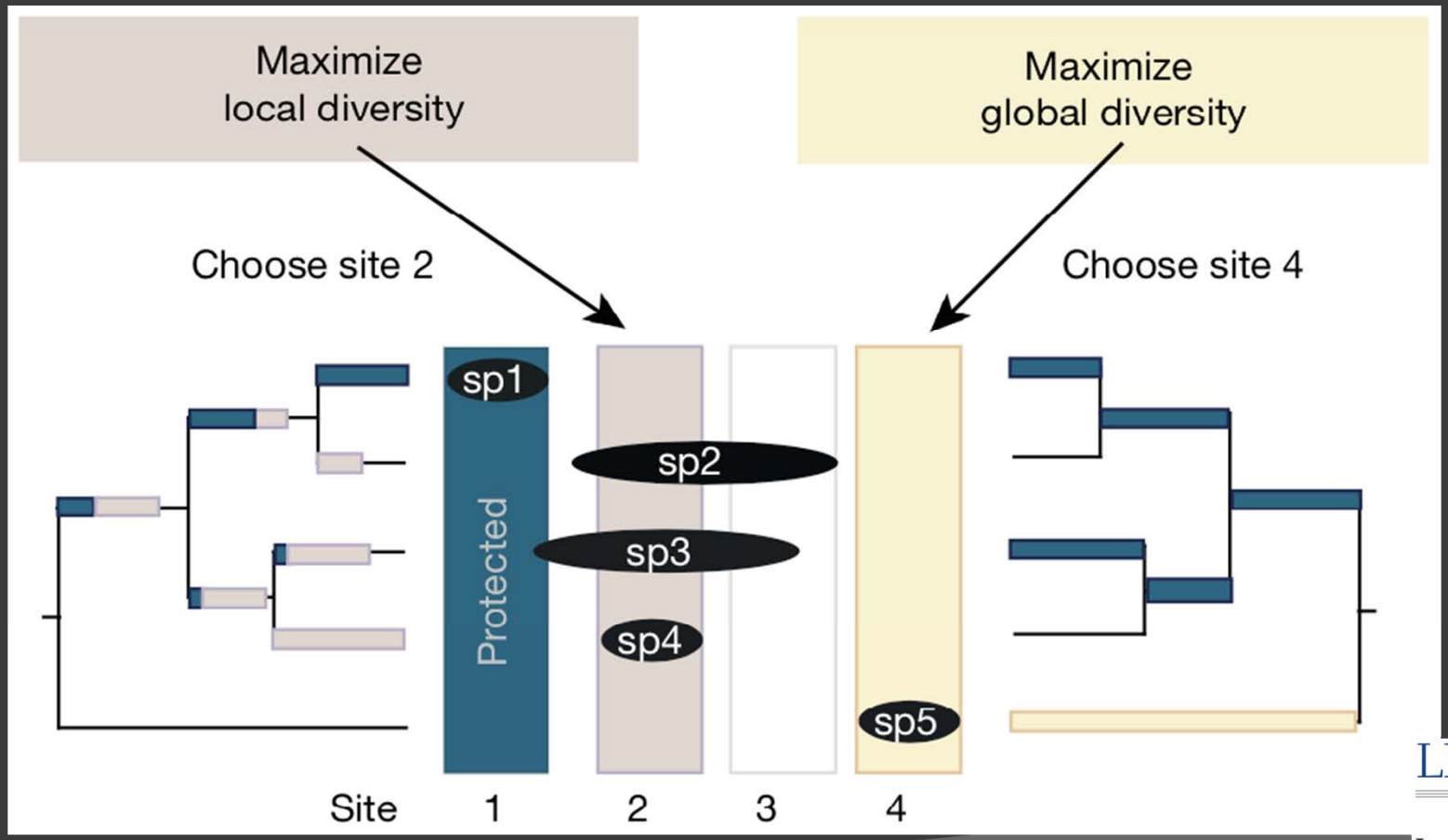


Functional tree of life



How well protected is global biodiversity?

How conservation objectives influence priorities for the phylogenetic or functional trees of life?



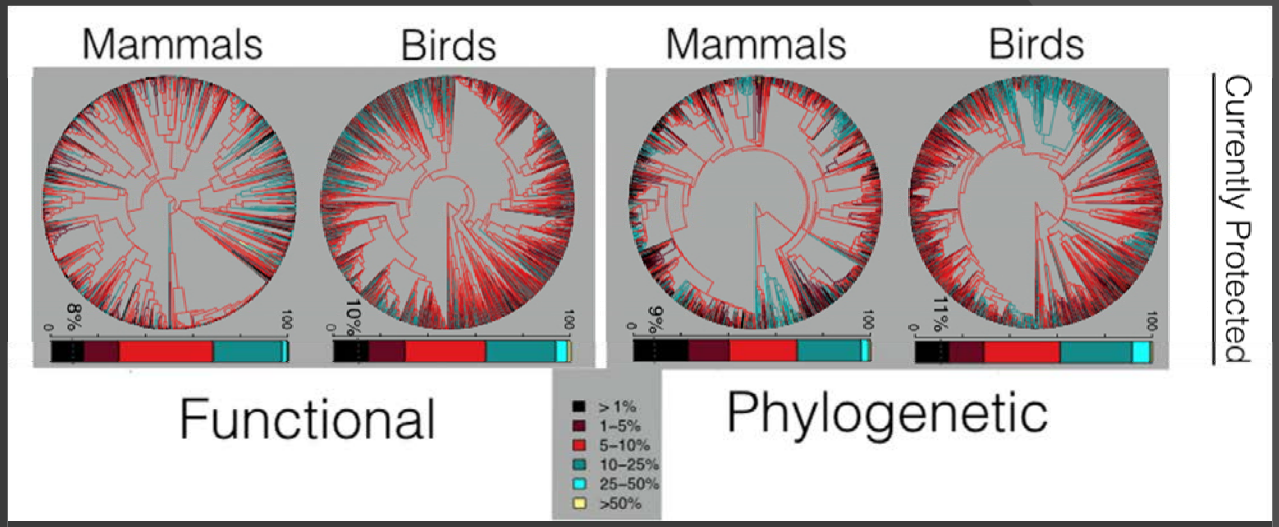
LETTER

doi:10.1038/nature22368

Large conservation gains possible for global biodiversity facets

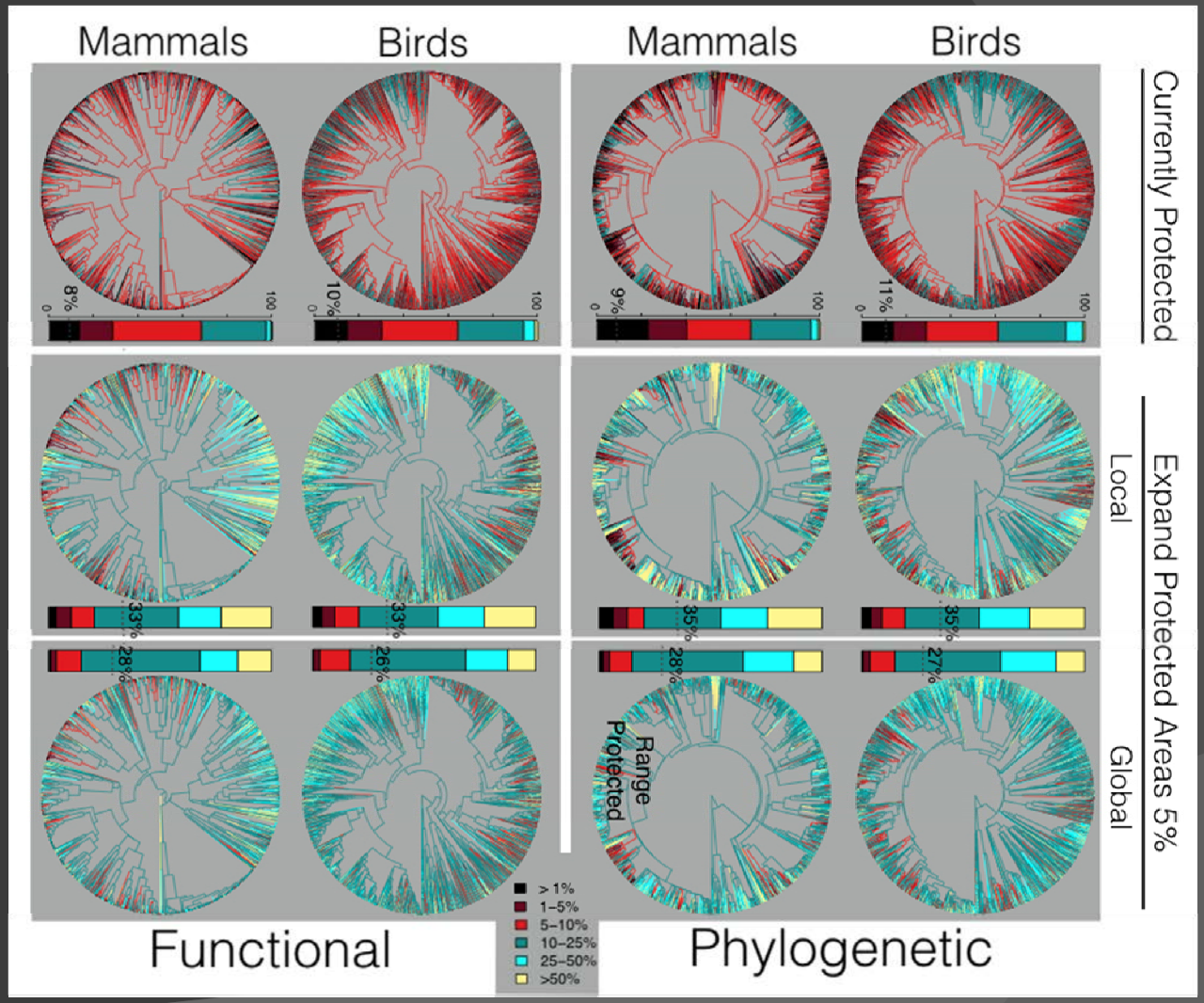
Laura J. Pollock[1], Wilfried Thuiller[1] & Walter Jetz[2,3]

How well protected is global biodiversity?

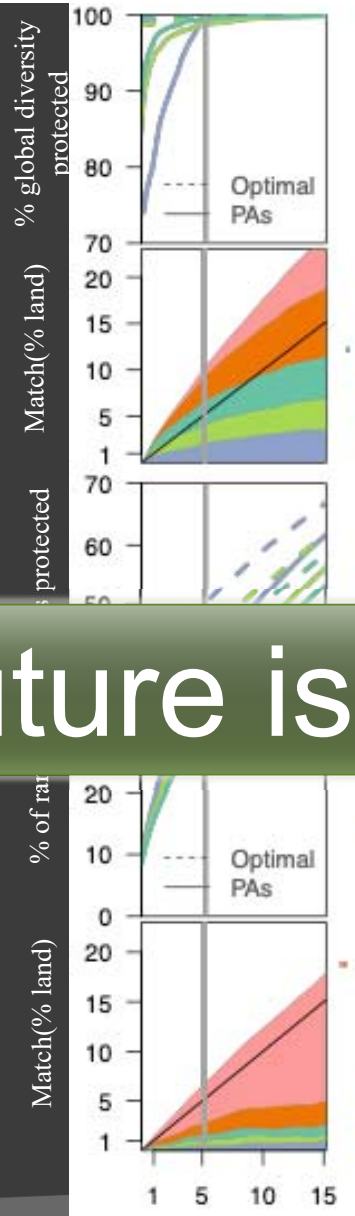


How well protected is global biodiversity?

