



IIS

**INTERNATIONAL
INSTITUTE FOR
SUSTAINABILITY**

PUC
RIO



RIO CONSERVATION AND
SUSTENTABILITY SCIENCE CENTRE

Systems Analysis, Restoration and Sustainable Development Goals

**Systems Analysis and the Americas
2019**

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UN Decade on Ecosystem Restoration

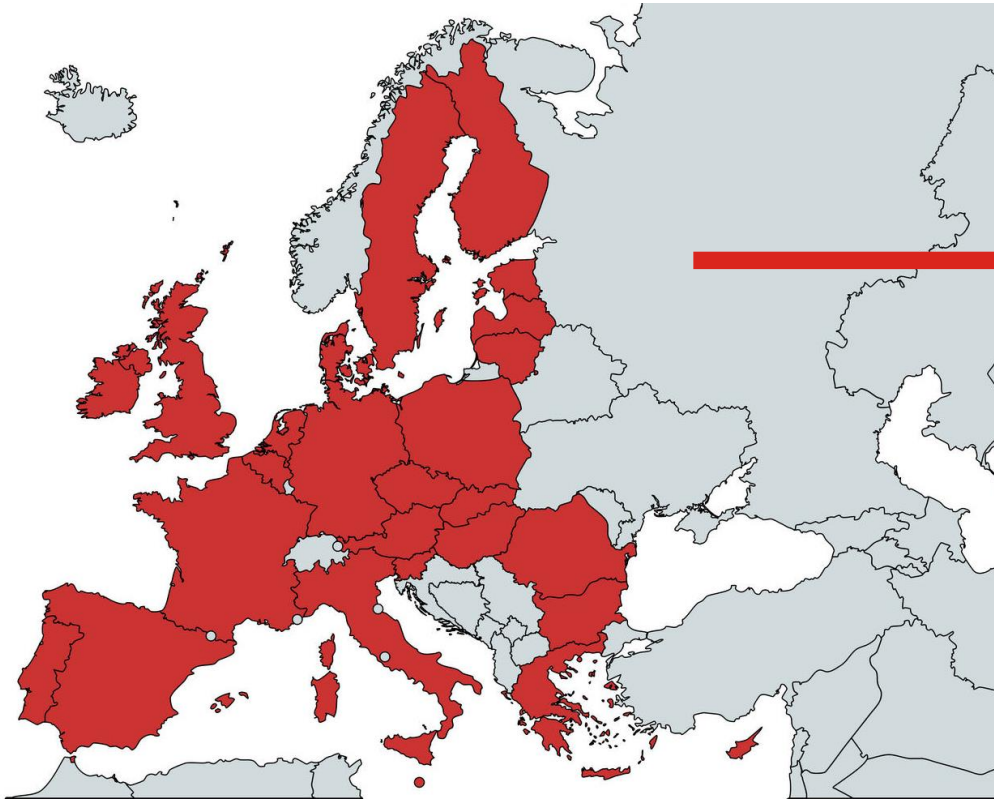
At the request of El Salvador, on March 1st, 2019 the UN General Assembly declared that 2021-2030 would be the UN Decade on Ecosystem Restoration

It aims to massively scale up the restoration of degraded and destroyed ecosystems as a proven measure to fight the climate crisis and enhance food security, water supply and biodiversity.

Ecosystem restoration provides multiple benefits but also incurs potential costs.

Identifying areas where these benefits can be jointly optimized at the same time that costs are minimized will increase the chances of restoration success.

Current Global Restoration Goals



- 15% of degraded lands (Aichi 15)

- 350 million hectares



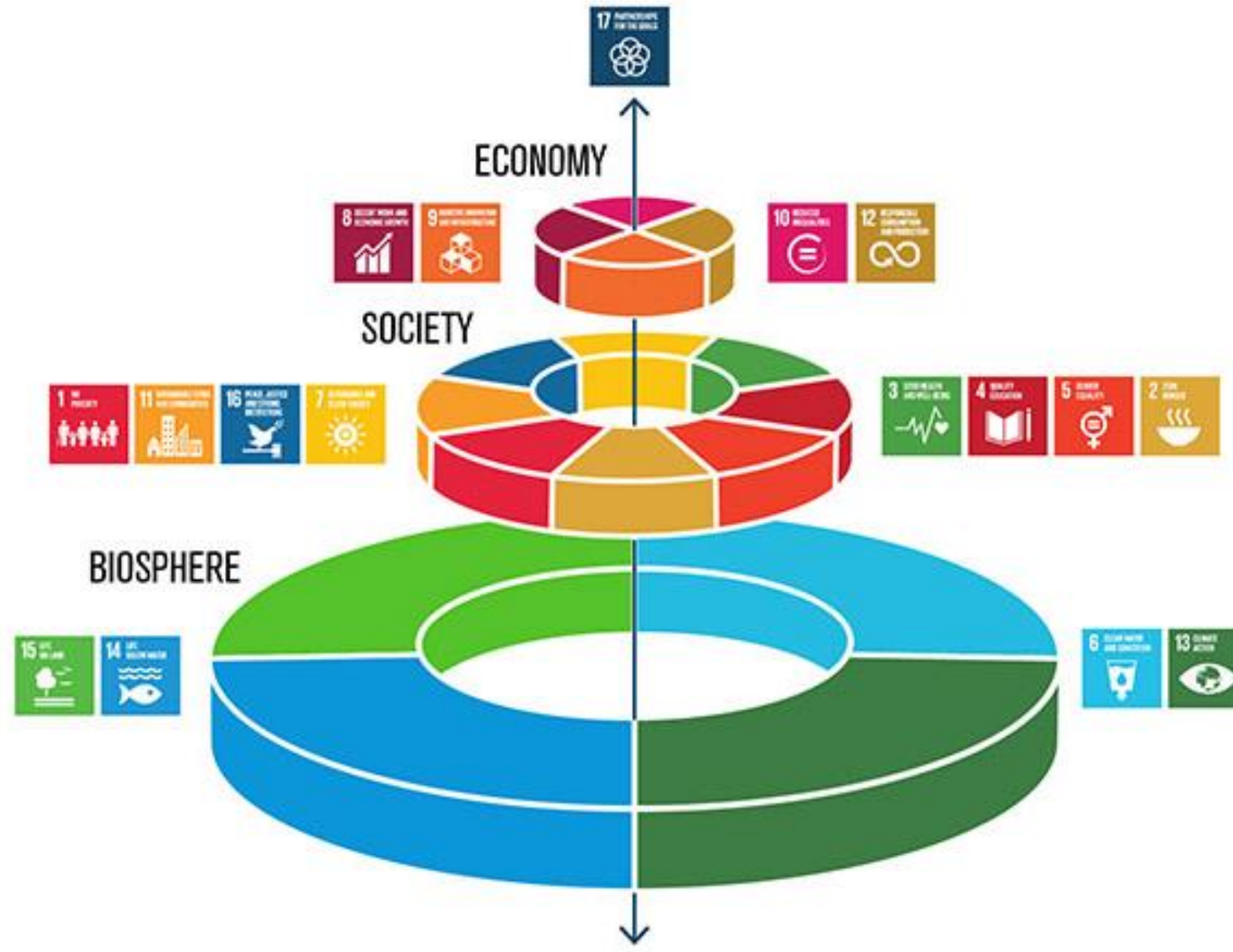
equivalente area of ecosystem
restoration in one human generation

*The fastest reshaping of land
surface in human history*



Current Global Restoration Goals





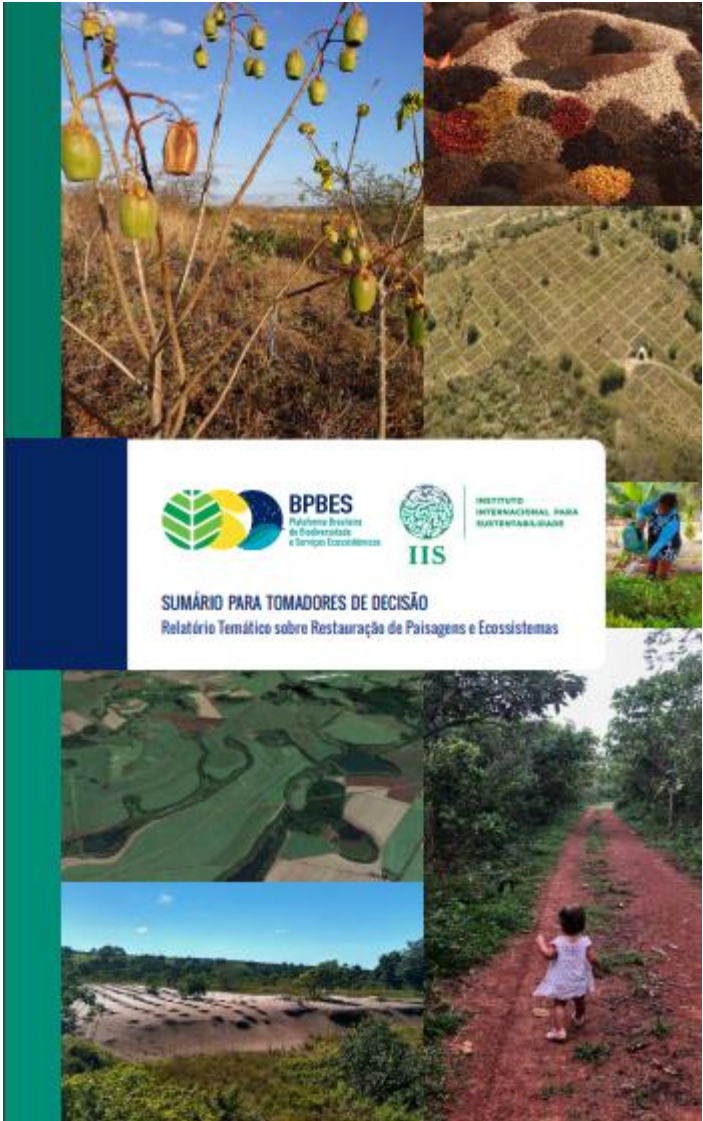
Restoring landscapes for a sustainable future



IIS



- 15 LIFE ON LAND
- 13 CLIMATE ACTION
- 8 DECENT WORK AND ECONOMIC GROWTH
- 3 GOOD HEALTH AND WELL-BEING
- 5 GENDER EQUALITY
- 10 REDUCED INEQUALITIES
- 2 ZERO HUNGER





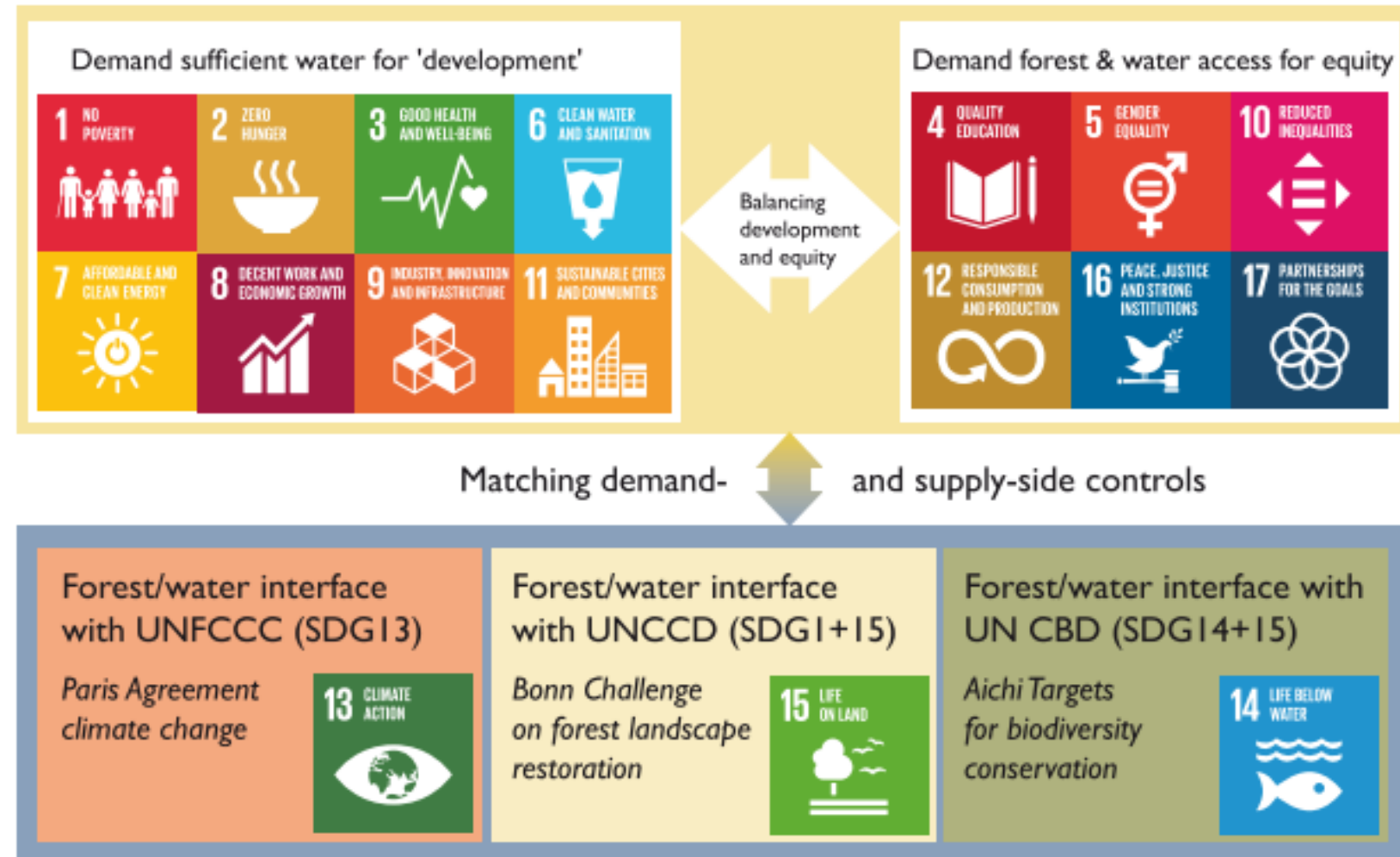
TARGET 6.6



PROTECT AND RESTORE
WATER-RELATED
ECOSYSTEMS

Sustainable Development Goals (SDGs) in relation to forest/water relations

Figure
1.1



Source: Authors' own elaboration

A strategic approach to restoration planning



In 2013, Brazil approved its Native Vegetation Protection Law, resulting in legal requirements to restore 12 million hectares.

From 2013 to 2017, IIS coordinated an international multidisciplinary team to develop a tool to identify priority areas for restoration and quantify their impacts.

This tool should:

1 Be flexible, to integrate multiple criteria chosen by decision makers;

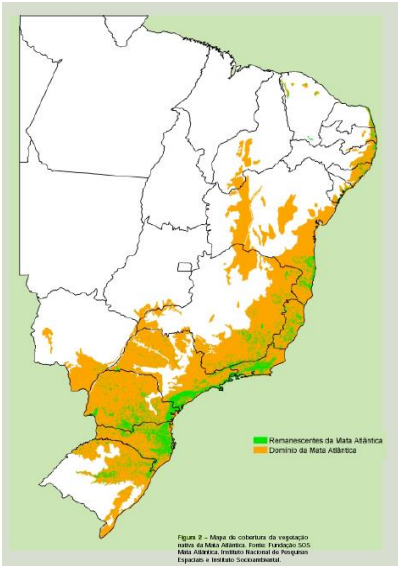
2 Be precise, identifying the exact priority areas for those criteria;

3 Be able to measure the impacts of the restoration in units decision makers can use (tonnes of CO₂ sequestered, number of species extinctions avoided, monetary cost etc); quantify synergies and trade-offs

A strategic approach to restoration planning

In 2017, we applied this tool for the first time to the Atlantic Forest in Brazil, a global biodiversity hotspot that already lost 80% of its original area and has a restoration target of approximately 5 million hectares;

These maps are going to be launched by the Brazilian government as official priority maps for restoration of the Atlantic Forest



In 2018, Brazil commissioned IIS to prepare similar analysis, priority maps and impact assessments for all six biomes of Brazil, to be used as official priority maps of restoration



A strategic approach to restoration planning

The logo for the journal Nature Ecology & Evolution is displayed on a dark olive green rectangular background. The text 'nature ecology & evolution' is written in a white, serif font, with 'nature' on the first line, 'ecology &' on the second, and 'evolution' on the third.

In December 2018, the scientific journal Nature Ecology and Evolution published a scientific paper detailing this tool and its application for the Atlantic Forest, based on the scientific advances developed and usefulness for policy implementation;

In 2018, in collaboration with members of the Convention on Biological Diversity, the International Union for the Conservation of Nature (IUCN), among others, IIS applied its tool to produce the first global prioritization for restoration and assessment of the outcomes of global restoration targets.



A first application: Brazil's Atlantic Forest

Strategic approaches to restoring ecosystems can triple conservation gains and halve costs

Bernardo B. N. Strassburg^{1,2,3*}, Hawthorne L. Beyer⁴, Renato Crouzeilles^{1,2,3}, Alvaro Iribarrem^{1,2}, Felipe Barros², Marinez Ferreira de Siqueira⁵, Andrea Sánchez-Tapia⁵, Andrew Balmford⁶, Jerônimo Boelsums Barreto Sansevero⁷, Pedro Henrique Santin Brancalion⁸, Eben North Broadbent⁹, Robin L. Chazdon^{2,10,11}, Ary Oliveira Filho¹², Toby A. Gardner^{2,13}, Ascelin Gordon¹⁴, Agnieszka Latawiec^{1,2,15,16}, Rafael Loyola¹⁷, Jean Paul Metzger¹⁸, Morena Mills¹⁹, Hugh P. Possingham^{20,21}, Ricardo Ribeiro Rodrigues²², Carlos Alberto de Mattos Scaramuzza²³, Fabio Rubio Scarano^{3,24}, Leandro Tambosi²⁵ and Maria Uriarte²⁶

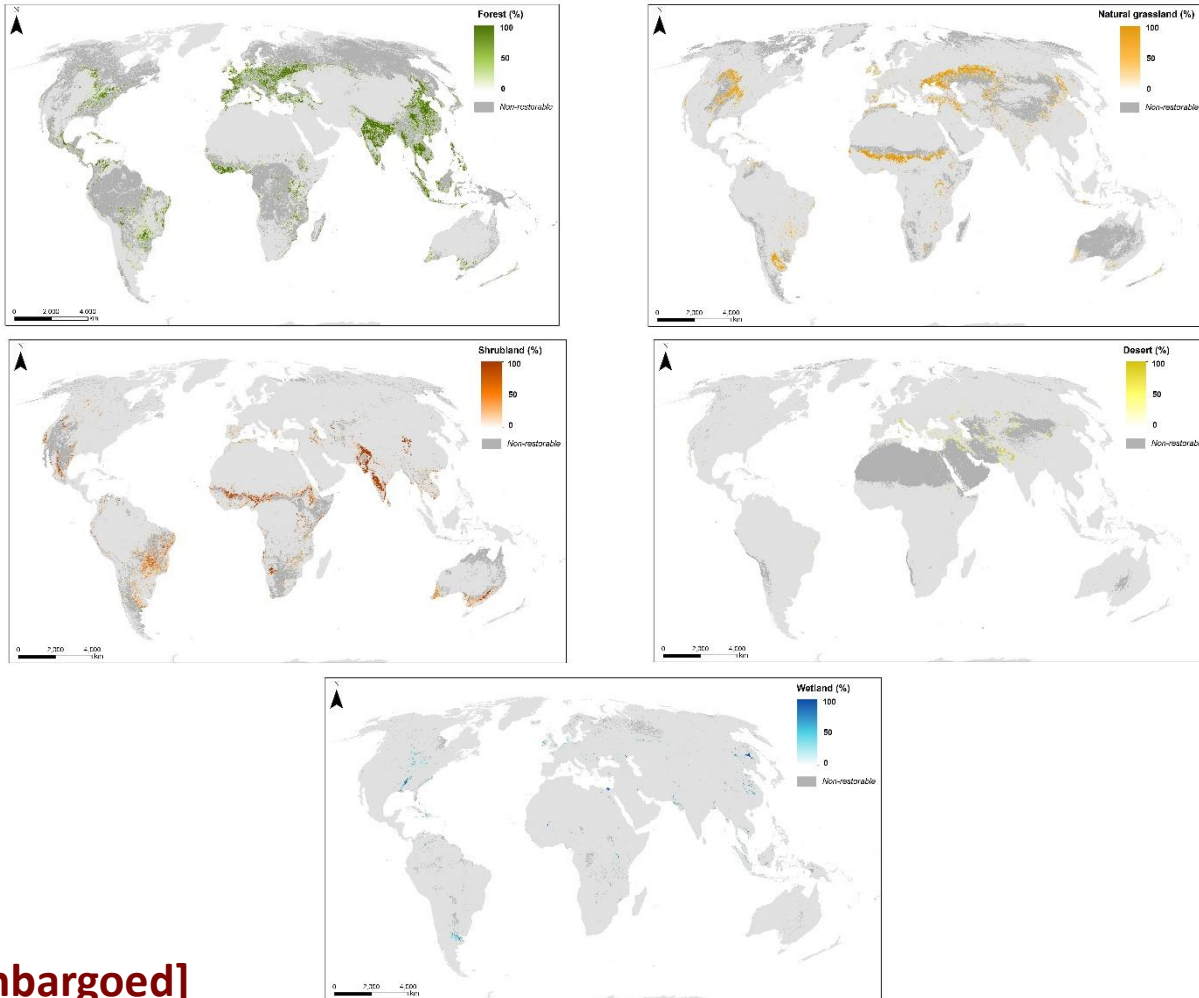
International commitments for ecosystem restoration add up to one-quarter of the world's arable land. Fulfilling them would ease global challenges such as climate change and biodiversity decline but could displace food production and impose financial costs on farmers. Here, we present a restoration prioritization approach capable of revealing these synergies and trade-offs, incorporating ecological and economic efficiencies of scale and modelling specific policy options. Using an actual large-scale restoration target of the Atlantic Forest hotspot, we show that our approach can deliver an eightfold increase in cost-effectiveness for biodiversity conservation compared with a baseline of non-systematic restoration. A compromise solution avoids 26% of the biome's current extinction debt of 2,864 plant and animal species (an increase of 257% compared with the baseline). Moreover, this solution sequesters 1 billion tonnes of CO₂-equivalent (a 105% increase) while reducing costs by US\$28 billion (a 57% decrease). Seizing similar opportunities elsewhere would offer substantial contributions to some of the greatest challenges for humankind.

A strategic approach to restoration planning – Going Global



- First global prioritisation effort
- 2.9 billion hectares of restorable lands identified
- Inclusion of forests, grasslands, shrublands, wetlands, deserts
- Individual focus for 22,431 species, estimates of conservation impact for them; IUCN -> ESH
- Estimates of carbon sequestration (ABGB + soil C)
- Estimates of agriculture opportunity costs
- Aichi Targets 15, NDCs, Bonn Challenge, NY Declaration on Forests
- Multiple collaborators

A strategic approach to restoration planning – Going Global



Restoration only back to original ecosystem type (no forests into grasslands...)

