

木材の収穫と燃焼が もたらす気候への影響

ティモシー・D・サーチンジャー
プリンストン大学上級研究員
世界資源研究所（WRI）食糧プログラ
ムテクニカルディレクター



The Climate Consequences of Harvesting & Burning Wood

Timothy D. Searchinger
Senior Research Scholar
Princeton University

Technical Director, Food Program
World Resources Institute



～800名の科学者からの手紙2018

～800 Scientist Letter 2018

LETTER FROM SCIENTISTS TO THE EU PARLIAMENT REGARDING
FOREST BIOMASS
January 9, 2018

To Members of the European Parliament,

As the European Parliament commendably moves to expand the renewable energy directive, we strongly urge members of Parliament to amend the present directive to avoid expansive harm to the world's forests and the acceleration of climate change. The flaw in the directive lies in provisions that would let countries, power plants and factories claim credit toward renewable energy targets for deliberately cutting down trees to burn them for energy. The solution should be to restrict the forest biomass eligible under the directive to residues and wastes.

Initial signatories:

John Beddington, Professor, Oxford Martin School, former Chief Scientist to the government of the United Kingdom

Steven Berry, Professor, Yale University, former Chairman, Department of Economics, fellow American Academy of Arts and Sciences, winner of the Frisch Medal of the Econometric Society.

Ken Caldeira, Professor, Stanford University and Carnegie Institution for Science, Coordinating lead author or lead author of multiple IPCC reports.

Wolfgang Cramer, Research Director, CNRS, Mediterranean Institute of marine and terrestrial Biodiversity and Ecology, Aix-en-Provence, member Académie d'Agriculture de France, Coordinating lead author and lead author of multiple IPCC reports.

Felix Creutzig, Chair Sustainability Economics of Human Settlement at Technische Universität Berlin, Leader, leader Mercator Research Institute on Global Commons and Climate Change, Lead author of IPCC V Assessment Report and coordinator of appendix on bioenergy.

Phil Duffy, President, Woods Hole Research Center, former Senior Advisor White Office of Science and Technology Policy, Contributing author of multiple IPCC reports.

Dan Kammen, Professor University of California at Berkeley, Director Renewable and Appropriate Energy Laboratory, Coordinating lead author or lead author of multiple IPCC reports.

Eric Lambin, Professor Université catholique de Louvain and Stanford University, member European and U.S. Academies of Science, 2014 laureate of Volvo Environment Prize

Simon Levin, Professor Princeton University, Recipient, U.S. National Medal of Science, member U.S. National Academy of Sciences

Wolfgang Lucht, Professor Humboldt University and Co-Chair of Potsdam Institute for Climate Research, lead author of multiple IPCC reports

Georgina Mace FRS, Professor, University College London, Lead author IPCC report and Winner International Cosmos Prize

William Moomaw, Emeritus Professor, Tufts University, Lead author of multiple IPCC reports

Peter Raven, Director Emeritus Missouri Botanical Society, Recipient U.S. National Medal of Science and former President of American Association for Advancement of Science

Tim Searchinger, Research Scholar, Princeton University and Senior Fellow, World Resources Institute

Nils Chr. Stenseth, Professor, University of Oslo, Past president of The Norwegian Academy of Science and Letters, member U.S. National Academy of Science, French Academy of Sciences, and Academia Europaea

Jean Pascal van Ypersele, Professor, Université catholique de Louvain, Former IPCC Vice-chair (2008-2015), member of the Royal Academy of Belgium, lead author or review editor of multiple IPCC reports

欧州環境機関科学委員会 2011年9月15日

European Environment Agency

Scientific Committee

15 September 2011

バイオエネルギーに関連する温室効果ガスの会計処理

Opinion of the EEA Scientific Committee on

Greenhouse Gas Accounting in Relation to Bioenergy

～500名の科学者からの手紙2021

～500 Scientist Letter 2021

Letter Regarding Use of Forests for Bioenergy
(February 11, 2021)

To President Biden, President von der Leyen, President Michel, Prime Minister Suga, and President Moon,

European Academies



Science Advisory Council

森林バイオマスエネルギーのカーボンニュートラルリティに関する
欧州アカデミー科学助言組織のコメント

**Commentary by the European Academies' Science Advisory Council (EASAC) on
Forest Bioenergy and Carbon Neutrality**

多くの研究が、樹木を伐採し燃やすことで数十年～数世紀にわたり
温暖化を悪化させると報告している。

**Multiple studies have found harvesting and burning wood will increase
global warming for decades to centuries.**

Laganière, J., Paré, D., Thiffault, E. & Bernier, P. Y. Range and uncertainties in estimating delays in greenhouse gas mitigation potential of forest bioenergy sourced from Canadian forests. *GCB Bioenergy* 9, 358–369 (2017).

