Biodiversity can benefit from long-term climate mitigation regardless of land-based measures

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Strategic Research on Global Mitigation and Local Adaptation to Climate Change (S-14)

Backgrounds

Over the last century, anthropogenic interventions in natural ecosystems have caused an exceptionally rapid loss of biodiversity.

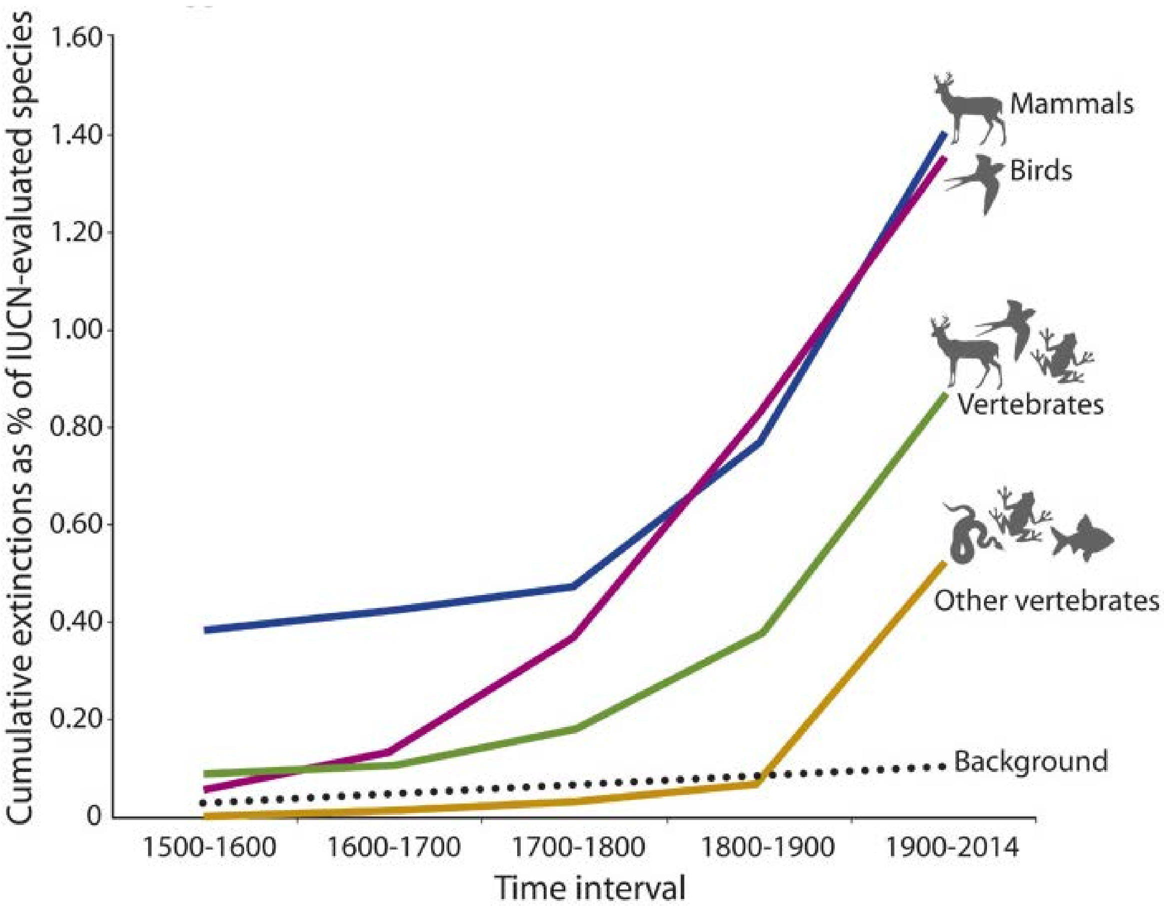


Fig. 1 Cumulative vertebrate species recorded as extinct or extinct in the wild by the IUCN (2012). Highly conservative estimate.

Ceballos *et al.* (2015) *Sci Adv* 1, e1400253

Backgrounds

Land-use change has been the largest driver of this biodiversity loss.
In particular, the expansion of agricultural area to support an increasing global population has caused major ecosystem changes over millenia.

Backgrounds

Recently, climate change is also becoming a major threat to biodiversity. Many organisms are likely changing their distributions as a means of adapting to climate change.

Backgrounds

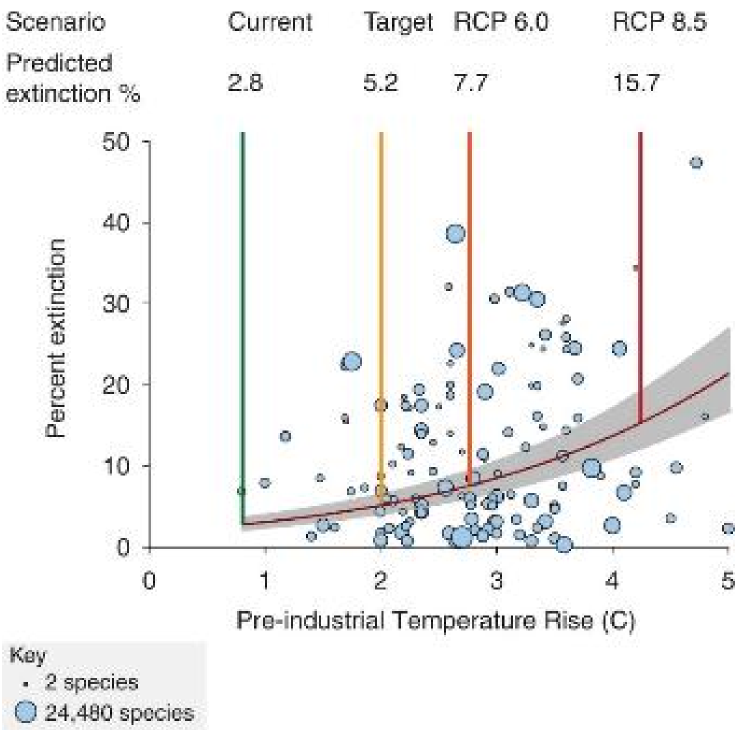
With an increasing recognition of the importance of biodiversity for human society, preventing further biodiversity loss is now a target of global sustainability policy, such as SGDs.