Estimates of original natural cover

Forests

Shrublands

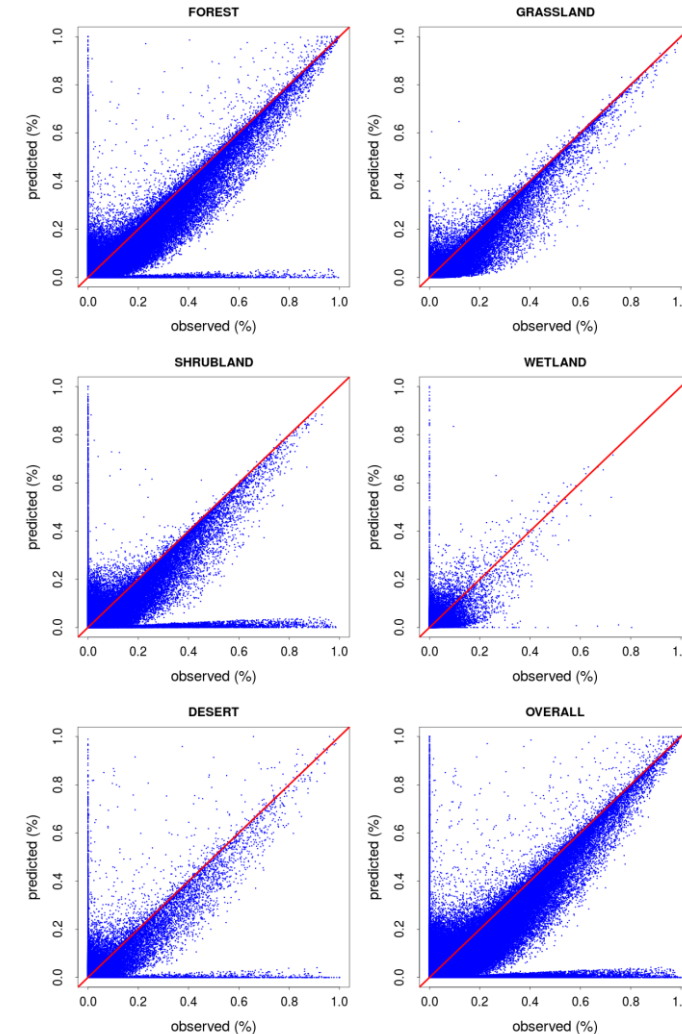
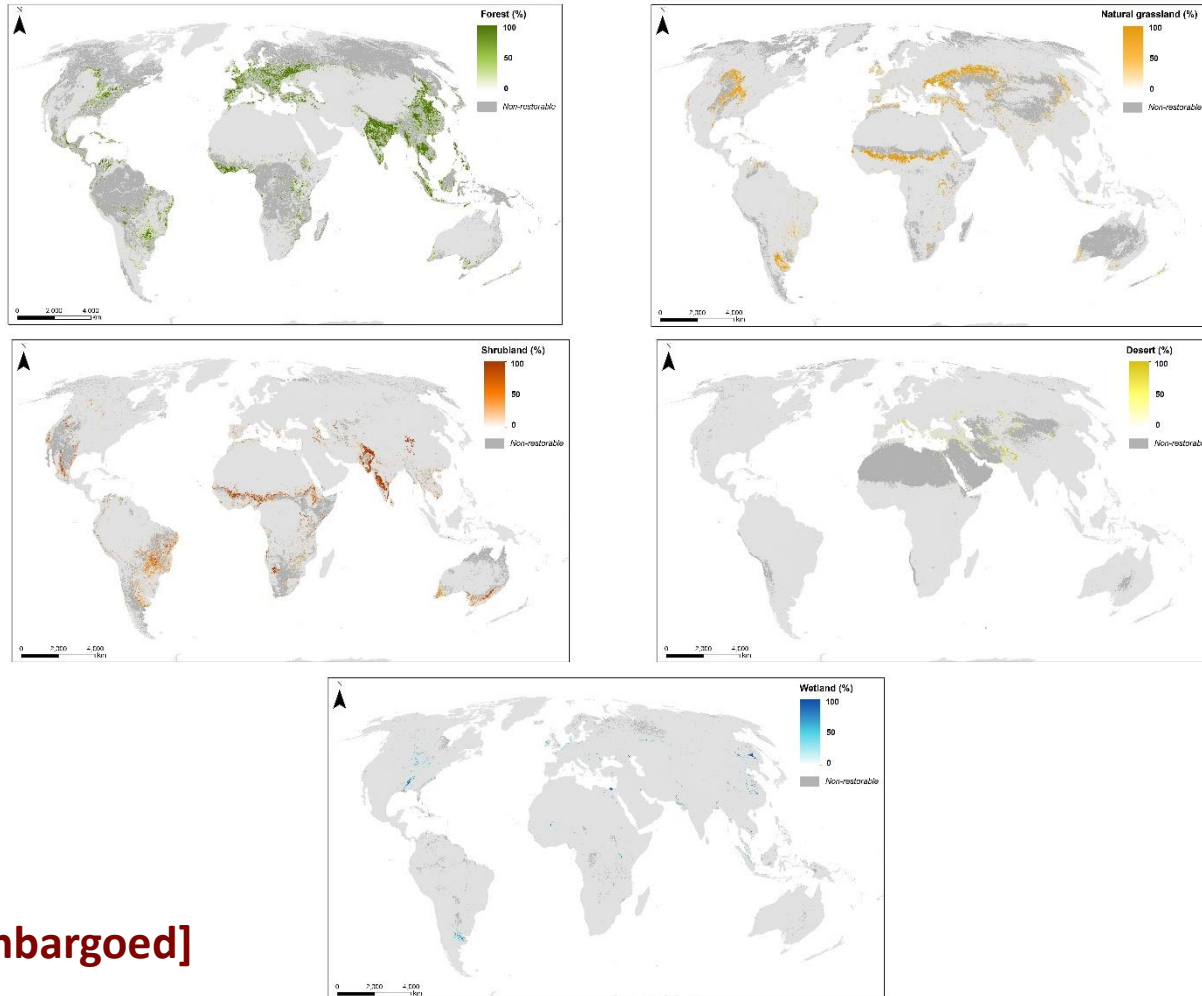
Wetlands

Grasslands

Deserts and semi-deserts

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A strategic approach to restoration planning – Going Global



Validation
using 25
years of
observed
data vs
estimated

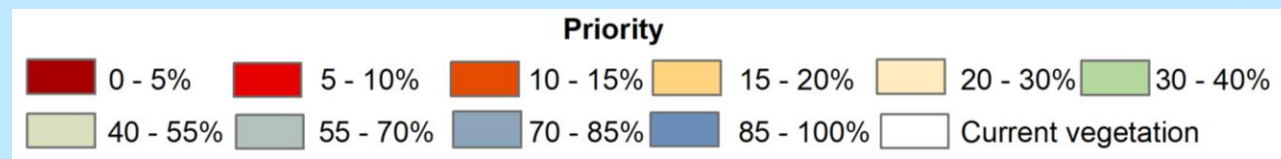
RMSE=6.73
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Global priority areas for restoration – Focus on Biodiversity only

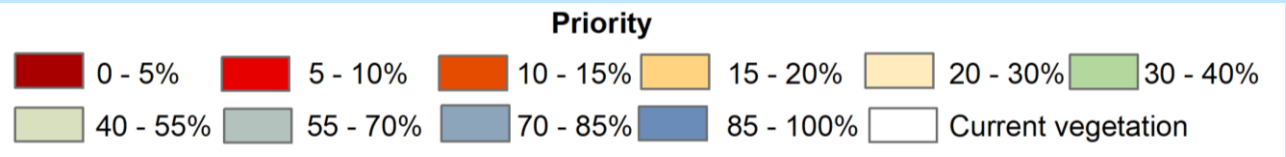
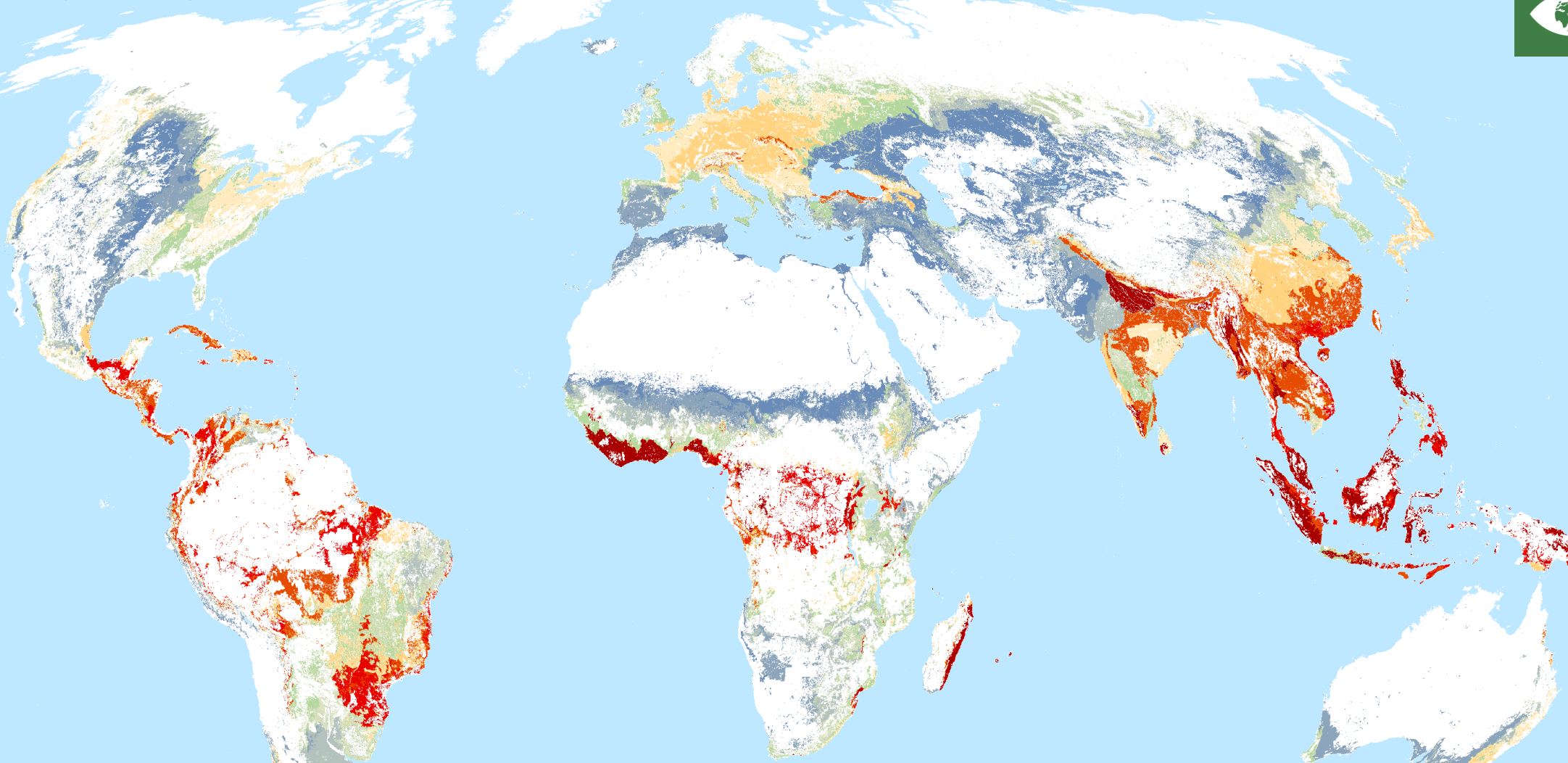


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Bernardo B. N. Strassburg

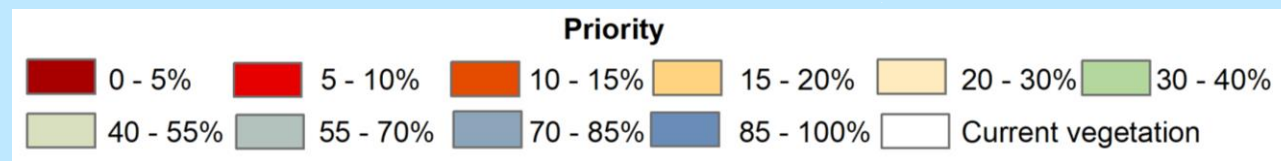
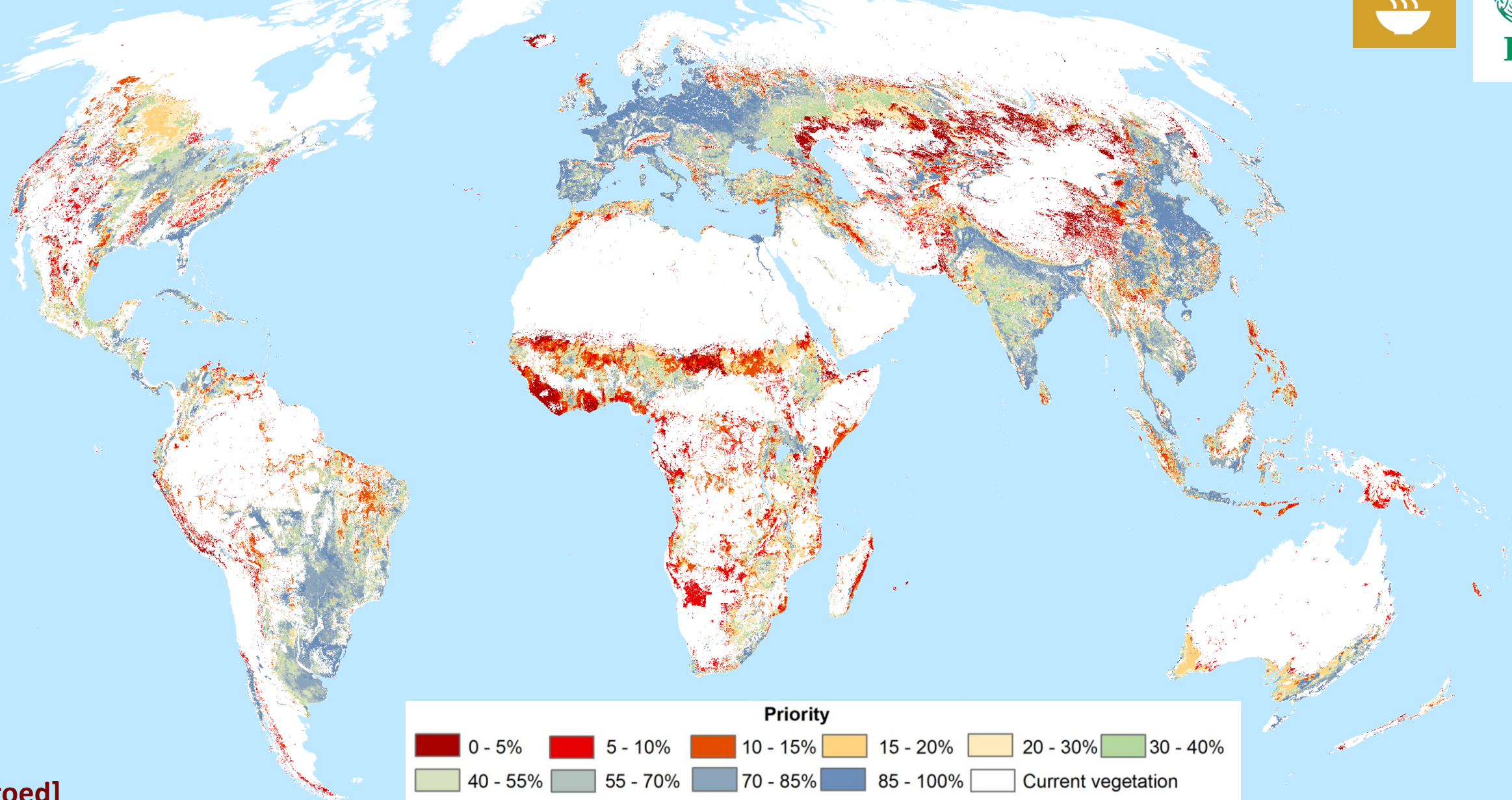
Global priority areas for restoration – Focus on Carbon only



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Bernardo B. N. Strassburg

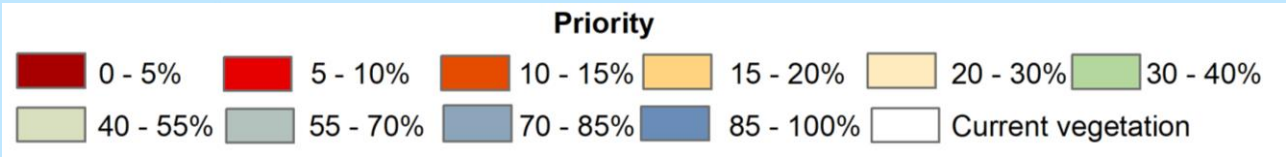
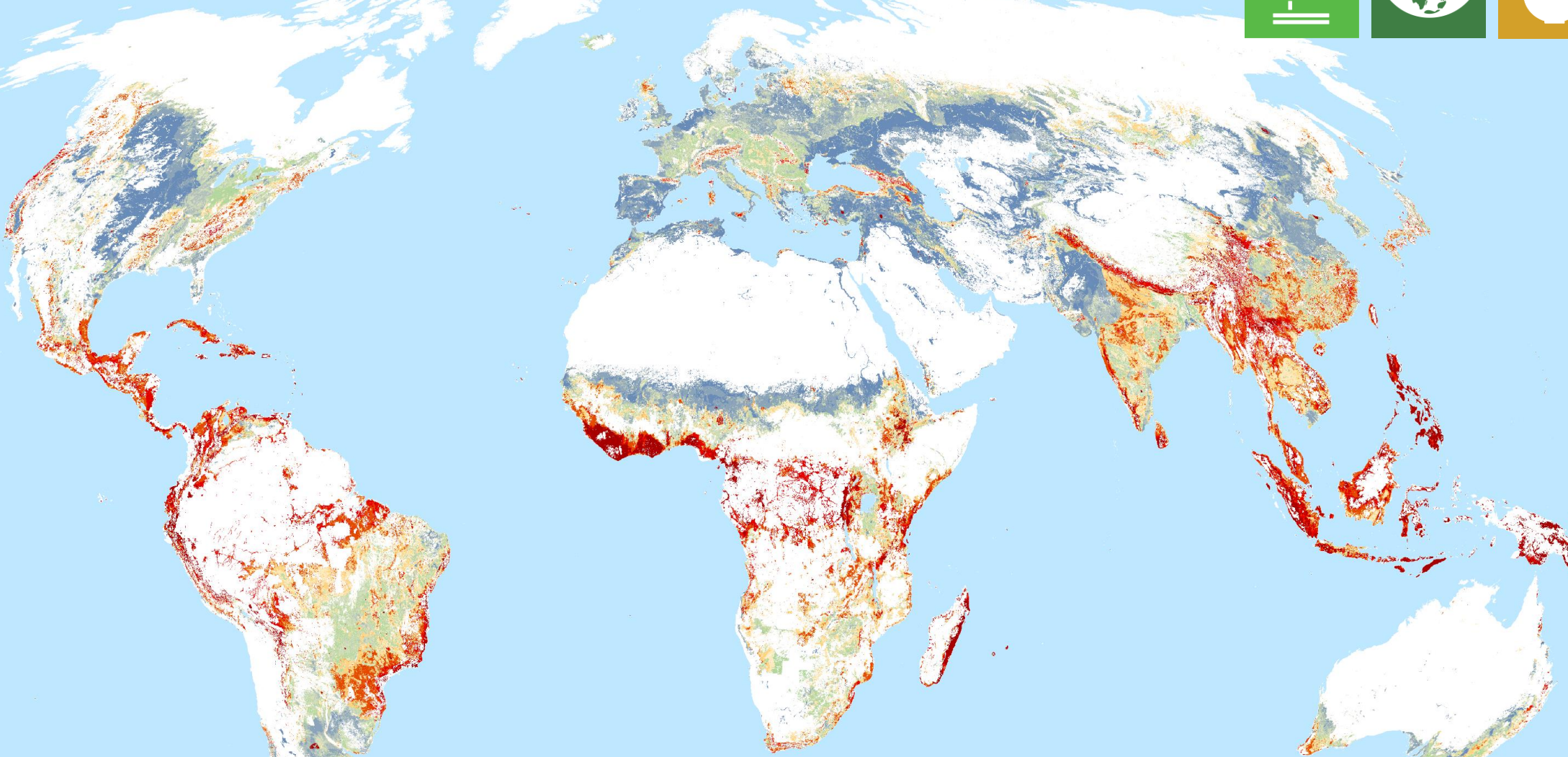
Global priority areas for restoration – Focus on Minimising opportunity costs only



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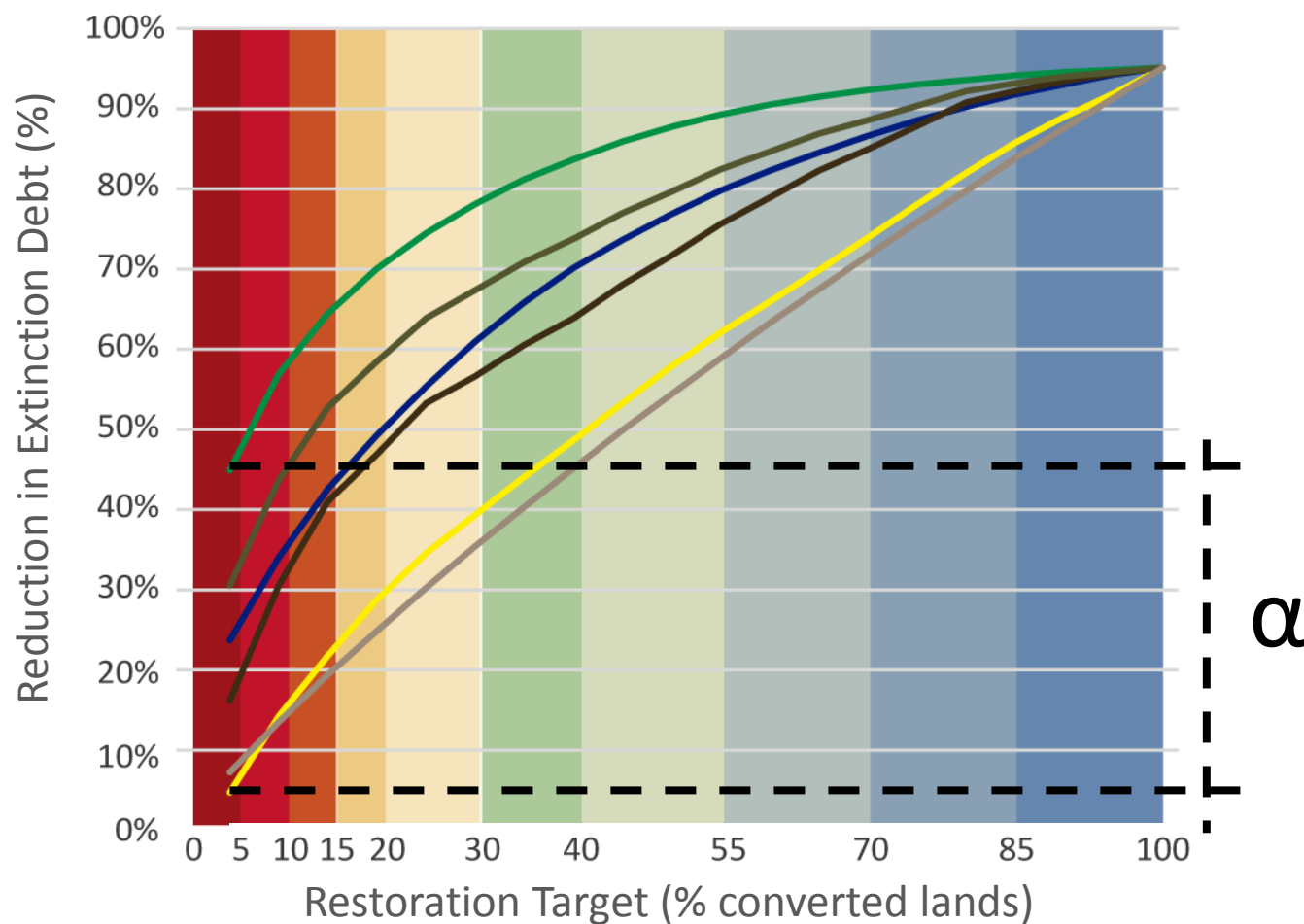
Bernardo B. N. Strassburg

Global priority areas for restoration – Multicriteria (inc costs)



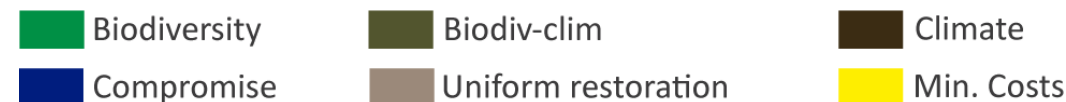
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Multiple restoration goals – the importance of Where

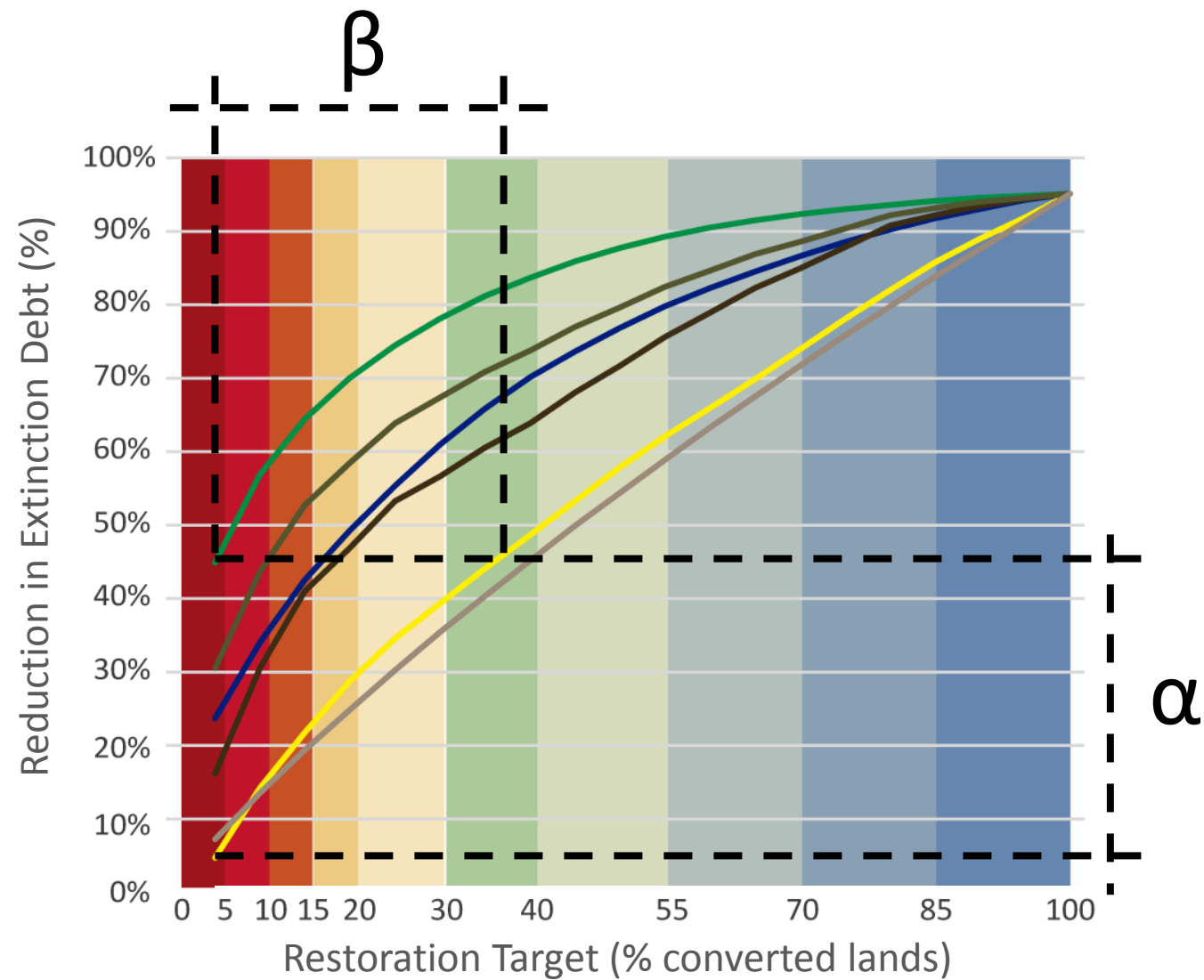


Huge differences in outcomes for the same area target, depending on where restoration takes place

