CIGSエネルギー環境セミナー
April 26th 2018

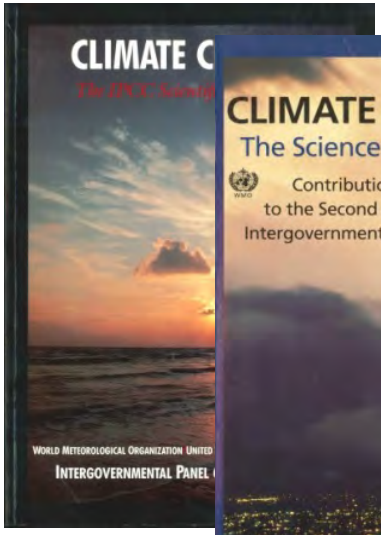
気候変動と土地利用：京都議定書、パリ協定、今後の課題

Head of GCP Tsukuba International Office

Yoshiki Yamagata

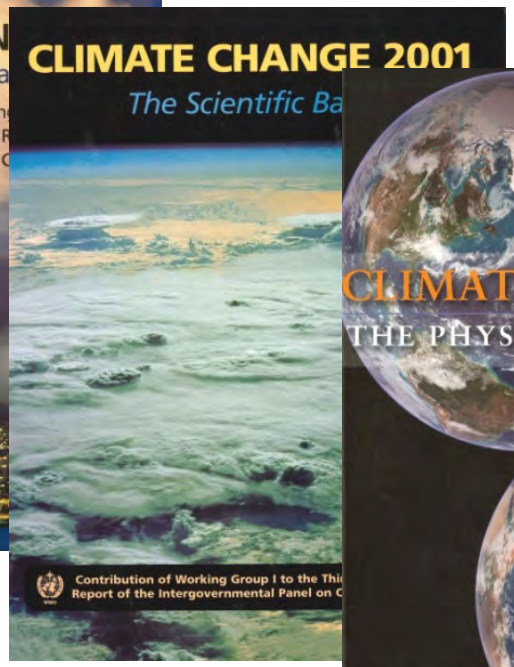
Center for Global Environmental Research,
National Institute for Environmental Studies, Japan

IPCC 評価報告書（第１－５次）

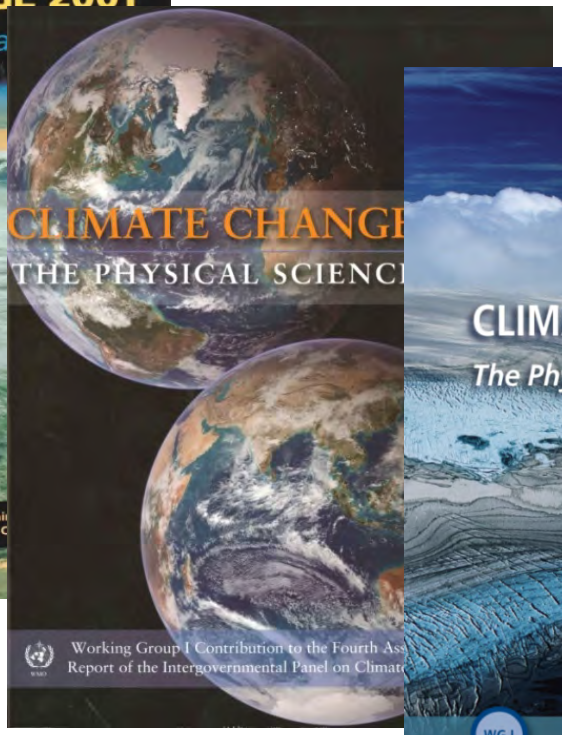


1990

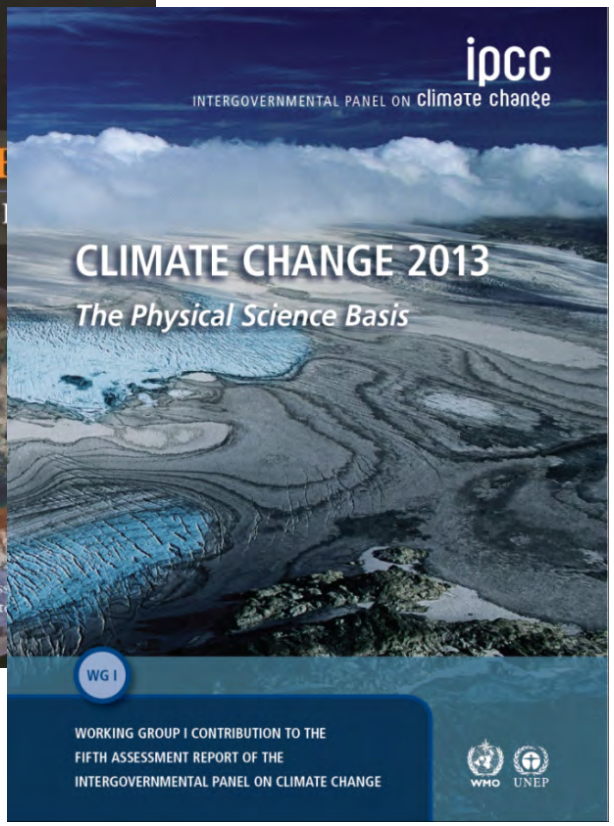
1995



2001



2007



2013

WIDESPREAD OBSERVED IMPACTS

A CHANGING WORLD

ipcc
INTERGOVERNMENTAL PANEL ON climate change

WIDESPREAD OBSERVED IMPACTS

A CHANGING WORLD

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VULNERABILITY AND EXPOSURE

AROUND THE WORLD

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INTERGOVERNMENTAL PANEL ON climate change


RISKS OF
CLIMATE CHANGE
INCREASE
WITH CONTINUED
HIGH EMISSIONS
ipcc
INTERGOVERNMENTAL PANEL ON climate change

EFFECTIVE CLIMATE CHANGE ADAPTATION

A MORE VIBRANT WORLD

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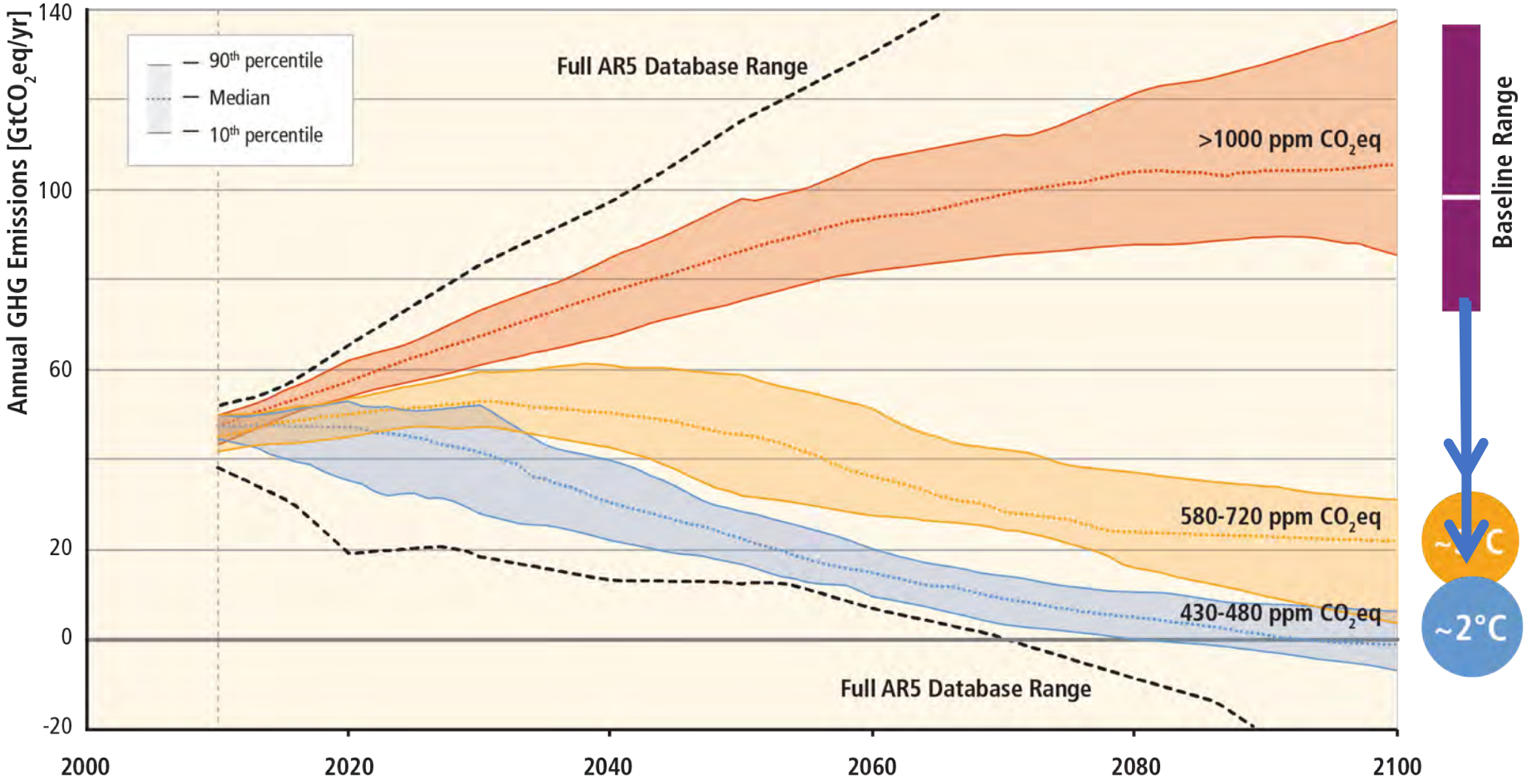
INTERGOVERNMENTAL PANEL ON climate change

パリ協定：グローバル２℃未満の温度上昇への抑制



futureearth
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グローバルカーボンプロジェクト（GCP）

CSIRO
NIES
U.S. Carbon Cycle Science Program
The Research Council of Norway
European Commission
CICERO Center for International Climate and Environmental Research - Oslo
LSCE
UEA University of East Anglia
Tyndall Centre for Climate Change Research
FONDATION BNP PARIBAS

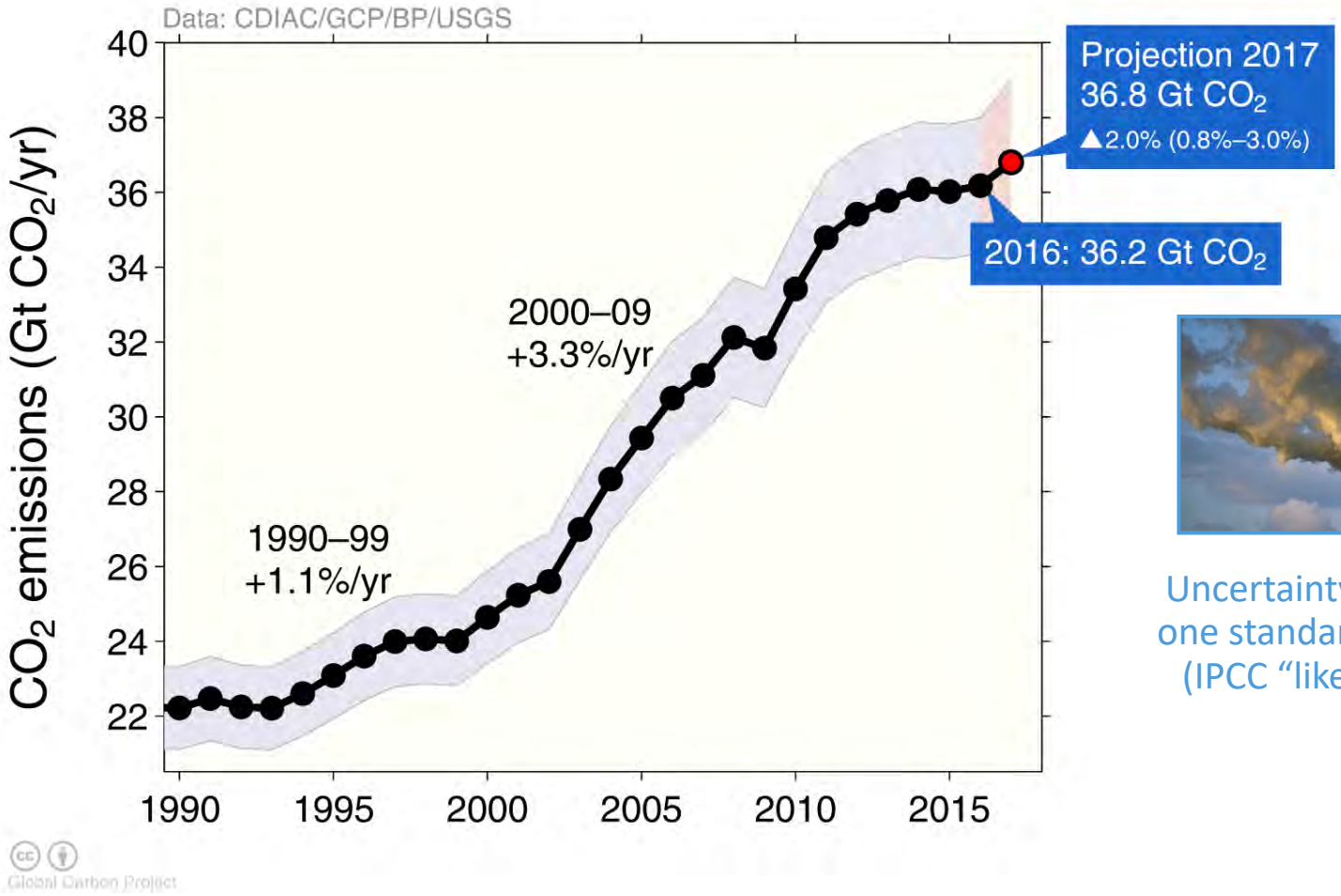
国別のCO_2排出量のマッピング（カーボンアトラス）

Global Carbon Project

化石燃料の燃焼による世界のCO_2排出量の変化

Global emissions from fossil fuel and industry: 36.2 ± 2 $GtCO_2$ in 2016, 62% over 1990

- Projection for 2017: 36.8 ± 2 $GtCO_2$, 2.0% higher than 2016

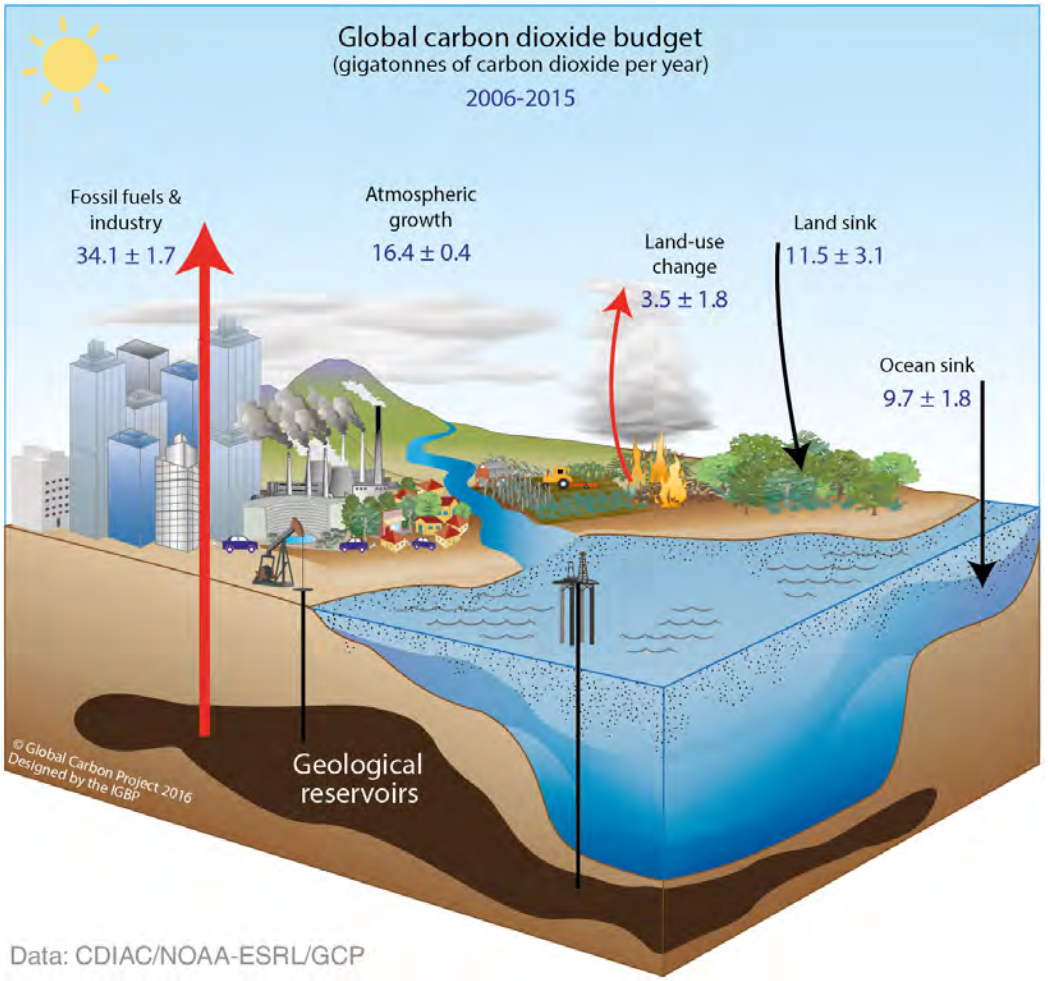


Uncertainty is ±5% for one standard deviation (IPCC "likely" range)