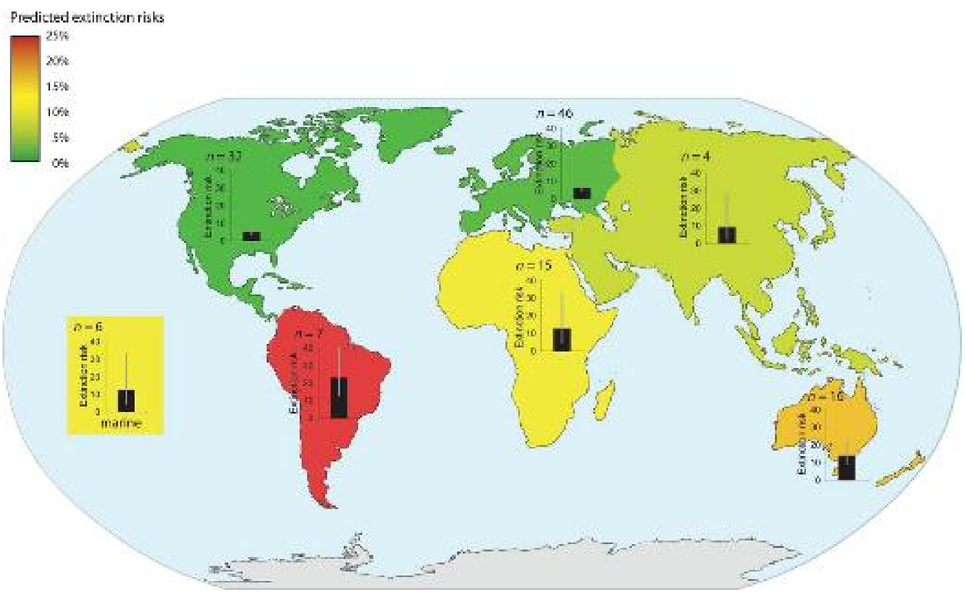
Backgrounds

Previous studies have agreed that reducing the degree of climate change by stringent greenhouse gas (GHG) mitigation activities can prevent a substantial loss of biodiversity.

Species extinction risk only under climate change (Urban 2015)

RCP2.6: 5.2 % **<** **RCP8.5: 15.7 %**





Urban (2015) *Science* 348, 571-573

Backgrounds

Recently, integrated assessment models revealed that the most stringent GHG mitigation scenarios require substantial land-based mitigation options such as large-scale bioenergy crop production, afforestation.

Potential land-use changes for GHG mitigation may cause further biodiversity loss.

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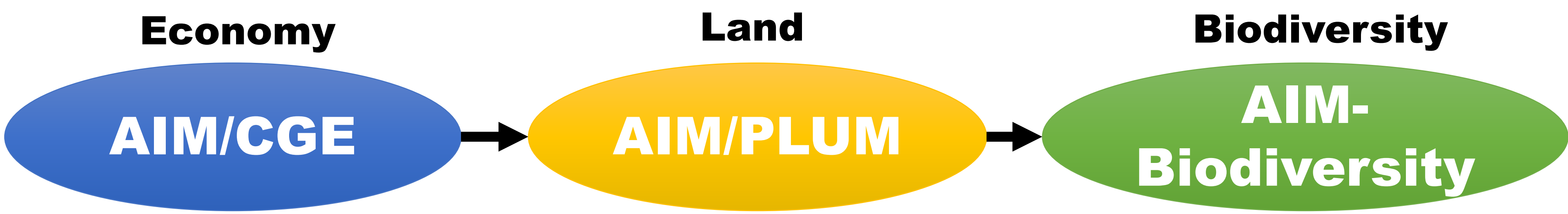
Backgrounds

Q: Whether climate change mitigation measures truly contribute to biodiversity conservation?

To answer this question…

Integrated assessment of climate change and land-use change by one-way economy-land-biodiversity modelling framework is needed.



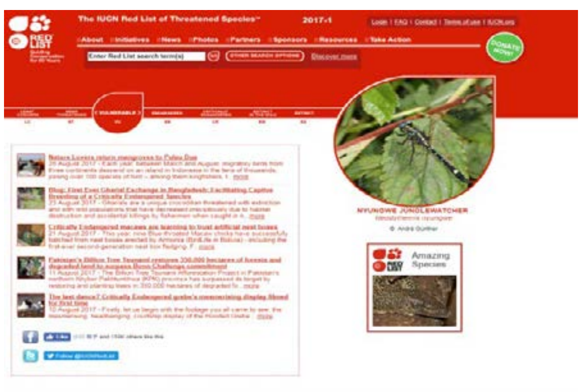
Methods: Species distribution model (SDM)

SDM: Statistical model based on the relationship between species' occurrence and environment

→ Useful for impact assessment of land use change and climate change at a large spatial scale

Target : 8,928 species of five major taxonomic groups (Plants, Amphibians, Reptiles, Birds, and Mammals)

- Terrestrial species evaluated by IUCN Red Data Book
- More than 30 valid occurrence points in GBIF database



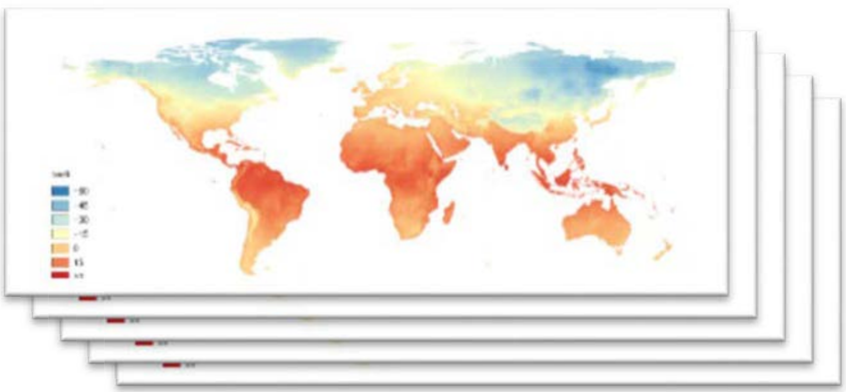
Methods: Environmental variables

Climate : WorldClim (http://www.worldclim.org/)

Land use : AIM/PLUM (Hasegawa *et al.* 2017)

Resolution : 0.5 degrees (*ca*. 60 km at the equator)

Explanatory variables :
Climate ×19 + Land use×5



We considered only relations with "linear" and "squared term" to prevent over-fitting of the model

No. of combinations: 16,777,216
Pearson's |r| < 0.70 &
VIF (variance inflation factors) **< 5 &**
Combinations not to be nested※

We selected the combinations which have a minimum AICc from candidate models for each species

※Coefficients of unnecessary variables are automatically assigned to zero in MaxEnt.