(Example: The same 5% target can reduce extinctions by 4% or by 43%)



Multiple restoration goals – the importance of Where

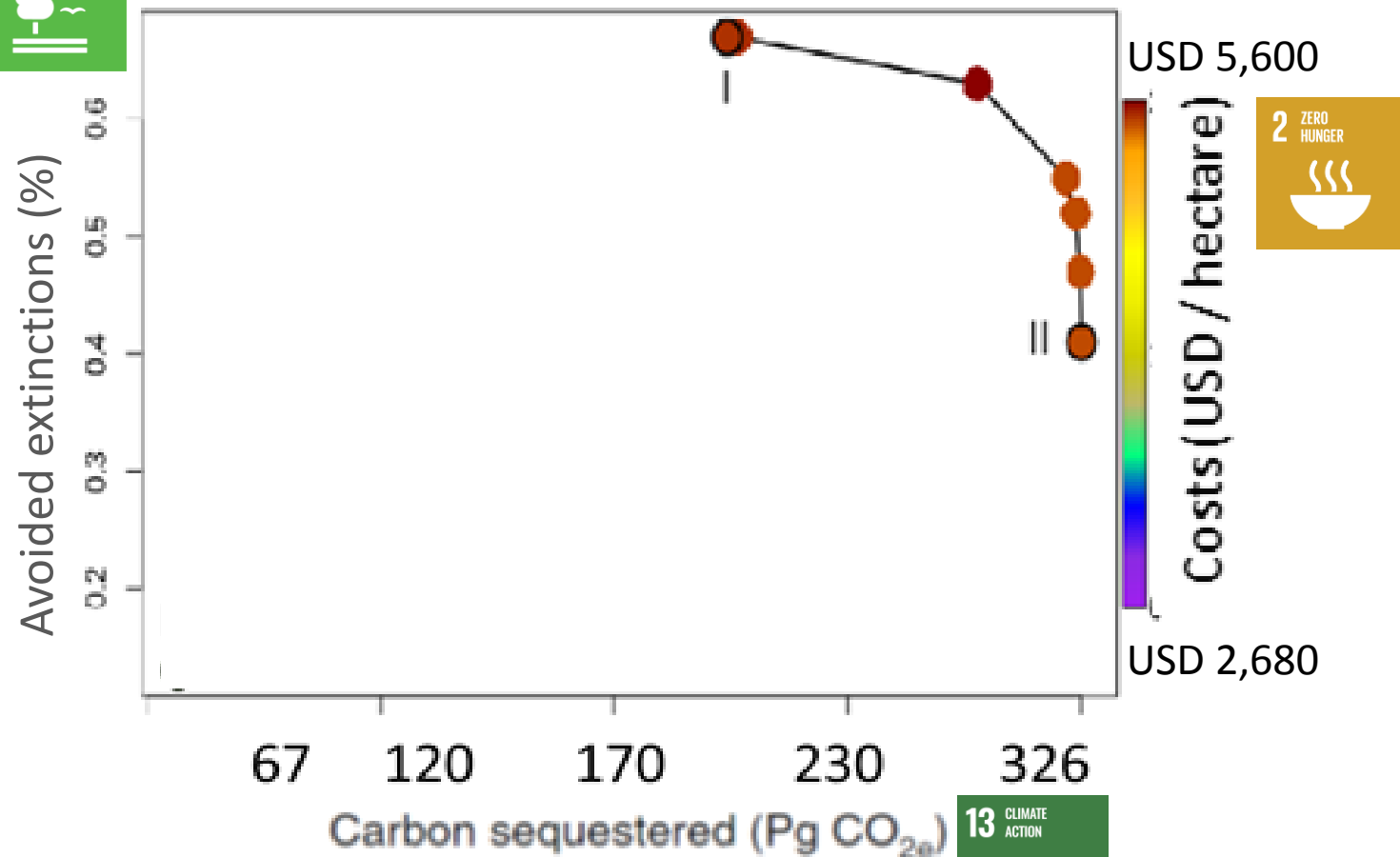


Huge differences in outcomes for the same area target, depending on where restoration takes place

(Example: The same reduction in extinctions would require 5% or 35% of the worlds converted lands)

- Biodiversity
- Biodiv-clim
- Climate
- Compromise
- Uniform restoration
- Min. Costs

Quantifying outcomes and trade-offs (Aichi 15)



Restoration is a very powerful tool for global challenges, with Aichi Target 15 resulting in major gains for:

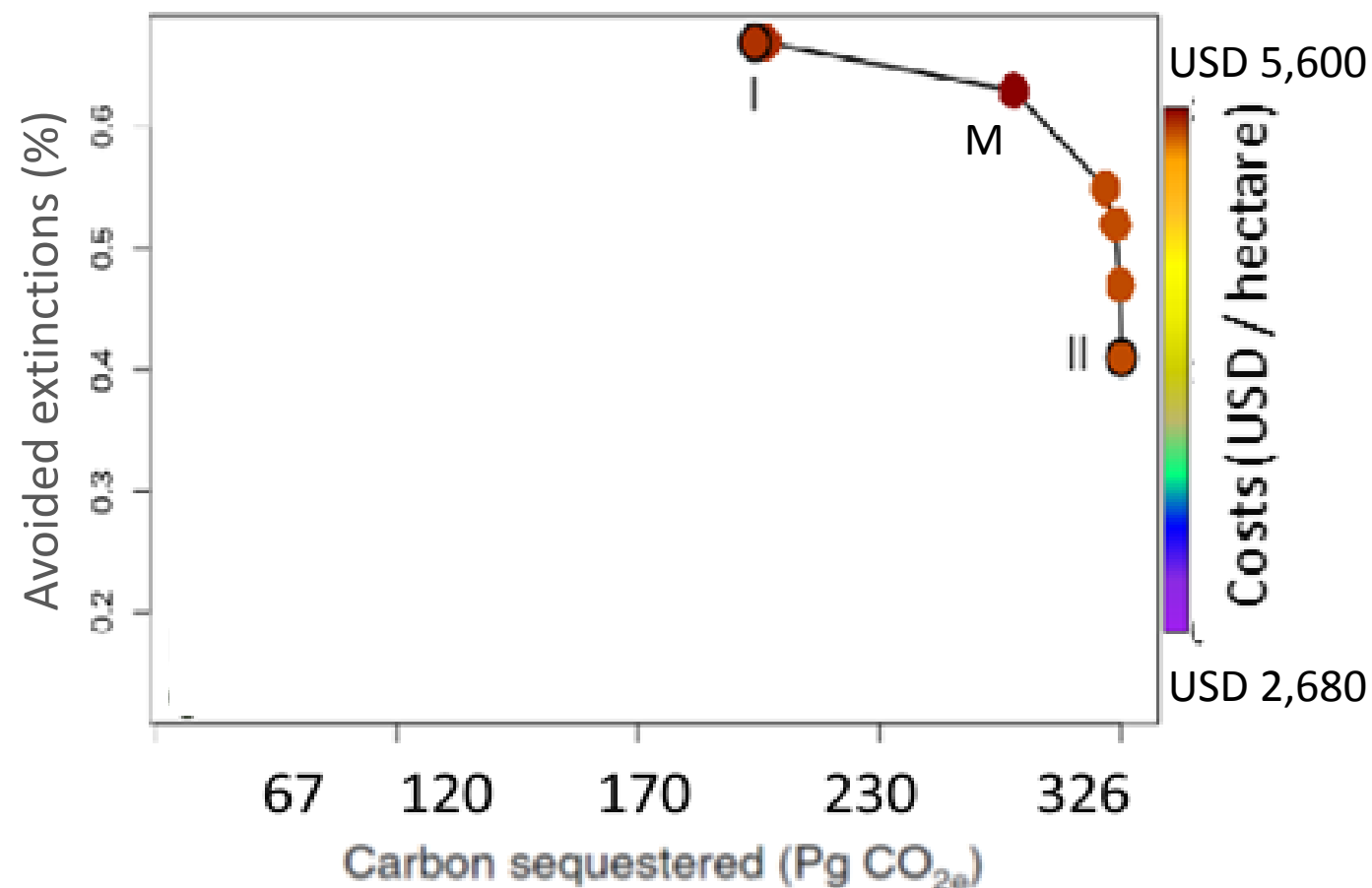
i) biodiversity conservation (saving up to 67% of species)

ii) offering major contributions for climate change mitigation (327 bill. tCO₂, 91% of remaining budget for 1.5C) and adaptation, (cost-effective, <USD10-15/tCO₂)

iii) land degradation



Quantifying outcomes and trade-offs (Aichi 15)



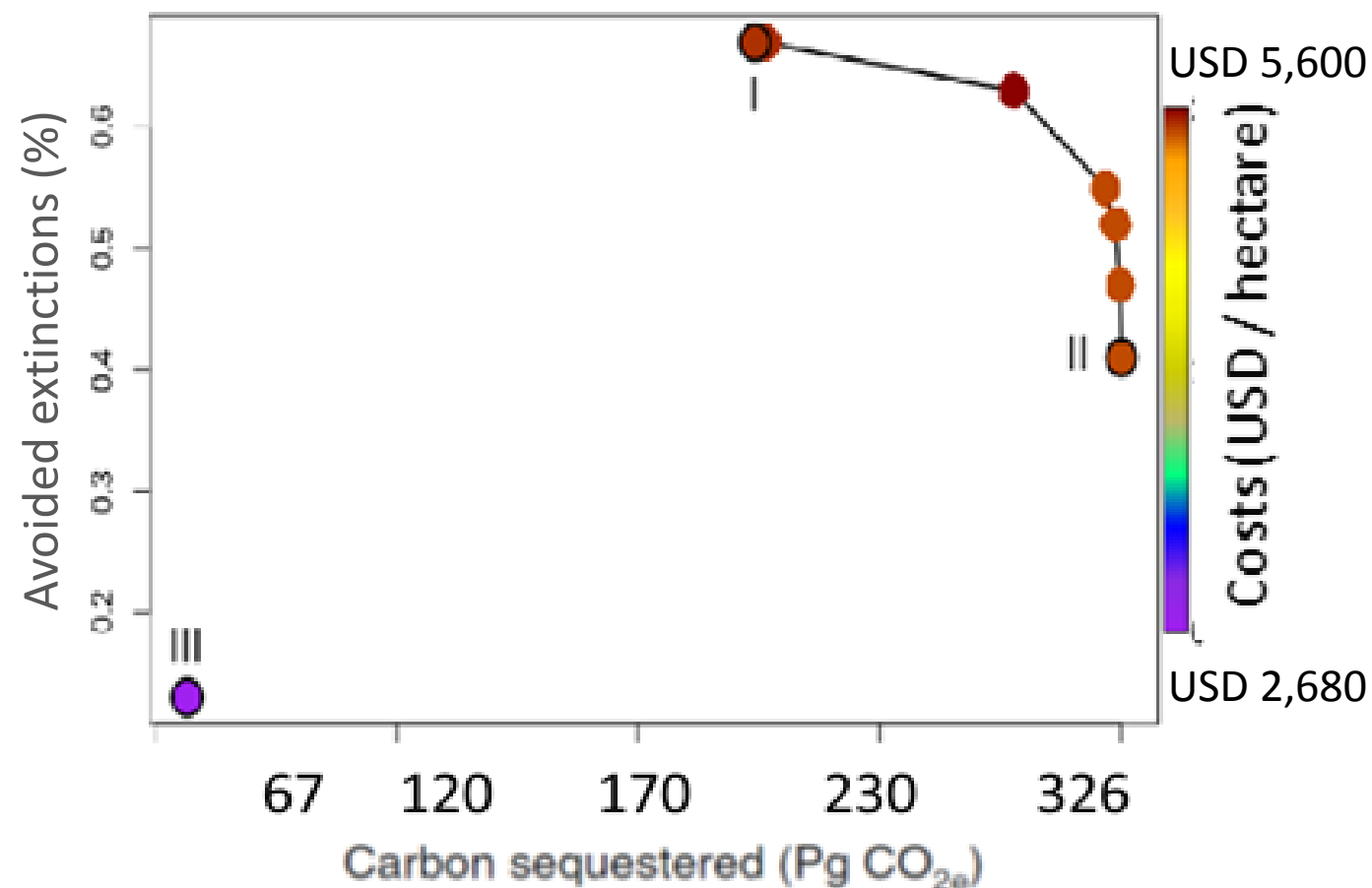
Trade-offs

Biodiversity focused delivers 70% of Max Carbon

Climate focused delivers 61% of max biodiversity

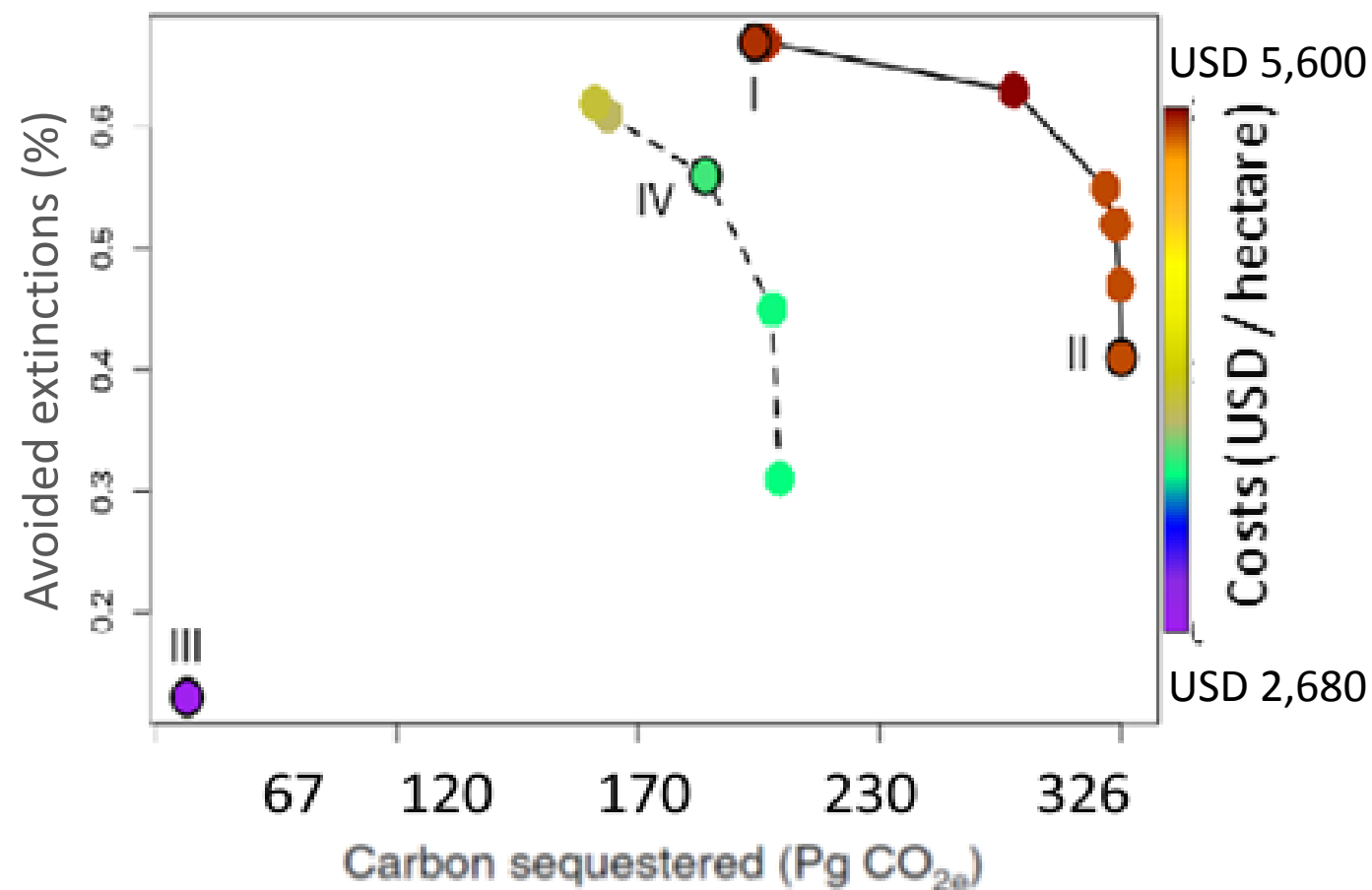
Multicriteria delivers 94% (Biodiversity) and 91% (Carbon)

Quantifying outcomes and trade-offs (Aichi 15)



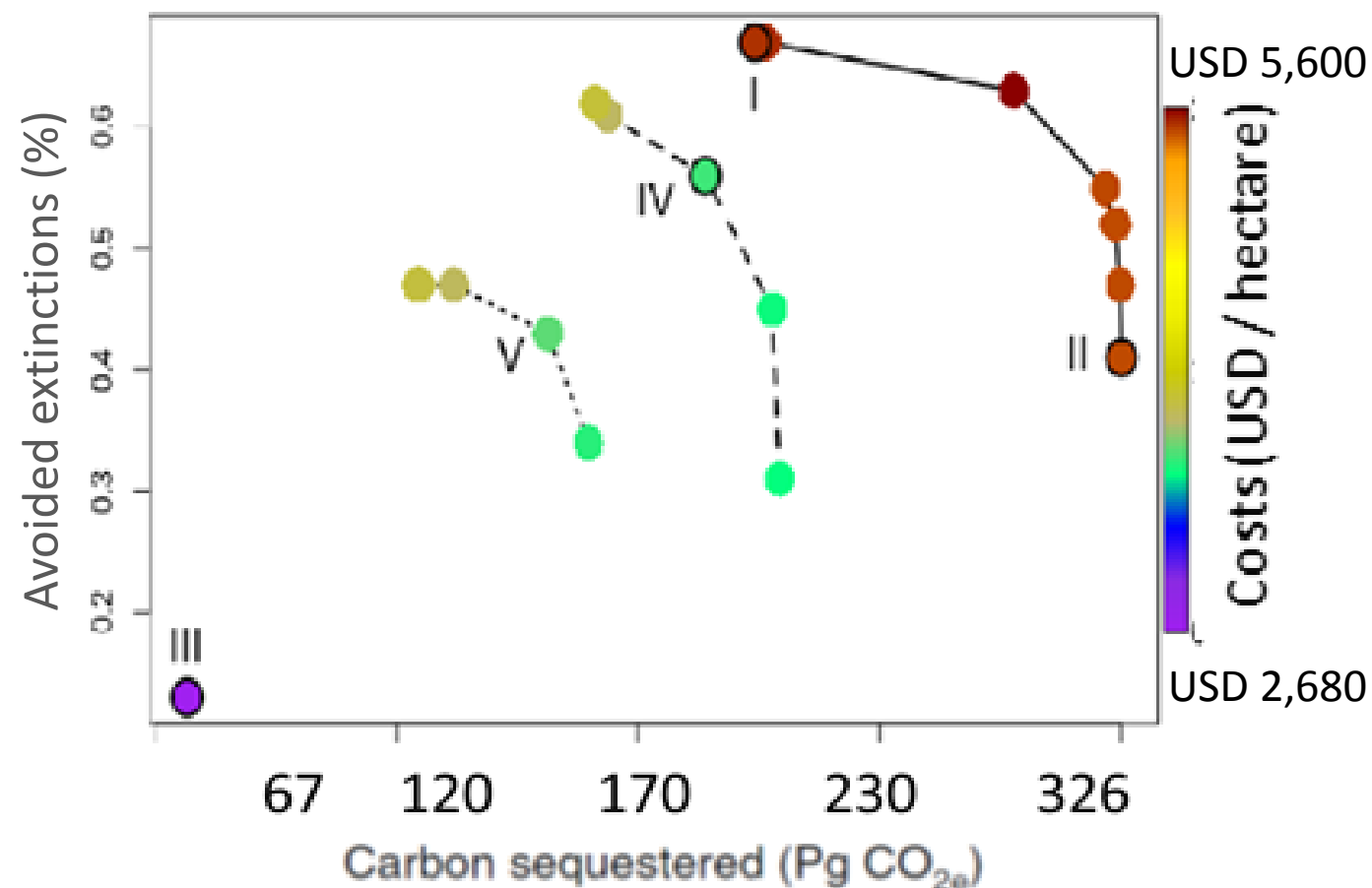
Focusing on minimising costs provides very weak environmental outcomes

Quantifying outcomes and trade-offs (Aichi 15)



Including costs in the optimisation reduces absolute benefits for biodiversity and climate, but increase cost-effectiveness

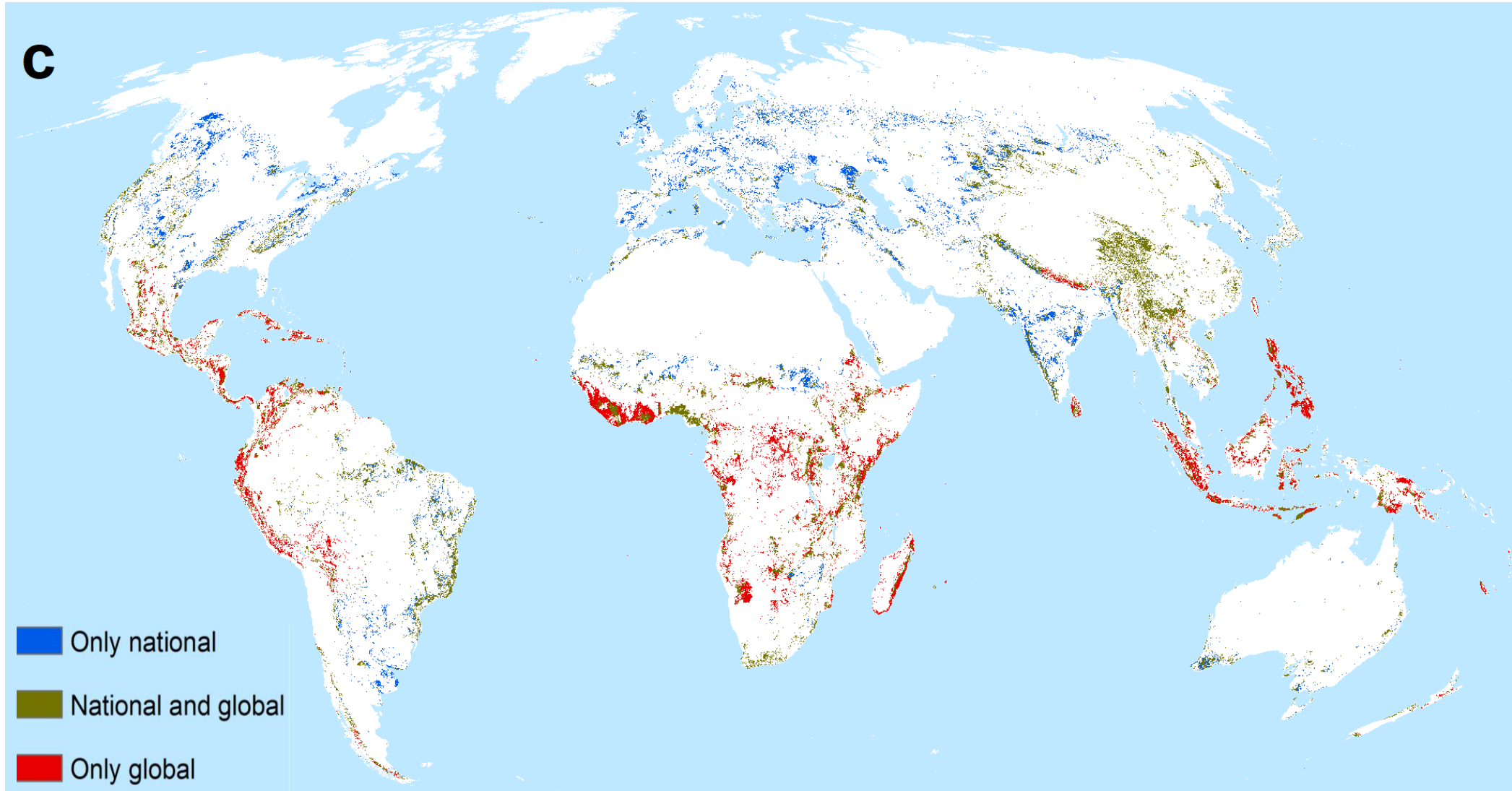
Aichi Target 15 - Outcomes for multiple goals, in multiple scenarios