Estimates for 2015 and 2016 are preliminary. Growth rate is adjusted for the leap year in 2016.
Source: CDIAC; Le Quéré et al 2017; Global Carbon Budget 2017

グローバルな炭素循環への人的な影響

Perturbation of the global carbon cycle caused by anthropogenic activities, averaged globally for the decade 2006–2015 ($GtCO_2$/yr)



Source: CDIAC; NOAA-ESRL; Le Quéré et al 2016; Global Carbon Budget 2016

グローバルなCO2の発生源と吸収源　(2006-2015)

34.1 $GtCO_2$/yr

91%

9%

3.5 $GtCO_2$/yr

Sources = Sinks

16.4 $GtCO_2$/yr

44%

31%

11.6 $GtCO_2$/yr

26%

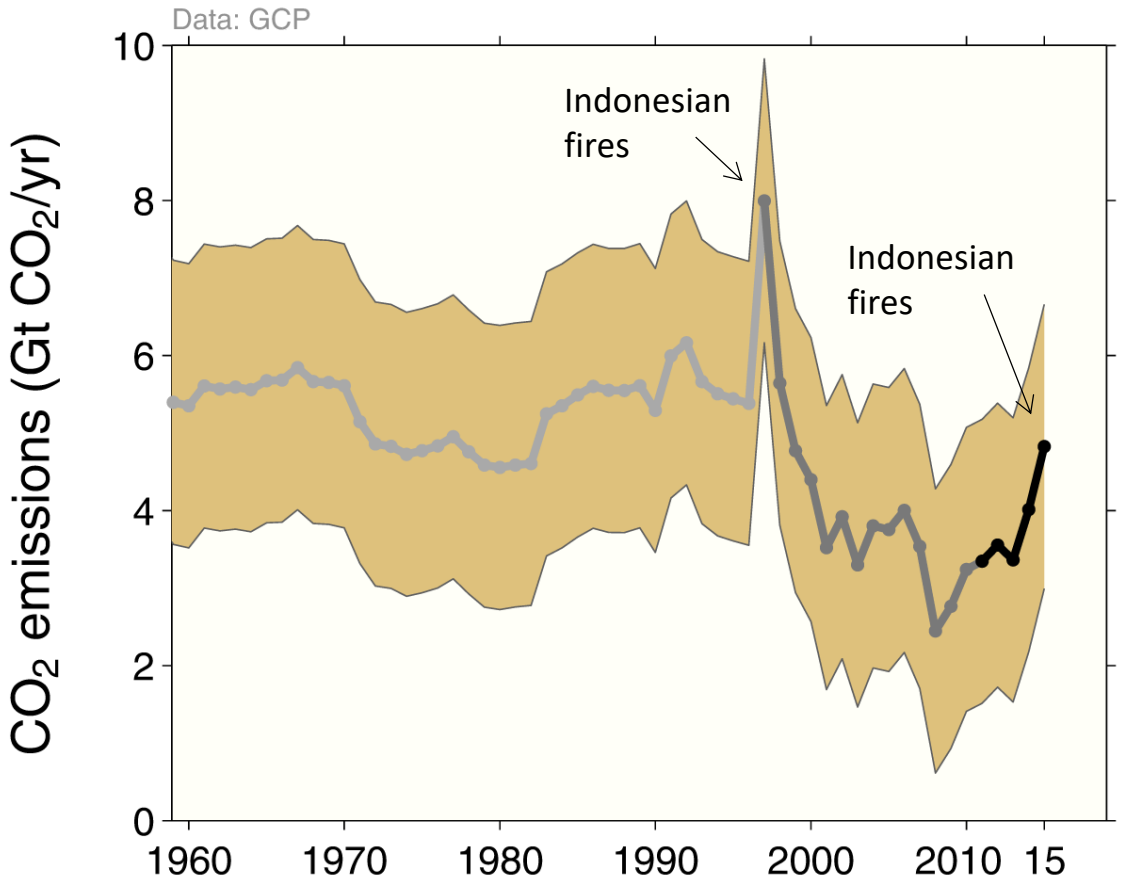
9.7 $GtCO_2$/yr

Source: CDIAC; NOAA-ESRL; Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2016; Global Carbon Budget 2016

土地利用変化からのCO_2排出量の変化

Emissions in the 2000s were lower than earlier decades, but highly uncertain

Higher emissions in 2015 are linked to increased fires during dry El Niño conditions in Asia

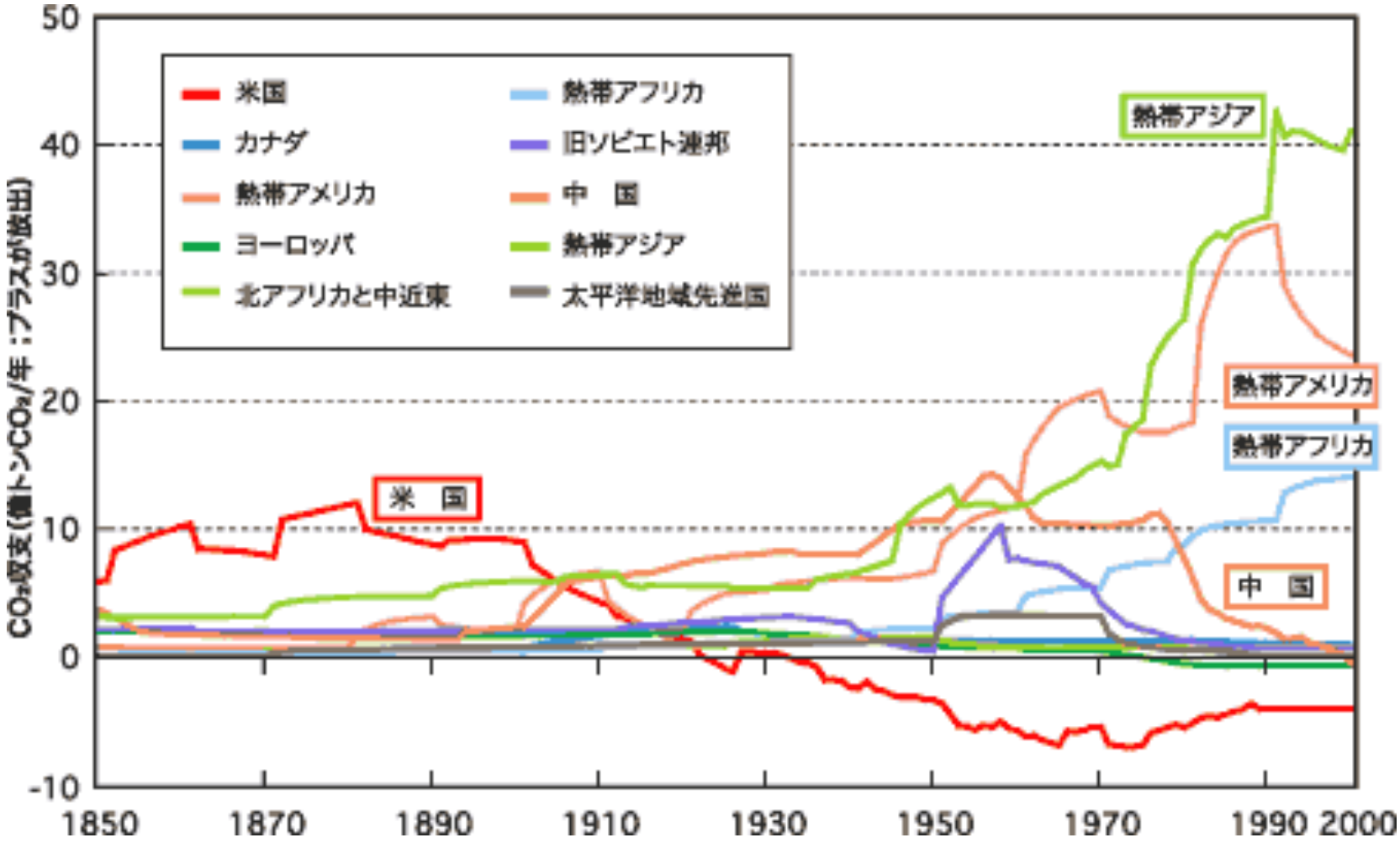


Three different estimation methods have been used, indicated here by different shades of grey

Land-use change also emits CH_4 and N_2O which are not shown here

Source: Houghton et al 2012; Giglio et al 2013; Le Quéré et al 2016; Global Carbon Budget 2016

森林減少に伴う地域（国）別CO_2排出量の変化

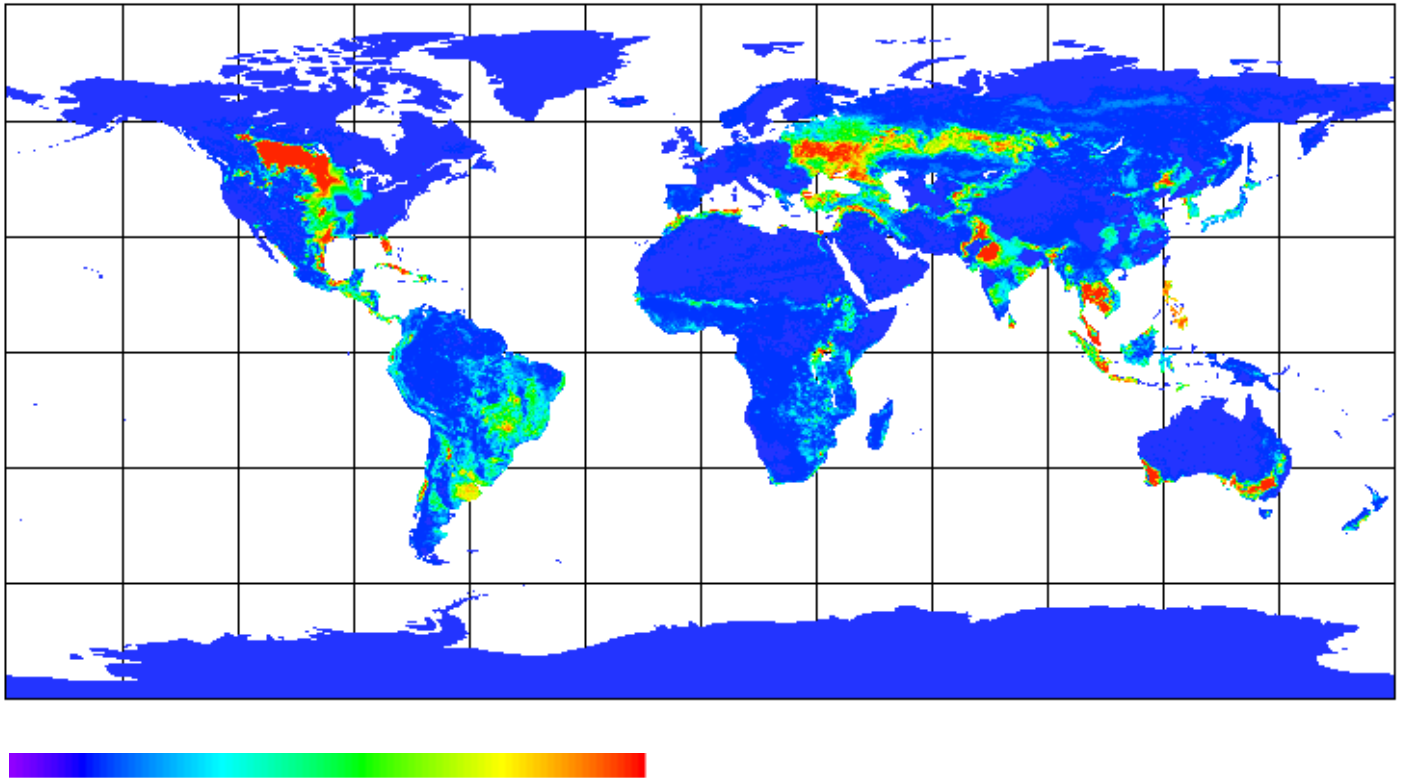


（CDIACのデータをもとに作成）

（ＮＩＥＳ山形）

過去の土地利用に伴うCO_2排出の推定

1901-1990



過去の耕作地面積

Ramankutty & Foley (1999)

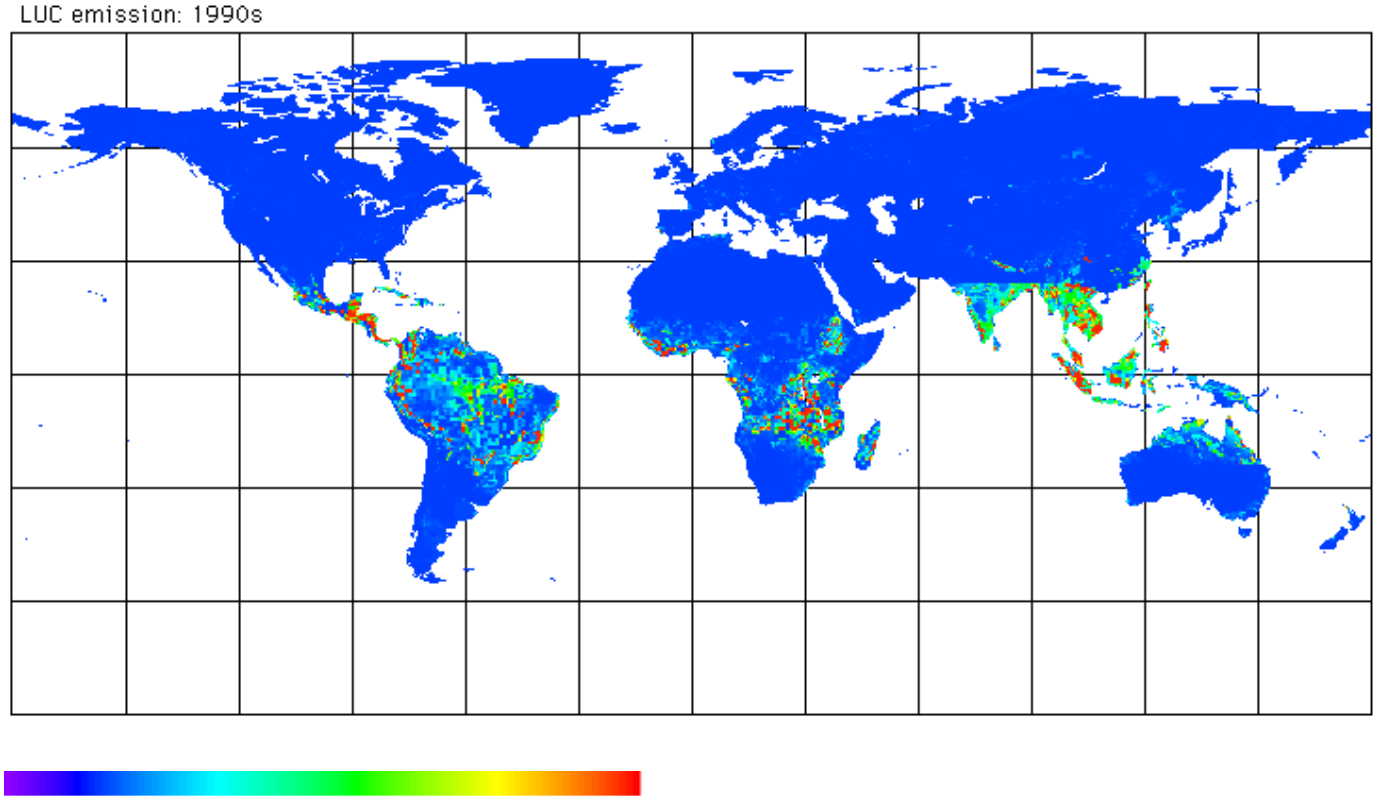
Hurtt et al. (2006)

NIES陸域生態モデルによる推定

（ＮＩＥＳ山形）

過去の土地利用に伴うCO_2排出の推定

1990-1999



過去の耕作地面積

Ramankutty & Foley (1999)

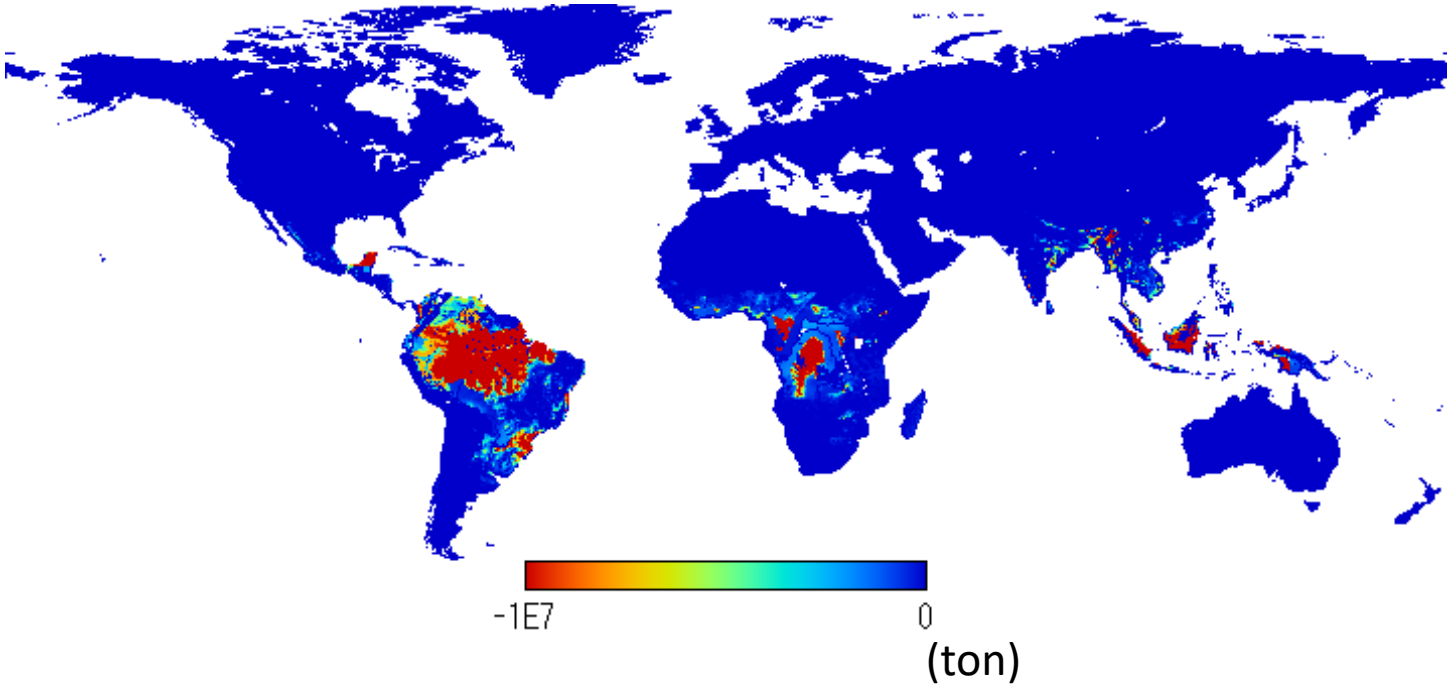
Hurtt et al. (2006)