Methods: Calculation of potential habitats

Species distribution model

Species occurrence data: GBIF

Predictor variables:

- Climate (WorldClim)
- Land use (AIM/PLUM)

Species traits database

Animal: body mass, foods, generation interval

Plant: dispersal traits, growth form

MaxEnt (Phillips *et al.* 2006)

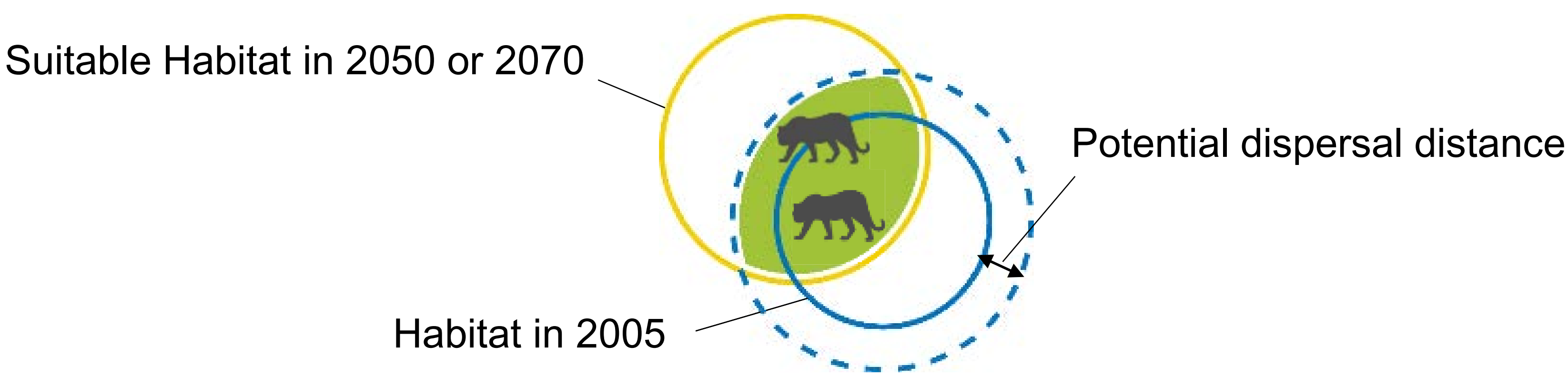
Allometric equations

Suitable habitat (2005)

Suitable habitat (2050, 2070)

Potential dispersal distance

Potential habitats in 2050 & 2070

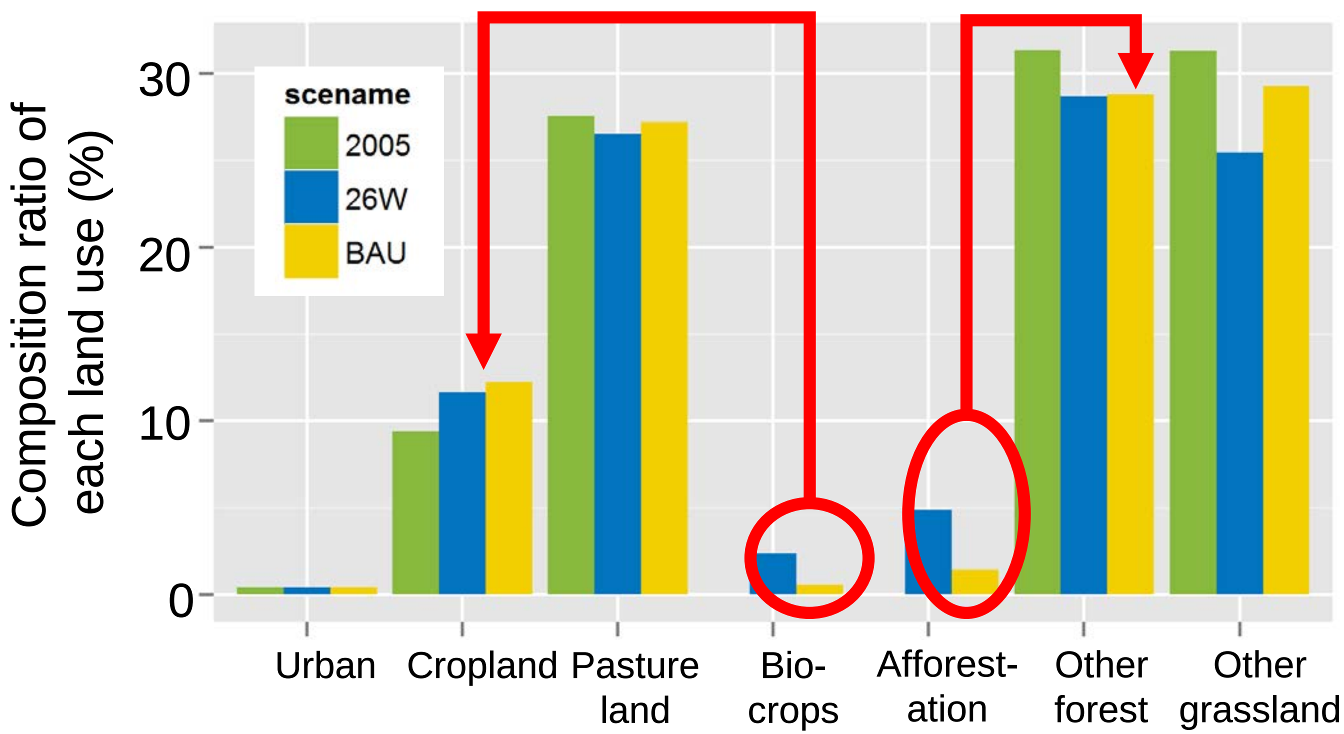


Source of the icon: http://icooon-mono.com/

Methods: Scenarios of future (2050s and 2070s)