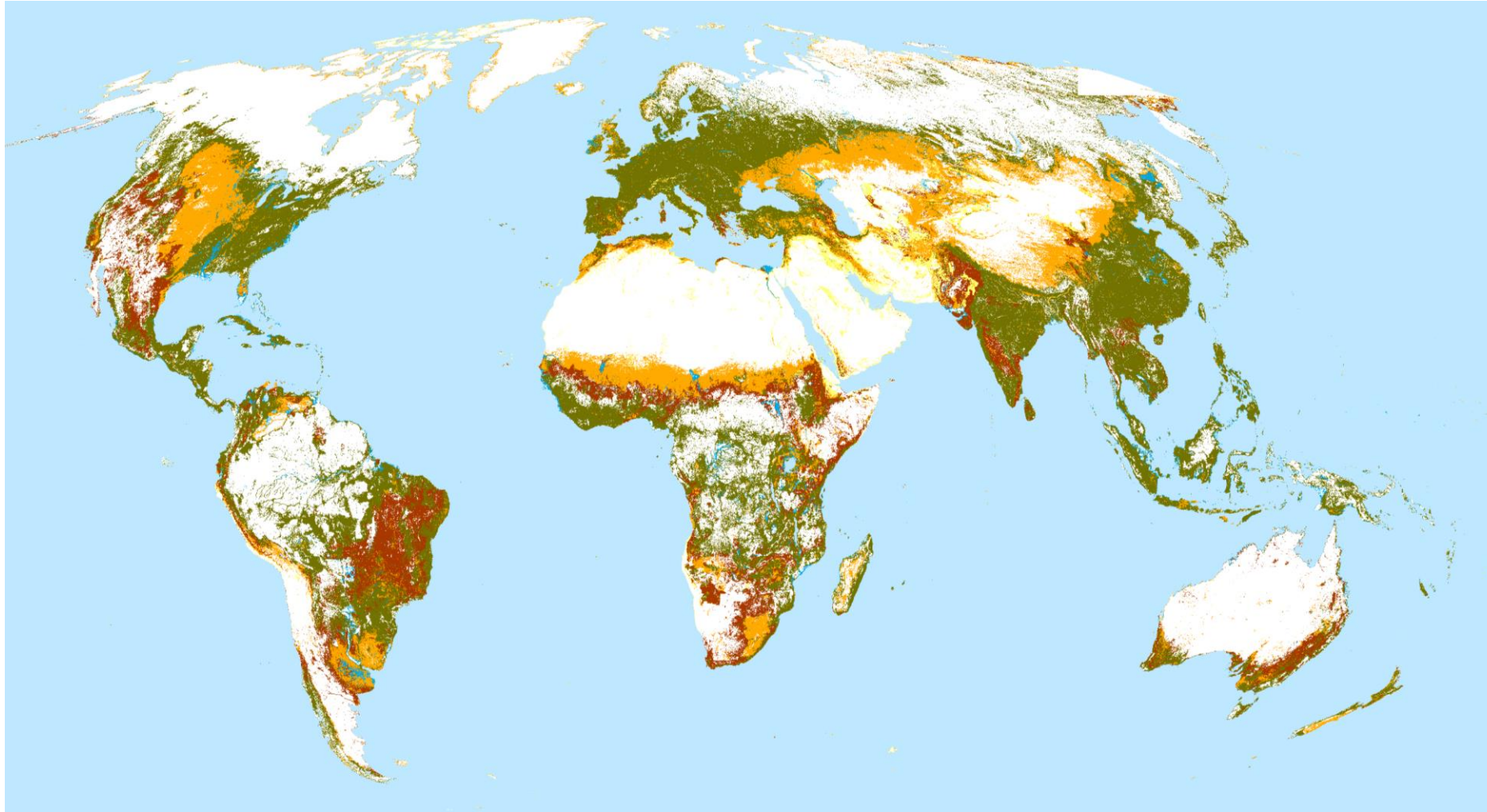
Reaching the 15% restoration target within national boundaries reduces further the global benefits, but costs remain approximately constant

Potential for international win-win collaborations

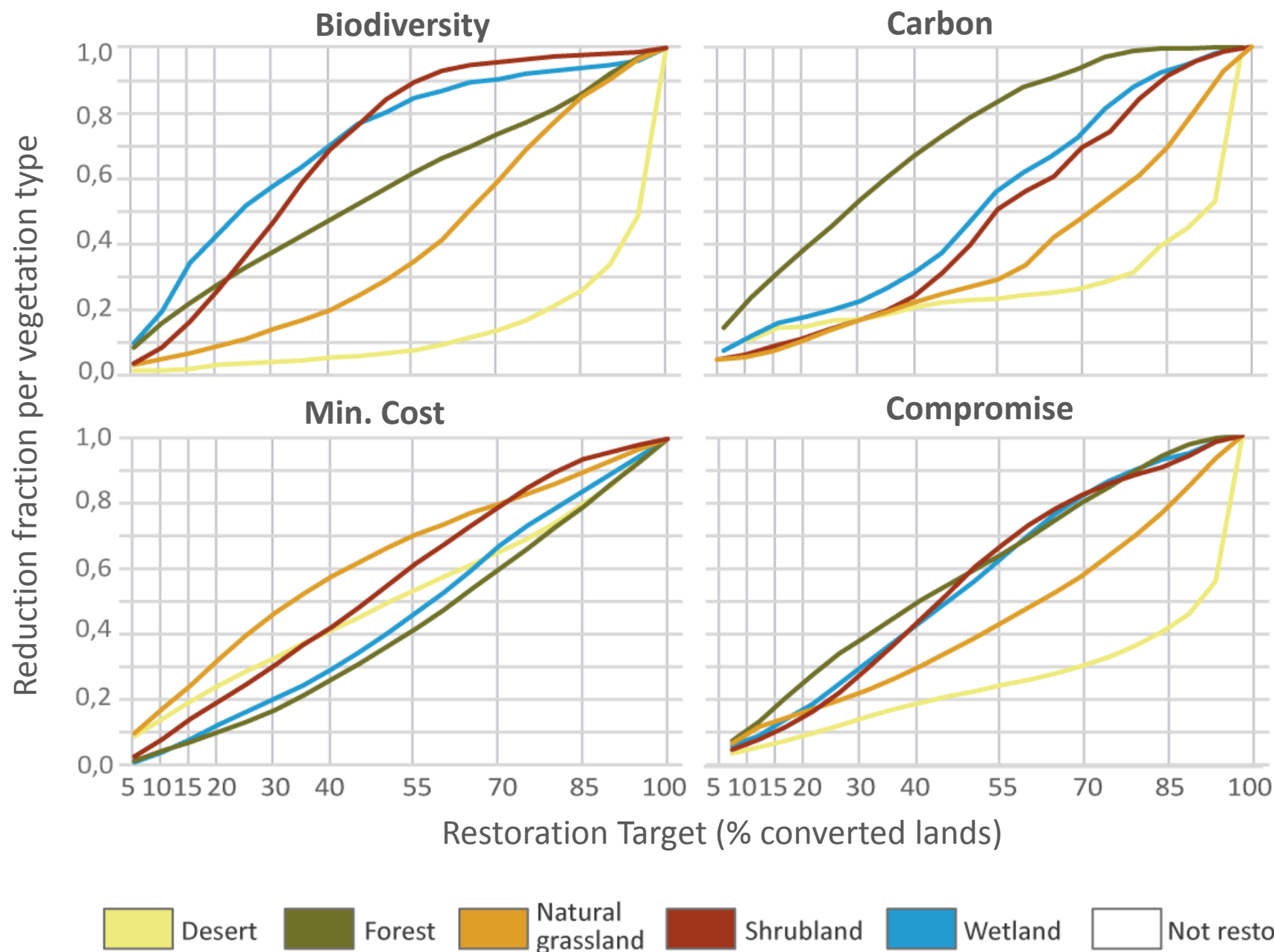
Global x National level priorities



Relative importance of different biomes

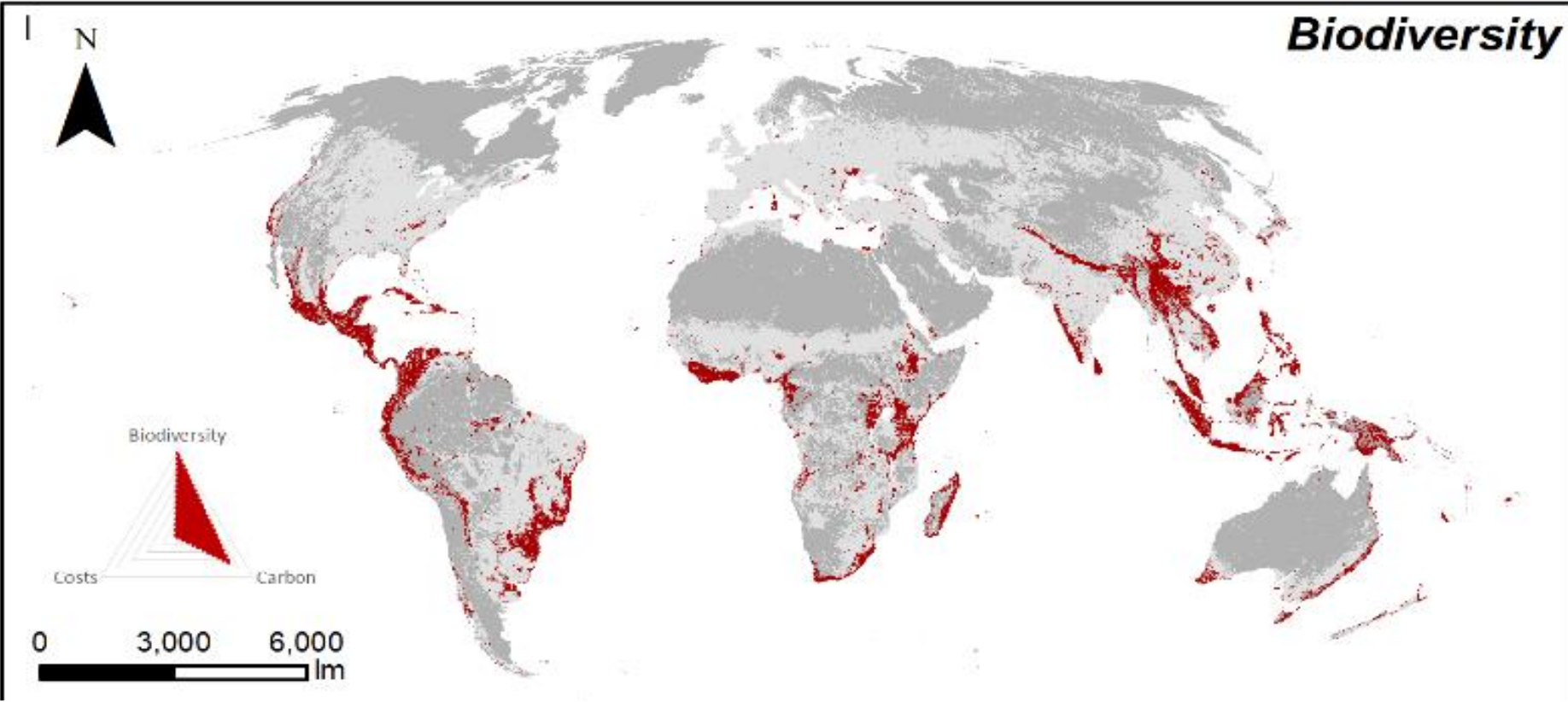
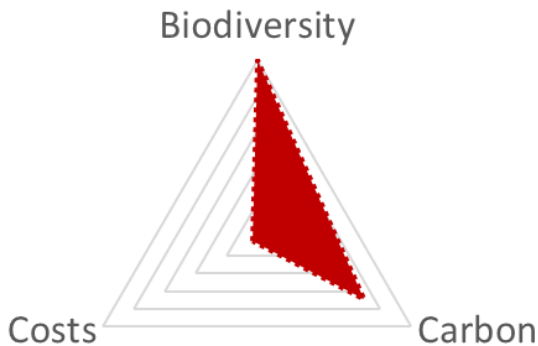


Relative importance of different biomes



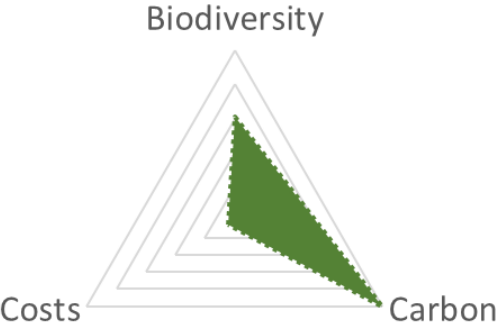
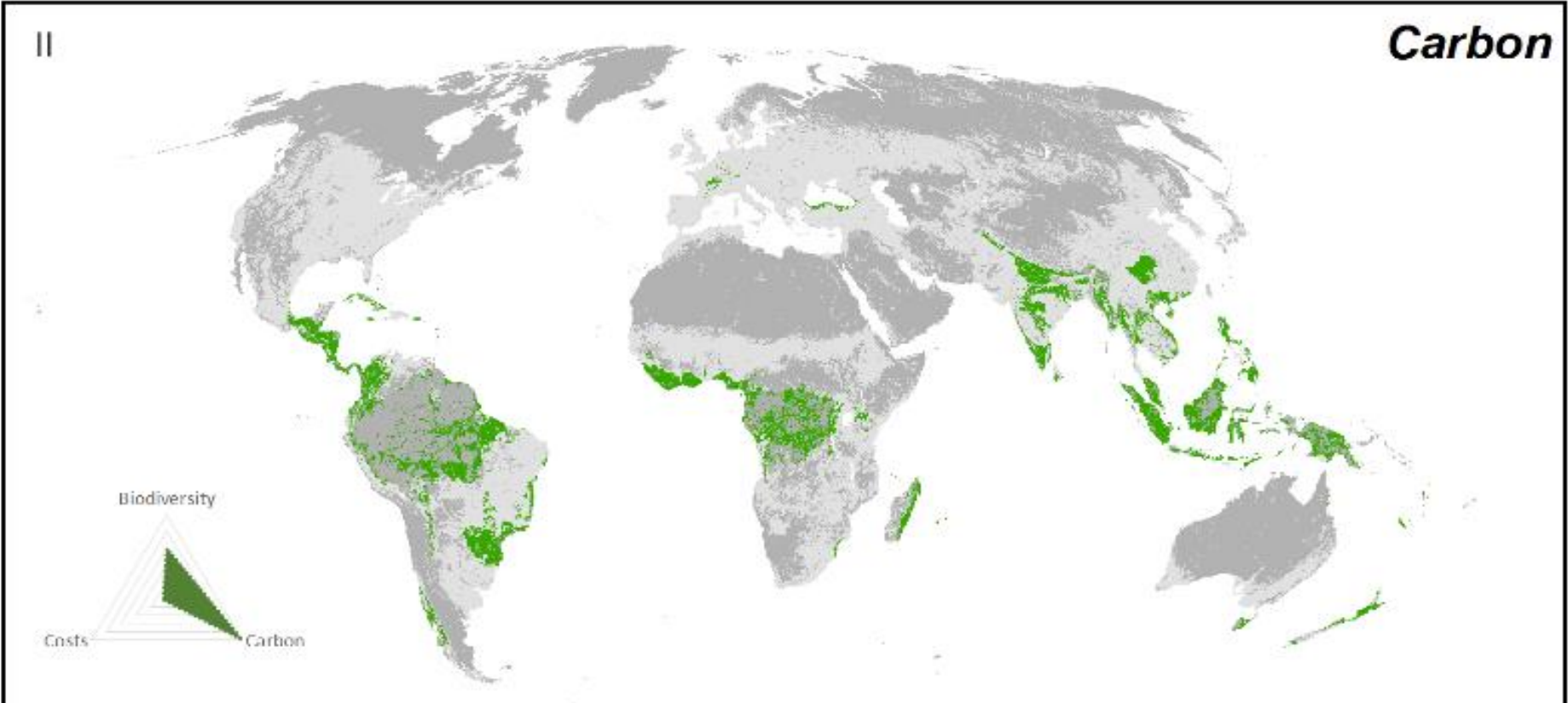
Global maximum single benefit scenarios:

Biodiversity



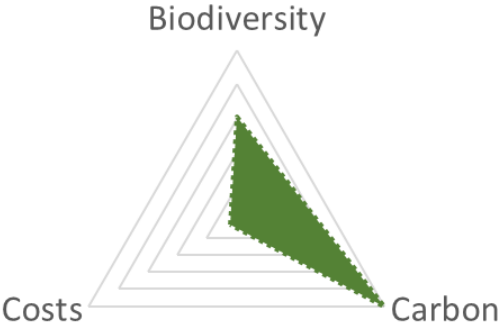
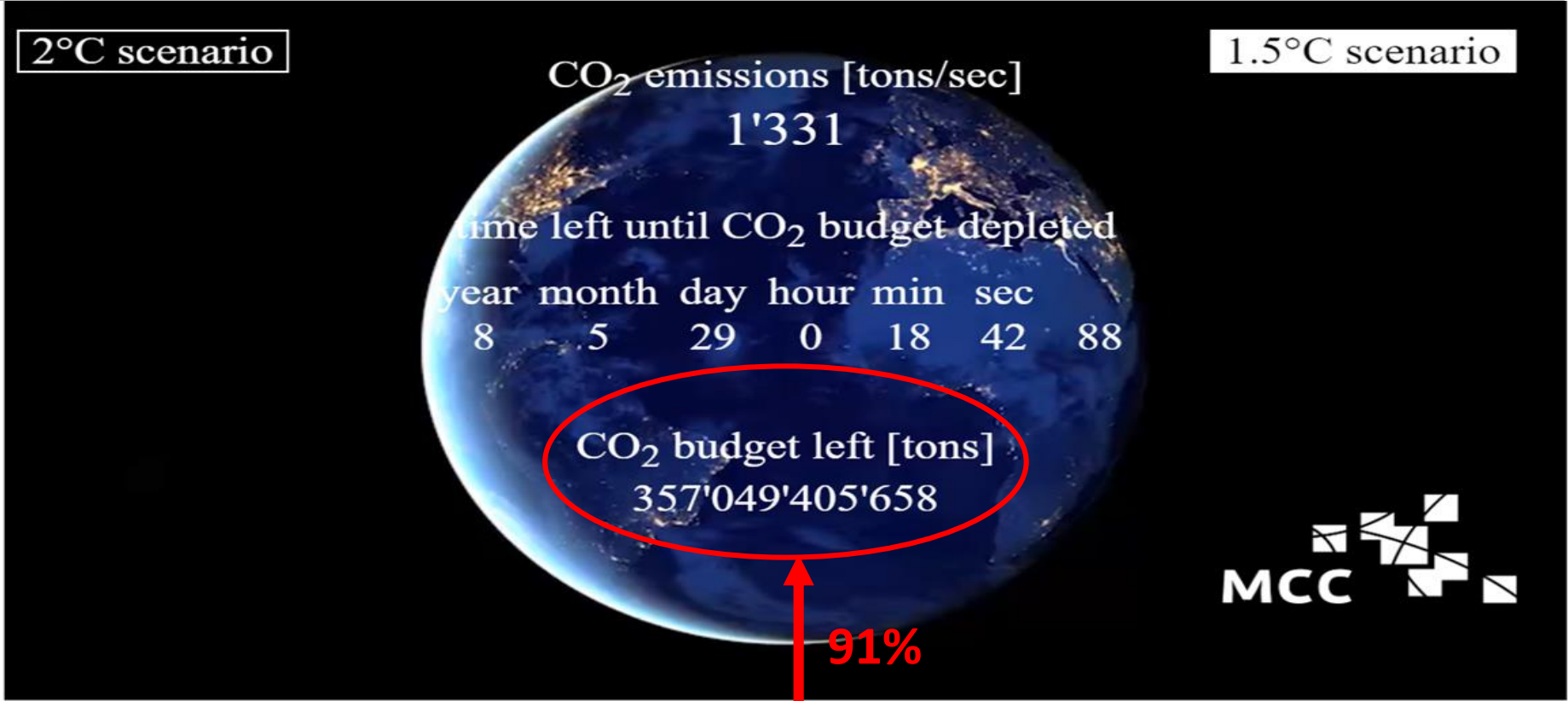
Reduction in Global Extinctions	CO2 Sequestered (Billions Tonnes)	Costs (USD / hectare)
67%	231	5,588

Global maximum single benefit scenario: Climate



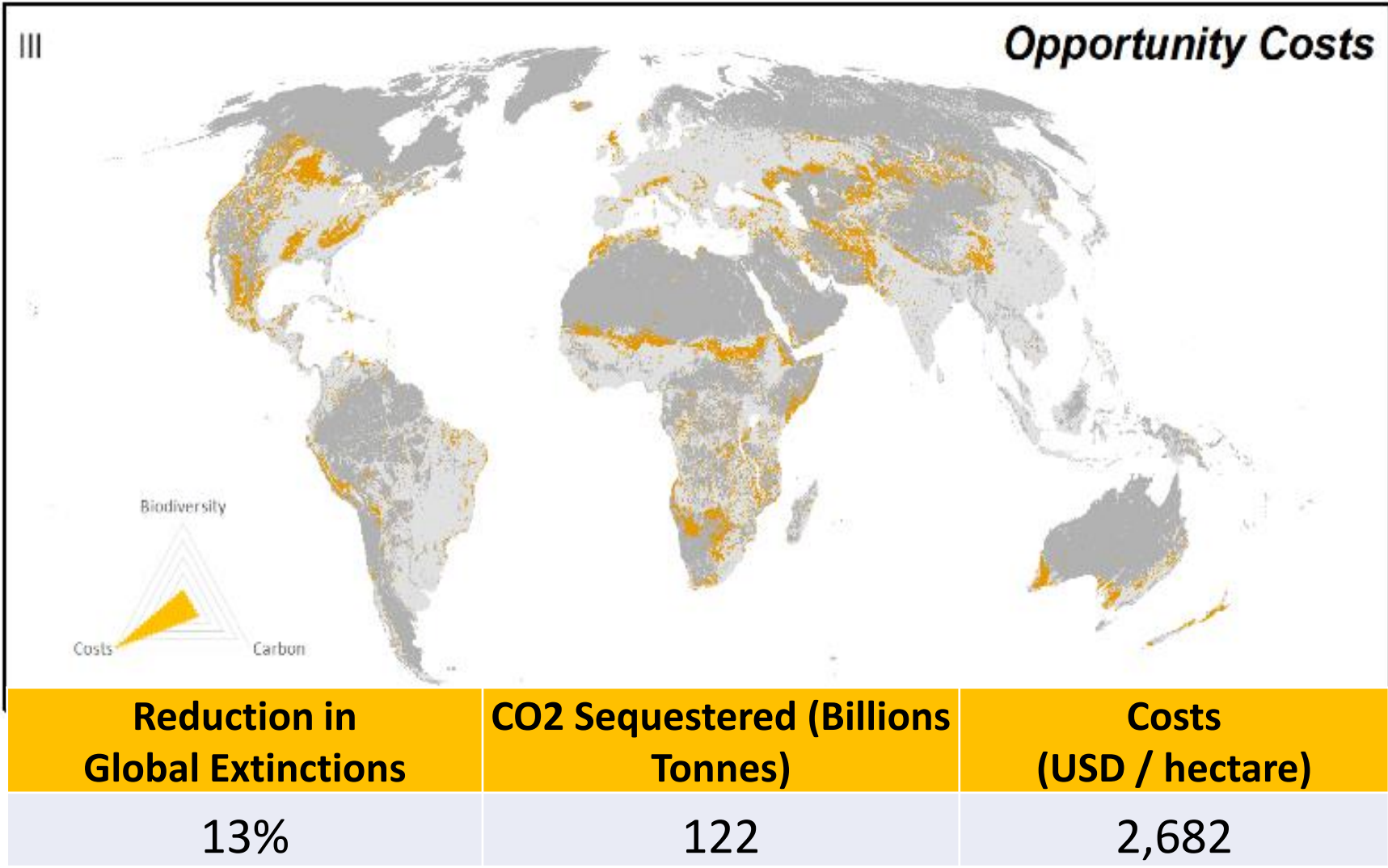
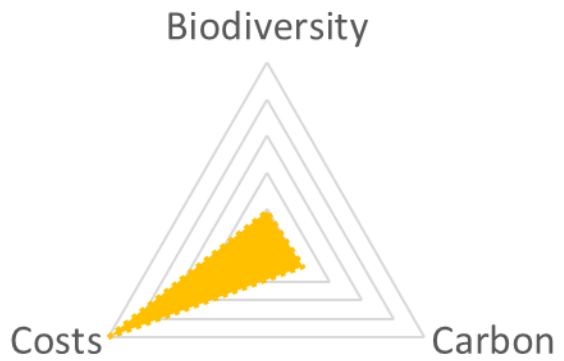
Reduction in Global Extinctions	CO2 Sequestered (Billions Tonnes)	Costs (USD / hectare)
41%	326	5,538