NIES陸域生態モデルによる推定

（ＮＩＥＳ山形）

過去の土地利用に伴うCO_2排出の推定

2000-2030



将来の耕作地面積は、IPCCシナリオ
として土地利用モデルで作成

NIES土地利用・陸域生態モデルによる推定

（ＮＩＥＳ山形）

京都議定書における炭素吸収源対策

- 植林・再植林　（京都議定書3条3項、CDM）
- 森林管理　（京都議定書3条４項）
- バイオマスの利用
  - 伐採木材の活用（住宅・家具）
  - バイオマスエネルギー（熱・電気）　（化石燃料からの排出削減として、CDM）
- 森林減少の防止（森林保全）

赤字：京都議定書での対策と認められていない

新規植林(Afforestation)

農地等の非「森林」　植林活動等　「森林」

再植林(Reforestation)

90年以降の土地利用変化
を伴う活動をカウントする
（非「森林」を「森林」する）

IPCCタイプ　農地等の非「森林」　「森林」

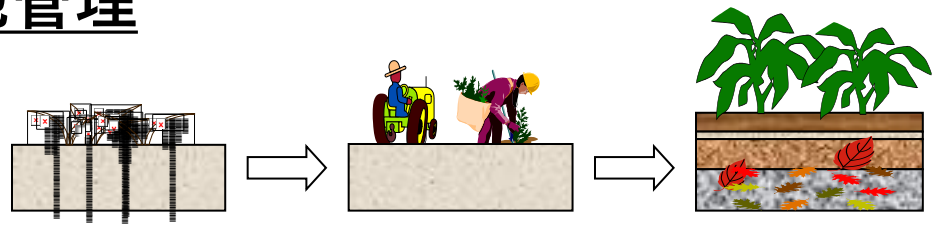
FAOタイプ　林業による伐採　森林再生

森林減少(Deforestation)

「森林」　伐採・開発等　農地等の非「森林」

３条３項（ARD)活動の概念図

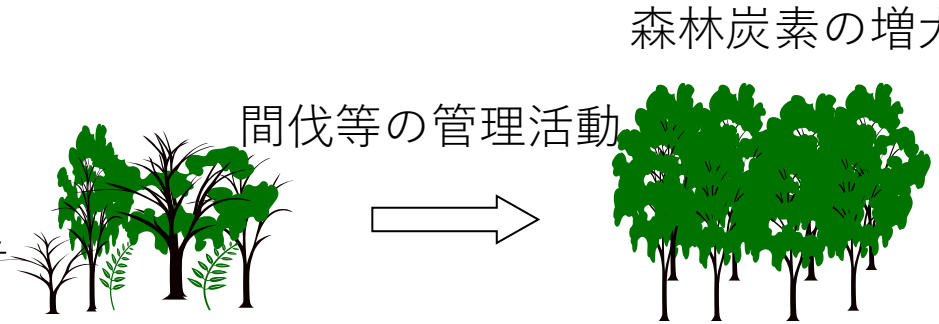
農（牧草）地管理



土壌保全活動　土壌炭素の増大

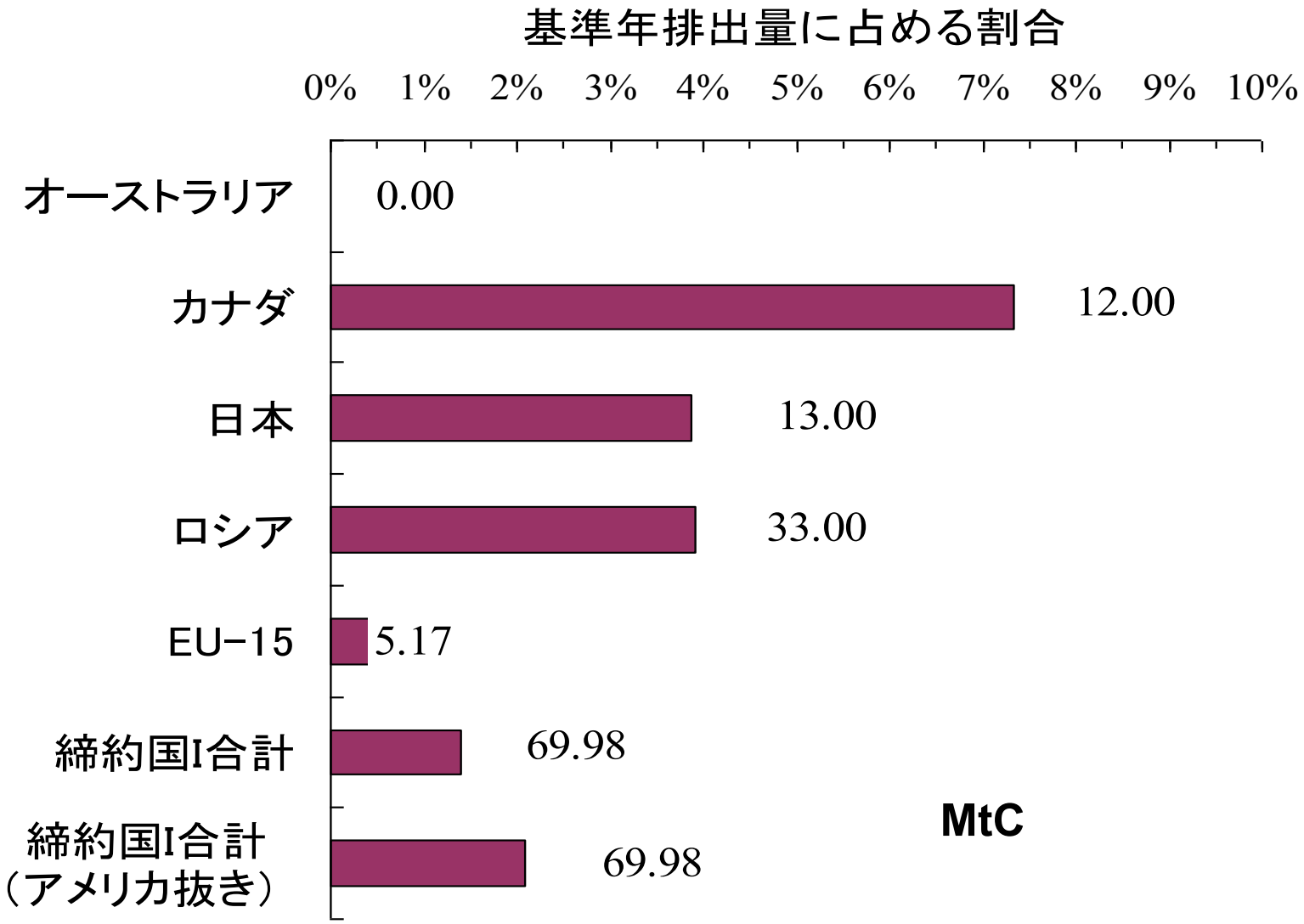
森林保全

森林管理



日本は90年排出量比3.9%を上限に森林管理による吸収量が認められる

3条4項活動の概念図



主要国における3条4項（森林管理）の算入上限値

森林減少によるエコシステムサービスの低下

生物多様性減少

植生変化

生息域減少

栄養分流出

森林破壊

水源涵養機能低下
土砂流出

表土流出
土壌表面崩壊

水源涵養機能低下

洪水

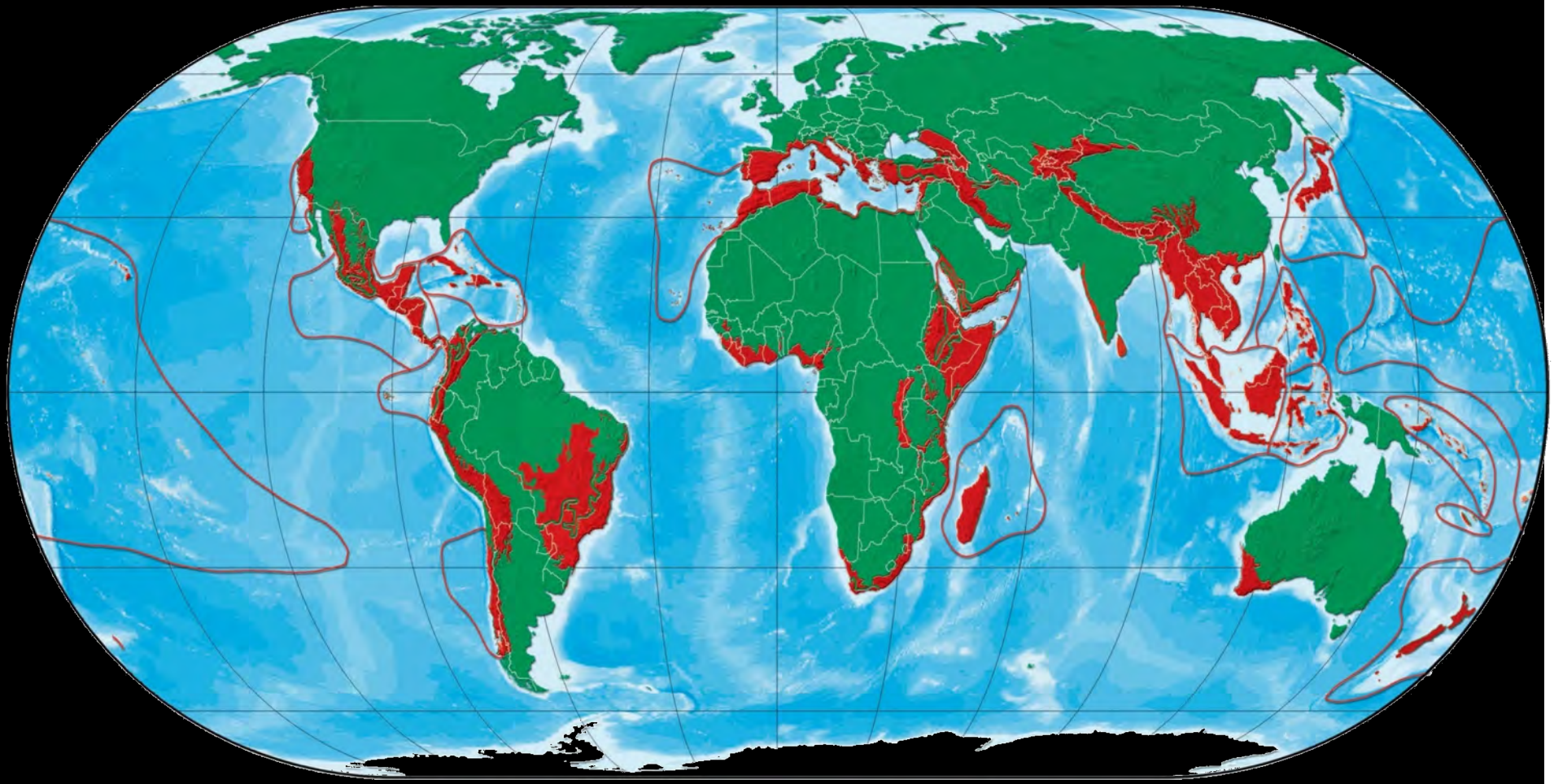
地震発生直後の松越地区。左下の道路と橋梁は山崩れに呑み込まれた

土砂崩れ

渇水

(NIES　山形)

生物多様性ホットスポット



地球規模での生物多様性が高いにも関わらず、破壊の危機に瀕している地域。
地表面積のわずか2.3%でありながら、最も絶滅が危惧されている哺乳類種、鳥類種、両生類種の75%が生息。

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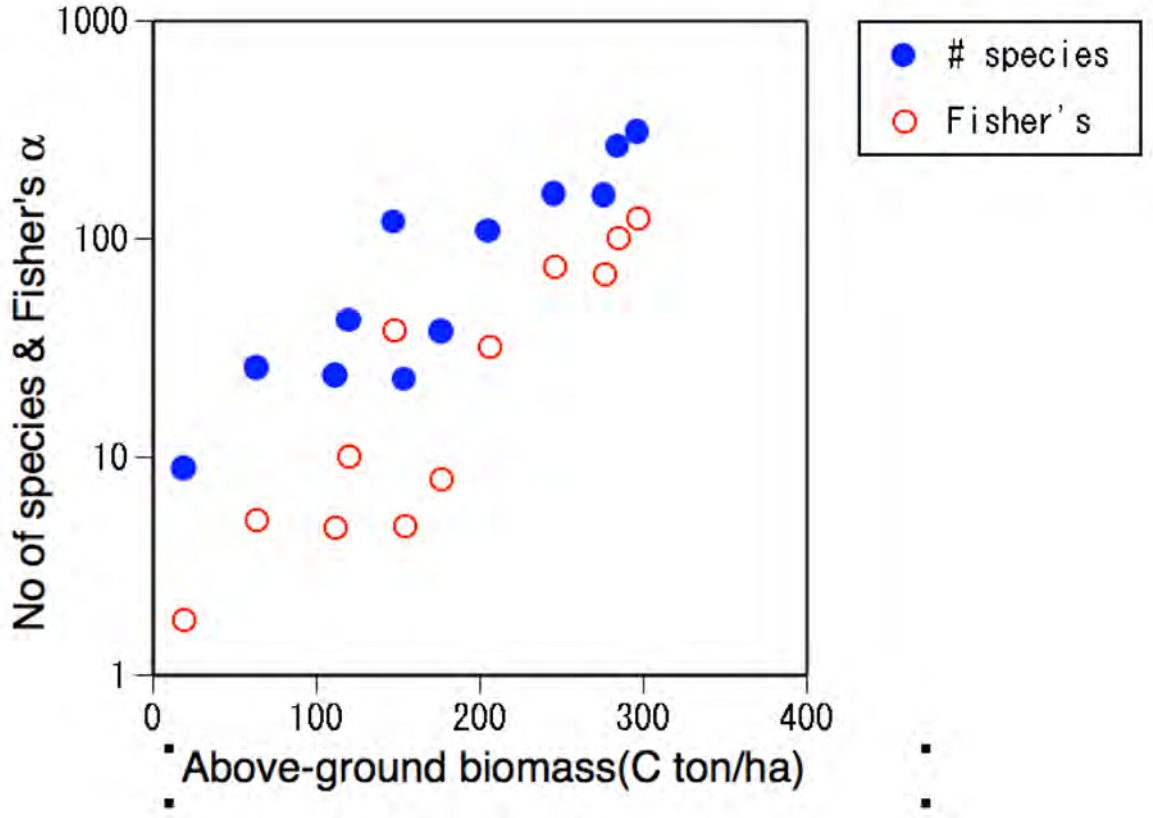
バイオマスと種多様性の関係

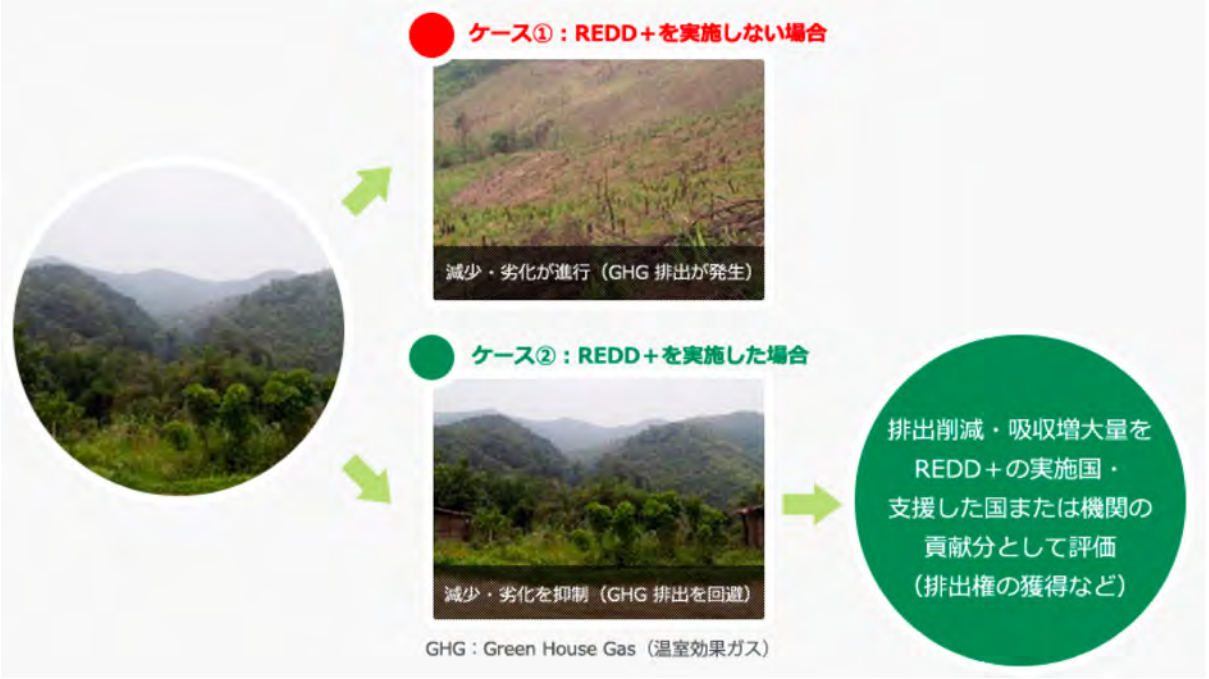


- ボルネオ島とジャワ島の低地熱帯多雨林と高標高の山地林に設置した長期観測のための森林調査区（おもに１ヘクタール）の地上部現存量と樹木種数，樹木種多様性の指数αとの関係。[Kohyama, et.al. 1999]