Mitchell, S. R., Harmon, M. E. & O'Connell, K. E. B. Carbon debt and carbon sequestration parity in forest bioenergy production. *GCB Bioenergy* 4, 818–827 (2012).

Stephenson, A. L. & MacKay, D. J. C. Life cycle impacts of biomass electricity in 2020 (Department of Energy & Climate Change, London, 2014).

Bernier, P. & Paré, D. Using ecosystem CO₂ measurements to estimate the timing and magnitude of greenhouse gas mitigation potential of forest bioenergy. *GCB Bioenergy* 5, 67–72 (2013).

Holtmark, B. Harvesting in boreal forests and the biofuel carbon debt. *Clim. Change* 112, 415–428 (2012).

Hudiburg, T. W., Law, B. E., Wirth, C. & Luysaert, S. Regional carbon dioxide implications of forest bioenergy production. *Nat. Clim. Change* 1, 419–423 (2011).

McKechnie, J., Colombo, S., Chen, J., Mabee, W. & MacLean, H. L. Forest bioenergy or forest carbon? Assessing trade-offs in greenhouse gas mitigation with wood-based fuels. *Environ. Sci. Technol.* 45, 789–795 (2011).

Manomet Center for Conservation Sciences. Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources (2010).

Zanchi, G., Pena, N. & Bird, N. Is woody bioenergy carbon neutral? A comparative assessment of emissions from consumption of woody bioenergy and fossil fuel. *GCB Bioenergy* 4, 761–772 (2012).

Holtmark, B. The outcome is in the assumptions: analyzing the effects on atmospheric CO₂ levels of increased use of bioenergy from forest biomass. *GCB Bioenergy* 5, 467–473 (2013).

Booth, M. S. Not carbon neutral: assessing the net emissions impact of residues burned for bioenergy. *Environ. Res. Lett.* 13, 035001 (2018).

Sterman, J.D., L. Siegel, J. N. Rooney-Varga, Does replacing coal with wood lower CO₂ emissions? Dynamic lifecycle analysis of wood bioenergy, *Environ. Res. Lett.* 13 (2018) 015007

Ter-Mikaelian, M. et al. T. (2015). Carbon debt repayment or carbon sequestration parity? Lessons from a forest bioenergy case study in Ontario, Canada. *Global Change Biology Bioenergy*, 7, 704–716.

Malcolm, J., B. Holtmark, P. Piasckik, Forest harvesting and the carbon debt in boreal east-central Canada, *Climatic Change* 112:415-418 (2020)

Colne et al., Biomass supply and carbon accounting for Southeastern Forests (Biomass Energy Resources Center, Forest Guild, Spatial Informatic Group 2012)

木を燃やすのが良いことなら、
紙のリサイクルをするべきではないことになる。
If it is good to burn wood, we should not recycle paper.



木質ペレットは、主に大きな丸太で作られている
Wood pellets mainly come from large logs.



© Copyright 2010 General Biofuels, Inc. All Rights Reserved.



Picture on Georgia Biomass'
Own Website
ジョージアバイオマス社の
HPの写真



<http://www.bloomberg.com/news/videos/2015-05-20/how-green-is-biomass-power-from-forest-to-furnace>



Enviva Wood Pellet Mill
(Sampson County, North Carolina, February 2017)

エンビバ社の木質ペレット工場（ノースカロライナ）

Photo courtesy Dogwood Alliance

製紙原料品質の木材（パルプ材）は残材ではない Paper-making quality trees (pulpwood) are not residues.