Global maximum single benefit scenario: Climate

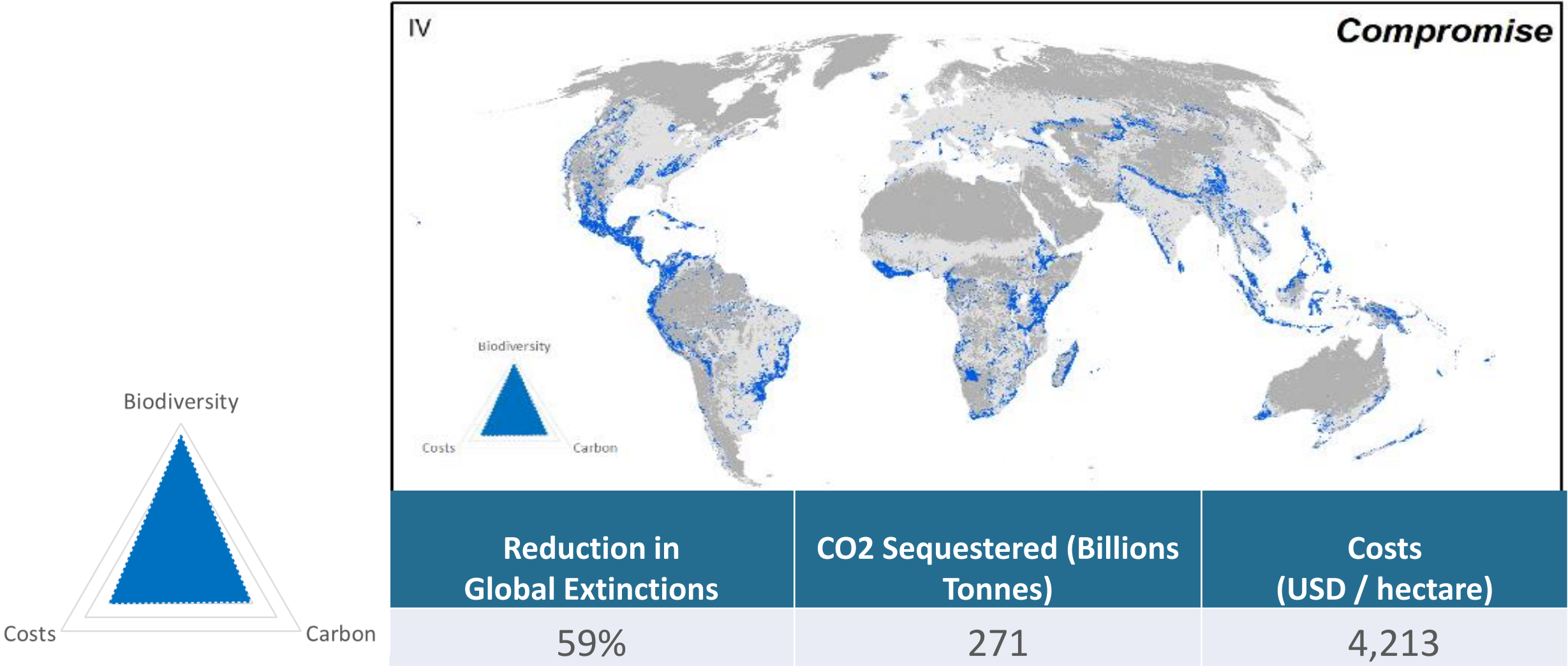


Reduction in Global Extinctions	CO2 Sequestered (Billions Tonnes)	Opportunity Costs (USD / hectare)
41%	326	5,538

Global Opportunity cost scenario

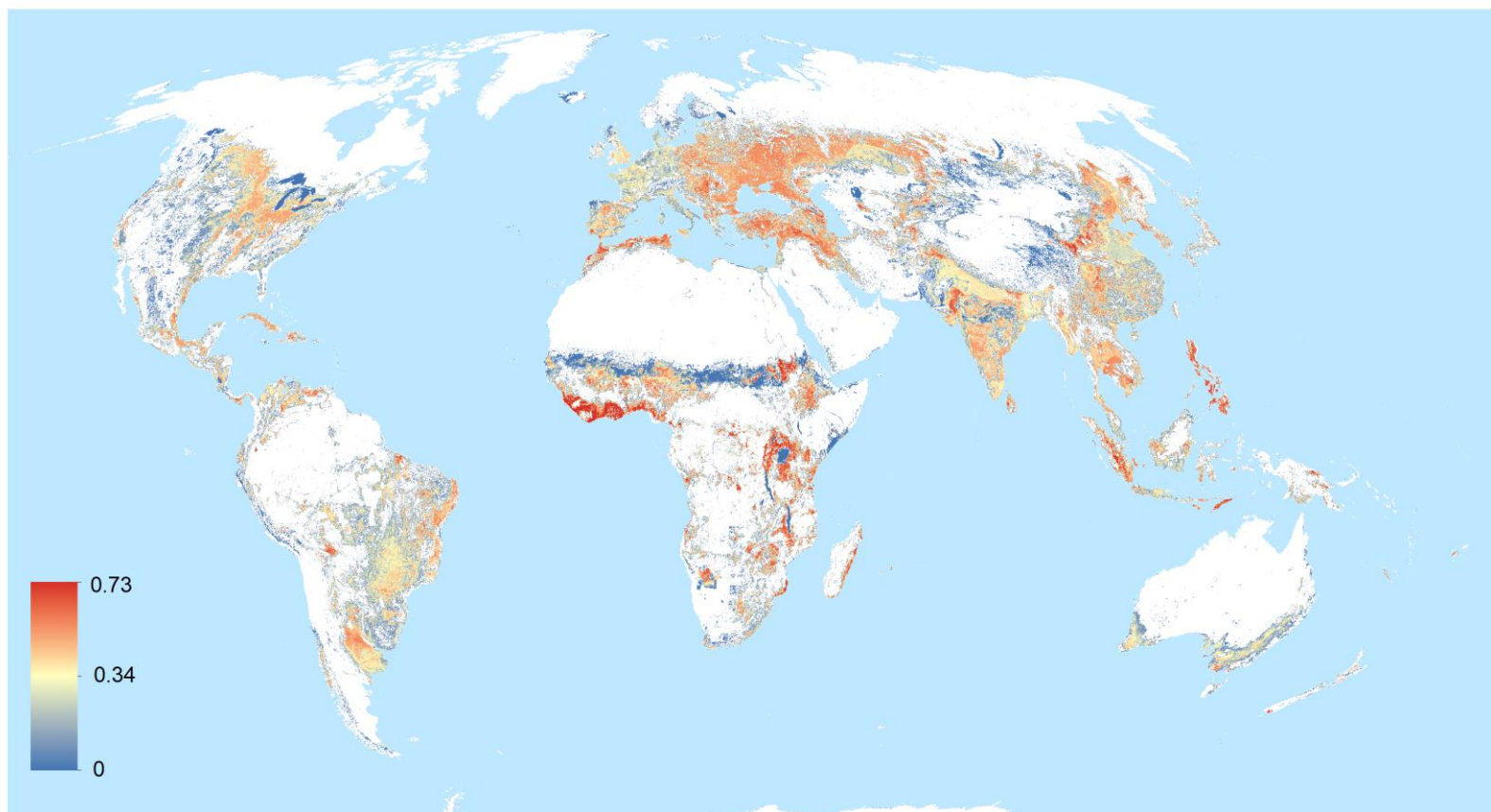


Global Compromise scenario



Restoration in spared lands

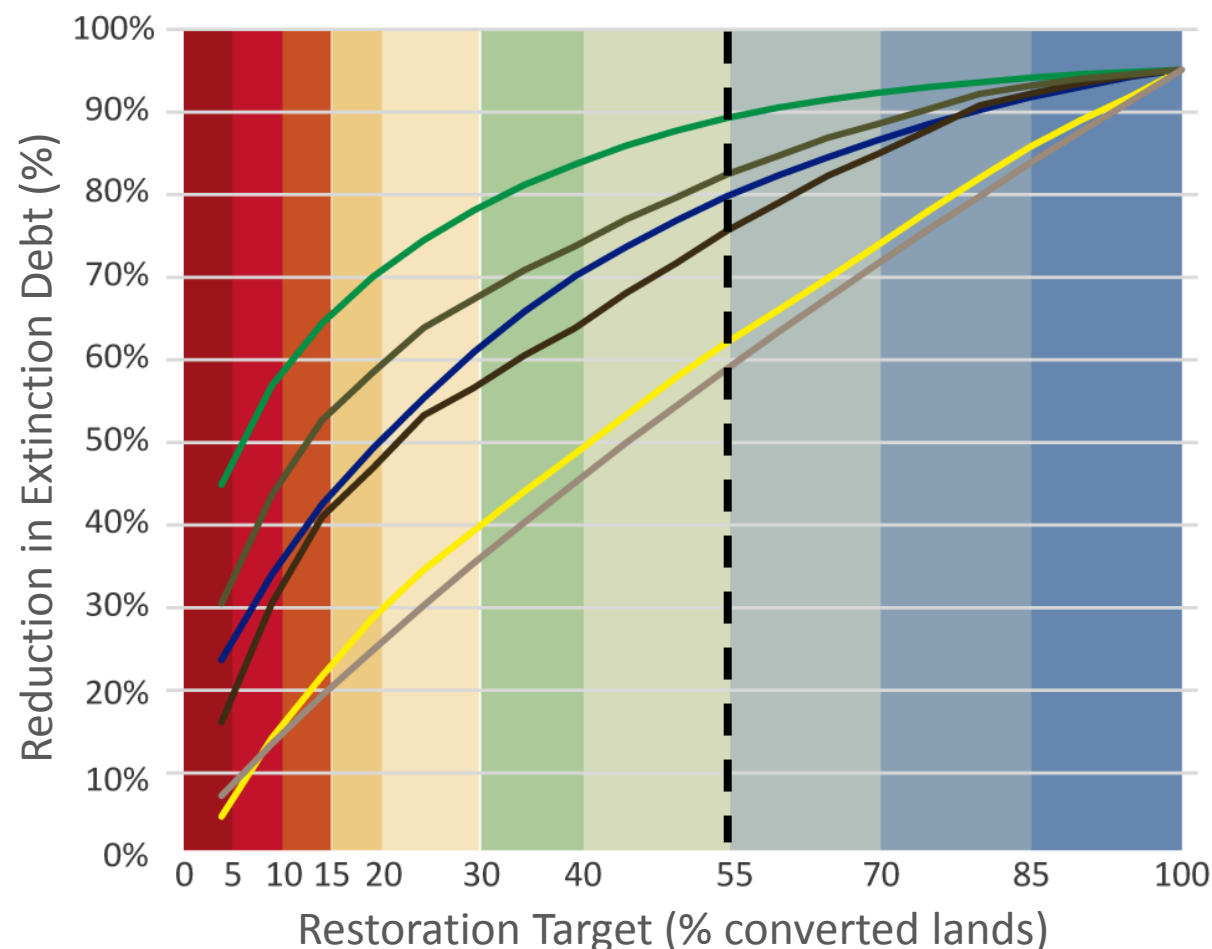
Rainfed yield gaps



- Closing 75% of yield gaps
- Maintaining current agricultural production
- Restoring on spared lands
- If implemented at landscape level
 - 90% of Biodiversity and 76% of Climate
- If implemented at country level
 - 96% of both Biodiversity and Climate

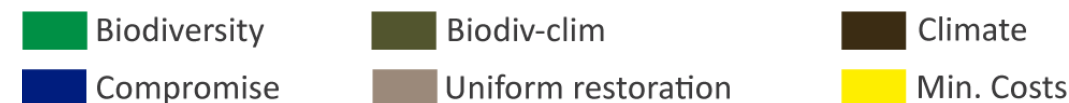


Restoration in spared lands

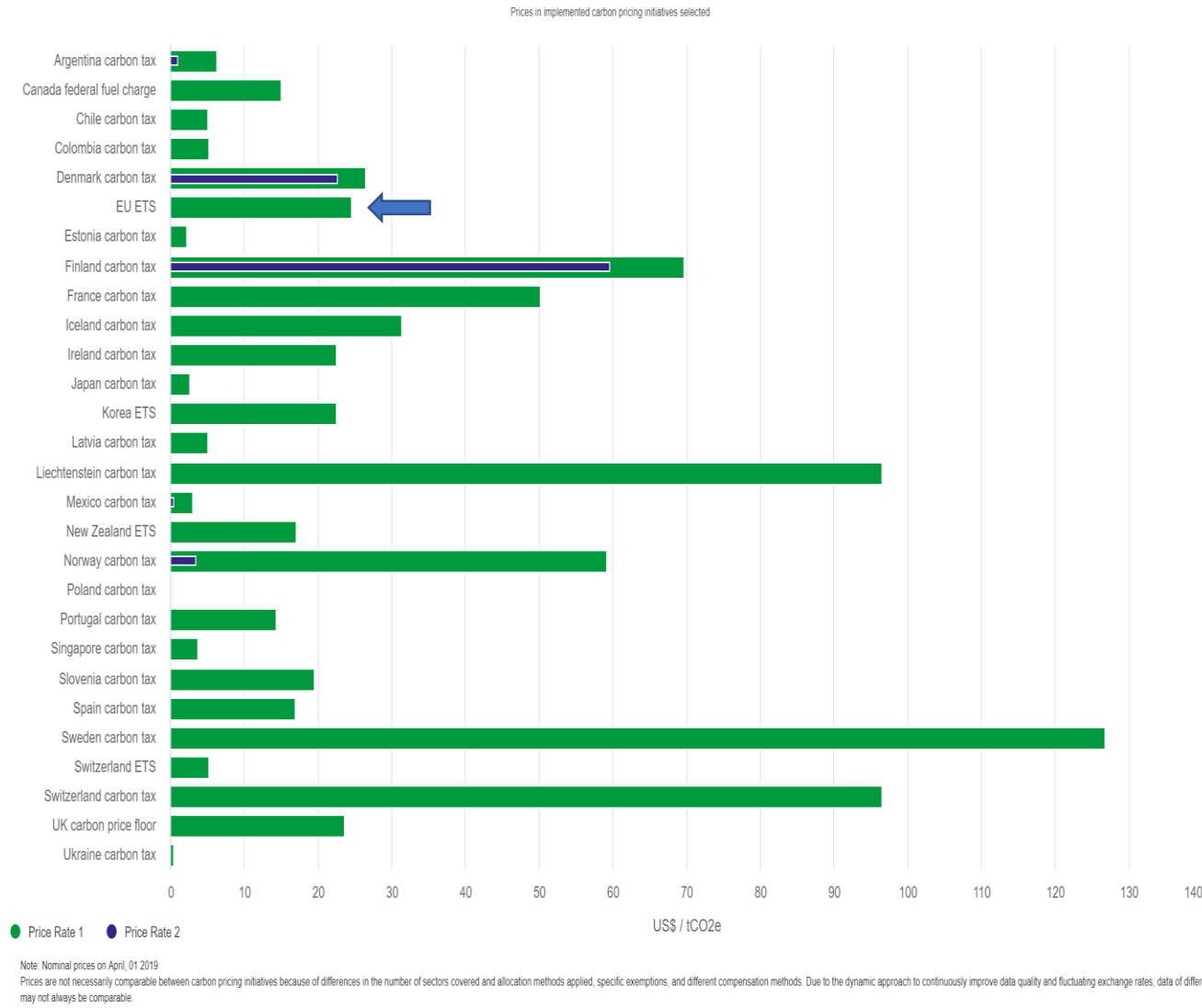
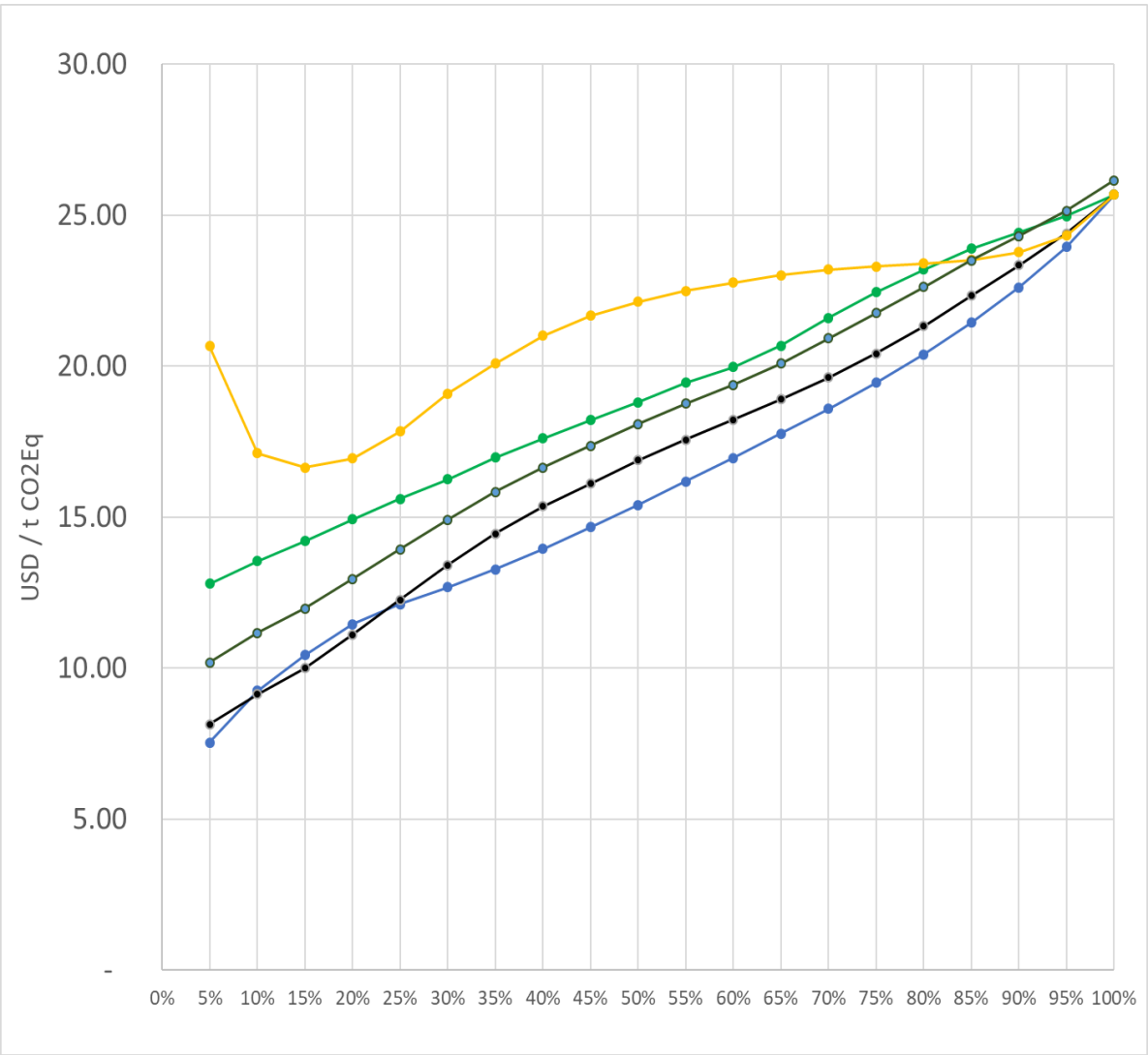


- Closing 75% of yield gaps
- Maintaining current agricultural production
- Restoring on spared lands

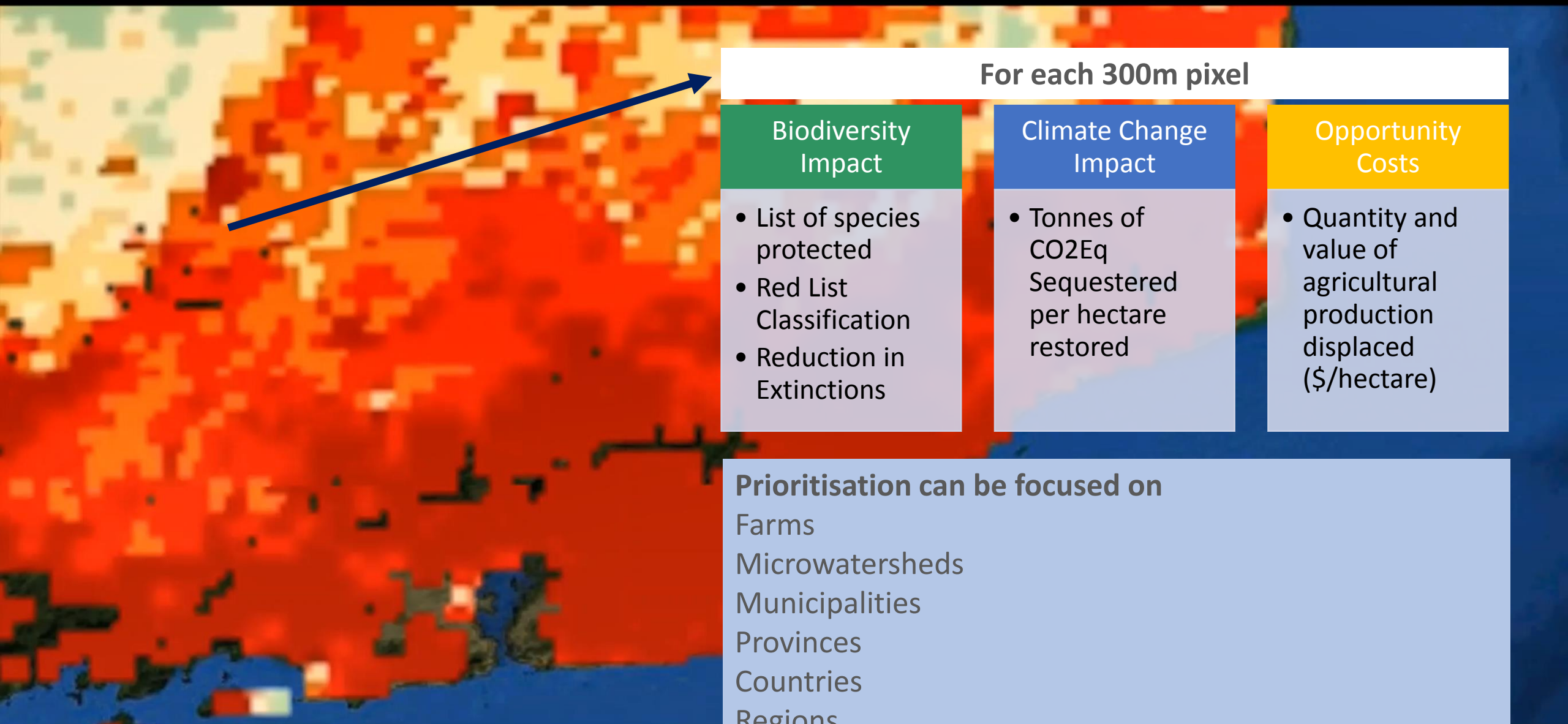
At the global level, 55% of current agricultural lands could be restored without compromising agricultural production (1,4 bill. hectares)



Cost-effectiveness of restoration for climate mitigation







For each 300m pixel

Biodiversity Impact

- List of species protected
- Red List Classification
- Reduction in Extinctions

Climate Change Impact

- Tonnes of CO2Eq Sequestered per hectare restored

Opportunity Costs

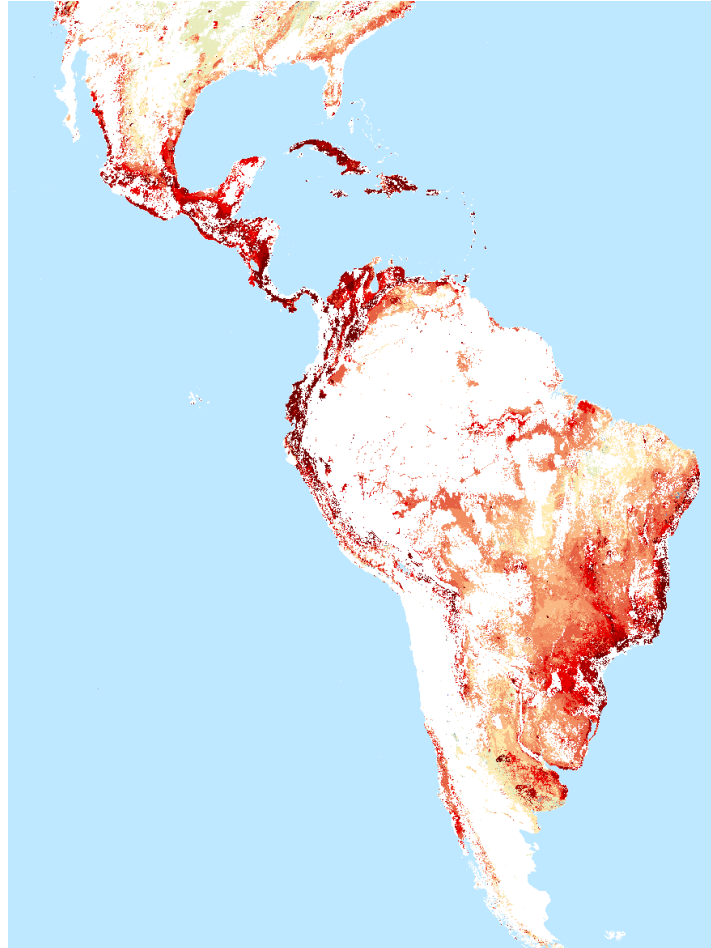
- Quantity and value of agricultural production displaced (\$/hectare)

Prioritisation can be focused on

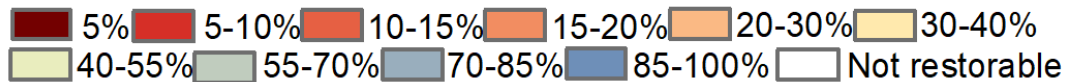
- Farms
- Microwatersheds
- Municipalities
- Provinces
- Countries
- Regions
- Globe

Biodiversity

Some LatAm results



Priority



Criteria 1: Absolute area (km2) restored in the Scenario focused on Biodiversity only

Country	Area available (km2)	Priority areas (km2)	% of area available that is top global priority
Brazil	2,435,604	494,046	20%
Mexico	461,592	201,075	44%
Colombia	165,905	121,684	73%
Peru	123,411	82,491	67%
Argentina	657,091	76,497	12%
Venezuela	183,308	67,483	37%
Cuba	57,954	57,619	99%
Ecuador	41,532	40,824	98%
Nicaragua	42,649	40,055	94%
Guatemala	33,653	32,903	98%
Bolivia	109,469	28,014	26%
Honduras	27,427	26,381	96%
Panama	23,210	21,833	94%
Dominican Rep.	21,373	20,309	95%
Haiti	18,749	16,057	86%
Costa Rica	13,696	13,654	100%
Chile	52,781	11,706	22%
Paraguay	98,139	11,269	11%
El Salvador	4,851	4,736	98%
Uruguay	35,000	3,855	11%
Belize	3,069	3,067	100%
Jamaica	2,701	2,690	100%
Trinidad and Tobago	1,130	1,109	98%
Suriname	923	330	36%
Guyana	3,165	234	7%
Barbados	229	215	94%
Bahamas	181	135	75%
Antigua and Barb.	132	125	95%
St. Kitts and Nevis	46	45	100%
Saint Lucia	32	32	100%
St. Vin. and Gren.	22	22	100%
Grenada	16	16	100%
Dominica	2	2	100%



Key messages

- Strategic approaches can provide an eightfold increase in conservation cost-effectiveness.
- Where restoration happens makes a vast difference for its costs and benefits
- Spatial optimisation, Natural regeneration and Project Size play a key role in reducing restoration costs, if its potential is taken into consideration when planning restoration indicatives; Reduction of over 60% in costs
- Revenues can also be generated, and synergies with agriculture production (pollination, water, soil conservation)
- Our flexible tool can be applied at any resolution, using multiple criteria, identify and measure the impacts of restoration prioritisation, to offer support for decision makers

Next steps

- Ongoing conversations with the CBD and other partners to provide support to countries, NGOs, businesses with a decision support assisted platform for integrating restoration with conservation and land-use planning Capacity building
- Partnership with NatureMaps (UNSDSN, IIASA, UNEP-WCMC & IIS) to apply our algorithm to priority maps for restoration;
- Integrated analysis with Marine and Freshwater systems, inc. associated telecouplings
- Ongoing implementation at country, state, city and farm levels, with custom benefits and costs



Also, for your information, the International Institute for Sustainability will host a workshop on **5 November 2019**, in Rio de Janeiro, for selected participants to interact with its restoration planning platform that includes integrated spatial planning and estimates of impacts for species conservation and climate change mitigation. Interested Parties are encouraged to nominate experts to attend this workshop.