REDD＋とは？

途上国における森林減少・劣化の抑制や持続可能な森林経営などによって温室効果ガス排出量を 削減あるいは吸収量を増大させる努力にインセンティブを与える気候変動対策

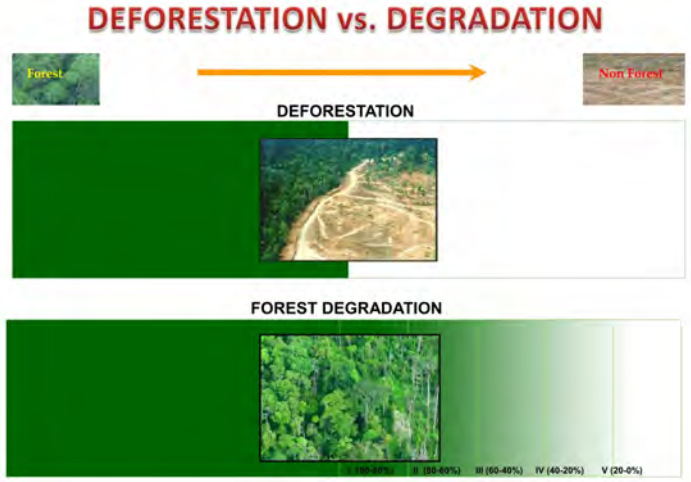
２０１５年の『パリ協定』の目標達成のため、炭素吸収源・貯蔵庫の保全や強化、また生物多様性や生態系保全のため、REDD＋を利用することが可能



森から世界を変えるREDD＋ プラットフォーム　ホームページより引用

REDD+の宿題と今後の論点

1. 森林減少、森林劣化をどう定義？



2. 森林減少防止のために有効な政策?
   （国 への援助ODAか、プロジェクト活動CDMか？…）
3. ＣＯ$_2$排出量削減の科学的評価が可能？
4. 特に生態系サービスの観点から、総合的に土地の劣化の防止や回復を実現するためにはどのような国際的なルールの構築が必要か？

Why Does IPBES Matter?

- Biodiversity & nature's contributions to people underpin almost every aspect of human development.
  - Production of food
  - Clean water
  - Climate regulation
  - Disease control
- Also key to the success of the Sustainable Development Goals (SDGs)
- Yet they are being depleted & degraded faster now than at any point in human history
- IPBES is unique:
  - Harnessing best expertise from across disciplines & knowledge communities
  - Providing policy-relevant knowledge and options for responses
  - Catalysing implementation of knowledge-based policies at all levels of Government, the private sector and civil society

UNITED NATIONS UNEP UNESCO Food and Agriculture Organization of the United Nations UNDP

BES

IPBES/6/L.9/Rev.1

ipbes Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services

Distr.: Limited
24 March 2018

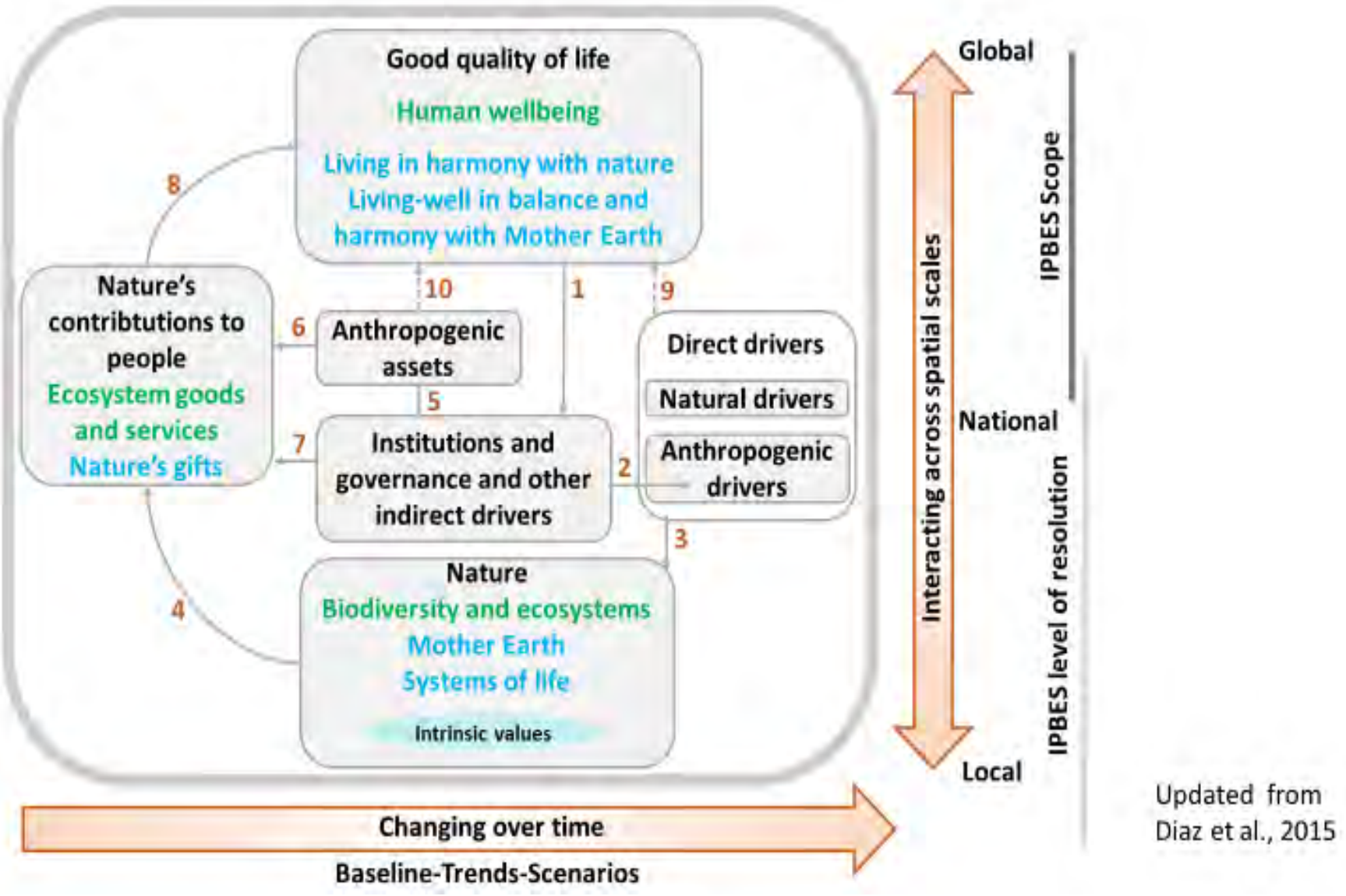
Original: English

Plenary of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
Sixth session
Medellin, Colombia, 18–24 March 2018
Item 7 of the provisional agenda*

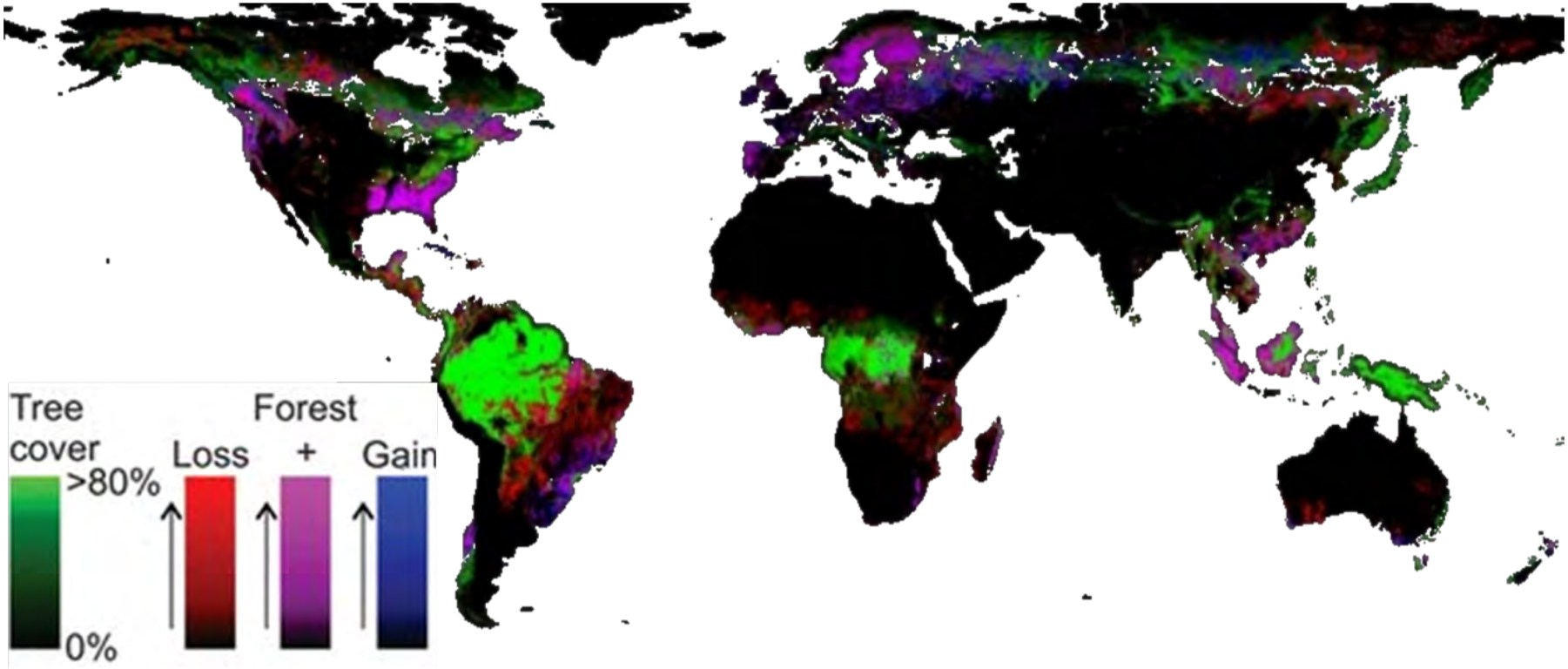
Thematic assessment of land degradation and restoration

Summary for policymakers of the thematic assessment of land degradation and restoration

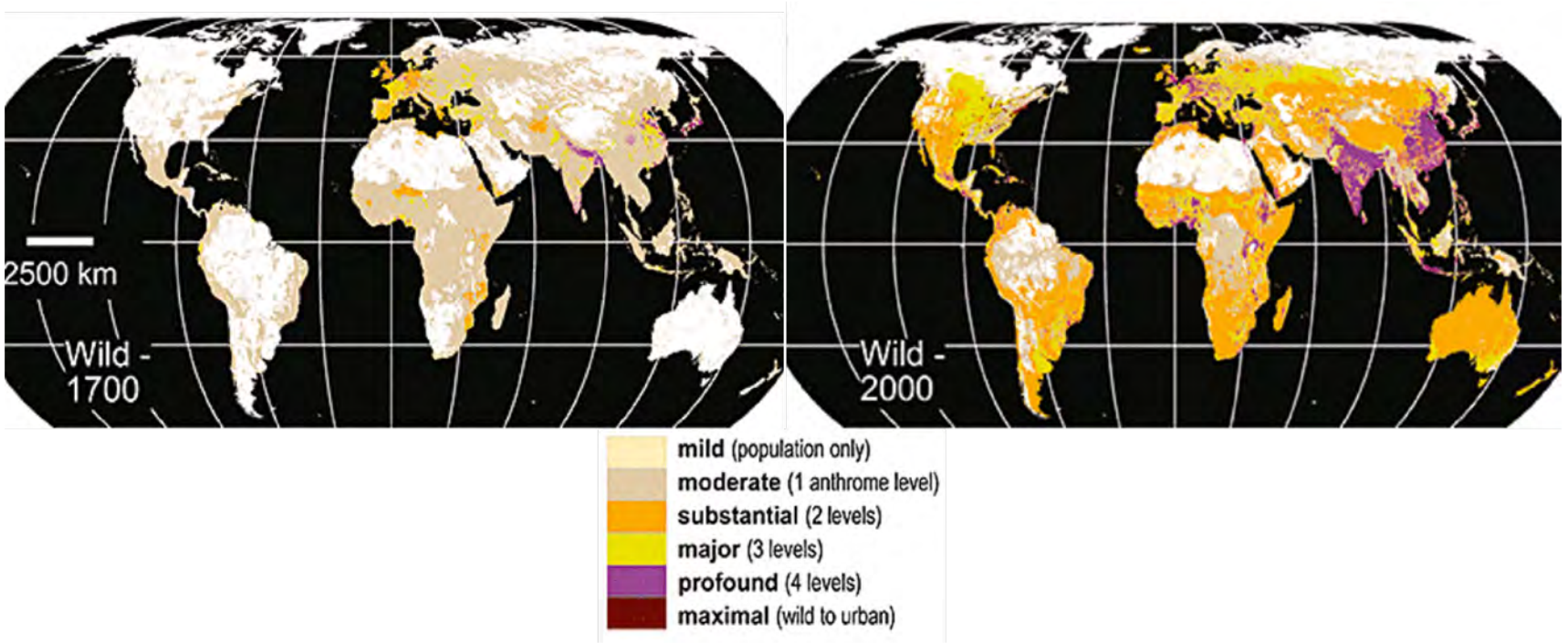
IPBES 概念フレームワーク： 人と自然が相互作用するシステム



森林減少率のマッピング（人工衛星の活用）



土地劣化は産業革命以降に世界的に発生



Global patterns of human transformation of land cover. (a) Estimated land cover in 1700, before the industrial age; (b) land cover in 2000. (Ellis et al. 2010)

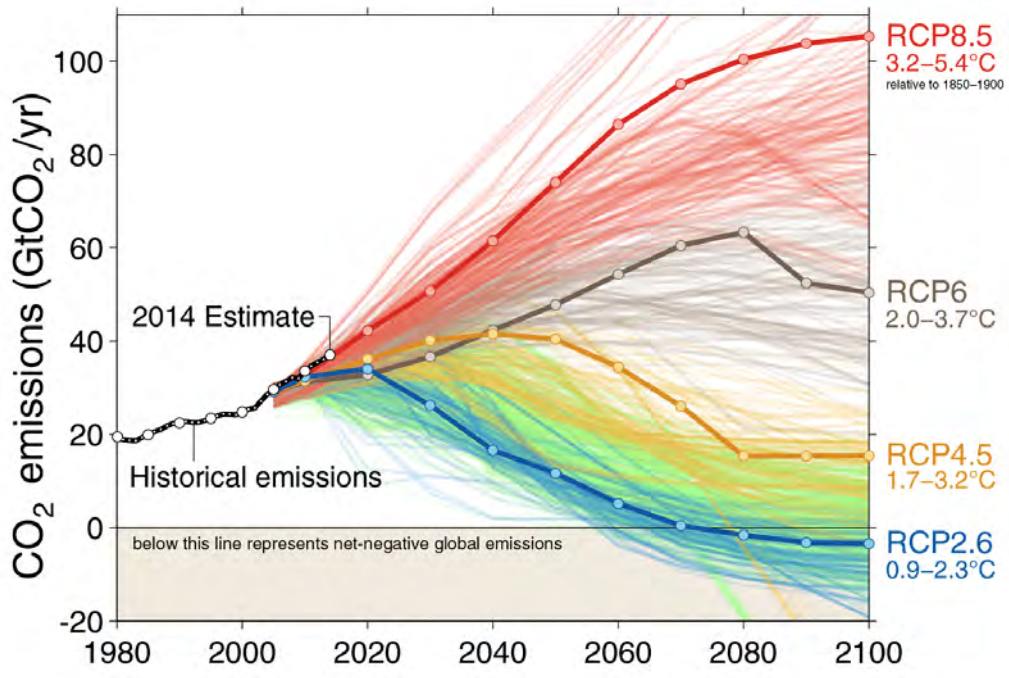
食料やエネルギー利用が間接的に土地利用に影響

Example: Long distance connections are obstacles to full awareness of consumers' choices. **Education** might focus on how individuals' consumption choices can have unintended consequences in distant locations

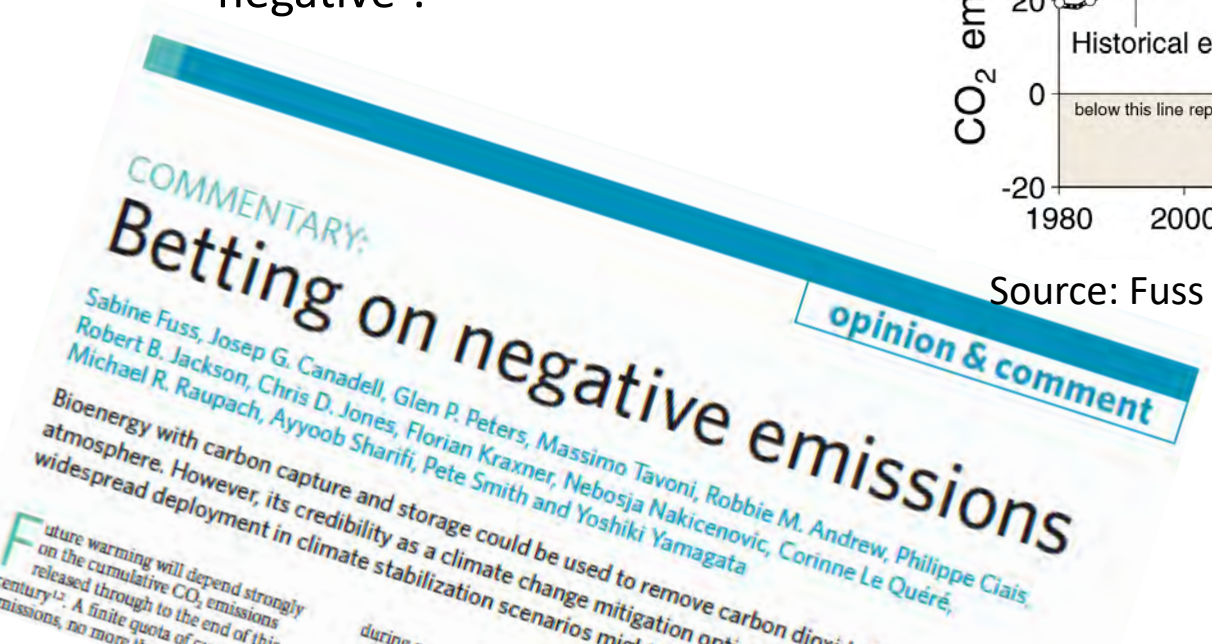
パリ協定を超えてさらに２１世紀以降を見据えて必要となる対策

IPCC AR5:

Achieving 2°C is still possible, but it entails huge contributions from bioenergy - in most scenarios combined with Carbon Capture & Storage to go “negative“.