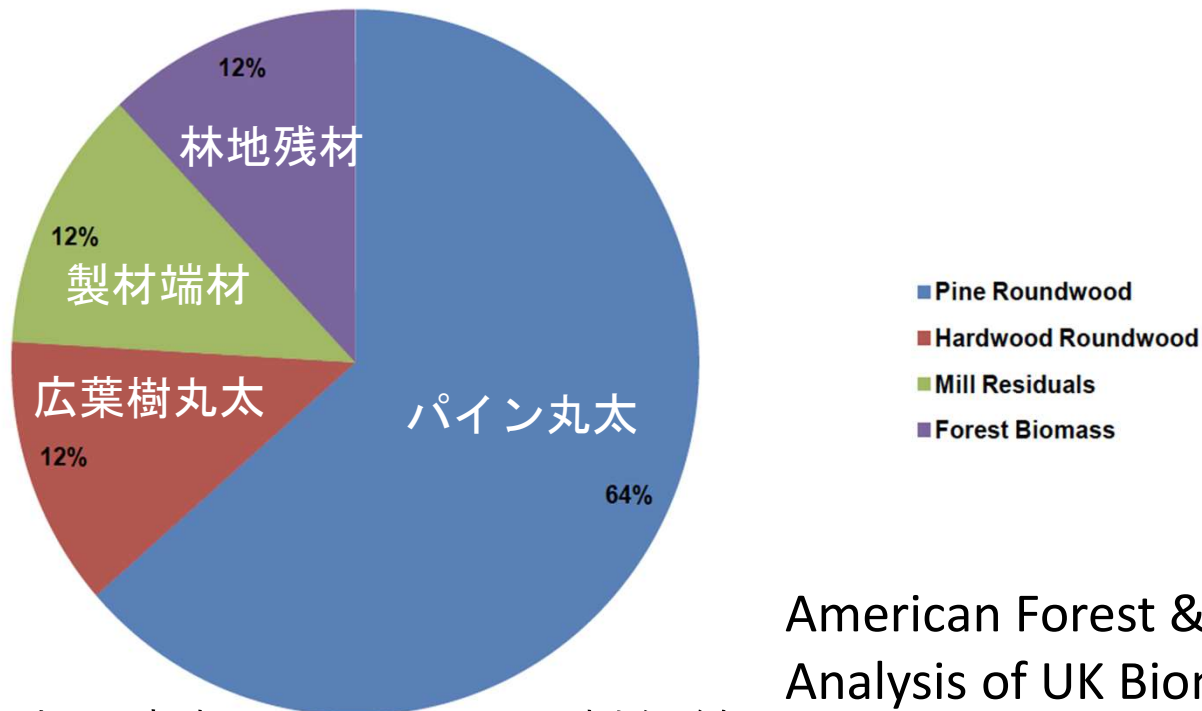
エンビバ社の木質ペレット工場に入るトラック
ノースカロライナ
Truck entering Enviva Wood Pellet Plant, North
Carolina



近所の製紙工場に入るトラック
Truck entering nearby pulp mill.

林地残材から作られる木質ペレットは12%のみ Only 12% of wood pellets come from wood harvest residues.

Figure 7
US South Wood Pellet Fiber Furnish
Percent of the Total, 2015



米国南部のペレット原料供給
2015年の割合

American Forest & Paper Association, An
Analysis of UK Biomass Power Policy (2015)

残材とはこのようなもの
(大きな幹ではない)
This is what residues look like
(not big stems)



Even “sustainable” wood harvest still increases global warming!

たとえ、「持続可能」な森林伐採であっても、地球温暖化を加速する。

Why?