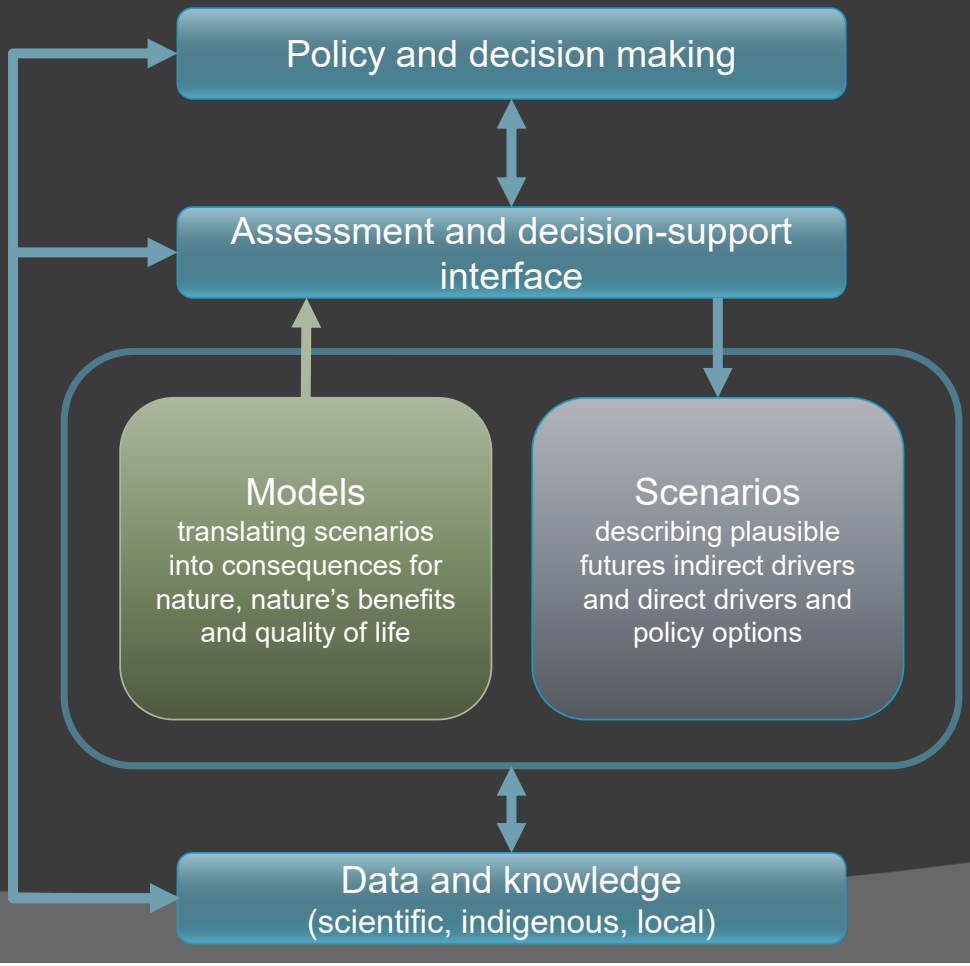
A 5% increase

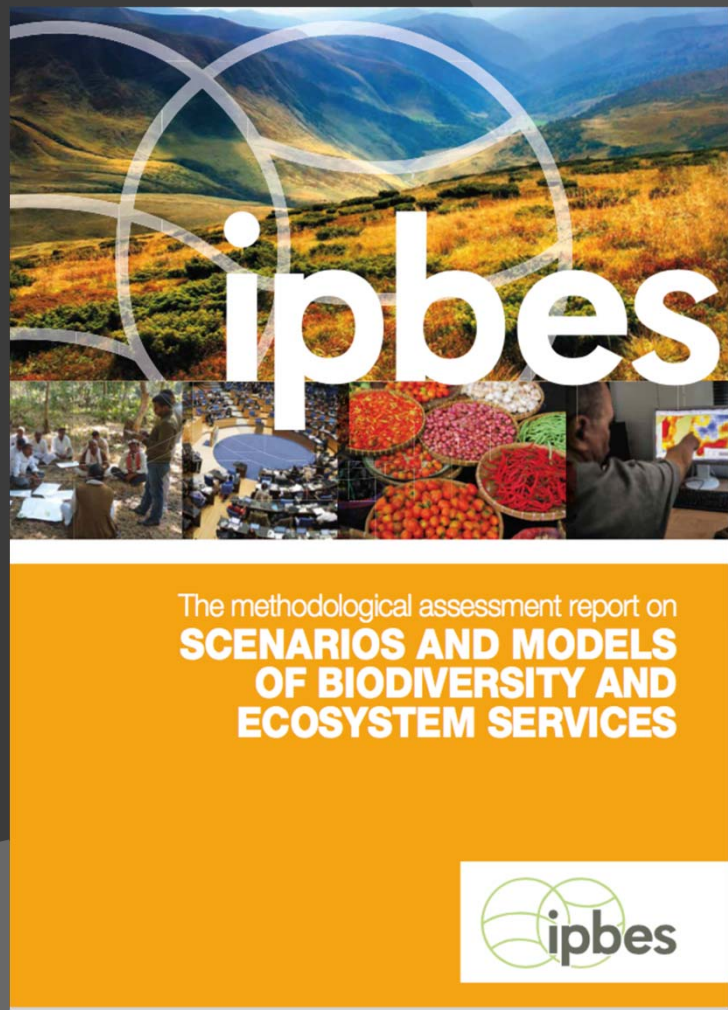


What the future is gonna look like ?



The need for biodiversity models and scenarios





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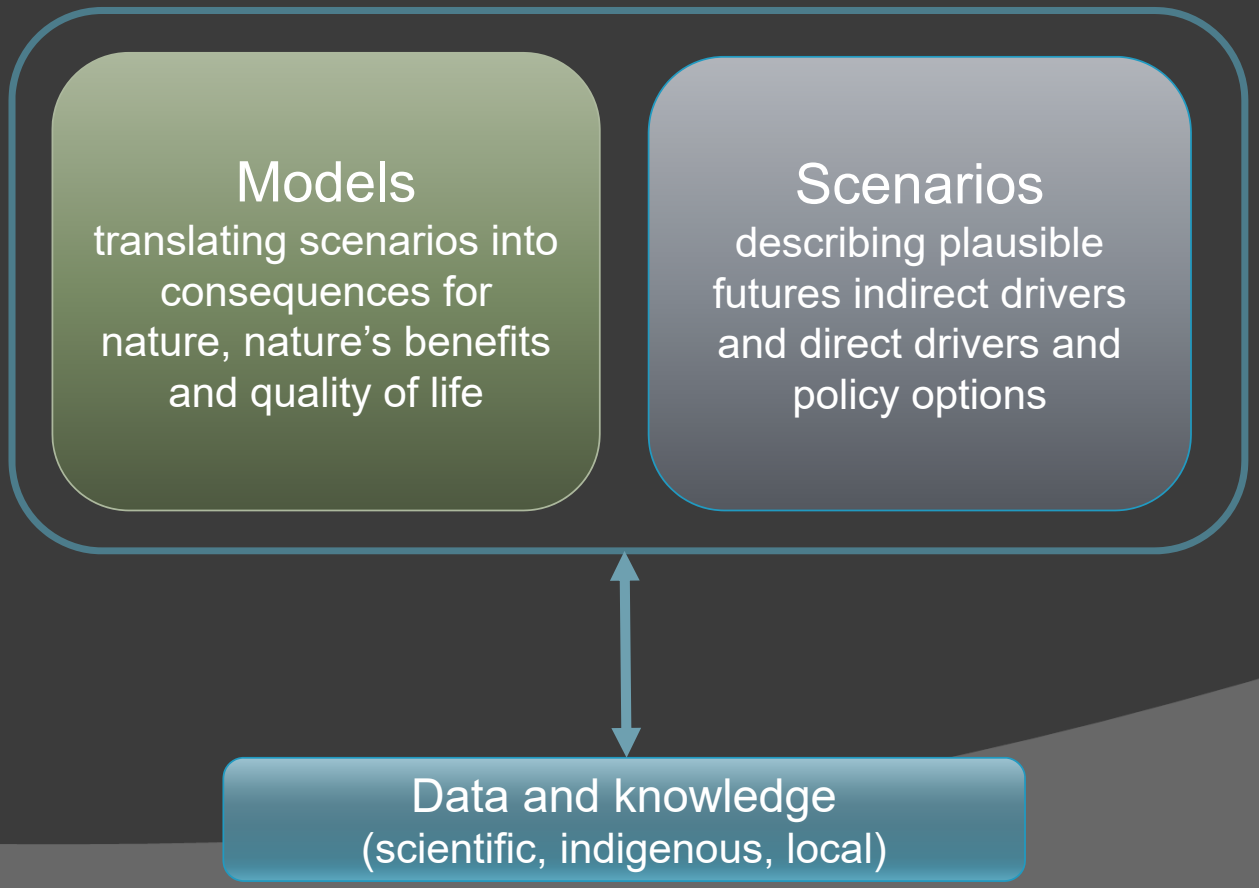

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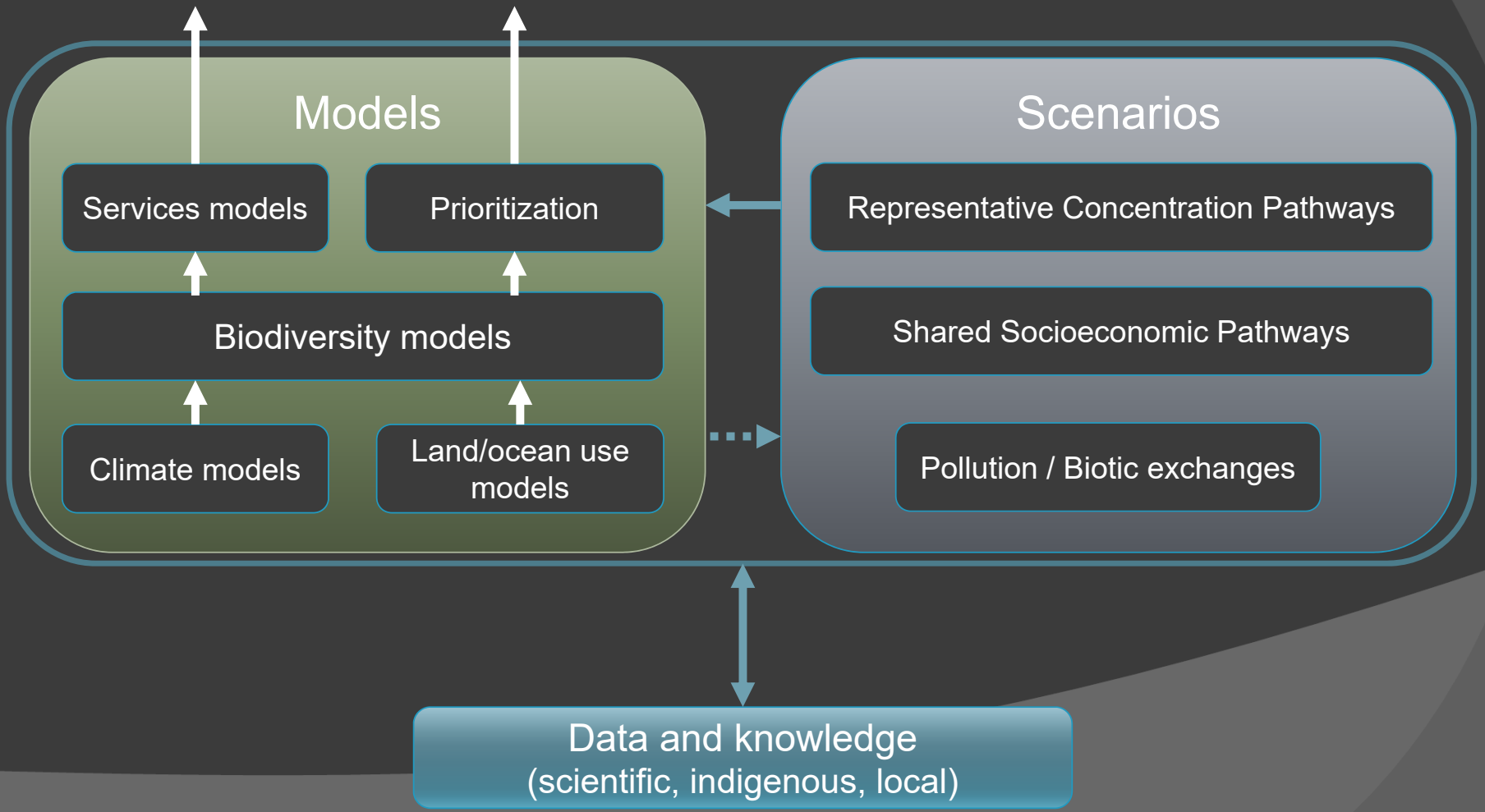
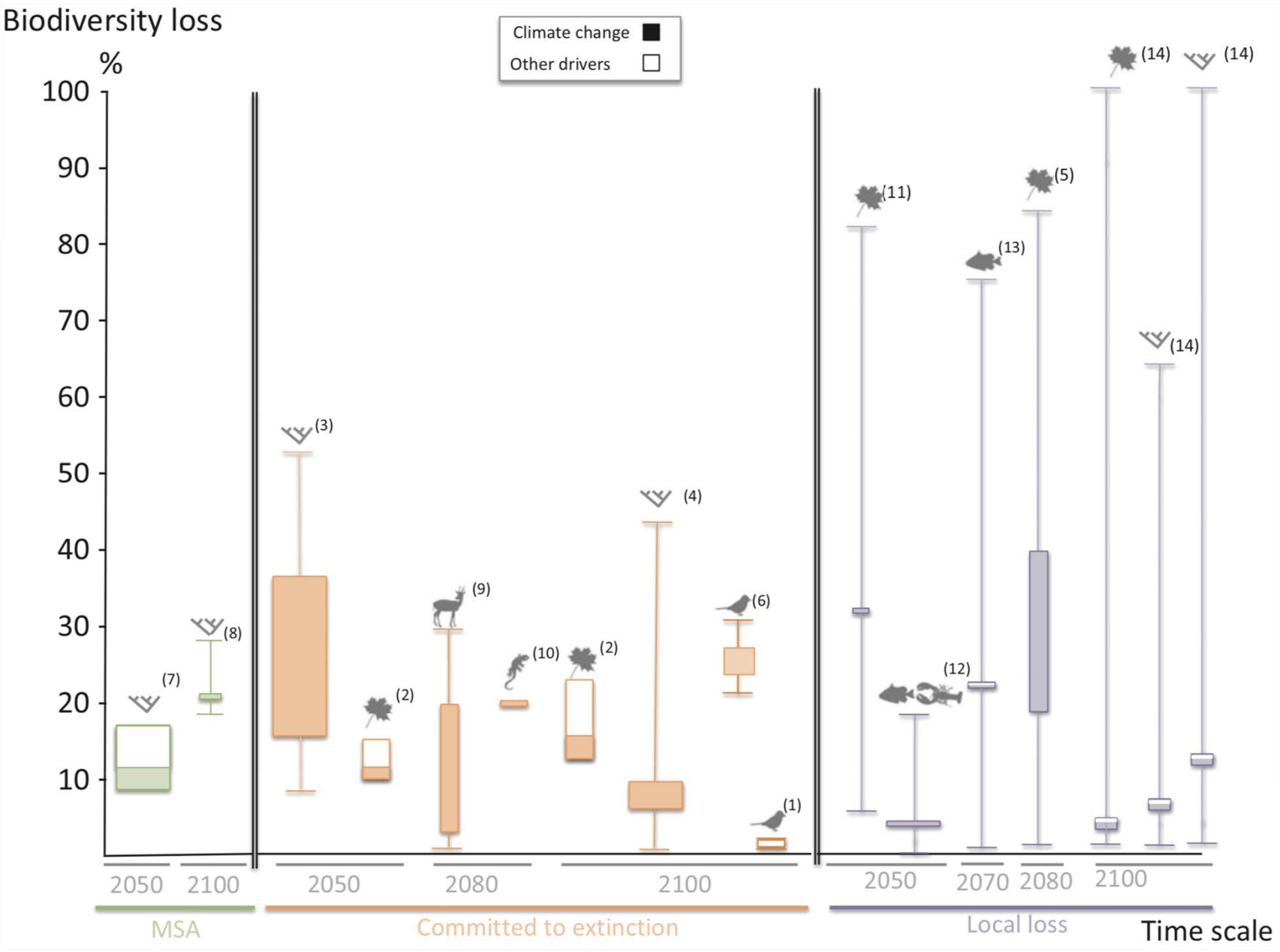