Source: Fuss et al. (2014), Nature Climate Change.


COMMENTARY:

Betting on negative emissions

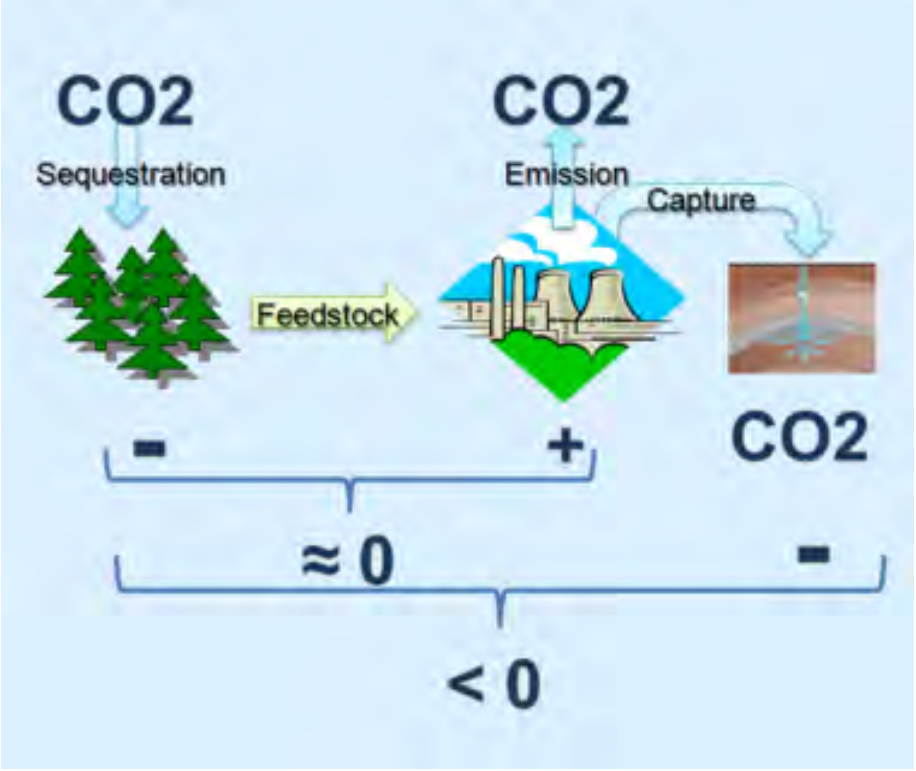
opinion & comment

Sabine Fuss, Josep G. Canadell, Glen P. Peters, Massimo Tavoni, Robbie M. Andrew, Philippe Ciais, Robert B. Jackson, Chris D. Jones, Florian Kraxner, Nebosja Nakicenovic, Corinne Le Quéré, Michael R. Raupach, Ayyoob Sharifi, Pete Smith and Yoshiki Yamagata

Bioenergy with carbon capture and storage could be used to remove carbon dioxide from the atmosphere. However, its credibility as a climate change mitigation option is questionable if widespread deployment in climate stabilization scenarios might

Future warming will depend strongly on the cumulative CO_2 emissions released through to the end of this century[1,2]. A finite quota of

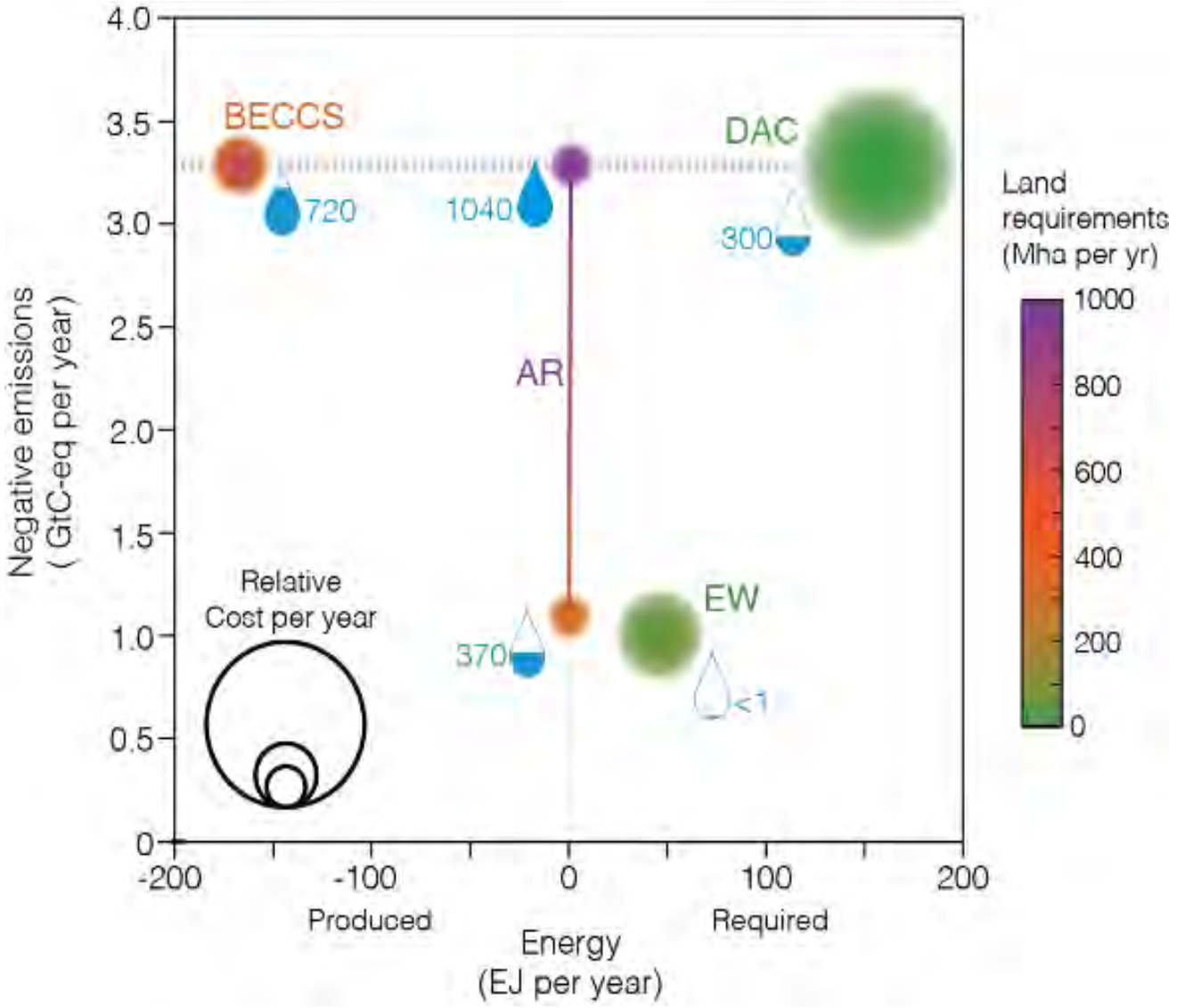
バイオマスCCSを用いたネガティブエミッションの実施



- Sustainable biomass as feedstock for carbon-neutral bioenergy (i.e. the biomass sequesters as much as is produced during ist combustion)
- Combined with Carbon Capture and Storage = BECCS
- In order to remove carbon from the atmosphere and thus decrease cumulative emissions.

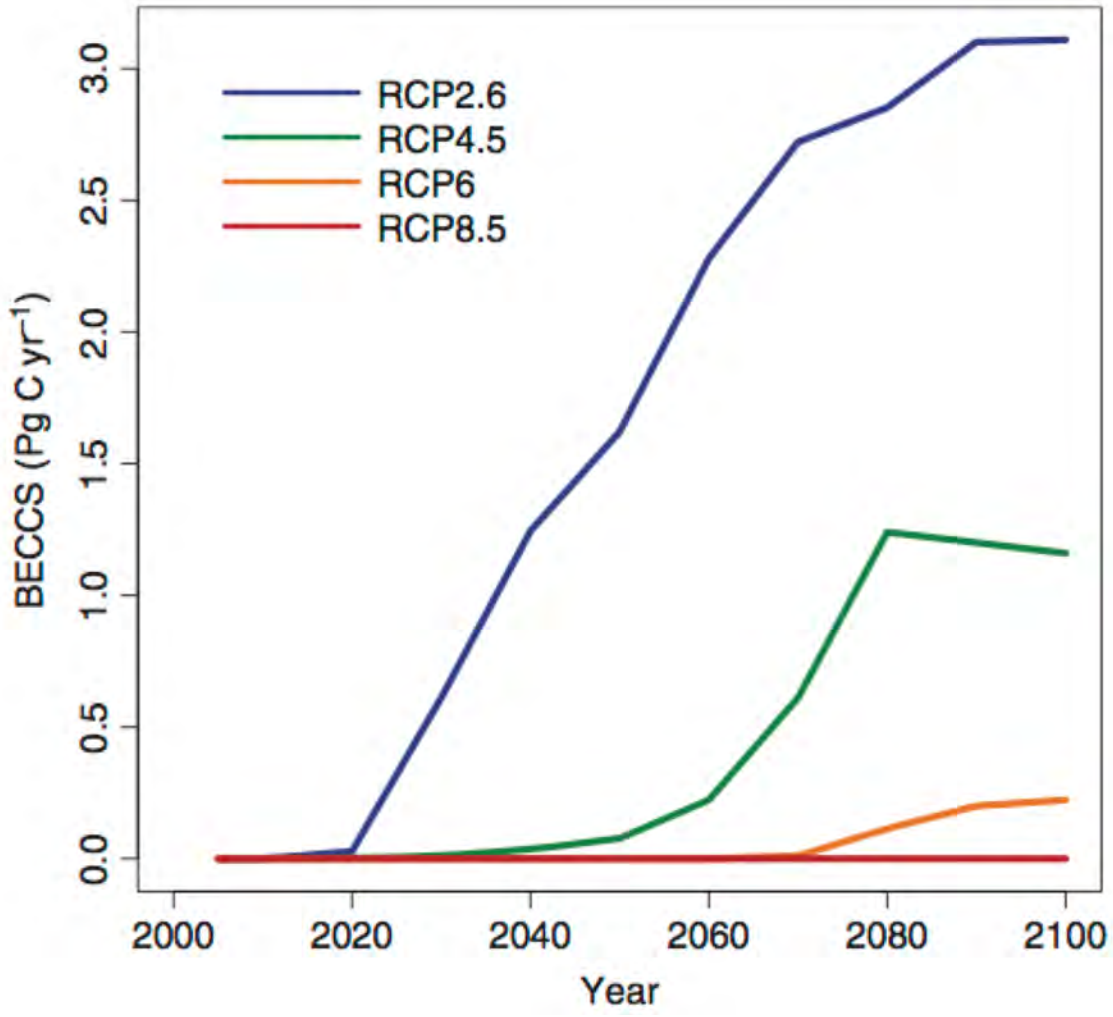
Source: Kraxner at al., in: Handbook of Clean Energy Systems 2015