Please accept, Madam/Sir, the assurances of my highest consideration.

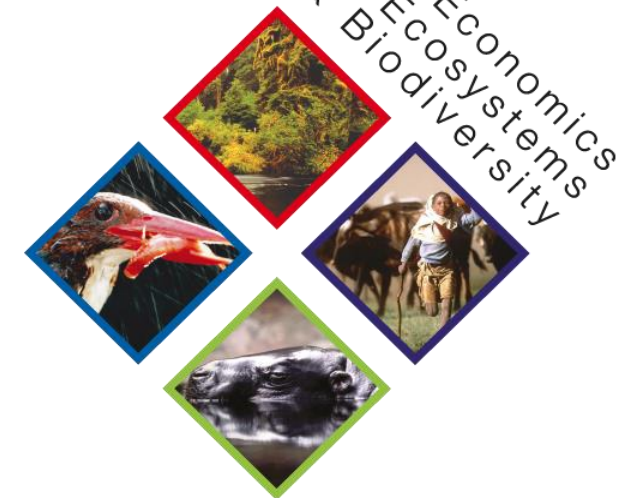
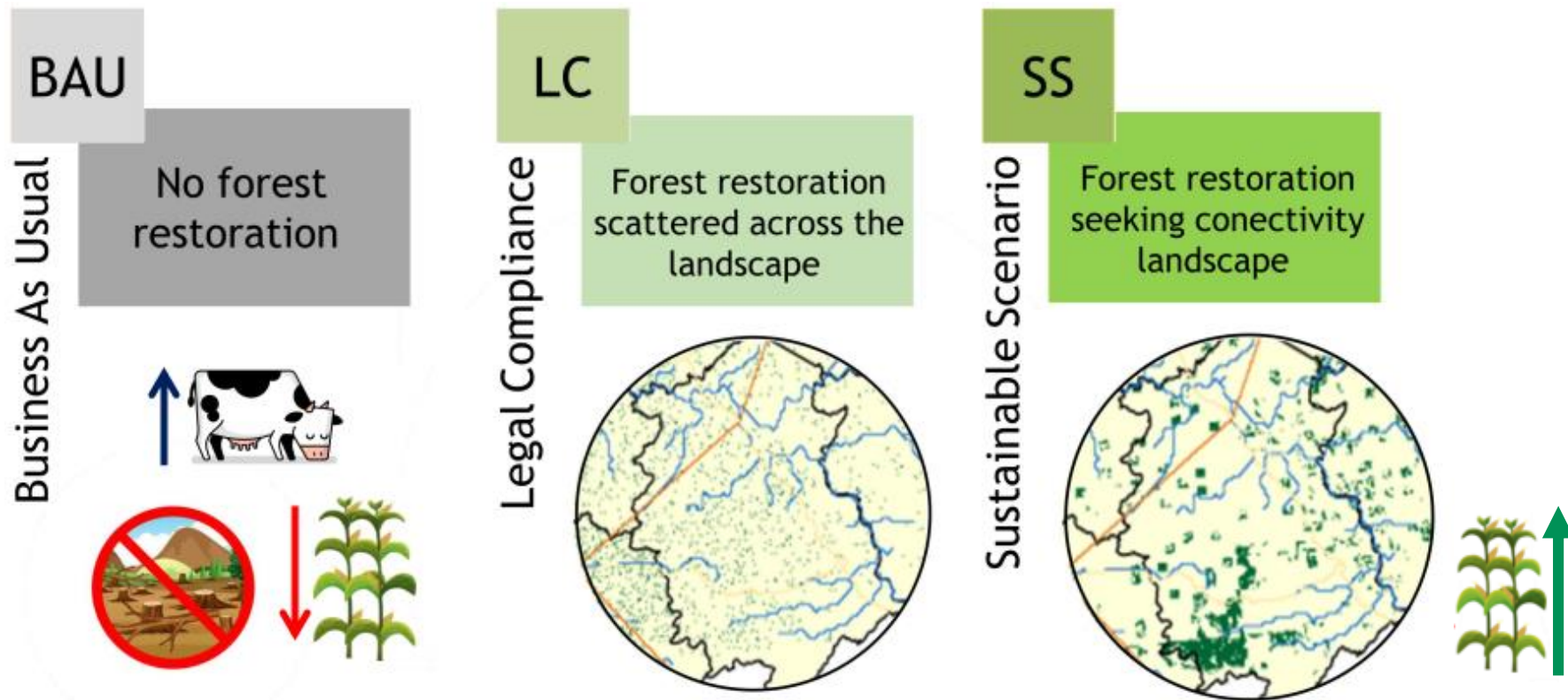
Cristiana Paşca Palmer, PhD
Executive Secretary

Bernardo B. N. Strassburg

TEEB: Paraíba do Sul River Basin – São Paulo State



The Economics
& of Ecosystems
& Biodiversity



InVEST

integrated valuation of
ecosystem services
and tradeoffs

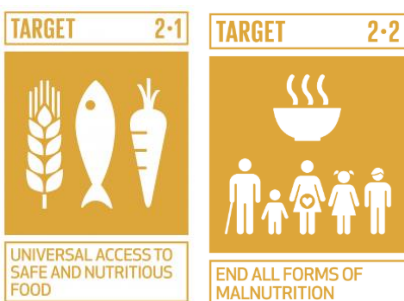
15 LIFE ON LAND



Biophysical and ecological valuation: Pollination



- Almost 90% of plant species require some animal pollinator
- About 1/3 of world agricultural production depends on pollinators
- Agricultural yield, quality and stability
- Human nutritional quality (IBPES 2016)



WITH BEES

WITHOUT BEES

15 LIFE ON LAND



Biophysical and ecological valuation: Pollination



InVest

- Focused on wild bees - main pollinators in natural ecosystems and essential for many crops (Kremen and Chaplin-Kramer 2007).
- The model is based on estimates of nesting places and floral resources availability and on the flight capacity of bees.



Inputs:

- Land use and coverage maps
- Landscape Parameter Table
- Pollinator table



Outputs:

- Abundance Index
- Visitation Potential

15 LIFE ON LAND

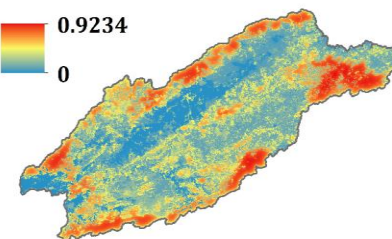
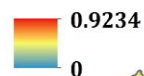


2 ZERO HUNGER

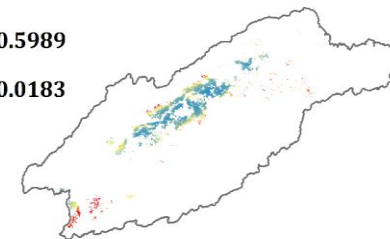
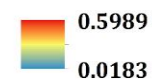


Biophysical and ecological valuation: Pollination

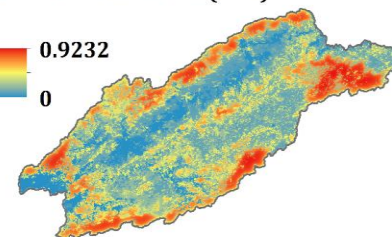
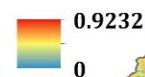
Índice de Abundância (NOW)



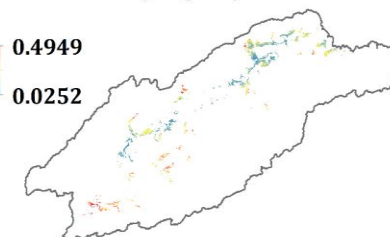
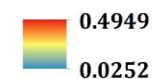
Potencial de visitação (NOW)



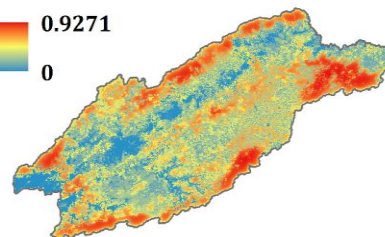
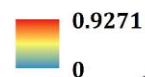
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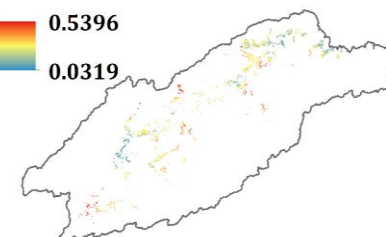
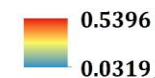
Potencial de visitação (BAU)



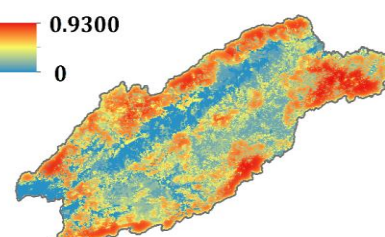
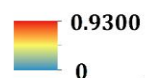
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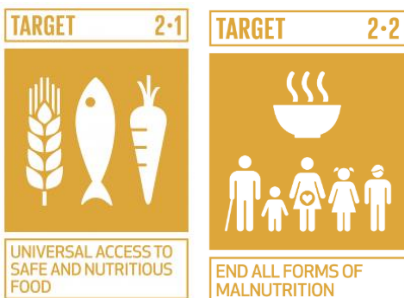
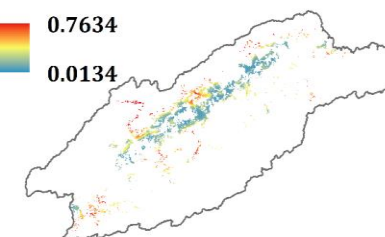
Potencial de visitação (CL)



Índice de Abundância (MSP)



Potencial de visitação (MSP)



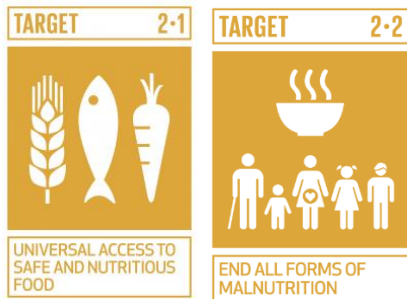
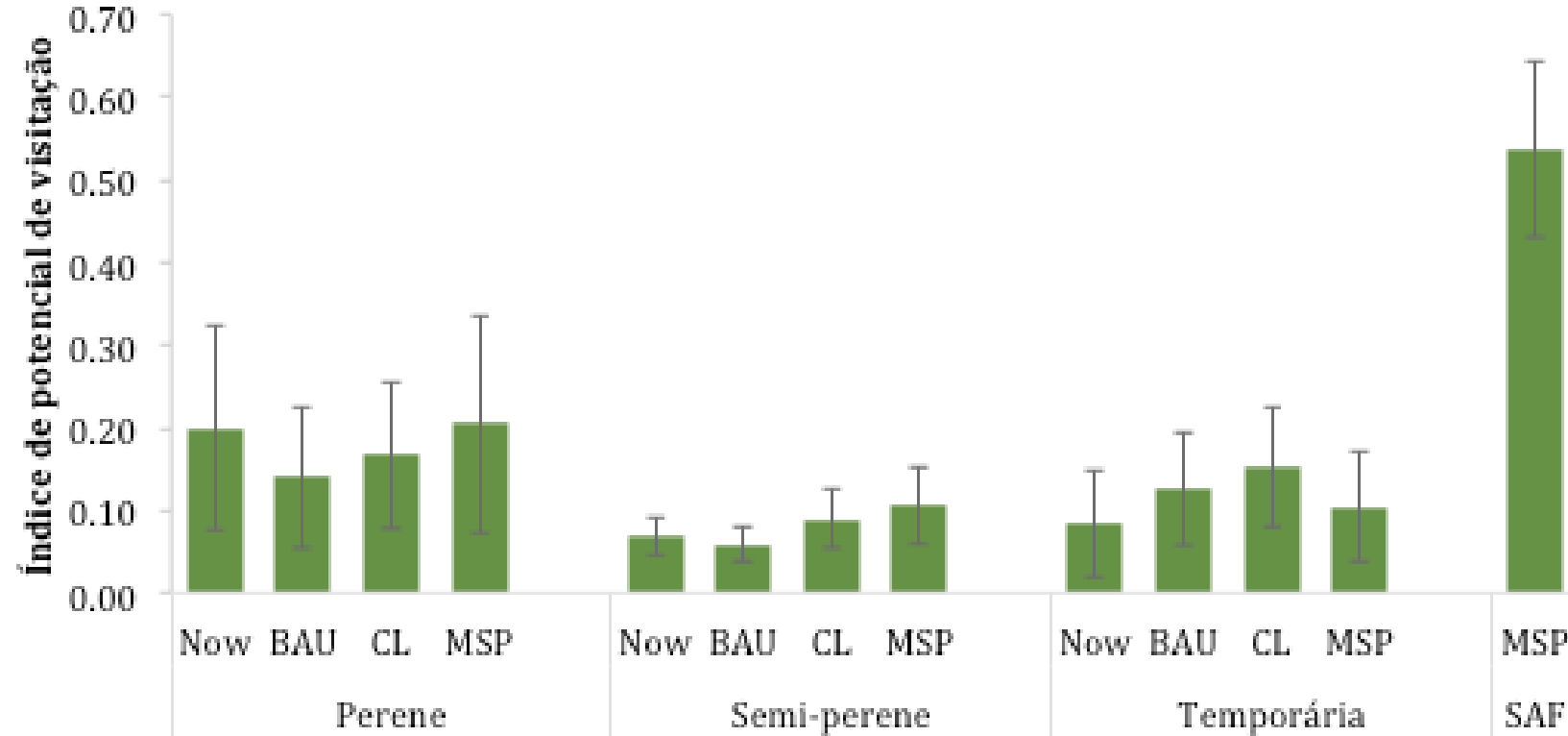
15 LIFE ON LAND



Biophysical and ecological valuation: Pollination



2 ZERO HUNGER



15 LIFE ON LAND



Biophysical and ecological valuation: Pollination



2 ZERO HUNGER



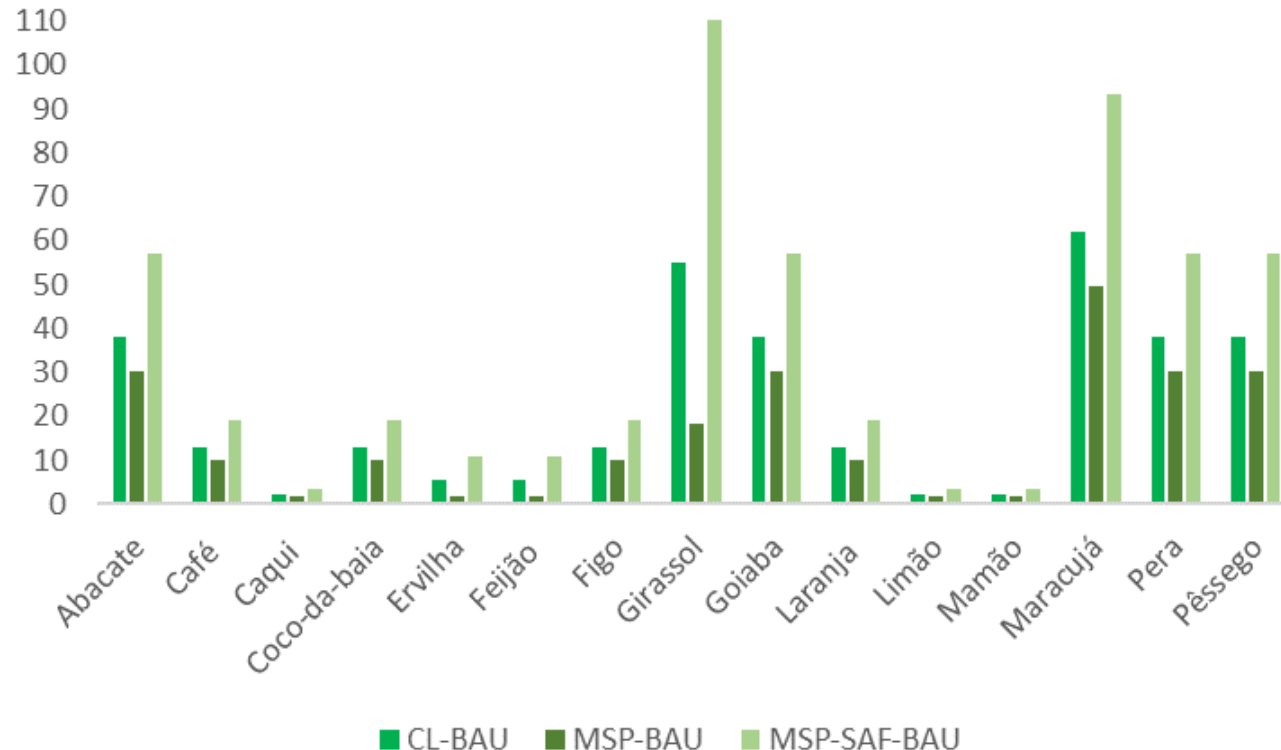
Production yield
(IBGE)

x

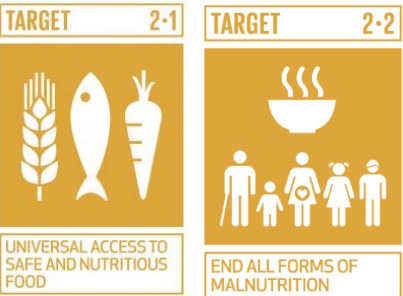
Pollinator dependence
on crop
(Giannini et al 2015)

x

Visitation
potential



What is the impact on production in different scenarios?