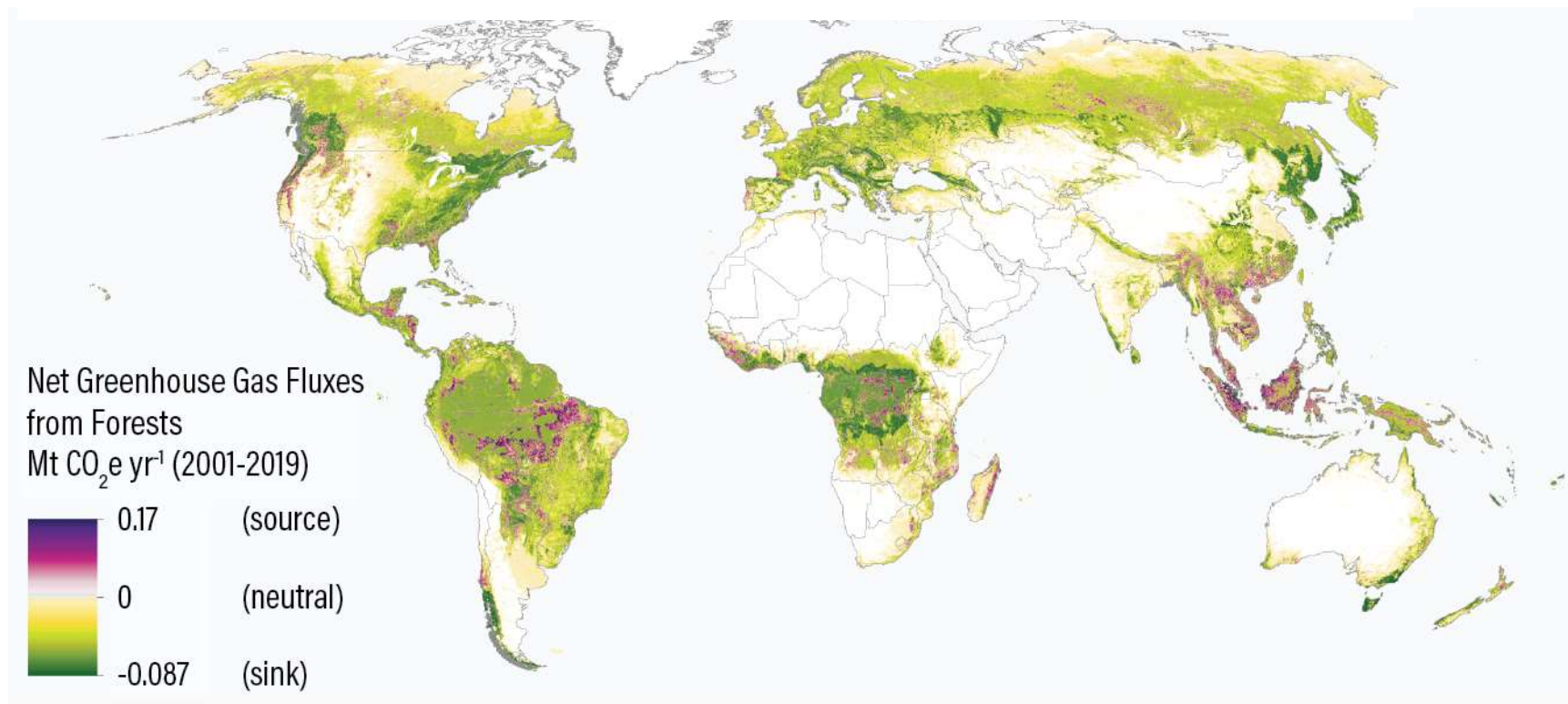
なぜか？

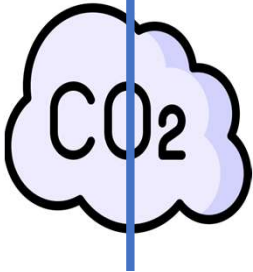
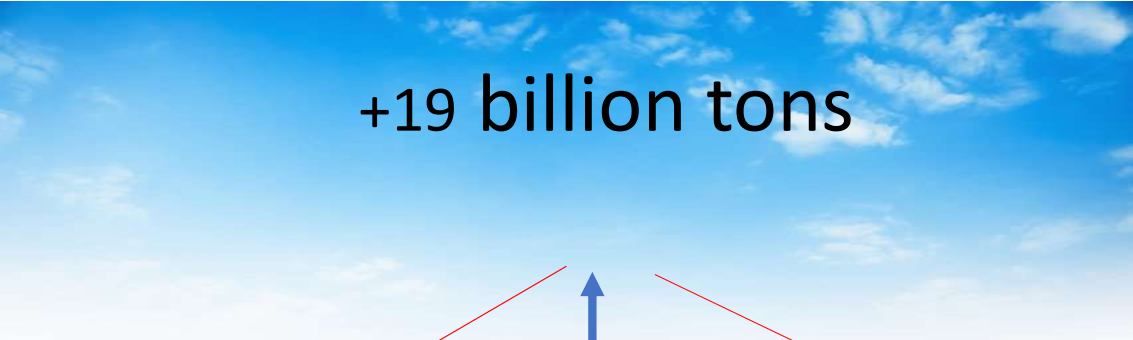
Because without these harvests, forests would grow more and remove more carbon from the air.