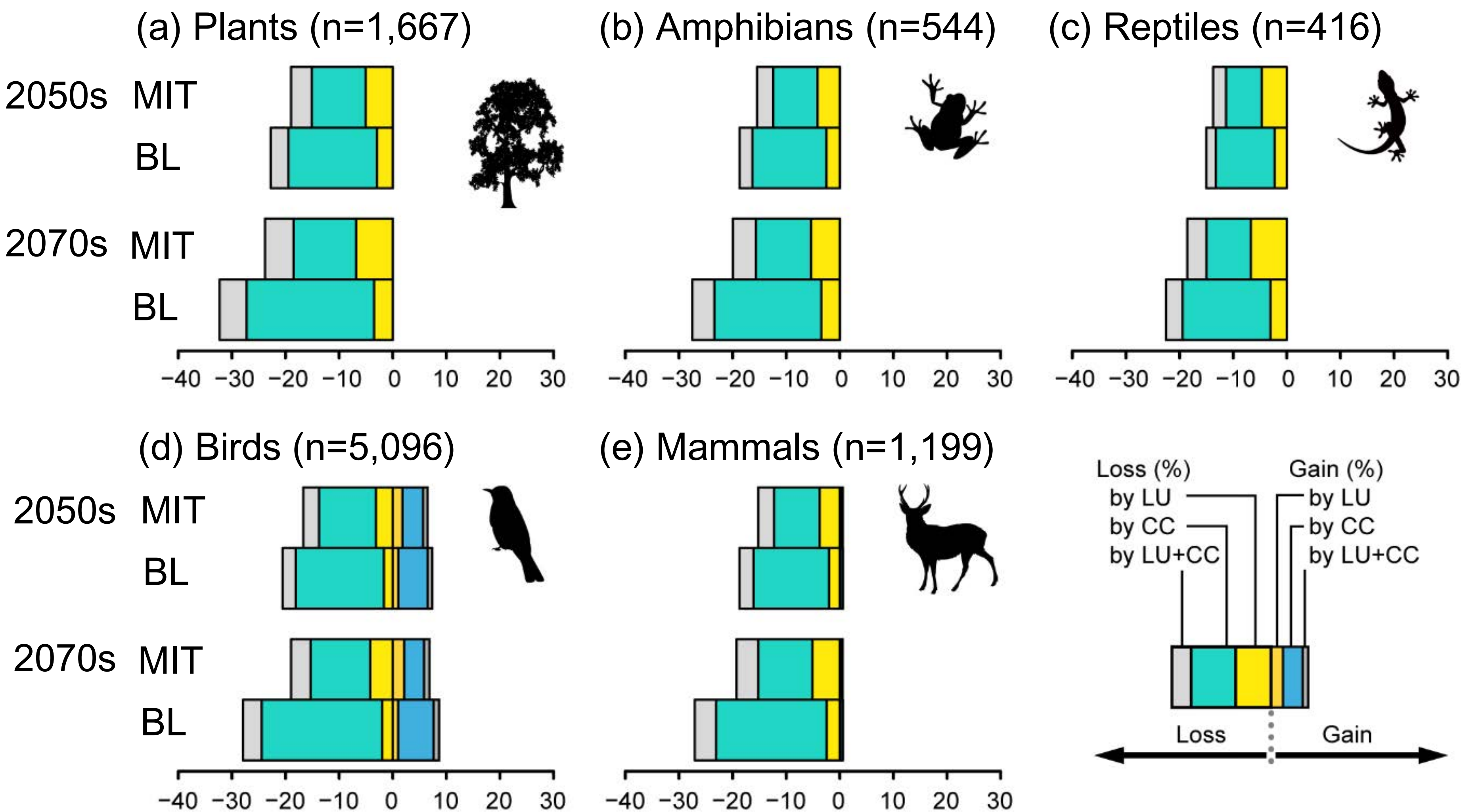
Scenario	Climate (5 GCMs*)	Land use (1 SSP)	Summary
Mitigation (MIT)	**RCP2.6**	26W	Implementation of mitigation measures such as afforestation and renewable energy use on a large scale to achieve 2-degree goal
Baseline (BL)	**RCP8.5**	BAU	No efforts against global warming

*GFDL-CM3; HadGEM2-ES;IPSL-CM5A-LR; MIROC-ESM-CHEM; NorESM1-M



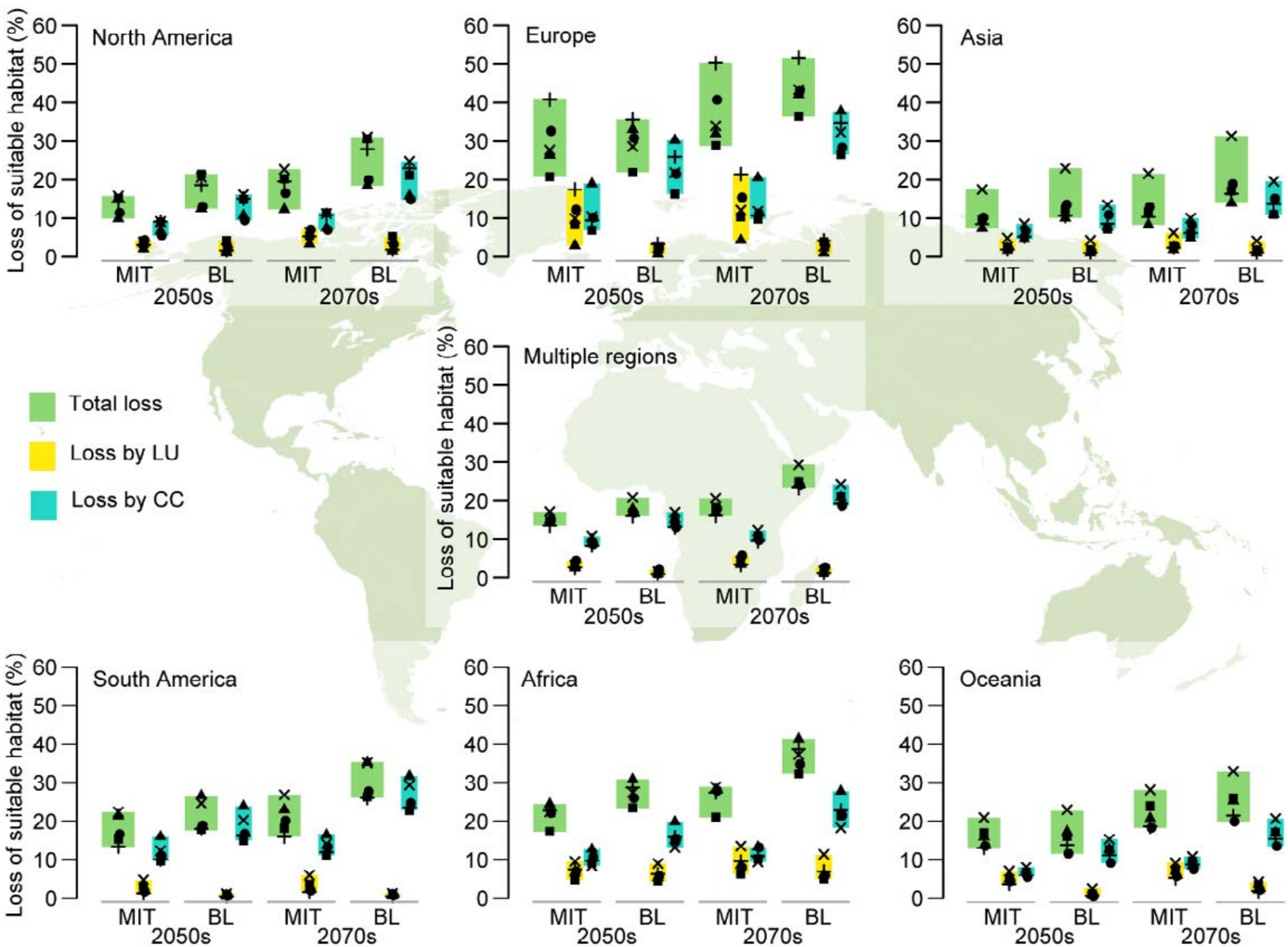
Hasegawa *et al.* (2017) *Science of the Total Environment* 580: 787-796