Bellard et al. 2012 Ecology Letters

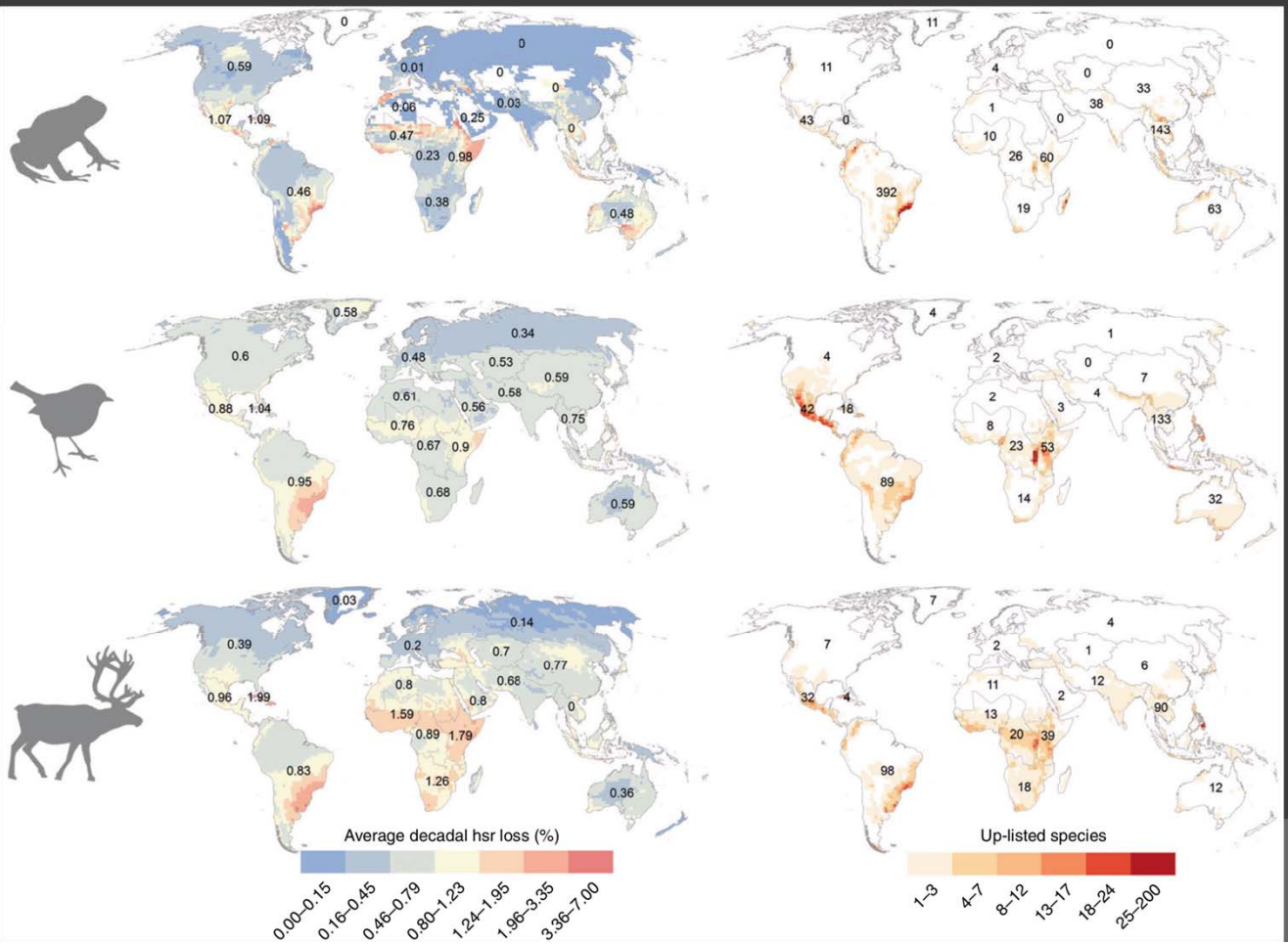
nature climate change

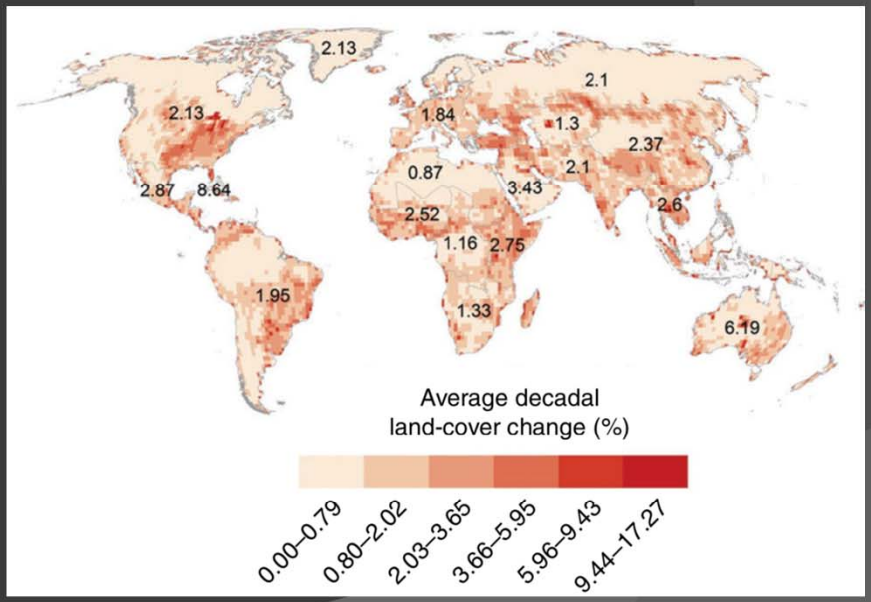
LETTERS

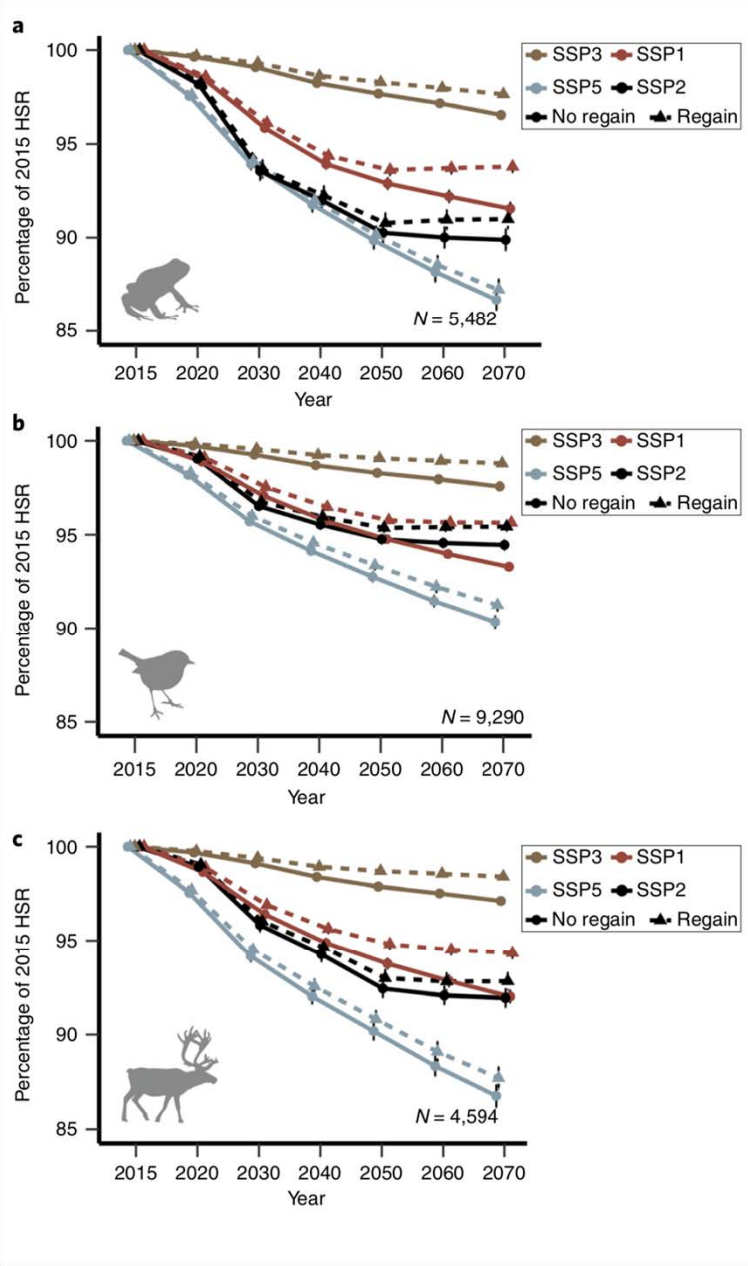
https://doi.org/10.1038/s41558-019-0406-z

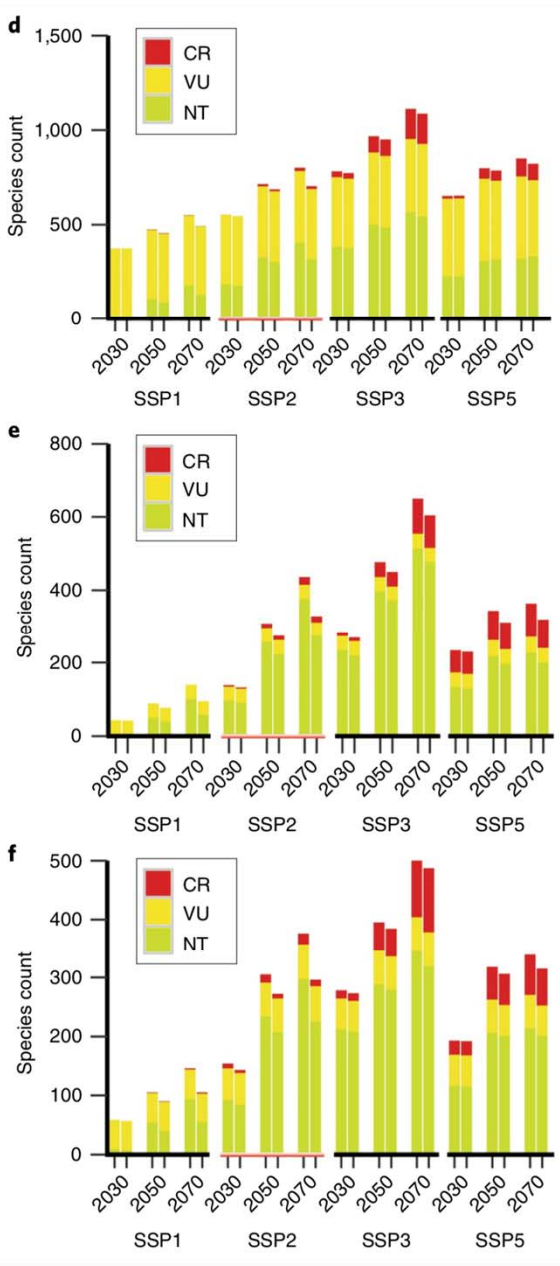
Global habitat loss and extinction risk of terrestrial vertebrates under future land-use-change scenarios

Ryan P. Powers and Walter Jetz*









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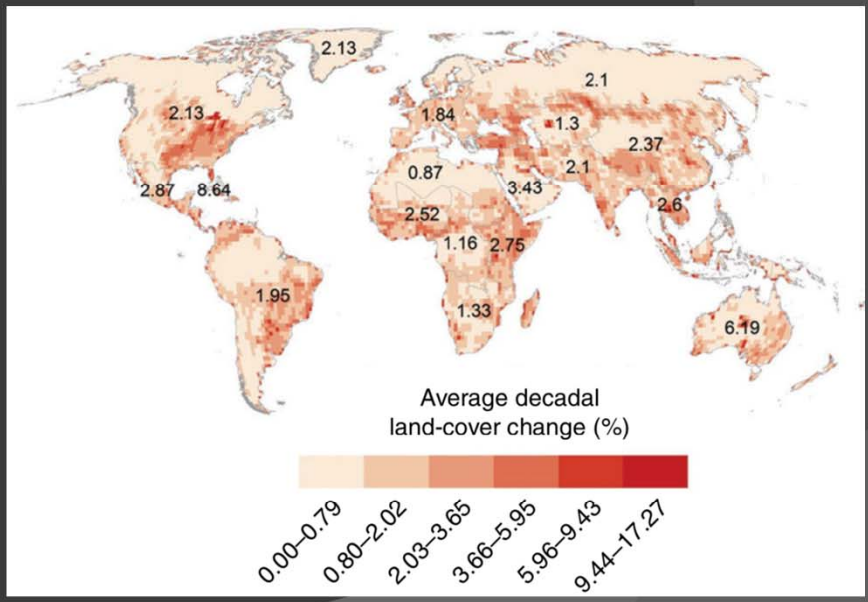