15 LIFE ON LAND



6 CLEAN WATER AND SANITATION

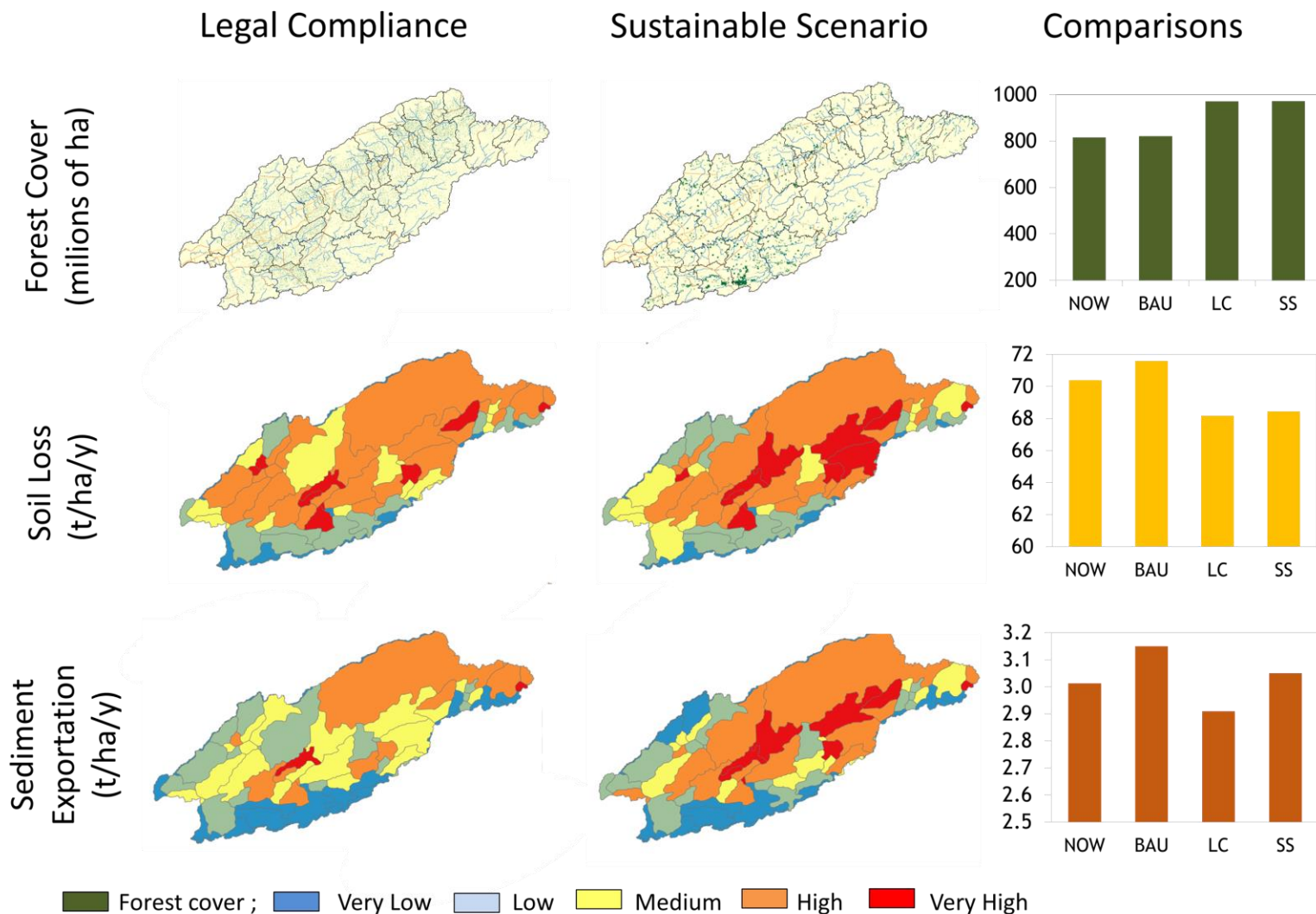


TARGET 6-6



PROTECT AND RESTORE WATER-RELATED ECOSYSTEMS

Restoration and Water Quality - Sedimentation



InVEST

integrated valuation of ecosystem services and tradeoffs

15 LIFE ON LAND



6 CLEAN WATER AND SANITATION



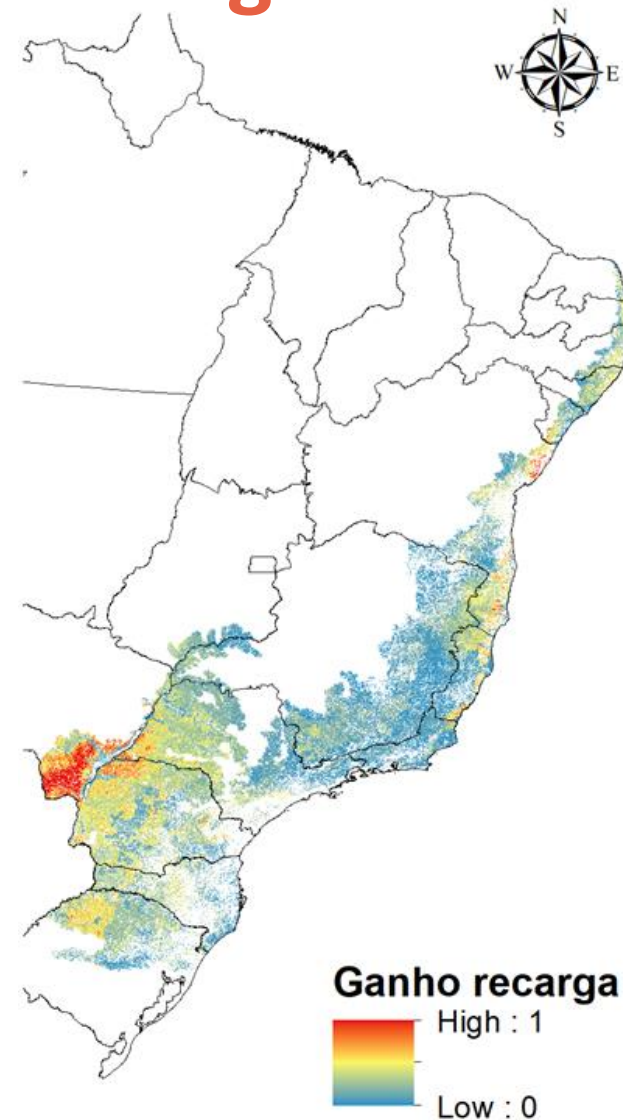
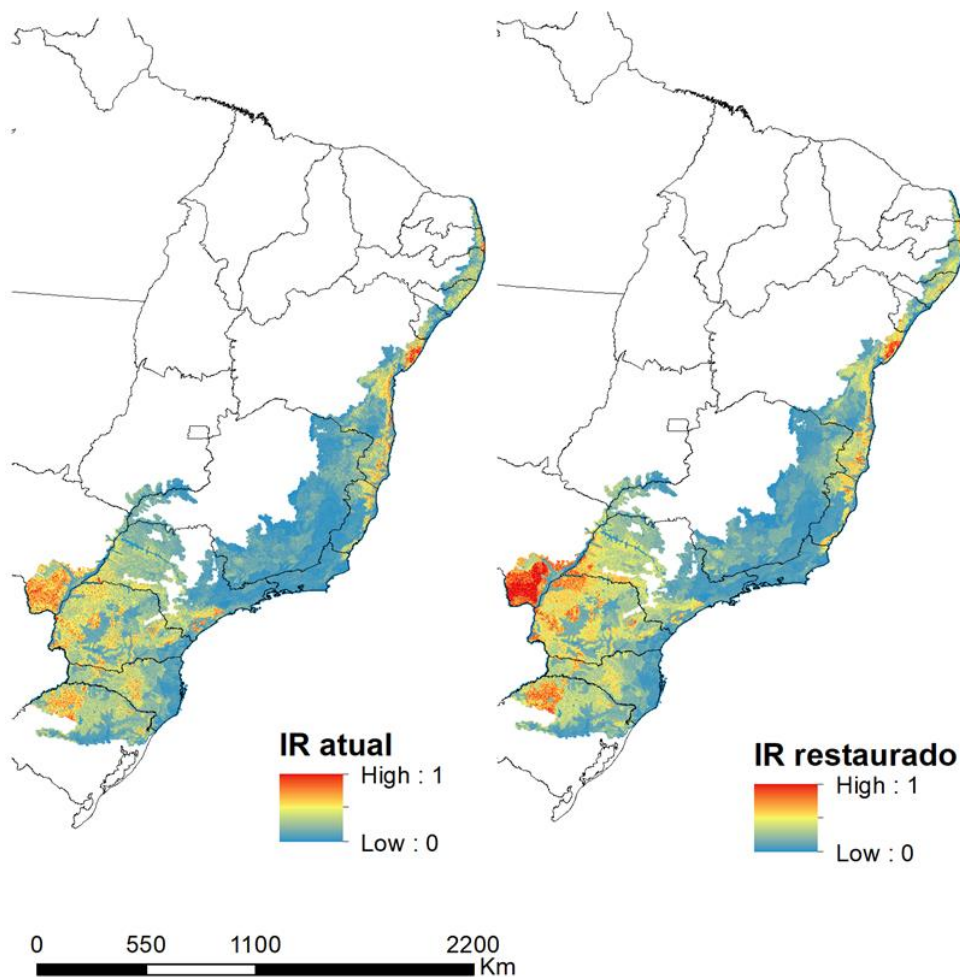
TARGET

6.6



PROTECT AND RESTORE
WATER-RELATED
ECOSYSTEMS

Restoration and Groundwater Recharge



15 LIFE ON LAND



Restoration and Water Quality - Pollution



6 CLEAN WATER AND SANITATION



KING'S
College
LONDON

TARGET 6-6

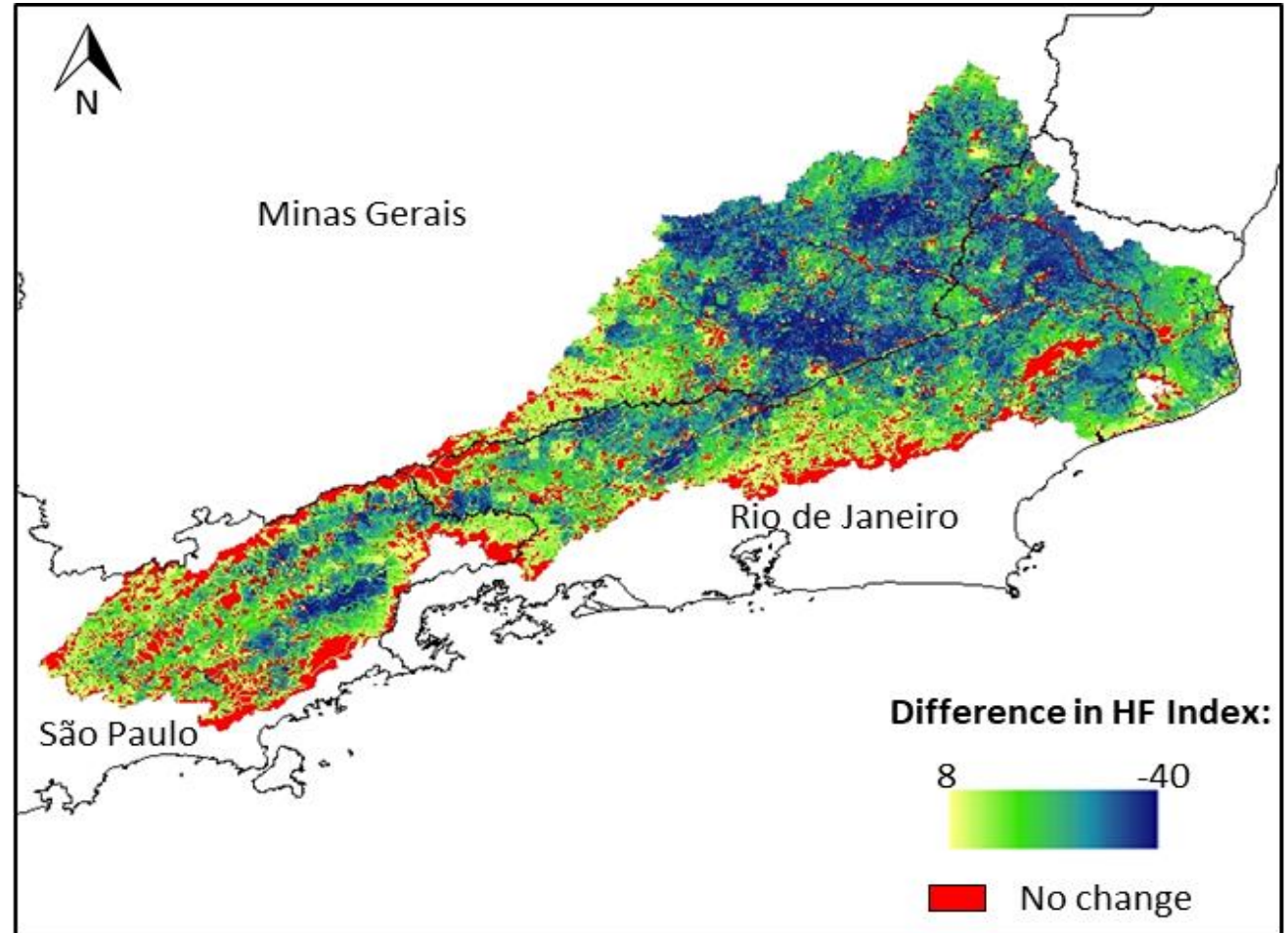


PROTECT AND RESTORE
WATER-RELATED
ECOSYSTEMS

KING'S
water



WaterWorld



15 LIFE ON LAND



6 CLEAN WATER AND SANITATION



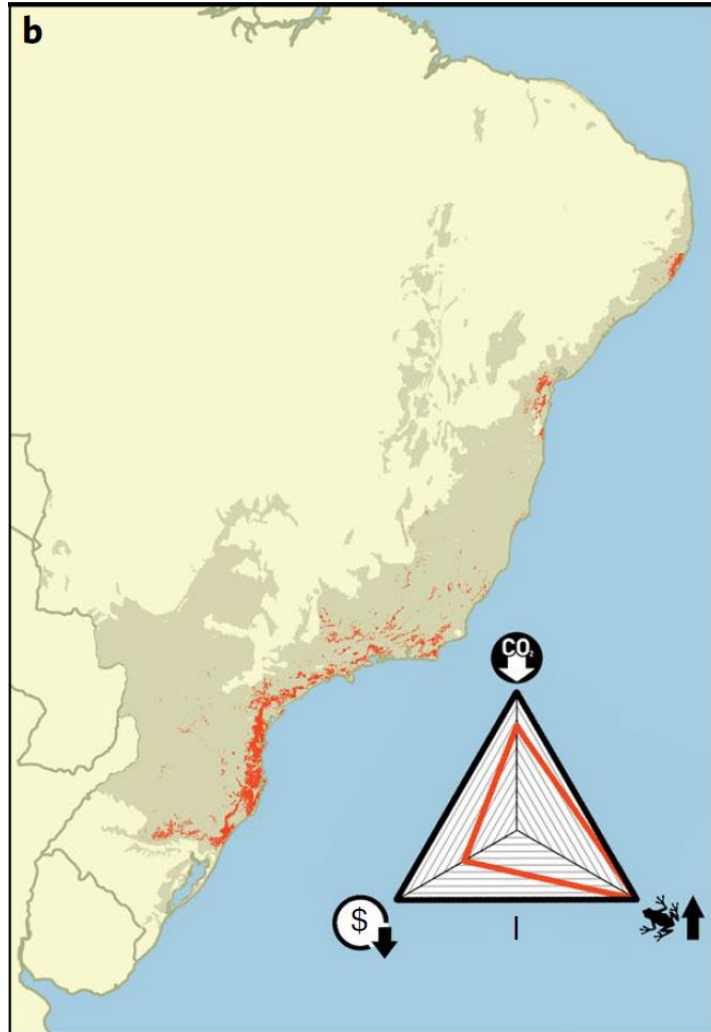
TARGET 6-6



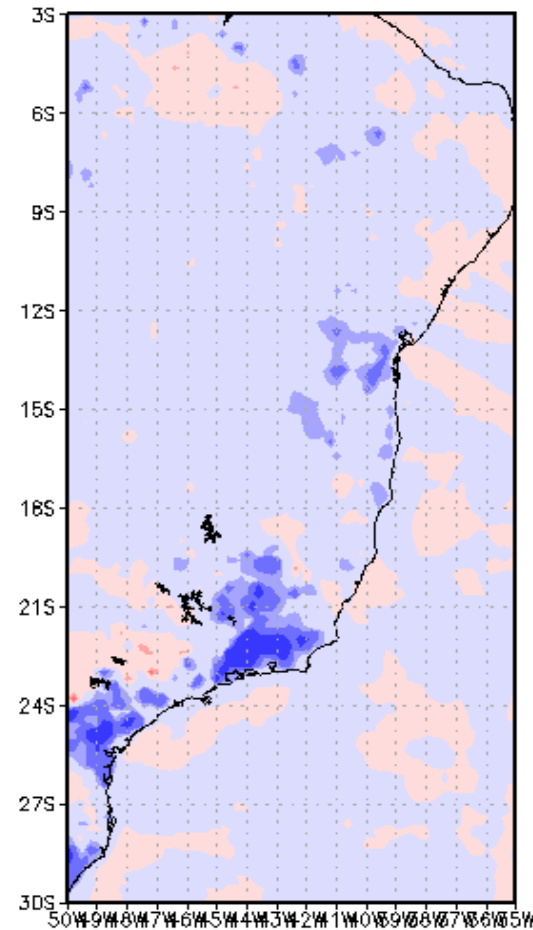
PROTECT AND RESTORE WATER-RELATED ECOSYSTEMS

Restoration and Rain

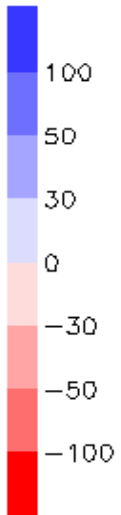
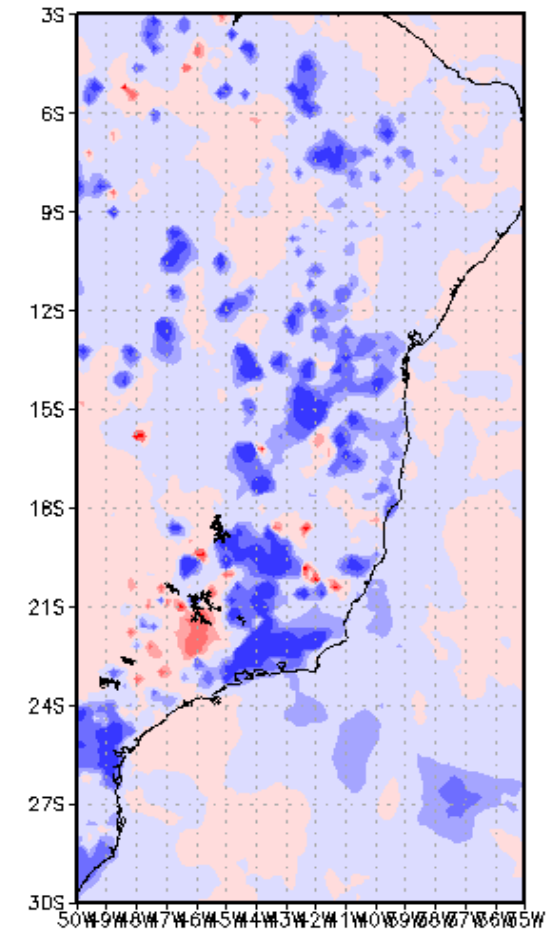
Precipitation Changes (mm)



Wet season



Dry Season



Dib et al., in prep.

Bernardo B. N. Strassburg

15 LIFE ON LAND



6 CLEAN WATER AND SANITATION

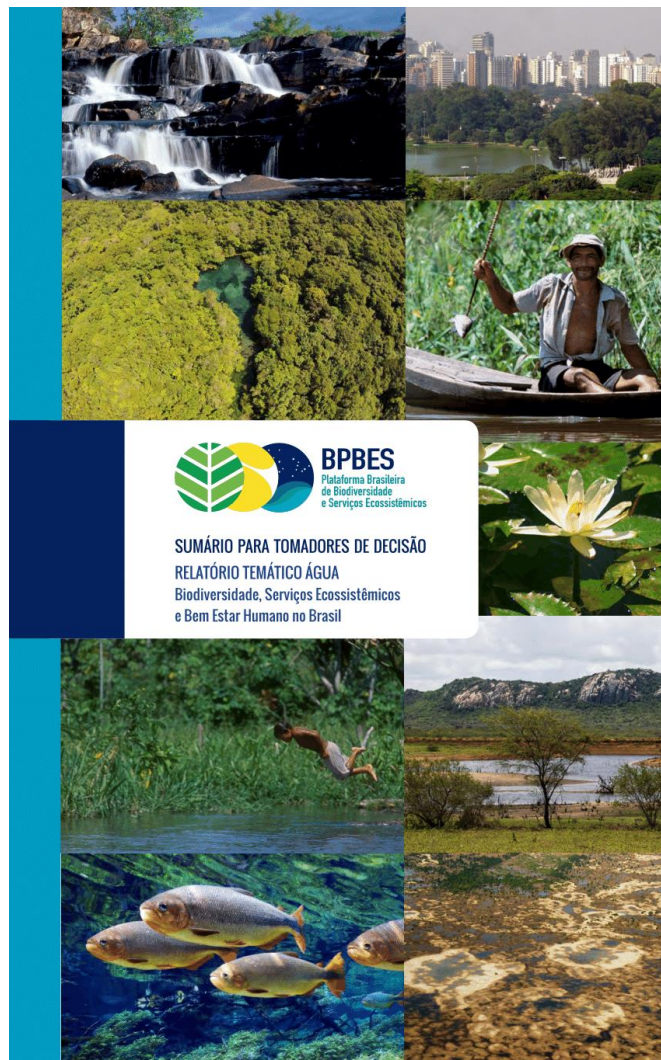


TARGET 6.6



PROTECT AND RESTORE WATER-RELATED ECOSYSTEMS

BPBES Thematic Report on Water



SUMÁRIO PARA TOMADORES DE DECISÃO
RELATÓRIO TEMÁTICO ÁGUA
Biodiversidade, Serviços Ecossistêmicos
e Bem Estar Humano no Brasil

OS CAMINHOS PARA A ÁGUA

2020

Cumprimento da Lei recompará parte da **vegetação nativa** em áreas ribeirinhas, contribuindo para a qualidade das águas brasileiras.

Proteção de ambientes de água doce é um dos pontos mais críticos para o cumprimento das **Metas de Aichi**.

A cada R\$ 1 investido em segurança hídrica, entre **R\$ 15 e R\$ 20** são obtidos em benefícios, sendo o setor de serviços o mais favorecido.

2030

Fortalecimento das instituições de **gestão da água** colocará o país em uma posição privilegiada no contexto global.

Previsão de crescimento de **46,6%** na produção da pesca e aquicultura, o maior da América Latina.

A meta do **Plano Nacional de Saneamento Básico** é que **93% do território** brasileiro tenha tratamento do esgoto e que a perda na distribuição da água gire em torno de **30%.**

2035

Cerca de **74 milhões** de pessoas estarão sob risco hídrico no Brasil.

Risco econômico associado à segurança hídrica será em torno de **R\$ 520 bi.**, + que o dobro do valor observado em **2017.**

Mais de **R\$ 70 bi/ano** será o investimento requerido para a diminuição do risco para os setores produtivos.

2050-2100

Aumento em **54% da** captação de águas subterrâneas no Brasil.

As mudanças climáticas e de uso do solo comprometerão a biodiversidade dos ambientes aquáticos.

Redução na biodiversidade para a **Raia Amazônica** e extremo sul do país em cerca de **25%.**

Eventos extremos de precipitação e alteração da disponibilidade hídrica afetarão os grandes centros urbanos.

Relatório Temático

Água: Biodiversidade, Serviços Ecossistêmicos e Bem Estar Humano no Brasil



OS VÁRIOS BRASIS DA ÁGUA

Cerca de **40%** DO TERRITÓRIO NACIONAL possui níveis de AMEAÇA de moderado a alto dos corpos hídricos



Acesse o documento em: www.hpb.es.net.br



Bernardo B. N. Strassburg

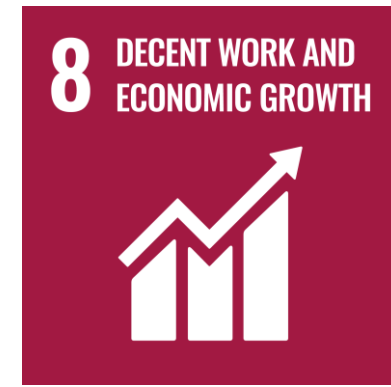


Estimating benefits via:

- Job creation in restoration projects
- Income generation in sustainable forest management



TARGET 1-A	TARGET 1-B
MOBILIZE RESOURCES TO IMPLEMENT POLICIES TO END POVERTY	CREATE PRO-POOR AND GENDER-SENSITIVE POLICY FRAMEWORKS
TARGET 1-2	TARGET 1-5
REDUCE POVERTY BY AT LEAST 50%	BUILD RESILIENCE TO ENVIRONMENTAL, ECONOMIC AND SOCIAL DISASTERS



TARGET 8-1	TARGET 8-3
SUSTAINABLE ECONOMIC GROWTH	PROMOTE POLICIES TO SUPPORT JOB CREATION AND GROWING ENTERPRISES
TARGET 8-4	TARGET 8-9
IMPROVE RESOURCE EFFICIENCY IN CONSUMPTION AND PRODUCTION	PROMOTE BENEFICIAL AND SUSTAINABLE TOURISM