Results



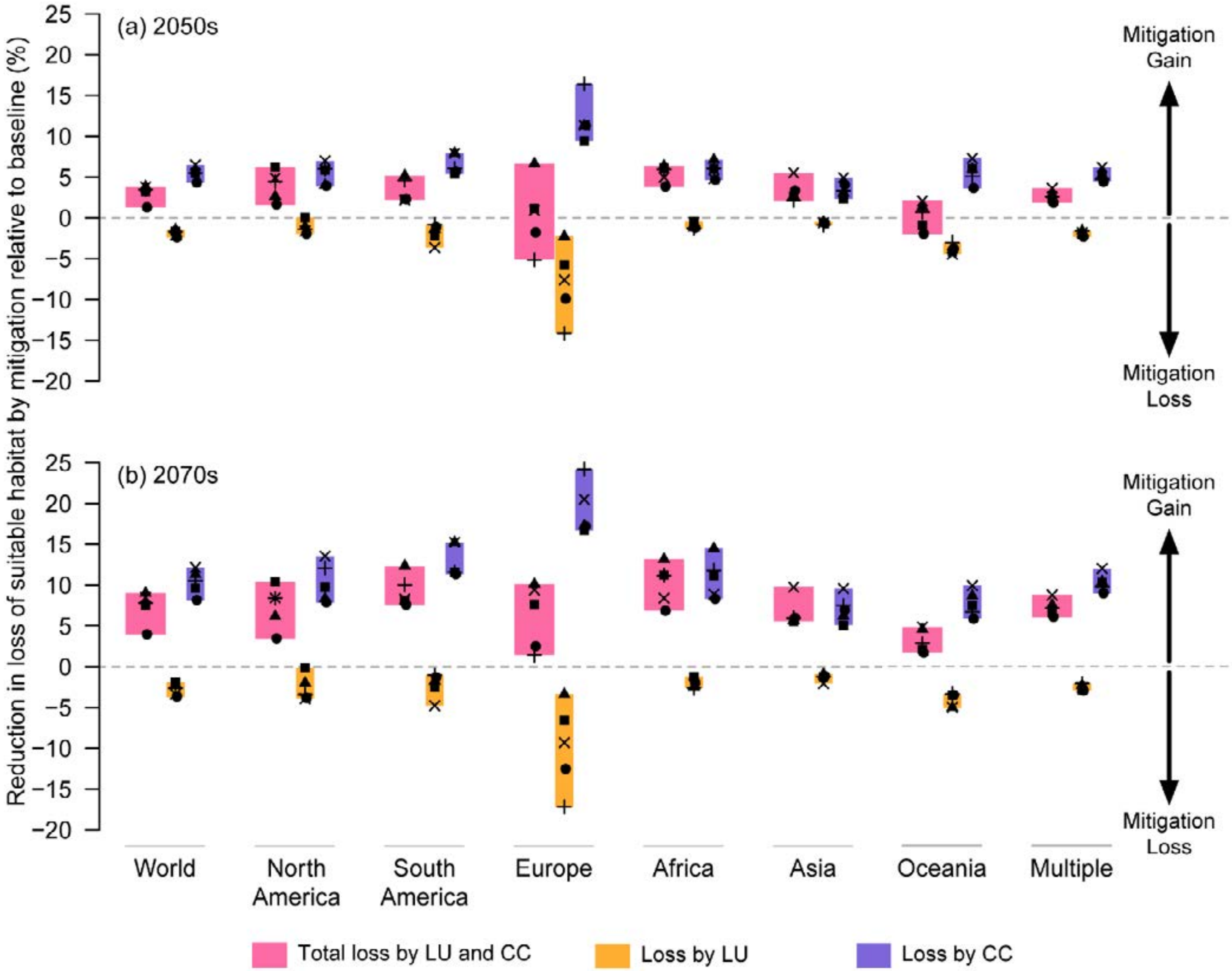
Proportion of losses and gains in suitable habitat from the present to 2050s and 2070s in mitigation (MIT) and baseline (BL) scenarios.