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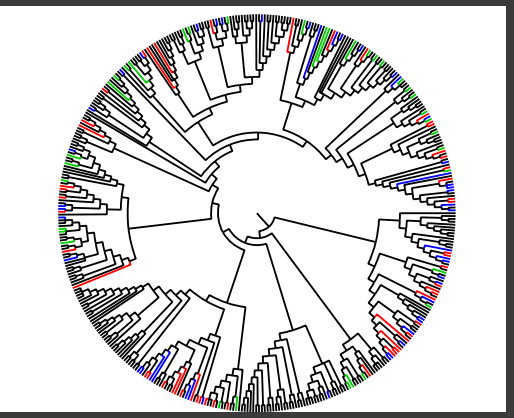
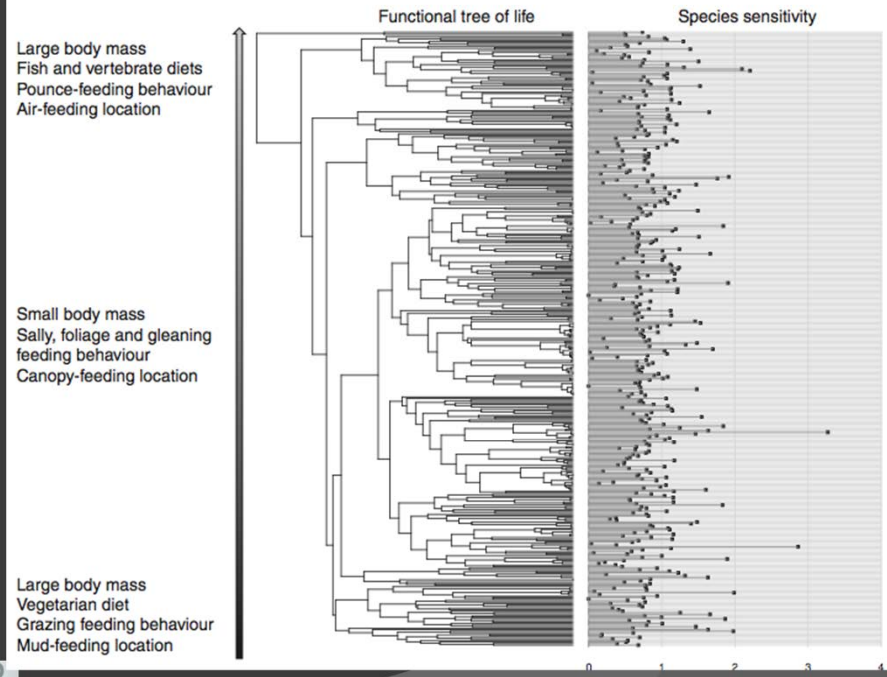
LETTER

doi:10.1038/nature09705

Consequences of climate change on the tree of life in Europe

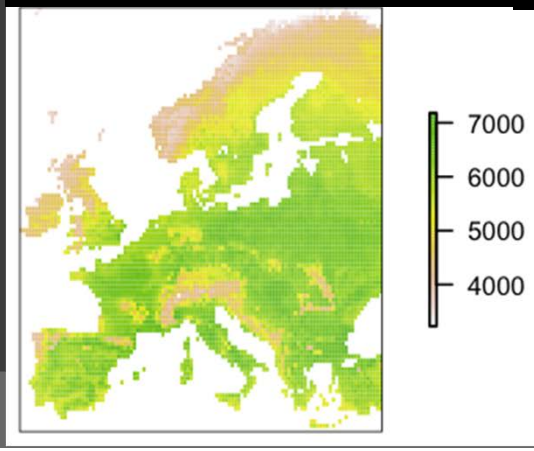
Wilfried Thuiller[1], Sébastien Lavergne[1], Cristina Roquet[1], Isabelle Boulangeat[1], Bruno Lafourcade[1] & Miguel. B. Araujo[2,3]



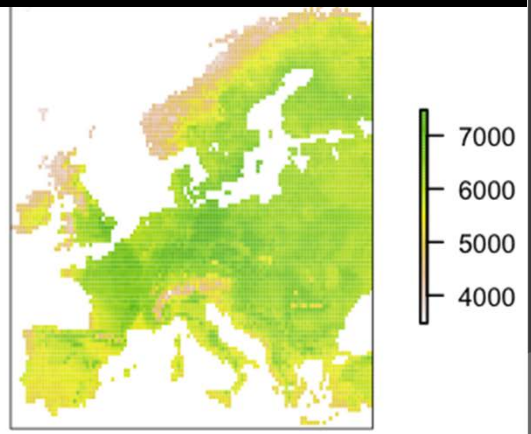


Phylogenetic diversity of European breeding birds

Current



Future 2080



nature COMMUNICATIONS

Received 25 Feb 2013 | Accepted 16 Dec 2013 | Published 23 Jan 2014

DOI: 10.1038/ncomms4118

The European functional tree of bird life in the face of global change

Wilfried Thuiller[1], Samuel Pironon[1,2], Achilleas Psomas[3], Morgane Barbet-Massin[4], Frédéric Jiguet[4], Sébastien Lavergne[1], Peter B. Pearman[3], Julien Renaud[1], Laure Zupan[1] & Niklaus E. Zimmermann[3]

Potential Impacts of Climate Change on Ecosystem Services in Europe: The Case of Pest Control by Vertebrates

EMILIO CIVANTOS, WILFRIED THUILLER, LUIGI MAIORANO, ANTOINE GUISAN, AND MIGUEL B. ARAÚJO

BioScience • *July 2012 / Vol. 62 No. 7*

GLOBAL CHANGE BIOLOGY BIOENERGY

GCB Bioenergy (2014), doi: 10.1111/gcbb.12178

Balance between climate change mitigation benefits and land use impacts of bioenergy: conservation implications for European birds

LAURA MELLER[1,2], WILFRIED THUILLER[2], SAMUEL PIRONON[2,3], MORGANE BARBET-MASSIN[4,5], ANDRIES HOF[6] and MAR CABEZA[1]

LETTER

Biodiversity funds and conservation needs in the EU under climate change

Tobias Lung[1,2], Laura Meller[3,4], Astrid J.A. van Teeffelen[3,5], Wilfried Thuiller[4], & Mar Cabeza[3]

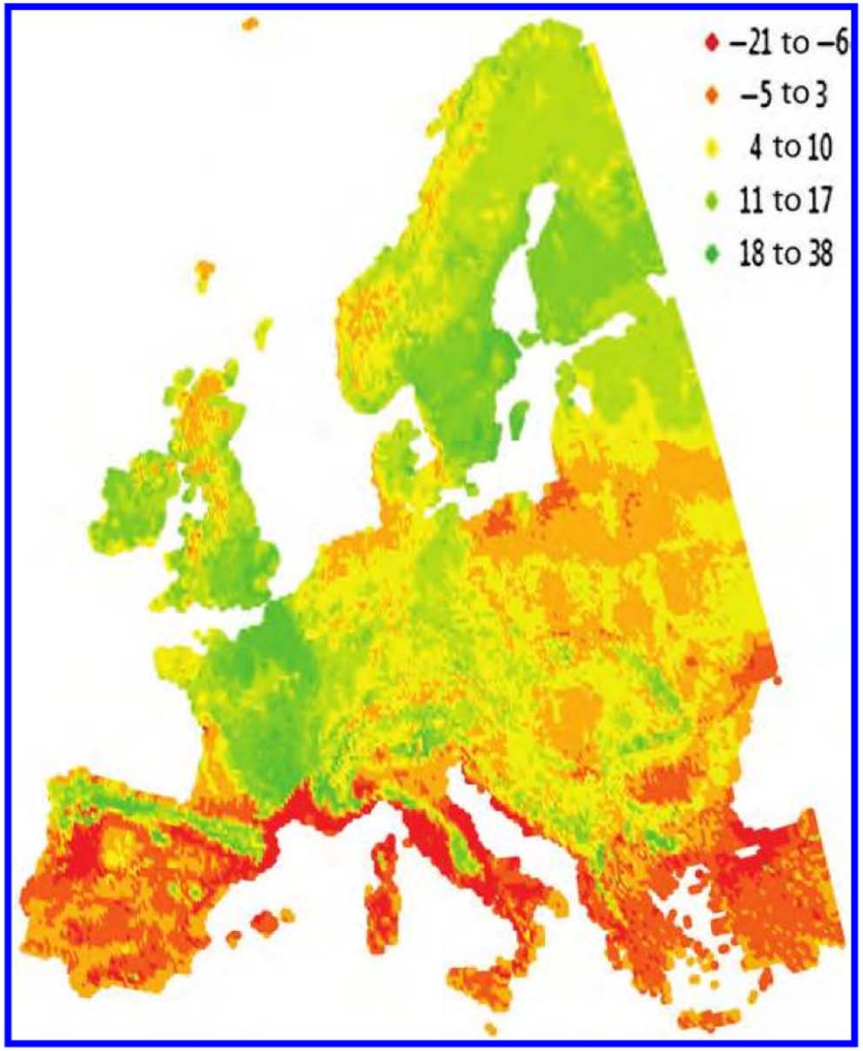
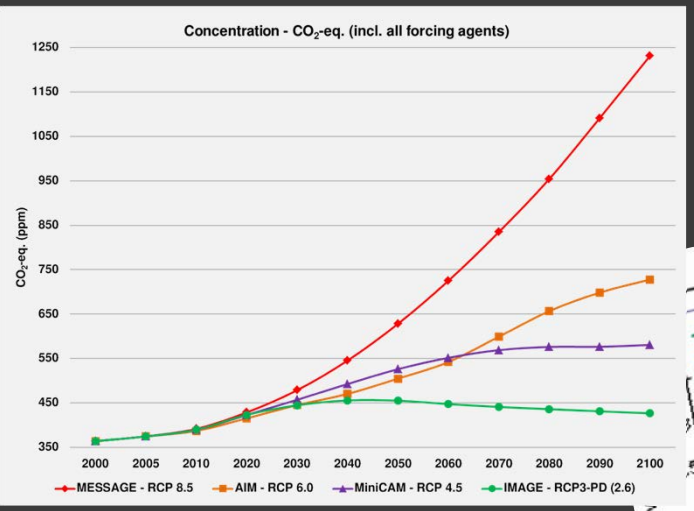
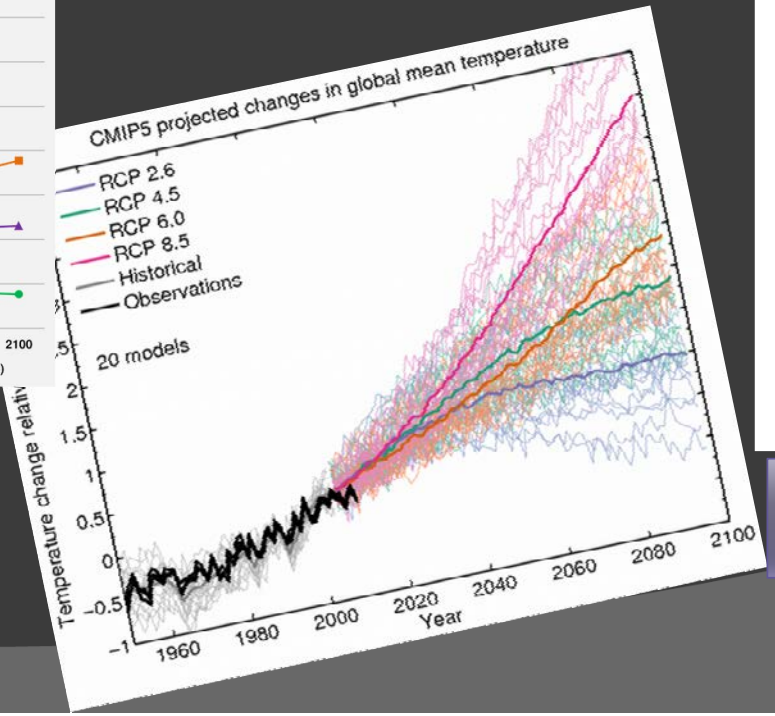


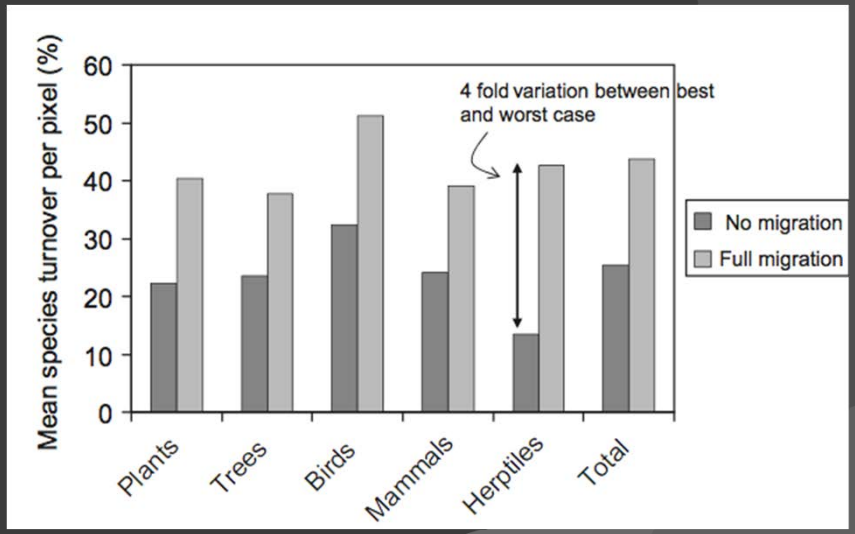
Figure 5. Gains and losses of species providing pest control on invertebrates for 2080 (under the pessimistic scenario) in respect to current conditions. Red represents losses, yellow represents a stable population, and green represents gains.

What are the key challenges to address?

- Integrating multiple sources of uncertainties







Uncertainties in projected mean species turnover in Europe by 2050

What are the key challenges to address?