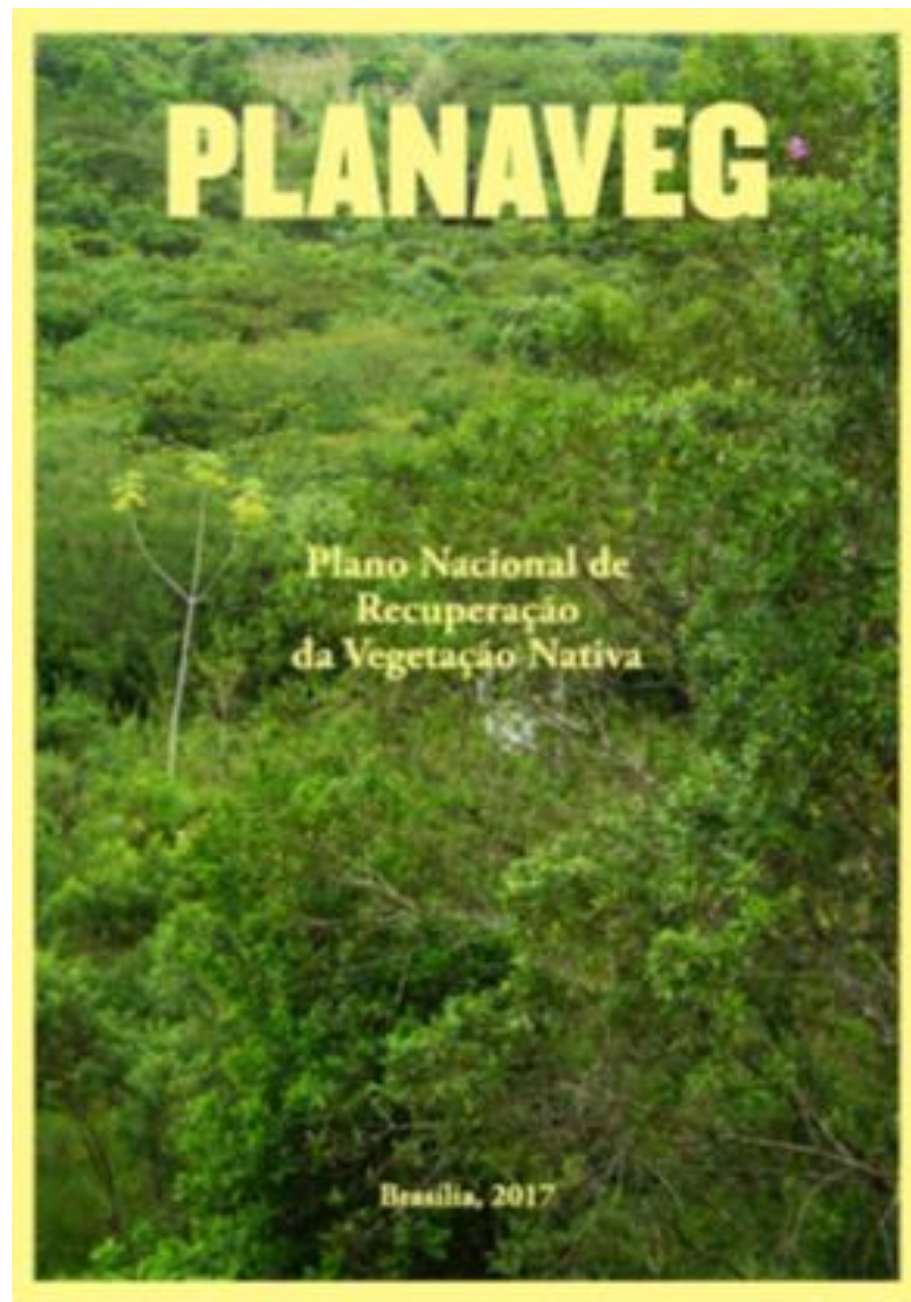
15 LIFE
ON LAND



1 NO
POVERTY



8 DECENT WORK AND
ECONOMIC GROWTH



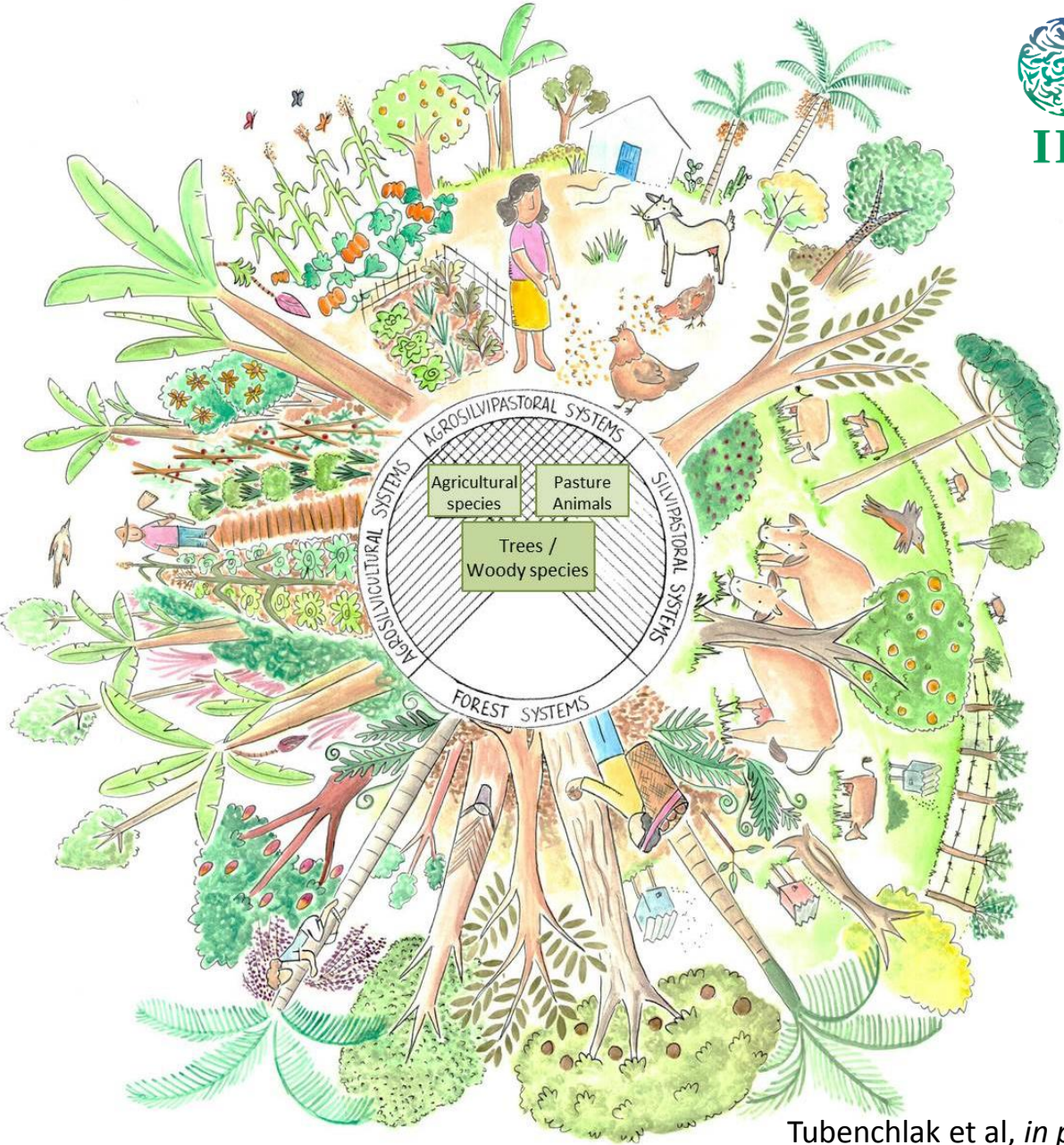


Agroforestry and Landscape Restoration

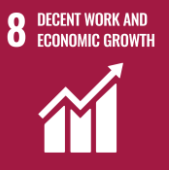
TARGET

2-4

SUSTAINABLE FOOD PRODUCTION AND RESILIENT AGRICULTURAL PRACTICES



Tubenchlak et al, *in press*



Technical Basis for Rio de Janeiro State Climate Adaptation Plan



Ecosystem-based Adaptation

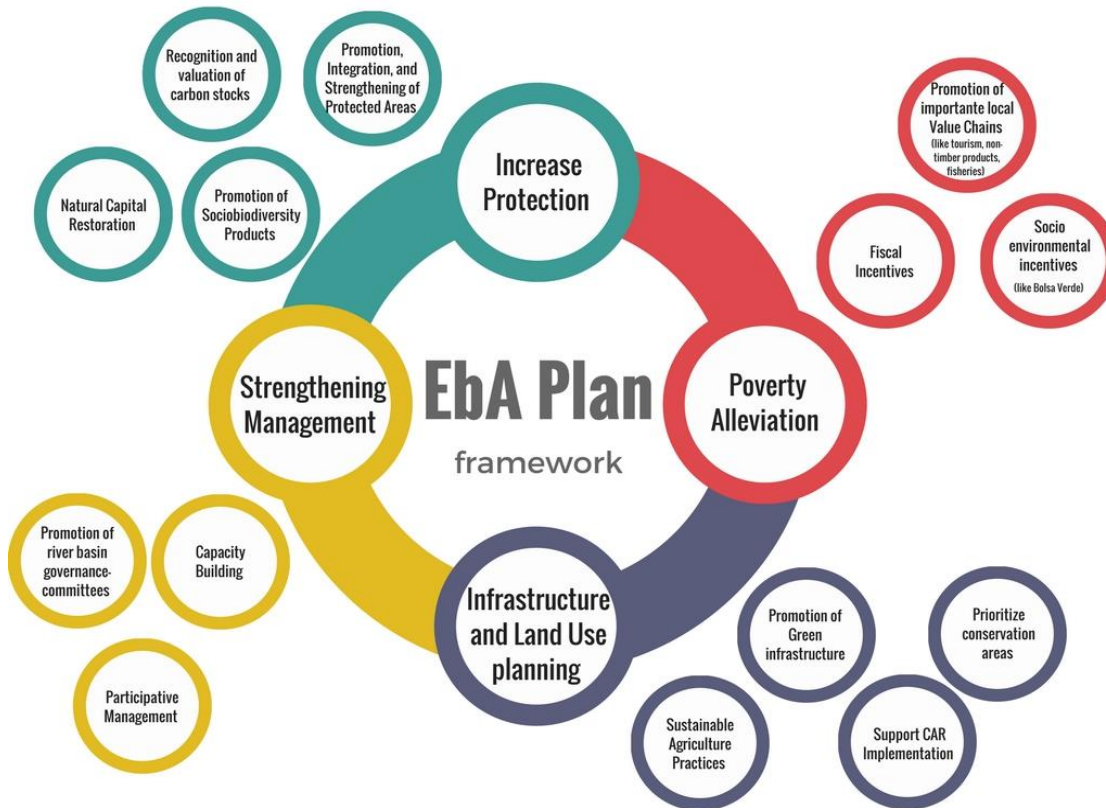
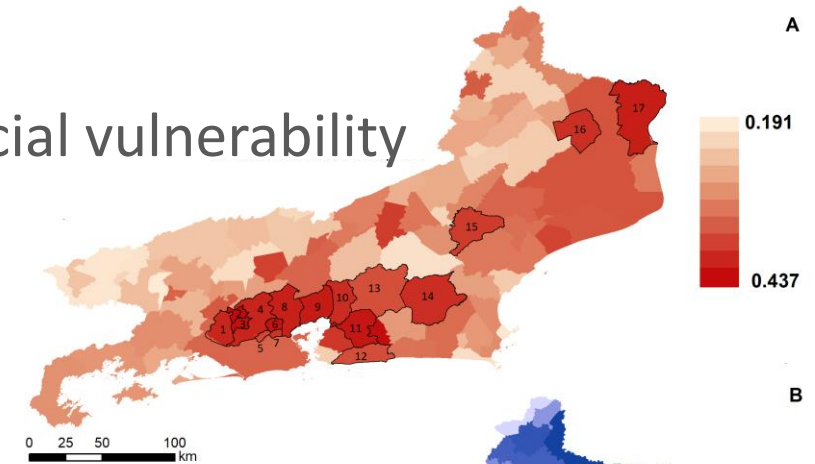
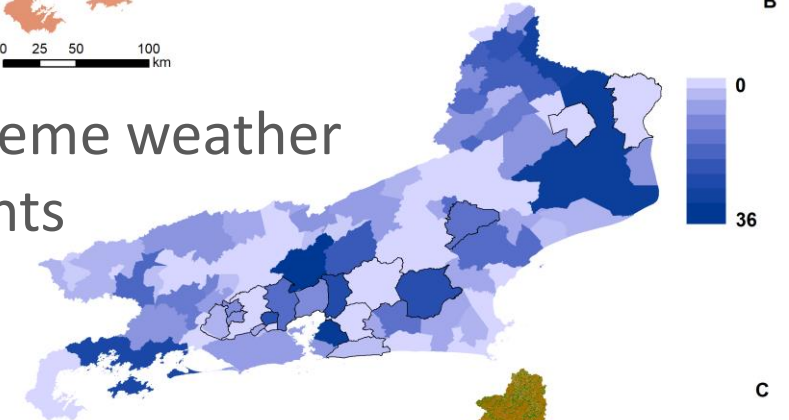


Figure kindly provided by Thais P. Kasecker

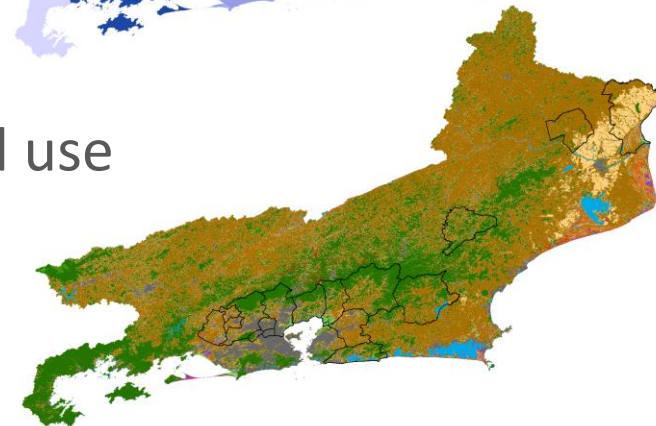
Social vulnerability



Extreme weather events

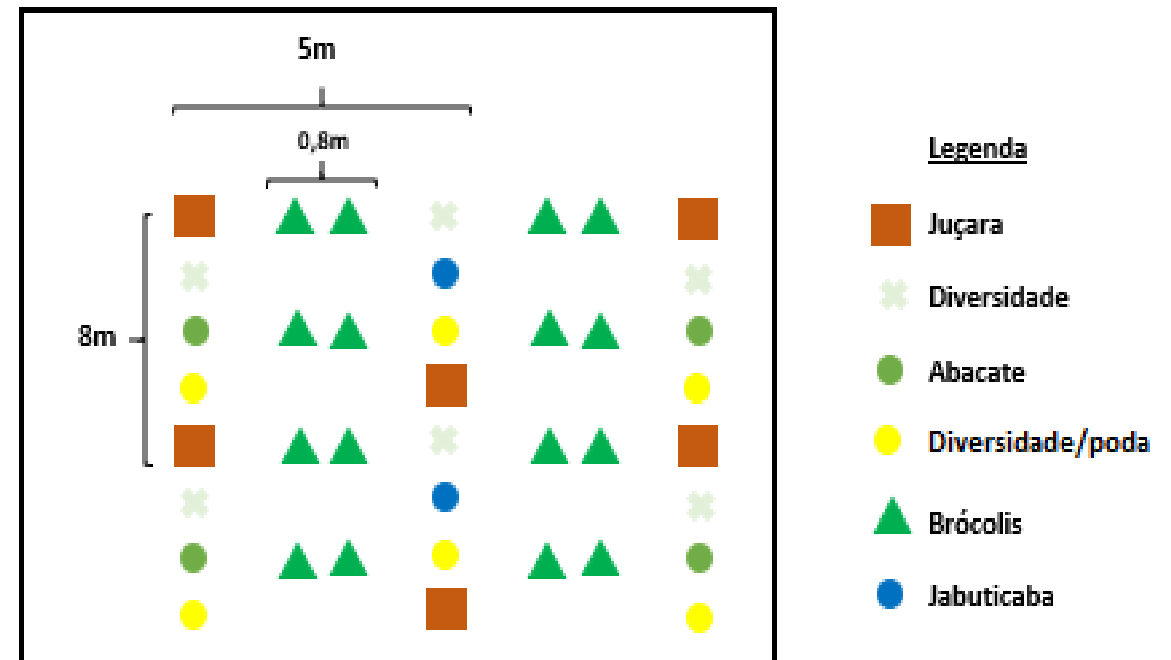
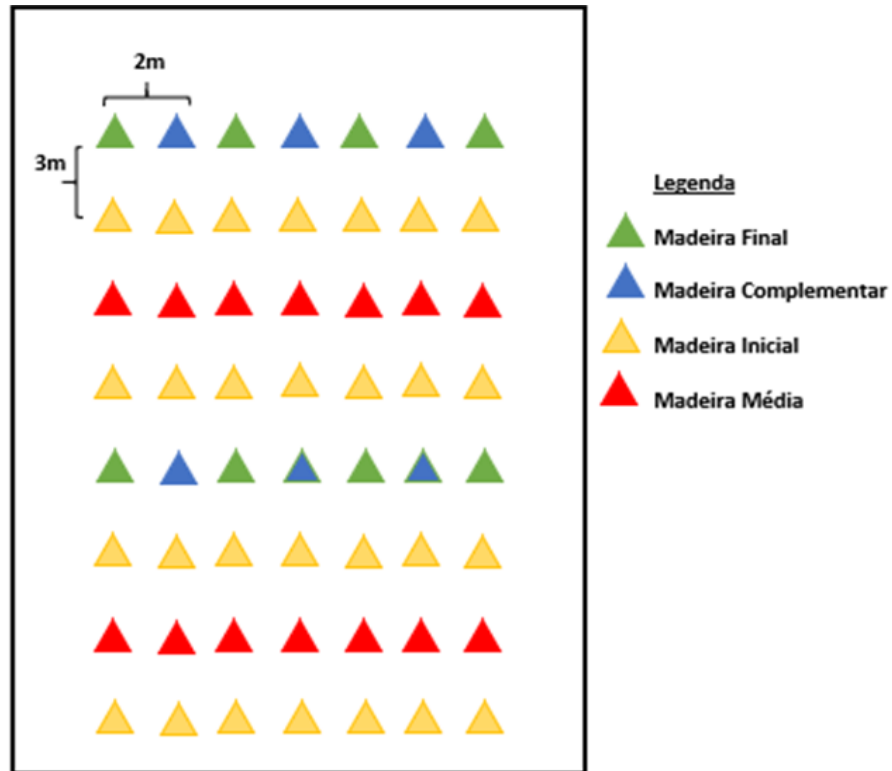


Land use



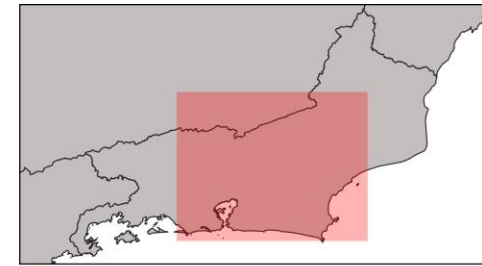
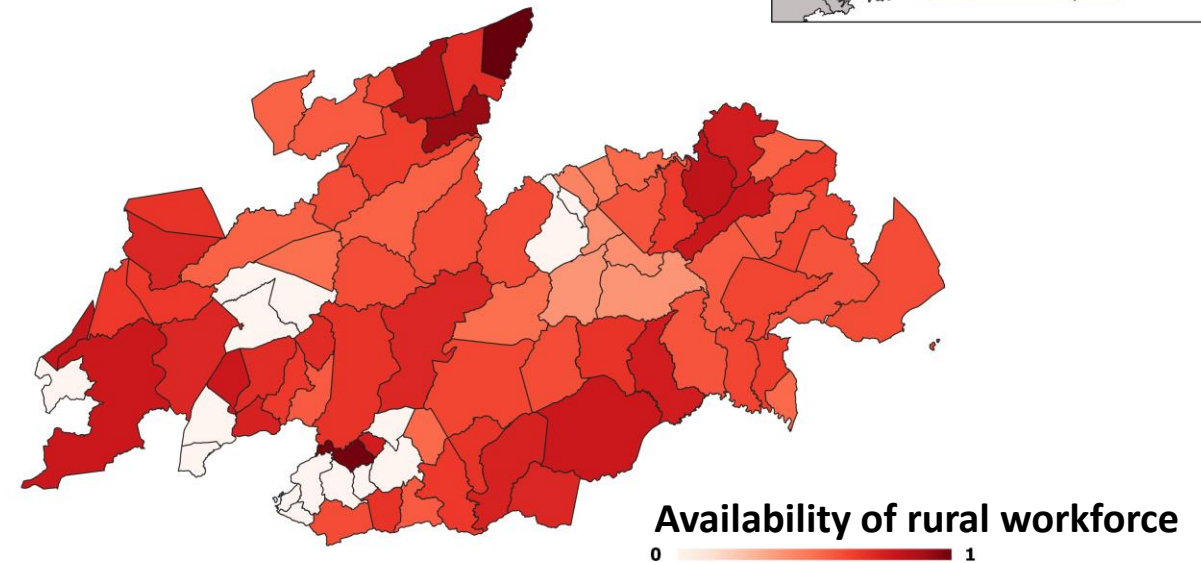
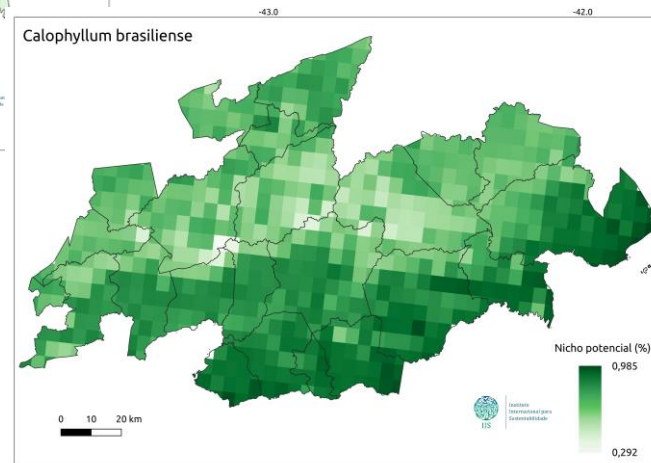
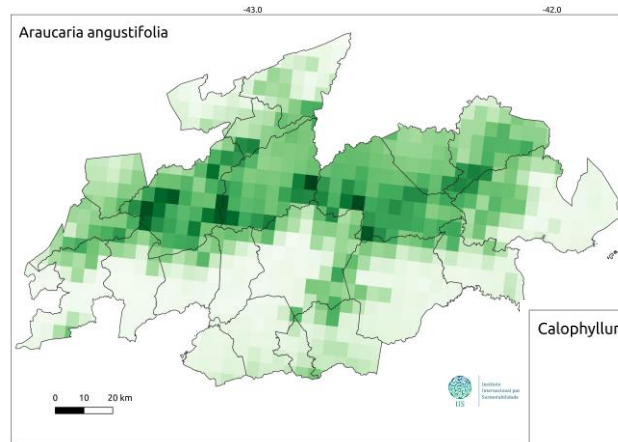
Economic Analysis of the Restoration supply chain in Central Rio de Janeiro State

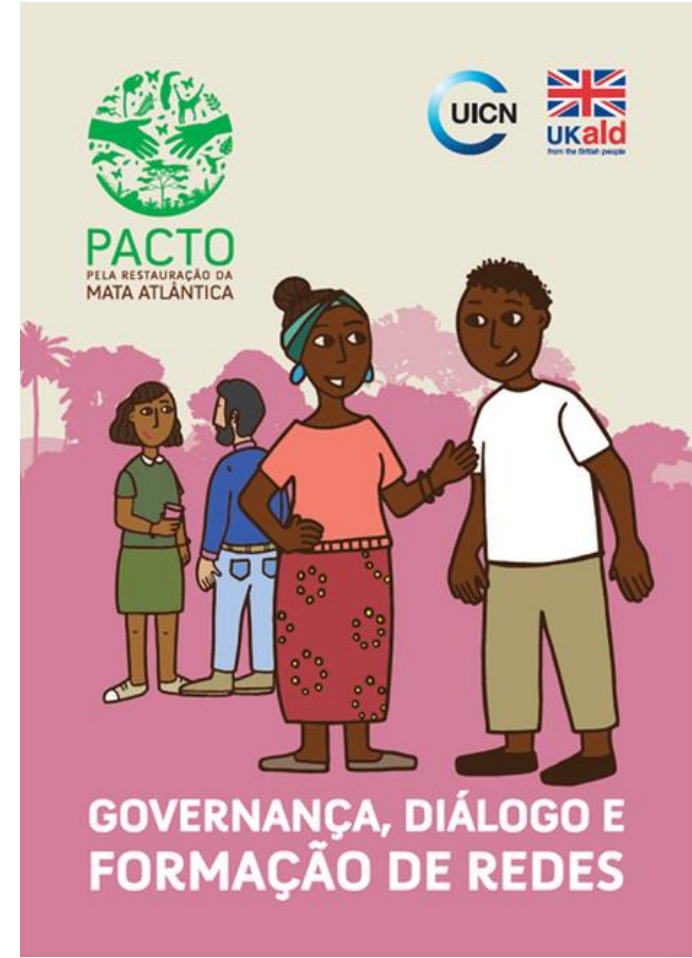
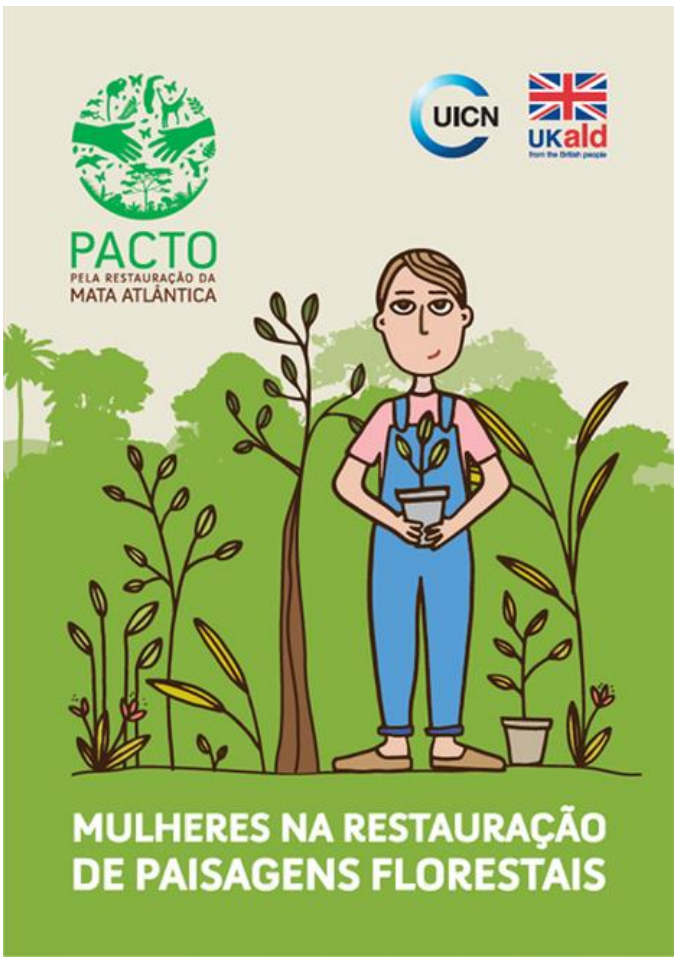
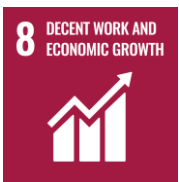
- Socio-ecological diagnosis
- Economic valuation of different restoration models, including agroforestry systems



Economic Analysis of the Restoration supply chain in Central Rio de Janeiro State

- Spatial allocation of the different models according to ecological, social and economic factors: natural regeneration potential, ecological connectivity, opportunity costs, labour availability, and food demand;
- Niche models for native tree species





Key Messages

- Restoration is a very powerful tool for global challenges and SDGs, with Aichi Target 15 resulting in major gains for
 - i) biodiversity conservation (saving up to 67% of species)
 - ii) offering major contributions for climate change mitigation (326 bill. tCO₂, 91% of remaining budget for 1.5C) and adaptation, (cost-effective, <USD10-15/tCO₂)
- Trade-offs and very strong synergies among Rio conventions, SDGs
- integrated systems analyses can illuminate, map, quantify and offer actionable evidence



Thank you

Systems Analysis and the Americas
2019

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