Results



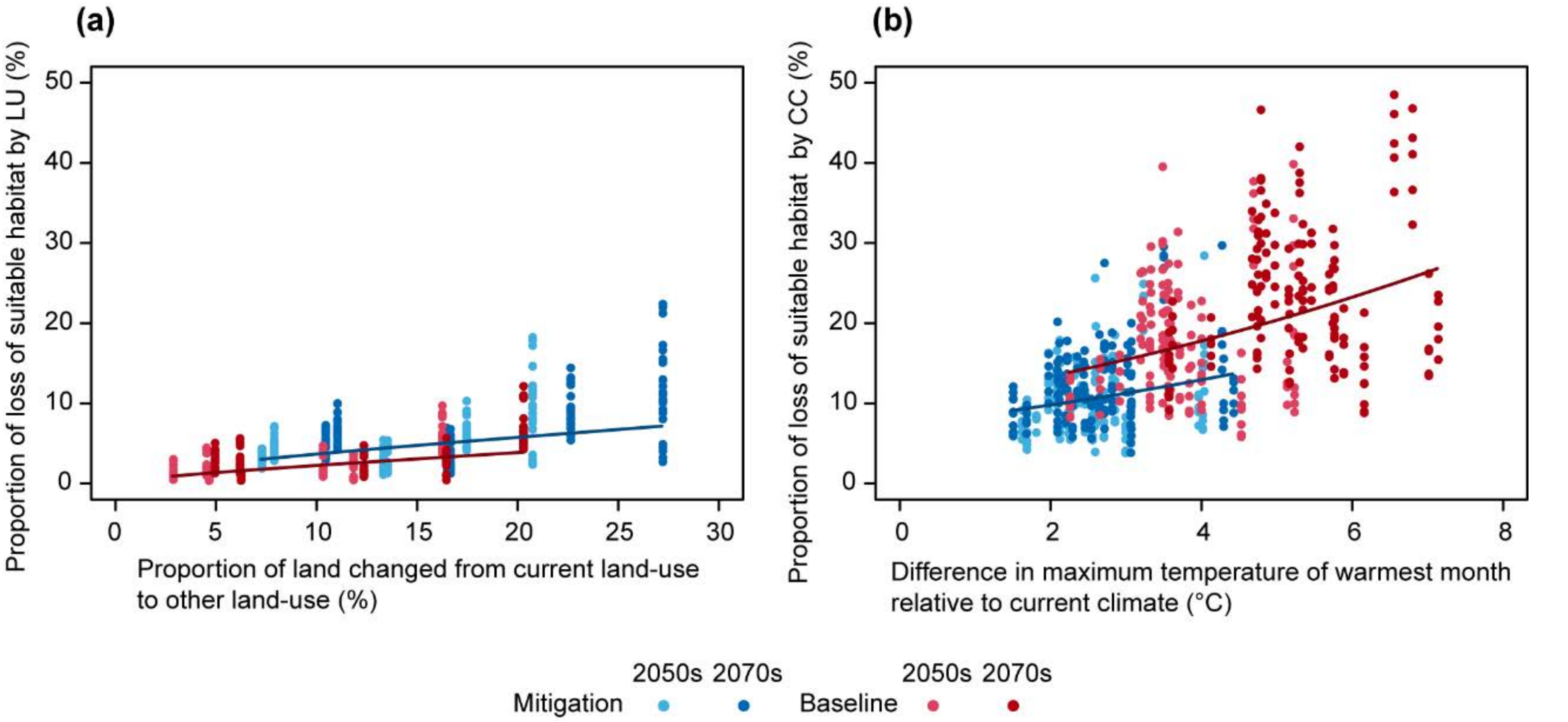
Proportion of total loss, loss due to land-use change, and loss due to climate change in suitable habitat from current to 2050s/2070s in mitigation (MIT) and baseline (BL) scenarios, aggregated by species' native region and taxonomic groups.

Results



Net benefit of mitigation policy: reduction of proportion of loss of suitable habitat from the present to 2050s/2070s by mitigation relative to baseline, aggregated by species' native region and taxonomic groups.

Results



Effect of magnitude of land-use change and climate change on regional variation in loss of suitable habitat. (a) Difference in proportion of land changed (b) difference in Maximum temperature of warmest month

Summary

- Compared to a lack of climate change policies, we found that stringent greenhouse gas mitigation, in general, can bring a net benefit to global biodiversity even if land-based mitigation is adopted.

- This trend is strengthened in the latter half of this century.

- However, some regions projected to experience a large growth in land-based mitigation (i.e., Europe and Oceania) are expected to suffer a loss of biodiversity.

- Our results support the enactment of stringent climate change mitigation policies in terms of biodiversity, but to conserve local biodiversity, these policies will require careful design along with land-use regulation.

Thank you for your attention!!

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- Special thanks to

  Hiroyuki MATSUDA (YNU), Akira MORI (YNU), Kei-ichi OKADA (YNU), Yusuke YONEKURA (YNU), Takuto SHITARA (Tsukuba Univ.),Tomomi KUBOTA (FFPRI), Keita FUKASAWA (NIES)

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Strategic Research on Global Mitigation and Local Adaptation to Climate Change (S-14)

Impact assessment on biodiversity by using Integrated Assessment Model

- **<u>Integrated Assessment Model</u>**

…A model for future projection of human society and ecosystems under climate change and mitigation measures such as energy use, industrial development, agriculture, and land use change (e.g., deforestation, agricultural lands).

→ Important to assess the impact of socio-economic activities on ecosystem and to propose appropriate policy options

T. Hasegawa et al. / Science of the Total Environment 580 (2017) 787–796

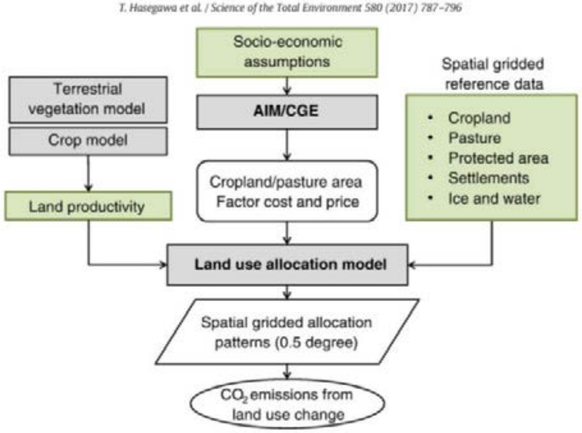

Fig. 1. Overall framework of the land-use allocation methodology.

Hasegawa *et al*. (2017) Science of the Total Environment
Land use projection at a global scale by using Integrated Assessment Model, AIM/CGE
→ It is possible to predict impact on biodiversity

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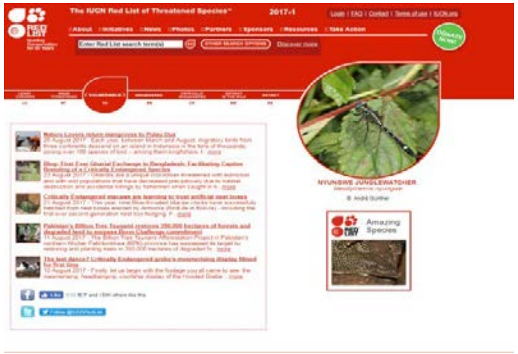
AIM ASIA-PACIFIC INTEGRATED MODEL