異なるネガティブエミッション技術の影響

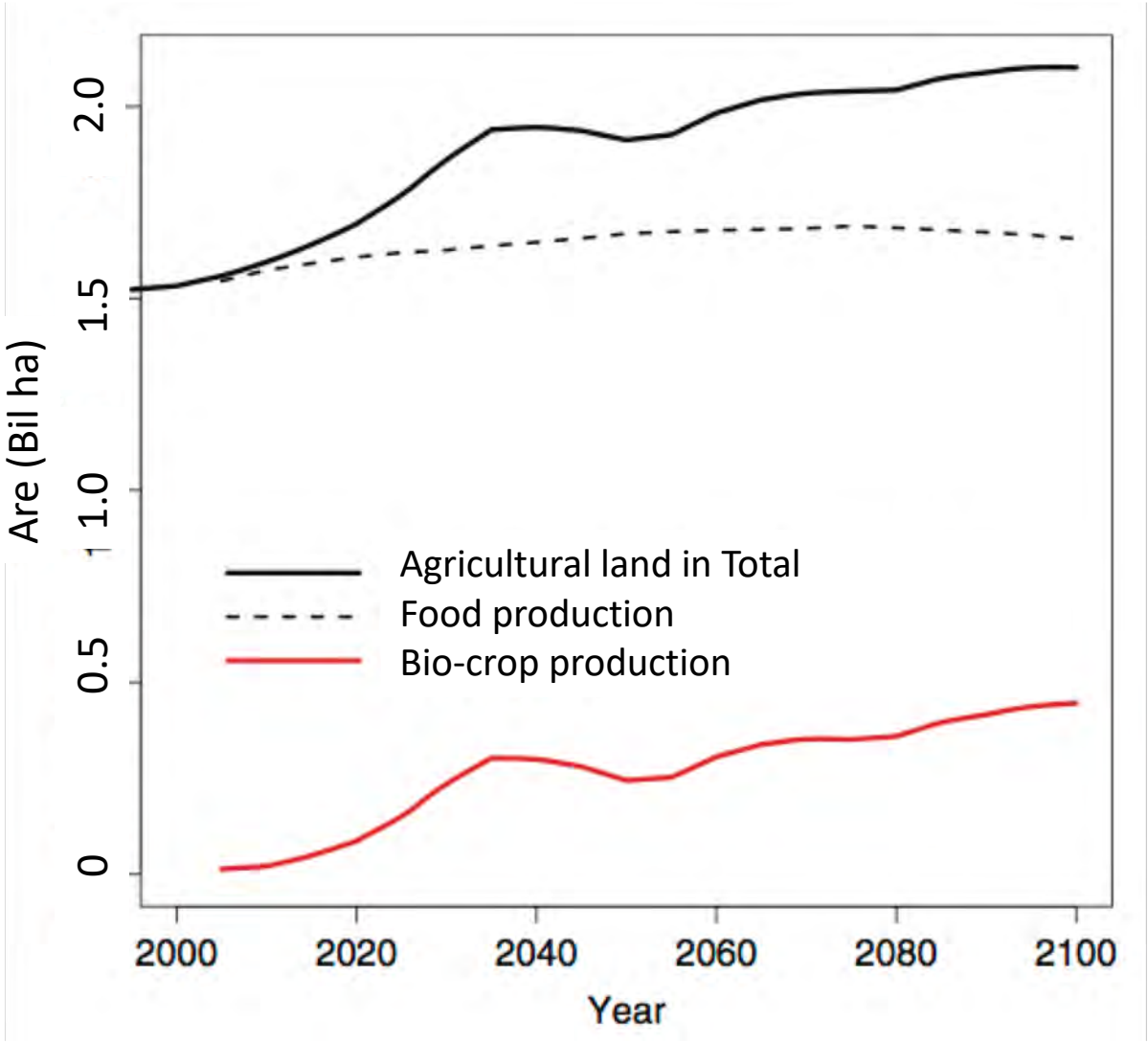


Source: Smith et al. 2016

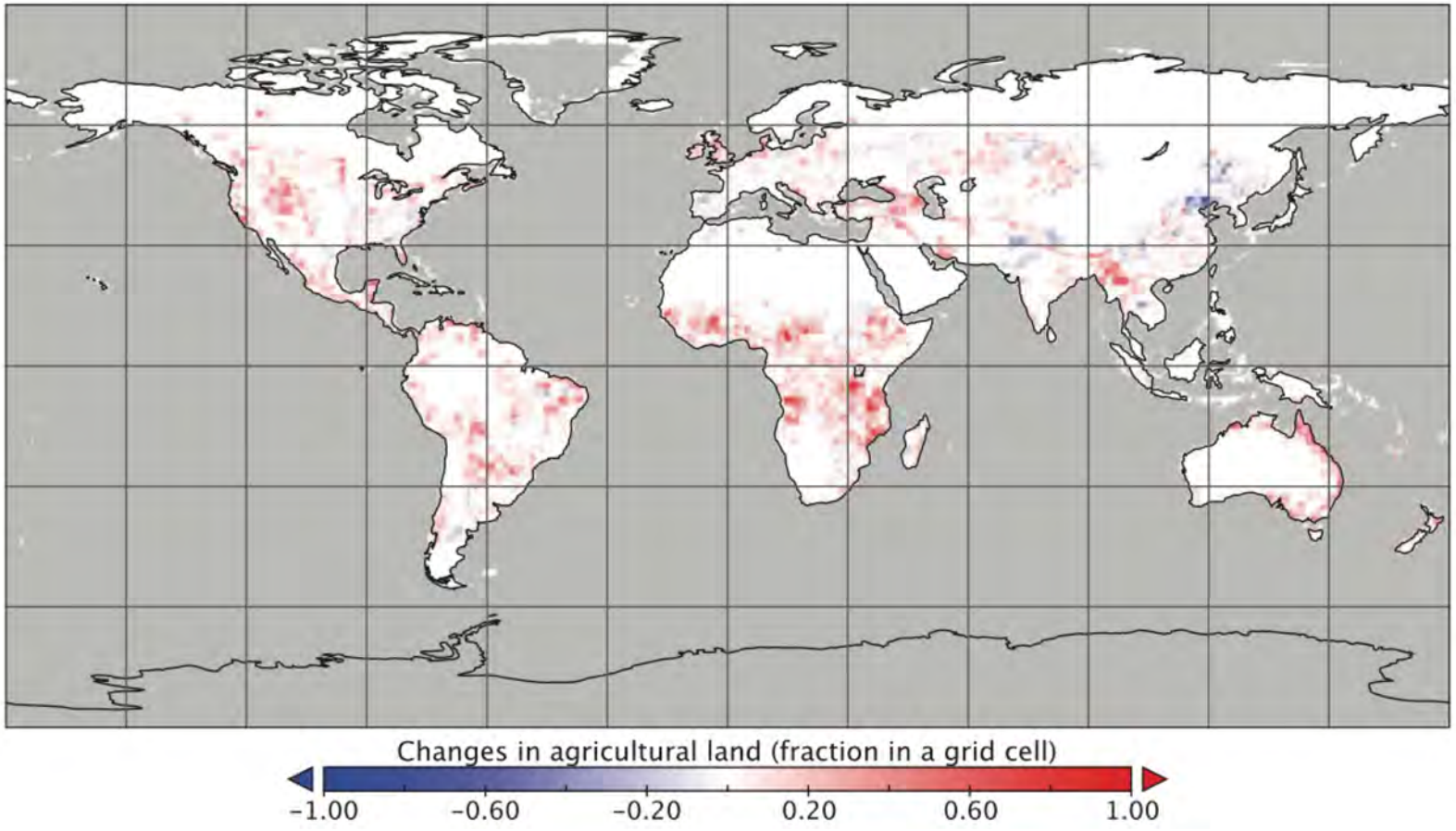
IPCCのRCPシナリオにおけるBECCS導入



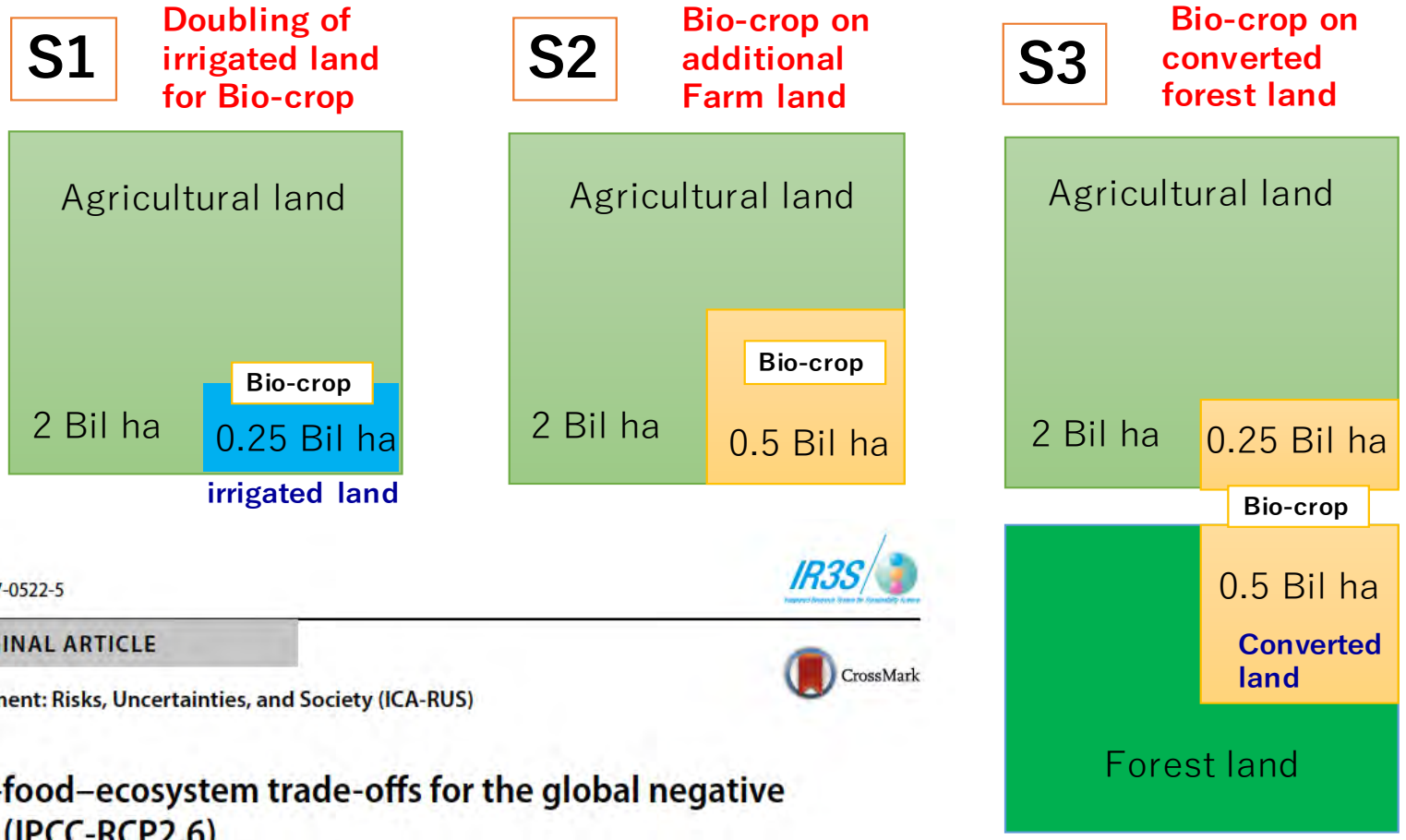
RCP２．６（２度シナリオ）における バイオマスのための土地利用



バイオ燃料用作物の栽培 (RCP2.6: 2005－2100)



バイオ燃料作物の土地利用シナリオ（RCP2.6、2100）



Sustainability Science
https://doi.org/10.1007/s11625-017-0522-5

IR3S

SPECIAL FEATURE: ORIGINAL ARTICLE

CrossMark

Integrated Climate Assessment: Risks, Uncertainties, and Society (ICA-RUS)

Estimating water–food–ecosystem trade-offs for the global negative emission scenario (IPCC-RCP2.6)

Yoshiki Yamagata[1] · Naota Hanasaki[1] · Akihiko Ito[1] · Tsuguki Kinoshita[2] · Daisuke Murakami[3] · Qian Zhou[1]

Received: 28 August 2017 / Accepted: 10 December 2017
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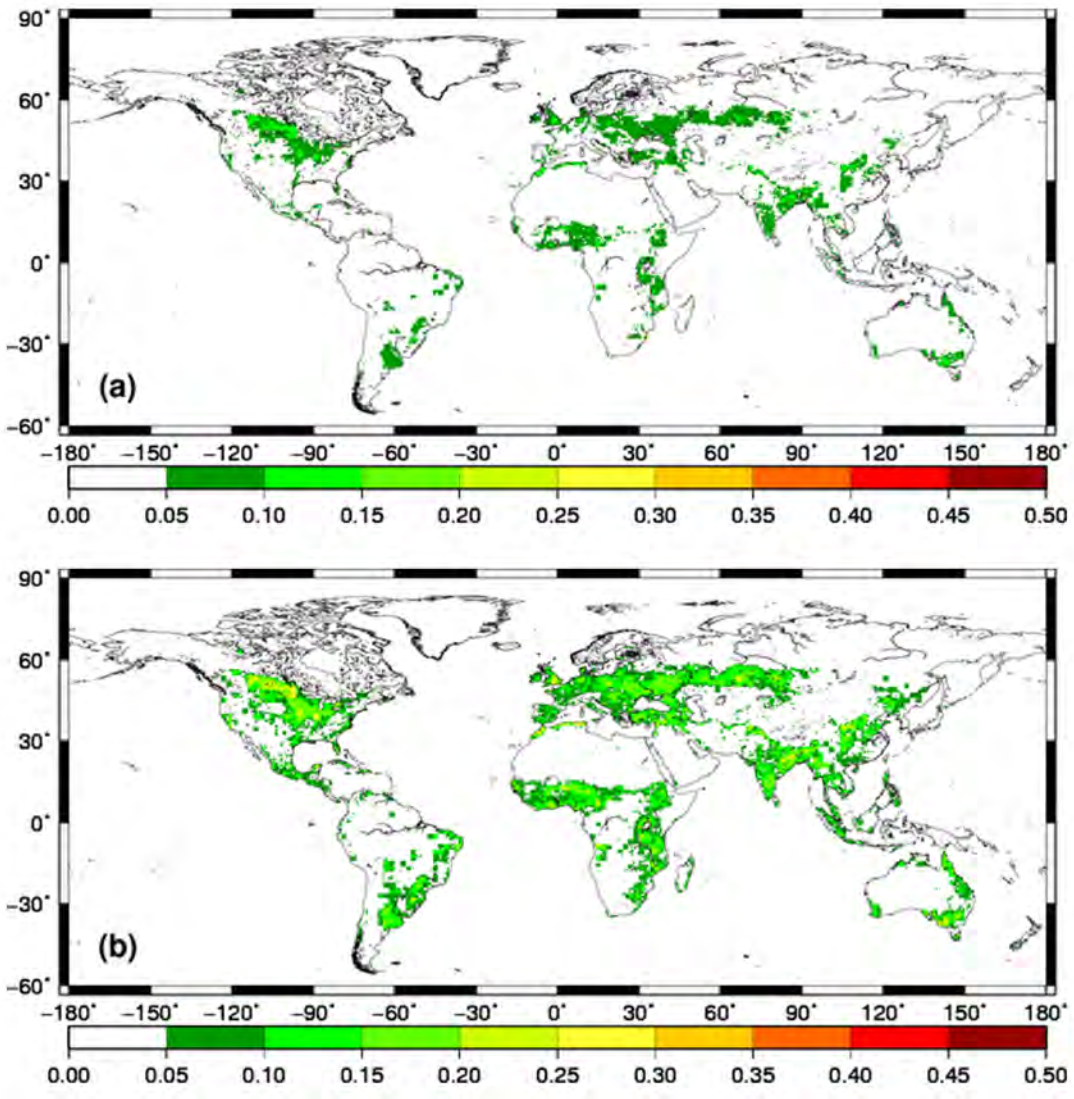
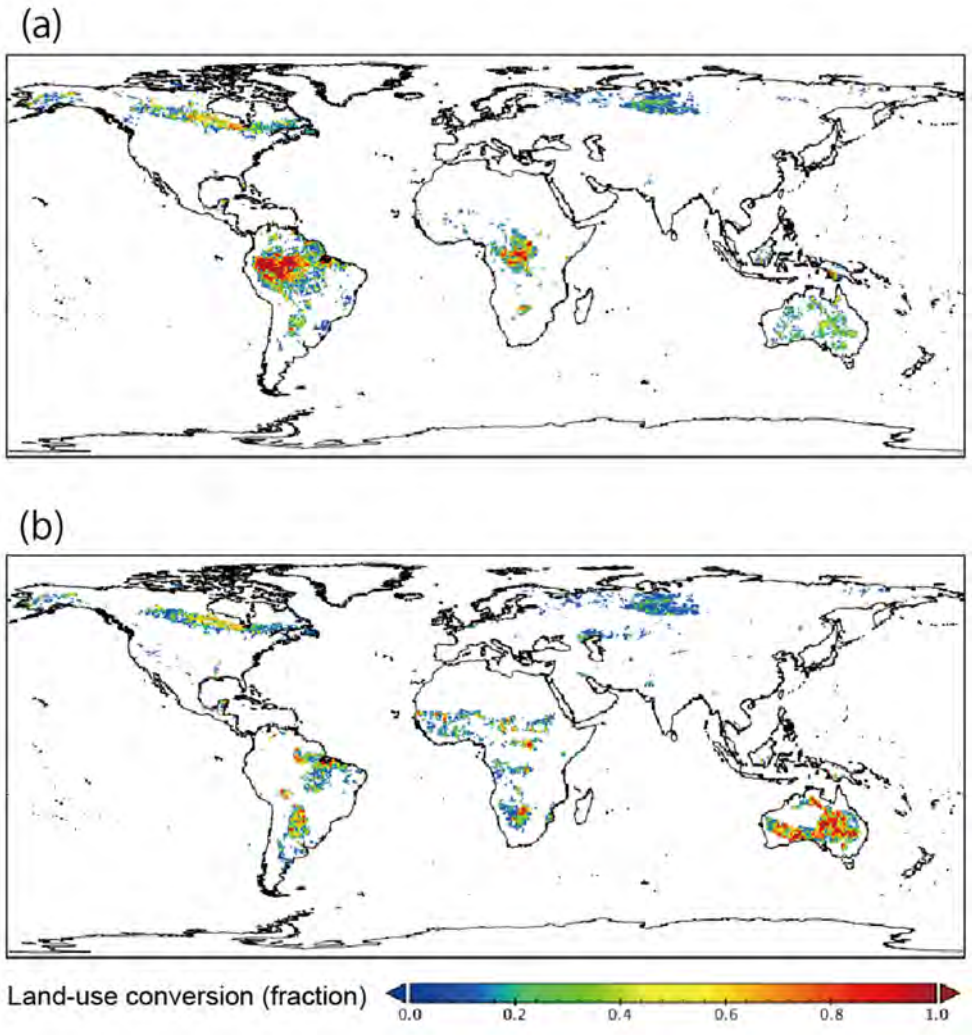
バイオ燃料用作物の作付け面積（2100）



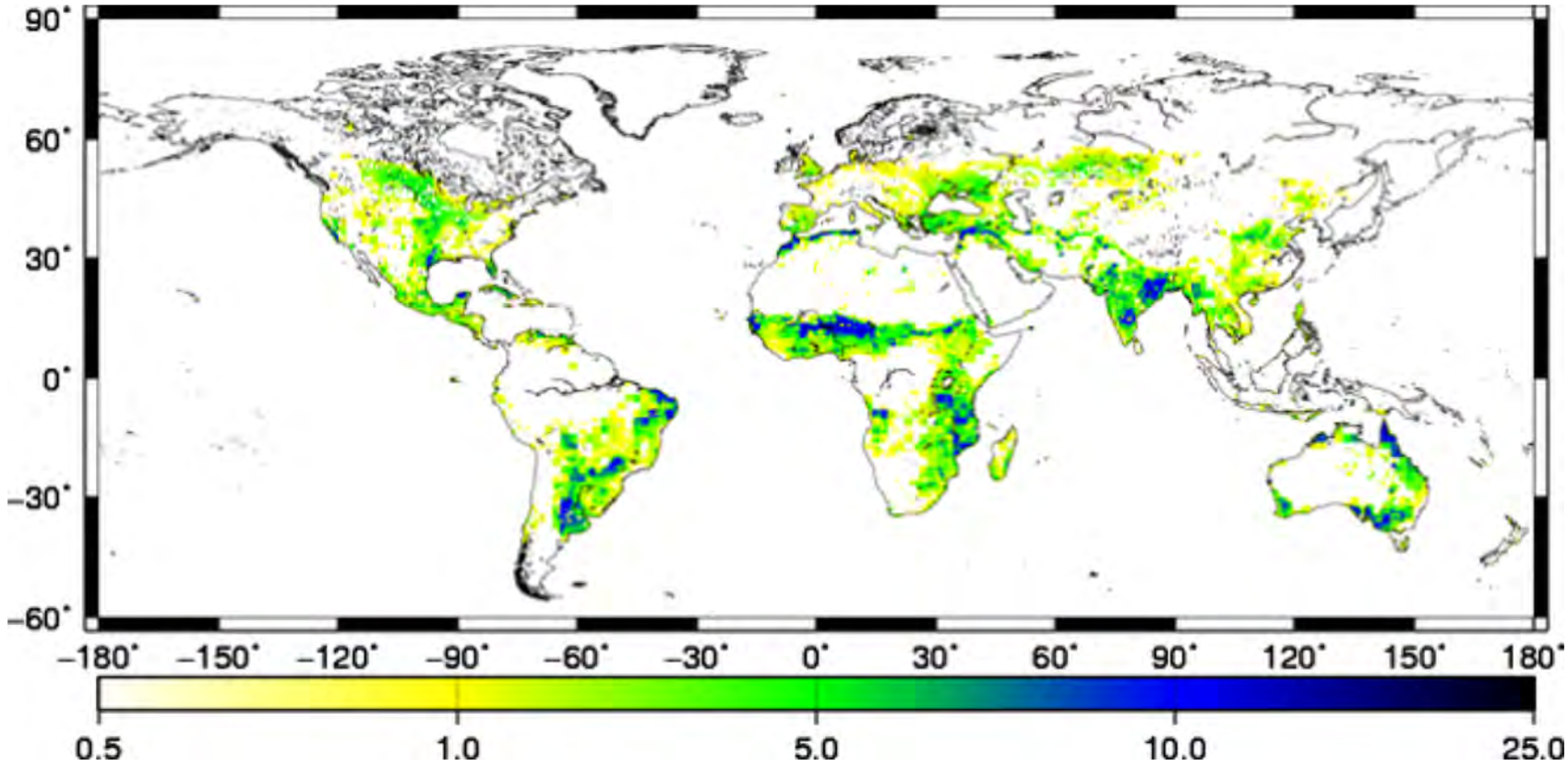
(a)S1 and S3 (excluding farmland transferred from forest), (b) S2