- Integrating multiple sources of uncertainties/variations
- Trade-off between mechanism and pattern modelling

Review

Towards Process-based Range Modeling of Many Species

Margaret E.K. Evans,[1,2,*] Cory Merow,[3] Sydne Record,[4] Sean M. McMahon,[5] and Brian J. Enquist[2,6,7]

nature ecology & evolution

ARTICLES

PUBLISHED: 12 JUNE 2017 | VOLUME: 1 | ARTICLE NUMBER: 0182

Extinction debt and colonization credit delay range shifts of eastern North American trees

Matthew V. Talluto[1*], Isabelle Boulangeat[2], Steve Vissault[3], Wilfried Thuiller[1] and Dominique Gravel[3]

ECOLOGY LETTERS

Ecology Letters, (2013) 16: 94–105

doi: 10.1111/ele.12104

IDEA AND PERSPECTIVE

A road map for integrating eco-evolutionary processes into biodiversity models

Wilfried Thuiller,[1*] Tamara Münkemüller,[1] Sébastien Lavergne,[1] David Mouillot,[2,3] Nicolas Mouquet,[4] Katja Schiffers[1] and Dominique Gravel[5]

Abstract

The demand for projections of the future distribution of biodiversity has triggered an upsurge in modelling at the crossroads between ecology and evolution. Despite the enthusiasm around these so-called biodiversity

Opinion

Process, Mechanism, and Modeling in Macroecology

Sean R. Connolly,[1,*] Sally A. Keith,[2,3] Robert K. Colwell,[2,4,5] and Carsten Rahbek[2,6]

Global Change Biology (2016) 22, 2651–2664, doi: 10.1111/gcb.13251

Benchmarking novel approaches for modelling species range dynamics

DAMARIS ZURELL[1], WILFRIED THUILLER[2,3], JÖRN PAGEL[4], JULIANO S. CABRAL[5,6], TAMARA MÜNKEMÜLLER[2,3], DOMINIQUE GRAVEL[7], STEFAN DULLINGER[8], SIGNE NORMAND[9], KATJA H. SCHIFFERS[2,3,10], KARA A. MOORE[11] and NIKLAUS E. ZIMMERMANN[1,12]

Ecography 37: 1198–1209, 2014

doi: 10.1111/j.1600-0587.2013.00574.x

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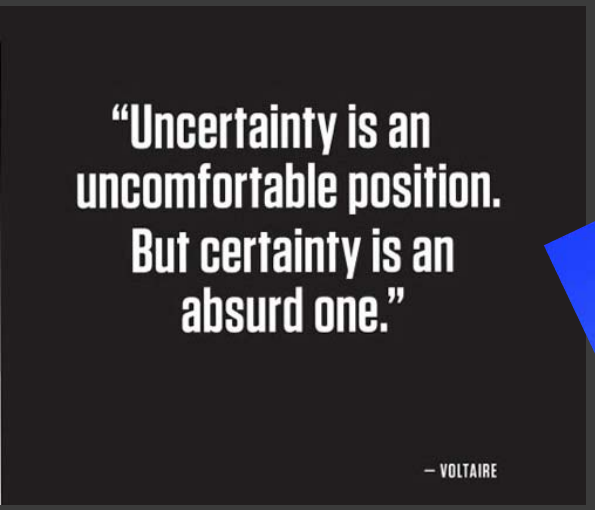
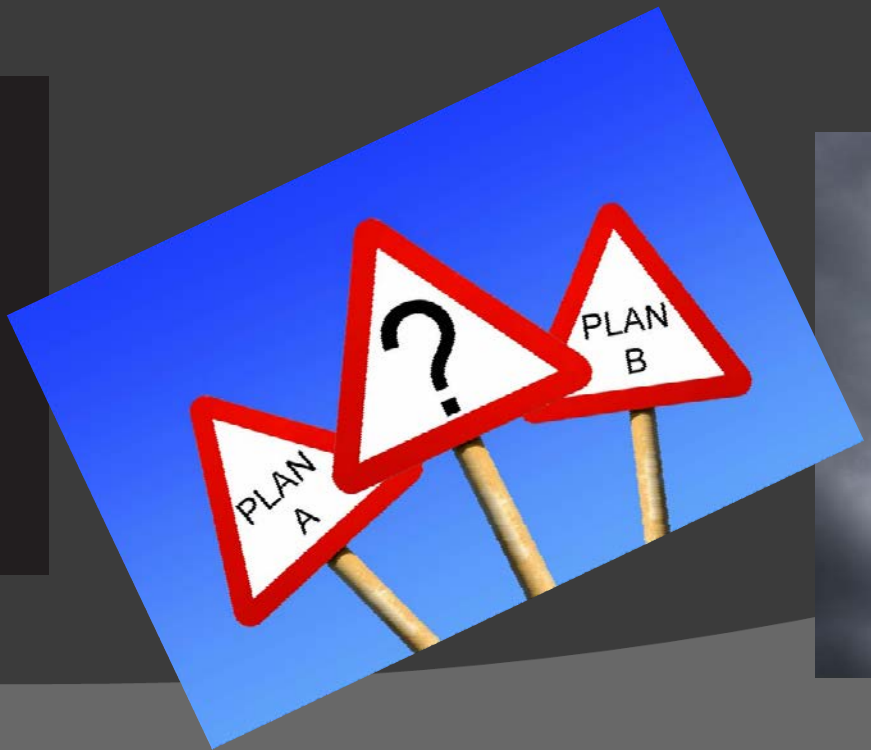
The influence of interspecific interactions on species range expansion rates

Jens-Christian Svenning, Dominique Gravel, Robert D. Holt, Frank M. Schurr, Wilfried Thuiller, Tamara Münkemüller, Katja H. Schiffers, Stefan Dullinger, Thomas C. Edwards, Jr, Thomas Hickler, Steven I. Higgins, Julia E. M. S. Nabel, Jörn Pagel and Signe Normand

Integrating multiple sources of uncertainties

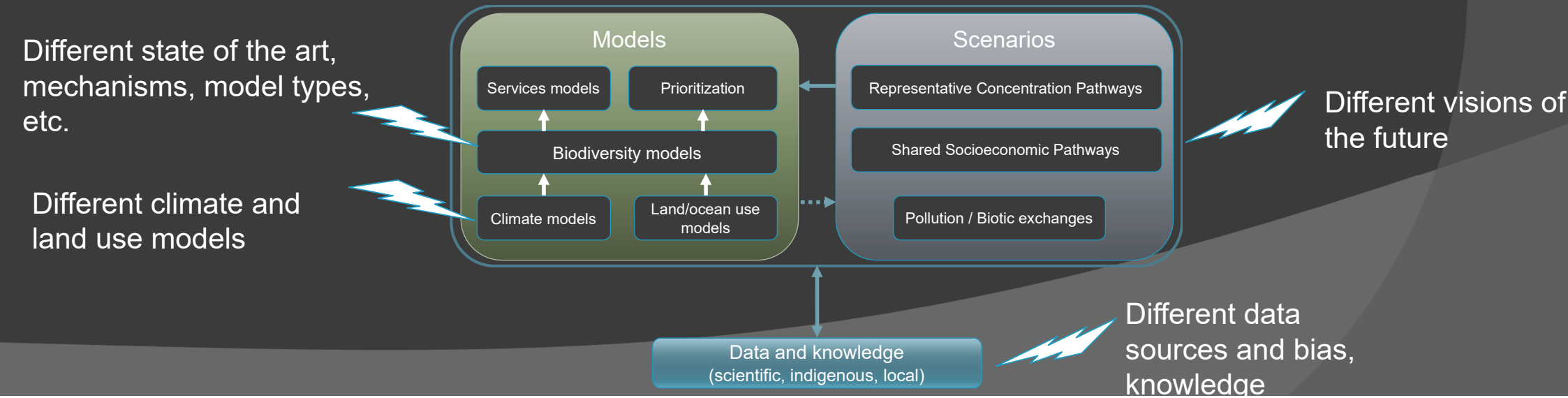
- The future is uncertain => how to deal with this uncertainty when making biodiversity projections?





Integrating multiple sources of uncertainties

- The future is uncertain => how to deal with this uncertainty when making biodiversity projections?
- How about climate?
- How about biodiversity modelling?



Integrating multiple sources of uncertainties

- Different types of models => different projections

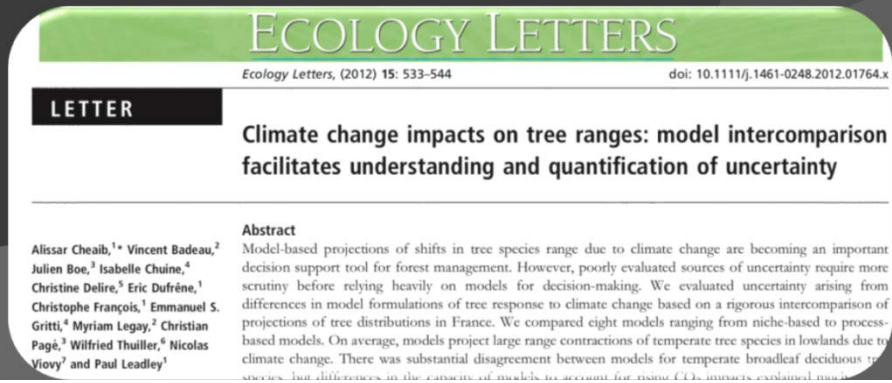
Phenomenological models

« Niche - Based » Models or « Bioclimate envelope » Models

- **Nancy NBM** (*V. Badeau, INRA Nancy*)
- **BIOMOD** (*W. Thuiller, 2009.* W. Thuiller, Grenoble)
- **STASH** (*Sykes et al, 1996.* E. Gritti, CEFE Montpellier)

Process-based models

« Phenology – Based » Model	**PHENOFIT** (*Chuine and Beaubien 2001.* I. Chuine, CEFE Montepellier)
Tree C balance and Growth	**CASTANEA** (*E. Dufrêne et al, 2005.* C. François and A. Cheaib, ESE Orsay)
Dynamic Global Vegetation Models (DGVMs)	**ORCHIDEE** (*Krinner et al, 2005.* N. Viovy CEA)
	IBIS (*Kucharik et al, 2000.* C. Delire Météo France)
	LPJ (*Stich et al, 2003.* E. Gritti, CEFE Montpellier)



ECOLOGY LETTERS

Ecology Letters, (2012) **15**: 533–544 doi: 10.1111/j.1461-0248.2012.01764.x

LETTER

Climate change impacts on tree ranges: model intercomparison facilitates understanding and quantification of uncertainty

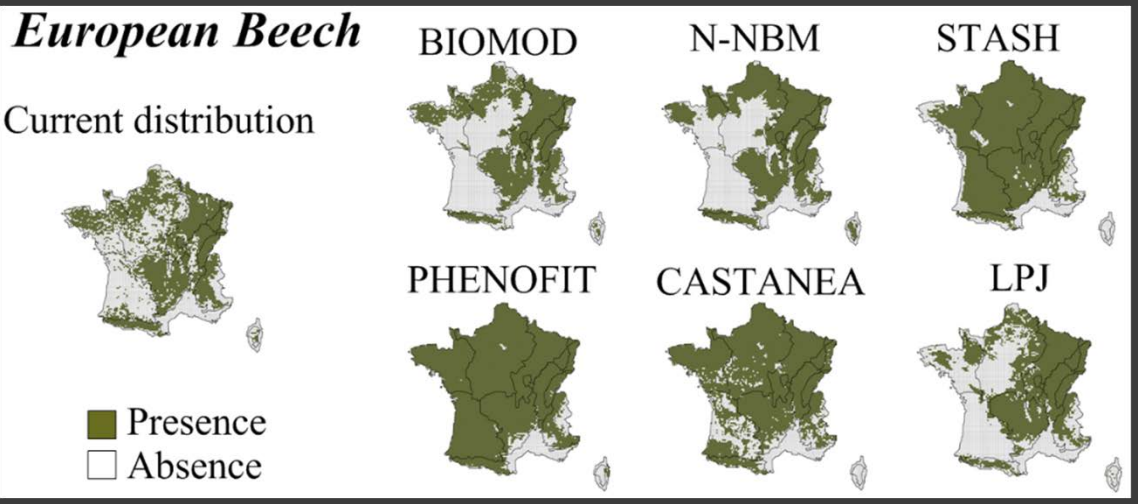
Alissar Cheaib,[1]* Vincent Badeau,[2] Julien Boe,[3] Isabelle Chuine,[4] Christine Delire,[5] Eric Dufrêne,[1] Christophe François,[1] Emmanuel S. Gritti,[4] Myriam Legay,[2] Christian Pagé,[3] Wilfried Thuiller,[6] Nicolas Viovy[7] and Paul Leadley[1]

Abstract

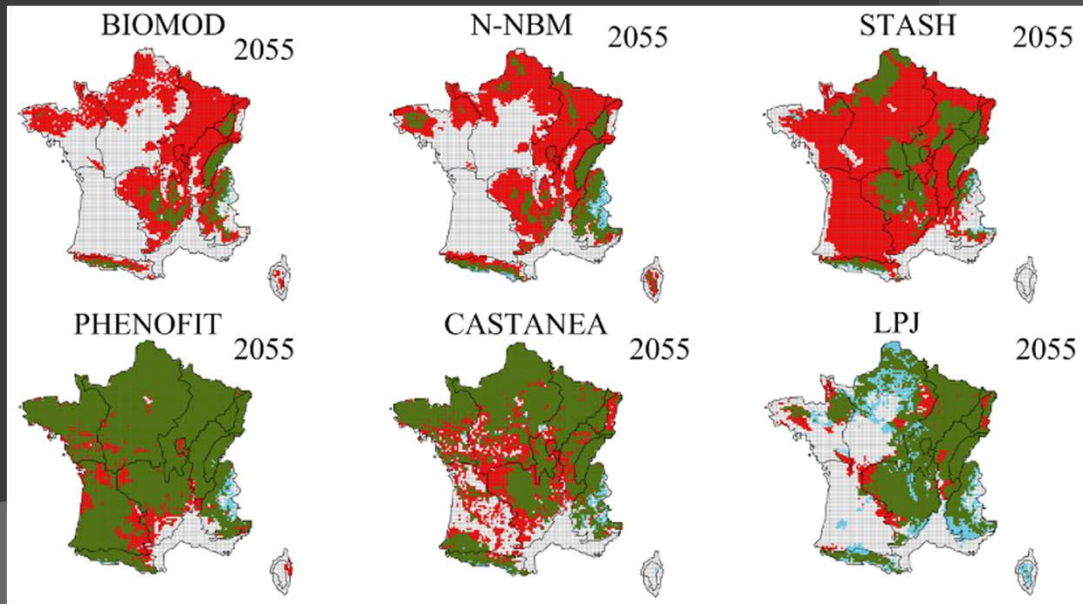
Model-based projections of shifts in tree species range due to climate change are becoming an important decision support tool for forest management. However, poorly evaluated sources of uncertainty require more scrutiny before relying heavily on models for decision-making. We evaluated uncertainty arising from differences in model formulations of tree response to climate change based on a rigorous intercomparison of projections of tree distributions in France. We compared eight models ranging from niche-based to process-based models. On average, models project large range contractions of temperate tree species in lowlands due to climate change. There was substantial disagreement between models for temperate broadleaf deciduous tr