もし、この伐採がなければ、森林はより大きく成長し、より多くの炭素を空気から取り除くからである。

Global forests are growing and gaining carbon (everywhere green and yellow). This plays a critical role in limiting climate change.

世界の森林は成長し、炭素を吸収しており（下図：緑・黄色）、気候変動の抑制に重要な役割を果たしている。





~ 38 billion tons



実際には世界には大きな森林の「炭素吸収源」がある。年間80億トンもの二酸化炭素を吸収している可能性がある。PNAS 116:4382 (2018)

人間が空気中に加えるCO₂の25%は、高いCO₂濃度のために成長が速くなった樹木により再吸収される。

もし森林のレベルを今のままにして、「森林の炭素を燃やし尽くす」レベルまで木を伐採したら気候変動はさらにずっと悪化するだろう。

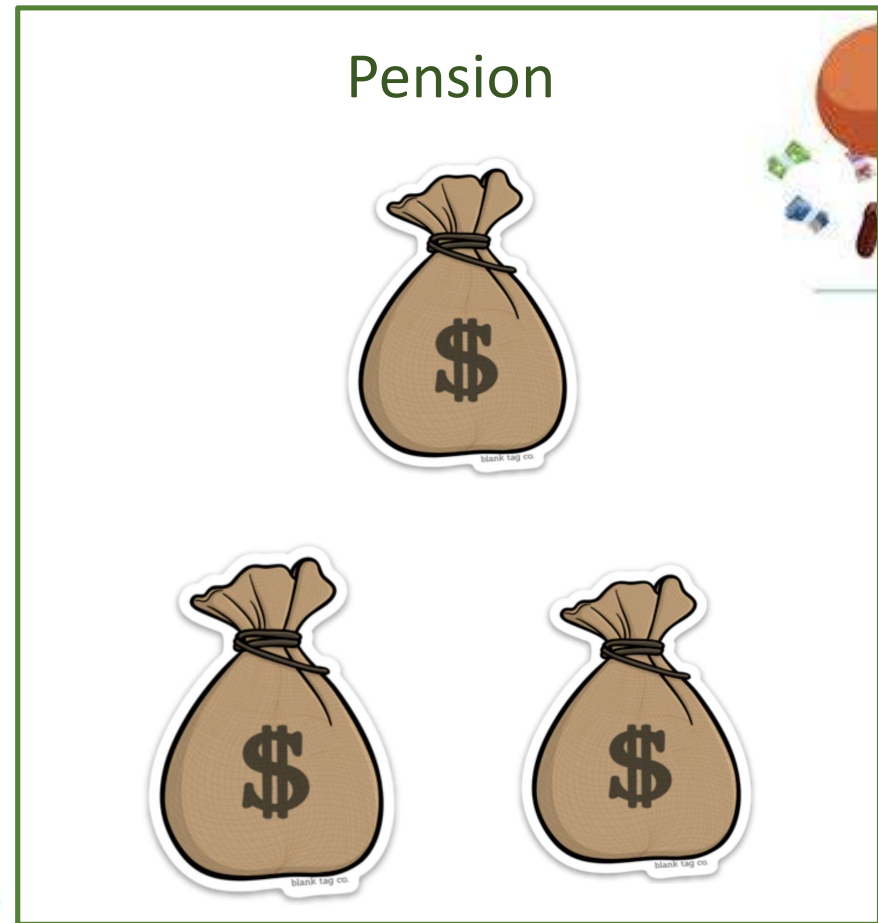
In fact, world has large forest “carbon sink.” Maybe as big as 8 billion tons of carbon dioxide per year. PNAS 116:4382 (2018)

25% of all CO₂ people add to the air is reabsorbed by trees that grow faster because of that higher CO₂

If we just keep forest levels as they are now, if we harvest trees to the level that we “burn up the forest carbon ,” climate change will be much, much worse.