森林から転用されたバイオ燃料作物の栽培（2100）

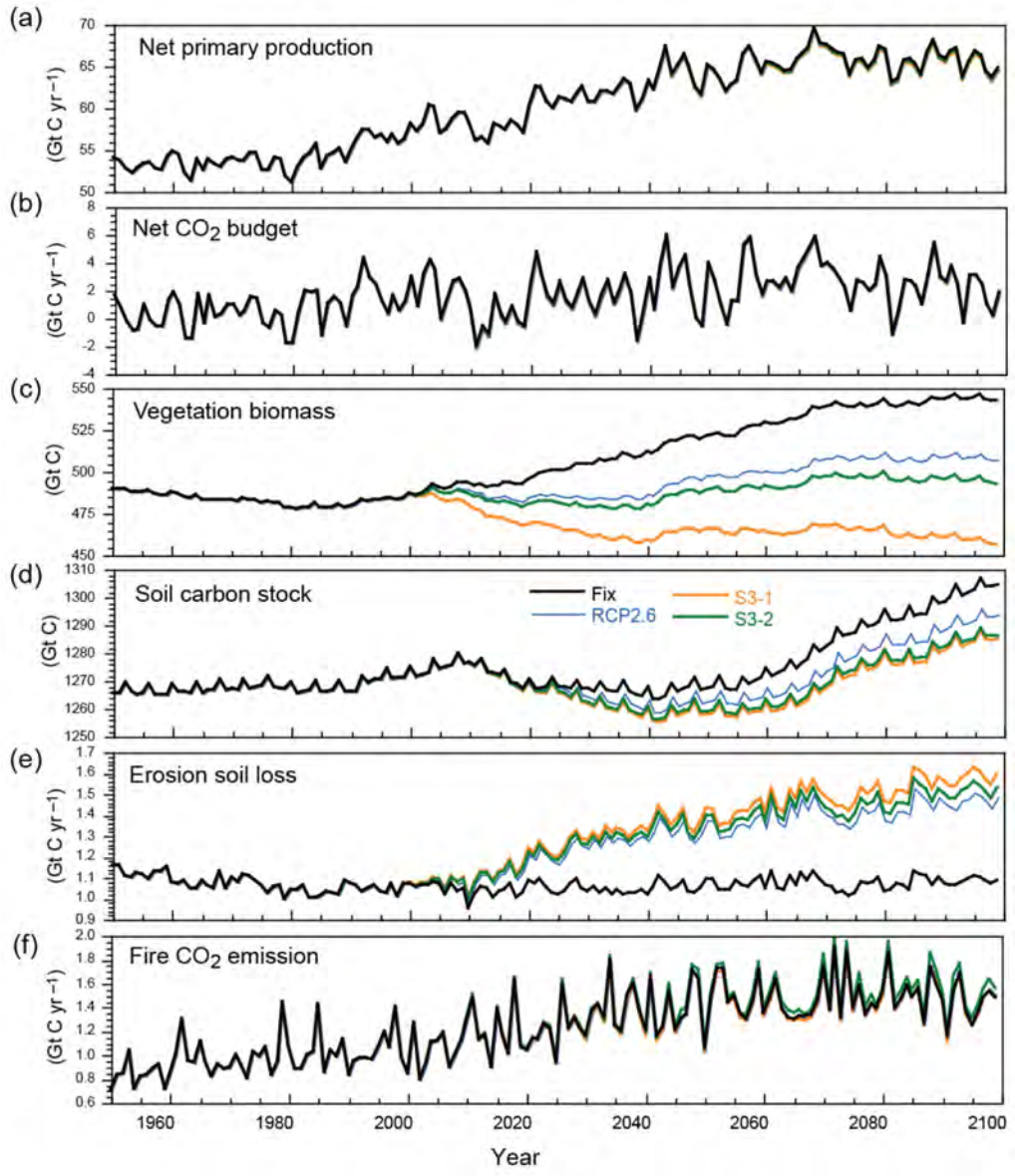


REDD+等の生物多様性保護条約が (a)無い場合 (b)有る場合

バイオ燃料作物栽培に必要となる灌漑水の量（2100）



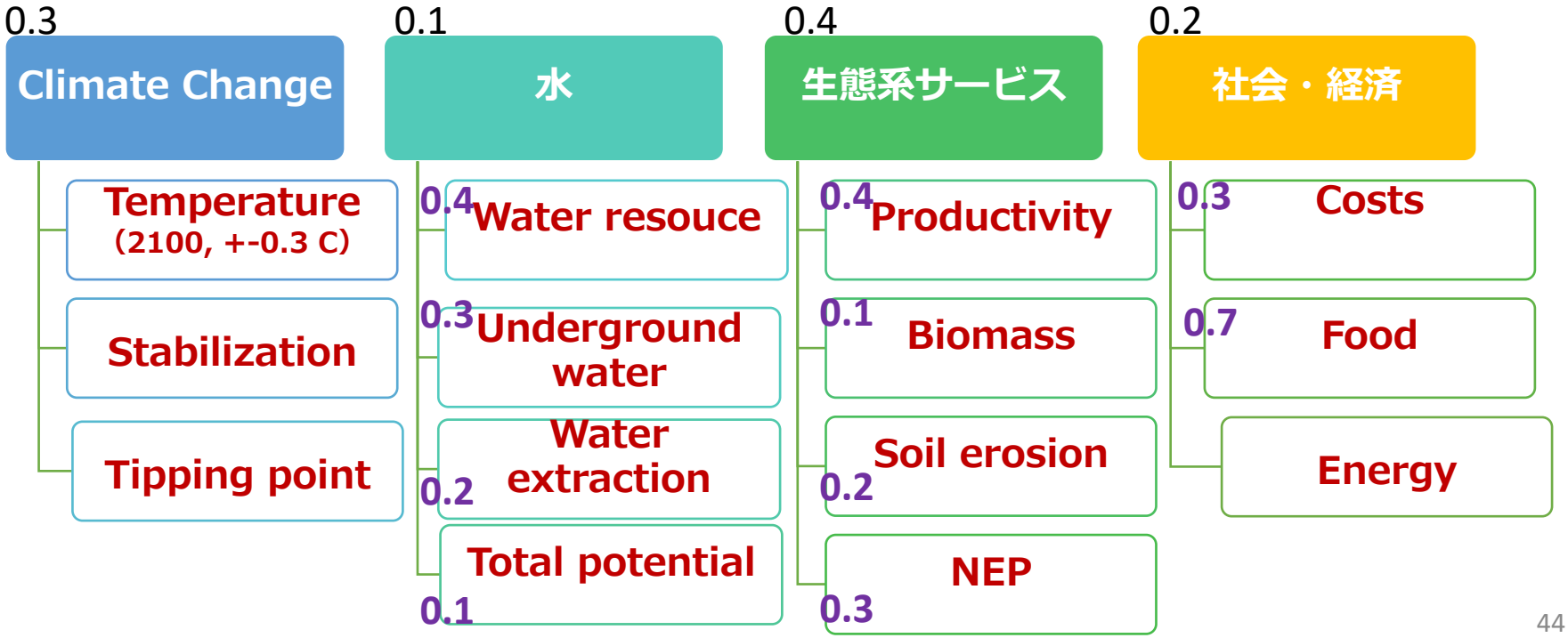
BECCS土地利用シナリオの生態系サービスへの影響



(a) 純一次生産
(b) CO_2 収支
(c) 植生バイオマス
(d) 土壌炭素ストック
(e) 土壌流出
(f) バイオマス燃焼

黒線はBECCS無しの土地利用
農地のみをBECCS利用した場合
生物多様性保全無しの場合
生物多様性保全有りの場合

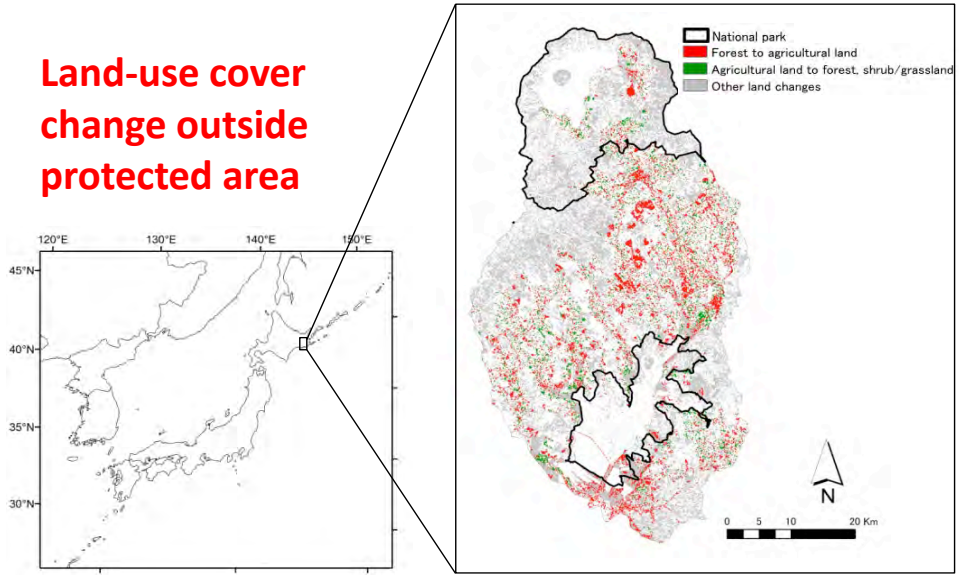
SDGs(4つの持続可能性目標)のトレードオフ評価



*Weights show tentative numbers for tradeoff assessment

釧路における流域土地利用シナリオ分析例

Land-use cover change outside protected area



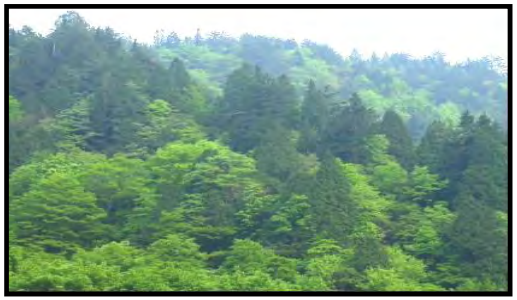
Shoyama K., Yamagata Y., (2014) Predicting land-use change for biodiversity conservation and climate-change mitigation and its effect on ecosystem services in a watershed in northern Japan. Ecosystem services

Fig. 1. Map of the Kushiro watershed showing land-use changes that occurred between 1977 and 2011

Scenario development

BAU(Trend) **Biodiversity conservation** **Climate change mitigation**

Agriculture **+ Tourism** **+Bioenergy**



釧路流域での土地利用シナリオ

BAU(Trend)