Asia-Pacific Integrated Model

Habitat assessment model

Target : 8,928 species of plants, amphibians, reptiles, birds, and mammals

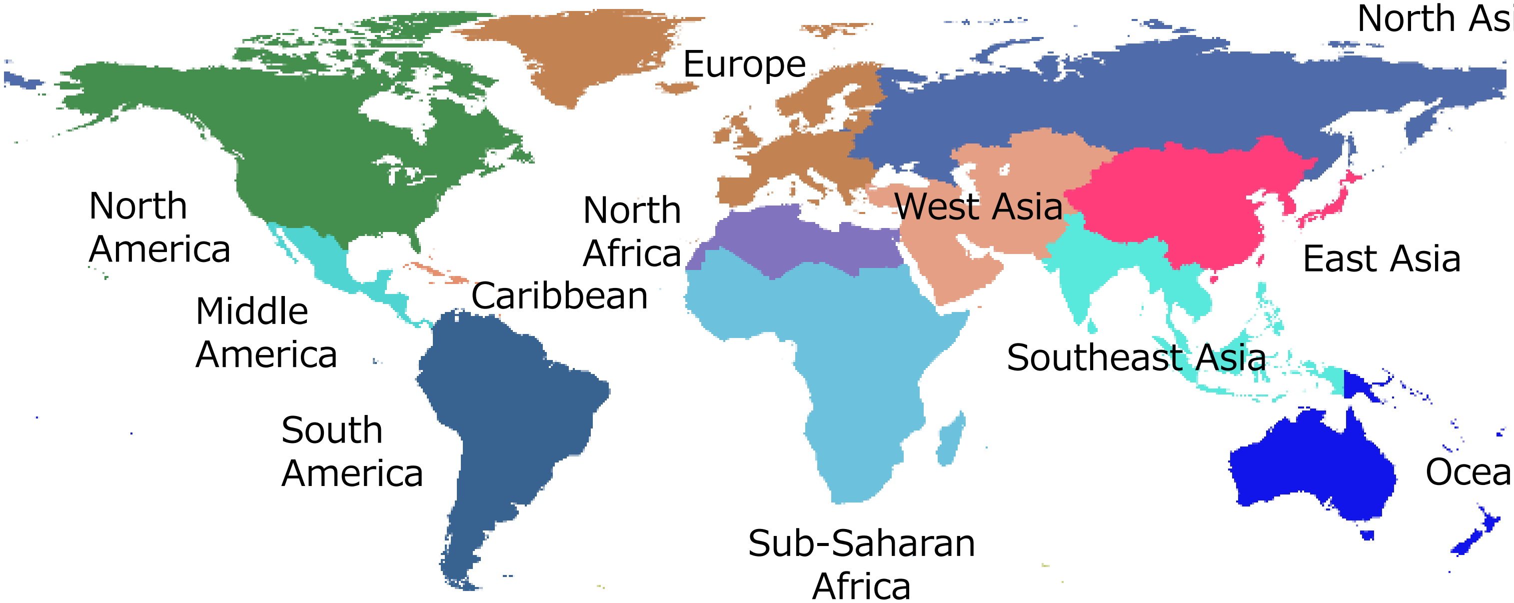
- Terrestrial species evaluated by **IUCN Red Data Book**
  (We can obtain enough information on ecology and distribution of these species)
- More than **30 presence points** (in their native distribution region)



IUCN HP（http://www.iucnredlist.org）

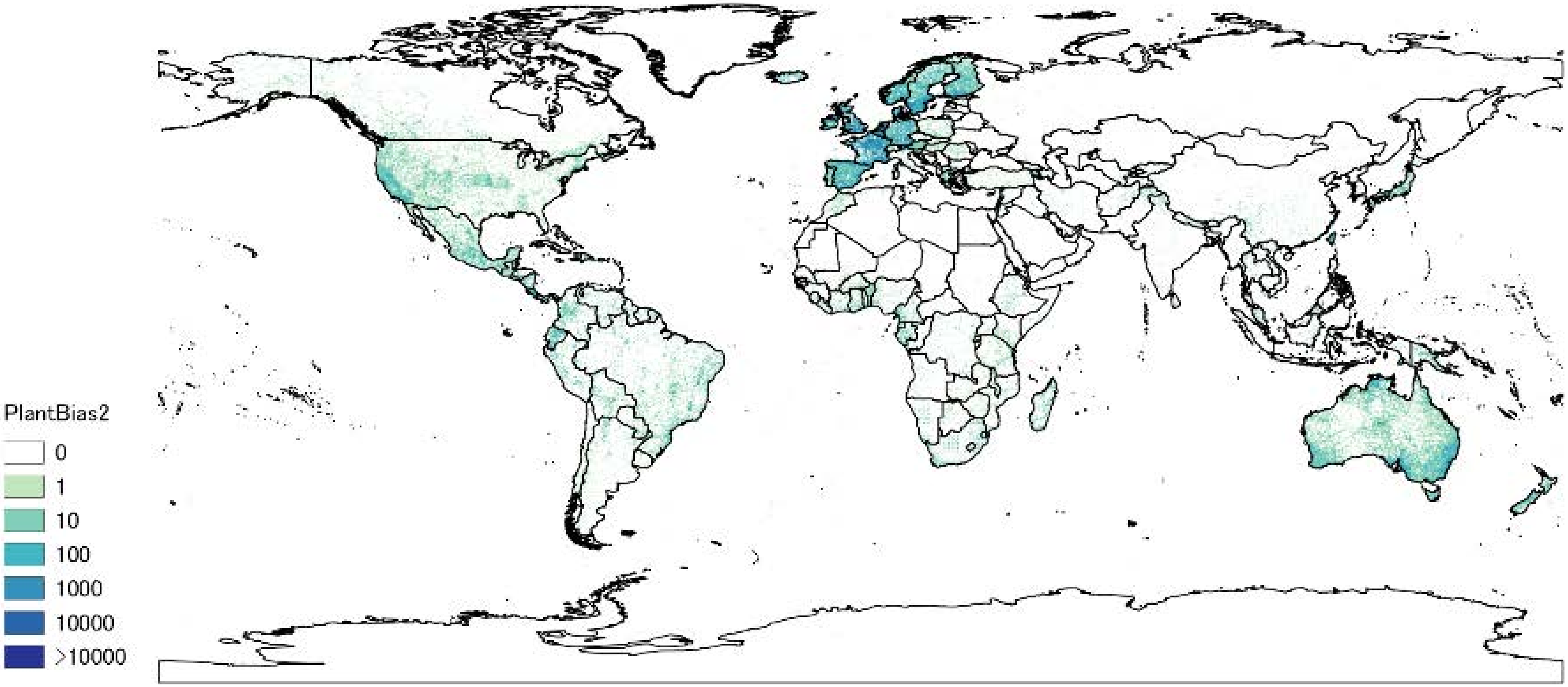
→ We obtained a list of native habitats (12 areas except Antarctica)

- **Presence / absence classification of each regions**
  - **Recognition as a background area**



Bias correction of spatial distribution data

No. of data in each grid (Plant)



Counting the No. of data in each grid on Plantae, Amphibia, Reptilia, Aves, Mammalia

→ Correcting a bias following Phillips *et al.* (2009) *Ecol. Appl.* 19, 181-197.