Integrating multiple sources of uncertainties

- Different types of models => different projections

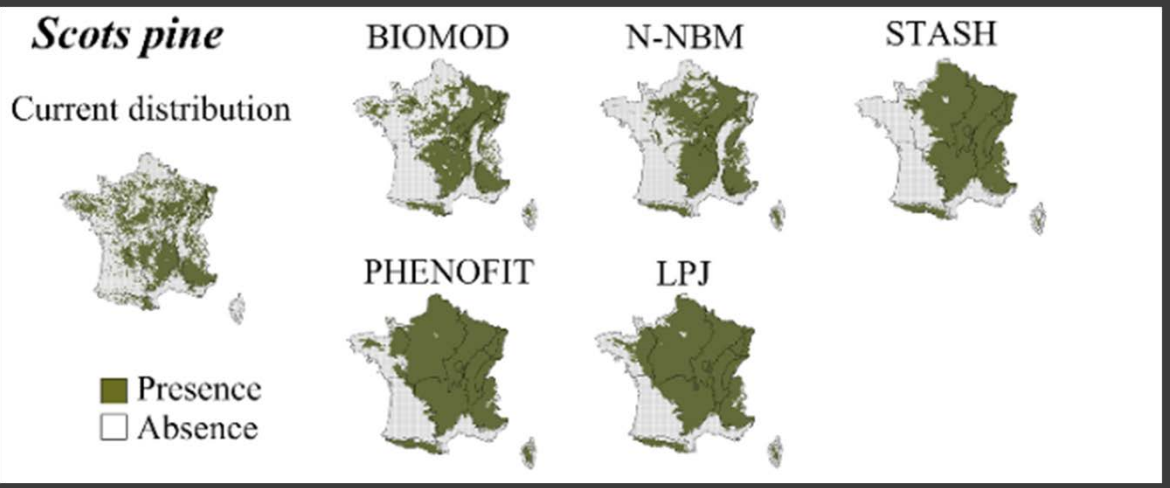


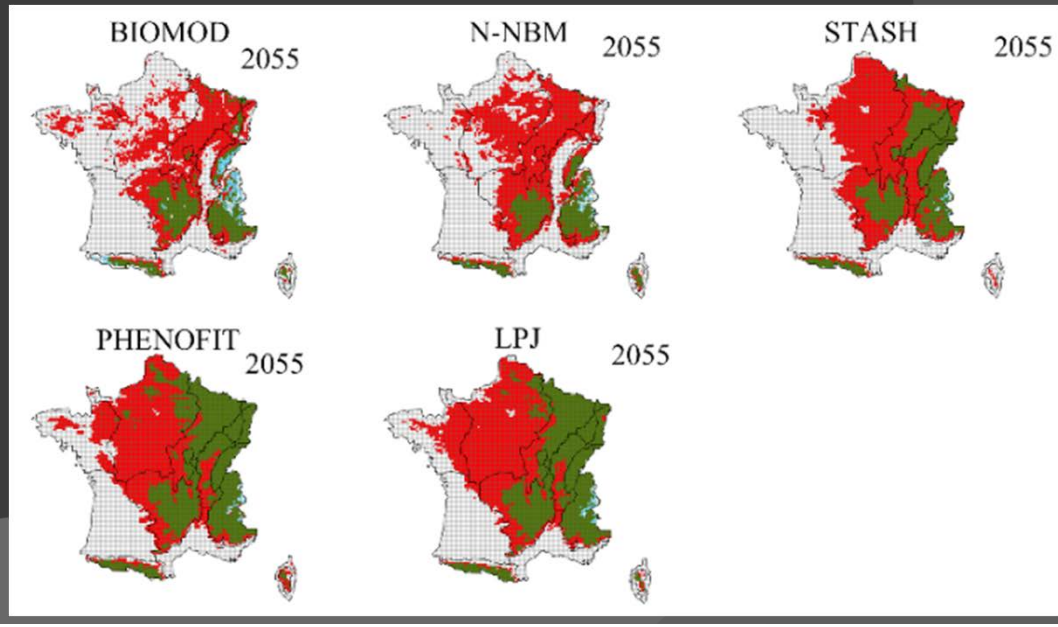
Regional climate modeling
Arpège A1b SRES
Régionalised (≈ 8 X 8 km) - L. Terray, J. Boé, C. Pagé, CERFACS



Integrating multiple sources of uncertainties

- Different types of models => different projections





Integrating multiple sources of uncertainties

- Uncertainty in global biodiversity scenarios

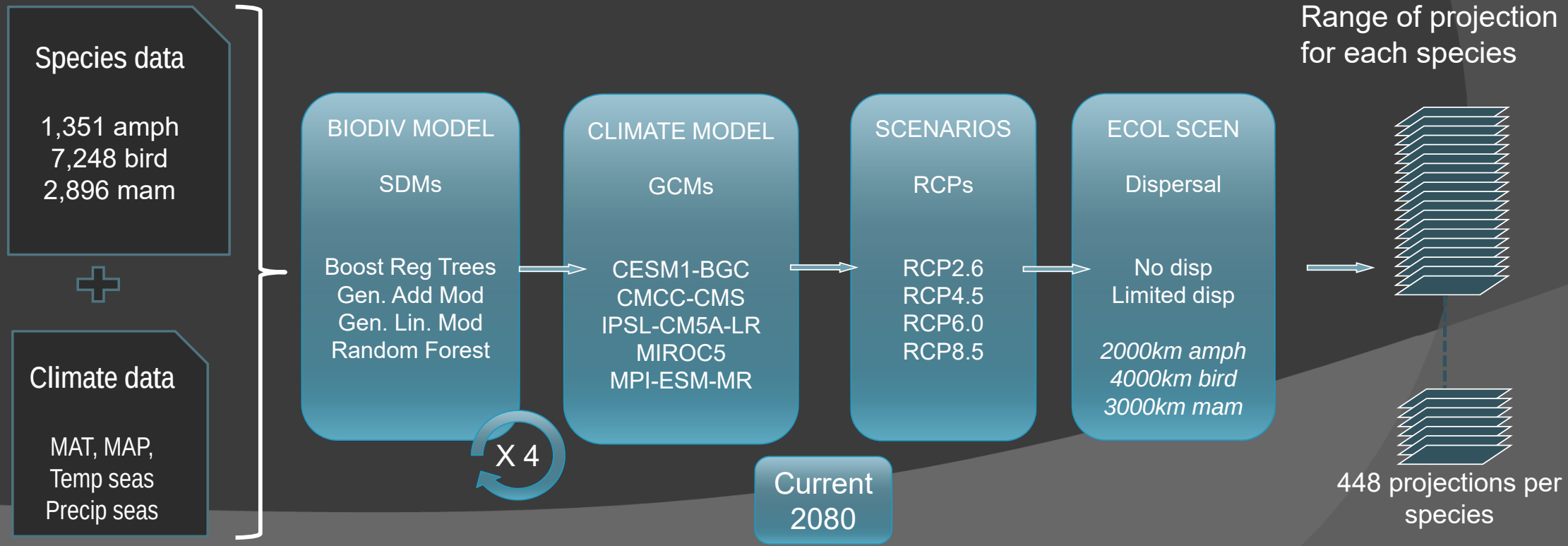
nature COMMUNICATIONS

ARTICLE

https://doi.org/10.1038/s41467-019-09519-w OPEN

Uncertainty in ensembles of global biodiversity scenarios

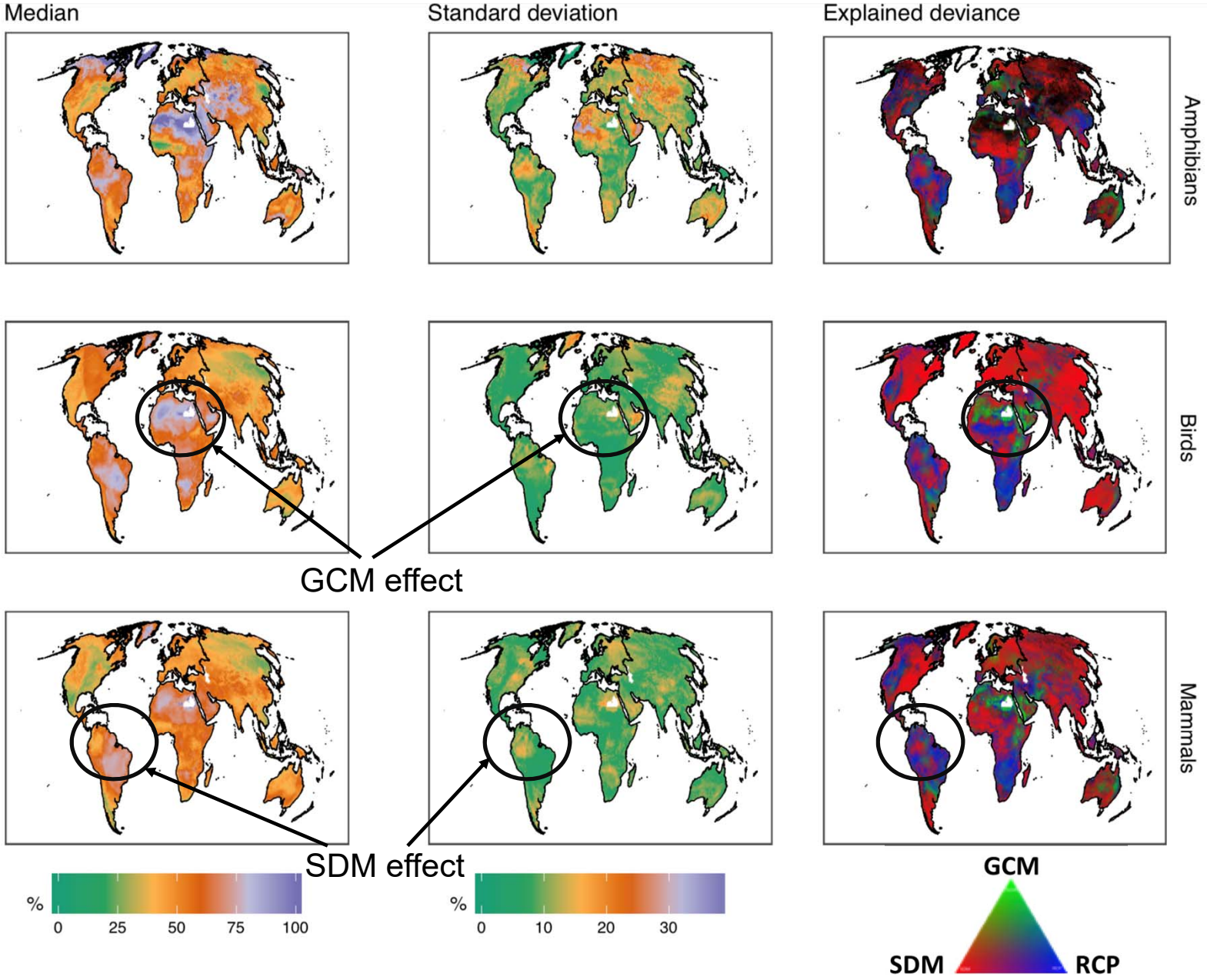
Wilfried Thuiller[1], Maya Guéguen[1], Julien Renaud[1], Dirk N. Karger[2] & Niklaus E. Zimmermann[2]