a) Trend scenario

Population -1.0%/year

Pop. in working age -0.5%/year

Abandoned farmland 40％

Biodiversity

b) Biodiversity scenario

Population --0.8%

Pop. in working age -0.3%

Abandoned farmland 20％

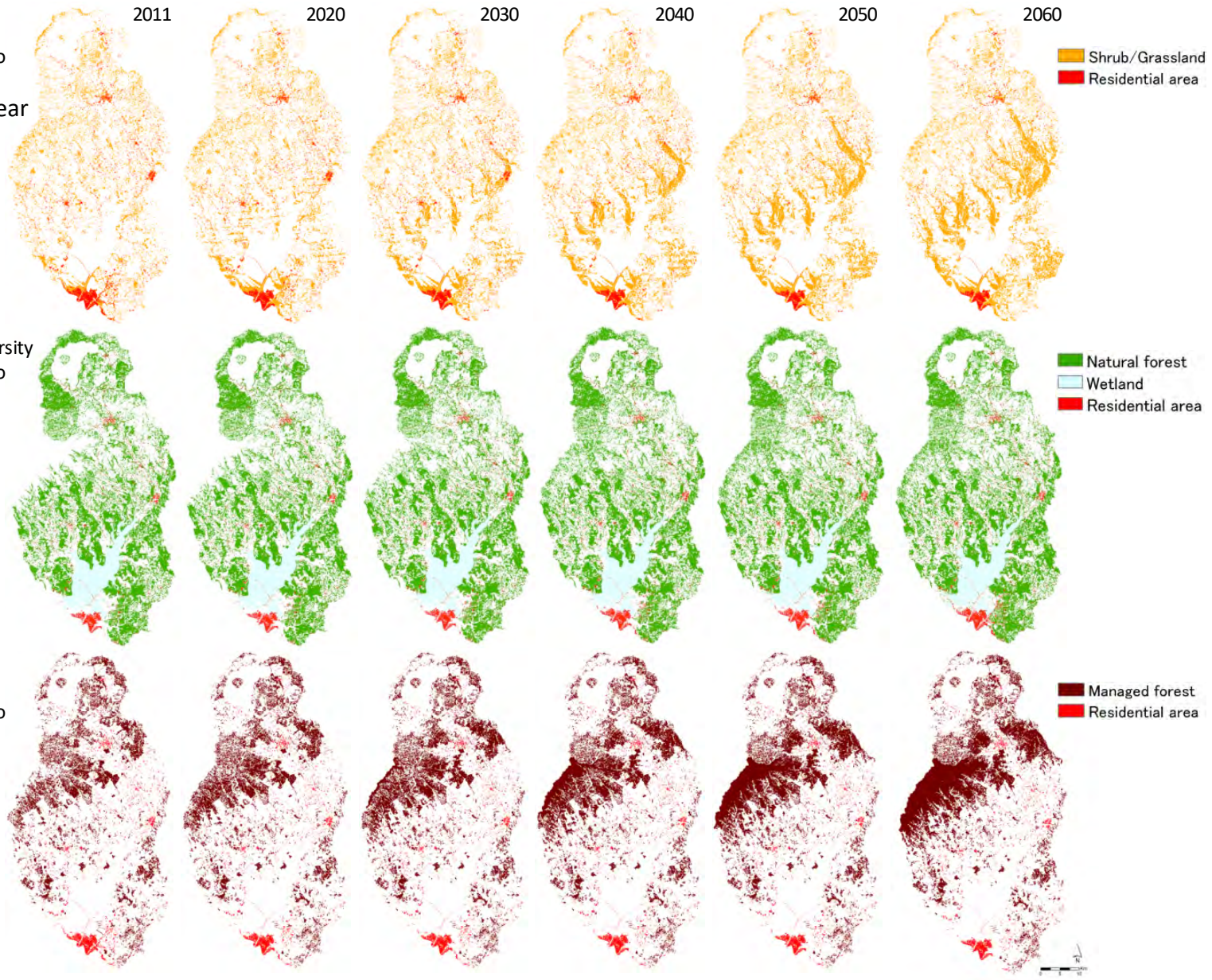
CC mitigation

c) Climate scenario

Population -0.8%

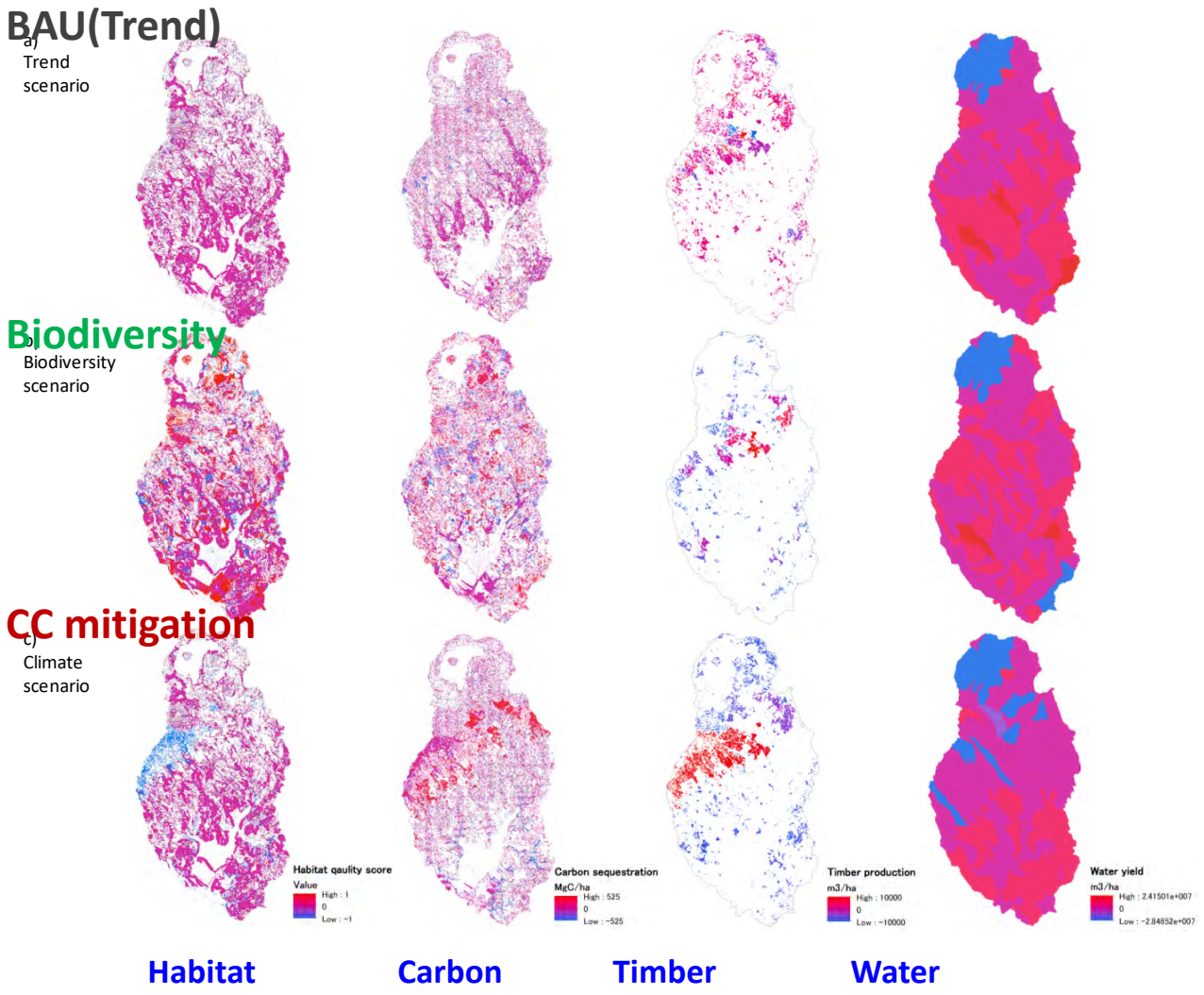
Pop. in working age -0.3%

Abandoned farmland 20％



2000s → **2060s**

土地利用シナリオ毎の生態系サービスの変化



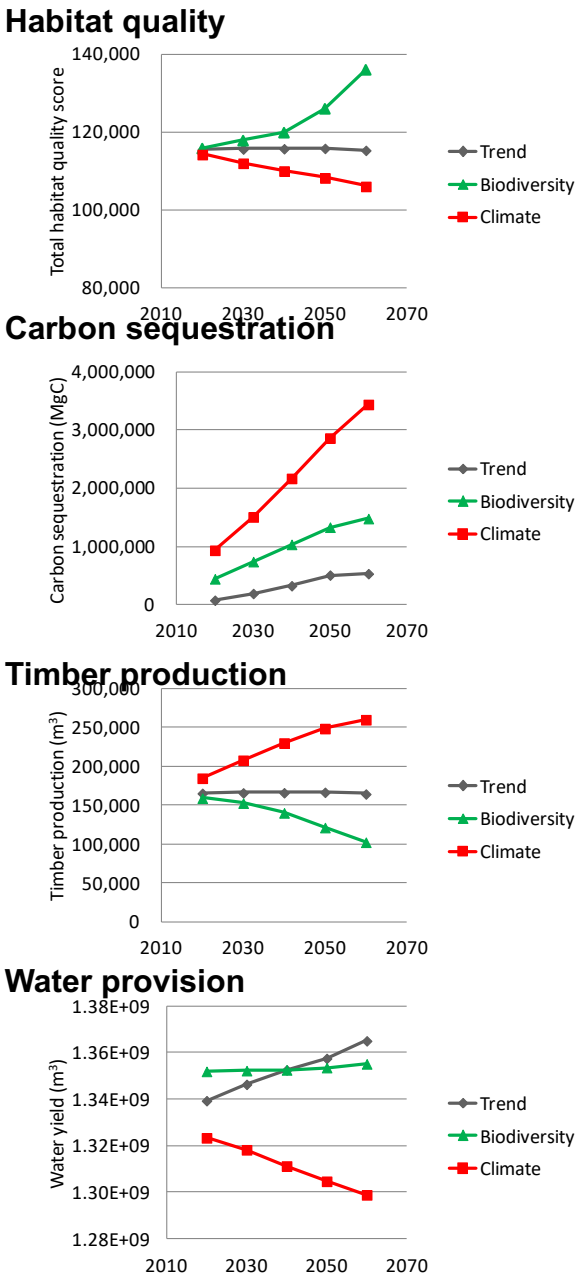


Fig. 5. Changes in the distribution of ecosystem services between 2011 and 2060 according to the three scenarios

土地利用シナリオの社会評価実験（地域と全国）

	OPTION A	OPTION B	BASE LINE
HABITAT QUALITY	−10%	NO CHANGE	+20%
	LESS WILDLIFE	DECREASING TREND	MAINTAIN WILDLIFE
CARBON SEQUESTRATION	−3%	NO CHANGE	+5%
	LESS CARBON SEQUESTRATION	MAINTAIN CARBON SEQUESTRATION	MORE CARBON SEQUESTRATION
TIMBER PRODUCTION	−40%	NO CHANGE	+50%
	LESS TIMBER PRODUCTION	MAINTAIN TIMBER PRODUCTION	MORE TIMBER PRODUCTION
WATER PROVISION	−5%	NO CHANGE	
	LESS WATER	MAINTAIN WATER	
YEARS	MEASURES HAS AN EFFECT AFTER 10/50/100		
COST PER YEARS (FOR 10YEARS)	500/1000/2000/5000 JPY		

- Web-based survey
- 3848 respondents throughout Japan

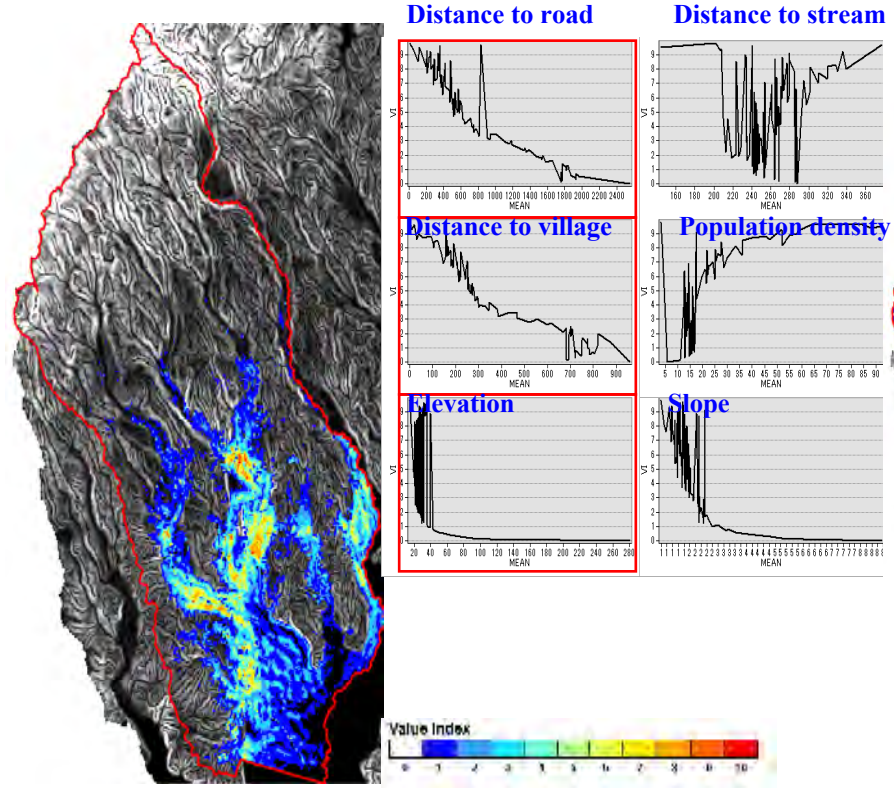
+

Stakeholder meeting in Tsurui village
(2013 September)

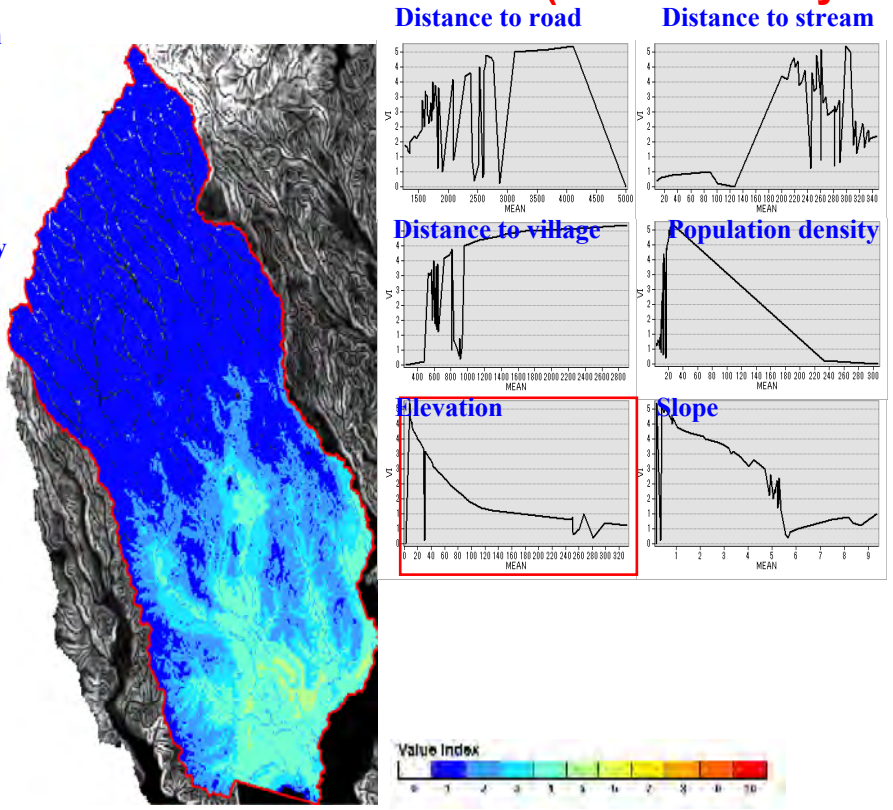
Shoyama K., Managi S., Yamagata Y. (2013) Public preferences for biodiversity conservation and climate-change mitigation: a choice experiment using ecosystem services indicators. Land Use Policy 34: 282-293

新・旧地域住民による生態系サービスの価値評価結果

A. Old-residents (over 30-years)



B. New-residents (less than 30-years)



- Mail-based survey
- 585 respondents

In Tsurui village and Shibetya town

Yamagata Y. and Shoyama K. (2014) Can We Make Use of Abandoned Land for Carbon Management and Ecosystem Restoration? AGU Fall meeting.

持続可能な都市・地域システムのデザイン

Urban compaction

Climate resiliency

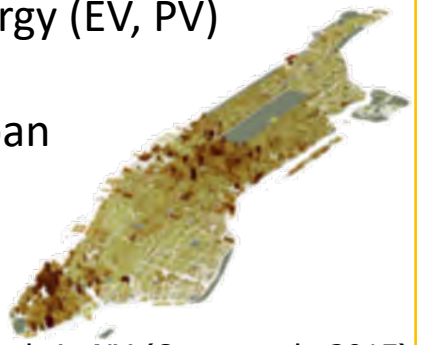
- Mitigation, adaptation

A flood in 2015 in Japan

Heatstroke risk in Japan

Low carbon energy

- Renewable energy (EV, PV)
- Smart grid
- Sustainable urban metabolism



Building energy demands in NY (Quan et al., 2015)

Trade-off / synergy

Environmental sustainability

- Green recovery
- Eco-urbanizm

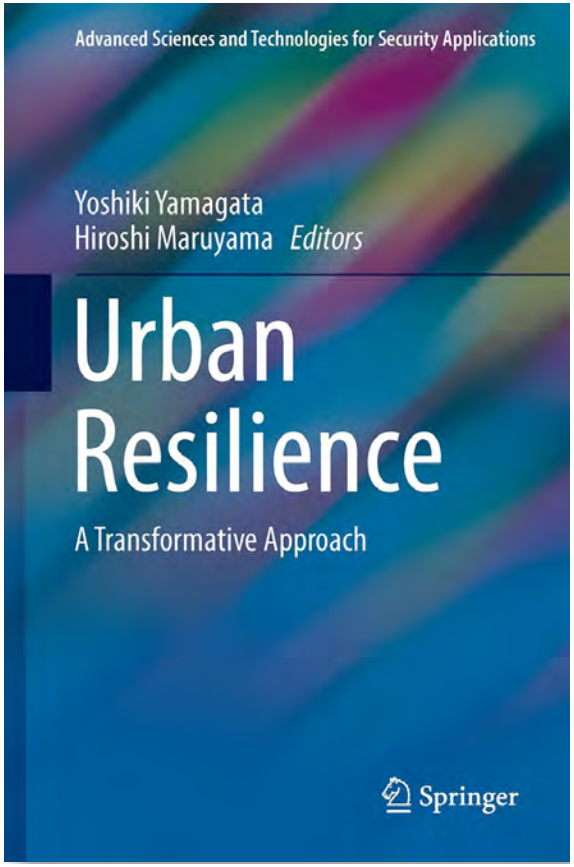
Local community

- Help each other
- Sharing (e.g., car)
- Well-being

Wise-shrink

Urban compaction that achieve high environmental standards as well as improve human well-beings.

都市レジリエンスに関する研究成果

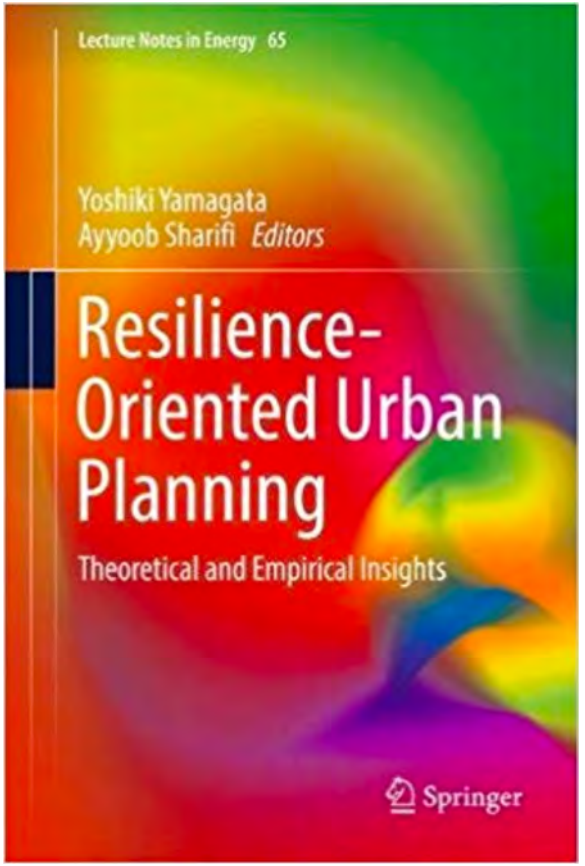


This book is on urban resilience – how to design and operate cities that can withstand major threats such as natural disasters and economic downturns and how to recover from them.

Bouncing forward

⇩

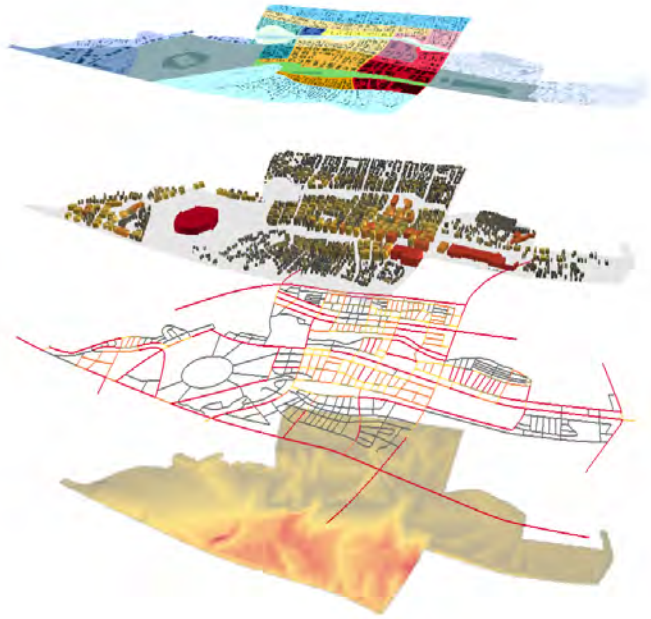
Transformative approach



IoTを活用する都市システムデザインの提案

We are launching a new projects for Urban Systems Design by integrating IoT, Big Data and AI

To create Green Smart City



SUSTAINABLE DEVELOPMENT GOALS

今後の課題

- グローバルとローカルの課題間の連関への注目
- 生産者ではなく消費者目線での政策の検討
- SDGsをきっかけとする国家からビジネスが主体となる持続可能性問題への取り組みへの期待
- CO_2だけではなく各種な生態系サービスへの注目
- 今後3百年を考えてのグローバルな土地利用革命
- 人間社会の地球環境負荷限界（Planetary Boundary)とAIで大きく変わる都市形態（Urban Form)との関係を問い直す研究に着手