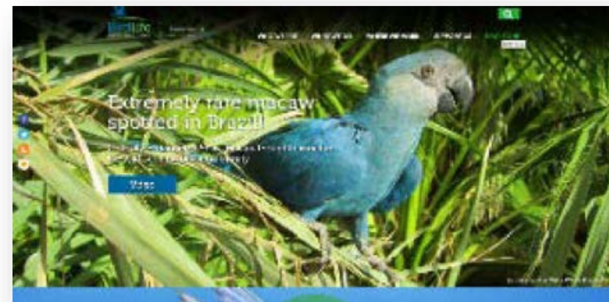
Building of species traits database

[Plant : Dispersal characteristics, Growth form ; Animal : Weight, Generation interval, Feeding habit※]

※Feeding habit including Mammals and Aves only

IUCN Red List of Threatened Species

Birdlife International



Amphibia web

Data papers

Plant dispersal characteristics : Confirmed by literature

Allometric equations

Plant : Tamme *et al.* (2014) *Ecology* 95: 505-513
Mammals, Aves : Hilbers *et al.* (2016) *Ecology* 97: 615-626

Hilbers *et al.* (2016)

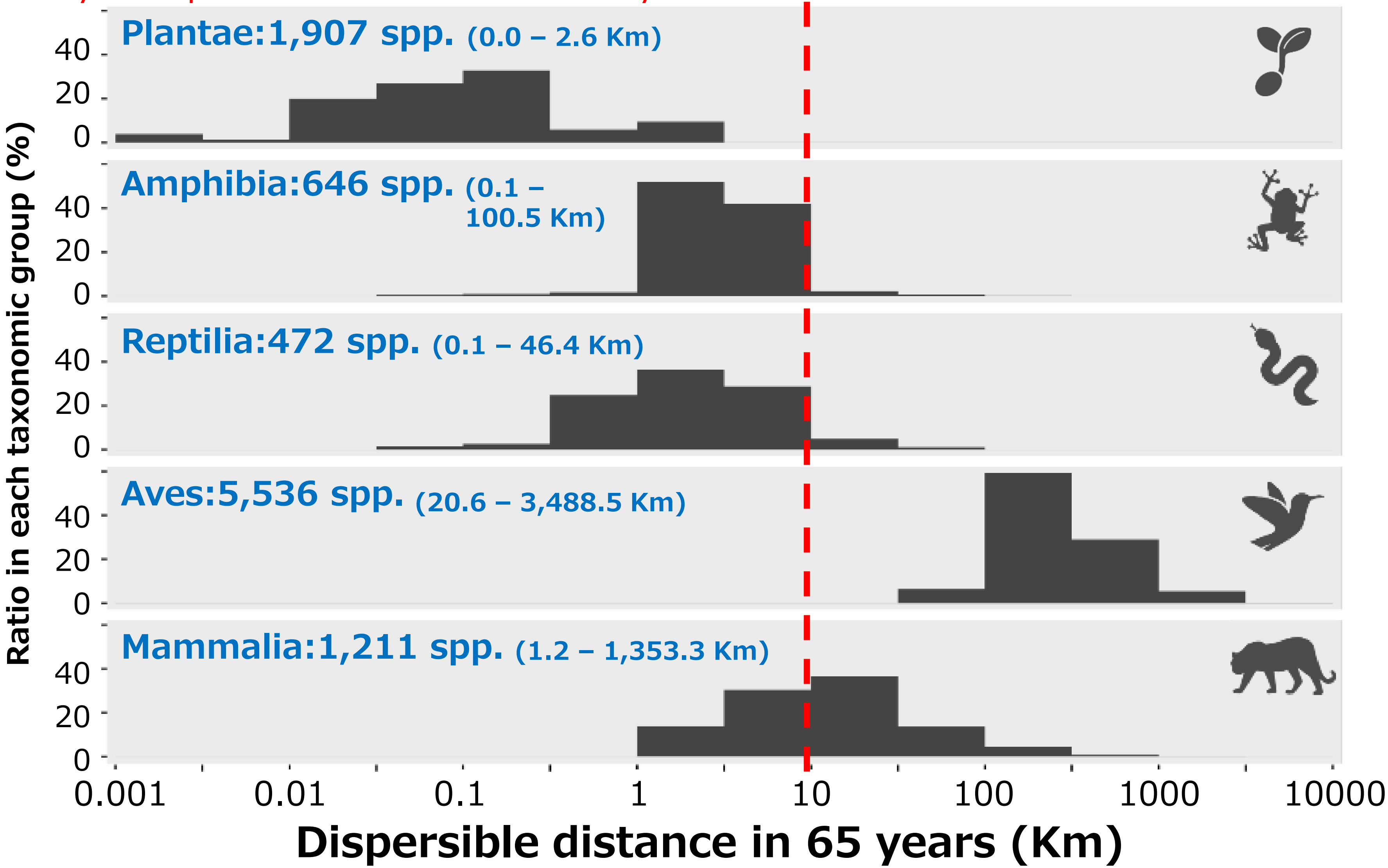
Home range size	HR	km^2	$\frac{3 \times m^{\varepsilon}}{N_D}$	carnivorous birds	$2.1 \times 10^2 \times m^{1.13}$
				non-carnivorous birds	$3.7 \times 10^1 \times m$
				carnivorous mammals	$3.8 \times 10^{-1} \times m^{1.13}$
				non-carnivorous mammals	$5.4 \times 10^{-2} \times m$
Median natal dispersal distance	d_m	km/ generation	$\gamma_H \times \sqrt{HR}$	carnivorous/non-carnivorous birds	$12 \times HR^{0.5}$
				carnivorous/non-carnivorous mammals	$5.6 \times HR^{0.5}$

e.g. Grouse (*Lagopus muta*)(岩雷鳥)
Weight : 521 g
Feeding habit : Omnivore or herbivore
Generation interval : 4.2 years
→ Dispersed distance in 65 years is 815.4 Km (calculated)

※Amphibia, Reptilia : Developed allometric equations (Dispersed distance - Weight)

Estimate value of dispersible distance by using species traits database

It was difficult to detect the influence of dispersal by the spatial resolution in this analysis



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