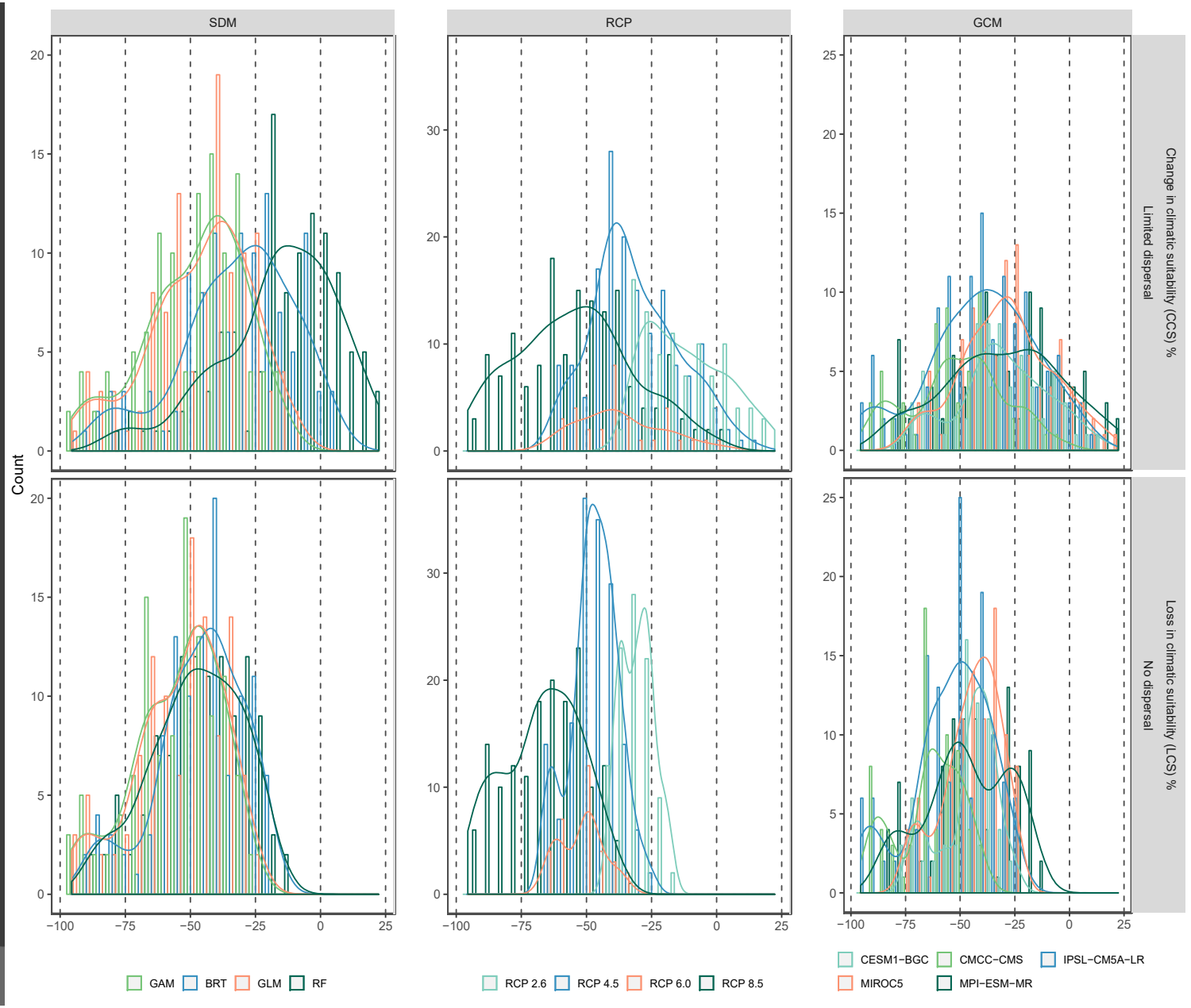


Diversity-based indices

Temporal turnover

Median
SD
Explained deviance

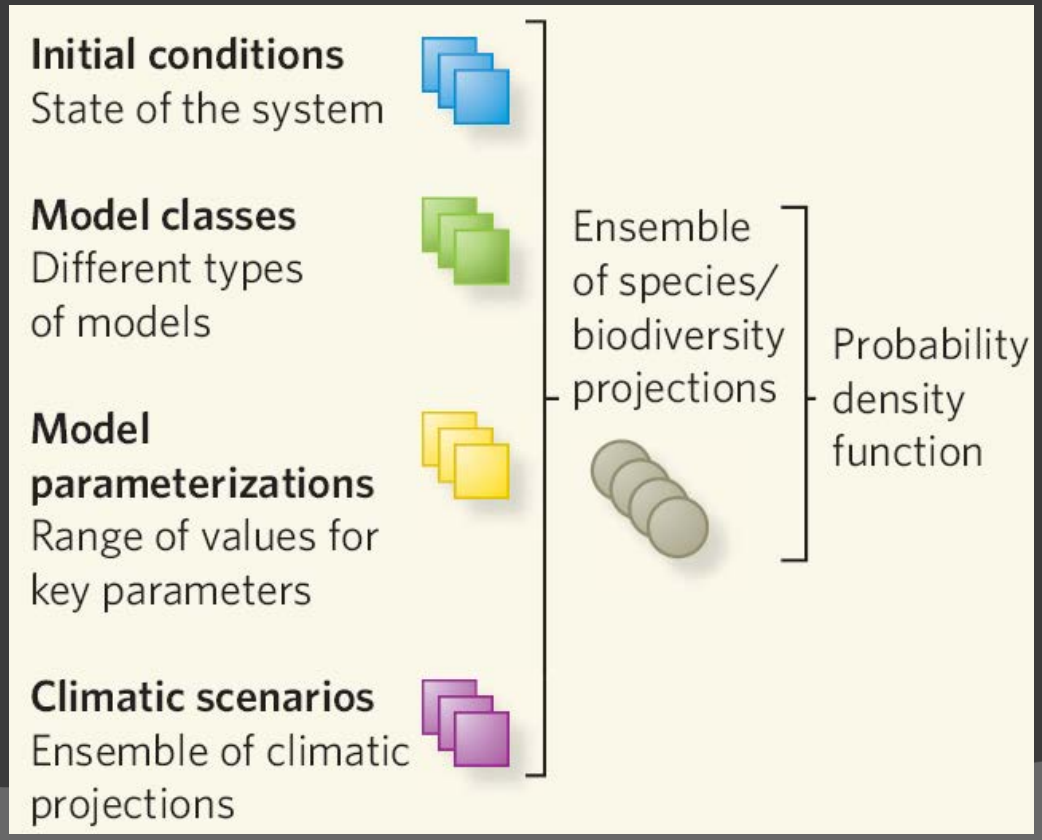


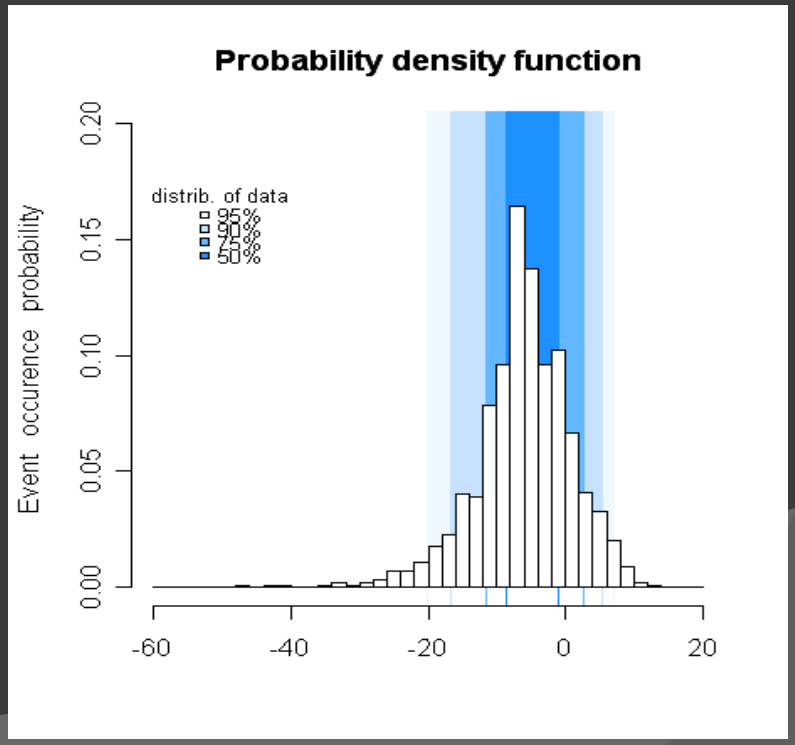


Bearded Woodpecker

Where to go from here?

- Think ensemble!





Thuiller 2007 Nature

Where to go from here?

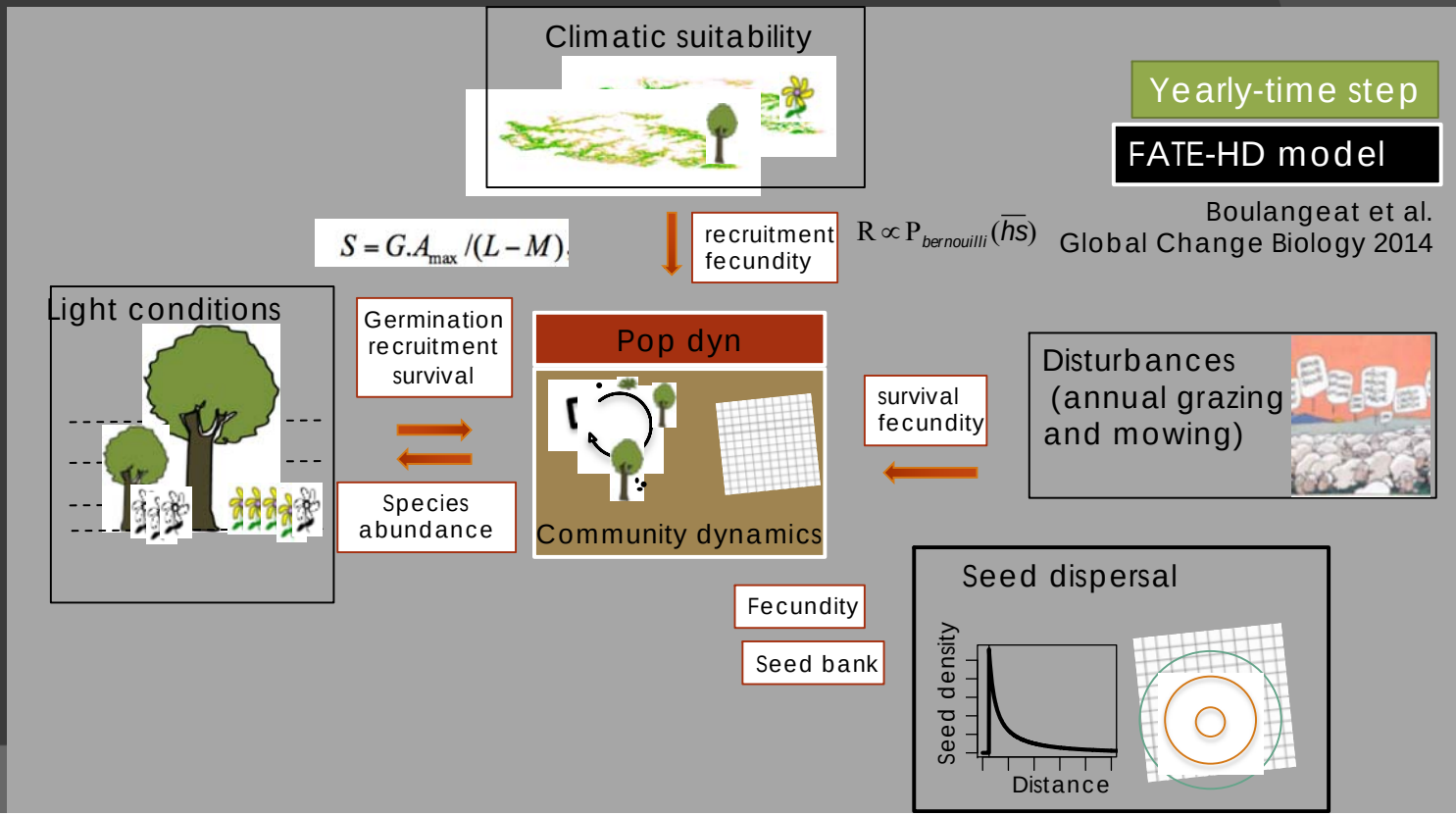
- More dynamic and mechanistic vegetation models useful for decision making

Global Change Biology (2014) **20**, 2368–2378, doi: 10.1111/gcb.12466

TECHNICAL ADVANCE

FATE-HD: a spatially and temporally explicit integrated model for predicting vegetation structure and diversity at regional scale

BOULANGEAT ISABELLE , GEORGES DAMIEN and THUILLER WILFRIED



Where to go from here?

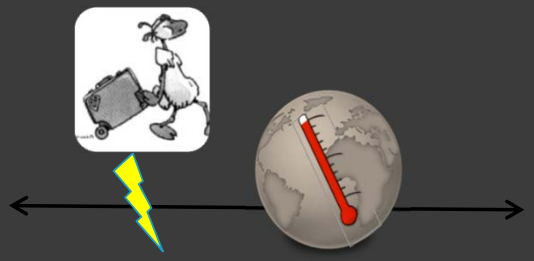
- More dynamic and mechanistic vegetation models useful for decision making

Ecography 37: 1230–1239, 2014
doi: 10.1111/ecog.00694

Subject Editor: Signe Normand. Accepted 4 March 2014

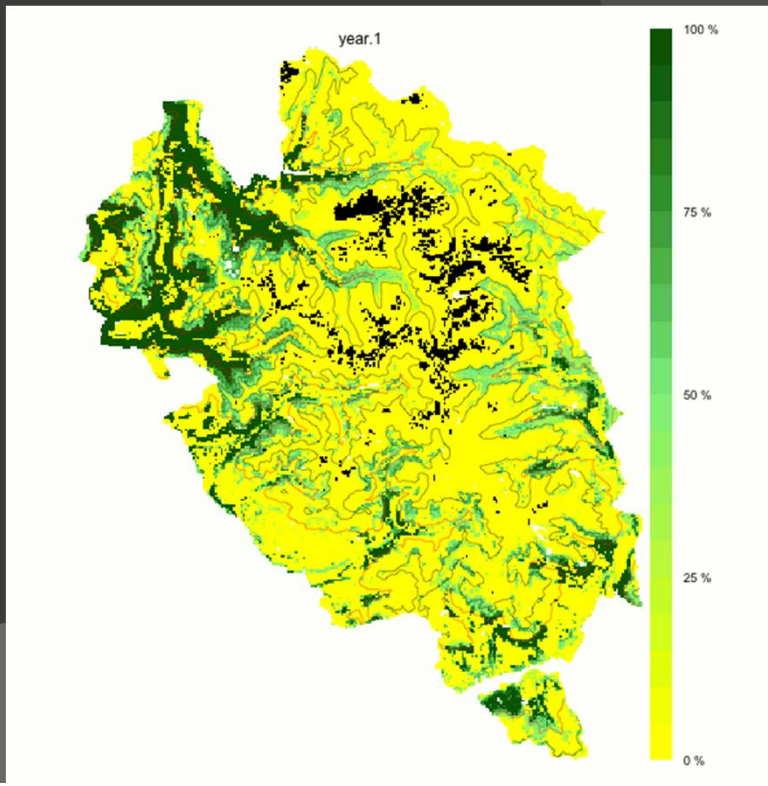
Anticipating the spatio-temporal response of plant diversity and vegetation structure to climate and land use change in a protected area

Isabelle Boulangeat, Damien Georges, Cédric Dentant, Richard Bonet, Jérémie Van Es, Sylvain Abdulhak, Niklaus E. Zimmermann and Wilfried Thuiller



Canopy closure (%)

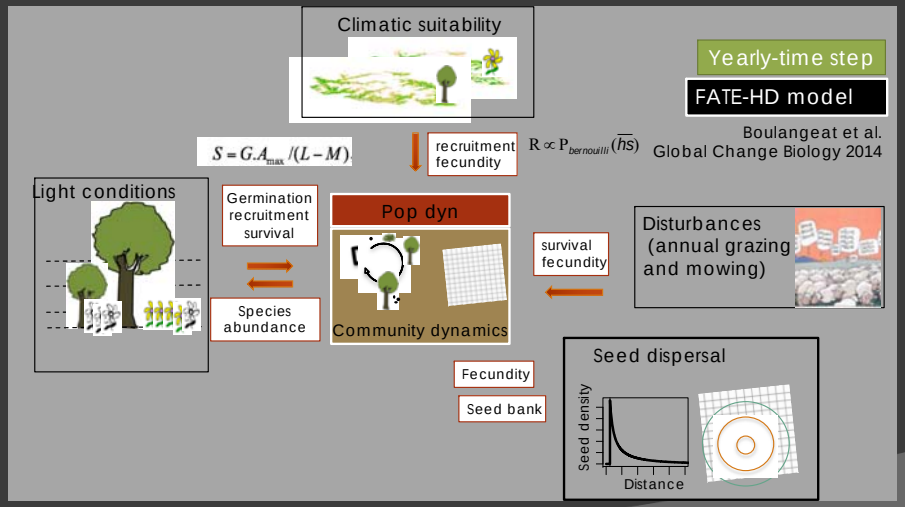
Climate change and abandonment



Where to go from here?