You add money to your pension every year. If a thief only steals only this money, your pension stays the same size, but you are still poorer.

毎年、年金にお金を足しているとする。泥棒が足した分のお金のみ盗んだ場合、あなたの年金は同じ金額にとどまるが、それはあなたが一層貧しい状態であることを意味する。



木材の伐採と燃焼による生物起源の排出は、

より大きな「炭素負債」—より多い大気中の炭素量—を生む

Biogenic emissions from harvesting and burning wood creates a larger “carbon debt”
– more carbon in the air.

大気中のCO₂ CO₂ in atmosphere

収穫残材の分解
(根、その他) 30%+
Harvest Decay (roots,
some residues) 30%+



Forest 森林

乾燥、樹皮剥ぎ、ペレット化、
輸送での損失 15-35%
Drying, debarking
Pelletizing Transport losses
15-35%



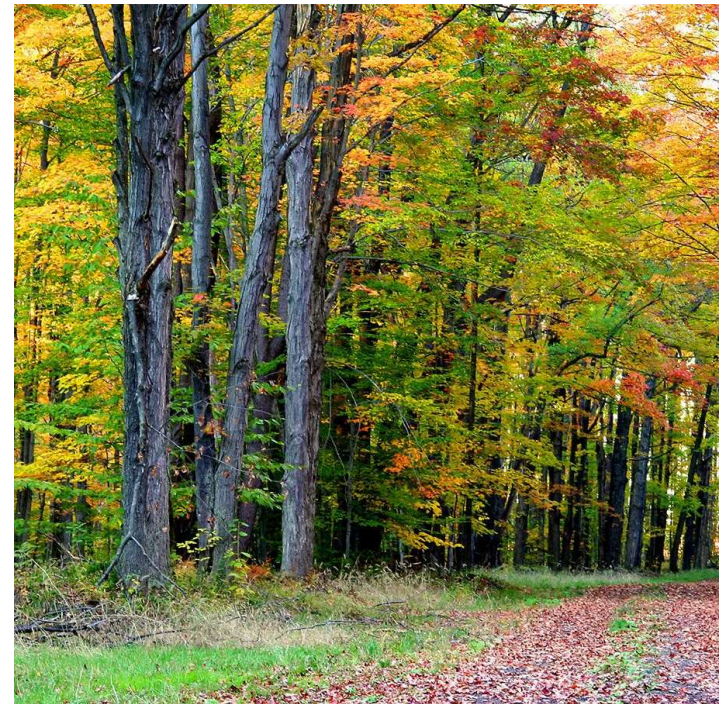
Chip/Pellet Production
チップ・ペレット製造

発電所での燃焼
化石燃料の1.5-3倍
Burning in power plant
1.5x-3x fossil fuels



Power Plant 発電所

伐採され再生した木々は、炭素を再吸収するが最初はゆっくり。
もし伐採されなければ、木々は成長を続ける長を続ける。
伐採後数年の間、成長の遅さのために炭素負債が増加する。
Regrowing trees reabsorb carbon but at first slowly. If not harvested, trees
would still grow. For some years, the slower growth increases the “carbon
debt.”