- More dynamic and mechanistic vegetation models useful for decision making

Multi-trophic interactions



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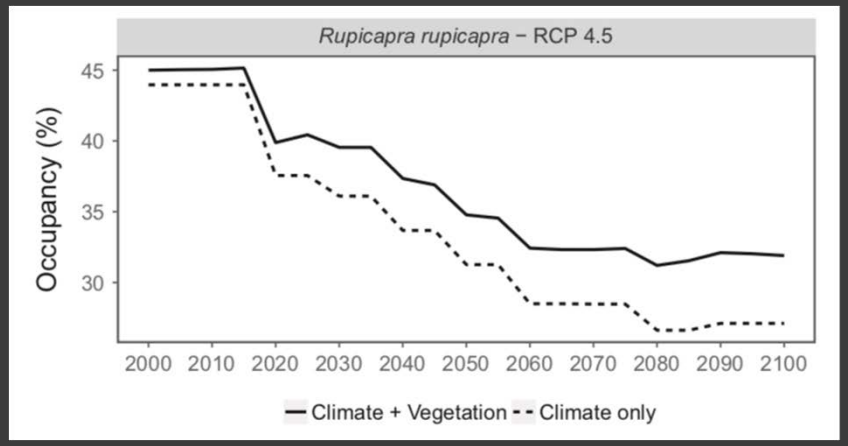
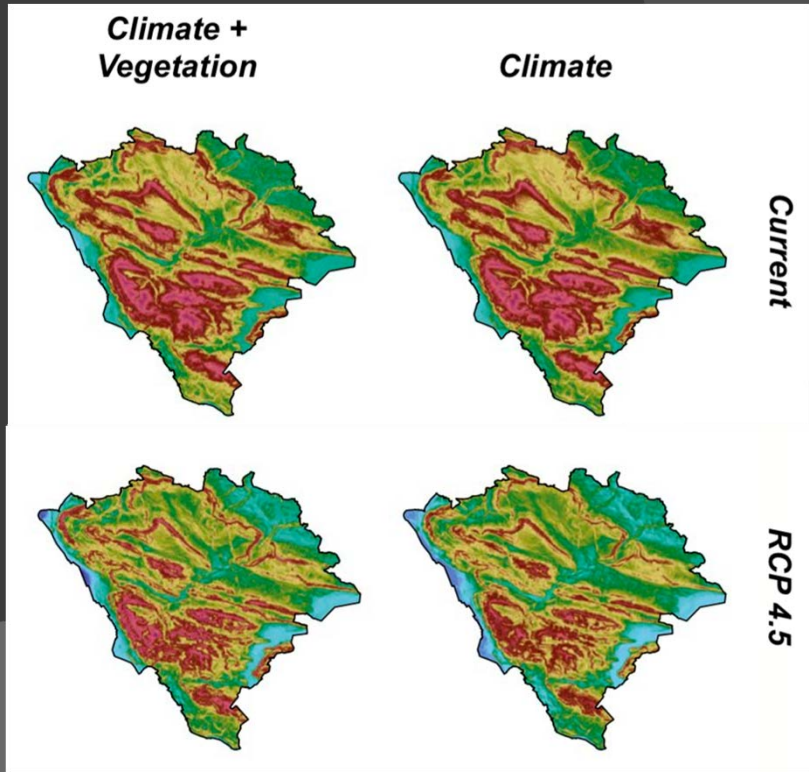
Wild herbivores

Where to go from here?

- More dynamic and mechanistic vegetation models useful for decision making

Multi-trophic interactions





BIODIVERSITY RESEARCH
WILEY Diversity and Distributions

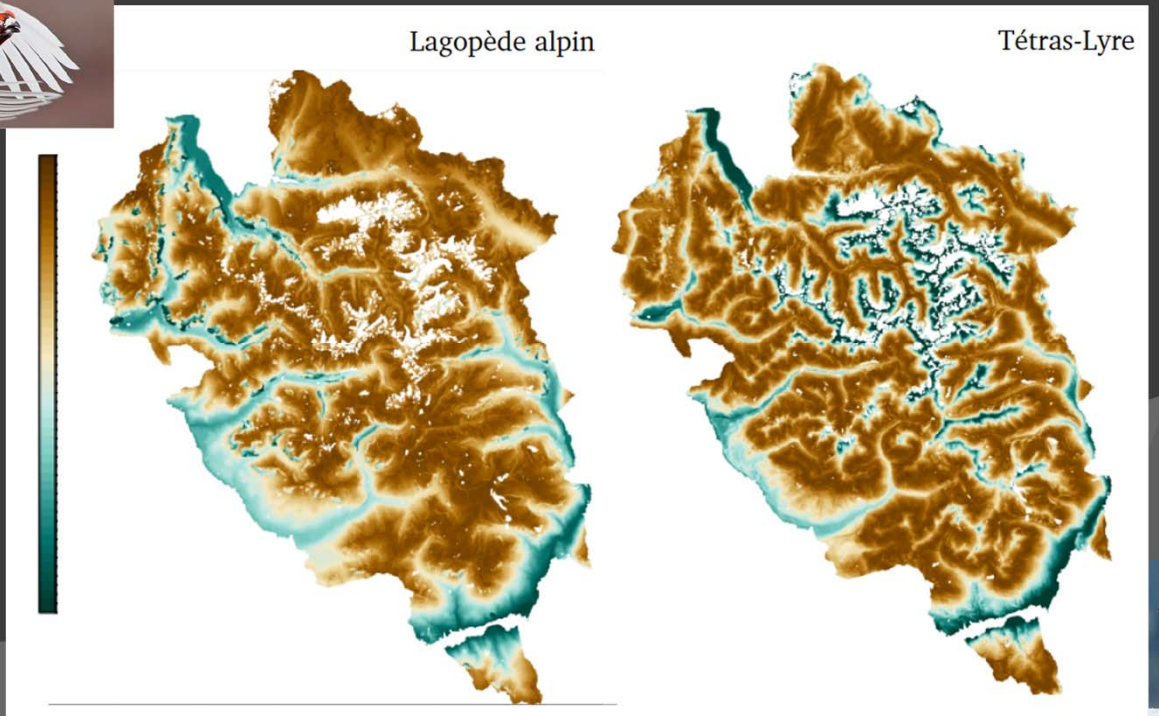
Combining point-process and landscape vegetation models to predict large herbivore distributions in space and time—A case study of *Rupicapra rupicapra*

Wilfried Thuiller[1*] | Maya Guéguen[1*] | Marjorie Bison[1,2] | Antoine Duparc[1] | Mathieu Garel[3] | Anne Loison[1] | Julien Renaud[1] | Giovanni Poggiato[1*]

Where to go from here?

- More dynamic and mechanistic vegetation models useful for decision making

Multi-trophic interactions



Concluding remarks

- Impacts of on-going environmental changes on biodiversity, ecosystem functioning and nature-benefit to people are declining globally
- Strong measure should be taken to halt this crisis
  - Better reliance on biodiversity models to consider conservation and management options
  - Better developments of biodiversity models that should integrate novel research on experiments and observations

Thanks for your attention!

Changement climatique – biodiversité

Expérimentations – vers des Alpes Volants !

COL DU GALIBIER (HAUTES-ALPES) | Plus de 100 chercheurs analyseront les données pendant une dizaine d'années

Ils déplacent des prairies pour étudier l'impact du réchauffement climatique

L'équipe à l'origine de l'expérience appelle celle "les alpages volants". Et pour cause, à quelques mètres en dessous de l'hélicoptère du Sud, des sacs se dandinent entre le col du Galibier et celui du Lautaret. Certains font le même trajet dans l'autre sens. Dans ces sacs, des morceaux de prairie.

Le but de l'opération, qui s'est déroulée entre le 26 et le 30 septembre, est scientifique. Il s'agit de décrypter les effets du réchauffement climatique en descendant les morceaux de parcelles 600 mètres plus bas, soit une augmentation brutale de 3 °C, en seulement quelques secondes. Ces petites parcelles ont été prélevées à 2 500 m d'altitude, sur les pentes du Galibier.

« Nous pensons obtenir les premiers résultats au bout de deux ou trois ans »

« Nous avons choisi 3 °C car c'est la prévision moyenne standard d'ici 50-80 ans », précise Wilfried Thuiller, directeur de recherche au CNRS. Les analyses, elles, s'étaleront sur les dix prochaines années. Environ 100 scientifiques seront mobilisés, et plus d'une dizaine de laboratoires.

Les chercheurs du laboratoire d'écologie alpine, de l'Université de Grenoble Alpes, de celle de Savoie Mont-Blanc et du CNRS y participent. « Nous verrons comment réagissent les champignons, les insectes, les bactéries… les différentes tranches de l'écosystème, pour avoir une idée de l'impact du réchauffement climatique », explique Tamara Münkemüller, employée au CNRS et au laboratoire d'écologie alpine. « Nous verrons comment l'espèce et le fleurissement évoluent, si les feuilles contiennent de graisse… Tout cela peut dépendre du climat, mais pas seulement. Cela peut être dû aussi à la présence d'autres espèces, plus fortes. Tout cela devra être analysé. »

Des parcelles ont été découpées puis remises dans les trous. C'est une convention entre la Station [illegible] les-Bains (Hautes-Alpes) qui a permis cela. Photo Le DLA

Chaque parcelle a une surface d'environ 4 m². « Nous pensons obtenir les premiers résultats au bout de deux ou trois ans », ajoute-t-elle. Les morceaux d'alpage ainsi emmenés replacés dans des trous à même le sol, là où ont été prélevées d'autres parcelles. C'est une inversion entre celles récupérées à 2 500 m et celles découpées à 1 900 m.

« En haut, les espèces sont plus petites et adaptées au froid », détaille Wilfried Thuiller, le directeur de recherche au CNRS. « En bas, elles sont plus compétitrices. Mais on peut s'attendre à des acclimatations de certaines d'entre elles. »

Cette expérience se déroule en collaboration avec la Suisse, lancée par l'Europe avec le soutien du CNRS et l'Université de Grenoble. Un programme qui devrait réunir une dizaine d'écologie en Europe. « Ce n'est pas la première qu'une opération [illegible] est réalisée », ajoute-t-il.

Simulation du réchauffement climatique dans les Alpes : "il suffit de descendre les prairies de 600 mètres"

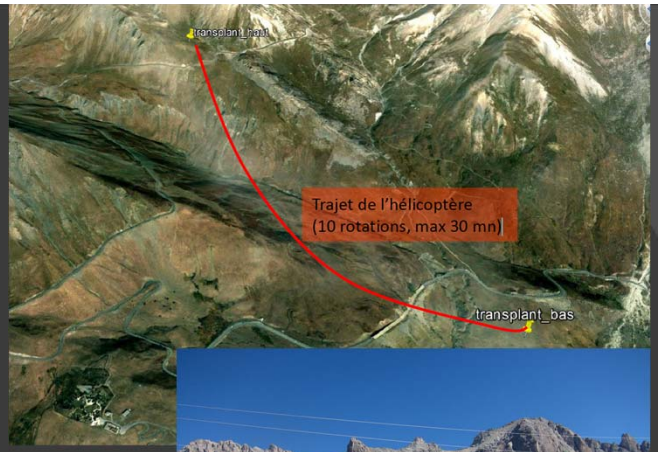
Des morceaux de pelouse sont découpés et prélevés à 2 500 mètres d'altitude avant d'être descendus par hélicoptère 600 mètres plus bas. L'objectif est de simuler le réchauffement climatique comme l'explique sur franceinfo Wilfried Thuiller, directeur de recherche au CNRS.

Héliportage de containers souples en 2012 (AMÉLIE MAURETTE / MAXPPP)

Station alpine Joseph Fourier

UMS 3370 UJF CNRS

Grenoble - Col du Lautaret [2100 m]



Site haute altitude (A) : 2450

Basse altitude (B) : 1950m


Galibier2450m
20cm
Lautaret, 1950m
+ 3°C