Article

The carbon costs of global wood harvests

Liqing Peng¹✉, Timothy D. Searchinger^{1,2}✉, Jessica Zionts¹ & Richard Waite¹



論文「世界の森林伐採の炭素コスト」（ネイチャー. 2023年8月3日）



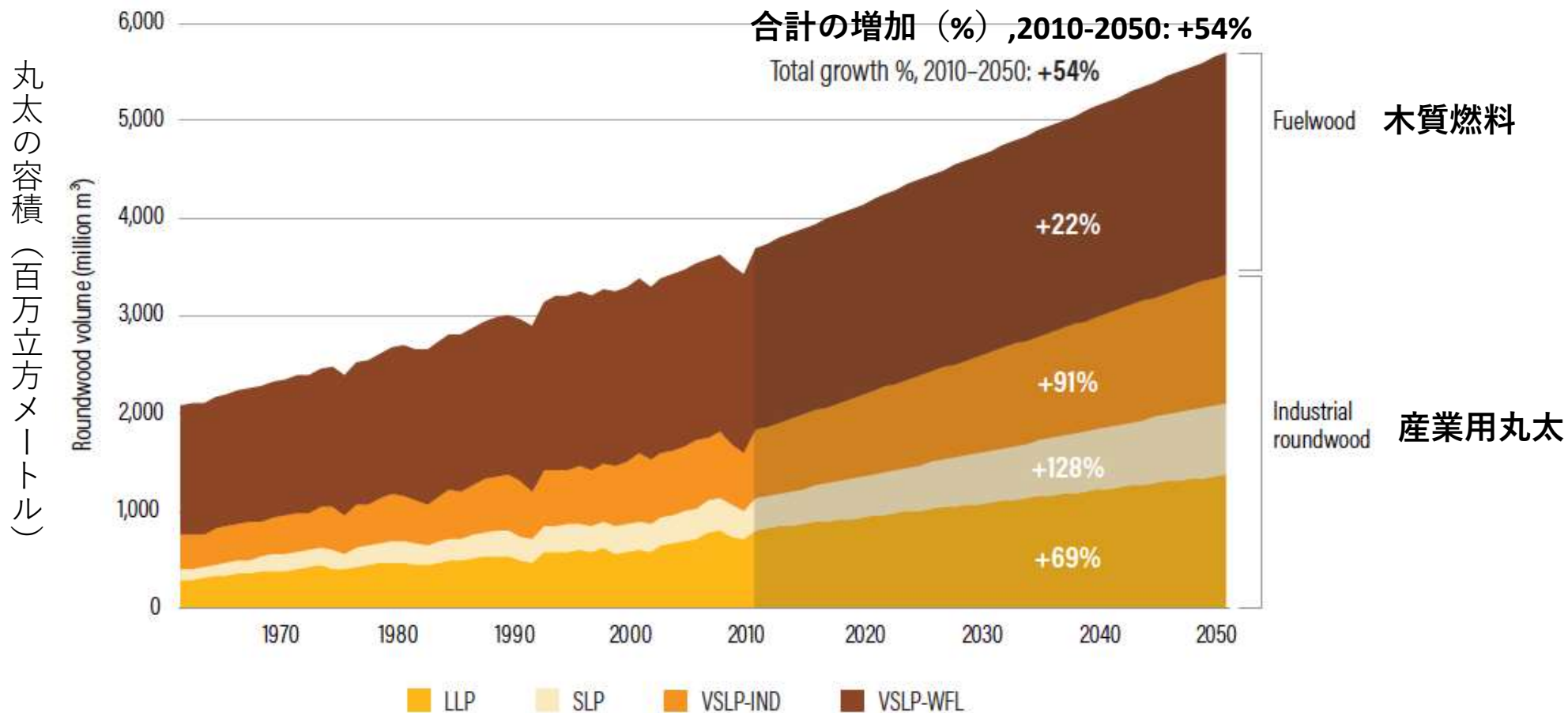
Global wood use will emit **3.5-4 billion tons of CO₂/year**

世界の木材利用により、年間35～40億トンのCO₂が排出される。

3 times emissions from aviation

航空部門からの排出の3倍である

Wood Demand to Grow 54% (2010 to 2050) Without New Wood-Burning Policies 木材需要は54%増加する（2010年～2050年）～新規の木材燃焼政策がない場合でも



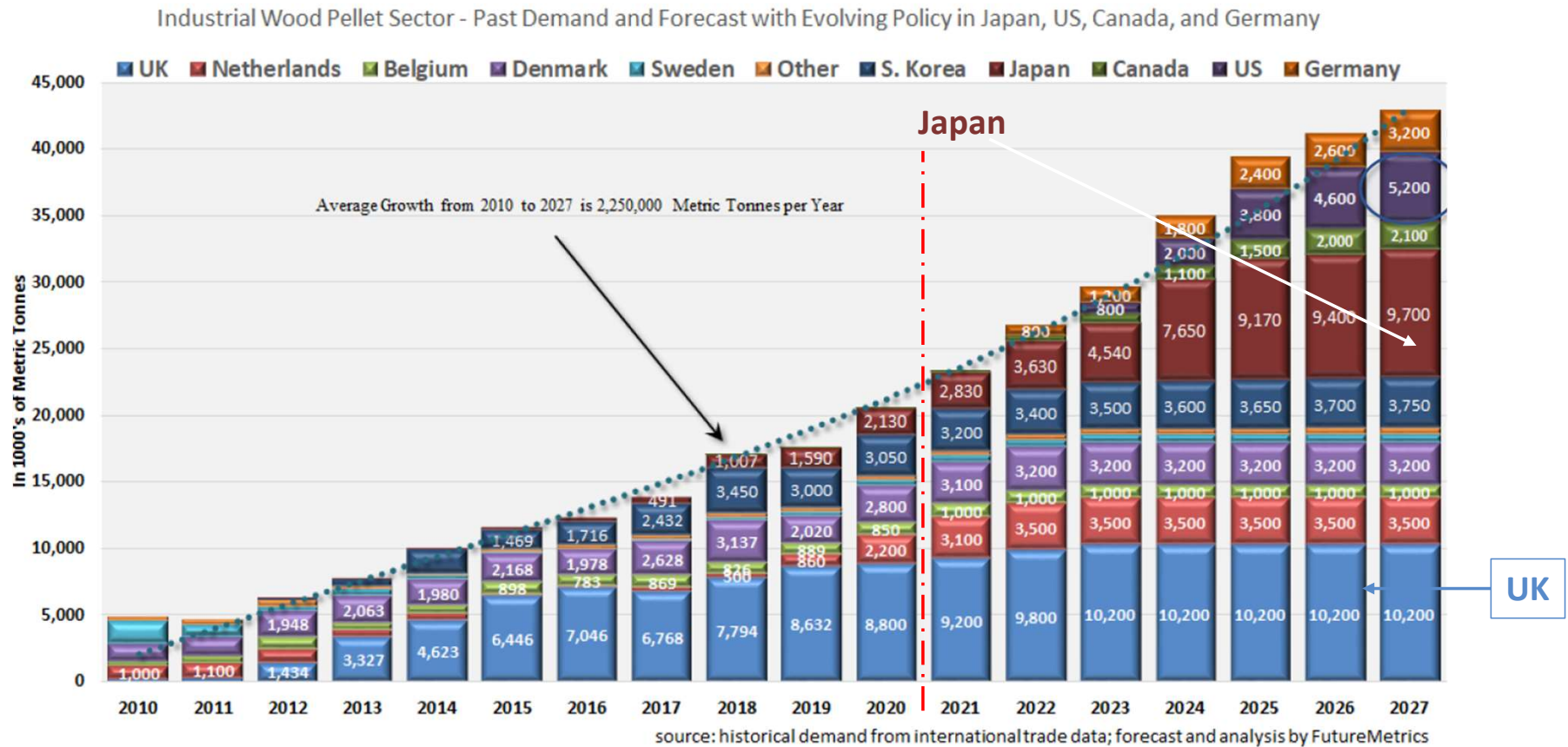
Peng et al., Nature (2023)

Global Biomass Demand Forecast

世界のバイオマスの需要予測

Doubling from 2020 to 2027 (43 million tons)

2020年～2027年の間に2倍（4300万トン）に達する





COMMENT

DOI: 10.1038/s41467-018-06175-4

OPEN

“ヨーロッパの再生可能エネルギー指令により、世界の森林が損なわれることになる” (2018年)

Europe's renewable energy directive poised to harm global forests

Timothy D. Searchinger ¹, Tim Beringer², Bjart Holtsmark³,
Daniel M. Kammen ⁴, Eric F. Lambin^{5,6}, Wolfgang Lucht^{7,8}, Peter Raven⁹ &
Jean-Pascal van Ypersele⁶

NATURE COMMUNICATIONS | (2018)9:3741 |

**To provide just 2% more world energy,
world must double the commercial harvest of wood.**
世界のエネルギーの2%のエネルギーを新しく供給するために、
世界で木材の商業伐採量を2倍にしないといけない